TAXONOMIC STUDY OF FAMILY LINDERNIACEAE BORSCH, KAI MÜLL. & EB.FISCH. IN NEPAL

A Dissertation submitted for partial fulfillment of the Requirements for the Award of the Degree of Master's in Botany

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DECLARATION

Dissertation entitled **"Taxonomic study of family Linderniaceae Borsch, Kai Müll. & Eb.Fisch. in Nepal"** is a research work carried out by me under the supervision of Prof. Dr. Sangeeta Rajbhandary, CDB, TU is being submitted to the Central Department of Botany (CDB), Institute of Science and Technology (IOST), Tribhuvan University (TU), Nepal for the award of the degree of Master of Science in Botany.

This research contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree. Except where otherwise indicated, this research is my own work.

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Kiran Panthi

March, 2023

LETTER OF RECOMMENDATION

This is to certify that the dissertation work "**TAXONOMIC STUDY OF FAMILY LINDERNIACEAE Borsch, Kai Müll. & Eb.Fisch. IN NEPAL**" has been completed by **Mr. Kiran Panthi** under my supervision. This entire research was accomplished on the basis of candidate's original work. To the best of my knowledge the work has not been submitted for consideration for any other academic degree. It is hereby recommended for the acceptance of this dissertation as part of the requirement for a Master's degree in botany at the institute of Science and Technology, Tribhuvan University, Kathmandu Nepal.

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Supervisor

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Date……

LETTER OF APPROVAL

This dissertation entitled **"Taxonomic study of family Linderniaceae Borsch, Kai Müll. & Eb.Fisch. in Nepal"** submitted by Mr. **Kiran Panthi** has been accepted for partial fulfillment of the requirements for the award of the degree of Master of Science in Botany.

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ABSTRACT

Linderniaceae, false Pimpernel family is recognized as a distinct family based upon recent molecular evidences. The family, which is represented by its type genus *Lindernia* All., comprises 20 genera and about 314 species distributed worldwide in moist tropical, subtropical and temperate zones of both the Old and New Worlds. The taxon is distinctive mainly in being herbs with simple and opposite leaves; zygomorphic flowers; winged or unwinged calyx; geniculate, swollen or appendaged anterior stamens; disc around ovary and bilipped ciliated stigma. There was a lack of comprehensive account of Nepalese Linderniaceae based on fresh collections. Enumeration accounts of Nepalese Linderniaceae were based on herbarium specimens deposited at national and world herbaria, but still they had some problems regarding identification, nomenclature of the taxa and their distribution. This study resolved the taxonomic problems of the family, on the basis of comprehensive morphological study of fresh collections and the herbarium specimens.

The collection of the specimens was done during flowering seasons of the taxa in different regions of Nepal. The herbarium preparation was done by following standard guidelines. A detailed description of each taxon was prepared after identification, and morphological study of the specimens along with distribution, illustration, field photographs and cluster analysis.

This study describes 20 species of Linderniaceae in Nepal under six genera (*Bonnaya:* 5 species, *Craterostigma:* 1 species, *Lindernia;* 2 species, *Torenia*: 8 species, *Vandellia:* 2 species *and Yamazakia*: 2 species). Taxa mainly differ in shape, size, colour and texture of stem; leaf shape and venation; pedicel texture; calyx shape; corolla colour and texture; stamens; ovary shape and texture; and capsule shape. *Lindernia* spp. are delimited from other genera by palmately veined leaves over pinnately veined leaves. *Bonnaya* spp. are delimited by the presence of two fertile stamens and anterior staminodes. *Torenia* spp. are distinguished by their winged clayx, mainly appendaged anterior stamens and apically pubescent ovary. *Vandellia* spp. and *Yamazakia* spp. are delimited by their glandular pedicel and clayx. Nomenclature is updated based on recent molecular studies.

The species distribution has shown a great variation in horizontal or vertical geographic regions. Among 20 species, 11 species are distributed in West (W), Central (C) and Eastern (E) Nepal, six species are reported only from Central and Eastern Nepal. Similarly, two species are found to be restricted in only Central Nepal. Furthermore, taxonomy of three species namely *Craterostigma sessiliflorum, Torenia cordata* and *T. hookeri* is discussed thoroughly and suggested to research further. Presente study excludes *C. nummularifolia* because of confusion.

ABBREVIATIONS AND ACRONYMS

General abbreviations

APG	Angiosperm Phylogeny Group
CBD	Convention on Biological Diversity
GPS	Global Positioning System
GSPC	Global Strategy for Plant Conservation
GTI	Global Taxonomy Initiative
IUCN	International Union for Conservation of Nature

Regions of Distribution

C	Central	SE	Southeast
E	East, eastern	SW	Southwest
N	North	W	West, western
S	South		

Herbaria

BM	The Natural History Museum Herbarium, London, UK
BLAT	The Blatter Herbarium, St. Xavier's College, Mumbai, India
C	Natural History Museum Denmark Herbarium, Denmark
E	Royal Botanic Gardens Edinburgh, Edinburgh, UK
JE	Friedrich-Schiller-UniversitÌ_t Jena Herbarium Haussknecht, Jena
K	Royal Botanic Gardens, Kew, UK
KATH	National Herbarium and Plant Laboratories, Lalitpur, Nepal
KW	National Herbarium of Ukraine, Ukraine
LD	Lund University Herbarium, Lund, Sweden
TI	University of Tokyo, Tokyo Japan
TUCH	Tribhuvan University Central Herbarium, Kathmandu, Nepal
WIS	University of Wisconsin Herbarium, Madison, U.S.A.

Taxonomic Treatments and other

asl	above sea level	mm	millimeter
ca.	*circa*- approximately	no.	Number
cm	centimeter	Pp	Photo plate
etc.	*Et cetera*- and other things	S.N.	Serial number
Fig	Figure	sp.	species (singular)
Fl	Flowering	var.	variety
Fr	Fruiting		
Ha	hectare		
i.e.	*id est*- that is		
m	meter		

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CHAPTER 1: INTRODUCTION

1.1. Background

Taxonomy is the branch of science that helps people to recognize and characterize organisms. The study of phenetic, genetic, and phylogenetic interactions among taxa is widely recognized as systematics (Radford 1986). Systematics provides a basis of knowledge about the incredible diversity of life. It also provides an opportunity to comprehend all aspects of group evolution and interactions, scientific framework for recognizing or delimiting species and infraspecific taxa (Simpson 2010). To emphasize the theory of plant classification, Swiss botanist Candolle (1813) coined the term 'Taxonomy' in the Herbarium of Geneva (Stuessy 2009). Taxonomy in Greek refers to 'putting in order'. Similarly, systematics refers to 'putting together' (Haider 2018). It needs more investment for the capture, storage and retrieval of data (Maxted 1922). Taxonomy sometimes is taken as a synthetic science. It draws the data from various fields like morphology, anatomy, molecular biology, cytology, genetics, cytogenetics and chemistry (Rouhan and Gaudeul 2014). There are a lot of species hypotheses which remain untested as new specimens accumulate in herbaria due to lack of proper revision and monographs. Besides, their content of information and reliability of identified material are degrading slowly (Wheeler 2004). The main result of the taxonomic process is typically the organization of organisms into a deep hierarchical structure. A hierarchy depicts the connections between various groups of components (Alberdi and Sleeman 2000). Today, much of taxonomy is believed to be in the grip of a new crisis: a lack of reputation and resources that is hindering the further cataloguing of biodiversity (Godfray 2002).

After all, its overarching goal is to thoroughly uncover and describe the species of an entire planet. To meet this last-ditch attempt to document species, taxonomy not only deserves support but tremendous assistance as well. We can now add intensity to the fundamental conceptual importance of taxonomy for biology. The biodiversity issue has the potential to eliminate most of the evidence of evolutionary history before it is documented (Wilson 1985, Wen *et al.* 2015). In the context of this biodiversity disaster, it is crucial to regenerate taxonomy intellect and infrastructure (Wheeler and Cracraft 1996). The Global Taxonomic Initiative (GTI) was developed by the Conference of the Parties (COP) to address the "taxonomic impediment" of the dearth of taxonomic knowledge and resources in many regions of the world.

In taxonomy, monographs and revisions are essentially the two categories under which taxon-based herbarium research falls. A monograph is a comprehensive account and compares all taxonomic data related to a taxon that is currently available, whereas a revision is more constrained and is primarily limited to a comparison of morphological and geographic data for a taxon within limited geographical scope (Rajbhandary 2015). Assembling as many specimens of the targeted taxon from as many herbaria as possible is the first step towards a revision or monograph. Then, the specimens' morphology is glanced at. Although it is possible to analyze various types of data, such as anatomical, paleontological, and biochemical, morphology is the most practical and widely used data in such a study.

1.2. Taxonomy of Linderniaceae

Lamiales, mint order of the flowering plants is one of the most diverse orders of the angiosperms. Angiosperm Phylogeny group (APG IV 2016) placed Lamiales under the clade Asterids or sympetalous lineage of flowering plants. It comprises 24 families, about 1,059 genera and more than 23,755 species (Berry, 2021). The major families in this monophyletic order are Lamiaceae, Scrophulariaceae, Acanthaceae, Gesneriaceae, Bignoniaceae, Oleaceae, and also the small carnivorous families Lentibulariaceae and Byblidaceae. Recent molecular studies have revealed that the family Scophulariaceae, one of the largest families of the order Lamiales, is polyphyletic. Molecular phylogenetic analysis (Olmsted and Reeves 1995) based upon *rbcL* and *ndhF* sequences first indicated the phylogenetic status of Scrophulariaceae. The polyphyly of this family was confirmed after the phylogenetic analysis of Lamiales and its main representatives (Bremer *et al.* 2002, Muller *et al.* 2004). This family was divided into several distinct families using a broader sampling of genes. Several genera which were previously placed in Scrophulariaceae *s.l.* are now kept under different new or related families.

The polyphyly of the Scrophulariaceae *s.l.* was verified by various phylogenetic analyses (Bremer *et al. 2002*, Hilu *et al. 2003* & Muller *et al.* 2004). The fossil history of Lamiales only goes back to the Tertiary period (Magallon *et al.* 1999). The use of highly dynamic plastid sequences has considerably enhanced the determination of relationships among Lamiales groups. Gesneriaceae and Calceolariaceae are found to be in the sister relationship. Nevertheless the actual position of Linderniaceae within the main core of Lamiales is unknown (Schaferhoff *et al.* 2010). There is still

a need to investigate species that have been underrepresented in molecular analyses to date, with the goal of establishing the taxonomic position and phylogenetic relationship of various genera from Africa, Asia, and the Americas, as well as resolving the affiliation between *Micranthemum* and the subgenera within the *Lindernia s.str.* circumscription (Biffin *et al.* 2018).

Linderniaceae, false Pimpernel family was represented as a distinct family based upon the molecular evidences. 13 genera with more than 80 species from tropical Africa and Southeast Asia were published under this family (Rahmanzadeh *et al.* 2005). Previously this taxon was recognized as Lindernieae as a tribe of the traditionally defined Scrophulariaceae and subtribe of Gratiolae. Linderniaceae as a distinct lineage was supported by Albach *et al.* (2005), Oxelman *et al.* (2005) and Tank *et al.* (2006), and was verified in the thorough analysis of the Lamiales (APG III 2009).

The family is represented by its type genus *Lindernia* All., comprises 20 genera and about 314 species worldwide (Banki *et al.* 2023). The Linderniaceae are distinctive in being herbs with simple, opposite leaves, zygomorphic, bisexual flowers, winged or unwinged, 5-lobed or 2-lipped calyx, bilabiate corolla, epipetalous, 2 or 4, didynamous, geniculate or appendaged anterior filamentous stamens, ciliated bilipped stigma, and subglobular to cylindric dehiscent capsule. Linderniaceae as a distinct lineage is supported morphologically by abaxial geniculate filaments (Bazarragchaa 2019).

The type genus *Lindernia* was based on *L. procumbens* from Europe. This name was proposed by Allioni after Franz Balthasar von Lindern (1682-1755). In *Tournefortius Alasticus* (1728), the first illustration of *Lindernia pyxidaria* L. was published. Specific epithet was not mentioned by Allioni in the description of this species, which was collected from Alasac-Lorraine in France. Instead, a specimen collected by Gagnebin in Switzerland was cited and illustration was done (Baden 2005). This was only the species native to Europe of the genus *Lindernia* (Rico et al. 2006). Philcox (1965) found that the first authorized publication of this name was by Linneaus, but also proposed that the Linnean name was illegitimate. He considered that *Anagalloides procumbens* Krock. was the first legitimate name for European native *Lindernia*. He then proposed a new combination *Lindernia procumbens* (Krock) Philcox based on Krock's *Anagalloides procumbens* for that species. Being the type

specimen of *Lindernia*, it shares various characters (vegetative as well as reproductive) with other species.

Previously majority of the species of family Linderniaceae have been placed in a single genus *Lindernia s.l.* and some of the species in different genera like *Torenia*, *Artanema* and *Craterostigma* (Pennel 1935 and Philcox 1968). In Nepal Linderniaceae was represented by two genera *Lindernia s.l.* and *Torenia s.l. with* 14 and six species respectively (Press *et al.* 2000). Shrestha *et al.* (2022) and Rajbhandari *et al.* (2022) have published the checklist of the family trying to consider the recent changes in nomenclature of the species but still there are some issues with the names of those taxa, and a detailed taxonomic account of the family in Nepal is lacking.

1.3. Statement of the problem and Justification of the study

- Enumeration of Nepalese Linderniaceae also varies in accordance with literatures. Press *et al.* (2000) enumerated 14 species under *Lindernia s.l.* and 6 species under *Torenia s.l.* Rajbhandari (2015) listed 14 species under *Lindernia s.l.* and 4 species under *Torenia s.l.* Shrestha *et al.* (2022) listed 20 species under Linderniaceae whereas Rajbhandari *et al.* (2022) published 21 species under six genera in Linderniaceae. These publications were based on herbarium specimens deposited on national and world herbaria, but still there were some problems on proper identification, nomenclature of the taxa and their distribution.
- Most of the taxa of Linderniaceae are considered as weeds and get less attention from taxonomists.
- Some studies was conducted outside Nepal based on dried specimens, but could not cover all morphological characters. Detailed work based on live plants was still waiting.
- There was still a Problem in identification and type specimens of some species.
- Taxa of Linderniaceae are also economically valuable. They are not just weeds but widely used in traditional medicines (Umarithika 2021), aquarium (Jabir *et al.* 2016) and gardens as ornamental plants (Swapna *et al.* 2011). It is

thus necessary to revise this taxon based on both live plants and dried specimens.

- In our national herbaria (KATH), Linderniaceae was represented by very few collections from limited areas. Few species like *Bonnaya tenuifolia*, *Torenia hookeri, Vandellia multiflora* and *Yamazakia viscosa* had no any collection. While some species were represented by less than 2%. About 21.9% of the housed specimens were misidentified and about 2 % of the species were unidentified.
- There is still a need to investigate species that have been underrepresented in molecular analyses to date, with the goal of establishing the taxonomic position and phylogenetic relationship of various genera
- Nepal has also signed The Convention on Biological Diversity (CBD) and Global Strategy for Plant Conservation (GSPC) to document the plant resources of Nepal by publishing Flora. To fulfill the target of this commitment, revision on such neglected taxa was mandatory.
- This study has tried to resolve the above mentioned taxonomic problems of the family, and pattern of distribution of sub-familial taxa on the basis of collections and comprehensive morphological study of the species.

1.4. Objectives of the study

The broad objective of this study is to prepare a detailed taxonomic account of the family Linderniaceae in Nepal.

The specific objectives of this study were:

i. To carry out the comparative study of the species based on macro-morphological characters and prepare taxonomic keys, description, illustration and photo plates for easy identification.
ii. To find out the distribution patterns of the species within the country based on collection and deposited specimen in national and world herbaria.
iii. To analyze the resemblances between species with taxonomic keys and cluster analysis.
iv. To prepare a draft account of Linderniaceae for the *Flora of Nepal.*

1.5. Limitations

- Despite examining only the morphological characteristics of taxa, this study solved many problems regarding the taxonomy of Linderniaceae.
- Due to outbreak of Covid-19 Pandemic driven series of lockdowns, the planned works were considerably affected. However efforts have been made to complete the field work collecting all the species as much as possible.

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CHAPTER 2: LITERATURE REVIEW

2.1. Taxonomic history of Linderniaceae

Bentham (1846) originally suspected that a group of taxa that would now be included in the Linderniaceae family were a subtribe (named as Lindernieae) of the Gratioleae. The Lindernieae, on the other hand, had already been identified as a distinct tribe of the Scophulariaceae (Reichenbach 1831). The corolla shape and geniculate stamens of the taxon served as the foundation for its recognition as a distinct tribe. Scrophulariaceae was considered to be the largest family in the Lamiales, according to Bentham (1846) and Wettstein (1891) circumscription. Orobanchaceae, Lentibulariaceae and Plantaginaceae which were previously considered to be derived from an ancestral stock of Scrophulariaceae were included in Scrophulariaceae by Hailler (1903). Takhtajan (1980), Cronquist (1981), and Throne (1992) have followed Wettstein (1891) considering Scrophulariaceae as the larger family and splitted it into subfamilies such as Pseudosolaneae, Antirrhinoideae and Rhinanthoideae (Wettstein 1891), or two subfamilies: Pseudosolaneae, Antirrhinoideae (Thieret, 1967) or all three subfamilies mentioned above including Orobanchaceae (Takhtajan 1980, Cronquist 1981). On the way of resolving the phylogeny of Scrophulariaceae, Olmstead and Reeves (1995) performed the first molecular phylogenetic analysis using, *rbc*L, and *ndh*F sequences in a broader sample size and indicated that the Scrophulariaceae is polyphyletic and later this taxon was divided into several distinct families namely Scrophulariaceae, Veronicaceae and Orobanchaceae (Olmstead *et al.* 2001).

Fischer (2004) treated the Lindernieae as a tribe separately from the Gratioleae. The separation of Lindernieae from Gratiolae was also supported by molecular systematic analyses of the Scrophulariaceae *s.l.* (Albach *et al.* 2005, Oxelman 2005). Lindernieae was recognized at the rank of family as Linderniaceae based on the molecular phylogenetic analysis of *trnK* and *matK* gene with a larger sampling (Rahmanzadeh *et al.* 2005). Based on the morphological synapomorphy i.e. abaxial geniculate stamens and molecular synamorphy, they have described 13 genera under the family Linderniaceae. The comprehensive analysis of the Lamiales in APG III (2009) has confirmed the separation of this taxon.

2.2. Generic makeup of the family

Despite being the type genus of the family, taxonomy of *Lindernia* has been widely discussed, leading to a complicated taxonomic history with recommendations to either include all species under the umbrella genus *Lindernia* or divide them into various other genera (Fischer *et al.* 2013). This taxon was created by Allioni without a specific epithet. The binomial *Lindernia pyxidaria* L. was published in *Mantissa Plantarum* by Linnaeus (1771) in the reference of Allioni's illustration and his own *Capraria gratioloides*. But this name was nominated as illegitimate for the designation of the type specimen of genus (Philcox 1965).

Later, Krocker (1790) in *Flora Silesiaca* published *Anagalloides procumbens* with a detail description. In contrast to Allioni, Krocker only gave an illustration of this taon as the type, not a type specimen. This illustration was later used by Philcox (1965) and described an important taxonomic treatment with a new combination *Lindernia procumbens* (Krock.) Philcox, which is then designated as the type specimen of the genus.

Linnaeus (1751) provided the first description of the genus *Torenia*. T. asiatica which is designated as type of *Torenia*, was obtained from and named after Olof Toron who collected it around Canton in 1748-49. Much earlier than *Lindernia pyxidaria*, Linnaeus (1753) designated another species of *Lindernia s.l.* under the name *Ruellia antipioda* L. in his *Species Plantarum*, which is now described as *Bonnaya antipoda* (L.) Druce. Retzius (1790) described *Gratiola veronicifolia* Retz. and *Gratiola grandiflora* Retz. based on flower size (both are now synonymized as *Bonnaya antipoda*).

Burman (1768) in his dissertation *Nova Plantarum Genera*, in *Flora Indica*, designated *Ruellia angallis* Burm.f. which was used as basionym of *Lindernia anagallis* (Burm.f.) Pennell, and later *Torenia anagalis* (Burm.f.) Wannan, W.R.Barker & Y.S.Liang.

On a thesis of Gratiolae, Colsman (1793) significantly described some taxa such as *Gratiola ruellioides* Colsm. (*Bonnaya ruellioides* (Colsm.) Spreng.), *G. cordifolia* Colsm. (*Torenia anagallis* (Burm.f.) Wannan, W.R.Barker & Y.S.Liang.) and *G. verbenaefolia* Colsm. (*Bonnaya antipoda* (L.) Druce.). These species are

synonymized later in various publications such as Cramer (1981) and Press and Shrestha (2000).

Roxburgh summarized various species such as *Gratiola serrata* (*Bonnaya ciliata* (Colsm.) Spreng.) and *G. reptens* (*Bonnaya ruellioides* (Colsm.) Spreng. in *Flora Indica* (1820) and *Flora Indica* (1832). The most through observations made by Roxburgh (1832) provide incredibly useful references for comprehending the Asian *Lindernia* species.

In *Annals of Nature*, Rafinsque (1820) described a new genus *Ilysanthes* on the basis of characters of stamen and pistil. This taxon was mostly a semi-aquatic type. It differs with *Gratiola* by the calyx, corolla and capsule. Link and Otto (1828) described another genus *Bonnaya*; *B. brachiata* as the type species. Description of new genera was ongoing and another new genus name *Tittmania* was given by Reichenbach (1824) based on the characters of stamens. Similarly, a new combination was made by Sprengel (1824, 1825) and *Gratiola cordifolia, G. verbenaefolia and G. veronicifolia* were resurrected into the genus *Bonnaya*.

Taxonomy of overall Scrophulariaceae of Buitenzorg/Bataviam (Java) was described by Blume (1825). In *Bijdragen tot de Flora van Nederlandsch Indie* Blume (1825) treated taxonomy of various taxa such as *Diceros glanduliferus* (*Yamazakia viscosa* (Hornem.) W.R.Barker, Y.S.Liang & Wannan) was distinguished from *Gratiola*. Similarly, *Mimulus javanicus* (*Torenia crustacea* (L.) Cham. & Schltdl.) and *Torenia obtusa* (*Torenia anagallis* (Burm.f.) Wannan, W.R.Barker & Y.S.Liang.) were distinguished from *Mazus*.

Linnaeus' *Capraria crustacea* L. was moved into *Torenia crustacea* (L.) Cham. & Schltdl. by Chamiso (1827). This was only the taxon in *Lindernia* complex characterized by a tubular calyx with short wings along the margin. This was a fascinating move.

Bentham (1835) in *Scrophulariaceae Indiceae* recognized genera *Vandellia* L. and *Bonnaya* Link and Otto. These taxa were distinguished on the basis of the characters of stamen. Where *Bonnaya* are characterized by 2 fertile stamens and 2 staminodia and those of *Vandellia* possess 4 fertile stamens. In the tribe Gratiolae, solely encompassing Asian species (including Nepalese *Lindernia s.l.* except *Gratiola multiflora* and *Vandellia hookeri*) were described. Later, in 1846 in De Candolles'

Prodromus Systema Naturalis, Bentham described *Lindernia* in a distinct subtribe Lindernieae based upon European taxon concept. This species was known only from Europe. *Gratiola* was placed under the subtribe Eugratiolae with other genera like *Mazus*, *Bacopa* and *Mimulus.* Most of our species were represented in Lindernieae. Within this subtribe, other genera *Vandellia*, *Ilysanthus, Hemianthus*, *Peplidium, Torenia*, *Curanga, Bonnaya and Artnema* were also described.

A new combination was made by Urban (1884). *Bonnaya* and *Ilysanthes* with 2 fertile stamens were lumped into *Ilysanthes*. *Ilygeton*, *Tittmania* and *Vandellia* with 4 stamens were lumped into *Lindernia*. Wettstein (1891) and Hepper (1963) had also accepted this concept.

Torenia and *Craterostigma* were recognized as separate genera by Wettstein (1891). Gamble (1923) circumscribed *Torenia asiatica* (which was published in Flora of British India with several varieties) as *T. travancorica* Gamble. Alston (1931) removed the name *T. asiatica* from *Ceylon Flora*.

A major achievement was made by Pennell (1935) in his *Scrophulariaceae of Eastern Temperate North America.* He merged the two anthered *Ilysanthes* Raf. and *Bonnaya* Link and Otto with the four anthered *Lindernia* All. and *Vandellia* L. into a broadly circumscribed genus *Lindernia* arguing that a reduction of stamens cannot be used as a character for genera.

On the basis of leaf and seed morphology, Yamazaki (1954), proposed a division into *Vandellia* and *Lindernia*. The former was characterized by pinnately veined leaf with serrate margin and seed with 1-celled chalazar haustorium and alveolate endosperm, and the latter was characterized by palmately veined leaf with subentire or weakly dentate margin and seed with 2-celled chalazar haustorium and smooth non-alveolate endosperm. This separation was also followed in Hara (1966).

Saldanha (1966) revised the *Torenia* from Western Peninsular India, accepting *T. asiatica* with two new species namely *T. indica* and *T. linderniodies.*

Philcox (1968) in his *Revision of Malesian Species of Lindernia s.l.,* described 24 Malesian species in 9 sections based mainly on the morphology, pollination pattern and cytological examination of few species as well.

In the Revision of the New World species of *Lindernia*, Lewis (2000) treated an overall 12 distinct species. Although the revision was done with New World taxa alone, it is also useful for Nepalese Linderniaceae by means of specific and generic affinities made on the discussion.

After the disintegeration of Scrophulariaceae, Linderniaceae was described with 13 genera as a distinct lineage (Rahmanzadeh *et al.* 2005). This separation was supported by further molecular studies such as Albach *et al.* (2005) and Oxelman (2005), and APG III (2009) verified its separation.

After the recognition of family Linderniaceae, a comprehensive review of the family was carried out down to the species level including synonyms by Fischer *et al.* (2013). This molecular study supported the recognition of *Artanema*, *Craterostigma*, *Crepidorhopalon*, *Stemodiopsis* and *Torenia* of the previous studies. Similarly, many species of *Lindernia* were then transferred to several old and newly recognized genera. Another new genus *Linderniella* was also described based on molecular phylogeny. *Lindernia ciliata* and *L. ruellioides* were revived into already existing genus *Bonnaya*. *Craterostigma* (including *Lindernia nummularifolia*) is described here as a well-supported genus. They also transferred *Lindernia crustacea* to *Torenia crustacea*. This species have affinities to *Torenia* which was already mentioned by some authors (Philcox 1968) and is indeed the member of *Torenia*. Based on ridged calyx tube and genetic data, *Lindernia* sect. *Torenioides* is circumscribed as the genus *Torenia*.

Recent studies such as Liang and Wang (2014) revised *Bonnaya* of Australia on the basis of morphological evidences and a new species *B. sanpabolensis* Y.S. Liang and J.C. is described. Liang and Wang (2016) resurrected *Lindernia sessiliflora* as *Craterostigma sessiliflora* distinct from *Craterostigma nummularifolia* on the basis of morphology and molecular phylogeny. Similarly, *Vandellia taishanensis* (F.Z.Li) Y.S.Liang & J.C.Wang is circumscribed as *Torenia taishanensis* (F.Z.Li) Y.S.Liang & J.C.Wang and *Lindernia kinmenensis* Y.S.Liang, Chih H.Chen & J.L.Tsai to *Torenia kinmenensis* (Y.S.Liang, C.H.Chen & J.L.Tsai) Y.S.Liang & J.C.Wang.

Some major changes were done (Biffin *et al.* 2018) in phylogenetic placement of Australian Linderniaceae to resolve the polyphyly of genus *Vandellia*. *V. pussilla* and *V. viscosa* (which have previously placed in *Titmannia*, but this name was rejected)

were transferred into a new genus named *Yamazakia.* Similarly, in previous studies, due to the lack of molecular evidences and evolutionary relationships, *V. anagallis* (Burm.f.) T. Yamaz. was placed in Section *Angustifoliae* Hara (as in Philcox 1968) or moved to genus *Vandellia* (as in Fischer *et al.* 2013), by the analysis of its phylogenetic hypothesis, this species has been transferred to *Torenia* as a novel finding.

Bazarragchaa *et al.* (2019) revised the family Linderniaceae in Korea with a taxonomic treatment of four genera, six species and one variety. *Lindernia micrantha* D. Don and *L. angustifolia* (Benth.) Wett. are synonymized to *Vandellia micrantha* (D.Don) Eb. Fisch., Schäferh. & Kai Müll. Similarly, *Lindernia atteunata* Muhl. and *L. dubia* var. *major* (Pursh) Pennel were synonymized under *L. dubia* L.

Recently, three new species in *Lindernia* All. *s.l.,* namely *L. stantonii* Wannan, *L. beasleyi* Wannan and *L. barkeri* Wannan for Australia were recorded (Wannan 2016). A new species *Lindernia tamilnadensis* M.G. Prasad & Sunojk. was reported (Prasad and Sunojkumar 2014) from Tamil Nadu, India. New species of *Bonnaya- B. milindii* Shimpale & Sardesai was recorded from western ghat of India (Shimpale *et al.* 2019). Darbyshire and Fischer (2017) described a new species of *Craterostigma* (*C. loitense* I.Darbysh. & Eb.Fisch.) from Kenya. *Torenia siliguriensis* A. Pal & M. Chowdhury was another new species recorded from India (Pal and Chowdhury 2021). *Torenia maculata* was another recently recorded species for Thailand (Sutthisaksopon *et al.* 2021) for family Linderniaceae. Similarly, another new species *Lindernia sallyae* Eb. Fisch., Vollesen & I. Darbysh. is described by Fischer *et al.* (2023) from Tanzania.

2.3. Delimitation of family Linderniaceae from closely related taxa

After the redefinition of Scrophulariaceae, the Linderniaceae is represented as new family from the molecular analyses (Rahmanzadeh *et al.* 2005). Further morphologically, the family is recognized as a distinct lineage in Lamiales from closely related taxa. Mainly, the reproductive characters such as abaxial geniculate, curved or spurred filaments either in stamens or staminodes of the species are the major characters taken to distinguish the family (Fischer 2004). Additionally, phytochemical analyses also support the delimitation of these taxa as they lack iridoid compounds and the type of protein bodies which are common in Veronicaceae (Albach *et al.* 2005). The genera under the family had a close relationship with

Stemodiopsis and *Crepidorhopalon* and later these were also included in the family Linderniaceae (Fischer *et al.* 2013) and described the monophyly of the family.

Morphological and phylogenetic analyses show the affinities of Linderniaceae with major four families- Byblidaceae, Gesneriaceae, Mazaceae and Plantaginaceae. Nepalese species of the family are morphologically closer to the species (e.g., *Mazus, Bacopa, Limnophila, Mecardonia*) of latter two families. The members of Linderniaceae can be differentiated by geniculate or swollen or reduced anterior stamens, bicarpellate pistil, axile placentation of ovules, ovary positioned above a disc, ciliate bifid stigma and persistent calyx in the fruit.

2.4. Taxonomy of Himalayan Linderniaceae

The Himalayas form a wide, continuous range for nearly 1600 miles along the northern border of the Indian subcontinent, extending from the Indus in the northwest to the Brahamaputra in the east. The Himalayan region is a major biodiversity hotspot. It is about 2400 km long and 250-350 km wide mountain range that rises sharply from the Indo-Gangetic plain. North of this mountain belt lies the plateau of Tibet, which extends northwards to the Kun Lun range (Karan & Mather 1976, Rana and Rawat 2017).

The history of botanical exploration in the Himalaya dates back to the collection of N.L. Burman (1734-1793), and author of *Flora Indica* (1768). William Roxburgh explored many regions of the Himalaya. Roxburgh (1885) described six species of *Torenia* in *Flora Indica: III*. Similarly, Richard Strachey and J. Winterbottam made an extensive collection from Kumaon and Garhwal Himalayan regions. Their work was published as '*A Catalouge of Plants of Kumaon and of the adjacent portion of Garhawal and Tibet.'* Starchey (1906), listed one species of *Torenia* (*T. cordifolia*), six species of *Vandellia* and two species of *Bonnaya* (*B. brachiata* and *B. veronicifolia*) of Linderniaceae (Scrophulariaceae *s.l.).* Pennel (1943) described ten species of *Lindernia s.l.* and only one species of *Torenia* (i.e. *T. cordifolia*) from western Himalayas. From Himachal Pradesh, Chowdhary and Wadhwa (1984) described 7 species of *Lindernia s.l.* and one species of *Torenia* (*T. cordifolia*). Stewart (1972) enumerated six species of *Lindernia s.l.* and only one species of *Torenia* (*T. cordifolia*) from West Pakistan and Kashmir.

Sir Joseph Dalton Hooker was the first European Botanist who collected plants from Himalaya. The collections were made in Sikkim Himalaya to northwest Himalaya. In his greatest botanical work, Flora of British India, 32 species of Linderniaceae were described under 4 genera (i.e., *Bonnaya, Ilysanthes, Torenia* and *Vandellia*).

Kanjilal (1938) in Flora of Asam III, described only one species *Vandellia hirusta*. In the revision of Indo-Burmese species of *Lindernia,* Mukarjee (1945) described 28 species from the same region with a new combination of the species like *L. oppositifolia* (L.) Mukarjee and *L. multiflora* (Roxb.) Mukarjee. Duthie (1960) described eight species of Linderniaceae under 4 genera namely *Torenia (T. cordifolia), Vandellia (V. crustacea, V. multiflora, V, nummularifolia* and *V. pdeunculata), Ilysanthes (I. parviflora)* and *Bonnaya (B. brachiata* and *B. veronicaefolia).* Hara (1996) enumerated eighteen species of present-day Linderniaceae under three genera, namely *Lindernia*, *Torenia* and *Vandellia* from the eastern Himalaya. Mill (2001) described ten species of *Lindernia s.l.* and five species of *Torenia* from Bhutan, including Sikkim and Darjeeling. From Arunanchal Pradesh, Giri *et al.* (2008) described 12 species of present-day Linderniaceae under two genera: *Lindernia s.l.* and *Torenia.*

Botanical exploration in Nepal was initiated by Francis Buchanan-Hamilton (1802-1803) (Shrestha *et al.* 2022). His collection of *Lindernia* were negligible but formed a basis for David Don's *Prodromus Florae Nepalensis*. In *Prodromus Florae Nepalensis,* D. Don (1825) described *L. micrantha* and *V. nummularifolia*. Hara *et al.* (1982) enumerated 14 species of *Lindernia s.l.* namely *Lindernia anagallis, L. antipoda, L. crustacea, L. hookeri, L. micrantha, L. multiflora, L. nummularifolia, L. oppositifolia, L. parviflora, L. procumbens, L. pussilla, L. ruellioides, L. viscosa* and five species of *Torenia* namely *T. asiatica, T. cordifolia, T. diffusa, T. fournieri* and *T. violacea.* However, 13 species listed here are native and *T. fourneiri* is cultivated. Malla *et al.* (1986) described two species of *Torenia* namely *T. cordifolia* and *T. diffusa* from Kathmandu valley. Both of these species were also reported from the southwest of the Kathmandu valley by Baniya and Sakya (1999). Siwakoti and Verma (1999) described eight species of *Lindernia s.l.* and one species of *Torenia* from the plains of eastern Nepal. Rajbhandari *et al.* (2020) enumerated nine species of Linderniaceae from Province no.1.

Press *et al.* (2000) enumerated 14 species of *Lindernia s.l.* and six species of *Torenia s.l.* from Nepal under Scrophulariaceae. They are:

1. *Lindernia anagallis* (Burm. f.) Pennell
2. *Lindernia antipoda* (L.) Alston
3. *Lindernia ciliata* (Colsm.) Pennell
4. *Lindernia crustacea* (L.) F. Muell.
5. *Lindernia hookeri* (C. B. Clarke) Wettst.
6. *Lindernia micrantha* D. Don.
7. *Lindernia multiflora* (Roxb.) Mukerjee
8. *Lindernia nummularifolia* (D. Don) Wettst.
9. *Lindernia oppositifolia* (L.) Mukerjee
10. *Lindernia parviflora* (Roxb.) Haines
11. *Lindernia procumbens* (Krock.) Borbas
12. *Lindernia pusilla* (Willd.) Bold
13. *Lindernia ruellioides* (Colsm.) Pennell
14. *Lindernia viscosa* (Hornem.) Bold
15. *Torenia asiatica* L.
16. *Torenia cordifolia* Roxb.
17. *Torenia diffusa* D. Don
18. *Torenia fournieri* Linden ex Fourn.
19. *Torenia parviflora* Hutch. & Dalze
20. *Torenia violacea* (Azaola ex Blanco) Pennell

Rajbhandari (2017) listed a total of 18 species of Linderniaceae in Nepal. Similarly, Shrestha *et al.* (2022) recorded a total of 20 species of Linderniaceae from Nepal. Recently, Rajbhandari *et al.* (2022) recorded 21 species and six genera under family Linderniaceae in Nepal.

2.5. Distribution of the species

Linderniaceae species are distributed in moist tropical, subtropical and temperate zones of both the Old and New Worlds with their centre of distribution and diversity in tropical Africa and south-east Asia (including northern Australia) (Rahmanzadh *et al.* 2005). The species of the New World span from southern Canada to Argentina and Uruguay (Philcox 1968 and Lewis 2000). Further, recent studies show the wider

distribution of taxa of Linderniaceae. Species of *Yamazakia* (*Yamazakia pusilla* and *Y. viscosa*) are distributed throughout the Eastern Himalaya, Southeast Asia and Australia. Species of *Torenia* are mostly distributed in China, Southeast Asia, South Asia, Australia, Africa and South America. However, being pan-tropical in its distribution, *Torenia crustacea* has the widest distribution. Species of *Lindernia* are cosmopolitan in distribution. Distribution of *Lindernia procumbens* ranges from Asia including Java and the Philippines to Europe, whereas *Vandellia multiflora* is recorded from south-east Asia to New Guinea, excluding Burma, Thailand and Sumatra (Philcox 1968).

2.6. Economic importance

Species of the family were formerly thought ofas weeds, but recent studies have discovered their medicinal benefits (Umakrithika 2021). Various species have a crucial role in traditional Chinese medicine, but they have not yet had their phytochemical and medicinal potential studied (Cheng *et al*. 2011, Tsai 2020)

Linderniosides A and B, and oleanane saponins are reported in *L. procumbens* which has anti-tumor property (Swapna *et al.* 2011). It can be used in esophageal cancer, hypertension and hemorrhage. Similarly, *Bonnaya antipoda* is characterized by flavonoid and flavonal which are used to cure joint pain, traumatic injury and to relieve rigidity of muscles. *Torenia crustacea* has anti and pro-lipase activity and used to cure asthma, tonsillitis and cervical syndrome. Likewise, *T. anagallis* which has anti-microbial and antioxidant properties, is used to treat pharyngitis (Chowdhury & Das 2015).

Species of *Torenia* (Wishbone flowers) are widely used in horticultural researches. It serves as a model plant for genetic engineering research on aesthetic traits and pest management. In the past 30 years many hybrids have been produced (Starman 2005).

Similarly, *Lindernia rotundifolia* and *L. antipoda* are the two major species which are mostly used in aquarium. The majorities of species are located in swamps and occasionally submerged areas. They primarily function as filters and cleaners for the water in waterways and lakes (Jabir *et al.* 2016).

CHAPTER 3: MATERIALS AND METHODS

3.1. Study area

Nepal lies to the temperate zone of North of Tropic of Cancer along the southern slopes of the Himalayan mountain ranges. The average length of the country is 885 km, and its width varies from 145 km to 241 km from east to west with the longitudinal coverage of 80˚04'-88˚12' and latitudinal range 26˚22'-30˚27'. It is a landlocked county surrounded by Tibet autonomous region of China in the north and by India in the east, west and south. The lowest elevation of the country is 59 m asl (Mukhiyapatti, Musharuiya, Dhanusha), and its highest elevation point is at 8848.86 m (Mount Everest, Solukhumbu). Stearn in 1960 divided Nepal into three regions: western Nepal (W; from Kumaon frontier to 83◦ E), central Nepal (C; from 83◦ E to 86◦ 30'E) and eastern Nepal (E; from 86◦ 30'E to Sikkim frontier) based upon floristic and geographic data. Similarly, it is divided into five major physiographic zones namely High Himal, High Mountains, Middle mountains (Middle Hills), Siwalik (Chure) and Tarai (LRMP 1986). Although Nepal covers less than 0.01 percent of the global land surface, it accounts 2.2 percent of the global phanerogames (Watson *et.al.* 2013). Dobremez (1976) identified 77 vegetation types in five (tropical, sub-tropical, temperate, sub-alipne and alpine) geographical zones. Stainton (1972) identified nine regions/subregions in Nepal and under those regions, he classified Nepal's forest in to 35 types where the vegetation differs in floristic composition from east to west Biodiversity Profile Report (1996) reported 118 ecosystem types; among them 112 represent vegetation types at different physiography, bioclimate, biogeographic regions, and the rest six types represent non-vegetation ecosystems. The report of DFRS (2015) shows that total forested area of Nepal is 5.96 million ha which is about 40.36 % of the area of the country.

3.2. Taxonomic Study

3.2.1. Protologue and Literature review

In this study, the protologues of all the species and genus were reviewed. The standard literatures used for the identification were: Cullen (1989), Siwakoti and Verma (1999), Zhengyi *et al.* (1998), Hooker (1885), Grierson and Long (2001), Li *et al.* (1993), Malla *et al.* (1986) and Philcox (1968). Similary the nomenclature changes

and confirmation was done by following relevant articles, checklists and other recently published literatures.

3.2.2. Literature based character matrix

Through literature review, the history and distribution of the taxon, morphological characters and other information related to the taxon under study were gathered. Character matrix was prepared on MS-Excel ver. 2010, mainly on the basis of review of different national and regional floras. The literature-based character matrix provided the basic framework to identify, understand and distinguish the taxa.

3.2.3. Study of Herbarium Specimens

Before starting the field work, a preliminary study of specimens housed at KATH and TUCH was carried out. Further, for the species whose specimens were not found in Nepal herbaria, the information on Nepalese specimens was extracted by using online catalogues and database of several herbaria like of TI, BM and RBGE.

3.2.4. Plant collection and herbarium preparation

The herbarium specimens studied from the herbaria provided only the basic information. For the detail morphological (vegetative and reproductive) study, the fresh specimens were collected by field visiting. The collection of the specimen and the herbarium preparation was done by following the guidelines of Bridson and Forman (1992).

Collection of specimen was done from March 2020 to August 2022 in different parts of Nepal such as Haldibari (Jhapa), Kanyam and Suryodaya (Ilam), Rajarani Tal (Morang), Dhurkot and Sirseni (Gulmi), Dohote (Arghakhanchi), Banganga and Imiliya (Kapilvastu), Gajeda Tal (Rupandehi), Nuwakot (Palpa), Kalikasthan, Syabrubensi, Bamboo and Thulo syabru (Rasuwa), Trisuhli (Nuwakot), Sauraha (Chitwan), Hetauda (Makwanpur), Dudhauli (Sindhuli), Chewabensi (Sankhuwasabha), Kattikeghat to Tiwaribhnjyang route (Bhojpur), Champadevi (Kathmandu), Godawari (Lalitpur), Suklaphanta National Park (Kanchanpur) in the flowering season of the species.

For the collection of fresh samples, tools such as field note form, pencil, notebook, camera, black velvet cloth, magnifying lens, collection polythene bags, GPS meter,

altimeter, newspaper, cardboard paper, blotting paper, herbarium press, measuring scale, forceps, blade and needle were used. Photographs of vegetative as well as reproductive parts were taken on their habitat as far as possible. Plant specimen then collected and further photography of other vegetative and reproductive parts was done by dissecting the flower. Field notes (date of collection, collection no., habit, habitat, locality, local name, GPS, altitude, special characters which may disappear after herbarium preparation, remarks) for each specimen was prepared in the field. Tagging and numbering was done for each specimen collected. Collected specimens then pressed in the herbarium sample by using blotting paper and newspaper to make them dry. For the reproductive parts paper envelope was used to collect and tissue paper was also used to protect. The newspapers were changed in regular interval to make the specimens dry and to protect from the fungal attack. The dried specimens then pressed with proper arrangement in standard herbarium sheet 43 cm× 29 cm with the help of glue, or stitched with the help of needle and cotton thread. The herbarium information including distinguishing field note was attached at lower right hand corner of the sheet. The prepared herbarium specimens were later deposited at TUCH and KATH.

3.2.5. Identification and Nomenclature

Specimens of the taxa were identified by different methods such as on-spot identification at field, expert identification in KATH and TUCH, examining the housed specimens at KATH. and standard literatures such as Cullen (1989), Siwakoti and Verma (1999), Zheng-yi *et al.* (1998), Hooker (1885), Grierson and Long (2001), Li *et al.* (1993), Malla *et al.* (1986) and Philcox (1968). Digital databases of E, K, BM, TI and RBGE were also used in identification and description of the taxa.Similarly for valid nomenclature and author citation, the recent articles such as Philcox (1968), Fischer *et al.* (2013), Liang and Wang (2014), Biffin *et al.* (2018), Shrestha *et al.* (2022), Rajbhandari *et al.* (2022) and other literatures which are cited respectively wherever used. Other online data bases such as the World flora online (worldfloraonline.org), Catalogue of life (catalogueoflife.org) and Plants of the World Online (powo.science.kew.org) were also used.

3.2.6. Morphological study of the specimen:

Some of the characters such as plant height, leaf colour, size, texture, flower colour, size and texture of the specimens were observed and studied in the field. Other vegetative and reproductive characters were studied in the taxonomy lab by using different tools. Simple microscope, Stereo microscope, hand lens, forceps, brush, measuring scale, dissecting blade, etc. were used to study the macro-morphological characters.

3.2.7. Format of specimen information and artificial keys

The generic and specific names of the taxa within family are arranged in alphabetical order. Valid scientific name of the particular taxon is written in bold first with author citation and bibliographic citation. The basionyms and synonyms in italics are mentioned after the valid names as in Fischer *et al.* (2013). The detailed description of each taxon is given based on morphological study. Description is followed by Flowering and fruiting period, ecology, Global distribution and elevational range. After this, the citation of voucher specimens which were used to prepare description and later deposited in TUCH is mentioned. This is followed by the citation of species examined in TUCH and KATH.

3.2.8. Construction of artificial keys

On the basis of characters observed artificial keys are constructed in 'bracketed key' format for the identification of the genus and species.

3.2.9. Description of taxa

A detailed taxonomic description of the taxa was prepared by using semi-technical terminologies based on Harris and Harris (2000) and Simpson (2010) following the contributors guideline of *Flora of Nepal*. On the basis of morphological characters observed and studied from the specimens, a character based matrix was prepared in MS-Excel V.2010. This helps to distinguish and link the species and genera of the family and also helps to construct the identification keys. The description of taxa at each level is made consistent as far as possible. Characters which are described or mentioned in higher level are not repeatedly used in subordinate taxa. In case of taxa whose specimens were neither collected from the study area nor available in National herbaria (KATH), were studied by the digital photographs obtained from online

database of TI and RBGE as well as from secondary literatures like flora, monographs, revisionary works and related articles.

3.2.10. Illustrations

On the basis of live plant as well as herbarium specimen, free hand line drawings of all the species were done. The sizes of plant parts were measured and calculated mathematically by using divider and rulers to make the illustration accurate. The illustration included habit sketch, leaf, flower, open calyx, open corolla, stamens, pistil and fruit. Rough outlines were drawn and finalized in A4 size drawing sheet and traced it on a tracing paper and ultimately scanned and printed.

3.2.11. Photographs and Distribution map

The photographs of various parts of plants including habit, leaf, flower, fruit, seeds and stomata are taken and photo plates were prepared for each taxon after editing them on Adobe Photoshop CS6 software.

By using QGIS 3.28.3 software, distribution pattern of all the species were shown in map of Nepal in two different categories; Places of collection with actual co-ordinates and places of collection whose only locality is known,.

3.2.12. Cluster analysis: Dendrogram

In this study, 20 species of family Linderniaceae were analyzed by cluster analysis and by the construction of Dendrogram. Dendrogram generally refers to the graphical representation of binary merge tree. Binary merge tree consists of hierarchical clustering. The dendrogram was constructed into species level in this study. Altogether 41 characters were taken to analyze the species by two-state or multi-state character coding. Equal importance was given to each character during analysis. Statistical software 'IBM Statistics SPSS-25.0 for Windows 10' was used for the clustering and dendrogram construction.

CHAPTER 4: RESULTS

4.1. Habitat

Most of the species of the family were found in natural riparian habitat such as species of *Bonnaya* and *Vandellia*. However, *Craterostigma nummularifolia* was found to be poikilohydric as a resurrection plant. Similarly, *Yamazakia viscosa, Torenia cordifolia, T. asiatica* and *T. diffusa* were found in moderate moist habitats. *T. violacea* and *T. crustaea* were more frequent in ruderal habitats.

4.2. Life form

Except *Bonnaya ruellioides*, the members of Linderniaceae are represented by annual herbs. *Bonnaya ruellioides* is the only species in the family with perennial herb (Appendix 3).

4.3. Morphological characters

4.3.1. Surface texture

The species vary in their surface appearance. Species such as *Bonnaya antipoda, Vandellia micrantha and Torenia anagallis* have glabrous plant surfaces while *Bonnaya Ruellioides and B. ciliata* have subglabrous surfaces. Similarly, some species (*Torenia crustacea, T. cordifolia, T. diffusa*, etc.) have sparsely pubescent surfaces. *Yamazakia viscosa* is the only species in the family with villous surface texture.

4.3.2. Trichome

The variations in trichome types distinguish the species of the family Linderniaceae. Both glandular and eglandular types of hairs were found within the taxa. *Vandellia multiflora* and *Yamazakia viscosa* possess glandular hairs (Fig.1 C) whereas the remaining species possess simple unicellular eglandular hairs (Fig.1 A, B). The hair type on outer surface of corolla tube of many species is glandular.

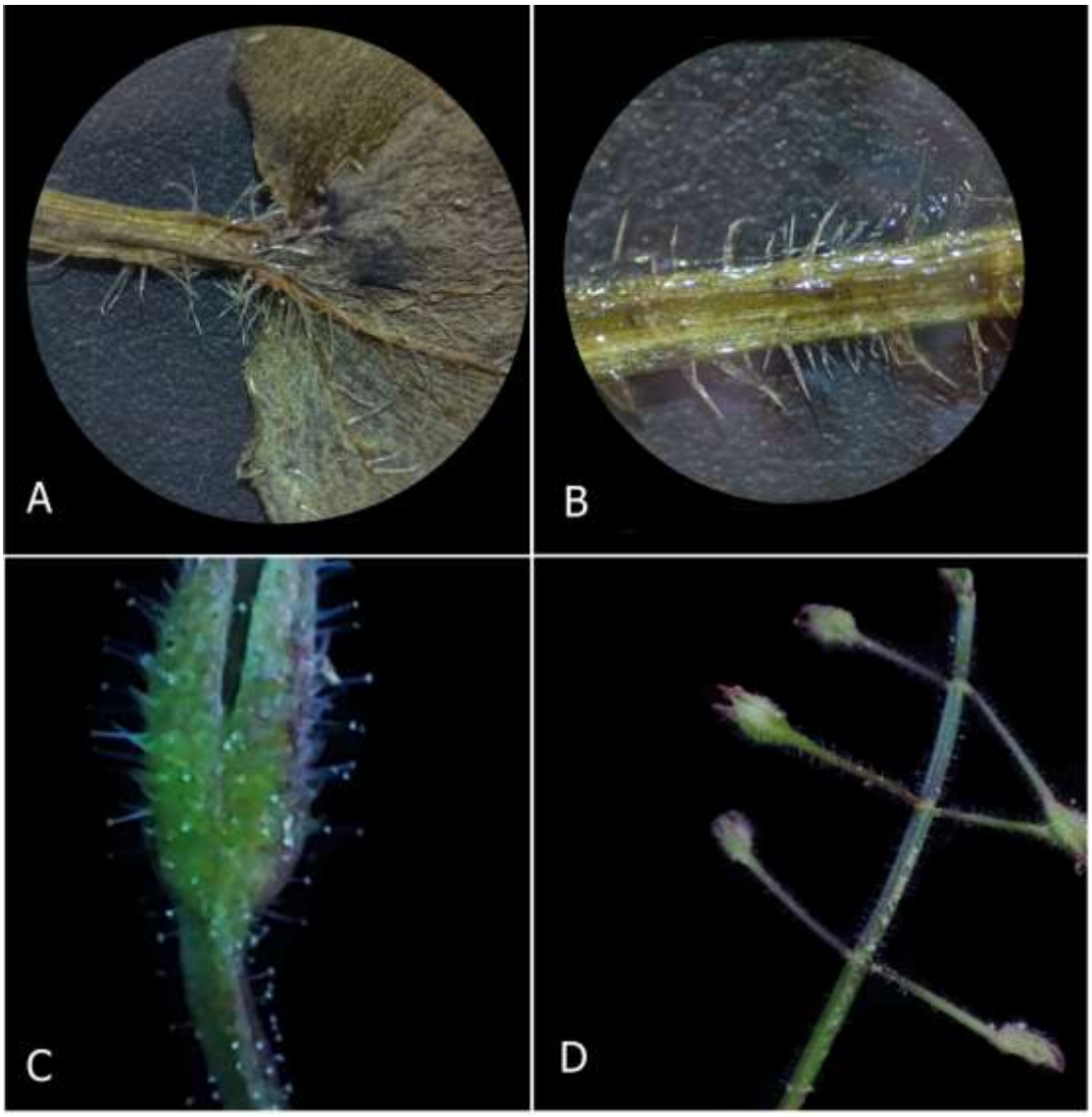


Fig. 1: Photographs showing the trichome types in Linderniaceae. A, B. Simple hairs (*Torenia cordifolia, Yamazakia pusilla*); C. Glandular hairs (*Vandellia multiflora*); D. Glandular hairs (*Yamazakia viscosa*).

4.3.3. Stem

a. Stem habit

The variation in stem type is one of the main characters to distinguish the taxa of Linderniaceae. The major stem form variations are erect, decumbent and prostrate. The stem is erect mainly in the species of *Lindernia s.str.* and *Torenia*; however the stem is prostrate in *Torenia asiatica* and *T. anagallis.* Stems in majority of *Bonnaya* are erect-decumbent type and sometimes rooting from last one or two nodes; however in *B. ruellioides* stem is of prostrate type. Similarly, stem in *Craterostigma* is erect. *Vandellia* and *Yamazakia* possess both erect and decumbent types of stem (Fig. 2).

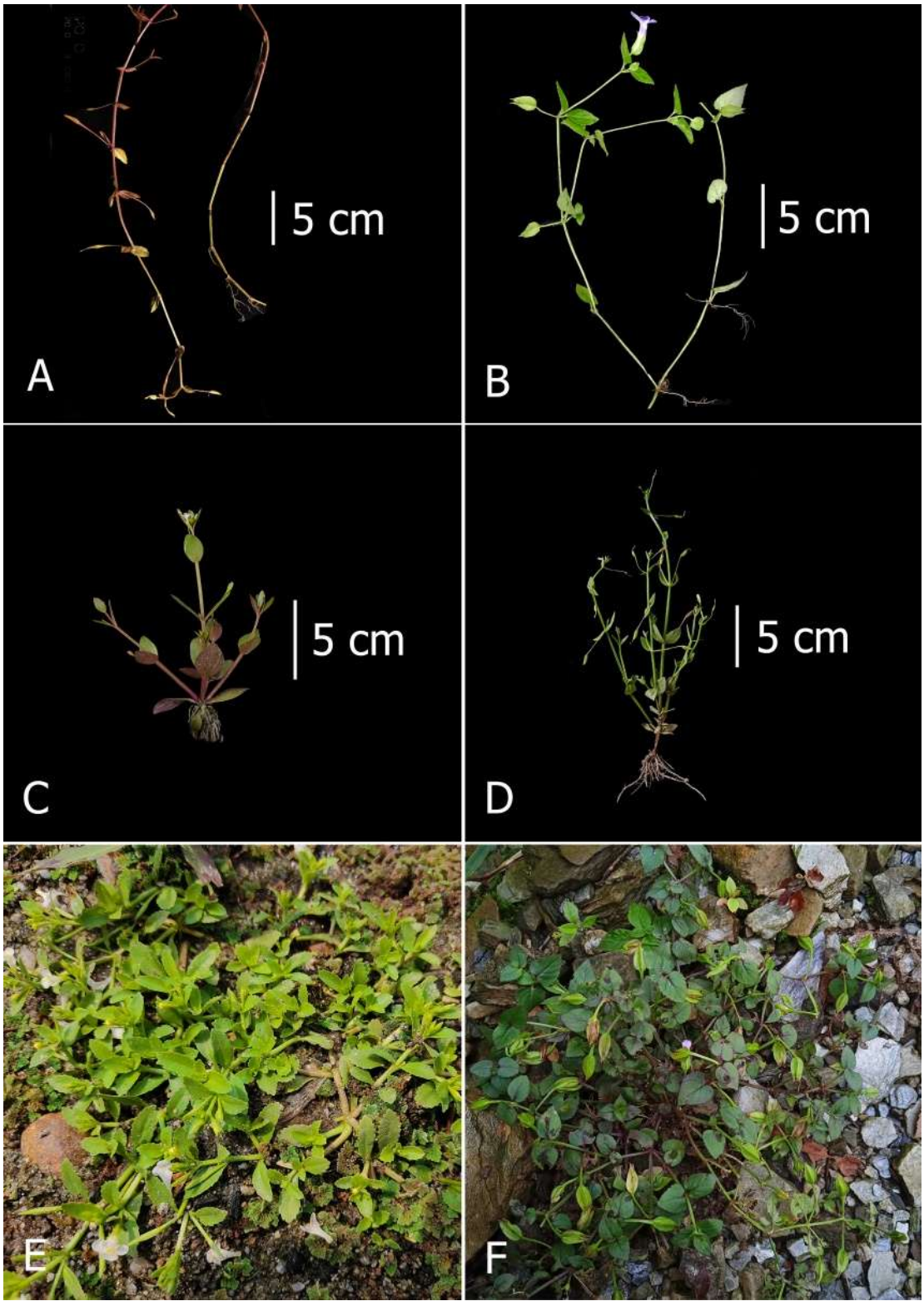


Fig. 2: Photographs showing the variation of stems between species of Linderniaceae. A. Prostrate stem with roots from basal nodes (*Torenia anagallis*); B. Prostrate stem (*T. asiatica*); C. Erect stem (*Lindernia procumbens*); D. Erect stem (*L. parviflora*); E. Decumbent stem (*Bonnaya antipoda*); F. Diffusely branched stem (*T. diffusa*).

b. Branching pattern

Stems of almost all the species within the family are branched variously. In *Torenia diffusa and T. asiatica,* stems are diffusely branched from base; however in *T. violacea, Lindernia procumbens* and *L. parviflora,* stems are branched above the base (Fig. 2, Appendix 3).

c. Stem size

The majority of the species of Linderniaceae have stems that are between 5 cm and 30 cm in length. However, *Torenia anagallis* is found to grow up to 60 cm, and the size of the stem in *Bonnaya ruellioides* and *T. asiatica* is found up to 40 cm (Appendix 3).

d. Stem texture

Variation in stem texture is another important character to distinguish the taxa. Mostly the stem in *Bonnaya* is glabrous (*Bonnaya antipoda*, *B. oppositifolia,* etc.) or subglabrous (as in *B. ruellioides* and *B. ciliata*). Majority of the species of *Torenia* have sparsely pubescent stem; however *T. anagallis* have glabrous stem. Similarly, in *Lindernia* and *Vandellia micrantha,* the stem is glabrous, whereas the stem of *Vandellia multiflora* is sparsely pubescent, mainly on angles and nodes. The stem of *Yamazakia viscosa* is found to be villous all over (Appendix 3).

4.3.4. Leaves

All the members of family Linderniaceae have simple and opposite leaves. However, leaf attachment, shape, size and pattern of venation vary from species to species (Appendix 4).

a. Leaf arrangement and attachment

Taxa of Linderniaceae vary in leaf attachment from sessile or subsessile to petiolate. Leaves are sessile in almost all the species of *Bonnaya* (except *B. ruellioides* which bear petiolate leaves), *Vandellia micrantha, Yamazakia pusilla,* and in *Lindernia.* Lower leaves are shortly petiolate and upper leaves are sessile in *Yamazakia viscosa and Vandellia multiflora*. Similarly, leaves are shortly petiolate or subsessile in *Craterostigma nmmularifolium*. Taxa having distinctly petiolate leaves are mainly the species of *Torenia*; however in *T. anagallis* leaves are sessile. Petiole size ranges between 2-20 mm among the petiolate species.

b. Leaf Shape

Leaf shape is one of the most important characters observed in Linderniaceae to distinguish the taxa. Mostly oblong and elliptic leaves are found among the species of *Bonnaya*; however *B. ruellioides* possesses elliptic-suborbicular type of leaves. Leaves are broadly ovate in *Yamazakia pusilla* and *Y. viscosa*. Broadly ovate or orbicular leaves are seen in *Craterostigma nmmularifolium*, whereas triangular ovate leaves are found in both the species of *Lindernia* (*L. procumbens and L. parviflora* (Fig 3 A, B). Mostly the leaves are ovate among the species of *Torenia* (Fig. 3 E) however *Torenia crustacea* bears triangular-ovate leaves. Oblong-ensiform leaves are seen in *Vandellia micrantha* (Fig. 3 C).

c. Leaf size

Among taxa having oblong or linear types of leaves, *Vandellia micrantha* and species of *Bonnaya* possess the leaf blade size between 5-50×2-12 mm.*Bonnaya tenuifolia* has the smallest leaves (5-30×0.5-5 mm) within the genus.

Similarly, among taxa having ovate orbicular type of leaves, *Vandellia multiflora, Yamazakia viscosa*, and the species of *Torenia* such as *Torenia asiatica, T. cordifolia, T. diffusa, T. violacea*, etc. have comparatively larger leaves (1.5-4.5×0.8-2.6 cm). However, *Craterostigma nummularifolium*, *Lindernia parviflora*, *L. procumbens, Torenia anagallis*, *T. crustacea* and *Yamazakia pusilla* possess medium or small sized leaves (1-2.5×0.4-2.1 cm).

d. Leaf base

Mostly the leaf bases among the taxa are cuneate. Broadly cuneate base is seen in *Bonnaya ciliata*. However, in *Craterostigma* and species of *Torenia* such as *T. asiatica*, *T. cordifolia* and *T. violacea* the leaf base is rounded or subcordate. Whereas, other species of *Torenia* possess cuneate leaf basees. Similarly, attenuate type of leaf base is found in *Vandellia multiflora* and *Yamzakia viscosa.*

f. Leaf margin

Leaf margin of majority of the species is serrate. However, in *Bonnaya ciliata* and *B. ruellioides* aristate-serrate type of margin is seen. Similarly, margin is subentire to denatate in leaves of *Lindernia parviflora*, and dentate in *L. procumbens*. Leaves of

Vandellia micrantha exhibit obscurely serrate margin.

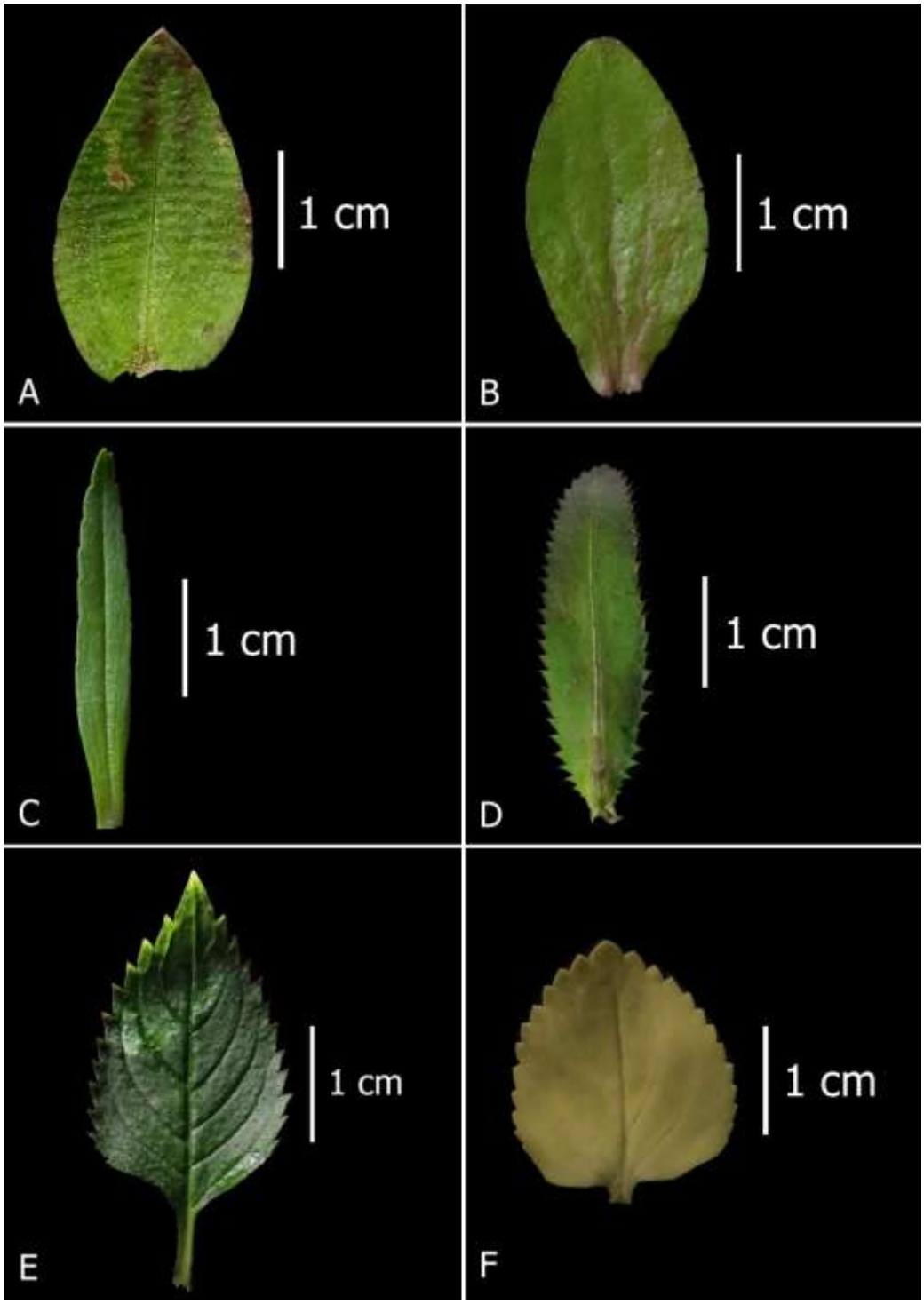


Fig. 3: Photographs showing the types of leaves in Linderniaceae. A. (*L. parviflora*); B. Sessile, Ovate palmately veined leaf (*L. procumbens*); C. Sessile Oblong-ensiform leaf (*V. micrantha*); D. Sessile, oblong pinnately veined leaf (lateral veins not distinct) (*B. ciliata*); E. Distinctly petiolate, ovate pinnately veined leaf (*T. cordifolia*); F. Shortly petiolate, suborbicular pinnately veined leaf (*Craterostigma nummularifolium*).

g. Leaf texture

Variation is also seen in the texture of leaves. Both surfaces are glabrous in *Craterostigma Lindernia, Vandellia*, and majority of the species of *Bonnaya*; however, leaves of *B. ciliata* are pubescent along veins abaxially. In *B. ruellioides* and *V. multiflora* leaves are subglabrous adaxially and sparsely pubescent along veins abaxially. Both surfaces are sparsely pubescent in the species of *Torenia* except *T. anagallis* . The leaves of *T. anagallis* are glabrous on both surfaces.

4.3.5. Inflorescence

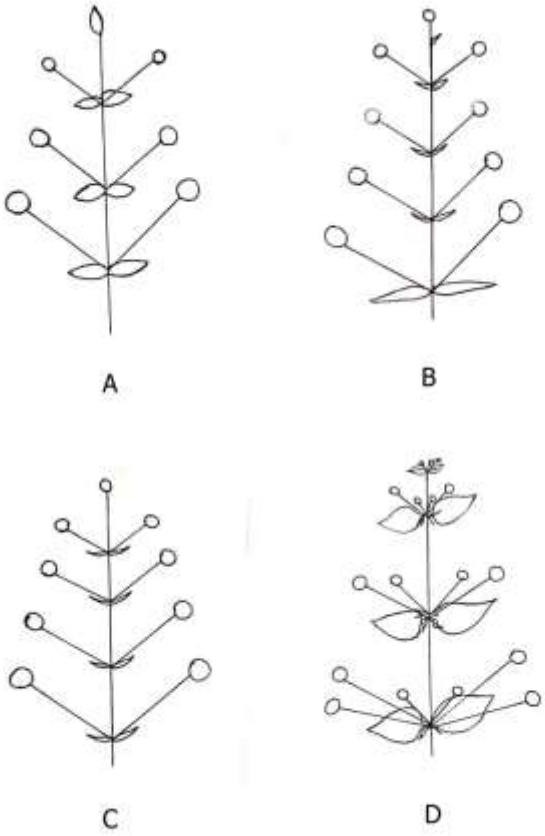


Fig. 4: Types of inflorescence in Linderniaceae. A. Flowers axillary solitary in leafy raceme; B. Flowers axillary solitary and in terminal raceme; C. Flowers in terminal racemes; D. Flowers in axillary umbel-like whorls.

a. Types of inflorescence

Mainly three types of inflorescence were observed among the species of

Linderniaceae. Among the species of *Vandellia* and *Yamazakia, Vandellia multiflora* and *Yamazakia viscosa* are characterized by raceme inflorescence (Fig. 4 C); whereas in *V. micrantha* and *Y. pusilla*, flowers are solitary (Fig. 4 A). Mainly the species of *Bonnaya* (*Bonnaya antipoda, B. ciliata, B. oppositifolia* and *B. tenuifolia*) are characterized by both solitary and raceme inflorescences (Fig. 4 B), however only raceme inflorescence is found in *Bonnaya ruellioides* (Fig 4 C). Solitary flowers are found in *Lindernia* and majority of *Torenia* (such as *Torenia anagllis, T. crustacea, T. asiatica* and *T. diffusa*) (Fig. 4 A). However, flowers are born in umbel-like or fasciculate inflorescence in *Torenia cordifolia* and *Craterostigma* (Fig. 4 D, Appendix 5).

b. Position of inflorescence

Solitary flowers are borne in leaf axils and give an appearance of leafy raceme in *Torenia* (*T. anagalis, T. asiatica*, etc). . Typical raceme type of inflorescence is found always on terminal position. In *Bonnaya antipoda, B. ciliata, B. oppositifolia and Torenia violacea* both solitary axillary and terminal raceme inflorescences are found. The umbel-like inflorescence in *T. cordifolia* is found in both axillary and terminal positions (Fig 4).

c. Number of flowers per raceme or fascicle

In terminal racemes, the number of flowers varies within species. 10-20 flowers per raceme are borne in *Vandellia multiflora*. Whereas in *Bonnaya antipoda* 6-12 flowers are found, and in *B. oppositifolia* and *B. ruellioides* the flower number ranges between 10-16. In each fascicle of *T. cordifolia*, 4-8 flowers are found.

4.3.6. Bract

Among 20 species of the family Linderniaceae, all the species of *Lindernia* (*L. parviflora* and *L. procumbens*), two species of Torenia (*T. anagallis* and *T. crustacea*), *Vandellia micrantha* and *Yamazakia pusilla*, possess ebracteate flowers. The remaining other 14 species have bracteate flowers (Appendix 5).

a. Bract type

In most of the species, the bracts are subtending and small, whereas in *Bonnaya oppositifolia* and *Vandellia multiflora* at least the lower flowers and in *Torenia*

cordifolia some flowers possess foliaceous bract.

b. Bract size

Subtending or small bracts ranges between 0.3-6×0.2-1.5 mm. Foliaceous bracts are larger and the size ranges between 4-12×6-18 mm.

c. Bract apex, margin and texture

In most of the taxa, bract apices are acute or acuminate type. Whereas, apex is aristate type in *Bonnaya ciliata*. Similarly, the margin of bract is serrate in all of the species. Both the surfaces of bracts are glabrous in *Bonnaya*, and sparsely pubescent in Torenia. The bract margin is ciliate in all the species of *Torenia*.

4.3.7. Pedicel

The size and texture of pedicel are important characters among the species of Linderniaceae. Generally, the flowers are pedicellate in all species. However, in *Craterostigma nummulariifolium,* the middle flowers are sessile and lateral flowers are pedicellate.

a. Pedicel Length

The length of the pedicels vary among the species, or within a species in flower and fruit too. The length ranges between 1-25 mm in flower and 2-40 mm in fruit.

b. Texture

Pedicels among the species are glabrous, subglabrous, sparsely pubescent with simple or glandular hairs. Pedicel is glabrous in some species of *Bonnaya (B. antipoda, B. oppositifolia* and *B. tenuifolia),* all species *Lindernia* (*Lindernia parviflora* and *L. procumbens*), while subglabrous in *B. ruellioides* and *B. ciliata.* Sparsely pubescent pedicels are found in the species of *Torenia (*except *T. anaglllis* which bears glabrous pedicel*).* Similarly, in *Yamazakia pusilla* pedicels are villous and those in *Vandellia multiflora* and *Yamazakia viscosa* are glandular.

4.3.8. Calyx

a. Calyx shape and lobes

Calyx is tubular, ovoid and bilipped in *Torenia* except *T. anagallis*. Such bilipped calyx is 2×3 lobed and lobes are winged. In *craterostigma nummularifolia* calyx is 5-lobed up to half of its length in flower and fruit whereas in *T. crustacea* lobed upto half in fruit. However, in all other remaining species of the family, calyx is distinctly 5-lobed and almost lobed to the base (Fig. 5, Appendix 6).

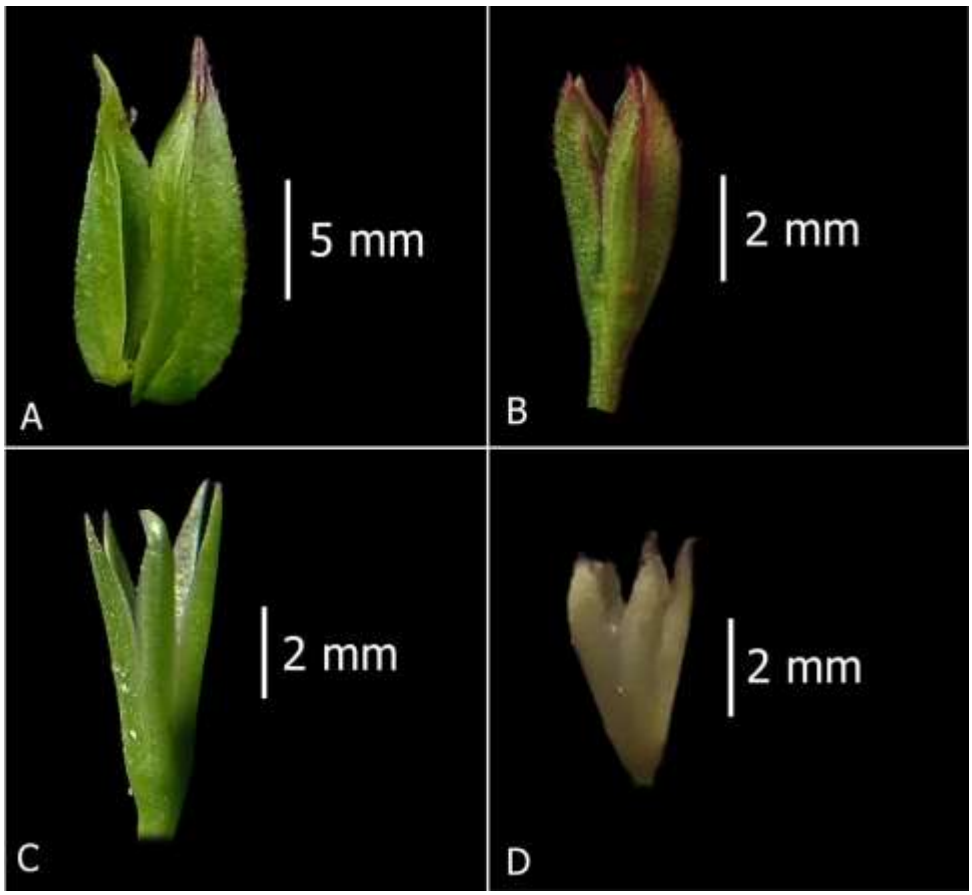


Fig. 5: Photographs showing the types of calyx in Linderniaceae. A, B. Bilipped and winged calyx; C. Deeply 5-lobed unwinged calyx; D. Calyx lobed up to half of its length and unwinged.

b. Sepals shape

Sepals or calyx lobes are linear-lanceolate in *Bonnaya, Vandellia* and *Yamazakia*. Similarly, elliptic-ovate or ovate sepals are found in *Torenia* (except in *T. anagallis*). However, in *Craterostigma nummularifolium* sepals are oblong-ovate (Appendix 6).

c. Sepals base, apex and margin

Mostly the base of the sepals is cuneate among the species. However, in *Torenia cordifolia*, base is round to subcordate. Similarly, in *Vandellia micrantha*, sepals base is attenuate. Apices of the lobes are acute or acuminate type in all the species. Margin of sepals and wings are serrate in all the species (Fig. 5, Appendix 6).

d. Sepals Texture

Surfaces of the lobes are glabrous in *Bonnaya*. However, midrib is sparsely pubescent in *B. ciliata.* Similarly surfaces along midvein and margins are subglabrous in *Lindernia*. Similarly, surfaces are sparsely pubescent in *Torenia* (except in *T. anagallis*). Surfaces are densely pubescent in *Yamazakia pussilla* and glandular pubescent in *Vandellia multiflora* and *Yamazakia viscosa* (Appendix 6).

4.3.9. Corolla

Species of the family Linderniaceae are characterized by bilabiate, zygomorphic and tubular corolla. Lower lip is distinctly 3-lobed and upper lip is notched at apex, or folded or seems weakly 2-lobed or even rounded too. Corolla tube base is broadened and constricted near base and gradually broadening towards throat mainly in the species of *Bonnaya*, *Torenia* and *Vandellia*; however in *B. ciliata* tube is not constricted. Similarly, in other taxa such as *Craterostigma* and *Yamazakia*, tube is gradually broadened towards throat but no constriction near base is observed. Shape, colour and texture of the corolla are important characters to distinguish the species (Fig. 6, Appendix 7).

a. Corolla colour

Colour of corolla varies between species and even within a flower of a species. Tube bases are yellow in all the species of *Bonnaya* (except *B. ciliata* in which base is white-pink) (Fig. 6 C), and four species of Torenia (*Torenia anagallis, T. cordifolia, T. crustacea* and *T. violacea*). Similarly, tube base is white or creamy white in *Craterostigma, Vandellia, Yamazakia* and some species of *Torenia* (*T.asiatica, T. diffusa and T. diffusa*). Above the base, tube is yellow upto half of its length in *Torenia violacea* (Fig. 6 F) and *T. fournieri*. Whereas tube is white or purple upto throat in the species of *Bonnaya* and *Torenia* (Fig. 6 C, D)However, in *B. ciliata and T. anagallis* and *Vandellia micrantha* tube is white pink. Whereas in *Lindernia,*

Craterostigma, Vandellia multiflora and *Yamazakia,* tube is white or creamy white (Fig 6 B).

Lobes of lower lip distinctly vary in colour from species to species. White purple lobes are prominent in most of the species. Whereas *B. ciliata, Torenia anagallis* and *Vandellia micrantha* possess white-pink lobes. Distinct mauve blue patch is seen in lateral lobes of *Torenia asiatica, T. cordifolia* and *T. violacea* (Fig 6. F) Similarly, a distinct yellow patch is seen at the base of middle lobe in *T. anagallis, T. violacea* and *V. micrantha* (Fig 6 E, F). Upper lip is brown, purple, pink or white among the species of Linderniaceae (Fig 6).

b. Corolla size

The size of corolla also varies within the taxa and rages from 5 to35 mm. Corolla is smaller in *Lindernia parviflora, L. procumbens, Vandellia multiflora, Yamazakia viscosa* which ranges between 5-8 mm. Similarly, medium sized corolla is observed in *Bonnaya antipoda, B. ruellioides, B. ciliata, Craterostigma nummularifolia, Torenia anagallis and Vandellia mircrantha,* which ranges between 7-12 mm. Corolla is larger (2-3.5 cm) which is observed among the species of *Torenia* such as *Torenia asiatica, T. cordifolia* and *T. violacea.*

c. Corolla texture

Tube is glandular outside in many species such as *Bonnaya antipoda, Torenia anagallis, T. asiatica, T. cordifolia, T. violacea, Vandellia micrantha, V. multiflora*. Whereas in *Bonnaya oppositifolia* and *yamazakia pussilla* tube is glabrous outside. The species of *Bonnaya* and *Lindernia parviflora* are ciliate inside tube around staminodes.

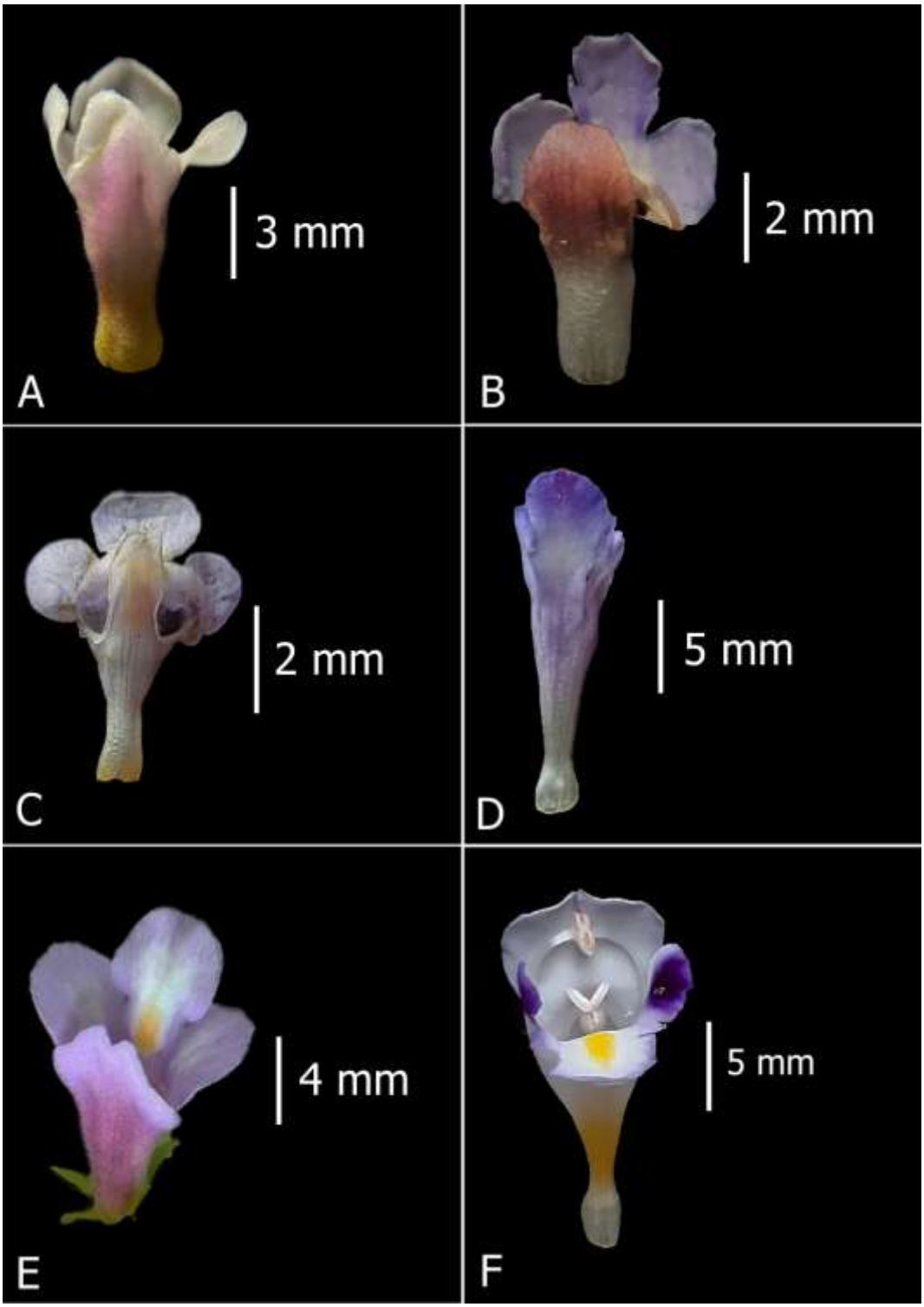


Fig. 6: Photographs showing forms of corolla in Linderniaceae. A. Pink coloured glandular corolla; B. Brown upper lipped corolla; C, D. Purple coloured corolla; E, F. Corolla with distinct yellow patch in anterior middle lobe.

4.3.10. Androecium

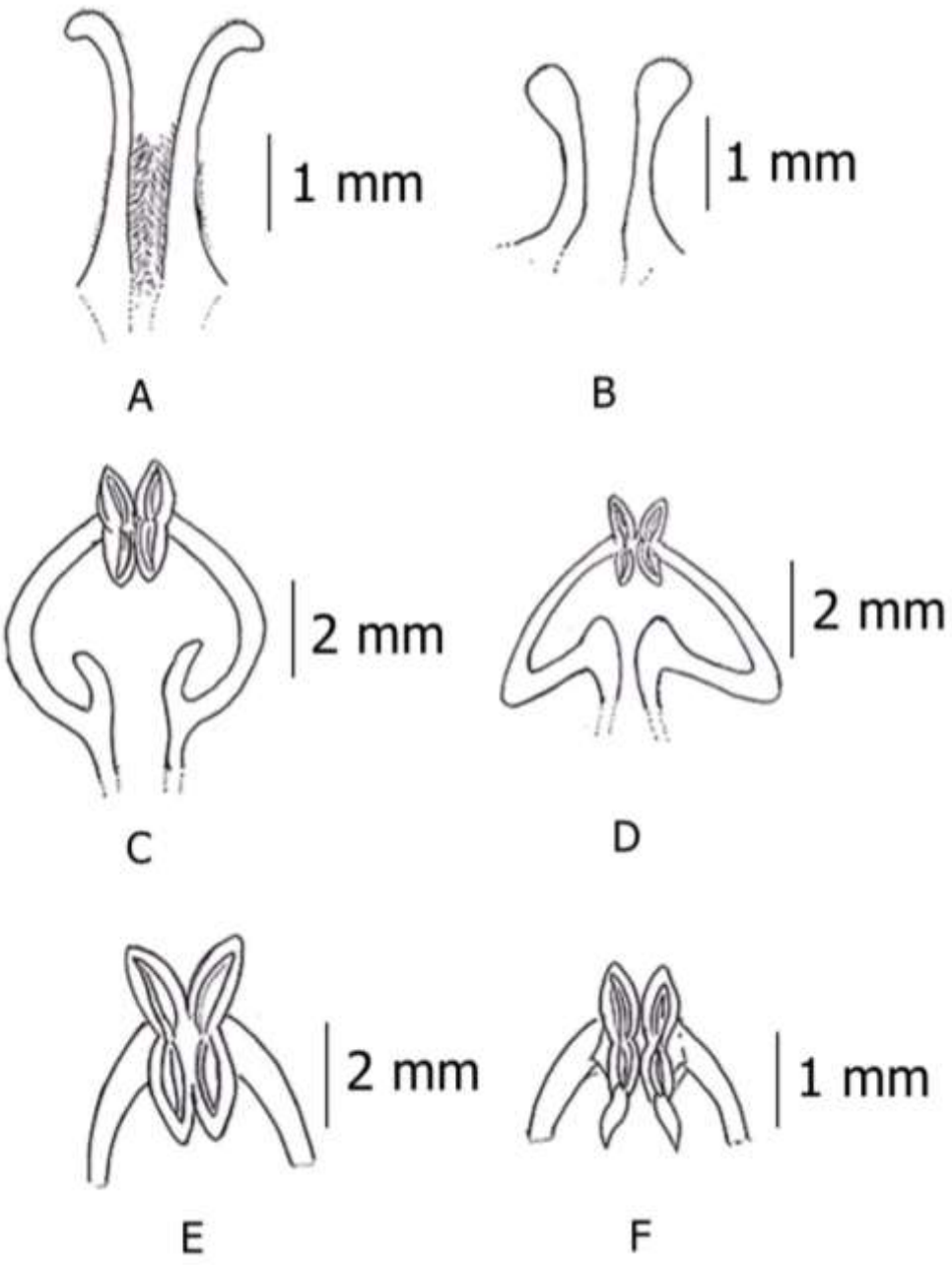


Fig. 7: Types of stamens in Linderniaceae. A. Anterior staminodes with villous base and hooked apex; B. Anterior staminodes with villous base and villous swollen apex; C. Anterior stamens with appendaged bases; D. Anterior stamens with swollen base appearing zig-zag; E. Posterior stamens without spur in anthers; F. Posterior stamens with spurred anthers.

Staminal characters are considered among the major characters to identify the species of this family. In all species, stamens are epipetalous, and anthers are jointed longitudinally with a connective (Fig. 7. Appendix 8).

a. Stamens number

Numbers of fertile stamens are either two or four. In all the species of *Bonnaya* and *Lindernia parviflora,* only two posterior stamens are fertile, whereas anterior stamens are reduced to staminodes. However, in the other remaining species, four fertile stamens are present.

b. Stamens size

Filaments of anterior stamens are longer (2.5-14 mm), Whereas those of posterior stamens are comparatively shorter (1.5-4.5 mm). Staminodes size ranges between 1 to 2.2 mm.

d. Stamens texture

Posterior stamens are glabrous in all the species; however, anterior stamens are villous around the base in *Torenia asiatica, T. cordifolia* and *T. crustacea*. Similarly, staminodes in *Bonnaya* are densely pilose around the bases and ciliate above (Fig 7).

c. Stamens base

Anterior stamens or staminodes are appendaged in all the species of *Torenia* (except *T. violacea*), *Lindernia parviflora, L. procumbens* and *Vandellia micrantha* (Fig 7 C). Whereas bases are swollen and form a zig-zag shape in *Craterostigma nummularifolium, Vandellia multiflora, Yamazakia viscosa and Y. pussilla* (Fig. 7 D).

e. Anthers

Each mature anther is dorsifixed, consists of two bisporangiate pollen sacs, coherent or apex of locules of anterior ones pointed or spurred. Posterior anthers pair are longer (0.5-3 mm), whereas anterior pair are shorter (0.3-2 mm). In *Torenia*, the anthers of each pair conjoined, which formed two wishbone-shaped structures (Fig 7 D). The spurred anthers are observed in *Torenia anagallis* and *Vandellia micrantha* (Fig 7 F).

4.3.11. Gynoecium

Pistil is hypogynous, positioned above a disc, bicarpellate and syncarpous among all the species. Similarly, the stigma is bilipped and the lips are ciliated inside. Ovary

shape and texture are important characters to distinguish the taxa (Fig 8, Appendix 9).

Fig. 8: Photographs showing the types of ovary in Linderniaceae. A, B. Ovaries with pubescent apex based on round yellow disc (*Torenia asiatica, T. violacea*); C. Ovary with glabrous apex based on anterior brown disc (*Vandellia micrantha*); D. Ovary with glabrous apex based on anterior green disc (*Bonnaya ruellioides*).

a. Ovary shape and size

The shape of ovary varies from species to species. The ovary is elliptic-oblong in T*orenia asiatica,* oblong-ovoid in *T. cordifolia, T. diffusa* and *T. violacea*. Similarly, in *Bonnaya, Craterostigma nummularifolium* and *T. crustacea* ovary is ovoid. Ovary is small in all species of *Bonnaya, Craterostigma, Vandellia and Yamazakia*, which ranges between 1 and 3 mm. However, in *Torenia* (except *T. anagallis* and *T. crustacea*) ovary is larger; (4-7 mm).

b. Ovary texture

The apex of ovary is glabrous in all the species of *Bonnaya, Craterostigma, Lindernia Vandellia* and *Yamazakia*. However, in *Torenia* (except *T. anagallis*), ovary apex is pubescent (Fig. 8 A, B).

c. Style length

Style is short (1.5-4 mm) in *Bonnaya ciliate, B. oppositifolia,, Vandellia multiflora* and all species of *Lindernia* and *Yamazakia.* Similarly, medium sized style (i.e., 4-7 mm) is observed in *Bonnaya antipoda, B. ruellioides, Craterostigma nummularifolium, Torenia anagallis and T. crustacea.*

4.3.12. Capsule

a. Capsule Shape

Shape of the capsule varies among the species. Capsules are cylindric in *Vandellia micrantha, Torenia anagallis* and all the species of *Bonnaya* (Fig. 9 A, B). Similarly, *Craterostigma nummularifolium, Vandellia multiflora, Yamazakia pussilla, Yamazakia viscosa* possess ovoid or globose type of capsules (Fig 9 C). In *Torenia crustacea,* capsule is oblong-ovoid (Fig. 9 D, Appendix 10).

b. Capsule position and size

Cylindric capsules are twice or more than twice longer than persistent calyx. Size ranges between 6 and 20 mm; among them, shorter capsules are prevalent in *Lindernia parviflora,* whereas longer capsules are prominent in *Bonnaya ruellioides.* Similarly, ovoid or globose types of capsules are equal or slightly longer than persistent calyx. The size of such capsules ranges between 2-6×1-2.2 mm. Whereas in *Torenia* (except *T. anagallis* and *T. crustacea*), capsules are enclosed inside the persistent calyx. In such capsules, size varies between 6 and 16 mm (Appendix 10).

c. Capsule texture

Capsules are glabrous in all other species except *Torenia asiatica, T. cordata, T. cordifolia, T. diffusa, T. fourneiri* and *T. violacea.* Capsules are pubescent at apex in above mentioned species of *Torenia* (Fig 9 D, E, F, Appendix 10).

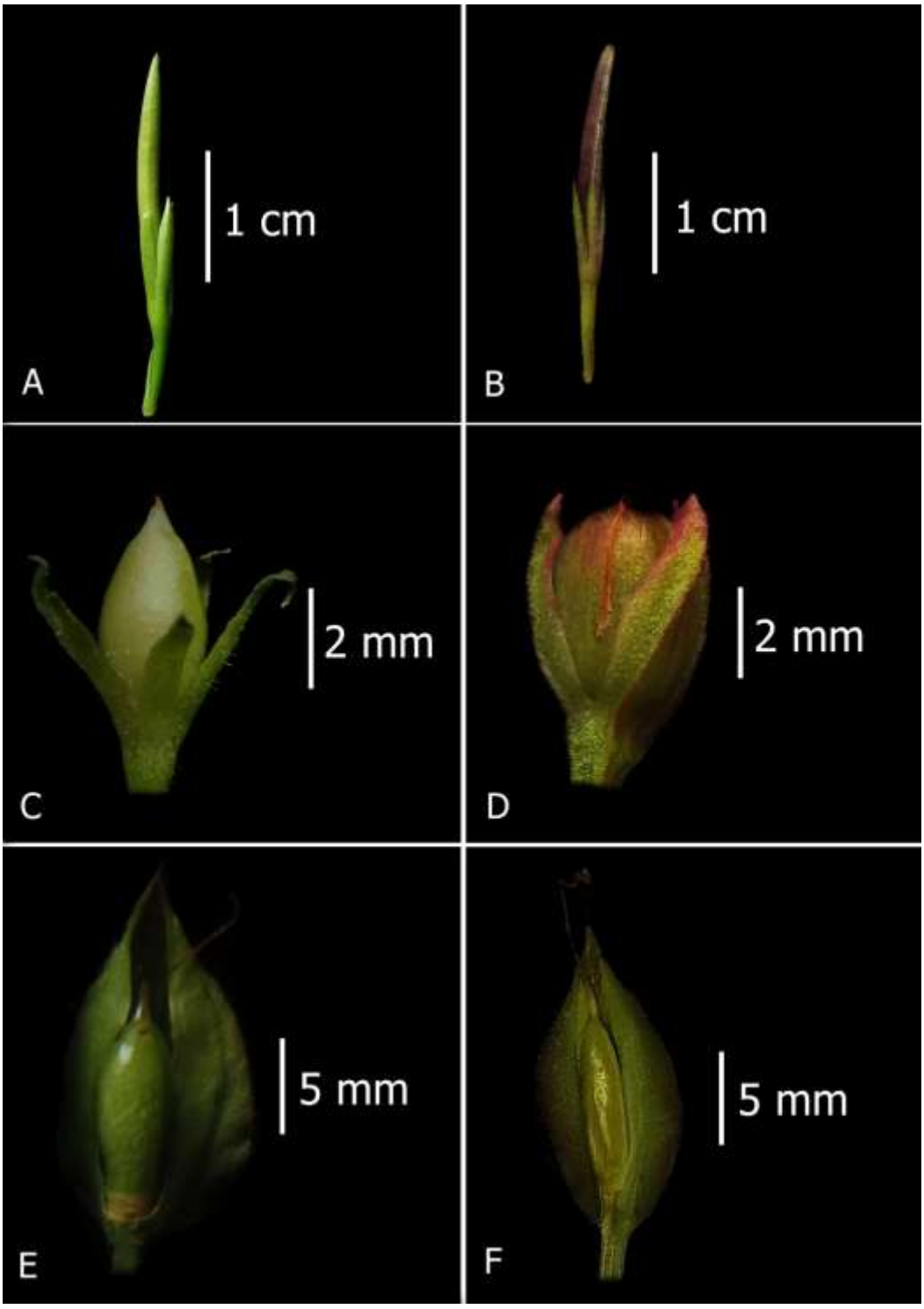


Fig. 9: Photographs showing the types of capsule in Linderniaceae. A,B. Capsule cylindric, longer than the persistant calyx (*Bonnaya ruellioides*, *B. ciliata*); C. Capsule ovoid, equal or slightly longer than persistent calyx (*Vandellia multiflora*); D. Capsule obovoid, equal or slightly longer than persistent calyx (*Torenia curstacea*); E, F. Capsule elliptic-ovoid, enclosed inside the persistent calyx (*Torenia cordifolia*, *T. violacea*).

4.4. Taxonomic Treatment

Linderniaceae Borsch, K. Müll. & Eb. Fisch.

Type genus: *Lindernia* All. Mélanges Philos. Math. Soc. Roy. Turin 3: 178 (1766).

Annual herbs. Roots fibrous. Stem erect, decumbent, prostrate or creeping, if creeping usually rooting at basal nodes, simple or diffusely branched, quadrangular or subqudrangular, glabrous or pubescent. Leaves exstipulate, opposite, sessile or petiolate, simple, glabrous or pubescent, pinnately or palmately veined. Inflorescence axillary or terminal racemes, umbel-like or solitary. Flowers bracteate or ebracteate, pedicellate, rarely sessile, zygomorphic, bisexual. Calyx deeply 5-lobed or lobed up to half of its length or bilipped, tube if present winged or not. Corolla bilabiate; lower lip distinctly 3-lobed, variously coloured, apices rounded, glabrous or pubescent inside; upper lip notched at apex or rounded, variously coloured, glabrous. Fertile stamens 2 of 4, if 4 didynamous, epipetalous; anterior filaments swollen or appendaged near base or unappendaged; anthers spurred or not; staminodes absent or 2. Pistil 1; ovary oblong-ovoid or ovoid; style slender; stigma bilipped, lips ciliate inside. Fruit a capsule, cylindric, ovoid, ellipsoid or ovoid-globose, shorter or longer than persistent calyx, glabrous or pubescent at apex. Seeds numerous.

Key to Genera

1a. Leaves palmately 3-5 veined…… ……. **Lindernia**
1b. Leaves pinnately veined…….…….. 2

2a. Fertile stamens 2. Staminodes 2…….…….....…….. **Bonnaya**
2b. Fertile stamens 4. Staminodes absent……...…… 3

3a. Calyx bilabiate, lobes winged or keeled. Ovary pubescent at apex…….. **Torenia**
3b. Calyx regular, lobes not distinctly winged or keeled. Ovary glabrous……. 4

4a. Calyx lobed up to half of its length. Leaves suborbicular or orbicular. Flowers sessile or/ and pedicellate…….…..……..…..…….. **Craterostigma**
4b. Calyx lobed almost to base. Leaves ovate, broadly ovate or lanceolate. Flowers always pedicellate……..…… 5

5a. Leaves villous. Capsule ovoid or globose…….. **Yamazakia**

5b. Leaves glabrous or subglabrous. Capsule cylindric or ovoid…… 6

6a. Stem prostrate or sub-erect. Flowers always solitary axillary. Leaves wider (3-12 mm).……..……... **Torenia** (*T. anagallis*)

6b. Stem erect or decumbent. Flowers solitary axillary or in terminal racemes, if solitary then leaves narrower (2-5 mm)……..……..…… **Vandellia**

Bonnaya Link and Otto.

Type species: *Bonnaya brachiata* Link & Otto, *Icon. Pl. Select. 25, t. 11 1820.*

Annual or perennial herbs. Stems erect, decumbent or prostrate, branched, quadrangular, glabrous or pubescent. Leaves sessile or petiolate, glabrous or pubescent beneath, pinnately veined. Flowers axillary solitary or in terminal racemes. Bracts lanceolate. Calyx deeply 5-lobed to base, margin ciliate. Corolla bilabiate; tube variously coloured, glandular or glabrous; lower lip lobes rounded; upper lip notched at apex. Fertile stamens 2, posterior; staminodes 2, anterior, uappendaged. Ovary ovoid or oblong-ovoid, glabrous. Capsules cylindric or cylindric-conical.

Key to Species

1a. Stem creeping. Leaves petiolate……...……**4**. **B. ruellioides**

1b. Stem erect or decumbent. Leaves sessile……..……...……2

2a. Staminodes pink. Corolla tube not constricted, whitish-pink. Leaf margin aristate. .....**2**. **B. ciliata**

2b. Staminodes yellow. Corolla tube base constricted, whitish-purple. Leaf margin serrate…… 3

3a. Corolla tube glandular outside, 7-10 mm, white lanate hairs between stamens ……..……..……..…….**1**. **B. antipoda**

3b. Corolla tube glabrous, upto 5 mm, tube, yellow lanate hairs between staminodes……..… **3**. **B. oppositifolia**

1. Bonnaya antipoda (L.) Druce, Rep. Bot. Exch. Club Soc. Brit. Isles 3: 415 (1913 publ. 1914) [**Basionym**: *Ruellia antipoda* L. in Sp. Pl.: 635 (1753)]; Fischer *et al.*, in Willdenowia 43 (2): 220 (2013); Liang & Wang in Aus. Syst. Bot. 27: 188 (2014); Shrestha *et al.* in Pl. Np. 657 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Np. 206 (2023)≡ *Ilysanthes antipoda* (L.) Merr. in Interpr. Herb. Amboin.: 467 (1917); Burkili in Re. Bot. Sur. In. x (1): 328 (1978) ≡ *Lindernia antipoda* (L.) Alston in H.Trimen, Handb. Fl. Ceylon 6 (Suppl.): 214 (1931); Philcox in Kew Bulletin 22 (1): 57-58 (1968); Hara in Hara *et al.*, Enum. Fl. Pl. Nepal 3:116 (1982); Press *et al.*, in Ann. Check. Fl. Pl. Np. (2000); Mill in Fl. Bhu. 2 (3): 1125 (2001); Rajbhandari & Parmar in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 102 (2012). ≡ *Vandellia antipoda* (L.) T.Yamaz. in J. Jap. Bot. 30: 177 (1955).

Type specimen: Ceylon, Hermann 235, (**Lectotype: BM!**) (**Photo!)**

Annual herbs, 5-25 cm. Stems erect or decumbent, diffusely branched, sometimes rooting from last few nodes, glabrous. Leaves sessile; lamina lanceolate-oblong or lanceolate, 15-50×5-15 mm, base cuneate, apex acute, margin ciliate-serrate, both surfaces glabrous. Flowers axillary solitary or in terminal racemes. Bracts 3-5×ca.1 mm, apex acute-acuminate, margin ciliate-serrate. Pedicels 11-15 mm in flowers, 15-20 mm in fruits, glabrous. Calyx lobes linear-lanceolate, 4-6 mm in flowers, 5-8 mm in fruits, apex acute-acuminate, margin finely serrate. Corolla tube pale yellow at base, white purple above, 5-7 mm, broadened end, constricted near base, gradually broadening towards throat, glandular outside. Lower lip lobes white or purplish-white, middle lobe larger than lateral lobes, 4-6×3-4.5 mm, lateral lobes 3-3.5×ca.3 mm, apices round, glabrous. Upper lip white or purplish-white, 4-5×2-2.5 mm, glabrous. Fertile stamens: filaments white or purplish-white, 1.5-2 mm, included; anthers 1.5-1.8 mm. Staminodes: yellow, 4-4.5 mm, exerted, base unappendaged, ciliate, apex hooked, glabrous. Ovary ovoid, 1.5-2 mm, glabrous, disc pale yellow, attached to ovary on anterior side, 0.6-0.8 mm, style 6-7 mm, glabrous. Capsules green, brown when matured, cylindric, 10-16 mm, glabrous. Seeds brown. (Fig. 10, Plate 1).

Fl. and Fr.: All around the year.

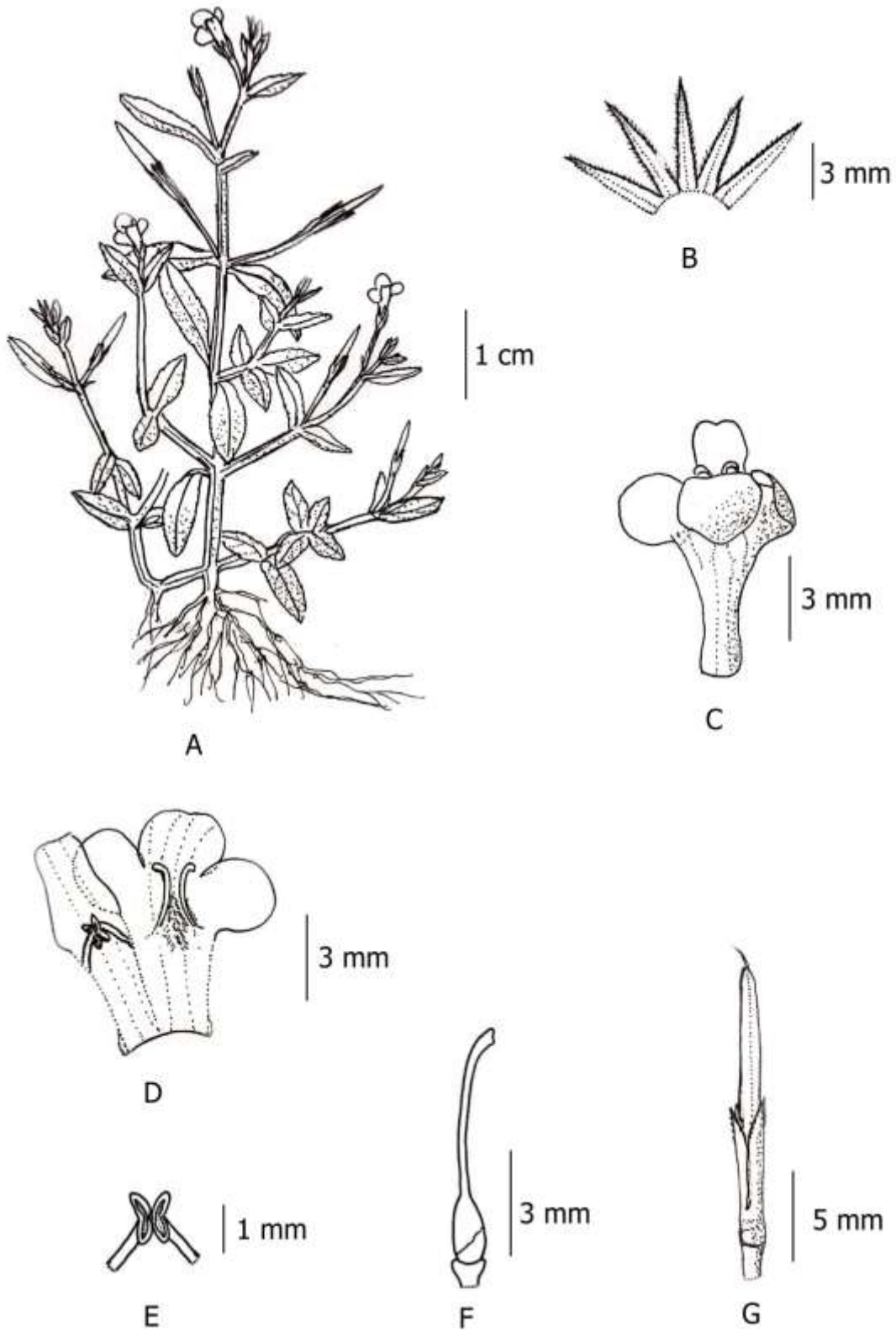


Fig. 10: Bonnaya antipoda: A. Habit sketch; B. Open calyx; C. Corolla front view; D. Opened corolla; E. Fertile stamens; F. Pistil; G. Fruit with persistant calyx.

Ecology: Grasslands, roadsides, foot trails, moist fields, rice fields, river and stream banks.

Distribution: Nepal (W, C & E), Assam-Burma, E Himalaya, SE Asia, N Asia, E Asia, S Asia, Australasia and N America.

Elevational range: 85-1500 m.

Voucher specimens: Lumbini Province, Gulmi, Wagla, 1207 m, 25 July 2021, K. Panthi, G02 (TUCH, KATH); Province no.1, Jhapa, Range Danda Badabari, 87 m, 12 March 2021, K. Panthi and Y.B. Poudel J02 (TUCH, KATH).

Specimens examined:

Eastern Nepal: Province no.1, Sankhuwasabha, Kyawa Khola-Sabha khola, 310 m, 320 m, 14 August 1997, S. Noshiro, N. Acharya, Y. Ibaragi, K. Kobayashi and T. Kurosawa 9760068 (TI); Province no.1, Sankhuwasabha, Pikhuwa-Mengtowa Besi-Tumlingtar, 460-500 m, 1 September 1997, S. Noshiro, N. Acharya, Y. Ibaragi, K. Kobayashi and T. Kurosawa 9760536 (KATH).

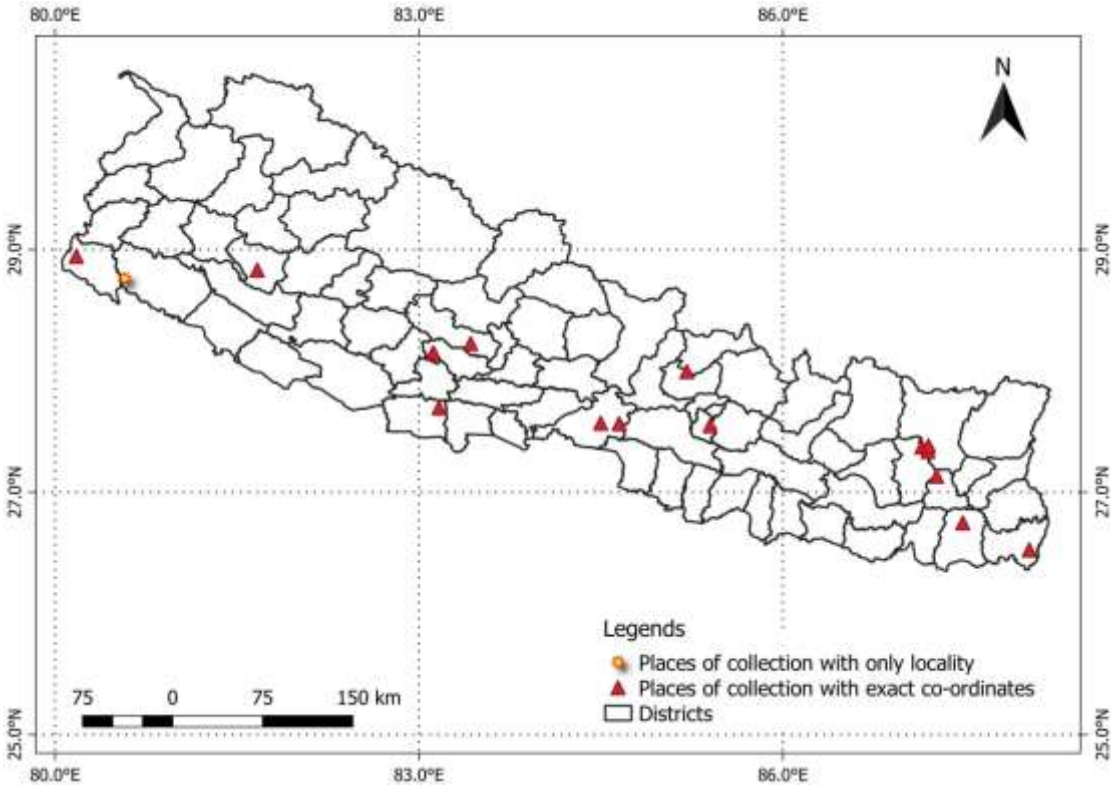


Fig. 11: Distribution of *B. antipoda* in Nepal based on herbarium specimens.

Central Nepal: Bagmati province, Chitwan, Sauraha-Kasara, 160-180 m, 13 January 1996, M. Suzuki, N. Acharya, T. Kurosawa, P. Lacoul, M. Mikage, A. Takahashi and K. Yoda 9614034 (KATH).

Western Nepal: Sudurpaschim province, Kailali, 200 m, 3 December 1996, D.H. Nicolson, 2824 (KATH).

2. Bonnaya ciliata (Colsm.) Spreng., Syst. Veg. ed. 16. 1: 41 (1824) [**Basionym**: *Gratiola ciliata* Colsm. in Prodr. Descr. Gratiol.: 14 (1793)]; Fischer *et al* in Willdenowia 43 (2): 220 (2013); Liang and Wang in Aus. Syst. Bot. 27: 189 (2014); Shrestha *et al.,* in Pl. Np. 657 (2022), Rajbhandari *et al.*,in A Hand. Fl. Pl. Np. 206 (2023) ≡ *Ilysanthes ciliata* (Colsm.) Kuntze in Revis. Gen. Pl.2: 461 (1891).
≡ *Lindernia ciliata* (Colsm.) Pennell in Brittonia 2: 182 (1936). Philcox in Kew. Bull. 22 (1): 51 (1968); Hara in Hara *et al.,* Enum. Fl. Pl. Nepal 3: 116 (1982); Press *et al* in Ann. Check. Fl. Pl. Np. (2000); Mill in Fl. Bhu. 2 (3): 1125 (2001); Rajbhandari and Parmar in Rajbhandari *et al.,* Cat. Nep. Fl. Pl. 3: 102 (2012) ≡ *Vandellia ciliata* (Colsm.) T.Yamaz. in J. Jap. Bot. 30: 176 (1955).
= *Bonnaya bracteoides* Blatt. & Hallb., J. Bombay Nat. Hist. Soc. 25: 416 (1918).
Vandellia brachiata Link & Otto. Haines in Bot. Bihar Orissa: 632 (1922) ≡ *Bonnaya brachiata* Link and Otto. Ridley in The Fl. Mal. Pen. 485 (1980); Collett in Fl. Sim. 354 (1980).

Type specimen: Java, Koenig *s.n.* (**Holotype**: **C!);**

Annual, herbs. 4-15 cm. Stem erect, branched, sometimes rooting from last nodes, sparsely pubescent. Lower leaves very shortly petiolate, upper leaves sessile; Petiole 2-3 mm, slightly pubescent. Lamina oblong or oblong-lanceolate, 8-38×3-12 mm, base amplexicaul, apex acute-aristate, margin aristate, both surfaces subglabrous, sparsely pubescent along veins. Flowers solitary axillary or in terminal raceme. Bracts 4-7×1-1.2 mm, apex spinelike, margin serrate. Pedicel 1-4 mm in flower, 3-6 mm in fruit. Calyx lobes lanceolate, 3-4×ca.0.5 mm in flower, 4-5.5×ca.0.5 mm in fruit, apex acute-spine like, margins sparsely ciliate, upper surface glabrous, lower surface sparsely pubescent on midrib. Corolla tube whitish pink, 3-4 mm, glandular outside. Lower lip lobes whitish pink, distinct pink spots in middle lobe near throat, middle lobe slightly longer, 1.8-2×2-2.2 mm, lateral lobes 1.5-1.8×2-2.2 mm, apices rounded, glabrous. Upper lip whitish pink, 2.5-3×1-1.2 mm, glabrous. Fertile stamens:

filaments white or pinkish white, 2-2.5 mm, glabrous; anthers 0.5-1 mm. Staminodes: pink, 1-1.5 mm, apex clavate, base ciliate. Ovary oviod-oblong, 0.8-1 mm, glabrous; disc pale yellow, attached to ovary on anterior side, ca. 0.3 mm; style 3-4 mm, glabrous. Capsule purplish green, brownish while matured, cylindric, 8-12 mm, glabrous. Seeds brown. (Fig. 13, Plate 2).

Fl. and Fr.: July-October.

Ecology: Grasslands, roadsides, foot trails, moist fields.

Distribution: Nepal (W, C & E), Assam-Burma, E Himalaya, SE Asia, N Asia, E Asia, W Himalaya, Tibetan Plateau, Australasia, N America.

Elevational range: 75-1600 m.

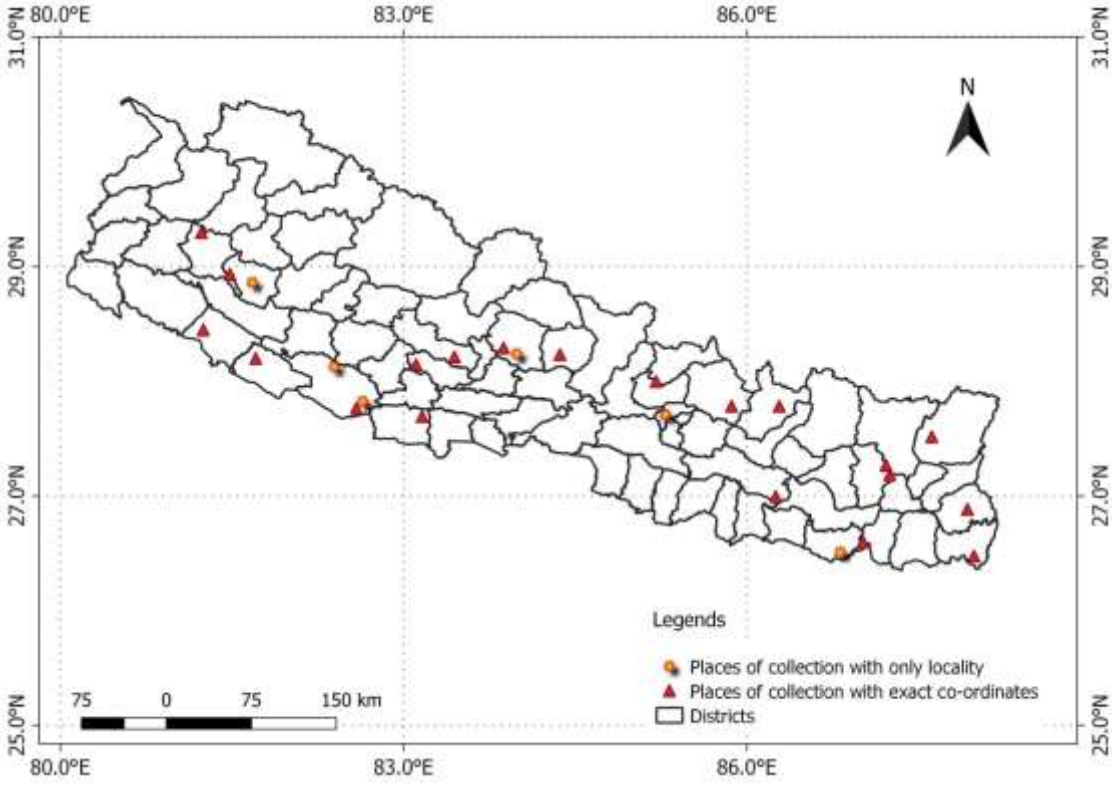


Fig. 12: Distribution of *B. ciliata* in Nepal based on herbarium specimens.

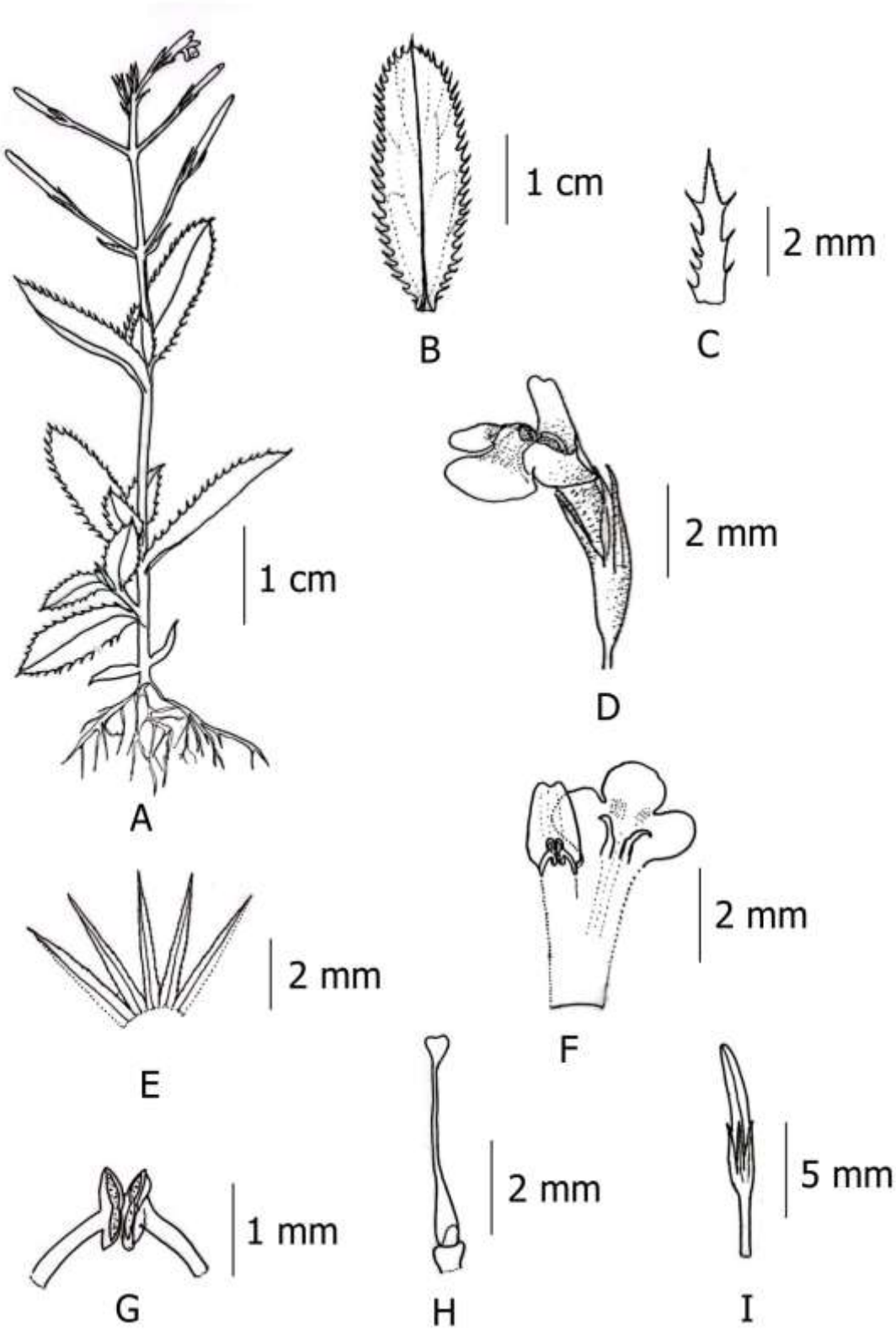


Fig. 13: Bonnaya ciliata: A. Habit; B. Single leaf; C. Bract; D. Flower later view; E. Opened calyx; F. Opened corolla; G. Fertile stamens; H. Pistil; I. Fruit with persistent calyx.

Voucher specimens: Lumbini Province, Gulmi, Wagla, 1207 m, 25 July 2021, K. Panthi, G03 (TUCH, KATH); Lumbini Province, Kapilvastu, Pipara, 176 m, 10 August 2021, K. Panthi and Y.B. Poudel K15 (TUCH, KATH); Bagmati Province, Rasuwa, Kalikasthan, 1487 m, 26 September 2021, K. Panthi R14 (TUCH).

Species examined:

Eastern Nepal: Koshi Province, Taplejung, Dumhan, Tamor river, 700 m, 31 October 1963, G Murata, M. Togashi and T. Tuyama 1477 (KATH); Koshi Province, Sankhuwasabha, Baide-Num, 960 m-1520 m, 13 August 1991, H. Ohba, S. Akiyama, H. Ikeda, T. Kikuchi, S. Nosiro, Y. Omari, M.N. Subedi and M. Wakabayashi 9110480 (KATH); Koshi Province, Ilam Godak-Maibesi, 3500 ft, 10 May 2014, P. Pradhan, K.R. Rajbhanadari and R. Niroula 230 (KATH); Madhesh province, Saptari, Chhoti, 600ft, 27 August 1971, Bhattacharya 3867 (KATH).s

Central Nepal: Bagmati province, Kathmandu, Swayambhu, 1300 m, 12 September 1970, N.P. Manandhar 4705 (KATH); Gandaki province, Kaski, Bagar, 880 m, 20 November, 1977, N.P. Manandhar, 595, (KATH); Lumbini Province, Kapilvastu, Maharajgunj, 200 m, 31 October 1992, P.P. Kurmi 155481 (KATH).

Western Nepal: Karnali Province, Dailekh, Sisnetar, 762 m, 27 October 1975, T.B. Shrestha and N.P. Manndhar 505 (KATH); Lumbini province, Dang, Bijauri, 680 m, 20 August 1979, K.R. Rajbhandari and B. Roy 154980 (KATH).

3. Bonnaya oppositifolia (Retz.) Spreng., Syst. Veg. ed. 16. 1: 41 (1824); [**Basionym**: *Gratiola oppositifolia* Retz., Observ. Bot. 4: 8 (1786)]; Hook. in Fl. Br. In.: 286 (1885). Fischer *et al.,* in Pl. Np.: 658 (2013); Linag and Wang in Aus. Syst. Bot. 27: 190 (2014); Shrestha *et al.,* in Pl. Np.: 658 (2022); Rajbhandari *et al.,* in A Hand. Fl. Pl. Np.: 207 (2023) ≡ *Vandellia oppositifolia* (Retz.) Haines, Bot. Bihar Orissa: 634 (1922) ≡ *Lindernia oppositifolia* (Retz.) Mukerjee, J. Indian Bot. Soc. 24: 134 (1945). Cooke in The Fl. Pr. Bom. II: 370 (1967); Hara in Hara *et al*., Enum. Fl. Pl. Nepal 3: 117 (1982). Press *et al.,* in Ann. Check. Fl. Pl. Np. (2000).

Type specimen: Tranquebar**,** India, Koenig *s.n.* (**Holotype: LD!)**

Annual herbs. 4-25 cm. Stem erect, branched, sometimes rooting from last node, both glabrous. Leaves sessile; Lamina oblong-lanceolate, 18-35×5-6 mm, base broadly cuneate, apex acute, margin serrate, both surfaces glabrous. Flowers axillary or in

terminal raceme. Bracts leaf like at inflorescence base, 5–15 cm long, with 4–10 (–12) flowers. Pedicel 4-6 mm in flower, 7-12 mm in fruit, slender, sparsely pubescent. Calyx lobes 1-2.5 mm in flower, 3.4 mm in fruit, apex acute, margin pubescent-serrate. Corolla tube base pale yellow, purple towards throat, 3-3.5 mm, glabrous. Lower lip lobes white-purple, subequal, 2-2.5×2.5-3 mm each, apices rounded, anterior lip ciliate inside near throat. Upper lip whitish purple, 2.5-3.5×1.2- 1.5 mm, glabrous. Fertile stamens: filaments white, 2.5-3 mm, included, glabrous; anthers ca. 0.3 mm. Staminodes: yellow, 2.8-3 mm, projected on throat, base unappendaged, villous, apex hooked, Ovary oblong-ovoid, 1.5-2 mm, glabrous; disc light green, attached to ovary on anterior side, ca. o.8-1 mm; style 3.5-4 mm, glabrous. Capsule green, brown while matured, cylindric, 9-12 mm, longer than persistant calyx, glabrous. Seeds brown. (fig. 14).

Fl and Fr.: July- October.

Ecology: Paddy field, forest edges, roadsides.

Distribution: Nepal (W, C & E), Assam-Burma, E Himalaya, South Asia.

Elevational range: 85- 1500 m.

Voucher specimen:; Province no. 1, Jhapa, Jalthal, 92 m, 10 September 2021, K. Panthi and Y.B. Poudel J004 (TUCH, KATH); Lumbini Province, Gulmi, Wagla, 1250 m, 20 July 2021, K. Panthi, G005 (TUCH).

Species examined:

Eastern Nepal: Province no. 1. Jhapa, Sibgunj. 85 m. 12 December 1963. G. Murata and M. Togashi. 1488. (KATH, TI).

Central Nepal: Bagmati Province. Chitwan , Rampur. 320 m. 5 August 1992. I. Shrestha and N. Joshi. 181.; Lumbini Province, Kapilvastu, Maharajgunj, 200 m, 30 October 1992 P.P. Kurmi KB 407 (KATH).

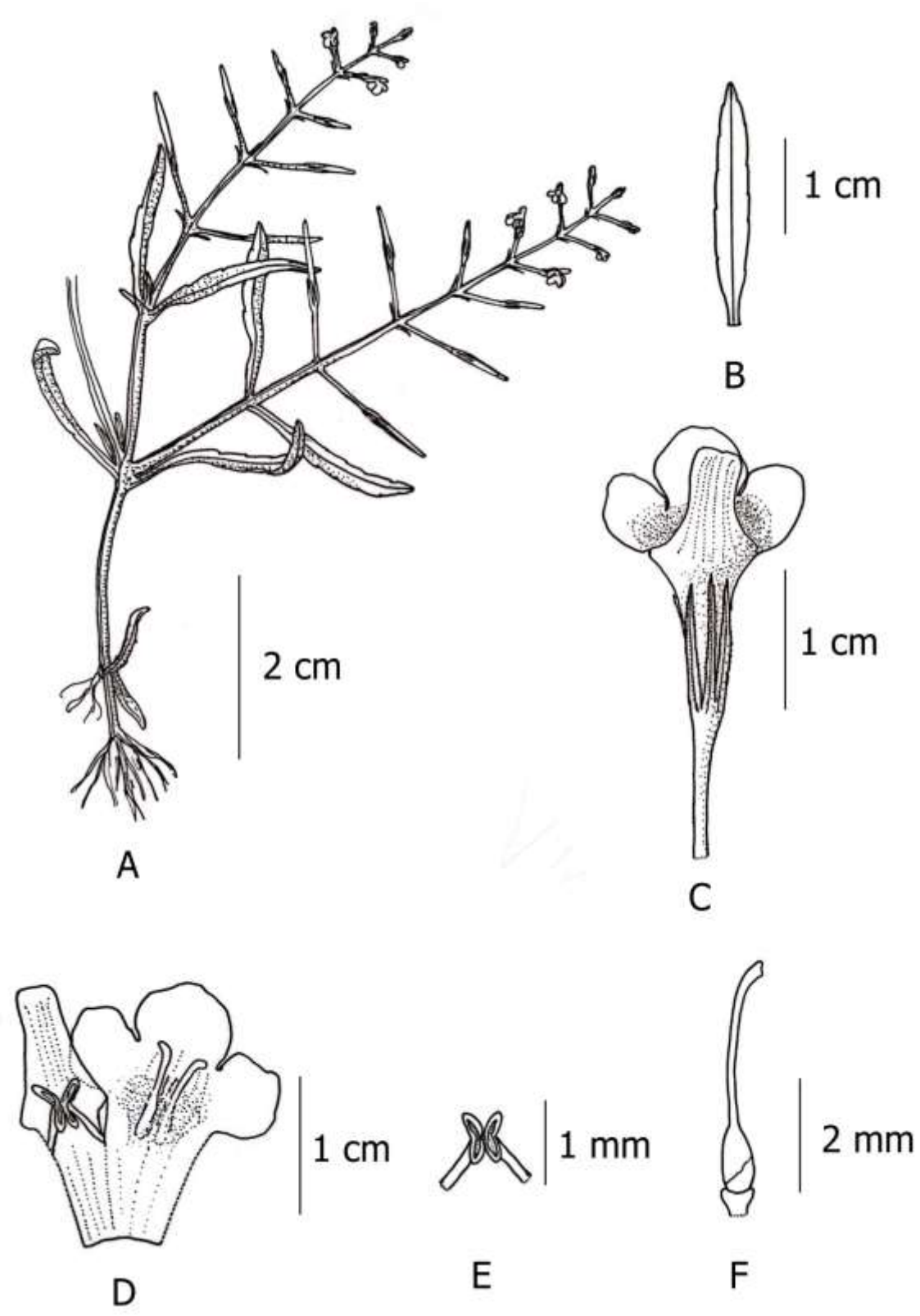


Fig. 14: Bonnaya oppositifolia: A. Habit sketch; B. Single leaf; C. Flower back view; D. Opened corolla; E. Fertile stamens; F. Pistil.

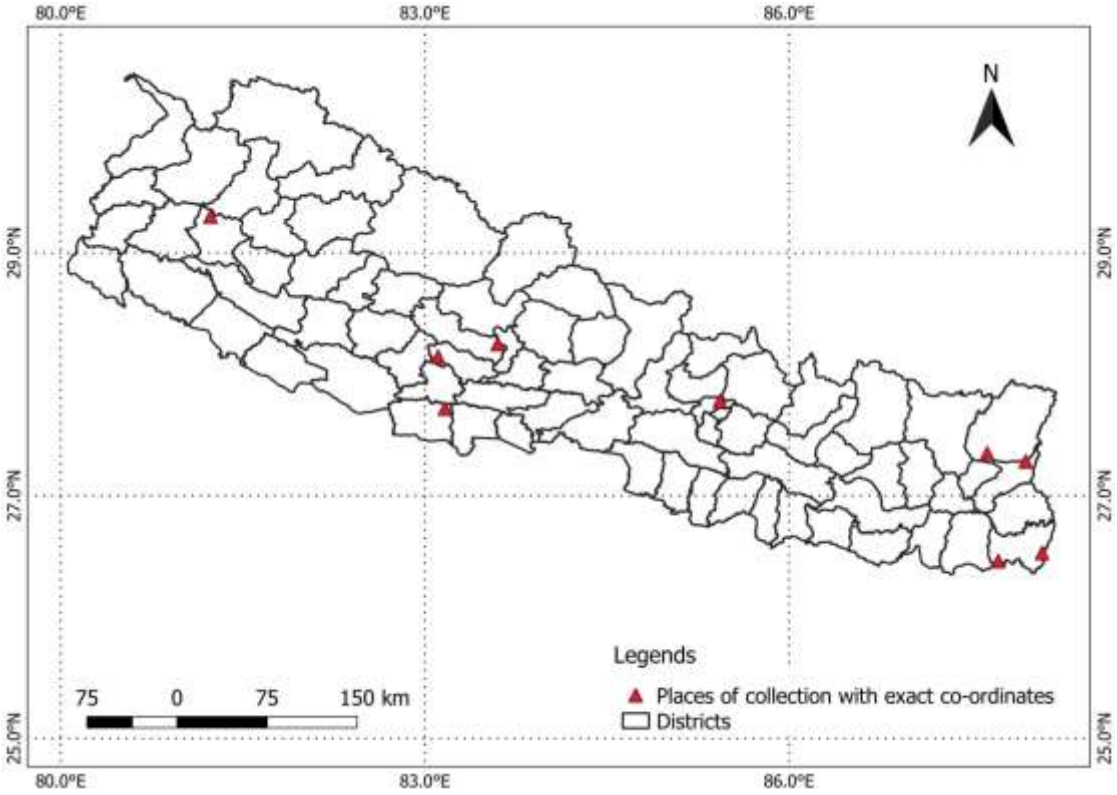


Fig. 15: Distribution of *B. oppositifolia* in Nepal based on herbarium specimens.

Western Nepal: Karnali province , Surkhet. 670 m. 29 Oct. 1975, T.B. Shrestha and N.P. Manandhar. 550 (KATH); Lumbini Province, Banke, Nepalgunj, 150 m. 24 October 1972, N.P. Manandhar 7602 (KATH); Sudurpaschim Province, Kanchanpur, Suklaphanta, 190 m, 11 September 1981, I. Sharma, R. Joshi, R. Uprety and I. Pandey, 261 (KATH); Sudurpaschim Province. Bajura, Tolebhir, 1070 m. 9 August 1991, M .Suzuki, M. Mikage, F. Miyamoto, K.R. Rajbhandari, H. Takayama and K Terada 9193585 (TI).

4. Bonnaya ruellioides (Colsm.) Spreng., Syst. Veg. ed. 16. 1: 41 (1824); [**Basionym**: *Gratiola ruellioides* Colsm. Prodr. Descr. Gratiol. 12 (1793)]; Fischer *et al*., in Willdenowia 43: 221 (2013); Liang and Wang in Aus. Syst. Bot. 27: 192 (2014); Sherestha *et al*., in Pl. Np. 658 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Np.: 207 (2023) ≡ *Lindernia ruellioides* (Colsm.) Pennell, Brittonia 2: 182 (1936). Philcox in Kew. Bull. 22 (1): 54 (1968); Hara in Hara *et al.*, Enum. Fl. Pl. Nepal 3: 117 (1982); Press *et al.*, Ann. Check. Fl. Pl. Np. (2000). Mill in Fl. Bhu. 2 (3): 1125 (2001).

= *Gratiola reptans* Roxb., Fl. Ind. 1: 140 (1820) ≡ *Bonnaya reptans* (Roxb.) Spreng.

Ridley in The Fl. Mal. Pen. II: 664 (1961).

Type specimen: Java and India, *Koenig s.n.* **(Holotype: C!)**

Perennial herbs. 5-30 cm. Stem prostrate, creeping, branched, rooting from nodes, subglabrous. Leaves petiolate; Petioles thicker at base, 4-20 mm. Lamina oblong-ovate or orbicular, 0.9-3.8×0.6-2.1 cm, base broadly cuneate, apex obtuse-round, margin hairy serrate, (14–) 20–34 (–42) pairs of acute, inwardly curved teeth, both surfaces sparsely pubescent. Flowers in terminal racemes. Bracts 4-6×1-1.5 mm, apex acute, margin serrate. Pedicel 8-12 mm in flower, 10-14 mm in fruit, glabrous. Calyx lobes linear to sublinear, 4-8×1.8-2 mm in flower, 8-10×1.8-2 mm in fruit, apex acute, margin serrate, both surfaces subglabrous. Corolla tube base whitish yellow, reddish purple towards throat, 6-10 mm, glandular outside, densely villous with yellow hairs inside between the bases of staminodes. Lower lip reddish purple, middle lobe of lower lip slightly larger, 3.5-4×5-5.5 mm, lateral lobes ca. 3.2 × ca. 4 mm, apices rounded, glabrous. Upper lip whitish purple, 5-5.5×4.5-5 mm, glabrous. Fertile stamens: filaments white, included, 2-2.2 mm, glabrous; anthers 0.5-0.6 mm. Staminodes: yellow, 2-2.2 mm, base unappendaged, ciliate, apex swollen, ciliate. Ovary oblong-ovoid, 2.5-3 mm, glabrous; disc greenish yellow, attached to ventral side of ovary ca. 1 mm; style 5-7 mm, glabrous. Capsule green, brow while matured, cylindric-conical, 18-20 mm. Seeds brown (Fig. 17, Plate 3).

Fl. and Fr.: July- November.

Ecology: Roadside, near the water logged area, forest margins, pond or stream sides.

Distribution: Nepal (C & E), Assam-Burma, SE Asia, E Asia and E Himalaya.

Elevational range: 400-1800 m.

Voucher Specimen: Lumbini Province, Gulmi, Wagla, 1255 m, 26 July 2021, K. Panthi G006 (TUCH, KATH). Koshi Province, Morang, Rajarani Lake, 483 m, 16 Oct. 2021, K. Panthi and Y. B. Poudel M05 (TUCH, KATH).

Species examined:

Eastern Nepal: Province no.1, Sankhuwasabha, Khandbari-Bhotebas, 1150 m-1800 m, 7 July 1988, M. Suzuki, N. Naruhashi, N. Kurosaki, Y. Kadota, M.N. Subedi, M. Minaki, S. Noshiro, H. Ikeda 8820226 (KATH); Province no.1, Sankhuwasabha,

Gola-Godhi Danda, 1120 m-1800 m, 27 August 1998, S. Noshiro, N. Acharya, K. Kobayashi, Y. Omarim K. Shinozaki and H. Tsukaya 9830175 (KATH)

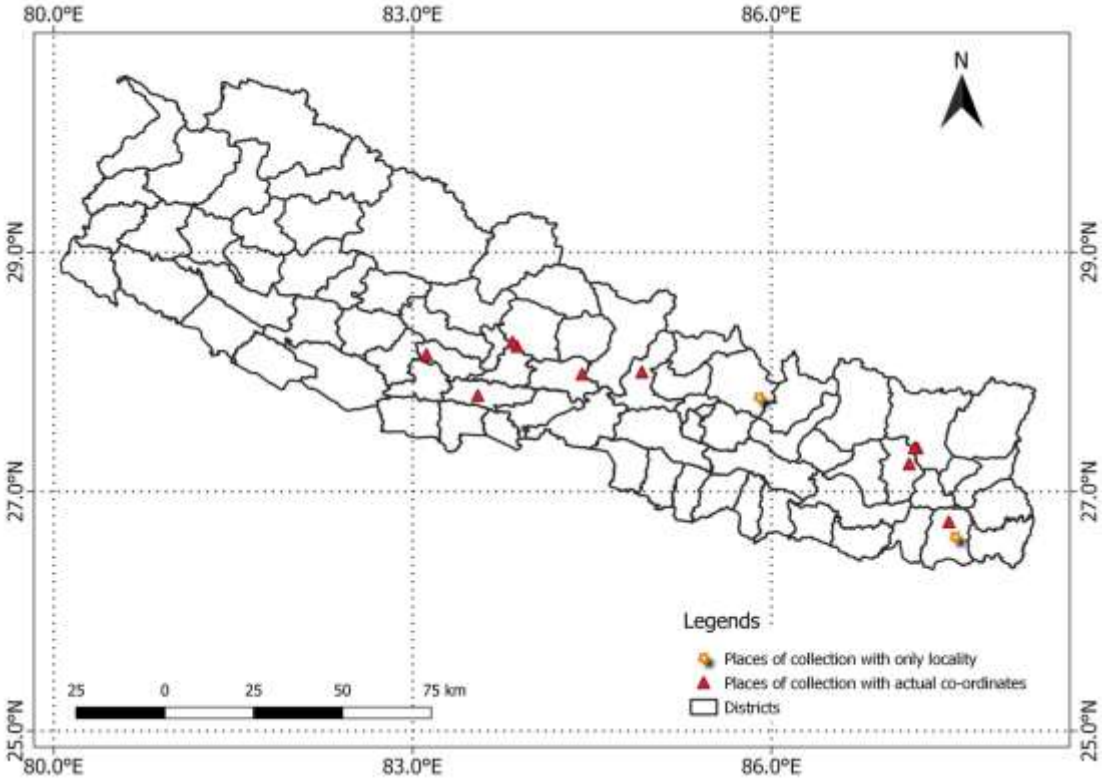


Fig. 16: Distribution of *B. ruellioides* in Nepal based on herbarium specimen.

Central Nepal: Bagmati Province, Sindhupalchowk, Barhabise-Bhansar, 500 m-630 m, 3 July 1973, D.P. Joshi and M.M. Amatya 73/154 (KATH); Gandaki Province, Kaski, Suikhet-Pathana, 1230 m- 2050 m, 7 July 1983, H. Ohba, H. Kanai, M. Wakabayashi, M. Suzuki and S. Akiyama 8330117 (KATH); Lumbini Province, Palpa, Prabhas, 880m, 20 October 2013, P. Shrestha 134070 (KATH); Gandaki province, Kaski, Tarebhir, Pumdi Bhumdi, 1920 m, 9 August 2014, P. Bhandari and A. Bhandari 691 (KATH).

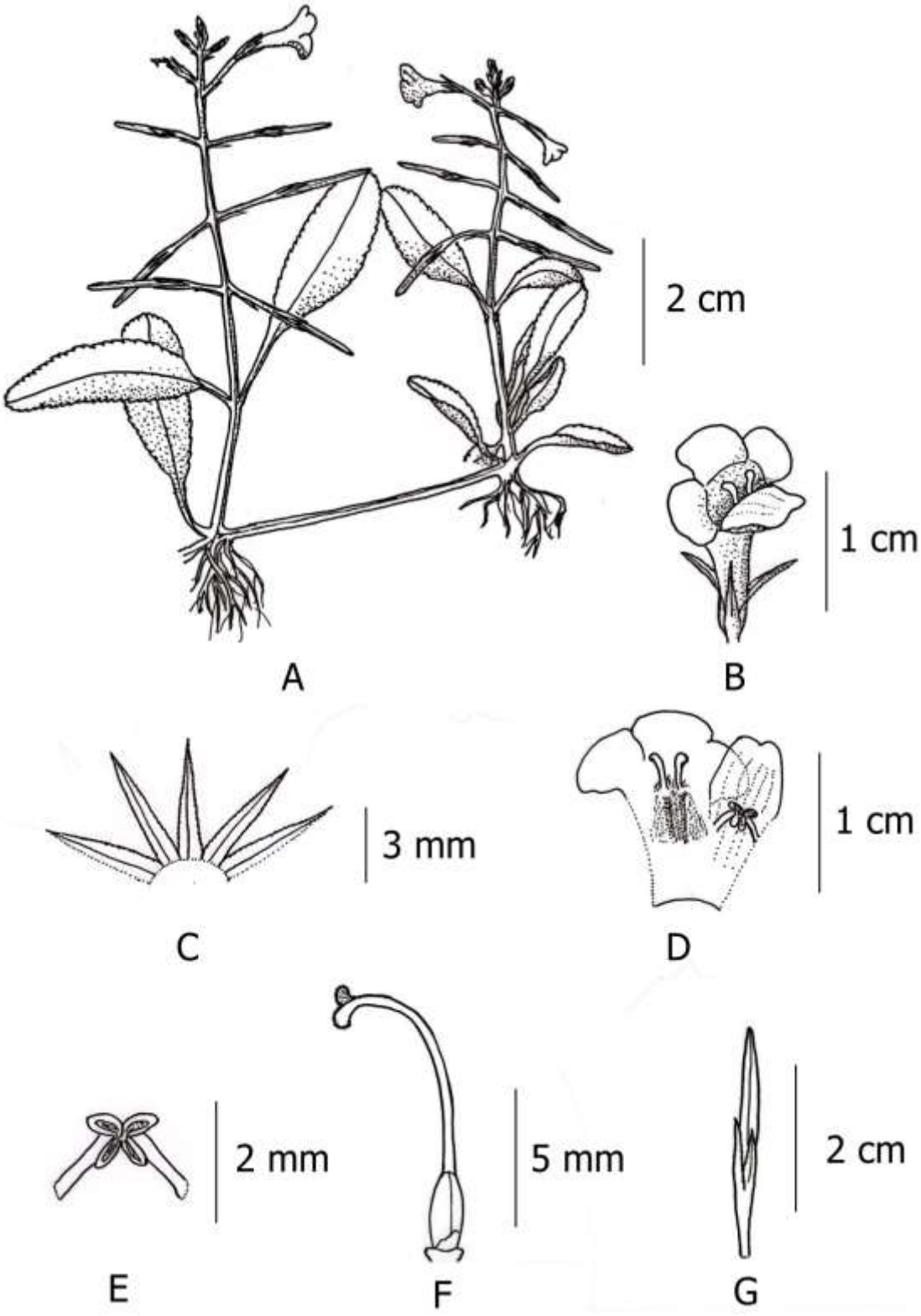


Fig. 17: Bonnaya ruellloides: A. Habit sketch; B. Flower front view; C. Opened calyx; D. Opened corolla; E. Fertile stamens; F. Pistil; G. Fruit with persistent calyx.

Craterostigma Hochst.

Type species: *Strigina pusilla* Engl**.** ≡ *Craterostigma pusillum* (Engl.) Eb. Fisch. Schaferh. & Kai Mull.

1. Craterostigma nummulariifolium (D. Don) Eb. Fisch., Schäferh. & Kai Müll. Willdenowia 43: 222 (2013); [**Basionym**: *Vandellia nummulariifolia* D.Don, Prodr. Fl. Nep.: 88 (1825); Collett in Fl. Sim, A Hand. Pl. Sim. 354 (1980)]; Biffin *et al.*, in Aus. Syst. Bot. 31: 244 (2018); Shrestha *et al.*, in Pl. Np. 658 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Np. 208 (2023) ≡ *Lindernia nummulariifolia* (D.Don) Wettst. in Engler & Pranl, Nat. Pflanzenfam. 4(3b): 80 (1891). Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 117 (1982). Press *et al.,* Ann. Check. Fl. Pl. Np. (2000); Mill in Grierson and Long Fl. Bhu. 2 (3): 1124 (2001); Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 102 (2012) ≡ *Pyxidaria nummulariifolia* (D.Don) Kuntze in Revis. Gen. Pl. 2: 464 (1891).
= *Vandellia minima* Royle ex Benth., Scroph. Ind.: 37 (1835).

Type specimen: Holotype: König s.n. **(LD!)**

Annual herbs. 5-15cm. Stem erect, branched, sparsely pubescent. Leaves sessile or shortly petiolate; petioles 1.5-2 mm, sparsely pubescent. Lamina broadly ovate or ovate-orbicular, 1.6-2.5×1.4-2.2 cm, base rounded, apex acute, margin serrate-dentate, pubescent both sides. Flowers in axillary whorl, or terminal umbel like. Bracts 0.6-0.8 mm, apex acute, sparsly pubescent. Central flowers subsessile or sessile, lateral flowers pedicellate; Pedicels 4-12 mm, pubescent. Calyx lobed to half of the tube in flower or near to the base in fruit, lobes 5, elliptic-ovate, 2-3×ca.1 mm in flower, 3-4×ca.1 mm in fruit, apex acute, margin and midveins pubescent. Corolla tube purplish white, 4.5-5 mm, glabrous outside, densely villous below the base of anterior stamens inside. Lower lip; lateral lobes pale purple, middle lobe dark purple, lobes subequal, 1.8-2×ca. 2 mm each, apices rounded, glabrous outside. Upper lip purple, 2.8-3.2×1.8-2.5 mm, apex rounded, pubescent along marginside. Stamens 4, didynamous. Posterior pair; filaments white, shorter, 1.5-2 mm, fertile, included; anthers 0.8-1 mm. Anterior pair; filaments longer, 2.2-2.5 mm, projected on throat, glabrous, base swollen to form zig-zag appearance; anthers 0.5-0.8 mm. Ovary oblong-ovoid, 1-1.2 mm, glabrous; disc greenish yellow, attached to ovary on anterior side, 0.6-0.8 mm;

style 4-5 mm, glabrous. Capsule green, brown while matured, ovoid, 4-6×1-1.5 mm, longer than persistant calyx, glabrous. Seeds brown (Fig. 19, Plate 4).

Fl. and Fr.: July-October.

Ecology: Forest margins, roadside, moist surfaces, rock surfaces.

Distribution: Nepal (W, C & E), Assam- Burma, W Himalaya, E Himalaya.

Elevational range: 1200-3000 m.

Voucher Specimen: Lumbini Province, Gulmi, Wagla, 1260 m, 25 July 2021, K. Panthi, G007 (TUCH, KATH); Bagmati Province, Rasuwa, Kalikasthan, 1487 m, 26 September 2021, K. Panthi R15 (TUCH, KATH).

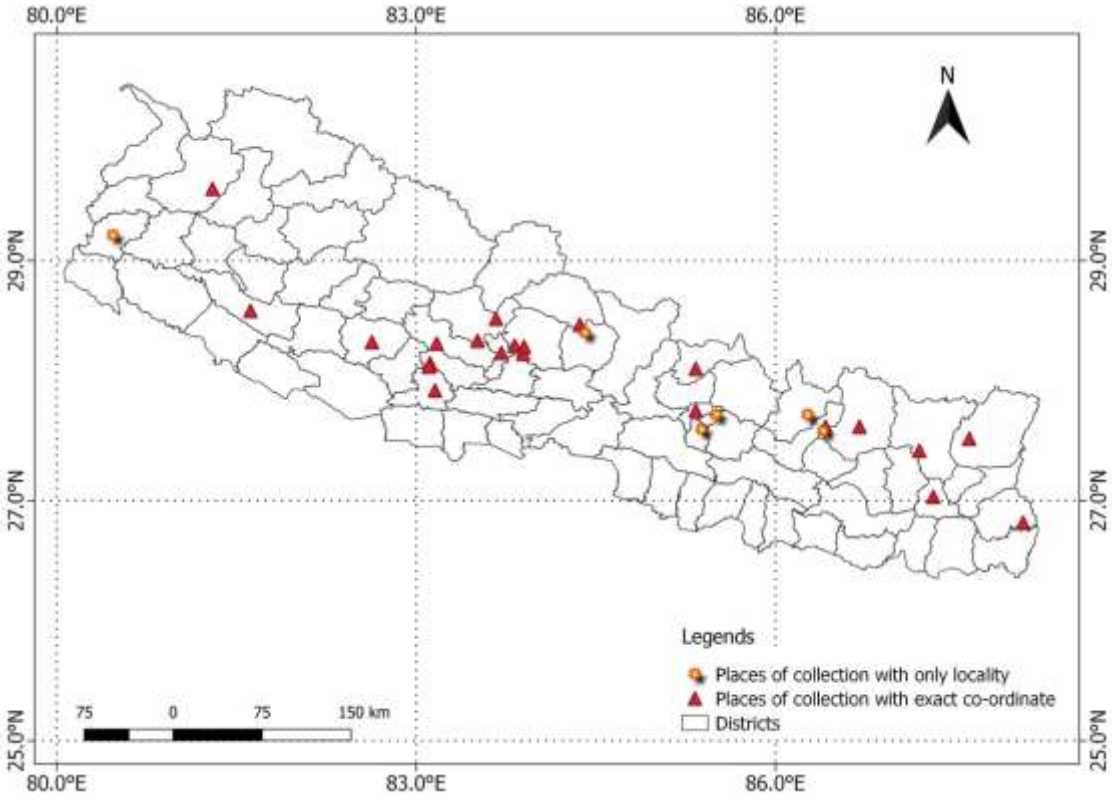


Fig. 18: Distribution of *C. nummulariifolium* in Nepal based on herbarium specimen.

Species examined:

Eastern Nepal: Bagmati province, Ramechhap, Sibalaya-Bandar, 1725 m-1960 m, 19 July 1995, F. Miyumato, M. Amono, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu

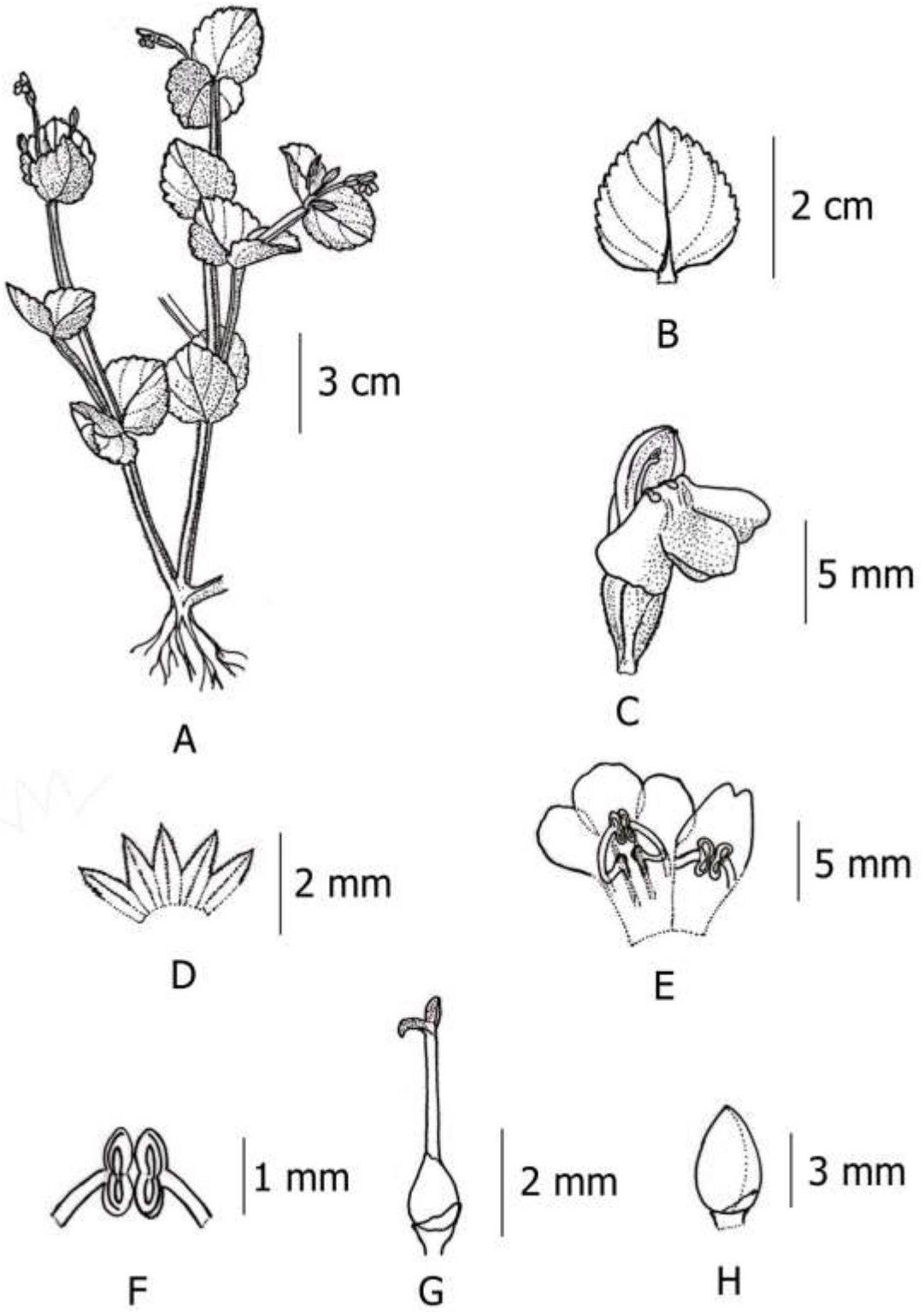


Fig. 19: Craterostigma nummularifolium: A. Habit sketch; B. Leaf; C. Corolla lateral view; D. Opened calyx; E. Opened corolla; F. Posterior stamens; G. Pistil; H. Fruit.

9592038 (KATH); Province no.1, Solukhumbu, Kharikhola-Takisindu, 1960-2940 m, 31 August 1995, F. Miyumato, M. Amono, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu 9596570 (KATH).

Central Nepal: Bagmati Province, Lalitpur, Godawari, 5000ft, 15 August 1963, T.B. Shrestha 1025 (KATH).

Lindernia All.

Type species: *Anagalloides procumbens* Krock., Fl. Siles. 2 (1): 398 (1790).
≡ *Lindernia procumbens* (Krock.) Philcox, Taxon 14: 30 (1965).

Annual herbs. Stem erect or decumbent, branched, qudrangular. Leaves sessile, ovate or elliptic-ovate, glabrous both surfaces, palmately 3-5 veined. Flowers axillary-solitary. Pedicel quadrangular, glabrous. Calyx distinctly 5-lobed almost to the base; lobes lanceolate or linear-lanceolate, pubescent. Corolla tube glandular or glabrous, lower lips apices rounded, upper lip apex notched or rounded. Fertile stamens 2 or 4. Pistil 1, ovary oblong-ovoid, stigma bilipped, lips ciliate inside. Capsule oblong-clyndric or oblong-ovoid, equal or longer than persistent calyx.

Key to species:

1a. Fertile stamens 2. Corolla creamy white. Capsule distinctly longer than persistent calyx……...**1. L. parviflora**
1b. Fertile stamens 4. Corolla white pink. Capsule equal or slightly longer than persistent calyx…….……...…….**2. L. procumbens**

1. Lindernia parviflora (Roxb.) Haines., Bot. Bihar Orissa: 635 (1922) **[Basionym**: *Gratiola parviflora* Roxb. Pl. Coromandel 3: 3 (1811); Roxb. in Fl. Ind. i: 140 (1971)**]**; Hara in Hara *et al.*, Enum. Fl. Pl. Np. 3: 117 (1982); Press *et al*., Ann. Check. Fl. Pl. Np. (2000); Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 103 (2012); Fischer *et al*., in Willdenowia 43: 226 (2013); Shrestha *et al.*, Pl. Np. 658 (2022); Rajbhandari *et al.*, A Hand. Fl. Pl. Np. 209 (2023) ≡ *Bonnaya parviflora* (Roxb.) Benth. in Wallich, Numer. List: no. 3867 (1831) ≡ *Ilysanthes parviflora* (Roxb.) Benth. in de Candolle, Prodr. 10: 419 (1846); Hook. In Fl. Br. Ind. iv: 283 (1885); Cooke in Fl. Bom. ii: 296 (1967); Duthe *et al.*, Fl. Up. Gang. Plain. ii: 25 (1965).

Type specimen: Roxburgh, Pl. Coromand. 3:3, t. 203. 1819. Illustration **(Holotype E!).**

Plants 5-30 cm. Stem erect, or sometimes decumbent, branched, glabrous. Leaves: Lamina triangular ovate, 8-14×5-8 mm, base cuneate, apex acute, margin dentate, both surfaces glabrous, usually pal,mately 3-veined. Pedicels 9-13 mm in flower, 10-16 mm in fruit, glabrous. Calyx lobes lanceolate, 2-3×ca. 1 mm in flower, 2.5-4×ca. 1 mm in fruit, apex acute, margin and midvein pubescent. Corolla tube white, 5-6 mm, glandular outside, densely villous around staminodes inside. Lower lip lobes creamy white, subequal, ca.1.5×1.5 mm each, glabrous. Upper lip creamy white, 1.5-2×ca.2 mm, glabrous. Stamens 2, posterior; filaments white, 1-1.2 mm, included, glabrous; anthers 0.5-0.8 mm, villous. Staminodes 2 , anterior; filaments white, 1.5-2 mm, exerted from tube, villous, base appendaged; appendages white, 0.6-0.8 mm, villous. Ovary oblong-ovoid, 1.5-2 mm, glabrous; disc yellow, attached to ovary at base; style 2.5-3 mm, glabrous. Capsule green, brown while matured, oblong-cylindric, 4-6 mm, longer than persistant calyx. Seeds yellow brown (Fig. 20, Plate 5).

Fl and Fr.: February-October.

Ecology: Moist field, river banks.

Distribution: Nepal (WCE), Assam-Burma, S Asia, SE Asia, W Himalaya, Africa.

Elevational range: 87-2300 m.

Voucher Specimen: Province no.1, Jhapa, Jalthal Range Danda, 87 m, 13 March 2021, K. Panthi and Y.B. Poudel JF149 (TUCH, KATH); Bagmati Province, Rasuwa, Syafrubensi, 1456 m, 25 September 2021, K. Panthi R01 (TUCH, KATH).

Species examined:

Eastern Nepal: Province no. 1, Jhapa-Morang, Mahara Bahara-Gaurigunj-Kathgara, 75 m, 13 December 1963, H. Hara, H. Kanai, S. Kurosawa, G. Murata and M. Togashi 1492 (KATH).

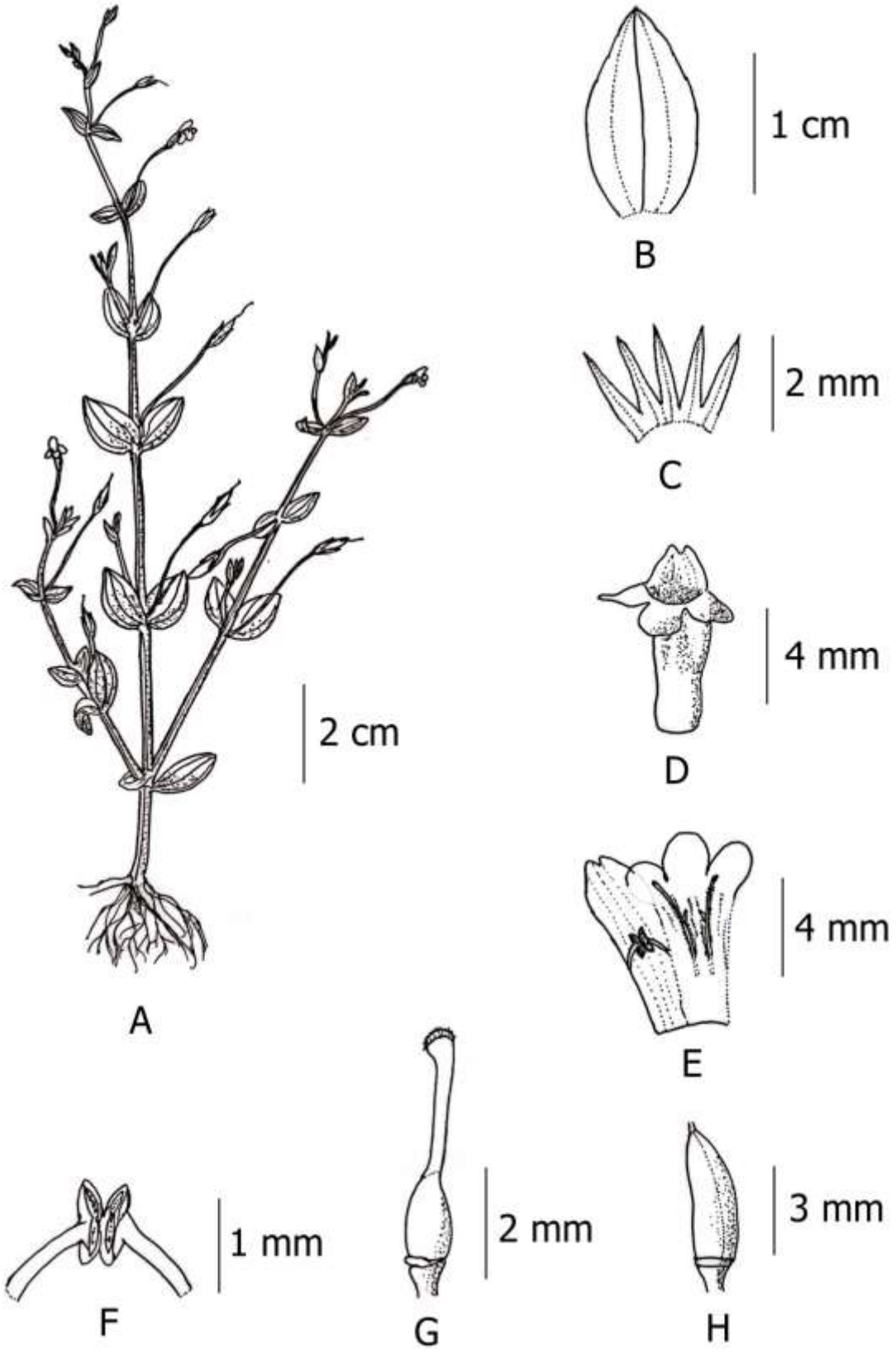


Fig. 20: Lindernia parviflora: A. Habit sketch; B. Single leaf; C. Opened calyx; D, Corolla front view; E. Opened corolla; F. Fertile stamens; G. Pistil; H. Fruit.

Western Nepal: Karnali Province, Jumla, 2280 m, 14 October 1982, H.Tabata, D.P. Joshi, K. Tsuchiya and Y. Yasuda 13683 (KATH); Karnali province, Dolpa, Dunai-Juphal airport, 2090 m-2480 m, 15 October 1991, M. Minaki, K.K. Joshi, Y. Kadota, H . Sugita, A. Takahashi, S. Tsuda, H. Yagi and C. Yonebayashi 10008503 (TI)

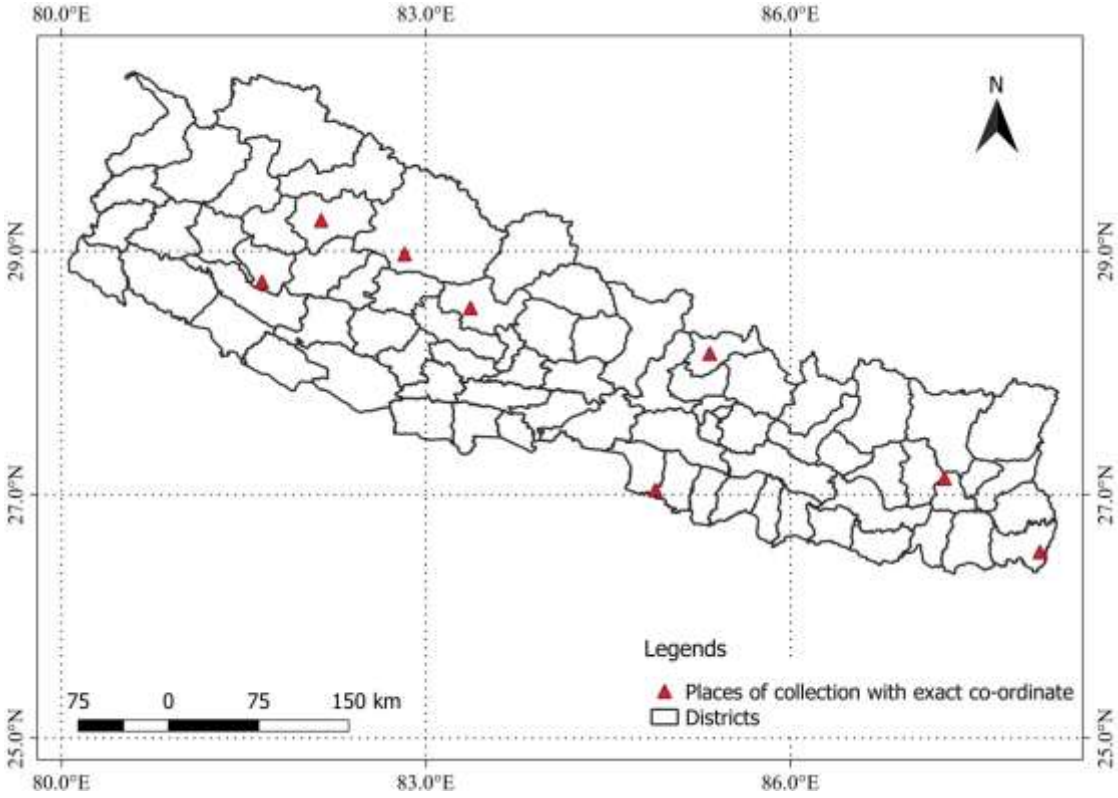


Fig. 21: Distribution of *L. parviflora* in Nepal based on herbarium specimens

2. Lindernia procumbens (Krock.) Borbás., Békésvármegye Fl.: 80 (1881); [**Basionym**: *Anagalloides procumbens* Krock., Fl. Siles. 2(1): 398 (1790)]; Philcox in Taxon 14: 30. (1965). Philcox in Kew Bull. 22 (1): 29 (1968); Hara in Hara *et al.*, Enum. Fl. Pl. Np. 3: 117 (1982); Press *et al.*, in Ann. Check. Fl. Pl. Np. (2000); Mill in Grierson and Long Fl. Bhu. 2 (3): 1122 (2001). Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 103 (2012); Fischer *et al.*, in Willdenowia 43(2): 226 (2013); Shrestha *et al.*, in Pl. Np. 658 (2022); Rajbhandari *et al.*, in A hand. Fl. Pl. Np. 209 (2023).

= *Lindernia pyxidaria* All. in Mélanges Philos. Math. Soc. Roy. Turin 3: 178 (1766).

= *Vandellia erecta* Benth., Scroph. Ind.: 36 (1835); Hook. in Fl. Br. In. iv: 281 (1885).

Type specimen: *Vandellia erecta* Benth., Scroph. Ind. 36. 1835 (**Isotype: BM**! **Lectotype: K**!, Wallich, 3947C) **(Photo!)**

Plants 5-20 cm. Stem erect, branched, sometimes rooting from last nodes, glabrous. Leaves: Ovate-elliptic, 12-23×4-15 mm, base cuneate, apex acute-round or obtuse, margin obscurely crenate, both surfaces glabrous, palmately 3-5 veined. Pedicels 7-10 mm in flower, 10-16 mm in fruit, glabrous. Calyx lobes linear-lanceolate, 3-3.5×1-1.5 mm, apex acute, margins and midveins pubescent. Corolla tube 2.5-3 mm, creamy white, glabrous. Lower lip lobes white-pink, middle lobe slightly larger than lateral lobes, 2-2.4×2-2.2 cm, lateral lobes 2-2.2×1.2-1.5 cm. Upper lip white-pink, 1.8-3×1.5-2 mm, ovate, apex rounded, glabrous. Stamens 4, didynamous, fertile. Posterior pair; filaments white, shorter, 0.3-0.5 mm, included. Anterior pair; filaments creamy white, longer, 0.8-1 mm, exerted from tube, glabrous; Bases appendaged; appendages pink, less than 1 mm, glabrous. Ovary oblong-ovoid, 1-1.5 mm, glabrous; disc pale yellow, attached to the ovary at base; style 3-3.5 mm, glabrous. Capsule green, brown while matured, oblong-ovoid, 4-6×2-2.2 mm, equal or slightly longer than persistant calyx. Seeds brown (Fig 22, Plate 6).

Fl and Fr.: February-October.

Ecology: Water logged area, rice fields, river banks.

Distribution: Nepal (W, C & E), SW Asia, Assam-Burma, Europe, S Asia, E Asia, SE Asia.

Elevational range: 87-2500 m.

Voucher Specimen: Province no.1, Jhapa, Jalthal Range Danda, 87 m, 13 March 2021, K. Panthi and Y.B. Poudel J03 (TUCH, KATH).

Species examined:

Central Nepal: Bagmati province, Chitwan, Sauraha, 240 m, 11 May 1978, H. Tabata, K.R. Rajbhandari and Y. Shimizu, 9760 (KATH); Bagmati Province, Chitwan, Sauraha-Nandan Tal, 160 m, 18 Jan 1996, M. Mikage, N. Acharya, T. Kurosawa, P. Lacoul, A. Takahashi and K. Yoda 9614188 (TI).

Western Nepal: Karnali Province, Jumla, Giripandebara, Girikhola, 8000 ft, 9 July 1952, O. Polunin, W.R. Skyes and L.H.J. Williams 4476 (KATH).

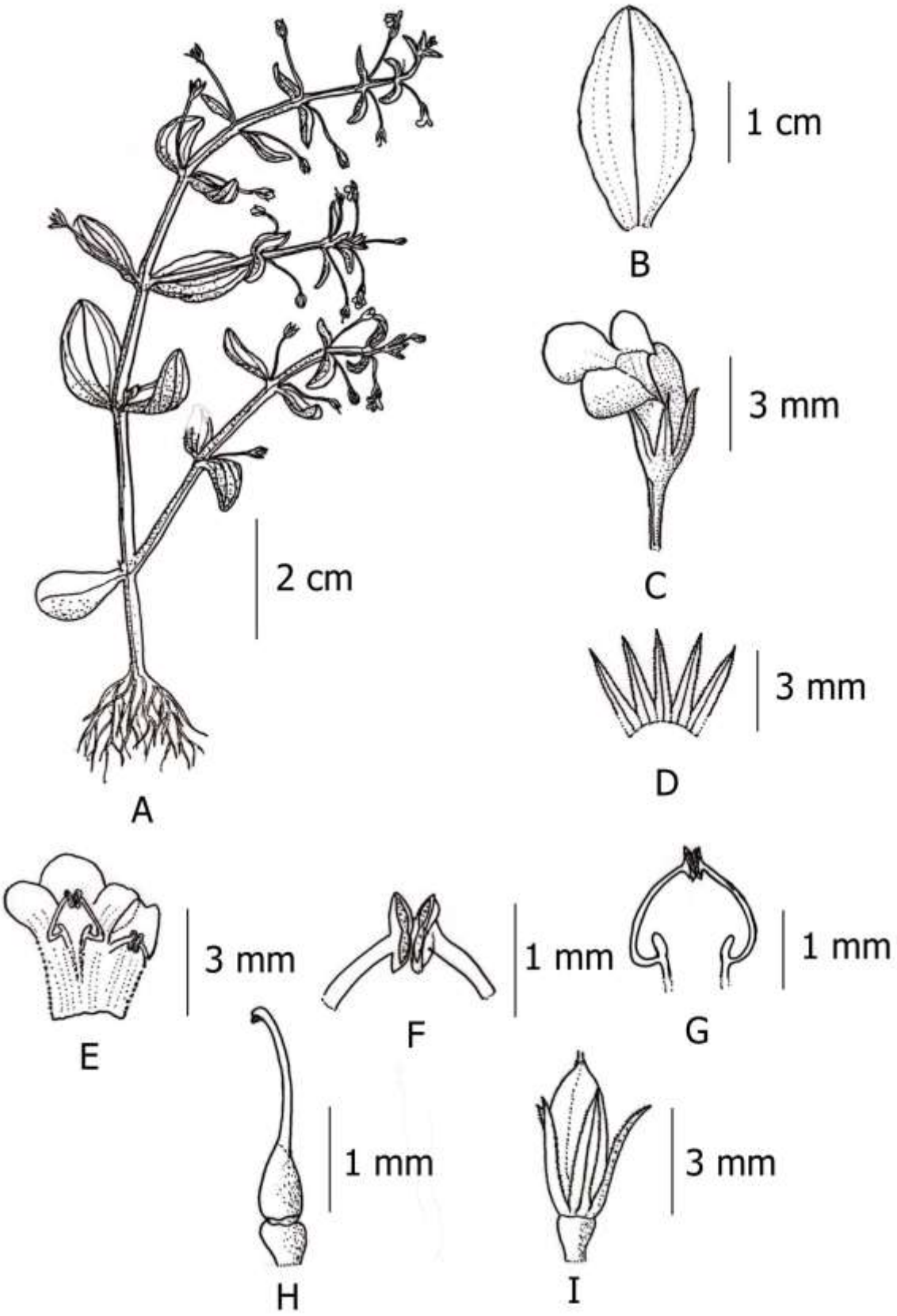


Fig. 22: Lindernia procumbens: A. Habit sketch; B. Leaf; C. Flower lateral view; D. Opened calyx; E. Opened corolla; F. Posterior stamens; G. Anterior stamens; H. Pistil; I. Fruit with persistent calyx.

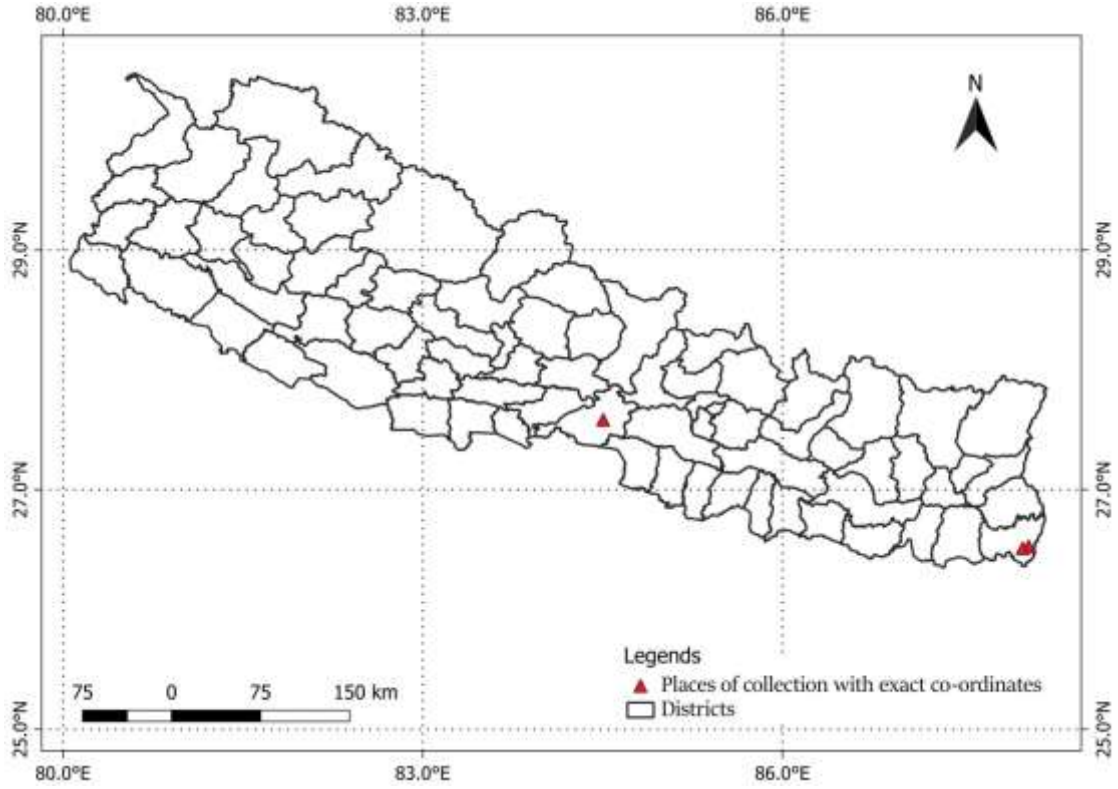


Fig. 23: Distribution of *L. procumbens* in Nepal based on herbarium specimen

Torenia L. Sp. Pl.: 619 (1753)

Type species: *Torenia asiatica* Sp. Pl.: 619 (1753); Hook. in Fl. Br. In. iv: 277 (1884).

Annual herbs. Stem erect, creeping or decumbent, quadrangular or subqudrangular glabrous or sparsely pubescent. Leaves sessile, subsessile or petiolate, triangular-ovate, ovate or suboricular, glabrous or pubescent. Inflorescences various. Pedicels quadrangular, glabrous or pubescent. Calyx 3×2 lipped or distinctly 5-lobed, lobes winged or not. Corolla variously coloured, tube glabrous or glandular. Stamens 4, all fertile, posterior pair shorter, included, anterior pair longer, exerted from tube, filaments appendage or not. Pistil 1, ovary oblong-lanceolate or oblong-ovoid, apex glabrous or pubescent, stigma bifid, lips ciliate inside. Capsule cylindric-ovoid or obovoid, enclosed inside the persistant calyx or longer. Seeds yellow or brown.

Key to species:

1a. Calyx unwinged. Fruit twice longer or more than persistant calyx. Stem glabrous……..…….…….. **1. T. anagallis**

1b. Calyx winged. Fruit enclosed inside or slightly longer than persistant calyx. Stem sparsely pubescent……..……...…….…….. 2

2a. Flowers ebracteate. Ovary apex glabrous. Calyx wings width less than 1mm…… …….…….**.....**……. **4. T. crustacea**

2b. Flowers bracteate. Ovary apex pubescent. Calyx wings width 1 mm or more than 1 mm ….……...……..…… 3

3a. Anterior filaments unappendaged at base. Middle lobe of lower lip of corolla with distinct yellow patch……..……...……..... 4

3b. Anterior filaments appendaged at base. Middle lobe of lower lip of corolla without distinct yellow patch……..……..…….. 5

4a. Corolla tube 2-4 cm. Stem erect or prostrate. Often cultivated……. ……...…..…….. **6. T. fourneiri**

4b. Corolla tube 12-18 mm. Stem mostly erect. Not cultivated…….…..…**7. T. violacea**

5a. Tube yellow just above the constriction. Calyx base truncate or subcordate, wings wavy…….……...…..…. **3. T. cordifolia**

5b. Tube white or purple just above the constriction. Calyx base cuneate, wings linear…….…….…….…… 6

6a. Stem prostrate to suberect. Lateral lobes of lower lip of corolla ciliate inside near throat, anterior filament appendages 3-4 mm…….. **2. T. asiatica**

6b. Stem erect or decumbent. Latereal lobes glabrous inside near throat. Anterior filament appandages 1-2 mm……..…….……..... **5. T. diffusa**

1. Torenia anagallis (Burm.f.) Wannan, W.R. Barker & Y.S. Liang., Aust. Syst. Bot. 31: 250 (2018) [**Basionym**: *Ruellia anagallis* Burm.f., Fl. Indica: 135 (1768)];

Rajbhandari *et al.,* in A Hand. Fl. Pl. Nep. 210 (2023) ≡ *Ilysanthes anagallis* (Burm.f.) Hochr. in Candollea 5: 208 (1934) ≡ *Lindernia anagallis* (Burm.f.) Pennell J. Arnold Arbor. 24: 252 (1943). Hara in Hara et al., Enum. Fl. Pl. Nep. 3: 116 (1982); Press *et al.,* in Ann. Check. Fl. Pl. Nep. (2000); Mill in Grierson and Long Fl. Bhu. 2 (3): 1123 (2001); Rajbhandari & Parmer in Rajbhandari *et al.,* Cat. Nep. Fl. Pl. 3: 102 (2012) ≡ *Vandellia anagallis* (Burm.f.) T.Yamaz., J. Jap. Bot. 30: 176 (1955). Fischer *et al.,* in Willdenowia 43 (2): 232 (2013); Shrestha *et al.,* in Pl. Nep. 659 (2022).
= *Vandellia pedunculata* Benth. Scroph. Ind.: 37 (1835); Gamble in Fl. Pre. Mad. II: 673 (1967).

Type specimen: Benth., East Bengal, Sylhet, Bangladesh, Wallich #3949G (**Holotype: K!) 00859701. (Photo!)**

Plants 10-50 cm (-60 cm). Stem green or reddish green, prostrate, branched, rooting from nodes, quadrangular, glabrous. Leaves subsessile to short petiolate; Petioles 2-3 mm, glabrous. Leaves ovate or oblong, 10-15×8-12 mm, base subcordate or truncate, apex acute, margin serrate, both surfaces glabrous, pinnately veined, 3-4 lateral veins on each side of midrib. Flowers axillary solitary. Pedicel 8-14 mm in flower, 2-2.5 cm in fruit, quadrangular, glabrous. Calyx deeply lobed almost to the base; lobes 5, green in flower, reddish green in fruit, lanceolate, apex acute, margin finely serrate, surfaces glabrous. Corolla tube base yellow, purple or pink white above, 6-8 mm, broadened end, constricted near base, gradually thickening towards throat, glandular outside, glabrous inside. Lower lip lobes purplish or pinkish white, yellow patch in middle lobe near throat, middle lobe larger than lateral lobes, 3-3.5×3.5-4 mm, lateral lobes 2.5-3×ca. 3 mm, apices rounded, glabrous outside. Upper lip whitish purple, 2.5-3×3.5-4 mm, apex notched, glabrous. Posterior pair stamens; filaments white, shorter, ca. 1.5-2 mm, glabrous; anthers ca. 1 mm, base spurred; spur ca.1 mm. Anterior pair stamens; filaments purplish white, longer, 3-4.5 mm, glabrous, base appendaged; appendages 0.8-1 mm, glabrous; anthers 1-1.5 mm. Ovary elliptic, 1.5-2 mm, glabrous; disc yellow, attached to the ovary at base; style 3-3.5 mm, glabrous. Capsule cylindric, 5-15 mm, longer than persistant calyx, glabrous. Seeds yellow brown (Fig. 25, Plate 7).

Fl and Fr.: All around the year.

Ecology: water logged area, paddy field, river banks.

Distribution: Nepal (W, C & E), Assam-Burma, E Himalaya, S Asia, E Asia, SE Asia, W Himalaya, Australasia, Africa.

Elevational range: 87-1500 m.

Voucher Specimen: Lumbini Province, Gulmi, Wagla, 1268 m, 23 July 2021, K. Panthi G04 (TUCH, KATH); Province no.1, Jhapa, Jalthal Range Danda, 87 m, 13 March 2021, K. Panthi and Y.B. Poudel J04 (TUCH, KATH).

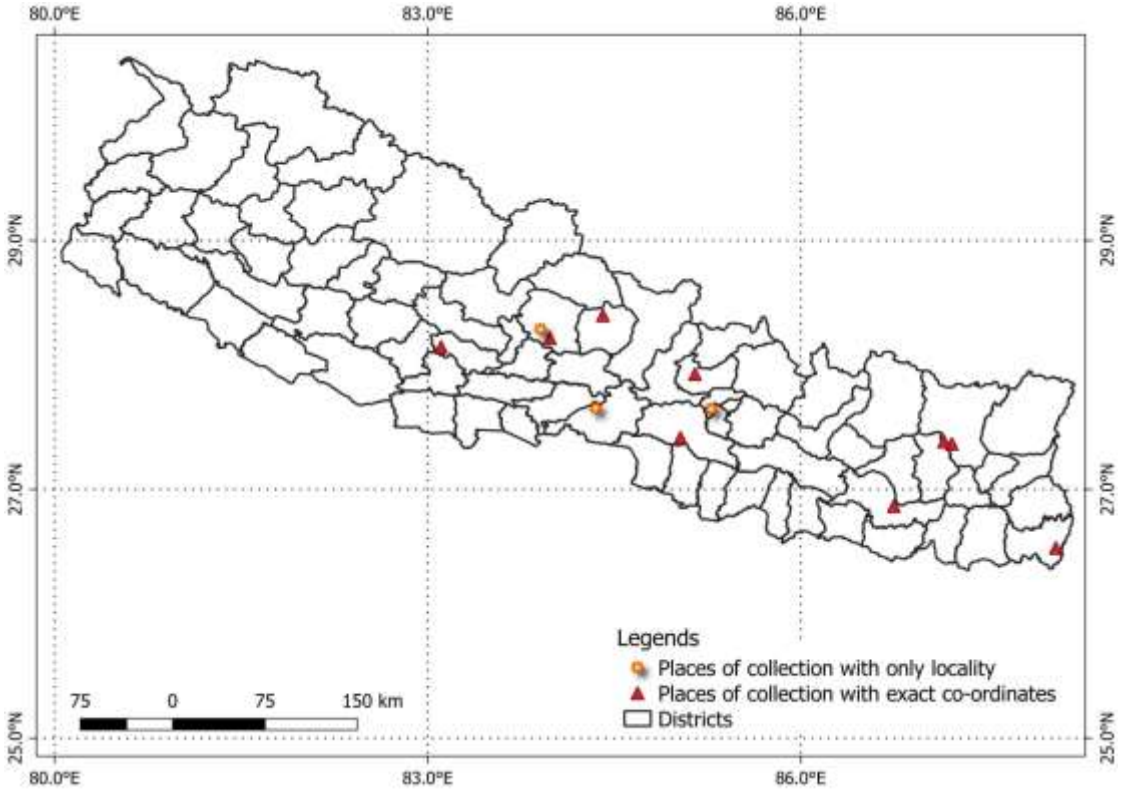


Fig. 24: Distribution of *T. anagallis* in Nepal based on herbarium specimen.

Species examined:

Eastern Nepal: Province no. 1, Dhankuta, Tamor valley, 1000 ft, 17 April 1956, J. D. A. Stainton 65 (RBGE); Province no. 1, Sankhuwasabha, Khandbari-Bhotebas. 1150-1800m, 7 July, 1988, M. Suzuki, N. Naruhashi, S. Kurosaki, Y. Kadota, M.N. Subedi, M. Minaki, S. Noshiro and H. Ikeda. 8820227 (KATH).

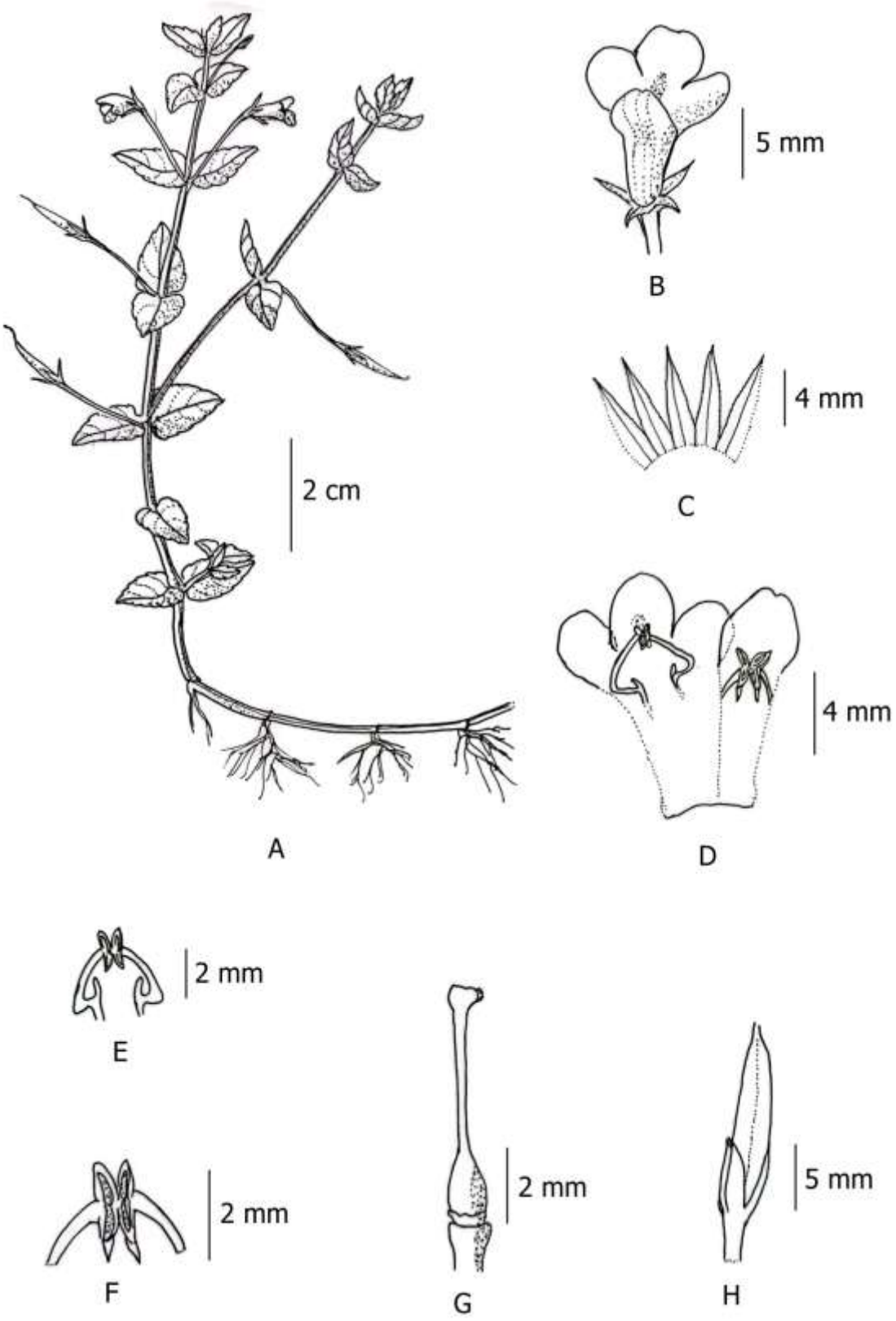


Fig. 25: Torenia anagallis: A. Habit sketch; B. Flower dorsal view; C. Opened calyx; D. Opened corolla; E. Anterior stamens; F. Posterior stamens; G. Pistil; H. Fruit.

Central Nepal: Gandaki Province, Kaski, Pokhara,-Suikhet, 950 m-1230 m, 6 July, 1983, H. Ohba, H. kanai, M. Wakabayashi, M. Suzuki and S. Akiyama 836282 (KATH); Gandaki Province, Kaski, 880 m, 29 June 1986, N.P. Manandhar 11086 (KATH); Bagmati province, Chitwanm Rampur, 320 m, 4 August 1992, I. Shrestha and N. Joshi 165 (KATH); Bagmati Province, Makwanpur, Hetauda, 500 m, 28 November 2004, C.A. Pandey, K.K. Shtrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pulum, L.R. Shakya, S. Shrestha and M. Siwakoti 162 (KATH).

2. Torenia asiatica L. Sp. Pl.: 619 (1753); Hook. in Fl. Br. In. iv: 277 (1884); Henry in A Hand. Fl. Ceyl. III: 249 (1974); Hara in Hara *et al.*, Enum. Fl. Pl. Nep. 3: 127 (1982); Brutt in Rheedea 1 (1&2): 5 (1991); Press *et al.*, in Ann. Check. Fl. Pl. Np. (2000); Fischer *et al.*, in Willdenowia 43 (2013); Shrestha *et al.*, in Pl. Nep. 658 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 210 (2023).

= *Torenia obtusifolia* Sm. in Rees, Cycl. 36: no. 5 (1817).
= *Gratiola alata* Roxb., Fl. Ind. 1: 137 (1820) ≡ *Torenia alata* (Roxb.) Benth. in de Candolle, Prodr. 10: 411 (1846).

Type specimen: Torén, #770.1 (LINN) **(Lectotype: BM!)**

Plants 5-30 cm. Roots fibrous. Stem prostrate, branched, rooting from nodes, quadrangular, sparsely pubescent. Leaves petiolate; Petiole 13-16 mm, pubescent. Lamina triangular-ovate, 1.5-3.2×1-2 cm, base cuneate, apex acute, margin pubescent- serrate or dentate, both surfaces sparsely pubescent, abaxially more hairs on veins, primary veins 4-6 pairs, alternate but lowest pair very closed to each other. Flowers axiallary solitary or in terminal solitary. Bracts linear-lanceolate, 3-20 mm, apex acuminate, margin pubescent serrate. Pedicel 1.5-2.5 cm in flower, 2.5-3 cm in fruit, pubescent. Calyx green, elliptic- ovoid, bilipped, 3×2 lobed apically; lobes elliptic-ovate, 10-20×5-8 mm in flower, 12-23×5-8 mm in fruit, base rounded or slightly cuneate, apex acute, 5-winged; wings green, wings width 1-1.5 mm, margin pubescent-serrate, sparsely pubescent all over externally. Corolla tube; base white, purple above, 2-2.4 cm, broadened end, constricted at about 1/3 way up from base then gradually broadening towards throat, covered with glandular hairs outside. Lower lip lobes purple, lateral lobes with dark purple patches, middle lobe distinctly longer than lateral lobes, 7-12×6-10 mm, lateral lobes 5-9×4-8 mm, glabrous outside, lateral lobes villous on throat inside. Upper lip white purple, 7-11×8-9 mm, apex

rounded or weakly notched, glabrous. Posterior pair stamens; filaments white purple, shorter, 3-4.5 mm, glabrous; anthers 2.5-3 mm. Anterior pair stamens; filaments pale purple, longer, 6-8 mm, exerted from tube, filaments glabrous above, pubescent around base, base appendaged; appendages purple, 3-4 mm, glabrous, anthers 1.8-2 mm. Ovary oblong, 3-5 mm, apex pubescent around, glabrous below, style 15-20 mm, glabrous, stigma bifid, lips ciliate inside. Capsule green, brown while matured, cylindric ovoid, enclosed inside the persistant calyx, 12-16 mm, apex pubescent, glabrous below. Seeds brown (Fig. 27, Plate 8).

Fl and Fr.: July- October

Ecology: Roadsides, shady and moist margins of forest.

Distribution: Nepal (C & E), E Himalaya, Tibetan Plateau, E Asia, SE Asia

Altitudinal range: 1500-2000 m

Voucher Specimen: Province no.1, Ilam, Lasune, 1347 m, 13 Sept. 2021, K. Panthi and Y.B. Poudel I002 (TUCH).

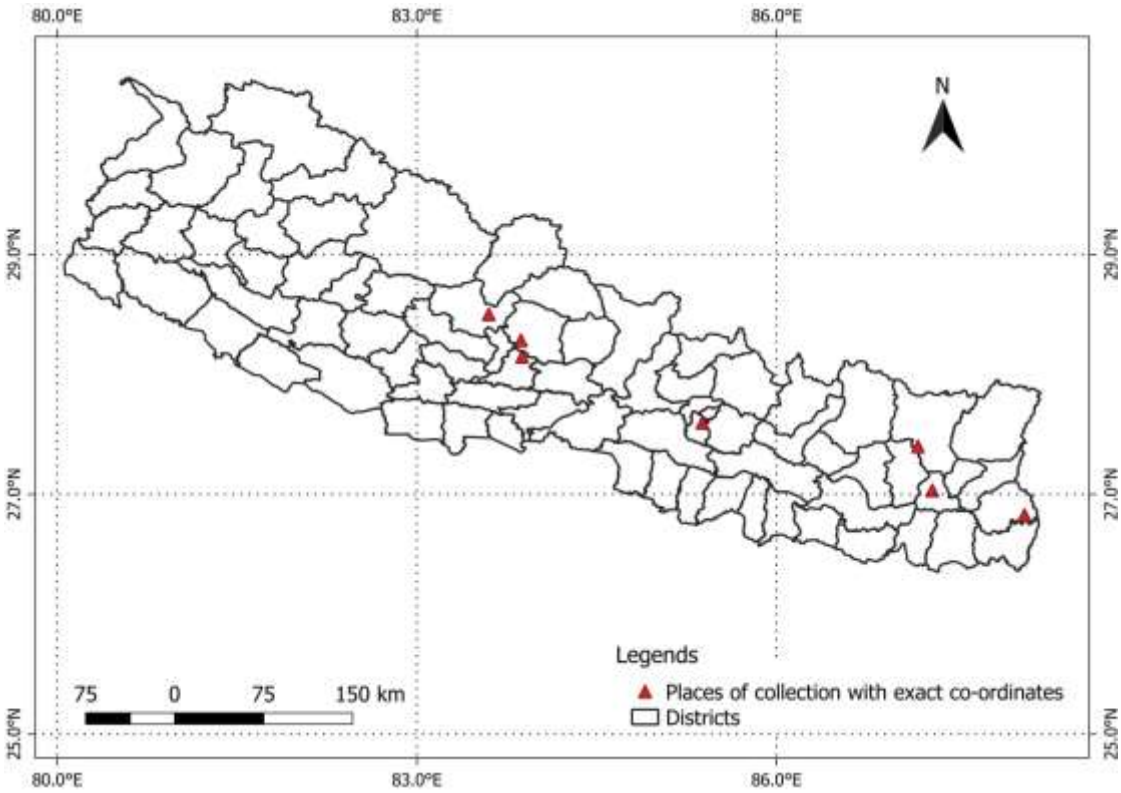


Fig. 26: Distribution of *T.asiatica* in Nepal based on herbarium specimens

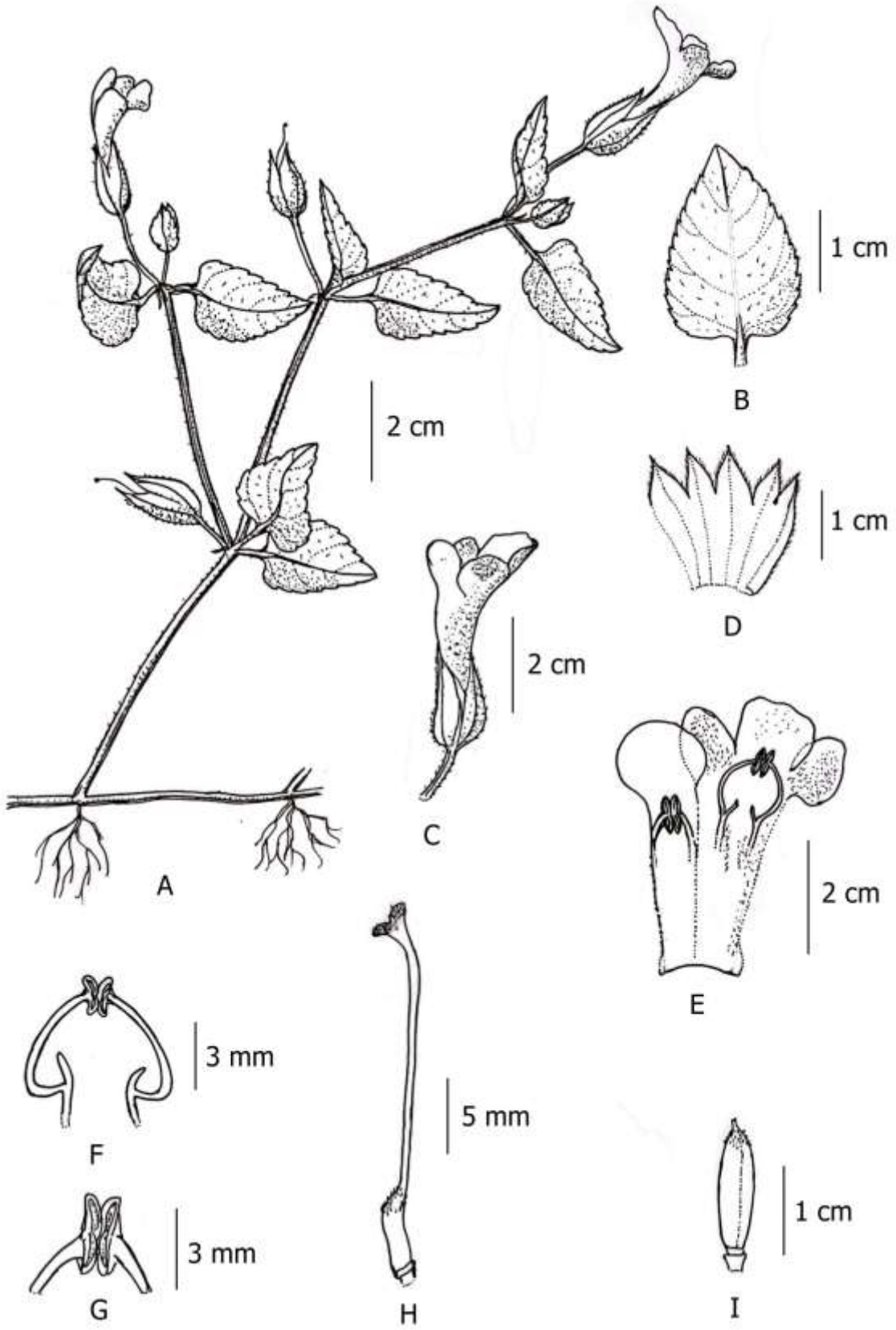


Fig. 27: Torenia asiatica: A. Habit sketch; B. Single leaf; C. Flower lateral view; D. Opened calyx; E. Opened corolla; F. Anterior stamens; G. Posterior stamens; H. Pistil; I. Fruit.

Species examined:

Eastern Nepal: Province no.1, Taplejung, Birgaun-Papung, 1600-2000 m, 30 June 1972, H. Kanai, H. Ohaboi et.al. 790959 (KATH); Province no.1, Dhankuta, Patle, 6000 ft, 30 July 1976, N.P. Manandhar 46 (KATH); Province no.1, Solukhmbu, Kharikhola-Nnthala, 2100-2250 m, 30 August 1997, M. Wakabayashi, M. Amana, M. Mari, K.R. Rajbhandari and K. Shinozaki 9720336 (KATH).

Central Nepal: Gandaki Province, Kaski, Naudanda, 4000 ft, 27 October 1971, Dr. Malla, Shrestha and Rajbhandari 13805 (KATH); Gandaki Province, Kaski, Tamage-Khahare, 1765 m- 1730 m, 7 August 1999, M. Mikage, M. Yoshimitsu, A. Konada, C. Mouri, S. Tatsukawa, Y. Asada, M. Senoo 9963007 (KATH); Bagmati province, Lalitpur, Godawari, 1500 m, 15 July 2020, T.K. Thapa and N. Pandey 01 (KATH)

Western Nepal: Sudurpaschim Province, Darchula-Dailekh, 840-1810 m, 28 August 1982, M.M. Amatya and P.M. Regmi 518/82 (KATH).

3. Torenia cordifolia Roxb.,Pl. Coromandel 2: 32 (1805); Hook in Fl. Br. In. iv: 276 (1885); Duthe in Fl. Up. Gang. Pl. ii: 23 (1960); Roxb. in Fl. Ind. 490 (1960); Hains in Fl. Bih. Ori. ii: 660 (1961); Collett in Fl. Sim. 353 (1980); Gamble in Fl. Pre. Mad. ii: 671 (1967); Hara in Hara *et al.*, Enum. Fl. Pl. Nep. 3: 127 (1982); *Press et al.*, in Ann. Check. Fl. Pl. Nep. (2000); Mill in Grierson & Long Fl. Bhu. 2 (3): 1118 (2001); Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 112 (2012); Fischer *et al.*, in Willdenowia 43: 230 (2013); Shrestha *et al.*, in Pl. Nep. 659 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 211 (2023).

Type specimen: Not seen.

Plants 5-30 cm. Roots fibrous. Stem erect, branched from base, sometimes rooting from nodes of branches, quadrangular, sparsely pubescent. Lower leaves petiolate, upper leaves shortly petiolate; petiole 4-8 mm, pubescent. Lamina triangular-ovate, 1.5-4.5×0.8-2.6 cm, base rounded, apex acute, margin pubescent-serrate, both surfaces pubescent. Flowers in terminal solitary or umbel like. Bracts leaves like or lanceolate-ovate, 4-12×3-6 mm, apex acute-acuminate, margin pubescent-serrate, both surfaces pubescent. Pedicels 7-13 mm in flower, 1.5-2.2 cm in fruit, pubescent. Calyx green, whole calyx ovoid and broadest towards base, bilipped, 3×2 lobed apically; lobes ovate, 8-12×3-4 mm in flower, 10-14×4-5 mm in fruit, base truncate

or subcordate, apex acuminate, sparsely pubescent all over externally, reticulate-veined in fruit, 5-winged; wings width 1-1.5 mm, margin ciliate-serrate and undulate. Corolla tube: base whitish yellow, purple towards throat, 14-16 mm, constricted at about 1/3 way up from base then gradually broadening towards throat, glabrous. Lower lip lobes whitish purple, lobe tips with dark blue patches, subequal, 3.5-5×4.5-5 mm, glabrous. Upper lip purple, 4-6×5.5-6 mm, apex rounded, glabrous. Posterior pair stamens; filaments purplish white, shorter, 3-4 mm, glabrous; anthers 2.5-3 mm. Anterior pair stamens; filaments purplish white, longer, 4-6 mm, glabrous above, pubescent around base, base appendaged; appendages purple, 1.5-2 mm, glabrous; anthers 1.5-1.8 mm. Ovary oblong-ovoid, 2-3 mm, apex pubescent, smooth below; disc yellow, attaché to the ovary around base; style 14-17 mm, glabrous. Capsule green; brown while matured, cylindrical ovoid, enclosed inside the persistent calyx, 7-9 mm, pubescent around apex, smooth below. Seeds brown (Fig. 29, Plate 9).

Flowering and Fruiting: July- October.

Ecology: Forest margins, mostly in moist places, roadsides and foot trails.

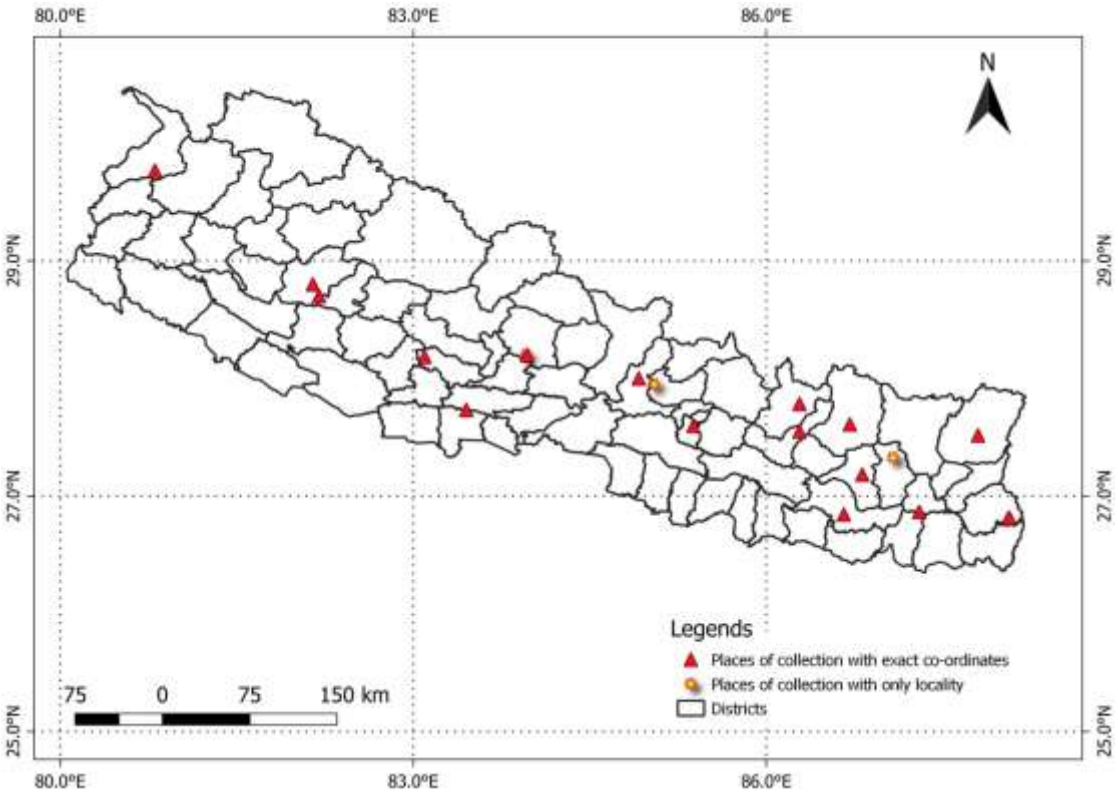


Fig. 28: Distribution of *T. cordifolia* in Nepal based on herbarium specimens

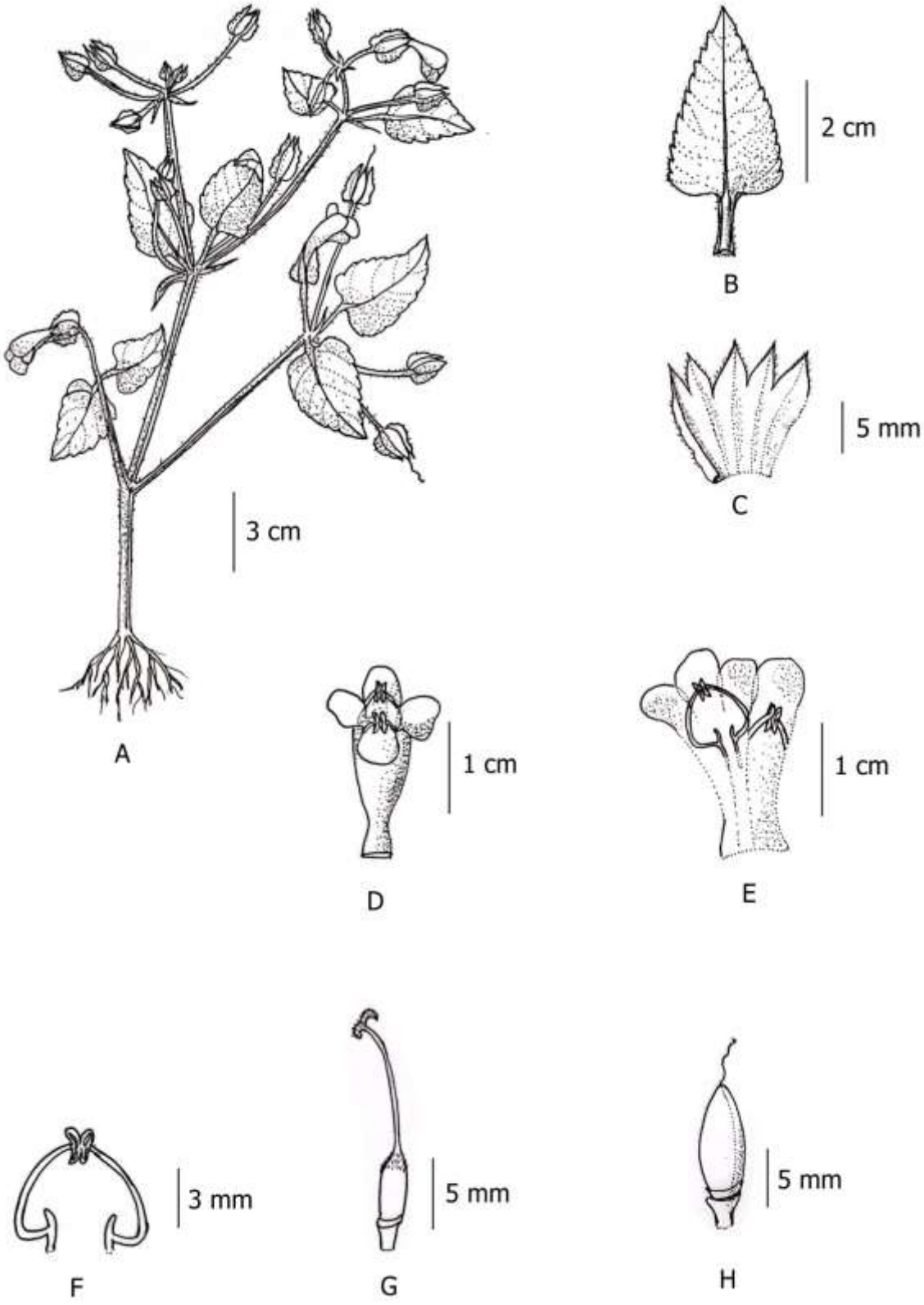


Fig. 29: Torenia cordifolia: A. habit Sketch; B. Single leaf; C. Opened corolla; D. Flower front view; E. Opened corolla; F. Anterior stamens; G. Pistil; H. Fruit.

Distribution: Nepal (W, C & E), W Himalaya, E Himalaya, S Asia, E Asia, SE Asia.

Elevational range: 800-1600m.

Voucher Specimens: Lumbini Province, Gulmi, Wagla, 1300 m, 28 July 2021, K.Panthi G10 (TUCH, KATH). Koshi Province, Ilam, Lasune, 1310 m, 13 Sept. 2021, K. Panthi and Y.B. Poudel I001 (TUCH, KATH).

Species examined:

Central Nepal: Bagmati province, Dolakha, Suri Dobhan-Khanigoun, 1000-1700 m, 15 September 1983, H. Ohba, M. Wakabayashi, M. Suzuki and S. Akiyama 8332121 (KATH); Gandaki province, Kaski, Pokhara, 800 m, 15 Sepetmber 1995, M. Mikage, N. Anjiki, N. Kondo, R. Lacoul and K. Yonekura 9552058 (KATH).

Western Nepal: Karnali Province, Jajarkot, Dar, 1180 m, 15 September 1982, N.P. Manandhar 8890 (KATH).

4. Torenia crustacea (L.) Cham. & Schltdl. Linnaea 2: 570 (1827) [**Basionym:** *Carparia crustacea* L. Mant. Pl. 1: 87 (1767)]; Fischer *et al.*, in Willdwnowia 43 (2013); Shrestha *et al.*, in Pl. Nep. 659 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 211 (2023) ≡ *Lindernia crustacea* (L.) F. Muell. Syst. Census Austral. Pl.: 97 (1882). Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 116 (1982). Press *et al.*, in Ann. Check. Fl. Pl. Nep. (2000); Mill in Grierson and Long Fl. Bhu. 2 (3): 1124 (2001); Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 102 (2012).
≡ *Pyxidaria crustacea* (L.) Kuntze in Revis. Gen. Pl. 2: 464 (1891) ≡ *Vandellia crustacea* (L.) Benth., Scroph. Ind.: 35 (1835); Hook. in Fl. Br. In. 279 (1885); Dutthe in Fl. Up. Gang. Pl. ii: 23 (1960); Hains in Fl. Bih. Ori. ii: 661-662 (1961); Collett in Fl. Sim. 354 (1980).

Type specimen: India, W. Hamilton, Wallich #3961 (**Holotype-K!)** 000820838 **(Photo!), (isotype- KW!**).

Plants 5-20 cm. Stem decumbent, rooting from last few nodes, much branched. Branches spreading, sub-quadrangular, subglabrous, hairs simple. Petiole 1-7 mm, sparsely pubescent. Leaves: lamina triangular-ovate, 12-20×5-16 mm, base cuneate, apex acute, margin shallowly serrate, subglabrous along veins and margins. Flowers axillary or in apical racemes. Ebractate. Pedicels 6-15 mm in flower, 8-20 mm in fruit,

sparsely pubescent. Calyx green, whole calyx bilipped, tubular, shallowly 2×3-lobed; lobes purple along margin and midvein above the half, triangular-ovate, 4-6×1.5-2 mm in flower, 5-7×1.5-2 mm in fruit, base cuneate, apex acuminate, sparsely pubescent all over; narrowly winged, wings width 1 mm or less than 1 mm, margin sparsely pubescent. Corolla tube: base yellow, purple above, 5- 8 mm, slightly longer than calyx, glabrous outside, throat ciliate inside near junction, hairs yellow. Lower lip lobes white-purple, distinct white patches middle of each lobe, subrobicular, subequal, 2-2.5×2-2.2 mm each, middle lobe apex acute-round, lateral lobes apices round, glabrous. Upper lip whitish-purple, ovate-round, 3-3.3×ca.3.5 (-4) mm, apex notched, glabrous. Posterior pair stamens; filaments whitish purple, shorter, 2.5-3 mm, fertile, filament glabrous; anthers 1.1-1.3 mm. Anterior pair; filaments whitish purple, longer, 4-5 mm, fertile, glabrous above, base densely pubescent, hairs yellow, filaments appendaged near base; appendages purple, 1.5-1.8 mm, glabrous; anthers 0.8-1 mm. Ovary oblong-ovoid, 1.5-2 mm, glabrous; style 4.5 -5 mm, glabrous. Capsule pale green to brown while matured, ovoid, 4-5×2-2.3 mm, equal or slightly longer than persistant calyx, glabrous. Seeds brown, sub-globoose (Fig. 30, Plate 10).

Fl and Fr.: June- December.

Ecology: Moist areas, forest margins, roadsides, rice fields, grassland, river banks.

Distribution: Nepal (W, C & E), W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia, SE Asia, S America, Africa, N America

Elevational range: 85-2000 m

Voucher Specimen: Lumbini Province, Gulmi, Wagla, 1207 m, 13 July 2021, K. Panthi G009 (TUCH, KATH); Koshi Province, Jhapa, Badabari, 113 m, 14 Sept. 2021, K. Panthi and Y. B. Poudel J16 (TUCH, KATH).

Species Examined:

Eastern Nepal: Province no. 1, Dhankuta, Bireni Bagar- Diyale, 320 m- 760 m, 1 September 1998, S. Noshiro, K. Kobayashi, Y. Omari, K. Shinozaki and H. Tsukaya 9830231 (KATH).

Central Nepal: Gandaki Province, Lamjung, Jagat- Bahundanda, 1300 m, 9 August 1983, H. Ohba, H. kanai, M. Wakabayashi, M. Suzuki and S. Akiyama 843283

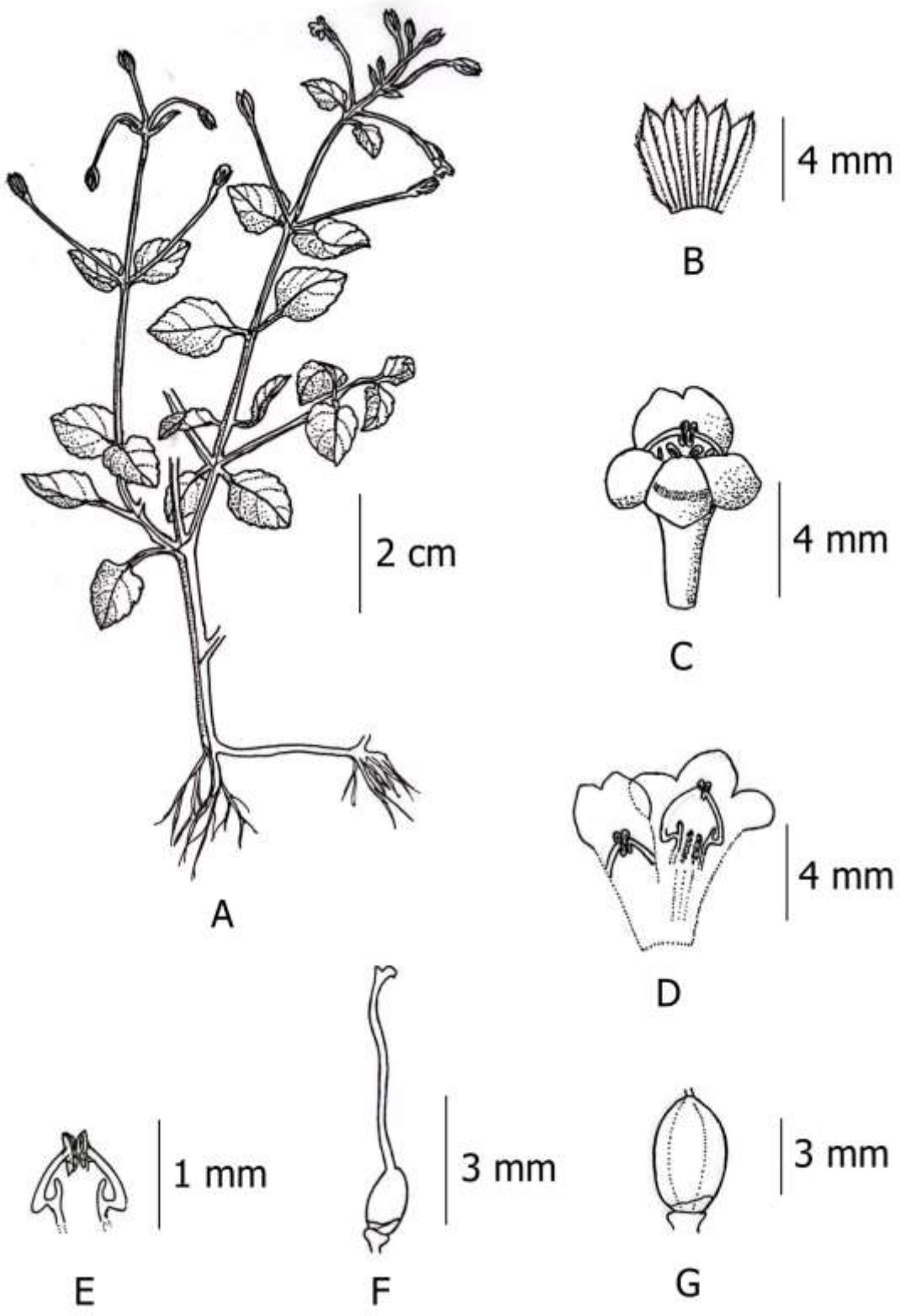


Fig. 30: Torenia crustacea: A. Habit sketch; B. Opened calyx; C. Corolla front view; D. Opened corolla; E. Anterior stamens; F. Pistil; G. Fruit.

(KATH); Bagmati Province, Chitwan, Rampur, 320 m, 3 August 1992, I. Shrestha and N. Joshi 139 (KATH); Gandki province, Baglung and Myagdi, Ratnechour- Beni, 820-840 m, 1 september 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahasi and K. Yonekura 9685010 (KATH); Lumbini Province, Kapilvastu, Banganga, 142 m, 23 August 2021 K. Panthi and Y.B. Poudel B002 (TUCH).

Western Nepal: Lumbini Province, Banke, Nepalgunj, 150 m, 10 October 1977, R. Rana 1885 (KATH); Sudurpaschim Province, Bajhang, Talkot-Agan, 2000 m, 18 August 1991, K.R. Rajbhandari 15326 (KATH); Sudurpaschim Province, Darchula , 840 m, 26 August 1982, M.N. Amatya and P.M. Regmi 982 (KATH).

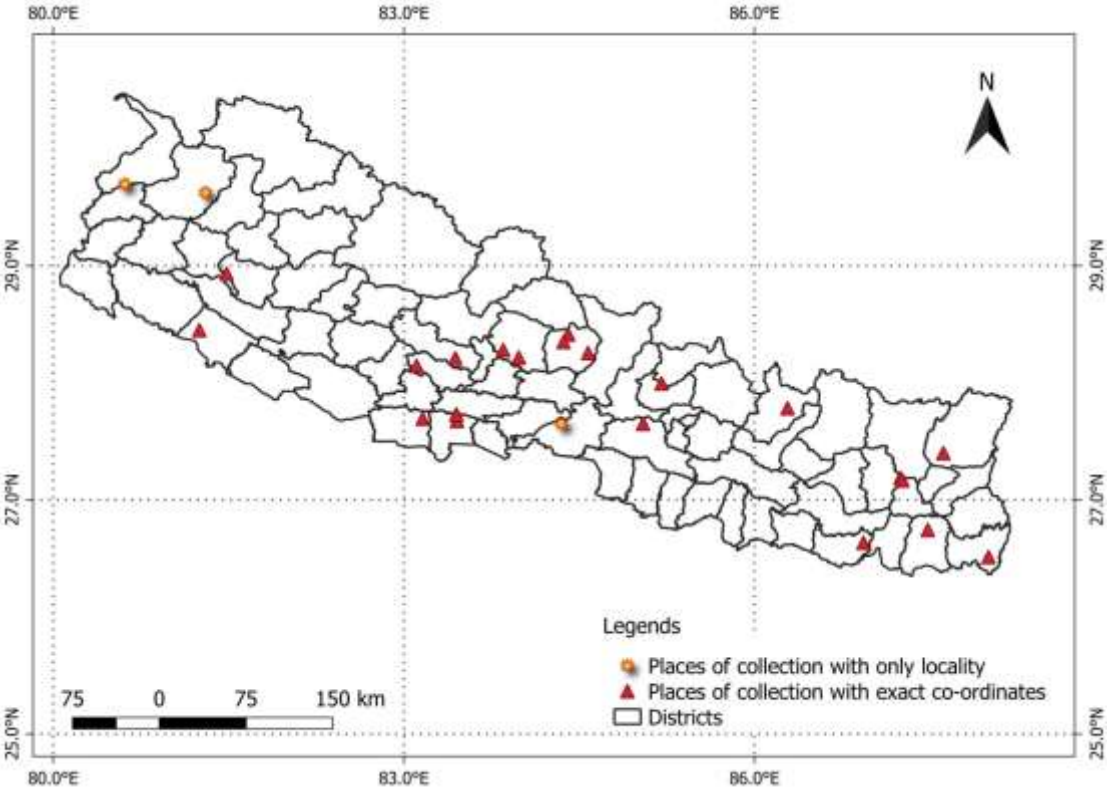


Fig. 31: Distribution of *T. crustacea* in Nepal based on herbarium specimen

5. Torenia diffusa D. Don**.,** Prodr. Fl. Nepal.: 86 (1825); Roxburgh in Fl. In. 490 (1971). Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 127 (1982). Press *et al.,* in Ann. Check. Fl. Pl. Nep. (2000); Fischer *et al.*, in Willdwnowia 44 (2013); Rajbhandari & Parmer in Rajbhandari *et al.,* Cat. Nep. Fl. Pl. Suppl. 1:35 (2015); Shrestha et al., in Pl. Nep. 659 (2022); Rajbhandari *et al.,* in A Hand. Fl. Pl. Nep. 211 (2023).

= *Torenia hians* Roxb., Fl. Ind. ed. 1832, 3: 96 (1832).

= *Torenia hirtella* Hook. f., Fl. Br. India 4: 277 (1885).

= *Torenia vegans* in Hook. in Fl. Ind. Ed. 1832, 3: 96 (1832).

Type specimen: Nilagiri, India, Ed. RF. Hohenacker #1156 **(Syntype: JE!)** 00019801 **(Photo!).**

Plants 8-30 cm. Roots fibrous. Stem erect-prostrate, diffusely branched from base, rooting from last few nodes of branches, quadrangular, pubescent. Petioles 3-10 mm, pubescent. Leaves; lamina triangular-ovate, 1.8-3.2×1-2.5 cm, base cuneate, apex acute, margin serrate, both surfaces pubescent, much hairs on veins below. Flowers axillary or terminal solitary, 1-2 flowers in each axil. Bracts linear-lanceolate, 1-3×ca.0.5 mm, apex acuminate, margin pubescent-serrate, both surfaces pubescent. Pedicels 6-15 mm in flower, 1.4-2.5 cm in fruit, pubescent specially on angles. Calyx green, margin and midrib red-purple in fruit, whole calyx ovoid, 3×2 lobed; lobes lanceolate-ovate, 15-18×4-6 mm, base rounded or slightly cuneate, apex acute, 5 winged; wings width 1-1.2 mm, margin pubescent-serrate, sparsely pubescent all over externally. Corolla tube; base white, purple towards throat, 14-16 mm, broadened end, constricted at about 1/3 way up from base then gradually broadening towards throat, glabrous. Lower lip lobes purple, creamy white patch at the centre of middle lobe, subequal, 4-6×4-6 mm each, apices rounded, glabrous. Upper lip whitish purple, 5-7×4-7 mm, apex weakly 2-lobed or rounded, glabrous. Posterior pair stamens: filaments purple, shorter, 1.5-2 mm, glabrous, anthers 1.8-2 mm. Anterior pair: filaments purple, longer, 4-7 mm, glabrous, base appendaged, appendages purple, 1-2 mm, glabrous, anthers 1-1.2 mm. Ovary oblong, 3-4 mm, apex pubescent around, glabrous below; disc yellow, attached to ovary around base; style 8-10 mm, glabrous. Capsule green; brown while matured, ellipsoid, enclosed inside the persistant calyx, 10-15 mm, pubescent around apex, glabrous below. Seeds brown (Fig. 33).

Fl. and Fr.: July-October.

Ecology: Forest margins, moist places, shady areas of roadsides and foot trails.

Distribution: Nepal (W, C & E), E Himalaya, E Asia

Elevational range: 1000-2200 m

Voucher Specimen: Gandaki Provonce, Kaski Naudanda, 1450 m, 24 Oct. 2021, K. Panthi K001 (TUCH, KATH).

Species examined:

Eastern Nepal: Province no. 1, Ilam, Chulachuli region, 1000 m, 18 September-19 October 1972, T.B. Shrestha and T.K. Bhattacharya 72-189 (KATH); Province no.1, Panchthar, Chyangtharpu-Dabale, 1590-2000 m, 233 June 1992, S. Noshiro, S. Akiyama and N Acharya 160577 (KATH); Province no.1, Ilam, Mai Majuwa, 2100 m, 27 August 2007, R.M. Kunwar, J. Pandey, N.B. khatri and M.K. Dhamala 013 (KATH).

Central Nepal: Bagmati Province, Kathmandu, Sundarijal, 4800 ft, 19 May 1976, M.M. Amatya, I. Sharma and R. Shrestha 152/76 (KATH).

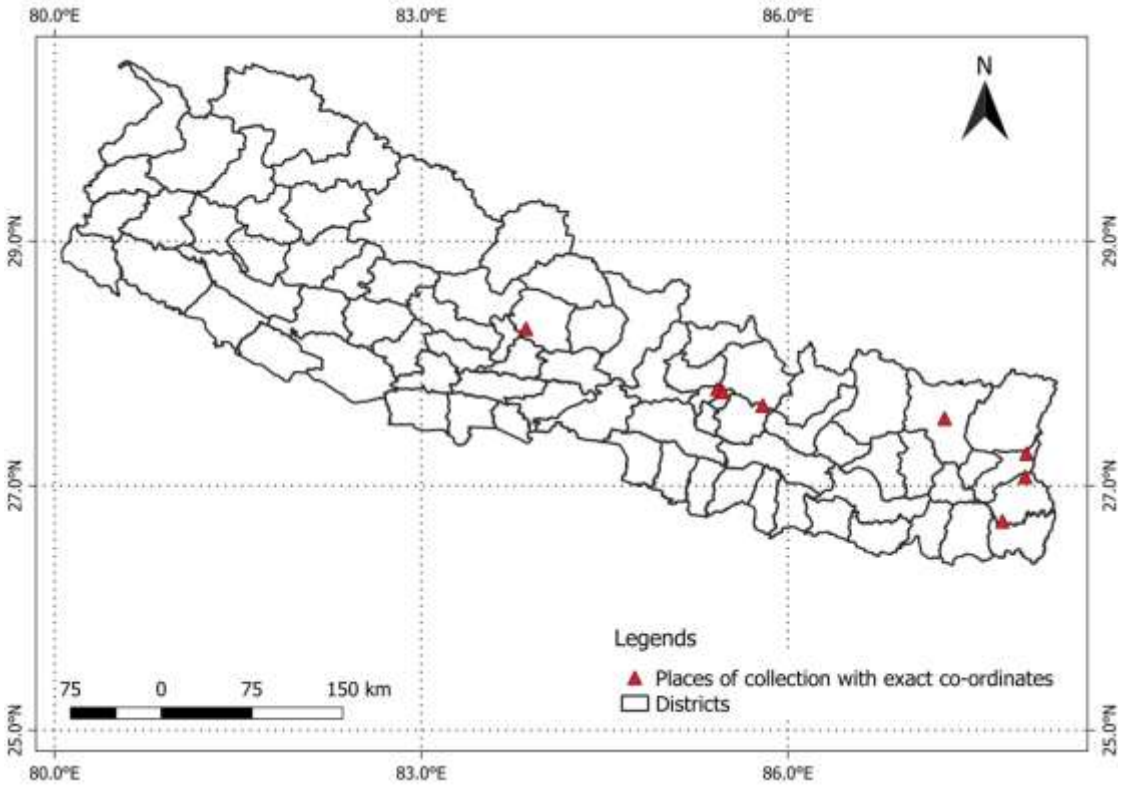


Fig. 32: Distribution of *T. diffusa* in Nepal based on herbarium specimens

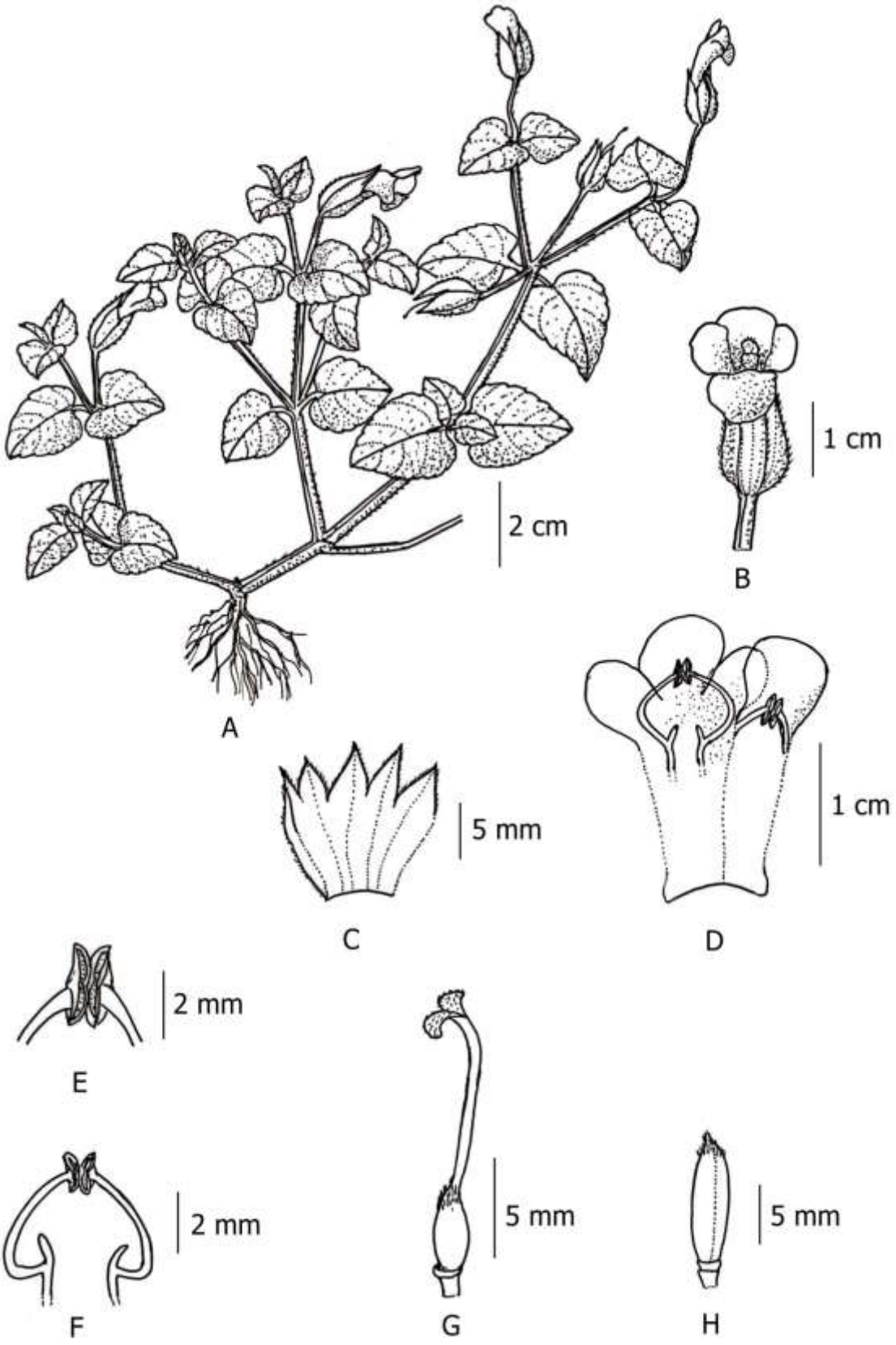


Fig. 33: Torenia disffusa: A. Habit sketch; B. Flower front view; C. Opened calyx; D. Opened corolla; E. Posterior stamens; F. Anterior stamens; G. Pistil; H. Fruit.

6. Torenia fournieri Linden ex E.Fourn., Ill. Hort. 23: 129, t. 249 (1876);

Plants 10- 40 cm. Stem erect. Roots fibrous. Stem erect or prostate, rooting form last few nodes, quadrangular, branched from base, decumbant somewhat, sparsely pubescent, more hairs on angles, swollen nodes. Petiole 1-3 cm, pubescent. Leaves; lamina triangular-ovate, 2-5×1.5-3 cm, base rounded or slightly cuneate, apex acute, margin serrate, pubescent both sides, pinnately veined. Flowers axillary solitary and in terminal raceme. Bracts lanceolate or leaf like in axillary flower, leafy bracts 2-2.5×1-1.2 cm, small bracts 5-8×ca.1mm , pubescent both sides. Pedicels 2-2.5 cm in flower, 2.5-3.5 cm in fruit, sparsely pubescent. Calyx green, midrib red-purple, tubular, bilipped, apically 2×3 lobed; lobes elliptic ovate, 12-18×3-5 mm, base slightly cuneate, apex acute, 5- winged; wings width 1-1.3 mm, margin pubescent-serrate and undulate. Corolla tube; base white, yellow upto half, upper half white purple or white pink, 2-2.5 cm, broadened end, constricted at about 1/3 way up from base then gradually broadening towards throat, glandular outside upto throat, glandular inside around and below throat, Lower lip distinctly 3 lobed; lobes white pink, or white purple, dark bluish/mauve or pink patch on half of the lobes towards tip, distinct yellow patch at the mid of middle lobe, middle lobe slightly larger than lateral lobes 8-12×10-14 mm, lateral lobes 7-10×8-10 mm, apices rounded, margin and base inside ciliate with simple hairs,. Upper lip purple/pink, 12-15×18-20 mm, glabrous, apex obtuse or obtuse notched. Stamens 4, didynamous, posterior pair purple or pink, shorter, filaments 3-4 mm, included, glabrous, anthers 3.8-4.1 mm, anterior pair purple/pink white, longer, filaments 12-14 mm, exerted from tube, glabrous, base unappendaged, anthers 2-3 mm. Ovary oblong, 4-5 mm, apex pubescent around, glabrous below; disc yellow, attached to ovary at base; style 18-20 mm, glabrous, stigma bifid, lips ciliate inside. Capsule green; brown while matured, ellipsoid, enclosed inside the persistant calyx, 12-15 mm, pubescent around apex, glabrous below. Seeds yellow brown.

**Note: This species is found to be cultivated in different parts of Nepal. Hence only the detailed description is mentioned here.*

6. Torenia violacea (Azaola ex Blanco) Pennell., J. Arnold Arbor. 24: 255 (1943); [**Basionym**: *Mimulus violaceus* Azaola ex Blanco Fl. Philip. Ed. 2: 357 (1845)]; Hara in Hara *et al.,* Enum. Fl. Pl. Nep. 3: 127 (1982); Press *et al.*, in Ann. Check. Fl. Pl. Nep. (2000); Mill in Grierson and Long Fl. Bhu. 2 (3): 1120 (2001); Rajbhandari &

Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 113 (2012); Fischer *et al., in* Willdenowia 43: 231 (2013); Shrestha et al., in Pl. Nep. 659 (2022); Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 4: 212 (2023) ≡ *Torenia violacea* var. *chinensis* T.Yamaz. in J. Jap. Bot. 30: 362 (1955).
=*Torenia peduncularis* Benth. ex Hook. in Fl. Br. Ind. iv: 276 (1885); Ridley in The Fl. Mal. Pen. II: 482 (1967).

Type Specimen: India, N. Wallich, 3956. **(Isotype: BM!),** India, R. Strachey & J.E. Winterbottom, #s.n. **(Isotype: BM!)** 00997877 **(Photo!).**

Plants 5-25 cm. Stem erect or sometimes decumbent, branched, rooting from last nodes, stem quadrangular, sparsley pubescent. Petiole 5-8 mm, pubescent. Leaves ovate, 1.8-3.5×1-2.1 cm base slightly cuneate, apex acute, margin serrate-dentate, pubescent both surfaces, adaxially more hairs on veins, pinnately veined. Flowers axillary or in terminal raceme. Bracts lanceolate, 3-4 mm, apex acuminate, margin pubescent-serrate. Pedicel 1.5-3 cm in flower, upto 3.5 cm in fruit. Calyx green, elliptic-ovoid, apically 3×2 lobed; lobes elliptic-ovate, midrib purplish green, 12-16×3-3.5 mm in flower, 14-18×3-4 mm in fruit, base cuneate, apex acute, 5-winged; wings width 1-1.2 mm , margin pubescent-serrate. Corolla tube; base white, yellow upto half, upper half purplish white, broadened end, 12-18 mm, constricted at about 1/3 way up from base then gradually broadening towards throat, covered with glandular hairs outside. Lower lip distinctly 3-lobed; lobes purplish white, dark bluish/mauve patch on half of the lobes towards tip, distinct yellow patch at the mid of middle lobe larger than lateral lobes, 4-4.5×5-6 mm, lateral lobes 3.5-4×3.5-4 mm, apices round, glabrous outside, villous on throat inside. Upper lip purplish white, 5-6×8-9 mm, apex round or weakly notched. Posterior pair stamens; filaments white purple, shorter, 3-3.5 mm, fertile, glabrous, anthers 2.5-3 mm. Anterior pair; filaments purplish white, longer, 6-7.5 mm, glabrous, base unappendaged; anthers 1.8-2 mm. Ovary oblong, 3-5 mm, apex pubescent around; disc yellow, attached to ovary around base; style 10-12 mm, glabrous. Capsule green, brown while matured, cylindric ovoid, enclosed inside the persistent calyx, 8-10 mm, apex pubescent, glabrous below. Seeds brown (Fig. 35).

Fl. and Fr.: July-October.

Ecology: River banks, Roadsides, Forest edges, Stream sides.

Distribution: Nepal (WCE), Assam-Burma, E Himalaya, W Himalaya, S Asia, E Asia, SE Asia**.**

Elevational range: 150-1800 m.

Voucher Specimen: Province no.1, Ilam , Lasune, 1340 m, 13 Sept. 2021, K. Panthi and Y. B. Poudel I003 (TUCH).

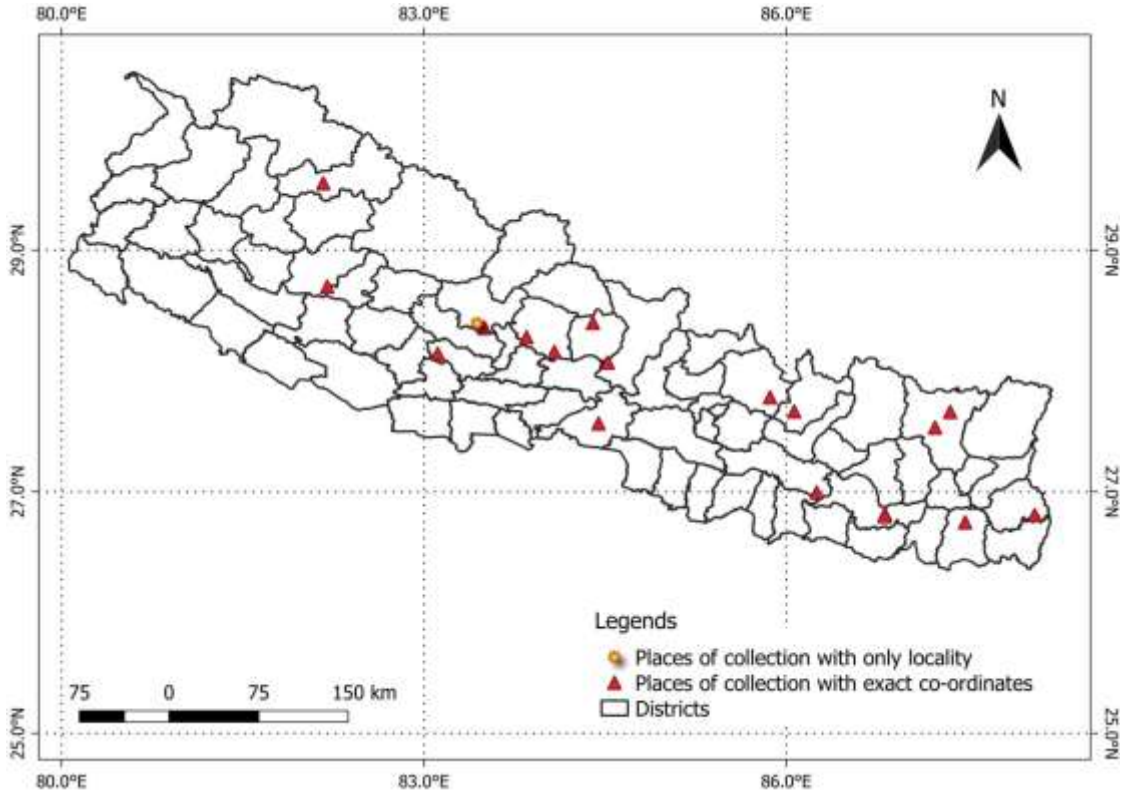


Fig. 34: Distribution of *T. violacea* in Nepal based on herbarium specimens

Species Examined:

Eastern Nepal: Province no.1, Jhapa, Sanaicharem 200 m, 30 March 1967, D.H. Nicolson, 3060 (KATH); Province no.1, Udayapur , Beltar, 180 m-600 m, 24 October 1995, M. Mikage, T. kajita, F. Kiuchi, N. Kondo, P. Lacoul, M. Suzuki and K. Yonekura 9554114 (KATH); Province no.1, Sankhwasabha, Gola- Pathibhara Danda-Ganchi Danda, 1120 m-1520m-1180 m, 27 August 1998, S. Noshiro, N. Acharya, K. Koyabashi, Y. Omori, K. Shinozaki and H. Sukaya 9830170 (KATH).

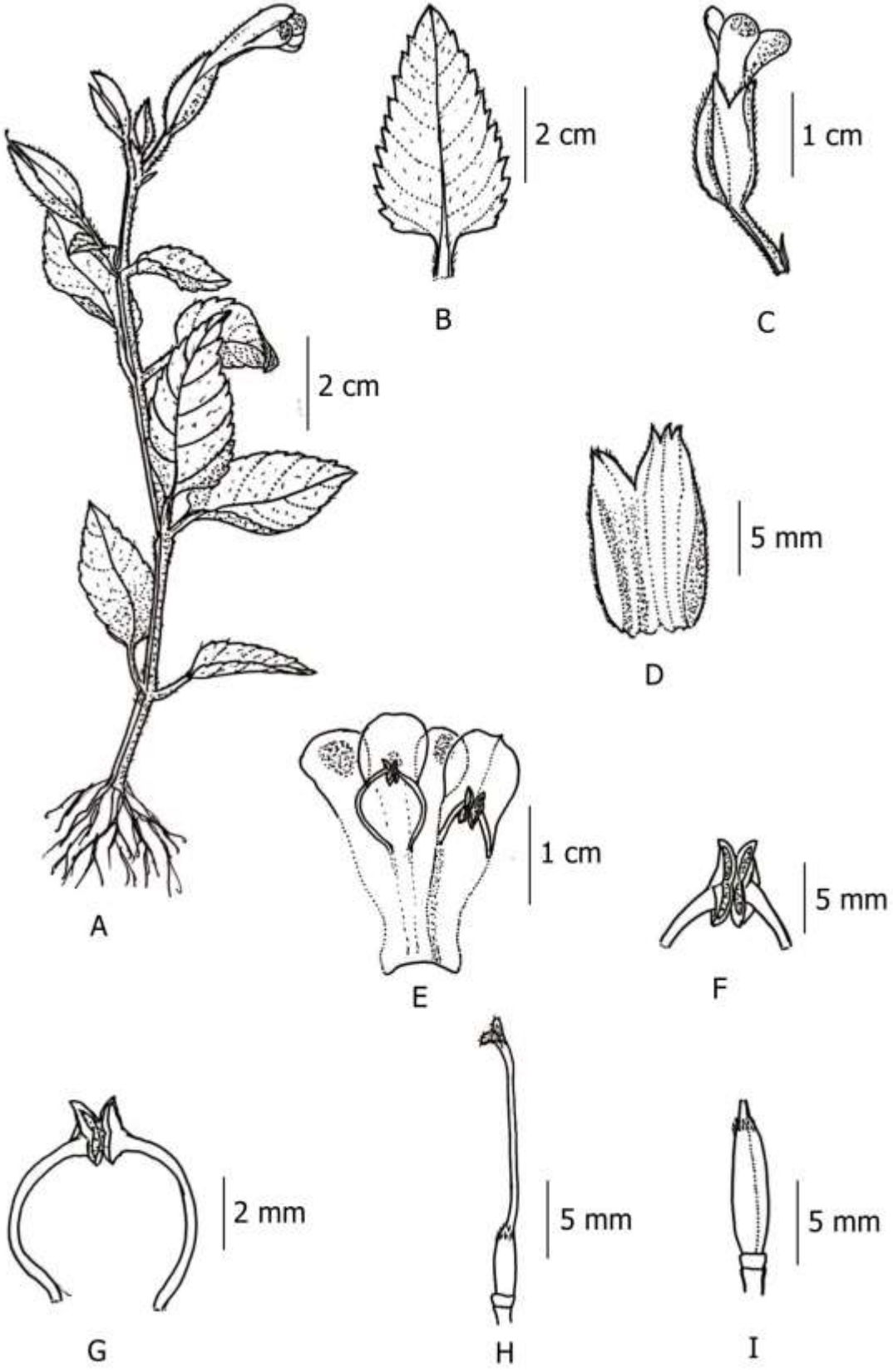


Fig. 35: Torenia violacea: A. Habit sketch; B. Single leaf; C. Flower lateral view; D. Opened calyx; E. Opened corolla; F. Posterior stamens. G. Anterior stamens; H. Pistil. I. Fruit.

Central Nepal: Bagmati Province, Kathmandu, Swayambhu, 1300 m, 12 September 1970, N.P. Manandhar, 4705 (KATH); Gandaki Province, Kaski, Bagar, 855 m, 20 November 1977, N. P. Manandhar 595 (KATH)

Vandellia L.

Type species: *Vandellia diffusa* L. Mant. Pl.: 89 (1767).

Annual herbs. Stem erect or decumbant, branched above or diffusely branched quadrangular, glabrous or pubescent. Leaves sessile or shortly petiolate, oblong, ensiform or ovate, glabrous or glabrescent. Flowers axillary solitary or in terminal receme. Bracteate or ebracteate. Pedicellate; pedicel glabrous or glandular. Calyx deeply 5-lobed; lobes lanceolate, glabrous or glandular. Corolla creamy white or whitish pink, tube glabrous or glandular. Stamens 4, didynamous, all fertile, posterior pair shorter, anterior pair longer, base appendaged or swollen and bent. Ovary oblong-ovoid, glabrous, style 1, glabrous, stigma bifid, lips ciliate inside. Capsule green or brown when matured, equal or longer than persistant calyx, cylindric or ovoid, glabrous. Seeds brown.

Key to species:

1a. Leaves oblong or ensiform. Pedicel glabrous. Corolla whitish pink. Base of anterior stamens appendaged……..……**1. V. micrantha**

1b. Leaves ovate. Pedicel glandular. Corolla creamy white. Base of anterior stamen swollen…….……..…..…... **2. V. multiflora**

1. Vandellia micrantha (D.Don) Eb.Fisch., Schäferh. & Kai Müll., Willdenowia 43: 234 (2013) [**Basionym**: *Lindernia micrantha* D. Don, Prodr. Fl. Nepal.: 85 (1825); Hara in Hara et al., Enum. F1. Pl. Nepal 3: 116 (1982); Press *et al.*,in Ann. Check. Fl. Pl. Nep. (2000); Rajbhandari & Parmer in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 3: 102 (2012)]; Shrestha et al., in Pl. Nep. 659 (2022); Rajbhandari in A Hand. Fl. Pl. Nep. 4: 213 (2023).

= *Vandellia angustifolia* Benth., Scroph. Ind.: 37 (1835).

Type specimen: N. Wallich. Nepal, 3951B **(Isosyntype: E!)** 00273712 **(Photo!)**

Plants 5-25 cm. Stem erect, branched, glabrous. Leaves sessile; lamina oblong or ensiform, 11-28× 2-5 mm, base cuneate, apex acute, margin obscurely serrate, both surfaces glabrous, pinnately veined; lateral veins not distinct. Flowers solitary axillary. Ebracteate. Pedicel 9-15 mm in flower, 11-20 mm in fruit, glabrous. Calyx lobes lanceolate, 3-4 mm in flower, 4.5-5 mm in fruit, base broadly attenuate, apex acute or acuminate, margin ciliate-serrate. Corolla tube; base yellow, whitish pink above, 5-7 mm, base broadened, constricted near base and gradually thickening towards throat, glandular outside, ciliate inside with yellow and white simple hairs. Lower lip slightly longer than upper lip; lobes whitish pink, middle lobe with distinct yellow spot inside near throat, subequal, 3-4×2.5-3 mm each, apices rounded, glabrous. Upper lip white or whitish pink, 3-3.5×4-5 mm, apex notched, glabrous. Posterior pair stamens; filaments white, shorter, 2-2.5 mm, glabrous, anthers 1.5-2 mm. Anterior pair; filaments white, longer, filaments 4-5 mm, glabrous, base appendaged; appendages white, ca. 1.5 mm, glabrous; anthers 1-1.5 mm. Ovary oblong- ovoid, 2-2.5 mm, glabrous; disc pale green, attached to ovary around base; style 6-8 mm, glabrous, persistant. Capsule green or pale brown while matured, cylindric, 9-15 mm, longer than persistant calyx, glabrous. Seeds brown (Fig. 36, Plate 11).

Fl and Fr: July- October.

Ecology: Riversides, paddy field.

Distribution: Nepal (C & E), Assam-Burma, S Asia, E Asia, SE Asia.

Elevational range: 1000-1800 m.

Voucher specimen: Lumbini Province, Gulmi, Wagla, 1205 m, 23 July 2021, K. Panthi G012 (TUCH, KATH); Bagmati province, Rasuwa, Laharepauwa Kalikasthan, 1538 m, 26 Sept. 2021, K. Panthi R002 (TUCH, KATH).

Species examined:

Eastern Nepal: Province no. 1, Sankhuwasabha, Shidua, 1300 m, 22 September, 1991, D.G. long, R.J.D. McBeath, D.R. Mckean, D.A.H. Rae, N.R. Bhattarai 174 (KATH).

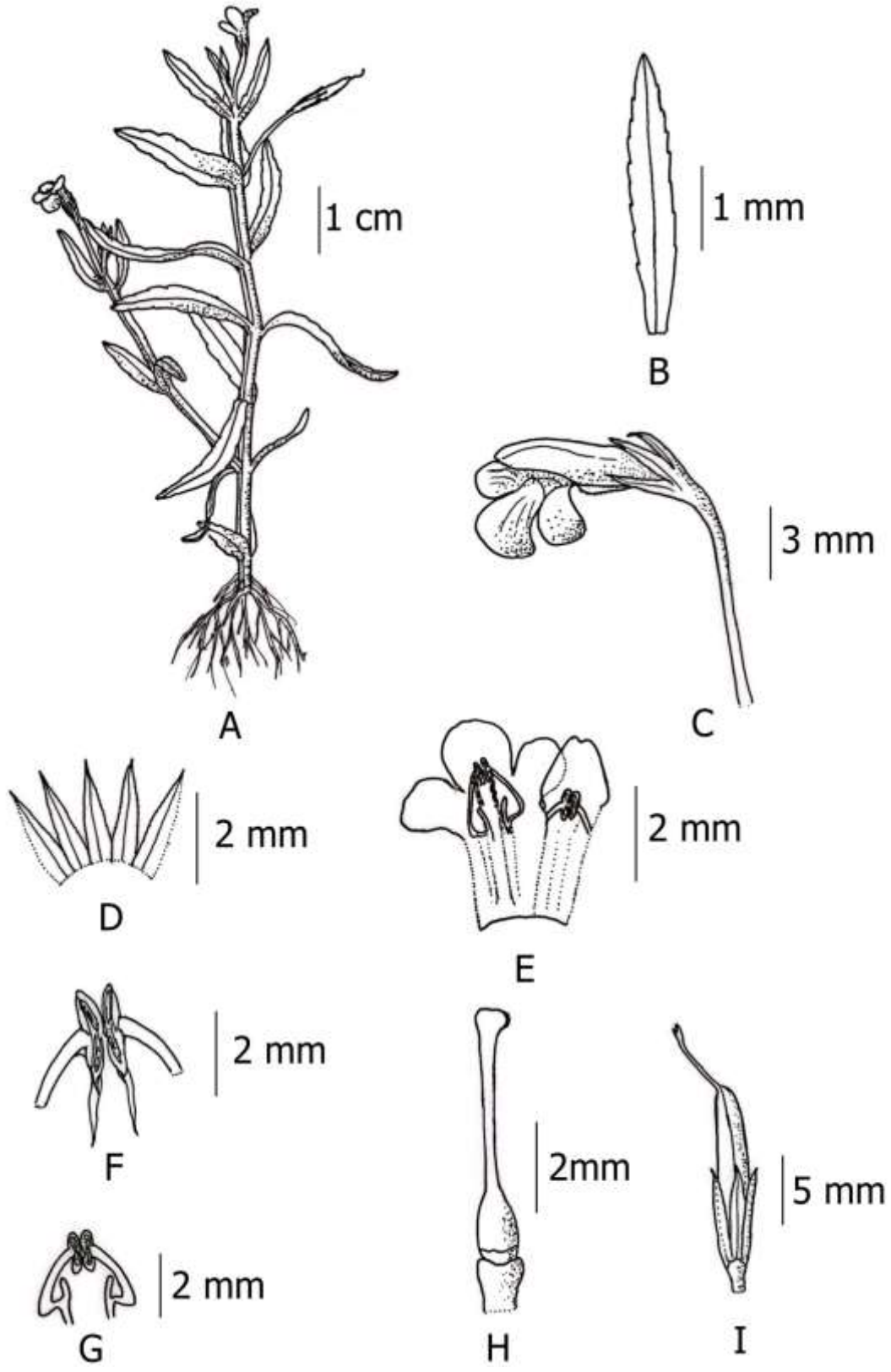


Fig. 36: Vandellia micrantha: A. Habit sketch; B. Single leaf; C. Flower lateral view; D. Opened calyx; E. Opened corolla; F. Posterior stamens; G. Anterior stamens; H. Pistil; I. Fruit with persistent calyx.

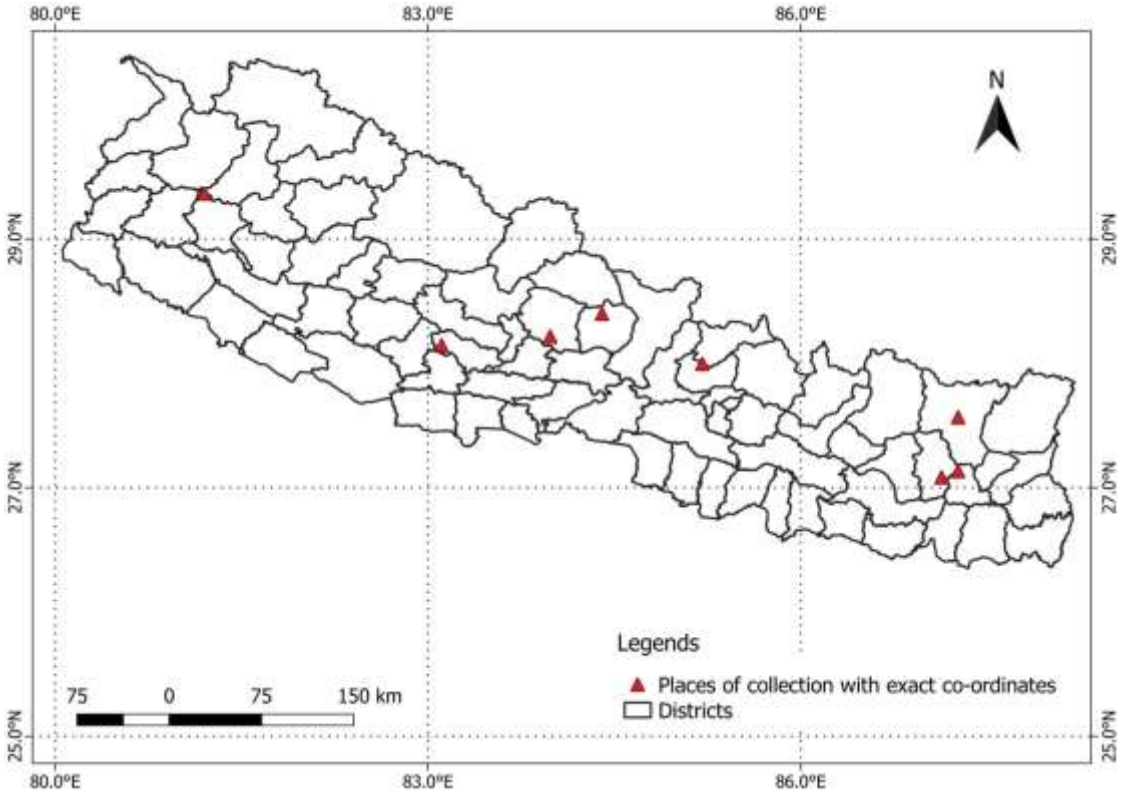


Fig. 37: Distribution of *V. micrantha* in Nepal based on herbarium specimen

2. Vandellia multiflora (Roxb.) G. Don., Gen. Hist. 4:549 (1837 – 1838) [**Basionym**: *Torenia multiflora* Roxb., Fl. Ind. ed. 1832. 3: 96 (1832)]; Hook in Fl. Br. In. iv: 280 (1885); Dutthe in Fl. Up. Gang. Pl. ii: 24 (1960); Roxburgh in Fl. In 490 (1971); Hains in Fl. Bih. Ori. ii: 662 (1961); Fischer *et al.,* in Willdenowia 234 (2013); Shrestha *et al.,* in Pl. Nep. 660 (2022) ≡ *Lindernia multiflora* (Roxb.) Mukerjee J. Ind. Bot. Soc. 24: 131 (1945). Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 116 (1982). Press *et al.,* in Ann. Check. Fl. Pl. Nep. (2000). Rajbhandari *et al.,* in A Hand. Fl. Pl. Nep. 4: 209 (2023).

= *Lindernia papuana* Pennell, J. Arn. Arb. 24: 251 (1943).

= *Lindernia trichotoma* Schltr., Bot. Jahrb. Syst. 59: 107 (1924).

Type specimen: M.S. Clemens, Papua New Guinea, 10907 **Isotype WIS!**

Plants 5-20 cm. Stem erect or sometimes decumbent, branched from base, sparsely pubescent on angles, more villous around nodes. Lower leaves shortly petiolate, upper leaves sessile; petiole 2-3 mm, sparsely pubescent. Lamina ovate, 10-25×8-18 mm, base atteunate, apex acute, margin ciliate serrate, upper surface glabrescent, lower

surface sparsely pubescent on midrib, pinnately veined. Flowers in terminal raceme, 6-16 flowers, peduncle covered with simple hairs below, glandular above. Lower bracts leaf like, ovate-suborbicular, 8-10×5-8 mm, glabrescent above, sparsely pubescent on veins below; upper bracts small, triangular-ovate, ca. 1×1 mm, sparsely pubescent. Pedicel 3-5 mm in flower, 7-9 mm in fruit, quadrangular, covered with glandular hairs. Calyx lobes lanceolate, 2.5-3×ca. 0.5 mm in flower, 4-4.5×0.8-1 mm in fruit, margin finely serrate, covered with glandular hairs. Corolla tube creamy white all over, yellow spot inside near throat, 3-3.5 mm, glabrous. Lower lip lobes pinkish white, middle lobe 1.8-2×ca.1 mm, glabrous, lateral lobes 1.2-1.5×ca.1 mm, glabrous. Upper lip pinkish brown, 1.8-2×1.2-1.5 mm, glabrous. Posterior pair stamens; filaments white, filaments shorter, 1-1.2 mm, glabrous; anthers ca.0.8 mm. Anterior pair; filaments creamy white, longer, 2-2.5 mm, anthers ca. 0.5 mm, base bent to form swollen node. Ovary ovoid, ca 0.4 mm, glabrous, disc green, attached tpo ovary at anterior side; style 1.8-2 mm, glabrous. Capsule green, brown while matured, ovoid, 2-4×1.5-2 mm, equal or slightly longer than persistant calyx, glabrous. Seeds yellowish brown (Fig. 39).

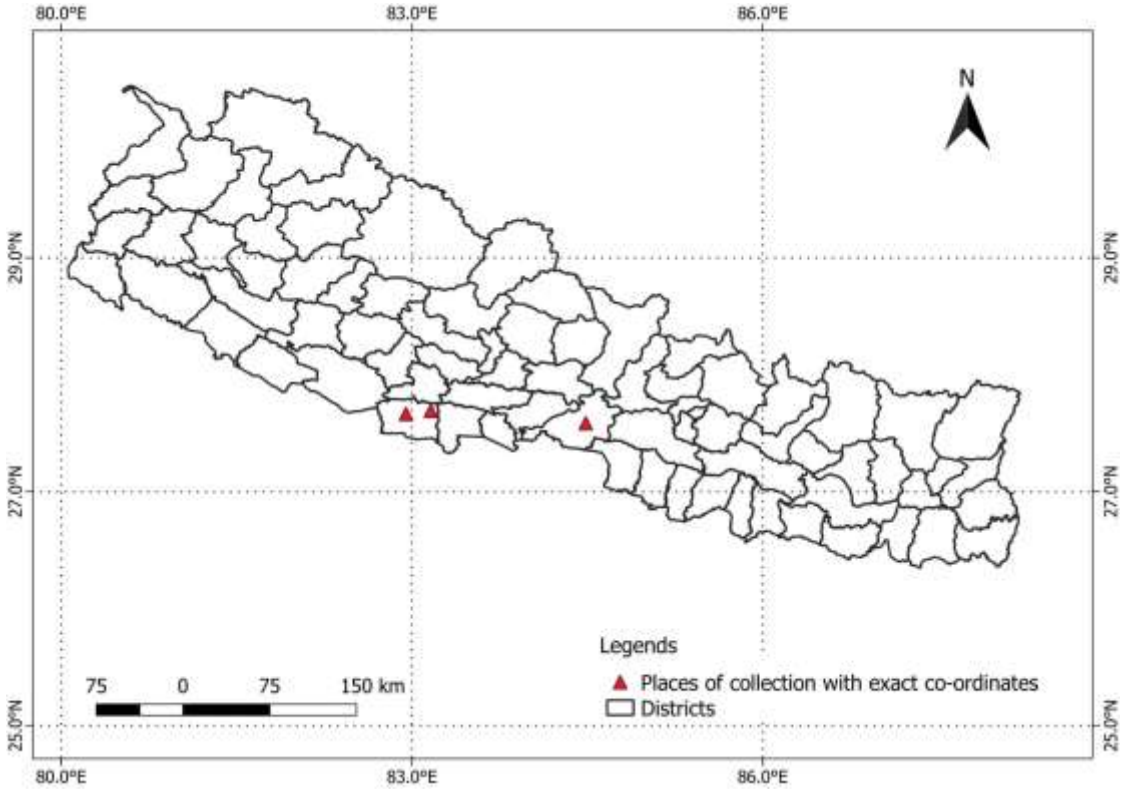


Fig. 38: Distribution of *V. multiflora* in Nepal based on herbarium specimen

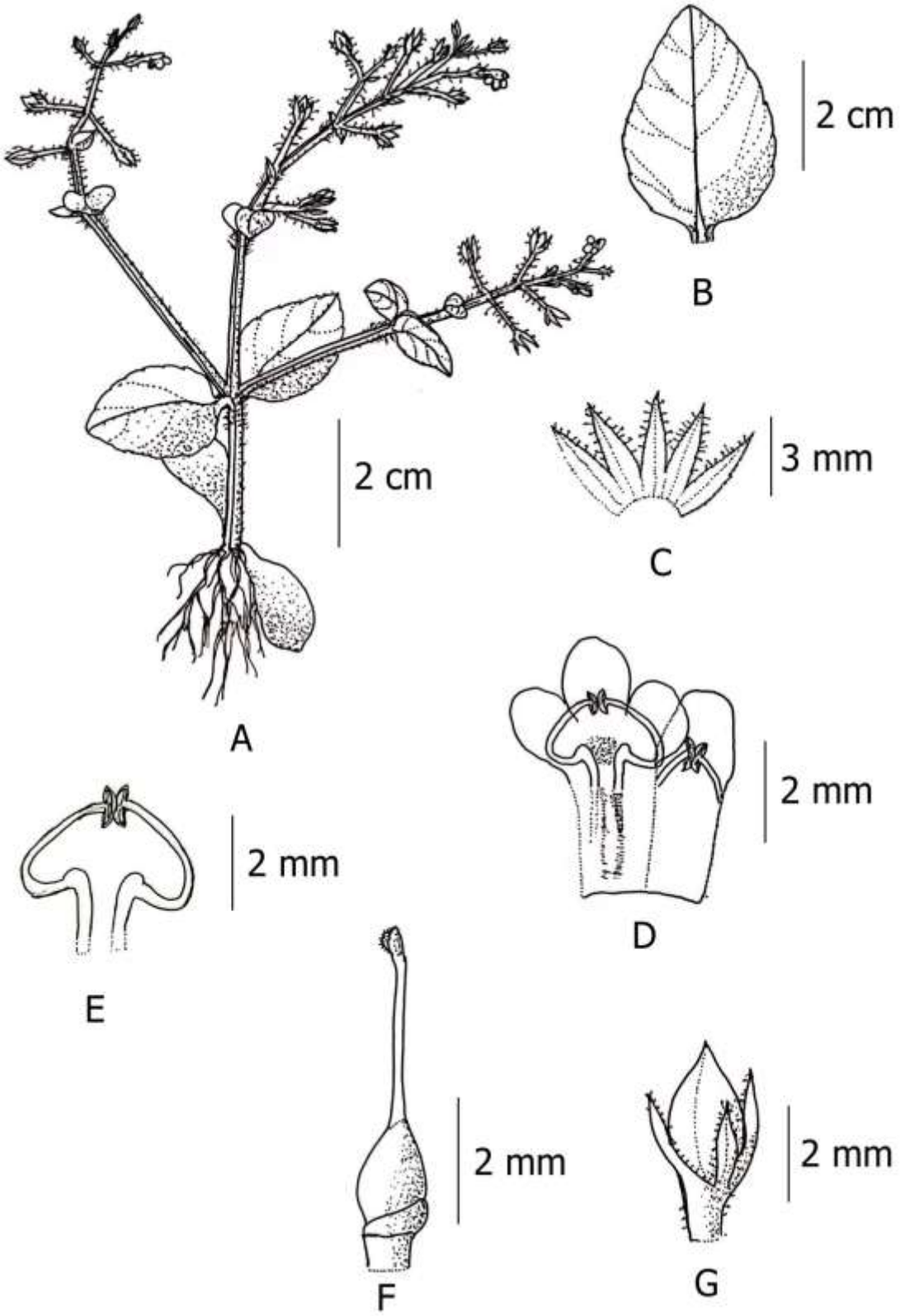


Fig. 39: Vandellia multiflora: A. Habit sketch; B. Single leaf; C. Opened calyx. D. Opened corolla. E. Anterior stamens; F. Pistil. G. Fruit.

Fl and Fr.: July-October.

Ecology: Roadsides, paddy field.

Distribution: Nepal (C & E), Assam-Burma, S Asia, SE Asia.

Elevational range: 100-400 m.

Voucher specimen: Lumbini Province, Kapilvastu, Imiliya, 120 m, 21 July 2022, K. Panthi B003 (TUCH).

Yamazakia W.R.Barker, Y.S.Liang & Wannan.

Type species: *Yamazakia viscosa* (Hornem.) W.R. Barker, Y.S. Liang and Wannan ≡ *Gratiola viscosa* Hornem., Enum. Pl. Hort. Hafin. Suppl. 19 (1807).

Annual herbs. Stem erect or decumbent, branched, quadrangular, sparsely pubescent or hirsute all over. Leaves sessile or shortly petiolate, elliptic or elliptic ovate, margin pubescent-serrate or hirsute, pubescent both surfaces. Flowers axillary or in terminal raceme. Bracteate or ebracteate. Pedicel slender or quadrangular, pubescent. Calyx deeply 5-lobed, lanceolate, or lanceolate-ovate, pubescent. Corolla variously coloured, upper lip brown, glabrous. Stamnes 4, all fertile, posterior pair shorter, included, anterior pair longer, exerted from tube. Pistil 1, ovary oblong or ovoid, stigma bifid. Capsule globoose, or ovoid, equal or slightly longer than persistant calyx. Seeds brown.

Key to species:

1a. Pedicel and calyx with simple hair. Flowers ebracteate. Stem sparsely pubescent. ……**1. Y. pussilla**

1b. Pedicel and calyx with glandular hair. Flowers bracteates. Stem hirsute all over.. ……**2. Y. viscosa**

1. Yamazakia pussilla (Willd) W.R. Barker, Y.S. Liang and Wannan., Austral. Syst. Bot. 31: 250 (2018) [**Basionym**; *Gratiola pusilla* Willd. Sp. Pl., ed. 4, 1: 105 (1797)]; Rahbhandari *et al.*, in A Hand. Fl. Pl. Nep. 4: 213 (2022) ≡ *Lindernia pusilla* Willd. Bold., Zakfl. Java: 165 (1916). Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 117 (1982);

Press *et al.,* in Ann. Check. Fl. Pl. Np. (2000); Rajbhandari & Parmer in Rajbhandari *et al.,* Cat. Nep. Fl. Pl. 3: 103 (2012) ≡ *Tittmania pusilla* (Willd) Benth. Numer. List (Wallich) no. 3945 ≡ *Vandellia pusilla* (Willd.) Merr. in Philipp. J. Sci., C 7: 246 (1912); Burkili in Re. Bot. Sur. Ind. x (1): 329 (1978); Fischer *et al.,* in Willdenowia 43: 234 (2013); Shrestha et al., in Pl. Nep. 660 (2022).
= *Columnea minuta* Roxb., Fl. Ind. ed. 1832, 3:98 (1832).

Type Specimen:

Plants 4-25 cm. Stem erect or decumbent, branched, rooting from last few nodes, sparsely pubescent. Leaves sessile or shortly petiolate; petiole 0.5-2 mm, glabrous. Lamina ovate to broadly ovate, 10-18×7-17 mm, base cuneate, apex acute, margin pubescent-serrate, both surfaces pubescent, pinnately veined. Flowers axillary solitary. Ebracteate. Pedicel 1-2.5 cm in flower, 2-3 cm in fruit, quadrangular, sparsely pubescent. Calyx lobes lanceolate-ovate, 3.5-4×0.8-1 mm, apex acute-acuminate, densely pubescent outside. Corolla tube creamy white, 4-5 mm, glabrous. Lower lip lobes creamy white, subequal, 2.5-3×2.8-3 mm, glabrous, apices rounded. Upper lip brown, 2.5-3×ca. 3 mm, apex notched. Posterior pair stamens; filaments creamy or purplish white, shorter, 1.8-2 mm, glabrous; anthers ca. 1 mm. Anterior pair; filaments white pink, longer, 4.5-5 mm, glabrous above, swollen rounded appendages towards base; anthers ca 0.5 mm. Ovary ovoid, 1-1.2 mm, glabrous, disc pale yellow, attached to ovary around base; style 4-5 mm, glabrous. Capsule green, brown while matured, globoose, 3.5-4×2-2.2 mm, equal or slightly longer than persistant calyx, glabrous. Seeds yellow brown (Fig. 40).

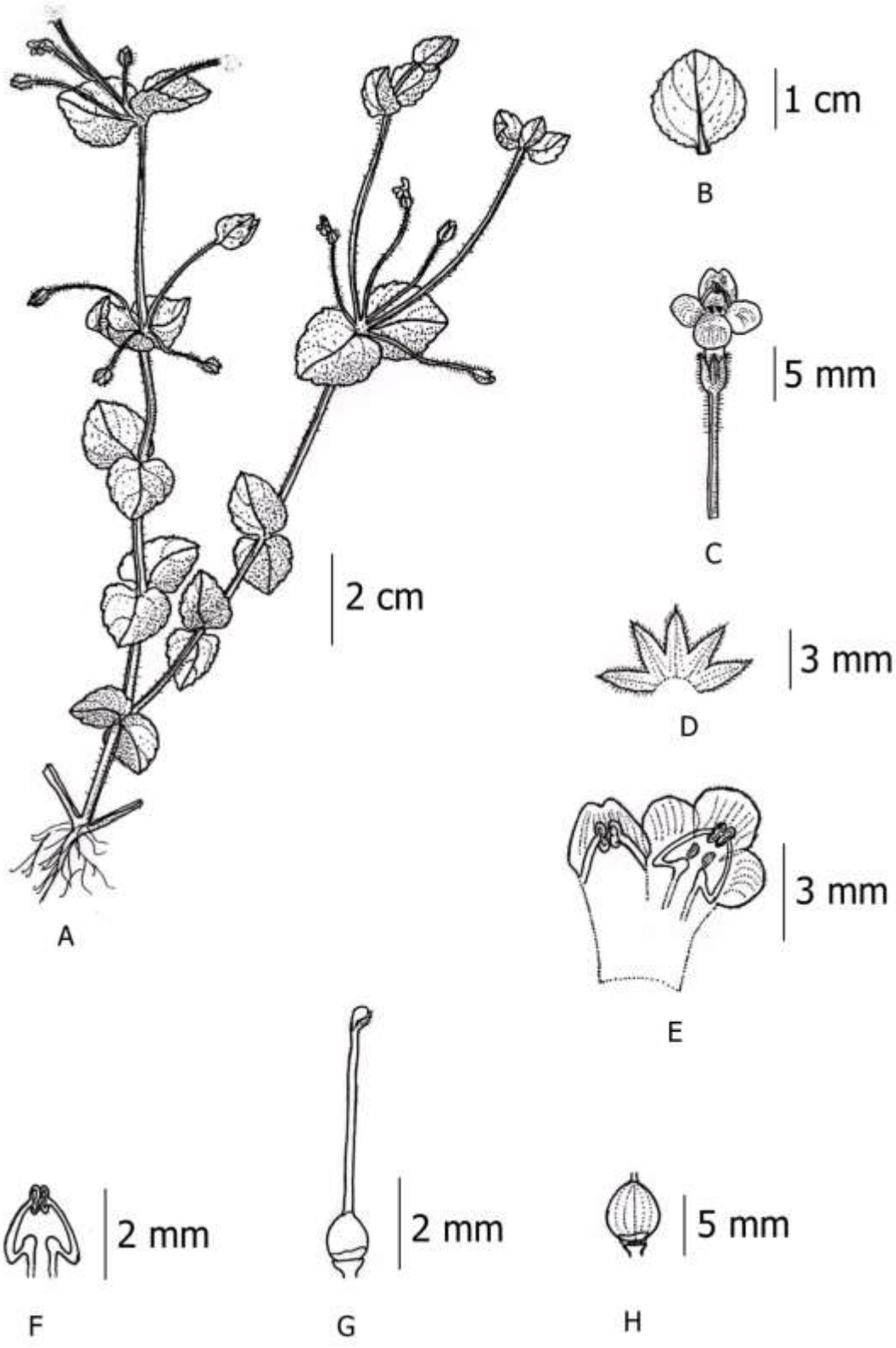
Fl. and Fr.: June-November.

Ecology: Forest margins, paddy field, roadsides, moist fields, river banks.

Distribution: Nepal (CE), Assam-Burma, S Asia, SE Asia, W Himalaya, Africa.

Altitudinal range: 87-1800 m.

Voucher specimen: Lumbini Province, Gulmi, Wagla, 1207 m25 July 2021, K. Panthi G11 (TUCH, KATH); Koshi Province, Jhapa, Range Danda, 87 m, K. Panthi and Y.B. Poudel J012 (TUCH, KATH).



Fi**g. 40: Yamazakia pusilla**: A. Habit sketch; B. Single leaf; C. Flower front view; D. Opened calyx; E. Opened corolla; F. Anterior stamens; G. Pistil; H. Fruit.

Species examined:

Eastern Nepal:

Central Nepal: Bagmati province, Makwanpur, Hetauda Manohamona temple, 500 m, 28 November 2004, C.A. Pandey, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S.Shrestha, M. Siwakoti 192 (KATH).

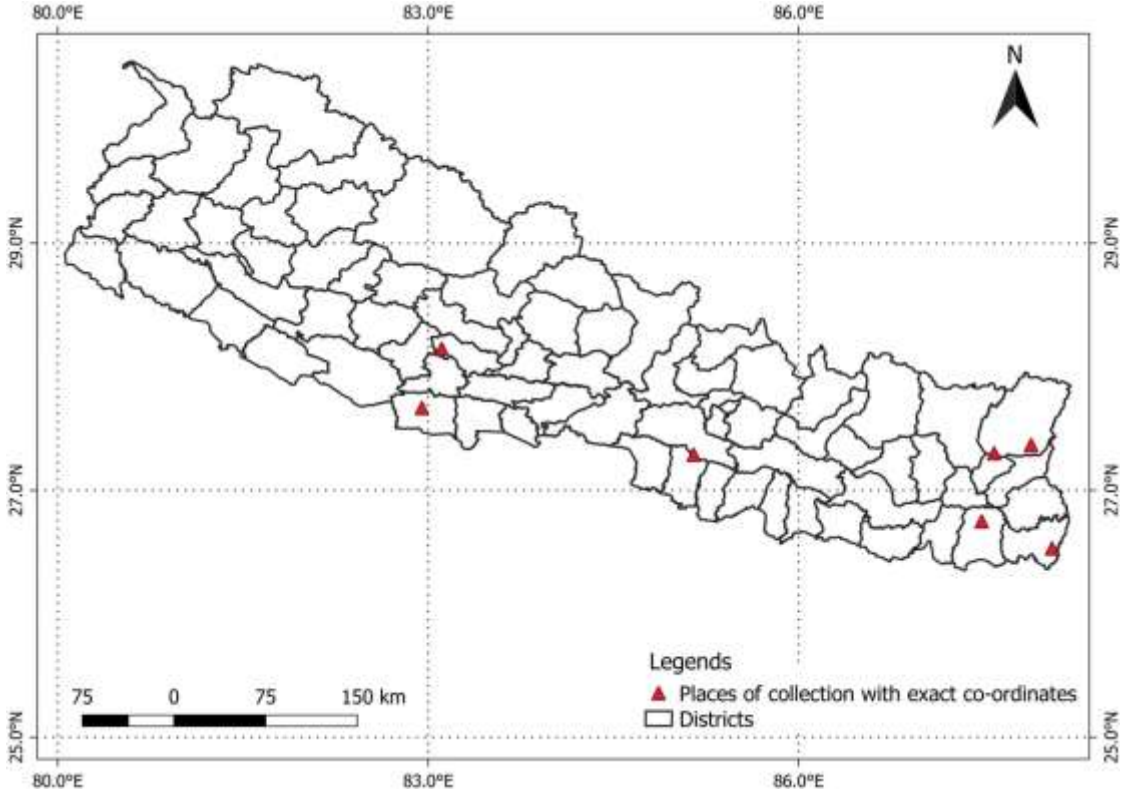


Fig. 41: Distribution of *Y. pusilla* in Nepal based on herbarium specimen

2. Yamazakia viscosa (Hornem.) W.R. Barker, Y.S. Liang & Wannan. Austral. Syst. Bot. 31: 249 (2018) [**Basionym**: *Gratiola viscosa* Hornem., Enum. Pl. Hort. Hafn.: 19 (1807)]; Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 4: 214 (2022) ≡ *Lindernia viscosa* (Hornem.) Bold., Zakfl. Java: 165 (1916). Philcox in Kew Bull. 22 (1): 41 (1968); Hara in Hara et al., Enum. Fl. Pl. Nepal 3: 117 (1982). Press *et al.*, in Ann. Check. Fl. Pl. Nep. (2000). Mill in Grierson and Long Fl. Bhu. 2 (3): 1122 (2001) ≡ *Tittmannia viscosa* (Hornem.) Rchb., Iconger. Bot. Exot. 1:26, t 38 (1824).

= *Vandellia hirsuta* Buch.-Ham. ex Benth., Scroph. Ind.: 36 (1835); Hook. in Fl. Br. In iv: 280 (1885); Hains in Fl. Bih. Ori. II: 662 (1961); Kanjilal *et al.*, in Fl. As. III:

539 (1939); Burkuli in Re. Bot. Sur. In. x (1): 329 (1978); Fischer *et al.,* in Willdenowia 43: 235 (2013).

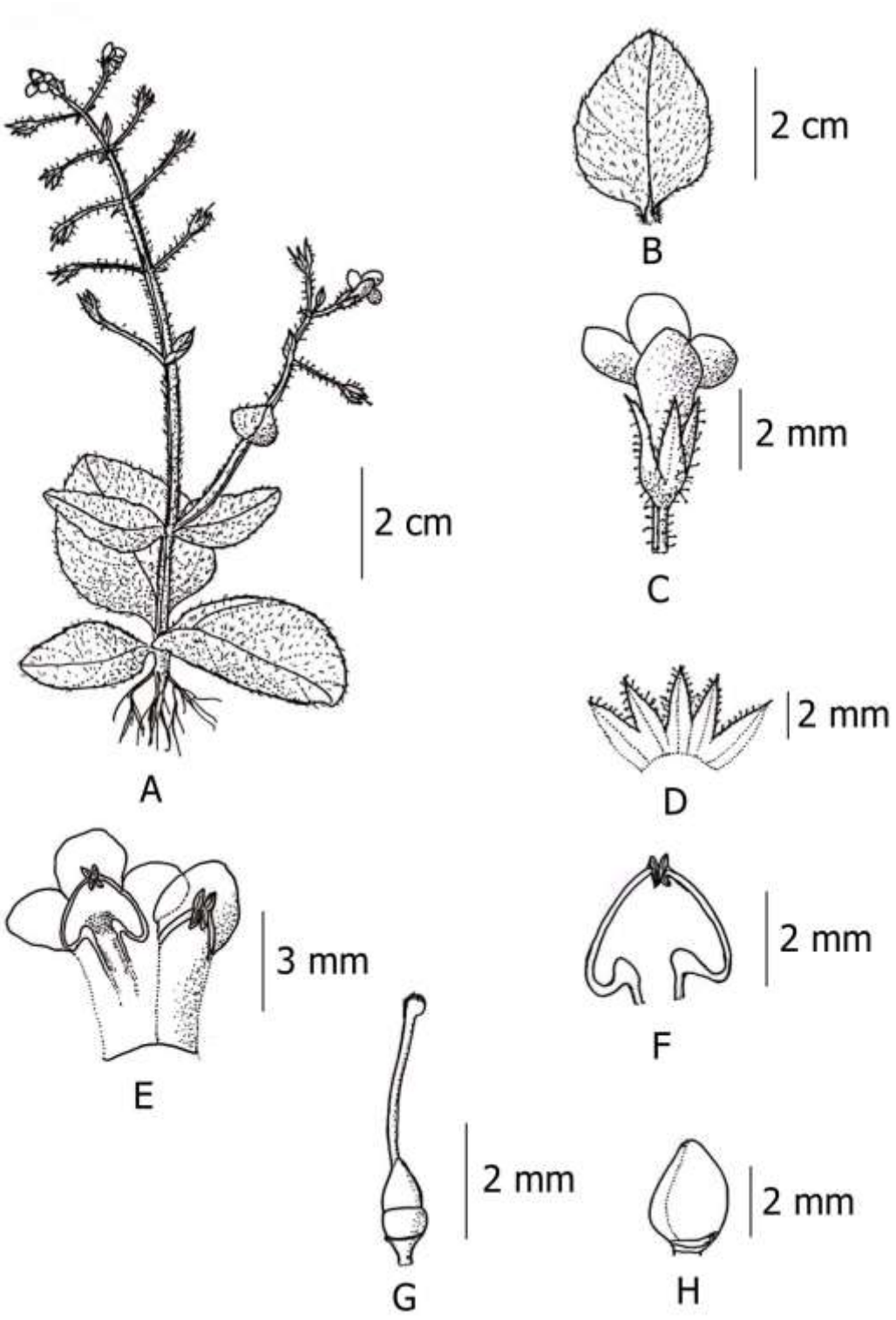


Fig. 42: Yamazakia viscosa: A. Habit sketch; B. Single leaf; C. Flower back view; D. Opened calyx; E. Opened corolla; F. Anterior stamens; G. Pistil; H. Fruit.

Type specimen: India (India), Buchanan-Hamilton, Francis, #1380 **(Isosyntype: E!)** 00273700. (**Photo!)**

Plants 4-20 cm. Stem erect, sometimes rooting from last nodes, branched from base, hirsute all over. Lower leaves petiolate, upper leaves subsessile; petiole 2-10 mm, hirsute. Lamina elliptic to broadly ovate, 0.9-3.1×0-8-2.1 cm, base attenuate, apex acute or obtuse, margin ciliate serrate or crenate, both surfaces villous, pinnately veined. Flowers axillary or in terminal raceme. Lower bracts leaf like, subtending bracts lanceolate, 1.3-2.1×ca.0.5 mm, apex acute, pubescent. Pedicels slender, 3-5 mm in flower, 7-10 mm in fruit, covered with glandular hairs. Calyx lobes linear-lanceolate, 2.5-3×ca. 0.8 mm in flower, 3-4×0.8-1.1 mm in fruit, apex acute, margin ciliate serrate, covered with glandular hairs. Corolla tube bluish white, 2.5-3 mm, glabrous. Lower lip creamy white, middle lobe with distinct yellow patch between anterior stamens inside, distinctly 3-lobed; lobes subequal, 1.3-1.5×1-1.2 mm, apices rounded, glabrous. Upper lip brown, 1.8-2×ca.2 mm, apex notched, glabrous.Posterior pair stamens: filaments white, shorter, 1.5-1.8 mm, glabrous; anthers ca.1 mm. Anterior pair: filaments creamy white, longer, 2.8-3.1 mm, glabrous, base swollen; anthers ca.0.8 mm. Ovary 1-1.5×ca.1 mm, oblong-ovoid, glabrous; disc pale yellow, attached to ivary around base; style 3.5-4 mm, glabrous. Capsule green to brown while matured, globoose or ovoid , 3.5-4×2-2.2 mm. Seeds brown (Fig. 42).

Fl. and Fr.: June – Sept.

Ecology: Forest sides, foot trails, riverbanks.

Distribution: Nepal (E), Assam-Burma, S Asia, E Asia, SE Asia.

Elevational range: 80- 300 m.

Voucher specimen: Province no.1, Jhapa, Jalthal, 109 m, 8 Sept 2021, K. Panthi and Y.B. Poudel J012 (TUCH).

Species examined:

Eastern Nepal: Province no.1, Sankhuwasabha, Chelisa Bensi-Chewa Bensi, 300 m, 3 September 1997, S. Noshiro N. Acharya, Y. Ibaragi, K. Kobayashi and T. Kurosawa 9760575 (TI).

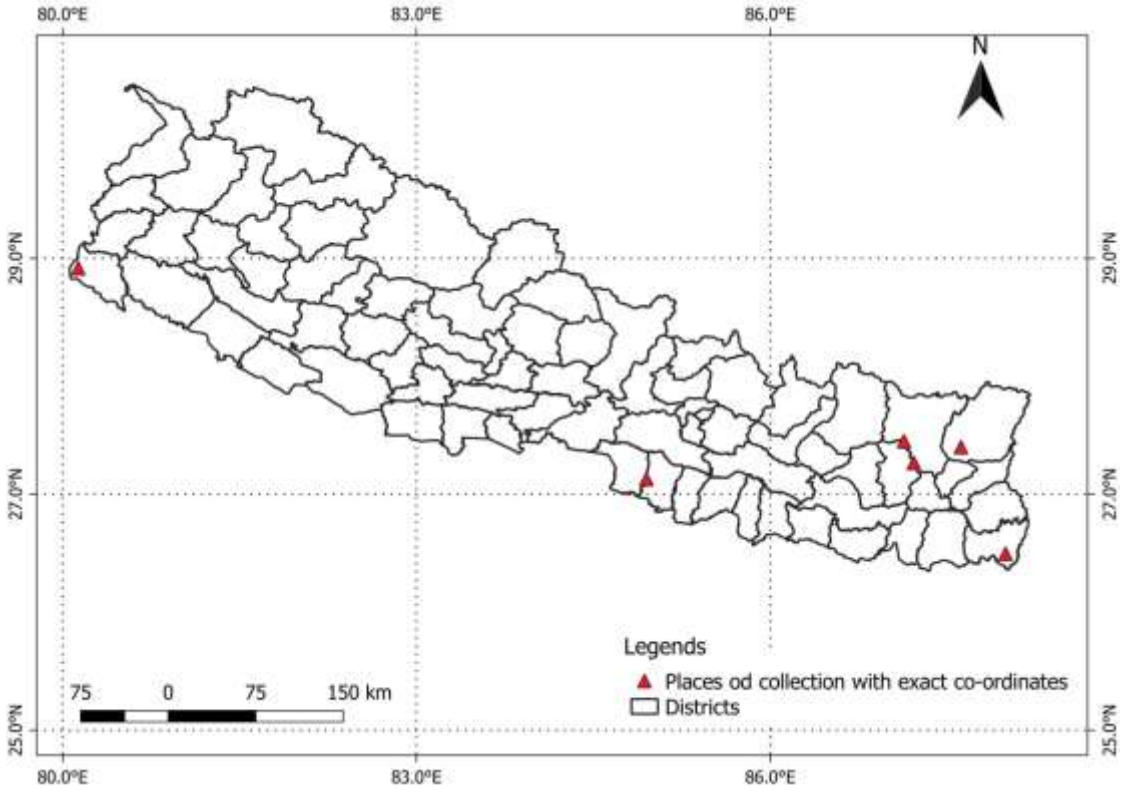


Fig. 43: Distribution of *Y. viscosa* in Nepal based on herbarium specimen

Species studied with the secondary literatures:

Following species were studied from secondary literatures due to unavailability of the herbarium or fresh collection.

1. Bonnaya tenuifolia (Colsm.) Spreng. Syst. Veg. ed. 16. 1: 42 (1824); [**Basionym**: *Gratiola tenuifolia* Colsm., Prodr. Descr. Gratioil.: 8 (1793)]; Hook. in Fl. Br. In. iv: 286 (1885); Rajbhandari *et al.*, in A Hand. Fl. Pl. Nep. 4: 207 (2022) ≡ *Lindernia tenuifolia* (Colsm.) Alston in Trimen, Hand. Fl. Ceylon 6 (Suppl.): 214 (1931).
≡ *Vandellia tenuifolia* (Colsm.) Haines, Bot. Bih. Ori: 634 (1922).
= *Bonnaya pusilla* Griff., Not. Pl. Asiat. 4: 107 (1854).

Type specimen: Ceylon, *Koenig s.n.* **(Holotype: C!)**

Annual herbs. 5-20 cm. Stem erect to ascending, branched, quadrangular, glabrous. Leaves sessile, linear-lanceolate, 8-30×0.5-5 mm, base cuneate, apex acute, margin of lower leaves crenate, upper leaves subentire, glabrous both surfaces, pinnately veined. Flowers in terminal raceme. Bracts linear-ovate, apex acute, 1-1.2×ca. 0.2 mm.

Pedicel 2-10 mm, ascending in flower, deflexed in fruit, glabrous. Calyx 5-lobed, lobed almost to the base, lobes 2-2.2 mm, glabrous. Corolla tube 2-3 mm, constricted near base, glandular outside, lower lip distinctly 3-lobed, lobes purple, subequal 2-2.5×3-3.5 mm, glabrous, upper lip oblong, 2-2.5×2-2.2 mm, apex notched, glabrous. Fertile stamens 2, posterior; filament white, 1-1.2 mm, anther 0.5-0.7 mm. Staminodes 2, anterior, 0.5-1.5 mm, base villous, apex clavate. Ovary elliptic, 1-1.2 mm, glabrous. Style 3.5-4 mm, glabrous. Capsule cylindric, 5-12 mm, glabrous. Seeds brown or pale yellow.

2. Torenia cordata (Griff.) N.M. Dutta Bull. Bot. Soc. Bengal 19: 25 (1965); [**Basionym**: *Treisteria cordata* Griff. in Not. Pl. Asiat. 4: 109 (1854)]; Rajbhandari *et al.* in A Hand. Fl. Pl. Nep. 4: 211 (2023).
= *Treisteria lanceolata* Griff. in Not. Pl. Asiat. 4: 111 (1854).

Type specimen: Burma, Mergui, Griffith 561 **(Isotype: E!)**

Annual herbs. Stem prostrate or creeping below, diffusely branched, quadrangular, subglabrous or pubescent. Petiole 3-7 mm. Leaves ovate or lanceolate, ca. 6 cm long, base subcordate or cuneate, apex acute or acuminate, margin crenate or serrate, glabrous or pubescent. Flowers axillary solitary or subumbellate. Pedicels 1.5-6 cm, slender. Whole calyx 5-20 mm, bilipped; lobes lanceolate, base decurrent, winged, glabrous. Corolla tube bluish purple, 2.5-3 cm. Lower lip distinctly 3-lobed, lobes bluish purple, lateral lobes with dark violet patches. Stemens 4, didynamous, posterior pair shorter; ca. 5 mm, anthers ca. 2 mm, anterior pair longer; ca. 1 cm, base appendaged; appendages ca. 6 mm, anthers ca. 2 mm. Ovary narrowly oblong, 5-10 mm, apex acute, style filiform, 2.5-3 cm, stigma bilipped, lips ciliate inside. Capsule oblong, apex acuminate, ca. 2 cm, enclosed inside the persistant calyx. Seeds minute ca. 5 mm, oblong, brown.

3. Torenia hookeri (C.B.Clarke ex Hook.f.) A. Pal & M. Chowdhury Phytotaxa 549 (2): 230-234 [**Basionym**: *Vandellia hookeri* C.B.Clarke ex Hook. Fl. Brit. India 4: 280 (1884); Shrestha et al., in Pl. Nep. 659 (2022); Rajbhandari et al., in A Hand. Fl. Pl. Nep. 4: 213 (2022)] ≡ *Lindernia hookeri* Wettst. in H.G.A.Engler & K.A.E.Prantl. Nat. Pflanzenfam. 4(3b): 80 (1891); Press et al., in Ann. Check. Fl. Pl. Nep. (2000);

Mill in Grierson and Long Fl. Bhu. 2 (3): 1123 (2001) ≡ *Pyxidaria hookeri* (C.B.Clarke ex Hook.f.) Kuntze in Revis. Gen. Pl. 2: 464 (1891).

Type specimen: INDIA. Khasia J.D. Hooker & T. Thomson **10** (**Lectotype: K!** 000859668)**.**

Annual herbs. 5-30 cm. Stem erect or somehow ascending, branched, quadrangular, hispid all over. Petiole 4-6 mm, quadrangular, pubescent. Leaves ovate-lanceolate, 15-25×5-15 mm, base cuneate to subcordate, apex acute, margin serrate with bristles on apices, hispid both surfaces, pinnately veined. Flower axiallary solitary or in a terminal raceme or subumbel at branch apices. Pedicel 5-15 mm in flower, 9-20 mm in fruit, quadrangular, pubescent. Calyx purple green, whole calyx tubular, 3×2 lobed; lobes lanceolate-ovate, 4-5 mm in flower, 6-7 mm in fruit, wings 1-1.5 mm, densely villous. Corolla tube base yellow, purple-yellow above 4.5-5 mm, tube, lower lip distinctly 3-lobed; lobes white purple, middle lobe with distinct yellow patch near throat, subequal, 2.3-2.5×2.5-2.7 mm each, apices rounded, glabrous, upper lip purple, 2-2.5×3-3.5 mm, apex notched, glabrous. Stamens 4, didynamous, posterior stamens white purple, shorter, ca. 1.5 mm, anterior pair pale purple, longer ca. 2.5 mm, base appendaged; appendages ca. 0.3 mm. Ovary linear-oblong, ca. 2 mm, apex pubescent anteriorly, disc greenish yellow, covering $1/6^{th}$ of the ovary at base. Capsule completely enclosed by calyx. Seeds irregular in shape with rounded surfaces (bothrospermous).

***Note: This taxon is mentioned in most of the Nepalese literatures based upon the specimen deposited in TI. The locality which was mentioned in the specimen, it could not be found during field visiting. Instead from other localities of Nepal, another species has been found which is morphologically similar and differing in reproductive features.*

Excluded taxon:

1. *Craterostigma sessiflorum* (Benth.) Y.S.Liang & J.C.Wang Phytotaxa 247: 148 (2016).

**Note: Von Wettstein published this taxon in Engler & Prantl's Natürliche Pflanzenfamilien IV (3b) of 1895 in Vandellia section including Lindernia nummulariifolia (D.Don) Wettst. from the Himalaya. This is just mentioned by Rajbhandari et al. (2022) in Handbook of flowering plants of Nepal, on the basis of the specimen from KATH but the same specimen is also cited for C. nummularifolium. During field fisiting, the species could not be found even in its flowering season. It is doubtful and thus recommended the further study for its conformation.*

4.5. Hierarchial cluster analysis

Based upon the morphological characters and character states within the species of the family are mentioned in Table 1. Dendrogram is obtained shown in fig. after the hierarchial cluster analysis.

Table 1: Character and character state coding

S. N.	Character	SPSS code	Character state
1.	Life form	L.f.	Annual 0: perennial 1
2.	Stem form	St. form	Erect or decumbent 0: prostrate/creeping 1
3.	Stem texture	St. txt	Glabrous 0; subglabrous 1; sparsely pubescent 2; villous 3
4.	Leaf attachment	Lf. At.	Sessile 0; Subsessile to short petiolate 1; all leaves petiolate 2
5.	Leaf shape	Lf. shape	Oblong-lanceolate 0; ovate to broadly ovate 1; elliptic-suborbicular 2; ovate-suborbicular 3
6.	Leaf base	Lf. base	Cuneate or amplexicaul 0; atteunate 1; rounded 2; rounded to subcordate 3
7.	Leaf apex	Lf. apex	Acute or acuminate 0; round 2
8.	Leaf margin	Lf. margin	Subentire-weakly serrate 0; serrate-dentate 1, mucronate- serrate 2
9.	Upper surface	Up. surface	Glabrous 0, sparsely pubescent 1; soft villous 2
10.	Lower surface	Lo. surface	Glabrous 0, sparsely pubescent 1; soft villous 2
11.	Venation	Lf. venation	Palmately veined 0; pinnately veined 1; lateral veins not distinct 2
12.	Inflorescence	Infl.	Axillary solitary 0; axillary and terminal solitary 1; axillary solitary or terminal raceme 2; terminal umbel like 3; axillary whorled 4
13.	Bract	Br.	Absent 0; present 1

14.	Pedicel texture	Pd. text	Glabrous 0; simply pubescent 1, glandular 2
15.	Calyx lobes	Ca. lobes	Lobes unwinged 0 Winged 1
16.	Calyx base	Ca. base	Cuneate 0, round 1, round to subcordate 2, attenuate 3
17.	Size of lobes	Lb. size	Upto 3mm 0; more than 3 mm 1
18.	Lobe texture	Lb. text	Glabrous 0, pubescent 1, glandular 2
19.	Corolla tube size	Tb. size	Upto 4 mm 0 more than 4 mm 1
20.	Tube base	Tb. base	Constricted 0; not constricted 1
21.	Tube base colour	Tb. Base col	Yellow 0; white 1
22.	Tube colour	Tb. col	Yellow 0; white 1; purple or purplish white 2, pinkish white 3, purple or pink 4
23.	Tube texture outside	Tb. Txt. out	Glabrous 0; glandular 1
24.	Tube texture inside near throat	Tb. Text	Glabrous 0; ciliate 1
25.	Upper lip colour	Up .lip	Brown 0; white 1, pink 2; purple 3; purple white 4, pink white 5, purple or pink white 6
26.	Upper lip length	Up. size	Upto 3 mm 0; more than 3 mm 1
27.	Middle lobe	Md. lobe	yellow patch at centre or near throat 0, without yellow patch 1; yellow patches with stamens 2
28.	Lateral lobes inside	Lt. lobes	Glabrous 0, ciliate 1
29.	No. of Stamen	No.of st.	Fertile stamen 4 0, fertile stamen 2 1
30.	Anterior Stamen or staminode base	St. base	Unappendaged 0, appendaged 1, swollen 2
31.	Anterior Stamen or staminode colour	St. col	Yellow or whitish yellow 0; White 1; white purple 2; pink 3
32.	Anterior Stamen or staminode base texture	St. txt	Glabrous 0; villous 1
33.	Anthers base	An. base	Spurred 0; not spurred 1
34.	Ovary size	Ov. length	Upto 2 mm 0; more than 2 mm 1
35.	Ovary shape	Ov. shape	Ovoid 0 , Oblong-ovoid 1, elliptic ovoid 2
36.	Ovary apex	Ov. apex	Glabrous 0; pubescent 1
37.	Style length	St. length	Upto 4 mm 0; more than 4 mm 1
38.	Fruit shape	Fr. shape	Cylindric 0; cylindric ovoid 1; ovoid or globoose 2
39.	Fruit size	Fr. size	Upto 4 mm 0; more than 4 mm 1
40.	Fruit position	Fr, post	Enclosed inside the calyx 0; slightly longer or equal to calyx 1; Longer than calyx 2
41.	Fruit texture	Fr. Text.	Glabrous apex 0; Pubescent apex 1;

The following dendrogram helps to show the highest similarity among the species of the given taxa:

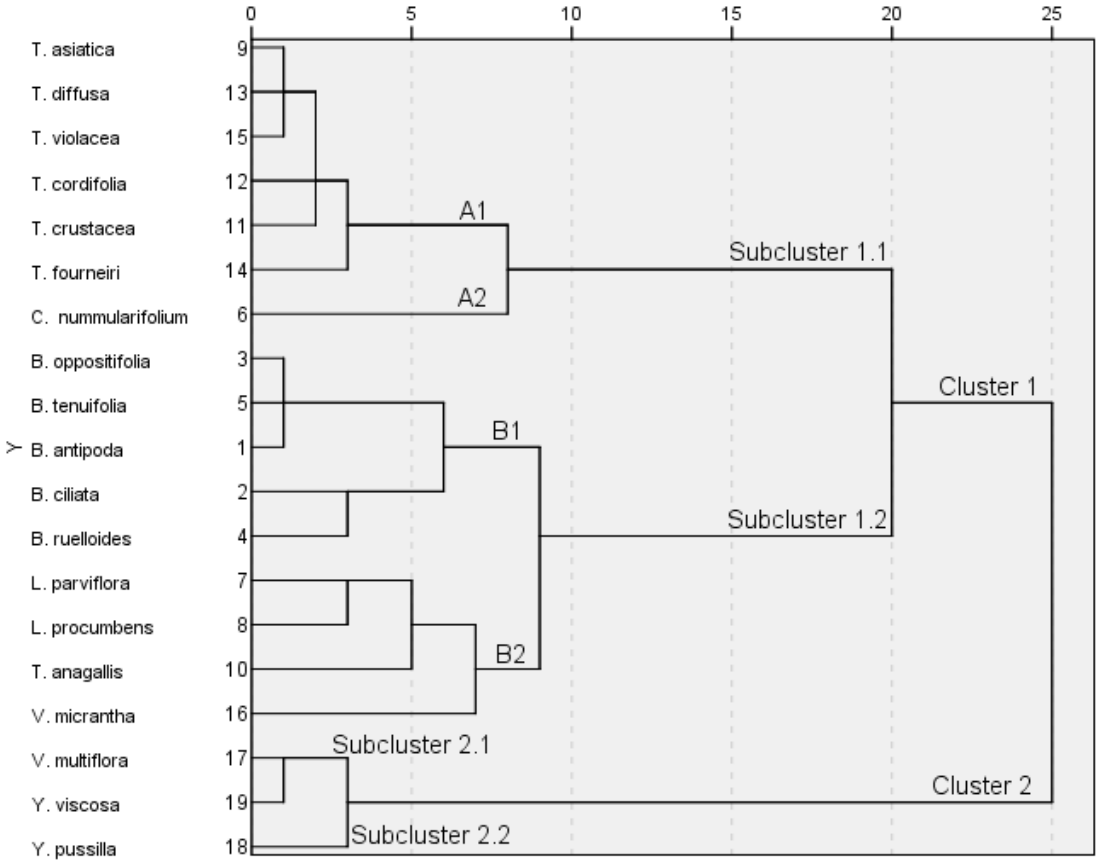


Fig. 44: Dendrogram showing the average linkage among the species of Linderniaceae.

In the dendrogram above, two clusters have been generated clearly. Cluster 1 is represented by 16 species while cluster 2 is represented by only 3 species. There is not only character that represent all the species. These two clusters are formed mainly on the basis of texture of calyx lobe and stamen filament. Species in cluster 1 are characterized by glabrous or sparsely pubescent calyx lobes and anterior stamens either appendaged or slightly curved, whereas the species in cluster 2 are mainly represented by pubescent or glandular calyx and zig-zag type bent filament with swollen node.

Cluster 1:

Cluster 1 is represented with the higher number of species. Two sub-clusters have been formed in this cluster. Subcluster 1.1 is formed by *Torenia* and *Craterostimga*, where the species are characterized by calyx lobed only at the apex or upto the half of the sepal length. However subcluster 1.2 is formed by the taxa featured by distinctly 5-lobed calyx upto the base.

Subcluster 1.1 is further divided into two branches A1 and A2. Where A1 represents the *Torenia* (except *T. anagallis*) mainly characterized by the winged calyx, comparatively larger flowers and apically pubescent ovary. However A2 represents a single species which calyx is not winged and comparatively smaller flowers and apically glabrous ovary.

Subcluster 1.2 is aslo divided into two further branches B1 and B2. B1 is represented by 5 species of Bonnaya. The major distinguished character to delimit these genera is the presence of two fertile stamens and anterior staminodes. Whereas B2 represents the taxa with 4 fertile stamens (except *Lindernia parviflora*).

Cluster 2:

Cluster 2 is further classified into two subclusters . Subcluster 2.1 is represented by two species which are delimited on the basis of presence of glandular pedicels and calyx. Whereas, in subcluster 2.1 only one species is generated, this is characterized by pubescent pedicel and calyx with simple hairs.

4.6. Phenology: A phenomenon of flowering and fruiting

Flowering and fruiting season of the species of the family Linderniaceae has been obtained mainly by field visiting, analyzing the specimen of different herbaria, data on floras and other literatures. There are differences in the phenology within species. The peak months for the flowering and fruiting are July, August and September. However, *Bonnaya antipoda* and *Torenia anagalis* flower all around the year (Fig. 45, Table 2).

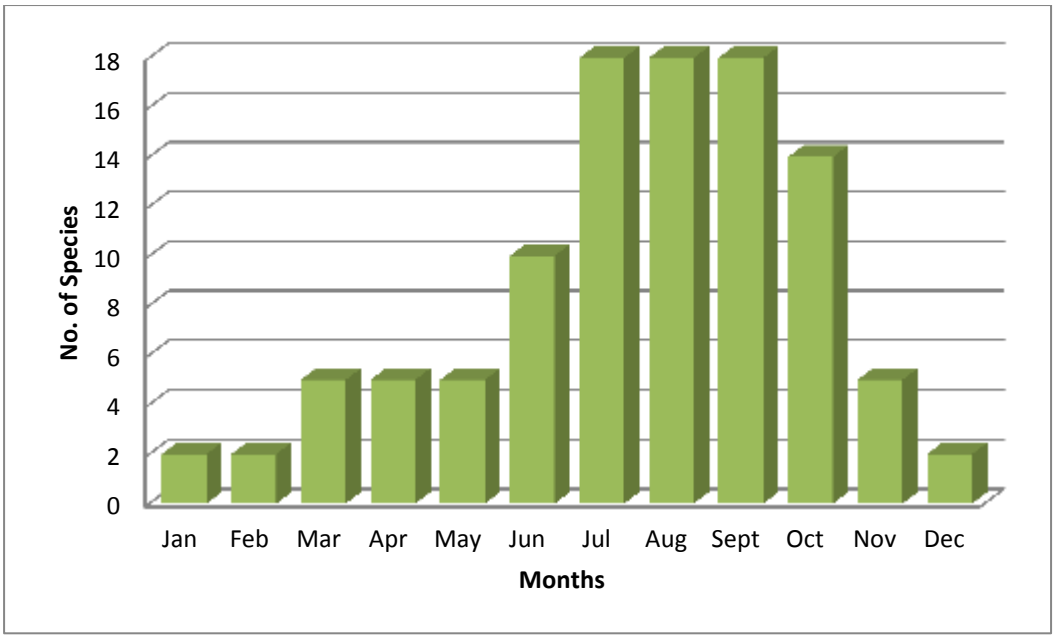


Fig. 45: Bar-graph showing the no. of species with their phenology in different months

Table 2: flowering and fruiting seasons of 18 species of family Linderniaceae

S.N.	Name of the Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.	*B. antipoda*												
2.	*B. ciliata*												
3.	*B. oppositifolia*												
4.	*B. ruellioides*												
5.	*B. tenuifolia*												
6.	*C. nummularifolium*												
7.	*L. parviflora*												
8.	*L. procumbens*												
9.	*T. asiatica*												
10.	*T. anagallis*												
11.	*T. crustacea*												
12.	*T. cordifolia*												
13.	*T. diffusa*												
14.	*T. violacea*												
15.	*V. micrantha*												
16.	*V. multiflora*												
17.	*Y. pussilla*												
18.	*Y. viscosa*												

CHAPTER 5: DISCUSSION

5.1. Taxonomy of Nepalese Linderniaceae

The taxa of Linderniaceae described in the current study are annual and herbs except *Bonnaya ruellioides* which is perennial. Philcox (1968) described this species as an annual whereas recent studies such as Liang and Wang (2014) described it as a perennial creeping herb. Similarly, one desiccation tolerant species, *Craterostigma* is also descried in the current study. *Craterostigma* and *Lindernia* as resurrection plants or desiccation tolerant species were already described by Bartles *et al.* (1990), Fischer (2004), and Rahmanzadh *et al.* (2005). Current study also supports the *Craterostigma* as a resurrection genera as it was collected from such habitat. But in case of *Lindernia* both the species (*L. parviflora and L. procumbens*) described during this study were found in moist or water logged condition and thus are not poikilohydric.

Representation of Linderniaceae in Nepal is controversially described by various authors. Press *et al.* (2000) enumerated 20 species under two genera i.e *Lindernia s.l.* and *Torenia*, Rajbhandari *et al.* (2017) enumerated 18 species under same genera. Very recently Shrestha *et al.* (2022) enumerated 20 species under 6 genera whereas Rajbhandari *et al.* (2022) enumerated 21 species under same genera as Shrestha *et al.* These studies are based on the herbarium specimen collected at National Herbarium (KATH) and international herbaria (Such as TI and BM). This study described 20 species of the family are described under 6 genera.

As mentioned in the result, species of the family show great variation in morphological characters which are sufficient to distinguish them. Major characters that are relevant in delimitation of the taxa are related to leaves, trichomes, stamens and pistil.

Mainly two types of leaves are observed in the members of Linderniaceae based on pattern of leaf veins; palmately veined leaves which are observed in *Lindernia s.s.* and pinnately veined leaves observed in remaining genera (*Bonnaya, Craterostigma, Torenia, Vandellia and Yamazakia*). Beside venation, leaf shapes (lanceolate, ovate, broadly ovate or orbicular) observed among the taxa are also the wise characters used in the current study. Lewis (2000) and Baden (2005) have widely used the leaf

characters such as leaf shape, venation and texture to delimit the species of *Lindernia s.l.* Leaf shapes in Nepalesse species are mainly lanceolate, ovate or broadly ovate type of leaves are found in. These results show similarities with above mentioned literatures and with Philcox (1968), Fischer *et al.* (2013), Bazarragchha (2019) as well.

Calyx in *Torenia* are mainly tubular, bilipped and 2×3 lobed and winged (except *T. anagallis*) however in *Bonnaya*, *Lindernia*, *Vandellia* and *Yamazakia* distinctly 5-lobed calyx is obtained in *Craterostigma* it is lobed at least half of the sepal length. Philcox (1968) and Burtt (1991) also emphasized the calyx type for the delimitation of taxa. Lewis (2000) distinctly discussed about the similar result. Former calyx type of *Lindernia s.l.* was found among the species discussed under the sections *Brachycarpae, Lindernia Bonnaya* and *Tittmannia*. Similarly section *Nummularia* and *Torenoides* calyx is of latter type.

The flowers among the taxa of Linderniaceae are typically chasmogamous, however the widely distributed *Lindernia procumbens* was found to exhibiting cleistagamous flowers as well mainly towards the more temperate region of its range of Asia and Europe (Kunth 1909). The anterior filaments in such corolla are straight and only slightly longer than posterior filaments, whereas the Nepalese specimens of *L. procumbens* do not exhibit the cleistogamous flowers. Philcox (1968) in the revision of Malesian *Lindernia* also observed only chasmogamous flowers for this taxon from that region and tropical Asia.

As mentioned in the result section of present study, stamens in Linderniaceae are characterized by anterior geniculate stamens. This character is taken as one of the most important character to delimit the family Linderniaceae as discussed by Philcox (1968), Lewis (2000), Rahmanzadh *et al.* (2005) and Fischer *et al.* (2013). However except *Bonnaya* and one species of *Torenia* (*T. violacea*), the family represents the taxa with either appendaged or swollen anterior stamens. In '*Bonnaya* section of Australian *Bonnaya',* Linag and Wang described similar type of filaments. Similarly, Brutt (1991) and Fischer *et al.* (2013) described *Torenia* with the apically pubescent ovary as well as also used to prepare the key to distinguish the taxa. Similar morphology of ovary observed in the current study. Majority of the species of *Torenia* possess the ovary with pubescent apex however *T. anagallis* has the glabrous

ovary. Ovary disc which is another widely used character in the present study specially to delimit the taxa between groups or within group mainly in *Torenia* and *Bonnaya*. This character is also used by Philcox (1968), Baden (2005), Liang and Wang (2014), Biffin *et al.* (2018).

5.2. Distribution

The distribution of taxa under the family is recorded throughout the country from eastern to western Nepal. Eastern Nepal accommodates 18 species among 20 species. Among these species one species of *Bonnaya* (*Bonnaya ruellioides*) and four species of *Torenia* (*Torenia anagallis, T. asiatica, T. diffusa* and *T. violacea*) are distributed to central Nepal but not so far recorded from western Nepal. Previous as well as recent studies have not recorded *B. ruellioides* from Western Himalaya and adjacent regions. Global distribution also shows its restriction to East Asia, East Himalaya and South-east Asia. Similarly *T. asiatica* was described from East Asia and still it is recorded only from East Asia, South-east Asia and Tibet. It seems that these are mostly the eastern elements and the westernmost distribution ranges to central Nepal. Though *T. anagallis*, *T. diffusa* and *T. violacea* are also recorded along wide range of Himalaya, their abundance must have on western Nepal also but has not been recorded from west Nepal probably due to the poor exploration in these areas.

Similarly, from the present study, it is seen that central Nepal accommodates all 20 species, Moreover 2 species; *Torenia hookeri* and *Vandellia multiflora* are restricted to central Nepal only. However, the Himalayan distribution of *V. multiflora* shows the distribution in western Himalaya (Hooker 1885, Pennell 1943, Chowdhary and Wadhwa 1984, and Stewart 1972) and in eastern Himalaya and southeast Asia (Malasiya and New Guinea) as well (Philcox, 1968). This scenario shows that this taxon could not be restricted only in central Nepal. As being the larger zone of Himalaya, it might occur in western and Eastern Nepal but not so far recorded. Further exploration in these regions may find the occurrence of this taxon.

Vertical distribution of taxa ranges from tropical (≤ 1000 m) to temperate zone (≤ 3000 m) within the country. Tropical and subtropical zones accommodate higher number of taxa. Tropical zone accommodates *Bonnaya* (5 spp.), *Lindernia* (2 spp.), Torenia (4 spp.), *Vandellia* (1 sp.) and *Yamazakia* (2 sp.). However, 2 species (*V.*

multiflora and *Y. viscosa*) are purely tropical. Similarly, in subtropical zone the distribution of species is as *Bonnaya* (5 spp.), *Craterostigma* (1 sp.), *Lindernia* (2 spp.), *Torenia* (7 spp.), *Vandellia* (1 sp.) and *Yamazakia* (1 sp.). 3 species of *Torenia* (*T. asiatica*, *T. diffusa* and *T. hookeri*) are restricted only in subtropical zone. Similarly 2 species, *Craterostigma nummularifolium* and *Torenia diffusa* are extended up to Temperate (upto 3000 m) zone. Both the species of *Lindernia* has wider range; tropical (80 m) to temperate (2500 m) of vertical distribution. (Appendix 2). This result resembles the worldwide distribution of the taxa of Linderniaceae as described by Philcox (1968), Lewis (2000), Liang and Wang (2014). The resemblance of geography of Nepal with global pattern might play a role in distribution matching of the taxa.

5.3. Hierarchial cluster analysis and generic affinities

The hierarchial cluster analysis is done within 19 species of Linderniaceae. Three species studied described from secondary literature are not included in cluster analysis as sufficient characters could not be obtained from literatures. Similarly one cultivated species *Torenia fournieri* is included to analyse the linkage between or within the species of *Torenia*. This result shows two distinct clusters in the dendrogram (Fig. 44). Cluster 1 is formed with the species of *Torenia, Bonnaya, Craterostigma, Lindernia and Vandellia* (Except *V. multiflora*). Subcluster 1.1 shows the *Torenia* group in A1 which are mainly characterized by winged tubular calyx and 4 fertile stamens with typically larger flower. Similarly in A2 *Craterostigma* is formed in a single cluster. This resembles the *Torenia* in many characters mainly the half lobed calyx. The well supported clade of *Craterostigma* near *Torenia* is shown by the molecular phylogenetic analysis such as Rahmanzadeh *et al.* (2005), Fischer *et al.* (2013) and Biffin *et al.* (2018). *Bonnaya* group in Subcluster 1.2 is divided into two major groups B1 and B2. Where B1 is represented by *Bonnaya* which are characterized by lanceolate shaped leaves and two fertile stamens. Anterior stamens are reduced into stamninodes. Fischer *et al.* (2013) as well as Liang and Wang (2014) in their molecular phylogenetic analysis strongly described this group as a distinct clade in phylogram from Bayesian inference of *trnK /matK* phylogeny. Whereas B2 is represented by *Lindernia* and *Vandellia*. A clade of *Lindernia* is distinctly formed featured by palmately veined leaves. This result is similar to Fischer *et al.* (2013) but

weakly matched with the result of Biffin *et al.* (2018) in which *Vandellia* is resolved as polyphyletic. (Fig. 44).

In cluster 2, two subclusters are formed where subcluster 2.1 is represented by two species each of *Vandellia* and *Yamazakia*. As mentioned earlier, *V. multiflora* and *Y. viscosa* share common inflorescence, glandular pedicel and calyx. However, *Y. pusilla* is near to the *Y. viscosa* which is characterized by the non-glandular pubescent pedicel and calyx. However this result is weakly matched with the molecular phylogenetic analyses. Biffin *et al.* (2018) suggested further morphological and molecular study to resolve the circumscription of *Yamazakia*.

5.4. Nomenclature change

Previously, majority of the species of Linderniaceae were circumscribed in a single genus *Lindernia* All. (*Lindernia s.l.*; Pennell 1935; 1943, Philcox 1968, Lewis 2000) or in separated genera (Link and Otto 1820, Wettstein 1891, Yamazaki 1954, Fischer 2004). Recent molecular phylogenetic studies have adopted a huge changing in nomenclature.

Before Linderniaceae, Nepalese taxa were also described under Scrophulariaceae under various genera. A major achievement was made by Rahmanzadeh *et al.* (2005) and Fischer *et al.* (2013) in nomenclature changing based on molecular and morphological analysis. Hara *et al.* (1982) and Press *et al.* (2000) enumerated 18 and 19 species of Nepalese Linderniaceae under two genera *Lindernia* s.l. and *Torenia* .

This study accepted the nomenclature change after Fischer *et al.* (2013). Where *Lindernia antipoda* (L.) Alston., *L ciliata,* (Colsm.) Pennell, *L. oppositifolia* (L.) Mukerjee *and L. Ruellioides* (Colsm) Pennell. are described under *Bonnaya*. Similarly, *L. nummularifolia* (D. Don) Wettst. is circumscribed as *Craterostigma nummularifolium* (D.Don) Eb.Fisch., Schäferh. & Kai Müll. as a new combination done based on *Vandellia nummularifolia* D. Don. Similarly *L. micrantha* D. Don. is changed as *Vandellia micrantha* (D.Don) Eb.Fisch., Schäferh. & Kai Müll. as a new combination. *L. multiflora* (Roxb.) Mukerjee is accepted as *Vandellia multiflora* (Roxb.) G. Don. Under *Lindernia s.str.* only two species, *L. parviflora* and *L. procumbens* are described.

Recent studies such as Liang and Wang (2014), (Biffin et al. 2018), and Rajbhandari *et al.* (2022) accepted the above mentioned names. However, Shrestha *et al.* (2022) accepted *Vandellia multiflora* (Roxb.) G. Don and for the same taxon and Rajbhandari *et al.* (2022) mentioned *Lindernia multiflora* (Roxb.) Mukerjee. Current study also followed Shrestha *et al.* (2022) and synonymized *L. multiflora* as recent molecular studies supports the similar nomenclature.

Lindernia anagallis (Burm. f.) Pennell. was changed into *Vandellia anagallis* (Burem.f.) T. Yamaz. (Fischer 2013). Recently it is changed as *Torenia anagallis* Burm.f.) Wannan, W.R.Barker & Y.S.Liang (Biffin et al. 2018). This study also followed the same nomenclature for this taxon. *Lindernia pusilla* (Willd.) Bold and *Lindernia viscosa* (Hornem.) Bold are circumscribed under new genera *Yamazakia* (Biffin *et al.* 2018). The new names for the taxa accepted in this study are *Y. pussilla* (Willd.) W.R.Barker, Y.S.Liang & Wannan and *Y. viscosa* (Hornem.) W.R.Barker, Y.S.Liang & Wannan. Recently *Lindernia hookeri* Wettst. Has been changed into *Torenia hookeri* (C.B.Clarke ex Hook.f.) A.Pal & M.Chowdhury as a new combination (Pal and Chowdhary (2022) which was used in previous literatures as *Vandellia hookeri* C.B.Clarke ex Hook.f.

5.5. Taxonomic problems

Problems with *Craterostigma sessiflorum* with *C. nummularifolium*

Recently Rajbhandari *et al.* (2022) enumerated *Craterostigma sessiflora* (Benth.) Y.S. Liang & J.C. Wang based on a specimen collected from Dadeldhura, west Nepal (KATH 012345). However, this taxon has not been enumerated in Shrestha *et al.* (2022). The specimen cited by first author has been studied and also compared other adjacent specimen in KATH, but could not confirm its presence in Nepal. Liang and Wang (2016) described this species based on *Vandellia sessiliflora* Bentham as a new combination. This taxon is delimited by its prostrate stem and sessile flowers. Whereas *C. nummularifolium* is characterized by erect stem and both sessile and pedicellate flowers, no character matching with *C. sessiliflorum* has been observed, instead this resembles with *C. nummularifolium*. Beside this, same specimen is cited for above mentioned two taxa. This study hence confirmed the specimen as *C. nummularifolium.* A further field based study is suggested for the confirmation of this taxon.

Doubt on Torenia hookeri

As many literatures such as Hara *et al.* (1982), Press et al. (2000), Shrestha *et al.* (2022), Rajbhandari *et al.* (2022) enumerated this taxon based on a specimen collected from central Nepal deposited in TI. Is this *Torenia hookeri* ?? In Present study, a field visit was made in September 2021 for the collection of this taxon around the places of collection but could not be found. However the description and photographs studied in literatures (Hooker 1885, Kumar and Maurya 2020, Pal and Chowdhury 2022 etc), vegetative characters matched with specimens collected during this study but differs in reproductive characters. It might be misidentified or the taxon might be extinct. A further detailed study is required for the confirmation of the presence of this species.

Problem of Torenia cordata with T. asiatica

Torenia cordata (Griff.) N.M.Dutta enumerated recently in Shrestha *et al.* (2022) and Rajbhandari *et al.* (2022) based on a specimen form eastern Nepal (KATH). However, during the morphological study of the specimen, its confirmation could not be done. Moreover its characters are much similar to *T. asiatica* and description is not in much detail in protologue. The recognition of this species was also mentioned as doubtful by Brutt (1991). This species was described by Dutta (1995) based on two specimens cited from Bengal; Brutt (1991) did not find similar plants from northen India but *T. cordata* was very similar to the *Torenia* collected from southern India which is discussed under *T. trancancorica.* Rajbhandari (2022) mentioned *T. cordata* as naturalized species in Nepal. A further plan for the collection and study of this species is made by the author of present study.

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CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The taxonomic study of newly recognized family Linderniaceae in Nepal is carried out based upon morphological characters of the taxa. A total of 20 species were described under six genera namely *Bonnaya, Craterostigma, Lindernia, Torenia, Vandellia and Yamazakia*. Out of which 17 species were studied by examining the fresh specimens collected by field visiting, whereas three species (*Bonnaya tenuifolia, Torenia cordata, Torenia hookeri*) by various secondary literatures due to unavailability of herbarium specimens.

Species of the family show great variation in morphological characters which were sufficient to distinguish them. Major characters that were relevant in delimitation of the taxa are related to leaves, trichomes, flowers, stamens and pistil. On the basis of these characteristics, a detailed description with identification keys, distribution pattern and cluster analysis is prepared. The distribution pattern of the species is somehow unclear that shows the poor exploration of taxa in western Nepal. A great change in nomenclature of the taxa based on recent molecular studies is accepted. A final draft of taxonomic study of Linderniaceae for the partial fulfillment of Master's degree is prepared. This work hopefully will contribute for upcoming update of the flora of Nepal and further research.

6.2. Recommendations

This work is mainly based upon fresh specimens collected from various parts of Nepal and herbarium specimens housed in TUCH and KATH. This is only a small part of revisionary work done to fulfill the partial requirement of Master's degree. However this study scratched a part of taxonomy of Linderniaceae and recommends further works to do as following:

- Representation of the taxa of the family is poor in our National herbaria, a further exploration from western part is highly recommended.
- Species which are enumerated in recent literatures are based on the specimen housed in international herbaria. Some of the species enumerated in such literatures are doubtful and being difficult to conclude the presence of taxa in Nepal.

- Some of the specimens housed in KATH were found with a label containing very little informations; this should be improved as the label is the primary information of the taxon.
- Some of the potologues are not easily accessible; there is a need to have standard journals and literatures in our libraries or access to them.
- The concerned authorities should take the initiation for the easier availability of the laboratory instruments, improvement in the sophisticated working environment.
- A molecular level study is required to solve the problems of taxa mentioned in discussion, but the environment for this should be created first. I recommend the concerned authorities to take this action.

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APPENDICES:

Appendix 1

Data matrix prepared for cluster analysis

		Character state coding																	
S.N.	Species	L.F.	St.F.	St. Txt.	Lf.At.	Lf. Shape	Lf. Base	Lf. Apex	Lf. Margin	Ad. Surface	Ab. Surface	Lf.Vein	Infl.	Br.	Pd. Text	Ca. lobes	Ca. base	Lb. size	Lb.Txt.
1.	*B. antipoda*	0	0	0	0	0	0	0	1	0	0	1	2	1	0	0	1	1	0
2.	*B. ciliata*	0	0	1	1	0	0	1	2	1	1	1	2	1	1	0	0	1	1
3.	*B. oppositifolia*	0	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0	0	1
4.	*B. ruellioides*	1	1	1	2	2	0	2	2	1	1	1	2	1	0	0	0	1	1
5.	*B. tenuifolia*	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0
6.	*C. nummularifolium*	0	0	2	1	3	2	0	1	1	1	1	4	1	1	0	1	0	1
7.	*L. parviflora*	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1
8.	*L. procumbens*	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1
9.	*T. asiatica*	0	1	2	2	1	0	0	1	1	1	1	1	1	1	1	0	1	1
10.	*T. anagallis*	0	1	0	1	1	3	0	1	0	0	1	0	0	0	0	0	1	0
11.	*T. crustacea*	0	0	1	2	1	0	0	1	1	1	1	2	0	1	1	0	1	1
12.	*T. cordifolia*	0	0	2	2	1	0	0	1	1	1	1	3	1	1	1	2	1	1
13.	*T. diffusa*	0	0	2	2	1	0	0	1	1	1	1	1	1	1	1	1	1	1
14.	*T. fourneiri*	0	0	2	2	1	0	0	1	1	1	1	2	1	1	1	0	1	1
15.	*T. violacea*	0	1	2	2	1	0	0	1	1	1	1	2	1	1	1	0	1	1
16.	*V. micrantha*	0	0	2	1	0	0	0	0	0	0	2	0	0	0	0	3	1	0
17.	*V. multiflora*	0	0	2	1	1	1	0	1	1	1	1	2	1	2	0	0	1	2
18.	*Y. pussilla*	0	0	3	1	1	0	0	1	1	1	1	0	0	1	0	0	1	1
19.	*Y. viscosa*	0	0	3	1	1	1	0	1	2	2	1	2	1	2	0	0	0	2

S.N.	Species	Tb. Size	Tb. Base Col.	Tb. Col.	Tb. Base	Tb. Txt. Out	Tb. Txt.in	Up. Lip	Up. Size	Md. Lobe	Lt. lobes	No. of St.	St Col.	St. base	St. txt.	An. Base	Ov. Length	Ov. Shape	Ov. Apex	Sty. Length	Fr. Shape	Fr. Size	Fr. Post	Fr. Txt.
1.	*B. antipoda*	1	0	2	0	1	1	4	1	1	0	1	0	0	1	1	0	0	0	1	0	1	2	0
2.	*B. ciliata*	0	1	3	1	1	1	2	1	1	0	1	0	0	1	1	0	0	0	0	0	1	2	0
3.	*B. oppositifolia*	0	0	2	0	0	1	4	0	1	0	1	0	0	1	1	0	0	0	0	0	1	2	0
4.	*B. ruellioides*	1	1	2	0	1	1	4	1	1	0	1	0	0	1	1	1	1	0	1	0	1	2	0
5.	*B. tenuifolia*	0	0	2	0	1	1	4	0	1	0	1	2	0	1	1	0	0	0	0	0	1	2	0
6.	*C. nummularifolium*	1	0	2	1	0	1	4	0	2	0	0	2	2	1	1	0	0	0	1	2	1	2	0
7.	*L. parviflora*	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	0	1	0	0	1	1	2	0
8.	*L. procumbens*	0	1	1	0	0	0	5	0	1	0	0	1	1	0	1	0	1	0	0	1	1	1	0
9.	*T. asiatica*	1	1	2	0	1	1	4	1	1	1	0	2	1	1	1	1	1	1	1	1	1	0	1
10.	*T. anagallis*	1	0	2	0	1	0	4	0	0	0	0	2	1	0	0	0	2	0	0	0	1	2	0
11.	*T. crustacea*	1	0	2	1	0	1	4	1	1	0	0	2	1	1	1	0	1	0	1	2	1	1	0
12.	*T. cordifolia*	1	1	2	0	0	0	3	1	1	0	0	2	1	1	1	1	1	1	1	1	1	0	1
13.	*T. diffusa*	1	1	2	0	0	0	4	1	1	0	0	2	1	0	1	1	1	1	1	1	1	0	1
14.	*T. fourneiri*	1	0	4	0	1	1	6	1	0	1	0	1	0	0	1	1	1	1	1	1	1	0	1
15.	*T. violacea*	1	0	2	0	1	0	4	1	0	0	0	1	0	0	1	1	1	1	1	1	1	0	1
16.	*V. micrantha*	1	0	3	0	1	1	5	1	0	0	0	1	1	0	0	0	0	0	1	0	1	2	0
17.	*V. multiflora*	0	1	1	1	0	0	0	0	0	0	0	1	2	0	1	0	0	0	0	2	0	1	0
18.	*Y. pussilla*	1	1	1	1	0	0	0	0	2	0	0	3	2	0	1	0	0	0	1	2	0	1	0
19.	*Y. viscosa*	0	1	2	1	0	0	0	0	2	0	0	1	2	0	1	0	0	0	0	2	0	1	0

Appendix 2:

Distribution pattern of taxa of Linderniaceae in Nepal

Species	Vertical Distribution (Elevation in Meter)	Horizontal Distribution
B. antipoda	80-1500	WCE
B. ciliata	80-1600	WCE
B. oppositifolia	85-1500	WCE
B. ruellioides	400-1800	CE
B. tenuifolia	87-1500	WCE
C. nummularifolium	1200-3000	WCE
L. parviflora	80-2300	WCE
L. procumbens	80-2500	WCE
T. anagallis	80-1600	CE
T. asiatica	1500-2000	CE
T. cordifolia	800-1800	WCE
T. crustacea	80-2000	WCE
T. diffusa	1000-2200	CE
T. hookeri	1500-1600	C
T. violacea	150-1800	CE
V. micrantha	1000-1800	WCE
V. multiflora	100-400	C
Y. pussilla	80-1800	CE
Y. viscosa	80-300	WCE

Appendix 3: Comparative account on stem habit and stem in Linderniaceae

S.N.	Name of the Species	Life form	Habit	Size	Stem				
					Colour	Form	Shape	Branching	Texture
1.	*B. antipoda*	Annual	Herb	5-25 cm	Green	Erect or Decumbent	Quadrangular	Diffusely branched from base	Glabrous
2.	*B. ciliata*	Annual	Herb	4-15 cm	Green	Erect	Quadrangular	Branched above	Sparsely pubescent
3.	*B. oppositifolia*	Annual	Herb	4-25 cm	Green	Erect	Quadrangular	Branched	Glabrous
4.	*B. ruellioides*	Perennial	Herb	5-30 cm	Green or purplish green	Prostrate	Quadrangular	Branched	Subglabrous
5.	*B. tenuifolia*	Annual	Herb	5-20 cm	Green	Erect or ascending	Quadrangular	Branched	Glabrous
6.	*C. nummularifolium*	Annual	Herb	5-15 cm	Green to light green	Erect	Quadrangular	Branched	Sparsely pubescemt
7.	*L. parviflora*	Annual	Herb	5-30 cm	Green	Erect	Quadrangular	Branched	Glabrous
8.	*L. procumbens*	Annual	Herb	5-20 cm	Green to Reddish Green	Erect	Quadrangular	Branched	Glabrous
9.	*T. anagallis*	Annual	Herb	10-50 (-60) cm	Green to Purplish Green	Prostrate	Quadrangular	Branched	Glabrous
10.	*T. asiatica*	Annual	Herb	5-30 cm	Green	Prostrate	Quadrangular	Branched	Sparsely pubescent
11.	*T. cordata*	Annual	Herb	-	-	prostrate	Quadrangular	Diffusely Branched	Subglaborus or pubescent
12.	*T. cordifolia*	Annual	Herb	5-30 cm	Green	Erect	Quadrangular	Branched from base	Sparsely pubescent
13.	*T. crustacea*	Annual	Herb	5-20 cm	Green or purplish green	Decumbent	Quadrangular	Branched from base	Sparsely pubescent
14.	*T. diffusa*	Annual	Herb	8-30 cm	Green	Decumbent	Quadrangular	Diffusely branched from base	Sparsely pubescent
15.	*T. hookeri*	Annual	Herb	5-30 cm	Green	Erect or ascending	Quadrangular	Branched	Hiruste all over
16.	*T. violacea*	Annual	Herb	5-25 cm	Green or purplish green	Erect	Quadrangular	Branched	Sparsely pubescent
17.	*V. micrantha*	Annual	Herb	5-25 cm	Green	Erect	Quadrangular	Branched	Glabrous
18.	*V. multiflora*	Annual	Herb	5-20 cm	Green	Erect or decumbent	Quadrangular	Branched	Sparsely pubescent mainly on nodes
19.	*Y. pussilla*	Annual	Herb	5-25 cm	Green	Erect or decumbent	Quadrangular	Branched	Sparsley pubescent
20.	*Y. viscosa*	Annual	Herb	4-20 cm	Green	Erect	Quadrangular	Branched	Hirsute all over

Appendix 4: Comparative account on Leaves in Linderniaceae.

S.N.	Name of the Species	Leaves										
		Arrangement	Attachment			Shape	Size	Base	Apex	Margin	Texture	Venation
			Sessile	Petiolate								
				Petiole Size	Texture							
1.	*B. antipoda*	Opposite	Sessile	-	-	lanceolate-oblong lanceolate	15-50×5-15 mm	Cuneate	Acute	Ciliate Serrate	Glabrous	Pinnate
2.	*B. ciliata*	Opposite	Upper leaves Sessile	2-3 mm	Sparsely pubescent	Oblong or Oblong-lanceolate	8-38×3-12 mm	Broadly cuneate or amplexicaul	Acute-aristate	Aristate	Sparsely pubescent	Pinnate
3.	*B. oppositifolia*	Opposite	Sessile	-	-	Oblong-lanceolate	18-35×5-6 mm	Cuneate	Acute	Serrate	Glabrous	Pinnate
4.	*B. ruellioides*	Opposite	-	4-20 mm	Subglabrous	Oblong ovate or suborbicular	0.9-3.8×0.6-2.1 cm	Cuneate	Obtuse-round	Ciliate Serrate	Glabrous	Pinnate
5.	*B. tenuifolia*	Opposite	Sessile	-	-	Linear-lanceolate	8-30×0.5-5 mm	Cuneate	Acute	Crenate	Glabrous	Pinnate
6.	*C. nummularifolium*	Opposite	Sessile to short petiolate	1.5-2 mm	Sparsely pubescent	Broadly ovate - orbicular	1.6-2.5×1.4-2.2 cm	Rounded	Acute	Serrrate	Sparsely pubescent	Pinnate
7.	*L. parviflora*	Opposite	Sessile	-	-	Trinagular ovate	8-14×5-8 mm	Cuneate	Acute	Subentire to dentate	Glabrous	Palmate
8.	*L. procumbens*	Opposite	Sessile	-	-	Triangular ovate	12-23×4-15 mm	Cuneate	Acute	Dentate	Glabrous	Palmate
9.	*T. anagallis*	Opposite	Subsessile to short petiolate	2-3 mm	Glabrous	Ovate	10-15×8-12 mm	Cuneate	Acute	Serrate	Glabrous	Pinnate
10.	*T. asiatica*	Opposite	-	13-16 mm	Sparsely pubescent	Ovate	1.5-3.2×1-2 cm	Cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
11.	*T. cordata*	Opposite	-		Sparsely pubescent	Ovate or lanceolate	6 cm long	Subcordate or cuneate	Acute	Crenate or serrate	Sparsely pubescent	Pinnate

12.	*T. cordifolia*	Opposite	-	4-8 mm	Sparsely pubescent	Ovate	1.5-4.5×0.8-2.6 cm	Round - subcordate	Acute	Serrate	Sparsely pubescent	Pinnate
13.	*T. crustacea*	Opposite	-	1-7 mm	Subglabrous	Triangular- Ovate	12-20×5-16 mm	Cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
14.	*T. diffusa*	Opposite	-	3-10 mm	Sparsely pubescent	Ovate	1.8-3.2×1-2.5 cm	Cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
15.	*T. hookeri*	Opposite	-	5-8 mm	Sparsely pubescent	Ovate	15-25×5-15 mm	Cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
16.	*T. violacea*	Opposite	-	5-8 mm	Sparsely pubescent	Ovate	1.8-3.5×1-2.1 cm	Round-slightly cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
17.	*V. micrantha*	Opposite	Sessile	-	-	Oblong-ensiform	11-28×2-5 mm	Cuneate	Acute	Obscurely serrate	Glabrous	Pinnate
18.	*V. multiflora*	Opposite	Upper leaves sessile	2-3 mm	Sparsely pubescent	Ovate	10-25×8-18 mm	atteunate	Acute	Serrate	Sparsely pubescent on midrib	Pinnate
19.	*Y. pussilla*	Opposite	-	0.5-2 mm	Sparsely pubescent	Ovate	10-18×7-17 mm	Cuneate	Acute	Serrate	Sparsely pubescent	Pinnate
20.	*Y. viscosa*	Opposite	-	2-10 mm	Densely villous	Elliptic –broadly ovate	0.9-3.1×0-8-2.1 cm	Atteunate	Acute	Serrate	Hiruste	Pinnate

Appendix 5: Comparative account on bract and pedicel in Linderniaceae.

S.N.	Name of the Species	Type of inflorescence	Bract					Pedicel	
			Ebracteate	Bracteate				Size	Texture
				Shape	Size	Apex	Margin/Texture		
1.	*B. antipoda*	Axillary solitary or terminal raceme	-	Lanceolate	3-5×ca. 2 mm	Acute-acuminate	Margin ciliate, surface glabrous	11-15 mm	Glabrous
2.	*B. ciliata*	Axillary solitary or terminal raceme	-	Lanceolate	4-7×1-1.2 mm	Spinelike	Margin Ciliate serrate, surface glabrous	1-4 mm in flower, 3-6 mm in fruit	Glabrous
3.	*B. oppositifolia*	Axillary or terminal raceme	-	Oblong lanceolate at base, upper bracts lanceolate	5-15 mm	Acute	Margin Ciliate serrate, surface glabrous	4-6 mm in flower, 7-12 mm in fruit	Glabrous
4.	*B. ruellioides*	Terminal raceme	-	Lanceolate	4-6×1.1.5 mm	Acute	Margin ciliate Serrate, surface glabrous	8-12 mm in flower, 10-14 mm in fruit	Glabrous
5.	*B. tenuifolia*	Terminal raceme	-	Linear-ovate	1-1.2× ca.2 mm	Acute	-	2-10 mm	Glabrous
6.	*C. nummularifolium*	Axillary and terminal umbel like	-	Lanceolate-ovate	0.6-0.8 mm	Acute	Margin ciliate serrate, surfaces sparsely pubescent	4-12 mm in flower and fruit	Pubescent
7.	*L. parviflora*	Axillary solitary	Ebracteate	-	-	-	-	9-13 mm in flower, upto16 mm in fruit	Glabrous
8.	*L. procumbens*	Axillary solitary	Ebracteate	-	-	-	-	7-10 mm in flower, 10-16 mm in fruit	Glabrous
9.	*T. anagallis*	Axiallary solitary	Ebracteate	-	-	-	-	8-14 mm in flower, 1.6-2.5 cm in fruit	Glabrous
10.	*T. asiatica*	Axillary and terminal solitary	-	Linear-lanceolate	3-20 mm	Acute-Acuminate	Margin ciliate serrate, surfaces sparsely pubescent	1.5-2.5 cm in flower, 2.5-3 cm in fruit	Sparsely pubescent
11.	*T. cordata*								
12.	*T. cordifolia*	Axillary umbel like	-	Lanceolate	4-12×3-6 mm	Acute-acuminate	Margin ciliate serrate, surfaces sparsely pubescent	7-13 mm in flower, 1.5-2.2 cm in fruit	Sparsely pubescent
13.	*T. crustacea*	Axillary solitary	Ebracteate	-	-	-	-	6-15 mm in flower, upto 20 mm in fruit	Sparsely pubescent
14.	*T. diffusa*	Axillary solitary	-	Linear-lanceolate	1-3×ca. 0.5 mm	Acuminate	Margin ciliate serrate, surfaces sparsely pubescent	6-14 mm in flower, 1.5-2.5 cm in fruit	Sparsely pubescent

15.	*T. hookeri*	Axillary solitary or terminal umbel-like	-	-	-	-	-	5-15 mm in flower, 9-25 mm in fruit	Densely pubescent
16.	*T. violacea*	Axillary solitary and terminal raceme	-	Lanceolate	3-4 mm	Acuminate	Margin ciliate serrate, surfaces sparsely pubescent	1.5-3 cm in flower, upto 3.5 cm in fruit	Pubescent
17.	*V. micrantha*	Axillary solitary	Ebracteate	-	-	-	-	9-15 mm in flower, upto 20 mm in fruit	Glabrous
18.	*V. multiflora*	Terminal raceme	-	Lower bracts ovate-suborbicular, upper bracts triangular-ovate	8-10×5-8 mm	Acute	Margin ciliate serrate, surfaces Villous	3-5 mm in flower, 7-9 mm in fruit	Glandular
19.	*Y. pussilla*	Axillary solitary	Ebracteate	-	-	-	-	1-2.5 cm in flower, upto 3 cm in fruit	Pubescent
20.	*Y. viscosa*	Terminal raceme		Lower bracts ovate-broadly ovate, upper bracts lanceolate	1.3-2.1 cm	Acute	Margin ciliate serrate, surfaces pubescent	3.5 mm in flower, 7-10 mm in fruit	Glandular

Appendix 6: Comparative account on calyx in Linderniaceae.

S.N.	Name of the Species	Calyx shape/lobes	Tube shape	Tube Base	Lobes shape	Lobes size	Apex	Lobes margin	Wings margin	Lobes texture
1.	*B. antipoda*	Distinctly 5-lobed upto base	-	-	Lanceolate	4-6 (-8)× ca. 0.3 mm	Acute	Serrate	-	Glabrous
2.	*B. ciliata*	Distinctly 5- lobed upto base	-	-	Lanceolate	3-5 (-6)×ca. 0.5 mm	Acute	Serrate		Glabrous
3.	*B. oppositifolia*	Distinctly 5- lobed upto base	-	-	Linear-lanceolate	1-3 (-4)×ca. 0.3 mm	Acute	Serrate		Glabrous
4.	*B. ruellioides*	Distinctly 5- lobed upto base	-	-	Lanceolate	4-8 (-10)×1.8-2 mm	Acute	Serrate		Subglabrous
5.	*B. tenuifolia*	Distinctly 5- lobed upto base	-	-	Lanceolate	2-2.2 mm	Acute	-	-	Glabrous
6.	*C. nummularifolium*	5- Lobed upto half of the tube	obovoid	round	Elliptic-ovate	2-3 (-4)×ca. 1 mm	Acute	Pubescent-Serrate	-	Midvein Sparsely pubescent
7.	*L. parviflora*	Distinctly 5- lobed upto base	-	-	Lanceolate	2-3 (-4)×ca. 1 mm	Acute	Serrate	-	Midvein subglabrous
8.	*L. procumbens*	Distinctly 5- lobed upto base	-	-	Lanceolate	3-3.5×1-1.5 mm	Acute	Serrate	-	Midvein subglabrous
9.	*T. anagallis*	Distinctly 5-lobed upto base	-	-	Lanceolate	3-5×1-1.5 mm	Acute-acuminate	Serrate	-	Glabrous
10.	*T. asiatica*	Bilipped, 2×3 lobed	Elliptic-ovoid	Rounded - Cuneate	Elliptic-ovate	10-20 (-23)×5-8 mm	Acute	Serrate	Pubescent Serrate	Sparsely pubescent
11.	*T. cordata*	Bilipped, 2×3 lobed	Lanceolate-ovate	decurrent	Lanceolate	5-20 mm	-	-	-	Glabrous
12.	*T. cordifolia*	Bilipped, 2×3 lobed	Ovoid, broadest towards base	Rounded-subcordate	Ovate	8-12 (-14)×3-5 mm	Acute-acuminate	Serrate	Pubescent-serrate	Sparsely pubescent
13.	*T. crustacea*	Bilipped, 2×3 lobed	Tubular	Cuneate	Triangular-ovate	4-6 (-7)×1.5-2 mm	Acute-acuminate	Serrate	Pubescent serrate	Pubescent

14.	*T. diffusa*	Bilipped, 2×3 lobed	Elliptic-Ovoid	Rounded or slightly cuneate	Lanceolate-ovate	15-18×4-6 mm	Acute	Serrate	Pubescent serrate	Sparsely Pubescent
15.	*T. hookeri*	Bilipped, 2×3 lobed	Tubular	-	Lanceolate-ovate	4-5 mm in flower, 6-7 mm in fruit	-	-	Pubescent serrate	Densely pubescent
16.	*T. violacea*	Bilipped, 2×3 lobed	Elliptic - ovoid	Cuneate	Elliptic-ovate	14-18×3-4 mm	Acute	Serrate	Pubescent	Sparsely pubescent
17.	*V. micrantha*	Distinctly 5-lobed to the base	-	-	Lanceolate	3-4 9-5.5)×ca. 0.5 mm	Acute-acuminate	Ciliate-Serrate	-	Glabrous
18.	*V. multiflora*	Distinctly 5-lobed to the base	-	-	Lanceolate	2.5-3× ca. 0.5 mm	Acute-acuminate	Serrate	-	Glandular
19.	*Y. pussilla*	Distinctly 5-lobed	-	-	Lanceolate-ovate	3.5-4×0.8-1 mm	Acute-acuminate	Serrate	-	Pubescent
20.	*Y. viscosa*	Distinctly 5-lobed	-	-	Lanceolate	2.5-3× ca.0.8 mm	Acute	Ciliate-serrate	-	Glandular

Appendix 7: Comparative account on Corolla in Linderniaceae.

S.N.	Name of the Species	Corolla tube			Lower lip					Upper lip		
		Colour	Size	Texture	Middle lobe colour	Middle lobe size	Lateral lobes colour	Laeral lobes size	Texture	Colour	Size	Texture
1.	*B. antipoda*	Base yellow, whitish purple above	5-7 mm	Glandular outside, ciliate inside between staminodes	White or Whitish purple	4-6×3-4.5 mm	White or Whitish purple	3-3.5×ca. 1 mm	Glabrous	White or whitish purple	4-5×2-2.5 mm	Glabrous
2.	*B. ciliata*	Base white, whitish pink above	3-4 mm	Glandular outside, ciliate inside near throat	White pink with pink spots	1.8-2×2-2.2 mm	Whitish pink	1.5-1.8×2-2.2 mm	Glabrous	Whitish pink	2.5-3×1-1.2 mm	Glabrous
3.	*B. oppositifolia*	Base pale yellow, white pink above	3-3.5 mm	Glabrous	Whitish pink	2-2.5×2.5-3 mm	Whitish pink	2-2.5×2.5-3 mm	Glabrous	Whitish pink	2.5-3.5×1.2-1.5 mm	Gabrous
4.	*B. ruellioides*	Base pale yellow, reddish purple above	6-10 mm	Glandular outside, ciliate inside between staminodes	Reddish purple	3.5-4×5-5.5 mm	Reddish purple	3-3.2×3.8-4 mm	Glabrous	Whitish purple	5-5.5×4.5-5 mm	Glabrous
5.	*B. tenuifolia*	Bluish purple	2-3 mm	Glandular outside	Purple	2-2.5×3-3.5 mm	Purple	2-2.5×3-3.5 mm	Glabrous	-	2-2.5×2-2.2 mm	Glabrous
6.	*C. nummularifolium*	Purplish white	4.5-5 mm	Glabrous outside, ciliate inside at the base of stamens	Dark purple	1.8-2×1.5-2 mm	Pale purple or white purple	1.8-2×1.5-2 mm	Glabrous	Purple	2.8-3.2×1.8-2.5 mm	Pubescent along marginside
7.	*L. parviflora*	Creamy white	5-6 mm	Glandular outside, ciliate inside, ciliate inside between staminodes	Creamy white	ca. 1.5×1.5 mm	Creamy white	ca. 1.5×1.5 mm	Glabrous	Creamy white	1.5-2×ca. 2 mm	Glabrous
8.	*L. procumbens*	Creamy white	2.5-3 mm	Glabrous	Whitish pink	2-2.4×2-2.2 mm	Whitish pink	2-2.2×1.2-1.5 mm	Glabrous	White pink	1.8-3×1.5-2 mm	Glabrous
9.	*T. anagallis*	Base yellow, purple-pink white above	6-8 mm	Glandular outside, glabrous inside	Purplish or pinkish white, with yellow patch at middle	3-3.5×3.5-4 mm	Purplish or pinkish white	2.5-3×ca. 3 mm	Glabrous	Purplish or pinkish white	2.5-3×ca. 3 mm	Glabrous
10.	*T. asiatica*	Base white, white purple above	2-2.4 cm	Glandular outside, ciliate inside near throat	Whitish Purple	7-12×6-10 mm	Whitish purple with dark purple patches	5-9×4-8 mm	Glabrous outside, bases ciliate insdide	Whitish purple	7-11×8-9 mm	Glabrous

11.	*T. cordata*	Bluish purple	2.5-3 cm	-	Bluish purple	-	Bluish purple	-	Bluish purple with dark violet patches	-	-	-
12.	*T. cordifolia*	Base whitish yellow, purple towards throat	14-16 mm	Glandular outside, glabrous inside	Whitish Purple	3.5-5×4.5-5 mm	Whitish purple or with dark blue patches	3.5-5×4.5-5 mm	Glabrous	Whitish purple	4-6×5.5-6 mm	Glabrous
13.	*T. crustacea*	Base yellow, purple above	5-8 mm	Glabrous outside, ciliate inside near throat	White purple with distinct white patch	2-2.5×2-2.2 mm	White purple	2-2.5×2-2.2 mm	Glabrous	White purple	3-3.3×3.3-3.5 mm	Glabrous
14.	*T. diffusa*	Base white, purple above	14-16 mm	Glabrous	Whitish Purple	7-12×6-10 mm	Whitish purple	5-9×4-8 mm	Glabrous	Purple	7-11×8-9 mm	Glabrous
15.	*T. hookeri*	Base yellow purple yellow above	4.5-5 mm	-	White purple with distinct yellow patch	2.3-2.5×2.5-2.7 mm	White purple	2.3-2.5×2.5-2.7 mm	Glabrous	Purple	2-2.5×3-3.5 mm	Glabrous
16.	*T. violacea*	Base white, yellow upto half, purplish white above	12-18 mm	Glandular outside, glabrous inside	Purplish white, distinct yellow patch in middle inside	4-4.5×5-6 mm	Purplish white	3.5-4×3.5-4 mm	Glabrous	Purplish white	5-6×8-9 mm	Glabrous
17.	*V. micrantha*	Base yellow, whitish pink above	5-7 mm	Glandular outside, ciliate inside near throat	Whitish pink, distinct yellow patch inside	3-4×2.5-3 mm	Whitish pink	3-4×2.5-3 mm	Glabrous	White or whitish pink	3-3.5×4-5 mm	Glabrous
18.	*V. multiflora*	Creamy white, distinct yellow spot near throat	3-3.5 mm	Glabrous	Pinkish white	1.8-2×ca.1 mm	Whitish pink	1.2-1.5×ca.1 mm	Glabrous	Pinkish brown	1.8-2×1.2-1.5 mm	Glabrous
19.	*Y. pussilla*	Yellowish white	3.5-4 mm	Glabrous	Creamy or purplish white	2.5-3×2.8-3 mm	Creamy or purplish white	2.5-3×2.8-3 mm	Glabrous	Brown	2.5-3×ca. 3 mm	Glabrous
20.	*Y. viscosa*	Creamy white	4-5 mm	Glabrous	Creamy white	1.3-1.5×1-1.2 mm	Creamy white	1.3-1.5×1-1.2 mm	Glabrous	Brown	1.8-2×ca.2 mm	Glabrous

Appendix 8: Comparative account on Androecium in Linderniaceae

S.N.	Name of the Species	Posterior stamens				Anterior stamens/staminodes					
		Filaments			Anthers	Filaments				Appendages	Anthers
		Colour	Size	Texture	Size	Colour	Size	base	texture	Size	Size
1.	*B. antipoda*	White or purplish white	1.5-2 mm	Glabrous	1.5-1.8 mm	Yellow	4-4.5 mm	unappendaged	Villous	-	-
2.	*B. ciliata*	Pinkish white	2-2.5 mm	Glabrous	0.5-1 mm	Whitish pink	1-1.5 mm	unappendaged	villous	-	-
3.	*B. oppositifolia*	Purplish white	2.5-3mm	Glabrous	0.3-0.4 mm	Yellow	2.8-3 mm	unappendaged	villous	-	-
4.	*B. ruellioides*	Purplish white	2-2.2 mm	Glabrous	0.5-0.6 mm	Yellow	2-2.2 mm	unappendaged	villious	-	-
5.	*B. tenuifolia*	Purplish white	1-1.2 mm	Glabrous	0.5-0.7 mm	-	0.5-1.5 mm	unappendaged	Villous	-	-
6.	*C. nummularifolium*	white	1.5-2 mm	Glabrous	0.8-1 mm	Purplish white	2.2-2.5 mm	Swollen node	glaborus	-	0.5-0.8 mm
7.	*L. parviflora*	White	1-1.2 mm	Glabrous	0.5-0.8 mm	Creamy white	1.5-2 mm	appendaged	villous	-	-
8.	*L. procumbens*	Pinkish white	0.3-0.5 mm	Glabrous	0.3-0.5 mm	Creamy white	0.8-1 mm	appendaged	villous	0.5-0.7 mm	0.3-0.5 mm
9.	*T. anagallis*	White	1.5-2 mm	Glabrous	ca. 1 mm	Purplish white	3-4.5 mm	appendaged	glabrous	0.8-1 mm	1-1.5 mm
10.	*T. asiatica*	Whitish purple	3-4.5 mm	Glabrous	2.5-3 mm	Pale purple	6-8 mm	appendaged	Pubescent around	3-4 mm	1.8-2 mm
11.	*T. cordata*	-	ca. 5 mm	-	ca. 2 mm	-	ca. 1 cm	appendaged	-	ca. 6 mm	ca. 2 mm
12.	*T. cordifolia*	Whitish purple	3-4 mm	Glabrous	2.5-3 mm	Pale purple	4-6 mm	appendaged	Pubescent around	1.5-2 mm	1.5-1.8 mm
13.	*T. crustacea*	Whitish purple	2.5-3 mm	Glabrous	1.1-1.3 mm	Pale purple	4-5 mm	appendaged	Pubescent around	1.5-1.8 mm	0.8-1 mm
14.	*T. diffusa*	Whitish purple	1.5-2 mm	Glabrous	1-1.2 mm	Pale purple	4-7 mm	appendaged	glabrous	1-2 mm	1-1.2 mm
15.	*T. hookeri*	White purple	ca. 1.5 mm	-	-	Pale purple	ca. 2.5 mm	appendaged	-	ca. 0.3 mm	-
16.	*T. violacea*	Whitish purple	3-3.5 mm	Glabrous	2.5-3 mm	Purplish white	6-7.5 mm	unappendaged	glabrous	-	1.8-2 mm
17.	*V. micrantha*	White	2-2.5 mm	Glabrous	1.5-1.8 mm	White	4-5 mm	appendaged	glabrous	1.2-1.5 mm	1-1.2 mm
18.	*V. multiflora*	White	1-1.2 mm	Glabrous	0.3-0.5 mm	Creamy white	2-2.5 mm	Swollen	glabrous	-	0.8-1 mm
19.	*Y. pussilla*	White	1-1.2 mm	Glabrous	1-1.2 mm	Creamy white	2-2.5 mm	Swollen	villous	-	0.8-1 mm
20.	*Y. viscosa*	White	1.5-1.8 mm	Glabrous	0.8-1 mm	White	2.8-3.1 mm	Swollen	glabrous	-	0.6-0.8 mm

Appendix 9: Comparative account on Gynoecium in Linderniaceae.

S.N.	Name of the species	Ovary			Disc		Style		Stigma	
		Shape	Size	Texture	Colour	Position	Size	Texture	Shape	Texture
1.	*B. antipoda*	Ovoid	1.5-2 mm	Glabrous	Pale Yellow	Anterior	6-7 mm	Glabrous	Bilipped	Ciliate inside
2.	*B. ciliata*	Oblong-Ovoid	0.8-1 mm	Glabrous	Greenish yellow	Anterior	3-4 mm	Glabrous	Bilipped	Ciliate inside
3.	*B. oppositifolia*	Oblong-Ovoid	1.5-2 mm	Glabrous	Pale green	Anterior	3.5-4 mm	Glabrous	Bilipped	Ciliate inside
4.	*B. ruellioides*	Oblong-Ovoid	2.5-3 mm	Glabrous	Greenish yellow	Anterior	5-7 mm	Glabrous	Bilipped	Ciliate inside
5.	*B. tenuifolia*	Elliptic	1-1.2 mm	Glabrous	-	-	3.5-4 mm	Glabrous	Bilipped	Ciliate inside
6.	*C. nummularifolium*	Ovoid	1-1.2 mm	Glabrous	Greenish yellow	Anterior	4-5 mm	Glabrous	Bilipped	Ciliate inside
7.	*L. parviflora*	Oblong-Ovoid	1.5-2 mm	Glabrous	Yellow	Anterior	2.5-3 mm	Glabrous	Bilipped	Ciliate inside
8.	*L. procumbens*	Oblong-Ovoid	1-1.5 mm	Glabrous	Pale yellow	Basal	3-3.5 mm	Glabrous	Bilipped	Ciliate inside
9.	*T. anagallis*	Elliptic	1.5-2 mm	Glabrous	Yellow	Basal	3-3.5 mm	Glabrous	Bilipped	Ciliate inside
10.	*T. asiatica*	Oblong	3-5 mm	Apex pubescent	Yellow	Basal	15-20 mm	Glabrous	Bilipped	Ciliate inside
11.	*T. cordata*	Narrowly Oblong	5-10 mm	-	-	-	2.5-3 cm	Glabrous	Bilipped	Ciliate inside
12.	*T. cordifolia*	Oblong	2-3 mm	Apex pubescent	Yellow	Basal	14-17 mm	Glabrous	Bilipped	Ciliate inside
13.	*T. crustacea*	Oblong-Ovoid	1.2-1.5 mm	Apex Subglabrous	Pale yellow	Basal	5-6 mm	Glabrous	Bilipped	Ciliate inside
14.	*T. diffusa*	Oblong	3-4 mm	Apex pubescent	Yellow	Basal	8-10 mm	Glabrous	Bilipped	Ciliate inside
15.	*T. hookeri*	Linear-Oblong	Ca. 2 mm	Apex pubescent	Greenish yellow	Basal	-	-	-	-
16.	*T. violacea*	Oblong	3-5 mm	Apex pubescent	Yellow	Basal	10-12 mm	Glabrous	Bilipped	Ciliate inside
17.	*V. micrantha*	Oblong-Ovoid	2-2.5 mm	Glabrous	Pale green	Basal	6-8 mm	Glabrous	Bilipped	Ciliate inside
18.	*V. multiflora*	Ovoid	ca. 0.4 mm	Glabrous	Green	Anterior	1.8-2 mm	Glabrous	Bilipped	Ciliate inside
19.	*Y. pussilla*	Ovoid	1-1.2 mm	Glabrous	Pale green	Basal	4-5 mm	Glabrous	Bilipped	Ciliate inside
20.	*Y. viscosa*	Ovoid	1-1.5 mm	Glabrous	Pale yellow	Basal	3.5-4 mm	Glabrous	Bilipped	Ciliate inside

Appendix 10: Comparative account on fruit in Linderniaceae.

S.N.	Name of the species	Capsule		
		Shape	Size	Texture
21.	*B. antipoda*	Cylindric	10-16 mm, longer than persistent calyx	Glabrous
22.	*B. ciliata*	Cylindric	8-12 mm, longer than persistent calyx	Glabrous
23.	*B. oppositifolia*	Cylindric	9-12 mm, longer than persistent clayx	Glabrous
24.	*B. ruellioides*	Cylindric	18-20 mm, longer than persistent calyx	Glabrous
25.	*B. tenuifolia*	Cylindric	5-12 mm, longer than persistent calyx	Glabrous
26.	*C. nummularifolium*	Oblong-Ovoid	4-6 mm, longer than persistent calyx	Glabrous
27.	*L. parviflora*	Oblong-Cylindric	4-6 mm, longer than persistent calyx	Glabrous
28.	*L. procumbens*	Oblong-Ovoid	4-6 mm, equal or slightly longer than persistent calyx	Glabrous
29.	*T. anagallis*	Cylindric	5-15 mm, longer than persistent calyx	Glabrous
30.	*T. asiatica*	Cylindric-Ovoid	12-16 mm, enclosed inside the persistent calyx	Apex pubescent
31.	*T. cordata*	Oblong	Ca. 2 cm, enclosed inside the persistant calyx	-
32.	*T. cordifolia*	Cylindric-Ovoid	7-9 mm, enclosed inside the persistent calyx	Apex pubescent
33.	*T. crustacea*	Oblong-Ovoid	4-5 mm, slightly longer than persistent calyx	Apex subglabrous
34.	*T. diffusa*	Ellipsoid	10-15 mm, enclosed inside the persistent calyx	Apex pubescent
35.	*T. hookeri*	-	-	-
36.	*T. violacea*	Cylindric-Ovoid	8-10 mm, enclosed inside the persistent clayx	Apex pubescent
37.	*V. micrantha*	Cylindric	9-15 mm, longer than persistent calyx	Glabrous
38.	*V. multiflora*	Ovoid	2-4 mm, equal or slightly longer than persistent calyx	Glabrous
39.	*Y. pussilla*	Globoose	3- 4 mm, equal or slightly longer than persistent calyx	Glabrous
40.	*Y. viscosa*	Ovoid-globoose	3-4 mm, equal or slightly longer than persistent calyx	Glabrous

Appendix 11: Photoplates

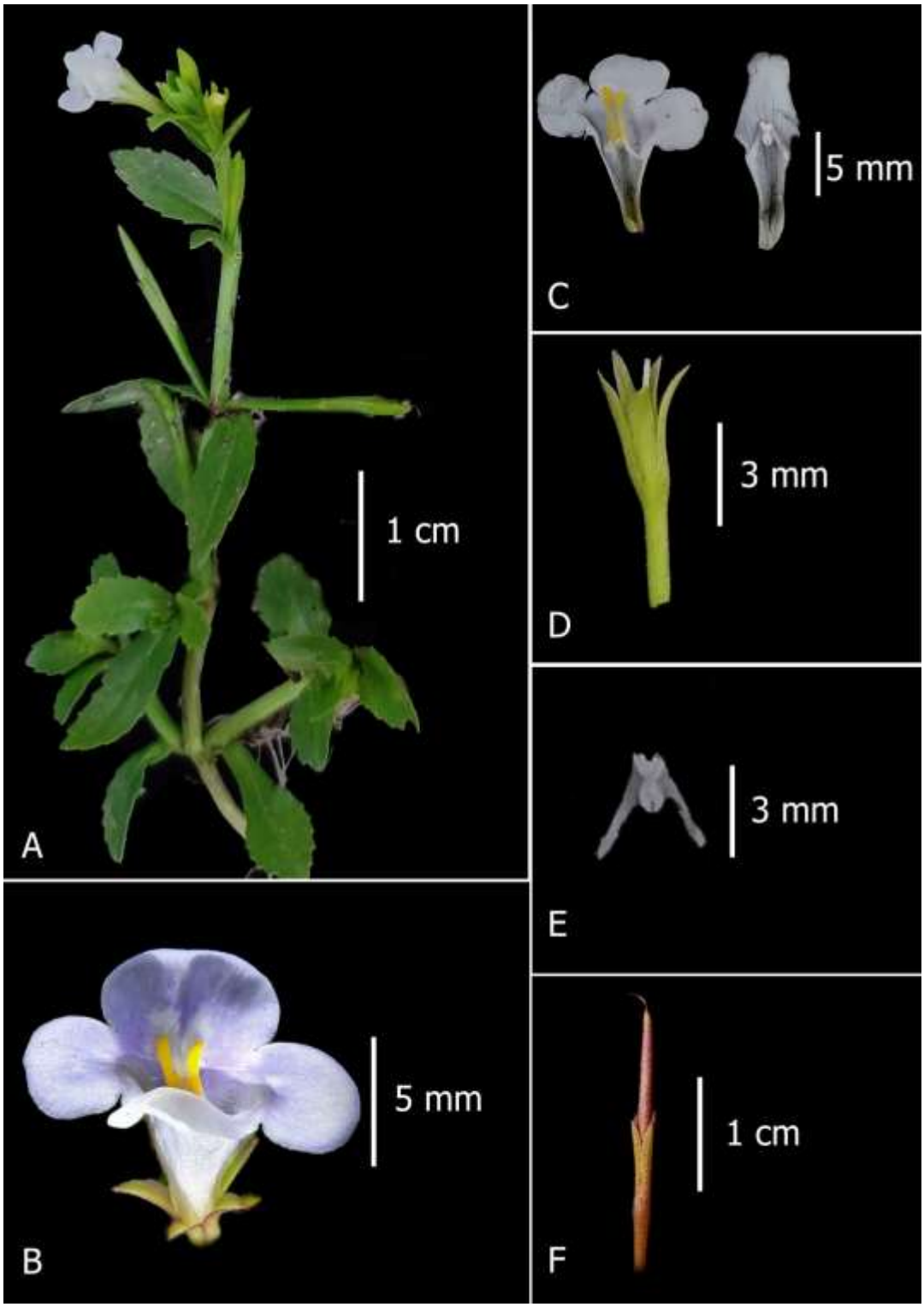

Plate 1: Bonnaya antipoda: A. Habit; B. Flower; C. Opened corolla; D. Calyx; E. Fertile stamens; F. Fruit.

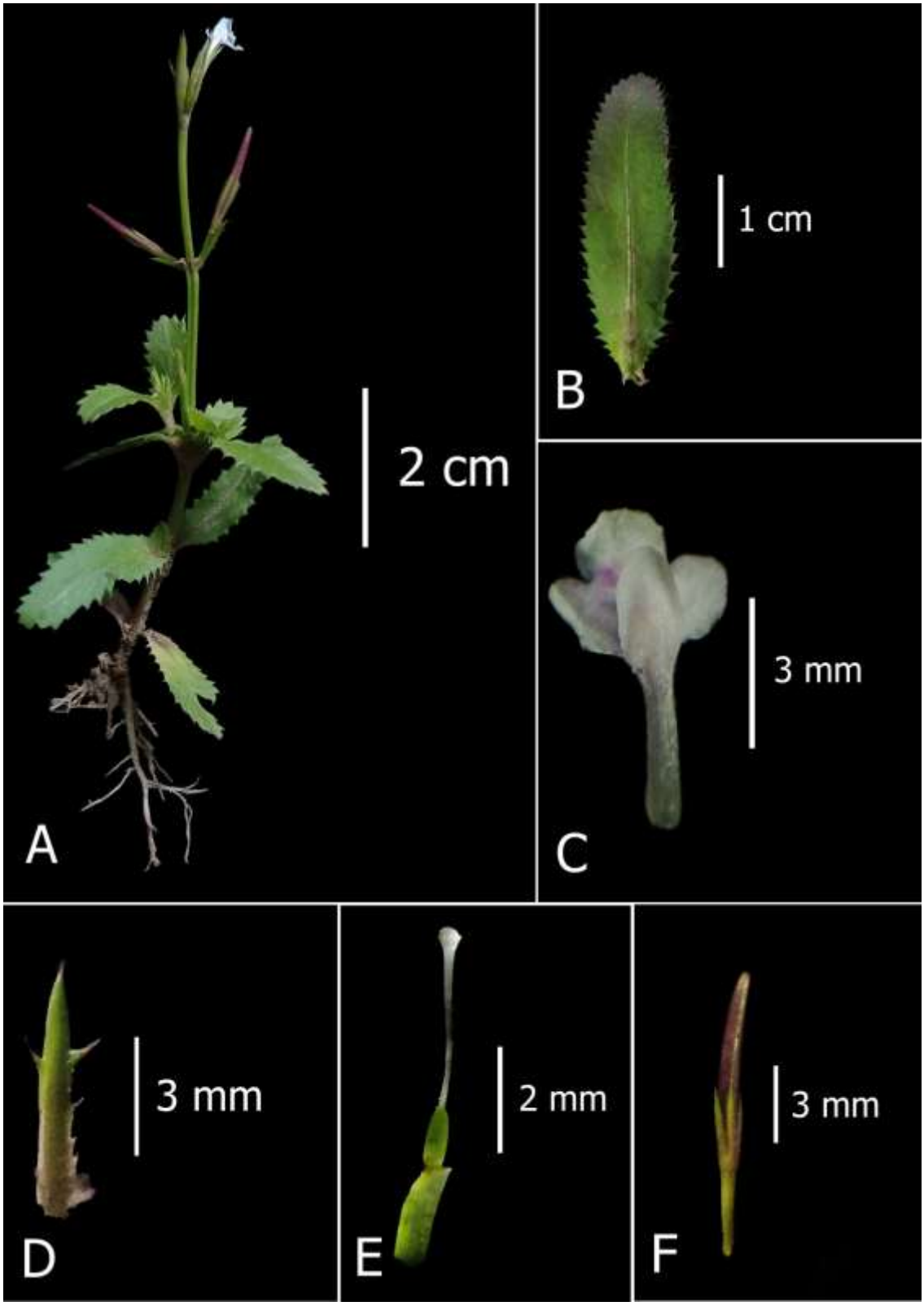

Plate 2: Bonnaya ciliata: A. Habit; B. Single leaf; C. Corolla back view; D. Bract; E. Pistil; F. Fruit with persistent calyx.

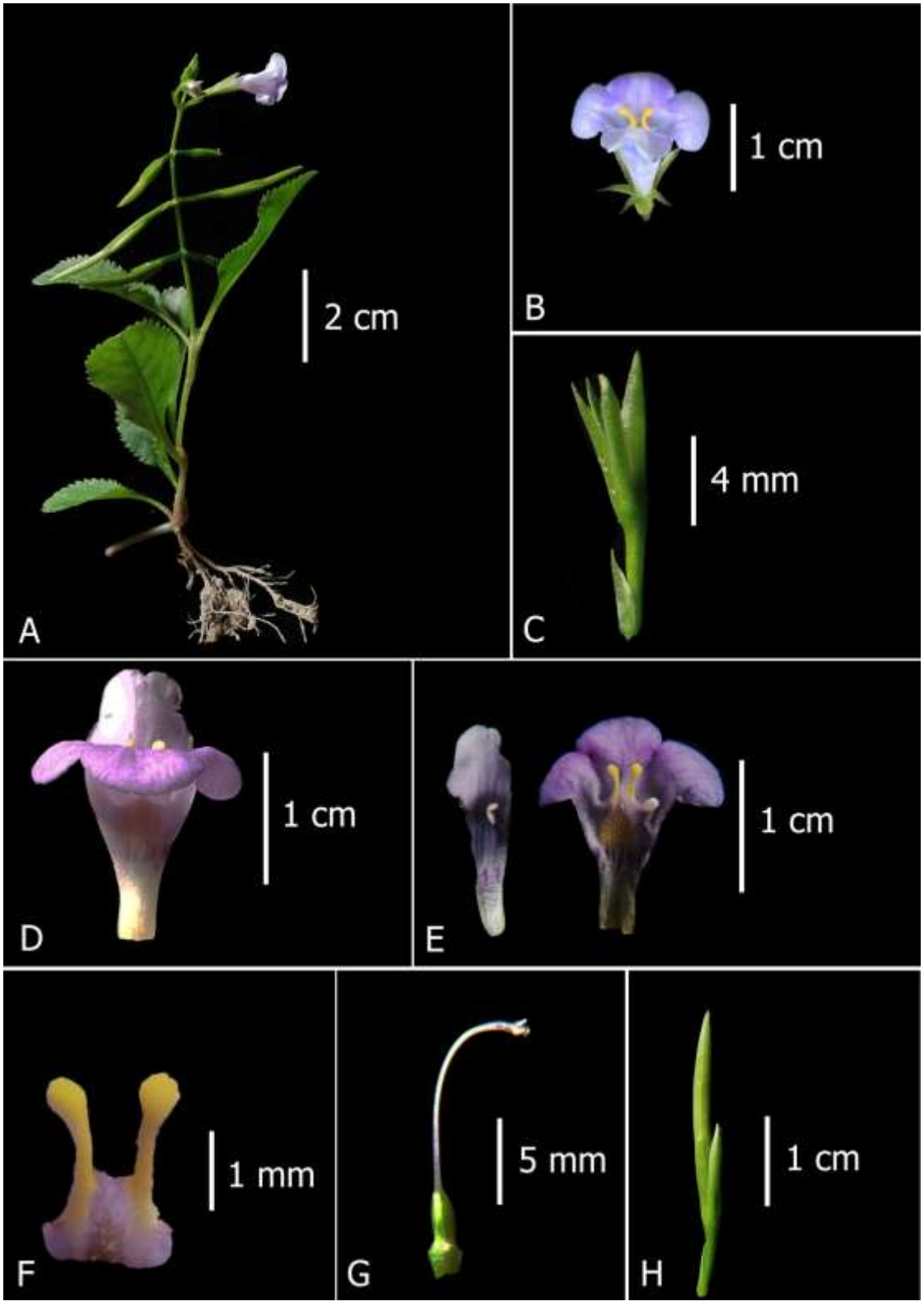

Plate 3: Bonnaya ruellioides: A. Habit; B. Flower; C. Calyx; D. Corolla front view; E. Opened corolla; F. Stamoinodes; G. Pistil; H. Fruit with persistent calyx

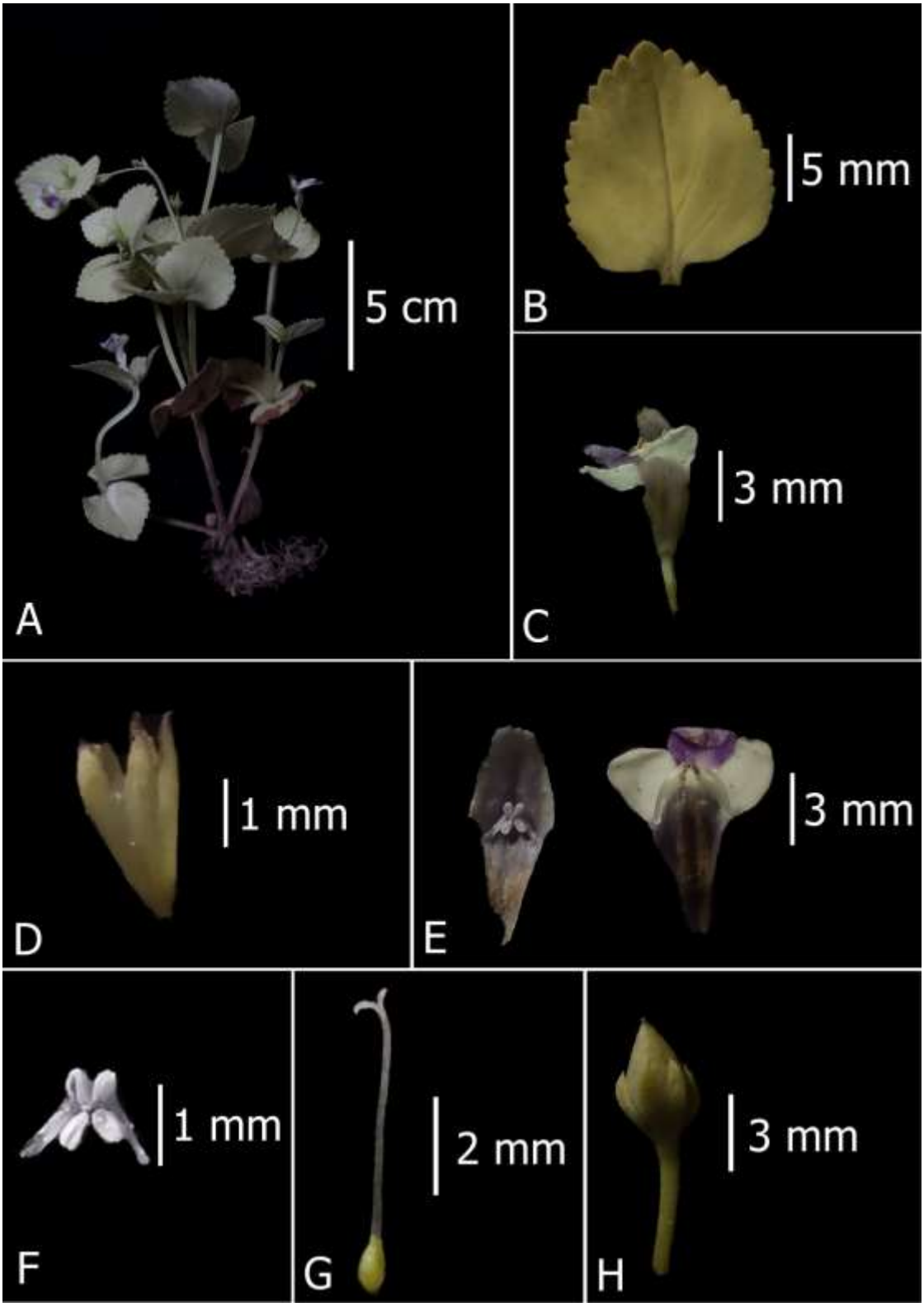

Plate 4: Craterostigma nummulariifolium: A. Habit; B. Single leaf; C. Flower lateral view; D. Calyx; E. Opened corolla; F. Posterior stamens; G. Pistil; H. Fruit with persistent calyx.

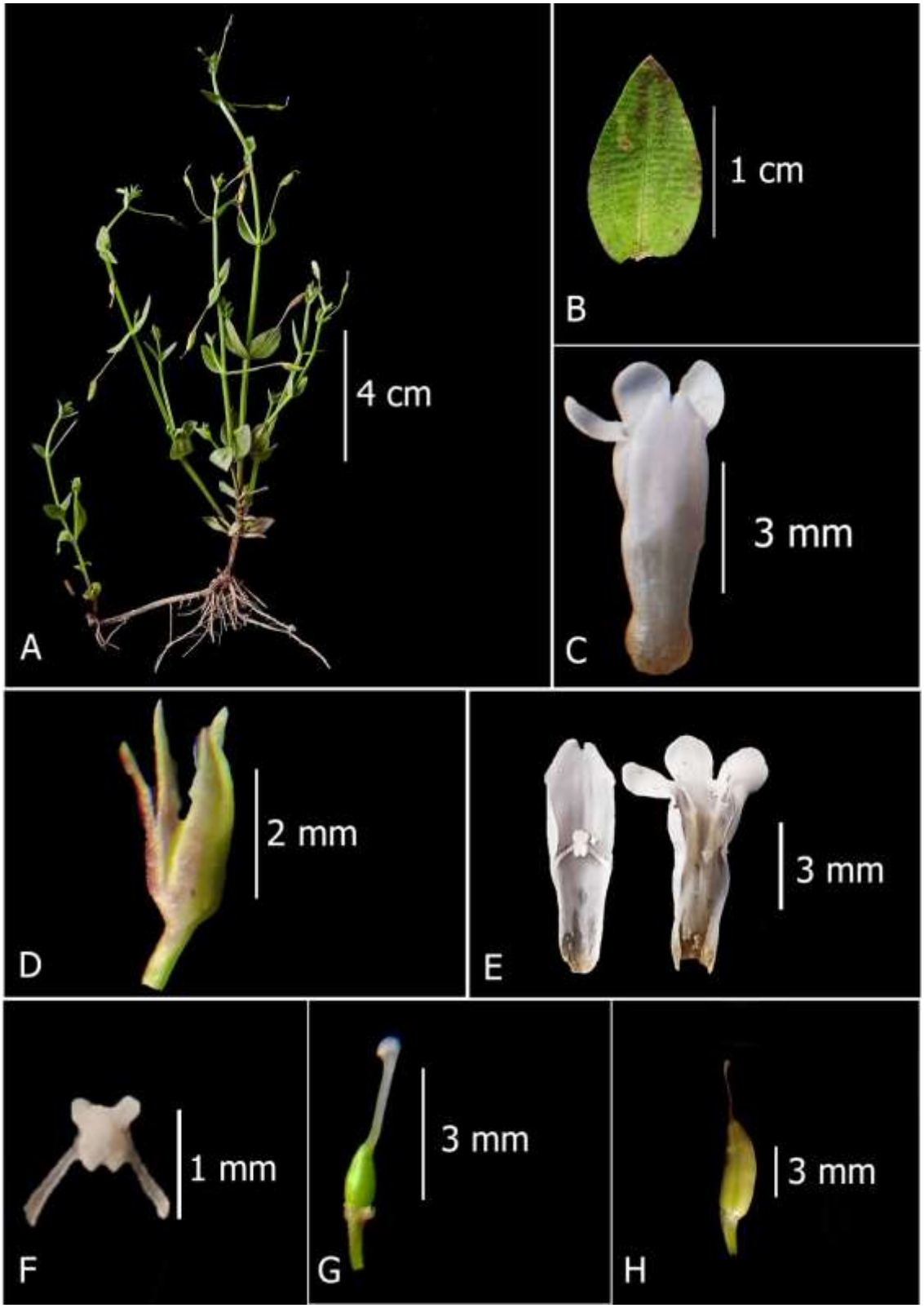

Plate 5: Lindernia parviflora: A. Habit; B. Single leaf; C. Flower back view; D. Calyx; E. Opened corolla; F. Fertile stamens; G. Pistil; H. Fruit.

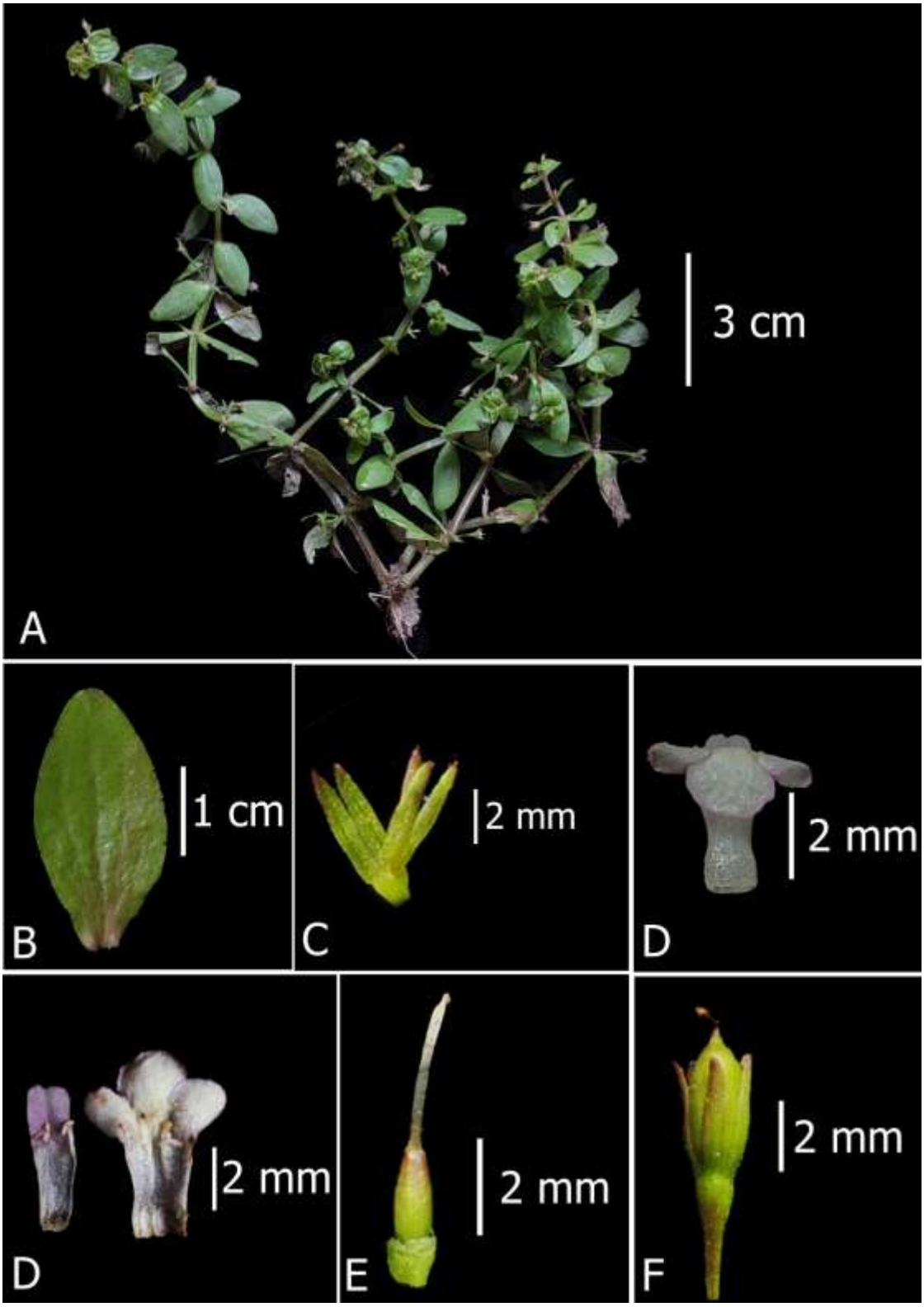

Plate 6: Lindernia procumbens: A. Habit; B. Single leaf; C. Opened calyx; D. Corolla front view; D. Opened corolla; E. Pistil; F. Fruit with persistent calyx.

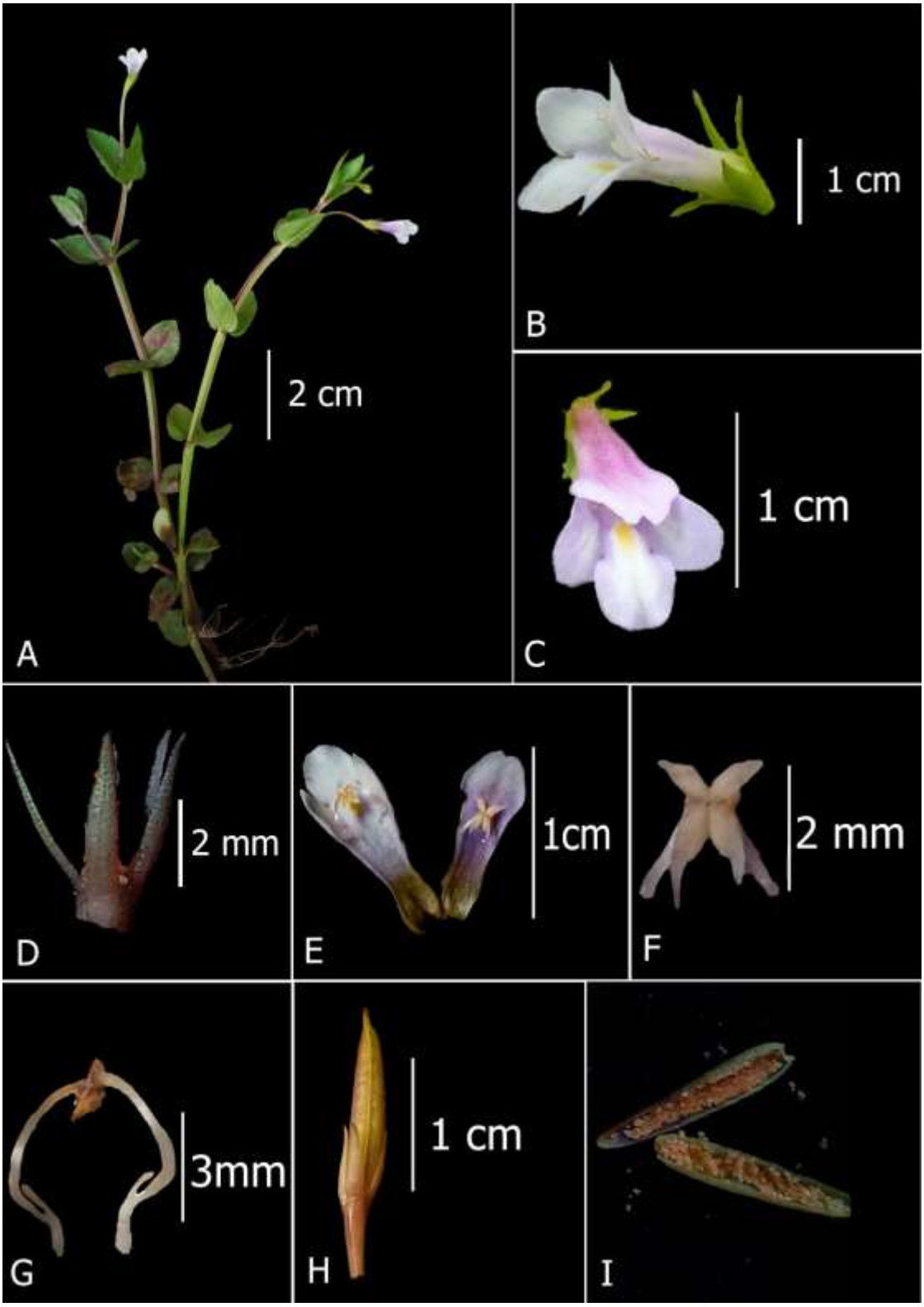

Plate 7: Torenia anagallis: A. Habit; B. Flower lateral view; C. Flower front view; D. Opened calyx; E. Opened corolla; F. Posterior stamens; G. Anterior stamens; H. Fruit with persistent clayx; I. Opened fruit releasing seeds.

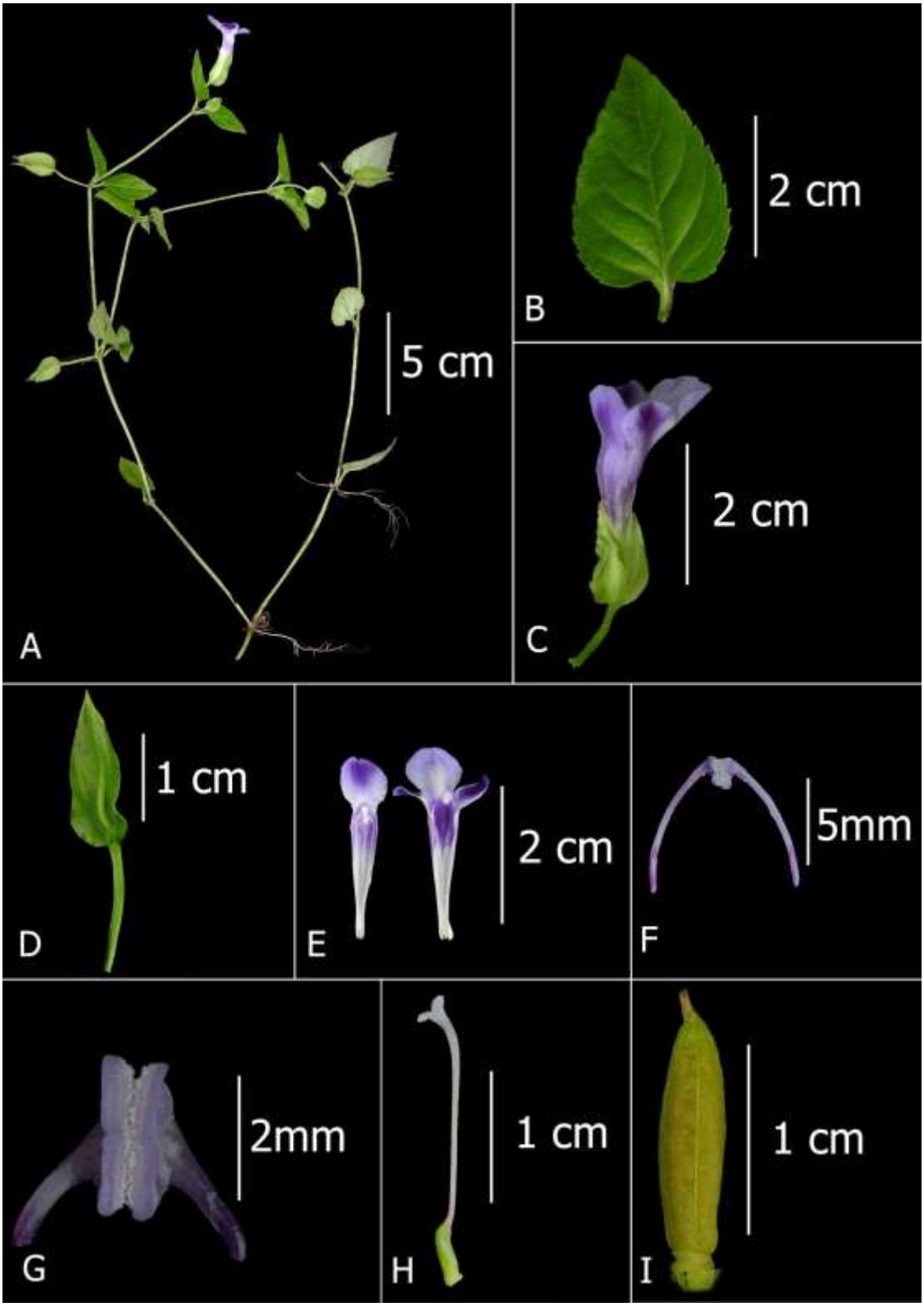

Plate 8: Torenia asiatica: A. Habit; B. Single leaf; C. Flower lateral view; D. Calyx lobe; E. Opened corolla; F. Anterior stamens; G. Posterior stamens; H. Pistil; I. Fruit.

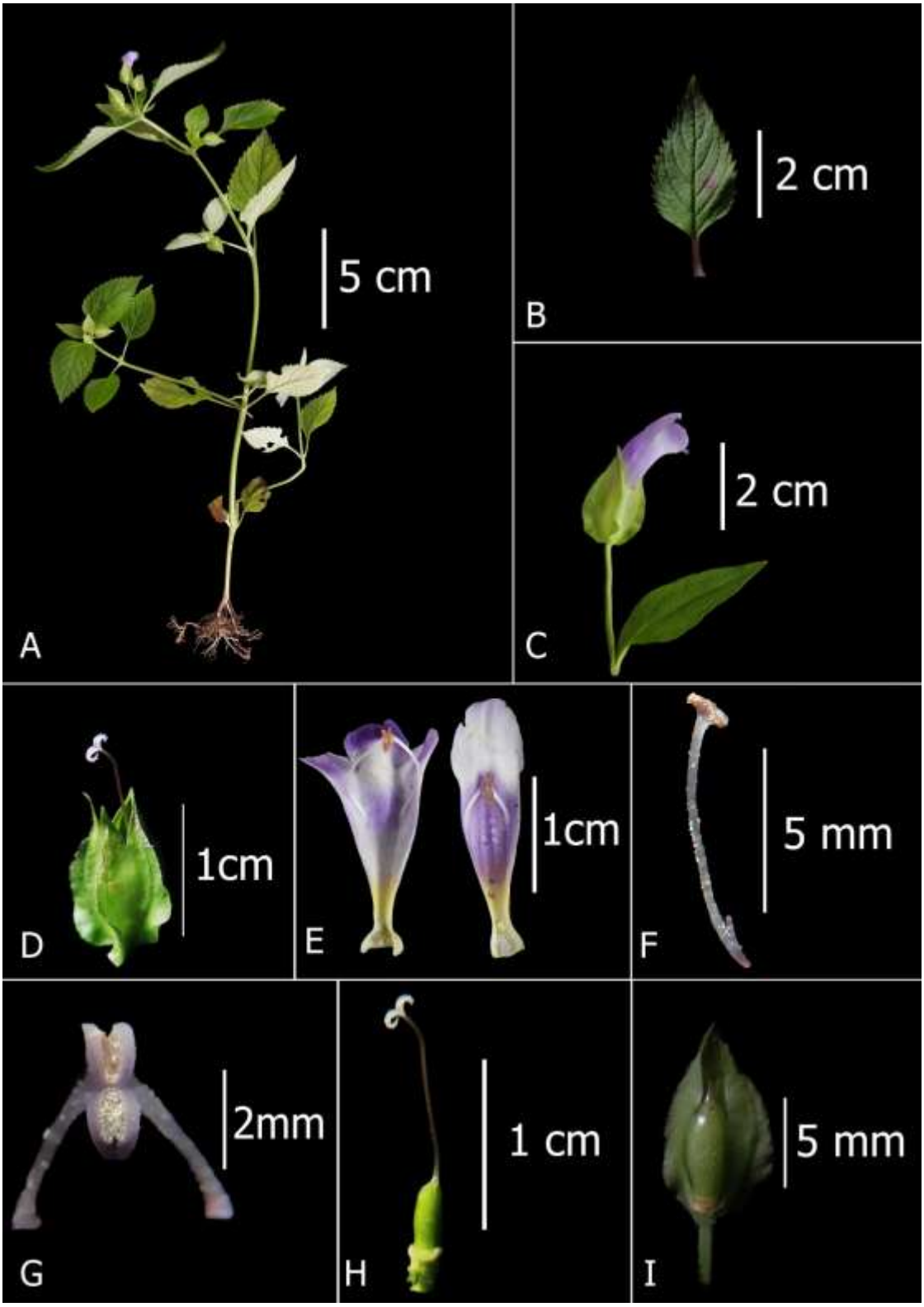

Plate 9: Torenia cordifolia: A. Habit; B. Single leaf; C. Flower lateral view; D. Clayx with style; E. Opened corolla; F. Anterior stamen; G. Posterior stamens; H. Pistil; I. Fruit with persistent calyx.

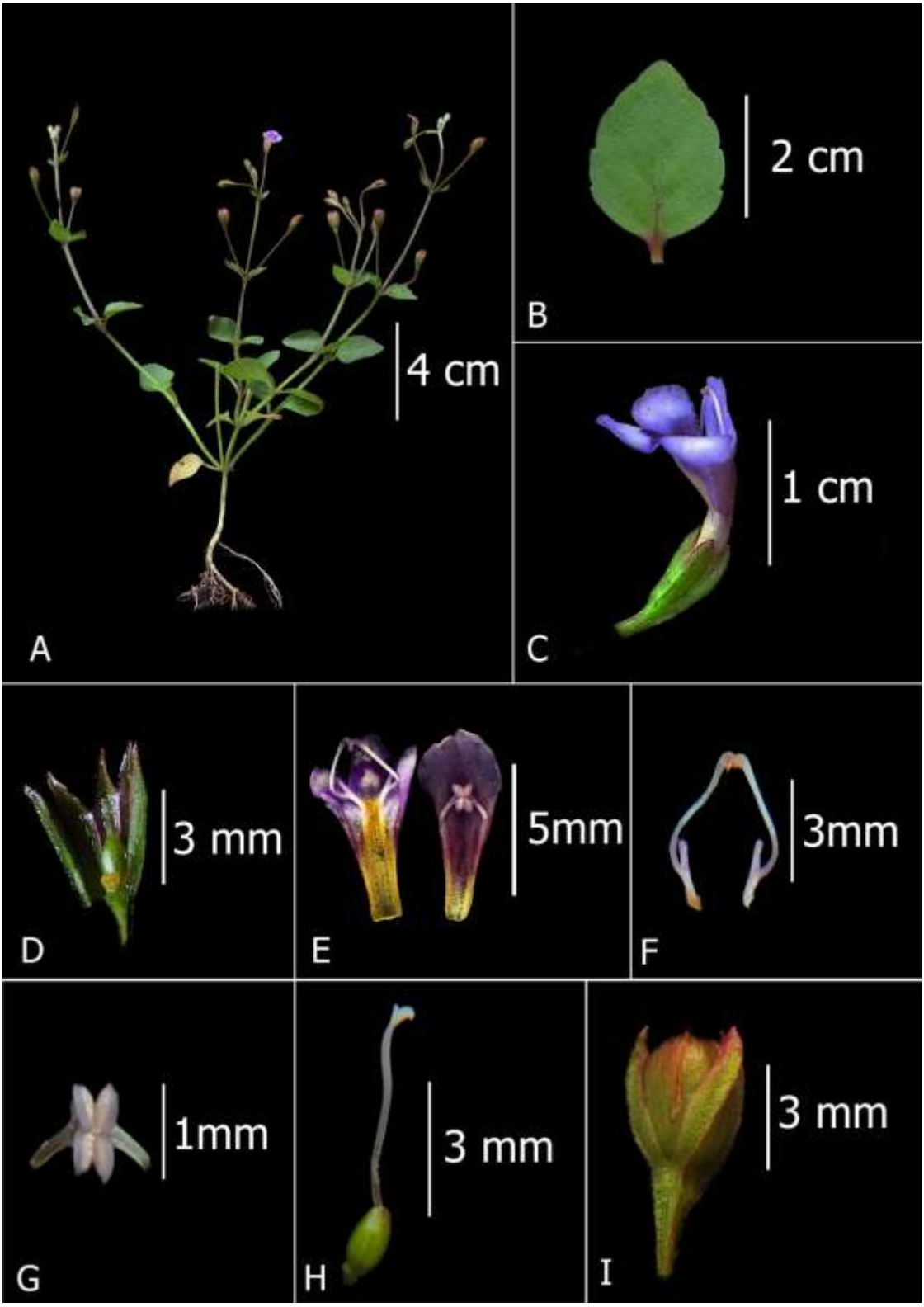

Plate 10: Torenia crustacea; A. Habit; B. Single leaf; C. Flower lateral ciew; D. Opened calyx showing ovary; E. Opened corolla; F. Anterior stamens; G. Posterior stamens; H. Pistil; I. Fruit with persistent clayx.

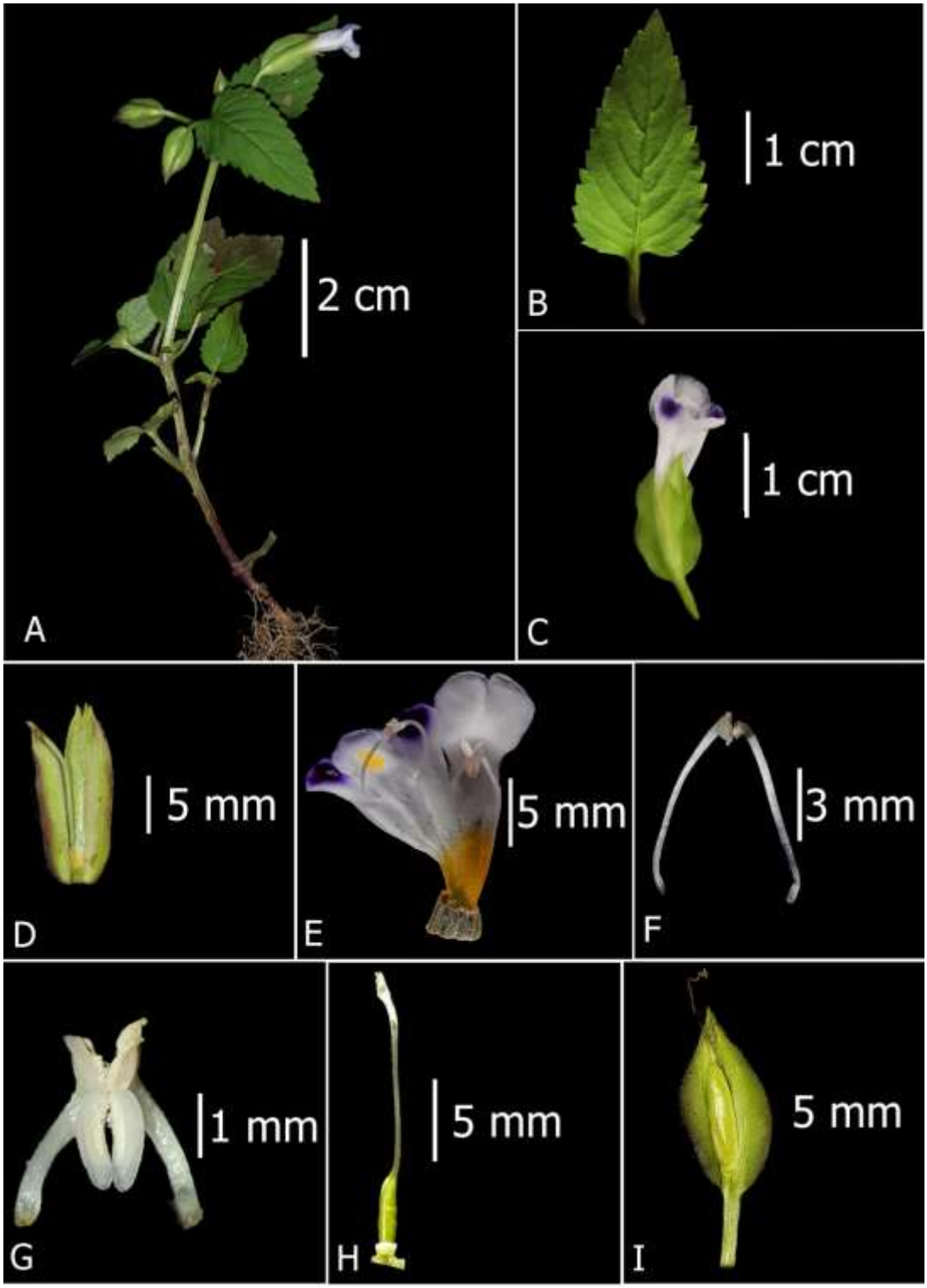

Plate 11: Torenia violacea: A. Habit; B. Single leaf; C. Flower lateral view; D. Open calyx; E. Opened corolla; F. Anterior stamens; G. Posterior stamens; H. Pistil; I. Fruit inside the persistent calyx

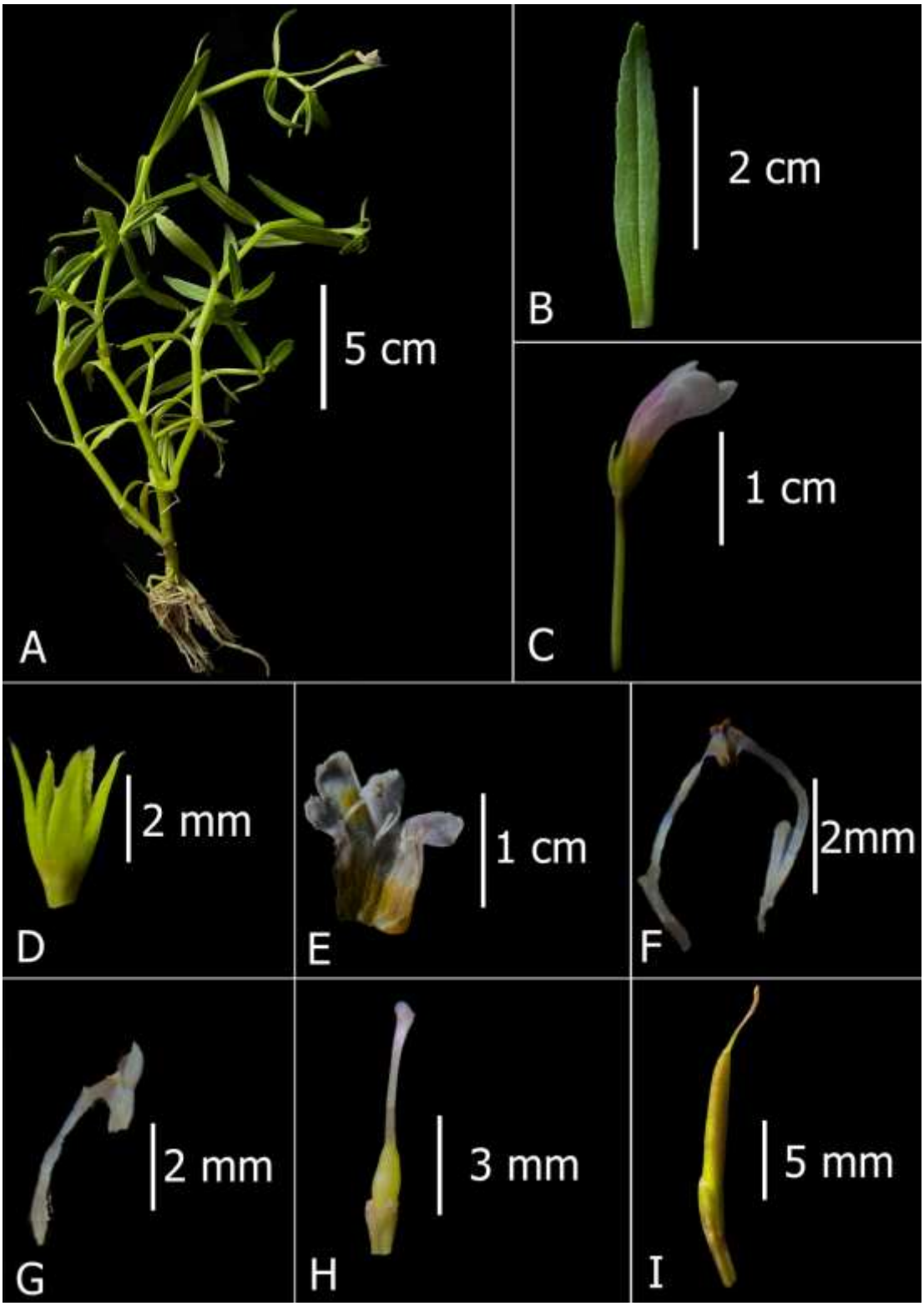

Plate 12: Vandellia micrantha: A. Habit; B. Single leaf; C. Flower lateral view; D. Calyx; E. Opened corolla; F. Anterior stamens; G. Posterior stamen; H. Pistil; I; Fruit.

Plate 13: Type specimens: A. *Vandellia alba* Benth.(=**Torenia crustacea** (L.) Cham. & Schltdl); B. *Torenia hirtella* Hook. f. (=**Torenia diffusa** D.Don); C. *Vandellia angustifolia* Benth. (=**Vandellia micrantha** (D.Don) Eb.Fisch., Schäferh. & Kai Müll.); D. *Lindernia papuana* Pennell (=**Vandellia multiflora** (Roxb.) G.Don); E. *Torenia peduncularis* Benth (=**Torenia violacea** (Azaola ex Blanco) Pennell); F. *Vandellia erecta* Benth. (=**Lindernia procumbens** (Krock.) Borbás).

Plate 14: Type Specimens: A. *Ruellia antipoda* L. (≡ **Bonnaya antipoda** (L.) Druce): B. *Vandellia nummularifolia* D. Don (≡ **Craterostigma nummmularifolium** (D.Don) Eb.Fisch., Schäferh. & Kai Müll.); C. *Ruellia anagallis* Burm.f. (≡ **Torenia anagallis** (Burm.f.) Wannan, W.R.Barker & Y.S.Liang); D. *Vandellia hirsuta* Buch.-Ham. ex Benth. (= **Yamazakia viscosa** (Hornem.) W.R.Barker, Y.S.Liang & Wannan).