

**Taxonomic Revision of the Genus *Crotalaria* L. (Fabaceae)
in Nepal**

A Dissertation

**Submitted for Partial Fulfillment of the Requirements for the
Master's Degree in Botany**



Submitted by

Bishnu Parajuli

Plant Systematics and Biodiversity Conservation Unit

Symbol No: 707

T.U. Regd. No.: 5-2-52-14-2014

Batch: 2075

Central Department of Botany

Tribhuvan University

Kirtipur, Kathmandu, Nepal

January 2024

DECLARATION

I, Bishnu Parajuli, hereby declare that this dissertation entitled “**Taxonomic Revision of the Genus *Crotalaria* L. (Fabaceae) of Nepal**” is my original work, and all other sources of the information used are duly acknowledged. I have not submitted it or any of its parts to any other universities for any academic award.

.....

Bishnu Parajuli

Central Department of Botany

Tribhuvan University, Kathmandu, Nepal

Date:

LETTER OF RECOMMENDATION

This is to certify that the dissertation work “**Taxonomic Revision of the Genus *Crotalaria* L. (Fabaceae) of Nepal**” has been completed by Ms. **Bishnu Parajuli** under my supervision. This entire research was accomplished on the basis of the 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.

.....

Supervisor

Prof. Dr. Sangeeta Rajbhandary

Central Department of Botany

Tribhuvan University, Kirtipur, Kathmandu.

Date:



TRIBHUVAN UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

CENTRAL DEPARTMENT OF BOTANY

Ref No:

Kirtipur, Kathmandu
NEPAL

LETTER OF APPROVAL

The M.Sc. dissertation entitled “**Taxonomic Revision of the Genus *Crotalaria* L. (Fabaceae) of Nepal**” submitted to the Central Department Botany, Tribhuvan University by Bishnu Parajuli has been accepted for the partial fulfillment of the requirement of Master of Science in Botany (Systematics and Biodiversity Conservation).

EXAMINATION COMMITTEE

Supervisor and Head of the Department

Prof. Dr. Sangeeta Rajbhandary
Central Department of Botany
Tribhuvan University, Nepal

External Examiner

Prof. Dr. Sudha Joshi
Patan Multiple Campus
Tribhuvan University, Nepal

.....
Internal Examiner

Assoc. Prof. Dr. Deepak Raj Pant
Central Department of Botany
Tribhuvan University, Nepal

Date:

ACKNOWLEDGEMENT

I would like to express my sincere gratitude and deep respect to my research supervisor and the Head of the Central Department of Botany, Prof. Dr. Sangeeta Rajbhandary, Tribhuvan University, for all the support, valuable guidance and for providing me the opportunity to carry out this work under her supervision with constant encouragement.

I am grateful to the former Head of the Central Department of Botany, Tribhuvan University, Prof. Dr. Ram Kailash Prasad Yadav, for his invaluable support.

I am thankful to the President Chure-Terai Madhesh Conservation Board and the University Grants Commission Nepal, for providing me the financial support to carry out this thesis work, which was really helpful.

I would like to acknowledge Jacek Wajer, Curator of General Herbarium II, Natural History Museum, London, for providing the herbarium specimen image of *Crotalaria mysorensis* Roth. for this study.

Furthermore, I want to express my sincere appreciation to Prof. Arun. K. Pandey, Vice Chancellor, Mansarovar Global University, Bhopal, India, for providing one of his research papers needed in my work and to Dr. Marianne Le Roux, e-Flora Coordinator, for providing me the clear vision of callosities structure through mail.

I am thankful to the Department of National Parks and Wildlife Conservation (DNPWC), Kathmandu, and the National Herbarium & Plant Laboratories (KATH) for granting me the necessary permission for collection of samples necessary for this work and also to the staff of the KATH for helping me in the examination of the herbarium specimens.

Lastly, I want to extend my gratitude to my friends, parents, relatives and local people of respective places, who helped me in field work, as well as to my seniors for sharing their ideas, experiences and knowledge related to the work.

Thank You

.....
Bishnu Parajuli

23rd July 2023

ABBREVIATIONS AND ACRONYMS

AD	Anno Domini
Arc GIS	Arc Geographic Information System
Ann. Check. Fl. Pl. Nepal	Annotated Checklist of the Flowering Plants of Nepal
APG	Angiosperm Phylogeny Group
BHL	Biodiversity Heritage Library
BM	The Natural History Museum, London, UK
Bull. Bot. Surv. India	Bulletin of the Botanical Survey of India
Bull. Dept. Med. Pl.	Bulletin of the Department of Medicinal Plants.
C	Central
ca.	<i>Circa</i> ; about (approximate)
Cat. Nep. Fl. Pl	Catalogue of Nepalese Flowering Plants
cm	Centimeter
E	Eastern
E	Royal Botanical Garden, Edinburgh, UK
e.g.	For example
ed	Edition
eds.	Editors
Enum. Fl. Pl. Nep.	An Enumeration of the Flowering Plants of Nepal
<i>et al.</i>	And others
etc.	<i>Et cetera</i>
Fig.	Figure
Fl. Bhutan	Flora of Bhutan
Fl. E. Himalaya	Flora of Eastern Himalaya

Fl. Ind.	Flora Indica
GBIF	Global Biodiversity Information Facility
GPS	Global Positioning System
Handb. Fl. Pl. Nepal	A Handbook of the Flowering Plants of Nepal
ICBN	International Code of Botanical Nomenclature
i.e.	that is
IPNI	International Plant Name Index
J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist.	Journal of the Asiatic Society of Bengal. Part 2. Natural History.
JSTOR	Journal Storage
K	Royal Botanical Garden, Kew, UK
KATH	National Herbarium and Plant Laboratories, Nepal
m	Meter
mm	Millimeter
MS Excel	Microsoft Excel Spreadsheet
No.	Number
SE	South East
SW	South west
TI	University Museum, University of Tokyo, Japan
TUCH	Tribhuvan University Central Herbarium, Nepal
Vol.	Volume
W	Western

ABSTRACT

Crotalaria L. is a large genus of the family Fabaceae with 702 species worldwide. Due to this large number of species in this genus, none of the studies till yet have been able to include all the species in their study. Different taxonomic research has found to comprise one or few Nepalese species but comprehensive taxonomic study including all the Nepalese species was lacking. This study was carried out to make a comparative and comprehensive study of detailed morphological structures, distribution patterns, and reproductive phenology. Field observations, sample collection and detail herbarium study of national and international herbaria from a taxonomic point of view was done. Some anatomical observations were also done preparing temporary slide. Many morphological characters related to shape, size, surface, orientation and position of different vegetative (stem, stipule, leaf, bract, bracteoles and peduncle) and reproductive (inflorescence, flower, calyx, standard petals, ovary, style, fruit and seed) structures of *Crotalaria* species are found to be important as diagnostic characters and for taxonomic delimitation. Total 18 species are found to be present in Nepal. Among them, 15 are native, one is naturalized (*C. pallida*) and two are exotic (*C. micans* and *C. juncea*). *C. juncea* is cultivated exotic, while the state of *C. micans* in nature needs further exploration, as the labels of herbarium specimens of this species deposited at TUCH show they have also been collected from the wild. Excluding two exotic species, 16 species are distributed in three different sections (Calycinae, *Crotalaria* and Hedriocarpae) but section of *C. acicularis* is still unclear. Due to some distinctive differences in some morphological aspects of the plant like (habit, leaf texture, color, size and surface of fruit) there are two probable new varieties of *C. prostrata*. *Crotalaria quinquefolia* has been recollected after 60 years from the same district. *Crotalaria* species are found to be widely distributed within Nepal from east to west. The most suitable bioclimatic zones for *Crotalaria* in Nepal are found to be tropical and subtropical zones but two species (*C. calycina* and *C. sessiliflora*) are found up to sub-alpine zone as well. With the exception of the endemic species *C. kanaii* all the other species are common to SE Asia. Among the micromorphological characters, Leaf epidermal cell shape and cell wall pattern both did not show much significance, but stomatal index can be used in combination with macromorphological characters in species delimitation. Regarding phenological patterns, flowering has been found to

begin in three different seasons. The majority of species start flowering in summer, *C. medicaginea* in spring while other flowers in early autumn (*C. spectabilis* and *C. calycina*) to mid-autumn (*C. acicularis* and *C. quinquefolia*). Moreover, based on overall similarity, cluster analysis showed *C. acicularis* and *C. prostrata* as being very close, while the two species, *C. sessiliflora* and *C. calycina*, although having similar appearance, stomatal index value, and distributional elevational range, were not found to be closely associated in cluster analysis.

LIST OF FIGURES

Figure 1 : <i>Crotalaria acicularis</i> Buch. -Ham. ex Benth.....	54
Figure 2 : <i>Crotalaria alata</i> Buch. -Ham. ex D. Don.	58
Figure 3: <i>Crotalaria albida</i> B. Heyne ex Roth.....	62
Figure 4 : <i>Crotalaria calycina</i> Schrank.	65
Figure 5 : <i>Crotalaria cytisoides</i> Roxb. ex-DC.....	69
Figure 6 : <i>Crotalaria humifusa</i> Grah. ex Benth.....	72
Figure 7 : <i>Crotalaria Kanaii</i> H. Ohashi.....	75
Figure 8 : <i>Crotalaria lejoloba</i> Bartl.....	78
Figure 9 : <i>Crotalaria medicaginea</i> Lam.	81
Figure 10 : <i>Crotalaria mysorensis</i> Roth	84
Figure 11 : <i>Crotalaria pallida</i> Aiton	89
Figure 12 : <i>Crotalaria Prostrata</i> Rottler ex Willd	92
Figure 13 : <i>Crotalaria Quinquefolia</i> L	95
Figure 14 : <i>Crotalaria Sessiliflora</i> L	99
Figure 15 : <i>Crotalaria Spectabilis</i> Roth	102
Figure 16 : <i>Crotalaria tetragona</i> Roxburgh ex Andrews	105
Figure 17 : Dendrogram formed through cluster analysis of morphological characters.	109

LIST OF TABLES

Table 1: Comparison of shape of bract and bracteoles	25
Table 2: Comparison of size of bracts and bracteoles	27
Table 3 Comparison of tube length and calyx lobe length.....	32
Table 4: Shape of abaxial and adaxial calyx lobe in the calyx.	33
Table 5: Phenology of the <i>Crotalaria</i> species.....	115

LIST OF PHOTOPLATES

Photoplate 1: Habit range in <i>Crotalaria</i> species:	15
Photoplate 2: Leaf type in <i>Crotalaria</i> species:.....	16
Photoplate 3: Range of leaf size in <i>Crotalaria</i> species:	17
Photoplate 4: Common leaf base types in <i>Crotalaria</i> species:	18
Photoplate 5: Type of leaf margin in <i>Crotalaria</i> species:	19
Photoplate 6: Common leaf apex types in <i>Crotalaria</i> species:.....	19
Photoplate 7: Symmetry in leaf of <i>Crotalaria</i> species:.....	20
Photoplate 8: Different type of stipule orientation in <i>Crotalaria</i> species:.....	20
Photoplate 9: Stipule of the <i>Crotalaria</i> species:	22
Photoplate 10: Inflorescence at different position in <i>Crotalaria</i> species:.....	23
Photoplate 11: Flowers number and peduncle length in <i>Crotalaria</i> species:.....	24
Photoplate 12: Bracts of the <i>Crotalaria</i> species:.....	26
Photoplate 13: Position of bracteoles in <i>Crotalaria</i> species:	28
Photoplate 14: Bracteoles of the <i>Crotalaria</i> species:.....	29
Photoplate 15: Flower size range in <i>Crotalaria</i> species:	30
Photoplate 16: Flower color in <i>Crotalaria</i> species:	30
Photoplate 17: Calyx type in <i>Crotalaria</i> species:	31
Photoplate 18: Size range of the standard petal:	35
Photoplate 19: Base type in standard petal of <i>Crotalaria</i> species:.....	35
Photoplate 20: Apex of the standard petal:	36

Photoplate 21: Callosity type in <i>Crotalaria</i> species:.....	36
Photoplate 22: Types of shape of the wings in <i>Crotalaria</i> species:.....	37
Photoplate 23: Base of the wings petal:	38
Photoplate 24: Basal claw position:	39
Photoplate 25: Elongation pattern of basal claw in wings petal:	39
Photoplate 26: Shape of the keel petal:..	40
Photoplate 27: Apex type in keel of <i>Crotalaria</i> species:	40
Photoplate 28: Curvature types if keel petal of <i>Crotalaria</i> species:	41
Photoplate 29: Relative length of tube and filament of androecium:.....	42
Photoplate 30: Shape of the ovary:.....	43
Photoplate 31: Curvature of the style in <i>Crotalaria</i> :.....	44
Photoplate 32: Types of shapes of the <i>Crotalaria</i> fruit:.....	45
<i>Photoplate 33:</i> Seed number in <i>Crotalaria</i> species:.....	45
Photoplate 34: Inclusiveness of the fruit inside calyx:.....	46
Photoplate 35: Shape of the seed:.....	47
Photoplate 36: Range of seed size in Nepalese species of <i>Crotalaria</i> :	47
Photoplate 37: vestiture in stem of the <i>Crotalaria</i> species:	108
Photoplate 38: Vestiture on ventral and dorsal surface of the leaf:.....	109
Photoplate 39: Surface of Calyx:.....	111
Photoplate 40: Surface type of standard petal:	111
Photoplate 41: Surface of the ovary:	112

Photoplate 42: Surface hairs in the style:	113
Photoplate 43: Different types of fruit surface:.....	113
Photoplate 44: A. <i>C. tetragona</i> (one line of hairs):.....	116
Photoplate 45: <i>C. prostrata</i> var. <i>nigrisperma</i> (A, B, C, D, E, F, H, I); <i>C. prostrata</i> var. <i>levis</i> (G and j). (Rokade <i>et al.</i> , 2019).....	118
Photoplate 46: Probable variety 1 st :.....	119
Photoplate 47: Probable variety 2 nd :.....	120
Photoplate 48: <i>Crotalaria quinquefolia</i> L;.....	121

LIST OF DISTRIBUTION MAP

Map 1 : Distribution of <i>Crotalaria acicularis</i> in Nepal	53
Map 2 : Distribution of <i>Crotalaria alata</i> in Nepal.....	57
Map 3 : Distribution of <i>Crotalaria albida</i> in Nepal.....	61
Map 4 : Distribution of <i>Crotalaria calycina</i> in Nepal	64
Map 5 : Distribution of <i>Crotalaria cytisoides</i> in Nepal	68
Map 6 : Distribution of <i>Crotalaria humifusa</i> in Nepal	71
Map 7 : Distribution of <i>Crotalaria kanaii</i> in Nepal.....	74
Map 8 : Distribution of <i>Crotalaria lejoloba</i> in Nepal.....	77
Map 9 : Distribution of <i>Crotalaria medicaginea</i> in Nepal.	80
Map 10 : Distribution of <i>Crotalaria mysorensis</i> in Nepal.....	83
Map 11 : Distribution of <i>Crotalaria pallida</i> in Nepal	87
Map 12 : Distribution of <i>Crotalaria prostrata</i> in Nepal.....	91
Map 13 : Distribution of <i>Crotalaria quinquefolia</i> in Nepal.....	94
Map 14 : Distribution of <i>Crotalaria sessiliflora</i> in Nepal	99
Map 15 : Distribution of <i>Crotalaria spectabilis</i> in Nepal.....	101
Map 16 : Distribution of <i>Crotalaria tetragona</i> in Nepal.	104

TABLE OF CONTENTS

DECLARATION	ii
LETTER OF RECOMMENDATION	iii
LETTER OF APPROVAL	iv
ACKNOWLEDGEMENT	v
ABBREVIATIONS AND ACRONYMS	vi
ABSTRACT	viii
LIST OF FIGURES	x
LIST OF TABLES	xi
LIST OF PHOTOPLATES	xii
LIST OF DISTRIBUTION MAP	xv
1. INTRODUCTION	1
1.1 Background	1
1.2 Statement of the Problem	2
1.3 Objectives	3
1.4 Limitations and Delimitations	3
2. LITERATURE REVIEW	5
2.1 Different Aspects of Taxonomic Study of the Genus <i>Crotalaria</i> L.	7
2.2 Efforts on Infrageneric Classification of <i>Crotalaria</i> Species.....	9
2.3 Distribution of <i>Crotalaria</i> Species	10
3. MATERIALS AND METHODS	11
3.1 Taxonomic Study	11
3.1.1 Protologue and literature review	11
3.1.2 Literature-based character matrix:.....	11
3.1.3 Plant collection and preparation of herbarium specimens.....	11
3.1.4 Identification of specimens	12

3.1.5 Morphological study.....	12
3.1.6 Leaf epidermal characteristics.....	12
3.1.7 Surface vestiture type.....	12
3.1.8 Illustrations, photography and distribution map.....	12
3.1.9 Construction of the identification key.....	13
3.2 Cluster Analysis.....	13
3.3 Phenology.....	13
4. RESULTS.....	14
4.1 Range of Morphological Characters in the Genus <i>Crotalaria</i> L.....	14
4.1.1 Life forms.....	14
4.1.2 Stem.....	15
4.1.3 Leaves.....	15
4.1.4 Stipule.....	20
4.1.5 Inflorescence.....	22
4.1.6 Bract and Bracteoles.....	24
4.1.7 Flower.....	30
4.1.8 Calyx.....	30
4.1.9 Corolla.....	34
4.1.10 Androecium.....	41
4.1.11 Ovary.....	43
4.1.12 Style.....	43
4.1.13 Fruit.....	44
4.1.14 Seed.....	47
4.2 Taxonomic Treatment.....	48
4.3 Leaf Epidermal Characters (epidermal cells and stomata):.....	107
4.4 Vestiture.....	107

4.5 Flowering and fruiting phenology	113
4.6 Cluster analysis.....	109
5. DISCUSSION	111
5.1 Taxonomy of the genus <i>Crotalaria</i> L:.....	111
5.1.1 Vegetative Characters.....	111
5.1.2 Reproductive Characters	113
5.1.3 Does recent sectional classification include all Nepalese species?.....	115
5.1.4 Probable two new varieties of <i>C. prostrata</i> Roxb. ex Willd.	116
5.1.5 Rediscovery of <i>Crotalaria quinquefolia</i> L. from Nepal:.....	121
5.2 Distribution.....	122
5.2.1 With in Nepal	122
5.2.2 Distribution range of Nepalese <i>Crotalaria</i> species outside Nepal	122
5.3 Vestiture types in Nepalese species of <i>Crotalaria</i> L species:	123
5.4 Leaf Epidermal Characters	124
5.5 Hierarchical cluster analysis.....	126
5.6 Flowering and Fruiting phenology	126
6. CONCLUSION AND RECOMMENDATION	128
6.1 Conclusion.....	128
6.2 Recommendation.....	129
REFERENCES	131
APPENDICES	I

1. INTRODUCTION

1.1 Background

Description, identification, nomenclature and classification of organism are the main steps of the systematic study which is accomplished by acquiring, analyzing and synthesizing information about plants and their parts (Smith, 2006). The systematic study of the taxa in any country adds vital information for writing the flora and knowing the status of the taxa. The systematic work can help in updating the enumeration. It further helps in finding the new locality and depositing new specimens in herbaria. One important benefit of systematic work is to update nomenclatural changes. Side by side, the systematic study adds additional information on the floral biology during collection of the specimens.

A revision involves restudy of a group to correct or improve its diagnosis, description, or phylogeny (Winston, 1999). According to Qualls (1986) a revision is a treatment of selected taxa throughout at least a major portion of their range, including a study of nomenclature and classification along with description based on several types of evidence. Therefore, a revision is such a less comprehensive monographic work that covers the treatment of taxa restricted to a continent or small geographical area (Chaudhary, 1998).

The Fabaceae is a large economically important family of flowering plants. The group is widely distributed and is the third-largest land plant family in terms of number of species, after the Orchidaceae and Asteraceae, with 765 genera and about 19,500 species (Christenhusz *et al.*, 2016). *Astragalus* with over 2400 species, *Acacia* with over 950 species, *Indigofera* with around 700 species, *Crotalaria* with around 700 species and *Mimosa* with around 500 species are the five largest genera of the family Fabaceae (Magallon and Sanderson, 2001; Judd *et al.*, 1999).

Species of the family Fabaceae are mostly found in tropical rain forests and in dry forests (Burnham & Johnson, 2004). According to recent molecular and morphological evidence Fabaceae is a single monophyletic family (Lewis *et al.*, 2005). It has been supported by all the recent phylogenetic studies based on DNA sequences (Wojciechowski *et al.*, 2004). It is closely related with Polygalaceae, Surianaceae and Quillajaceae of the order Fabales (APG, 2009).

The first systematic plant collection including Fabaceae in Nepal were done by Buchanan Hamilton in 1802-1803 and Wallich in 1820-1821 mainly from Kathmandu valley (Rajbhandari and Bhattarai, 2001). According to Press *et al.* (2000) there are 91 genera and 379 species in family Fabaceae in Nepal and according to recently published data there are 99 genera and 304 species in Nepal in Family Fabaceae (Shrestha *et al.*, 2022).

Crotalaria L. is one of the largest genera of the Fabaceae. Species are commonly known as rattlepods. The species of *Crotalaria* exhibit great diversity in terms of habit and for choice of ecological preferences. About 702 species are described worldwide and are distributed in tropical and subtropical regions of the world especially in the Southern Hemisphere (Van Wyk, 2005; Jianqiang *et al.*, 2010). About 543 species are distributed in Africa and Madagascar which are considered as primary centers of origin (Polhill and Raven, 1981; Polhill, 1982). *Crotalaria* species are also distributed to Asia including India, China, Nepal, Pakistan, Sri Lanka, south-east Asia, Malaysia, Japan, Myanmar, Bhutan, N. Australia, Afghanistan, and central and tropical America (Rajbhandari and Rai, 2019).

Rajbhandari and Rai (2019), listed 16 species of *Crotalaria* (15 native and one naturalized). Shrestha *et al.* (2022) along with these 16 also mentioned additional two species which are exotic in Nepal. *Crotalaria* are distributed from tropical to temperate zone, altitudinally between 200m to 2900m (Press *et al.*, 2000) and recently, Shrestha *et al.* (2022) made slight change in lower elevational point as 60m to 2900m. *Crotalaria* is recognized by its unique combination of characters, like presence of a rostrate keel, inflated pod, a hairy style, a 5+5 anther configuration and paired callosities on the standard petal (Polhill, 1982; Van Wyk and Verdoorn, 1990; Van Wyk, 2005).

The species of *Crotalaria* also has great economic importance used in veterinary pharmacy in preventing liver diseases (Nwude and Ibrahim, 1980), fix nitrogen in soil, useful as green manure in agriculture and many more.

1.2 Statement of the Problem

Taxonomic revision of the taxa is one of the important taxonomic works. Taxonomic revision generally refers to the restudy of the taxa of limited geographical area rather encompassing the species of the whole world. Taxonomic revision of the taxa helps to make correction or improvements of the taxa in terms of their description,

identification, nomenclature flaws and classification (Rajbhandari, 2015). Different taxa are thus revised from time to time, as a result of which changes in nomenclature, classification and improvements in identification keys, improved and added description, etc. could be generated.

Taxonomic work is very limited in Nepal. There are many families and the genera of plants whose comprehensive taxonomic work has not been carried out yet. Thus, continuous work and effort is needed on taxonomic work.

Further, *Crotalaria* genus being one of the largest genera of the family Fabaceae with 702 species worldwide, detail comprehensive study including all 702 species has not been possible yet. Various taxonomic research papers include one or few Nepalese species, but inclusive study comprising all the Nepalese species is lacking. Further, herbarium specimens of some of the species are not available in both herbaria (KATH and TUCH) of Nepal, which shows the lack of field collection either due to their rare distribution or may be some other reasons. Therefore, there is the need of proper field exploration for this.

Therefore, to make correct enumeration of the species of the genus, to update the nomenclatural changes of the species, to explore the current status of the *Crotalaria* species in nature and to finally make comprehensive taxonomic revisionary work on this genus, this study or this thesis work has been proceeded.

1.3 Objectives

The general objective of this study is to carry out a taxonomic study of the genus *Crotalaria* L. in Nepal and specific objectives are as follows:

1. To study gross morphological (macro and micro) characters of the Nepalese *Crotalaria* L. species.
2. To prepare a complete taxonomic account of the genus *Crotalaria* L. in Nepal.
3. To construct identification keys, illustrations, distribution maps and explore the phenology of Nepalese *Crotalaria* L.
4. To construct a dendrogram to analyze similarity among species.

1.4 Limitations and Delimitations

One of the essential factors which determines the quality of any taxonomic work is taxonomic literatures. Taxonomic literature is limited in our herbaria and libraries.

Similarly, herbarium specimens are most important factor that determine the quality of taxonomic research work. Due to lack of replicate specimens of some of the species in the herbarium, it was difficult to make floral study. Due to lack of some of the herbarium specimens in herbaria of Nepal (TUCH and KATH), Study was done with the help of digital photographs from BM, and TI. Since all the species of the genus could not be found in one locality, and due to time constraints sufficient field visit and extensive study was tough. Furthermore, due to lack of enough facilities and infrastructure, this study does not cover molecular study it is focused only on morphological and anatomical study.

2. LITERATURE REVIEW

The genus *Crotalaria* L. belongs to Fabaceae, subfamily Papilionoideae consisting of the about 700 species (Le Roux *et al.*, 2013). The genus *Crotalaria* L. comprises herbaceous and shrubby species with simple one-foliolate or digitately three-five foliolate leaves and inflated legumes. This genus was first named and described by Linnaeus in 1753. In his book “Species plantarum” he described 13 species which are *Crotalaria perfoliata* L., *C. sagitalis* L., *C. juncea* L., *C. trifloral* L., *C. villosa* L., *C. verrucosa* L., *C. lotifolia* L., *C. lunaris* L., *C. laburnifolia* L., *C. micans* L., *C. albaa* L. *C. quinquefolia* L.

Then, in 1786 Lamarck increased the species number to 37. De Candolle (1825) reported 375 species in his book “Prodromus Systematis Naturalis Regni Vegetabilis”. Le Roux *et al.* (2013) reported 700 species in this genus.

Different authors have played very important role to record different species of *Crotalaria* in Africa. Thunberg (1823), reported 11 species from the Cape, South Africa. Similarly, Harvey (1862) described 24 new species from the same region. Furthermore, Verdoorn (1928) published a taxonomic revision of the genus where he recognized and reported 124 species from Southern Africa and south tropical Africa excluding Angola. Polhill (1982), conducted a thorough taxonomic revision on *Crotalaria* species in Africa and Madagascar and reported 511 species. Taubert (1893) reported 56 West African species. Milne-Redhead (1961) and Polhill (1968) conducted in depth studies and revised the species within the genus in East tropical Africa and reported 199 species in the area. In Angola 62 new species were described by Wilczek (1953) and he revised 189 species from the same country. Hepper (1958) revised the species of West Africa and reported 51 species and da Torre (1960) described 36 new species and revised 138 species. Likewise, Du Puy and Labat (2002) conducted research on Madagascar species and enumerated 53 species.

Although center of diversity of the *Crotalaria* genus is in Africa and Madagascar (Polhill, 1968; Polhill, 1982; Le Roux and Van Wyk, 2013), it is almost cosmopolitan in distribution being distributed across the tropical and subtropical regions of the world (Lewis *et al.*, 2005). And secondary center for *Crotalaria* diversity is India with approximately 92 species (Ansari, 2008). Further, this genus is widely distributed

across the southern hemisphere, reaching up to Asia and North Africa (Hutchinson *et al.*, 1985).

Study of the genus *Crotalaria* is not limited only up to Africa but many taxonomic works about *Crotalaria* have also been done in other parts of the world. One of the earliest studies on Western hemisphere was done by Humboldt *et al.* (1824). They described nine new species in “Revision of the new world species”. Later Bentham reported 32 species from Brazil in 1859. Flores and de Azevedo Tozzi (2005) described and illustrated new species from southeastern Brazil. Senn (1939) revised 31 species from North America and found that majority of the species were endemic to Mexico and West Indies. Windler (1974), treated 12 unifoliate species from the North America. Woodson *et al.* (1980) reported 11 species in the Panama region. Again, Windler and Skinner (1981) reported nine new species in America, they also described seven nomenclatural changes on the existing species. Leverett and Woods (2012) reported seven species from Alabama.

A number of taxonomic works related to genus *Crotalaria* has been carried out in Asia continent. One of the earliest works was conducted by Wight and Walker-Arnott (1834). They conducted taxonomic revision of Indian species and reported 58 species in the country. Before that, Roxburgh and Carey (1832) described seven new species in their flora Indica. Baker (1876) published descriptions of 77 species of *Crotalaria* from British India. De Munk (1962) in his revision of Malaysian legume, published a list of 38 species within the genus. Wu *et al.* (2003) reported 6 species in their study on herbarium records, actual distribution and critical attributes of invasive plants: Genus *Crotalaria* in Taiwan. Jianqiang *et al.* (2010) reported a detailed description of 42 species from China.

In case of Nepal different local floras and check list has listed the *Crotalaria* species recorded from Nepal. Malla *et al.* (1986) described six species in flora of Kathmandu valley, Press *et al.* (2000) had listed total 18 species including both native and introduced species, Rajbhandari and Rai (2019), also listed 16 species excluding two introduced species and Shrestha *et al.* (2022) has also listed same number of species of *Crotalaria* as 15 native, one naturalized and two exotic species.

Morphological and anatomical study of taxa has always played very important role in taxon delimitation. Anatomical, epidermal and morphological characters of leaves,

stem, roots, and petiole play important role in plant taxonomy, especially of particular groups at generic and specific levels (Roeder and Wiedenfeld, 2009) and have been used to solve taxonomic problems in several plant families (Wollenwebber and Schnesder, 2000). Ekeke and Agogbua (2020) studied the anatomy of 16 species of *Crotalaria* of south Eastern Nigeria, which includes 3 species which is also found in Nepal (*C. juncea*, *C. pallida*, *C. spectabilis*). But anatomical study of other species of *Crotalaria* found in Nepal has not been carried out yet.

2.1 Different Aspects of Taxonomic Study of the Genus *Crotalaria* L.

Till this date many different studies had been made on this genus by different authors and also different approaches has also been used to classify and delimited them. Some have utilized morphometrics approach (Yaradua *et al.*, 2018), where morphological similarity of species is used. On the other hand, few phylogenetic studies utilizing the molecular data have been also carries out (Le Rux *et al.*, 2013; Subramanian *et al.*, 2013). Similarly, along with morphological and molecular studies, cytological studies have also been made in past to delimit the taxa (Flores *et al.*, 2006). Windler (1974) studied the chromosome counts of the nine species of the section calycinae. Oliveira and Anguiar-Perecin (1999), analyzed the karyotypes of five species. Further, Mondin (2003) made a karyotypic study utilizing chromosomal banding and fluorescent in situ hybridization. Boulter *et al.* (1970) reported that majority of the species are diploid with chromosome number, $2n=16$, only a few species are with $2n=14$ or with $2n=22$. Flores *et al.* (2006), studied the Brazilian species of *Crotalaria* and also concluded that most frequent chromosome number is $2n=16$ and $2n=32$. $2n=14$ was found in only *C. incana* L among studied species and *C. tweediana* Benth. had chromosome number $2n=54$. Chromosome number $n=8$ and 7 are found to be basic for this genus (Palomino and Vasquez, 1991). Therefore, chromosome number in this genus shows not much value in understanding interspecific relationships (Gupta, 1978) as this genus shows remarkable uniformity in the chromosome number. However, some importance of chromosomal parameters has been shown in the characterization of the section calycinae and chrysocarycinae (Flores *et al.*, 2006).

Few studies are related to the anatomical aspects of leaf, stem, fruit and seed of the *Crotalaria* species. Anatomical features of leaf have been studied and used in solving different kind of taxonomic problem in different plant families (Wollenwebber &

Schnesder, 2000). Odewo *et al.* (2018) studied the foliar epidermal characteristics of the eight Nigerian species trying to provide easy identification and delimitation of the species even in the fragmentary condition. Among anisocytic and anomotetracytic stomatal type, anisocytic stomata found to be predominant. Further, polygonal and irregular shaped epidermal cells have been reported, trichomes were simple, unicellular and unbranched on the abaxial surfaces, while they were glabrous on the adaxial surface. Pollen grains found to be tricolporate (Wollenwebber & Schnesder, 2000). Many of the characters about morphology and anatomy in Brazilian species were relatively uniform (Devecchi *et al.*, 2014).

At section level, only one character i.e., trichome with a base composing radially distributed cells was found useful in the diagnosis of *Crotalaria* section Calycinae, while at the species level, various characters have been found to have diagnostic value e.g., those related to the texture, the venation pattern (formation of the areolae and insertion of the ribs secondary to midrib), and in particular the epidermis showed potential for aiding the circumscription of some species (Devecchi *et al.*, 2014). Similarly, some of the other studies restricted to the only leaf epidermis are also available (Krishnamurthy and Kannabiram, 1979; Gill *et al.*, 1982). Roux *et al.* (2011) focused on the anatomy of the cell wall of the fruits of the *Crotalaria* and related genera of the Crotalarieae (Fabaceae) and reported the taxa shows differences in terms of the orientation of the fibers, the overall thickness of the fruit wall, the relative proportion of the pericarp layers, the degree of lignification and the presence or absence of trichomes. Similarly, Sonje *et al.* (2013a, 2013b) studied the stem anatomy of *Crotalaria albida* and *Crotalaria hirsuta*. Miller (1967) studied the seed morphology and anatomy of the *Crotalaria*. Later Buth & Narayan (1986) reported the diversity in size, shape, color, shape of embryo and structure of cuticle, macrosclereids, osteosclereids and hilum and thus provide the taxonomic tool for identification of species within a genus. In *Crotalaria* species pod also shows differences among species with respect to their size, color, persistence of the calyx, presence absence of trichome and number of seeds per pod (Subramaniam *et al.*, 2022).

Thus, systematic studies of the Crotalarieae including the genus *Crotalaria* have covered morphological and anatomical (Leaf, stem, fruit, seed) (Roux *et al.*, 2011), cytogenetics (Windler, 1974), chemotaxonomical (Flores, 2004) and molecular level work (Le Roux *et al.*, 2013; Subramaniam *et al.*, 2013). Subramaniam *et al.* (2013)

analyzed the sequence of the nuclear internal transcribed spacer from species representing all the six sections of the Indian *Crotalaria* species and revealed 5 major clades. Similarly, Le Rux *et al.* (2013) performed the molecular systematic study based on nuclear internal transcribed spacer & the plastid markers and revealed that *Crotalaria* is monophyletic.

Although few to many studies in different aspects of the *Crotalaria* species from different parts of the world are available but none of them comprises all the species of Nepal. Some study covers only few species from Nepal while other even do not cover single species that are reported from Nepal. Further, one endemic species of Nepal i.e., *C. kanaii* is not included in any of the studies available.

2.2 Efforts on Infrageneric Classification of *Crotalaria* Species

Since *Crotalaria* genus is large, highly reticulate and has complex interspecific variation there are difficulties in developing infrageneric classification and many different efforts are going on (Senn, 1939; Bisby, 1970). One of the most widely accepted infrageneric classification of the *Crotalaria* genus was provided by Bisby & Polhill (1973), based on the morphological characters of the flowers of African species. Polhill (1968), Bisby (1973), and Le Rux *et al.* (2013) are important contributors to infrageneric classification of the *Crotalaria* genus.

Polhill (1968) re-evaluated the infrageneric classification system following many previous work and divided *Crotalaria* species of Africa and Madagascar into 11 sections and 8 subsections based on floral and fruit characters. Later on in 1973, Polhill and Bisby combined their datasets and made some minor changes to the previous infrageneric system of the Polhill (1968) thus modified system with 8 sections and 9 subsections, also based on the floral characters like callosities position, shape of keel, curvature of keel, beak of keel, curvature of keel, beak of keel, curvature of style, number of lines of trichomes of style, etc.

Later on, Ansari (2006, 2008) worked on the Indian species of the *Crotalaria* and published the revision of the infrageneric classification system of genus *Crotalaria* and created 4 new subsections in section Calycinae and 2 new sub section in section *Crotalaria* but he did not study the range of variation in extra-Indian species. Later Le Rux *et al.* (2013), based on molecular phylogeny made a new interpretation of important morphological characters of diagnostic value including specialization of the

calyx, keel, standard petal and style. They formalized 11 sections: Amphitrichae, Calycinae, *Crotalaria*, Geniculatae, Glaucae, Grandiflorae, Hrdriocarpae, Incanae, Schizostigma, Borealigeniculatae and Stipulosae.

2.3 Distribution of *Crotalaria* Species

Crotalaria species are almost cosmopolitan in distribution. There is no detail and comprehensive information available about the distribution pattern of the *Crotalaria* species in different floristic region, continent and countries of the world. However, according to available information what we know is, this genus is widely distributed, having primary center of species diversity in tropical and subtropical Africa and Madagascar (Van Wyk, 2005; Jianqiang *et al.*, 2010; Le Roux *et al.*, 2013). Temperate Asia, Tropical Asia and Australasia (with 159 species), South America (with 64 species) and North America (with 34 species) represent the areas with secondary radiation of the *Crotalaria* species (Flores *et al.*, 2006; Pandey *et al.*, 2010; Le Roux *et al.*, 2013). Thus, species of the genus *Crotalaria* are mainly found to be distributed to the Southern hemisphere (Jianqiang *et al.*, 2010). Study of the distribution of the Brazilian species shows that, the species are concentrated in regions with tropical climate, especially in savanna vegetation at high altitude (Flores *et al.*, 2008). Now it is important to know the distribution pattern of Nepalese species of *Crotalaria* within Nepal and to know their affinities with those of other countries and geographic regions.

3. MATERIALS AND METHODS

3.1 Taxonomic Study

3.1.1 Protologue and literature review

Protologue and various old/new literatures were studied. Literatures were obtained from libraries and online databases. Old and new publications related to taxonomy of the family Fabaceae and genus *Crotalaria* L., were thoroughly reviewed. Various online botanical databases, like IPNI (International Plant Name Index), JSTOR (Global Plant on JSTOR), World Flora Online, GBIF (Global Biodiversity Information Facility) etc. were utilized to fulfill the purpose of this study. Protologues were obtained from online databases like, BHL (Biodiversity Heritage Library) and JSTOR. Further various floras like, Flora of China, Flora of Pakistan, Flora of Bhutan, Flora of Kathmandu Valley, Flora of British India, etc. were studied.

3.1.2 Literature-based character matrix:

After extensive study of the literatures of genus *Crotalaria*, various morphological characters were recorded arranging the different characteristics in columns to prepare a data matrix. This data matrix helps to observe variation in particular character among different species in a single sheet.

3.1.3 Plant collection and preparation of herbarium specimens

Along with visiting different herbaria of Nepal i.e., KATH and TUCH, collection of live specimens was also made and vaucher specimens were thus prepared. Representative live samples of 13 native species (3 species were not found in filed) of *Crotalaria* were collected from different parts of the country. Plants were collected in their flowering or fruiting state with proper condition of the leaves and other parts. Proper field notes were noted for each collections including species name, altitude, GPS location, habit and habitat, etc. Proper photographs of each species were taken in the field and herbarium press, newspapers, ropes and other required material for collection and herbarium preparation were taken in the field. Mainly tropical and sub-tropical rarely temperate part of the country were visited from the month of July to February, 2022 A.D. The collected samples were pressed, dried and mounted following standard technique to prepare herbarium (Bridson and Forman, 1998).

3.1.4 Identification of specimens

Each collected samples from field were cross examined with the help of herbarium specimen deposited at KATH, TUCH and digital photographs of herbarium specimens of international herbaria like, TI, BM, K and E. Keys and descriptions available at different national and international floras and protologues of the species were also used for the correct identification of the species.

3.1.5 Morphological study

Maximum available and observable vegetative and reproductive characters were taken into consideration. Characters were studied in fresh condition of the plants. For minute characters lens and stereomicroscope were used. Measurement was mainly taken from mature parts of the plant. Detailed taxonomic description including all or maximum possible observable vegetative and reproductive characters of each species were also written.

3.1.6 Leaf epidermal characteristics

Leaves of 13 species which were collected from field were soaked in water for 24 hours for softening. Abaxial epidermal layer was peeled out for each species and stained and observed under compound microscope following Paul *et al.* (2017). Epidermal cells and stomata were also observed. Shape of epidermal cells, nature of cell wall along with stomata numbers and epidermal cells count of adaxial surface were observed and stomatal index of 13 species were calculated following Mishra (1997) and compared.

3.1.7 Surface vestiture type

Surface vestiture type of stem, leaf, stipule, bract and bracteoles, calyx, standard and keel petal, ovary and style surface and of fruits were observed through naked eye and with the help of stereo microscope.

3.1.8 Illustrations, photography and distribution map

Free hand illustration was prepared on the basis of fresh live sample of plants and also observing the herbarium specimens. The illustrations include the habit sketch, leaf, flower, androecium, gynoecium and fruit. Photographs of the vegetative and reproductive parts of representative samples were captured and photo plates were prepared. To prepare distribution map of different species, location information

recorded in the labels of herbarium specimens deposited at KATH, TUCH, and other international herbaria were recorded and also the location information of field collection was recorded for every species and thus using the collected information about locations of their past record distribution map was prepared using the ArcGIS version 10.0.

3.1.9 Construction of the identification key

For easy identification of the species taxonomic key has been prepared. Dichotomous key in bracketed format has been prepared using vegetative and reproductive characters.

3.2 Cluster Analysis

Hierarchical cluster analysis was performed using 50 different qualitative and quantitative characters of the species (Appendix 2), to observe maximum similarity or dissimilarity among different species. Among 16 native species, one species has been excluded from cluster analysis due to unavailability of the enough characters as both live sample and herbarium specimens were not available for this (*C. mysorensis*) species. Both two-state and multi-state coding were done as per the requirement. SPSS 16.0 was used for the analysis.

3.3 Phenology

Phenological table has been prepared recording the month of flowering and fruiting from data of labels of herbarium specimens deposited at national (KATH and TUCH) and international herbaria (TI, BM, E) and by the observation done during the sample collection in the field.

4. RESULTS

4.1 Range of Morphological Characters in the Genus *Crotalaria* L.

4.1.1 Life forms

Crotalaria shows variation in life forms of the species. Among 16 species studied here majority of species are herbs. *C. medicaginea*, *C. acicularis*, *C. prostrata*, are example of small herb species while there are other species which are subshrub to shrub. *C. tetragona*, *C. cytisoides* and *C. pallida* are example of shrub species. Some herb species are very small i.e., not even exceeding 20cm while some shrub grows up to 3m. Species orientation range from prostrate, ascending or erect. Further majority of the species are annuals while few are perennials. The *Crotalaria* species of Nepal with their different life forms can be grouped as follows:

1. Prostrate annual herb: *C. humifusa*, *C. prostrata*
2. Prostrate to slightly ascending annual herb: *C. acicularis*
3. Prostrate perennial herb: *C. kanaii*
4. Semi prostrate annual herb: *C. medicaginea*
5. Erect annual herb: *C. calycina*, *C. sessiliflora*, *C. mysorensis*
6. Erect annual herb to subshrub: *C. spectabilis*, *C. quinquefolia*
7. Erect or ascending annual or perennial herb to subshrub: *C. lejoloba*
8. Erect perennial small or medium bushy shrub: *C. cytisoides*
9. Erect perennial herb to shrub: *C. pallida*, *C. tetragona*
10. Erect, spreading or sometimes prostrate, annual or perennial small herb to subshrub: *C. albida*
11. Erect or prostrate or ascending annual herb, undershrub to shrub: *C. alata*



Photoplate 1: Habit range in *Crotalaria* species: A. shrub (*C. pallida*); B. herb (*C. sessiliflora*); C. herb (*C. alata*).

4.1.2 Stem

Different stem characteristics in which *Crotalaria* species shows differences are, stem shape, surface hairs, branching pattern, etc. All species are branched however based on branching pattern, four group can be formed.

1. Branched: *C. tetragona*, *C. quinquefolia*, *C. prostrata*, *C. acicularis*, *C. mysorensis*
2. Profusely branched: *C. spectabilis*, *C. pallida*, *C. kanaii*, *C. humifusa*, *C. lejoloba*, *C. cytisoides*
3. Branched or unbranched: *C. sessiliflora*, *C. calycina*, *C. alata*
4. Branched to profusely branched: *C. albida*, *C. medicaginea*

Texture of stem may be soft (*C. medicaginea*, *C. Pallida*, *C. quinquefolia*, *C. spectabilis*) or slightly rough to rough (*C. acicularis*, *C. alata*, *C. calycina*, *C. lejoloba*, *C. prostrsta*, *C. sessiliflora*, *C. tetragona*), further in terms of stem shape most of the species are terete (12 species), while three species have angular stem (*C. spectabilis*, *C. quinquefolia* and *C. tetragona*,) and remaining one species i.e., *C. pallida* stem is marked with slender longitudinal grooves. Stem of all the species have trichomes.

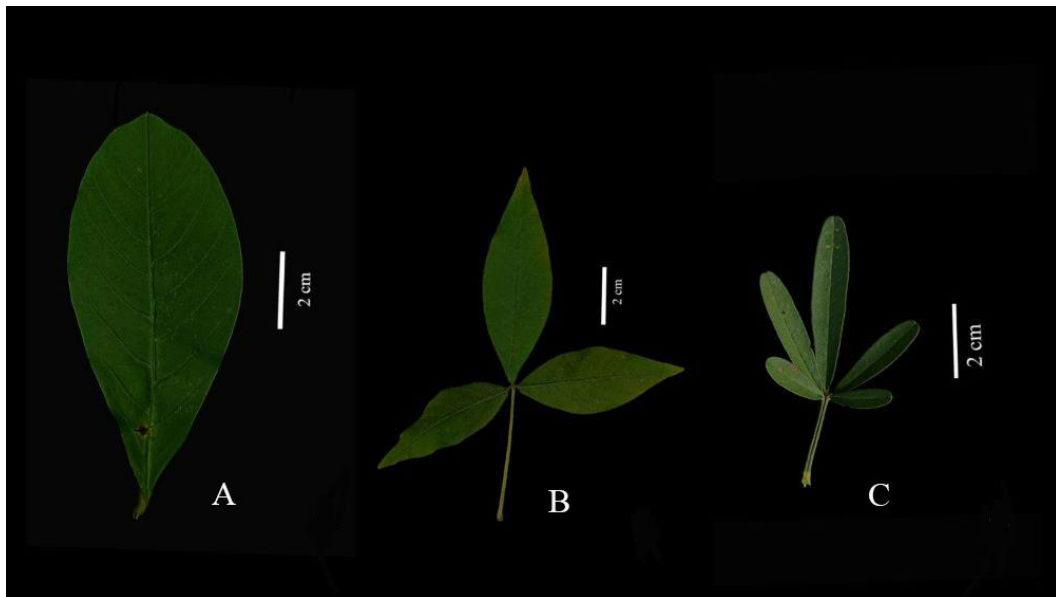
4.1.3 Leaves

In terms of leaves, *Crotalaria* species shows variation in characters like petiole length, leaf type, shape, size, apex, base, margin, surface, and distinctiveness of veins. Leaves

are alternate in all species. Shape of leaf is variable among species and also within the same individual of the same species. Leaves in majority of species are stipulate while two species (*C. prostrata* and *C. albida*) are exstipulate. Midrib is distinct in all species but secondary veins are prominent only in 6 species (*C. tetragona*, *C. spectabilis*, *C. pallida*, *C. kanaii*, *C. cytisoides*, *C. alata*).

a. Leaf type

In terms of leaves, *Crotalaria* species shows variation in characters like petiole length, leaf type, shape, size, apex, base, margin, surface, and distinctiveness of veins. Leaves are alternate in all species. Shape of leaf is variable among species and also within the same individual of the same species. Majority of species are stipulated while two species are exstipulate (*C. prostrata* and *C. albida*). Midrib is distinct in all species but secondary veins are prominent in only 6 species (*C. tetragona*, *C. spectabilis*, *C. pallida*, *C. kanaii*, *C. cytisoides*, *C. alata*) while pale to non-distinct in other.



Photoplate 2: Leaf type in *Crotalaria* species: A. simple leaf (*C. spectabilis*); B. trifoliate leaf (*C. cytisoides*); C. pentafoliate leaf (*C. quinquefolia*).

b. Petiole

Leaves of species like *C. acicularis*, *C. kanaii*, *C. prostrata* are almost sessile having petiole of 1mm or short. Three trifoliate species i.e., *C. cytisoides* (2-4.5cm), *C. pallida* (1.5-5.8cm) and *C. quinquefolia* (1.5-7cm) are with longest petiole, while other remaining species have intermediate sized petiole. Further shape of petiole is terete in

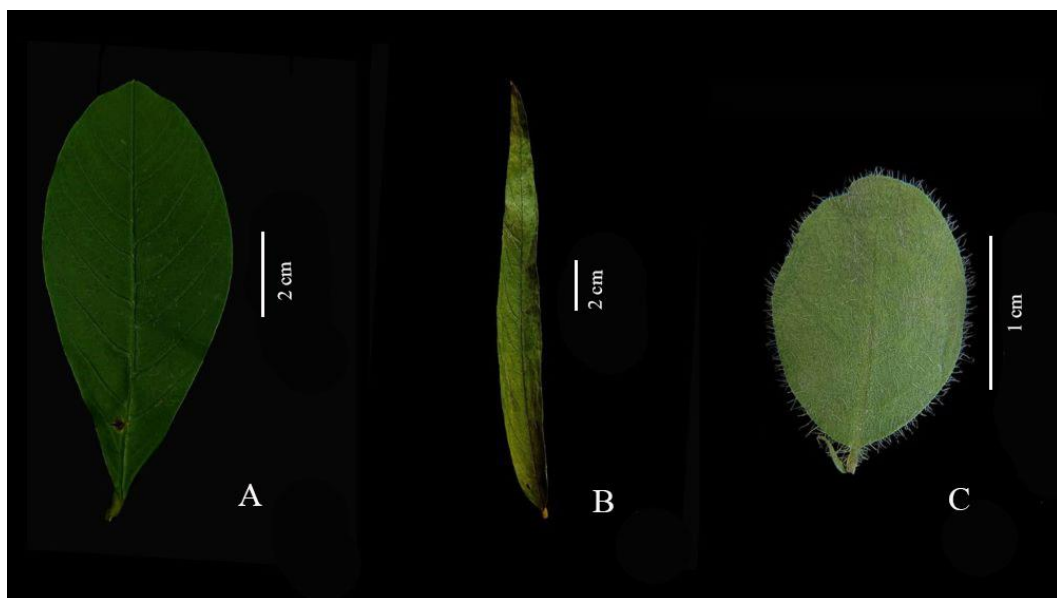
all except *C. cytisoides*, *C. pallida*, *C. medicaginea* and *C. quinquefolia* where petiole is channeled (Single longitudinal groove adaxially). (Appendix 4).

c. Leaf shape

The shape of leaf varies from species to species and also within the species. Different leaf shapes seen in *Crotalaria* species of Nepal are suborbicular, broadly oblong, oblong, narrowly oblong, elliptic, narrowly elliptic broadly elliptic, oblanceolate, linear, lanceolate, obovate, lanceolate-elliptic, oblong-linear, linear-lanceolate, orbicular, oblong-elliptic, ovate, broadly ovate, oblong-ovate, oblanceolate, oblance-oblong, narrowly elliptic, ovate-oblong, lance-ovate, oblong-lanceolate, linear-oblong or oblanceolate and sometime rhomboidal.

d. Leaf size

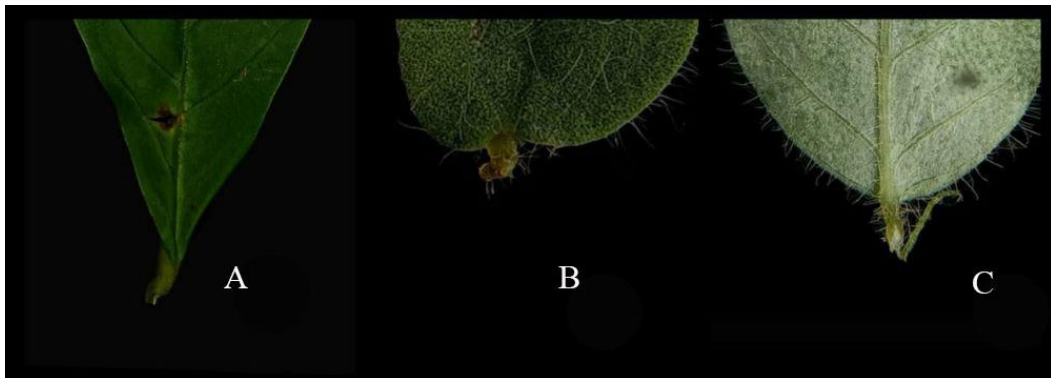
Leaf size varies from very small to large. In species like *C. acicularis*, *C. kanaii* and *C. humifusa* leaves are small, while in some species leaves are up to 26 cm long (*C. tetragona*). Smallest and narrowest leaflets are found in *C. medicaginea* (0.6-1.4 × 0.2-0.5 cm), while broadest leaves are found in *C. spectabilis* where leaves are up to 7.2cm broad. (Appendix 4).



Photoplate 3: Range of leaf size in *Crotalaria* species: A. Broad leaf (*C. spectabilis*); B. long leaf (*C. tetragona*); C. small leaf (*C. humifusa*).

e. Leaf base

- I. Cuneate: Majority of species have cuneate leaf base (*C. alata*, *C. calycina*, *C. medicaginea*, *C. mysorensis*, *C. pallida*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis*, *C. cytisoides*).
- II. Oblique: *C. acicularis* leaf has oblique leaf base.
- III. Other remaining species shows variation in leaf base within species. For example, *C. tetragona* has cuneate or rounded and *C. humifusa* has oblique, cuneate or rounded leaf base.
- IV. *C. Kanaii* has cordate, rounded, truncate, oblique, or broadly cuneate leaf base, *C. prostrata* has oblique, cuneate or rounded base, *C. lejoloba* has cuneate or slightly oblique base while *C. albida* has attenuate to cuneate leaf base.

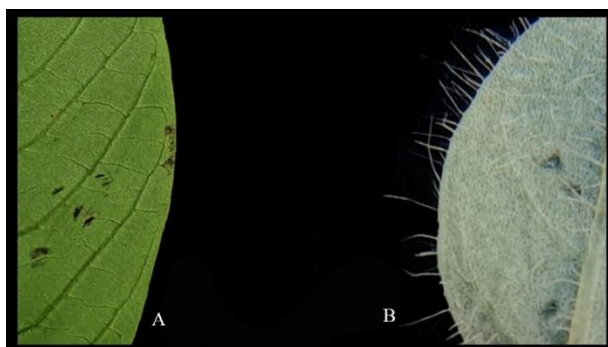


Photoplate 4: Common leaf base types in *Crotalaria* species: A. cuneate (*C. spectabilis*); B. oblique (*C. acicularis*); C. rounded (*C. humifusa*).

f. Leaf margin

There is not much variation in the margin of the leaf of the species. Species has either entire margin or ciliated margin.

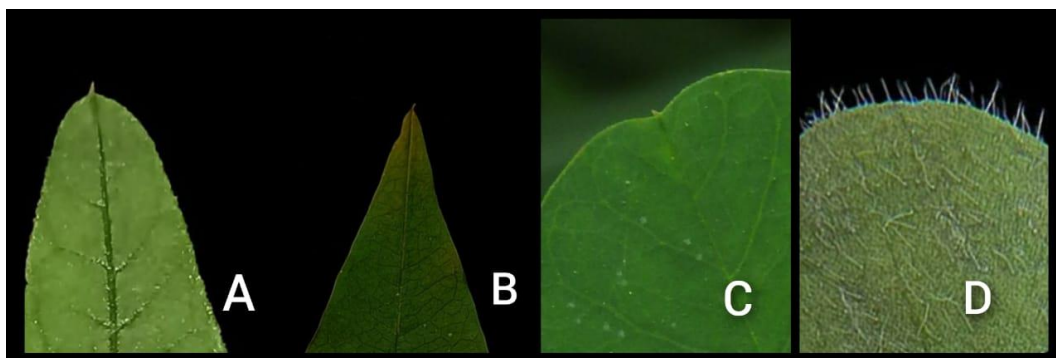
- I. Entire: majority (12 species) of species has entire margin (*C. albida*, *C. alata*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. medicaginea*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis*, *C. tetragona*).
- II. Ciliated: remaining four species has ciliated margin (*C. humifusa*, *C. kanaii*, *C. acicularis*, *C. mysorensis*).



Photoplate 5: Type of leaf margin in *Crotalaria* species: A. Entire (*C. spectabilis*); B. ciliated (*C. humifusa*).

g. Leaf apex

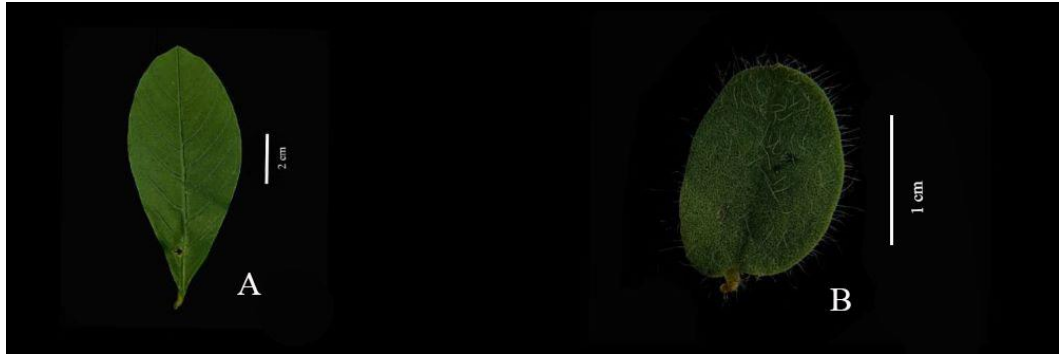
Different type of apex has been encountered in species of *Crotalaria*. Most frequent is mucronate, which comes with combination of some other type of apex for example, obtuse and mucronate (*albida* and *C. alata*), acute and mucronate (*C. calycina*), acute or acuminate with mucronation (*C. cytisoides*), rounded and mucronate (*C. mysorensis*), emerginate with short mucronation or rounded (*C. pallida*). Other apex types found in species of *Crotalaria* are rounded, truncate, retuse. Variation has also occurred within the same species.



Photoplate 6: Common leaf apex types in *Crotalaria* species: A. obtuse and mucronate (*C. alata*); B. acute and mucronate (*C. cytisoides*); C. emerginate and mucronate (*C. pallida*); D. rounded (*C. humifusa*).

h. Leaf symmetry

Majority of the species i.e., 14 species have symmetrical leaves. *Crotalaria acicularis* has asymmetrical leaves. Remaining one species (*C. prostrata*) has mostly asymmetrical leaves but mature leaves in some individual has symmetrical leaves.



Photoplate 7: Symmetry in leaf of *Crotalaria* species: A. symmetric (*C. spectabilis*); B. assymmetric (*C. acicularis*).

1.1.4 Stipule

Stipules are present in all species except in *C. albida* and *C. prostrata*. The stipule is persistent but caducous in two i.e., *C. pallida* and *C. calycina*. Stipule varies in shape, size, surface, orientation, base and margin. Apex of stipule is acute or acuminate in *Crotalaria* species of Nepal.

a. Orientation

Stipules are in different orientation from appressed (*C. cytisoides*, *C. sessilifora*, *C. tetragona*), inclined (*C. calycina*, *C. medicaginea*), divergent (*C. kanaii*, *C. lejoloba*, *C. pallida*, *C. spectabilis*), reflexed (*C. acicularis*, *C. quinquefolia*) to whole length wise attachment to stem (*C. alata*). *C. humifusa* has either divergent or recurved stipule. (Appendix 5).



Photoplate 8: Different type of stipule orientation in *Crotalaria* species: A. reflexed (*C. acicularis*); B. divergent (*C. spectabilis*); C. appressed (*C. tetragona*); D. sidewise wholly attached (*C. alata*).

b. Shape

Stipules are found in different shapes. Linear in *C. alata*, *C. sessiliflora* and *C. tetragona*, subulate in *C. cytisoides* and *C. humifusa*, Triangular in *C. pallida*, narrowly triangular in *C. quinquefolia*, lanceolate in *C. acicularis*, broadly lanceolate with one side incurved (*C. lejoloba*), further other shapes found in other remaining species are lance-ovate, filiform, triangular-filiform, narrowly lanceolate and linear-lanceolate. *C. alata* has the longest elongated stipule among all, which is elongated almost throughout the stem length on both side in decurrent form giving the appearance of wing. (Appendix 5)

c. Size

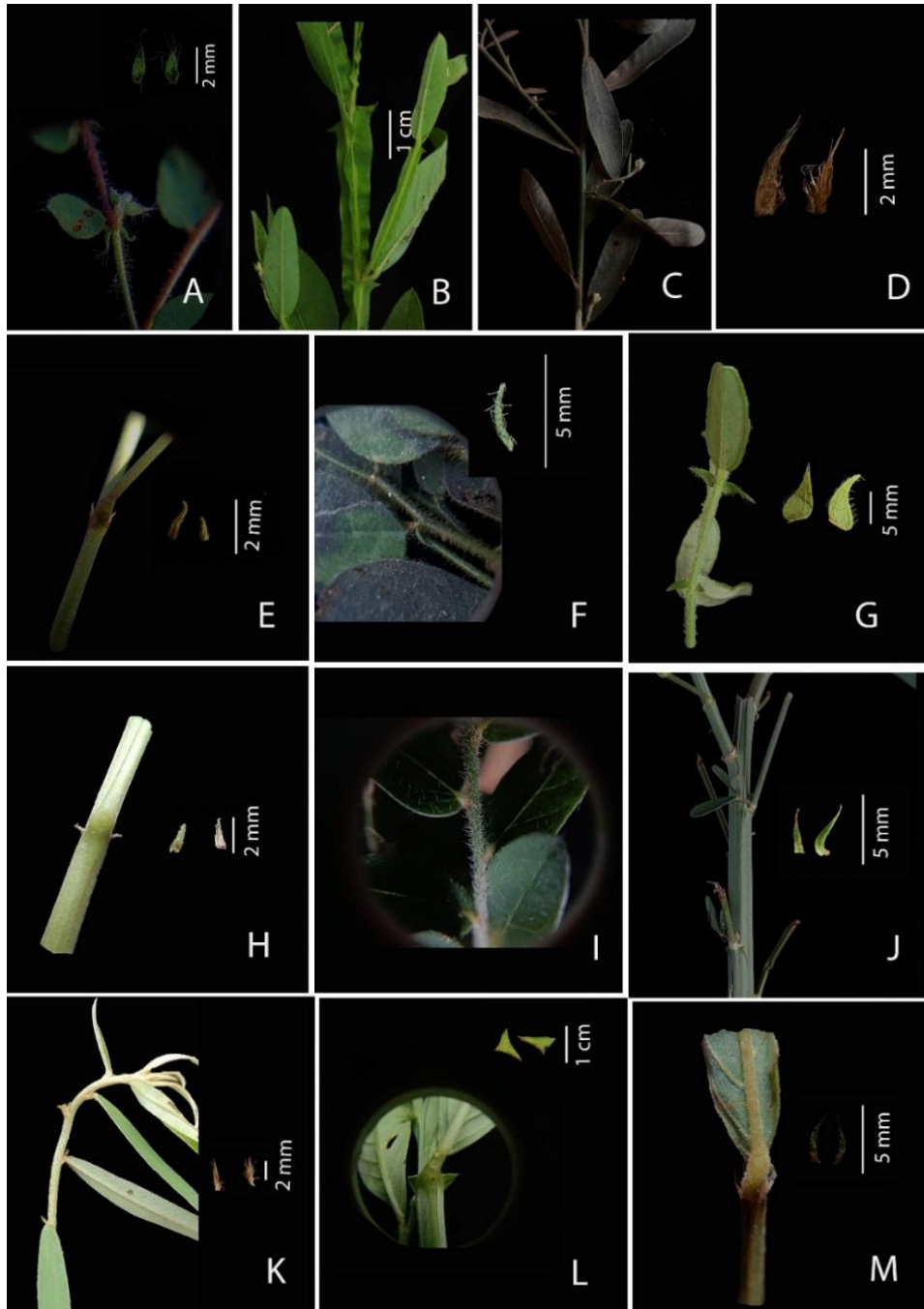
In most of the species stipule size is small. Ten species have stipule length within the range of 1-6mm (*C. acicularis*, *C. calycina*, *C. cytisoides*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora*, and *C. tetragona*), while in other three species i.e., *C. lejoloba*, *C. mysorensis* and *C. spectabilis* reach up to 1cm to slightly longer. Further *C. alata* has the longest stipule having length 2.5-10cm. stipule may be very narrow about 0.2mm broad as in *C. kanaii*, or could be broad up to 7mm (*C. spectabilis*), to 8mm (*C. alata*). (Appendix 5).

d. Base

Majority of species have stipule with truncate/ flat base (*C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora*, *C. spectabilis*, *C. tetragona*), while *C. alata* and *C. acicularis* have rounded or cuneate base of their stipule similarly *C. mysorensis* has rounded base of stipule. (Appendix 5).

e. Margin

In stipule majority of species have ciliated (*C. acicularis*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. mysorensis*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora*, and *C. tetragona*) margin and few other species (*C. alata*, *C. cytisoides* and *C. spectabilis*) have entire margin.



Photoplate 9: Stipule of the *Crotalaria* species: A. *C. acicularis*; B. *C. alata*; C. *C. albida* (stipule absent); D. *C. calycina*; E. *C. cytisoides*; F. *C. humifusa*; G. *C. lejoloba*; H. *C. pallida*; I. *C. prostrata* (stipule absent); J. *C. quinquefolia*; K. *C. sessiliflora*; L. *C. spectabilis*; M. *C. tetragona*.

4.1.5 Inflorescence

Inflorescence is racemose in all the species of *Crotalaria* but in some species along with racemose inflorescence axillary solitary flowers are also found (*C. humifusa*, *C. sessiliflora* and *C. calycina*). Inflorescence varies from species to species in terms of its position, length, number of flowers, compactness of the flowers and peduncle

length. In some species flowers are compactly arranged to give very congested appearance (*C. cytisoides*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora*), while in other flower arrangement is very lax (*C. tetragona*, *C. prostrata*, *C. humifusa*, *C. lejoloba*, *C. calycina*, *C. alata*, *C. spectabilis*).

a. Inflorescence position

Inflorescence are found to arise terminally (*C. albida*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora* and *C. mysorensis*), opposite to leaf (*C. lejoloba*), from leaf axil or from internode (*C. alata*) in *Crotalaria* species. In some other species inflorescences are found to arise from two or more different position in the same individual plant as:

- I. Terminal or leaf opposed: *C. acicularis*, *C. kanaii*, *C. medicaginea*, *C. prostrata* and *C. tetragona*
- II. Terminal or axillary: *C. spectabilis*,
- III. Leaf-opposed, terminal or solitary flowers in axil: *C. humifusa* and *C. calycina*
- IV. Terminal, leaf-opposed or axillary: *C. cytisoides*



Photoplate 10: Inflorescence at different position in *Crotalaria* species: A. terminal (*C. pallida*); B. leaf-opposed (*C. lejoloba*); C. internodal (*C. alata*); D. Terminal and axillary (*C. spectabilis*).

b. Number of flowers per inflorescence

There is great variation in number of flowers per inflorescence in *Crotalaria* species. Some species are with only few flowers in their inflorescence while some species are many flowered. *C. kanaii* is the species with lowest number of flowers (1-2) in their inflorescence, while *C. spectabilis* is the species with largest number of flowers (upto 64) in their inflorescence. Similarly other species having many flowers in their inflorescence are *C. pallida* (14 to 52 flowers), *C. cytisoides* (7 to 41 flowers), *C. albida*

(2 to 34 flowers), *C. sessiliflora* (2 to 27 flowers), *C. quinquefolia* (4 to 26 flowers). In six species (*C. alata*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. prostrata*, and *C. mysorensis*) flower number found to be below 10, and in remaining species *C. acicularis*, *C. medicaginea* and *C. tetragona* number of flowers were found up to 15. (Appendix 6)



Photoplate 11: Flowers number and peduncle length in *Crotalaria* species: A. inflorescence with very short peduncle and medium number of flowers (*C. sessiliflora*); B. inflorescence with long peduncle and few number of flower (*C. alata*); C. inflorescence with many flowered (*C. spectabilis*).

c. Inflorescence Length

Generally, species having large number of flowers has longer inflorescence and species with few numbers of flower per inflorescence has shorter inflorescence. Longest inflorescence is found in *C. spectabilis* where length reach up to 70cm, similarly *C. kanaii* has shortest inflorescence of only 1-1.5cm with only 1 or 2 flowers. While other remaining species has intermediate length of their inflorescence. (Appendix 6)

d. Peduncle length

Species having longest peduncle are *C. alata* (2 to 10.5cm), *C. quinquefolia* (3.8-10.5cm) and *C. lejoloba* (2-10cm), and shortest peduncle is found in species like *C. medicaginea* (1.1-2cm) and *C. sessiliflora* (0.5-1.5cm) (Appendix 5). Shape of peduncle and peduncle surface/vestiture character are same as stem.

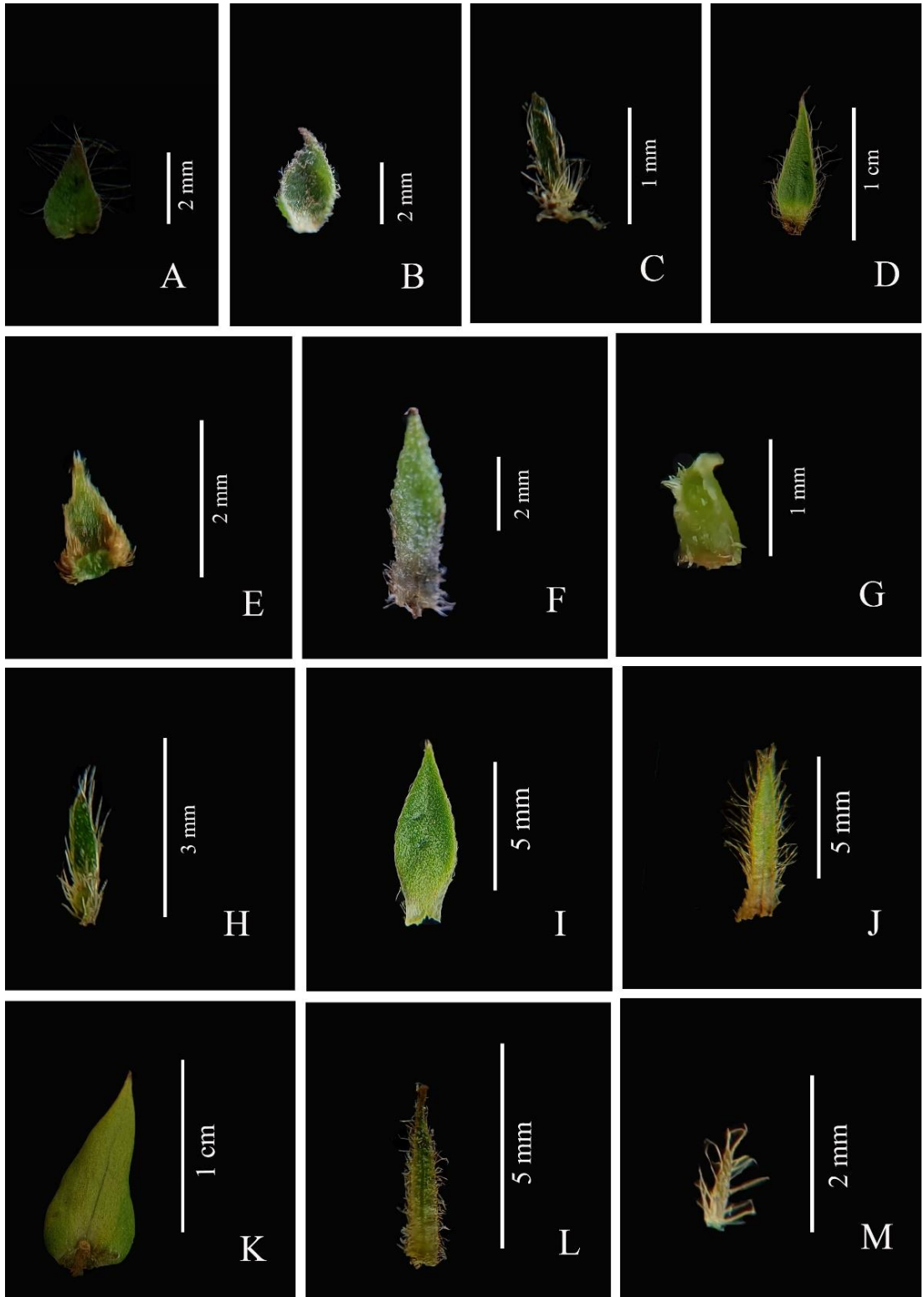
4.1.6 Bract and Bracteoles

Bract and bracteoles are foliaceous, bract is caducous in *C. pallida* in other species bract and bracteoles both are persistent. In bract midrib is distinct in only two species (*C. spectabilis* and *C. tetragona*) while in bracteoles midrib is not distinct in any species. Further shape and size of bract and bracteoles also varies in different species. In terms of shape, some species has same shape of bract and bracteoles while in other

species shape of bract and bracteoles are different. In *C. alata* and *C. mysorensis* both bract and bracteoles are lanceolate in shape, *C. humifusa* has subulate bract and bracteoles, *C. medicaginea* has linear shaped bract and bracteoles, other remaining species has different shape of bract and bracteoles which are shown in the table below.

Table 1: Comparison of shape of bract and bracteoles

S. N.	Species	Shape of bract	Shape of bracteoles
1	<i>C. acicularis</i>	Cordate	Lanceolate
2	<i>C. albida</i>	Linear	Linear to narrowly elliptic
3	<i>C. alata</i>	Lanceolate	Lanceolate
4	<i>C. calycina</i>	Broadly Lanceolate	Narrowly lanceolate
5	<i>C. cytisoides</i>	Ovate	Triangular-ovate
6	<i>C. lejoloba</i>	Lanceolate	Linear
7	<i>C. humifusa</i>	Subulate	Subulate
8	<i>C. kanaii</i>	Narrowly triangular	Filiform
9	<i>C. medicaginea</i>	Linear	Linear
10	<i>C. mysorensis</i>	Lanceolate	Lanceolate
11	<i>C. pallida</i>	Broadly lanceolate- triangular	Linear
12	<i>C. prostrata</i>	Lanceolate	Subulate
13	<i>C. quinquefolia</i>	Lanceolate	Subulate
14	<i>C. sessilifora</i>	Subulate/narrowly triangular	Linear
15	<i>C. spectabilis</i>	Lanceolate or cordate	Lanceolate
16	<i>C. tetragona</i>	Narrowly triangular	Linear



Photoplate 12: Bracts of the *Crotalaria* species: A. *C. acicularis*; B. *C. alata*; C. *C. albida*; D. *C. calycina*; E. *C. cytisoides*; F. *C. lejoloba*; G. *C. pallida*; H. *C. prostrata*; I. *C. quinquefolia*; J. *C. sessiliflora*; K. *C. spectabilis*; L. *C. tetragona*.; M. *C. humifusa*.

a. Size of Bract and Bracteoles

In some species bract and bracteoles both are all most equal in size, while in other species one of them is comparatively larger than other. In terms of bracts, species having large sized bracts are *C. spectabilis* (6-16 × 3-8mm), *C. sessilifora* (5-14 × 0.5-1mm), *C. calycina* (8-14 × 2-3mm) and *C. quinquefolia* (6-11 × 2-3mm), and other remaining species have small bracts, among all, smallest bract is found in *C. albida* (1 × 0.2mm).

Table 2: Comparison of size of bracts and bracteoles

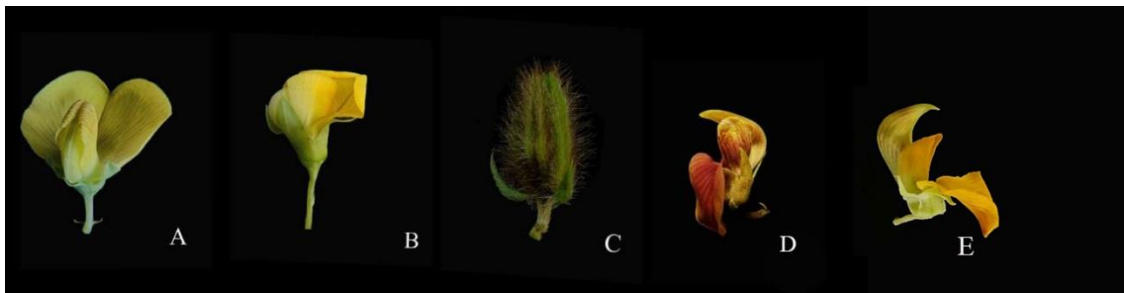
S. N.	Species	Size of bracts	Size of bracteoles
1	<i>C. acicularis</i>	3-4 × 1.5-2.5 mm	1-2 × 0.5 mm
2	<i>C. albida</i>	1 × 0.2 mm	1-3 mm
3	<i>C. alata</i>	4-5 × 2-3 mm	3-5 × 1-2 mm
4	<i>C. calycina</i>	8-14 × 2-3 mm	6-13 × 2-3 mm
5	<i>C. cytisoides</i>	1-2.5 × ca. 1 mm	2-2.5 (3) × 1 mm
6	<i>C. lejoloba</i>	3-4.5 × 1 mm	4-5 × c.1 mm
7	<i>C. humifusa</i>	0.7-1.5 × 0.2 mm	1.5-2 × 2 mm
8	<i>C. kanaii</i>	2-3 × 0.5 mm	1.5-2 × 0.2 mm
9	<i>C. medicaginea</i>	1-2 × 0.2 mm	0.5 × 0.1 mm
10	<i>C. mysorensis</i>	ca. 7 × 2 mm	ca. 9 × 1 mm
11	<i>C. pallida</i>	1-1.5 × 0.5 mm	1-1.5 × 0.2 mm
12	<i>C. prostrate</i>	1-2 × 0.3-0.4 mm	2 × 0.3 mm
13	<i>C. quinquefolia</i>	6-11 × 2-3 mm	1.5-2 × 0.3 mm
14	<i>C. sessilifora</i>	5-14 × 0.5-1 mm	3-8 × 0.5 mm
15	<i>C. spectabilis</i>	6-16 × 3-8 mm	1 × 0.4-0.5 mm
16	<i>C. tetragona</i>	3-5 × 1-2 mm	4-6 × 0.5-1 mm

b. Position of bract and bracteoles:

In terms of position of bract and bracteoles, Bract have always found to be present at the base of pedicel while bracteoles were found to be present in different positions like,

at the base of calyx, top of pedicel, middle of pedicel to basal part of pedicel. So, based on these different position of bracteoles five categories can be formed:

- I. At the basal part of pedicel: *C. quinquefolia*
- II. Middle of pedicel: *C. spectabilis*
- III. Top of pedicel: *C. tetragona*, *C. medicaginea*, *C. calycina*, and *C. kanaii*
- IV. Base of calyx tube: *C. sessilifora*, *C. prostrata*, *C. humifusa*, *C. cytisoides*, *C. alata*, *C. albida*, *C. acicularis*, and *C. mysorensis*.
- V. Middle of calyx tube: *C. pallida* and *C. lejoloba*



Photoplate 13: Position of bracteoles in *Crotalaria* species: A. at the base of pedicel (*C. quinquefolia*); B. at middle of the pedicel (*C. spectabilis*); C. at the top of the pedicel (*C. calycina*); D. at the base of calyx tube (*C. cytisoides*); E. at the middle of calyx tube (*C. pallida*).

c. Base, Margin, Apex:

In Majority of species of *Crotalaria*, base of bract and bracteoles both is truncate. Except truncate other base shape in bract are cordate (*C. acicularis*), reniform (*C. alata*), cuneate (*C. prostrata*) and rounded (*C. spectabilis* and *C. mysorensis*). While in bracteoles other than truncate other base types are broadly cuneate (*C. acicularis*), cuneate (*C. albida*), obtuse or rounded (*C. alata*), and narrowly cuneate (*C. sessilifora*).

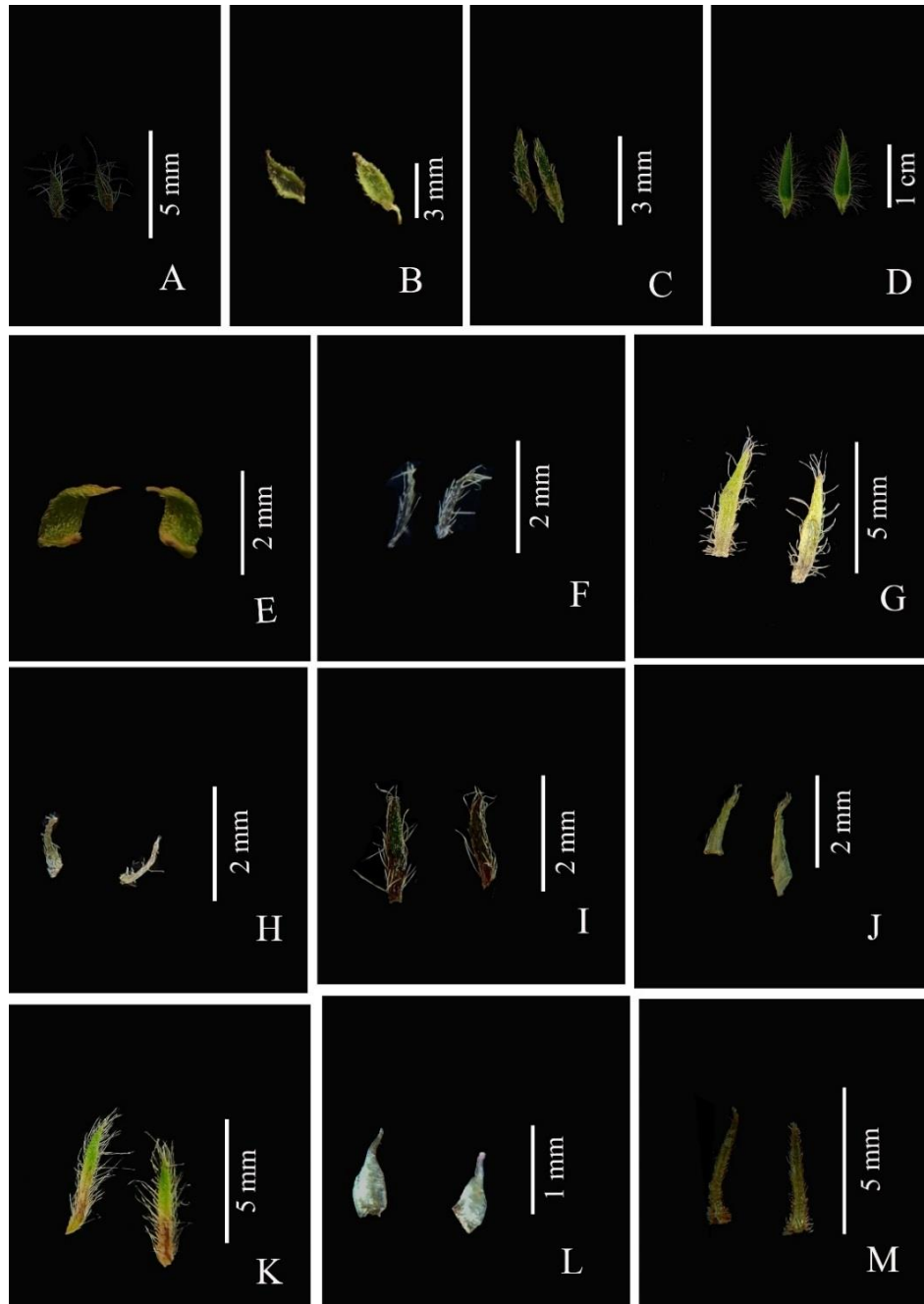
Margin of bract and bracteoles is ciliated in all species except in *C. spectabilis*.

Further apex of bracts of *Crotalaria* species found to be:

- I. Acute: *C. acicularis*, *C. albida*, *C. lejoloba*, *C. humifusa*, *C. medicaginea*, *C. pallida*, *C. prostrata*, *C. sessilifora*, *C. tetragona* and *C. mysorensis*
- II. Acuminate: *C. alata*, *C. calycina*, *C. cytisoides*, *C. kanaii* and *C. quinquefolia*
- III. Acute or Acuminate: *C. spectabilis*.

Similarly, in bracteoles also majority of species has acute apex. Along with acute other apex types found in *Crotalaria* species of Nepal are:

1. Acute: *C. albida*, *C. cytisoides*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. pallida*,
C. prostrata, *C. quinquefolia*, *C. sessiliflora* and *C. tetragona*
2. Acuminate: *C. alata* and *C. spectabilis*
3. rounded: *C. medicaginea*
4. narrowly acute: *C. calycina*
5. acute or acuminate: *C. acicularis*



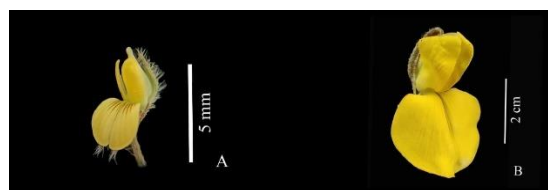
Photoplate 14: Bracteoles of the *Crotalaria* species: A. *C. acicularis*; B. *C. alata*; C. *C. albida*; D. *C. calycina*; E. *C. cytisoides*; F. *C. humifusa*; G. *C. lejoloba*; H. *C. pallida*; I. *C. prostrata*; J. *C. quinquefolia*; K. *C. sessiliflora*; L. *C. spectabilis*; M. *C. tetragona*.

4.1.7 Flower

Since *Crotalaria* has papilionaceous flowers, flower is zygomorphic. Flower of *Crotalaria* species of Nepal recorded till date are yellow in color except one species i.e., *C. sessiliflora*, where, flower is whitish to purplish in color. Flower size in *Crotalaria* range from only about 3mm to 4.5cm long. Smallest flower is found in *C. humifusa* (3-5 × 2-2.5mm), and *C. prostrata* (4-5 × 4mm) and then followed by *C. acicularis* (3-6 × 4-5mm), *C. medicaginea* (5-7 × 4-6mm) and *C. albida* (6-8 × 7-9mm). Other remaining species has flower comparatively larger, exceeding the length of 1cm. Among all *C. tetragona* had largest flower (4-4.5 × 2.2.5cm), other species with comparatively large flower size exceeding the length of 1cm were: *C. mysorensis* (2 × 0.5cm), *C. calycina* (1.5-3 × 1.1-2.5cm), *C. quinquefolia* (1.4-2 × 1.6-2.3 cm), *C. spectabilis* (1.2-1.8 × 1.2-2cm), *C. pallida* (1.3-1.7 × 1-1.5cm), *C. sessiliflora* (1-1.6 × 0.8-1cm), *C. cytisoides* (1.3-1.7 × 0.5-0.7 cm), *C. lejoloba*(1-1.6 × 0.5-0.7cm), *C. alata* (1.4-1.8 × 0.5 cm) and *C. kanaii* (0.7-1.3 × 0.6-1cm) (Appendix 6).



Photoplate 16: Flower color in *Crotalaria* species; A. Purple (*C. sessiliflora*); B. Yellow (*C. tetragona*).



Photoplate 15: Flower size range in *Crotalaria* species; A. Small (*C. humifusa*); B. Large (*C. tetragona*).

4

4.1.8 Calyx

Calyx shows differences in terms of their type, size, surface character, tube length, calyx lobe shape, calyx lobe length, apex of calyx lobe, extent of attachment of abaxial and adaxial lips, etc. Majority of species has calyx divided into two-lipped (*C. acicularis*, *C. albida*, *C. alata*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. prostrata*, *C. sessiliflora*, *C. spectabilis*, *C. tetragona* and *C. mysorensis*) and other remaining species has sub-campanulate calyx (*C. cytisoides*, *C. medicaginea*, *C. pallida*, *C. quinquefolia*).



Photoplate 17: Calyx type in *Crotalaria* species: A. sub-campanulate (*C. cytisoides*); B. two-lipped (*C. calycina*).

a. Size

Some species have large calyx reaching the length up to 3cm, while in some other species calyx is very small in size i.e., only 3-4mm long. Based on this range species have been categorized in two groups:

- I. **Species with Calyx length exceeding 1cm:** *C. calycina*, *C. tetragona*, *C. spectabilis*, *C. sessilifora*, *C. quinquefolia*, *C. lejoloba*, *C. alata*, *C. mysorensis*. (Appendix 7)
- II. **Species with calyx length 1cm or below:** *C. acicularis*, *C. albida*, *C. cytisoides*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. pallida*, *C. prostrata*. (Appendix 7).

b. Tube/calyx lobe length

In species having campanulate calyx, tube found to be almost equal or slightly different in the length from the calyx lobe but in case of two-lipped calyx, two lipped are generally deeply divided and thus the tube joining two lip of calyx is minute as compared to the size of the calyx lobe. For example, in *C. pallida* sub campanulate calyx tube is 2-3mm long and calyx lobe is also almost equal i.e., 2-4mm long, while in *C. tetragona*, which has two-lipped calyx, tube is 3-5mm and calyx lobe length is 12-18mm (Table 3).

Table 3 Comparison of tube length and calyx lobe length

S. N	Species	Calyx type	Tube length	Calyx lobe length
1	<i>C. acicularis</i>	Two lipped	c. 1 mm	3-5 mm
2	<i>C. albida</i>	Two lipped	1-2 mm	5-8 mm
3	<i>C. alata</i>	Two lipped	c.3 mm	9-13 mm
4	<i>C. calycina</i>	Two lipped	3 mm	1.7-2.7 cm
5	<i>C. cytisoides</i>	Broadly sub-campanulate	2 mm	4-6 mm
6	<i>C. lejoloba</i>	Two lipped	2-3 mm	1.3-1.5 cm
7	<i>C. humifusa</i>	Two lipped	1 mm	3-5 mm
8	<i>C. kanaii</i>	Two lipped	1-3 mm	5-6 mm
9	<i>C. medicaginea</i>	Sub-campanulate	1-1.5 mm	1.5-2.5 mm
10	<i>C. mysorensis</i>	Two lipped	2-3 mm	1.2-1.3 cm
11	<i>C. pallida</i>	Sub campanulate	2-3 mm	2-4 mm
12	<i>C. prostrate</i>	Two lipped	1 mm	2-4 mm
13	<i>C. quinquefolia</i>	Sub campanulate	4 mm	5-6 mm
14	<i>C. sessilifora</i>	Two lipped	2 mm	0.7-1.4 cm
15	<i>C. spectabilis</i>	Two lipped	4-5 mm	8 mm
16	<i>C. tetragona</i>	Two lipped	3-5 mm	12-18 mm

c. Shape of calyx lobe:

In species having sub-campanulate calyx, all five-calyx lobe are found same in shape for example, in *C. cytisoides*, *C. medicaginea* and *C. paliida* all calyx lobes are triangular, except in *C. quinquefolia*, where calyx is sub-campanulate but all calyx lobes are not of same shaped, upper 3 calyx lobe are broadly oblong and lower 2 calyx lobe are triangular in shape. In species having two-lipped calyx, shape of abaxial calyx lobe and adaxial calyx lobe are different, for e.g., in *C. acicularis* abaxial calyx lobes are linear and adaxial calyx lobe are linear-lanceolate, in *C. albida* abaxial calyx lobes

are triangular and adaxial calyx lobes are broadly lanceolate-elliptic, and so on (Table 4).

Table 4: Shape of abaxial and adaxial calyx lobe in the calyx.

S. N	Species	Type	Shape of abaxial 3 calyx lobe	Shape of adaxial 2 calyx lobe
1	<i>C. acicularis</i>	Two lipped	Linear	Linear-lanceolate
2	<i>C. albida</i>	Two lipped	Triangular	Broadly lanceolate-elliptic
3	<i>C. alata</i>	Two lipped	Linear	Lanceolate
4	<i>C. calycina</i>	Two lipped	Triangular-lanceolate	Elliptic
5	<i>C. cytisoides</i>	Broadly sub-campanulate	Triangular	Triangular
6	<i>C. lejoloba</i>	Two lipped	Linear	Linear-lanceolate
7	<i>C. humifusa</i>	Two lipped	Linear	Linear-lanceolate,
8	<i>C. kanaii</i>	Two lipped	Linear	Triangular-lanceolate
9	<i>C. medicaginea</i>	Sub-campanulate	Triangular	Triangular
10	<i>C. mysorensis</i>	Two lipped	–	–
11	<i>C. pallida</i>	Sub campanulate	Triangular	Triangular
12	<i>C. prostrate</i>	Two lipped	Triangular-linear	Linear-lanceolate
13	<i>C. quinquefolia</i>	Sub campanulate	Broadly oblong	Triangular
14	<i>C. sessilifora</i>	Two lipped	Linear	Lanceolate-elliptic
15	<i>C. spectabilis</i>	Two lipped	Triangular	Triangular-lanceolate
16	<i>C. tetragona</i>	Two lipped	Curved, connate, linear	Triangular-lanceolate

d. Attachment of adaxial and abaxial calyx lobe in their respective lip

In case of sub-campanulate calyx, there are no two-lipped condition, but in species where calyx is not campanulate, they are two lipped. Adaxial lip with two calyx lobe and abaxial with three calyx lobes. Each lobe is attached to some extent in their respective lip and remaining portion is free. In *C. humifusa*, in both lip calyx lobes were attached up to 2mm up, in species like *C. calycina*, *C. kanaii*, *C. spectabilis*, *C. tetragona* 3 abaxial calyx lobes were attach up to higher extent than two adaxial calyx lobe. And in other remaining species 2 adaxial calyx lobes were attach up to higher extent than 3 calyx lobes of abaxial lip (Appendix 7).

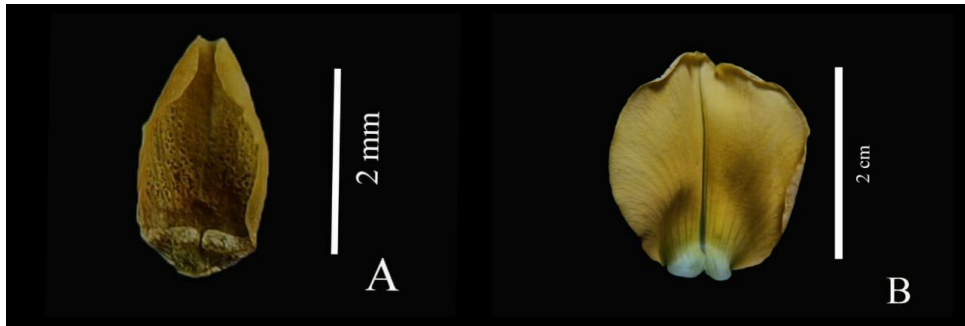
4.1.9 Corolla

Corolla has five petals, one single broad standard petal, two wings on each side and a keel (form by the fusion of two petals along adaxial margin) which protects the androecium and gynoecium in it.

A. Standard

Standard is single large upper petal of the flower, also known as vexillum or banner petal. In *Crotalaria* standard petal shows variation in terms of shape, size, surface, apex, callosity type, basal claw length and its surface characteristics, while base is truncate in all species. Shape may vary among and within the species. Different shapes of standard found in *Crotalaria* are obovate (*C. acicularis*), suborbicular (*C. tetragona*, *C. spectabilis*, *C. quinquefolia*), other shapes are elliptic, obovate-orbicular, elliptic-obovate, orbicular, broadly elliptic, oblong-orbicular, oblong, broadly ovate, ovate-oblong, widely elliptic or pentagonal. Size of standard is according to the size of the flower.

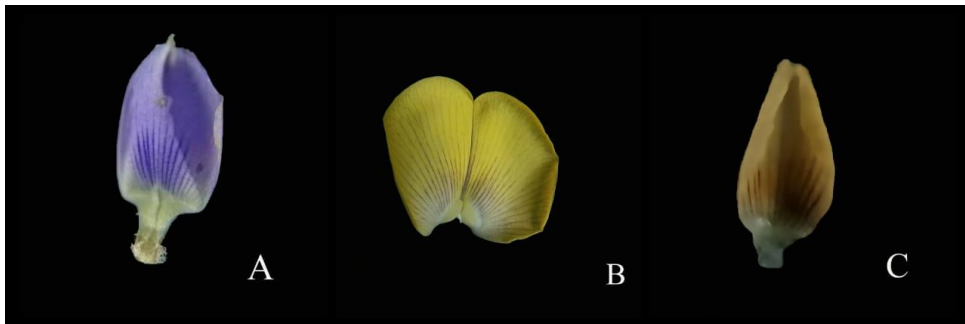
- I. **Species with standard 10 mm or less:** *C. acicularis* (2.5-3 × 2-2.5mm), *C. albida* (6-7 × 6-7mm), *C. alata* (6-9 × 6-8mm), *C. lejoloba* (8-10 × 6-7mm), *C. humifusa* (2.5-3 × 2.5-3mm), *C. kanaii* (9 × 10-11mm), *C. medicaginea* (4-5 × 3mm), *C. pallida* (6-10 × 6-8mm), *C. prostrata* (2.5-3 × 1.7-2mm), *C. sessilifora* (6-6.5 × 4-5.5mm). (Appendix 8)
- II. **Species with standard exceeding the length of 1cm:** *C. quinquefolia* (1.4-1.8 × 2-2.2cm), *C. spectabilis* (1.1-1.9 × 1.4-2cm), *C. tetragona* (1.7-2.3 × 1.4-2cm), *C. calycina* (1.2-1.3 × 0.9-1cm), *C. cytisoides* (0.8-1.1 × 0.7-1cm). (Appendix 8)



Photoplate 18: Size range of the standard petal: A. Small standard petal (2.5mm, *C. acicularis*); B. large standard petal (2.3cm, *C. tetragona*).

a. Base

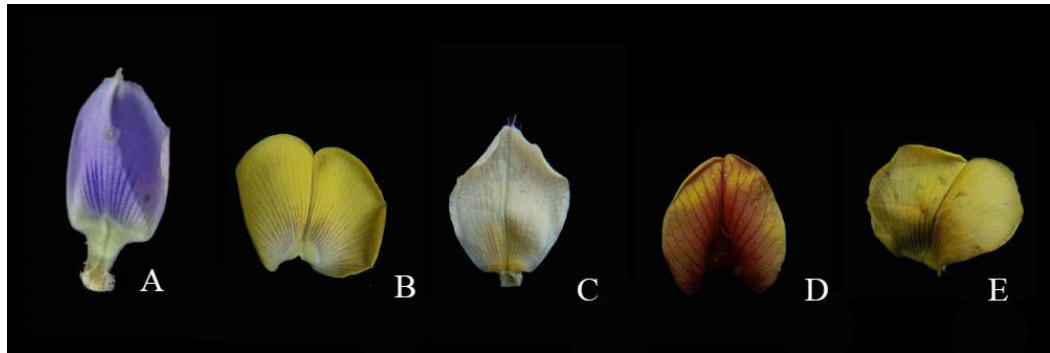
There is not much variation in case of the base of standard in *Crotalaria*. Three types of bases are observed truncate (*C. acicularis*, *C. alata*, *C. calycina*, *C. lejoloba*, *C. pallida* and *C. prostrata*), rounded (*C. cytisoides*, *C. humifusa*, *C. kanaii*, *C. tetragona* and *C. medicaginea*) or concavely shallow (*C. albida*, *C. quinquefolia*, *C. sessiliflora* and *C. spectabilis*).



Photoplate 19: Base type in standard petal of *Crotalaria* species: A. truncate base (*C. sessiliflora*); B. concave base (*C. quinquefolia*); C. rounded base (*C. humifusa*).

b. Apex

In terms of apex there is not much variation. Apex may be rounded, obtuse, retuse or emarginate. Majority of species has rounded apex (*C. acicularis*, *C. albida*, *C. alata*, *C. lejoloba*, *C. kanaii*, *C. sessiliflora*, *C. pallida*), species which has standard petal with obtuse apex are *C. calycina*, *C. medicaginea*, *C. tetragona*. Some species also has retuse (*C. humifusa*, *C. spectabilis*), emarginate (*C. quinquefolia*), in *C. cytisoides* apex is rounded and slightly oblique, while that in *C. humifusa* obtuse or retuse apex.



Photoplate 20: Apex of the standard petal: A. rounded (*C. sessiliflora*); B. emarginate (*C. quinquefolia*); C. obtuse (*C. calycina*); D. slightly oblique (*C. cytisoides*); retuse (*C. spectabilis*).

c. Callosity type

One of the important characteristics of standard petal in *Crotalaria* is callosity type. Callosity is a thickened or hardened basal part of the standard petal. 3 types of callosities have been observed in the species from Nepal.

- I. Lamelliform: *C. acicularis*, *C. alata*, *C. albida*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. prostrata*, *C. quinquefolia*, *C. sessiliflora*, *C. spectabilis* and *C. tetragona*.
- II. Disc: *C. kanaii* and *C. medicaginea*
- III. Ridged: *C. pallida* and *C. cytisoides*



Photoplate 21: Callosity type in *Crotalaria* species: A. lamelliformae (*C. calycina*); B. lamelliformae (*C. tetragona*); C. ridged shaped (*C. pallida*).

d. Basal claw

Length of basal claw varies in different species and in majority of species margin of basal claw found to be covered with soft, dense, white, continuous woolly trichomes. In *C. calycina*, trichome were rather discontinuous and in patches. In *C. humifusa* claw was glabrous. In *Crotalaria sessiliflora* hairs were concentrated towards basal marginal

region of the claw while in *C. prostrata* hairs were concentrated at top marginal region. On the basis of length of basal claw species can be categorized into two groups:

- I. Species with basal claw length shorter than or equal to 1mm: *C. acicularis* (0.5mm), *C. humifusa* (0.3mm), *C. prostrata* (0.5mm or shorter), *C. albida* (1mm), *C. alata* (1mm), *C. calycina* (1mm), *C. humifusa* (1mm), *C. kanaii* (1mm or short), *C. medicaginea* (0.8-1mm).
- II. Species with basal claw length longer than 1mm: *C. tetragona* (2mm), *C. spectabilis* (2mm), *C. sessilifora* (1-2mm), *C. quinquefolia* (3mm), *C. pallida* (c. 2mm), *C. cytisoides* (3mm).

B. Wings

There are two wing petals on each side of close keel petal. In eight species shape of the wing petals is oblong (*C. acicularis*, *C. albida*, *C. alata*, *C. humifusa*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. sessilifora*), while three (*C. tetragona*, *C. spectabilis*, *C. quinquefolia*) are broadly oblong. In *C. calycina* wings are obovate-oblong, in *C. cytisoides* oblong, elliptic or obovate, *C. pallida* has oblong or lance-ovate, and *C. prostrata* has linear or oblong shaped wings.



Photoplate 22: Types of shape of the wings in *Crotalaria* species: A. oblong (*C. albida*); B. broadly oblong (*C. tetragona*); C. obovate-oblong (*C. calycina*); D. obovate (*C. cytisoides*); E. linear (*C. prostrata*).

a. Size

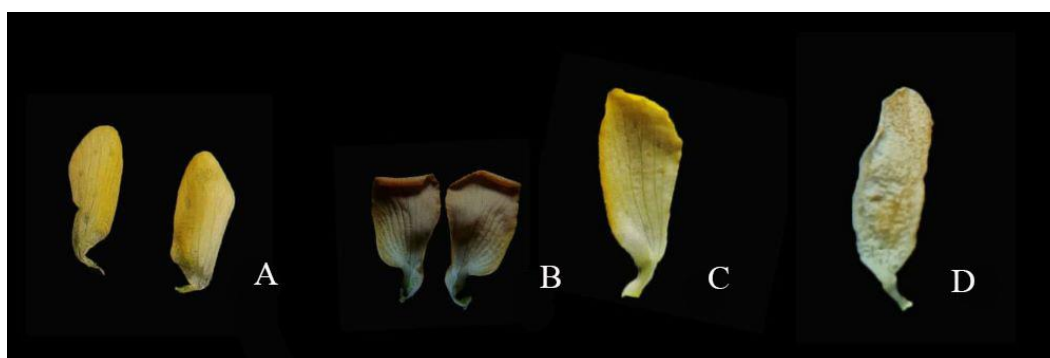
Wings are smaller than standard. Only in few species wings exceeds 1cm as in *C. calycina* (1.3 × 0.4cm), *C. quinquefolia* (1 × 0.8-0.9cm), *C. spectabilis* (11-12 × 8-9mm) and *C. tetragona* (1.7-1.8 × 0.9cm) in other remaining species wings are shorter than 1cm. (Appendix 9)

b. Apex

In majority of the species apex of wings are found to be rounded (*C. albida*, *C. alata*, *C. cytisoides*, *C. humifusa*, *C. medicaginea*, *C. prostrata*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis*) while other species (*C. acicularis*, *C. lejoloba*, *C. kanaii*) have obtuse, acute (*C. calycina*, *C. pallida*) or irregular (*C. tetragona*) apex. (Appendix 9)

c. Base

Base of the wings may be cuneate, obtuse, rounded or truncated. Majority of species has cuneate base of the wings (*C. acicularis*, *C. albida*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. medicaginea*, *C. pallida* and *C. prostrata*), while 3 species have truncated base (*C. quinquefolia*, *C. sessilifora* and *C. tetragona*), two species with rounded base are *C. spectabilis* and *C. alata*. The remaining two species has obtuse base (*C. humifusa* and *C. kanaii*).

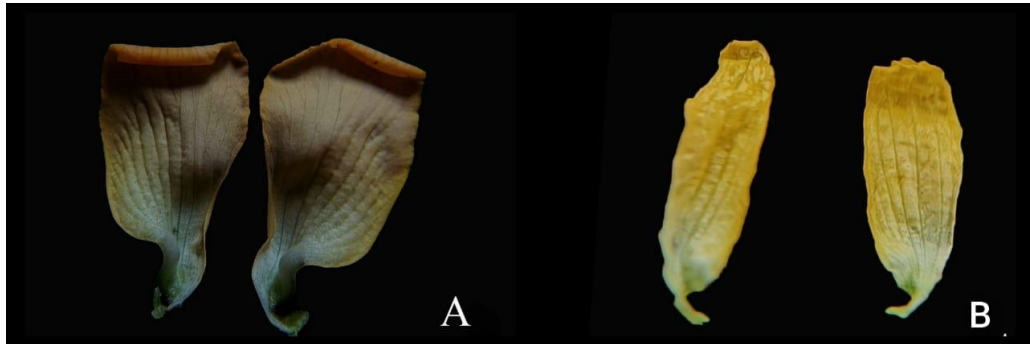


Photoplate 23: Base of the wings petal: A. cuneate (*C. lejoloba*); B. truncate (*C. tetragona*); C. rounded (*C. alata*); D. obtuse (*C. humifusa*).

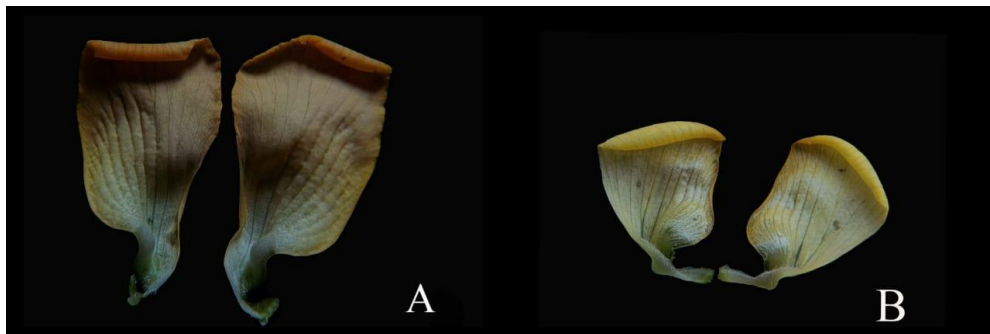
d. Basal claw of wings

In terms of basal claw of wings, they vary in length and their orientation. In five species basal claw is short, less than 1mm (*C. acicularis*, *C. albida*, *C. humifusa*, *C. medicaginea*, *C. prostrata*), remaining species has claw of 1mm or longer. There are mainly two kinds of orientation of basal claw, in some species basal claw is in center (*C. acicularis*, *C. albida*, *C. alata*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. pallida* and *C. prostrata*) while in some other (*C. quinquefolia*, *C. sessilifora*, *C. spectabilis* and *C. tetragona*) basal claw lies in the one extreme side of the claw. On the other hand, some species (*C. spectabilis*, *C.*

quinquefolia, *C. pallida*, *C. medicaginea*, and *C. kanaii*) has perfectly horizontally elongated claw while in other species (*C. acicularis*, *C. albida*, *C. alata*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. humifusa*, *C. prostrata*, *C. sessilifora* and *C. tetragona*) claw is not horizontally elongated.



Photoplate 24: Basal claw position: A. at side (*C. tetragona*); B. at center (*C. albida*).



Photoplate 25: Elongation pattern of basal claw in wings petal: A. vertically elongated (*C. tetragona*); B. horizontally elongated (*C. spectabilis*).

C. Keel

Keel also called the carina, consists of innermost fused petals, overlapped by the lateral petals, the wings. In *Crotalaria* species keel shows differences in terms of the characters like shape, size, curvature, surface, apex, base, and basal claw length. Different shapes of keel found in *Crotalaria* are:

- I. Suborbicular: *C. acicularis* and *C. kanaii*
- II. Rounded: *C. albida*, *C. cytisoides*, *C. humifusa*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis* and *C. tetragona*
- III. Angled: *C. calycina*, *C. humifusa* and *C. medicaginea*
- IV. Sub-angled: *C. alata*



Photoplate 26: Shape of the keel petal: A. suborbicular (*C. acicularis*); B. angled (*C. calycina*); C. subangled (*C. alata*); D. rounded (*C. cytisoides*).

a. Size

In terms of size, only four species (*C. tetragona*, *C. quinquefolia*, *C. cytisoides*, *C. calycina*) have keel 1cm or longer and all other remaining species has keel smaller than 1cm. (Appendix 10)

b. Apex

Two keel petals fused together and form either vertically or horizontally elongated, twisted or untwisted narrower beak shaped apex. Among 15 species observed, two species i.e., *C. cytisoides* and *C. pallida* are with the untwisted apex while rest of other species has twisted apex/beak.



Photoplate 27: Apex type in keel of *Crotalaria* species: A. untwisted (*C. cytisoides*); B. twisted (*C. calycina*).

c. Keel curvature

Most of the species have the keel with the curvature at about the middle giving apically narrowed or horizontally narrowed twisted or untwisted beak but some species has the keel with the curvature in the lower third. Therefore, based on these characters, species of Nepal can be categorized as follows:

- I. Curvature at about middle with apically narrowed keel: *C. acicularis*, *C. albida*, *C. calycina*, *C. lejoloba*, *C. humifusa* and *C. prostrata*
- II. Curvature at about middle with horizontally narrowed beak: *C. cytisoides*, *C. kanaii*, *C. pallida*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis* and *C. tetragona*
- III. Curvature at lower third with apically narrowed beak: *C. medicaginea*.
- IV. Curvature slightly below middle with apically narrowed beak: *C. alata*.



Photoplate 28: Curvature types of keel petal of *Crotalaria* species: A. Curvature at middle with horizontal beak (*C. cytisoides*); B. Curvature about middle with vertical beak (*C. calycina*); C. Curvature slightly below middle with sub-apical beak (*C. alata*); D. Curvature at lower third with apical beak (*C. medicaginea*).

4.1.10 Androecium

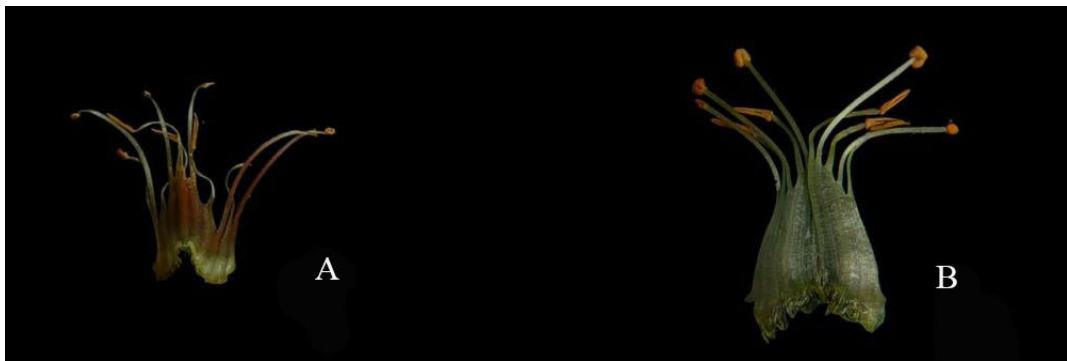
In *Crotalaria* species androecium is protected inside keel petals. Androecium is Monadelphous and dimorphic. Androecium are with ten stamens (5+5), 5 with longer filaments bearing smaller, dorsifixed anther alternating with another 5 short filaments bearing long, oblong-linear, basifixed anther. These basic pattern of arrangement of stamen is same in all species but they vary basically in terms of the length of the filaments, anthers and the tube joining filaments together. In majority of the species filaments bearing minute dorsifixed anthers are longer than the tube joining all filaments together and also longer than the filaments which bears oblong anther. If we compare the length of longer 5 filaments and the length of tube then species can be grouped as follows:

1. Species with filaments longer than the tube: *C. acicularis*, *C. albida*, *C. alata*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. prostrata*, *C. sessilifora*, *C. tetragona*

2. Species with filaments equal or shorter than the tube: *C. cytisoides*, *C. pallida*, *C. quinquefolia*, *C. spectabilis*.

Similarly, if we compare the length of shorter 5 filaments and the length of tube then, species can be grouped as:

- I. Species with filaments longer than the tube: *C. acicularis*, *C. calycina*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. tetragona*
- II. Species with filaments equal or shorter than the tube: *C. albida*, *C. alata*, *C. cytisoides*, *C. lejoloba*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis*.



Photoplate 29: Relative length of tube and filament of androecium: A. Stamen with filament longer than tube (*C. tetragona*); B. stamen with filament shorter than tube (*C. calycina*).

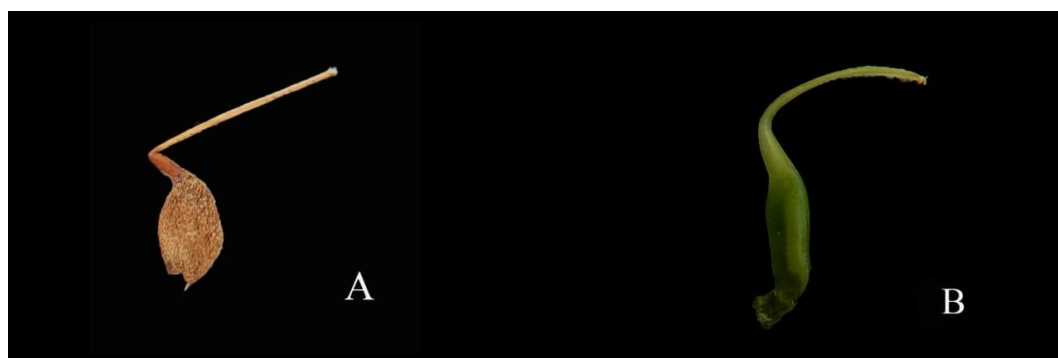
a. Anther

The range of the size of 5 oblong anthers in Nepalese species of *Crotalaria* is 0.2-2.5mm long. In 11 species it is 1mm or longer while in other 4 species it is smaller than 1mm. Another 5 small, elliptic or ovate anthers are minute and thus always less than 1mm in length. (Appendix 11). Based on the length of oblong anther the two groups formed are:

- I. Species with anther 1mm or longer: *C. albida*, *C. alata*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. kanaii*, *C. medicaginea*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. spectabilis* and *C. tetragona*
- II. Species with anther shorter than 1mm: *C. acicularis*, *C. humifusa* and *C. sessilifora*.

4.1.11 Ovary

In terms of ovary, *Crotalaria* species shows variations in size, surface, and presence or absence of stalk. Shape is invariably oblong in all species except in *C. medicaginea* where ovary is elliptic. Length do not exceed 1cm in *Crotalaria* species studied here. Longest ovary is found in *C. tetragona* (7-8 × 3-4mm) and smallest ovary is found in *C. acicularis* (1.5-2 × 0.5mm). Surface is glabrous in most of the species but some species has hairy ovary (*C. tetragona*, *C. pallida*, *C. medicaginea*, *C. cytisoides*), *C. albida* has glabrous ovary but hairs present on abaxial margin. Similarly, some species are sessile (*C. alata*, *C. calycina*) while other are not. Longest stalk is found in *C. quinquefolia* (2-2.5mm) followed by *C. pallida* (2mm), *C. cytisoides* (1-2mm), *C. spectabilis* (1.5mm) and *C. tetragona* (1mm). The species like *C. acicularis*, *C. albida*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. prostrata* and *C. sessilifora* are subsessile (Appendix 12).



Photoplate 30: Shape of the ovary: A. elliptic (*C. medicaginea*); B. oblong (*C. spectabilis*).

4.1.12 Style

Style is terminal in position and varies in terms of its length, curvature and surface characters among different species. Shortest style is found in *C. humifusa*, *C. acicularis* and *C. prostrata* i.e., 2mm long, followed by *C. sessilifora* and *C. medicaginea* with style length 5mm. In the five species *C. albida* (6-7.5mm), *C. alata* (7mm), *C. lejoloba* (6-8mm), *C. kanaii* (8-9mm) and *C. pallida* (7-9mm) style length is in the range of 6-9mm. Longest style is in *C. tetragona* (16mm). Furthermore *C. spectabilis*, *C. quinquefolia*, *C. cytisoides* and *C. calycina* are the species having style length between 10 to 16mm. (Appendix 12).

a. Style curvature

Two types of curvature are found in the style similar to keel petal i.e., in some species style is geniculated while in some other species style is rounded. Style may be horizontally or vertically extended. Based on these characters species can be categorized as:

- I. Style rounded and vertically elongated: *C. albida*, *C. calycina*, *C. sessilifera* and *C. tetragona*
- II. Style rounded and horizontally elongated: *C. cytisoides*, *C. kanaii*, *C. pallida*, *C. quinquefolia* and *C. spectabilis*
- III. Style geniculated and vertically elongated: *C. alata*, *C. lejoloba* and *C. medicaginea*
- IV. Style geniculated and horizontally elongated: *C. acicularis*, *C. humifusa* and *C. prostrata*.



Photoplate 31: Curvature of the style in *Crotalaria*: A. style rounded with vertical elongation (*C. calycina*); B. style rounded with horizontal elongation (*C. spectabilis*); C. style geniculated with horizontal elongation (*C. alata*); D. style geniculated with vertical elongation (*C. lejoloba*).

4.1.13 Fruit

Fruit is pod and shows differences in terms of its shape, size, color, and surface, number of seed, its exertion from calyx and its inflation. All species has inflated pod except *C. cytisoides*, which has scarcely inflated, flat, appressed fruit. In Majority of the species pod are oblong in shape. Species having other shape of pod rather than oblong are, *C. calycina* (oblanceolate), *C. cytisoides* (oblong-elliptic), *C. humifusa* (oblong-cylindrical), *C. medicaginea* (globose) and *C. pallida* (narrowly oblong). (Appendix 13)



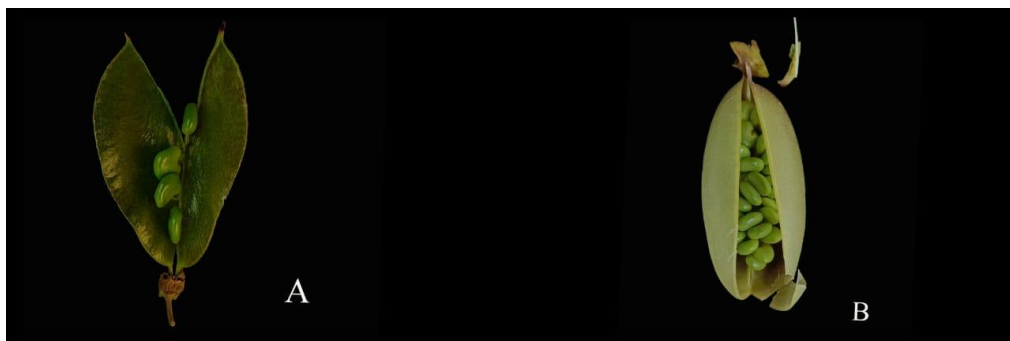
Photoplate 32: Types of shapes of the *Crotalaria* fruit: A. narrowly oblong (*C. pallida*); B. oblong-elliptic (*C. cytisoides*); C. oblong (*C. spectabilis*); D. oblong-cylindrical (*C. humifusa*); E. oblanceolate (*C. calycina*); F. globose (*C. medicaginea*)

a. Size

C. medicaginea has smallest fruit having the size of 3-4×2-3.5mm, followed by *C. humifusa* (4-7 ×2-3mm) and *C. acicularis* (5-7 × 3-4mm). Fruits of all other species exceeded 1cm length. Species which has fruit larger among all are *C. quinquefolia* with the size of 5-6.5 × 1.1-2.5cm, *C. tetragona* (4.5-5.5 × 1.5cm), *C. spectabilis* (3.3-5 × 1.3-2.2cm) and *C. alata* (3-5 × 1cm) and other remaining species has medium sized fruit. (Appendix 13).

b. Number of seed

Number of seed is not exactly fix even in the same species but in *C. medicaginea* number of seed is invariably two, this is the same species with lowest number of seed in their fruits. Another species with low number of seed is *C. cytisoides* with seed number 1-5 per fruit while some of the species have fruit with many seed. For e.g., *C. calycina* (19-36 seeded), *C. pallida* (up to 35 seed), *C. quinquefolia* (26-32 seed) and *C. lejoloba* (20-30 seed). Other remaining species has seed number below 30. (Appendix 13).



Photoplate 33: Seed number in *Crotalaria* species: A. few seeded (*C. cytisoides*); B. many seeded (*C. quinquefolia*).

c. Fruit exsertion out of calyx

Calyx is persistent in the fruit of *Crotalaria* species. In some species calyx is long enough to cover the fruit completely, while in some species calyx only cover the stipe or basal region and in some other cases calyx covers the fruit comparatively up to greater extent of length. So, based on the extent of the exsertion of the fruit out of the calyx species can be grouped as follows:

- I. Species having inclusive fruit: *C. sessiliflora* and *C. calycina*
- II. Species with slightly exserted fruit (3/4th covered): *C. acicularis*, and *C. albida*,
- III. Species with calyx covering about half of the portion of the fruit (1/2 covered): *C. lejoloba*, *C. humifusa*, *C. medicaginea* and *C. tetragona*.
- IV. Species with calyx covering only stipe or small basal portion of fruit (<1/4th covered): *C. alata*, *C. cytisoides*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. mysorensis* and *C. spectabilis*.



Photoplate 34: Inclusiveness of the fruit inside calyx: A. inclusive (*C. calycina*); B. Slightly exserted (*C. albida*); C. halfly exserted (*C. lejoloba*); D. fully exserted (*C. pallida*).

d. Color of the fruit

At maturity Fruit color changes to golden-brown to brown in majority of species while in some other species it turns to black.

- I. Species with golden brown or brown fruit: *C. acicularis*, *C. alata*, *C. cytisoides*, *C. humifusa*, *C. medicaginea*, *C. pallida*, *C. quinquefolia*, *C. sessiliflora*, *C. mysorensis* and *C. tetragona*.
- II. Species with black fruit: *C. albida*, *C. calycina*, *C. lejoloba*, *C. prostrata* and *C. spectabilis*.

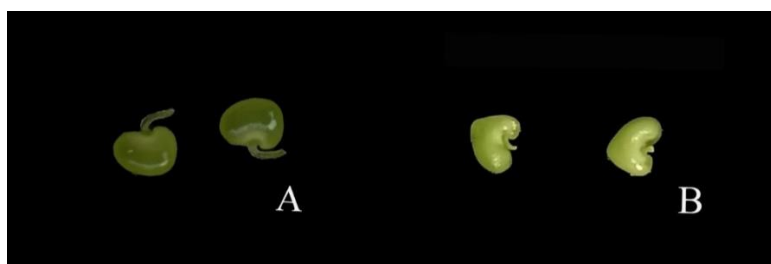
4.1.14 Seed

a. Shape

Two types of seed shapes are found in the studied species. Some species has reniform seed while some other has triangular-harp shaped seed.

Reniform: *C. acicularis*, *C. albida*, *C. alata*, *C. lejoloba*, *C. humifusa*, *C. medicaginea*, *C. quinquefolia*, *C. sessilifora* and *C. mysorensis*.

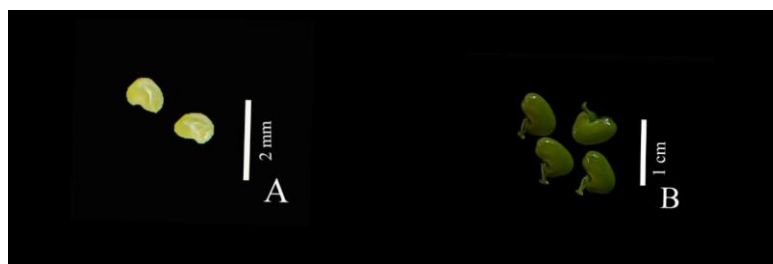
Harp shaped: *C. calycina*, *C. cytisoides*, *C. pallida*, *C. spectabilis*, *C. tetragona* and *C. prostrata*.



Photoplate 35: Shape of the seed: A. reniform (*C. lejoloba*); B. harp-shaped (*C. pallida*).

b. Size

Seed size in the species of the *Crotalaria* range from 1mm to 7mm in length and 0.5-5mm in breadth. Species having smallest seed are *C. acicularis*, *C. humifusa*, *C. medicaginea* with seed size 1×1 mm while largest seed is found in *C. tetragona* having seed of 7×5 mm, followed by *C. quinquefolia* ($5-6.5 \times 4-5$ mm), *C. cytisoides* ($5-6 \times 5$ mm), *C. spectabilis* (4×4 mm). (Appendix 13).



Photoplate 36: Range of seed size in Nepalese species of *Crotalaria*: A. 1×1 mm (*C. humifusa*); B. 7×5 mm (*C. tetragona*).

c. Color

In majority of the species mature seeds are brown while in some other dark brown, brownish-black or greenish-brown in color.

- I. Species with brown seed: *C. acicularis*, *C. albida*, *C. calycina*, *C. cytisoides*, *C. pallida*, *C. prostrata*, *C. quinquefolia* and *C. sessilifora*
- II. Species with dark-brown seed: *C. humifusa*, *C. medicaginea* and *C. mysorensis*
- III. Species with brownish-black seed: *C. alata*, *C. lejoloba* and *C. spectabilis*
- IV. Species with greenish-brown seed: *C. tetragona*.

4.2 Taxonomic Treatment

Crotalaria L., Sp. Pl.: 714 (1753).

Erect, prostrate, spreading or ascending annual or perennial herb, subshrub to shrub. **Stem** branched to profusely branch rarely unbranched, herbaceous or woody, terete, angular or marked with slender longitudinal grooves, variously hairy, rough or silky in texture. **Leaf** simple, trifoliate, quadrifoliate or Penta foliate, alternate, inclined, divergent or sometime recurved; **Stipule** usually present rarely absent, persistent or caducous, foliaceous, reflexed, inclined, appressed, divergent, recurved or attached wholly sidewise to the stem, variable in shape, base truncate, rounded or cuneate, apex acute or acuminate, margin usually ciliate, rarely entire, adaxially usually glabrous, abaxially variously pubescent. **Leaf blade** symmetrical or asymmetric, variable in shape, base cuneate, broadly cuneate, oblique, rounded, cordate, truncate or attenuate, apex obtuse and mucronate, acute and mucronate, acuminate and mucronate, rounded and mucronate, emerginate and mucronate, obtuse, rounded, truncate or retuse, margin entire or ciliated, adaxially glabrous, sparsely hairy or densely hairy, abaxially always hairy, pinnate-veined. **Inflorescence** terminal, leaf-opposed, axillary or solitary axillary, racemose. **Bracts** present at the base of pedicel, persistent or caducous, foliaceous, variable in shape, base mostly truncate, cordate, reniform, cuneate, or rounded, apex acute or acuminate, margin ciliated, rarely entire, adaxially mostly glabrous, rarely hairy, abaxially pilose, pubescent, puberulent, or tomentose, rarely glabrous, midrib usually not distinct. **Bracteoles** present at variable position from base of pedicel to middle of calyx tube, persistent, foliaceous, variable in shape, base truncate, broadly cuneate, cuneate, narrowly cuneate, obtuse or rounded, apex acute, acuminate or rounded, margin ciliated rarely entire, surface same as bract, midrib not distinct. Flowers yellow or purple. **Calyx** two lipped or sub-campanulate, two lipped parted to base while sub-campanulate calyx has tube length about equal to the calyx lobe length, calyx lobes variable in shape, margin ciliated or entire, glabrous, pilose,

pubescent, puberulent or tomentose. **Standard** variable in shape, base truncate, rounded, or concavely shallow, apex rounded, obtuse, retuse or emerginate, margin entire, glabrous or bearded abaxially, callosity lamelliform, disc or ridged type. Basal claw covered with continuous or discontinuous trichome, sometime concentrated toward basal or apical region, rarely glabrous. **Wings** oblong, broadly oblong, broadly oblong, obovate-oblong, elliptic, lance-ovate or linear, base cuneate, obtuse, rounded or truncate, apex rounded, obtuse, acute or irregular, margin entire, glabrous, rarely pilose toward basal region. **Keel** suborbicular, rounded, angled or sub angled, narrowed apically from middle or slightly below with long twisted or untwisted beak, glabrous being margin at one or both sides lanate. **Stamen** 10, Monadelphous, dimorphic, oblong anther basifixed, elliptic anther dorsifixed. **Ovary** oblong, rarely elliptic, glabrous or hairy, sessile or subsessile, **style** one, two or multiple lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns golden brown, brown to black when mature, usually oblong but also other i.e., narrowly oblong, oblanceolate, oblong-elliptic, oblong-cylindrical and globose, glabrous, glabrescent or hairy, inclusive, slightly exerted or almost fully exerted, inflated or appressed, 2-many seeded. **Seed** green turns golden brown, brown or blackish when mature, reniform or harp shaped, glabrous or sometimes few numbers of hairs present.

Key to the species

- 1a. Leaf compound (tri- to penta-foliolate), calyx sub-campanulate.....2
 - b. Leaf simple, calyx two-lipped.....6
- 2a. Small erect or semi-procumbent herb, fruit globose..... *C. medicaginea*
- b. Erect herb or shrub, fruit shape other than globose.....3
- 3a. Fruits appressed, surface covered with appressed brown pubescent.....
 - *C. cytisoides*
 - b. Fruits inflated, glabrescent or glabrous,4
- 4a. Fruit glabrous, leaves tri- to penta-foliolate leaf, calyx glabrous..... *C. quinquefolia*
- b. Fruit glabrescents, leaves trifoliolate, calyx hairy.....5

5a. Fruits slender, 0.6-0.8cm broad, stem marked with longitudinal lines.....	<i>C. pallida</i>
b. Fruits broad, 1.2-1.5cm broad, stem terete.....	<i>C. micans</i>
6a. Pod densely pubescent, leaf exceeds 20cm.....	<i>C. tetragona</i>
b. Pod glabrous, Leaf smaller than 20cm.....	7
7a. Calyx glabrous, bracts glabrous.....	<i>C. spectabilis</i>
b. Calyx with dense trichomes, bracts hairy.....	8
8a. Stipule absent, herb to subshrub.....	9
b. Stipule present, herb or shrub.....	10
9a. Seeds reniform, fruits slightly exserted.....	<i>C. albida</i>
b. Seeds harp-shaped, fruits almost fully exserted.....	<i>C. prostrata</i>
10a. Small prostrate herbs, stem pilose.....	11
b. Erect herbs or shrubs, stem pilose or other (pubescent, puberulent, tomentose, hirsute)	13
11a. Perennial, inflorescence with 2 flowers.....	<i>C. kanaii</i>
b. Annual, inflorescence with more than 2 flowers.....	12
12a. Leaf asymmetrical, base oblique, stipule lanceolate.....	<i>C. acicularis</i>
b. Leaf symmetrical, base rounded to broadly cuneate, stipule subulate.....	<i>C. humifusa</i>
13a. Leaf adaxially almost glabrous with sparse hairs around midrib, fruit inclusive.....	14
b. Leaf densely hairy on both surfaces, fruit fully or half exserted.....	15
14a. Flowers yellow, 1.5-3cm long, bracteoles at upper part of the pedicel.....	<i>C. calycina</i>
b. Flowers purple, 1-1.6cm long, bracteoles at the base of calyx.....	<i>C. sessiliflora</i>

- 15a. Stipule wing like, inflorescence internodal..... *C. alata*
- b. Stipule not wing like, inflorescence at other position (leaf-opposed, terminal or axillary)16
- 16a. Fruits densely hairy, stem angular..... *C. juncea*
- b. Fruits glabrous, stem terete.....17
- 17a. Bracteoles at the middle of the calyx tube, pods black when mature.... *C. lejoloba*
- b. Bracteoles at the base of the calyx tube, pods brownish when mature...*C. mysorensis*

1. *Crotalaria acicularis* Buch. -Ham. ex Benth., Lond J. Bot. 2:476 (1843); Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Grierson A.J.C. & Long D.G., Fl. Bhutan 1(3): 736 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 113(2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2: 100 (2019).

Crotalaria disticha Zoll. & Moritzi, Natuur- Geneesk. Arch. Ned. -Indië iii. (1846) 75.

Type specimen

East India, Masurgunj, Montains of prome & Tang Dong, *Wallich*, 5390 (LE, **Isotype**)

Prostrate to slightly ascending annual herb, diffuse or procumbent 15-40cm long. Slender tap root with secondary branches. **Stem** branched, spreading, herbaceous, terete, slender, purplish-green, sub-dense long, white spreading pilose, slightly rough. **Leaf** simple, inclined; **Stipule** present, persistent, foliaceous, lanceolate, reflexed, 1.5-3 × 0.5-1mm, adaxially glabrous, abaxially few long pilose trichome present, base rounded or cuneate, margin ciliated, apex acute. Petiole very short up to 1mm long, pale green; **leaf blade** suborbicular, broadly oblong or elliptic, asymmetric i.e., right half of the blade is slightly narrower and longer than left half, 0.5-2.2 × 0.4-1.9cm, base oblique, apex obtuse to rounded, margin ciliated, both surfaces sparsely white, silky, pilose, adaxially more densely pilose, pinnately veined, midrib distinct, secondary veins not much distinct. **Inflorescence** terminal or leaf-opposed, racemes, 2-11 flowered, 2.3-5.5cm long. **Peduncle** 0.7-3cm long. **Bracts** present, at the base of pedicel, persistent, cordate, 3-4 × 1.5-2.5mm, base cordate, apex acute, margin ciliated, adaxially glabrous, abaxially only few numbers of long, silky trichomes, midrib not distinct. **Pedicel** 2-4mm long, terete, purplish, covered with long, white to brownish

pilose hairs. **Bracteoles** green to purplish in color, at the base of the calyx tube, persistent, lanceolate, $1-2 \times 0.5$ mm, base broadly cuneate, apex acute to acuminate, margin ciliated. **Flowers** yellow, $3-6 \times 4-5$ mm. **Calyx** two lipped, parted to base, 4-6mm long, tube ca. 1mm long, abaxial 3 calyx lobe linear, attached up to 1.5mm, adaxial 2 calyx lobes linear-lanceolate, attached up to 2mm, abaxial calyx lobe slightly longer, narrower than adaxial calyx lobe, surface covered with dense, long, white, pilose hairs. **Standard** obovate, $2.5-3 \times 2-2.5$ mm, base truncated, apex rounded, glabrous, callosity lamelliform type, c. 0.5mm long basal claw, margin of basal claw has woolly trichome. **Wings** oblong, $2 \times 0.5-1$ mm, base cuneate, apex obtuse, glabrous, basal claw short c. 0.5mm. **Keel** suborbicular with long twisted beak, $3 \times 1-2$ mm, base broadly cuneate, apex twisted, both margin with minute hairs, glabrous, basal claw c. 0.5mm long. **Stamen** 10, Monadelphous, dimorphic, longer filament 2mm long, shorter filament 1-1.5mm long, oblong anther basifixed, 0.2-0.3mm long, ovoid anther minute and dorsifixed. **Ovary** oblong, $1.5-2 \times 0.5$ mm, glabrous, subsessile, style 2mm long, entirely hairy. **Stigma** minute. **Pod** green turns brown when mature, oblong, $5-7 \times 3-4$ mm, glabrous, slightly exerted, inflated, 5-10 seeded. **Seed** green turns brown when mature, reniform, $1 \times 0.5-1$ mm, glabrous.

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

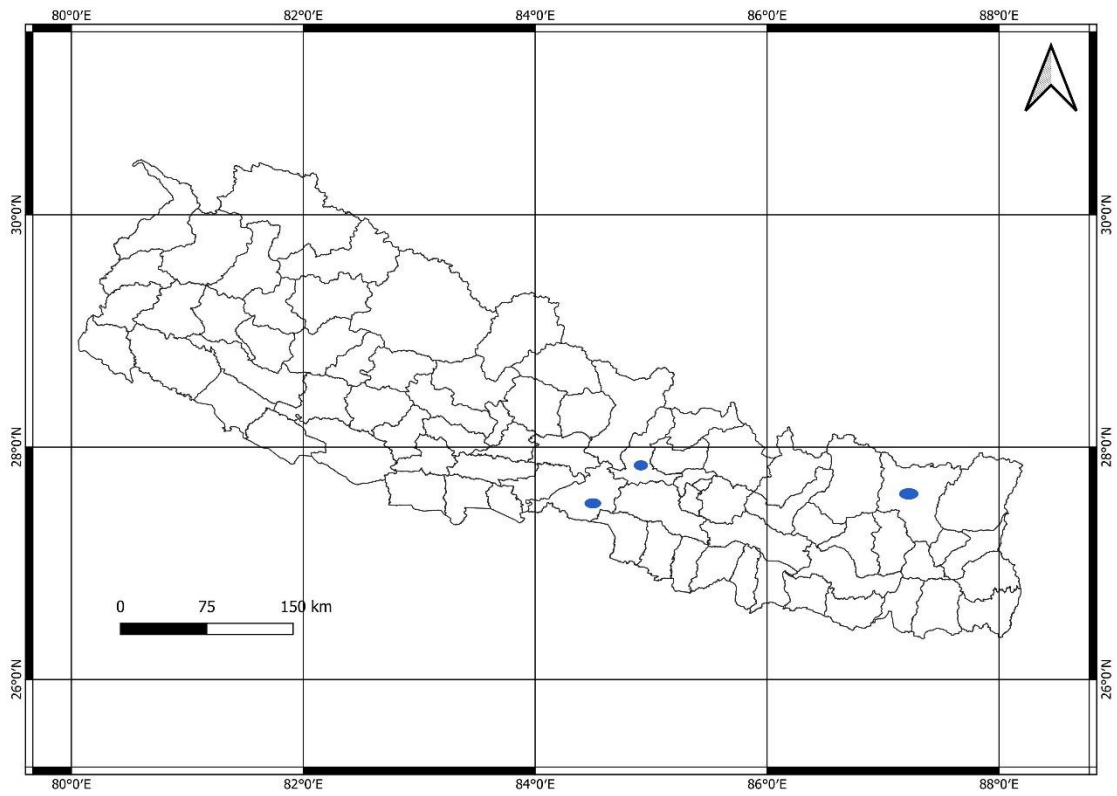
Altitude: 225-800m.

Ecology: In *Shorea robusta* C.F. Gaertn. (Sal) forest, associated with grasses and other herbs.

Flowering/ Fruiting: October-November.

Voucher Specimen:

Central Nepal: Chitwan district, Madi, 243m, $27^{\circ} 25' 58''$ N, $84^{\circ} 22' 49''$ E, 13th Oct. 2022, B. Parajuli and K. Parajuli, CH01 (TUCH)



Map 1: Distribution of *Crotalaria acicularis* in Nepal based on herbarium records and field collections.

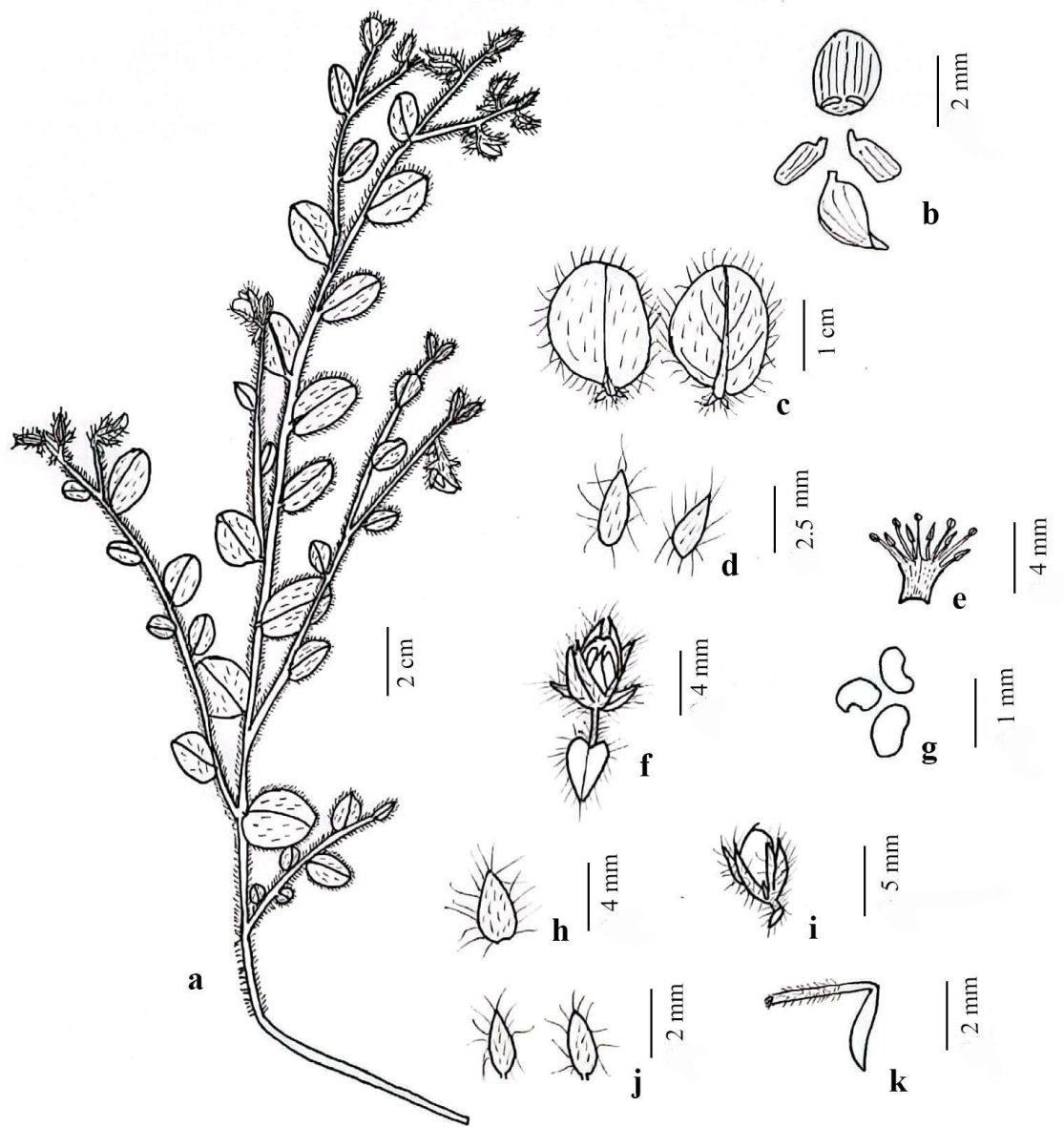


Figure 1 : *Crotalaria acicularis* Buch. -Ham. ex Benth; a. Habit sketch; b. Petals; c. Leaf; d. Stipule; e. Androecium; f. Flower; g. Seed; h. Bract; i. Fruit; j. Bracteoles; k. Gynoecium.

2. *Crotalaria alata* Buch. -Ham. ex D. Don, Prodr. Fl. Nepal.: 241 (1825). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 735 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 109 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011). Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019). Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Homotypic synonym:

Crotalaria alata H. Lev., Fl. Kouy-Tcheou: 229 (1915), nom. Illeg;

Heterotypic synonyms:

Crotalaria bialata Roxb. Fl. Ind. ed. 1832, 3: 274 (1832) nom. Illeg;

Crotalaria collettii Prain J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 66: 349 (1897)

Crotalaria sagitticaulis Wall. Numer. List: n. ° 5357 (1831) nom. nud.

Type specimen: Central Nepal, Kathmandu District, Suambu, 1802. 7. 17, F. Buchanan-Hamilton s.n. (BM, **Holotype**)

Erect, herb, undershrub to shrub (prostrate herb on moist place, also ascending herb at dry places), 12.5 to 100cm. **Stem** branched rarely unbranched, woody, terete, winged, roughly tomentose. **Leaves** simple, divergent to inclined; **Stipule** present, persistent, foliaceous, decurrent, large elongated from one node to another node, attached sidewise to stem, 2.5-10 × 0.1-0.8cm, base round or cuneate, apex acute, margin entire, white tomentose. Petiole 2-4mm long. **Leaf blade** lanceolate, elliptic, obovate, to broadly oblong to oblong, symmetric, 2-7.5 × 0.8-5cm, base cuneate, apex obtuse and mucronate, margin entire, both surface appressed, white, pubescent to tomentose, both midrib and secondary veins distinct. **Inflorescence** arises from upper internodes, racemose, up to 8 flowered, 1.5 to 10cm long. **Peduncle** 2 to 10.5cm, **Bracts** present, at the base of pedicel, persistent, lanceolate, 4-5 × 2-3mm, surface hairy, base reniform, apex acuminate, margin entire, abaxially dense tomentose and adaxially few sparse hair, midrib not distinct, stalk of 1mm long. **pedicel** 3-7mm long. **Bracteoles** present, at the base of calyx, lanceolate, 3-5 × 1-2mm, base obtuse or rounded, apex acuminate, margin entire, tomentose, stalk of 1mm long. **Flower** yellow, 1.4-1.8 × 0.5cm. **Calyx** two lipped, parted to base, 12-16mm long, tube ca. 3mm, adaxial two calyx lobe

boarder than abaxial three calyx lobe, calyx lobe of each lip are connate at the tip, abaxial calyx lobe linear, attached up to 4mm up, adaxial calyx lobe lanceolate, attached up to 6-6.5mm, apex acuminate, margin entire, densely hairy, tomentose. **Standard** obovate-orbicular, 6-9 × 6-8mm, base truncate, apex rounded, surface glabrous, callosity lamelliform, basal claw of 1mm long, top of basal claw with woolly trichome. **Wings** oblong, 6-7 × 3mm, base rounded, apex rounded, surface glabrous, basal claw 1 mm. **Keel** ovate with a long-twisted beak, 7.5-9 × 4-5mm, glabrous except cottony trichome at incurved margin. **Stamen** Monadelphous, dimorphic, tube 3mm long, long filaments c.4mm, short filaments c. 3mm long, oblong anthers 1-1.5mm long, ovoid anther always less than 1mm. **Ovary** oblong, 3 × 1mm, glabrous, sessile. **Style** 7mm long, two lines of trichomes, dense toward lower side, **stigma** minute. **Fruit** pod, green turns to brown when mature, oblong, 3-5 × 1cm, glabrous, exerted fully beyond calyx covering only basal portion, inflated, many seeded (30-50). **Seed** green turn into purplish when mature, reniform/obliquely cordate, 2-4 × 2-2.5mm, glabrous.

Vernacular name: छिन छिने (Chhin hhine), ठुलो बोक्सी बाजा (Thulo boksi baja).

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

Altitude: 112-1750 m.

Ecology: Found to be grown in *Shorea robusta* -*Pinus* mixed Forest, open hill slope, open grassy slope, open sunny wet path side, path side in Sal (*Shorea robusta* C.F. Gaertn.) forest, path side grassland, sunny, open and dry land, south facing slopes, open grassland, open grassy place in *Pinus roxburghii* forest, exposed slope in *Schima* Forest, open and rocky land and along river in sand.

Flowering: June-November

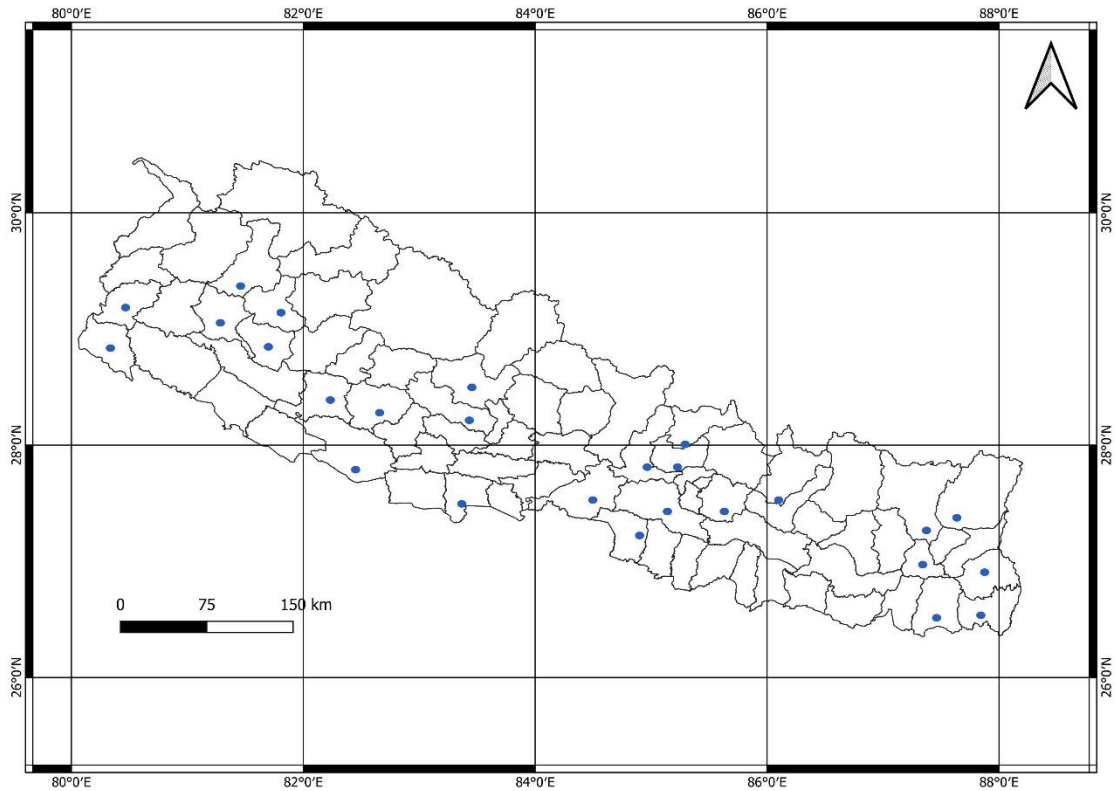
Fruiting: July-January.

Vaucher specimens:

Central Nepal: Chitwan district, Madi, 207-250m, 27° 26' 05"N, 84° 22' 50"E, 6th Oct 2022, B. parajuli and K. Parajuli, CH03 (TUCH); Kathmandu district, Sundarijal, 1577m, 27° 45' 34"N, 85° 25' 16"E, 28th July, 2022, B. Parajuli and S. Rauniyar, KT28 (TUCH).

Western Nepal: Kalikot district, Badalkot, 1590m, 29° 10' 45"N, 81° 39' 31"E, 25th Oct 2022, B. Parajuli, T.R. Parajuli and D.S. Thakuri, KL26 (TUCH).

Eastern Nepal: Jhapa district, Pathivara Kalika community forest, Haldibari-4, 124m, 26° 30' 12"N, 87° 59' 42"E, 6th July 2022, B. Parajuli, S. Aryal and B. Dhakal, JH06 (TUCH).



Map 2: Distribution of *Crotalaria alata* in Nepal based on herbarium records and field collections.

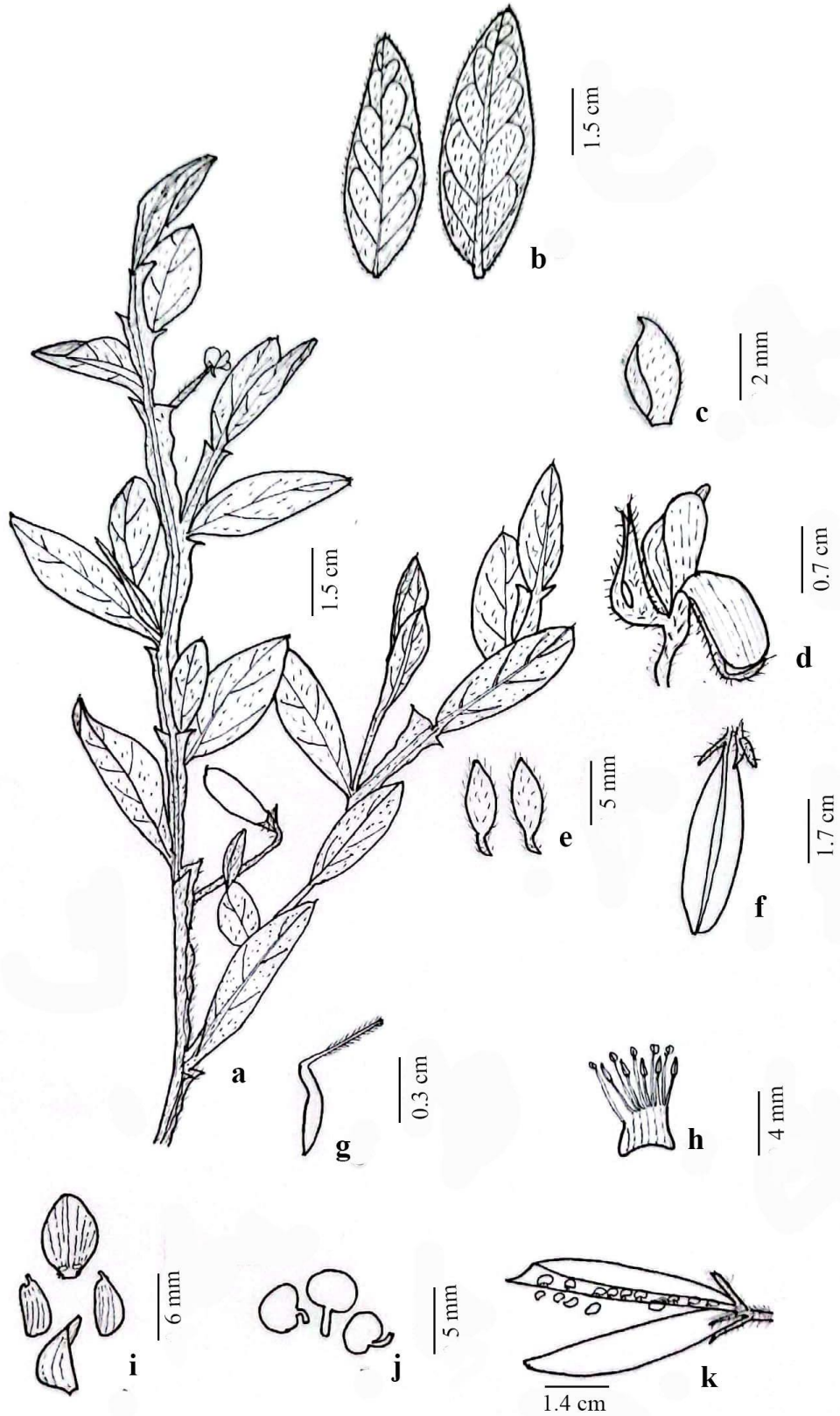


Figure 2 : *Crotalaria alata* Buch. -Ham. ex D. Don; a. Habit sketch; b. Leaf; c. Bract; d. Flower; e. Bracteoles; f. Fruit; g. Gynoeceum; h. Androecium; i. Petals; j. Seed; k. Transversely open flower.

3. *Crotalaria albida* B. Heyne ex Roth, Nov. Pl. Sp.: 333(1821). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Hooker in fl. Brit Ind. 2: 71 (1876); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 735 (1987); Kitamura in Fn. Fl. Nep. Himal. 1: 164 (1955); Banerji in Bull. Bot. Surv. India. 19 (2): 37 (1966); Ohashi in Fl. E. Himal. 145 (1966); Bull. Dept. Med. Pl. Nep. 2: 25 (1969); Enum. Fl. Pl. Nep, 2: 113 (1979); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 114 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:101 (2019). Shrestha *et al.*, in Pl. Nep. 1: 321 (2022)

Crotalaria deflexa Benth., Pl. Jungh. [Miquel] 2: 206 (1852);

Crotalaria montana Roxb., Hort. Bengal. 54., Fl. Ind. iii. 265. Nom. illeg.

Type specimen: India, Heyne, B, s.n. (L, **Isotype**)

Erect, spreading or sometimes prostrate in moist places, annual or perennial small herb to subshrub, 13-100cm tall. Branched to profusely spreading tuft with diffuse stem, branches arising only at base or arising above base. **Stem** woody, terete, pale silvery green, appressed pale silky pubescent. **Leaves** simple, alternate, divergent; **Stipule** absent. Petiole short in length 1-2mm; leaf blade oblanceolate, elliptic, linear to narrowly oblong, symmetric, $0.6-6.1 \times 0.2-1.6$ cm, base attenuate to cuneate, apex obtuse and mucronate, margin entire, both surface sparse to dense appressed, white, pilose, secondary veins not prominent. **Inflorescence** terminal both in main stem and branches, racemose, many (2-34) flowered, 2.5- 24cm long. **Peduncle** long 1.7-7.1cm. **Bracts** present, at the base of pedicel of each flower, persistent, linear, minute about 1×0.2 mm long, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially pubescent, midrib not distinct. **pedicel** 3-5mm (6-7mm). **Bracteoles** present, at base of calyx tube, persistent, linear to narrowly elliptic, $1-3 \times 0.3$ mm long, base cuneate, apex acute, margin ciliated. **Flower** yellow, $6-8 \times 7-9$ mm; **Calyx** two lipped, deeply divided into five calyx lobe, 6-10mm, two lip attach up to 1-2mm up, calyx lobe equal, abaxial 3 calyx lobe triangular, attached up to 2mm, adaxial 2 calyx lobe broadly lanceolate-elliptic, attached up to 2.5-3mm up, apex acute, margin ciliated, pubescent. **Standard** suborbicular to elliptic, $6-7 \times 6-7$ mm, adaxially glabrous, abaxial surface has long, silky, pilose hair, callosity lamelliform type, basal claw 1mm, margin of basal claw with cottony trichome. **Wings** oblong, $5-6.7 \times 2-3$ mm, glabrous, basal claw less than

1mm. **Keel** narrowed, apically from middle and extended into a twisted beak, 6.5-7 × 3.3-4mm, both margin with woolly trichome other part glabrous, basal claw minute 0.25mm. **Stamen 10**, Monadelphous, dimorphic, filament tube 1.5-2mm long, longer filament ca. 3mm, shorter filament ca. 1.5-2mm, oblong anther 1mm long, ovoid anther c. 0.5mm. **Ovary** oblong, 2 × 1mm, glabrous, subsessile, **style** 6-7.5mm long, two lines of trichome, Stigma minute. **Fruit** green, turns to black when get mature, oblong, 9-15 × 4mm, exerted slightly beyond calyx, glabrous, inflated, 4-15 seeded. **Seed** reniform, 1-1.5 × 1.1.5mm, green in young turns brown when mature, glabrous.

Vernacular name: पुतली फूल (Putali phul), भेडि फूल (Bhedi phul)

Distribution Range: Nepal (ECW), W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia, SE Asia and Australasia.

Altitude: 150- 2700m

Ecology: in open and dry place, *Shorea robusta* C.F.Gaertn forest, shady and moist place, dry hill slope, rocky and exposed slope, steep grassy banks, amongst shrubs, in tropical forest, hill *Shorea robusta* C.F.Gaertn forest, under hedges, *schima - castanopsis indica* forest, sunny margin of thicket.

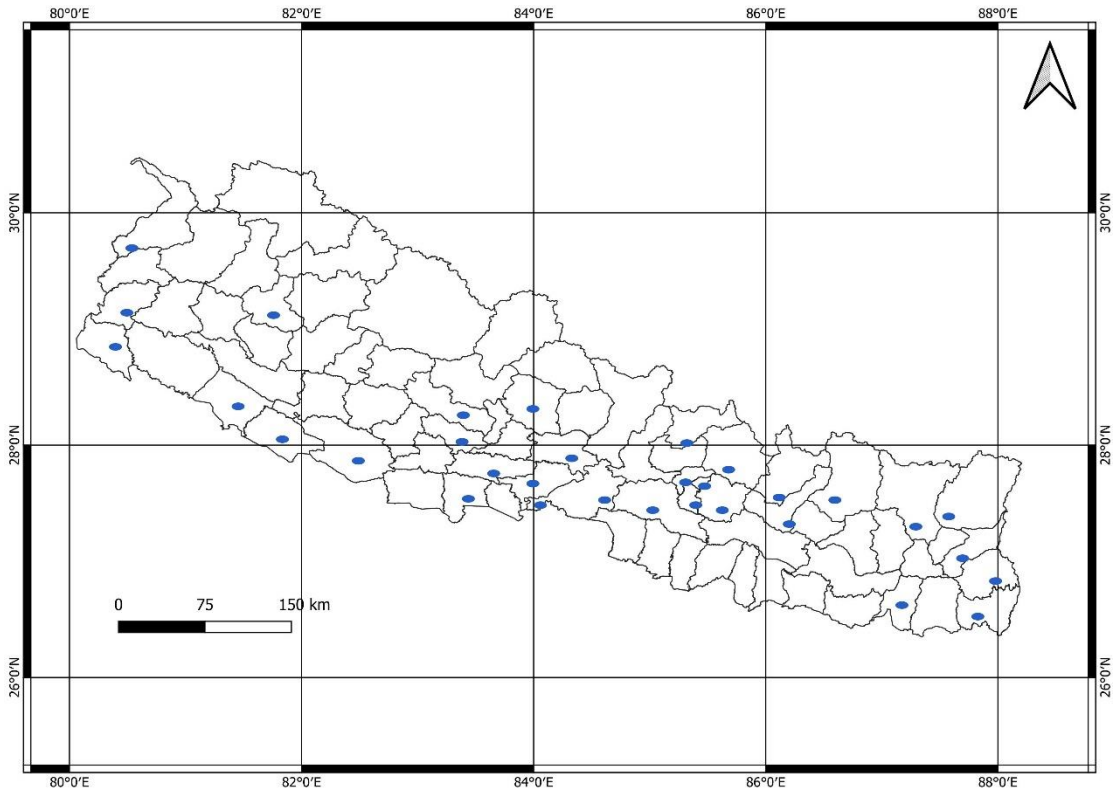
Flowering: June- April

Fruiting: August-April

Vaucher specimen:

Central Nepal: Chitwan district, Madi, 241m, 27° 25' 59"N, 84° 22' 50"E, 5th Oct 2022, B. Parajuli and K. Parajuli, CH02 (TUCH); Rupandehi district, Golpark, Butwal, 249m, 27° 42' 45"N, 83° 27' 50"E, 13th Oct 2022, B. Parajuli and S. Parajuli, BT13 (TUCH); Gulmi district, Tamghas, 1540m, 28° 03' 56"N, 83° 14' 56"E, 24th Nov 2021, K. Panti and B. parajuli, GL24 (TUCH);

Western Nepal: Kalikot district, Badalkot, 1711m, 29° 10' 40"N, 81° 38' 11"E, 25th Oct 2022, B. Parajuli, T. Parajuli and D. Shahi, KL25 (TUCH);



Map 3: Distribution of *Crotalaria albida* in Nepal based on herbarium records and field collections.

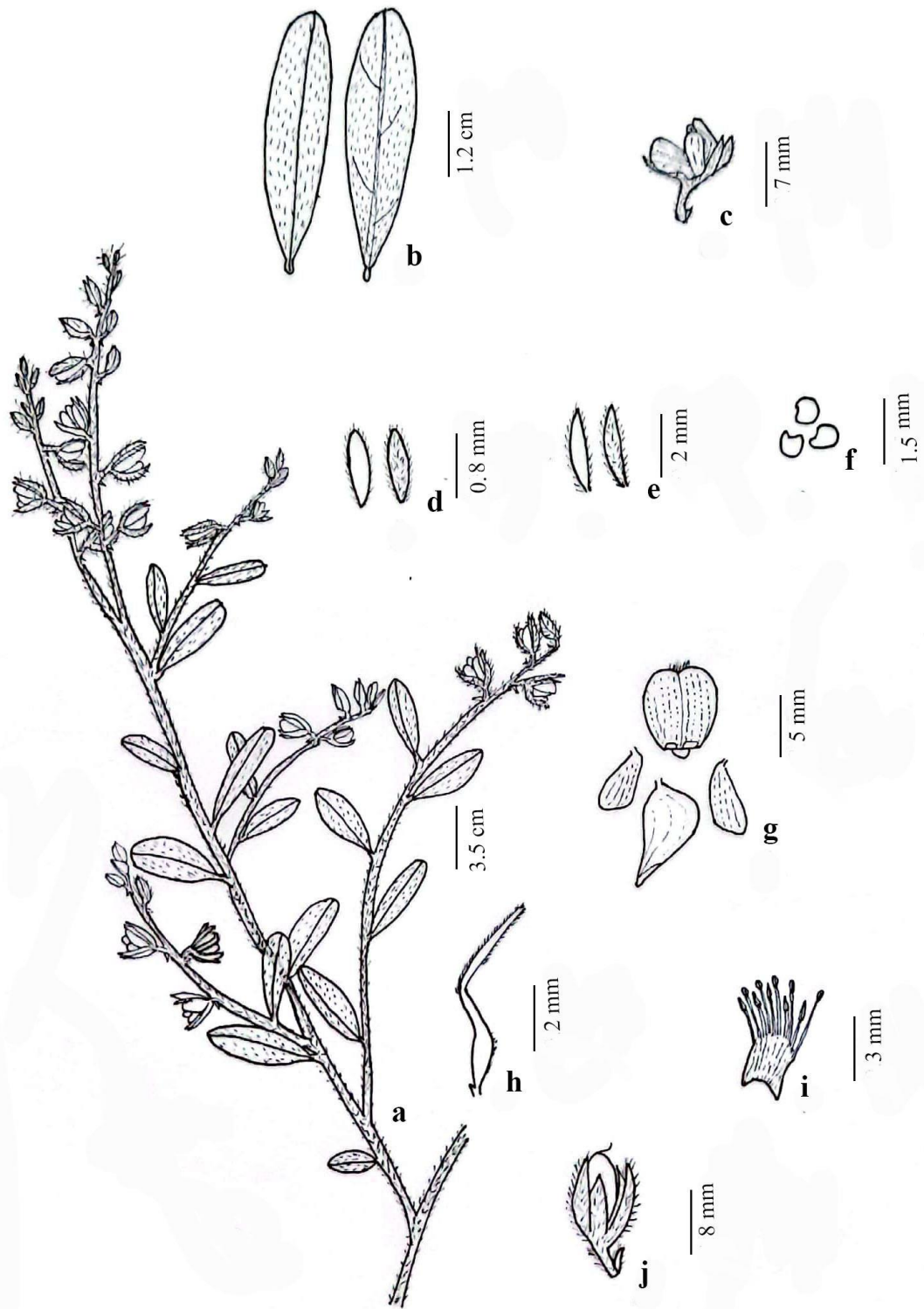


Figure 3: *Crotalaria albida* B. Heyne ex Roth; a. Habit sketch; b. Leaf; c. Flower; d. Bract; e. Bracteoles; f. Seed; g. Petals; h. Gynoeceum; i. Androecium; j. Fruit

4. *Crotalaria calycina* Schrank, Pl. Rar. H. Monac.: t. 12 (1817); Baker in Hook. f., Fl. Brit. Ind. 2:72. (1876); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 734 (1987); Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 112 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:101 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria anthylloides D.Don, Prodr. Fl. Nepal. 241 (1825);

Crotalaria crenata Wight & Arn. Prodr. Fl. Ind. Orient.: 181 (1834)

Crotalaria nipaulensis G. Don, Gen. Hist. 2: 137 (1832)

Crotalaria stricta Roxb., Hort. Bengal. 54., Fl. Ind. Iii. 265;

Type specimen: Nepal, Nathaniel Wallich, 1821 (BM, **Isotype**)

Erect annual herb, 15-100cm, **Stem** diffuse or erect, solitary unbranched to branched, branches mostly arise from basal parts, herbaceous, terete, green, cover with white, appressed, densely hirsute vestiture, slightly rough. **Leaf** simple, divergent; **Stipule** present, caducous, variation in shape of stipule, filiform, linear to narrowly lanceolate, inclined, 3-5 × 0.5-1mm, base truncate or rounded, apex acute, margin ciliated, adaxially glabrous, abaxially dense, appressed, brown, pilose; **Petiole** very short 2-3mm; **Leaf blade** Linear, elliptic, lanceolate-elliptic, oblong-linear, linear-lanceolate to oblong or oblanceolate, symmetrical, 2.4-15 × 0.4-1.7cm, base cuneate, apex acute & mucronate or obtuse, margin entire, adaxially glabrous or trichome present on mid-vein, abaxially appressed, dense pubescent, pinnate-netted, secondary veins not much distinct. **Inflorescence** terminal or solitary, racemose, 1-3 flowers in axillary raceme, 2-9 flowers in terminal raceme, 1.5-8cm long, **Peduncle** 2-4.3cm. **Bracts** present, at the base of pedicel, persistent, Lanceolate, 0.8-1.4 × 0.2-0.3cm, base truncate, apex acuminate, margin ciliated, adaxially glabrous, abaxially densely appressed pubescent, midrib not distinct, small stalk of 1mm. **Pedicel** short 2-6mm; **Bracteoles** present, at upper part of pedicel, persistent, narrowly lanceolate, 0.6-1.3 × 0.2-0.3cm, base truncate, apex narrowly acute, margin ciliated, stalk short about 2mm. **Flower** yellow, 1.5-3 × 1.1-2.5cm; **Calyx** two lipped, parted to base, 2-3cm, tube 3mm long, lobes subequal abaxial 3 lobes triangular-lanceolate, attached up to 9mm, apex acute, margin ciliated, adaxial two lobes adaxial lobes elliptic, attached up to 6mm up, apex obtuse,

margin ciliated, dense, appressed, brownish pilose, **Standard** elliptic-obovate, 1.2-1.3 × 0.9-1cm, base truncate, apex obtuse, surface adaxially glabrous, abaxially long pilose trichome present at top-middle region, callosities lamelliform type, basal claw of 1mm. **Wings** obovate-oblong, 1.3 × 0.4cm, glabrous, base broadly cuneate, apex obtuse, basal claw 2mm long. **Keel** pale green, upwardly curved from middle, 1.3 × 0.5cm, apex twisted, both margin with soft, white cottony trichome, basal claw c. 1mm, sides with woolly trichome in patches. **Stamen** 10, Monadelphous, dimorphic, Filaments attached up to 4mm up, longer filament 8mm long, with minute, globose, dorsifixed, about 0.2mm of anther, shorter filament 5mm long with oblong, basifixed, c. 2mm anther. **Ovary** oblong, 4mm × 2mm, glabrous, subsessile, **Style** 0.9-1cm, few number of hairs adaxially, abaxially dense trichome toward top region, **Stigma** minute. **Pod** green turns black when mature, oblanceolate, 1.8-2 × 0.6-0.8cm, inclusive, glabrous, inflated, 19-36 seeded. **Seed** green turns brownish when mature, harp shaped, 2 × 2mm, glabrous.

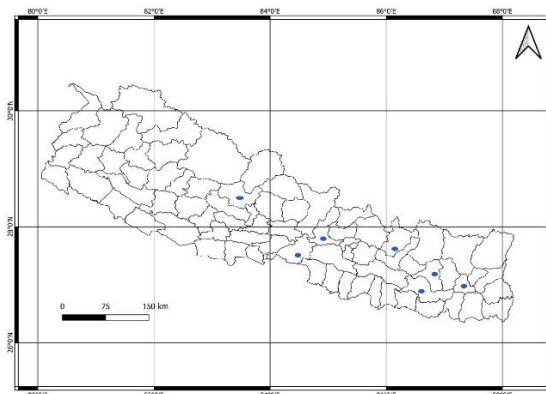
Distribution Nepal: Nepal (W, C & E), W. Himalaya, E. Himalaya, Tibetan Plateau, S Asia, E. Asia, SE. Asia, Africa and Australasia.

Altitude: 165-3450m

Ecology: On open place, Hill slope, open grassland, at roadside, roadside track with grasses, in *Shorea robusta* C.F.Gaertn forest.

Flowering/Fruiting: September-December

Vaucher specimen: Central Nepal: Chitwan district, Madi, 207-250m, 27° 25' 50"N, 84° 22' 49"E, 5th Oct 2022, B. Parajuli and K. Parajuli, CH04 (TUCH); Chitwan district, Golaghat, 157m, 27° 36' 31"N, 84° 16' 03"E, 6th Oct 2022, B. Parajuli and K. Parajuli, CH05 (TUCH).



Map 4 : Distribution of *Crotalaria calycina* in Nepal based on herbarium records and field collections.

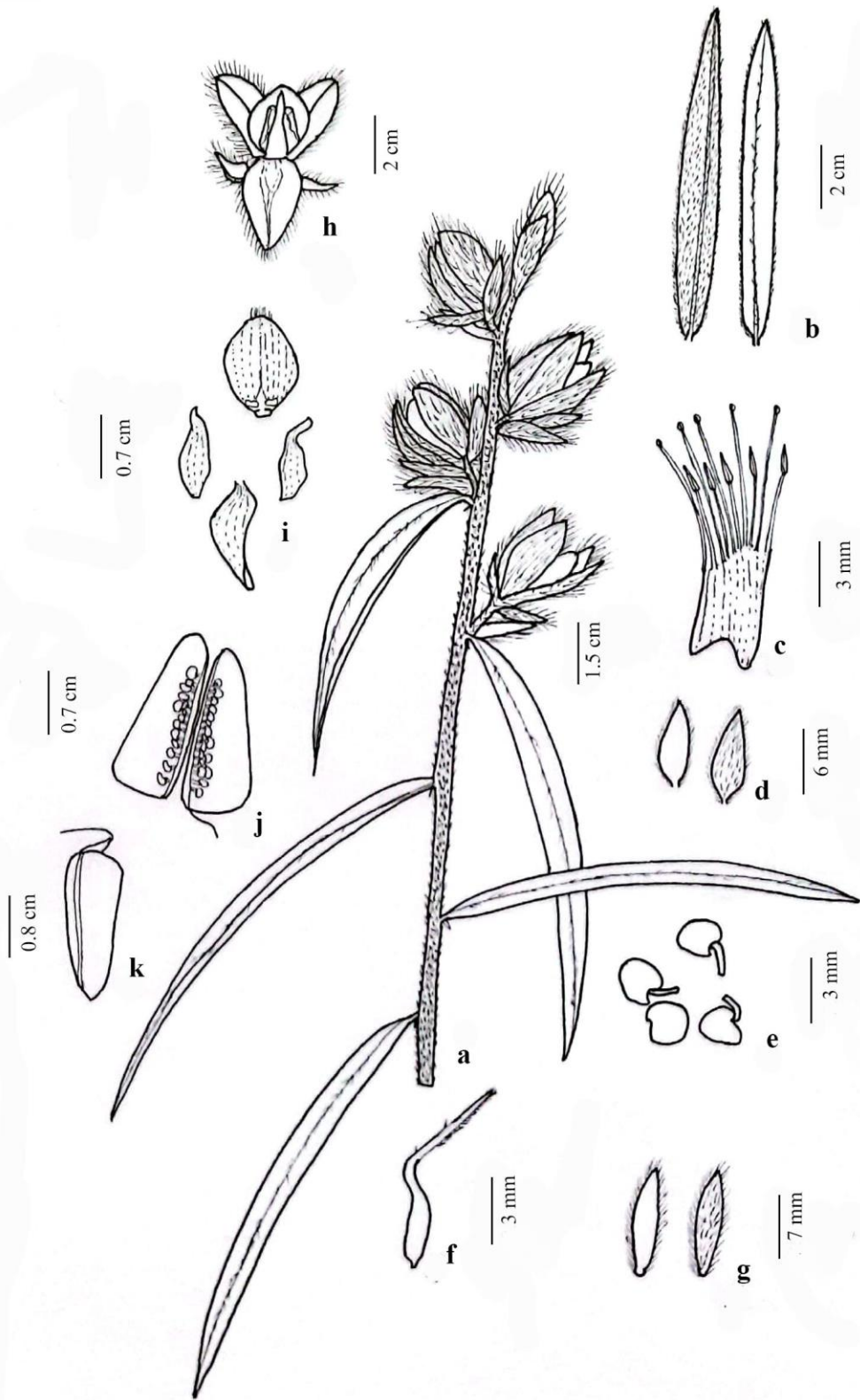


Figure 4 : *Crotalaria calycina* Schrank; a. Habit sketch; b. Leaf; c. Androecium; d. Bract; e. Seed; f. Gynoecium; g. Bracteoles; h. Flower; i. Petals; j. Transversely open fruit; k. Fruit.

5. *Crotalaria cytisoides* Roxb. ex-DC., Prodr. 2: 131 (1825). Ohashi in Hara & Williams, Enum. El. Pl. Nep. 2: 113 (1979). Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 732 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:101-102 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria psoralioides D.Don, Prodr. Fl. Nepal. 242 (1825);

Priotropis cytisoides (Roxb. ex-DC.) Wight & Arn, Prodr. Fl. Ind. Or. 180 (1834).

Crotalaria szemaensis Gagnep., Notul. Syst. (Paris) 3: 37 (1914).

Type Specimen: Nepal, 1819, *N. Wallich*, s.n, (G, **Syntype**)

Nepalia (Nepal), 1821.01.01, *N. Wallich*, s.n (G, **Lectotype**)

Erect small or medium bushy shrub, 1-3m. **Stem** much branched, woody, terete, pale green, densely appressed white to rusty brown pubescent. **Leaf** trifoliate, divergent; **Stipule** present, persistent, inclined, subulate, 1.5-3.5mm, base truncate, apex acute, margin entire, adaxially glabrous, abaxially dense, appressed pubescent. **Petiole** channeled, 2-4.5cm; **Petiolule** short 1-2mm, **Leaflets** elliptic, symmetrical, 3.4 -10 × 1.3 - 3cm, base cuneate to narrowly cuneate, apex acute and mucronate or acuminate and mucronate rarely obtuse, margin entire, adaxially glabrous, abaxially puberulent, midvein and secondary veins both are distinct. **Inflorescence** terminal, leaf-opposed or axillary in position, raceme, 7-41 flowered, 2-21cm long. **Peduncle** 0.3-3.2cm. **Bracts** present, at the base of pedicel, persistent, ovate, 1-2.5 × c. 1mm, base truncate, apex acuminate, margin entire, adaxial surface sparsely puberulent, abaxial surface densely appressed pubescent, midrib not distinct. **Pedicel** 3-7mm; **Bracteoles** present, at the base of calyx tube, persistent, reflexed, triangular-ovate, curved, 2-2.5 (3) × 1mm, base truncate, apex acute, margin entire. **Flower** yellow to reddish brown, 1.3-1.7 × 0.5-0.7 cm, appressed, recurved; **Calyx** broadly campanulate, 6-8 mm long, tube 2 mm long, calyx lobe triangular, subequal, abaxial 3 calyx lobe slightly longer than adaxial 2 calyx lobe, apex acute, margin entire, covered with dense, short, appressed, puberulent vestiture. **Standard** yellow with usually reddish streaks, suborbicular to orbicular, 0.8-1.1 × 0.7-1cm, base rounded, apex rounded and slightly oblique, margin entire, few short hairs at central-top region of abaxial surface, adaxially glabrous, Callosity ridged type, 3mm long basal claw, margin of basal claw with woolly trichome. **Wings** oblong,

elliptic or obovate, 7.5- 9 × 4-5mm, base cuneate, apex rounded, glabrous, basal claw short 3mm long. **Keel** yellowish green with reddish patches, suborbicular with long untwisted beak, 0.8-1 × 0.5-0.7cm, base broadly cuneate, margin entire, glabrous but both margin at basal portion hairy, basal claw 3mm long. **Stamen** 10, Monadelphous, dimorphic, tube 6-7mm, longer filament 5-7mm long, shorter filament 3-4mm long, oblong anther basifixed, 1.5mm long, ovoid anther minute c. 0.5mm and dorsifixed. **Ovary** oblong, 4-6 × 1mm, covered with appressed white pilose trichome, denser toward adaxial margin, stalk 1-2mm long, **style** curved and horizontally elongated, 1.1-1.3cm long, single line of trichome. **Stigma** minute. **Pod** green turns brown when mature, oblong-elliptic, 2.1-3.8 × 1-1.5cm, scarcely inflated (appressed), appressed, brown pubescent, fully exerted calyx covering only stipe portion, 1-5 seeded. **Seed** green turns brown when mature, harp shaped, 5-6 × 5mm, glabrous or with few (1-2) silky hairs.

Vernacular name: चेम्गी फूल (Chemgi phul)

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

Altitude: 150-2770m

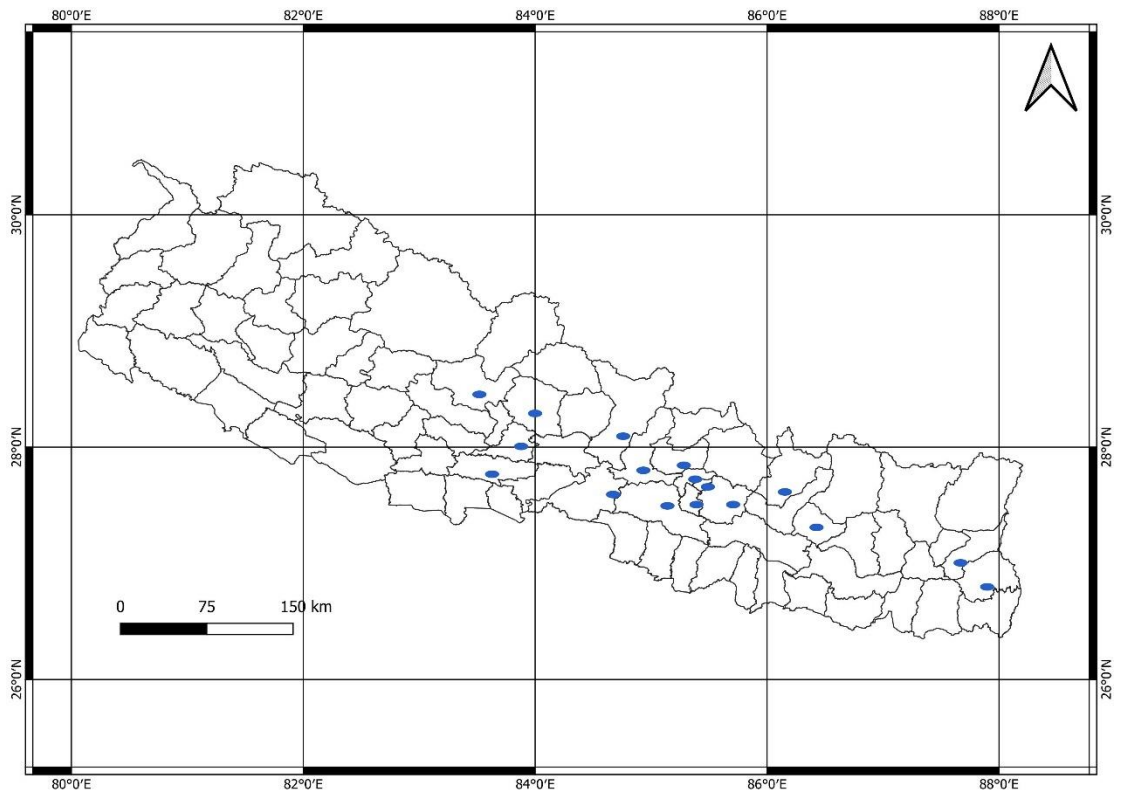
Ecology: On dry slopes, open land, shady place, steep gully in degraded oak-pine forest, sunny steep slope at roadside, in a thicket, on scanty forest on steep slope facing east, on open dry slopy place, on the field mixed with *Quercus*.

Flowering: July-December

Fruiting: August-January

Vaucher Specimen:

Central Nepal: Kathmandu district, Shivapuri, 1650m, 27° 47' 31"N, 85° 22' 01"E, 29th Nov 2022, B. Parajuli and K.R. Parajuli, KT29 (TUCH); Kathmandu district, Chandragiri, 2015m, 27° 40' 44"N, 85° 11' 51"E, 4th Jan 2023, B. Parajuli, S. Basyal, P. Basyal and B. Rawat, KT04 (TUCH);



Map 5 : Distribution of *Crotalaria cytisoides* in Nepal based on herbarium records and field collections.

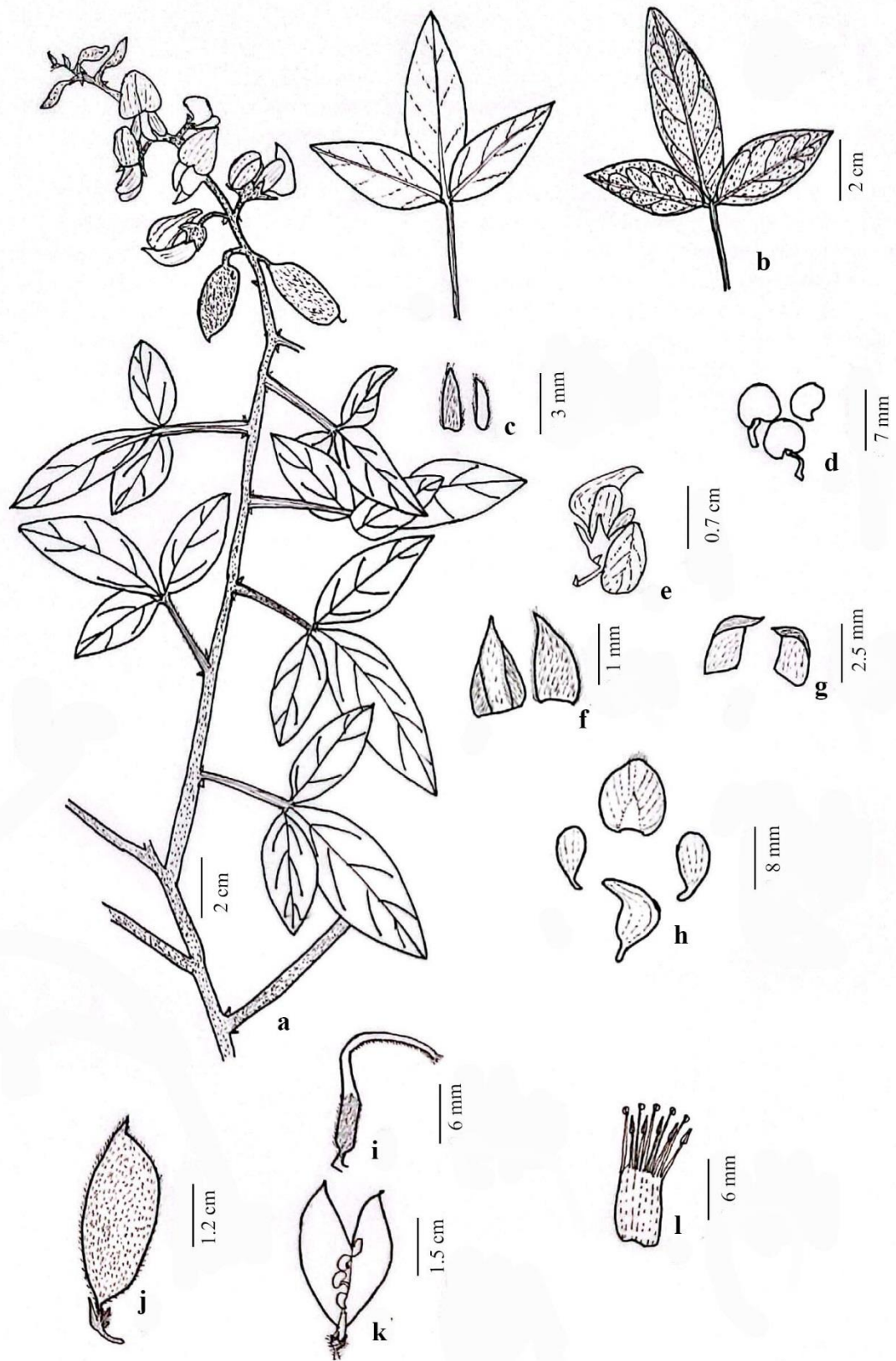


Figure 5 : *Crotalaria cytisoides* Roxb. ex-DC; a. Habit sketch; b. Leaf; c. Stipule; d. Seed; e. Flower; f. Bract; g. Bracteoles; h. Petals; i. Gynoecium; j. fruit; k. Transversely open fruit.

6. *Crotalaria humifusa* Grah. ex Benth. In Hooker, Lond. J. Bot. 2: 476 (1843); Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 736 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 115 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011). Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:102 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Type Specimen: India orient, Wallich, 5421, (LE, **Isotype**)

Prostrate annual herb, 9-50cm. Tap roots with spreading secondary branches with nodules and tertiary roots. **Stem** diffuse, procumbent, profusely branched, branches arise mostly from base, herbaceous, terete, green, spreading white long silky pilose, silky. **Leaf** simple, mostly inclined or divergent, **Stipule** present, persistent, divergent or recurved, subulate, 2-4.5 × 0.5mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially sparse, few long silky pilose. petiole short 1-2mm; leaf blade varies in shape, broadly elliptic, obovate, orbicular, suborbicular, oblong-elliptic, ovate, oblanceolate or sometime rhomboidal, Symmetrical, 0.6-3.5 × 0.4-2.4cm, base rounded to broadly cuneate, apex obtuse, rounded or obtuse, margin ciliated, both surfaces appressed, white, pilose, midrib distinct, secondary veins pale. **Inflorescence** leaf-opposed, terminal on short flowering branch or solitary flowers in axil, racemes, 2-8 flowered, 1.5-9cm long. **Peduncle** 1-6.5cm long, slender. **Bracts** present, at the base of pedicel, persistent, subulate, 0.7-1.5 × 0.2mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially sparse, appressed pilose, midrib not distinct. **Pedicel** 1-5mm; **Bracteoles** present, at the base of the calyx tube, persistent, subulate, 1.5-2 × 2mm. Flowers yellow, 3-5 × 2-2.5mm. **Calyx** two lipped, parted to base, up to 4-6mm long, tube 1mm long, calyx lobe subequal, abaxial 3 lobe linear, 3-4mm, attached up to 2mm up, falcate, adaxial 2 calyx lobe linear-lanceolate, 2-3mm, attached up to 2mm up, connate and wider than abaxial lobes, margin ciliated, apex acute, dense, appressed, white to brownish pilose. **Standard** oblong-orbicular or broadly oblong, 2.5-3 × 2.5-3mm, base truncate, apex retuse, margin entire, glabrous, callosity lamelliform type, 0.3mm long basal claw, claw glabrous. **Wings** oblong, 2-2.5 × 0.6-0.8mm, base oblique, apex rounded, glabrous, basal claw short 0.5mm long. **Keel** rounded, with a sharp angle at middle and an extension into a straight, slightly twisted beak, 2-3 × 1.5-2mm, base broadly cuneate, margin entire, glabrous, basal claw 0.3mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 0.5-0.6mm up,

longer filament c. 2mm long, shorter filament c.1mm long, oblong anther basifixed, 0.3mm long, elliptic anther minute c. 0.2mm and dorsifixed. **Ovary** oblong, ca. 2 × 0.5mm, glabrous, subsessile, **style** about 2mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns brown when mature, oblong-cylindrical, glabrous, 4-7 × 2-3mm, half exerted, inflated, 12-19 seeded. **Seed** green turns pale to dark brown when mature, reniform, 1 × 1mm, glabrous, stalk 0.5mm long.

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

Altitude: 160-1828m

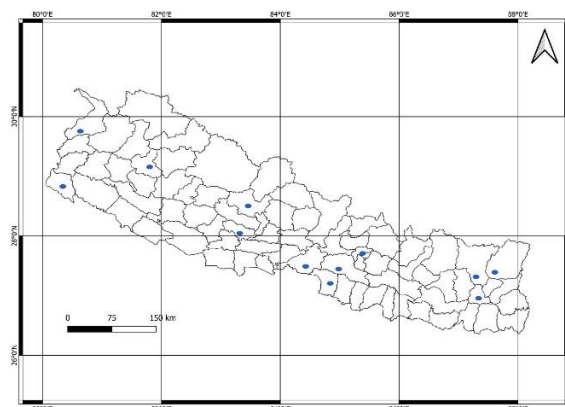
Ecology: On dry sunny place, ground by tracks and bordering wetlands streams, alluvial substrate, the floor of *Castanopsis* forest, under semi shade, transition between tropical and subtropical forest, bank of paddy field, open and dry place, dry bank, sunny wasteland at pathside, roadside on margin of roadside sal (*Shorea robusta*) forest, moist slopy place, on dry-open grassy slopes.

Flowering: June-January

Fruiting: July-January

Vaucher Specimen: Western Nepal: Kalikot district, badalkot, 1369m, 29° 10' 47"N, 81° 39' 25"E, 25th Oct, 2022, B. Parajuli and D.S. Thakuri, KL27 (TUCH);

Central Nepal: Kathmandu district, Chobhar, Kirtipur, 1423m, 27° 39' 53"N, 85° 17' 29"E, 2nd Sep 2022, B. Parajuli, KT02 (TUCH); Kathmandu district, Sundarijal, 1500m, 27° 45' 34"N, 85° 25' 16"E, 28th July 2022, B. Parajuli and S. Rauniyar, KT028 (TUCH).



Map 6 : Distribution of *Crotalaria humifusa* in Nepal based on herbarium records and field collections.

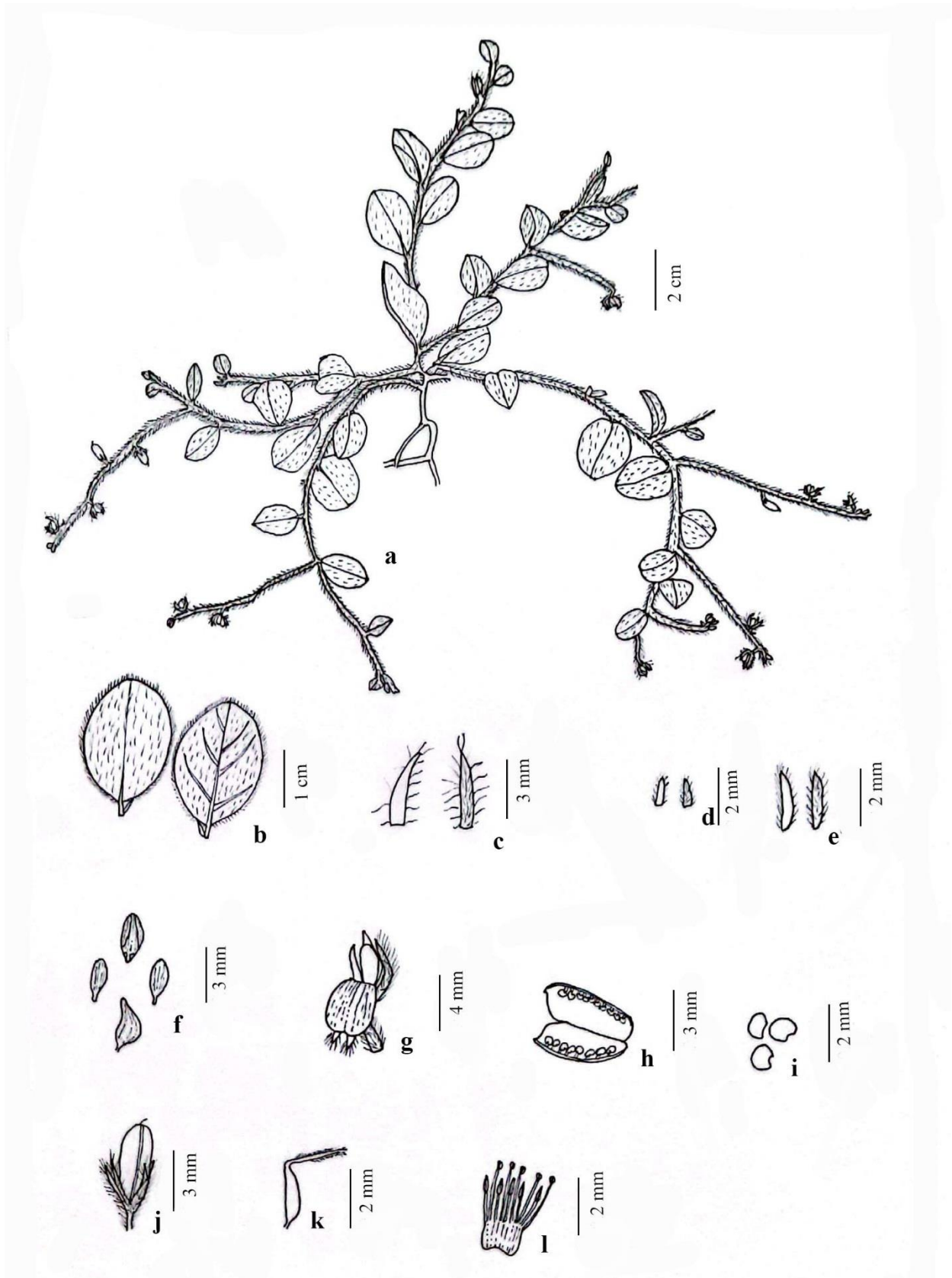


Figure 6 : *Crotalaria humifusa* Grah. ex Benth; a. Habit sketch; b. Leaf; c. Stipule; d. Bract; e. Bracteoles; f. Petals; g. Flower; h. Transversely open fruit; i. Seed; j. fruit; k. Gynoecium; l. Androecium.

7. *Crotalaria Kanaii* H. Ohashi, J. Jap. Bot. 51: 301 (1976). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Type specimen: Central Nepal, Rasuwa district, Dhunche, Trishuli khola-Singum Gomba, 27° 07' N, 85° 21' E, 2300 m, 1972.8.22, H. Kanai, H. Hara & H. Ohba, 721801 (TI, **Holotype**)

Makwanpur district, Chitlang Thankot, 2100m, 1970.9.4, H. Kanai 672761 (TI, **Paratype**).

Prostrate perennial herb, 16-25cm long. Thick, stuff tap root system. **Stem** diffuse, profusely branched, branches spreading, slender, arise from base to top, herbaceous, terete, pale green, spreading, long, brownish pilose, rough. **Leaf** simple, divergent to inclined, **Stipule** present, persistent, divergent, triangular-filiform, 1-2 × 0.25mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially pilose, sessile; petiole short 1mm or short; leaf blade broadly ovate, suborbicular, obovate, oblong-ovate or oblong, symmetric sometime asymmetric, 0.3-2.1 × 0.3-1.7cm, base cordate, rounded, truncate, oblique, or broadly cuneate, apex rounded or obtuse, margin ciliated, both surfaces sparsely pilose, trichome long 1-2mm long, midrib & secondary veins distinct. **Inflorescence** terminal or leaf-opposed, racemes, 1-2 flowered, 1-1.5cm long. **Peduncle** 1-4cm long. **Bracts** present, at the base of pedicel, persistent, narrowly triangular, 2-3 × 0.5mm, base truncate, apex acuminate, margin entire, adaxially glabrous, abaxially sparsely pubescent, midrib not distinct. **Pedicel** 2-4mm long. **Bracteoles** present, at the middle or top of pedicel, persistent, filiform, 1.5-2 × 0.2mm. **Flowers** yellow, 7-13 × 6-10 mm. **Calyx** two lipped, parted to base, up to 6-9 mm long, tube 1-3 mm long, calyx lobe subequal, abaxial 3 calyx lobe linear, attached up to 3mm up, adaxial 2 calyx lobe triangular-lanceolate, attached up to 2mm up, abaxial calyx lobe slightly longer and narrower than lower calyx lobe, apex acute, margin ciliated, dense, appressed, long, white to brownish pilose. **Standard** broadly ovate, 9 × 10-11mm, base truncate, apex rounded, margin entire, adaxially glabrous, abaxially short, silky hairs at central-top portion, marked with purplish longitudinal lines, callosity disc shaped, basal claw 1mm or short, margin with woolly trichome. **Wings** oblong, 6-8 × 3-4mm, base curved-obtuse, margin entire, apex obtuse, glabrous, basal claw short

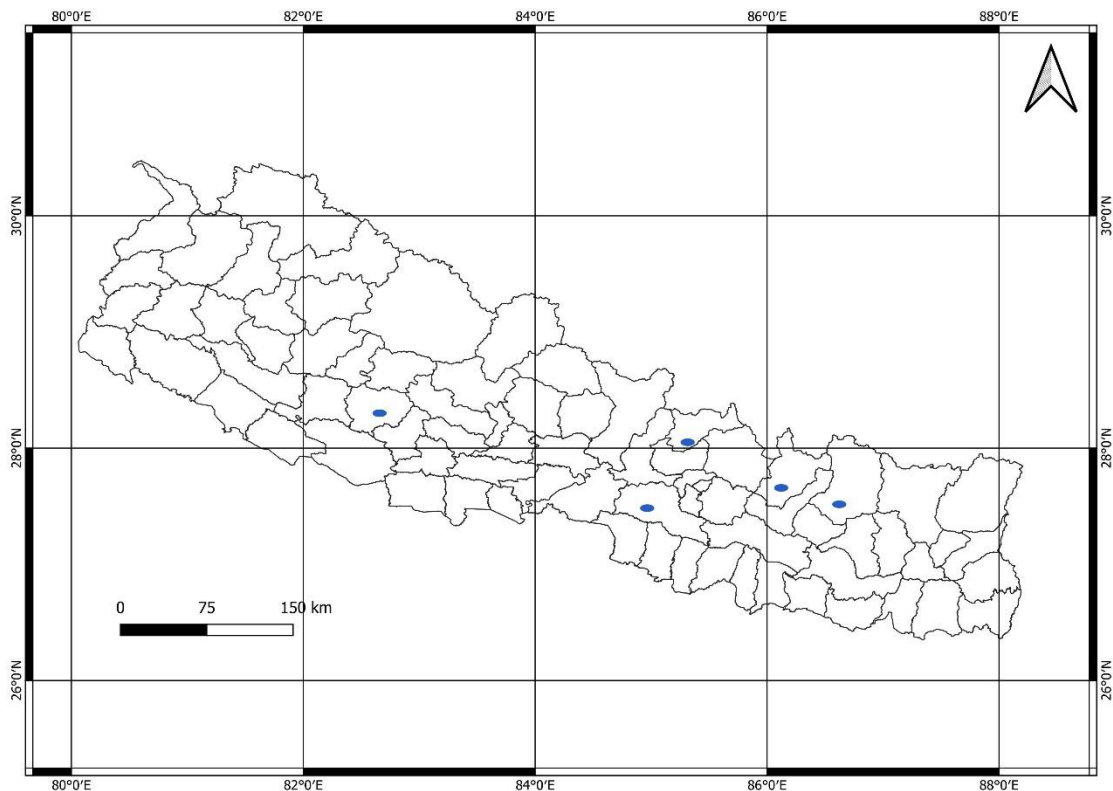
1mm long. **Keel** suborbicular with long twisted beak, 9×5 mm, base broadly cuneate, glabrous being margin at both sides hairy, basal claw c. 1mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 3mm up, longer filament 5-6mm long, shorter filament 4mm long, oblong anther basifixed, 1-1.5mm long, elliptic anther minute c.0.5mm and dorsifixed. **Ovary** oblong, $3-4 \times 1$ mm, glabrous, subsessile, **style** 8-9mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs.

Distribution Range: Nepal (ECW); Endemic to Nepal

Altitude: 1981-2940m

Ecology: Grows in Rhododendron-Quercus mixed forest, also reported from open fields.

Flowering/ Fruiting: September



Map 7 : Distribution of *Crotalaria kanaii* in Nepal based on herbarium records.

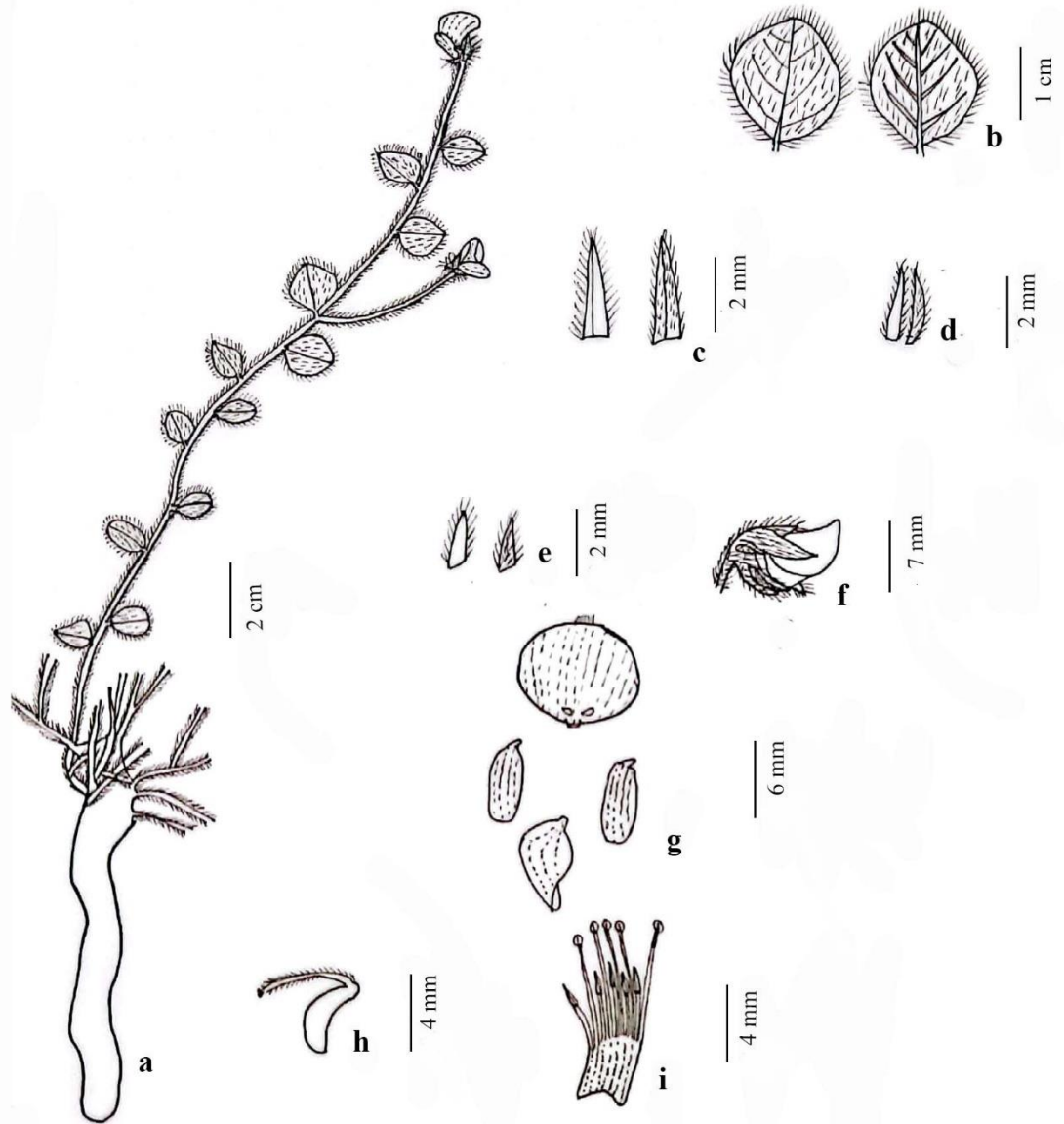


Figure 7 : *Crotalaria Kanaii* H. Ohashi; a. Habit sketch; b. Leaf; c. Bract; d. Bracteoles; e. Stipule; f. Flower; g. Petals; h. Gynoeceium; i. Androeceium.

8. *Crotalaria lejoloba* Bartl. Index Seminum (GOET, Gottingensis) 1837: 2 (1837); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria Lejoloba Grah. Ex Benth. In Hooker, Lond. J. Bot. 2: 476 (1843);

Crotalaria pilosissima Miq. in Fl. Ned. Ind. 1(1): 327 (1855);

Crotalaria lejoloba var. *pilosissima* Benth. ex-Baker in J.D.Hooker, Fl. Brit. India 2: 68 (1876);

Type specimen: Indonesia, Java, Jawa Timur, Bromo, Indonesia, Java Tengger, Merde Sable du Bromo au Pied du col de l' idjo, 2200m, 1905. 1. 23, Hochreotiner, BPG, 2747. (L, **Neotype**)

Erect or ascending annual or perennial herb to subshrub, 15-85cm tall. **Stem** much branched, branches arise from base to top, woody, terete, appressed or spreading white or brown pubescent, spreading pilose or sometime appressed tomentose, rough. **Leaf** simple, mostly inclined, few divergent or recurved; **Stipule** present, persistent, divergent, broadly lanceolate with one side incurved, 4-12 × 2-4.5mm, base truncate, margin ciliated, apex acuminate, both surface with sparse, appressed, pubescent. Petiole short, 1-4mm long, leaf blade elliptic, obovate, oblong or suborbicular, asymmetric 1.7-7.3 × 0.5-2.9cm, base cuneate or slightly oblique, apex obtuse, rounded or mucronate, margin entire, both surfaces appressed, white, pubescent but abaxially denser, midrib distinct, secondary veins pale. **Inflorescence** leaf-opposed, racemes, 2-5 flowered, 4-7cm long. **Peduncle** 2-10cm long. **Bracts** present, at the base of pedicel, persistent, lanceolate, 3-4.5 × 1mm, adaxially glabrous, base truncate, apex acute, margin entire, abaxially sparse, puberulent but basal part long dense tomentose, midrib not distinct. **Pedicel** 4-5mm. **Bracteoles** present, at the middle of the calyx tube, persistent, linear, 4-5 × ca.1mm, base truncate, apex acute, margin ciliated. Flowers yellow, 1-1.6 × 0.5-0.7cm. **Calyx** two lipped, parted to base, up to 1.8cm long, tube 2-3mm long, calyx lobe subequal, abaxial 3 calyx lobe linear, 10-11mm, attached up to 6mm up, adaxial 2 calyx lobe linear-lanceolate, 10mm, attached up to 7mm up, apex acute, margin ciliated, dense, appressed, white to brownish pilose. **Standard** broadly elliptic or obovate, 8-10 × 6-7mm, base truncate, apex rounded, adaxially glabrous, abaxially top middle region has short silky trichome, callosity lamelliform type, 1mm long basal claw, margin with woolly trichome. **Wings** oblong, 7-8 × 3mm, base cuneate, apex obtuse, glabrous, basal claw short 1mm long. **Keel** rounded, narrowed

apically from middle with long twisted beak, $7-8 \times 4.5-5\text{mm}$, base truncate, glabrous being margin at both sides woolly, basal claw 1mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 3mm up, longer filament 5mm long, shorter filament 3mm long, oblong anther basifixed, 1mm long, elliptic anther minute ca. 0.5mm and dorsifixed. **Ovary** oblong, $3-4 \times 1\text{mm}$, glabrous, sessile, **style** 6-8mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns black when mature, oblong, glabrous, $1.7-3 \times 0.8-1\text{cm}$, half of the fruit exerted out of calyx, inflated, 20-30 seeded. **Seed** green turns brownish-black when mature, reniform, $2.5-3 \times 2-2.5\text{mm}$, glabrous, stalk hairy at both margins.

Vernacular name: जुनग्राबन (Jungraban)

Distribution Range: Nepal (W, C & E), W. Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia and SE Asia.

Altitude: 1300-1900m

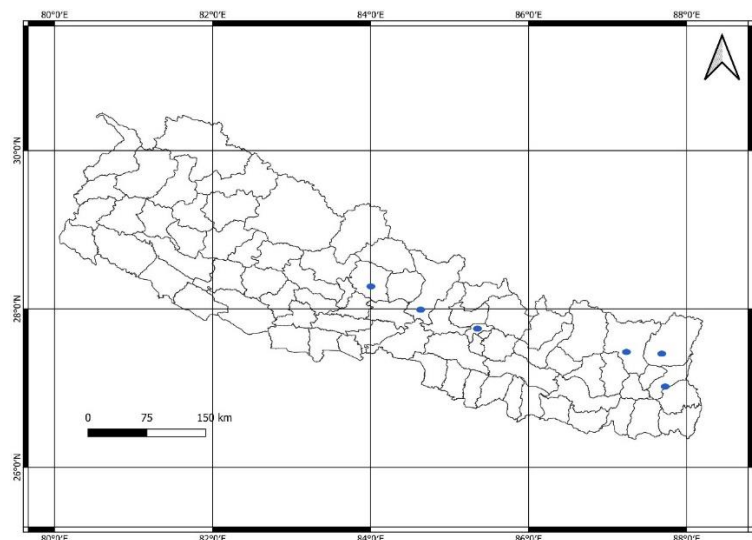
Ecology: In grassland associated with *Schima wallichii* (DC.) Korth.

Flowering: Aug-Nov

Fruiting: Sep-Nov

Vaucher Specimen:

Central Nepal: Gorkha district, 1185m, $27^{\circ} 59' 48''\text{N}$, $83^{\circ} 37' 53''\text{E}$, 15th July 2022, M. Thapa, R. Magar B. Parajuli, GR15 (TUCH).



Map 8 : Distribution of *Crotalaria lejoloba* in Nepal based on herbarium records and field collection.

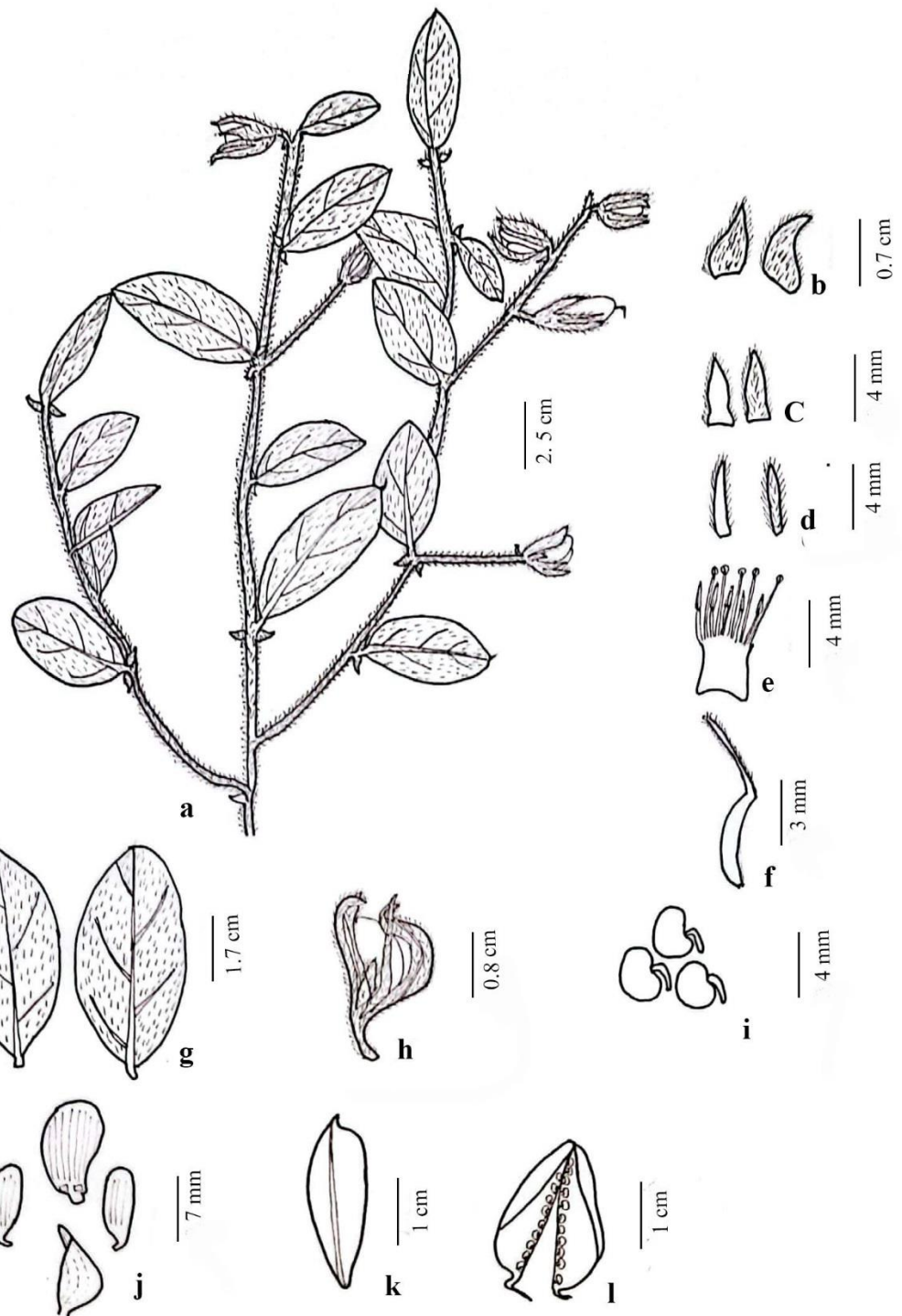


Figure 8 : *Crotalaria lejoloba* Bartl; a. Habit sketch; b. Stipule; c. Bract; d. Bracteoles; e. Androecium; f. Gynoeceum; g. Leaf; h. Flower; i. Seed; j. Petals; k. Fruit; l. Transversely open fruit.

9. *Crotalaria medicaginea* Lam, Encycl. 2: 201 (1786). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 113 (1979). Baker in Hook. F., Fl. Brit. Ind. 2. 81. (1876); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 108 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011), Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria chincia Buch. -Ham. Ex Wall. Numer. List: n. ° 5437 (1831);

Crotalaria foliosa Rottler Neve SchriftenGes. Naturf. Freunde Berlin 4: 217 (1803);

Crotalaria procumbens Roxb. Fl. Ind. Ed. 1832, 3: 278 (1832) nom. Illeg

Type Specimen: Acquis en, Novembre 1886, MNHN. (P, **Lectotype**)

Erect annual semi-procumbent herb, 8-17cm tall. **Stem** diffuse or erect, branched or profusely branched, branches arise from base to top, woody, terete, appressed, brown, pubescent, soft texture. **Leaf** trifoliate, inclined. **Stipule** present, caducous, inclined, filiform, 1-3mm. Petiole short. **petiolule** small 0.5mm, **leaflets** oblanceolate, oblance-oblong, narrowly elliptic or narrowly oblong, symmetrical, 6-14 × 2-5mm, base cuneate, apex truncate, retuse or rounded, margin entire, adaxially glabrous, abaxially short, appressed, brownish pubescent, midrib distinct, secondary veins pale. **Inflorescence** terminal or leaf-opposed, racemes, 2-15 flowered, 1.8-4.8cm long. **Peduncle** 11-20mm long. **Bracts** present at the base of pedicel, persistent, linear, 1-2 × 0.2mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially sparsely puberulent, midrib not distinct. **Pedicel** 2-4mm. **Bracteoles** present, at the top of the pedicel, persistent, linear, 0.5 × 0.1 mm, base truncate, apex rounded, margin entire. **Flowers** yellow, 5-7 × 4-6mm. **Calyx** sub-campanulate, 3-4mm long, tube 1-1.5mm long, calyx lobe triangular, calyx lobe equal, 1.5-2.5mm, apex acute, margin entire, dense, appressed, white pubescent. **Standard** ovate-oblong, 4-5 × 3mm, base truncate, apex obtuse, adaxially glabrous, abaxially top middle region has short silky trichome, callosity disc type, 0.8-1mm long basal claw, margin with woolly trichome. **Wings** oblong, 3-3.5 × 1-1.2mm, base cuneate, apex rounded, basal claw short, and 0.8mm long. **Keel** angled, narrowed sharply, apically from lower third with long twisted beak, 4 × 2mm, base rounded, glabrous being margin at both sides woolly, basal claw 0.1-0.2mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 1mm up, longer filament 5mm long, shorter filament 2mm long, oblong anther basifixed, 1mm long, elliptic anther minute and dorsifixed. **Ovary** elliptic, 2 × 1.5mm,

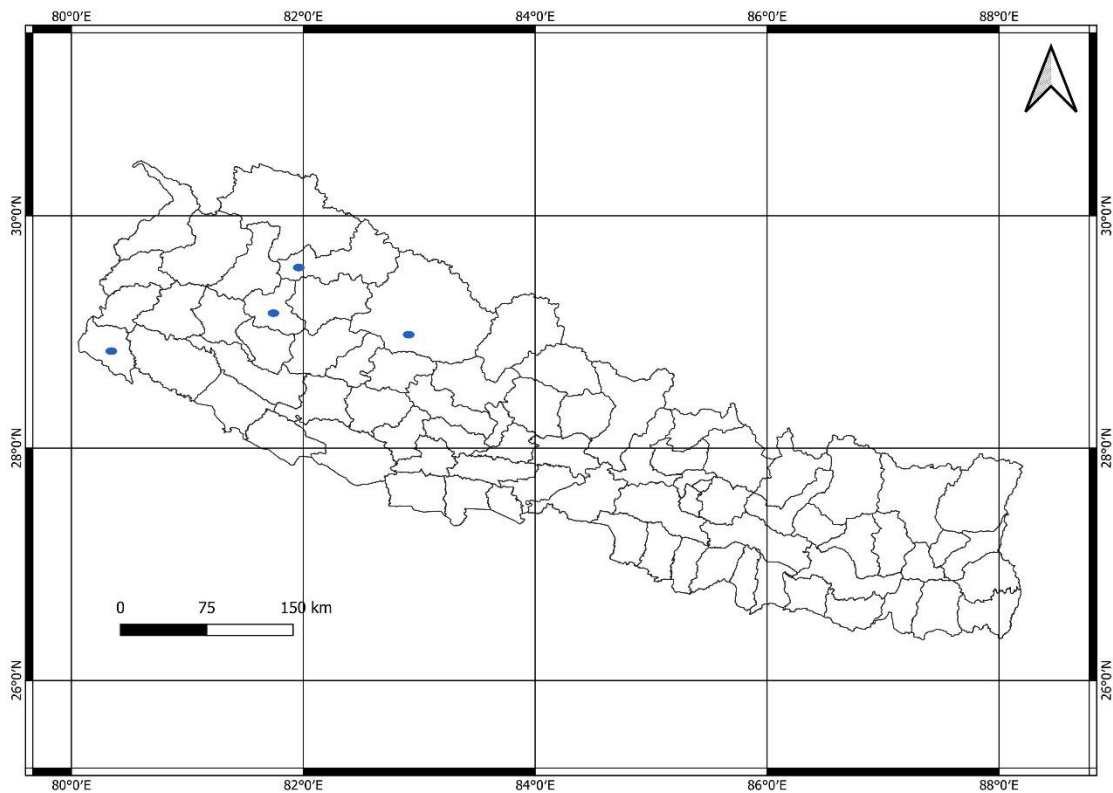
densely, appressed, short, pubescent, subsessile, stalk short, 0.25mm, **style** 5mm long, sparsely hairy, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns light brown when mature, globose, apex with small beak, pubescent, 3-4 × 2-3.5mm, exerted being half of the fruit being exerted, inflated, 2 seeded. **Seed** green turns dark brown when mature, reniform, 1 × 1mm, glabrous.

Distribution: Nepal (W), W. Himalaya, E. Himalaya, Assam-Burma, S Asia, E. Asia, SE Asia, SW Asia and Australasia.

Altitude: 235-2438m

Ecology: Found to be grown in open and dry places, by path on open grassy places, associated with *saccharum spontaneum* L.

Flowering/ Fruiting: March-September



Map 9 : Distingution of *Crotalaria medicaginea* in Nepal based on herbarium records.

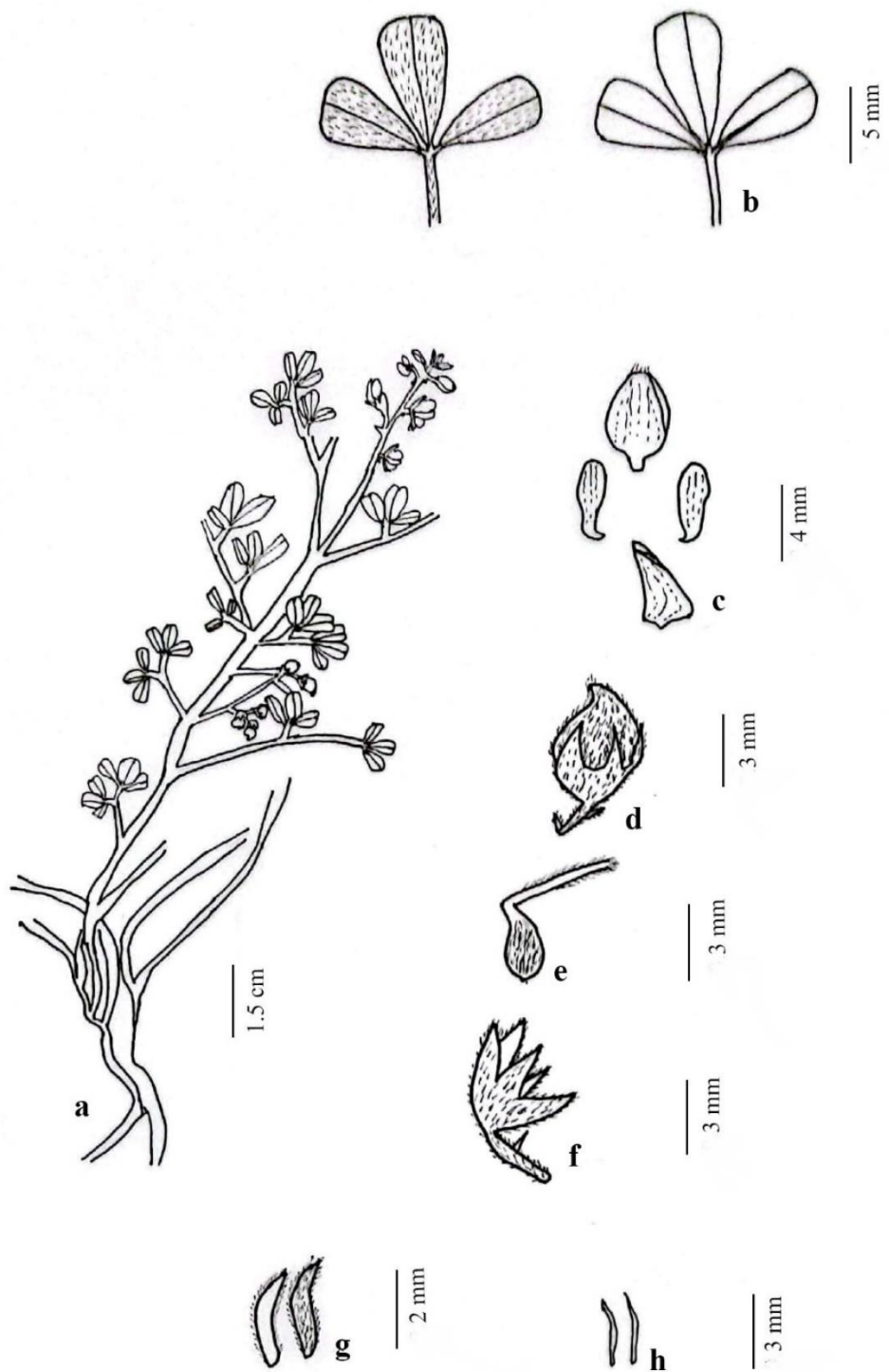


Figure 9 : *Crotalaria medicaginea* Lam; a. Habit sketch; b. Leaf; c. Petal; d. Fruit; e. Gynoecium; f. Calyx; g. Bract; h. Bracteoles.

10. *Crotalaria mysorensis* Roth, Nov. Pl. Sp.: 338 (1821). Baker in Hook. F., Fl. Brit. Ind. 2. 70. (1876); Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Jianqiang *et al.*, in Fl. China 10: 108 (2010); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria stipulacea Roxb. Fl. Ind. ed. 1832, 3: 264 (1832);

Crotalariaeia hirsuta Roxb. Fl. Ind. Ed. 1832, 3: 270 (1832) nom. Illeg;

Crotalaria membranacea W. Fitzg. J. Proc. Roy. Soc. Western Australia 3: 150 (1918);

Type specimen:

India, Mysore, Heyne, B, S.n. (L, **Isotype**)

India, Mysore, 1801, Heyne, Benjamin, HWP 676, (E, **Isotype**)

India, Mysore, Heyne, B, S.n. (L, **Isotype**)

Erect herb, 72cm tall. **Stem** branched, branches arise from base to top, terete, spreading brown-rusty pilose. **Leaf** simple, divergent or inclined; **Stipule** present, linear-lanceolate, 1-2.3 × 0.2-0.4 cm, base rounded, apex acute, margin entire. Petiole short, 1.2mm long. leaf blade oblong, elliptic or linear-oblong, symmetric, 3-7 × 0.5-2cm, base cuneate, apex rounded, margin ciliated, both surface appressed, brown sparse, pilose, midrib distinct, secondary veins pale. **Inflorescence** terminal on stem or branches, racemes, 3-8 flowered, up to 16cm long. **Peduncle** 4.5-8cm. **Bracts** present, at the base of pedicel, persistent, lanceolate, 7 × 2mm, base rounded, apex acute, margin ciliated, midrib not distinct. **Pedicel** 5-13mm. **Bracteoles** present, at the base of calyx tube, persistent, similar to bract, 9 × 1mm. Flowers yellow, about 2 × 0.5cm (close flower). **Calyx** two lipped, parted to base, up to 1.5cm long, tube 2-3mm long, dense, rusty, brown pilose. **Pod** green turns dark brown when mature, oblong, glabrous, 2.7-3 × 1.5-1.7cm, fully exerted, calyx only covering stipe, inflated, many seeded. **Seed** green turn's dark brown when mature, reniform, 2 × 2mm, glabrous.

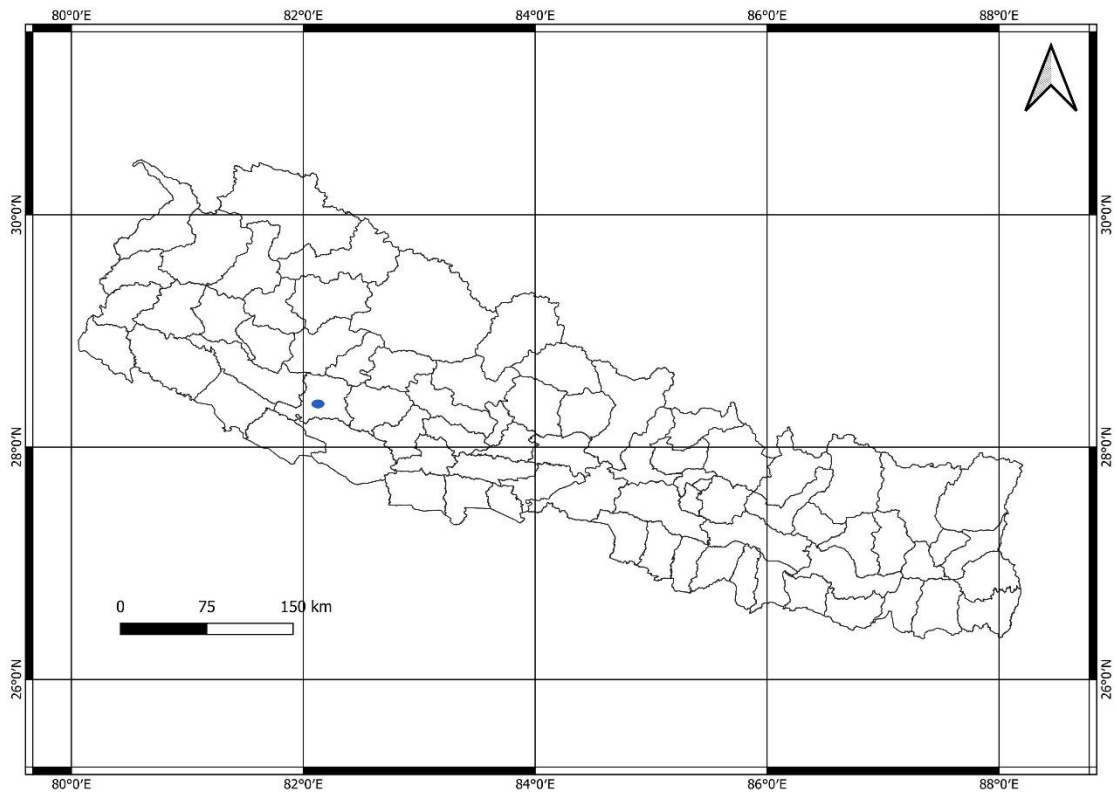
Distribution Range: Nepal (W), W Himalaya, E Himalaya, S Asia, E. Asia, SE Asia and Australasia.

Altitude: 1000-1100m

Ecology: growing in earthy and grassy slopes.

Flowering/ Fruiting: August

Note: Since Herbarium specimen of this species is not available in Nepal, Character was studied through image of international herbarium, therefore detail observation of the all the characteristics was not possible.



Map 10 : Distribution of *Crotalaria mysorensis* in Nepal based on herbarium records.



Figure 10 : *Crotalaria mysorensis* Roth (Habit sketch).

11. *Crotalaria pallida* Aiton, Hort. Kew. 3: 20 (1789). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979). Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 732 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 99(2000); Jianqiang *et al.*, in Fl. China 10: 108 (2010); Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 89 (2011). Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:103 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria mucronate Desv. J. de Bot. Desv. 3: 76 (1814).

Crotalaria brownie Bertero ex Dc. Prodr. 2: 130 (1825);

Crotalaria striata DC. Prodr. 2: 131 (1825);

Type Specimen: United Kingdom, Anon., s.n. (BM, **Holotype**)

Erect perennial herb or shrub, 0.5-1.5m tall. **Stem** much branched, branches arise mostly at top, woody, stout, marked with slender longitudinal grooves, appressed, dense to sparse puberulent, smooth. **Leaf** trifoliate, inclined or divergent. **Stipule** present, caducous, divergent, triangular, minute, c.1-1.5 × 0.5mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially dense, appressed, puberulent. petiole long 1.5-5.8cm long, single longitudinal groove adaxially; short petiolules i.e., 1-3mm long, leaflets obovate, symmetrical, 2.1-8.2 × 0.9-5.7 cm, base cuneate, apex mostly emarginate with short mucronation or rounded, margin entire, adaxially glabrous, abaxially dense, appressed, transparent, silky, pubescent, midrib and secondary veins both are distinct. **Inflorescence** terminal, racemes, 14 to 52 flowered, 18-29cm long. **Peduncle** 3-7.8cm long, **Bracts** present, at the base of pedicel, caducous, broadly lanceolate-triangular, 1-1.5 × 0.5 mm, base truncate, apex acute, margin sparsely ciliated, adaxially glabrous, abaxially puberulent, midrib not distinct. **Pedicel** 2-6mm. **Bracteoles** present, at middle of calyx tube, persistent, linear 1-1.5 × 0.2mm, base truncate, apex acute, and margin entire. **Flowers** yellow, 1.3-1.7 × 1-1.5cm. **Calyx** sub campanulate, 5-7mm long, tube 2-3mm long, calyx lobe triangular, equal in length, 2-4mm long, apex acute, margin entire, dense, appressed, white puberulent. **Standard** orbicular, elliptic, widely elliptic or pentagonal, 6-10 × 6-8mm, base truncate, apex rounded or irregular, glabrous, callosity ridged type, ca. 2mm long basal claw, adaxially lanate. **Wings** oblong or ovate, 6-8.5 × 3mm, base cuneate, apex acute, marginally pilose on basal part, remaining part glabrous, basal claw 2mm long, margin pilose. **Keel** shallowly rounded with narrow and projecting untwisted beak, 6-9 × 4-5mm, base truncate, glabrous being margin lanate to some length, basal claw 2-

2.5mm long, margin of basal claw lanate. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 9mm up, longer filament 5-6 mm long, shorter filament 2-3mm long, oblong anther basifixed, 2mm long, elliptic anther minute 0.5mm and dorsifixed. **Ovary** oblong, 5-6 × 1mm, surface hairy, shining white, silky trichome, denser trichome at margin, with about 2mm long stalk. **Style** 7-9mm long, one line of hair, stigma minute, covered with one line of long silky hairs. **Pod** green turns golden-brown when mature, narrowly oblong, long, slender, inflated, glabrescent, 3-4 × 0.6-0.8cm, fully exerted calyx only covering basal portion, Inflated, many seeded. **Seed** green turns golden-brown when mature, harp shaped, 3 × 2.5mm, glabrous, stalk hairy at both margins.

Distribution Range: Naturalized in Nepal (W, C & E), native range is Central to tropical America but naturalized in E Asia, S Asia, E Himalaya, SE Asia, Assam-Burma and Africa.

Altitude: 60-1768m

Ecology: Mostly found to be growing on dry, open land/slopes, in open grassland, open and sunny place, but also in moist and open place too. Again, it is also commonly located along tracks, roadside areas, sandy river banks, and ground by tracks and bordering wetlands and streams, on mud flat, and sometimes found on surface of the land in mixed *Shorea robusta* C.F.Gaertn forest too.

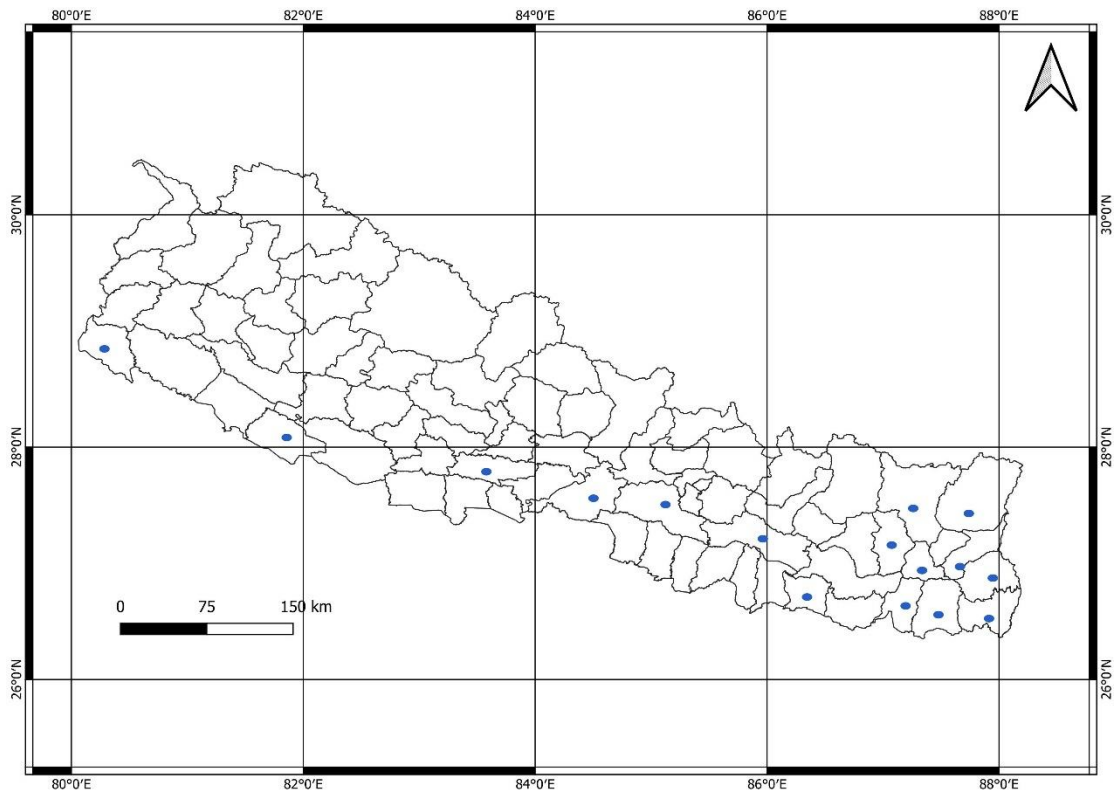
Vernacular name: छिन छिने (Chhin hhine).

Flowering/ Fruiting: April- February.

Vaucher Specimen:

Central Nepal: Makwanpur district, Near Brindaban Botanical Garden, Hetauda, 110m, 27° 25' 09"N, 85° 00' 19"E, 20th Oct 2022, B. Parajuli and S. Aryal, HT20 (TUCH).

Eastern Nepal: Jhapa district, Haldibari, 110, 26 ° 30' 27"N, 87 ° 59' 31"E, 7th July 2022, B. Parajuli, S. Sirjana, B. Dhakal, JH07 (TUCH); Morang district, Kathari ward no 1, Biratnagar, 87m, 26° 28' 03"N, 87° 18' 38"E, 6th Nov 2022, BR06 (TUCH);



Map 11 : Distribution of *Crotalaria pallida* in Nepal based on herbarium records and field collection.

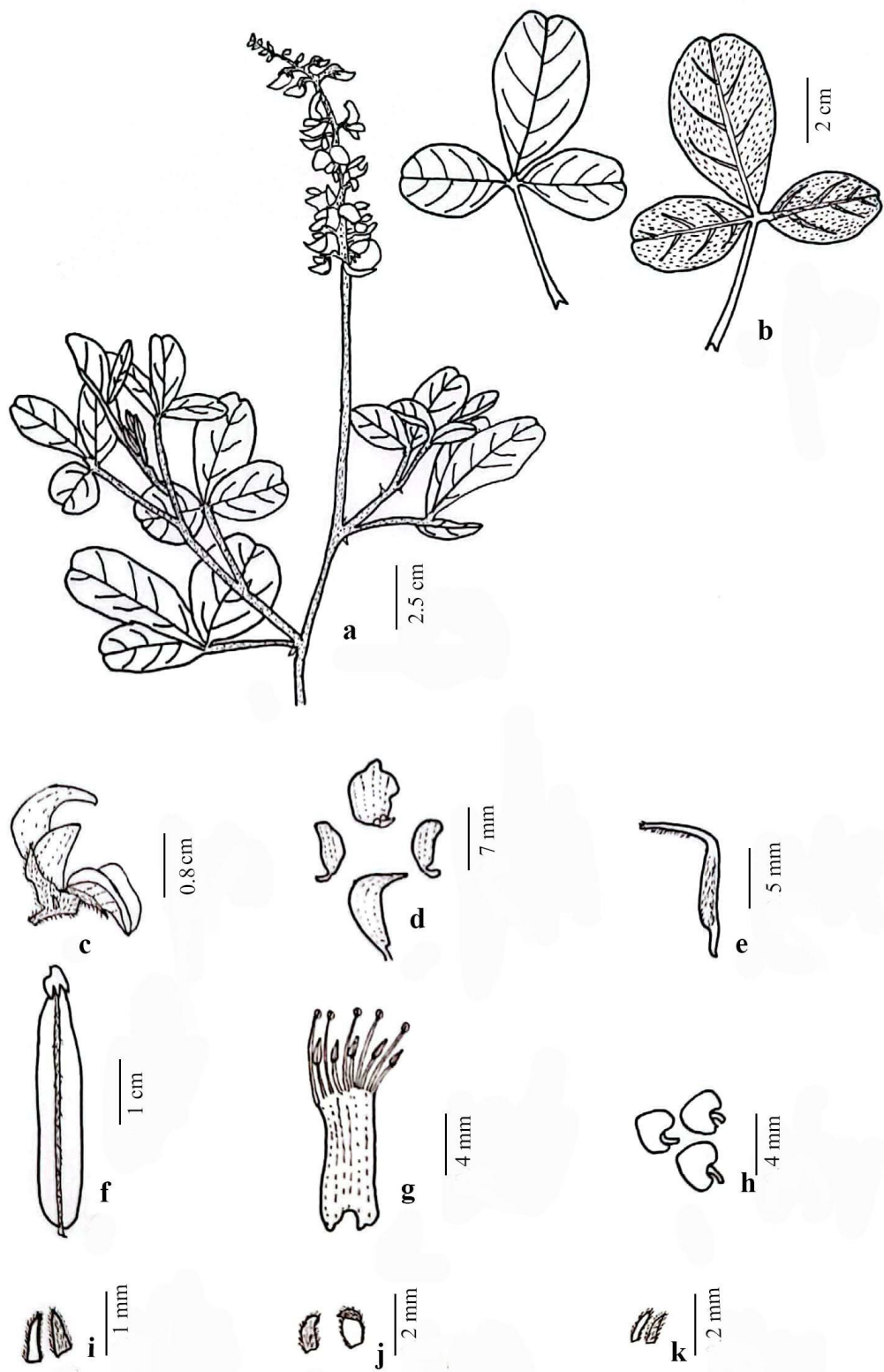


Figure 11 : *Crotalaria pallida* Aiton; a. Habit sketch; b. Leaf; c. Flower; d. Petals; e. Gynoecium; f. Fruit; g. Androecium; h. Seed; i. Stipule; j. Bracts; k. Bracteoles.

12. *Crotalaria prostrata* Rottler ex Willd., Enum. Pl: 747 (1809). Baker in Hook. F. Fl. Brit. Ind. 2: 67 (1876); Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979). Jianqiang *et al.*, in Fl. China 10: 115 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 90 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:104 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Homotypic synonyms:

Crotalaria prostrata Roxb. ex D.Don, Prodr. Fl. Nepal. 241. (1825);

Heterotypic synonyms:

Crotalaria ciliate Buch. -Ham. Ex D. Don Prodr. Fl. Nepal: 241 (1825);

Crotalaria jinpingensis C.Y.Yang. Bull. Bot. Lab. N.-E. Forest. Inst., Harbin 7: 113. (1980);

Crotalaria obliqua Buch. -Ham. Numer. List: n. ° 5388 (1831) nom. nud;

Type Specimen: Ex orientali, Rottler, J.P., #893, (M, **Isotype**)

Prostrate, diffuse annual herb, 10-36cm. **Stem** branched, slender, branches mostly arise from base, herbaceous, terete, appressed to spreading white, long, dense, pilose. **Leaf** simple, mostly inclined or divergent, **Stipule** absent, leaf subsessile with very short petiole, 1mm or short; leaf blade varies in shape, elliptic, ovate-oblong, oblong, lanceolate or ovate, young leaf asymmetric, mature leaf mostly symmetrical, 0.7-4.5 × 0.4-2cm, base oblique in most of the young leaf while most of the mature leaf has cuneate or rounded base, apex obtuse, rounded, rarely retuse, margin entire, both surfaces has appressed, white, pubescent, more denser toward abaxial surface, midrib distinct, secondary veins pale. **Inflorescence** terminal or leaf-opposed, racemes, 1-7 flowered, 1.2-4.7cm long. **Peduncle** 1.5-3.3 cm. **Bracts** present, at the base of pedicel, persistent, lanceolate, 1-2 × 0.3-0.4 mm, base cuneate, apex acute, margin ciliated, adaxially glabrous, abaxially appressed, white, pilose, midrib not distinct. **Pedicel** 2-3mm. **Bracteoles** present, at the base of calyx, persistent, subulate, 2 × 0.3mm, base truncate, apex acute, margin sparsely ciliated. **Flowers** yellow, 4-5 × 4mm. **Calyx** two lipped, parted to base, up to 3-5mm long, tube 1mm long, calyx lobe sub-equal, abaxial 3 calyx lobe triangular-linear, attached up to 2mm up, adaxial 2 calyx lobe linear-lanceolate, attached up to 3mm up, apex acute, margin ciliated, dense, appressed to spreading,

white pilose. **Standard** suborbicular, elliptic or oblong, $2.5-3 \times 1.7-2$ mm, apex obtuse to retuse, margin entire, glabrous, callosity lamelliform type, 0.5mm or shorter basal claw, margin at top lanate. **Wings** linear or oblong, $2-3 \times 0.4-0.7$ mm, base cuneate, apex rounded, glabrous, basal claw short, 0.2-0.5mm. **Keel** rounded, narrowed apically from middle with long twisted beak, $2.5-3 \times 1.5-2$ mm, base truncate, glabrous being margin lanate to some length, basal claw 0.1-0.2mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 0.6-0.8mm up, longer filament 1.1-1.3mm long, shorter filament 0.6-0.8mm long, oblong anther basifixed, 0.3mm long, elliptic anther minute and dorsifixed. **Ovary** oblong, $2-3 \times 0.5-1$ mm, glabrous, subsessile, **style** 2mm long, multiple lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns black when mature, oblong, glabrous, $1-1.6 \times 0.3-0.6$ cm, exerted calyx covering basal portion only, inflated, 16-25 seeded. **Seed** green turns brown when mature, harp-shaped, 1.5x1mm, glabrous.

(Note: Two different (Probably new variety) was found in the field which has not been included in this description as it has not been proven yet through valid publication.)

Vernacular name: सानो बोक्सी बाजा (Sano boksi baja)

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

Altitude: 150-1620m

Ecology: commonly grows in open places with grasses, e.g., grassy banks of river, with grasses beside track, open grasslands, hill slope etc. Further it has also been collected from forest floor of *Adina-Terminalia* Forest and other open, dry, sandy places, rocky hill slopes, rarely from moist and shady places.

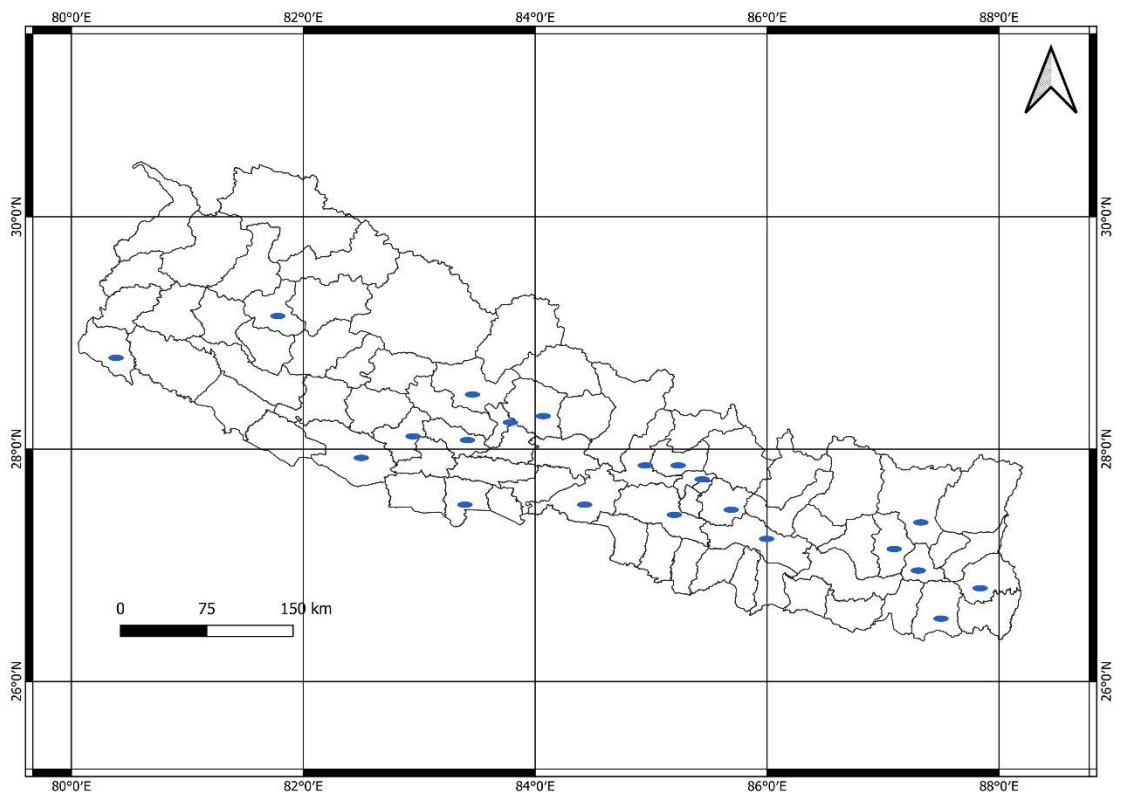
Flowering: July-march

Fruiting: July-march

Vaucher Specimen:

Western Nepal: Kalikot district, 1369m, $29^{\circ} 10' 47''$ N, $81^{\circ} 39' 25''$ E, 27th Oct 2022, B. Parajuli, T.R. Parajuli and B. Pokhrel, KL27 (TUCH).

Central Nepal: Kathmandu district, Sundarijal, 1450m, $27^{\circ} 45' 34''$ N, $85^{\circ} 25' 16''$ E, 2nd Aug 2022; B. Parajuli and S. Rauniyar, KT22(TUCH).



Map 12 : Distribution of *Crotalaria Prostrata* in Nepal based on herbarium records and field collection.

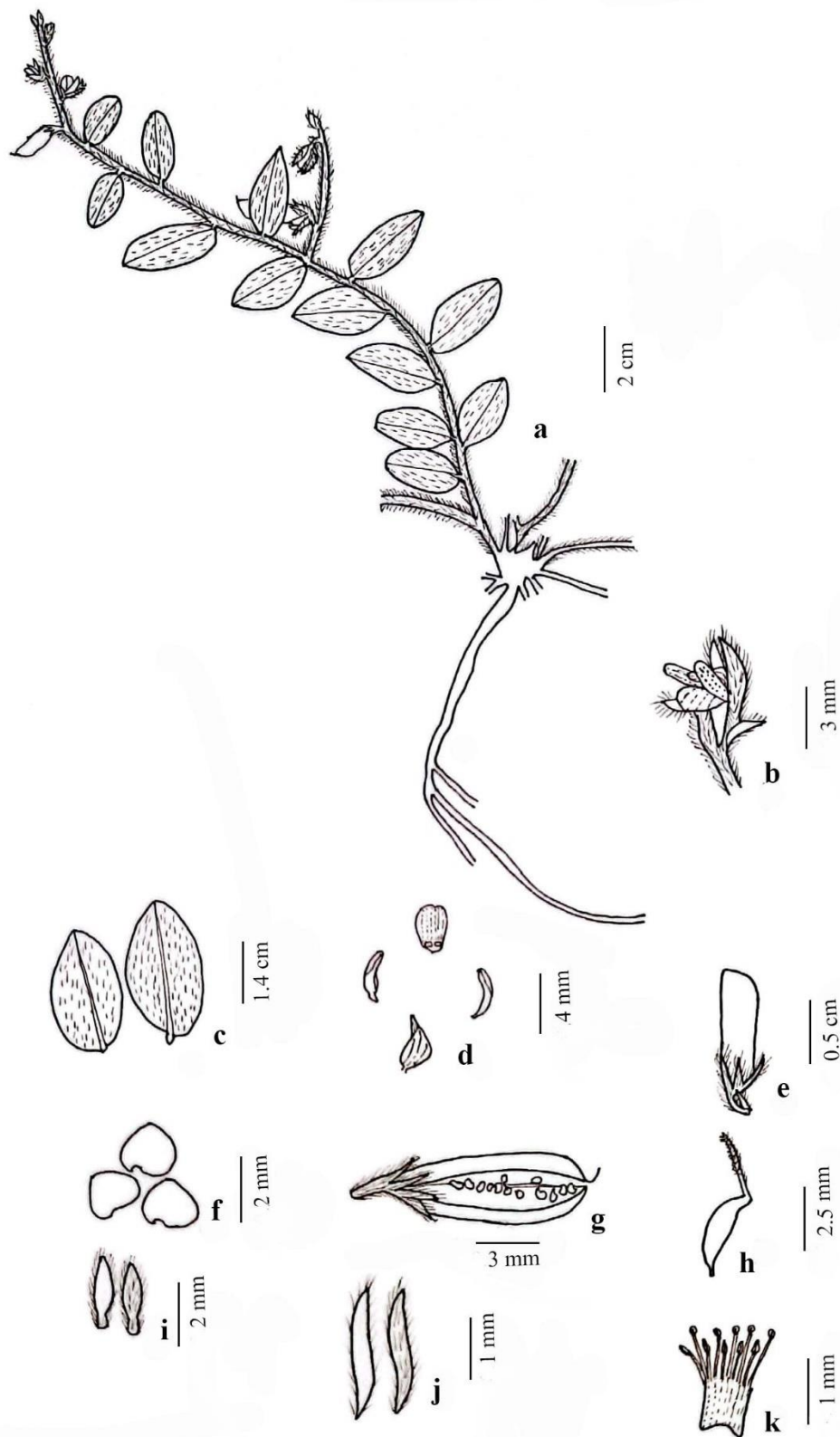


Figure 12 : *Crotalaria Prostrata* Rottler ex Willd; a. Habit sketch; b. Flower; c. Leaf; d. Petals; e. Fruit; f. Seed; g. Transversely open fruit; h. Gynoecium; i. Bract; j. Bracteoles; k. Androecium.

13. *Crotalaria Quinquifolia* L., Sp. Pl.: 716 (1753). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 98(2000); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019); Shrestha *et al.*, in Pl. of. Nep. 1: 321 (2022).

Crotalaria ekmanii Windler & S.G. Skinner, Phytologia50: 185 (1982);

Crotalaria heterophylla L.f. Suppl. Pl.: 323 (1782);

Lupinus javanicus Burm.f. Fl. Indica: 157 (1768);

Type Specimen: Niyomdham in Thai Forest Bull., Bot. 11: 151. 1978, (**Lectotype**)

Erect annual herb to subshrub, 60-100cm tall. **Stem** erect or diffuse, branched, branches arise mostly from base but also arises at top, woody, hollowed, furrowed, angled, appressed white, short, sparse, puberulent, silky. **Leaf** tri-, quadra- to penta-foliolate, mostly inclined or divergent. **Stipule** present, persistent, reflexed, narrowly triangular, 1-4 × 0.5mm, base truncate, apex narrowly acute, margin ciliated, adaxially glabrous, abaxially appressed, sparse, pubescent. **Petiole** 1.5-7cm long, channeled; Petiolule 1-3mm long; Leaflets oblong-elliptic, oblong-lanceolate, linear-oblong or oblanceolate, among 5 leaflets middle one is longest one followed by left and then right ones respectively, symmetric, 3-5 × 1cm, base cuneate, apex retuse and mucronate, margin entire, adaxially glabrous, abaxially appressed white, pubescent, midrib distinct, secondary veins not much distinct. **Inflorescence** terminal, racemes, 4-26 flowered, 9.5-30cm long. **Peduncle** 3.8-10.5cm, furrowed. **Bracts** present, at the base of pedicel, persistent, lanceolate, 6-11 × 2-3mm, base truncate, apex acuminate, margin entire, adaxially glabrous, abaxially dense, appressed, white pilose, midrib not distinct. **Pedicel** 5-11mm. **Bracteoles** present, at the basal part of pedicel, persistent, subulate, minute, 1.5-2 × 0.3mm, base truncate, apex acute, margin ciliated, membranous. **Flowers** yellow, 1.4-2 × 1.6-2.3 cm. **Calyx** campanulate, 11-12mm long, tube 4mm long, abaxial 3 calyx lobe broadly oblong, attached up to 6mm up, adaxial 2 calyx lobe triangular, attached up to 6-7mm up, calyx lobe equal, 5-6mm long, apex acute and mucronate, margin entire, glabrous. **Standard** suborbicular, 1.4-1.8 × 2-2.2cm, base truncate, apex emerginate, margin entire, glabrous, callosity lamelliform type, 3mm long basal claw, basal margin with woolly trichome. **Wings** broadly oblong, 1 × 0.8-0.9cm, base truncate, margin entire, apex rounded, glabrous with purplish streaks, basal claw 4mm long. **Keel** rounded, narrowed horizontally at middle with twisted beak, 1 ×

0.7cm, basal margin of incurved surface pilose, upcurved margin with short, white trichome, remaining portion glabrous, basal claw 3-4mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 8mm up, longer filament 7mm long, shorter filament 4mm long, oblong anther basifixed, 2mm long, elliptic anther minute ca. 0.4mm and dorsifixed. **Ovary** oblong, $7 \times 1.5-2$ mm, glabrous, stalk 2.2.5mm long, **style** 10-11mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns golden brown when mature, oblong, glabrous, $5-6.5 \times 1.1-2.5$ cm, fully exerted, and calyx covering only stipe of the fruit, inflated, 26-32 seeded. **Seed** pale green turns into brownish when mature, reniform, $5-6.5 \times 4-5$ mm, glabrous, stalk glassy transparent, 3mm long.

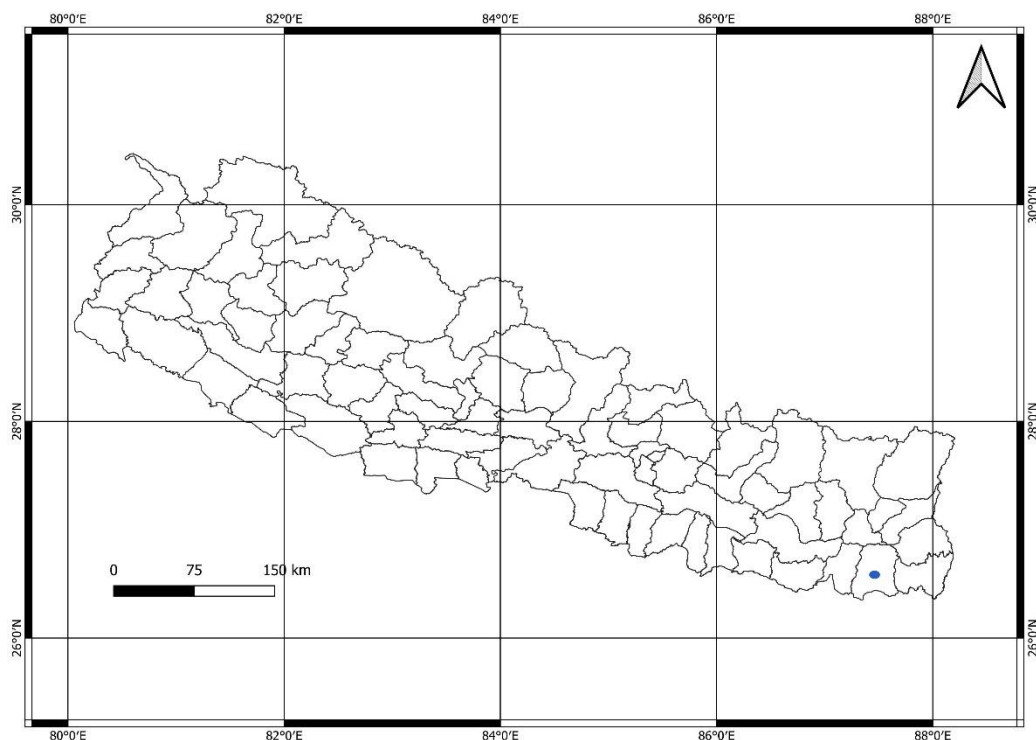
Distribution range: Nepal (E), Assam-Burma, S Asia, SE Asia, Australasia,

Altitude: 88-200m

Ecology: Bank of small ditches, among dense grasses.

Flowering/ Fruiting: October-December.

Vaucher specimen: Morang district, Kathari gaupalika, 88m, $26^{\circ} 28' 05''$ N, $87^{\circ} 18' 11''$ E, 20th oct 2022, B. Parajuli and A.N. Rajbanshi, BR20 (TUCH).



Map 13 : Distribution of *Crotalaria quinquefolia* in Nepal based on herbarium records and field collection.

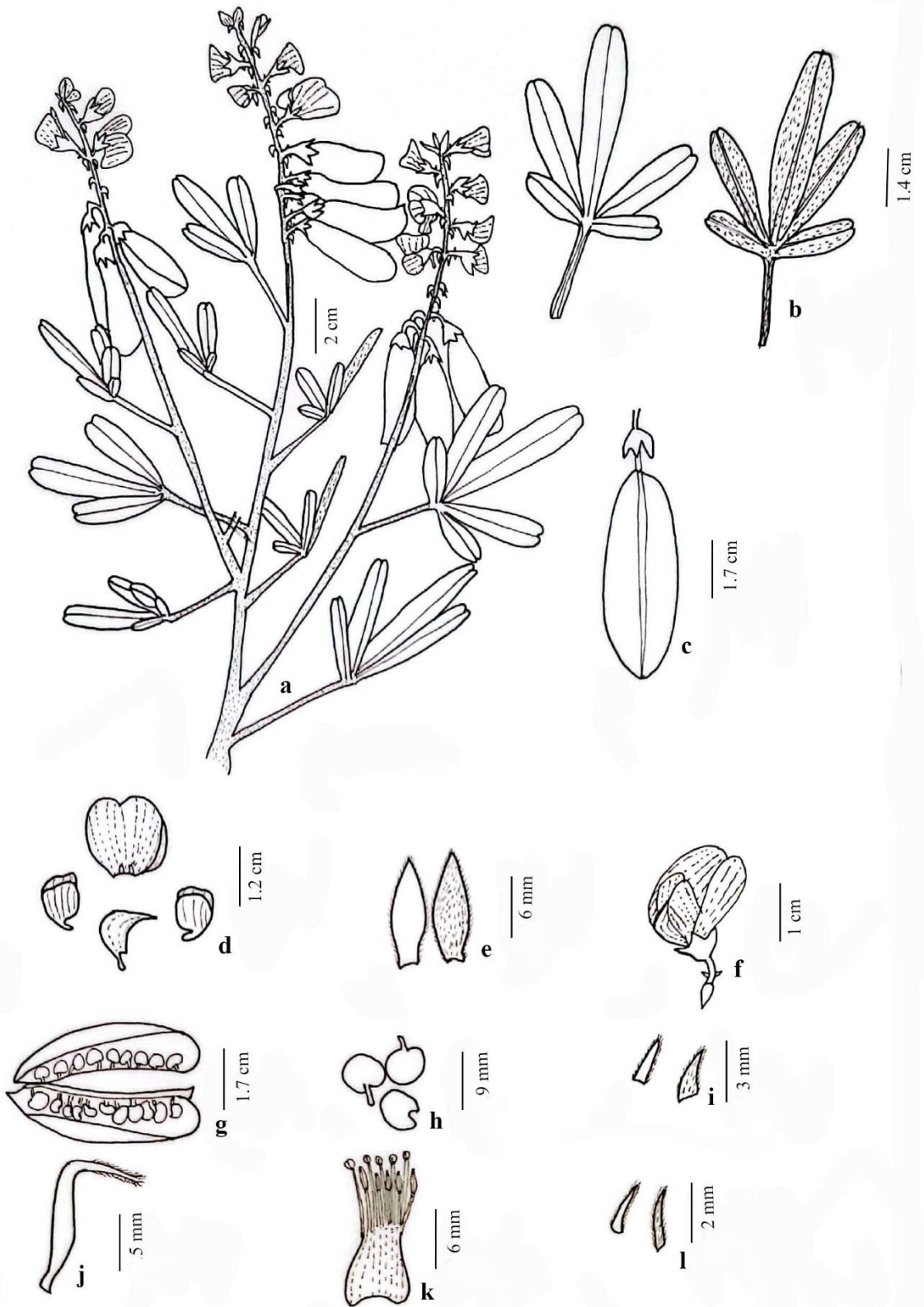


Figure 13 : *Crotalaria Quinquefolia* L; a. Habit sketch; b. Leaf; c. Fruit; d. Petals; e. Bract; f. Flower; g. Transversely open fruit; h. Seed; i. Stipule; j. Gynoecium; k. Androecium; l. Bracteoles.

14. *Crotalaria Sessiliflora* L., Sp. Pl. ed. 2: 1004 (1763). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979). Malla *et al.*, in Fl. Ktm. Val. 1: 253 (1986); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 736 (1987); Jianqiang *et al.*, in Fl. China 10: 108 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 90 (2011); Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:100 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria anthylloides Lam., Encycl.2: 195 (1786);

Crotalaria brevipes Champ. Ex Benth. Hooker's J. Bot. Kew Gard. Misc. 4: 44 (1852);

Crotalaria napaulensis Dc. Prodr. 2: 128 (1825);

Crotalaria nepalensis Link Enum. Hort. Berol. Alt. 2: 228 (1822);

Type Specimen: Anon., s.n. (LINN, **Neotype**)

Erect annual herb, 6-100cm tall. **Stem** brown, erect or diffuse, branched, mostly branches arise from basal part or unbranched, woody, terete, appressed, brown, dense, coarse, hirsute, and rough. **Leaf** simple, divergent or reflexed, **Stipule** present, persistent, linear, 2-6mm long, base truncate, apex acute, margin ciliated, appressed, adaxially glabrous, abaxially long, brown, pilose. Petiole short 1-4mm long. Leaf blade variable, linear, linear-lanceolate, oblong-elliptic, lanceolate-elliptic, narrowly elliptic, elliptic, oblong, or lanceolate, symmetrical, 1-11.8 × 0.3-1.5cm, base cuneate, apex obtuse and mucronate, acute or rounded and mucronate, margin entire, adaxially glabrous or very few, sparse hairs, abaxially dense, appressed, brownish, pilose, pinnate-veined, midrib distinct, secondary veins pale. **Inflorescence** terminal, racemes, 2-27 flowered, congested (spike like), 1-8.5cm long. **Peduncle** very small 0.5-1.5cm. **Bracts** present, at the base of pedicel, persistent, subulate/narrowly triangular, 5-14 × 0.5-1mm, base truncate, apex acute, and margin ciliated, adaxially glabrous, abaxially long, dense, brownish, pilose, midrib not distinct. **Pedicel** 1-2mm. **Bracteoles** present, at the base of the calyx tube, persistent, linear, 3-8 × 0.5mm, base narrowly cuneate, apex acute, margin ciliated. **Flowers** whitish to purple, 1-1.6 × 0.8-1cm. **Calyx** two lipped, parted to base, up to 0.9-1.6cm long, tube 2mm long, abaxial 3 calyx lobe linear, attached up to 4mm up, adaxial 2 calyx lobe lanceolate-elliptic, attached up to 5.5-7mm up, calyx lobe subequal, apex acute, margin ciliated, dense, appressed to spreading, white and brown pilose. **Standard** suborbicular, oblong or obovate, 6-6.5 × 4-5.5mm,

base truncate, apex rounded, adaxially glabrous, top middle region has short silky trichome abaxially, callosity lamelliform type, 1-2mm long basal claw, margin at basal part with woolly trichome (lanate). **Wings** oblong, 5-6 × 2-2.5mm, glabrous, base asymmetrical, apex rounded, margin entire, basal claw short 1mm long. **Keel** bent sharply at middle with twisted beak, 5-7 × 3mm, base truncate, glabrous being incurved margin lanate, basal claw 1mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 2-2.5mm up, longer filament 3mm long, shorter filament 1.5-2mm long, oblong anther basifixed, 0.5mm long, elliptic anther minute 0.3mm and dorsifixed. **Ovary** oblong, 4x1.5mm, glabrous, subsessile, **style** 5mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns dark brown when mature, oblong, glabrous, 0.8-1.3 × 0.4-0.6cm, inclusive, inflated, 5-15 seeded. **Seed** green turns brown when mature, reniform, 1-2 × 1-2mm, glabrous, stalk glassy, shining, transparent.

Vernacular Name: सेतो फूल (Seto phul).

Distribution Range: Nepal (ECW), W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia, SE Asia, and Australasia.

Altitude: 140-3450 m

Ecology: This herb most commonly found on open grassy slopes or on sunny grassy hill slope at path side to level grass areas beside river. These are also common in *Shorea robusta* C.F.Gaertn forest, or on path side of *Shorea robusta* C.F.Gaertn forest. Along with this, the herb is also found on dry limestone, rocks, open filed, moist or sunny places.

Flowering: July-December

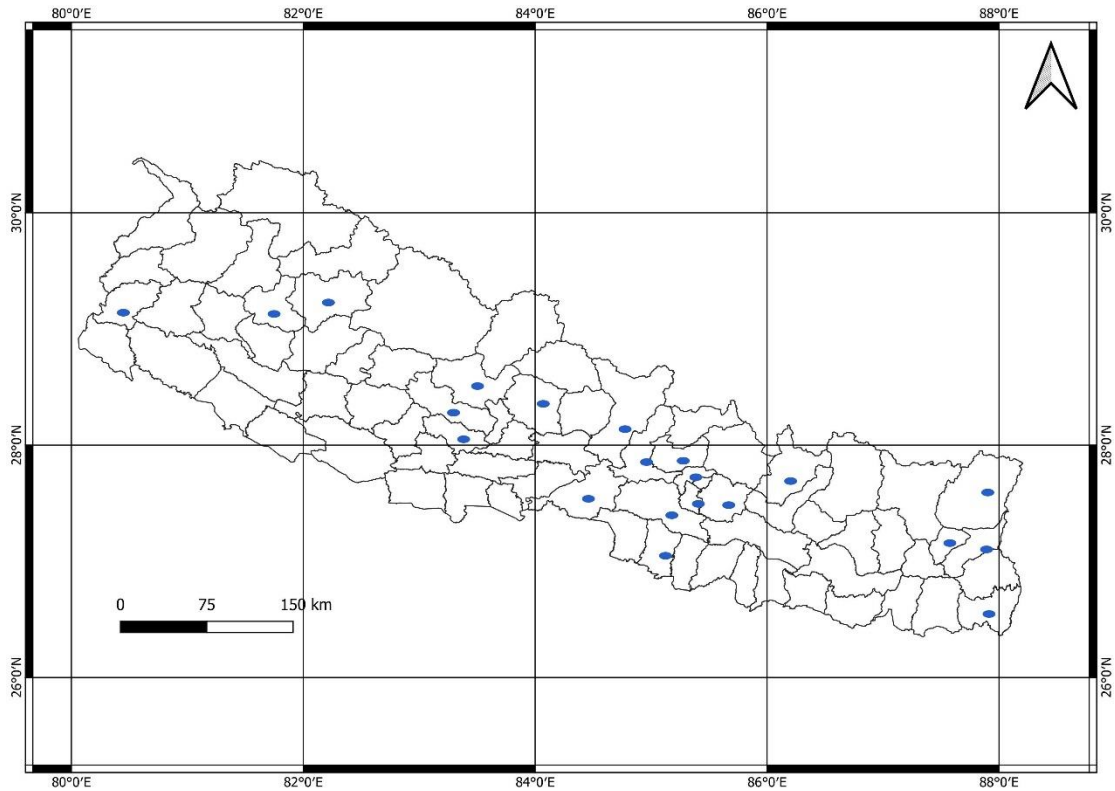
Fruiting: July-January.

Vaucher Specimen:

Western Nepal: Kalikot district, badalkot, 2582m, 29° 11' 32"N, 81° 39' 39"E, B. Parajuli and D.S.Thakuri, KL28 (TUCH).

Central Nepal: Chitwan, Madi, 271m, 27° 25' 41"N, 84° 22' 44"E, 6th Oct 2022, B. Parajuli and K. Parajuli, CH08 (TUCH); Kathmandu, Chobhar, 1450m, 27° 39' 53"N, 85° 17' 29"E, 8th Sep 2022, B. Parajuli, KT08 (TUCH); Kathmandu, Dakxinkali,

1368m, 27° 38' 35"N, 85° 16' 36"E, 15th Sep 2022, B. Parajuli, N.K. Somai, M. Thapa and S. Aryal, KT15 (TUCH).



Map 14 : Distribution of *Crotalaria sessiliflora* in Nepal based on herbarium records and field collection.

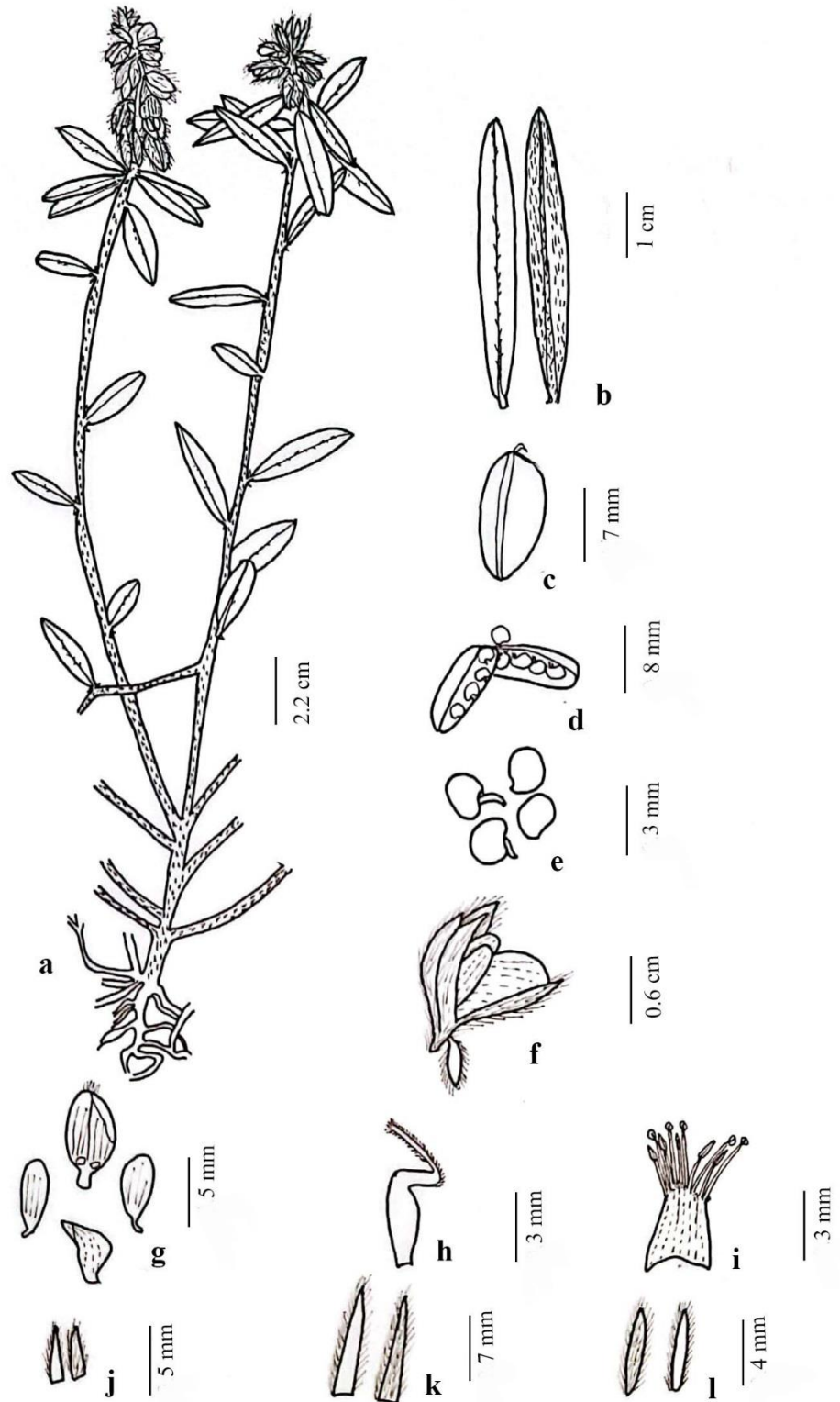


Figure 14 : *Crotalaria Sessiliflora* L; a. Habit sketch; b. Leaf; c. Fruit; d. Transversely open fruit.; e. Seed; f. Flower; g. Petal; h. Gynoeceum; i. Androecium; j. Stipule; k. Bract; l. Bracteoles.

15. *Crotalaria Spectabilis* Roth, Nov. Sp. Ind. Orient.: 341 (1821). Ohashi in Hara & Williams, Enum. Fl. Pl. Nep. 2: 114 (1979); Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 733(1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 99 (2000); Jianqiang *et al.*, in Fl. China 10: 110 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 90 (2011). Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:104 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria sericea Retz. Observ. Bot. 5: 26 (1788);

Crotalaria leschenaultia DC. Prodr.2: 125 (1825);

Crotalaria alatipes Raf. New Fl. 2: 57 (1837);

Type Specimen: Ind. Orientalis, 1814, Heyne, B., S.n. (L, **Isotype**).

Erect annual herb to subshrub, 0.35-2.4m tall. **Stem** profusely branched, branches arise from base to top, herbaceous, hollow, angular, sparsely puberulent, texture silky. **Leaf** simple, mostly inclined, few divergent or inclined. **Stipule** present, persistent, divergent, triangular or lance-ovate, 3-10 × 2-7mm, base truncate, apex acute, margin entire, adaxially glabrous, abaxially sparse, short, puberulent. **Petiole** short up to 2-6mm; leaf blade obovate, oblanceolate, oblong, oblong-linear, or narrowly elliptic, symmetrical, 4-15 × 1.8-7.2cm, base cuneate, margin entire, apex rounded and mucronate, obtuse and mucronate, or acuminate & mucronate, adaxially glabrous to subglabrous (very few, sparse, short hair), abaxially appressed puberulent, midrib & secondary veins both are distinct. **Inflorescence** axillary or terminal in position, racemes, many flowered (12-64), 7.6-70cm long. **Peduncle** 1-4.8cm. **Bracts** present, at the base of pedicel, persistent, lanceolate or cordate, 0.6-1.6 × 0.3-0.8cm, base rounded, apex acute or acuminate, margin entire, midrib distinct. **Pedicel** 8-15mm. **Bracteoles** present, at the middle of pedicel, persistent, lanceolate, 1 × 0.4-0.5mm, base truncate, apex acuminate, margin entire, membranous. **Flowers** yellow, 1.2-1.8 × 1.2-2cm. **Calyx** two lipped, parted to middle, 1.2-1.3cm long, tube 4-5mm long, abaxial 3 calyx lobe narrower, triangular, attached up to 7mm up, adaxial 2 calyx lobe broader, broadly lanceolate-triangular, attached up to 5mm up, calyx lobe subequal, apex acute, margin entire, glabrous. **Standard** suborbicular, 1.1-1.9 × 1.4-2cm, base truncate, apex retuse, margin entire, glabrous, marked with purple streaks, callosity lamelliform type, 2mm long basal claw, margin with woolly trichome. **Wings** broadly oblong, 11-12 × 8-9mm, glabrous, apex rounded, basal claw 4-5mm long. **Keel** rounded, with short &

slightly incurved at middle with twisted beak, 7.5×6 mm long, base broadly cuneate, glabrous being both margin lanate, basal claw 4 mm long. **Stamen** 10, Monadelphous, dimorphic, Filament attach up to 8 mm up, longer filament 7-8 mm long, shorter filament 5 mm long, oblong anther basifixed, 2 mm long, globose anther minute c. 0.5 mm and dorsifixed. **Ovary** oblong, $5-6 \times 2$ mm, glabrous, stalk 1.5 mm long, **style** 10 mm long, two lines of trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns black when mature, oblong, and glabrous, $3.3-5 \times 1.3-2.2$ cm, exerted, calyx covering only basal portion of the fruit, inflated, and 16-23 seeded. **Seed** green turns brownish-black when mature, harp-shaped, 4×4 mm, glabrous.

Vernacular name: भुबन झार (Bhuban jhar), छिन छिने (Chhin chhine).

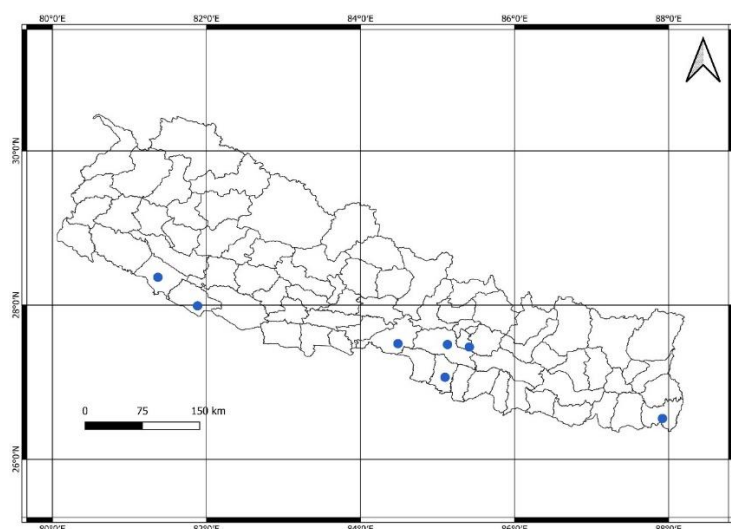
Distribution: Nepal (W, C & E), W Himalaya, E Himalaya, Assam-Burma, S Asia, E Asia and SE Asia.

Altitude: 121-2286 m

Ecology: Grows in *Shorea robusta* C.F.Gaertn and mix *Shorea robusta* C.F.Gaertn forest on moist and shady places, sandy bank of river. But also found in open, shady places, roadside areas, cleared areas under electricity pylons and in some places, people have planted it for ornamentation.

Flowering/ Fruiting: September-January

Vaucher Specimen: Central Nepal: Chitwan, Madi, 192 m, $27^{\circ} 27' 06''$ N, $84^{\circ} 23' 07''$ E, 6th Oct 2022, B. Parajuli and K. Parajuli, CH09 (TUCH).



Map 15 : Distribution of *Crotalaria spectabilis* in Nepal based on herbarium records and field collection

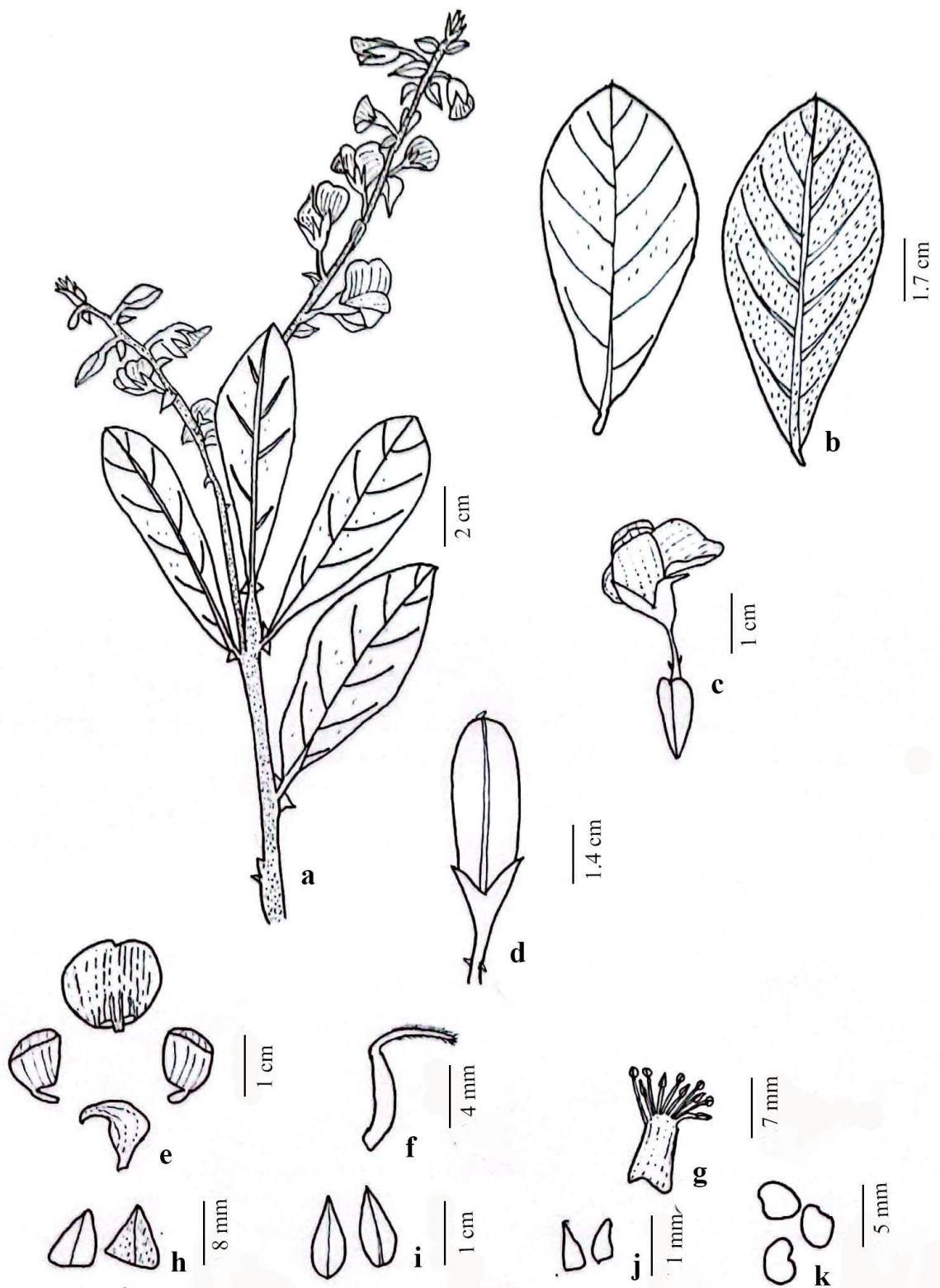


Figure 15 : *Crotalaria Spectabilis* Roth; a. Habit sketch; b. Leaf; c. Flower; d. Fruit; e. Petals; f. Gynoecium; g. Androecium; h. Stipule; i. Bract; j. Bracteoles; k. Seed.

16. *Crotalaria tetragona* Roxburgh ex Andrews, Bot. Reposit. 10: t. 593 (1810). Ohashi in Hara & Williams, Enum, Fl. Pl. Nep. 2: 114 (1979). Grierson A.J.C. & Long D.G. in FL. Bhutan 1(3): 733 (1987); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 100 (2000); Jianqiang *et al.*, in Fl. China 10: 111 (2010); Rajbhandari in Rajbhandari *et al.*, Cat. Nep. Fl. Pl. 2: 90 (2011), Rajbhandari & Rai, Handbk. Fl. Pl. Nepal 2:105 (2019); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria esquirolii H. Lev. Fl. Kouy-Tcheou: 229 (1915);

Crotalaria teragonoloba Roxb. ex Steud. Nomencl. Bot., ed. 2, 1: 445 (1840);

Type specimen: Reinwardt, CGC Indonesia, Botany, L0018856. (L, **Isotype**)

Erect perennial herb to shrub, 1-2m tall. **Stem** branched, branches arise from base to top, woody, angled (4-5angled), green, appressed brown pubescent, slightly rough. **Leaf** simple, mostly inclined or pendent; **Stipule** present, persistent, appressed, linear, 2-4 × 0.5mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially appressed pubescent. **petiole** short 2-6mm; leaf blade linear, linear-lanceolate or lanceolate, symmetrical, 7.5-26 × 0.5-5.6cm, base cuneate or rounded, apex acute, margin entire, both surfaces appressed, white, pubescent but abaxially denser, midrib & secondary veins distinct. **Inflorescence** terminal or leaf-opposed, racemes, 2-14 flowered, 4.5-30 cm. **Peduncle** 2-6.5cm. **Bracts** present, at the base of pedicel, persistent, narrowly triangular, 3-5 × 1-2mm, base truncate, apex acute, margin ciliated, adaxially glabrous, abaxially appressed tomentose, midrib distinct. **Pedicel** 7-13mm. **Bracteoles** present, at the top of the pedicel, persistent, linear, 4-6 × 0.5-1mm, base truncate, apex acute, margin ciliated, foliaceous, midrib not much distinct. **Flowers** yellow, 4-4.5 × 2.2.5cm. **Calyx** two lipped, parted to base, up to 1.5-2.3cm, tube 3-5mm, abaxial 3 calyx lobe connate, curved, adaxial 2 calyx lobe triangular-lanceolate, attached up to 4-5mm up, calyx lobe subequal, apex acute, margin ciliated, dense, appressed to spreading, brownish pubescent. **Standard** suborbicular, 1.7-2.3 × 1.4-2cm, apex obtuse, adaxially glabrous, abaxially short, sparse, white trichome toward top-central region & decorated with purplish dotted structure, callosity lamelliformae type, 2mm long basal claw, appressed abaxially, margin with woolly trichome. **Wings** broadly oblong, 1.7-1.8 × 0.9 cm, base asymmetrical, apex rounded, basal claw short 5mm long. **Keel** rounded, with long twisted beak apically, 1.5-1.7 × 1-1.3cm, base cuneate, glabrous but margin has short, white, soft trichome, basal claw 1mm long.

Stamen 10, Monadelphous, dimorphic, Filament attach up to 3mm up, longer filament 8-12mm long, shorter filament 6-8mm long, oblong anther basifixed, 2-2.5mm long, ovoid to rhomboid anther 0.5-0.8mm and dorsifixed. **Ovary** oblong, 7-8 × 3-4mm, covered with dense, appressed, silky, white pilose hairs, subsessile, stalk short 1mm long, **style** 16mm long, and one line of silky trichome. **Stigma** minute, covered with long silky hairs. **Pod** green turns brown when mature, oblong, inflated, dense, white, shining, and appressed to spreading tomentose, 4.5-5.5 × 1.5cm, exerted with less than half portion covered by calyx, inflated, 20-24 seeded. **Seed** green turns greenish-brown when mature, harp-shaped, 7 × 5mm, glabrous, stalk glabrous, shiny 2-3mm long.

Vernacular name: सनइ (Sanai), छिन छिने (Chhin chhine).

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

Altitude: 341-1906m

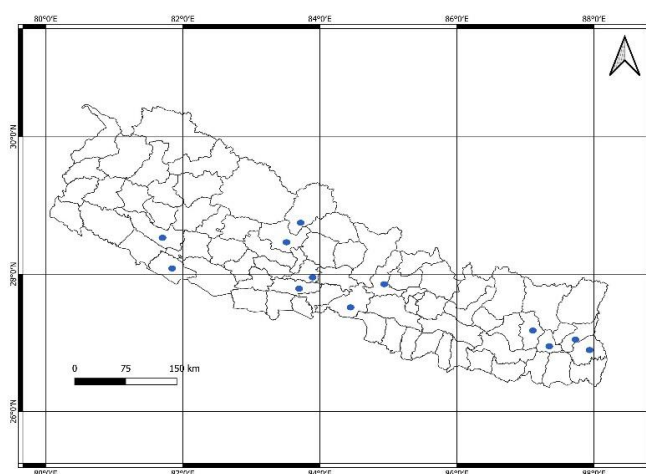
Ecology: Grows in *Shorea robusta* C.F. Gaertn forest, castanopsis forest, hill slopes with grasses, open moist places, also among riverine shrub.

Flowering: August-December

Fruiting: September-February

Vaucher Specimen:

Western Nepal: Surkhet, 1906m, 28° 37' 33"N, 81° 39' 12"E, Jan 15 2023, S. Neupane and B. Parajuli, SR15 (TUCH).



Map 16: Distribution of *Crotalaria tetragona* in Nepal based on herbarium records and field collection.

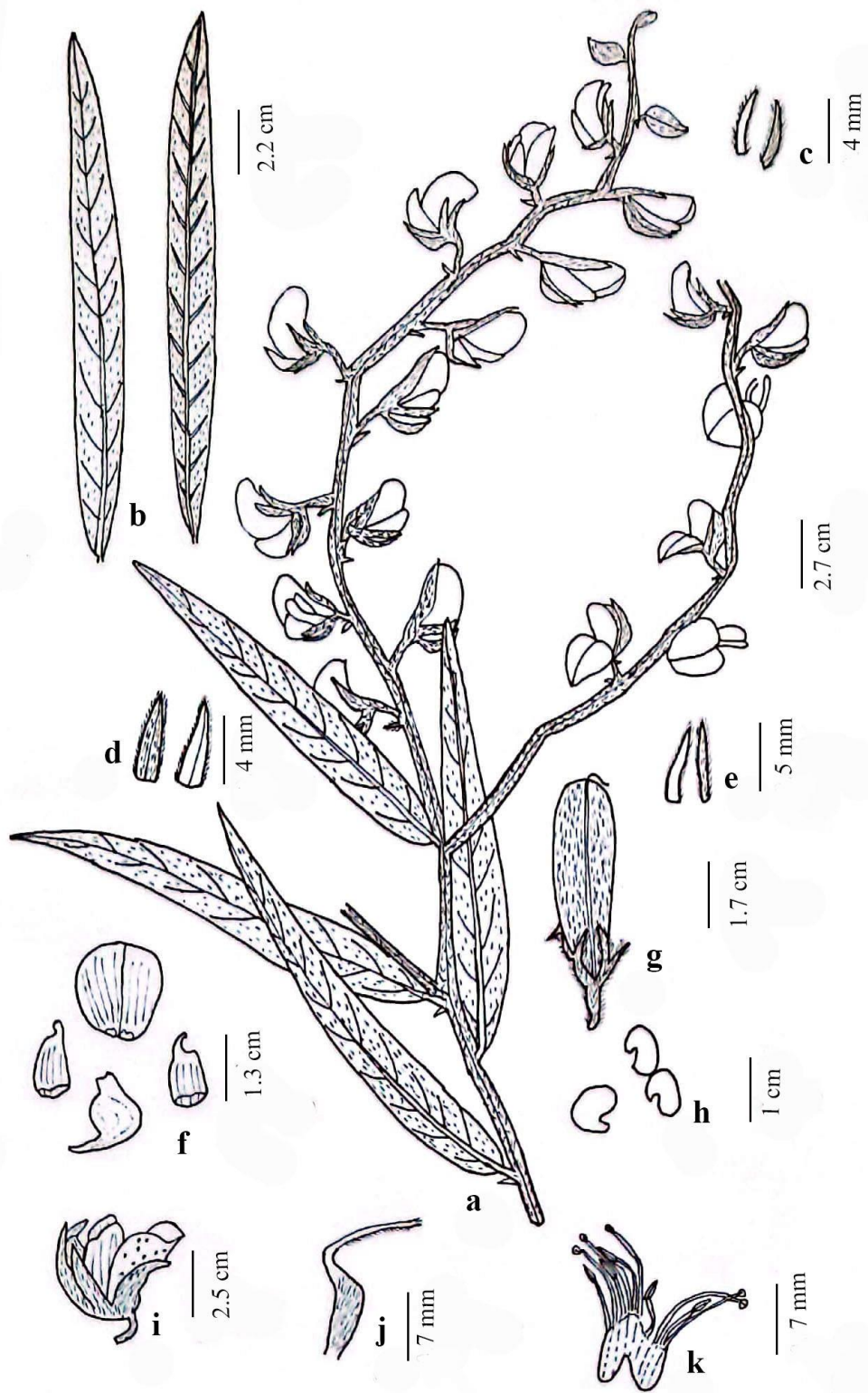


Figure 16 : *Crotalaria tetragona* Roxburgh ex Andrews; a. Habit sketch; b. Leaf; c. Stipule; d. Bract; e. Bracteoles; f. Petals; g. Fruit; h. Seed; i. Flower; j. Gynoecium; k. Androecium.

Non-native species:

There are two more species of *Crotalaria* in Nepal which are not native. One is *Crotalaria micans* Link (syn. *C. anagyroides*) which is introduced from tropical America (Press *et al.*, 2000; Shrestha *et al.*, 2022) another is *Crotalaria juncea* L., which is cultivated in different parts of Nepal for its fiber and inflorescence which has been found to be used as vegetables.

17. *Crotalaria micans* Link. Enum. Hort. Berol. Alt, 2: 228 (1822); Press *et al* in Ann. Check. Fl. Pl. Nep. 99 (2000); Jianqiang *et al.*, in Fl. China 10: 107(2010); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria anagyroides Kunth Nov. Gen. Sp. 6: 404 (1824);

Type specimen: Colombia, Humboldt, 2172 (P, **Isotype**)

Shrub, erect, up to 2m tall, branched, woody, terete, short, appressed pubescent. **Leaf** trifoliate, alternate, inclined. **Stipule** present, persistent or caducous, filiform, 2-4mm long. petiole 2-4.9cm, petiolule 2mm; Leaflets elliptic or oblanceolate, symmetrical, 3.5-7× 1-2.5cm, base cuneate, apex acuminate, obtuse or rounded, margin entire. **Peduncle** 2.6-7.6cm long. **Inflorescence**, terminal, racemose, 7-38 flowered with additional crown like structure of immature inflorescence at top, 8-24.5cm long. **Bracts** present, at the base of pedicel, caducous. **Bracteoles** present, toward apex of pedicel, persistent, filiform, 7-10mm. Pedicel 6-10mm, terete, pubescent. **Flower** yellow, 1.6-2 × 0.9-2cm. **Calyx** sub-campanulate, 9-10mm long, tube 4-5mm, calyx lobe 4-6mm, densely appressed brown pubescent, calyx lobe broadly lanceolate, apex acuminate, margin entire. Pod green turns into black when mature, oblong, 3-4 × 1.2-1.5cm, glabrescent, 14 seeded. Seed turns to brown in maturity, reniform, 5-5.5x4mm, glabrous.

Elevation range: 100-2735m

Distribution: C & E Nepal, Native of N and S America.

18. *Crotalaria Juncea* L. Sp. Pl.: 714 (1753); Press *et al.*, in Ann. Check. Fl. Pl. Nep. 99 (2000); Jianqiang *et al.*, in Fl. China 10: 111 (2010); Shrestha *et al.*, in Pl. Nep. 1: 321 (2022).

Crotalaria benghalensis Lam. Encycl. 2: 196 (1786);

Crotalaria cannabinus Royle III. Bot. Himal. Mts.: 82 (1834).

Vernacular name: छिन छिने (Chhin chhine).

Type specimen: Anon, s. n. LINN-HL 895-11. L, (**Lectotype**).

Distribution: Native to SE Asia to SW Asia.

4.3 Leaf Epidermal Characters (epidermal cells and stomata):

Leaf epidermal characters include the characters related to epidermal cells and stomata. Shape of epidermal cells of the Nepalese *Crotalaria* species have found to be triangular, tetragonal, pentagonal, polygonal, and circular to irregular. Shape of the epidermal cells are variable between species and also within species. Majority of the species have the irregular shape of the epidermal cells. Similarly, cell wall of the epidermal cells has found to be straight in some species (*C. acicularis*, *C. alata*, *C. calycina*, *C. prostrata*, *C. quinquefolia*), while in other they are wavy (*C. albida*, *C. cytisoides*, *C. lejoloba*, *C. tetragona*), further in other remaining species walls are found to be both straight to slightly wavy. (Appendix 15).

Another characteristic studied about epidermal layer is about stomata i.e., stomatal index. Stomatal index is found to be variable in different species of *Crotalaria*. Stomatal index has been found to be highest in *C. sessiliflora* with the value of 54.54, followed by *C. calycina* with index value of 53.5, *C. spectabilis* (44.03), *C. tetragona* (43.48), *C. albida* (42.41), *C. paliida* (41.94), *C. quinquefolia* (41.2), while *C. acicularis* is the species with the lowest value of stomatal index i.e., 15.82, followed by *C. alata* (24.62) and rest of other species have the stomatal index within the range of 30-40. (Appendix 16).

4.4 Vestiture

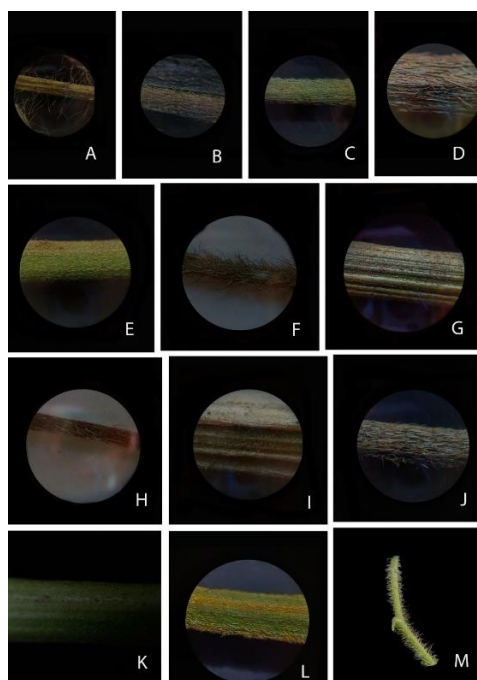
Species of *Crotalaria* shows great variation in the vestiture. Vestiture represent the combination of the different character of the trichome like, trichome type, length, strength, shape, density and color. All studied species of *Crotalaria* are hairy at one or more parts of the plant. In majority of the species, almost all structures (vegetative and reproductive) of the plant have been found with some kind of trichomes except wings petals and seed. Stem, abaxial surface of leaf, stipule and peduncle are hairy in all

studied species while others parts of the plant like adaxial surface of leaf and stipule, adaxial and abaxial surface of the bract and bracteoles, calyx, surface of standard, margin of the keel petal, ovary and fruits are glabrous in some species while with trichome in others.

Type of vestiture found in different species of *Crotalaria* species studies here are pilose, pubescent, puberulent, hirsute and tomentose. Further, Different parts of the plant of the different species of the *Crotalaria* species and the type of the vestiture in them are explained below:

a. Stem

Five types of vestiture have been found in the stem of *Crotalaria* species of Nepal. Pilose in four species (*C. acicularis*, *C. humifusa*, *C. kanaii*, *C. prostrata*), Pubescent in four species (*C. albida*, *C. cytisoides*, *C. medicaginea*, *C. tetragona*), Puberulent in three (*C. pallida*, *C. quinquefolia*, *C. spectabilis*), Hirsute in two (*C. sessiliflora*, *C. calycina*) and Tomentose in *C. alata*. While in case of *C. lejoloba* variation in vestiture has been found within species or even within same individual also, appressed or spreading white or brown pubescent, spreading pilose or sometime appressed tomentose vestiture has been observed in *C. lejoloba*.

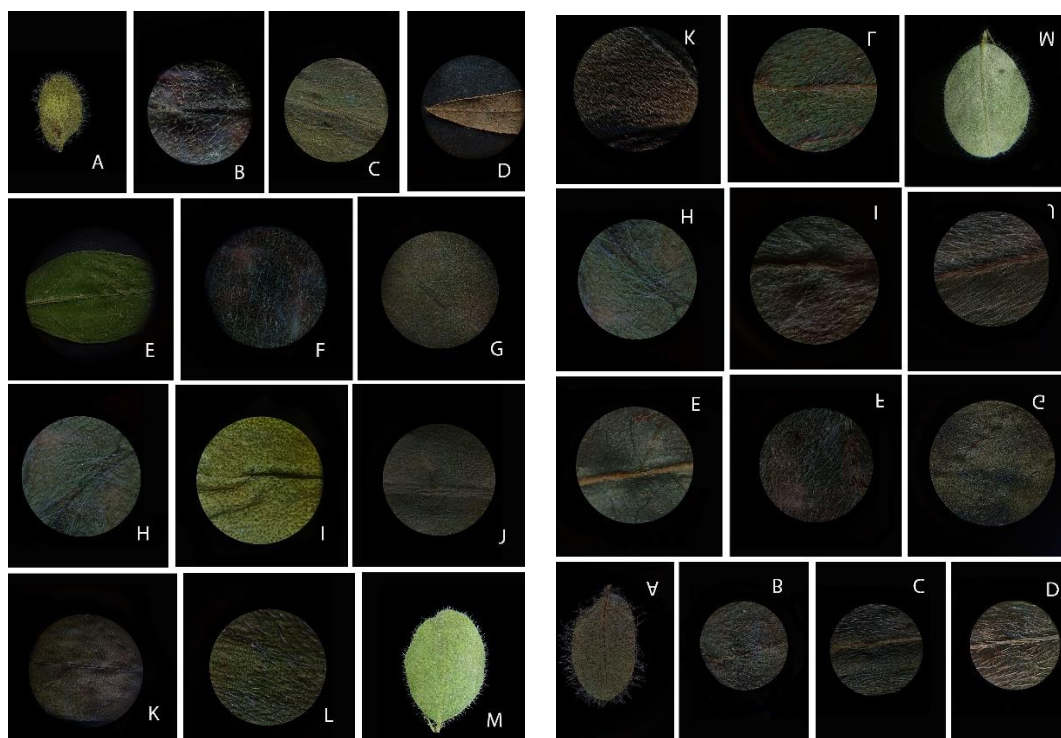


Photoplate 37: vestiture in stem of the *Crotalaria* species: A. *C. acicularis*; B. *C. alata*; C. *C. albida*; D. *C. calycina*; E. *C. cytisoides*; F. *C. lejoloba*; G. *C. pallida*; H. *C. prostrata*; I. *C. quinquefolia*; J. *C. sessiliflora*; K. *C. spectabilis*; L. *C. tetragona*.; M. *C. humifusa*.

b. Leaf

Abaxial surface is hairy in all species but adaxial surface of some species is glabrous while in other it is hairy. Further, the type of hairs is different in different species, it varies from pilose, pubescent, and puberulent to tomentose. On the basis of adaxial surface all species can be grouped in to: adaxially glabrous (*C. cytisoides*, *C. medicaginea*, *C. pallida*, *C. quinquefolia*), sparsely hairy with few numbers of hairs around midrib (*C. calycina*, *C. sessiliflora* and *C. spectabilis*) and adaxially hairy: *C. acicularis*, *C. albida*, *C. alata*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. tetragona* and *C. prostrata*.

Further in case of abaxial surface 4 different types of vestiture has been found in this study; pilose (*C. acicularis*, *C. albida*, *C. calycina*, *C. humifusa* and *C. kanaii*), pubescent (*C. lejoloba*, *C. medicaginea*, *C. pallida*, *C. prostrata*, *C. quinquefolia*, *C. sessiliflora* and *C. tetragona*), puberulent (*C. cytisoides* and *C. spectabilis*) and pubescent to tomentose (*C. alata*).



Photoplate 38: Vestiture on ventral and dorsal surface of the leaf: A. *C. acicularis*; B. *C. alata*; C. *C. albida*; D. *C. calycina*; E. *C. cytisoides*; F. *C. lejoloba*; G. *C. pallida*; H. *C. prostrata*; I. *C. quinquefolia*; J. *C. sessiliflora*; K. *C. spectabilis*; L. *C. tetragona*; M. *C. humifusa*.

c. Stipule

The stipule in all species (*C. acicularis*, *C. calycina*, *C. cytisoides*, *C. humifusa*, *C. kanaii*, *C. pallida*, *C. quinquefolia*, *C. sessilifora*, *C. spectabilis* and *C. tetragona*) are with vestiture in abaxial surface while adaxial surface of species is glabrous in all except in *C. alata* and *C. lejoloba*. Four Different vestiture types of abaxial surface of stipule are: pilose (*C. acicularis*, *C. calycina*, *C. humifusa* and *C. kanaii*), pubescent (*C. cytisoides*, *C. lejoloba*, *C. quinquefolia*, *C. sessilifora* and *C. tetragona*), Puberulent (*C. pallida* and *C. spectabilis*), Tomentose (*C. alata*).

d. Bract and bracteoles

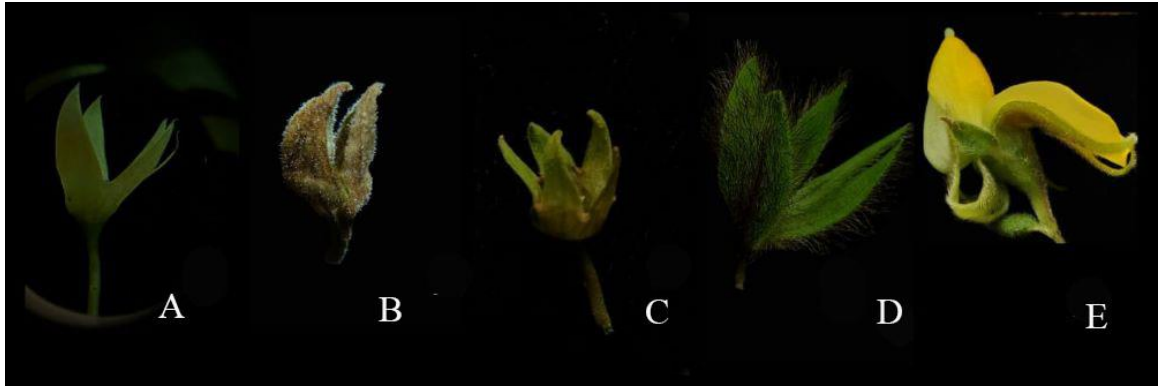
In majority of species adaxial surface of bract and bracteoles is glabrous but sparsely tomentose in *C. alata* and sparsely puberulent in *C. cytisoides* (Photoplate 12). *C. spectabilis* is the one where both adaxial and abaxial surfaces of bract and bracteoles are glabrous. In case of other remaining species abaxial surface is hairy, and the four types of hairs are found as in the other case, they are:

1. Pilose: *C. acicularis*, *C. humifusa*, *C. kanaii*, *C. prostrata*, *C. quinquefolia* and *C. sessilifora*,
2. Pubescent: *C. albida*, *C. calycina* and *C. cytisoides*
3. Puberulent: *C. lejoloba*, *C. medicaginea* and *C. pallida*,
4. Tomentose: *C. alata* and *C. tetragona*

e. Surface of calyx

Surface of calyx in *Crotalaria* varies from being glabrous to densely hairy. Different types of vestiture are found in different species of *Crotalaria* they are: pilose, pubescent, puberulent or tomentose. Majority of species (7 species) have dense, silky pilose vestiture, two species have glabrous calyx and other remaining species have other vestiture type as below:

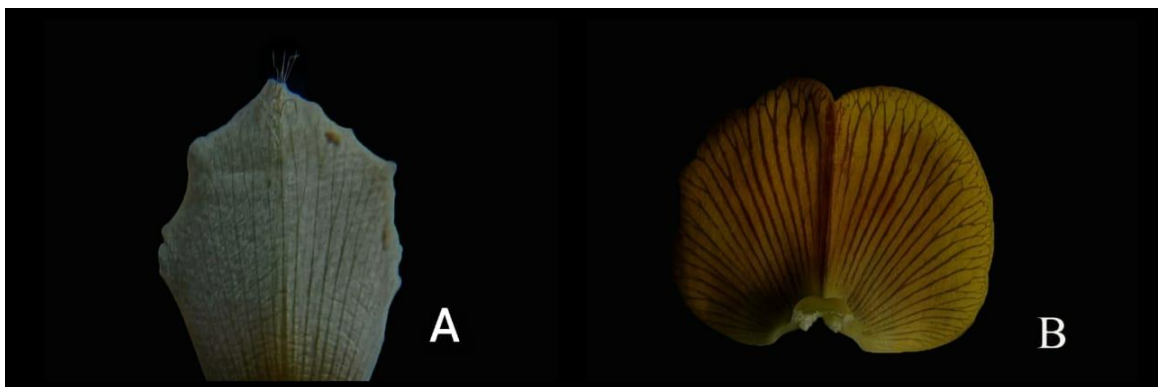
1. Glabrous: *C. spectabilis* and *C. quinquefolia*,
2. Pilose: *C. acicularis*, *C. calycina*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. prostrata* and *C. sessilifora*,
3. Pubescent: *C. albida*, *C. medicaginea* and *C. tetragona*
4. Puberulent: *C. cytisoides* and *C. pallida*,
5. Tomentose: *C. alata*



Photoplate 39: Surface of Calyx; A. Glabrous (*C. spectabilis*); B. Pubescent (*C. tetragona*); C. Puberulent (*C. cytisoides*); D. Pilose (*C. calycina*); E. Tomentose (*C. alata*).

f. Surface of standard petal:

Surface of standard is either glabrous on both sides or hairy abaxially. 7 species are glabrous on both sides (*C. acicularis*, *C. alata*, *C. humifusa*, *C. pallida*, *C. prostrata*, *C. quinquefolia* and *C. spectabilis*) and other remaining species are Bearded abaxially.



Photoplate 40: Surface type of standard petal; A. bearded (*C. calycina*); B. glabrous (*C. quinquefolia*)

g. Surface of the keel petal

Surface is glabrous in all species but margin at one or both side and the basal claw is hairy. Incurved margin is hairy in all species while upcurved margin is glabrous in two species, *C. alata* and *C. sessiliflora*. Hairs are very short, medium or in some cases long pilose. Species with minute hairs at both sides of margin are *C. acicularis*, *C. humifusa*, *C. kanaii*, *C. medicaginea*, *C. pallida* (but basal claw with long pilose hairs), *C. prostrata*, *C. tetragona*. Some other species have comparatively larger i.e., medium sized hairs at the margin of the keel petals they are, *C. albida*, *C. alata*, *C. calycina*, *C. cytisoides*, *C. lejoloba*, *C. sessiliflora*. While *C. quinquefolia* has minute hairs at

upcurved margin while pilose, long hairs at incurved margin and similarly in *C. spectabilis* incurved margin has minute hairs while upcurved margin has medium hairs.

h. Ovary

Surface is glabrous in most of the species but some species have trichomes in their ovary (*C. tetragona*, *C. pallida*, *C. medicaginea*, *C. cytisoides*) and *C. albida* has glabrous ovary but hairs present on abaxial margin and the remaining species have glabrous ovary.

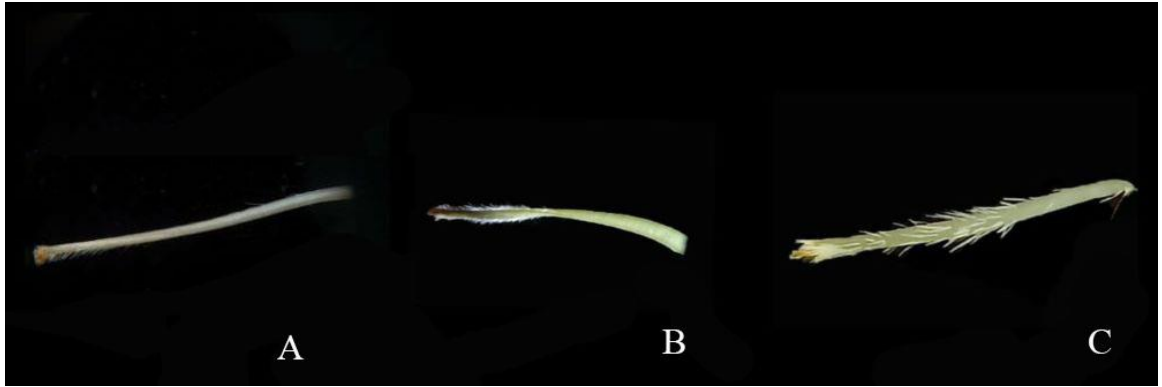


Photoplate 41: Surface of the ovary; A. hairy (*C. tetragona*); B. glabrous (*C. spectabilis*)

i. Style

Surface hairs of style in *Crotalaria* shows variation. In some species only one line of hairs present, in some 2 lines of hairs present and in some species, hairs present all over the surface without defined number of lines. So, based on the lines of hairs on style species can be categorized as follows:

1. One line of hairs: *C. cytisoides*, *C. pallida*, *C. tetragona* and *C. calycina* (few numbers of hairs also present adaxially).
2. Two lines of hairs: *C. albida*, *C. alata*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. quinquefolia*, *C. sessiliflora* and *C. spectabilis*.
3. All over the surface: *C. acicularis*, *C. medicaginea* and *C. prostrata*.



Photoplate 42: Surface hairs in the style: A. single line of trichome (*C. calycina*); B. double lines of trichome (*C. quinquefolia*); C. multiple lines of hairs (*C. acicularis*).

j. Fruit Surface

Surface of the pod may be glabrous, glabrescent or hairy. Majority of the species are glabrous but *C. pallida* is glabrescent i.e., hairy in young but at maturity becomes glabrous. Similarly, pod of *C. cytisoides* has appressed, brown pubescence, *C. medicaginea* also has pubescent pod, the pod of *C. tetragona* has dense, white, shining, appressed to spreading tomentose. The remaining species have glabrous fruits.



Photoplate 43: Different types of fruit surface; A. glabrescent (*C. pallida*); B. Pubescent (*C. cytisoides*); C. Tomentose (*C. tetragona*); D. Glabrous (*C. spectabilis*).

4.5 Reproductive phenology

Reproductive phenology is the term related to the flowering and fruiting pattern of the plant species. In *Crotalaria* species studied here based on herbarium specimen and field collection, peak period of flowering and fruiting is in the month of September to November as in each of these three months (Sep, Oct and Nov) 13 species are found either in flowering or fruiting condition as per the past collection records of others and present collection record. Flowering starts in *Crotalaria* species from March to

October. Usually there is no clear demarcation in the timing of the flowering and fruiting period separately. *C. medicaginea* is the species in which flowering is earliest i.e., flowering starts in March and last up to September. Similarly, *C. acicularis* is the species with late flowering i.e., flowering starts in October. In *Crotalaria* species fruiting may last up to the month of April. Most species are in flowering or fruiting condition from the month of July to January while in other month i.e., Feb to June only few species are found to be in their flowering or fruiting state. However, in overall species of *Crotalaria* genus are found to be in their flowering or fruiting condition all over the year. Majority of the species found to be start flowering in the month of June-August and majority shows the end of the reproductive phenology in the month of January-February.

Table 5: Phenology of the *Crotalaria* species

Species	Jan	Feb	Ma	Apr	Ma	Jun	Jul	Au	Sep	Oct	Nov	Dec
<i>C. acicularis</i>												
<i>C. alata</i>												
<i>C. albida</i>												
<i>C. calycina</i>												
<i>C. cytisoides</i>												
<i>C. humifusa</i>												
<i>C. kanaii</i>												
<i>C. lejoloba</i>												
<i>C. medicaginea</i>												
<i>C. mysorensis</i>												
<i>C. pallida</i>												
<i>C. prostrata</i>												
<i>C. quinquefolia</i>												
<i>C. sessilifora</i>												
<i>C. spectabilis</i>												
<i>C. tetragona</i>												

4.6 Cluster analysis

Dendrogram separates the 15 species into two major large clusters. At first one cluster with 9 species (*C. cytisoides*, *C. pallida*, *C. quinquefolia*, *C. spectabilis*, *C. calycina*, *C. tetragona*, *C. alata*, *C. lejoloba* and *C. albida*) and another cluster with rest of the 6 species (*C. sessiliflora*, *C. medicaginea*, *C. kanaii*, *C. humifusa*, *C. prostrata* and *C. acicularis*) indicating these 6 species are comparatively more similar with one another than to the rest of other.

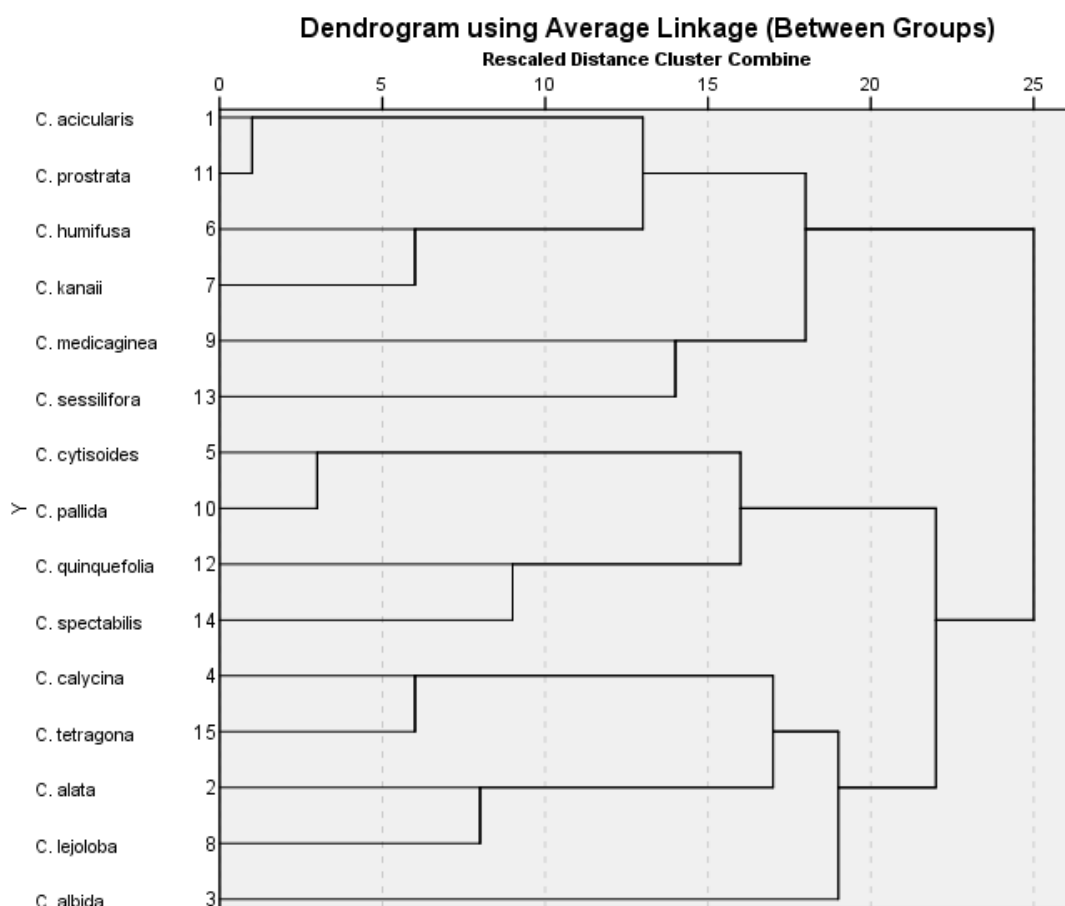


Figure 17 : Dendrogram formed through cluster analysis of morphological characters.

1st cluster with 9 species further divided into 2 sub clusters separating the *C. cytisoides*, *C. pallida*, *C. quinquefolia* and *C. spectabilis* with other remaining five species, and further these 4 species are separated into two small cluster one with *C. pallida* and *C. cytisoides* separating from *C. quinquefolia* and *C. spectabilis*. And the 2nd sub cluster with 5 species also further divided into 2 groups, one with *C. calycina* and *C. tetragona* and another with remaining 3 species of that sub cluster (*C. alata*, *C. lejoloba* and *C.*

albida). Among these 3 species *C. alata* and *C. lejoloba* form one group separating from *C. albida*.

Now in 2nd major cluster with 6 species, we can see the two sub clusters, one with *C. sessiliflora* and *C. medicaginea* and another sub cluster with remaining four species (*C. acicularis*, *C. humifusa*, *C. prostrata* and *C. kanaii*). Finally, *C. acicularis* and *C. prostrata* forms one and *C. humifusa* and *C. kanaii* forms another cluster.

5. DISCUSSION

5.1 Taxonomy of the genus *Crotalaria* L:

Taxonomy is mainly about classifying organisms into different hierarchical groups or taxa and for these objective various characters are taken under consideration. In genus *Crotalaria* also at different times different characters has been studied to know if they are valuable or not from taxonomic or systematic point of view. For e.g., yaradua *et al.* (2018), utilized morphometrics approach to know the importance of morphological characters. Flores *et al.* (2006), windler (1974) and Oliverin & Anguiar-perecin (1999) studies the karyological pattern. Along with these few anatomical (Odewa *et al.*, 2018), and even molecular studies (Le Roux *et al.*, 2013; Subramanian *et al.*, 2013) has been done.

Comparative study of gross morphological characters and anatomical characters of Nepalese species were conducted under this study.

5.1.1 Vegetative Characters

Among various characters of different vegetative structure some have been found more important while some not much valuable from taxonomic point of view. Three types of habitual form have been found in Nepalese species of *Crotalaria* i.e., herb, subshrub and shrub. Although majority of the species are found in only one habit, other species are found to be in different habitual form on different habitat under this study. Jianqiang *et al.* (2010), described *C. albida* as erect or diffuse herb, Grierson and Long (1987), mentioned it to be found in both as herb or undershrub, further, Malla *et al.* (1986), also mentioned it as undershrub. But under this study it is found that *C. albida* is usually herb but in some dry habitat grows as subshrub. Further this is usually in erect form but in some moisture places it was also recorded in prostrate form. Similar case has seen in *C. alata*. Again, Jianqiang *et al.* (2010) described *C. pallida* and *C. tetragona* as perennial herb, Grierson and long (1987) described them as shrub, and in Nepal under this study both *C. tetragona*, and *C. pallida* are usually shrub but occasionally found as herb, and still other species like *C. spectabilis*, *C. quinquefolia*, and *C. lejoloba* are found either as subshrub or herb. In this way different habitat may sometime found to influence the habit of some *Crotalaria* species to some extent. Among different characters of stem, shape and surface vestiture are comparatively significant from

taxonomic point of view therefore, even in other international floras these characters have been used to describe the *Crotalaria* species (Jianqiang *et al.*, 2010; Grierson and Long, 1987). Although majority of the species of has terete stem, three species have angular stem (*C. tetragona*, *C. spectabilis* and *C. quinquefolia*) and one (*C. pallida*) have stem marked with slender longitudinal grooves. Thus, these species can be delimited from other species having terete stem.

In case of leaf important characters are leaf type (simple, trifoliate or penta-foliate), leaf size, symmetry, margin and surface vestiture which has also been used by all authors (Nasir & Ali, 1984; Malla *et al.*, 1986; Grierson & long, 1987; Jianqiang *et al.*, 2010) of different floras as basic character of the species. Characters like leaf shape, leaf apex and base are although not much valuable distinctive character in this genus as these are found variable even within same species and also within same individuals of the species, but as basic feature these have been used in species descriptions from earlier time. Further, whether secondary veins are distinct or not in the species found to be one additional diagnostic character in this study.

Stipule is present is all Nepalese *Crotalaria* species except in two (*C. albida* and *C. prostrata*). According to Grierson & long (1987) stipule present but is caducous in *C. albida* but according to Nasir & Ali (1984) and Malla *et al.*, 1986, Stipule is absent and Jianqiang *et al.* (2010) mentioned both conditions, sometime apparently absent and also mentioned it as minute and caducous. In *C. prostrata* also stipule found absent (Nasir & Ali, 1984; Jianqiang *et al.*, 2010). In present study, Stipules was absent in both fresh and all herbarium specimen available, whether it is really absent or its due to its caducous nature is thus doubtful. Shape and size of the stipule are only characters that have been used regarding stipule in available floras and even some published revisionary work (Malla *et al.*, 1986; Jianqiang *et al.*, 2010; Le Roux and Van WYK 2013). But along with shape and size, its orientation and even margin shows importance as stipules had been found in 5 different types of orientation (appressed, inclined, divergent, reflexed and whole length wise attachment) and margin of stipule is either entire or ciliated.

Shape and surface of the peduncle is same as that of stem, that's why these characters have not been found to be used in others floras too (Nasir & Ali, 1984; Grierson & Long, 1987). Only one Character of peduncle that has shown some significance is the

length as some species has very short (0.5-1.5cm, *C. sessiliflora*) peduncle while some has long (3.8-10.5cm, *C. quinquefolia*) peduncle.

Similarly, in case of Bract, Shape, size, surface has been found to be used commonly in description of the species of this genus. Le roux *et al.* (2013) in his “taxonomic revision of the section Amphitrichae of the genus *Crotalaria*” considered bract characters as less useful. But eight different shapes (cordate, linear, lanceolate, broadly lanceolate, ovate, subulate, narrowly triangular, broadly lanceolate-triangular) of the Nepalese species, and variable size of the bract (6-16 × 3-8mm to 0.7-1.5 × 0.2mm), and distinct midrib of the bract in two species (*C. spectabilis* & *C. tetragona*) gives it diagnostic value to some extent in this study.

Similarly, presence of seven different types of shapes (lanceolate, linear, narrowly elliptic, narrowly lanceolate, triangular-ovate, subulate and filiform) in Bracteoles, its variable position (From base of the pedicel to middle of the calyx), 6 types of bases observed in bracteoles (cuneate, broadly cuneate, obtuse, rounded, truncate and narrowly cuneate) makes it as one of the diagnostically important structures.

5.1.2 Reproductive Characters

Inflorescence position, number of flowers per inflorescence and the length of inflorescence were observed and compared. Le roux (2013), found terminal or leaf-opposed racemose inflorescences in all species of *Crotalaria* of Amphitrichae section. In this study inflorescence position found variable as terminal, leaf-opposed, axillary and internodal. In case of *C. sessiliflora*, no leaf opposed inflorescence has been found on observation of all the herbarium specimen available in Nepal, but Jianqiang *et al.* (2010) has mentioned that along with terminal and axillary solitary flower, inflorescence is leaf opposed too. Similarly, almost in all other species also position observed and position mentioned in different literature did not always find same that is why this character don't show diagnostic value. However, length of inflorescence, flower number per inflorescence, degree of compactness of flowers in inflorescence shows important diagnostic value. *C. kanaii*, the endemic species of Nepal is very similar with *C. acicularis* and *C. humifusa*, but only 2-3 flowers in inflorescence and comparatively larger flower size of *C. kanaii* helps to distinguish it from *C. acicularis* and *C. humifusa*. In some species compactness of the flower provide diagnostic value, flowers arrange so close to each other, leaving no gap between each other. *C.*

sessiliflora, *C. cytisoides*, *C. pallida*, *C. quinquefolia* have very congested flower arrangement. While some species like *C. tetragona*, *C. prostrata*, *C. humifusa*, etc. has very lax arrangement of flower with large gap between flowers.

Flower size and color have not found to be used in the description of the individual *Crotalaria* species in different floras (Nasir & Ali, 1984; Grierson & Long, 1987; Jianqiang *et al.*, 2010). But in some cases of Nepalese species flower size and color both have found diagnostically important, as *C. sessiliflora* and *C. calycina* are very similar in their other characters like habit, leaf character, calyx surface, and overall casual appearance but they can be differentiated with their flower character, as *C. sessiliflora* has comparatively small ($1-1.6 \times 0.8-1\text{cm}$) purple flower, and *C. calycina* has comparatively larger ($1.5-3 \times 1.1-2.5\text{cm}$) yellow flower.

Calyx is one of the important structure, calyx type, calyx lobe shape, size, surface have been considered and used in available literatures (Malla *et al.*, 1986; Grierson & Long, 1987; Jianqiang *et al.*, 2010). In case of Nepalese species, species with simple leaf has two-lipped calyx, while all those with trifoliate or penta-foliate species have sub-campanulate calyx. Correlation of having trifoliate leaf with sub-campanulate calyx has also seen in Chinese Species of *Crotalaria*, but correlation of having simple leaf with two-lipped calyx has not always found constant, as some simple leafed species also found to have sub-campanulate calyx (Jianqiang *et al.*, 2010). So, definitely, this correlation may not be universal but in general calyx type, tube length, calyx lobe shape, etc. can be used in species delimitation.

Shape, size and sometime surface character of standard petal has been utilized to described the species from previous time in different taxonomic literatures (Nasir & Ali 1984; Grierson & Long 1987; Jianqiang *et al.*, 2010) but one important character of standard petal i.e., callosity type has not been used frequently. Polhill (1982), utilized callosity type to distinguished between two groups in *Crotalaria*, as “unspecialised group” and “specialized group”. And recently Le roux *et al.* (2013) mentioned callosities type as important in sectional classification of *Crotalaria* species also. Three different types of callosities have been found in the Nepalese species they are: Lamelliform, ridged and disc shaped. Majority of the species has lamelliform callosity, two species has ridged type (*C. pallida* and *C. cytisoides*) and two species with disc type (*C. kanaii* and *C. medicaginea*). Therefore, along with shape, apex, surface,

callosities type also provide important distinguishing character in *Crotalaria* species. Similarly shape of the wing and shape, curvature and apex of the keel petal also shows some value for species delimitation. *C. pallida* and *C. cytisoides* are two species with untwisted apex of the keel petal.

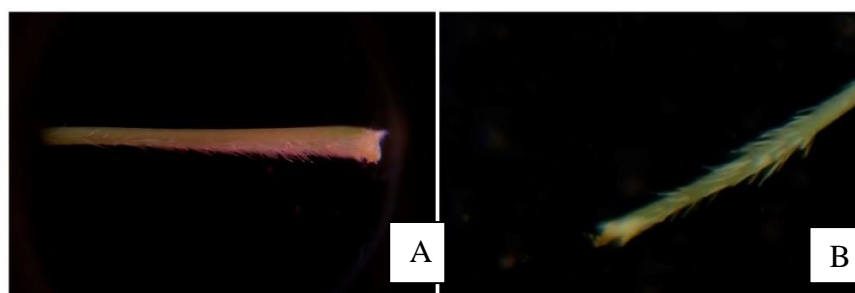
Androecium of all species has stamen of all 5 + 5 arrangement (five long basifixed anthers alternating with five short dorsifixed ones). The androecium has thus no diagnostic value at species level they just differ in the size. Many floras have thus skipped about androecium in the species description (Nasir and Ali, 1984; Jianqiang *et al.*, 2010). Similarly, character about ovary and style also have not found to be used constantly in different national and international floras (Nasir & Ali, 1984; Malla *et al.*, 1986; Grierson & Long, 1987; Jianqiang *et al.*, 2010). But Le roux *et al.* (2013), shows the importance of vestiture of the style as one of the important characters to classify species of *Crotalaria*. In study of Nepalese species of *Crotalaria* also ovary and style showed the diagnostic importance. Elliptic shape of ovary is diagnostic to *C. medicaginea*. Further surface of ovary, and style, curvature of style is also found to be important here.

Fruit is known to provide one of the important diagnostic values in *Crotalaria* species. Subramaniam *et al.* (2022), mentioned the size, color, persistence of calyx, presence of trichomes and number of seeds per pod of the *Crotalaria* as systematically valuable characters. Along with all these characters of fruit two additional characters are found diagnostically important here in Nepalese species, they are shape of the fruit, the exertion of fruit and inflation. Globose shape of the pod is the diagnostic character of *C. medicaginea*, scarcely inflated fruit is the diagnostic to *C. cytisoides* and inclusive fruit help to delimited *C. sessiliflora* and *C. calycina* from other species.

5.1.3 Does recent sectional classification include all Nepalese species?

Based on recent sectional classification of the genus *Crotalaria* published by Le roux *et al.* (2013), Nepalese species are included in the 3 different sections i.e., section Calycinae, *Crotalaria* and Hedriocarpae. Based on the presence of disc callosities which is restricted to the standard petal blade, keel rounded below or about the middle, twisted beak, style rounded or geniculated and style with two lines of hairs *C. kanaii* and *C. medicaginea* falls in the Section *Crotalaria*. Further based on characters like, ridge callosities on the standard petal blade and claw, keel rounded at about middle, rounded

style and trichome in style in one-line, truncate calyx, etc *C. cytisoides* and *C. paliida* lies in the section Hedriocarpae. And remaining all other species lies in the Section calycinae as they have lamelliform callosities on the standard petal blade, twisted beak of the keel, style rounded or geniculated, and trichome in style in one or two lines. There is one species, *C. acicularis* which has lamelliform callosities on the standard petal blade, twisted beak of the keel, style geniculated with multiple lines of hair. Other character leads this species to the section Calycinae but its characteristics of having multiple lines of hairs around style is restricting it to be included in the section Calycinae, as Le roux (2013) have included species only with one or two lines of hairs in style in this section. And if we think of placing it in other section, its lamelliform callosities do not allow that.



Photoplate 44: A. *C. tetragona* (one line of hairs); B. *C. acicularis* (multiple lines of hairs).

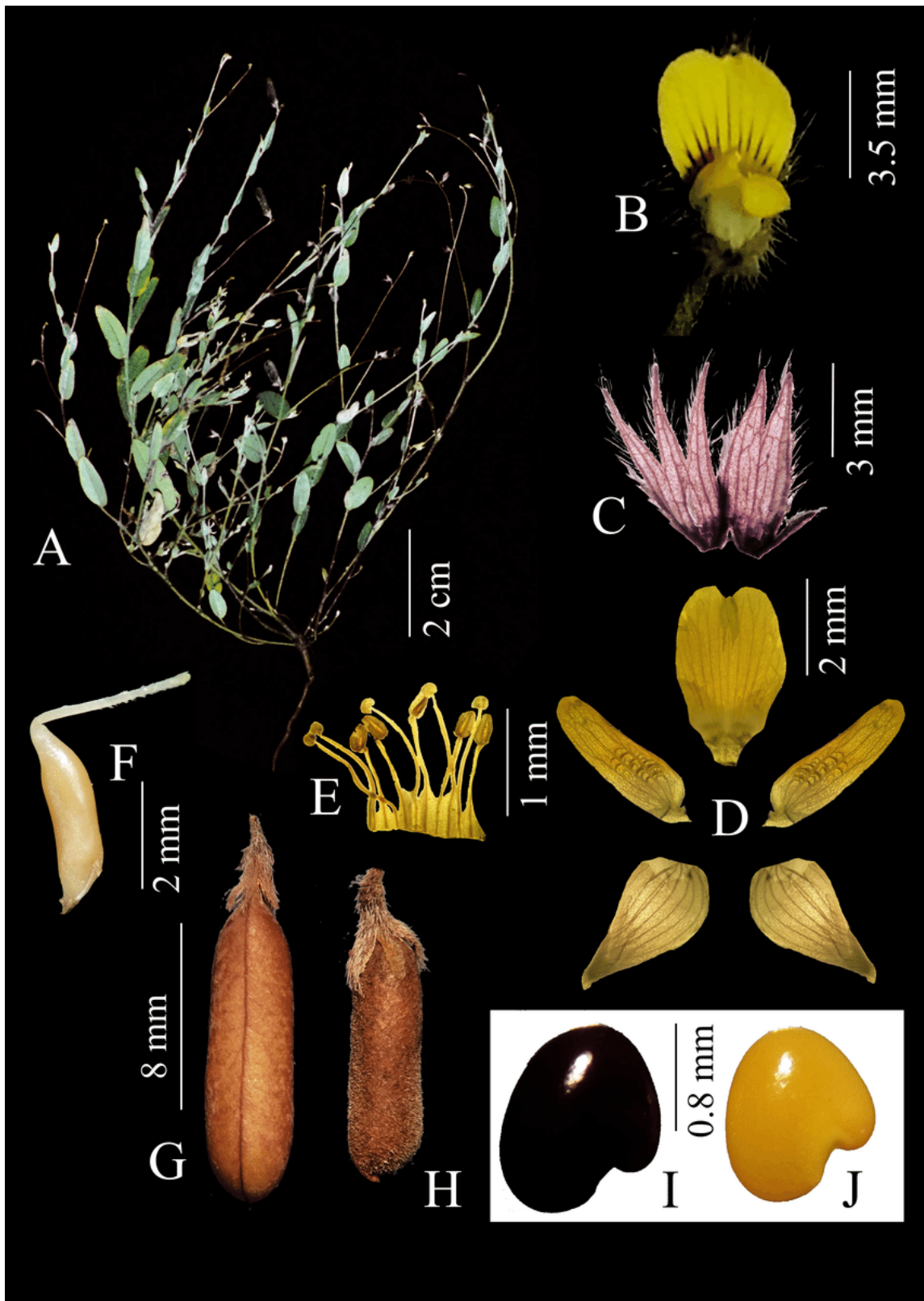
5.1.4 Probable two new varieties of *C. prostrata* Roxb. ex Willd.

According to POWO, there are three accepted varieties of *Crotalaria prostrata* Roxb. ex Willd. Two probable new varieties collected during this study differ from all the three existing varieties (*Crotalaria prostrata* var. *levis* Haines, *Crotalaria prostrata* var. *nigrisperma* K.H. Rokade, Dalovi, N.B, Gaikwad & S.R. Yadav., and *Crotalaria prostrata* var. *prostrata*) of *Crotalaria prostrata* in some morphological characters such as habit, fruit surface, leaf size and calyx length with respect to the fruit length.

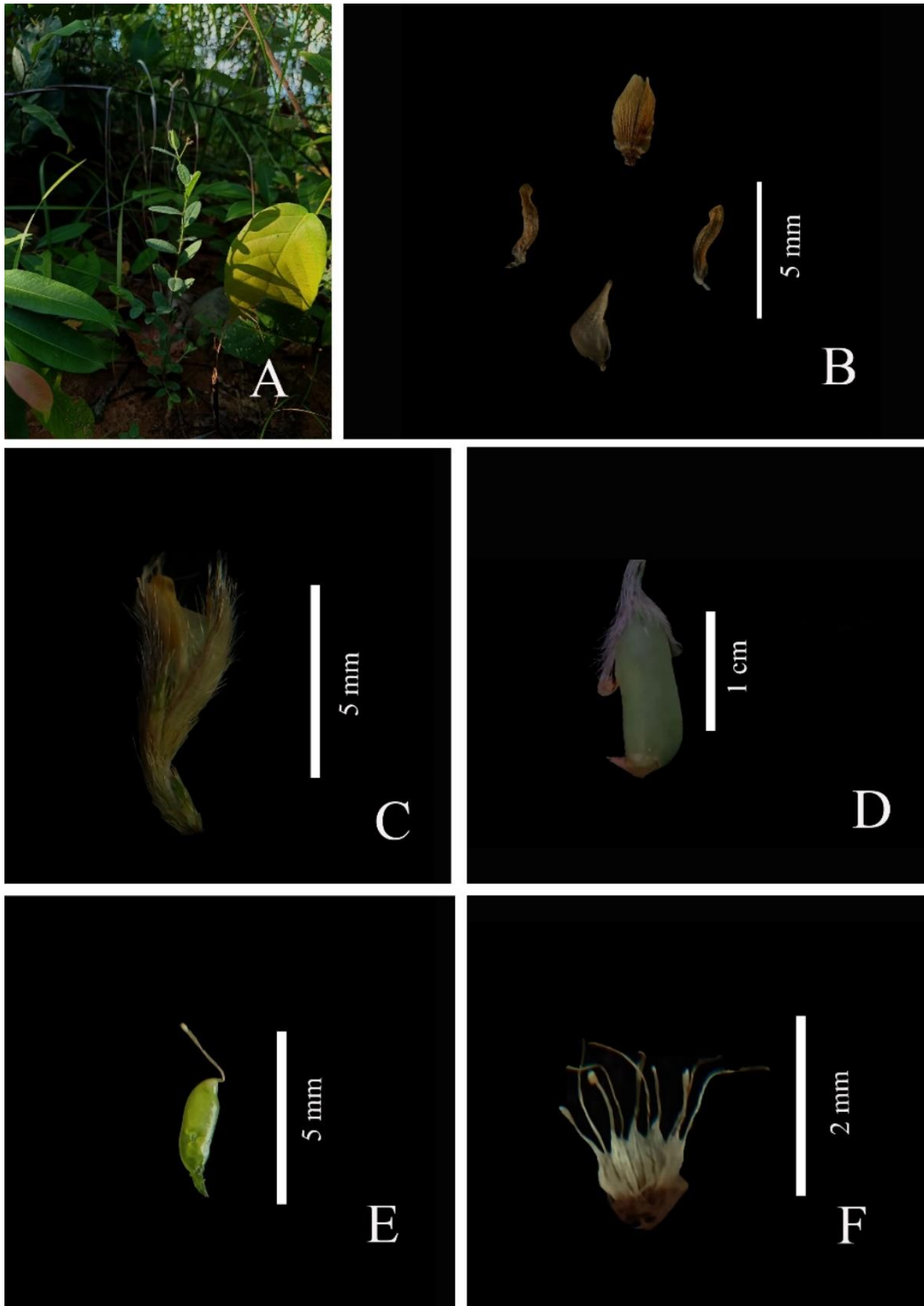
1. Probable variety 1st: It differ from all three existing varieties as it is erect in nature, it differs from *C. prostrata* var. *nigrisperma* as along with being erect in form, its fruit is glabrous. Further it differs from *Crotalaria prostrata* var. *levis* as along with being erect, calyx covers greater extent of fruit, leaf is distinctively broader in size.

Voucher specimen: Chitwan district, Madi, 245m, 27° 25' 58"N, 84° 22' 49"E, 7th Oct 2022, B. Parajuli and K. Parajuli, CH07(TUCH);

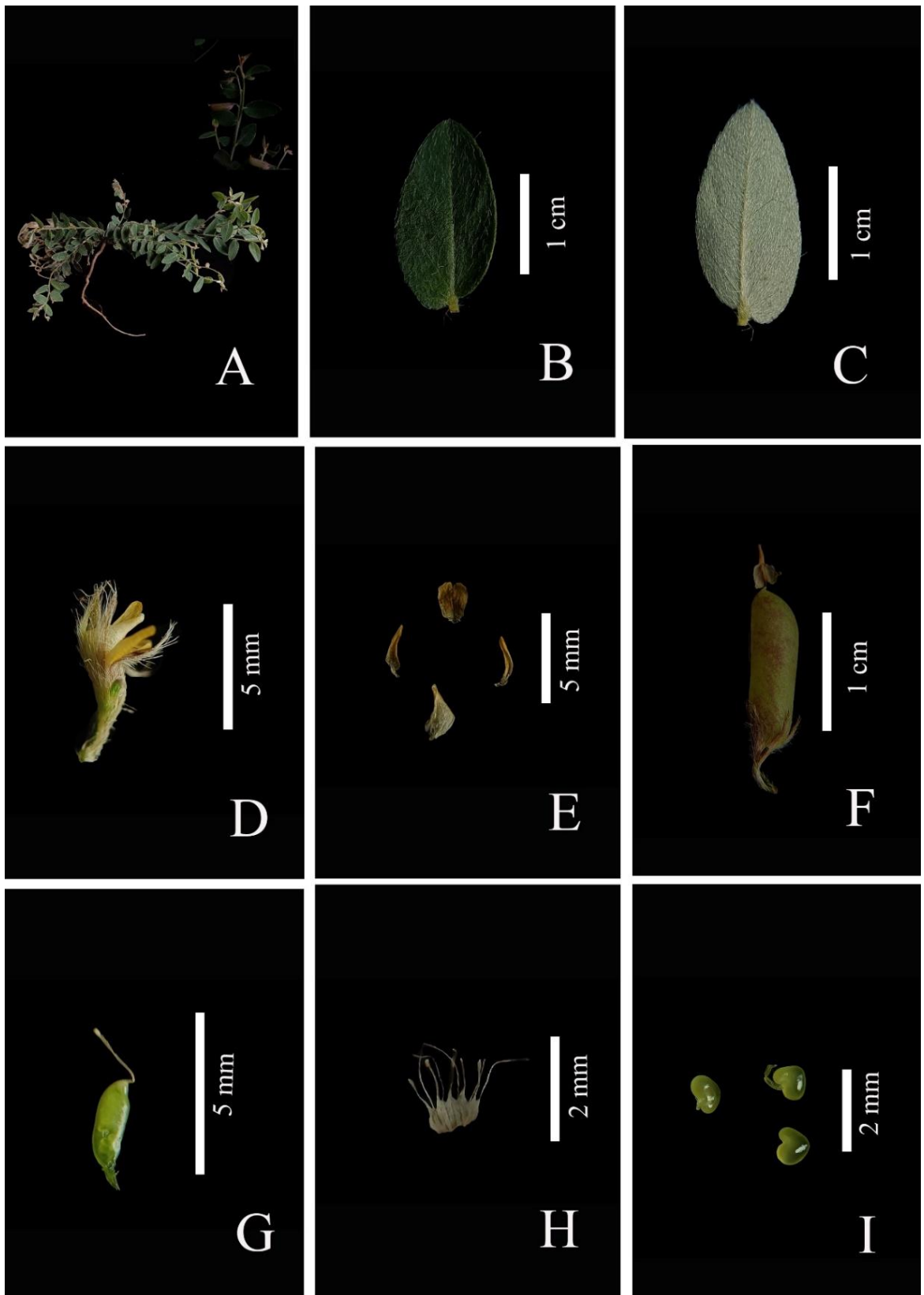
2. Probable variety 2nd: it differs from all existing varieties as it has dark green leaf with thick texture, differs from *Crotalaria prostrata* var. *levis* as leaf is distinctively broader and fruit is comparatively more inclusive. Lastly it differs from *Crotalaria prostrata* var. *nigrisperma* along with its thick dark green leaves its fruit is glabrous.



Photoplate 45: *C. prostrata* var. *nigrisperma* (A, B, C, D, E, F, H, I); *C. prostrata* var. *levis* (G and j).
 (Rokade *et al.*, 2019).



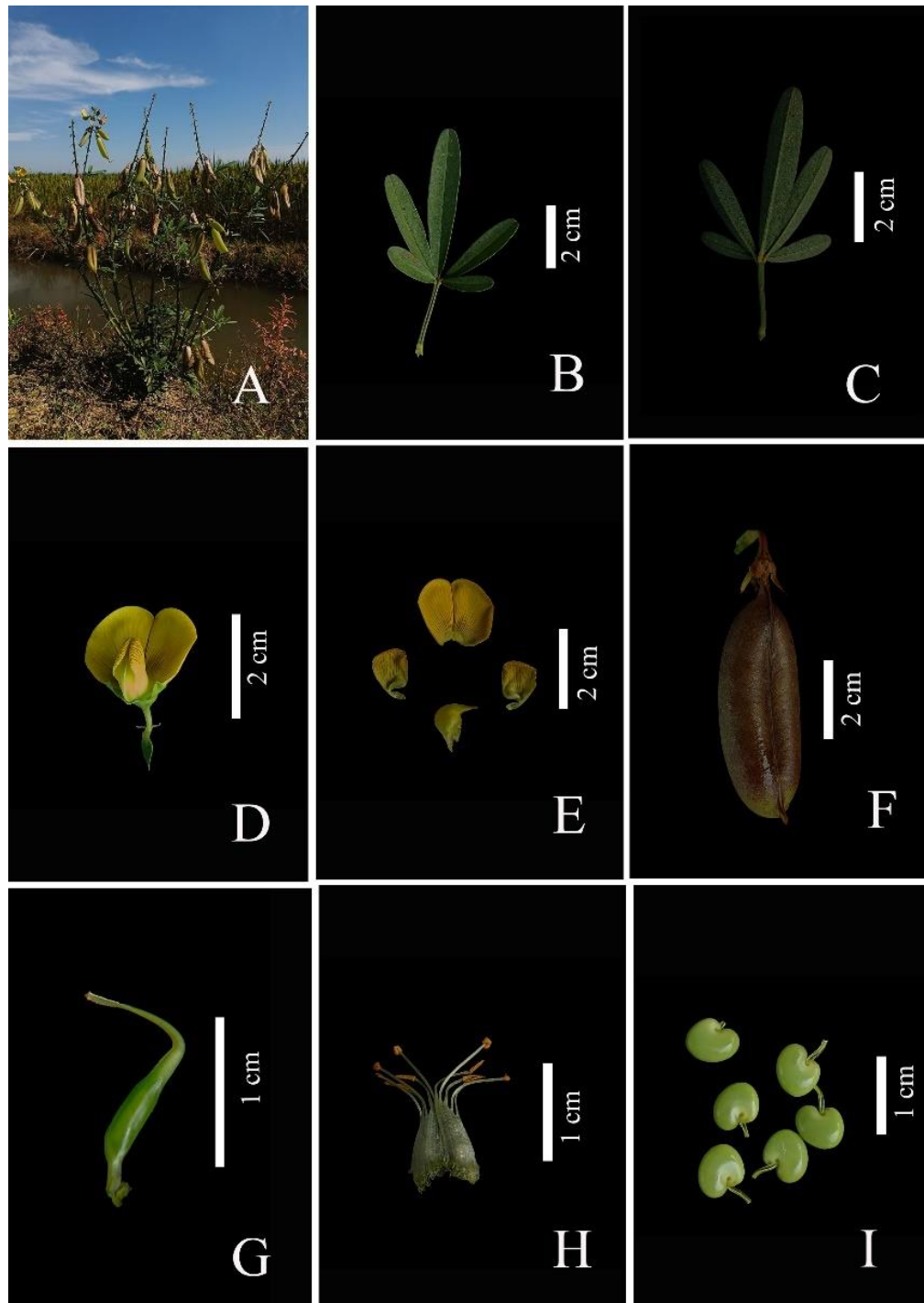
Photoplate 46: Probable variety 1st: A. habit; B. Petals; C. Flower; D. Fruit; E. Gynoecium; F. Androecium.



Photoplate 47: Probable variety 2nd: A. habit; B. ventral leaf; C. dorsal leaf; D. Flower; E. Petals; F. Fruit; G. gynoecium; H. Androecium; I. Seed.

5.1.5 Rediscovery of *Crotalaria quinquefolia* L. from Nepal:

Crotalaria quinquefolia L. was collected in 1963 from Morang district by H. Kanai, G. Murata & M. Togashi. This specimen has been deposited at TI; therefore, no single specimen was available in Nepalese herbarium. During this study this species has been found and collected from the same district but different locality.



Photoplate 48: *Crotalaria quinquefolia* L; A. Habit; B. ventral surface of Leaf, C. Dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoeceium; H. Androgynium; I. Seed.

5.2 Distribution

5.2.1 with in Nepal

Species of genus *Crotalaria* has been found to be distributed all over Nepal from east to west. Diversity is almost equal in east (14 species), central (13 species) and west (14 species) Nepal. 12 species are distributed from east to west Nepal, while two species are restricted to western Nepal only, they are *C. medicaginea* and *C. mysorensis*. *C. medicaginea* has been recorded from Kanchanpur, Dolpa, Rolpa, Mugu and Kalikot districts. *C. mysorensis* was recorded from Salyan district, western Nepal. Further there is one species i.e., *C. quinquefolia*, which have been recorded only from east Nepal. Similarly, one species i.e., *C. acicularis* is distributed from east to central Nepal but has not been recorded from west Nepal till this date.

Species are found to be distributed from very low tropical climatic zone to sub-alpine zone i.e., from 88 m to 3450 m. Among 16 native species of *Crotalaria*, two are only recorded from tropical climatic zone, they are; *C. acicularis* (225-800m) and *C. quinquefolia* (88-200m). While 7 species are recorded from tropical to subtropical climatic zone (*C. tetragona*, *C. prostrata*, *C. pallida*, *C. mysorensis*, *C. lejoloba*, *C. humifusa* and *C. alata*). There are 5 species which are reported up to temperate zone from tropical (*C. albida*, *C. cytisoides*, *C. Kanaii*, *C. medicaginea* and *C. spectabilis*). And only two species *C. sessiliflora* (140-3450m) and *C. calycina* (165-3450m) are found to be distributed from tropical to sub-alpine climate. In this way most diverse part of Nepal having a greater number of *Crotalaria* species is tropical and subtropical region each with 14 species of *Crotalaria* species. Further there is one introduced species of *Crotalaria* which was found to be collected from Eastern (Ilam and Jhapa) and central (different parts of Kathmandu) Nepal. What is the present distributional status of this species is not clear.

5.2.2 Distribution range of Nepalese *Crotalaria* species outside Nepal

Distribution of Nepalese *Crotalaria* species outside Nepal is wide, as the species are found in different geographical areas like E Asia, S Asia, SE Asia, Assam-Burma, E Himalaya, Tibetan-Plateau to few species are even recorded from Africa, W. Himalaya and tropical America. One Species (*C. kanaii*) is endemic to Nepal, remaining 15 other species are also recorded from SE Asia and further S Asia also has all the Nepalese species except *C. kanaii* and *C. humifusa*. Similarly, E Asia and Assam-Burma also

shares great similarity in terms of having similar species of *Crotalaria*, having all the species except *C. quinquefolia* and *C. kanaii* in E. Asia and except *C. calycina*, *C. kanaii* and *C. mysorensis* in Assam-Burma. Similarly, other geographical area which shares the Nepalese species of *Crotalaria* are E. Himalaya with 13 species, W. Himalaya 11, Tibetan-plateau with 5 species, Australasia with 9 species. On the other hand, Africa shares 2 Nepalese species of *Crotalaria* (*C. calycina* and *C. pallida*) and tropical America shares one *C. pallida*.

Further, in terms of country level endemism Only one species i.e., *C. kanaii* is endemic to Nepal. But if we go beyond country level then there are 6 species endemics to Asia as they are not found in Africa, Australasia, and Tropical part of America. Those 5 species are *C. cytosoides*, *C. prostrata*, *C. quinquefolia*, *C. sessiliflora* and *C. tetragona*.

5.3 Vestiture types in Nepalese species of *Crotalaria* L species:

Total 5 different types of vestiture have been found in the *Crotalaria* species of Nepal (pilose, pubescent, puberulent, tomentose and hirsute). Almost all structure is covered with vestiture in *Crotalaria* species. Nasir & Ali (1984) and Malla *et al.* (1986) mainly used the vestiture information of stem, leaf and calyx in the description of *Crotalaria* species. While Jianqiang *et al.* (2010), used the vestiture information of not only stem, leaf and calyx but also of standard petal, keel petal and fruit. Here in this study, along with above mentioned structure, other additional structures (Stipule, bract, bracteoles, Ovary and style) were also observed. Difference in the type of vestiture is useful in case of every structure that has hairs. For e.g., *C. acicularis*, *C. humifusa*, *C. kanaii*, *C. prostrata* has pilose stem, which help them to delineate them from rest of the other with non pilose species. Other than type some structure shows variation in distribution pattern of vestiture. In case of leaf along with the type, the distribution pattern of trichomes is also useful as, *C. cytisoides*, *C. medicaginea*, *C. pallida*, *C. quinquefolia* are glabrous adaxially, *C. calycina*, *C. sessiliflora*, *C. spectabilis* has only sparse hair adaxially around midrib while other has dense evenly distributed hairs at both surfaces. *C. alata* and *C. lejoloba* can be distinguish from other as these have both adaxial and abaxial surface of stipule are hairy while all other remaining species are glabrous adaxially. Similarly, glabrous bract is the distinguishing feature of the *C. spectabilis*. Le roux (2013), shows the vestiture as systematically important character in

Amphitrichae section of the *Crotalaria* species. In case of Nepalese species, 7 species (*C. acicularis*, *C. alata*, *C. humifusa*, *C. pallida*, *C. prostrata*, *C. quinquefolia* and *C. spectabilis*) have glabrous standard so these can be differentiated from remaining other species which has long or short, silky bearded trichome abaxially at top middle portion. Between two similar looking species (*C. kanaii* and *C. humifusa*), *C. kanaii* can be differentiated from *C. humifusa* based on bearded standard petal of *C. kanaii* while *C. humifusa* has glabrous standard petal.

Vestiture of the ovary and especially of style has been considered as systematically important at different taxonomic level in *Crotalaria* species (Le Roux and Van WYK 2013; Le roux *et al.*, 2013). In case of Nepalese species, *C. tetragona*, *C. pallida*, *C. medicaginea* and *C. cytisoides* these four species which has trichomes on their ovary can be delimited through other remaining species with glabrous ovary. Style of *Crotalaria* species shows 3 different forms i.e., single line of trichome (*C. cytisoides*, *C. pallida*, *C. tetragona*, *C. calycina*), two different lines of trichome (*C. albida*, *C. alata*, *C. lejoloba*, *C. humifusa*, *C. kanaii*, *C. quinquefolia*, *C. sessiliflora*, *C. spectabilis*) and other remaining species (*C. acicularis*, *C. medicaginea*, *C. prostrata*) with trichome all around the style. *C. acicularis*, *C. humifusa* and *C. kanaii* are very similar with each other on their general appearance, but *C. acicularis* can be differentiated from other two species based on its all-around distribution of trichome in its style, while other two (*C. humifusa* and *C. kanaii*) has two lines of trichome in their style. Subramaniam *et al.* (2022), shows the presence of trichome in fruit as systematically significant character. In this study variation in fruit surface has been seen as glabrous in majority of species, glabrescent (*C. pallida*), appressed, brown pubescent (*C. cytisoides*, *C. medicaginea*), and dense, white, shining, appressed to spreading tomentose (*C. tetragona*).

5.4 Leaf Epidermal Characters

Leaf epidermal character is often considered stable within a species (Stace, 1984). Therefore, comparative study of leaf epidermal character can provide insight into the evolutionary relationships between plant taxa. Here shape of epidermal cells, pattern of wall and stomatal index of the 13 different species of Nepalese *Crotalaria* species have been compared. Parveen *et al.* (2000) in his study of *Crotalaria* species of Eastern Ghats, observed that epidermal cells are variable in their shape, size and waviness. In

this study total 7 types of shapes of epidermal cell were found (pentagonal, triangular, slightly irregular, irregular, tetragonal, polygonal and circular). In majority of the species epidermal shape are irregular. Thus, In *Crotalaria* species of Nepal epidermal cell shape is either irregular or when shape is other than irregular, they are not constant but variable within species. Therefore, shape of epidermal shape in case of the Nepalese species of *Crotalaria* did not find very useful from taxonomic point of view.

Odewo (2018) found to have straight, curve and undulate pattern of wall in both surfaces of Nigerian *Crotalaria* species. Cell wall pattern has also been observed and compared in this study. In some species (*C. acicularis*, *C. alata*, *C. calycina*, *C. prostrata*, and *C. quinquefolia*) cell wall found to be smooth/straight while in some other (*C. albida*, *C. cytisoides*, *C. lejoloba* and *C. tetragona*) it is wavy and in other remaining four species cell wall is straight and wavy both. Thus, based on the wall pattern 13 species could be divided into three different groups but identification at species level is not possible based on only wall pattern in this genus.

Another thing observed and compared in the study is the stomatal index in 13 species of Nepalese *Crotalaria* species. Stomatal index helps to represent the different aspect of environmental adaptation, stress condition, photosynthetic capacity and even help in the climatic and genetic studies. Further stomatal index has been used in taxonomic comparison at different level as certain species may have inherent differences in stomatal index, representing their ecological niche and evolutionary history. Parveen *et al.* (2000), found the highest SI in *C. prostrata* and Lowest in *C. lamburnifolia* in the study of *Crotalaria* species of Eastern Ghats. Further, Odewo *et al.* (2018) also mentioned stomatal index as useful factor in delineation the *Crotalaria* species. Here in this study of Nepalese species of *Crotalaria* highest Stomatal index found in species like *C. sessiliflora* (54.54%), while species with lowest stomatal index is *C. acicularis* (15.82%). And other remaining species are with intermediate value of stomatal index. Stomatal index of *C. sessiliflora* and *C. calycina* are very close to each other and also these two species are look very similar to each other in their external morphological appearance. Further, *C. humifusa* and *C. prostrata* both are annuals herbs, prostrate in nature also shows very similar stomatal index, 34.25 and 33.07 respectively. Further, *C. pallida*, *C. quinquefolia*, *C. albida*, *C. tetragona* and *C. spectabilis* have the stomatal index in the range of 40-50.

5.5 Hierarchical cluster analysis

Cluster analysis gives two major cluster, one with six species which are invariably found as herb in every habitat (*C. sessiliflora*, *C. medicaginea*, *C. kanaii*, *C. humifusa*, *C. prostrata* and *C. acicularis*) and another cluster with rest of the nine species including subshrub, shrubs or species which are variable in habit with different habitat. 1st major cluster with 6 species, further divides into two sub-clusters, one with *C. sessiliflora* and *C. medicaginea* separating with other remaining four species based on the characters like, leaf with short petiole, adaxially sparsely hairy leaf, two lines of trichomes in style etc. and Finally, *C. acicularis* and *C. prostrata* forms one cluster separating with other two species *C. humifusa* and *C. kanaii*. Characters like symmetrical leaf, truncate base of bract, rounded base of standard petal, and two lines of trichome in style separates these two species with *C. acicularis* and *C. prostrata*.

Similarly, 2nd major cluster with nine species also further divides into two subcluster, separating the *C. cytisoides*, *C. pallida*, *C. quinquefolia* and *C. spectabilis* with other remaining 5 species, based on filaments equal or shorter than tube in androecium and horizontally elongated style. Further *C. cytisoides* and *C. pallida* forms minor cluster separating from *C. quinquefolia* and *C. spectabilis* based on their similarity with each other on having basal claw of wing at center, cuneate base of the wing, ovary with trichome, etc. Again, 2nd sub cluster with 5 species also further divided into 2 groups, one with *C. calycina* and *C. tetragona* being always erect, standard petal sometime or always exceed 1cm and apex of standard petal not rounded. Finally, among remaining 3 species, *C. alata* and *C. lejoloba* form one group separating from *C. albida* having leaf sessile, lax inflorescence, and flower number up to 15.

5.6 Flowering and Fruiting phenology

Most favorable months where almost all species (13 species) were found to be in flowering state are September, October and November. While the months with least number of species having flower or fruit in them is in may (2 species), March and April (3 species) and in February (4 species). In most of the Nepalese species of *Crotalaria* Flowering found to be begin in the month of July to September. Based on the comparative study of when does flowering begins and when does fruiting ends, *C. alata*, and *C. humifusa* shows higher similarity as in both of these species' flowering found to be begin in June (beginning of summer) and fruiting found to be end in

January. In *C. albida* also flowering found to be begins in June but fruiting found to be last up to April. Further species in which flowering begins in the other month of summer i.e., July are *C. cytisoides*, *C. prostrata* and *C. sessiliflora* and in August are *C. tetragona*, *C. lejoloba*. Species with most unique and different pattern is shown by *C. medicaginea*, in which flowering begins in March and fruiting end around September. Thus *C. medicaginea* can be delineated from other species based on this also, as other species generally found to be start flowering in summer but *C. medicaginea* in spring. While *C. pallida* has been found in flowering and fruiting state almost all around the years (Apr-Feb). Further some are found to start flowering in early autumn (*C. spectabilis* and *C. calycina*) to mid-autumn (*C. acicularis* and *C. quinquefolia*). While information is not enough for remaining 2 species i.e., *C. kanaii* and *C. mysorensis*, as herbarium specimen is also not much available and did not find in field too. However, based on available information *C. mysorensis* has been recorded to be in flowering state in August and *C. kanaii* in the month of September.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusions

Different aspects of *Crotalaria* species of Nepal were studied from taxonomic point of view, which are comparative gross morphological studies, some anatomical aspects (epidermal character of leaf), distribution pattern, phenological pattern and also the comparative study of similarity or dissimilarity utilizing the cluster analysis. Overall conclusion and recommendation of this study can be pointed as follows;

1. Regarding morphological study of all the 16 native *Crotalaria* species of Nepal, different characters which shows taxonomic significance are: Stem (shape and surface), leaf (type, size, distinctiveness of secondary veins, symmetry, margin & surface vestiture), Stipule (shape, size, orientation, and margin), Bracts (shape, size, margin, midrib distinctiveness), Bracteoles (shape, size, apex, base and margin), peduncle (length), inflorescence (length, Number of flower, compactness of the flower), flower (color and size), Calyx (type, size, surface), standard petal (shape, size, surface, callosity type), keel (shape, size, curvature and apex), Ovary (shape, surface and size), style (curvature, surface) stamen (size of the filaments and anthers), fruit (size, shape, surface, number of seed) and seed (shape and size). All these characters are variable among different species but are constant within species. Thus, combinations of the different contrasting character of vegetative and reproductive structure gives the clear delimitation of the species.
2. Since *Crotalaria* genus is large with 702 species worldwide, because of this the only sectional classification published for the species of *Crotalaria* worldwide is also feels lacking somewhere to include all the species. As *C. acicularis* did not seem to fit in any of the section published by Le Roux et. al. (2013).
3. Due to distinctive differences in some morphological aspects of the plant (habit, leaf texture, color, size and fruit surface) here are two probably new varieties of *C. prostrata*.
4. *Crotalaria* species are widely distributed inside Nepal from east to west Nepal. Except 20 districts all other districts are reported with one or more species of the *Crotalaria*. Most suitable elevation with higher diversity of *Crotalaria* in Nepal is tropical and subtropical climatic zone.

5. Sub-alpine elevation is with lowest diversity. Only 2 species (*C. calycina* and *C. sessiliflora*) are distributed up to sub alpine zone.
6. One species is endemic to Nepal and other species are common to many other geographical areas, highest similarity with SE Asia with all the 15 species found here are also recorded from there.
7. Regarding leaf epidermal characters, shape of epidermal cell and cell wall pattern both did not showed much taxonomic significance but stomatal index can be used combining with other characters for species delimitation and also to better understand their adaptation to different habitat, evolutionary relationships and plant diversification.
8. *Crotalaria quinquefolia* recollected after 60 years from same district.
9. Hierarchical cluster analysis shows the maximum similarity between *C. acicularis* and *C. prostrata*, followed by *C. cytisoides* and *C. pallida*.
10. Regarding phenological pattern, in majority of the species flowering found to be begin in summer (Jun -Aug), when monsoon provides water, but in *C. medicaginea* flowering begins in the spring (March), further *C. pallida* is in flowering or fruiting state all over the year. Even some species are found to start flower in early autumn to mid-autumn, thus species shows different phenological pattern.

6.2 Recommendation

1. *Crotalaria mysorensis* has not been collected from Nepal since 1952 onward, during this study also it has not found in field, further there are only few herbarium specimens of *C. kanaii* and *C. acicularis* in Nepalese herbaria. So, to know the present status of these species in Nepal more field exploration is needed.
2. Only one recently available global infrageneric classification system of the genus *Crotalaria* (Le Roux *et.al.*, 2013), based on molecular and morphological evidence which include representative samples from all continents also did not find fully inclusive for all the species as position of *C. acicularis* is still confusing. So, more inclusive study is still needed.
3. *Crotalaria* species are widely distributed all over Nepal from east to west Nepal but some of the districts even having suitable climatic zones are with no record. this might be due to lack of proper field exploration or may be some other

reason which is better if we try to find out the reason for this discontinuous distribution.

4. Distribution status of *Crotalaria micans* needed to be explore further so as check whether it is leading toward the processes of naturalization or invasion or any other pattern.

REFERENCES

- Angiosperm Phylogeny Group. 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society*, **161**: 399-436.
- Angiosperm Phylogeny Group. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society*, **161**: 122-127.
- Ansari, A.A. 2006. Taxonomic studies on the genus *Crotalaria* L. in India – II: Infrageneric classification. *J. Econ. Taxon*, **30**: 570–582.
- Ansari, A.A. 2008. *Crotalaria* L. in India. Dehra-Dunn: Bishen Singh Mahendra Pal Singh, pp. 376.
- Baker, J.G. 1876. *Crotalaria*. In: J.D. Hooker (ed), *Flora of British India*. London: Reeve and Co Limited. Vol. 2. pp. 65-85.
- Bentham, G. 1843. Enumeration of the Leguminosae indigenous to southern Asia and central and southern Africa XV. *Crotalaria*. *London Journal of Botany*, **2**: 472–481.
- Bisby, F. A. 1970. The evaluation and selection of characters in angiosperm taxonomy: an example from *Crotalaria*. *New phytologist*, **69**(4): 1149-1160.
- Bisby, F. A. 1973. The role of taximetrics in angiosperm taxonomy I. Empirical comparisons of methods using *Crotalaria* L. *New Phytologist*, **72**(3): 699-726.
- Bisby, F. A. and Polhill, R. M. 1973. The role of taximetrics in angiosperm taxonomy II. Parallel taximetric and orthodox studies in *Crotalaria* L. *New Phytologist*, **72**(3): 727-742.
- Boulter, D., Derbyshire, E., Frahm- Leliveld, J. A. and Polhill, R. M. 1970. observations on the cytology and seed- proteins of various African species of *crotalaria* l. (Leguminosae). *New Phytologist*, **69**(1): 117-131.
- Bridson, D and Forman, L. 1998. The Herbarium Handbook Royal Botanic Gardens. *Royal Botanic Gardens, Richmond*. pp.346.

- Burnham, R. J. and Johnson, K. R. 2004. South American palaeobotany and the origins of neotropical rainforests. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, **359**(1450): 1595-1610.
- Buth, G. M. and Narayan, A. 1987. Seed and seed coat anatomy of some members of Crotalaria (Papilionaceae). *Journal of the Indian Botanical Society*, **66**(3-4): 317-324.
- Chaudhary, R.P. and Majupuria, T.C.1998. *Biodiversity in Nepal: status and conservation: a most recent, profusely illustrated pioneer book with up-to-date information and pertinent references. (No Title)*.
- Christenhusz, M. J. and Byng, J. W. 2016. The number of known plants species in the world and its annual increase. *Phytotaxa*, **261**(3): 201-217.
- Da Torre A.R. 1960. *Taxa angolensia nova vel minus cognita. Junta de Investigacoes do Ultramar*. Vol. 19. pp. 21-49
- de Candolle, A.P.1864. *Prodromus systematis naturalis regni vegetabilis*. Vol. 15. Treuttel et Würtz.
- De Munk, W. G. 1962. Preliminary revisions of some genera of Malaysian Papilionaceae III—a census of the genus Crotalaria. *Reinwardtia*, **6**: 193-223.
- Devecchi, M. F., Pirani, J. R. and Melo-de-Pinna, G. F. D. A. 2014. Comparative leaf anatomy and morphology of some Brazilian species of Crotalaria L. (Leguminosae: Papilionoideae: Crotalarieae). *Acta Botanica Brasilica*, **28**: 583-593.
- du Puy, D. J., Labat, J. N., Rabevohitra, R., Villiers, J. F., Bosser, J., and Moat, J. 2002. *The Leguminosae of Madagascar*. Kew Royal Botanic Gardens, Richmond, London, UK.
- Ekeke, C. and Agobua, J. U. 2020. Comparative Taxonomic study on Crotalaria L. from some parts of South-Eastern Nigeria. *Bulletin of Pure and Applied Sciences*, **39** (2):94-105.
- Flores, A. S. and de Azevedo Tozzi, A. M. G. 2005. A new species of Crotalaria (Leguminosae, Papilionoideae) from southeastern Brazil. *Novon*, 418-420.

- Flores, A. S. and Tozzi, A. M. G. A. 2008. Phytogeographical patterns of *Crotalaria* L. species (Leguminosae-Papilionoideae) in Brazil. *Rodriguésia*, **59**: 477-486.
- Flores, A. S., Correa, A. M., Forni-Martins, E. R. and Tozzi, A. M. A. 2006. Chromosome numbers in Brazilian species of *Crotalaria* (Leguminosae, Papilionoideae) and their taxonomic significance. *Botanical Journal of the Linnean Society*, **151**(2): 271-277.
- Flores, A.S. 2004. Taxonomia, números cromossômicos de espécies de *Crotalaria* L. (Leguminosae, Papilionoideae, Crotalarieae) no Brasil. Tese DS. Campinas, Universidade Estadual de Campinas.
- Forman, L. and Bridson, D. 1998. *The Herbarium Handbook*. Royal Botanic Gardens Kew, UK. pp. 334.
- Gill, L. S., Olabanji, G. O. and Husaini, S. W. H. 1982. Studies on the structural variation and distribution of stomata in some Nigerian legumes. *Willdenowia*, 87-94.
- Grierson, A.J.C and Long, D.G. 1987. Flora of Bhutan Vol. I Part III. Royal Botanical Garden, Edinburgh and Royal Government of Bhutan.
- Gupta, R. 1978. Karyotypic studies in the genus *Crotalaria* Linn. *Cytologia*, **43**(2): 357-369.
- Harvey, W.H. 1862. *Leguminosae*. In: W.H. Harvey and O.W. Sonder (ed), *Flora Capensis*. Dublin: Hodges, Smith, and Co. Vol. 2. pp. 39- 47.
- Hepper, F.N. 1958. *Papilionaceae, Crotalaria*. In: R.W.J. Keay (ed), *Flora of West Africa*. London: Crown Agents, pp.544-553.
- Humboldt, F., Bonpland, A., and Kunth, C. 1824. Voyage aux régions équinoxiales du Nouveau Continent. *Nova genera et species plantarum*, **6**:397-406.
- Jianqiang, L., Sun, H., Polhill, R.M. and Gilbert, M.G. 2010. Crotalarieae: *Crotalaria*. In: Z.Y. Wu, P.H. Raven, D.Y. Hong (ed), *Flora of China vol. 10 (Fabaceae)*. Beijing: Science Press and St. Louis: Missouri Botanical Garden Press, pp.105-117.

- Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. and Donoghue, M. J. 1999. Plant systematics: a phylogenetic approach. *Ecología mediterránea*, **25**(2): 215.
- Lamarck J.B.A.P.M. de .1786. *Encyclopedie Methodique. Botanique Vol. 2*. Paris: Panckoucke, 774p.
- le Roux, M. M. and van Wyk, B. E. 2013. A taxonomic revision of Amphitrichae, a new section of *Crotalaria* (Fabaceae). *Systematic Botany*, **38**(3): 638-652.
- Le Roux, M. M., Boatwright, J. S and van Wyk, B. E. 2013. A global infrageneric classification system for the genus *Crotalaria* (Leguminosae) based on molecular and morphological evidence. *Taxon*, **62**(5), 957-971.
- Leverett, L. D. and Woods, M. 2012. The genus *Crotalaria* (Fabaceae) in Alabama. *Castanea*, **77**(4): 364-374.
- Lewis, G., Schrire B., Mackinder B. and Lock, M. 2005. *Legumes of the world*. Kew: Royal Botanical Gardens. pp. 577.
- Linnaeus, C. 1753. *Species Plantarum*. Stockholm: Laurentius Salvius. pp. 1200.
- Magallon, S. and Sanderson, M. J. 2001. Absolute diversification rates in angiosperm clades. *Evolution*, **55**(9): 1762-1780.
- Malla, S.B., Shrestha S.B., Rajbhandari S.B., Shrestha, T.B., Adhikari, P.M., Sakya, S.R., and Shakya, P.R. 1986. *Flora of Kathmandu valley*. Department of medicinal plants, Ministry of forest and soil conservation, HMG Nepal, Kathmandu, Nepal.
- Miller, R. H. 1967. *Crotalaria seed morphology, anatomy, and identification* (No. 1373). US Department of Agriculture.
- Milne-Redhead, E.1961. Miscellaneous notes on African species of *Crotalaria* L.: I. *Kew Bulletin*, **15**(1), 157-167.
- Mishra, M. K.1997. Stomatal Characteristics at Different Ploidy Levels in *Coffea*L. *Annals of Botany*, **80**(5): 689-692.
- Mondin, M. (2003). *Estudo da evoluçãocariotípica do gênero Crotalaria L. (Leguminosae-Papilionoideae) com o emprego de técnicas de*

bandamentocromossômico e hibridação in situ fluorescente (FISH) (Doctoral dissertation, Universidade de São Paulo).

- Nwude, N. and Ibrahim, M. A. 1980. Plants used in traditional veterinary medical practice in Nigeria. *Journal of Veterinary Pharmacology and therapeutics*, **3**(4): 261-273.
- Nasir, E and Ali, S. I. 1984. *Flora of Pakistan*. (No Title).
- Odewo, S. A., Adeyemo, A. and Ayodele, A. E. 2018. Foliar epidermal studies of the genus *Crotalaria* in Nigeria. *Journal of Medicinal Plants Studies*, **6**(6): 245-249.
- Oliveira, A. L. P. C. and Aguiar-Perecin, M. L. R. 1999. Karyotype evolution in the genus *Crotalaria* (Leguminosae). *Cytologia*, **64**: 165-174.
- Palomino, G. and Vazquez, R. 1991. Cytogenetic studies in Mexican populations of species of *Crotalaria* L. (Leguminosae-Papilionoideae). *Cytologia*, **56**(3): 343-351.
- Pandey, A., Singh, R., Sharma, S. K. and Bhandari, D. C. 2010. Diversity assessment of useful *Crotalaria* species in India for plant genetic resources management. *Genetic resources and crop evolution*, **57**: 461-470.
- Parmar, G. and Zaman, W. 2022. Trichomes' micromorphology and their evolution in selected species of *Causonis* (Vitaceae). *Horticulturae*, **8**(10): 877.
- Parveen, S. N., Murthy, K. S. R. and Pullaiah, T. 2000. Leaf epidermal characters in *Crotalaria* species (Papilionoideae) from Eastern Ghats. *Phytomorphology*, **50**(2), 205-212.
- Paul, V., Sharma, L., Pandey, R. and Meena, R. C. 2017. Measurements of stomatal density and stomatal index on leaf/plant surfaces. *Manual of ICAR Sponsored Training Programme for Technical Staff of ICAR Institutes on—Physiological Techniques to Analyze the Impact of Climate Change on Crop Plants*. pp. 27.
- Polhill, R. M. 1968. Miscellaneous notes on African species of *Crotalaria* L.: II. *Kew bulletin*, **22**(2): 169-348.
- Polhill, R. M. 1982. *Crotalaria in Africa and Madagascar*. CRC Press.

- Polhill, R. M. and Raven, P. H. 1981. *Advances in legume systematics*, Royal Botanic Gardens, Kew and Ministry of Agriculture, Fisheries and Food, London.
- Press, J. R., Shrestha, K. K. and Sutton, D. A. 2000. *Annotated checklist of the flowering plants of Nepal*. Natural History Museum Publications.
- Qualls, D. 1986. *Summary for revisionary studies of plant taxa*. AE Radford, Fundamentals of plant systematics. Harper & Row, New York. pp. 467-468.
- Rajbhandari, K. R. and Bhattarai, S. 2001. *Beautiful orchids of Nepal*. Keshab R. Rajbhandari.
- Rajbhandari, K.R. and Rai, S.K. 2019. *A handbook of the flowering plants of Nepal*. Government of Nepal, Ministry of Forests and Soil Conservation, Department of Plant Resources.
- Rajbhandary, S.R. 2015. Trends in Taxonomy: Main Tools in Taxonomic Revision In: Siwakoti, M. & Rajbhandary, S.R. eds *Taxonomic Tools and Flora Writing*. Department of Plant Resources, Ministry of Forests and Soil Conservation, Central department of Botany, Tribhuvan University, Kathmandu, Nepal. pp. 143-163.
- Roeder, E. and Wiedenfeld, H. 2009. Pyrrolizidine alkaloids in medicinal plants of Mongolia, Nepal and Tibet. *Die Pharmazie-An International Journal of Pharmaceutical Sciences*, **64**(11): 699-716.
- Rokade, K., Dalavi, J. V., Gaikwad, S., Gaikwad, N. and Yadav, S. 2019. A new variety of *Crotalaria prostrata* Roxb. (Fabaceae) from the northern Western Ghats, India. *Phytotaxa*, **414**(1): 35-40.
- Roux, M.M., Wyk, B., Boatwright, J.S. and Tinley, P.M. 2011. The systematic significance of morphological and anatomical variation in fruits of *Crotalaria* and related genera of tribe Crotalarieae (Fabaceae). *Botanical Journal of the Linnean Society*, **165**(1): 84-106.
- Roxburgh, W. and Carey, W. 1832. *Flora indica*. Serampore: W. Thacker pp. 745.
- Senn, H. A. 1939. Contributions From the Gray Herbarium of Harvard University—No. CXXV: the North American Species of *Crotalaria*. *Rhodora*, **41**(488): 317-367.

- Smith, T. 2006. Plant Systematics by Michael G. Simpson. *Systematic Botany*, **31**(3): 631-632.
- Sonje, S. B. and Bhuktar, A. S. (2013a). Anatomical studies of *Crotalaria albida* Heyne Ex Roth. *Science Research Reporter*, **3**(2): 155-158.
- Sonje, S. B., & Bhuktar, A. S. (2013b). Anatomical studies of *Crotalaria hirsuta* Willd. *Int. J. Int sci. Inn. Tech. Sec*, **2**(5): 19-21
- Stace, C.A., 1984. The taxonomic importance of leaf surface. In: Heywood, V.H. and D.M. Moore (eds.), *Current Concepts in Plant Taxonomy*, pp: 67–94. London: Academic Press, London.
- Subramaniam, S., Pandey, A. K., Geeta, R. and Mort, M. E. 2013. Molecular systematics of Indian *Crotalaria* (Fabaceae) based on analyses of nuclear ribosomal ITS DNA sequences. *Plant Systematics and Evolution*, **299**: 1089-1106.
- Subramaniam, S., Rather, S. A., Danda, S. and Pandey, A. K. 2022. The systematic significance of pod morphological and anatomical variations in Indian *Crotalaria* L. (Leguminosae). *Flora*, **290**: 152059.
- Taubert, P. 1893. *Crotalaria* in Engl. & Prantl. *Pflanzenfam*, **3**(3): 226-230.
- Thunberg, C. P. 1823. *Flora capensis* (Vol. 1). sumtibus JG Cottae.
- Van Wyk, B. E. 2005. *Crotalariaeae*. In: Lewis, G., Schrire, B., Mackinder, B. & Lock, M. (Eds.) *Legumes of the World*. Royal Botanic Gardens, Kew, pp. 273–281
- Verdoorn, I. C. 1928. A revision of the *Crotalaria*s of south and south-east-tropical Africa. *Bothalia*, **2**: 371-420.
- Wight, R. and Arnott, G. A. W. 1834. *Prodromus Florae Peninsulae Indiae Orientalis I*. Parbury, Allen & Co., London. Pp. 480.
- Wilczek, R. 1953. *Papilionaceae Genisteeae Congolanae Novae* (Robynsiophyton, *Crotalaria*, *Argyrolobium*). *Bulletin du Jardin botanique de l'Etat, Bruxelles/Bulletin van den Rijksplantentuin, Brussel*. pp. 125-221.

- Wilczek, R. 1953a. Papilionaceae Genisteeae Congolanae Novae (Robynsiophyton, *Crotalaria*, *Argyrolobium*). *Bulletin du Jardin Botanique de l'Etat a Bruxelles*, **23**: 125-211.
- Wilczek, R. 1953b. *Crotalaria*. In: W. Robyns, P. Staner, F. Demaret, R. Germain, G. Gilbert, L. Hauman, M. Homes, F. Jurion, J. Lebrun, M. Van den Abeele and R. Boutique (ed), *Flore du Congo Belge et du Ruanda-Urundi Vol. 4*. Brussels: Institut National pour l'Etude Agronomique du Congo belge, pp. 43-273.
- Wilczek, R., Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Boutique, R. 1953. *Crotalaria*. *Flora of the Belgian Congo*, **4**: 43-273.
- Windler, D. R. 1974. Chromosome numbers for native North American unifoliolate species of *Crotalaria* (Leguminosae). *Brittonia*, **26**(2): 172-176.
- Windler, D. R. 1974. A systematic treatment of the native unifoliolate *Crotalaria*s of North America (Leguminosae). *Rhodora*, **76**(806): 151-204.
- Winston, J. E. 1999. *Describing species: practical taxonomic procedure for biologists*. Columbia University Press.
- Wojciechowski, M. F., Lavin, M. and Sanderson, M. J. 2004. A phylogeny of legumes (Leguminosae) based on analysis of the plastid matK gene resolves many well-supported subclades within the family. *American journal of botany*, **91**(11): 1846-1862.
- Wollenweber, E. and Schneider, H. 2000. Lipophilic exudates of Pteridaceae—chemistry and chemotaxonomy. *Biochemical Systematics and Ecology*, **28**(8): 751-777.
- Woodson, R. E., Schery, R. W., Dwyer, J. D., D'Arcy, W. G., Dillon, M. O., White, P. S. and Lackey, J. A. 1980. Flora of Panama. Part V. Family 83. Leguminosae. Subfamily Papilionoideae (Conclusion). *Annals of the Missouri Botanical Garden*, **67**(3): 523-818.
- Wu, S. H., Chaw, S. M. and Rejmánek, M. 2003. Naturalized Fabaceae (Leguminosae) species in Taiwan: the first approximation. *Botanical Bulletin of Academia Sinica*, **44**:59-66.

Yaradua, S. S., Alzahrani, D. A. and Bello, A. 2018. Numerical taxonomic study of the genus *L.* (Crotalariaeae, Fabaceae) in Nigeria. *Biodiversity Research and Conservation*, **50**(1): 25-32.

APPENDICES

Appendix 1. Character code for cluster analysis

S.N	Character	Short form	Coding
1	Habit	Ha	0= always herb; 1= always shrub; 2= not always same (herb, subshrub, shrub)
2	life span	Ls	0=annual; 1=perennial; 2= annual or perennial
3	Orientation	Or	0=always erect; 1= not always erect; 2= always prostrate or ascending
4	Stem vestiture	Sv	0= pilose; 1=non-pilose; 2= mixture of two or more types of vestiture
5	Leaf type	Lt	0=simple; 1=trifoliolate; 2= tri- to penta-foliolate
6	Petiole length	Pl	0=subsessile (up to 3mm); 1= petiole short (up to 6mm); 2=petiole long (longer than 1cm)
7	Petiole shape	Ps	0= terete; 1= channeled
8	Leaf base	Lb	0=symmetrical; 1= asymmetrical; 2= both
9	Leaf margin	Lm	0=entire; 1= ciliated
10	Leaf surface	Ls	0= both side hairy, 1= abaxially dense, adaxially very scarcely hairy; 2= glabrous adaxially
11	Stipule	St	0=present; 1=absent
12	Stipule orientation	So	0=decurrent; 1=non-decurrent; 2= absent case
13	Base of stipule	Bs	0= truncate; 1= not truncate; 2= absent case
14	Margin of stipule	Ms	0= ciliated; 1=entire; 2= absent case
15	Surface of stipule	Ss	0= both surfaces hairy; 1= adaxially glabrous; 2= absent case
16	Compactness of the flower	Cf	0= congested; 1= lax; 2= very lax
17	Inflorescence position	Ip	0= always terminal; 1= not always terminal; 2= always leaf opposed; 3= internodal

18	No. of flower	Nf	0= one to three flowers; 1= up to 15 flowers; 2= many flowered
19	Surface of bract & bracteoles	Sb&b	0= both sides glabrous; 1= adaxially glabrous; 2= both sides hairy
20	Position of bracteoles	Pboles	0= at the base of calyx tube; 1= at other position
21	Base of bract	Bb	0= truncate; 1= not truncate
22	Base of bracteoles	Bboles	0=truncate; 1=not truncate
23	Margin of bract and bracteoles	Mb & b	0=ciliated; 1= entire
24	Flower color	Fc	0= purple; 1=yellow
25	Calyx type	Cat	0= two-lipped; 1= sub campanulate
26	Size of the calyx	Cs	0= 1cm or less; 1= longer than 1cm
27	Surface of calyx	Csur	0= glabrous; 1= hairy
28	Standard size	Ss	0= 1cm or less; 1= sometime or always exceed 1cm
29	Surface of standard	Ssr	0= glabrous both side; 1= abaxially hairy
30	Apex of standard	Sa	0= rounded; 1= other than rounded
31	Base of standard	Sb	0= truncated; 1= rounded; 2= concavely shallow
32	Callosity type	Ct	0= Lamelliform; 1= Disc; 2= Ridged
33	Wings basal claw extention	Wbce	0= horizontally; 1= vertically
34	Wing surface	Ws	0= glabrous; 1= basal margin with trichomes
35	Claw position of wing	Cpw	0= at center; 1= at side
36	Wing apex	Wa	0= rounded; 1= obtuse; 2= acute, 3= irregular
37	Base of the wings	Bw	0= cuneate; 1= truncated; 2= rounded; 3= obtuse
38	Keel shape	Ks	0= suborbicular; 1= rounded; 2= Angled; 3= Sub angled

39	Keel size	Ksz	0= less than 1cm; 1= 1cm or longer
40	Upcurved margin	Kum	0=glabrous; 1= hairy
41	Apex of keel	Ka	0=twisted; 1=untwisted
42	Keel curvature	Kc	0= at about middle; 1= slightly below middle; 2= at lower third
43	Length of basal claw of keel	Kbcl	0= below 1mm; 1= 1mm or longer
44	Length of long filament	Lfl	0= longer than tube; 1= equal or shorter than tube
45	Length of short filament	Sfl	0= longer than tube; 1= equal or shorter than tube
46	Length of basifixed anther	Bal	0= smaller than 1mm; 1= 1mm or longer anther
47	Ovary surface	Os	0= glabrous; 1= hairy; 2= only margin is hairy
48	Ovary stalk	Osl	0=sessile; 1=subsessile
49	Shape of ovary	Osh	0= oblong; 1= elliptic
50	Size of the style	Stylsz	0= 2mm; 1= 5mm; 2= 6-9mm; 3= 1cm or more
51	Surface of the style	Sstyl	0= one line of trichome; 1= two lines of trichome; 2= trichome all over
52	Style curvature	Sc	0= rounded; 1= geniculated
53	Elongation of style	Se	0= vertically elongated; 1= horizontally elongated
54	Fruit shape	Fs	0= globose; 1= other
55	Fruit inflation	Fi	0=inflated; 1= appressed
56	Fruit surface	Fsur	0= glabrous; 1= glabrescent; 2= hairy
57	Size of the fruit	Fsz	0= less than 1cm; 1= reaching 1cm or longer
58	Number of seed	Nse	0=always 2; 1= more than 2
59	Fruit exertion	Frex	0= inclusive; 1= exerted slightly; 2= about half exerted; 3= almost fully exerted

60	Fruit color	Frc	0= black; 1= non black
61	Seed shape	Ssp	0= reniform; 1= harp shaped
62	Seed size	Ssz	0= 1x1mm; 1= larger than 1x1mm
63	Seed color	Scl	0= brownish- black; 1= other than brownish-black.
64	Seed surface	Ssr	0= glabrous; 1= few numbers of hairs

Appendix 3. Vertical and horizontal distribution of *Crotalaria* in Nepal

S.n.	Species	Elevation range	Horizontal distribution
1	<i>C. acicularis</i>	225-800m	CE
2	<i>C. alata</i>	112-1750m	WCE
3	<i>C. albida</i>	150- 2700m	WCE
4	<i>C. calycina</i>	165-3450m	WCE
5	<i>C. cytisoides</i>	150-2770m	WCE
6	<i>C. humifusa</i>	160-1828m	WCE
7	<i>C. kanaii</i>	1981-2940m	WCE
8	<i>C. lejoloba</i>	1300-1900m	WCE
9	<i>C. medicaginea</i>	235-2438m	W
10	<i>C. mysorensis</i>	1000-1100m	W
11	<i>C. pallida</i>	60-1768m	WCE
12	<i>C. prostrata</i>	150-1620m	WCE
13	<i>C. quinquefolia</i>	88-200m	E
14	<i>C. sessiliflora</i>	140-3450 m	WCE
15	<i>C. spectabilis</i>	121-2286m	WCE
16	<i>C. tetragona</i>	341-1906m	WCE

Appendix 4. Comparative characteristics of the Leaf of the *Crotalaria* species.

S. N	Species name	Size	petiole length	Symmetry	Apex	Base
1	<i>C. acicularis</i>	0.5-2.2 × 0.4-1.9 cm	up to 1mm long	Asymmetric	Obtuse to rounded	Oblique
2	<i>C. albida</i>	0.6-6.1 × 0.2-1.6 cm	1-2mm	Symmetric	Obtuse and mucronate	Attenuate to cuneate
3	<i>C. alata</i>	2-7.5 × 0.8-5cm	2-4mm	Symmetric	Obtuse and mucronate	Cuneate
4	<i>C. calycina</i>	2.4-15 × 0.4-1.7cm	2-3mm	Symmetrical	Acute & mucronate or obtuse	Cuneate
5	<i>C. cytisoides</i>	3.4-10 × 1.3- 3 cm	2-4.5cm	Symmetrical	Acute and mucronate or acuminate and mucronate rarely obtuse	Cuneate to narrowly cuneate
6	<i>C. lejoloba</i>	1.7-7.3 × 0.5-2.9cm	1-4mm	Asymmetrical	Obtuse, rounded or mucronate	Cuneate or slightly oblique
7	<i>C. humifusa</i>	0.6-3.5×0.4-2.4cm	1-2mm	Symmetrical	Rounded or obtuse	Rounded to broadly cuneate
8	<i>C. kanaii</i>	0.3-2.1 × 0.3-1.7cm	1mm or short	Symmetrical	Rounded or obtuse	Cordate, rounded, truncate, oblique, or broadly cuneate
9	<i>C. medicaginea</i>	0.6-1.4 × 0.2-0.5cm	2-6mm	Symmetrical	Truncate, retuse or rounded	Cuneate
10	<i>C. mysorensis</i>	3-7 × 0.5-2cm	1-2mm	Symmetric	Rounded and mucronate	Cuneate
11	<i>C. pallida</i>	2.1-8.2 × 0.9-5.7cm	1.5-5.8cm	Symmetrical	Emarginated with short mucronation or rounded	Cuneate
12	<i>C. prostrata</i>	0.7-4.5 × 0.4-2cm	1mm or short	asymmetrical or symmetrical	Obtuse, rounded, rarely retuse	Oblique, cuneate or rounded
13	<i>C. quinquefolia</i>	3-5 × 1cm	1.5-7cm	Symmetrical	Retuse and Mucronate	Cuneate
14	<i>C. sessilifora</i>	1-11.8 × 0.3-1.5cm	1-4mm	Symmetrical	Obtuse and mucronate, acute or rounded and mucronate	Cuneate
15	<i>C. spectabilis</i>	4-15 × 1.8-7.2cm	2-6mm	Symmetrical	Rounded and mucronate, obtuse and mucronate, or acuminate & mucronate	Cuneate
16	<i>C. tetragona</i>	7.5-26× 0.5-5.6cm	2-6mm	Symmetrical	Acute	Cuneate or rounded

Appendix 5. Comparative characteristics of the stipule

S. N	Name of species	P/A	shape	Size	Orientation	Base	margin	apex	persistent/not
1	<i>C. acicularis</i>	P	Lanceolate	1.5-3 × 0.5-1mm	Reflexed	Rounded or cuneate	Ciliated	Acute	Persistent
2	<i>C. albida</i>	A	–	–	–	–	–	–	Persistent
3	<i>C. alata</i>	P	Elongated-linear	2.5-10 × 0.1-0.8cm	Attached wholly sidewise to stem	Rounded or cuneate	Entire	Acute	Persistent
4	<i>C. calycina</i>	P	Filiform, linear to narrowly lanceolate	35×0.5-1mm	Inclined	Truncate	Ciliated	Acute	Caducous
5	<i>C. cytisoides</i>	P	Subulate	1.5-3.5mm	Appressed	Truncate	Entire	Acute	Persistent
6	<i>C. ferruginea</i>	P	Broadly lanceolate with one side incurved	4-12 × 2-4.5mm	Divergent	Truncate	Ciliated	Acuminate	Persistent
7	<i>C. humifusa</i>	P	Subulate	2-4.5 × 0.5mm	Divergent or recurved	Truncate	Ciliated	Acute	Persistent
8	<i>C. kanaii</i>	P	Triangular-filiform	1-2×0.25mm	Divergent	Truncate	Ciliated	Acute	Persistent
9	<i>C. medicaginea</i>	P	Filiform	1-3mm	Inclined	–	–	–	Persistent
10	<i>C. mysorensis</i>	P	Linear-lanceolate	1-2.3× 0.2-0.4cm	–	Rounded	Ciliated	Acute	Persistent
11	<i>C. pallida</i>	P	Triangular	c.1-1.5 × 0.5mm	Divergent	Truncate	Ciliated	Acute	Caducous
12	<i>C. prostrata</i>	A	–	–	–	–	–	–	–
13	<i>C. quinquefolia</i>	P	Narrowly triangular	1-4 × 0.5mm	Reflexed	Truncate	Ciliated	Narrowly acute	Persistent
14	<i>C. sessilifora</i>	P	Linear	2-6mm	Appressed	Truncate	Ciliated	Acute	Persistent
15	<i>C. spectabilis</i>	P	Triangular or lance-ovate	3-10× 2-7mm	Divergent	Truncate	Entire	Acute	Persistent
16	<i>C. tetragona</i>	P	Linear	2-4 × 0.5mm	Appressed	Truncate	Ciliated	Acute	persistent

Appendix 6. Comparative characteristics of the inflorescence and flower

S..N	Species	No of flower	Length	flower arrangement	Position	Flower color	Flower Size
1	<i>C. acicularis</i>	2 to 11	2.3-5.5cm	Lax	Terminal or leaf-opposed	Yellow	3-6 ×4-5mm
2	<i>C. albida</i>	Many (2-34)	2.5- 24 cm	Lax	Terminal	Yellow	6-8 ×7-9mm
3	<i>C. alata</i>	2 to 8	1.5 to 10cm	Very lax	Internodal	Yellow	1.4-1.8 ×0.5 cm
4	<i>C. calycina</i>	2 to 9	1.5-8cm	Lax	Terminal or axillary	Yellow	1.5-3 ×1.1-2.5cm
5	<i>C. cytisoides</i>	7 to 41	2-21cm	Lax	Terminal, leaf-opposed or axillary	Yellow	1.3-1.7 ×0.5-0.7 cm
6	<i>C. lejoloba</i>	2 to 5	4-7cm	Very lax	Leaf-opposed	Yellow	1-1.6 ×0.5-0.7cm.
7	<i>C. humifusa</i>	2 to 8	1.5-9cm	Very lax	Leaf-opposed, terminal or solitary flowers in axil	Yellow	3-5 ×2-2.5mm
8	<i>C. kanaii</i>	1 to 2	1-1.5cm	Lax	Terminal or leaf-opposed	Yellow	7-13×6-10mm
9	<i>C. medicaginea</i>	2 to15	1.8-4.8cm	Lax	Terminal or leaf-opposed,	Yellow	5-7×4-6mm
10	<i>C. mysorensis</i>	3 to 8	up to 16cm	Lax	Terminal on stem or branches	Yellow	2× 0.5cm
11	<i>C. pallida</i>	14 to 52	18-29cm	Congested	Terminal	Yellow	1.3-1.7 ×1-1.5cm
12	<i>C. prostrata</i>	1to 7	1.2-4.7cm	Very lax	Terminal or leaf-opposed	Yellow	4-5×4mm
13	<i>C. quinquefolia</i>	4 to 26	9.5-30cm	Lax	Terminal	Yellow	1.4-2 ×1.6-2.3 cm
14	<i>C. sessilifora</i>	2 to 27	1-9.5cm	Congested	Terminal or Solitary flower in axil	purple/white	1-1.6 ×0.8-1cm
15	<i>C. spectabilis</i>	12 to 64	7.6-70cm	Very lax	Axillary or terminal	Yellow	1.2-1.8 ×1.2-2cm
16	<i>C. tetragona</i>	2 to 14	4.5-30 cm	Very lax	Terminal or leaf-opposed	Yellow	4-4.5×2.2.5cm

Appendix 7. Comparative characteristics of the calyx of the *Crotalaria* Species

S. N	Species	Type	tube length	Calyx lobe length	total length	3 abaxial lobe attach up to	2 adaxial lobe attached up to
1	<i>C. acicularis</i>	Two lipped	c. 1mm	3-5mm	4-6mm	1.5mm	2mm
2	<i>C. albida</i>	Two lipped	1-2mm	5-8mm	6-10mm	2mm	2.5-3mm
3	<i>C. alata</i>	Two lipped	c.3mm	9-13mm	12-16mm	4mm	6-6.5mm
4	<i>C. calycina</i>	Two lipped	3mm	1.7-2.7cm	2-3cm	9mm	6mm
5	<i>C. cytisoides</i>	Broadly sub campanulate	2 mm	4-6mm	6-8 mm	–	–
6	<i>C. lejoloba</i>	Two lipped	2-3mm	up to 1.3-1.5cm	up to 1.8cm	6mm	7mm
7	<i>C. humifusa</i>	Two lipped	1mm	3-5mm	4-6mm	2mm	2mm
8	<i>C. kanaii</i>	Two lipped	1-3mm	5-6mm	6-9mm long	3mm	2mm
9	<i>C. medicaginea</i>	Sub-campanulate	1-1.5mm	1.5-2.5mm	3-4mm	–	–
10	<i>C. mysorensis</i>	Two lipped	2-3mm	up to 1.2-1.3cm	up to 1.5cm	–	–
11	<i>C. pallida</i>	Sub campanulate	2-3mm	2-4mm	5-7mm	–	–
12	<i>C. prostrata</i>	Two lipped	1mm	2-4mm	3-5mm	2mm	3mm
13	<i>C. quinquefolia</i>	Sub campanulate	4mm	5-6mm	11-12mm	6mm	6-7mm
14	<i>C. sessiliflora</i>	Two lipped	2mm	0.7-1.4cm	0.9-1.6cm	4mm	5.5-7mm
15	<i>C. spectabilis</i>	Two lipped	4-5mm	8mm	1.2-1.3cm	7mm	5mm
16	<i>C. tetragona</i>	Two lipped	3-5mm	12-18mm	1.5-2.3cm	8-10mm	4-5mm

Appendix 8. Comparative characteristics of the standard petal of the *Crotalaria* species

S.N	Species	Shape	Size	Apex	Base	callosity type	basal claw length
1	<i>C. acicularis</i>	Obovate	2.5-3 × 2-2.5mm	Rounded	Truncate	Lamelliform	0.5mm
2	<i>C. albida</i>	Suborbicular to elliptic	6-7 × 6-7mm	Rounded	Slightly concave	Lamelliform type	1mm
3	<i>C. alata</i>	Obovate-orbicular	6-9 × 6-8mm	Rounded	Truncate	Lamelliformae	1mm
4	<i>C. calycina</i>	Elliptic-obovate	1.2-1.3 × 0.9-1cm	Obtuse	Truncate	Lamelliform	1mm
5	<i>C. cytisoides</i>	Suborbicular to orbicular	0.8-1.1 × 0.7-1cm	Rounded and slightly oblique	Rounded	Ridged	3mm
6	<i>C. lejoloba</i>	Broadly elliptic or obovate	8-10 × 6-7mm	Rounded	Truncate	Lamelliform	1mm
7	<i>C. humifusa</i>	Oblong-orbicular or oblong	2.5-3 × 2.5-3mm	Retuse	Rounded	Lamelliform	0.3mm
8	<i>C. kanaii</i>	Broadly ovate	9×10-11mm	Rounded	Rounded and slightly oblique	Disc shaped	1mm or short
9	<i>C. medicaginea</i>	Ovate-oblong	4-5×3mm	Obtuse	Truncate	Disc shaped	0.8-1mm
10	<i>C. mysorensis</i>	--	--	--	--	--	--
11	<i>C. pallida</i>	Orbicular, elliptic, widely elliptic or pentagonal	6-10 × 6-8mm	Rounded	Truncate	Ridged	c.2mm
12	<i>C. prostrata</i>	Suborbicular, elliptic or oblong	2.5-3×1.7-2mm	Obtuse to retuse	Truncate	Lamelliform	0.5mm or shorter
13	<i>C. quinquefolia</i>	Suborbicular	1.4-1.8 × 2-2.2cm	Emerginate	Concave	Lamelliform	3mm
14	<i>C. sessiliflora</i>	Suborbicular, oblong or obovate	6-6.5 × 4-5.5mm	Rounded	Truncate	Lamelliform	1-2mm
15	<i>C. spectabilis</i>	Suborbicular	1.1-1.9 × 1.4-2cm	Retuse	Truncate	Lamelliform	2mm
16	<i>C. tetragona</i>	Suborbicular	1.7-2.3 × 1.4-2cm	Obtuse	Rounded, with two appendages,	Lamelliformae	2mm

Appendix 9. Comparative characteristics of the wing petal of the *Crotalaria* species

S. N	Species	Shape	Size	Surface	Apex	base	basal claw length	orientation of basal claw
1	<i>C. acicularis</i>	oblong,	2 x 0.5-1mm	Glabrous	Obtuse	cuneate,	c. 0.5mm	central, vertical
2	<i>C. albida</i>	oblong,	5-6.7 x 2-3mm	Glabrous	Rounded	cuneate,	less than 1mm	central, vertical (not perfectly horizontal)
3	<i>C. alata</i>	Oblong	6-7 x 3 mm	Glabrous	Rounded	rounded,	1 mm	central, vertical
4	<i>C. calycina</i>	obovate-oblong	1.3 x 0.4cm	Glabrous	acute,	cuneate,	2mm	central, vertical
5	<i>C. cytisoides</i>	oblong, elliptic or obovate	7.5- 9 x 4-5mm	Glabrous	Rounded	cuneate,	3mm	central, vertical
6	<i>C. ferruginea</i>	Oblong	7-8 x 3mm	Glabrous	Obtuse	cuneate,	1mm	central, not perfectly horizontal
7	<i>C. humifusa</i>	Oblong	2-2.5 x 0.6-0.8mm	Glabrous	Rounded	obtuse,	0.5mm	central, vertical
8	<i>C. kanaii</i>	Oblong	6-8 x 3-4mm	Glabrous	Obtuse	curved-obtuse	1mm	central, horizontal
9	<i>C. medicaginea</i>	Oblong	3-3.5x1-1.2mm	Glabrous	Rounded	Cuneate	0.8mm	central, horizontal
10	<i>C. mysorensis</i>	—	—	—	—	—	—	—
11	<i>C. pallida</i>	oblong or lance-ovate	6-8.5 x 3mm	marginally pilose on basal part	acute,	cuneate, twisted	2mm, margin pilose	central, horizontal
12	<i>C. prostrate</i>	linear or oblong	2-3x0.4-0.7mm	Glabrous	Rounded	cuneate, oblique	0.2-0.5mm	central, vertical
13	<i>C. quinquefolia</i>	broadly oblong	1x0.8-0.9cm	glabrous	Rounded	truncate,	4mm	at extreme side, horizontal
14	<i>C. sessilifora</i>	Oblong	5-6 x 2-2.5mm	glabrous	Rounded	truncate,	1mm long	at extreme side, vertical
15	<i>C. spectabilis</i>	broadly oblong	11-12x8-9mm	Glabrous	Rounded	rounded,	4-5mm	at extreme side, horizontal
16	<i>C. tetragona</i>	broadly oblong	1.7-1.8x 0.9cm	Glabrous	Irregular	truncate	5mm	at extreme side, vertical

Appendix 10. Comparative characteristics of the keel petal of the *Crotalaria* specie

S. N	Species	Shape	Size	basal claw length	Apex	keel curvature
1	<i>C. acicularis</i>	suborbicular	3 x 1-2mm	0.3mm	twisted	at about middle with apically narrowed keel
2	<i>C. albida</i>	Rounded	6.5-7 x 3.3-4mm	0.25mm	twisted	at about middle with apically narrowed keel
3	<i>C. alata</i>	Subangled	7.5-9 x 4-5 mm	2mm	twisted	slightly below middle with apically narrowed beak
4	<i>C. calycina</i>	Angled	1.3 x 0.5cm	1mm	twisted	at about middle with apically narrowed keel
5	<i>C. cytisoides</i>	Rounded	0.8-1 x 0.5-0.7 cm	3mm long	Untwisted	at about middle with horizontally narrowed beak
6	<i>C. lejoloba</i>	Rounded	7-8 x 4.5-5mm	1mm	twisted	at about middle with apically narrowed keel
7	<i>C. humifusa</i>	Angled	2-3 x 1.5-2mm	0.3mm	slightly twisted	at about middle with apically narrowed keel
8	<i>C. kanaii</i>	suborbicular	9x5mm	1mm	twisted	at about middle with horizontally narrowed beak
9	<i>C. medicaginea</i>	Angled	4x2mm	0.1-0.2mm	twisted	at lower third with apically narrowed beak
10	<i>C. mysorensis</i>	—	—	—	—	—
11	<i>C. pallida</i>	shallowly rounded	6-9 x 4-5mm	2-2.5mm	Untwisted	at about middle with horizontally narrowed beak
12	<i>C. prostrata</i>	Rounded	2.5-3x1.5-2mm	0.1-0.2mm	twisted	at about middle with apically narrowed keel
13	<i>C. quinquefolia</i>	Rounded	1 x0.7cm	3-4mm	twisted	at about middle with horizontally narrowed beak
14	<i>C. sessilifora</i>	Rounded	5-7x 3mm	1mm	twisted	at about middle with horizontally narrowed beak
15	<i>C. spectabilis</i>	Rounded	7.5x 6mm long	4mm	twisted	at about middle with horizontally narrowed beak
16	<i>C. tetragona</i>	Rounded	1.5-1.7x1-1.3cm	1mm	twisted	at about middle with horizontally narrowed beak

Appendix 11. Comparative characteristics of the Androecium of the *Crotalaria* species

S. N	Species	filaments attach up to	Long filament length	short filament length	longer anther length	shorter anther length
1	<i>C. acicularis</i>	–	2mm long	1-1.5mm	0.2-0.3mm	Minute
2	<i>C. albida</i>	1.5-2mm	c. 3mm	c. 1.5-2mm	1mm	c. 0.5mm
3	<i>C. alata</i>	3mm	c.4mm	c. 3mm	1-1.5mm	less than 1mm
4	<i>C. calycina</i>	4mm up	8mm,	5mm	c. 2mm	0.2mm
5	<i>C. cytisoides</i>	6-7mm	5-7mm	3-4mm	1.5 mm	c. 0.5mm
6	<i>C. ferruginea</i>	3mm up	5mm	3mm	1mm	c. 0.5
7	<i>C. humifusa</i>	0.5-0.6mm up	c. 2mm	c.1mm	0.3mm	c. 0.2mm
8	<i>C. kanaii</i>	3mm up	5-6mm	4mm	1-1.5mm	c.0.5mm
9	<i>C. medicaginea</i>	1mm up	5mm	2mm	1mm	Minute
10	<i>C. mysorensis</i>	–	–	–	–	–
11	<i>C. pallida</i>	9mm up	5-6 mm long	2-3mm long	2mm	0.5mm
12	<i>C. prostrate</i>	0.6-0.8mm	1.1-1.3mm	0.6-0.8mm	0.3mm	Minute
13	<i>C. quinquefolia</i>	8mm up	7mm long	4mm long	2mm long	c. 0.4mm
14	<i>C. sessilifora</i>	2-2.5mm up	3mm long	1.5-2mm	0.5mm	0.3mm
15	<i>C. spectabilis</i>	8mm up	7-8mm	5mm	2mm long	c. 0.5mm
16	<i>C. tetragona</i>	3mm up	8-12mm	6-8mm	2-2.5mm	0.5-0.8mm

Appendix 12. Comparative characteristics of the ovary and style

S. N	Species	Shape	Size	style length	style curvature
1	<i>C. acicularis</i>	Oblong	1.5-2×0.5mm	2mm long	Geniculated and horizontal
2	<i>C. albida</i>	Oblong	2 ×1mm	6-7.5mm	Rounded and vertical
3	<i>C. alata</i>	Oblong	3 ×1 mm	7mm long	Geniculated and vertical
4	<i>C. calycina</i>	Oblong,	4mm ×2mm	0.9-1cm,	Rounded and vertical
5	<i>C. cytisoides</i>	Oblong	4-6 ×1mm	1.1- 1.3cm long	Rounded and horizontally elongated
6	<i>C. lejoloba</i>	Oblong	3-4 ×1mm	6-8mm long	Geniculated and vertically elongated
7	<i>C. humifusa</i>	Oblong	c.2 ×0.5mm	About 2mm long	Geniculated and horizontally elongated
8	<i>C. kanaii</i>	Oblong	3-4 ×1mm	8-9mm long	Rounded and elongated horizontally
9	<i>C. medicaginea</i>	Elliptic	2×1.5mm	5mm long	Geniculated and extending slightly vertically
10	<i>C. mysorensis</i>	-	-	-	-
11	<i>C. pallida</i>	Oblong	5-6 ×1mm	7-9mm long	Rounded and extended horizontally
12	<i>C. prostrate</i>	Oblong	2-3×0.5-1mm	2mm long	Geniculated and extended horizontally
13	<i>C. quinquefolia</i>	Oblong	7×1.5-2mm	10-11mm	Rounded and extended horizontally
14	<i>C. sessilifora</i>	Oblong	4×1.5mm	5mm long	Rounded and extended vertically
15	<i>C. spectabilis</i>	Oblong	5-6× 2mm	10mm long	Rounded and extended horizontally
16	<i>C. tetragona</i>	Oblong	7-8×3-4mm	16mm long	Rounded and extended slightly vertically

Appendix 13. Comparative characteristics of the fruit and seed

S. N	Species	fr shape	fr size	Inflation	Number of seed	fr exertion	fr color	seed shape	seed size
1	<i>C. acicularis</i>	Oblong	5-7 × 3-4mm	Inflated	5-10 seeded	Slightly exerted	Brown	Reniform	1 × 0.5-1mm
2	<i>C. albida</i>	Oblong	9-15 × 4mm	Inflated	4-15 seeded	Slightly exerted	Black	Reniform	1-1.5 × 1-1.5mm
3	<i>C. alata</i>	Oblong	3-5 × 1cm	Inflated	–	Fully exerted	Brown	Reniform/obliquely cordate	2-4 × 2-2.5mm
4	<i>C. calycina</i>	Oblanceolate	1.8-2 × 0.6-0.8cm	Inflated	19-36 seeded	Inclusive	Black	Harp shaped	2 × 2mm
5	<i>C. cytisoides</i>	Oblong-elliptic	2.1-3.8 × 1-1.5cm	Scarcely inflated	1-5 seeded	Fully exerted	Brown	Harp shaped	5-6 × 5mm
6	<i>C. lejoloba</i>	Oblong	1.7-3 × 0.8-1cm	Inflated	20-30 seeded	Half exerted	Black	Reniform	2.5-3 × 2-2.5mm
7	<i>C. humifusa</i>	Oblong-cylindrical	4-7 × 2-3mm	Inflated	12-19 seeded	Half exerted	Brown	Reniform	1 × 1mm
8	<i>C. kanaii</i>	–	–	–	–	–	–	–	–
9	<i>C. medicaginea</i>	Globose, with small beak	3-4 × 2-3.5mm	Inflated	2 Seeded	Half exerted	Brown	Reniform	1 × 1mm
10	<i>C. mysorensis</i>	Oblong	2.7-3 × 1.5-1.7cm	Inflated	Many seeded	Fully exerted	Dark brown	Reniform	2 × 2mm
11	<i>C. pallida</i>	Narrowly oblong	3-4 × 0.6-0.8cm	Inflated	35 seeded	Fully exerted	Golden-brown	Harp-shaped	3 × 2.5mm
12	<i>C. prostrate</i>	Oblong	1-1.6 × 0.3-0.6cm	Inflated	16-25 seeded	Fully exerted	Black	Harp-shaped	1.5 × 1mm
13	<i>C. quinquefolia</i>	Oblong	5-6.5 × 1.1-2.5cm	Inflated	26-32 seeded	Fully exerted	Golden brown	Reniform	5-6.5 × 4-5mm
14	<i>C. sessilifora</i>	Oblong	0.8-1.3 × 0.4-0.6 cm	Inflated	5-15 Seeded	Inclusive	Dark brown	Reniform	1-2 × 1-2mm
15	<i>C. spectabilis</i>	Oblong	3.3-5 × 1.3-2.2cm	Inflated	16-23 seeded	Fully exerted	Black	Harp shaped	4 × 4mm
16	<i>C. tetragona</i>	Oblong	4.5-5.5 × 1.5cm	Inflated	20-24 seeded	Almost half exerted	Brown	Harp shaped	7 × 5mm

Appendix 14. Type of vestiture of different parts of the *Crotalaria* species

S. N	Species	Stem	Leaf	Stipule	bract/bracteole	calyx	standard	Ovary	style	Fruit
1	<i>C. acicularis</i>	Pilose	Pilose	Pilose	Pilose	Pilose	Glabrous	glabrous	All over the surface	Glabrous
2	<i>C. alata</i>	Tomentose	Pubescent to tomentose	Tomentose	Tomentose	Tomentose	Glabrous	glabrous	Two lines of hairs	Glabrous
3	<i>C. albida</i>	Pubescent	Pilose	Absent	Pubescent	Pubescent	Bearded	Margin hairy	Two lines of hairs	Glabrous
4	<i>C. calycina</i>	Hirsute	Pilose	Pilose	Pubescent	Pilose	Bearded	Glabrous	One line of hairs	Glabrous
5	<i>C. cytisoides</i>	Pubescent	Puberulent	Pubescent	Pubescent	Puberulent	Bearded	Hairy	One line of hairs	Pubescent
6	<i>C. humifusa</i>	Pilose	Pilose	Pilose	Pilose	Pilose	Glabrous	glabrous	Two lines of hairs	Glabrous
7	<i>C. kanaii</i>	Pilose	Pilose	Pilose	Pilose	Pilose	Bearded	Glabrous	Two lines of hairs	Glabrous
8	<i>C. lejoloba</i>	Combination of pubescent, pilose and tomentose.	Pubescent	Pubescent	Puberulent	Pilose	Bearded	Glabrous	Two lines of hairs	Glabrous
9	<i>C. medicaginea</i>	Pubescent	Pubescent		Puberulent	Pubescent	Bearded	Hairy	All over the surface	Pubescent
10	<i>C. mysorensis</i>	–	–	–	–	–	–	–	–	–
11	<i>C. pallida</i>	Puberulent	Pubescent	Puberulent	Puberulent	Puberulent	glabrous	Hairy	One line of hairs	Glabrescent
12	<i>C. prostrata</i>	Pilose	Pubescent	Absent	Pilose	Pilose	Glabrous	Glabrous	All over the surface	Glabrous

13	<i>C. quinquefolia</i>	Puberulent	Pubescent	Pubescent	Pilose	Glabrous	Glabrous	Glabrous	Two lines of hairs	Glabrous
14	<i>C. sessiliflora</i>	Hirsute	Pubescent	Pubescent	Pilose	Pilose	Bearded	Glabrous	Two lines of hairs	Glabrous
15	<i>C. spectabilis</i>	Puberulent	Puberulent	Puberulent	Glabrous	Glabrous	Glabrous	Glabrous	Two lines of hairs	Glabrous
16	<i>C. tetragona</i>	Pubescent	Pubescent	Pubescent	Tomentose	Pubescent	Bearded	Hairy	One line of hairs	Tomentose

Appendix 15. Shape and pattern of epidermal cells of the adaxial surface of leaf

S.n	Species	shape of epidermal cell	pattern of wall
1	<i>C. acicularis</i>	Pentagonal, triangular, to slightly irregular	Straight
2	<i>C. alata</i>	Pentagonal, tetragonal, polyangular	Straight
3	<i>C. albida</i>	Irregular	Wavy
4	<i>C. calycina</i>	Irregular	Straight
5	<i>C. cytisoides</i>	Variably irregular	Wavy
6	<i>C. humifusa</i>	Variably irregular	Straight to slightly wavy
7	<i>C. lejoloba</i>	Irregular	Wavy
8	<i>C. paliida</i>	Tetragon or irregular	Straight to slightly wavy
9	<i>C. prostrate</i>	Variably irregular	Straight
10	<i>C. quinquefolia</i>	Variably irregular	Straight
11	<i>C. sessiliflora</i>	Pentagon, circular to irregular	Straight to slightly wavy
12	<i>C. spectabilis</i>	Irregular	Straight to slightly wavy
13	<i>C. tetragona</i>	Irregular	Wavy, undulated

Appendix 16. Stomatal index in *Crotalaria* species.

S.n	Species	Av no of S	Av no of E	SI
1	<i>C. acicularis</i>	9.75	51.875	15.82
2	<i>C. alata</i>	30.5	93.375	24.62
3	<i>C. albida</i>	40.875	55.5	42.41
4	<i>C. calycina</i>	54.5	47.375	53.5
5	<i>C. cytisoides</i>	44.25	82.125	35.01
6	<i>C. humifusa</i>	25	48	34.25
7	<i>C. lejoloba</i>	28	43.75	39.02
8	<i>C. paliida</i>	52.375	72.5	41.94
9	<i>C. prostrate</i>	46.25	93.625	33.07
10	<i>C. quinquefolia</i>	53.875	76.875	41.2
11	<i>C. sessiliflora</i>	69.125	57.625	54.54
12	<i>C. spectabilis</i>	49.75	63.25	44.03
13	<i>C. tetragona</i>	42.5	55.25	43.48

Appendix 17. Checklist.

1. *Crotalaria acicularis* Buch. -Ham. ex Benth

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

Altitude: 225-800m.

2. *Crotalaria alata* Buch. -Ham. ex D. Don

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

Altitude: 112-1750 m.

3. *Crotalaria albida* B. Heyne ex Roth

Distribution Range: Nepal (ECW), W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia, SE Asia and Australasia.

Altitude: 150- 2700m

4. *Crotalaria calycina* Schrank

Distribution Nepal: Nepal (W, C & E), W. Himalaya, E. Himalaya, Tibetan Plateau, S Asia, E. Asia, SE. Asia, Africa and Australasia.

Altitude: 165-3450m

5. *Crotalaria cytisoides* Roxb. ex-DC

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

Altitude: 150-2770m

6. *Crotalaria humifusa* Grah. ex Benth.

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

Altitude: 160-1828m

7. *Crotalaria Kanaii* H. Ohashi

Distribution Range: Nepal (E, C, & W); Endemic to Nepal

Altitude: 1981-2940m

8. *Crotalaria lejoloba* Bartl

Distribution Range: Nepal (W, C & E), W. Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia and SE Asia.

Altitude: 1300-1900m

9. *Crotalaria medicaginea* Lam

Distribution: Nepal (W), W. Himalaya, E. Himalaya, Assam-Burma, S Asia, E. Asia, SE Asia, SW Asia and Australasia.

Altitude: 235-2438m

10. *Crotalaria mysorensis* Roth

Distribution Range: Nepal (W), W Himalaya, E Himalaya, S Asia, E. Asia, SE Asia and Australasia.

Altitude: 1000-1100m

11. *Crotalaria pallida* Aiton

Distribution Range: Naturalized in Neapl (W, C &E), native range is Central to tropical America but naturalized in E Asia, S Asia, E Himalaya, SE Asia, Assam-Burma and Africa.

Altitude: 60-1768m

12. *Crotalaria Prostrata* Rottler ex Willd

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

Altitude:150-1620m

13. *Crotalaria Quinquifolia* L

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

Altitude: 88-200m

14. *Crotalaria Sessiliflora* L

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

Altitude: 140-3450 m

15. *Crotalaria Spectabilis* Roth

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

Altitude: 121-2286m

16. *Crotalaria tetragona* Roxburgh ex Andrews.

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

Altitude: 341-1906m

17. *Crotalaria micans* Link

Distribution: (Introduced in Nepal) C & E Nepal, Native of N and S America.

Altitude: 100-2735m

18. *Crotalaria Juncea* L

Distribution: (Introduced and cultivated in Nepal), Native to SE Asia to SW Asia.

Appendix 18. Photoplates

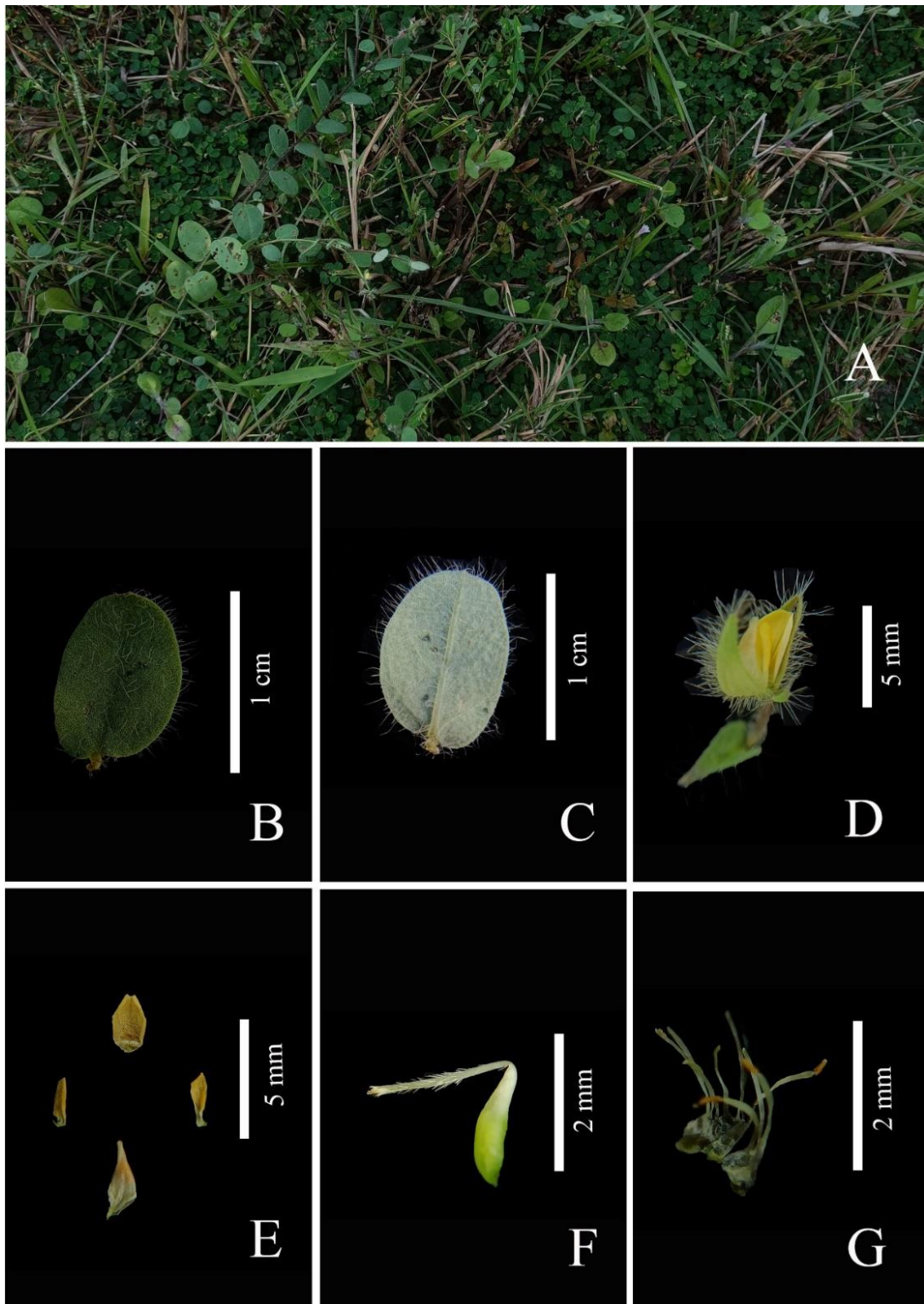
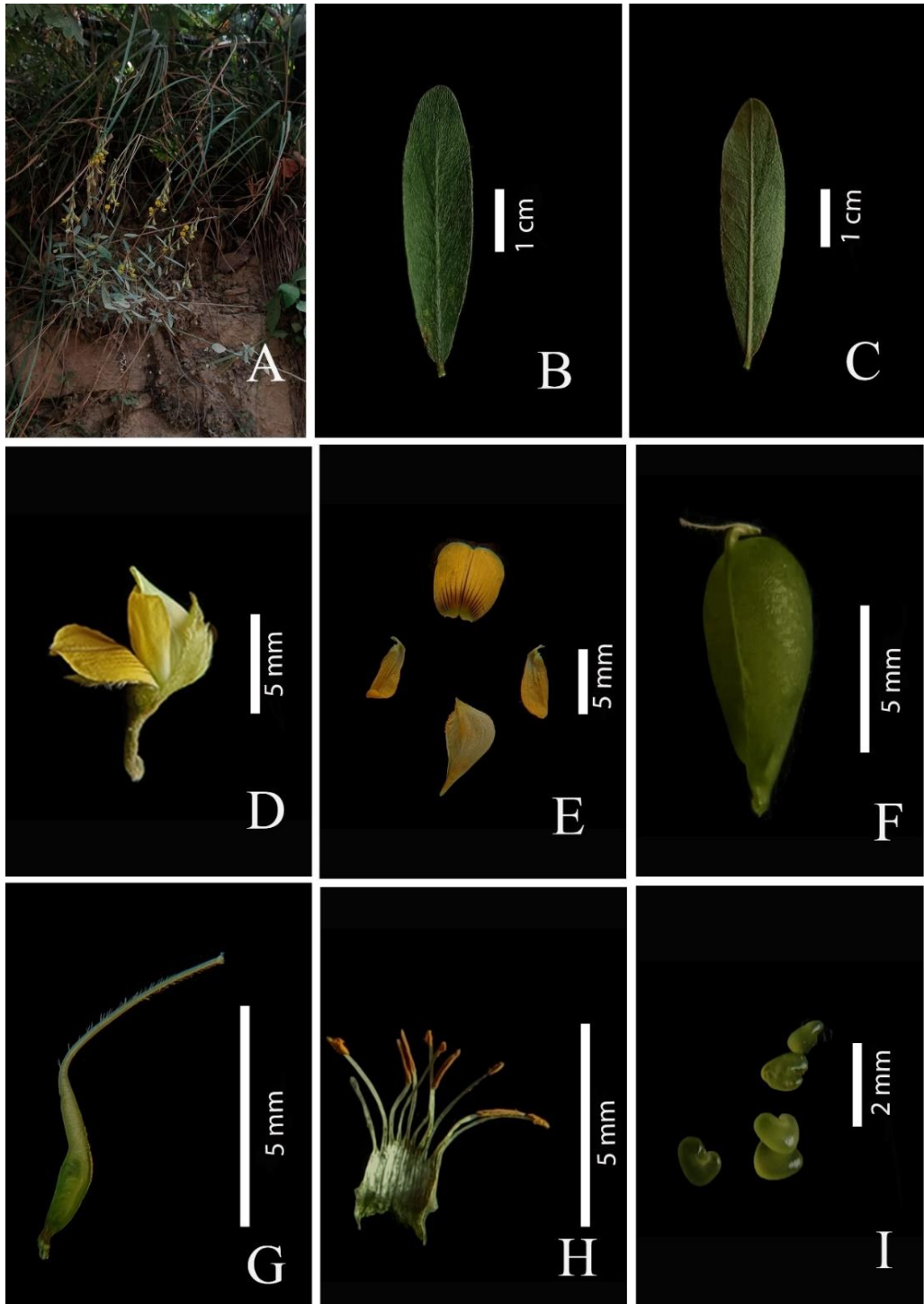


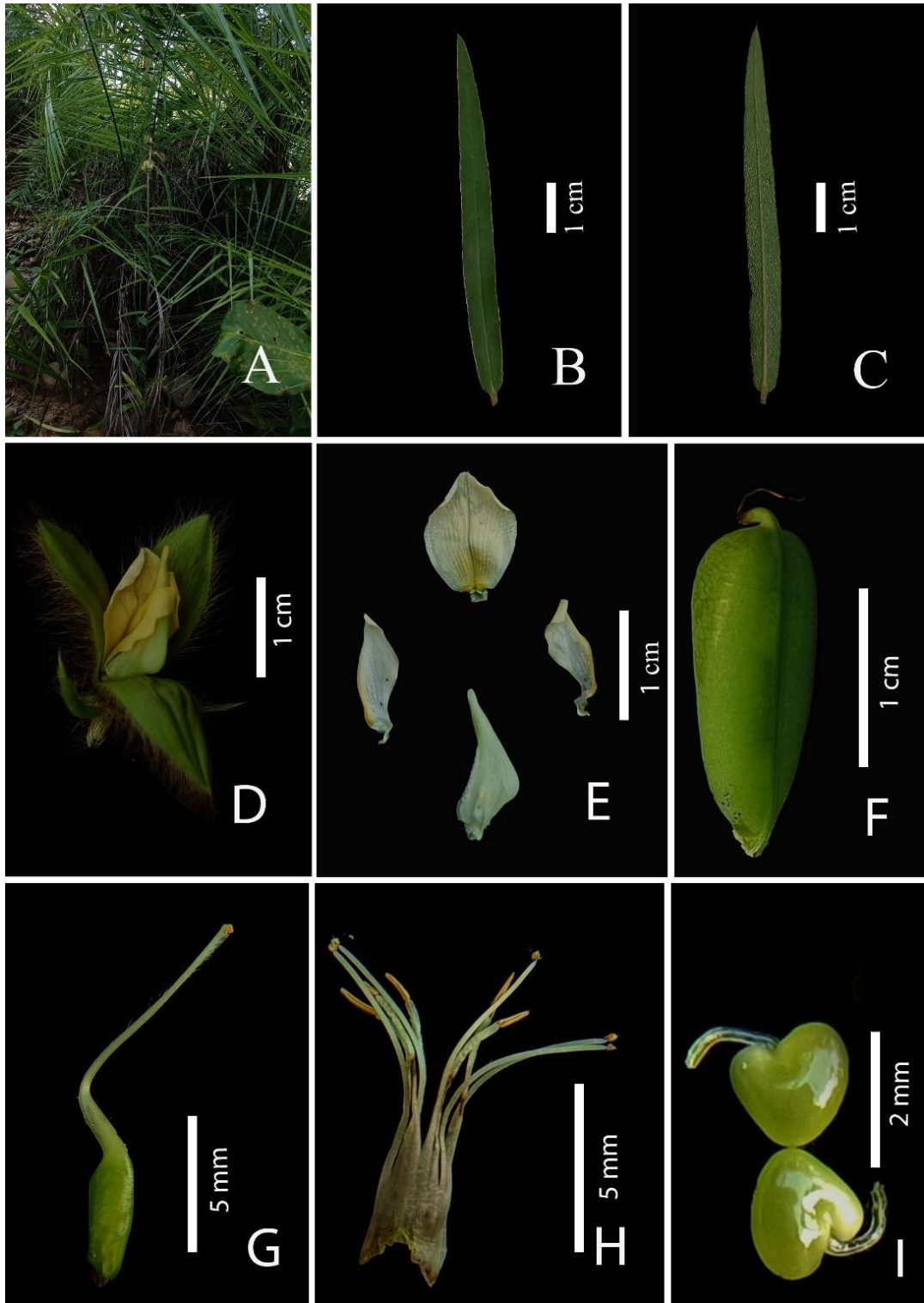
Photo plate 49: *Crotalaria acicularis*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Gynoecium; G. Androecium.



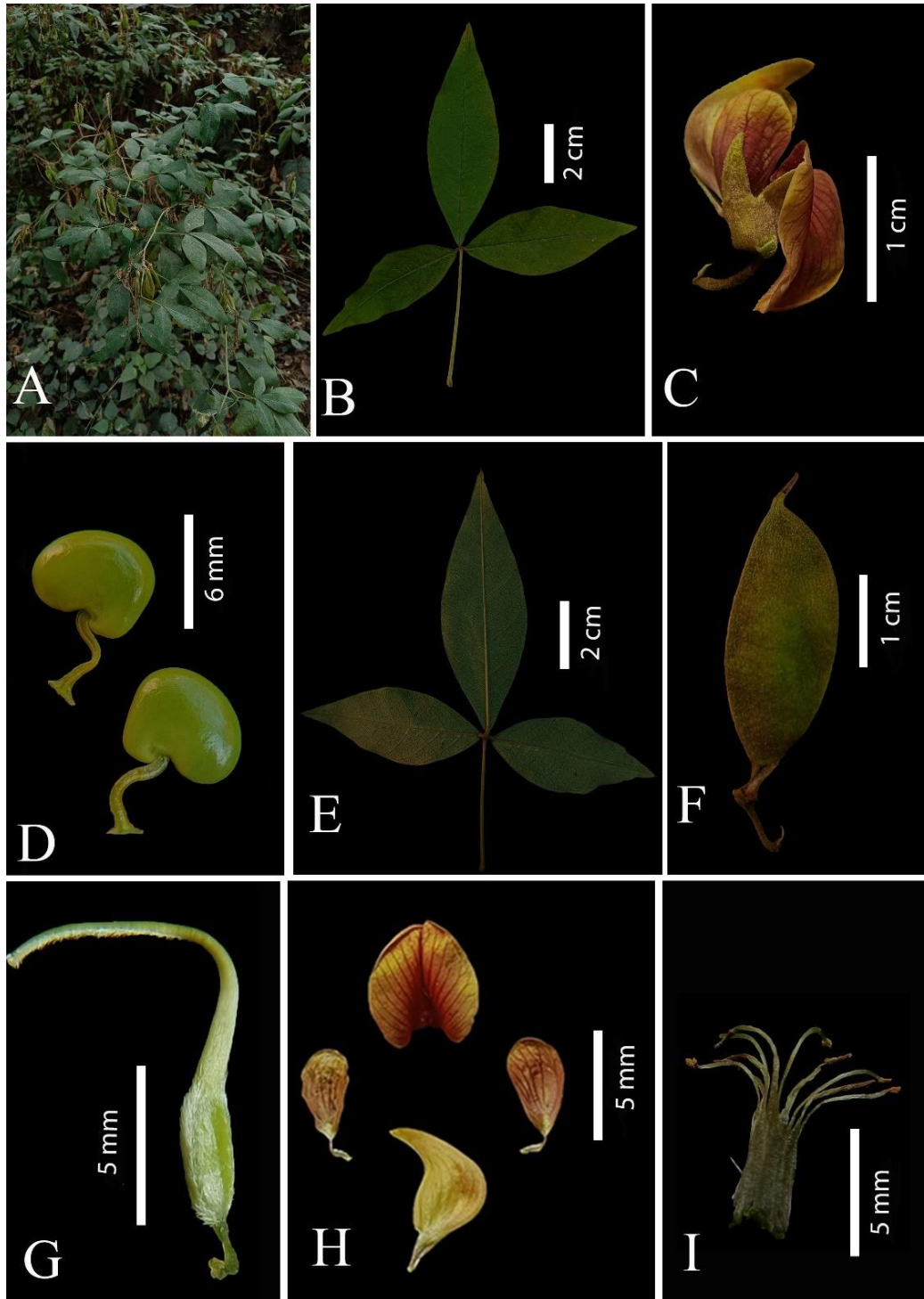
Photoplate 50: *Crotalaria alata*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



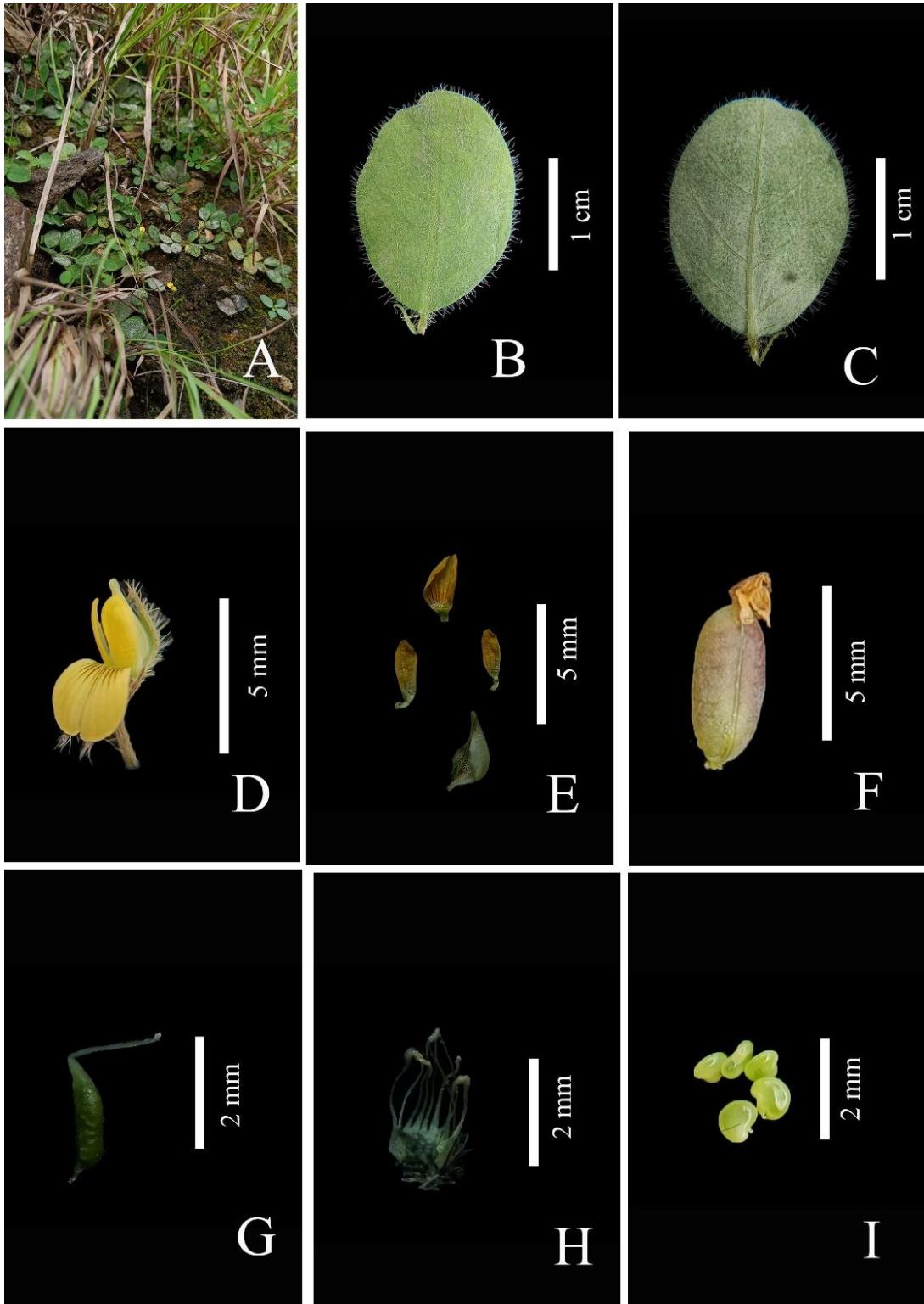
Photoplate 51: *Crotalaria albida*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



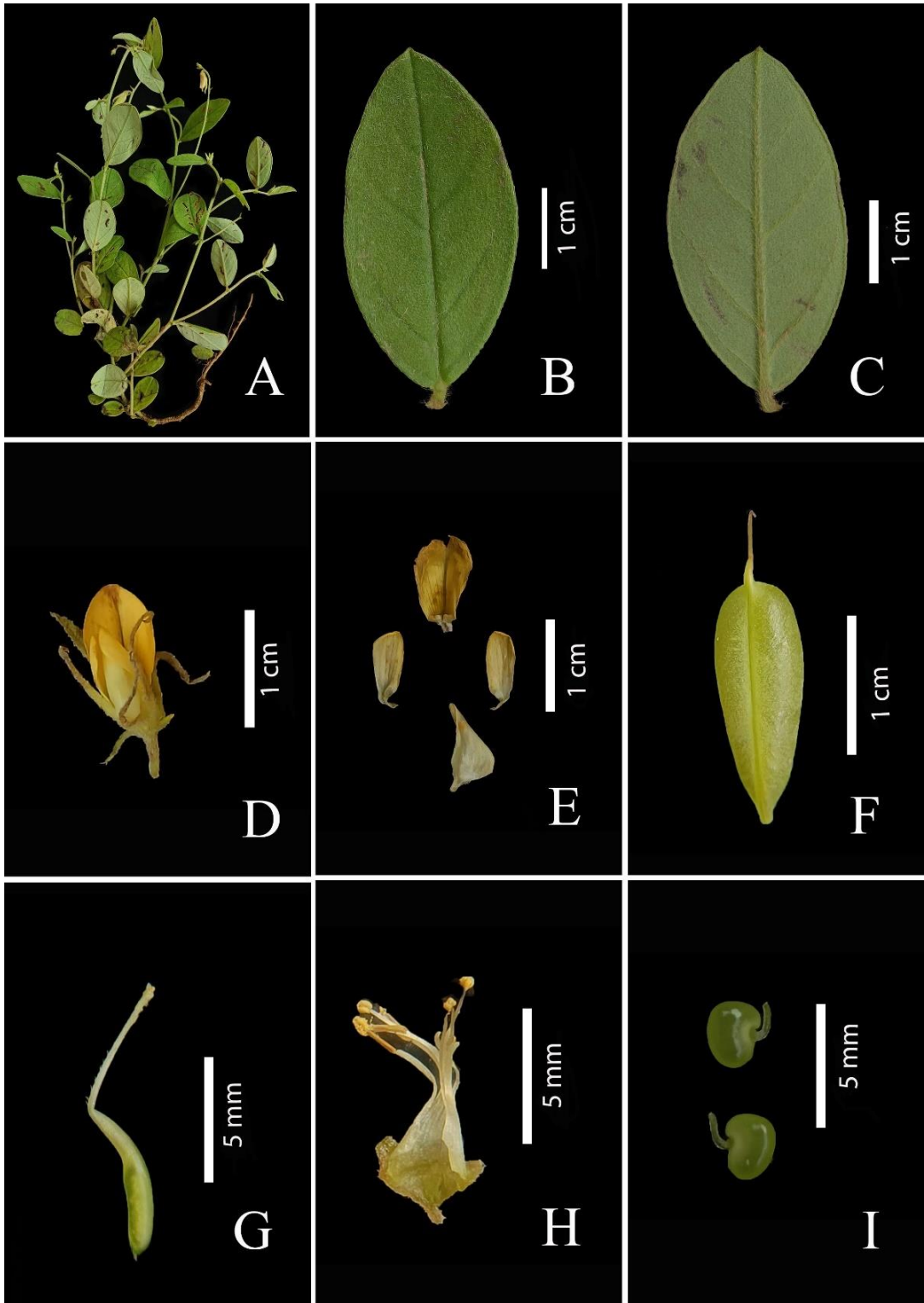
Photoplate 52: *Crotalaria calycina*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



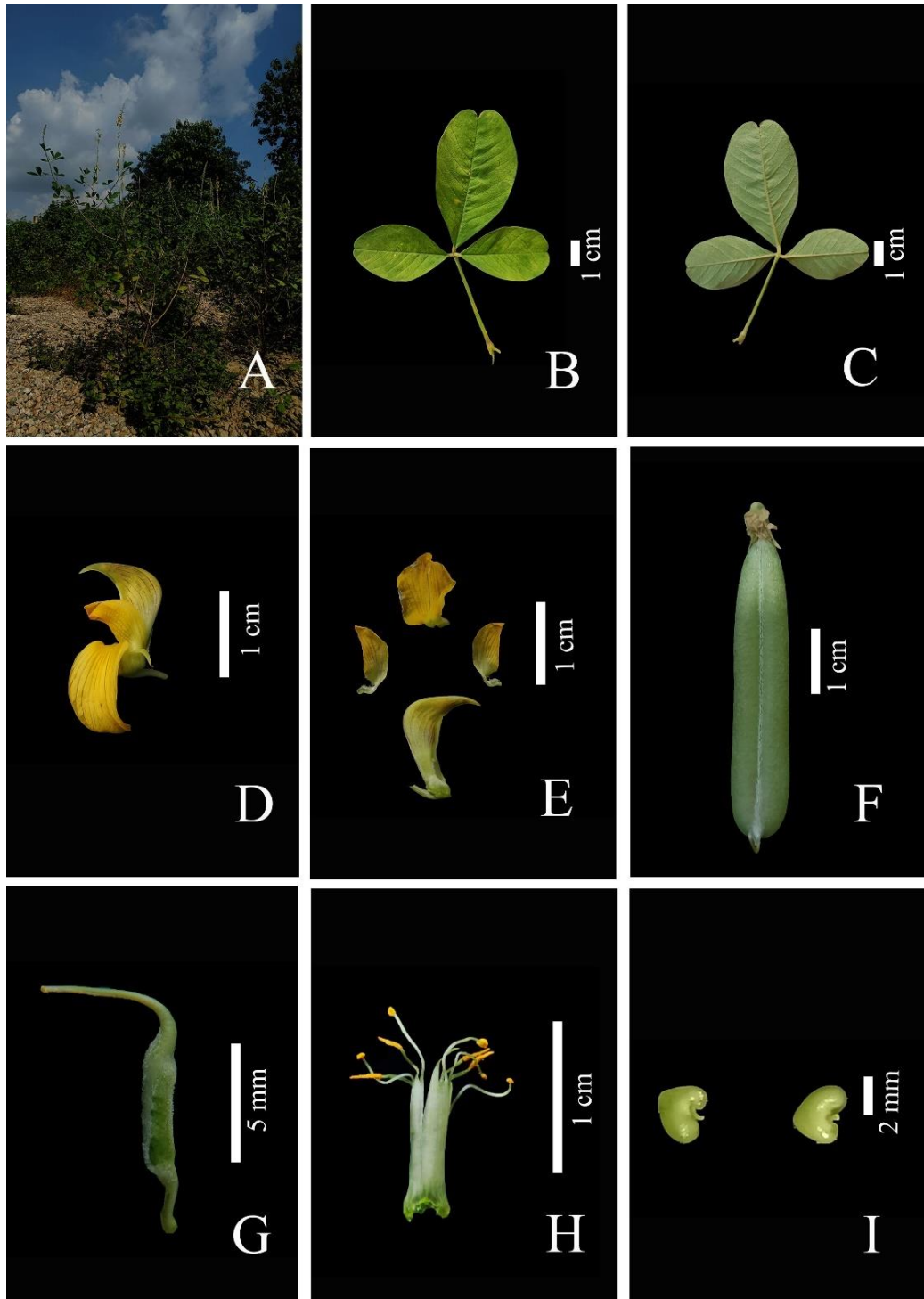
Photoplate 53: *Crotalaria Cytisoides*; A. Habit; B. Ventral surface of leaf; C. Flower; D. Seed; E. Dorsal surface of leaf; F. Fruit; G. Gynoecium; H. Petals; I. Androecium.



Photoplate 54: *Crotalaria humifusa*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



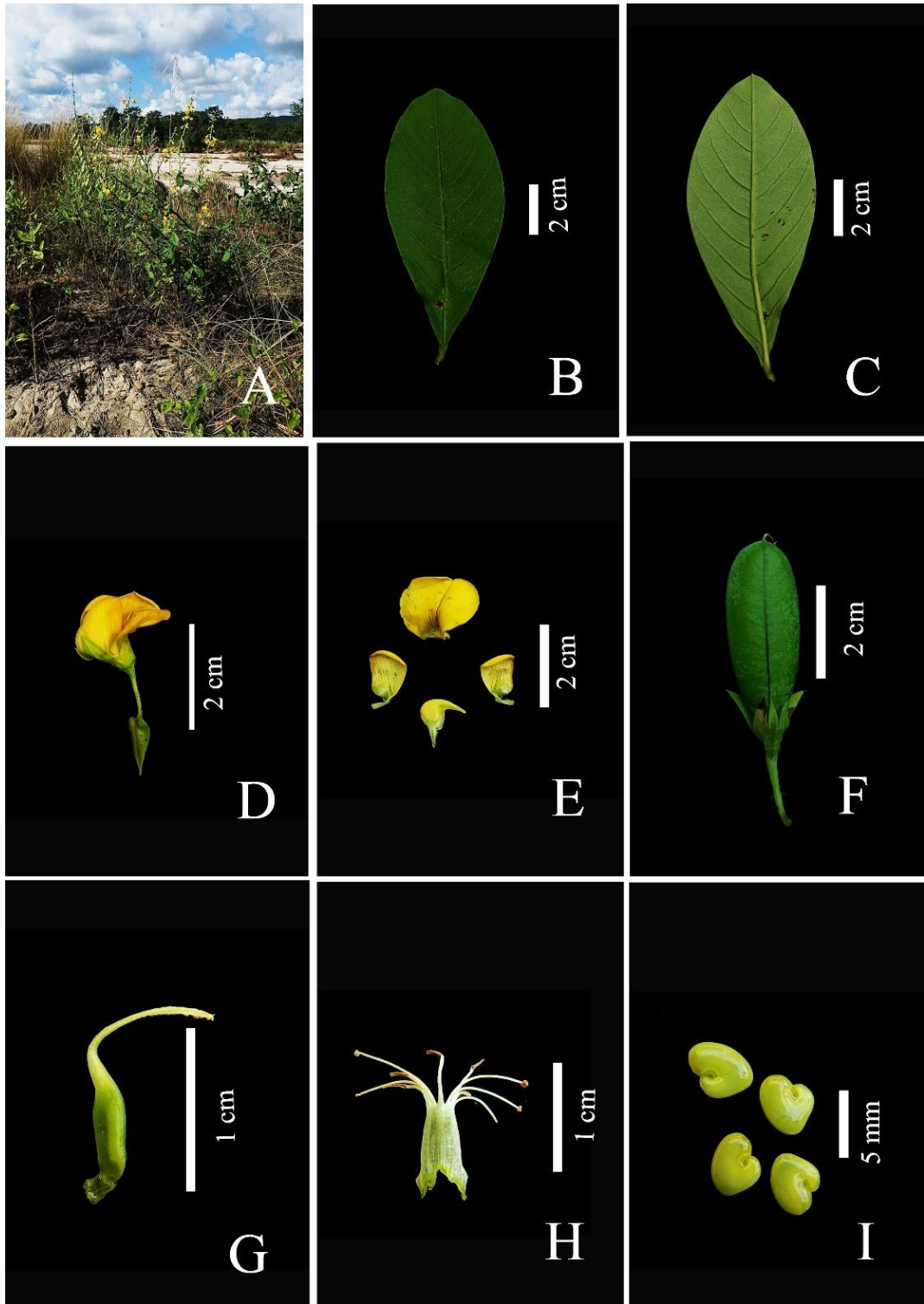
Photoplate 55: *Crotalaria lejoloba*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



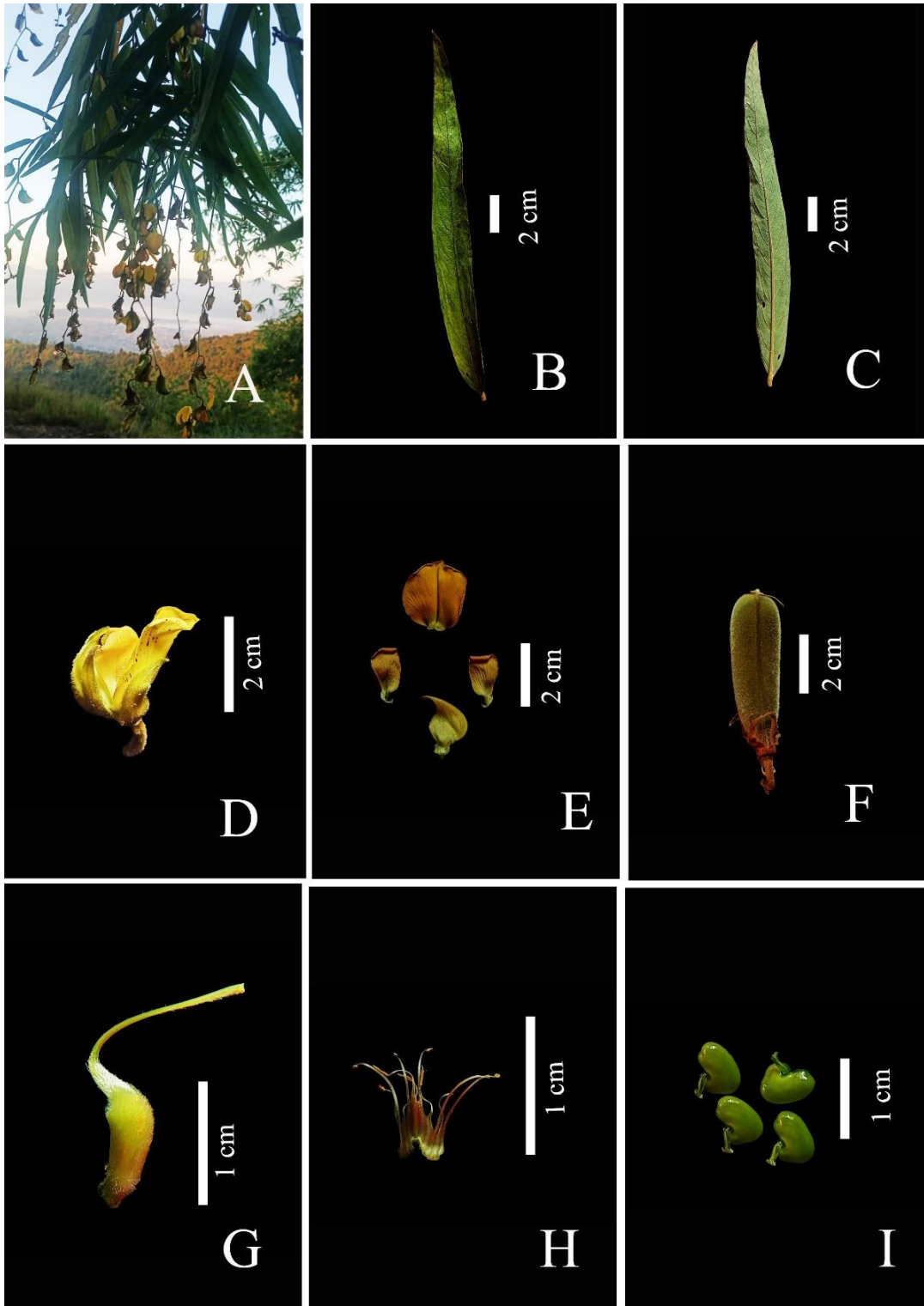
Photoplate 56: *Crotalaria pallida*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



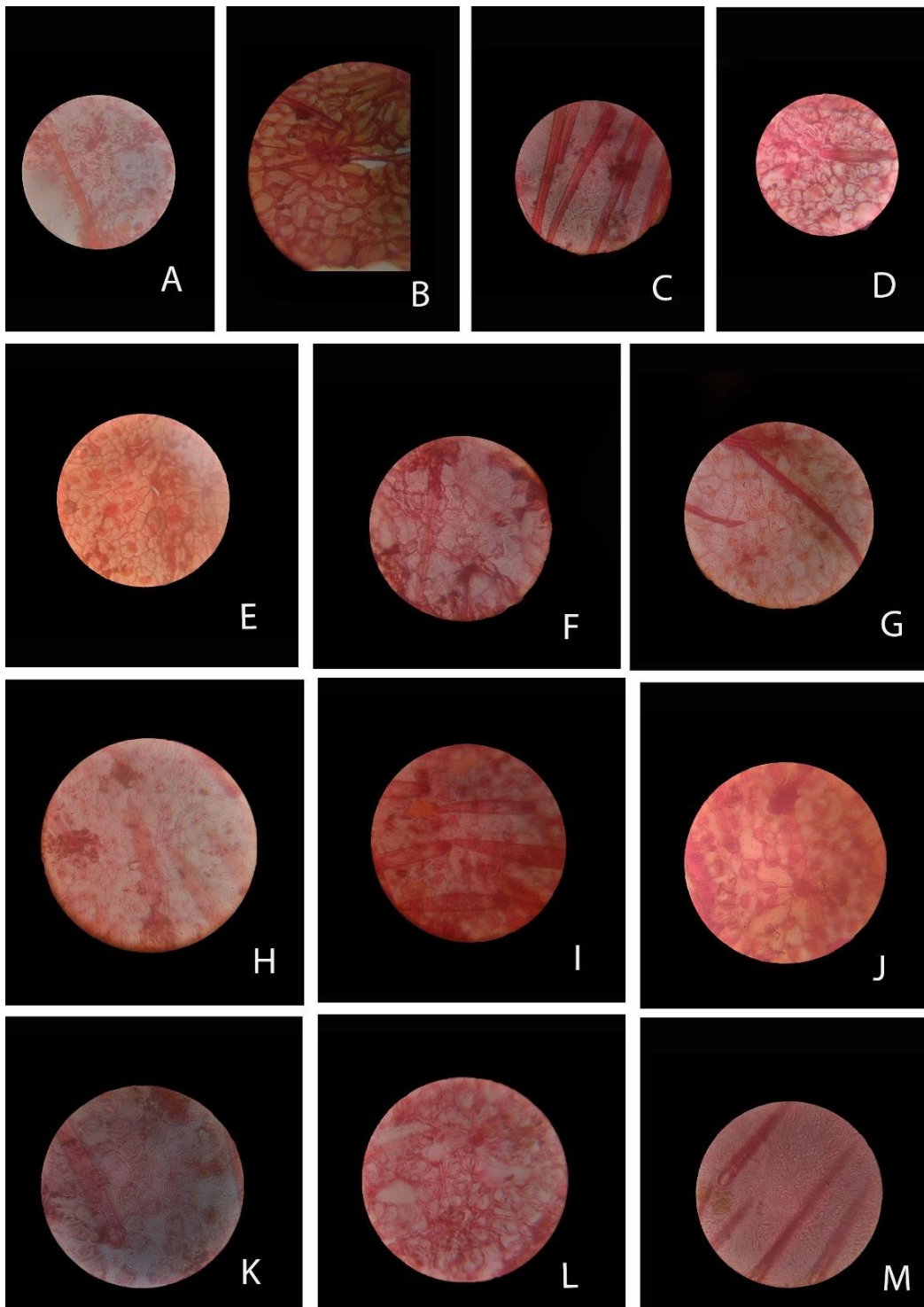
Photoplate 57: *Crotalaria sessiliflora*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



Photoplate 58: *Crotalaria Spectabilis*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



Photoplate 59: *Crotalaria tetragona*; A. Habit; B. Ventral surface of leaf; C. dorsal surface of leaf; D. Flower; E. Petals; F. Fruit; G. Gynoecium; H. Androecium; I. Seed.



Photoplate 60: Section of stomata in *Crotalaria* species: A. *C. acicularis*; B. *C. alata*; C. *C. albida*; D. *C. calycina*; E. *C. cytisoides*; F. *C. lejoloba*; G. *C. humifusa*; H. *C. pallida*; I. *C. prostrata*; J. *C. quinquefolia*; K. *C. sessiliflora*; L. *C. spectabilis*; M. *C. tetragona*.

Appendix 18. Specimens examined.

1. *Crotalaria acicularis*

Central Nepal: Dhading, Sangkosh, 800m, 17 October, 1995, M.P. Pudasaini and N. Thapa, 65/95 (KATH).

Eastern Nepal: Chirkhuakhola-Tumlingtar, 200ft, 12 November 1981, P.R. Shakya, 7421 (KATH).

2. *Crotalaria alata*:

Western Nepal: Dadeldhura, Sakail, 1100m, 5th Sep 1982, L. P. Kattel, 1104(KATH); Dadeldhura, Sakail, 1100m, 5th Sep 1982, L. P. Kattel, 1104(KATH); Bajura & Achham, Babali, Tasi, Thati, Sanfe bagar, 600-1410m, 11th Sep, 1981, M. Suzuki, H. Hatta, N. Kurosaki, M. Mikage, F. Miyamoto, K.R. Rajbhandari, H. Takayama & K. Terada, 013146 (KATH); Dang, Garhwa, 250m, 28th Aug 1982, N.P. Manandhar, & N.R. Bhattarai, 067788 (KATH); Dailekh, Tal Pokhari to Dugesar, 900m, 3rd July 1979, R. Rajbhandari & B. Roy, 2766 (KATH); Kalikot, Talaserogaon to Dahan, 1500m, 10th July 1979, K.R. Rajbhandari & B. Roy, 3149(KATH); Suklaphata to Mahendranagar, 190m, 11 Sep 1981, I. Sharma, R. Joshi, R. Uprety & I. Pandey, 5850(KATH); Kalikot, Manma, 1300m, 17th Aug 1981, N.P. Manandhar & D.P. Joshi, 8295(KATH); Kalikot, Manma, 1300m, 17th Aug 1981, N.P. Manandhar & D.P. Joshi, 8295(KATH); Rolpa, Bajabang, 730m, 3rd Sep 1982, N.P. Manandhar & M.R. Bhattarai, 8750(KATH); Marma Khola, 2500ft, 18th Oct 1952, O. Polinin, W.R. Sykes & L.H.J. Williams, 5850(KATH); Dailekh, Tal pokhari to Dugesar, 900m, 3rd July 1979, 2766(KATH); Rolpa, Bajabang, 730m, 3rd Sep 1982, N.P. Manandhar & N.K Bhattarai, 8750(KATH); Marma Khola, 3500ft, 24th Aug 1952, O. Polunin, W.R. Sykes & L.H.J. Williams, 572(KATH); Salyan, Jimali, 950m, 17th Aug 1979, K.R. Rajbhandari & B. Roy; Dadeldhura, Sakail, 1100m, 5th Sep 1982, L. P. Kattel, 1104(KATH);

Central Nepal: Gorkha, Khanchok to Arughat, 910m, 23rd July 2008, H. Ikeda, T. Kawahara, 20815007(KATH); Gorkha, Khanchok to Arughat, 500m, 23rd July 2008, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi & S.K. Acharya, 20816014(KATH); Myagdi & Baglung, Beni, Ramechour, Baglung, Below Baglung, 820-960m, 24th Sep 1996, M. Mikage, R. Hirano, A. Takahashi & K. Yonekura,

6576(KATH); Dolakha, Kirantichhap, 1200m, 20th Aug 1977, K.R. Rajbhandari & B. Roy, 2326(KATH); Dolakha, Nagdaha to Thotneri, 1500m, 3rd Aug 1977, K.R. Rajbhandari & B. Roy, 2035(KATH); Dolakha, Nagdaha to Thotneri, 1500m, 3rd Aug 1977, K.R. Rajbhandari & B. Roy, 2035(KATH); Dhading, Aadamara, 700m, 19th June 1986, N.P. Manandhar & L.P. Kattel, 10557(KATH); Kabhreplanchok, Bokse Community forest, Panchkhal V.D.C, 21st July 2001, 1084(KATH); Dhading, Tarke, 1170m, 21st June 1986, N.P. Manandhar & L.P. Kattel, 10659(KATH); Rasuwa, Betrabati, 715m, 28th Sep 1977, N.P. Manandhar & Party, 344(KATH); Near panchkhal, 3000ft, 8th Sep 1964, Dr. Peanery, T.B. Shrestha, A.V. Upadhyaya, 2510(KATH); Chitwan, Sauraha, 350m, 8th Aug 1992, N. Joshi & I. Shrestha, 327(KATH); Kabhreplanchok, Karketar community forest, Baluwa V.D.C. 20th July 2002, S.R. Baral & P.P. Kurmi, 1268(KATH); Kabhreplanchok, Dumreghari leasehold forest, baluwa V.D.C, 22nd July 2001, S.R. Barai, 1138(KATH); Kabhreplanchok, Dhotra, Panchkhal V.D.C. Ward No. 9, 18th July 2002, S.R. Barai & P.P. Kurmi, 1228(KATH), Makwanpur, Anti, 750m, 12th Nov 1989, N.P. Manandhar, 13327 (KATH); Dolakha, Nagdaha to Thotneri, 1500m, 3rd Aug 1977, K.R. Rajbhandari & B. Roy, 2035(KATH); Churiya hill, 2200ft, 23rd Aug 1967, P.R. Sakya, 9346(KATH); Dhading, Birjet, 1620m, 4th Nov 1989, N.P. Manandhar, 12949(KATH); Dolakha, Kirantichhap, 1200m, 20th Aug 1977, K.R. Rajbhandari & B. Roy, 2326(KATH); Dhading, Majuwa, 900m, 8th Nov 1989, N.P. Manandhar, 13149(KATH); Chitwan, Jarwan, 1050m, 16th Nov 1989, N.P. Manandhar, 13942(KATH); Near Panchkhal, 3000ft, 8th Sep 1964, Dr. Banerji, T.B. Shrestha & A.V. Upadhyaya; 2510(KATH); Rapti Valley, Churiya hill, 2200ft, 23rd Aug 1967, P.R. Sakya, 9346(KATH); Dhading, Todake, 1150m, 8th Nov 1989, N.P. Manandhar, 13228(KATH); Dhading, Mathiloorbang, 870m, 19th Nov 1989, N.P. Manandhar, 14128(KATH); Chitwan, Jarwang, 1050m, 16th Nov 1989, N.P. Manandhar, 13913(KATH); Nuwakot, Hop, 1350m, 15th Nov 1979, N.P. Manandhar, 3099(KATH); Dhading, Birjet, 1620m, 4th Nov 1989, N.P. Manandhar, 1084(KATH); Chitwan, Sauraha, 350m, 8th Aug, 1992, N. Joshi, & I. Shrestha, 327(KATH); Near Pachkhal, 3000ft, 8th Sep 1964, Dr. Banerji, T.B. Shrestha, & B.V. Upadhyaya, 2510(KATH); *Chitwan*, Jarwang, 1050m 16th Nov 1989, N.P. Manandhar, 13913(KATH); *Chitwan*, Chitwan nation park, Tamor Tal, beside observation tower, 140m, 19th Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Sakya, S. Shrestha, M. Siwakoti, DNEP2 B12(KATH); Chitwan, Sauraha, Padampur, Bhawanipur, Nandan Tal, Gaide

Wildlife Jungle Camp, Padampur, 150-160m, 17th Jan 1996, K. Yoda, N. Acharya, T. Kurosawa & P. Lacoul; 9614109(KATH); Parsa, Parsa Wildlife Reserve, along Mahadev Khola, 190-200m, 9th Oct 1995, M. Mikage, T. Kajita, N. Kondo, P.R. Shakya, T. Shimizu, P. Shrestha, Y. Tsuda & K. Yonekura, 9554036 (KATH); Baglung&Myagdi, Baglung, Ratnechour, Beni, 820-960m, 1st Sep 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohrl, A. Takahashi & K. Yonekura, 9682117(KATH); Chitwan, Sauraha, 17th Jan 1996, K.Yoda, N. Acharya, T. Kurosawa & P. Lacoul, 9614109(KATH); Hedauda farm area, 2000ft, 5th Oct 1967, P.S. Jamuwal, 4609(KATH); Dolakha, Nagdaha, Malephu, GUMU Khola, 890-940m, S. Noshiro, T. Kawahara, K. Kano, B. Tian, T. Tanaka & R.K. Uprety, 572(KATH); Dolakha, Kirantichhap, 1200m, 20th Aug 1977, K.R. Rajbhandari & B. Roy, 2326(KATH); Chitwan, Sauraha, Padampur, Bhawanupur, Nandan Tal, Gaide Wildlife Jungle Camp, Padampur, 150-160m, 17th Jan 1996, K.Yoda, N. Acharya, T. Kurosawa & P. Lacoul, 9614109 (KATH).

Eastern Nepal: Chulachuli, 900ft, 21st Sep 1972, T.B. Shrestha & T.K. Bhattacharya, 72/29(KATH); Below Jimi Gaon, 2350 ft, 8th NOV 19981, P.R. Sakya, 7351(KATH); Below Khandbari, 2900ft, 22nd Sep 1981, P.R. Sakya, 6576(KATH); Dhankuta, Gholi Kharka, Panche, Dihale, Bhainse, Mongmaya Khora, Mongmaya, Ramrista, 230-1230m, 24th July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi & H. Ikeda, 9080020(KATH); Pakhribas- Diyale, 4600ft, 15th Sep 1981, P.R. Shakya, 6523(KATH); Taplejung, Dobhan, 700m, 11th Aug 1976, N.P. Manandhar, 275(KATH); Pakhribas- Diyale, 4600ft, 16th Sep 1981, P.R. Shakya, 6523(KATH); Pakhribas- Diyale, 4600ft, 16th Sep 1981, P.R. Shakya, 6523(KATH); Below Khandbari, 2900ft, 22nd Sep 1981, P.R. Sakya, 6576(KATH); Sankhuwasabha, Pikuwa, MengtewaBesi- Bumlingtar, 460-610m, 1st Sep 1997, S. Noshiro, N. Acharya, Y. Ibaragi, K. Kobayashi & T. Kurosawa; Below Jimigaon, 2350ft, 8th Nov 1981, P.R. Sakya, 7351(KATH); Sankhuwasabha, Manebanjang, Danda Pangma, Sekaha, Chipe Gaun, Bhotebaa, Gogane, Chichila, 1130-1910m, 28th July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi & H. Ikeda, 9760546(KATH); Near Bumling, 1300m, 6th June 1989, T.B. Shrestha, 207(KATH).

3. *Crotalaria albida*

Western Nepal: Kanchanpur, Suklaphata, 160m, 9th July 1982, L.P. Kattel, 756(KATH). Bardiya, Betani, BNP, 260m, 6th magh 2052, Sagun Bista, 13(KATH); Kanchanpur, Janahit Mahakali community forest, 170m, 19th Nov 2018, N. Pandey, and B.B. Thapa, JMBK23(KATH). Dadeldhura to Siling, 1730-1490m, 18th Sep 1981, I. Sharma, R. Joshi, R. Uprety and I. Pandey, 546(KATH). Dadeldhura, Sakail, 1100m, 5th Sep 1982, L.P. Kattel, 1105 (KATH); Mahendranagar, 240m, 27th march 1984, P. Pradhan, R.K. Uprety, N. Pradhan and N. Dabadi, 938(KATH). Surkhet, Hurka, 780m, 22nd Feb 1991, N.P. Manandhar, 102-91(KATH); Suklahanta, 235m, 28th March 1984, P. Pradhan, R.K. Uprety, N. Pradhan and N. Dabadi, 995 (KATH); Kanchanpur, Suklaphata, 150m, 15 April 1981, L.P. Kattel and K.J. Malla, 274 ‘A’ (KATH); Koliabas, 21 March 1973, N.P. Manandhar and party, 9798(KATH); Koliabas, 21st March 1973, N.P. Manandhar and Party, 9798 (KATH);

Central Nepal: Chitwan, Chitwan nation park buffer zone, Bis hazar tal (Twenty thousand lake), 180m, 24th Nov 2004, C. A Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP2 A112(KATH); Rasuwa, Dhunche-Grang, 2000m, 1st Aug 1995, T. Hoshino, K. Dan, H. Koba, Y.Omori, C.P. Rauniyar, M. Sato, P. Shrestha and S. Takatsuki, 9539274(KATH). Baglung, Kali Gandaki River, 2500ft, 5th Sep 1954, Stainton, Sykes and Williams, 7009(KATH); Below Hedangha, 2800ft, 11 oct 1981, P.R. Sakya, 7001(KATH); Dang, Kharepani, 600m, 10th March 1976, N.P. Manandhar and P.B. Regmi, 286(KATH); Chitwan, Chitwan national park buffer zone, Bis hazar tal (Twenty thousand lake), 180m, 24th Nov 2004, C. A Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP2 B108(KATH); Marma khola, 2500ft, 18th Oct 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 5855(KATH). Kuepani, Bheri River, 3000ft, 1st Apr 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 3794(KATH); Aghor, 7500ft, 26th Aug 1960, S.B. Malla and S.B. Rajbhandari, 63(KATH); Makwanpur, Chisapani-deurali, 6000ft, 3rd Sep 1970, T.B. Shrestha, 17356(KATH); Bhalu lare Dol, 7500ft, 5th Oct 1967, 7484(KATH); Chitwan, Tiger trip Chitwan NP (841273), 300m, 12th Dec 1975, D.P. Joshi, I. Brajacharya and R. Kayastha, 75/3499(KATH); Dumkibass to Dawonae (834294), 350m, 18th Dec 1975, D.P. Joshi, I. Bajracharya and R. Kayastha, 75/3564(KATH); *Palpa*, Hathikot (833275), 1000m, 27th Feb 1974, D.P. Joshi and M.M. Amatya, 74/1279(KATH); Makwanpur, Makaldaman, 500m, 30 Nov 1988, N.P.

Manandhar, 12598(KATH); Chitwan, Jandala, 1650m, 16th Nov 1989, N.P. Manandhar, 14003(KATH), Deurali – Kulekhani-Chitlang, 1450-1900m, 3rd Sep 1970, K. Kanaii and T.B. Shrestha, 692752(KATH); Makwanpur, Kanle, 1000m, 22nd June 1986, N.P. Manandhar and L.P. Katel, 10,780(KATH), *Chitwan*, Jarwang, 1050m, 16th Nov 1989, N.P. Manandhar, 13976(KATH); *Chitwan*, Tiger top Chitwan, 300m, 12th Dec 1975, D.P. Joshi, I. Brajacharya and R. Kayastha, 067866(KATH); *Rasuwa*, Bharkhar, 2000m, 1st Oct, 1977, N.P. Manandhar and party, 402(KATH); *Chitwan*, Sauraha, Padampur, Bhawanipur, Nandan Tal, Gaide Wildlife jungle Camp, 150-160m, 17th Jan 1996, K. Yoda, N. Acharya, T. Kurosawa and P. Lacoul, 9614105(KATH); Lalitpur, Godawari, Camp site, Phulchoki, 1540-2130m, 3rd Oct 1995, M. Mikagr, T. Shhimizu and K. Yonekura, 9552632(KATH); Ramechhap, Bhandar-Deurali-Shivalaya, 1800-2000m, 3rd Sep 1997, M. Wakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki 9715314(KATH); Makwanpur, West of Hetauda, Saraswati forest above Laxminarayan Temple, 700m, 27th Nov 2004, C.A. Pendry, K.K Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNWP2 B136(KATH); Chisapani Deorali, 6000ft, 3rd Sep 1970, T.B. Shrestha, 17356(KATH); Palpa, Pravash, 890m, 5th Jan 2014, N. Joshi, 020709 (KATH); Jural to Gainladi, 5400 ft, 24th Apr 1965, T.B. Shrestha, 4015 (KATH); Ramechhap, Bhandar, Deurali, Khasrubus, Ahivalaya, 1800-2700m, 6th Aug 1985, H. Ohba, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8530801 (KATH); Ramechhap, Shivalaya, Khasrubus, Deolari, Bhandar 1800-2700m, 17th Aug 1985, H. Ohba, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 61367 (KATH); Nigale, 5500ft, 11th Sep 1964, Dr. B.H. Shrestha and H. Upadhyaya; 2624 (KATH); Nigale, 5500ft, 11th Sep 1964, Dr. B.H. Shrestha and H. Upadhyaya; 2624 (KATH); Ramechhap, Sibalaya, Sanmadara, Gatekhora, Bandar, 1725-2425m, 19th July 1995, 9596048 (KATH); Sindhupalchok, Sherpa gaon, 2364m, 17th Sep 2011, M.F. Walson, C.A. Pendry, D.A. Gray, R.S. Dani and N. Phuyal, EKSIN 252(KATH); Dadeldhura, Puilekh, 1500m, 27th Dec 1980, L.P. Kattel, 153(KATH); Kunja to Sette, 6500ft, 4th Sharwan 2014, Dr. Banerjee and P.R. Sakya, 5598 (KATH); Kunja to Sette, 6500ft, 4th Sharwan 2014, Dr. Banerjee and P.R. Sakya, 5598 (KATH); Dolakha, Gumu Khola, Shingathi, Suri Doban, Jamune, Jagat, 920-1120m, 14th Sep 2007, S. Noshiro, T. Kawahara, K. Kano, B. Tian, T. Tanaka and R.K. Uprety, 20720006(KATH); Khosori,

Kalinchok, 1500m, 12th Sep 1970, H. Kanai, Ch. Chuna and T. Nagano, 674770 (KATH).

Eastern Nepal: Below Hedangna,, 2800ft, 11th Oct 1981, P.R. Shakya; Below Hedangna, 2800ft, 11th Oct 1981, P.R. Shakya; 7001(KATH), Charkose jhari, 15th Oct 1993, M. Siwakoti, 627(KATH); Between Koshi and Kankaimai, Sangoon Bhanjyang, 4700ft, 2nd Oct 1972, T.B. Shrestha, and T.K. Bhattacharya, 72/369(KATH); Chisapani deorali, 6000ft, 3rd Sep 1970, T.B Shrestha, 17356(KATH); Kinja to Sethe, 6500ft, 4th Sarwan 2023, Dr. Banerhee and P.R Shakya, 5598(KATH); Dharan, Dharapani, 3500ft, 1st Oct 1972, T.B Shrestha and T.K. Bhattacharya, 72/287(KATH), Pachthar, Falainch-6, tintine, 1570m, 27th Sep 2007, K.K. Shrestha, J. Pandey, N.B. Khatri, R.M. Kunwar, K. Humain, R.M Kunwar, 0197(KATH); Sankhuwasabha, Mude, Suke, Deurali, Hururu, Chichila, Gogne, Bhotebas, 1840-2050m, 29th Aug 1998, S. Noshiro, N. Acharya, K. Kobayashi, Y. Omori, K. Shinozaki and H. Tsukaya, 9810187(KATH), Sankhuwasabha, Arun River near confluence of Barun Khola, 1250m, 14th Oct 1991, D.G. Long, R.J.D. McBeath, D.R. McKean, D.A.H. Rae, N.K. Bhattarai, 794 (KATH).

4. *Crotalaria calycina*

Western Nepal: Kaski, Gunde lake, Lekhnath, 641m, 28.166°N, 84.089°E, 9th Sep 2022, S. Dhakal & R. Magar, G12(KATH); Myagdi, Beni, Singa, Tatopani, Bholamza, Shimarchaur, Bablchor, 840-970m, 2nd Sep 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohrl, A. Takahashi & K. Yonekura, 9681034 (KATH).

Central Nepal: Dhading, Mathiloorbang, 870m, 19th Nov 1989, N.P. Manandhar, 14148(KATH); Chitwan, Kasara durbar (843274); 200m, 8th Dec 1975, D.P. Joshi, I. Bajracharya & R. Kayastha, 75/3397(KATH); Chitwan, Kasara durbar (843274); 200m, 8th Dec 1975, D.P. Joshi, I. Bajracharya & R. Kayastha, 75/3397(KATH);

Eastern Nepal: Udayapur & Khotang, Camp site, Chamling, Ghumne, Rasuwa, Dihigaon, 180-250m, 26th Oct 1995, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohrl, A. Takahashi & K. Yonekura, 9554152(KATH).

5. *Crotalaria cytisoides*:

Western Nepal: Near Pokhara, Pamdur, 5000ft, 6th Sep 1954, Stainton, Sykes & Williams, 7074(KATH); Yangjakot, 5000ft, 20th Oct 1954, Stainton, Sykes & Williams, 8969(KATH); Nr. Tilhar, 4000ft, 3rd Nov 1954, Stainton, Sykes & Williams,

9257(KATH); Manichur, Dobatechour, 6500ft, P.R. Sakya, 5921(KATH); Kaski, Tamage, Banjan, 1730-2035m, 9th Aug 1999, M. Mikage, M. Yoshimitsu, A. Kaneda, C. Mouri, S. Tatsukawa, Y. Asada, M. Senoo, 9964031(KATH); Kaski, Panchase forest, Bhadaure Tamage VDC, 2040m, 10th Aug 2014, P. Bhandari & A. Bhandari; Kaski, 1500m, 26th Sep 1982, K.R. Amatya & T. Shrestha, 9(KATH);

Central Nepal: On the way to Oyaghi, 6000ft, 26th Asoj 2022, M.M. Amatya 12758 (KATH); Near Mulkharka, 6200ft, 20th Aug 1969, S.B. Malla, 16010(KATH); Near Mulkharka, 6200ft, 20th Aug 1969, S.B. Malla, 16010(KATH); Chandragiri, 6500ft, 4th Sep 1970, T.B. Shrestha, 070924 (KATH); Nagarjun, 6000ft, 13th Sep 1962, Malla, Shrestha & Party, 3651(KATH); Chitlang, Chandragiri, Thankot, 1500-2250m, 4th Sep 1970, H. Kanai & T.B. Shrestha, 16010(KATH); South of Kathmandu, Phulchoki, 2200- 2770m, 9th Aug 1969, H. Kanai; Sim sar, Phulchoki, 8700ft, 8th Sep 1967, 7382 (KATH); Sim sar, Phulchoki, 8700ft, 8th Sep 1967, 9964031(KATH); Dobatochour, 6500ft, 27th Oct 1966, P.R. Sakya, 5921(KATH); Nagarjun, 6000ft, 31st vadau 2019, Malla, Shrestha & Party, 457(KATH); On the way to Naghi, 6000ft, 28th Aug 1969, M.M Amatya, 12759(KATH); On the way to Naghi, 6000ft, 28th Aug 1969, M.M Amatya, 12758(KATH); On the way to Naghi, 6000ft, 28th Aug 1969, M.M Amatya, 12759(KATH); Balaju, 5000ft, 31st Aug 1969, T.B. Shrestha & M.S. Bitu, 11030(KATH); On the way to Naghi, 6000ft, 16th Vadau 2026, M.M Amatya, 7074(KATH); Chandragiri, 6500ft, 4th Sep 1970, T.B. Shrestha, 8996(KATH); On the way to shivapuri top, 7000ft, 2nd Aug 1966, Dr S.B. Malla, 4861(KATH); Kathmandu, Shivapuri & Nagarjun, 6000ft, 2nd Asoj 2019, S.B. Malla & Party, 457(KATH); On the way to Shivapuri top, 7000ft, 2nd Aug 1966, Dr. S.B. Malla, 4861(KATH); About 10 km N of Bimphede on road to Kathmandu, 1700m, 29th Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha. M. Siwakoti, DNEP2 B211(KATH); Chitwan, Sauraha, Padampur, Bhawanipur, Harda Khola, 150-450m, 19th Jan 1996, M. Mikage, N. Acharya, T. Kurosawa, P. Lacoul, A. Takahashi & K. Yoda, 9611806(KATH); Lalitpur & Kabhrepalanchok, Camp site (N. ridge of Mt. Phulchoki), Ca. 1 km NW of Mt. Phulchoki, Godawari, 1540-2480m, 4th Oct 1995, M. Mikage, T. Shimizu & K. Yonekura, 9552729(KATH); Kathmandu, Shivapuri forest office, Chhap, Shivapuri Summit, 1620-2650m, 24th Aug 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M. N. Subedi & H. Ikeda; 9040356(KATH);

Kathmandu, Forest office, Chhap, Shiwapuri summit, 1620-2650m, 13th Sep 1988, M. Suzuki, T. Maeda, N. Naruhashi, R. Watanabe, M. N. Subedi, M. Minaki, S. Noshiro, H. Ikeda, 11521(KATH); Kathmandu, Forest office, Chhap, Shiwapuri summit, 1620-2650m, 13th Sep 1988, M. Suzuki, T. Maeda, N. Naruhashi, R. Watanabe, M. N. Subedi, M. Minaki, S. Noshiro, H. Ikeda, 8861059(KATH); Chitwan, Sauraha, Padampur, Bhawanipur, , Harda Khola, 150-450m, 19th Jan 1996, M. Mikage, N. Acharya, T. Kurosawa, P. Lacoul, A. Takahashi & K. Yoda, 9614206(KATH); Chitlang, Chandragiri, Thankot, 1500-2250m, 4th Sep 1970, H. Kanai & T.B. Shrestha, 7382(KATH); Nuwakot, Near Ganga bhanjyang, 2200m, 17th Nov 1979, N.P. Manandhar, 3181(KATH); Chitwan, Dhaparang, 1120m, 17th Nov 1989, N.P. Manandhar, 14055(KATH); Chitwan, Jarwang, 1050m, 16th Nov 1989, N.P. Manandhar, 13962(KATH); Makwanpur, Torke, 1590m, 1st Dec 1988, N.P. Manandhar, 12674 (KATH); Dhading, Bhimbunglek, 2000m, 2nd Dec 1988, N.P. Manandhar, 12759 (KATH); Godawari, 1500m, 1st Sep 1996, Icimod, 1196(KATH); Nuwakot, Near Ganga nhanjyang, 2200m, 17th Nov 1979, N.P. Manandhar, 3181(KATH); Tistung, Aglochuli Danda, 7500ft, 28 Sep 1966, Dr. H.S. Bista, 3651(KATH); Godawari, 1500m, 1st Sep 1996, Icimod, 1196(KATH); Godawari, 1500m, 1st Sep 1996, Icimod, 1/96(KATH); Godawari, 1500m, 1st Sep 1996, Icimod, 068059 (KATH); Aglochuci danda, Tistung, 7500ft, 28th Sep 1966, Dr. H.S. Bista, 3651(KATH);

Eastern Nepal: Panchthar, Prangbung-Goruwali Bhanjang (Bhanduke), 25th June 1992, S. Noshiro, S. Akiyama & N. Acharya, 9241082 (TI); Illam, Tumling, 600m, 27th Sep 1999.

6. *Crotalaria lejoloba*:

Western Nepal: Kaski, Deurali, Bhadaure Tamage VDC, 1500m, 10th Sep 2014, P. Bhandari & S. Budhamagar, P857 (KATH)

Central Nepal: Dakxinkali, 1300m, 15th Sep 1997, K.K. Pant. A40 (TUCH)

Eastern Nepal: Sankhuwasabha, Hatiya, Sursinkhola, Teju khola, Deurali, Hongaon, 1900m, 17th Aug 1998, S. Noshiro, N. Acharya, K. Kobayashi, Y. Omori, K. Shinozaki

& H. Tsukaya, 9810059 (KATH); Panchthar, Birwa, Yektin, below Yektin, 28th Nov 1963, H. Kanai et al, 8331452 (KATH);

7. *Crotalaria Humifusa*:

Western Nepal: Dhaulakot, 6000ft, 13th Oct 1952, O. Polunin, W.R. Sykes & L.H.J. Williams, 5617(KATH); Kanchanpur, Royal Suklaphata Wildlife Reserve, near the head quarter, Majhgaon, ca. 250m, 10th Oct 1996, M. Mikage, H. P. Acharya, K.K. Shrestha & A. Takahashi; 9689190 (KATH);

Central Nepal: Kathmandu, Taudaha, 4500ft, 31st Oct, B.F.C.S.H, 71328 (KATH); Chitwan, Sauraha, Kasara, 160-180m, 13th Jan 1996, M. Suzuki, N. Acharya, T. Kurosawa, P. Lacoul, M. Mikage, A. Takahashi & K. Yoda, 9614022 (KATH); Swayambhu, 1400m, 1st Oct 1970, N.P. Manandhar, 9835(KATH); Chitwan, Chitwan national park buffer zone, Bis hajartal (Twenty Thousand Lake), 180m, 24th Nov 2004, C.A Pendry, K.K. Shrestha, S. dahal, A. Giri, A.G. Millier, N. P andey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP2 A108 (KATH); Makwanpur, West of Hetauda, Bajhdanda-Village on ridge top in Saraswati forest above Laxminarayan Temple, 880m, 27th Nov 2004, C.A Pendry, K.K. Shrestha, S. dahal, A. Giri, A.G. Millier, N. P andey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP2 B162 (KATH); Black bridge near Jawalakhel, 9th Oct, BFC S.H, 71109 (KATH); Chitwan, Dhurba Chouki (843272), 200m, 10th Dec 1975, D.P. Joshi, I. Bajracharya & R. Kayastha, 75/3470 (KATH); Myagdi, Jugepani (Naura), Dhola khola, Murl, below Dhar, 1540m, 13th Sep 1996, M. Mikage, R. Hirano, A. Takahashi & K. Yonekura, 9682435 (KATH); Bhandarkhal, 4500ft, 27th Sep 1979, M. Gorkhalu, (KATH);

Eastern Nepal: Hurmidanda (Sedua), 1400m, 21st Sep 1971, P.R. Sakya & M. Ohasawa, 911(KATH);

8. *Crotalaria Kanaii*:

Western Nepal: *Rolpa*, Thabang VDC, Bhedakharka, 2600m, 26th Sep 2014, S.Budha Magar & B.B. Magar, 535(KATH).

Central Nepal: Aglochuci dada (Tistung), 7500ft, 28th Sep 1966, Mr. M.S. Bista, 3654 (KATH); Near Charikot, 6500ft, 14th Sep 1964, Dr. Banerji, J.B. Shrestha & A.V. Upadhyaya, 2730 (KATH);

Eastern Nepal: Solukhumbu, Takisindu-Junbesi, 2600m, 1st Sep 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai & T. Komatsu, 9592553 (KATH);

9. *Crotalaria medicaginea*:

Western Nepal: Kanchanpur, Suklaphanta wildlife reserve, 24th March 1976, 35 (KATH); Mugu, Karnali valley, between Daura & Mangri, 8000ft, 25th Aug 1952, O. Polunin, W.R. Sykes & L.H.J. Williams, 3035 (KATH); Suklaphanta, 235m, 28th March 1984, P. Pradhan, R.K. Uprety, N. Pradhan & N. Dabadi, 965 (KATH); Kalikot, Kota, Sangligad, Phukgad, 810-930m, 7th Aug 1991, M. Suzuki, H. Hatta, N. Kurosaki, M. Mikage, F. Miyamoto, K.R. Rajbhandari, H. Takayama & K. Terada, 9160341 (KATH);

10. *Crotalaria mysorensis*:

Western Nepal: Sitalpati, 3500m, 29th Aug 1952, O. Polunin, W.R. Sykes & L.H.J. Williams 1257 (BM).

11. *Crotalaria paliida*:

Western Nepal: Nepalganj, 25th Oct 1972, N.P. Manandhar, 4922 (KATH); Nepalganj, Surjegaon, 17th Sep 1975, L.R. Sakya, 254(KATH); Nepaljung, 5th Aug, 1984, D.B. Khatri, 4250(KATH), Nepaljung, 600m, 25th Apr 1935, C.R.P. Rayamaji, 1771 (KATH); Dhakheri, R.N. Sukla, 3397(KATH); Koholpur, 600m, 5th Nov 1937, Bhattacharya, 3293(KATH); Rampur, 25th May 1942, T.K. Bhattacharya, 5224(KATH); Khajura, 600ft, 3rd Asoj 2032, L.R. Sharma, 274(KATH); Rambua Ghat, 2000ft, 31st Sawan 2023, Dr. Banerjee & P.R. Sakya, 5741(KATH); Brindavan, 15th July 1976, Ramola, Tarakashari & P.R Sakya, 3648(KATH); Phusre-Samguri, 13th Sep 1981, P.R Sakya, 6447(KATH); Kanchanpur, Gobariya, 350m, 4th Jan 2002, B. Pant, 280(TUCH);

Central Nepal: Hetauda forest (851293), 500m, 5th Dec 1975, D.P. Joshi, I. Brajacharya & Ramila, 75/3335 (KATH); Tamagadi, 6th Jan 1979, H.K. Sayu & B. Roy, 1026/S.R.(KATH); Chitwan, Chitwan National Park, South bank of River Rapti west of Sauraha, 140m, 22nd Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha & M. Siwakoti, DNEP2 A85(KATH); Chitwan, Chitwan National Park Buffer Zone. Bis hazartal (Twenty thousand lake), 180m, 24th Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri,

A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha & M. Siwakoti, DNEP2 A104(KATH); Makwanpur, Brindawan, 500m, 8th July 2007, M. Ghimire, 06420(KATH); Chitwan, Khagendramalli (Chitwan Jungle Lodge)- Machan Wildlife Resort, 170-250m, 22nd Jan 1996, M. Mikage, N. charya, T. Kurosawa & A. Takahashi, 9614256(KATH); Hetauda, 10th Jan 1979, H.K. Sayu & B. Roy, 1031/ S.R(KATH); Siraha, Lohan-Mirchai, 111m, 15th June 2018, K.R. Rajbhandari, S. Khatri & R. Chhetri, 65a(KATH); Phusre-Sanguri, 2950ft, 13th Sep 1981, P.R. Shakya, 6447(KATH);

Eastern Nepal: Siraha, 17th Feb 1971, N.P. Manandhar, 17034 (KATH); Chatar, 9th May 1938, P.M. Sukla, 4027(KATH); Dharan to Sangari, 3000ft, 11th July 1971, T.B. Shrestha & D.P. Joshi, 11(KATH); Sunsari, Kushaha, Kosh tappu wildlife reserve, SW. of headquarter office, 60-65m, 21st Oct 1995, M. Mikage, T. Kajita, F. Kiuchi, N. Kondo, P. Lacoul, M. Suzuki & K. Yonekura, 9554070(KATH); Bhojpur & Dhankuta, Bastim, Mane Danda, Sano Dumma, Pokharitar, Arun River, Adherighat, Pharkushe, 270-1660m, 2nd Nov 1995, M. Mikage, T. Kajita, F. Kiuchi, N. Kondo, P. Lacoul, M. Suzuki & K. Yonekura, 9554276(KATH); Sindhuli, Ghunga, 360m, 18th May 1987, N.P. Manandhar & L.P. Katel, 11934(KATH); Sunsari, Prakashpur, 30th May 1993, P.R. Shakya, R. Manandhar & P. Shrestha, 339(KATH); Near Legua, 370m, 11th June 1977, P.R. Shakya, 4628(KATH); Dhankuta-Sankhuwasabha, Ramrista, Leguwa, Chanua, Bhaileni, Pileni, Khahare, 230-370m, 25th July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N Subedi & H. Ikeda, 9080028(KATH); Chulachuli, 1200ft, 21st Sep 1972, T.B. Shrestha & T.K. Bhattacharya, 72-57(KATH); GarhiDanra-Linkim-Tuwa, 4th Nov 1963, H. Hara, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyama, 6301486(KATH); Tarhara Tarst, 950m, 5th Oct 1972, T.B. Shrestha & T.K. Bhattacharya, 72-426(KATH); Bharomdin-Tharpu, 25th Nov 1963, H. Hara, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyama, 6301487(KATH); Sanichare-Sibganja, 11th Dec 1963, H. Hara, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyama, 6301488(KATH); Taplejung, 1768m, 8th Aug 1976, N.P. Manandhar, 236(KATH); Sindhuli, Ranibas, 400m, 23rd July 2002, R.R. Pokharel, 135(TUCH);

12. *Crotalaria prostrata*:

Western Nepal: Harpurkhola, S.E. of Bijauri, 2000ft, 25th march 1952, O. Polunin, W. R. Sykes & L.H.J. Williams, 3654 (KATH); Mahendranagar, 240m, 27th march 1984, P. Pradhan, R.K. Uprety, N. Pradhan & N. Dabadi, 928 (KATH); Mayangdikhola, 3000ft, 4th Sep 1954, Stainton, Sykes & Williams, 4135 (KATH); Naula, 960m, 13th Sep 1981, I. Sharma, R. Joshi, R. Uprety & I. Pandey, 310 (KATH); Dang, Bijauri, 680m, 20th Aug 1979, K.R. Rajnhandari & B. Roy, 4870 (KATH); Kanchanpur, Janahit Mahakali community forest, 198m, 27th Nov 2018, N. Pandey, R. Balayar & B.B. Thapa, JMBK43(KATH); Dang, Chaukiphedi, 1080m, 31st Aug 1982, N.P. Manandhar, N.K. Bhattarai, 8605 (KATH); Pyuthan, Ashurkot, 1000m, 5th Mar 1976, N.P. Manandhar, & P.M. Regmi, 176(KATH); Kanchanpur, Suklaphata, 150m, 15th Apr 1981, L.P. Kattel & K.J. Malla, 274(KATH); Gadava, 250m, 28th Aug 1982, N.P. Manandhar, & N.K. Bhatrarai, 8537 (KATH);

Central Nepal: Dhading, Birget, 1620m, 4th Nov 1989, N.P. Manandhar, 12952 (KATH); Nuwakot, Jagat, 750m, 14th Nov 1979, N.P. Manandhar, 3072 (KATH); Dhading, Todaka, 1150m, 10th Nov 1989, N.P. Manandhar, 13227 (KATH); Kabhrepalanchok, Karketar community forest, Baluwa V.D.C, 20th July 2002, S.R. Baral & P.P. Kurmi, 1267 (KATH); Kabhrepalanchok, Dhotra, Panchkhal V.D.C., Ward No. 9, 18th July 2002, S.R. Baral & P.P. Kurmi, 1216 (KATH); Kabhrepalanchok, Bokse community forest, Panchkhal V.D.C, 15th July 2001, S.R. Baral, 1028 (KATH); Makwanpur, Anti, 950m, 12th Nov 1989, N.P. Manandhar, 13328(KATH); Makwanpur, Alghe goon, 1000m, 12th Nov 1989, N.P. Manandhar, 13347(KATH);

Eastern Nepal: Irkhuwakhola, 1200ft, 11th Nov 1981, P.R. Shakya, 7410 (KATH); Sitalpati, 3500ft, 29th Aug 1952, O. Polunin, W. R. Sykes & L.H.J. Williams, 1242 (KATH); Tumlingtar, 1800ft, 15th Dec 1961, A.H. Norkett, 8076(KATH); Maivalley (Chulachuli region), 1100ft, 24thSep 1972, Lare, 72-214(KATH); Dhankuta, Baireni Bagar, Kyawakhola, Chanuwa, Leguwakhola, Legua Shibaratri, Mongmaya khola, Diyale, 260m, 1st Sep 1998, S. Noshiro, K. Kobayashi, Y. Omori, K. Shinozaki & H. Tsukaya, 9810224 (KATH); Biratnagar, 15th July 1992, 485 (KATH);

13. *Crotalaria quinquefolia*:

Eastern Nepal: Morang, Rangeli, 200m, 14th dec 1963, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyama 6301533 (KATH).

14. *Crotalaria sessiliflora*:

Western Nepal: Pokhara, Bagar, 7th Aug 1977, N.P. Manandhar, 335(KATH); Jumla, Gargiankot, 9000ft, 2nd Sep 1952, O. Polunin, W.R. Sykes & L.H.J. Williams, 3114 (KATH); Sanguri Bhanjyang, 4700ft, 2nd Oct 1972, T.B. Shrestha & T.K. Bhattacharya, 72/368 (KATH); Kalikot, Dillikot, 2220m, 26th Sep 1982, N.P. Manandhar, N.K. Bhattacharya, 9116 (KATH); Kaski, Deurali, Bhadauretamage VDC, 1500m, 10th Sep 2014, P. Bhandari & S. Budhamagar, P855(KATH); Dadeldhura, Ghanteswar, 2600m, 22nd July 1991, P.R. Shakya & D.P. Joshi, 214(KATH);

Central Nepal: Chitwan, Chitwan national park, about 1km E of Sukhibar post, beside lake, 140m, 23rd Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP 2 B99 (KATH); Makwanpur, Chainpur, 13th Nov 1989, N.P. Manandhar, 13819(KATH); Kabhreplanchok, Dapeha, 1740m, 16th Nov 1988, N.P. Manandhar, 12070 (KATH); Beni, 2800ft, 4th Sep 1954, Stainton, Sykes & Williams, 4151 (KATH); Lalitpur, Lele, 1540m, 4th Oct 1989, I. Shrestha & N. Pradhan, 50 (KATH); Royal Chitwan, Kasara (843274), 200m, 8th Dec 1975, D.P. Joshi, I. Bajracharya & R. Kayastha, 75/3450(KATH); Chitwan, Sauraha, Padampur, Bhawanipur, Nandan Tal, Gaide Wildlife jungle Camp, Padampur, 150-160m, 17th Jan 1996, K. Yoda, N. Acharya. T. Kurosawa & P. Lacoul, 9614108 (KATH); Myagdi, Jugepani (Naura), Dhola Khola, Muri, below Dhar, 1420-1820m 13th Sep 1996, M. Mikage, R. Hirano, A. Takahashi & K. Yonekura, 9682458(KATH); Myagdi, Narcheng, 1900m, Oct 1993, J.A. Friend, (KATH); Pokhara, 3500ft, 7th Sep 1954, Stainton, Sykes & Williams, 7119 (KATH); Dhading, Todake, 1150m, 8th Nov 1989, N.P. Manandhar, 13196 (KATH); Hetauda farm area, 2000m, 5th Oct 1967, Dr. Malla, 4608 (KATH); Myagdi, Jugepani(Naura), Dhola Khola, Muri, Below Dhar, 1750m, 13th Sep 1996, M. Mikage, R. Hirano, A. Takahashi & K. Yonekura, 9684157(KATH); Chitwan, Sauraha, Padampur, Bhawanipur, Harda Khola, 150-450m, 19th Jan 1996, M. Mikage, N. Acharya, T.Kurosawa, P. Lacoul, A. Takahashi & K. Yoda, 9614216 (KATH); Myagdi, Lumsung, Dhara khola, Mura, Phalalgaon, Sibang, Takum, Dharapani, Phedi, Darbang, 1450m, 22nd Sep 1996, M.Mikage, R. Hirano, A. Takahashi & K. Yonekura, 9684300 (KATH); Gothe hill (Phulchoki), 6000ft, 30th Aug 1967, Miss Manandhar & Party, 7372 (KATH); Kaski, Gunde lake, Lekhnath, 641m, 9th Sep 2022, S. Dhakal & R.

Magar, G12(KATH); Gokarna, 4400ft, 4th Nov 1966, P.Pradhan& R. Thapa, 4576(KATH);

Eastern Nepal: Taplejung, Tamur valley, Thapabu, 6000ft, 2nd Aug 1956, J.D.A. Stainton, 1186(KATH); Alauling-Sedua, 3300ft, 12th Oct 1981, P.R. Shakya, 7036 (KATH);

15. *Crotalaria spectabilis*:

Western Nepal: Khajura, 8th Sep 1973, N.P. Manandhar, 11096(KATH); Bardia, Ganga Patuwa, 600ft, 1st Sep 1939, R.N. Shukla, 5130 (KATH); Bardiya, Basata, 400ft, 6th Aug 1935, J.K. Bhattacharya, 3604 (KATH); Nepalgunj, 29th Nov 1972, N.P. Manandhar 9485 (KATH); Bardia, Ganga Paluwa, 600ft, 1st Sep 1939, R.N. Shukla, 5130(KATH);

Central Nepal: Bara, Adhabar, vicinity of Parsa wildlife reserve headquarter office, 230-250m, 8th Oct 1995, M. Mikage, T. Kajita, N. Kondo, P.R. Shakya, T. Shimizu, P. Shrestha, Y. Tsuda & K. Yonekura, 9554006 (KATH); Chitwan, Sauraha, Padampur, Bhawanipur, Harda Khola, 150-450m, 19th Jan 1996, M. Mikage, N. Acharya, T. Kuroswa, P. Lacoul, A. Takahashi & K. Yoda, 9614215(KATH); Bara, Ca. 1 km S of main entrance to Parsa wildlife reserve on road to Birgunj, 180m, 25th Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Siwakoti, DNEP 2 B120(KATH); Royal Chitwan, Madi (843274), 300m, 13th Dec 1975, D.P. Joshi, I. Bajracharya & R. Kayastha, 7513532 (KATH); Chappa Khadka, 7500ft, 13th Dec 1967, 8303 (KATH); Hetauda farm area, 2000ft, 4th Oct 1967, Dr. S.B. Malla, 4603 (KATH); Brindavan herbal farm, 2000ft, 6th Sep 2021, M.S. Bista, 3329(KATH); Chitwan, Jarwang, 1050m, 16th Nov 1989, N.P. Manandhar, 13925(KATH);

Eastern Nepal: Jhapa, Sanichare-sibganja, 11th Dec 1963, H. Hara, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyama, 6301493 (TI).

16. *Crotalaria tetragona*:

Western Nepal: Palpa, Thapadanda (Koldanda Panchayat 3), 700m, 28th Feb 1974, D.P. Joshi & M.M Amatya, 74/1139 (KATH); Tintre, N. of Dana, Kali Gandaki, 5500ft, 29th Aug 1954, Stainton, Sykes & Williams, 7551 (KATH); Palpa, Thapadanda

(Koldanda Panchayat 3), 700m, 28th Feb 1974, D.P. Joshi & M.M Amatya, 74/1339 (KATH);

Central Nepal: Myagdi & Mustang, Tatopani, Dana, Ruske Chhahra, Kopchepani, 1240m, 18th Sep 1995, M. Mikage, N. Anjiki, N. Kondo, R. Lacoul & K. Yonekura, 9550195 (KATH); Chitwan, Tungati, 380m, 15th Nov 1989, N.P. Manandhar, 13859 (KATH); Chitwan, Jandala, 1650m, 16th Nov 1989, N.P. Manandhar, 14017 (KATH); Chisapani, 800m, 22nd Aug 1982, K.J. Malla, 586(KATH);

Eastern Nepal: Bungling-IrkhuaKhola, 1120ft, 11th Nov 1981, P.R. Shakya, 7402/3 (KATH); Bungling-IrkhuaKhola, 1120ft, 11th Nov 1981, P.R. Shakya, 7402/1 (KATH); Bungling-IrkhuaKhola, 1120ft, 11th Nov 1981, P.R. Shakya, 7402/2 (KATH); Bungling-IrkhuaKhola, 1120ft, 11th Nov 1981, P.R. Shakya, 7402 (KATH);

17. *Crotalaria Micans*:

Central Nepal: Shivapuri, 1818m, 24th Oct 1992, M. Sayami, 61 (TUCH); Shivapuri, 1818m, 2nd Kartik 2049, H. Dangol, 44 (TUCH); Kirtipur, 1300m, 1st Dec 1993, 33 (TUCH); Shivapuri, 2735m, 1st Falgun 2049, S. Shrestha, 9 (TUCH); Phulchoki, 10th Sawan, 2049, M. Bajracharya, (TUCH); Panga, 21st Push 2036, D.R. Dangol, (TUCH). Chandragiri, 1550m, Bhadra 2049, Harital (TUCH). Kirtipur, 13th Oct 2049, S.K. Josi, 45 (TUCH).

Eastern Nepal: Illam, Phikkal gaon, 5000ft, 2nd Oct 1977, P. Pradhan, K.R. Rajbhandari and R. Niraula, 206 (KATH); Jhapa, Range danda, 100m, 24th Jan 2003, N. Thapa, G.D. Bhatta, S. Khatri, 2004 (KATH);