SYSTEMATIC STUDY OF THE GENUS *IPOMOEA* L. (CONVOLVULACEAE) OF NEPAL

Ipomoea nil (L.) Roth.

A DISSERTATION SUBMITTED FOR THE PARTIAL FULFILLMENT OF M.SC. DEGREE IN BOTANY (PLANT SYSTEMATICS)

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Declaration of Originality

It is declared that the dissertation entitled **"Systematic study of the genus *Ipomoea* L. (Convolvulaceae) of Nepal"** submitted for partial fulfillment of Master's Degree in Botany, to the best of my knowledge and belief, is original and my own work, except as acknowledged in the text. The material has not been submitted, either in whole or in part for a degree at this or any other university. The results obtained are in responsibility of my own risk.

April 20, 2009

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TABLE OF CONTENTS

LIST OF TABLE

LIST OF MAPS

LIST OF FIGURES

Page No.

LIST OF PLATES

ACRONYMS & ABBREVIATION

Ann. Checkl. Fl. Nep.	Annotated Checklist of Flowering Plants of Nepal.
Bull. Bot. Surv. Ind.	Bulletin of Botanical Survey of India
BM	British Museum (Natural History)
C	Central
ca.	Circa (about)
cm	Centimetre
dim.	Diameter
E	Eastern
(E)	Royal Botanical Garden Edinburgh.
EFPN	Enumeration of Flowering Plants of Nepal
et al.	And others
Fig	Figure
Fl. Bhu.	Flora of Bhutan
Fl. Brit. Ind.	Flora of British India
Fl. Ceylon.	Flora of Ceylon
F. Delhi.	Flora of Delhi
Fl. East. Himl.	Flora of Eastern Himalaya
Fl. Himl.	Flowers of Himalaya
Fl. Kath. Val.	Flora of Kathmandu Valley
Fl. Pres. Bomb.	Flora of Presidency of Bombay
F. Upper. Geng. Pl.	Flora of Upper Gigantic Plane
Gen. Pl	Genera plantarum
K	Royal Botanical Garden, Kew
KATH	National Herbarium and Plant Laboratories, Godawari, Lalitpur
m	Meter
mm	Millimetre
MO	Missouri Botanical Garden
NY	New York Botanical Garden, New York
W	Western
sp.	Species (Singular)
TUCH	Tribhuvan University Central Herbarium, Kathmandu, Nepal
var.	Variety
viz.	Videlicet (namely)

EXECUTIVE SUMMARY

The genus *Ipomoea* is a large and complex genus, commonly called by the name 'Morning glory', which comprises the largest number of species (ca. 600) within the family Convolvulaceae. The member of *Ipomoea* is widely distributed throughout the tropics and subtropics with the greatest species diversity occur in the Americas and Africa (Austin, 1997). In Nepal the genus is distributed throughout the Eastern, Central and Western region of the country with altitudinal distribution ranging from 80 to 2400m.

Out of ca. 600 species of *Ipomoea* around the world, 14 species were earlier reported from Nepal by press *et al*. (2000) with one subspecies. The present study confirmed the presence 15 species (*I. alba*, *I. aquatica, I. batatas, I. cairica, I. eriocarpa, I. hederifolia I. mauritiana, I. muricata*, *I. indica, I. nil, I. obscura, I. pes-tigridis, I. purppurea, I. quamoclit* and *I. triloba*) and one subspecies (*I. carnea* subsp. *fistulosa*). Among them two species are reported as new record for Nepal, including *I. indica* and *I. triloba*. A species which has a character similar with that of *I. aquatica* is reported as a doubtful species which require further study for confirmation.

Presence of these species in Nepal is confirmed by my own collection, thorough examination of all available literatures, herbarium specimens deposited in KATH and TUCH and images available from BM, E and MO from online journal and web-site.

Morphological characters are taken as the main basis of this study such as habit, shape and size of the leaves, shape, size and integuments of the sepals, shape and size of the corolla, number of lobes on pistil, integuments of the ovary and fruits etc. Apart from morphology, anatomical (stem and stomata), palynological and cluster analysis have also been carried out. Regarding the phenology, the flowering period of the most of the species is usually in February-October and fruiting period is in October-January. Among the studied species, *I. cairica* and *I. carnea* subsp. *fistulosa* are found to be bloom throughout the year.

The identification keys are prepared on the basis of morphological variation found among the species. The stomatal study conclude that the all the species of *Ipomoea* bear Paracytic or Rubiaceous type of stomata. The considerable variation was found in stomatal frequency, size and number of stomata among the species.

For palynoligical study, the new method applied by previous researcher was followed. Pentoporate, spheroidal or globose type of pollen grains with echinate exine pattern are found in all species of *Ipomoea*.

Some nomenclatural changes have been observed during study. The name *I. carnea* Jacq. is changed in to *I. carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy) D. F. Austin. Similarly species *I. turbinata* Lag. is now known as *I. muricata* (L.) Jacq.

Taxonomic study of the plant is very important for the country to innumerate the flora of that country, which helps to find out not only the status of plant diversity but also the economic important, status, history and distribution of plant taxa of that country. The author believes that present study helps to document and make better understanding about the genus *Ipomoea* of Nepal because there was no such kind of study was done previously in Nepal. The study was carried out in very short period of time therefore, the work on this genus should be continue in future for enumerating the whole species *Ipomoea* found in our country. It also helps to update the checklist and play a significant role in the preparation of Flora of Nepal.

Chapter 1
INTRODUCTION

1.1 Background

The systematic study includes the description, identification, nomenclature and classification of organisms. The primary goal of systematics is to reconstruct the phylogeny or evolutionary history of organism. Plant systematic is studied by acquiring, analyzing and synthesizing information about plants and plants parts (Simpson, 2006). Such study adds vital information for writing flora and provides knowledge on the status of the taxa found in any countries. The systematic work can help in updating the enumeration of plant taxa in terms of their nomenclatural changes and finding the new ranges of their distribution.

It has been estimated that approximately 250,000 species of vascular plants belonging to 428 families believed to occur on earth (Mabberley, 1997). The flowering plant (Division Magnoliophyta) consists of 392 families with 13,645 genera and 242,000 species (Judd *et al.* 1999). Koba *et al*. (1994) enumerated 6537 taxa of Angiosperms and Gymnosperms from Nepal. Recently, Press *et al*. (2000) enumerated 6500 species of flowering plants from Nepal.

The family Convolvulaceae, commonly called 'Morning glories', comprises about 55 genera and 1930 species. The record of microfossils attributed to the family is known as far back as the Eocene (40–45 million years ago; Stefanovic, 2000). *Ipomoea* with 600 species is the largest genus in the family Convolvuaceae, followed by *Convolvulus* (250 species), *Cuscuta* (150 species) and *Jacquemontia* (120 species) (Judd *et al.* 1999). Twenty-one genera and at least 750 species belonging to this family are native to the New World. The largest New World genera are *Ipomoea*, *Jacquemontia* and *Evolvulus*. Twelve genera have a single species (Austin, 1997a). In Nepal, Convolvulaceae is represented by 12 genera and 45 species (Press *et al*. 2000).

The distribution of the members of the family Convolvulaceae ranges from tropical rainforest to savannas, prairies, and deserts, although some species in Nepal also reach up to subalpine zones (e.g., *Convolvulus arvensis*) (Press *et al.* 2000). The highest species diversity is found in the America and Africa. Some genera extend around the world; others are endemic to one land mass. For example, 10 genera are endemic to the America, 13 to Africa and 10 to Asia. *Bonamia*, *Ipomoea*, *Merremia* and *Operculina* are distributed throughout the tropics (Austin, 1997a). In Nepal, the members of the family Convolvulaceae are distributed from tropical to subalpine region, with an altitudinal range of 100-4100 m (Press *et al*. 2000).

Although the family is best known in temperate regions for its weedy representatives (e.g., *Calystegia*, *Convolvulus*), many tropical species are valuable ornamentals, medicinal, and food crops. The sweet potato, *Ipomoea batatas*, is the world's second most important root crop (annual production: $>128 \times 10^9$ kg; Simpson and Ogorzaly, 1995).

1.2 Diagnostic Features of Convolvulaceae

Life-forms have been modified into low-creeping herbs or even trees (*Ipomoea* in the Americas, *Humbertia* in Madagascar; Austin, 1997b). Stems are either herbaceous or woody. Many species have twining, climbing or trailing stems, but others are erect and may reach 2-4 m high (e.g., *I. carnea* subsp. *fistulosa*) or even 5-15 m high (e.g., *I. arborescens*). Vegetative parts have milky latex that may be inconspicuous or obvious.

Leaves are alternate and commonly cordate in outline but vary to hastate, oblong, or linear. Margins are unlobed or divided into palmate or pinnate divisions. Petioles are either absent or are longer than the leaf blades and are channeled on the upper surface.

All members of the family have bisexual flowers except for the unisexual African *Cladostigma* and *Hildebrandtia* (Sebsebe & Austin, 1996). Inflorescences may be terminal, axillary or in both positions. Inflorescences vary from being solitary flowers to complex clusters derived from dichasia. From the basic 3-flowered dichasia, monochasia have arisen in several lineages.

Flowers have five free, overlapping sepals, five fused petals, five separate stamens alternating with the petals, and one pistil. Corolla shape varies from rotate, bell-shaped, and funnel-shaped to salver-shaped. Anthers dehisce longitudinally but twist into a spiral in *Merremia*, *Operculina* and their relatives. The pistil is of two carpels (3-5 in *Ipomoea* series *Pharbitis*) to produce a superior, compound ovary with the same number of locules as carpels. Styles are terminal, single, or divided apically or the full length, to produce two distinct stylar branches (e.g., *Bonamia*, *Evolvulus*). There are paired bracts or bracteoles below the flowers.

Fruits are often capsular but utricular fruits or berries also occur. Size ranges from 2-3 mm long (e.g., *Dichondra*, *Evolvulus*) to 30-40 mm long (e.g., *Maripa panamensis, Merremia discoidesperma*). Seeds vary from 1-4, through abortion and have large, curved or folded embryos. The endosperm is homogeneous and cartilaginous. Germinating seeds produce two cotyledons that are often bifid. Cotyledons emerge directly from the broken seed coat and are produced above-ground (epigeous) except in *Merremia discoidesperma* and *M. tuberosa* that are hypogeous (Austin, 1997b).

1.3 Classification of the Family

In the taxonomical studies of a plant one of the greatest difficulties is to find a proper criterion to determine which characters should be regarded as primitive and which as advanced. The same consideration applies to the family Convolvulaceae (Sengupta, 1972). Regarding the classification of the family, Bentham and Hooker (1873-1876) divided the members of the family Convolvulaceae into five tribes: Convolvuleae, Dichondreae, Nolaneae, Cresseae and Cuscuteae. Hooker (1885) studied the Indian species of Convolvulaceae and divided the family into three tribes: Convolvuleae, Cresseae and Cuscuteae.

Hallier (1893) considered pollen morphology as a part of his taxonomical study and divided the family on this basis into two main groups "Psiloconiae" and "Echinoconiae". He also considered other aspects of studies such as general morphology and anatomy of the plants in placing the genera and species in the proper position within the family. He placed Cuscuteae, Dichondreae, Dicranostyleae, Poraneae, Erycibeae and Convolvuleae under "Psiloconiae"; Ipomoeae and Argyreieae under "Echinoconiae".

The family Convolvulaceae has been divided by Peter (1897) into two subfamilies, Convolvuloideae and Cuscutoideae. Convolvuloideae is further divided into Dichondreae, Dicranostyleae, Hildebrandtieae, Argyreiinae, Convolvulinae and Erycibeae.

Ooststroom (1953) in the “Convolvulaceae of Malaysia” divided the family into two subfamilies: Cuscutoideae and Convolvuloideae. Cuscutoideae contains only one tribe Cuscuteae and one subtribe Cuscutinae. Convolvuloideae contains two tribes: Convolvuleae and Ipomoeae. The tribe Convolvuleae is again divided into six subtribes: Wilsoniinae, Dichondrinae, Dicranostylinae, Poraninae, Erycibinae, and Convolvulinae. The tribe Ipomoeae contains two subtribes, Ipomoeinae and Argyreiinae.

Porter (1959) classified the family under the order Polemoniales which is further subdivided into two sub-families, Convolvuloideae and Cuscutoideae. Engler and Diels recognized the order Tubiflorae to be Convolvulineae and family Convolvulaceae (Lawrence, 1951).

Since the 1890s most people have recognized tribes Argyreieae, Convolvuleae, Cresseae, Dichondreae, Erycibeae, Hildebrandtieae, Ipomoeeae, and Poraneae. The placement of genera in tribes, however, has changed considerably in the past 30 years as morphology of the species has become better known (Austin, 1973, Sebsebe & Austin, 1996).

Takhtajan (1986) kept the family Convolvulaceae under the order Convolvulales of the Superorder Lamianae. He also reported that the family is cosmopolitan but best developed

in tropical and subtropical region. Cronquist (1981-1988) classified the family Convolvulaceae under the order Solanales of the subclass Asteridae.

Several authors have suggested that the family most closely related to Convolvulaceae is the Solanaceae while others nominate the Polemoniaceae or Boraginaceae. A new study suggests that the Hydrophyllaceae may be closer to the Convolvulaceae than either of these (Austin, 1998). However, since few species have been examined with new genetic techniques (McDonald & Mabry 1992), the relationships remain controversial.

1.4 The Genus

The genus *Ipomoea* is a large and complex genus commonly called by the name "Morning glory" which comprises the largest number of species within the family Convolvulaceae. *Ipomoea* is usually estimated to contain ca. 600 species of climbers and shrubs in the world, which are widely distributed throughout the tropics and subtropics (Miller *et al*. 1999). Members of the genus *Ipomoea* are annual and perennial herbaceous plants, lianas, shrubs and small trees; most of the species are twining climbing plants. In Nepal, the genus comprises 15 taxa occurring in the tropical, subtropical and temperate region (Press *et al.* 2000).

The systematic status of the genus *Ipomoea* has been subjected to change from time to time. Regarding the classification of the genus *Ipomoea*, Bentham and Hooker (1873-1876) divided the genus into several subgenera; while Hallier (1893) segregated *Calonyction* and *Quamoclit* from *Ipomoea* and placed them as separate genera under the same group Ipomoeae along with the genus *Ipomoea.*

Hooker (1885) included the Indian species of *Ipomoea* under six subgenera (*Calonyction, Quamoclit, Pharbitis, Aniseia, Batatas* and *Euipomoea*). Hooker's subgenera of *Ipomoea* have been regarded as independent genera by Peter (1897). Ooststroom (1953) however, divided the genus *Ipomoea* into several sections.

Austin (1980, 1997) divided genus *Ipomoea* into three subgenera and each of these is again divided into sections, viz, subgenus *Ipomoea* into two sections, *Ipomoea* and *Pharbitis*; subgenus *Quamoclit* in to 6 sections viz. *Mina, Calonyction, Orthipomoea, Dasychaetia, Exogonium* and *Batatas* and subgenus *Eriospermum* into 5 sections, viz. *Eriospermum, Acmostemon, Poliothamnus, Xerophyta* and *Erpipomoea.*

Miller *et al.* (1999) divided the genus *Ipomoea* into three subgenera (*Ipomoea, Quamoclit* and *Eriospermum*) on the basis of Internal Transcribed Spacer (ITS) region of nuclear ribosomal DNA and sequences for three exon and two introns of the 3' end of the nuclear gene waxy.

There are relatively very few publications based on the genus *Ipomoea*. Most of the literature is based on international journal and floras. In contrast to Nepal where there is less work done on this genus, of which most of the works are confined to enumeration and local floras only.

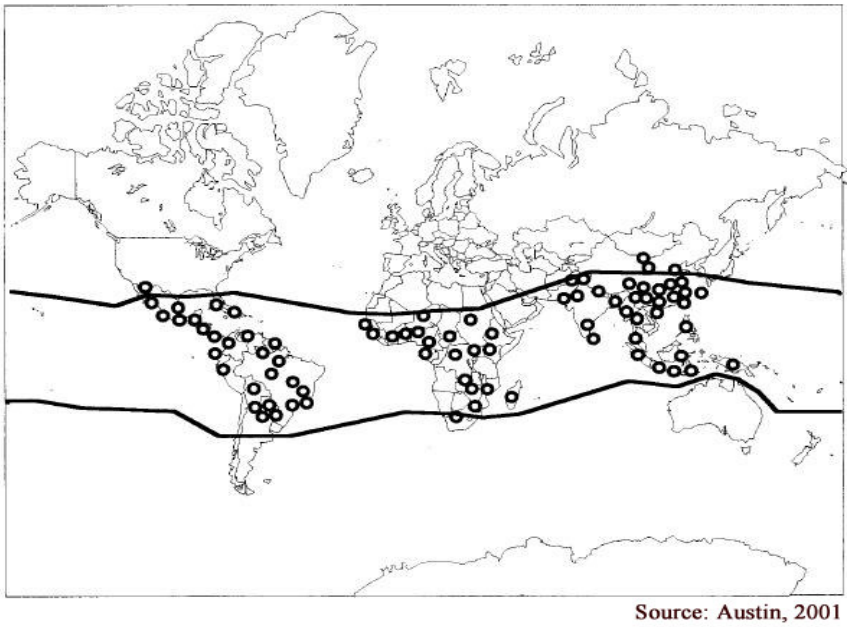


Fig.1. World wide distribution of the genus *Ipomoea* L.

Johari (1984) has recorded 27 species of the genus *Ipomoea* from Rajasthan, India of which 14 species viz. *I. aquatica, I. batatas, I. cairica, I. carnea* subsp *fistulosa, I. eriocarpa, I. hederifolia, I. indica, I. nil, I. obscura, I. pes-tigridis, I. purpurea, I. quamoclit, I. triloba and I. turbinata* are found in Nepal. The author has provided the efficiency of diagnostic description, local and English name, valid nomenclatural, phonological and ecological notes, geographical distribution and economic importance of the species. The publication is very helpful for the present study to cite the chromosome number of the different species of *Ipomoea*.

Botanical Survey of India (1893-1862) described 24 species of *Ipomoe*a from different part of the India, of which *I. eriocarpa, I. nil*, *I. obscura, I. pes-tigridis, I. alba* (as *I. bona-nox), I. batatas, I. muricata, I. purpurea, I. quamoclit* are found in Nepal.

Cooke (1905) described 21 species of *Ipomoea* from Bombay, of which five species of *Ipomoea* viz. *I. eriocarpa, I aquatica, I. obscura, I. palmata* and *I. pes-tigridis* are common in Nepal. He has provided the keys, description and distribution of the species. The study provides the good literature for identification of the species.

Burkill (1910) reported two species of *Ipomoea* viz. *I. bona-nox and I. hederacea,* from Hetuda, Nepal.

Haines (1922-1961) described 27 species of *Ipomoea* from Bihar and Orissa of India. Among 27 species, 5 species of *Ipomoea* viz*., I. pes-tigridis, I. obscura, I. carnea, I. palmata,* and *I. batatas* are common in Nepal. The topography of the Bihar is very similar to the topography of the tropical belt of Nepal so, most of the species which are found there are also common to Nepal. The author has provided the description of the species. This is good reference for the identification of the different species of *Ipomoea* that occur in Nepal.

Ridley *et* al. (1925) described 10 species of *Ipomoea* from Malay Peninsula region. Their collection was based on the tropical Asia. Among which *I. pes-tigridis* and *I. obscura* are found in tropical region of Nepal. The book has provided identification keys, description and distribution of the species.

Kanjilal *et al*. (1939) reported 10 species of *Ipomoea* from Assam, the sub-continent of India under the family Convolvulaceae, of which *I. cairica, I. purpurea, I. batatas, I. eriocarpa,* and *I. aquatica* are found in Nepal. The authors have provided identification keys and short description with synonyms of the species. This study is very helpful reference for the identification of the species.

Gamble (1957) described 24 species of *Ipomoea* from Madras, of which 3 species of *Ipomoea* viz. *I. pes-tigridis, I. cairica* and *I. obscura* are common in Nepal. He has provided the identification key with description of the species.

Duthie (1960) reported 12 species of *Ipomoea* from Gangatic plain of adjacent Siwalik and Sub Himalayan region. Among which 2 species viz. *I. obscura* and *I. pes-tigridis* are common in Nepal. He has provided the keys, description and distribution of the species. Banergi (1965) reported two species of *Ipomoea* viz. *I. eriocarpa* and *I. quamoclit* from Tamakohsi and Banepa of Nepal.

Hara (1966) recorded 8 species of *Ipomoea* from Eastern Himalaya, of which 7 sepcies viz. *I. aquatica, I. batatas, I. cairica, I. crassicaulis, I. pes-tigridis, I. purpurea* and *I. quamoclit* are found in Nepal. This study is very helpful reference for the enumeration of *Ipomoea* species in Nepal.

Patel (1968) reported 3 species of *Ipomoea* viz. *I. tropica, I. maxima* and *I. pes-tigridis* from Melghat, India, among which *I. pes-tigridis* is common in Nepal. Roxburgh (1971) described 11 species of *Ipomoea* from tropical India among them *I. muricata, I. pes-tigridis, I. aquatica* are common in Nepal. The author has provided description of the species however identification key of the species are missing.

Parker (1973) described 4 species of *Ipomoea* from Punjab and Delhi of which two species viz. *I. palmata* and *I. carnea* are found in Nepal. Trimen *et al*. (1974) described 29 species of *Ipomoea* from Ceylon, of which *I. bona-nox, I. pes-tigridis, I. obscura, I. aquatica* and *I. palmata* are common in Nepal. The authors have provided the identification keys, description of the species. However many of the species described in this study has undergone nomenclatural change. Nair (1977) reported *I. eriocarpa* and *I. purpurea* from Bashahr Himamalya which are also found in Nepal.

Hara *et al.* (1982) recorded 14 taxa of *Ipomoea*, viz. *I. alba, I. aquatica, I. arachnosperma, I. batatas, I. cairica, I. carnea* subsp. *fistulosa, I. eriocarpa, I. hederifolia, I. muricata, I. nil, I. pes-tigridis, I. purpurea, I. quamoclit and I. tuberculata* from Eastern Himalaya. The authors provided the description as well as synonyms and distribution of the species. This study is very helpful reference for the enumeration of species *Ipomoea.*

Hooker (1985) described the 57 species of *Ipomoea* from British India, under 6 subgenus (*Calonyction, Quamoclit, Pharbitis, Aniseia, Batatas* and *Euipomoea*). Among them 11 species under 5 subgenus viz. *I. bona-nox, I. muricata* under subgenus *Calonyction; I. quamoclit* under subgenus *Quamoclit; I. purpurea* under subgenus *Pharbitis; I. batatas* under subgenus *Batatas; I. pes-tigridis, I. eriocarpa, I. obscura, I. aquatica, I. pilosa* and *I. palmata* under the subgenus *Euipomoea* are common in Nepal. Many of the species described in this flora has nomenclatural change and some of the species viz. *I. unifora, I. chrysoides, I. renifromis, I. turpenthum* are classified in to another genus. This is one of the most important and valid publications about the flora of British India. This publication is very useful reference for identification and distribution of *Ipomoea* species but author miss the key of the species.

Collett (1986) discribed 6 species of *Ipomoea* from Simla of which except *I. chryscides* and *I. hederacea* all species viz., *I. pilosa*, *I. purpurea, I. muricata and I. eriocarpa* are occur in Nepal. The author has provided identification key, description and distribution of the species of *Ipomoea* on his publication.

Naithani (1990) recorded 15 species of *Ipomoea* from India, Nepal and Bhutan, of which *I. cairica, I. carnea* subsp. *fistulosa* and *I. indica* are recorded from Nepal. From the author's personal collection, the species *I. indica* are widely distributed in Nepal but not recorded in Checklist of Nepal Flora Thus the species *I. indica* may be a new record for Nepal.

Siwakoti (1995) described 10 species of *Ipomoea* from Plain region of eastern Nepal (Daran-Biratnagar Highway) viz. *I. mauritiana, I. obscura*, *I. turbinata, I. cairica, I. nil, I. aqutaica, I. eriocarpa, I. pes-tigridis, I. quamoclit, I. hederifolia* and *I. carnea* subsp. *fistulosa*. He reported *I. mauritiana* and *I. obscura* as a new record for Nepal. Author

has provided very good identification keys, description and distribution of the species. The publication is very useful reference for identification and preparation of the keys to the species.

Feng and Staples (1995) described 39 species of *Ipomoea* from China, of which 13 species and one subspecies are common in Nepal. The authors have provided the very good identification keys, description, distribution and some available notes about the species. This publication is very helpful during the identification of the most of the studied species.

Griekson *et al*. (1999) described 12 species of *Ipomoea* from Bhutan, of which 11 species are common in Nepal. The authors have provided the very good identification keys, description, distribution and citation as well. The publication is very helpful to identify the species during study.

Press *et al.* (2000) reported 15 taxa of *Ipomoea* from tropical to temperate region of Nepal viz. *I. alba, I.. auqatica, I. arachnosperma, I. batatas, I. cairica, I. carnea* subsp. *fistulosa, I. eriocarpa, I. hederifolia, I. nil, I. obscura, I. purpurea, I. quamoclit, I. turbinata* and *I. tuberculata.* The authors provided the synonyms, distribution and citation of the species. The present study is mostly based on this publication for reference on the number of species, synonyms and distribution published in it. So it is very helpful during the study.

1.5 Rationale

The detail systematic study of the genus *Ipomoea* has not been done previously in Nepal. Such study is very necessary for the country not only in enumeration and flora writing but also to know about the plants, their characters, their distribution and their economic importance.

It is expected that the present research will document further information on the status and distribution of the genus *Ipomoea* in Nepal. The study will also enable us to assess detail morphological, anatomical, palynological characters and interspecific relationship between the species of the genus *Ipomoea* found in Nepal. As such, new information on the distribution pattern, habitat and morphology could be unraveled. From the exploration of different places of the country it is believed that new records of new species, new characters and new locality will also be found during the study and also expected that the study will contribute to the flora of Nepal.

1.6 Objectives

The general objective of present study is to prepare the taxonomic treatment of the individual species of *Ipomoea* with illustration, author citation, full synonyms, description and economic use of the plants occurring in Nepal.

The specific objectives of present study include:

a) To prepare identification keys on the basis of the gross morphological characters of species found in Nepal.
b) To prepare distribution map of all species of *Ipomoea* on the basis of field visit, herbarium specimens and literatures.
c) To enumerate the taxa and update the nomenclatural changes of the taxa of the genus *Ipomoea* occurring in Nepal.
d) To study anatomical characters (stem and stomata) and pollen characters of all the available species of genus *Ipomoea.*
e) To present a cluster analysis of the species occurring in Nepal.

1.7 Justification of the Study

The systematic works in any genus help the nation to enumerate the plants found in the country, updating nomenclatural change, their conservation and helps to add the new taxa in the flora of that country. It also helps in adding information about uses, floral biology, ecology, distribution etc.

To date, detailed taxonomic study of the genus *Ipomoea* has not been carried out by any Nepalese scholar. So the information about *Ipomoea* is still lacking. *Ipomoea* is least studied genus in Nepal, so it becomes quite necessary to have a comprehensive study. *Ipomoea* are very common herbs found throughout the tropical, subtropical and temperate region. Thus present systematic study covers the overall aims based on the morphological characters, anatomical characters and palynology of various species of genus *Ipomoea* occur in Nepal.

1.8 Limitation of the study

The systematic study require a good quality of herbarium, type specimens, good quality of laboratory facilities for anatomical, palynological, cytological study; available literature and proper collection of plant species. But in context to our country, all above facilities are very poor in condition and most of them are out of our reach. The present study is mainly based on morphological, anatomical (stem and stoma) and palynological

study. Due to poor condition of equipments and lack of all required chemical for pollen analysis, the result obtained is also very poor and may be incomplete.

It is due to lack of personal resources; the collection of all plant specimens from different parts of the country is limited. Personal collection are from the Eastern Nepal includes Tehrathum, Dhankuta, Dharan, Itahari; Central Nepal covers the Lahan, Chitwan, Hetauda, Tanahun, Pokhara, Kathmandu, and Western Nepal covers the Butwal.

The examination of herbarium specimens deposited in the herbaria of Nepal (KATH and TUCH) and digital images of herbarium specimens of Royal Botanical Garden Edinburgh (E), Missouri Botanical Garden Herbarium (MO) and British Museum (BM) were done for the revisionary work. Due to time constrain and unfavorable circumstances, I could not examine herbarium deposited in other international herbaria.

Chapter 2
MATERIALS AND METHODS

The general taxonomic work of the genus was primarily done based on the gross morphological character obtained from the fresh collections and herbarium specimens. After morphological work as described in objectives, the other work based on anatomy (stem and stomata), pollens and cluster analysis were done.

Before starting the dissertation work, the deposited herbarium at TUCH and KATH were examined, from where information about the locality and flowering season of the species were obtained. According to the objectives of the study, the following methodologies were applied in this research.

2.1 Collection and Preparation of Herbarium

The fresh plant species of *Ipomoea* were collected from different parts of the Country. Plants were collected from Tehrathum. Dhankuta, Dhran, Itahari, Biratnagar, Lahan, Chitwan, Hetauda, Rampur, Kamthmndu, Bhaktapur, Lalitpur, Tanahun, Pokhara and Butwal, covering 15 districts. The collections were more from Eastern and Central Nepal. Due to unsuitable condition of flowering season and lack of time, the plants could not be collected from the Western Nepal.

The plants specimens with their reproductive parts were collected and photographs were taken and illustrations were drawn from the fresh specimens as far as possible. Field notes, tagging and numbering of all the species were done in the field.

The collected plants specimens were pressed immediately in the newspaper and tightened on herbarium pressed. The collected species were dried on a newspaper and finally well dried and complete specimens were mounted using standard method of herbarium preparation as described by Lawrence (1951), Woodland (1997) and Judd *et al*. (1999).

2.2 Preservation

The collected plants specimens were preserved in alcohol for morphological, anatomical and pollen studies. The flower of the *Ipomoea* was very delicate so it was very difficult to preserve, so the flowers were preserved in between the tissue paper. By this method the color of the flower remained the same as it was.

2.3 Morphological Study

The collected fresh plants were studied in the field as far as possible. The morphological studies of the collected fresh plants were done with the help of 2 x 20X magnification of Stereomicroscope, dissecting microscope and available literature. The dissected flowers were kept in paper and attached in it. All vegetative and reproductive parts were illustrated after examination.

2.4 Identification

The herbarium specimens were identified with the help of the available literatures. Some specimens were verified and identified by the Prof. Dr. Mohan Siwakoti, Central Department of Botany, Kirtipur, Kathmandu and by Dr. D.F. Austin from Arizona-Sonora Desert Museum, Tucson. The primary source of the identification of the species were based on the various available literatures and also by observing the picture of herbarium specimens available from online internet and the picture sent by Lecturer and Ph.D. Scholar, Ms. Sangeeta Rajbhandary from UK (E). During the identification, the collected specimens were compared with specimens deposited at TUCH, National Herbarium and Plant Laboratories (KATH), Godawari and picture of herbarium specimens from MO and BM.

2.5 Illustration and Photographs

Illustrations of the species were done on the basis of the examined herbarium specimens. The habit sketches of fresh plants were drawn in the field as far as possible. The illustration included habit sketch, bract, sepal, petal, pistil, stamen, fruit, etc. Photographs were also taken as far as possible.

2.6 Anatomical Study

The anatomical study of the stem and leaf were done from the collected plant specimens. For stem anatomy fine sections were sliced from the specimens and dehydrated with alcohol series i.e. Alcohol 30% (25 minutes)- Alcohol 50% (25 minutes)- Alcohol 70% (25 minutes)- Saffranin (25 minutes)-Wash with Alcohol 70% (15 minutes)-Alcohol 90%(25 minutes)-Light green (1 minute)-Wash with Alcohol 90%-Alcohol 100% (25 minutes)- Test in Xylene- Mount in DPX, and prepared the permanent slide then after studied the slide and photographs were taken.

The study of stomata was done by peeling the lower epidermal layer of the leaf of fresh species of *Ipomoea.* For the dried specimens, the leaf of the specimens were taken out

and boiled with 10% glycerin for about 5 minutes. Then lower epidermal layer was torn off and stained with Saffranin solution and slide was prepared. The stomata type and stomata frequency was studied with the help of light microscope and the measurement of stomata taken with the help of ocular and stage micrometer. Photographs of the slides were also taken for further studies.

2.7 Pollen Analysis

Palynology is the study of spores and pollen grains. Pollen grains have number of morphological and ultrastructural features. These palynological features have provided a wealth of characters that have been important in inferring phylogenetic relationships of plants. In addition, the features of spores and pollen grains can often be used to identify a particular plant taxon (Simpson 2006).

During present study due to the unavailability of Acetic anhydride, pollen analysis was done by the new method by using Benzyol Peroxide 5 gel in place of Acetic anhydride (Gajurel, 2008). For pollen analysis, Benzyol Peroxide 5 gel, Glycerine, Gelatin, Slides, Coverslips and Glycerin jelly were required.

The Glycerin jelly was prepared by mixing the 14g Gelatin with 150ml water then left for 30 minutes, after that the solution was heated for an hour without boiling it until the solution was cleared. 200 ml of glycerin was added and heated for an hour until all dissolved and liquid was cleared then poured on petty dices and left whole night without covering and then stored in deep freeze.

The anthers were kept in a small tube containing 10ml (9:1) glycerin and water for 12 hours to regain the shape of the pollens. 4ml of Benzyol Peroxide 5 gel was taken in a tube and 4 ml of water was mixed. The mixture was slowly stirred. The anthers were kept in a small tube containing mixture as prepared above. Then the tube was heated to make warm then the anthers were washed and kept in a watch glass. 2ml of Saffranin was added in the solution and kept for 2 minutes for staining.

Then the anther was kept in a watch glass and crushed with needle. It was mounted in a slide with glycerin jelly. At the time of mounting, the glycerin jelly which was already prepared was slice in to small stripe then with the help of needle a small piece was taken out and put on the slide then slightly heated to melt the jelly then cover it by putting cover slip and left it for 5 minutes in inverted position to regain its proper shape. Finally, the slide was observed under light microscope with magnification 15 x 10X for measuring size of the pollen grains and 15 x 45X for studying and measuring the size of the pore and photographs were also taken as far as possible.

2.8 Construction of Identification Keys

The keys are the basic tools for plant identification in Plant systematics. Key prepared in this study was constructed in bracketed format as suggested by Jones and Luchsinger (1987). In the genus *Ipomoea* key priority for the construction of keys was given in the vegetative as well as reproductive characters of the species viz. shape, size of leaves; shape, size and integuments of the sepals, lobes of stigma, integuments of ovary, fruits etc.

2.9 Cluster Analysis

Most of the classification of the organism is based on phylogenetic approach but in certain circumstances phylogenetic approaches are impossible and in that case phenetic approaches are useful for the classification of the organism. Among different methods of phenetic classification, cluster analysis is one of the particular methods of hypothesizing relationship among organism. Heywood (1974) and Raven (1976) believes that phenetic classification represent a more practical solution than phylogenetic ones. The beginning of this school of thought coincided with the independent introduction of the methods and concepts of numerical taxonomy or taximetrics by Sneath and Sokal (1973), applied respectively to bacteria and bees. Numerical taxonomy does not produce new data and is not a new system of classification or even a new set of principles underlying one, but rather new method of organizing data and obtaining from them a classification or some other form of presentation (Stace, 1989).

The present study attempts to reveal relationships among the Nepalese species of *Ipomoea*, which showed considerable variation in their vegetative as well as reproductive morphology. Considering these variations, cluster analysis was carried out during this study. For most of the species primary data on vegetative and reproductive morphology were collected based on herbarium specimens. However, for two species (*I. alba* and *I. eriocarpa*), which herbarium specimens are deposited in TUCH and KATH but detail study could not be performed due to poor herbarium quality, secondary source of information was used.

2.9.1 Operational Taxonomic Unit (OTU)

The basis unit of numerical taxonomy is the operational taxonomic unit (OTU), which is the term given to the lowest taxon being studied in a particular investigation. Hence in present study there are 16 species as OTUs, each OTU has to be scored for the possession of one or other character-state or attribute for each character.

2.9.2 Data Coding

Coding of data was done based on Austin (1998). Both qualitative as well as quantitative data were used. Each character was divided into different character states. The characters and character states were chosen based on their consistency traced during the study. In total, 20 characters were selected, and both two-state coding and multi-state coding was done as required. During this process, enough attention was given to avoid ambiguous and overlapping characters. Characters with missing values were omitted as far as possible for the simplicity of data analysis. The characters used in the study are given in Appendix 1 and the data matrix obtained from the character and character states are given in Appendix 2.

Data analysis

SPSS 11.5 was used for analyzing data and constructing dendrogram. The results of cluster analysis are often visualized as a hierchical dendrogram of phenetic relationship in which less and less similar OTUs are successively linked together. For clustering method, Ward's Method followed by Squared Euclidean distance was selected.

Chapter 3
RESULTS

3.1 Range of morphological characters in genus *Ipomoea*

3.1.1 Vegetative structure

The detail morphology of the plant has been studied from the fields study, herbarium specimens and various available literatures. The primary source of information has been derived from the field study and herbarium specimens of the genus *Ipomoea*. For those species which have not found in the field and herbarium specimens deposited in herbaria of Nepal (KATH and TUCH) are also lack of the most of the plant parts, the secondary sources of the information have been used. The following are the gross morphological treatment of the species of the genus *Ipomoea* found in Nepal.

3.1.1.1 Habitat

The genus *Ipomoea* was usually terrestrial, they were found open land, mostly on hedge and disturbed or dry habitat (*Ipomoea alba*, *I. purpurea, I. nil, I. obscura, I. batatas, I. eriocapra, I. pes-tigridis* and *I. triloba*); moist or shady habitat along with other species (*I. indica, I. cairica, I. mauritiana, I. muricata, I hederifolia* and *I. quamoclit*) and one species viz *I. aquatica* was aquatic in habitat, it was water loving and found on floating on water surface as well as on damp habitat and a species, *I. carnea* subsp. *fistulosa* which was often found in damp soil as well as dry land also.

3.1.1.2 Habit

The most of the species under these genera were annual and herbaceous (*I. alba*, *I. aquatica, I. batatas, I. eriocarpa, I. hederifolia, I. nil, I. obscura, I. muricata, I. purpurea, I. indica, I. quamoclit, I. triloba and I. pes-tigridis*) but *I. cairica* and *I. mauritiana* were perennial herbs, while *I. carnea* subsp *fistulosa* was perennial shrub.

Most of the species were twinners and climbing up to 1-3 m high (*I. alba*, *I. cairica, I. eriocarpa, I. hederifolia, I. nil, I. obscura, I. pes-tigridis, I. purpurea* and *I. triloba*) but *I. nil*, and *I. purpurea* were some time prostrate also, one species *I. quamoclit* was climber, prostrate and creeper, it reached the high up to 1-2 m from the ground. Some were prostrate and rooting at the node (*I. aquatica* and *I. batatas*). The species *I. indica, I. mauritiana* and *I. muricata* were extensively twinner and climbing, among them *I. indica* reached the high unto 6 m., while other two species reached upto 4 m. high from

the ground. Among the species,. *I. carnea* subsp *fistulosa* was stout, erect shrub, attained the high up to 2 m (Fig. 10-23).

3.1.1.3 Root

Most of the species of *Ipomoea* had tap root system but in *I. batatas* and *I. mauritiana* root were tuberous, red or white in color.

3.1.1.4 Stems

The morphological character of stem was fundamentally based on field study. The study shows that the stem of all species of *Ipomoea* was elongate, rounded, and fistular with milky sap. The stem was glabrous, terrete and rooting at nodes in *I. aquatica* and *I. batatas*; terrete and glabrous in *I. carnea* subsp *fistulosa*; terrete, glabrous and slightly angular in *I. alba* and *I. mauritiana*; glabrous and shining in *I. quamoclit* and *I. hederifolia*. In *I. obscura* and *I. triloba* stem was glabrous and minutely hairy or woolly (*I. obscura*). The species *I. muricata* was clearly distinct from other species by its muricate stem. Some species of *Ipomoea* viz. *I. eriocarpa*, *I. nil, I. purpurea*, *I. indica* and *I. pes-tigridis* stem was covered with dense retrosely hairs or trichomes. The hairs or trichomes of these species were long terminal cells with glandular base except in *I. eriocarpa*, *I. purpurea* and *I. pes-tigridis* in which trichome was cylindric without glandular base. In case of *I. cairica* the stem was glabrous in young while getting mature, stem became verruculose.

3.1.1.5 Leaves

Leaves were petiolated, simple, entire, lobed, or pinnately or palmately divided, alternate and exstipulate except *I. cairica* and *I. quamoclit* where leafy pseudostipules were found at the base of the petiole. The leaves of the species showed variation in their shape, size and integuments characters and number of lateral veins. The petiole ranges from 5 mm to 19 cm. The smallest petiole was found in *I. quamoclit* (5- 40 mm) and the longest was found in *I. purpurea* (up to 19 cm). While in other species the petiole ranges from 2.5 to18 cm. The petiole was retrosely hairy in *I. pes-tigridis*, *I. purpurea, I. nil* and *I. indica*. In *I. aquatica, I. batatas, I. eriocarpa*, *I. obscura* and *I. triloba* the petiole was slightly pubiscent. In *I. alba* and *I. muricata* the petiole was glabrous and muricate respectively. While other species viz. *I. hederifolia*, *I. quamoclit, I. mauritiana, I. carnea* subsp. *fistulosa* and *I. cairica* petiole was glabrous.

The shape of the leaves was varied from ovate-oblong, ovate-lanceolate, oblong-lanceolate, circular, and ovate to orbicular, sparsely lobed, slightly 3-lobed, and deeply

3-lobed and pinnately to palmately 5-7 lobed (fig.:2-5). This kind of variation on leaf shape often crates confusion in identification of some species of *Ipomoea* viz. *I. purpurea, I. nil,* and *I. indica*, on which leaves shape were broadly ovate to suborbicular; entire or rarely 3-lobed in *I. purpurea* (fig. 4-D); broadly ovate-orbicular, entire or 3-lobed in *I. nil* (fig. 4-A); ovate to circular and shallowly 3-lobed in *I. indica* (fig. 3-B and C). All these three species of *Ipomoea* bears 3-lobed leaves but in *I. purpurea*, lobed was often formed, in *I. nil* and *I. indica* lobed was slightly 3-lobed. In *I. obscura* leaves were entire, circular or ovate (fig. 4-B); broadly ovate to orbicular (*I. alba* and *I. muricata* (fig.5-B)); ovate, oblong-lanceolate and 3-lobed (*I. triloba*: fig. 5-C); lanceolate to oblong-lanceolate (*I. eriocarpa*); ovate to suborbicular (*I. hederifolia*: fig. 3-A); ovate to ovate-oblong (*I. carnea* subsp. *fistulosa*: fig. 2-E); leaf blade circular or transversely elliptic in outline and palmately 5 lobed to base (*I. cairica* : fig. 2-D) and *I. pes-tigridis* (fig. 4-C); palmately 5-7 lobed beyond the base, circular (*I. mauritiana*: fig. 3-D) and linear, deeply pinnactiset (9-19 pairs of leaflets) was found in *I. quamoclit* (fig. 5-A). In *I. aquatica* and *I. batatas* the shape of the leaves varies from ovate-lanceolate, oblong-lanceolate, entire or palmately lobed (fig. 2-A & B and fig. 2-C).

The size of the leaves varied from 2.6–33x1.5-17 cm. The smallest size of the leaf was recorded in *I. obscura* (2-6 x 1.5-5.5cm) and the largest size in *I. carnea* subsp. *fistulosa* (18-33 x 8.5-17 cm).

The apex of the leaf was acute, acuminte in most of the species, while in *I. eriocarpa*, *I. obscura, I. cairica, I. hederifolia, I. mauritiana* and *I. pes-tigridis* apex was acute, acuminate and muronate (fig. 2-5).

The lamina of the leaves were glabrous (*I. quamoclit* and *I. cairica*), sparsely pilose on midrib and veins (*I. alba, I. batatas, I. hederifolia, I. mauritiana, I. obscura* and *I. muricata*). The lamina was shortly pilose above and beneath (*I. aquatica, I. eriocarpa* and *I. carnea* subsp. *fistulosa*); densely short soft pubescent abaxially and sparsely hairy adaxially (*I. eriocarpa*, *I. indica*, and *I. purpurea*.); in *I. nil* and *I. pes-tigridis*, the leaf lamina was densely hirsute on both surface.

The leaf base was cordate in almost all of the species of *Ipomoea*, while in *I. aquatica* and *I. batatas* base varied from hastate, saggitate to cordate; truncate to shallowly cordate in *I. canea* subsp. *fistulosa*; sometimes attenuate in *I. quamoclit*, *I. cairica* and *I. pes-tigridis*. The leaf base was shallowly cordate in *I. eriocarpa* and *I. mauritiana*. While in other species viz, *I. alba*, *I. purpurea*, *I. nil, I. indica, I. obscura, triloba, I. hederifolia* and *I. muricata* the base of the leaves was deeply cordate (fig. 2-5).

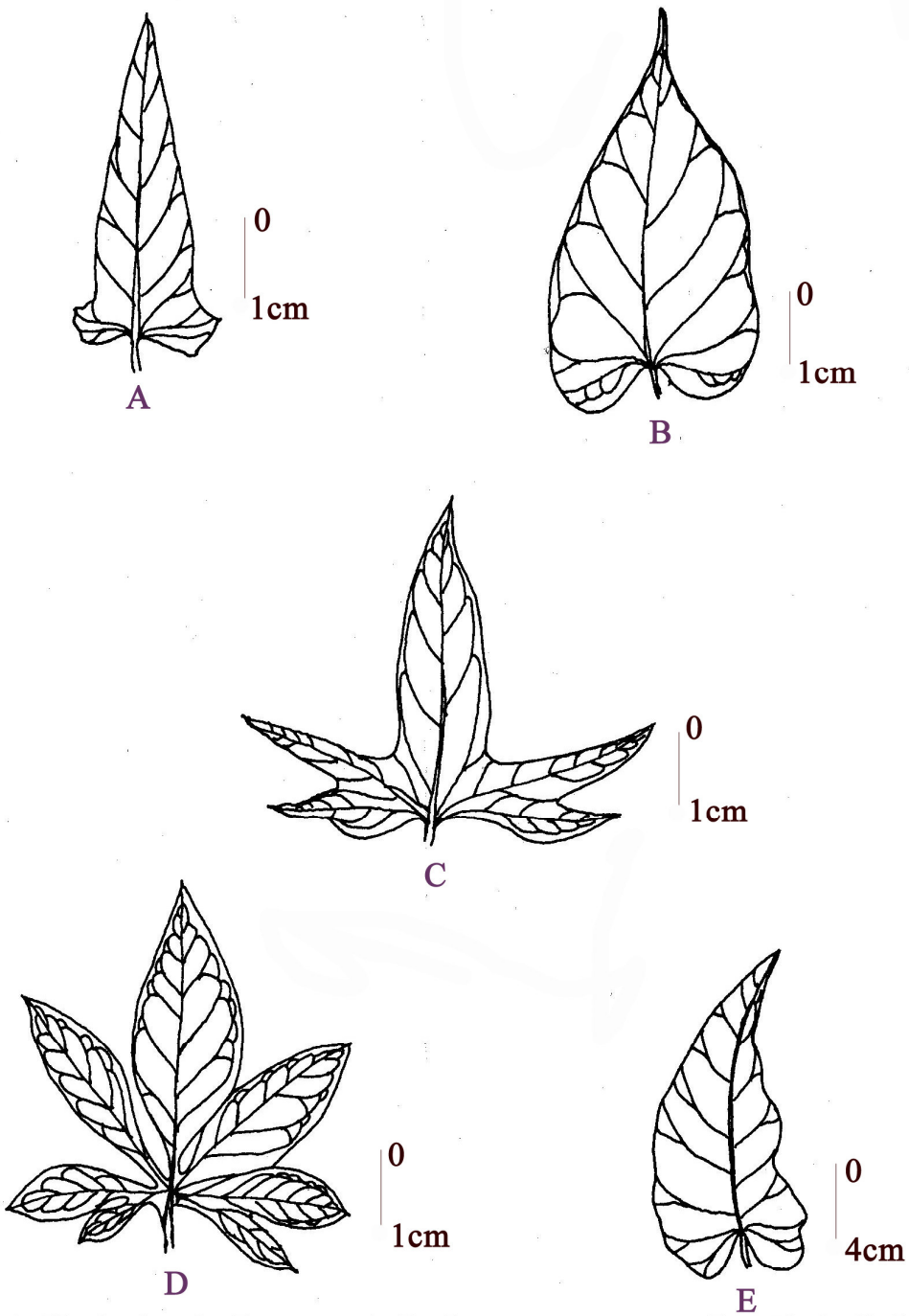


Fig. 2. Variation in Leaves: A-B. *Ipomoea aquatica* Forsskal; C. *I. batatas* (L.) Lam; D. *I. cairica* (L.) Sweet; E. *I. carnea* jacuin subsp *fisulosa* (Mart. ex Choisy). D. F. Austin.

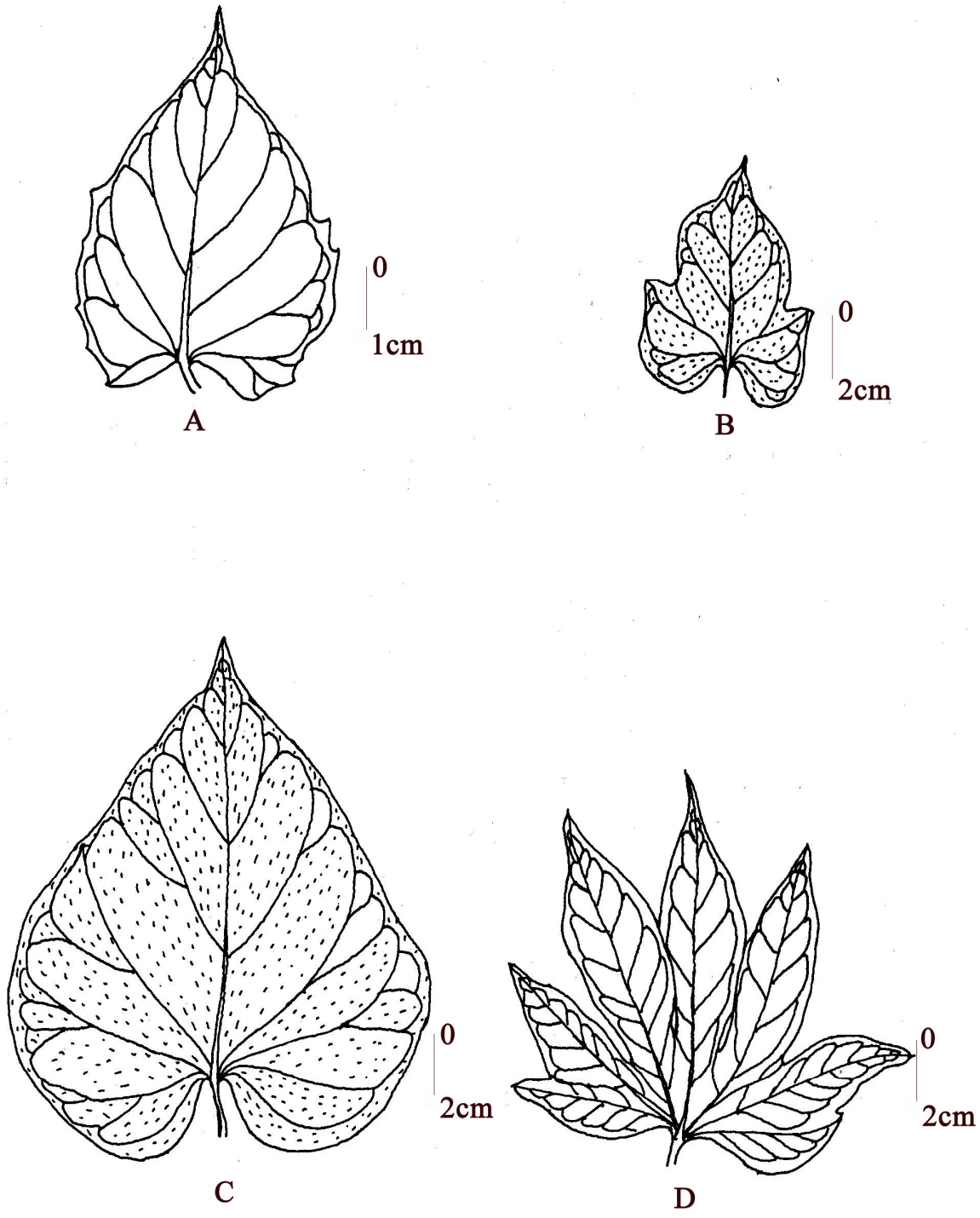


Fig. 3. Variation in Leaves: A. *Ipomoea hederifolia* L.; B-C. *I. nil* (Burman, f.) Merrill; D. *I. marutiana* Jacq.

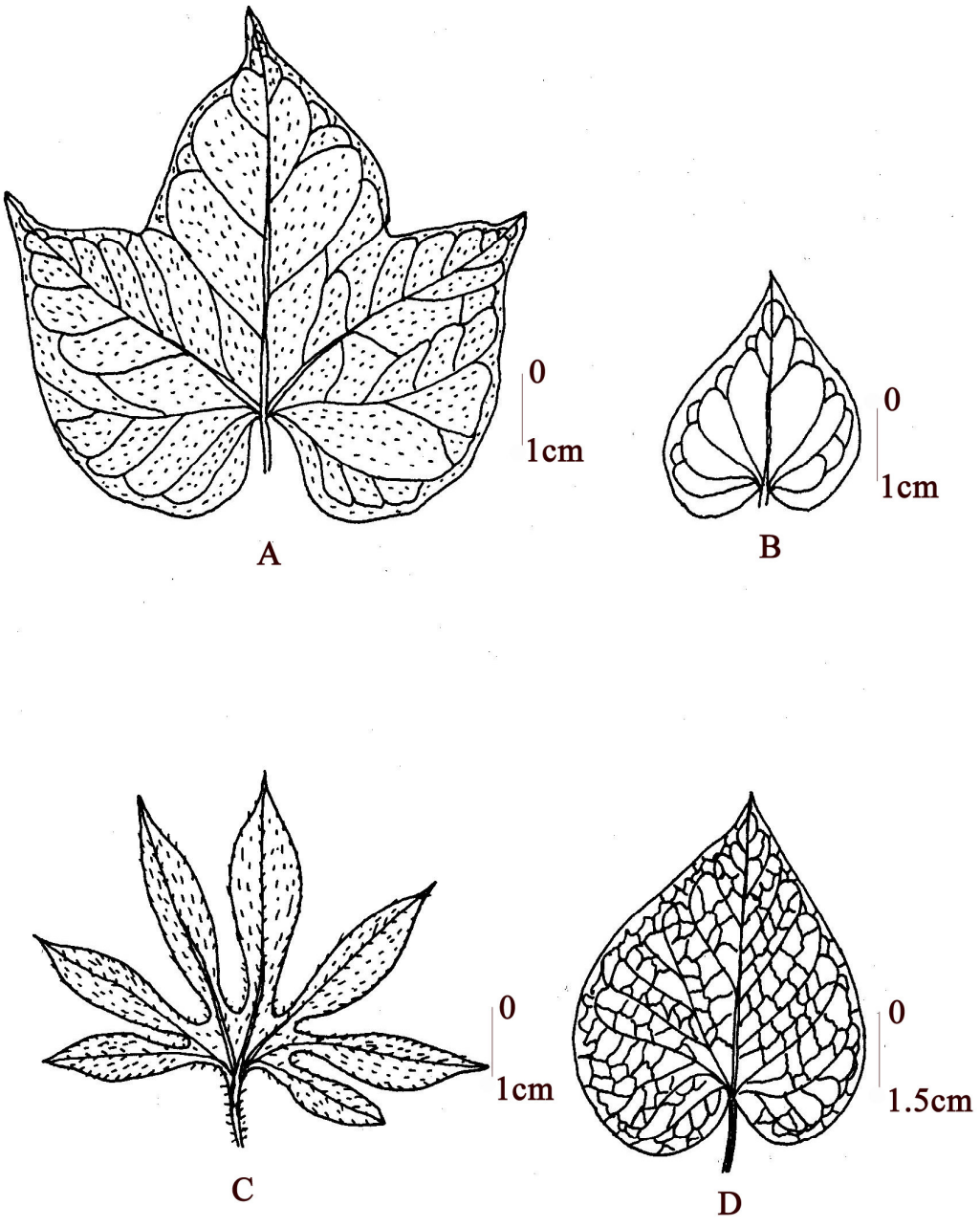


Fig. 4. Variation in Leaves: A. *Ipomoea nil* (L.) Roth; B. *I. obscura* (L.) Ker Gawl; C. *I. pes-tigridis* L.; D. *I. purpurea* (L.) Roth.

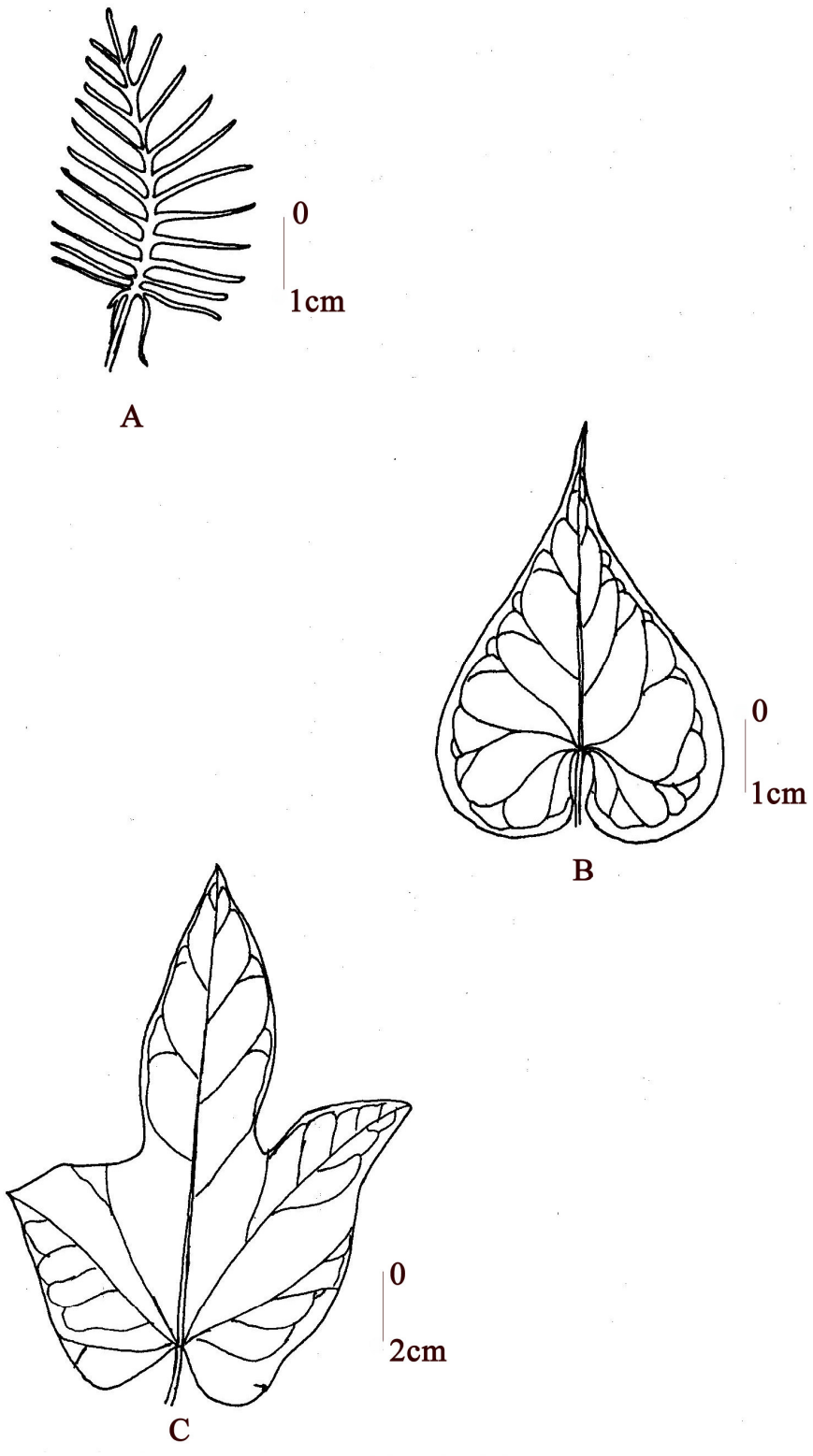


Fig. 5**. Variation in Leaves: A.** *Ipomoea quamoclit* **L.; B.** *I. muricata* **(L.) Jacq.; C.** *I. triloba* **L.**

3.1.2 Reproductive structure

The taxonomic treatment of the genus *Ipomoea* was delineating on the basis of the reproductive structures. The reproductive morphology showed variation mainly in the size of the peduncle, shape and size of the bracts, shape, size of the pedicel, shape, size and integuments of the calyx, color of the flower, lobes of the stigma and integuments of the ovary and capsule of the various species of the genus *Ipomoea*.

3.1.3 Inflorescence

The inflorescence of the genus was pedunculate or sessile or subsessile (*I. eriocarpa*), axillary, solitary or 1 to many flowered cyme. The species viz. *I. alba*, *I. aquatica, I. obscura, I. batatas, I. hederifolia, I. mauritiana, I. quamoclit, I. carnea* subsp. *fistulosa, I. muricata, I. purpurea* and *I. triloba*, bears 1 to few flowered axillary cyme. Dense umbel, axillary cyme was found in *I. indica* and *I. nil*. In case of *I. hederifolia*, first branch of peduncle was dichasial with alar flower and other monocahsical in arrangement. In *I. eriocarpa* inflorescence was axillary, sessile 1-4 flower cyme. The flowers in a dense capitates yellowish hirsute cyme subtended by involucres bracts were found in *I. pes-tigridis*.

The peduncles were varied from 1-20 cm. The shortest peduncle was found in *I. obscura, I. aquatica, I. mauritiana* and *I. cairica* (1-8 cm) and the longest peduncle was found in *I. batatas* (ca. 20 cm).

3.1.4 Bracts

The bracts were found on the base of the pedicel. It was deciduous or early deciduous in *I. cairica*, *I. carnea* subsp. *fistulosa* and *I. batatas*; bract was sub persistent in *I. obscura*, while in other species the bracts were persistant. The bract in most of the species was small ranges from 1.5-8 x 0.5-4.5 mm. The largest bract was found in *I. indica*, in which outer most bract was larger, linear ca. 2.5 cm and inner was ca. 1.5-2.2 cm.

The variation was found in the shape of the bracts. The shape was linear-lanceolate (*I. aquatica*, *I. batatas, I. eriocarpa, I. indica, I. nil, I. obscura, I. cairica* and *I. purpurea*); ovate-lanceolate (*I. carnea* subsp. *fistulosa*); oblong-lanceolate (*I. alba, I. triloba* and *I. muricata*); oblong to linear oblong (*I. pes-tigridis*). In *I. mauritiana* bract was concave-

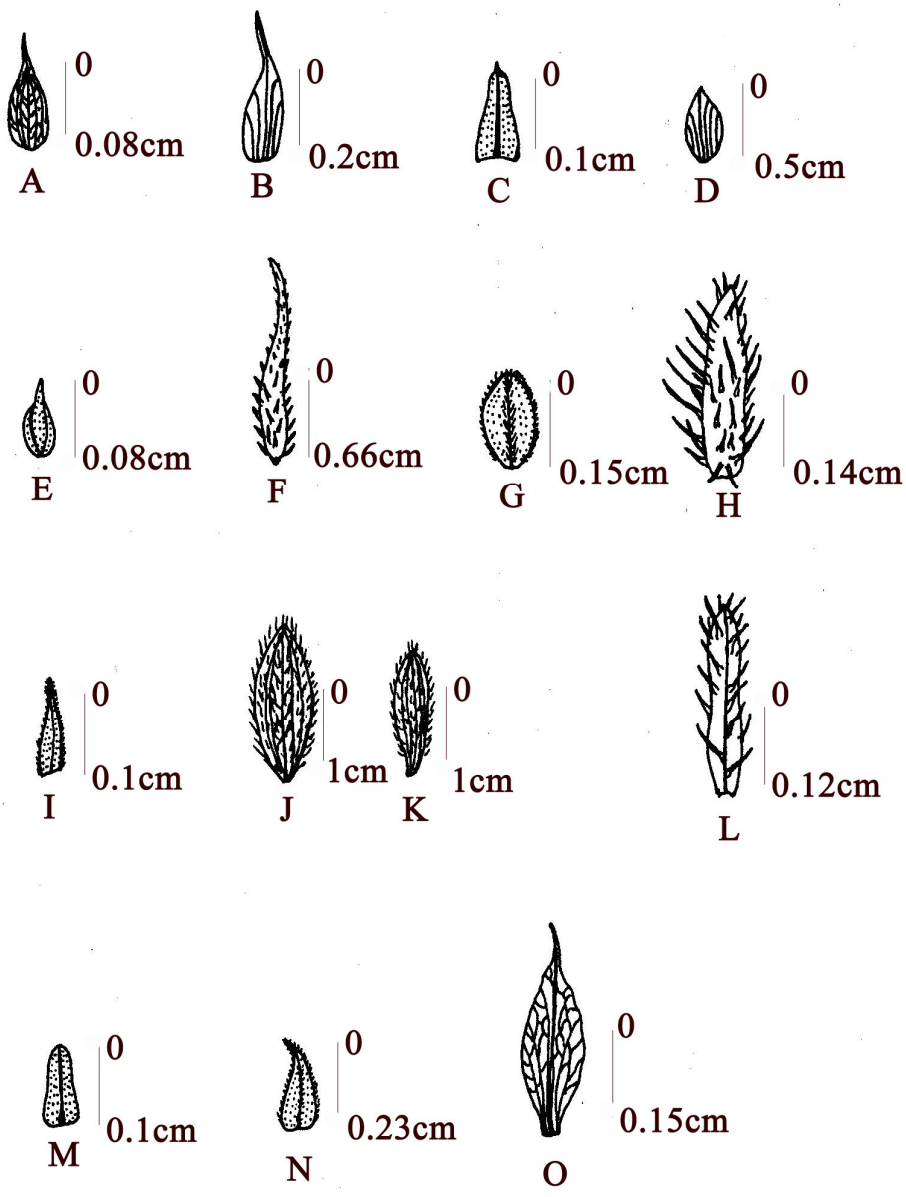


Fig. 6. Varaition in Bracts: A. *Ipomoea aquatica* Forsskal; B. *I. batatas* (L.) lam; C. *I. cairica* (L.) Sweet; D. *I. carnea* Jacuqin subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin; E. *I. hederifolia* L.; F. *I. indica* (Burman, f.) Merrill; G. *I. marutiana* Jacq.; H. *I. ni*l (L.) Roth; I. *I. obscura* (L.) Ker Gawl; J-K. *I. pes-tigridis* L. L. *I. purpure*a (L.) Roth; M. *I. quamoclit* L.; N. *I. triloba* L; O. *I. muricata* (L.) Jacq.

elliptic. The surface of bracts were glabrous in *I. alba*, *I. aquatica, I. batatas, I. quamoclit, I. carnea* subsp. *fistulosa, I. muricata, I. cairica*; sparsely pubiscent in *I. purpurea, I. obscura, I. mauritiana, I. eriocarpa* and *I. triloba*. In *I. nil, I. indica* and *I. pes-tigridis* the outer surface of bract was spreading hirsute.

The apex was acute in *I. alba*, *I. aquatica, I. eriocarpa, I. carnea* subsp. *fistulosa, I. nil* and *I. obscura*; acuminate in *I. muricata, I. quamoclit, I. indica* and *I. batatas*; obtuse apex found in *I. mauritiana* (fig. 6).

3.1.5 Flowers

The flowers were pedicelate, actinomorphic and bisexual. The size of the flower was small in *I. eriocarpa*, *I. obscura* and *I. triloba* (ca. 1-2 cm), while in other species the flower was large (up to 12 cm) showy, pentamerous, salvariform to infundibular and variously colored.

The pedicel was short (3-25 mm), glabrous or sparsely pubescent. The pedicel was found to be abscent in *I. eriocarpa*. In *I. alba, I. triloba I. quamoclit* and *I. muricata* the pedicel was thickened at fruits while in *I. purpurea, I. quamoclit I. nil* and *I. obscura* the pedicel was thickened, clavate and deflexed in fruits.

Calyx

The calyx was most important reproductive character for taxonomic treatment of some species of *Ipomoea* viz. *I. nil, I. indica* and *I. purpurea.* The variation was found in shape, size and integuments of the sepals. The sepal was 5, sub-equal or unequal, quinquincel in aestivation. The shape of the outer sepal varied from oblong to ovate (*I. alba, I. aquatica, I. eriocarpa, I. muricata* and *I. carnea* subsp. *fistulosa*); elliptic-ovate (*I. obscura*); lanceolate (*I. pes-tigridis*); oblong-elliptic (*I. batatas* and *I. triloba*); oblong- rectangular (*I. hederifolia*); ovate to narrowly lanceolate (*I. indica*); oblong (*I. purpurea* and *I. quamoclit*), ovate-lanceolate (*I. cairica*); ovate-elliptic (*I. nil*) and the sepal was circular, broadly elliptic-ovate and concave (*I. mauritiana*) (fig. 7-8). The inner sepal was linear lanceolate in most of the species. The apex was acute in almost all of the species while *I. mauritiana* apex was obtuse and in *I. carnea* subsp. *fistulosa,* apex found to be bifid sometimes. The species like *I. nil* and *I. indica* the apex was very long narrowly acuminate. So these species were disginguished by the character of pubiscent found on the lamina of the sepal. In *I. indica*, basal part of sepal was covered with soft, appressed hairs like wise in *I. nil*, the sepal was covered with dense yellowish bristle with swollen base and the sepals were strongly reflexed in fruits.In other species of *Ipomoea* the outer part of the sepal was minutely hairy except *I mauritiana*, in which sepal was glabrous (fig. 7-8).

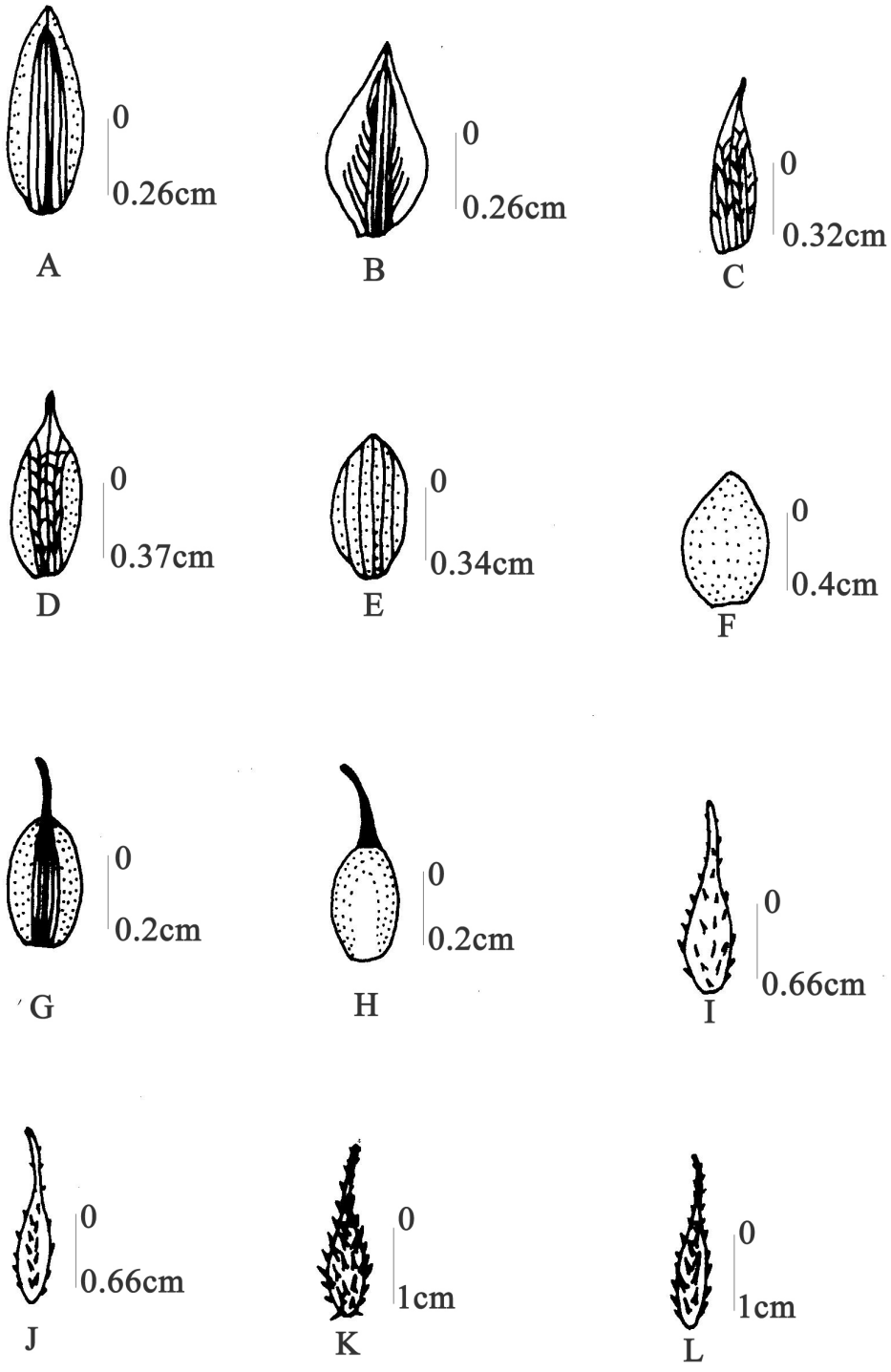


Fig. 7. Variation in Sepal: A-B. *Ipomoea aquatica* Forsskal (A-outer & B. inner); C-D. *I. batatas* (L.) Lam (C-outer & D. inner); E. *I. cairica* (L.) Sweet; F. *I. carnea* Jacquin subsp. *fistulosa* (Mart. ex Choisy) D. F. Austin; G-H. *I. hederifolia* L. (G- dorsal view & H-ventral view); I-J. *I. indica* (Burmann, f.) Merrill (I-outer & J-inner); K-L. I. *I. nil* (L.) Roth. (K-outer & L-inner).

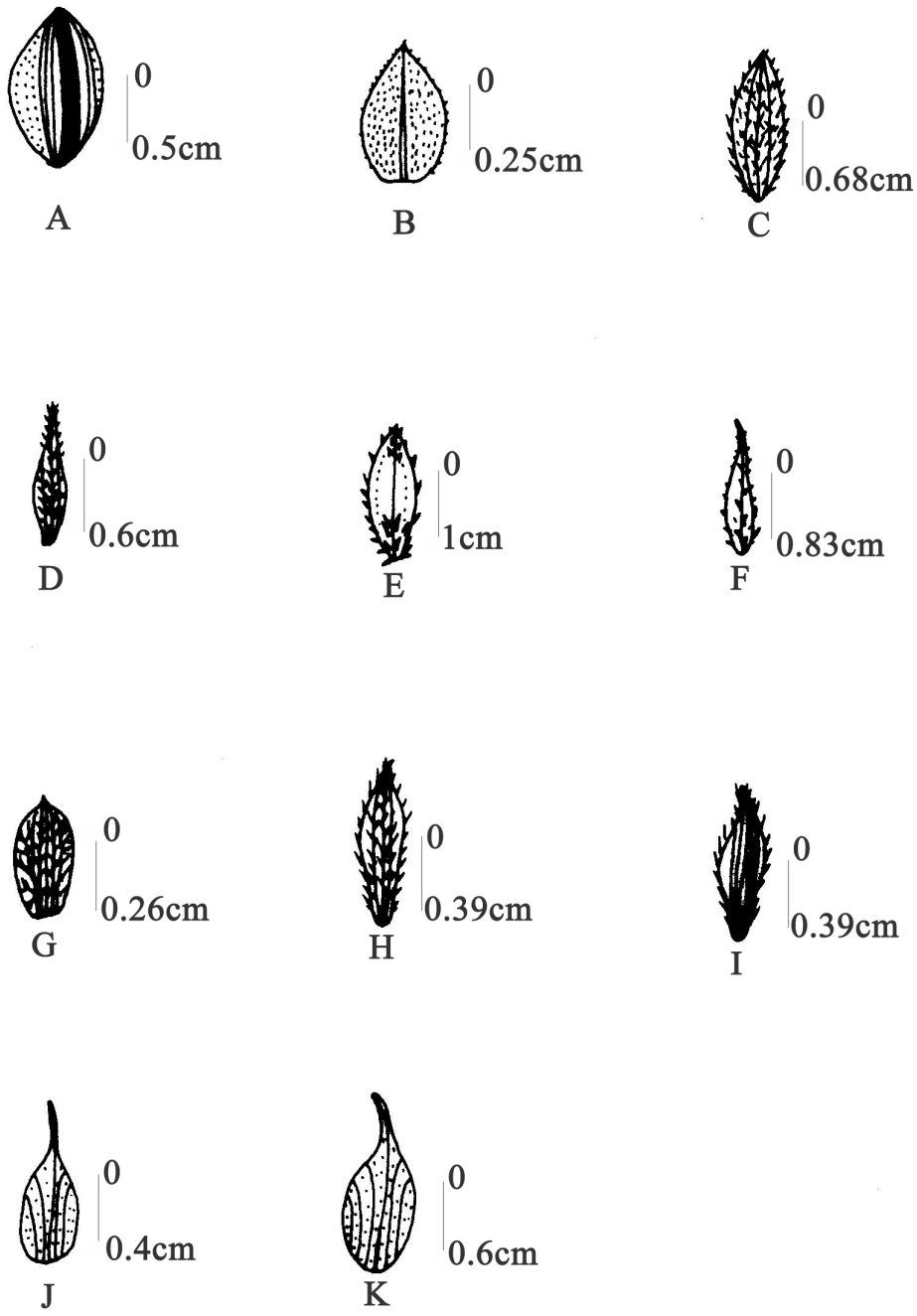


Fig. 8. Variation in Sepal : A. *Ipomoea marutiana* Jacq.; B. *I. obscur*a (L.) Ker Gawl; C-D. *I. pes-tigridis* L. (C-outer & D-inner); E-F. *I. purpure*a (L.) Roth. (E-outer & F-inner); G. *I. quamoclit* L.; H-I. *I. triloba* L. (H-outer & I-inner); J-K. *I. muricata* (L.) Jacq. (J-outer sepal & K-inner sepal).

Corolla

The Corolla was sympetalous, induplicate-valvate or twisted in bud, entire to slightly 5-lobed. The shape of the corolla was salverform in *I. alba*, *I. quamoclit*, *I. hederifolia* and *I. muricata*; companulate in *I. eriocarpa*, while in other species the corolla was funnelform. The corolla was plicate, brightly colored (commonly red, violet, blue, purple, pale-yellow or white), The color was varies from dark blue (*I. indica, I. purpurea* and *I. nil*) to pink or reddish purple with dark center (*I. mauritiana*), red or scarlet (*I. quamoclit* and *I. hederifolia*), white (*I. alba* and *I. pes-tigridis*) or yellowish-white or pale yellow (*I. obscura*), rose purple to pink (*I. aquatica, I. batata*s and *I. carnea* subsp. *fistulosa*); pink-purple to reddish purple (*I. eriocarpa, I. triloba* and *I. muricata*), In case of *I. purpurea* the color of petal was variable, which shows variation in color like red, pink, white, blue with dark midpetalline band with white tube.

Stamens

The stamens were always 5 in number, epipetalous at corolla base, which were included in the corolla tube except three species viz. *I. alba*, *I. quamoclit* and *I. hederifolia*, where stamens were exserted. In species in *I. muricata,* stamens were inserted in the apical part of the corolla tube. The present study reveled that the filaments were distinct, unequal; and anther lobes were basifixed. The upper part of the filaments was glabrous while basal part was covered with soft, tubular hairs. The anthers were oblong in shape; size of the anthers was 1.5-3.5 x 0.5– 1.5 mm, fertile, dehisce longitudianally and introse. The exines of the pollengrains were spiny.

Pistil

The genus *Ipomoea* was characterized by the presence of single pistil of 3 - 4 fused carpels to produce superior, compound ovary with same number of locules or carples. The pistil consists of stigma, long style and bulbous ovary. The size of the pistil was smaller in *Ipomoea eriocarpa*, *I. obscura* and *I. triloba* (less then 13 mm). While pistil size was largest in *I. aquatica* and *I. alba* (more than 6.5 cm). The variation can be observed only in lobes of the stigma and integuments of the ovary. The 2-lobed stigma was found in *I. alba*, *I. aquatica, I. batatas, I. cairica, I. carnea* subsp. *fistulosa*, *I. eriocarpa, I. hederifolia*, *I. mauritiana, I. obscura, I. muricata, I. pes-tigridis,* and *I. triloba* while in species viz. *I. purpurea, I. nil, I. indica* and *I. quamoclit*, 3-lobed stigma was found (fig. 9).

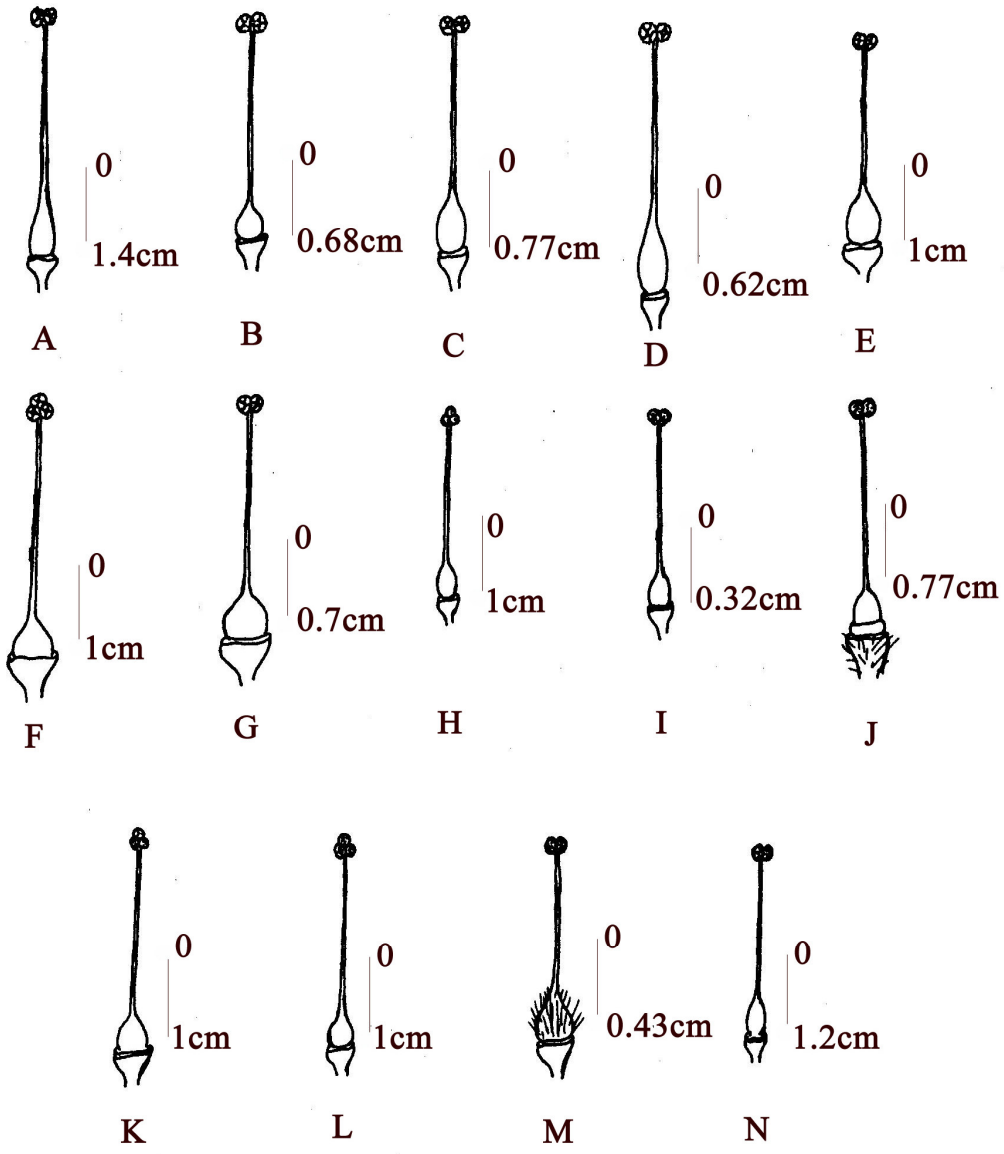


Fig. 9. Variation in stigma lobes: A. *Ipomoea aquatic*a Forsskal; B. *I. batatas* (L.) Lam; C. *I. cairica* (L.) Sweet; D. *I. carnea* Jauqin subsp. *fistulosa* (Mart.ex Choisy); E. *I. hederifoli*a L.; F. *I. indica* (Bruman, f.) Merrill; G. *I. marutiana* Jacq.; H. *I. nil* (L.) Roth; I. *I. obscura* (L.) Ker Gawl; J. *I. Pes-tigridis* L.; K. *I. purpurea* (L.) Roth; L. *I. quamoclit* L.; M. *I. triloba* L.; N. *I. muricata* (L.) Jacq.

In most of the species the ovary was glabrous except *in I. eriocarpa* and *I. triloba,* where ovary was found to be densely pilose.

3.1.2.4 Fruits

Fruits of the species of *Ipomoea* were 3-4 valved capsular. The capsule was globose or ovoid in shape. Size ranges from 5mm to 10 mm in diam. (*I. aquatica, I. purpurea, I. quamoclit, I. cairica, I. nil, I. hederifolia, I. obscura, I. eriocarpa* and *I. indica*) and 10–20 mm in diam. (*I. carnea* subsp *fistulosa, I. muricata,* and *I. mauritiana*). The largest fruit was found in *I. alba* (ca. 3cm in diam.). Dehiscence was generally longitudinal into 3 or 4 segments. Seeds were black brown or grayish in color, 2 seed in each locule, trigonous or ovoid in shape. In *I. carnea* subsp. *fistulosa* seeds were covered with dense black soft hairs, while in *I. mauritiana* seeds were covered with soft wool which was easily removable.

3.2 Taxonomic Treatment

The taxonomic treatment of the various species of the genus *Ipomoea* has been prepared on the basis of the morphological characters, illustrations, photographs and other available literatures. The primary source of information for the taxonomic treatment has been derived from the field study and the available herbarium specimens and the plant species which herbarium specimens were deposited in Nepal herbaria but detail studied could not performed due to lack of proper plant parts, for those species secondary source of information i.e. various literatures has been used.

Ipomoea L. Sp. Pl. 159. 1753 & Gen. Pl. ed. **5**. 76. 1754; Choisy in Mem. Sac. Phys. Geneve **6**: 383. 1833 & in D.C. Prods. **9**: 323. 1845; Benth. In Benth. & Hook, f. Gen. Pl. **2**: 870. 1876; Clarke in Hook, f. Fl. Brit. Ind. **4**: 196. 1883; Peter in Engl. & Prantl. Nat. Pflanzenfam. **4**(3a): 28. 1891; House in Ann. N.Y. Acad. Sci. **18**: 181. 1908; Austin in Dassanayke & Fosberg. Rev. Handb. Fl. Ceylon. **1**: 313. 1980; Feng and Staples, Fl. China. **16**: 301. 1995; Grick. & Long in Fl. Bhu. **2**(2): 844. 1999; Press *et al*. Ann. Chek. Fl. Pl. Nepl. 73. 2000.

Prostrate, twining, rarely repent, floating, suberect, annual, biennial, perennial herbs or shrubs. Root: tap root or tuberous. Stem often with milky latex. Leaves: variable in shape and size, alternate, entire, angular or lobed. Inflorescence: pedunculate or sessile or subsessile, axillary or terminal, 1-many flowered cymes. Flowers often showy, large, medium to small sized. Bracts: various, sub-persistant, persistent or deciduous. Sepal 5,

subequal to unequal, quinquincial in aestivation. Corolla 5-lobed, infundibuliform, campanulate to salverform, purple, pink, crimson, white to yellow. Stamens 5, unequal, epipetalous, pillose at the base, incluced or exserted, pollengrains pantoporate, globose, spinulose. Disc annular. Pistil: single, 2-4 fused carpels, Ovary superior, 2-4-locular, 4-ovuled or often 3-locular, 6-ovuled; stigma capitates, entire, 2-3 globular. Capsules globose or ovoid, 4 or rarely 6-valved. Seed 4, 6 or fewer, glabrous, tomentose or hairy.

Type: *Ipomoea pes-tigridis* L. (Lectotype).

3.2.1 Key to the species

1. Sepal awned at the apex, corolla salverform with long narrow tube; stamens and pistil slightly or mostly exerted……..……..…….…..2

   Sepal without awned, corolla mostly funnelform, stamen and pistil included…...5
2. Stem muricate, corolla purplish or white……..……..3

   Stem not muricate, corolla scarlet or red, rarely white……....…….4
3. Corolla purple, lobe less than 5cm long…….……....…*I. muricata*

   Corola white, lobe more than 5 cm long…….……*I. alba*
4. Leaves palmately parted or corsely dentate…….....*I. hederifolia*

   Leaves linear, pinnately divided into 9-19 pairs……*I. quamoclit*
5. Stem stout, erect or scandent shrub, corolla 6-9 cm long…….

   ……..…*I. carnea* subsp. *fistulosa*

   Stem prostrate, cliamber or twinner herb, corolla less then 6 cm long…….…….6
6. Stem with spreading or retrosely hairy …….……7

   Stem glabrous or sparsely or minutely hairy……...……..11
7. Peduncle abscent, corolla purple, less than 2 cm long……...……*I. eriocarpa*

   Peduncle present, corolla variously color, more than 2 cm long……..8
8. Leaves palmately divided into 5-7 segments, bract oblong, corolla pure white…….……...…*I. pes-tigridis*

   Leaves circular or oblong –ovate, slightly 3-lobed, bract linear, corolla variously color……...……..9
9. Sepal 10-18 mm long, apex acute, retrosely hairy……...……..*I. purpurea*

   Sepal 17-25 mm long, apex long acuminate……...……..10
10. Sepal soft, appressed pilose, trichome silvery white without swollen base……..……....*I. indica*

    Sepal densely or retrosely yellowish hirsute, trichome with swollen base…... *I. nil*
11. Leaves plamately divided into 5-7 lobed…….……12

    Leaves entire or orbicular or palmately lobed……..…….13
12. Lobe deeply divided up to the base, psudostipules present……...…….*I. cairica*

    Lobe shallowly divided not up to the base, psudostipules abscent…..*I. mauritiana*

13. Sepal glabrous, corolla more than 25 mm long……..…….……..14

    Sepal sparsely pilose, corolla less than 25 mm long……..…….……..15
14. Plant terrestrial, leaves sub-orbicular in outline, plant with subterranean tuber……*I. batatas*

    Plant aquatic, leaves entire, plant without subterranean tuber……*I. aquatica*
15. Corolla pale yellow with pinkish midpetaline band, ovary glabrous..…*I. obscura*

    Corolla purple, ovary densely pubescent……...…….*I. triloba*

3.2.1.1 Ipomoea alba L. Sp. Pl. 161. 1753; *I. bona-nox* L. Sp. Pl. ed. 2. 228. 1762; Nair n Rec. Bot. Surv. Ind. **21** (1): 178. 1978; Clarke in Hook, f. Fl. Brit. Ind. **4**: 197. 1883; Cooke, Fl. Pres. Bomb. **2**: 252. 1905 (Repr. ed. **1**: 559. 1960); Fang & Staples in Fl. China **16**: 309 (1995); Griekson & Long. **2** (2): 850.1999; Press et al. Ann. Check. Fl. Nep. :73.2000.

Ipomoea bona-nox L., Sp. Pl., ed. 2, 228 (1762). C.B. Clarke in Fl. Brit. Ind. **4**: 197 (1882). Burkill in Rec. B. Surv. Ind. **4**:121 (1910).

Herbs annual or perennial, twining, usually glabrous, rarely pubescent. Stems upto 10 m, terete, smooth or with soft prickles, sap milky. Petiole 5-20 cm; leaf blade ovate to circular in outline, 10-20 x 5-16 cm, base cordate, margin entire, angular to 3-lobed, apex acuminate, mucronulate. Inflororescences helicoid cymes, rarely dichasial, 1-to several flowered; peduncle stout, terete, 1-24 cm; bracts early deciduous, small. Pedicel 7-15 cm, clavate distally, enlarged in fruit. Flowers nocturnal, fragrant. Sepals elliptic to ovate, leathery, glabrous; outer 3 sepals 5-12 mm, apex with a stout spreading awn 4-9 mm; inner 2 sepals 7-15 mm, mucronate. Corolla white, with greenish bands, salverform; tube 7-12 cm, ca. 5 mm in diam.; limb 7-12 cm in diam., shallowly 5-undulate. Stamens exserted; filaments inserted in apical ½ of corolla tube, glabrous; anthers sagittate basally. Pistil exserted; ovary narrowly conical, glabrous. Stigma 2-lobed. Capsule ovoid, 2.5-3 cm, appiculate. Seeds white, brown, or black, ca. 10 x 7-8 mm, glabrous. Fl.- Frt: Oct-Dec. (Feng and Staples, 1995).

Type: Andapa, F. Rasoavimbahoaka 755 (MO).

Ecology: Cultivated.

English name: Moon Flower.

Distribution: C. Native of the New World tropics; cultivated as an ornamental and naturalized in most tropical areas.

Chr. No. : 2n = 30 Under *Ipomoea bona-nox* (Sharma & Datta, 1958); n = 15 (Vij, et al. 1977).

Uses: Ornamental.

Species examined:

Locality unknown, Jul 3, 1981. Bhandary and R.J. Shan 3214 (KATH).

Notes:

The species *Ipomoea alba* L. was reported by Hara (1987) and Press *et al*. (2000), but I was unable to find this plant while on field study. The herbarium specimens deposited in KATH were very poor in condition, due to which detail morphological, anatomical as well as palynological study could not be performed. By observing herbarium specimens deposited in KATH, present study confirms the presence of this species in Nepal Flora. The description of the species was based on Feng and Staples (1995).

3.2.1.2 Ipomoea aquatica Fl.

Aegypt.-Arab. 44 (1775); Trimen. A. Han. Book. Fl. Ceyl. 221.1874; EFPN **3**: 106 (1982); Clarke in Hook, f. Fl.Brit. Ind. **4**: 210. 1883; Cooke, Fl. Pres. Bomb. 2: 246. 1905; Duthie, Fl. Upper. Gang. Pl. **2**: 114. 1911; Puri *et al.* in Rec. bot. Surv. Ind. **19**(1): 95. 1964; Maheshwari, Ill. Fl. Delhi t. 139, 1966; Bhandari, Fl. Ind. Des. 252. 1978; Fang & Staples in Fl. China **16**:307 (1995). Siwakoti & Verma. Pl. Div. Est. Nep.:240.1999; Press *et al*., Ann. Check. Fl. Nep.:73.2000.

Ipomoea subdentata Miquel, Fl. Ned. Ind. **2**: 614. 1857.

Annual herbs, ca. 60 cm, aquatic, floating, stem glabrous terete, hollow, rooting at the nodes. Leaves petiolated, petiole 2.5-12.5 cm, glabrous but puberulent on tip, leaf blade variable, ovate, ovate-lanceolate, oblong-lanceolate, 5-12.5 x 1-7.5 cm. sparsely pilose on both surface, apex acute or acuminate, margin entire or palmately lobed, base cordate, saggitate, hastate. Inflorescence 1-3 flowered cyme, peduncle 1.5-8 cm, glabrous, base pubescent; bracts small, lanceolate or ovate, 1.5–2.2 x 1 mm, midrib thick, apex acute, squamiform; pedicel 1.4-4 cm, sparsely pubescent. Sepal 5, subequal, glabrous, outer 2 oblong to ovate, 7-8 x 3-3.5 mm, margin whitish, thin, membranous, apex acute, mucronate, apicule reddish in color, adaxially glabous, slightly puberulent abaxially. Corolla white, pink or purple with dark purple in center, funnelform 3.5-5 cm, glabrous, tube dark in color, 2-2.5 cm long, 4-4.5 cm in diam. Androecium 5, unequal, included, epipetalous 1.1-2 cm long, basifixed, lower surface of the filament hairy,

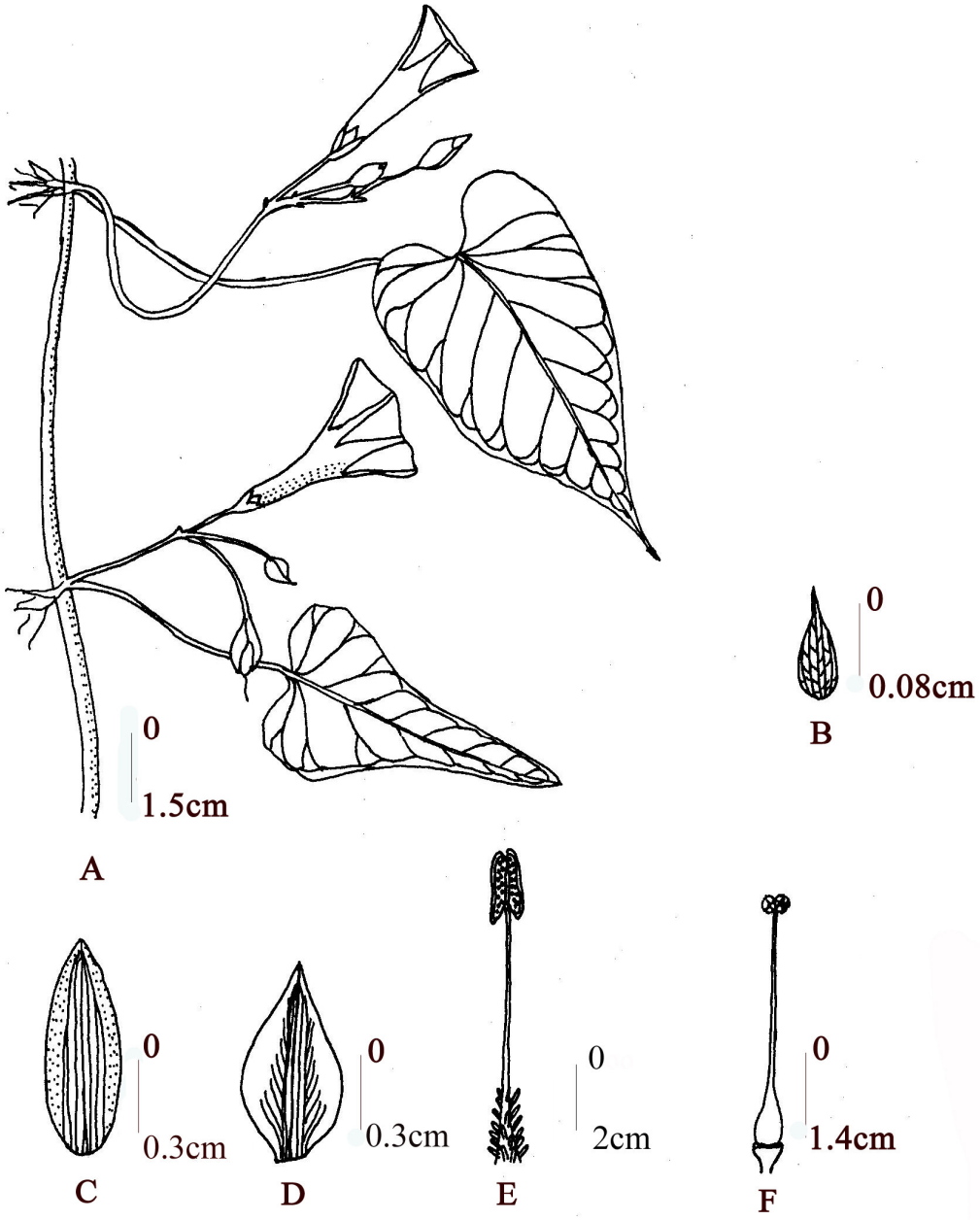


Fig. 10. Ipomoea aquatica Forsskal. A. Habit sketch; B. Bract; C. Outer Sepal; D. Inner Sepal; E. Stamen; F. Pistil (S. Shrestha 231).

anther 3.5 x 1.5 mm, dehisce longitudinally, extrose. Pistil included ca 6.5 cm long, ovary glabrous, superior and conical, 2-celled- 4 ovuled; stigma 2 lobed, capsule ovoid to globose, ca. 1 cm in diam. woody. Fl**:** Sept-Oct. Frt: Nov-Dec. (Fig. 10).

Type: Holotype: Egypt, *Forsskäl s.n.* (C).

Local name: Karmi saag,

English name: water spinach

Ecology: Mostly grow in the aquatic habitat and sometimes on the damp soil.

Distribution: WE. Alt.: 200-280 m, Nepal, Tropical Africa, Pakistan, India.

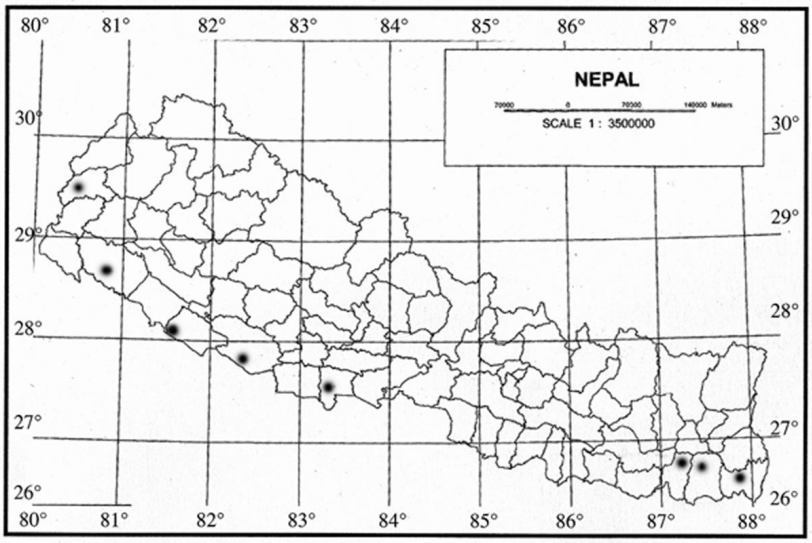
Chr. No.: 2n = 30 (Sharma and Datta, 1958); n=15 (Vij, et al., 1977).

Use: Tender shoots, leaves and rarely the roots are eaten as vegetable. Plant juice used medically as blood purifier.

Species examined:

Eastern Nepal: Sunsari, 200m, 6th Jun, 1993, P.R. Shakya, R. Manandhar & P. Sharestha, 361 (KATH);. Birtamod, **Jhapa**, 150m, 30th Sep, 1997, P. pradhan, K.R. Rajbhandari & R. Niroula, 161 (KATH); **Ithari,** 100m, 27th Oct, 2008, S. Shrestha 331 (TUCH); **Biratnagar**, 60m, 27th Oct, 2008, S. Shrestha, 332 (TUCH).

Western Nepal: Nepaljung, 181m, 25th Oct, 1972, N.P. Manandhar, 4919 (KATH); Dang, 230m, 21st Jul, 1981, N.P. Manandhar & D.P. Joshi, 6062 (KATH); **Kailali,** 200m, 1st Dec, 1966, D.H. Nicolson, 2806 (KATH); Sundarbasti, **Baitadi**, 175m, 16th Sep, 2003, D.J. Chapagain, 178 (TUCH); Dasmelitole, **Bhairahawa**, 150m, 10th May, 2006, M. Ghimire, K. Rajkarnikar & R.P. Kurmi 632 (KATH).



Map 1. Distribution map of *Ipomoea aquatica* Fl.

Notes:

The species *Ipomoea aquatica* Fl. was found in aquatic and marshy habitat with purple or scarlet colour with rooting at nodes (Plate 10: white flower-left). But at the time of field visit at Budasubba, Dharan the plants was found on shady habitat with very soft, glabrous stem and leaf with pure white corolla and lack of roots at nodes. After identification by Austin from Arizona-Sonora Desert Museum, the species was confirm as *I. aqutica* and he again said "This is slightly different from the other *I. aquatica*", so it needs further study for confirmation that's why I placed it on the list of doubtful species.

Regarding the origin and uses of *I. aquatica*, Austin (2007) on his article "**Water spinach (*Ipomoea aquatica*, Convolvulaceae) A Food gone Wild**" reported that: Water spinach (*I. aquatica*) has been considered native to Africa, Asia, and the southwestern Pacific Islands. The herbs have been a medicinal vegetable in southern Asia since at least 300 A.D., and perhaps since 200 B.C. People still gather plants from the wild and cultivate them. With European arrival in these regions in the late 1400s, they became aware of this medicinal food and began carrying water spinach around the world. As with other transported plants, Europeans took along some common names and cultural uses. With the later migration of people from Asian countries to other parts of the world, the food was imported into new areas. Doubt persists as to where the species was domesticated. Data from uses as food, regions of cultivation, medicinal use, phylogenetic studies, common names, and pathogens suggest that water spinach was first cultivated in southeastern Asia. The plants may have been domesticated in China and India, but the data are equivocal. The vegetable sometimes escapes from cultivation to become an ecologically invasive weed.

Regarding its uses, *I. aquatica* are widely used as food as well as medicinal purpose. There are several ways people consume these herbs, the young leaves and stems are mostly used as a vegetable. This is considered a food with medicinal effects. *I. aquatica* is considered a laxative, is recommended for piles, and "in certain nervous conditions with sleeplessness and head-ache". Some say the plant has a calming impact on people. Eating the plants is thought to aid in getting to sleep, and eating a sufficient quantity brings on drowsiness and eating a lot of the plant has a nerve-calming effect in cases of sleeplessness (Austin, 2007).

3.2.1.3 Ipomoea batatas (L.) Lam. Tabl. Encycl. **1**: 465. 1793; EFPN **3**: 106 1982; Hooker. Fl. Brit. Ind. **4**: 202. 1885; Fang & Staples in Fl. China **16**: 307 (1995); Griekson & Long. Fl. Bhu. **2** (2): 849. 1999; Press *et. al*., Ann. Check. Fl. Nep.:73. 2000.

Convolvulus batatas L., Sp. Pl. 154 (1753). Roxb., F. Ind. **2**: 69 (1832).

Annual herbs with ellipsoid, fusiform, elongated subterranean tuber, tubers red or white, sap milky, stem prostrate, twinner, glabrous or sparsely hairy, reddish to brown in colour, much branched, rooting at nodes. Leaves petiolated, petiole 2.5-11.5 cm, angular, sparsely hairy, blade broadly ovate to orbicular in outline, 3-10 x 3-11 cm, margin entire or 3-7 lobed, lobed broadly ovate to linear lanceolate, glabrous, sparsely hairy on veins, apex acute or shortly acuminate, base cordate or sometime attenuate, vein 7-9 pairs. Inflorescence 3-5 flowers cyme; peduncle 12-20 cm, greenish-brown; bract early decidius, lanceolate 2-4 x 1-1.1 mm, apex acuminate; pedicel 3-10 mm long, glabrous. Sepal 5, unequal, outer 2 shorter, oblong or elliptic 7-9 mm long, inner sepal 9-12 mm long, apex acuminate, cuspidate, glabrous, pilose abaxially, margin ciliate. Corolla pink, white or pale purple with darker center, campanulate to funnelform, 3-6 cm long, glabrous. Stamen 5, unequal, included, 1.5-2.2 cm; anther bisifixed, hairy on lower part of the filaments. Pistil-1 included, ca. 2 cm long, stigma 2- lobed, ovary glabrous, 4-celled-4 ovuled. Capsule rarely produced ovoid, seed glabrous. Fl.: Sept-Oct. Frt**.:** Nov-Dec. (Fig. 11).

Type: Lectotype: India. Herb. *Linnaeus* (LINN 218.12; microficha, isotype S).

Local name: Sakharkhanda, Suthuni.

English name: Sweet potato.

Ecology: Cultivated on large scale in field.

Distribution: E. alt.: 1000-2000m. Nepal, Probable native of tropical South America; cultivated throughout tropical areas.

Chr. No.: 2n = 30 (Sharma and Datta, 1958); n = 15 (Vij, et al. 1977).

Use: Roots are eaten for vegetable, also used as cattle feed. Green plats are used as fodder. Plants paste in scorpion bite; roots are laxative and a brain tonic (Johari, 1984).

Species examined:

Eastern Nepal: Dhankuta, 1150m, 2nd Oct, 2007, S. Shrestha, 202 (TUCH).

Central Nepal: Makawanpur, 1000m, 22nd Jun, 1986, N.P. Manandhar, 10785 (KATH); Thambu, **Dhading**, 1200m, 4th Nov, 1989, N.P. Manandhar, 12902 (KATH).

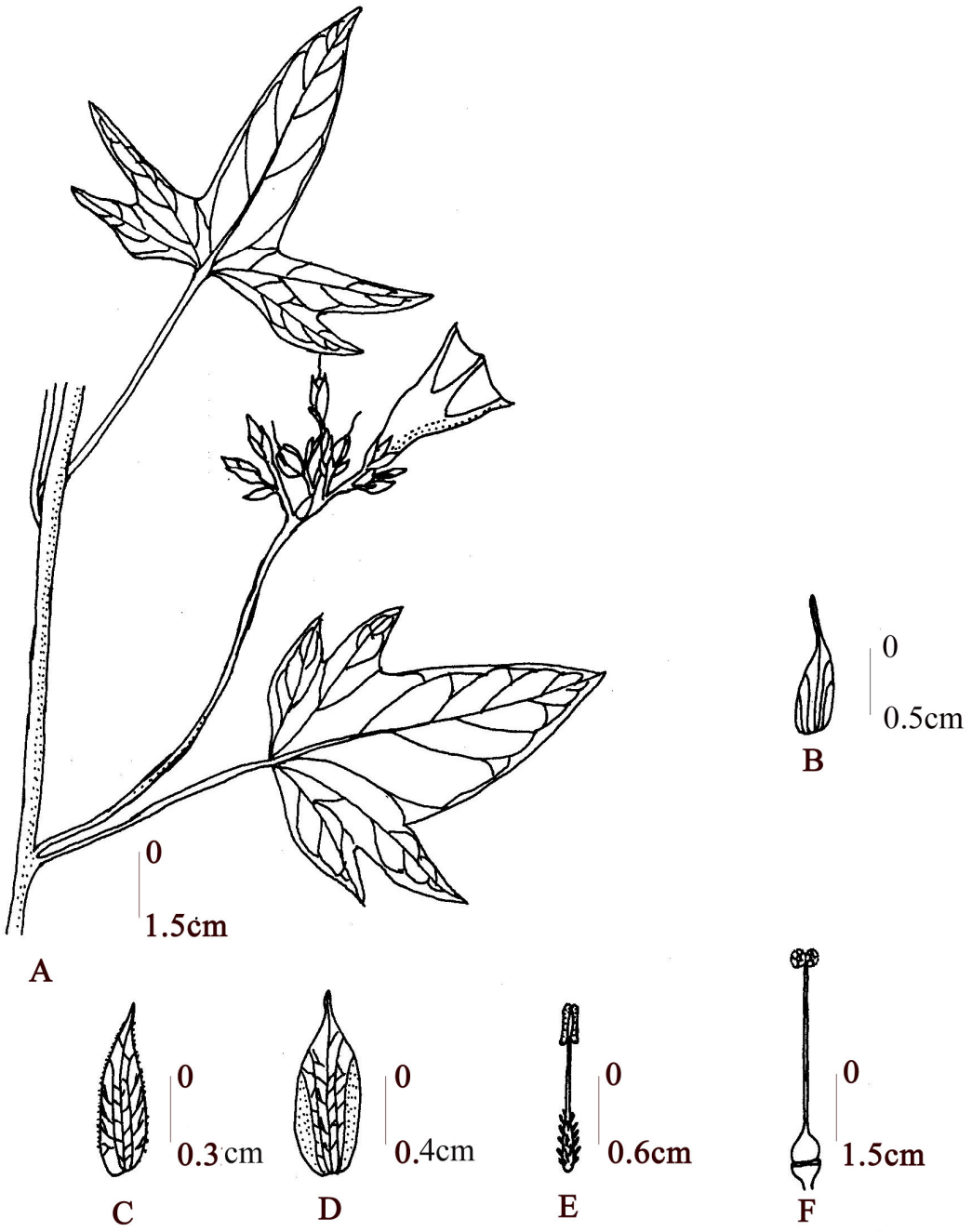
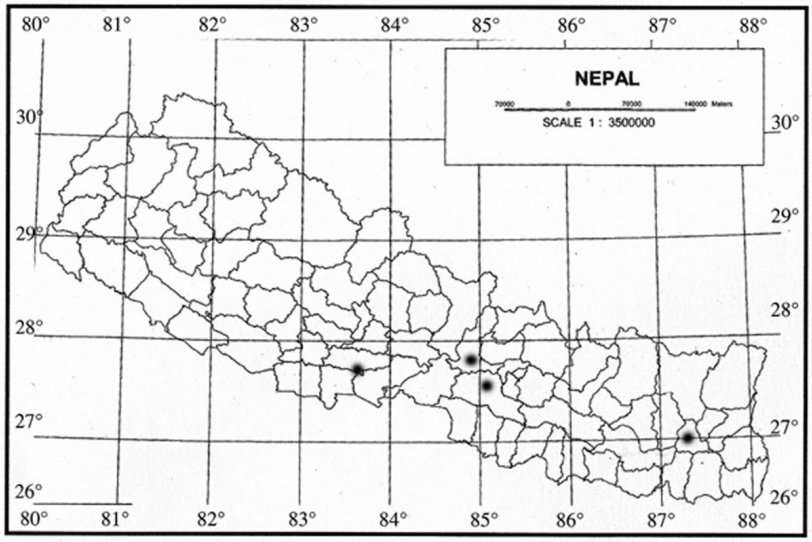


Fig. 11. Ipomoea batatas (L.) Lam. A. Habit sketch; B. Bract; C. outer sepal; D. Inner sepal; E. Stamen; F. Pistil (S. Shrestha 202).



Map 2. Distribution map of *Ipomoea batatas* (L.) Lam.

Notes:

Based on the field observation I found that the flowering period of the *Ipomoea batatas* was from 6 AM to about 1 PM and the flowers were bloom for only one day. I didn't see blooming of same flower on next morning and found that the flower was became shrink on next morning. The plants had great variety in shape of the leaves. During the field visit it was also found that the shape of the tuber of the species was two types, one was elongated and another was round. So there must be subspecies or variety in the species *I. batatas*, but lack of releavent literature I could not reach upto the lower rank. So futher study under this species must be essential.

3.2.1.4 Ipomoea cairica (L.) Sweet. Hort. Brit. 287. 1827; Hara *et al.* EFPN **3**: 106. 1982; Clarke in Hook. F. Fl Brit. Ind. **4**: 214. 1883; Maheshwari, Fl. Delhi 283. 1963; Puri *et al*., in Rec. Bot. Surv. Ind. **19** (1): 1964; Cooke, Fl. Pres. Bomb. **2**: 250. 1905; Duthie, Fl. Upper Gang. Pl. **2**: 117. 1911; Fang & Staples in Fl. China **16**: 312. 1995; Siwakoti & Verma. Pl. Div. East. Nep.: 243.1999;Press *et al*., Ann. Check. Fl. Nep. 73. 2000.

Ipomoea pentaphyla. Hooker. Fl. Brit. Ind. **4**: 202.1885.

Convolvulus cairicus L., Syst. Nat., ed. 10, 922 (1759).

Ipomoea palmata Forssk., Fl. Aegypt.-Arab. 43. 1775; C.B. Clarke in Fl. Brit. Ind. **4**: 214. 1883.
Convolvulus tuberculatus Desr. Bot. Mag. T. 699.
Ipomoea tuberculata (Desr.) Roem. & Schult. Bot. Reg. t. 86.

Perennial herbs, climbing and twinning. Stem upto 5 m, angular, younger glabrous but mature stem variculose. Internodes 6-9 cm long. Petiole 2(-3)-8(-13) cm, base with leafy pseudostipules, glabrous, slightly tuberculate, groove on ventral surface. Leaf blade palmately 5-parted to base; lobes entire, apex acute or obtuse, mucronate, basal pairs of leaf usually again lobed or parted; middle lobe longer, ovate-lanceolate or elliptic, 2.5-8 x 2-3.5 cm; venation lateral 9-11 pairs; base attenuate. Inflorescence 1-several flower cyme; peduncle (-1.5)2-8 cm, glabrous; bract early deciduous, small, squamiform, ca. 1.5 mm. Pedicel 5 -20(-25) mm. Sepal 5, unequal, apex acute; outer 2 ovate, 6-8 x 4-5 mm, inner ovate-lanceolate, 7-9 x 3-4.5 mm, margin entire, glabrous, scarious. Corolla pink-purple or reddish-purple, with a darker center, funnelform, 3-6 cm. Stamens 5, unequal, included, 1.2-2.5 cm long, filaments pinkish, swollen hairs on base; anther pink, basifixed, longitudinally dehiscence, ca. 5 mm long. Pistil -1, included, 2.7 cm long. Ovary glabrous, 2-celled-4-ovuled. Stigma 2-lobed, ca. 3 mm in diameter; capsule glabrous, ca. 1 cm in diam. Fl.: Aug.-Oct. Frt.: Nov-Dec. (Fig.12).

Type: Lectotype: Ilustr. de Vesling, *Obs. en Prosp. Alp. Pl. Aegypt.* 75. f. 1638.

English name: Railway Creeper.

Ecology: Mostly found on open dry land.

Distribution: E. alt.: 200m. Nepal, Widespread throughout the tropics.

Chr. No.: n = 15; 2n = 30 (Sanjappa and Gupta, 1981).

Use: Grown as an ornamental.

Species examined:

Eastern Nepal: Biratnagar, 70m, 14th Oct, 1963, H. Hara, K. Kanai, G. Murata & H. Ohashi, 6303921 (KATH); Soktin, **Dargiling**, 460m, 2nd Jun, 1969, T.B. Sharestha, 15369 (KATH); **Biratnagar**, 80m, 2nd Jul, 2008, S. Shrestha, 260 (TUCH).

Central Nepal: Shukla-Phanta, 800m, 27th Mar, 1980, T.K. Bhattacharya, 3688 (KATH); Kharjuwar, 600m, 24th Mar, 1980, D.K. Sharma, 2370 (KATH); Rampur, **Chitwan**, 600m, 10th Sep, 1985, T.K. Bhaacharya, 5223 (KATH); **Kaski,** 900m, 24th Jun, 1986, N.P. Manandhar & L.P. Katel, 10,842 (KATH); Kapilbastu, 200m, 7th Sep, 1992, P.P. Kurmi, K.B.482 (KATH); Teaching Hospital, **Kathmandu**, 950m, 10th Aug, 2007, S. Shrestha, 208 (TUCH); **Damauli**, 350m, 12th Jun, 2008, S. Shrestha 222 (TUCH).

Western Nepal: Nepaljung, 150m, 29th Nov, 1972, N.P. Manandhar & Uprety, 9482 (KATH); **Nepaljung**, 181m, 29th Nov, 1972, N.P. Manandhar & Party, 9478 (KATH); **Bake**, 180m, 13th Oct, 1977, Raunyor & Party, 1163 (KATH); Garhwa, **Dang,** 250m, 28th Aug, 1982, N.P. Manandhar & M. K. Bhattarai, 8518 (KATH); Kohalpur, Manaughat, **Bardia**, 200m, 4th Nov, 2001, Shrestha, K.K., Tiwari, N.N., Acharya, S.K., Adhikari, B., Shakya, D., Raut, L.B. and Bista, S.R. 2175 (TUCH).

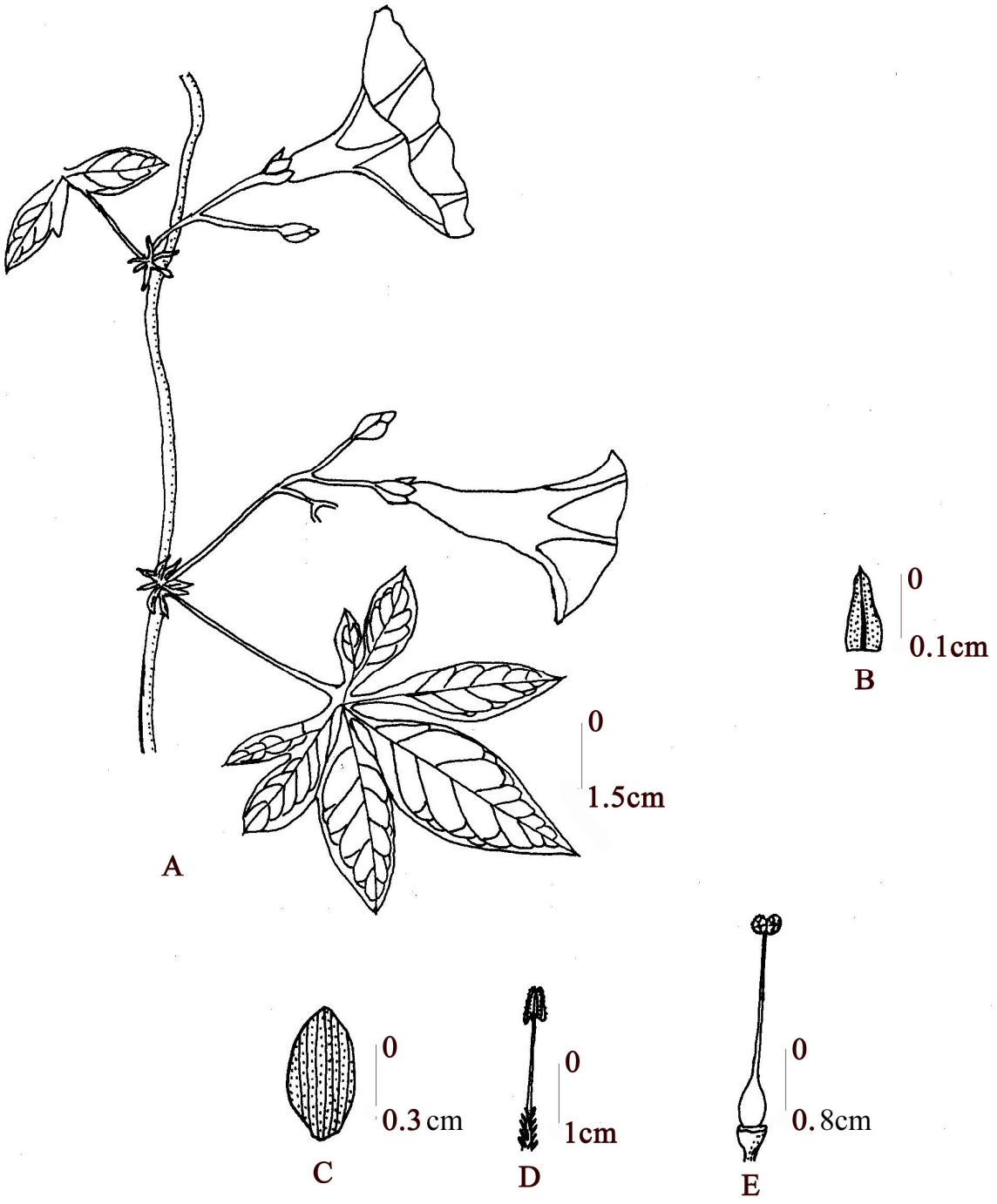
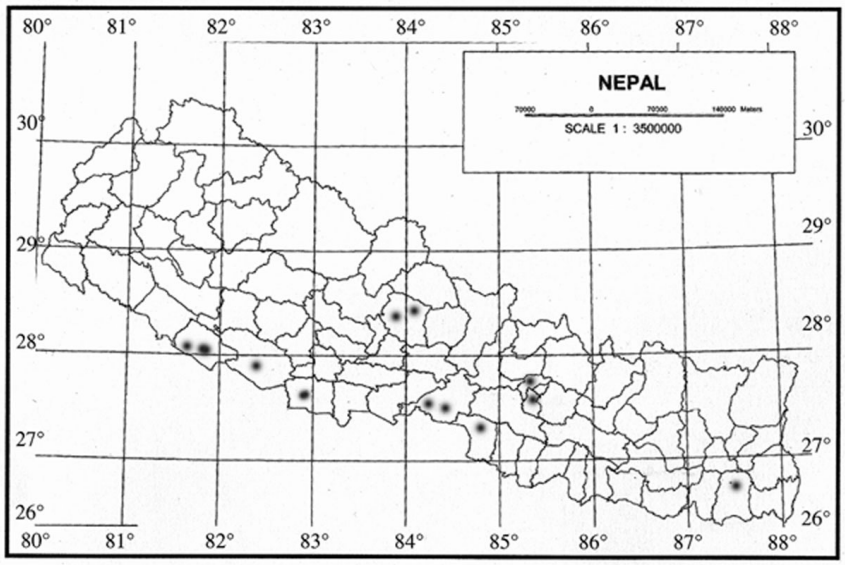


Fig. 12. Ipomoea cairica (L.) Sweet. A. Habit sketch; B. Bract; C. Sepal D. Stamen; E. Pistil (S. Shrestha 208).



Map 3. Distribution map of *Ipomoea cairica* (L.) Sweet.

3.2.1.5 Ipomoea carnea Jacquin Enum. Pl. Carib 13. 1760; Cooke, Fl. Pres. Bomb. **2**: 251. 1905; Maheshwari, Fl. Delhi 234.1963.

Glabrous or pubescent, perennial shrub up to 3 m high. Leaves; petioles 3.5 – 6.2 cm long. Lamina: 10-25 x 6.0–7.5 cm., base cordate to truncate; broadly ovate, ovate-oblong in outline, margin entire or subentire, apex acuminate or acute (Johari, 1994).

3.2.1.5.1 Ipomoea carnea Jacq. subsp. **fistulosa** (Mart. ex Choisy). D.F. Austin, Taxon **26**: 237. 1977; Hara *et al., Ipomoea fistulosa* Mart.ex Choisy in DC. Prodr. **9**: 349. 1845; EFPN **3:** 106. 1982; Maheshwari, Ill, Fl. Delhi 138. 1966; Majumdar in Bull. Bot. Surv. Ind. **18**: 52. 1976; Bhandari, Fl. Ind. Des. 255. 1978; Fang & Staples in Fl. China **16**: 311 (1995); Griekson & Long. Fl. Bhu. **2** (2): 851. 1999. Siwakoti & Verma. Pl. Div. Est. Nep.: 244.1999; Press *et al.*, Ann. Check.Fl. Nep.: 73. 2000.

Ipomoea fistulosa Mart. ex Choisy in DC., Prodr. **9**: 349 (1845).
Ipomoea crassicaulis (Benth.) B. L. Robinson in Proc. Am. Acad. **51**: 530 (1961). Yamazaki in Fl. E. Himl. 264 (1966).

Perennial, erect shrubs, 1.5 -2 m. axial parts slightly puberulent, later glabrous. Stem woody at base, hollow, sap mlky. Branches terete, stout. Leaves petiolate, petiole 8-12 cm, leaf blade ovate or ovate-oblong, 18-33 x 8.5–17 cm; base truncate to shallowly cordate, margin entire, minutely pubescent above and beneath, apex acuminate,

mucronulate, lateral veins 8-13 pairs. Inflorescence, terminal and axillary, 3-7 flowers cyme, peduncle stout, 13-18 cm, glabrous; bracts early deciduous, ovate-lanceolate, 5-8 x 4.5 mm, broad base, apex acute. Pedicel 1.5-2.5 cm. Sepal 5, unequall, outer ovate, broder 6-7 x 5-6 mm, apex acute, sometimes bifid, puberulent, shiny, reddish in colour, inner 3 are larger, ovate, 7-8 x 6-8 mm, tip and margin reddish, 2 small gland are present at the base of the each sepal, aestivation quinquincial. Corolla deep pink to rose purple or pink, funnelform, 5-9 cm, tube slightly puberulent outside 2.5-5 cm long, mid petal bands longitudinally 5 veined. Stamens-5, included, unequal, epipetalous, 1.8-2.8 cm, basifixed, anther linear 8 mm long, filaments glandular at the base. Pistil included ca. 2.5 cm long, stigma 2-lobed, ovary superior, capsule brown, ovoid 1.5-2 cm, 2-celled-4 valved, seed black, ca. 10 x 8 mm. densely covered with soft hairs. Fl: Jul-Jan. Frt.: Feb-Mar. (Fig. 13).

Type: Lectotype: Brasil, *Martius* 2398 (M).

Local name: Saruwa, Behaya, Besaram.

Ecology: Found on the hedge, dry or damp soil and also on the side of the river.

Distribution: WCE. Alt.: 100-400m. Nepal, Native of New world tropics; cultivated and becoming naturalized in other tropical areas.

Chr. No.: under *I. fistulosa*, n = 15 (Vij et al. 1977).

Use: Grown as ornamental and on hedge, milk latex used in skin disease. The dry stems are used as fuel by villagers. Cattle do not graze on it.

Species examined:

Eastern Nepal: Sanischare, **Jhapa**, 250m, 8th Jun, 1974, M, Amatya & R. Shrestha, 83/74 (KATH); **Biratnagar**, 70m, 14th Oct, 1963, H. Hara, H. Kanai, S. Kurosowa, G. Maratia, M. Tagoshi & T. Tuyma, 6303922 (KATH); Suryanagar, **Jhapa**, 60m, 19th Feb, 1986, H. Von, Irene & S. Cotter, 211 (KATH); Haldibari, **Sunsari**, 900m, 30th May, 1993, P.R. Shakya, R. Mannandhar & P. Shrestha, 249A (KATH); **Biratnagar**, 80m, 20th Jul, 2008, S. Shrestha 242 (TUCH); **Itahari**, 150m, 21st Jul, 2008, S. Shrestha 454 (TUCH).

Central Nepal: Nawalparasi, 150m, 18th Dec, 1975, D. Joshi, I. Bajracarya & R. Shrestha, 75/3623 (KATH); Kasori, **Kaski**, 880m, 29th Jun, 1986, N.P. Manandhar & L.P. Katel, 11105 (KATH);**Chitwan**, 250m, 6th Jun, 1919, N. Joshi & I. Shrestha, 217 (KATH); **Lahan**, 250m, 25th Jun, 2008, S. Shrestha 260 (TUCH); Kirtipur, **Kathmandu**, 1150m, 10th Jul, 2008, S. Shrestha 216 (TUCH).

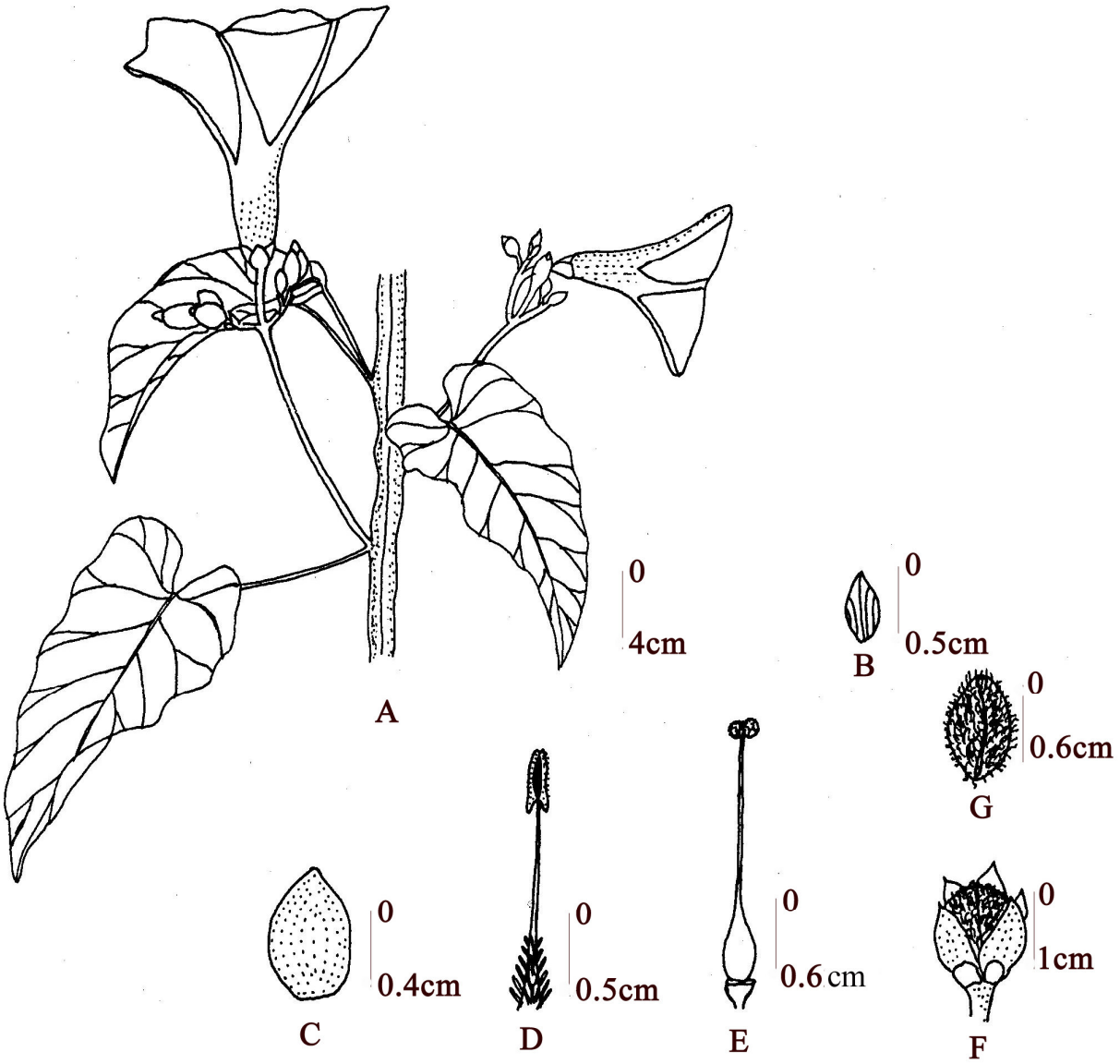
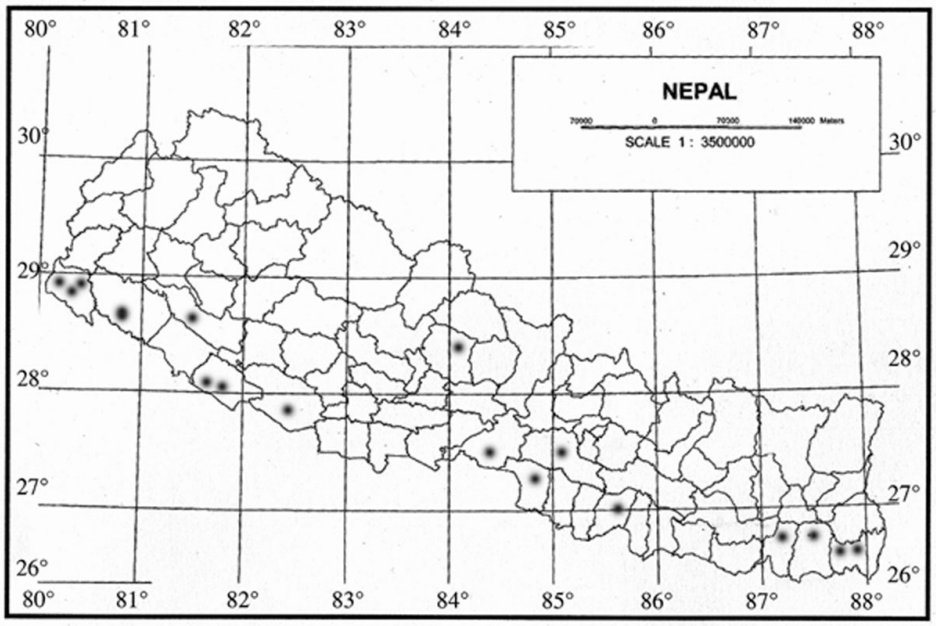


Fig. 13. Ipomoea carnea Jacquin subsp. **fistulosa** (Mart. ex Choisy) D.F Austin. A. Habit sketch; B. Bract; C. Sepal. D. Stamen; E. Pistil; F. Fruit; G. Seed (S. Shrestha 216).

Western Nepal: Nepaljung, 181m, 25th Nov, 1972, Chandrabali, 12498 (KATH); Sokighopte, **Surkhet**, 700m, N.P. Manandhar & N. Acharya, 13-91 (KATH); **Nepaljung**, 160m, 5th Jul, 1980, T.K. Bhattacharya, 3004 (KATH); Duddhara, **Dang**, 650m, 23rd Jul, 1981, N.P. Manandhar & D.P. Joshi, 6120 (KATH); Shukla Phanta, **Mahendranagar**, 190m, 11th Sep, 1981, I. Sharma, R. Joshi, R. Uprety & I. Pandey, 277 (KATH);**Mahendranagar**, 180m, 28th Dec, 1981, S.B. Malla & H.K. Saiju, 5/81 (KATH); Dhangarhi, **Kailali**, 600m, 23rd May, 1983, P.P. Kurmi, 4350 (KATH); **Mahendranagar**, 240m, 27th Mar, 1984, P. Pradhan, R.K. Uprety, N. Pradhan & N. dabadi, 906 (KATH); **Kanchanpur**, 230m, 4th Jun, 2002, Bikram Pant, 251 (TUCH).



Map 4. Distribution map of *Ipomoea carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy) D.F.Austin

Notes:

The name of this species *Ipomoea carnea* Jacquin subsp. *fistulosa* (Mart. ex Choisy). D.F. Austin was proposed by D.F. Austin in 1977 on his article *I. carnea* Jacq. var. *I. fistulosa* Mart. ex Choisy, in Taxon (Vol 26).

In spite of several publications dealing with the proper name for this widely cultivated species, there are still nomenclatural problems with what has been called *I. fistulosa*. Apparently Verdcourt (1963) was the first to point out that taxa two were related (Verdcourt in Menninger, 1970), but considered them as distinct species.

Three names have been used extensively in the literature for these plants: *I. carnea* Jacq., *I. crassicaulis* (Benth) Robinson and *I. fistulosa* Mart. ex Choisy. The first name

was based on material studed by Jacquin near Cartagena, Colombia, *I. crassicaulis*, a name more commonly synonymized wth *I. fistulosa* was based on plants colleted at Guayaqul, Ecuador.

O'Donell (1952) pointed out after examining the types of *I. fistulosa* and *I. carassicaulis*, that the two were synonymous. He further indicated that Benthem had seen Chisy's treatment when the basionyms for *I. crassicaulis* was published, thus of these two names, *I. fistulosa* has priority. A comparison of the species viz. *I. carnea* and *I. fistulosa* by Jacquin and Meisner, the two species are separate by the following criteria: a) shrubs in *I. fistulosa* and twinning in *I. carnea*, b) lanceolate-elongate leaves in *I. fistulosa* and ovate in *I. carnea* and c) mostly glabrous in *I. fistulosa* and pubescent in *I. carnea*.

Confusion has surrounded these plants. Austin believes that two major factors: 1) they are widely cultivated and escaped, and 2) the population contains wet habitats plants and dry habitat plants with some extent different morphology. The wet habitat plants are the most widespread and common through the American tropics and the dry habitat plants more restricted, because the plants are geographically isolated most of their ranges and allopatric where they grow in the same country, they may better be considered subspecies, that's why the name become *I. carnea* Jacquin subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin (Austin, 1977).

3.2.1.6 Ipomoea eriocarpa R. Br. Prodr. 484. 1810; Clarke in Hook, f. Fl. Brit. Ind. **4**: 204. 1883; Fang & Staples in Fl. China **16**: 303. 1995; Griekson & Long. **2** (2): 845. 1999; Press *et al*., Ann. Check. Fl. Nep. :73. 2000, *Convolvulus hispidus* Vahl, Symb. Bot. 3: 29. 1795.

Twining or prostrate annual. Stems slender, 1-2 m, pilose with spreading or retrose hairs. Leaves usually lanceolate to linear-or oblong-lanceolate, 2.5-6 x 0.5-1.5 cm, acute to acuminate, mucronulate, base cordate, shortly pilose above and beneath, with 7-8 pairs of lateral veins; petiole 0.7-8 cm, hairy. Inflorescences axillary, sessile or very shortly pedunculate, 1-4 flowered. Pedicels abscent or upto 3 mm. Sepals subequal, 7-8 mm, all linear-acuminate from ovate base, inner narrower than outer. Corolla pink or purple, tubular to infundibular, 7-9 mm, scarcely exceeding sepals; mid-petal bands pilose and paler outside. Stamens and style included. Ovary pubescent, 2-celled. Capsule broadly ovoid to globose, 5-6 mm, hairy. Fl. and Frt.: Aug-Jan. (Griekson and Long, 1999)

Type: Australia, New Holland" Banks & Solander (Holotype BM).

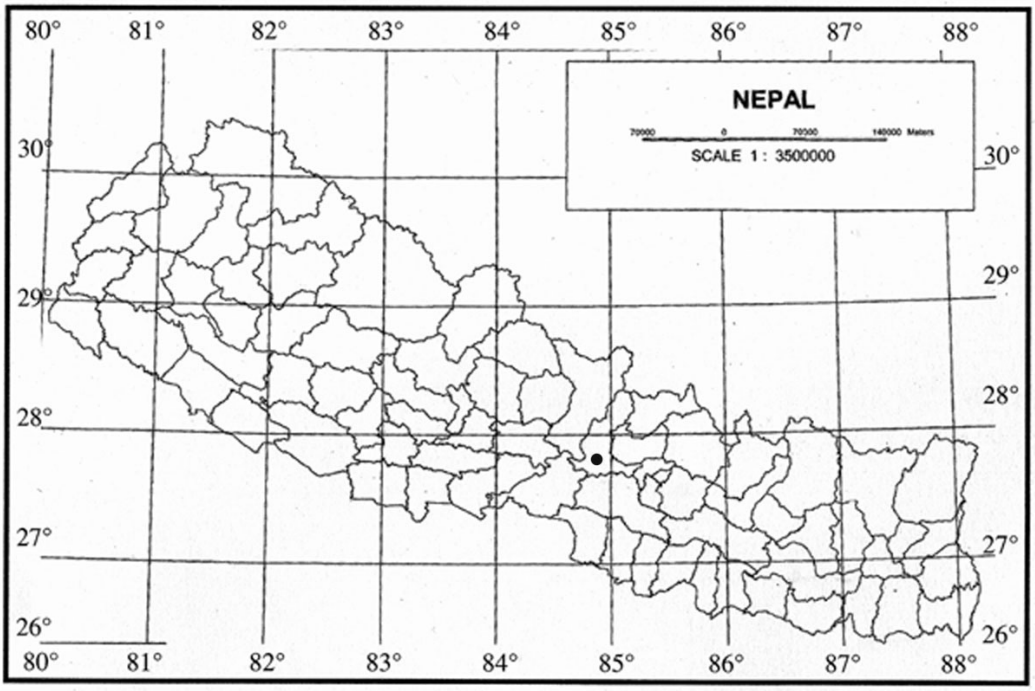
Ecology: open dry land.

Distribution: C. alt.: 610-760m. Nepal, Tropical Africa, Madagascar, tropical Asia, N. Australia.

Chr. No.: Under *I. hispida* 2n = 30 (Sharma & Datta, 1958); n = 15 (Vij, et al. 1977).

Species examined:

Central Nepal: Dolalghat, 760m, 9th Sep, 1064, Dr. Banerji, J. D. Shrestha & A.V. Upadyaya, 2534 (KATH).



Map 5. Distribution map of *Ipomoea eriocarpa* R. Br.

Notes:

The species *Ipomoea eriocarpa* R. Br was recorded by Hara *et al.* (1882) and Press *et al*. (2000) from Nepal. But during field study this species could not be collected. The presence of this species in Nepal is confirmed by the through examination of the herbarium specimens deposited in KATH. But present study unable to collect detail information about the. morphology, anatomy and palynological data because of unavailability of plant specimens in the field and the herbarium specimens which are deposited in KATH has lack of most of the parts of the plant (i.e. leaf, flower and fruits), so in presnt study only description was written which was based on Griekson and Long (1999).

3.2.1.7 Ipomoea hederifolia L., Syst. Nat. ed **10**: 925. 1759; Hara *et al*. EFPN **3**: 106. 1982; Fang & Staples in Fl. China **16**: 312 (1995); Griekson & Long. **2** (2): 850.1999; Siwakoti & Verma. Pl. Div. East. Nep.: 244.1999; Press *et al*., Ann. Check. Fl. Nep.:73. 2000.

Ipomoea angulata Lam., Tabl. Encycl. **1**: 464 (1793). C.R. Rao in Ind. For. **93**: 51 (1967).

Ipomoea phoenicea Roxb., Fl. Ind. **2**: 92 (1824).

Ipomoea coccinea Auct. Non L.: C.B. Clarke in Fl. Br. Ind. **4**: 199 (1883).

Convolvulus hederifolius (Linnaeus) Sprengel, Syst. Veg**. 1***:* 594. 1824.

Quamoclit hederifolia (Linnaeus) G. Don, Gen. Hist. **4**: 259. 1837.

Annual herbaceous, twinner. Stem glabrous or sparsely pilose cylindrical, hollow, stem ca. 2 m high. Leaves petiolated, 2-8 cm, sparsely pilose; leafblade ovate to saborbicular in outline, 3.5-10 x 3-7.5 cm, coarsely dentate; apex acuminate and mucronate; base cordate, pubescent; leaf lamina glabrous abxially, minutely hairy on midrib, base and upper surface; venation lateral, veins 5-7 pairs. Inflorescence axillary and terminal cyme, 1 to many flowers; peduncle 7.5-15 cm, slender, minutely pubescent, first branch of peduncle dichasial with alar-flower, other monochasical in arrangement; bract minute 1 x 0.7 mm, ovate; apex acute, base cordate, glabrous; pedicel erect 3-10 mm. Sepal 5, unequal, erect at anthesis but patent in fruits and each with a large normally linear-herbaceous awn, awn ca. 3 mm long, inserted just below the tips, outer sepal oblong-rettangular 1-2.5 x 1.5 mm, inner ovate 2.5-3 x 2mm, glabrous, shining. Corolla red or scarlet, salverform, glabrous, 2.5-3.5 cm, tube 1.5-2 cm, limb 1.5-2 cm in diam., spreading. Androecium-5, unequal, exerted, basifixed, lower surface of filament hairy, ca. 2.2 cm, anther basifixed, ca. 1.5 x .5 mm, dehisce longitudinally. Pistil 1, ca. 3.1 cm long, exerted. Stigma capitate, 2-lobed, sparsely pubiscent, ovary superior, glabrous, 4-celled, capsule glabose, 5-6 mm in diam. Seeds 4, ca. 4 x 3 mm, black, pubescent. Fl.: Sept-Oct. Frt.: Nov-Dec. (Fig. 14).

Type: Lectotype: *Quamoclit hederae folio trifido* Burm., *Pl. Amer.* fasc. 4, 82, t. 93, f. 2 (1756).

English name: Scarlet Creeper

Ecology: Found on shady place.

Distribution: E. alt.: 610-760m. Nepal, Tropical Africa, Madagascar, tropical Asia, N. Australia.

Uses: Grown as ornamental.

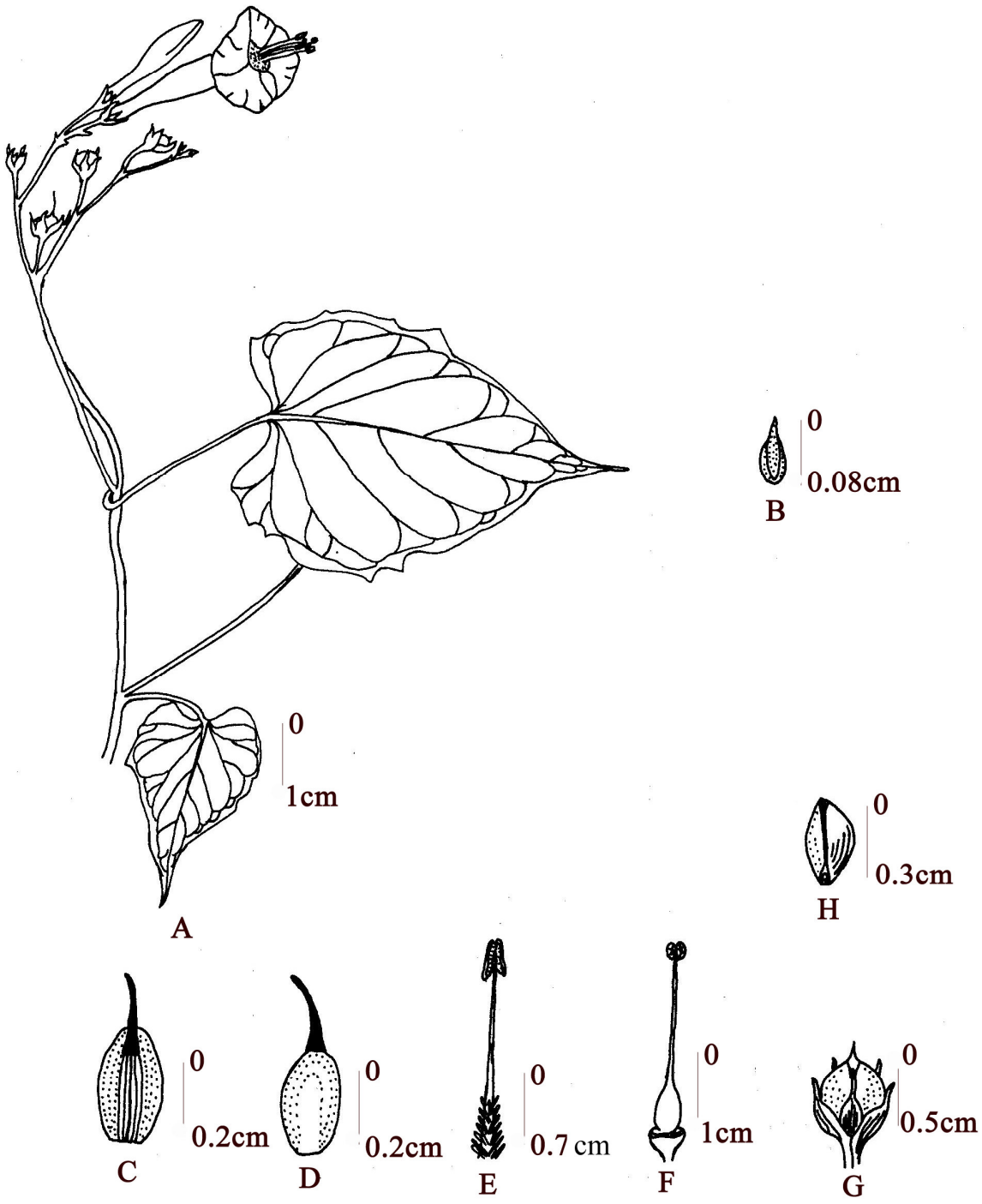
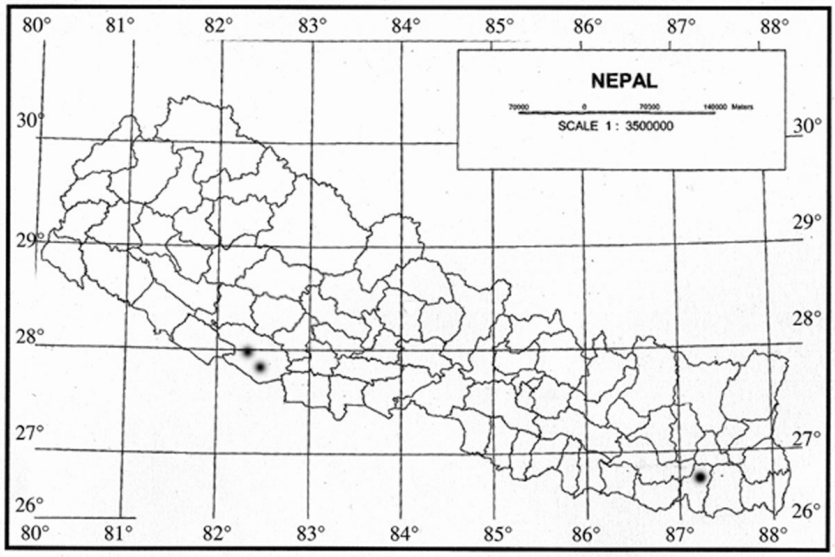


Fig. 14. Ipomoea hederifolia L. A. Habit sketch; B. Bract; C. Sepal (Dorsal view); D. Sepal (Ventral view); E. Stamen; F. Pistil; G. Fruit; H. Seed (S. Shrestha 237).

Species examined:

Eastern Nepal: Bijayapur, **Dharan**, 550m, 9th Nov, 2008, S. Shrestha, 237 (TUCH).

Western Nepal: Mangari, **Dang**, 630m, 28th Oct, 1999, S. Paudel, 5508 (TUCH); Bijuri, **Dang**, 628m, 8th Nov, 2001, Shrestha, K.K., Tiwari, N.N., Acharya, S.K., Adhikari, B., Shakya, D., Raut, L.B. and Bista, S.R. 241 (TUCH).



Map 6. Distribution map of *Ipomoea hederifolia* L.

3.2.1.8 Ipomoea indica (Burman f.) Merr. Int. Rumph. Herb. Amb. 445. 1917; Bhandari, Fl. Ind. Des. 256. 1978; *Ipomoea learii* Paxt. Bot. Mag **6**: t. 267. 1839; Cooke Fl. Pres. Bomb. **2**: 251. 1905; Duthie, Fl. Upper Geng. Pl. **2**: 117. 1911 (Repr. ed. **1**: 558. 1960; Fang & Staples in Fl. China **16**: 304. 1995; Grieson & Lang. Fl. Bhu. **2** (2): 848.1999.

Convolvulus acuminatus Vahl, Symb. Bot. 3: 26. 1794.

Convolvulus indicus Burman, Auctuarium, Index [6]. 1755.

Ipomoea acuminata (Vahl) Roemer & Schultes, Syst. Veg. 4: 288. 1819.

Ipomoea cathartica Poiret, in Lamarck, Encycl., Suppl. 4: 633. 1816.

Ipomoea indica (Burman) Merrill, var. *acuminata* (Vahl) Fosberg, Bot. Not. 129: 38. 1976.

Herbaceous, annual twinner or some time prostrate, with densely retrose pillose axial parts. Stem up to 6 m.; petiole 3-16 cm; retrose hairs, thickened at the base. Leaf blade ovate to circular, 3.5-15.5 x 3-14 cm, abaxially densely short, soft pubescent, adaxially sparsely pubescent; base cordate, margin entire or 3-lobed, apex acuminate, venation

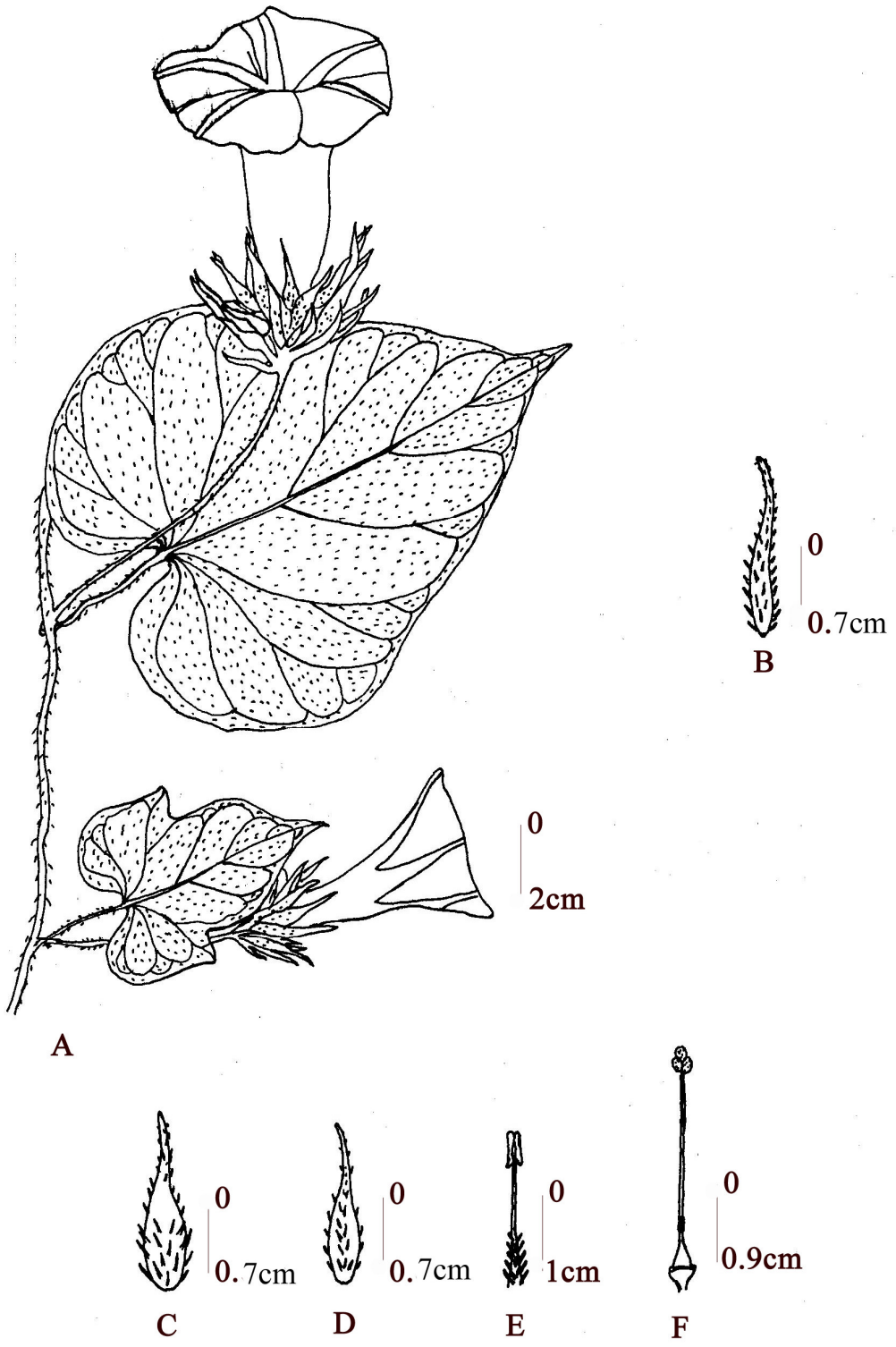


Fig. 15. Ipomoea indica (Bruman, f.) Merrill. A. Habit sketch; B. Bract; C. Outer sepal; D. Inner sepal; E. Stamen; F. Pistil (S. Shrestha 213).

lateral, 7-9 pairs. Inflorescence dense umbel, axillary cyme, many flowered. Peduncle 3-15 cm, stout, hairy; bract-3 in each flower, linear, outer most larger, ca. 2.5 cm and inner 1.5-2.2 cm, sparsely pubescent. Pedicel 3-7 mm. Sepals-5, subequal, lanceolate, 18-20 x 4-5 mm, outer 3 ovate-lanceolate, inner sepal narrowly lanceolate; apex linear-acuminate, hairs of sepal slivery white, soft appressed without bulbous base, margin hairy. Corolla bright blue or bluish purple, aging reddish purple or red, 5-7.5 cm, funnelform, glabrous, 5-7 cm in diameter. Stamen-5, unequal, 1.6-2.5 cm, included, epipetalous, lower part of the filaments silky white; anter basifixed, 5 x 1.5 mm, dehisce longitudianally, extorse. Gynoecium 1, included, 3.6 cm long. Ovary glabrous. Stigma 3-lobed, ovule 3-locular; capsule globose, ca. 1 cm in diam. Seed ca. 5 mm in diam., glabrous. Fl.: Feb-Oct. Frt.: Oct-Nov. (Fig. 15).

Type: Lectotype: based on Besler, *Hort. Eyst. Aest. Ord.* 13, 13, Vol. **8**, t. 2 (1613).

English name: Oceanblue Morning Glory

Ecology: On shady and moist place.

Distribution: EC. Alt.: 80-1150 m. Taiwan, Indonesia, Japan, Malaysia, Pakistan, Sri-Lanka, Native of south America, Tropical Africa, N. America.

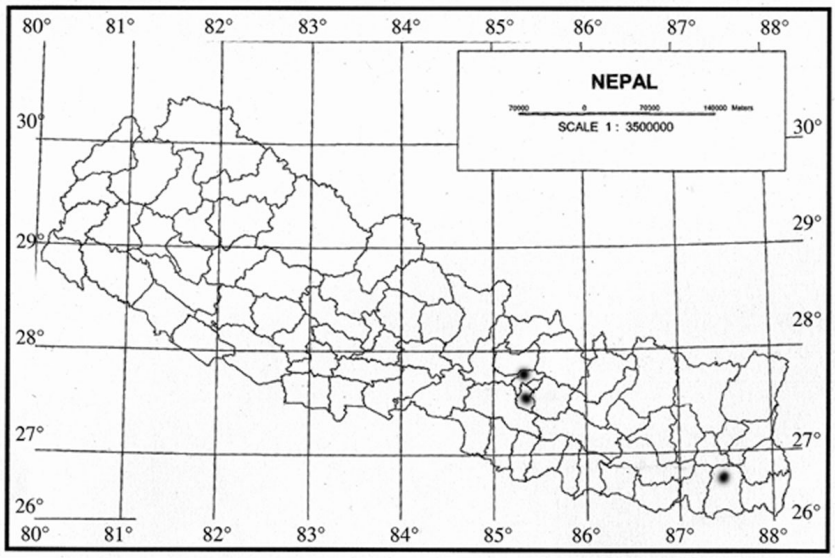
Chr. No.: Under *Ipomoea learii* Paxt. 2n = 30 (Sharma and Datta, 1958). Under *I. congesta* R. Br. n = 15 (Vij, et al., 1977).

Uses: Grown as an ornamental.

Species examined:

Eastern Nepal: Biratnagar, 80m, 8th Nov, 2008, S. Shrestha, 246 (TUCH).

Central Nepal: Kirtipur, **Kathmandu**, 1150m, 28th Aug, 2007, S. Shrestha, 213 (TUCH); Koteswor**, Kathmandu**, 900m, 10th Nov, 2008, S. Shrestha, 250 (TUCH).



Map 7. Distribution map of *Ipomoea indica* (Burman f.) Merr.

Notes:

The species *Ipomoea indica* (Burman f.) Merr. was deposited in KATH by naming *Pharbitis purpurea* L. But the detail morphological study concludes that the species deposited in KATH was *I. indica* and not the *P. purpurea*. This species shows similarity with *I. nil* and *I. purpurea*. The main distinguish character among these species was character of sepal.

In case of *I. purpurea* the sepal was short acute with densely pubescent but in *I. nil* and *I. indica*, the sepal was gradually narrowed towards the apex and the apex was long acuminate. In *I. nil*, the trichome of sepal was densely yellowish hirsute with swollen base but in case of *I. indica*, the trichome was soft silvery white without swollen base. The color and size of the flower was also the distinguishing character to separate these two species. The flower color of *I. indica* was bright blue or bluish purple, aging reddish purple or red, corolla 5-7.5 cm, while in *I. nil* flower color was pale to bright blue with whitish tube, turning red to reddish-purple, infundibular 5-6 cm long. Thus present study concludes that the species *I. indica* is first time reported and studied by auther. So it is new record to Nepal Flora.

3.2.1.9 Ipomoea mauritiana Jacq. Fang & Staples in Fl. China **16**: 310. 1995; Siwakoti & Verma. Pl. Div. East. Nep.:245.1999.

Extensive twinning, perennial herb, Root tuberos. Stem ca. 5 m, slightly angular, terate, glabrous. Petiole 4-12 cm, glabrous, bulbous base. Leaf blade circular in outline, 5-12.5 x 7-13 cm, palmately 5-7 lobed, lobes entire or shallowly lobed, lobes elliptic or lanceolate, apex acute or acuminate and mucronate, glabrous or minutely hairy on midvein, middle lobe longer and border then other, lateral veins 7-9 pairs. Inflorescence axillary few to many flower; peduncle 3-8 cm, glabours; bract very early deciduous, 2 x 1.2 mm, concave, elliptic, apex obtuse, midvein and margin pubiscent. Pedicel 1.3-2 cm, glabrous. Sepal 5, subequal, 9-12 x 6-9 mm, circular, broadly elliptic-ovate, concave, apex obtuse, glabrous, outer 2 shorter than inner, nerve obscure, margin wide, membranous. Corolla pink or reddish purple with dark center, fullenform, 5-6 cm long, limb 5 cm in diam., tube wide. Stamen included, unequal 1.5-2.5 cm long, basifixed, anther 6 x 2 mm, oblong, slightly bent upwards, dehisce longitudinally, pubiscent at the base. Style-1 included ca. 2.6 cm long, sigma 2-lobed, ovary glabrous, 4-celled, capsule ovoid, 1-1.4 cm in diam. Seeds dark brown, 6-8 x 4 mm, with soft long wool, wool easily removable. Fl.: Aug-Oct. Frt.: Sept-Oct. (Fig. 16).

Type: Lectotype: based on Besler, *Hort. Eyst. Aest. Ord.* 13, 13, Vol. **8**, t. 2 (1613).

English name: Giant Potato

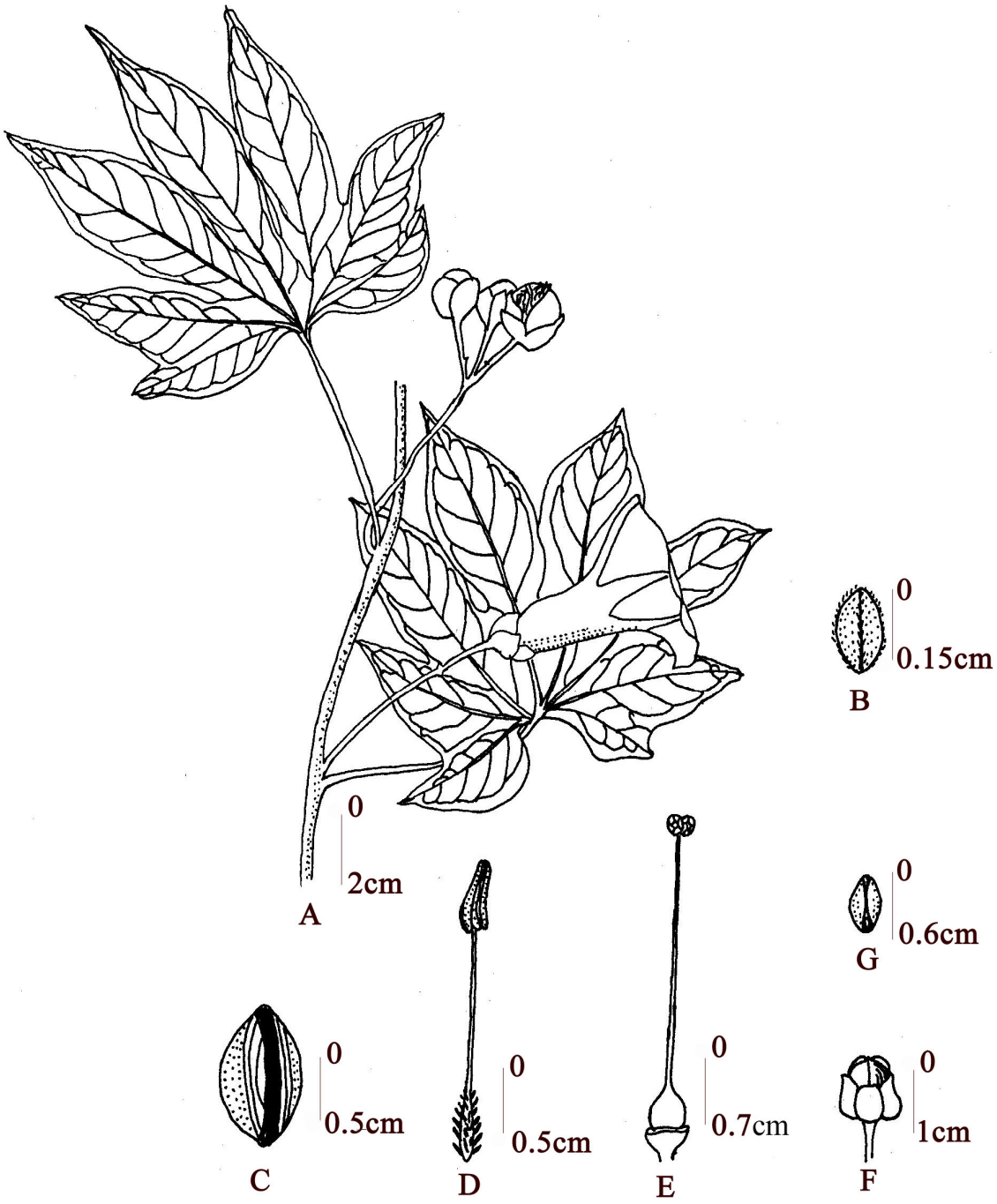


Fig. 16. Ipomoea marutiana Jacq. A. Habit sketch; B. Bract; C. Sepal; D. Stamen; E. Pistil; F. Fruit; G. Seed (S. Shrestha 240).

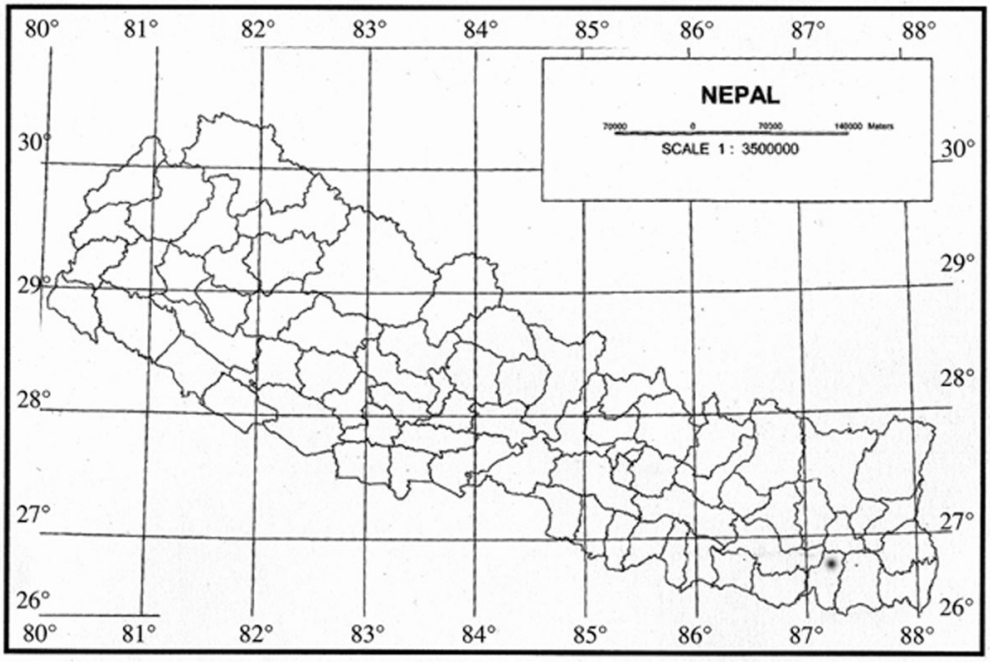
Ecology: Found on open and dry land.

Chr. No.: 2n = 30 (Fang & Staples, 1995).

Distribution: E. alt.: 650 m. Tropical Asia, Tropical Africa.

Species examined:

Eastern Nepal: Dantakali, **Dharan**, 550m, 9th Nov, 2008, S. Shrestha, 240 (TUCH).



Map 8. Distribution map of *Ipomoea mauritiana* Jacq.

Notes:

The species *Ipomoea mauritiana* Jacq. was reported from Eastern Nepal (Budasubba, Dharan, 550m), It was first time reported in Nepal flora by Dr. Mohan Siwakoti in his Ph.D. work entitled "Flora of Plane region of Eastern Nepal (Dharan-Biratnagar)" in 1995. He has reported two species of *Ipomoea* viz, *I. obscura* (L.) Ker Gawl. and *I. mauritiana* as a new record to Nepal Flora but this species *I. mauritiana* is not listed in Flora of Nepal Database. This species was recorded only from Eastern Nepal (Dharan, Budasubba, 550m) in small population and not found in other areas. The herbarium specimen of this species was not deposited either at KATH or at TUCH. The species was confirmed by the vast literature survey and comparing with digital image available from online version of "Catalogue of Madagascar Plant".

3.2.1.10 Ipomoea muricata (L.) Jacq. Hort. Schoenb, 3(2): 40. T. 323. 1793(1803); non Cav. (1799); C. b. Clarke in Fl. Br. Ind. 4 : 197. 1883; Roxburgh in Fl. Ind. 167. 1971; Collett in Fl. Siml. 336. 1980.

Ipomoea turbinata Lag., Gen. Sp. Pl. 10. 1816.
Convolvulus muricatus L., Mant. 44 (1767).
Calonyction muricatum (L.) G. Don, Gen. Syst. 4: 264 (1838). Kitam. In F & Fl. Nep. Him. 207 (1955).

Annual herbs, extensively climbing, twinner, nearly glabrous, with milky juice. Stem 2-5 m, muricate. Leaves petiolated, petiole 3.5-18 cm, grooved, muricate; leafblade broadly ovate to orbicular in outline, (-3.5)7–(-15.5)18 x (-3.5)6.5- (13.5)15 cm, apex acuminate, base cordate, lamina glabrous beneath but short bristles along main veins above; venation lateral, 5-7 pairs. Inflorescence axillary, 1-few flowered cyme; peduncle muricate (-2)3 -12(-13) cm; bracts oblong-lanceolate 4-5 x 1.5 mm, scarious, apex acuminate, nerve lateral, margin slightly orbicular. Pedicel (-5)10–20(-25) mm, much thicker apically, thickened in fruits. Sepals 5, unequal, oblong-ovate, fleshy, glabrous, distinctly enlarged in fruits and eventually reflexed; outer 2 sepal oblong-ovate 6-7 x 3-3.5 mm, without apicule, ticker in middle, apex attenuate into thick apicules, apicule 4-5 mm, inner sepal broadly ovate 6-10 x 4.5-5 mm; margin entire, apex acuminate, thick, 3-4 mm long, vein obscure, mid vein thick-dark brown in color. Corolla opening at night, pale-purple to white, salverform, glabrous, ca. 5 cm, tube 1.5-3 cm long, 2-3.5 cm diam. Androecium 5, unequal, included, sometimes slightly exserted; filaments inserted in apical part of corolla tubes, 2-2.5 cm, base sparsely short pubescent; anther large ca. 2.7 mm, basifixed, base cordate. Pistil slightly exerted or not, ca. 3.6 cm in length. Stigma 2-lobed; ovary glabrous, superior; capsule ovoid, ca. 2 cm diam., 4-valved. Seed-4, black, glabrous 9-10 mm in diam. Fl.: Jul-Sep. Frt.: Oct-Nov. (Fig. 22).

Type: Holotype: India, *Braad* (Herb. Linnaeus 218.18 LINN; microfisha).

Ecology: Found on dry and shady place associated with *lantana camera*.

English name: Purple Moon flower.

Distribution: WC. Pakistan, Himalaya (Kashmir, Nepal), India, Sri Lanka, Myanmar, China (cultivated), Japan, Vietnam, Indonesia, Phillipines, Africa, N. & S. America.

Chr. No.: Under *I. muricata* N = 15 (Vij, et al. 1977).

Uses: As an ornamental. Seeds are used as cure for snake bite and as a substitute for the seeds of *I. nil*, plants juice used as an insecticide.

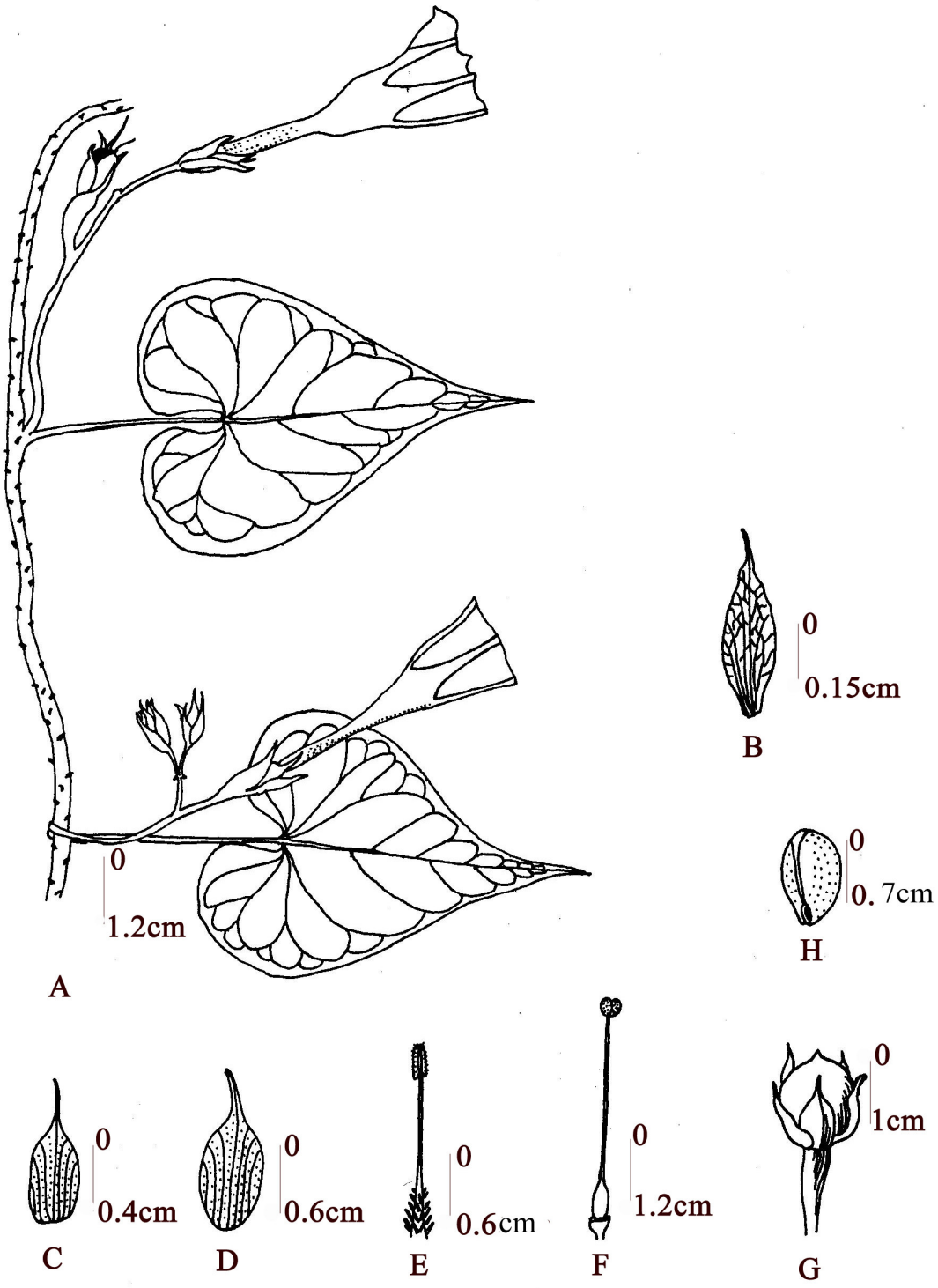


Fig. 17. Ipomoea muricata (L.) Jacq. A. Habit sketch; B. Bract; C. Outer sepal; D. Inner sepal; E. Stamen; F. Pistil; G. Fuite; H. Seed (S. Shrestha 215).

Notes:

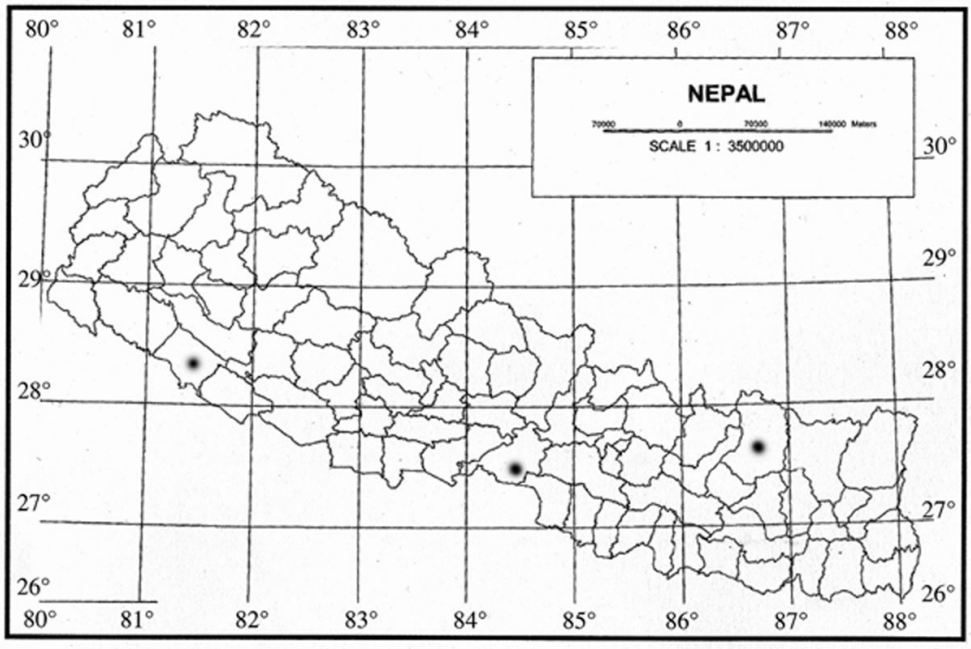
The species *Ipomoea muricata* (L.) Jacq. was collected from Chitwan. It was collected at 5:45 PM.and found as a blooming at that time also. Due to which it is commonly known as 'Moon Flower'.During present study little variation was observed in size of the leaves. The leaves of the collected species were smaller than that of herbarium specimens deposited in KATH and TUCH. Similarly little variation was also observed in the size of the pedicel.

Species examined:

Eastern Nepal: Mayanghi Khola, 900m, 5th Sep, 1958, Stainton, Sykes & William, 4185 (KATH); Bhandar, **Solukhumbu**, 2300m, 18th Aug, 1985, H. Ohba, M. Wakaboyoshi, M. Suzuki, N. Kurosaki, K. R. Rajbhandari & S.K. Wu, 8580926 (KATH); Maggtawa V.D.C. 1200m, 1st Oct, 1995, M.B. Rai, B.M. 202 (KATH).

Central Nepal: Chitwan, 25m, 13th Aug, 2007, S. Shrestha 115 (TUCH).

Western Nepal: Guleria, **Bardia**, 130m, 31st Jun, 2001, Shrestha, K.K., Tiwari, N.N., Acharya, S.K., Adhikari, B., Shakya, D., Raut, L.B. and Bista, S.R. 1915 (TUCH).



Map 9. Distribution map of *Ipomoea muricata* (L.) Jacq.

3.2.1.11 Ipomoea nil (L.) Roth. Cal. Bot. **1**: 36. 1797; Hara *et al.* EFPN **3**: 107.1982; Clarke in Hook, f. Fl. Brit. Ind. **4**: 199. 1883; Hooker. Fl. Brit. Ind. **4**: 204.1885; Maheshwari, Fl. Delhi 238. 1963; Trimen. A. Han. Book. Fl. Ceyl.: 217.1974; Majumdar in Bull. Bot. Surv. Ind. **18**: 52. 1976; Cooke, Fl. Pres. Bomb. **2**: 252. 1905; Duthie, Fl. Upper Gang. Pl. **2**: 1911 (Repr. ed. **1**: 556. 1960); Fang & Staples in Fl. China **16**: 305 (1995); Griekson & Long. Fl. Bhu. **2** (2): 845.1999; Siwakoti & Verma. Pl. Div. East. Nep.: 244.1999. Press *et al*., Ann. Check. Fl. Nep.:73. 2000.

Convolvulus nil L., Sp. L., ed. 2, **1**; 219 (1972); Fang & Staples in Fl. China **16**: 305 (1995).

Ipomoea hederaceus auct. Non Jacq.: Wall., Cat. 84, n. 1373 (1829). C.B. Clarke in fl. Br. Ind. **4**: 199 (1883).

Pharbitis nil (L.) Choisy in Mem. S. Phys. Nat. Geneve **6**: 439 (1834).

Herbaceous, annual, twinner, sometimes prostrate. Stem 2-5 m, retrosely hirsute (hair ca. 2.2 mm), hollow, cylindrical, reddish green in color. Petiole 3-(-10)15 cm, retrose, densely hirsute; leaf blade broadly ovate to orbicular, 4-12 x 3-10 cm, entire or 3-lobed, apex acute to acuminate, lamina highly pubescent on upper surface, hairs ca. 9 mm long with bulbous base, whitish, less puburelent on lower surface, venation lateral, 7-8 pairs. Inflorescence axillary, 1-few flowered in small umbel cymes. Peduncle 1-10 cm, densely hirsute; bract linear, 5-7 x 0.5 mm; apex acute, spreading hirsute. Pedicel 2-(-5)-10 mm, retrose-hirsute. Sepal-5, unequal, 17-25 x 2-4 mm, basal part ovate-elliptic, densely spreading yellowish hirsute bristle with swollen base; apex narrowed into very long, linear acuminate, less hairy upper part, glabrous internally. Corolla pale to bright blue with whitish tube, turning red to reddish-purple, funnelform, 5-6 cm long, glabrous, 3-4 cm across. Stamens-5, unequal, included, 1.9-2.6 cm, base hairy; anther basifixed, ca. 2 mm in length. Pistil 1, included, ca. 2.8 cm long, glabrous; stigma 3-lobed; ovary glabrous, 3-celled-6-ovuled, capsule globose, ca. 10 mm in diam., glabrous. Seed black, ovoid-trigonous, 5-6 mm, gray puberulent. Fl.: Apr-Oct. Frt.: Oct-Nov. (Fig. 18).

Type: Lectotype: Dillenius, *Hort. Eltham.* t. 80, f. 91. 1732 (MO).

Ecology: On shady place, commonly on hedge.

Nepali name: Siudi.

English name: Japanese Morning Glory.

Distribution: WC. Alt.: 760-2000 m. probably a native of the New World tropics now widely cultivated and naturalized in other tropical and temperate areas.

Chr. No.: n = 15 (Vij, et al. 1977).

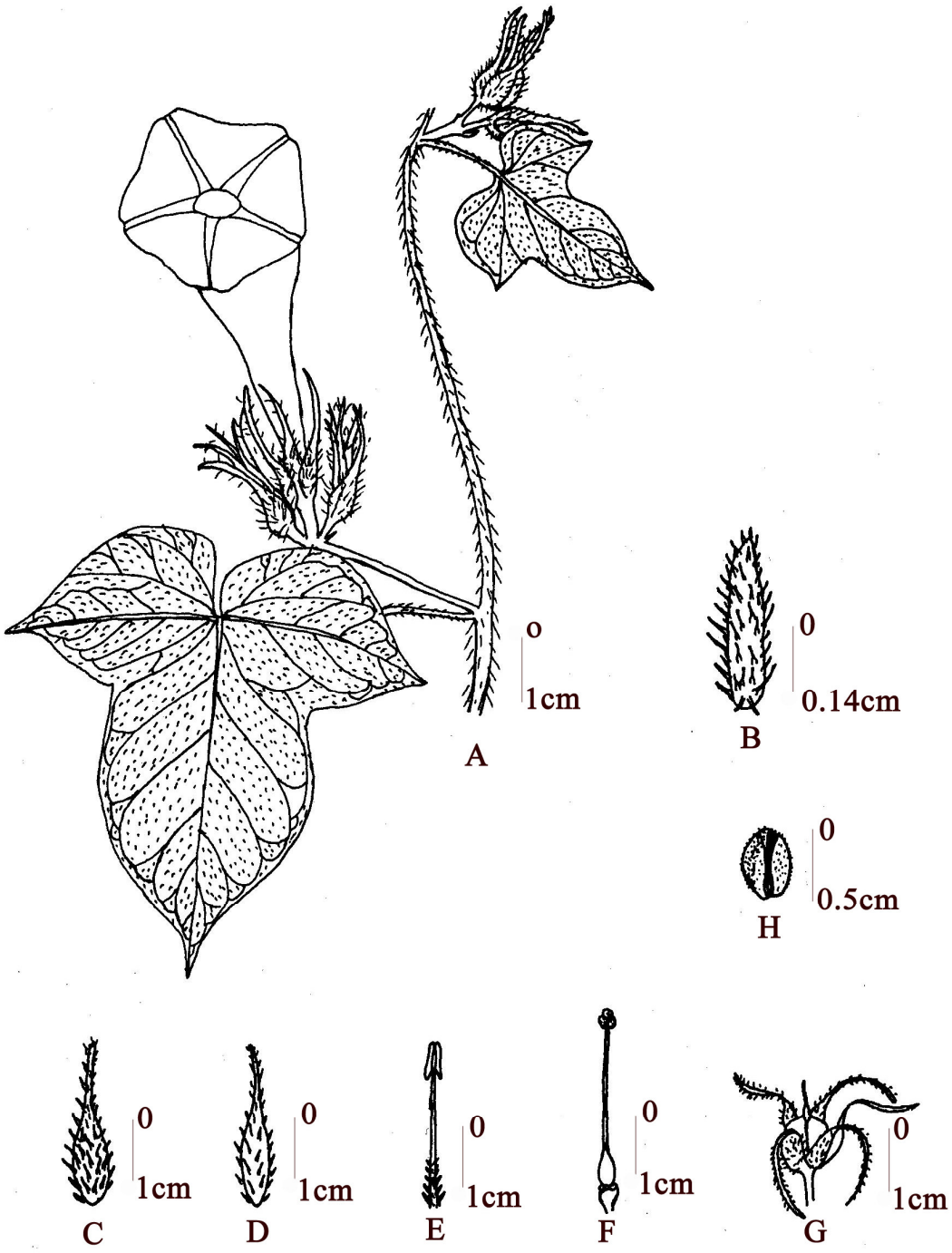


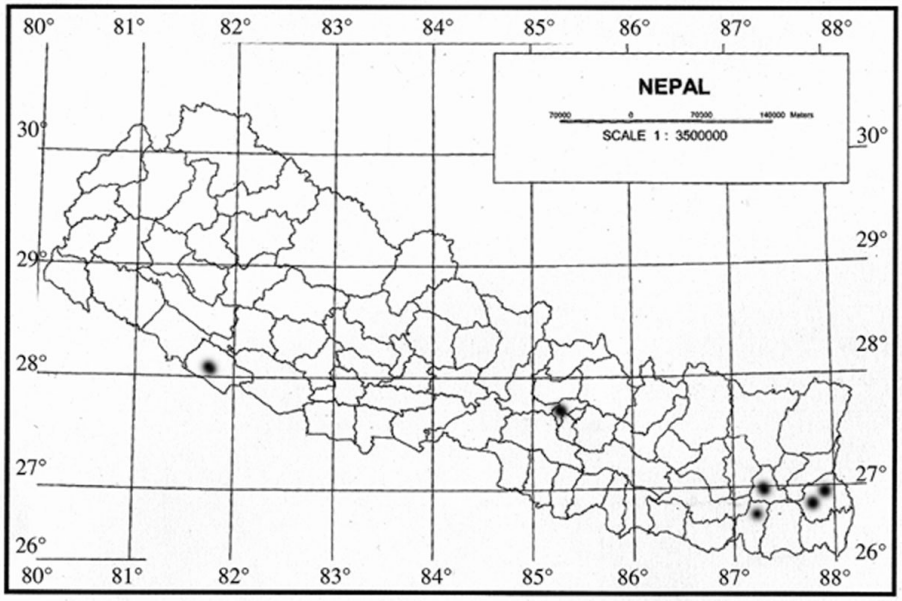
Fig. 18. Ipomoea nil (L.) Roth. A. Habit sketch; B. Bract; C. Outer sepal; D. Inner sepal; E. Stamen; F. Pistil; G. Fruit; H. Seed (S. Shrestha 234).

Species examined:

Eastern Nepal: Hanspokhari, **Ilam**, 1667m, 12th Jun, 1974, P. Pradhan, M. Amatya & Regmi, 281/74 (KATH); Aaitabare, **Ilam**, 1100m, 8th Jun, 1978, P.Pradhan & R. Niraula, 476 (KATH); Dhara Pani, **Dhankuta**, 1000m, 4th Sep, 1997, H. Ohoshi, H. Kanai, H. Obha & Y. Teleizhi 771348 (KATH).**; Dhankuta**, 1150m, 4th Nov, 2008, S. Shrestha, 234 (TUCH).

Central Nepal: Sunauli, 1200m, 22nd Nov, 1988, H.P. Manandhar, 12332 (KATH).

Western Nepal: Raila, 1890m, 31st Sep, 1952, O. Polunin, W.R. Sykes & L.H.J. William, 1292 (KATH); Chunjzi, **Dang**, 1600m, 10th Sep, 1949, F. Ludlow & G. Sherriff & Hicke, 2100 (KATH).



Map 10. Distribution map of *Ipomoea nil* (L.) Roth.

Notes:

The species *Ipomoea nil* (L.) Roth. is commoly known as 'Japanese Morning Glory'. The Japanese morning glory seems to have been originally introduced from China in Nara era (710-784). With regards to the Asian strains such as the Chinese Peking Tendan and the Nepal, it can be assumed that the place of origin of the Japanese morning glory is somewhere in Southeast Asia, including the area of Nepal. However, *I. nil* has been collected widely in tropical to temperate regions of the world (Austin *et al*.,2001; Yoneda, 1998-2004).

Regarding the nomenclature of *I. nil,* a one variety of *Convolvulus hederaceus* in the first edition (1753) of Linnaeus's Species Plantarum was assumed to correspond to *I. nil*,

in the second edition (1763), the academic name of *C. nil*. to *I. nil* was first recorded, as was that of *C. purpureus* to *I. purpurea*. Linnaeus mentioned *I. nil*'s habitat was North America. As the *Convolvulus* of Linnaeus was recognized to have considerably heterogeneous species by later taxonomic studies, the genus *Calystegia* was newly proposed and some species included in *Convolvulus* were moved to *Ipomoea* or to the new *Calystegia* moved *C. nil*. and *C. purpureus*. into genus *Ipomoea* in 1797. Thus the name of the morning glory became *I. nil* (L.) Roth.(Yoneda,1998-2004).
Yoneda (1998-2004), the species *I. nil* which is found in Nepal has narrow-lobe which is TKS (Tokyo Kokei Standard) strains. He has also concluded that the high number of flowers per peduncle in the four Colombian strains, as well as in the Brazil and Africa strains, is considered to reflect the primitive characteristics of the morning glory.

3.2.1.12 Ipomoea obscura (L.) Ker Gawl. In Edwards Bot. Reg. **3**: t. 239. 1817; Clarke in Hook, f. Fl. Brit. Ind. **4**: 207. 1883; Cooke, Fl. Pres. Bomb. **2**: 248. 1905 (Repr. ed. **2**: 317. 1958); Buthie. Fl. Upper Gang. Pl. **2**: 115. 1911 (Repr. ed. 1: 556. 1960); Maheshwari, Fl. Delhi 236. 1963; Trimen. A. Han. Book. Fl. Ceyl.:220.1974; Bhandari, Fl. Ind. Des. 257. t. 90. 1978; Fang & Staples in Fl. China **16**: 307 (1995); Siwakoti & Verma. Pl. Div. East. Nep.:246.1999; Press *et al*., Ann. Check. Fl. Nep.: 74.2000.

Convolvulus obscurus Linnaeus, Sp. Pl. ed. 2., **2**: 220. 1762.

Annual herbs, twinning. Stem hairy, slightly angular, axial part glabrous, 1-2 m. Petiiole 2-6 cm, hairy; leaf blade circular-cordate or ovate, 2-6 x 1.5–5.5 cm, glabrous or sparsely pilose, apex acute, attenuate and mucronate, margin entire or slightly undulate, base cordate, lateral veins 5-7 pairs. Inflorescence 1-3 flowered, axillary cyme; peduncle 1-8 cm, hairy; bract ca. 1.5 x 0.8 mm, linear-lanceolate, apex acute, thick midveins, minutely pubescent, sub-persistant; pedicel 1-2 cm, retrosely hairy, thickned and recurved at fruit. Sepal 5, sub-equal, elliptic-ovate, 4-5 x 3-4 mm, reflexed at fruit, slightly pubescent, mucronate, margin whitish. Corolla-funnelform, yellowish-white or pale-yellow with darker midpetaline bands and always purple spot on the base. Flower small ca. 2 cm diam., 2-2.5 cm long. Stamen 5, included, unequal, 5-10 mm long, epipetalous, pubiscent at base; anther oblong, ca. 2 x 1 mm, dehisce longitudinally. Pistil 1, included, ca. 9.5 mm long; stigma 2-lobed; ovary glabrous, 2-celled-4-ovuled. Capsule conical, ovoid, globose, 6-8 mm in diam. Seed grayish brown, 4 x3.5 mm. glabrous. Fl.: Aug-Oct. Frt.: Nov-Dec. (Fig. 19).

Type: Java, Batavia III, of Convolvulus Flore Minore Lactea=Dill. Hort, Elth. 83. (Syntype).

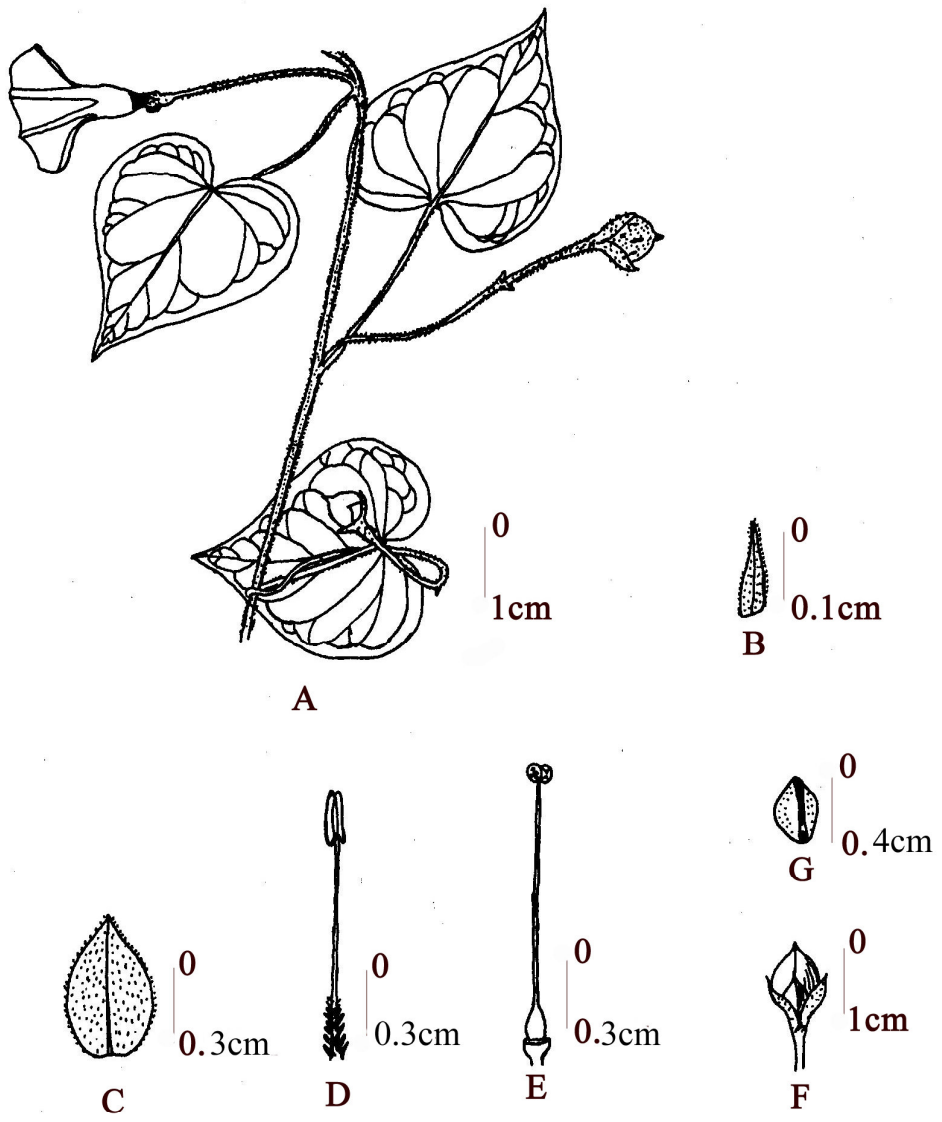


Fig. 19. Ipomoea obscura (L.) Ker Gawl. A. Habit sketch; B. Bract; C. Sepal; D. Stamen; E. Pistil; F. Fruit; G. Seed (S. Shrestha 230).

English name: Obscure Morning Glory

Ecology: In dry and open hedge.

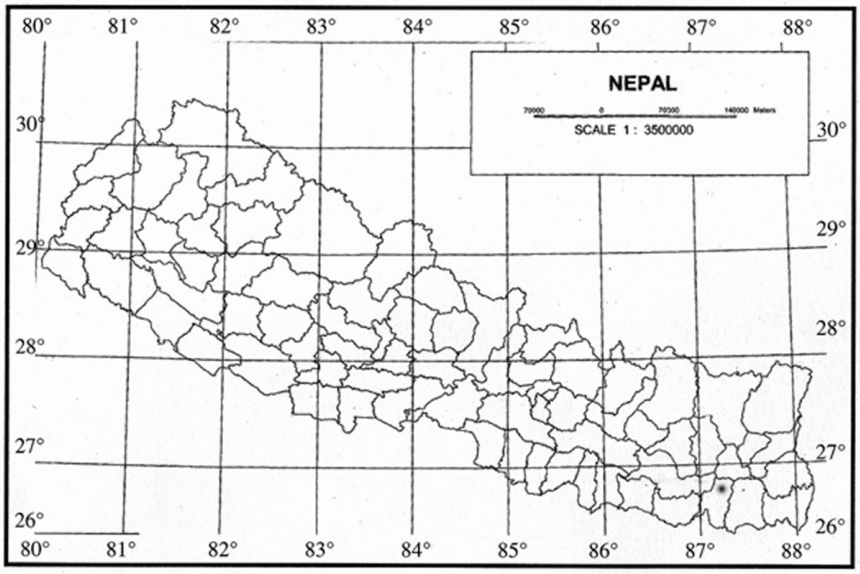
Distribution: E. alt.: 625m. Nepal, Taiwan, Yunnan, India, Indonesia, Cambodia, Malaysia, Myanmar, E. Africa, N. Australia.

Chr. No.: 2n = 30 (Sharma and Datta, 1958); n = 15 (Vij, et al. 1977).

Uses: Leaves possess a pleasant smell and mucilaginous tests, medicinally used in apthous affection after roasting and boiling with ghee (Hajari, 1984).

Species examined:

Eastern Nepal: Bijayapur, **Dharan,** 550m, 27th Oct, 2008, S. Shrestha, 230 (TUCH); Bargachii, Dharan, 350m, S. Shrestha, 241 (TUCH).



Map 11. Distribution map of *Ipomoea obscura* (L.) Ker Gawl..

Notes:

The species *Ipomoea obscura* (L.) Ker Gawl. was first time reported in Nepal by Siwakoti (1995) from Eastern Nepal. Present study reported the same species from Dharan (Budasubba, Bhanu Chock and Bargachai) and it was not found other area except Dharan. The plant was common in hedge, found on single or with other plant, extensively twinning around the other plant or on fence. The flower was small, very attractive, yellowish white or pale yellow with distrinct purple midpetaline band. The herbarium specimen of this species was not deposited either in KATH or in TUCH. So present study add the herbarium specimens of this species on both herbaria of Nepal.

3.2.1.13 Ipomoea pes-tigridis L. Sp. Pl. 162. 1753; Clarke in Hook, f. Fl. Brit. Ind. **4**: 204. 1883; Cooke, Fl. Pres. Bomb. **2**: 250. 1905 (Repr. ed. **2**: 320. 1958); Duthie, Fl. Upper Gang. Pl. **2**: 116. 1911 (Repr. ed. **1**: 557. 1960); Maheshawri, Fl. Delhi. 237. 1963; Puri *et al*. in Rec. Bot. Surv. Ind. **19** (1): 95. 1964; Majumdar in Bull. Bot. Surv. Ind. **18**: 52. 1976; Bhandari, Fl. Ind. Des. 258. t. 91. 1978; Fang & Staples in Fl. China **16**: 306 (1995); Griekson & Long. Fl. Bhu. **2** (2): 848.1999; Press *et al*., Ann. Check. Fl. Nep.: 74. 2000.

Annual, herb, twining or prostrate. Stem densely retrose hispid with stiff bristles, 1-2 m. Petiole slender, 1.5(-2.5)-6(-12.5) cm. Leaf blade orbicular to elliptic in outline, cordate, 3-9 x 3-14 cm, densely pilose on both side, palmately deeply divided nearly to base into 5-7 segments; segments elliptic, apex acuminate and mucronate, narrowed at the base, margin entire, densely hirsute on both side. Inflorescence dense capitates yellowish hirsute cyme, subtended by an involucre bract. Peduncle 4-11(-14) cm, patent hirsute; bract hirsute, outer involucral bract oblong to linear-oblong 1.3-3 x 5-6 mm, apex acute, densely yellowish hirsute on upper and lower surface, inner smaller, lanceolate. Sepal unequal, lanceolate, outer speal lanceolate 13-15 x 5-6 mm, apex acute, densely yellowish hirsute on both side; inner sepal 12-15 x 3-4 mm, apex slightly acuminate, hirsute on base, midrib and apex, glabrous or appressed hirusute on abaxial. Corolla white, funnelform, 3-4 cm, midpetalline bands sparsely pubiscent. Stamen included filaments hairy on basal part, 1.5-.2.2 cm, and anther 4 mm long. Pistil included ca. 2.7 cm long. Stigma 2-lobed. Ovary glabrous, 2-celled-4-ovuled. Capsule ovoid, ca. 8 mm in diam., 4-valved. Seed ellipsoid, ca. 5 x 3 mm, gray, tomentose. Fl. – Frt.: Aug-Dec. (Fig. 20).

Type: Ceylon (Sri Lanka), Hermann, herbarium 4:82 (Lectotype BM).

English name: Tiger foot *Ipomoea.*

Ecology: Found in open grass land, cultivated field.

Distribution: WCE. Alt.; 460-2400m, Nepal. Native to the New World tropics; extensively cultivated as an ornamental and widely naturalized in tropical Africa and Asia.

Chr. No.: 2n=30 (Moore, 1970); n=15; 2n=30 (Vij *et al.* 1977).

Uses: As fodder, medicinally root taken as purgative and antidote to mad dog-bite. (Hajari, 1984).

Species examined

Eastern Nepal: Dhankuta, 1100m, 4th Oct, 1963, H. Hara, H. Kanai & S. Kurossa, 6303923 (KATH).

Central Nepal: Kapilbastu, 200m, 7th Sep, 1992, P.R. Kurmi, KB 477 (KATH); **Bara** district, vicinity of the Parsa Wildlife Reserve, 245m, 2nd Oct , 1995, M. Mikage, T.

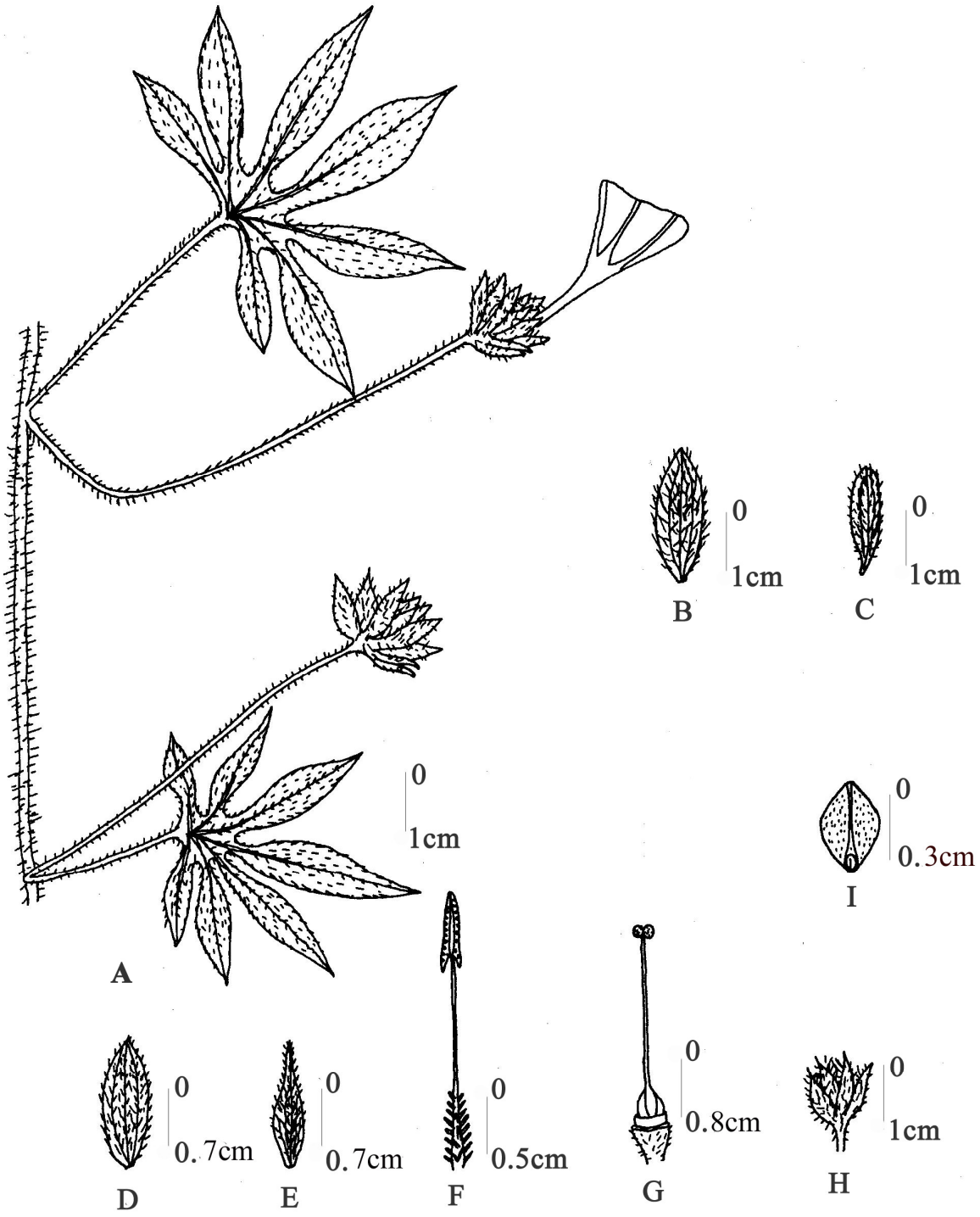
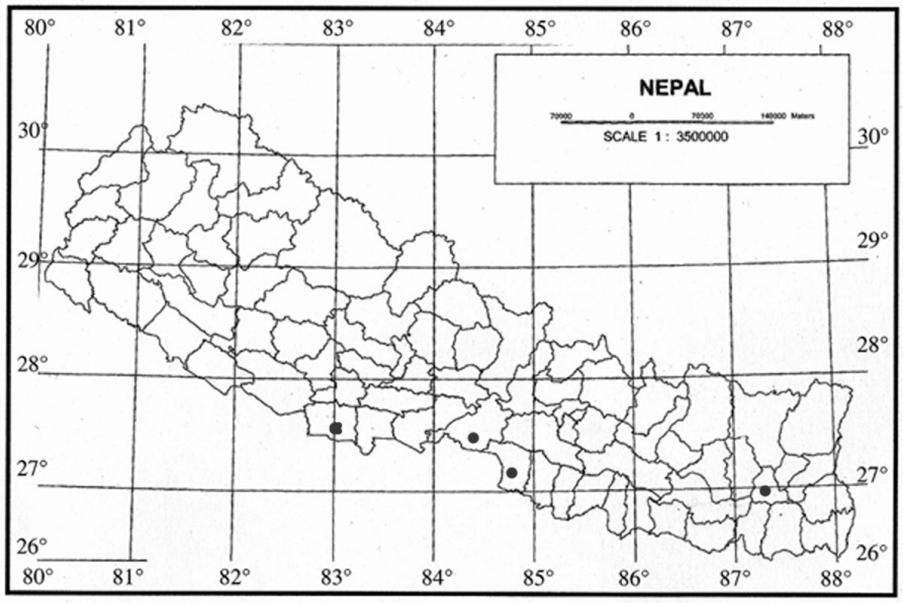


Fig. 20. Ipomoea pes-tigridis L. A. Habit sketch; B. Outer bract; C. Inner bract; D. Outer sepal; E. Inner sepal; F. Stamen; G. Pistil; H. Fruit; I. Seed (Mikage *et at*. 9552745 KATH).

Kajita, H. Kundo, P.R. Shakya, T. Shimizu, P. Shrestha Y. Tsuda & K. Yonekure, 9552745 (KATH).

Western Nepal: Joglauda, 360m, 14th Sep , 1981, I. Sharma, R. Joshi, R. Uprety & I. Pandey, 332 (KATH); Baijapur, **Dang**, 350m, 5th Nov. 1980, R.N. Shukla, 3338 (KATH).



Map 12. Distribution map of *Ipomoea pes-tigridis* L.

Notes:

Due to unfavorable flowering period the author unable to collect this species during field study. The detail morphological, anatomical and palynological study of this species *Ipomoea pes-tigridis* L. was carried out on the laboratory of National Herbarium and Plant Laboratory, Godawari, Lalitpur (KATH).

3.2.1.14 Ipomoea purpurea (L.) Roth EFPN **3**: 107. 1982; Hooker. Fl. Brit. Ind. **4**: 200. 1885; Griekson & Long. Fl. Bhu. **2** (2): 848.1999; Fang & Staples in Fl. China **16**: 305. 1995; Siwakoti & Verma. Pl. Div. East. Nep.: 246.1999; Press *et al*., Ann. Check. Fl. Nep.: 74. 2000.

Convolvulus purpureus L., Sp. Pl. ed. 2, 129.1762.

Pharbitis purpureus (L.) Voight, H. Suburb. Cale, 354. 1845; Kitam. In F. & Fl. Nep. Him. 207. 1955.

Herbaceous annual twinners, stem with short appressed hairs and longer retrosely patent bristles, ca 2.5 cm, swollen gland at the base. Leaves petiolated, petiole 6.5-19 cm, reddish green, densely retrose hairs, leaf blade broadly ovate to suborbicular in outline, 6.5-17 x 7-15 cm, usually unlobed but sometimes 3 lobed, apex acute or shortly acuminate, pilose on both surface, bases deeply cordate. Inflorescence 1-5 flowers cyme, axillary, peduncle 4-17 cm, densely pilose; bract linear 3-6 x 1 mm, pilose on midrib and margin. Pedicel 1.5-2 cm, deflexed in bud and fruits, erect at anthesis. Calyx 5, unequal, outer 2 oblong, lanceolate, 1.5–1.8 x 4.5 mm, densely spreading hirsute on lower part, margin and apex, adaxially glabrous, inner sepal linear-lanceolate, 1–1.5 x 3-4 mm, pilose on base, midrib and margin, glabrous adaxially, nerve obscure, apex acute. Corolla funnelform, 4-6 cm, glabrous, red, pink, redish purple, white or blue; tube white or pink with fading white center. Stamen 5, unequal, included, epipetalous, 1.5–2.5 cm long, anther basifixed, 3.1 mm long, dehisce longitudinally, filaments hairy on lower surface. Pistil included 2.5-3 cm long, stigma 3-lobed, glabrous, and ovary superior, glabrous, 3-celled-6-ovuled. Capsule globose, 9-10 mm in diam., 3- valved. Seed black, ovoid-trigonous, ca. 9 mm in diam, glabrous or sparsely pilose. Fl.: May-Nov. Frt.: Dec.-Jan. (Fig. 21).

Type: Lectotype: Dillenius, *Hort. Eltham.* t. 84, f. 97. 1732

Local name: Siudi.

English name: Morning glory.

Ecology: On shady place.

Distribution: WCE. Alt.: 910-2400m. Nepal, Native of the New World tropics; extensively cultivated as an ornamental and widely naturalized in tropical Africa and Asia.

Chr. No.: 2n=30 (Fang & Staples, 1995).

Use: Grown as an ornamental.

Species examined:

Eastren Nepal: Chulachuli, **Dhankuta**, 900m, 18th Sep, 1972, T.B. Shrestha & T.K. Bhattacharya, 72 (KATH); **Dhankuta**, 1150m, 4th Nov, 2008, S. Shrestha, 241 (TUCH); Morang, **Tehrathum**, 1650m, 18th Oct, 2008, S. Shrestha, 228 (TUCH).

Central Nepal: Kupandol, **Kathmandu**, 1200m, 28th Jul, 1970, M. Manandhar & Ms, Rijal, 16734 (KATH); **Dhunche**, 1900m, 8th Jul, 1984, B. Roy & H. K. Saiju, 1 (KATH);Khangjung, **Rasuwa**, 1828m, 6th Aug, 1985, H. Von, T & Irene, S. Cotter, N/80 (KATH); Ele Ghat, Gandaki Zone, 1620-2140m, M. Suzuki, N. Acharya, N. Fujii, L. Joshi, T. Kazita, N. Kondo, M. Mikage, S. Nosniro & K. Yoda, 9470166 (KATH); kirtipur, **Kathmandu**, 1150m, 27th jun, 2004, Gurung, L.J. and M. Tamang, 241 (TUCH).Kirtipur, **Kathmandu**, 1250m, 15th Sep, 2007, S. Shrestha, 201 (TUCH); Teaching Hospital, **Kathmandu**, 950m, 10th Aug, 2007, S. Shrestha, 207 (TUCH);

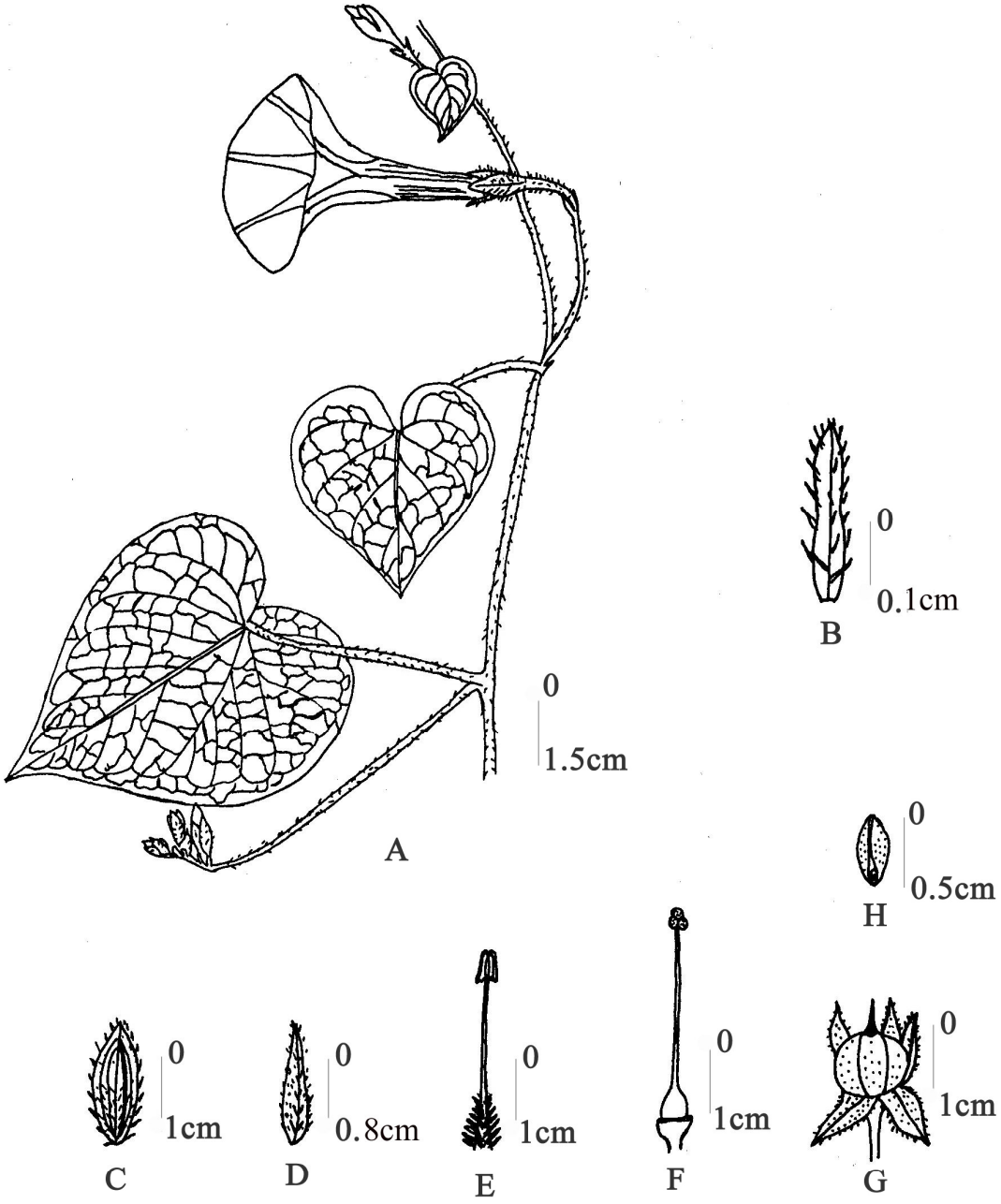
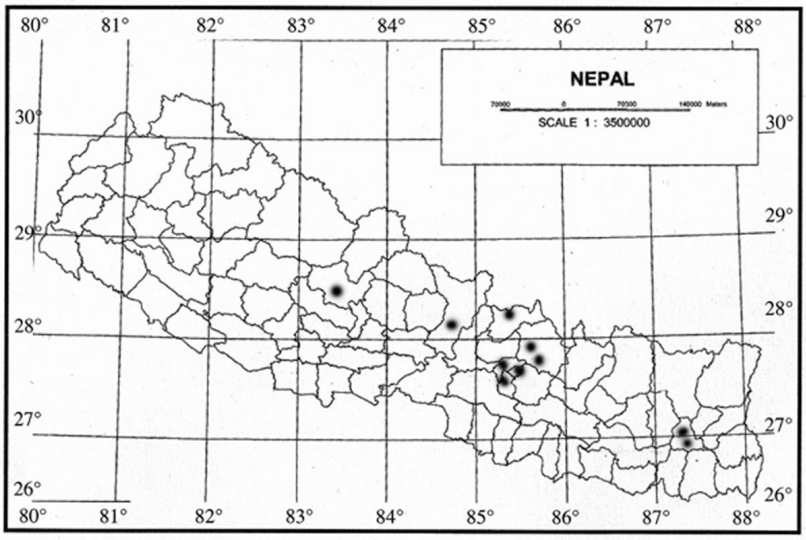


Fig. 21. Ipomoea purpurea (L.) Roth. A. Habit sketch; B. Bract; C. Outer sepal; D. Inner sepal; E. Stamen; F. Pistil; G. Fruit; H. Seed (S. Shrestha 228).

Kalanki, Kathamandu, 1200m, 30th Aug, 2007, S. Shrestha, 214 (TUCH); Tangla, **Kirtipu**r, 1250m, 20th Jul, 2008, S. Shrestha, 223 (TUCH); Tinkune, **Kirtipur**, 1100m, 6th Sep, 2008, S. Shrestha 226 (TUCH).

Western Nepal: TatoPani, **Magdhi**, 1500m, 3rd Jul, 1979, H. K. Saiju & S.R. Tuladhar, 81/79 S.T. (KATH).



Map 13. Distribution map of *Ipomoea purpurea* (L.) Roth**.**

3.2.1.15 Ipomoea quamoclit L. Sp. Pl. 159. 1753; *Quamoclit pinnata* (Dess.) Bojer, Hort, Maurit. 224. 1837; Clarke in Hook, f. Fl. Brit. Ind. **4**: 199. 1883; Maheshwari, Fl. Delhi 234. 1963; Bhandari, Fl. Ind. Des. 259. T. 92. 1978; Nair in Rec. Bot. Surv. Ind. **21**(1): 180. 1978; Cooke, Fl Pres. Bomb. **2**: 261. 1905 (Repr. ed. 2: 331. 1958); Buthie, Fl. Upper Gang. Pl. **2**: 122. 1911 (Repr. ed. **1**: 563. 1960); Hara *et al*., EFPN **3**: 107. 1982; Fang & Staples in Fl. China **16**: 312 (1995); Griekson & Long. Fl. Bhu. **2** (2): 850.1999; Siwakoti & Verma. Pl. Div. East. Nep.: 246.1999; Press *et al*., Ann. Check. Fl. Nep.: 74.2000.

Annual herbaceous, up to 2 m, glabrous, climber, prostrate and creeping, stem glabrous, shiny, hollow, leaves 1-12 cm, deeply pinnactiset, 9-19 pairs of opposite or subopposite leaflets, very narrowly linear, 10-22 x 3-5 mm, nerve obscure. Inflorescence axillary, solitary, 3-5 flowered cyme; peduncle 2-14 cm, longer then leaves; bract-2, ovate, 1.5 x 0.5 mm, apex acuminate, glabrous; pedicels 8-20 mm, longer then calyx, thickned and clavate in fruit. Sepal-5, unequal, oblong or oblong-elliptic, outer 2 longer, 4-4.5 x 2 mm and inner 5.2-5.5 x 2-2.5 mm with awn, apex mucronate, margin hyline, glabrous adxially, minutely hairs on midrib and vein abaxially. Corolla red or white, narrowly salverform, glabrous, tube ca. 2 cm, limb patent, 1.5-2 cm diameter with deep triangular lobes. Stamens-5, exerted, unequal, 2-2.6 cm, anther basifised, 1.2 mm long, dehisce

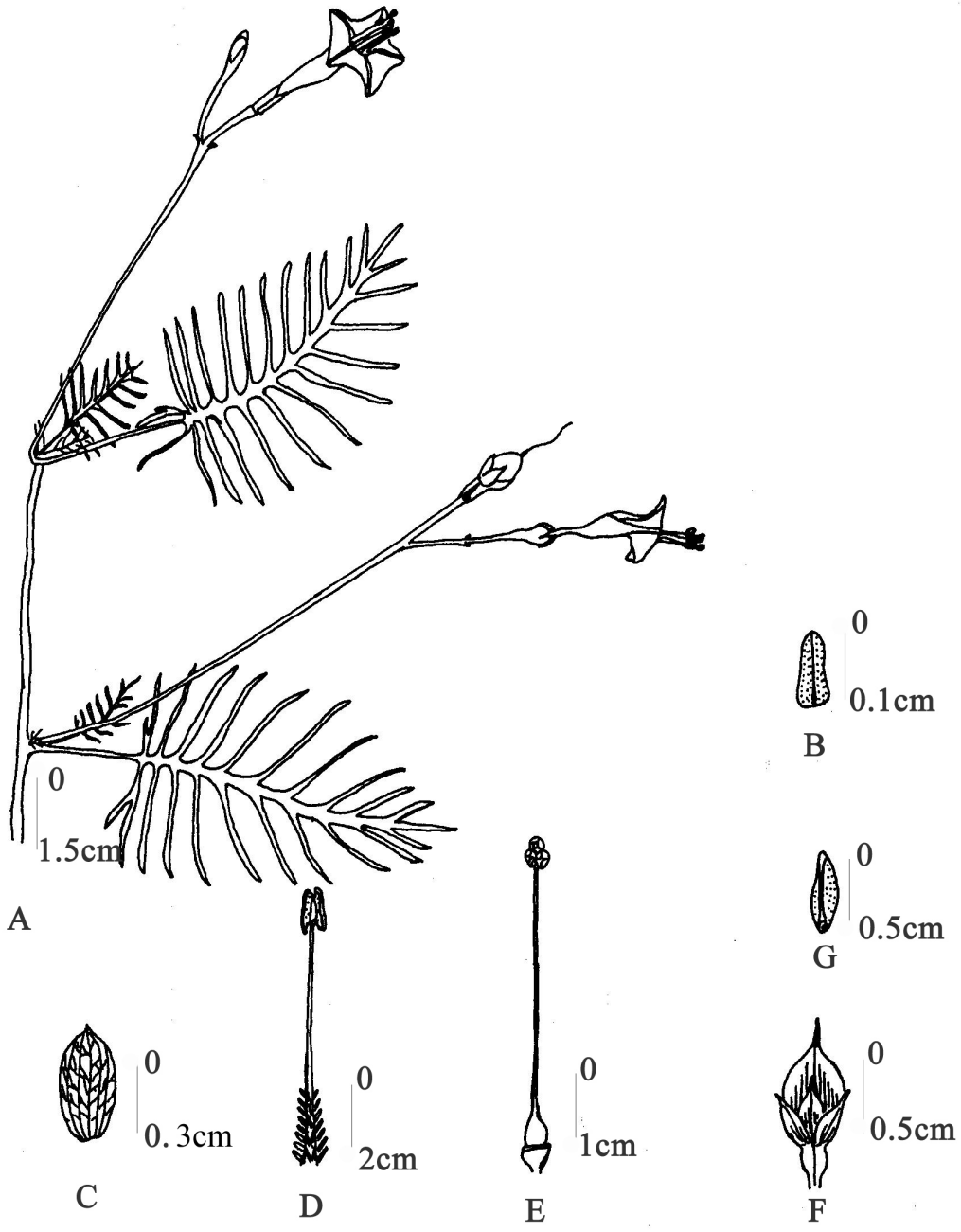


Fig.22. Ipomoea quamoclit L. A. Habit sketch; B. Bract; C. Sepal; D. Stamen; E. Pistil; F. Fruit; G. Seed (S. Shrestha 212).

longitudinally, filaments hairy on base. Pistil-1, ca. 3.2 cm long. Ovary superior, glabrous, 4-celled, placentation axile. Stigma 3-lobed; capsule ovoid, 5-7 mm. Seed dark brown or black, 5-6 mm. in diam. Fl.: May-Juy.Frt.: Aug-Sept. (Fig. 22).

Type: Holotype: India. herb. Linnaeus (219.1 LINN; microfiche).

Ecology: Found on the moist and shady place.

English name: Red Jasmin or Cypress Vine.

Distribution: WCE. Alt.: 460-1100m. Believed to be native of the New Wrold tropics; cultivated as an ornamental and now naturalized throughout most of tropical Asia.

Chr. No.: 2n = 30 (Sharma and Datta, 1958); n = 15 (Vij, et al. 1977).

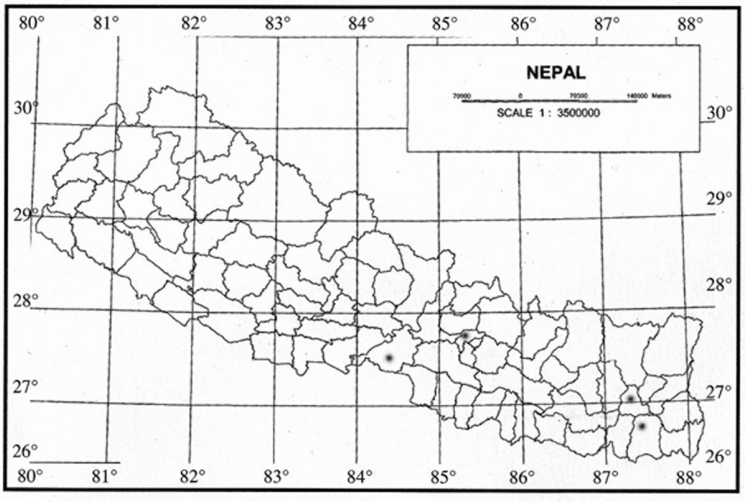
Use: Grown as ornamental. Plants are used to cure breast pain and ulcer.

Species examined:

Eastern Nepal: Soktim, **Ilam**, 460m, 2nd Jun, 1969, T.B. Shrestha, 15369 (KATH). Mulghat, **Dhankuta**, 850m, 21st Jul, 2008, S. Shrestha, 241 (TUCH).

Central Nepal: Lagankhel, **Kathmandu**, 1150m, 7th Oct, 1972, N.P. Manandhar, 8920 (KATH); Zabadaha, **Rampu**r, 180m, 12th Oct. 1981, T.K. Bhattacharya, 5223 (KATH); Bindabasini, **Kaski**, 900m, 24th Jun, 1986, N.P. Manandhar, and L.P. Katel, 10,842 (KATH); **Chitwan**, 250m, 8th Aug, 2007, S. Shrestha, 212 (TUCH); Airport, **Kathmandu**, 1100m, 15th Aug, 2007, S. Shrestha 206 (TUCH).

Western Nepal: Nepaljung, 181m, 29th Nov. 1972, N.P. Manandhar, 9472 (KATH); Kohalpur, **Bake**, 180m, 13th Oct. 1977, Rauny and Party, 1163 (KATH); Kohalpur, **Bake**, 180m, 26th Aug, 1980, Bhattacharya and R.J. Shahi, 3184 (KATH); Jaspur, **Dang,** 580m, 8th Nov, 2001. Shrestha, K.K., Tiwari, N.N., Acharya, S.K., Adhikari, B., Shakya, D., Raut, L.B. and Bista, S.R. 2317 (TUCH); Pathiya, **Bardia,** 583m, 1st Nov, 2001, Shrestha, K.K., Tiwari, N.N., Acharya, S.K., Adhikari, B., Shakya, D., Raut, L.B. and Bista, S.R.(TUCH).



Map14. Distribution map of *Ipomoea quamoclit* L.

Notes:

Among the studied species of *Ipomoea, Ipomoea quamoclit* L. is different than other species due to its linear and pinnately dividied leaflets which is ranging from 9 to 19 pairs. At the base of the petiole leafy psudostipules are common in this species but in most of the literature, presence of psudostipules is not desctrbed. Presence of psudostipules is one of the distinguishing characters of this species. The flower of *I. quamoclit* was scarlet and white. During study it was found that majority of plants bears red or scarlet flower and flower with white flower was found in less population. Due to its attractive flower, it is grown as an ornamental plant.

3.2.1.16 Ipomoea triloba L. Sp. Pl. **1**: 161. 1753. Shah Fl. Gujarat **1**: 475. 1978; Singh & Pandey in Bull. Bot. Surv. Ind. **21**: 92. 1979; Fang & Staples in Fl. China **16**: 305. 1995.

Twinning or prostrate annual herbs, glabrous or sparsely pilose. Stem 1-2 m. Petiole 2-5 cm, glabrous sometime tuberculate. Leaf blade broadly ovate to circular in outline, 2.5-7 x 2-6 cm, glabrous or sparsely pilose, margin entire or coarsely dentate to deeply 3-lobed, lobe lanceolate, middle lobe longer, apex obtuse, mucronate, base cordate; lateral veins 6-7 pairs. Inflorescence axillary, dense umbel cyme, 1-several flowers; peduncle 1 -4.5 cm, glabrous, angular, dark green, bract linear-lanceolate, apex acuminate, 3-5 mm, minutely hairy on upper surface; pedicel very short 2-8 mm, thickened at fruit. Sepal 5, subequal, 7-9 mm, linear-acuminate from ovate base, apex acuminate, abaxially very hirsute, adaxially glabrous, margin fimbriate, inner sepal slightly narrower than outer; vein lateral. Corolla pink or purplish, tubular, 14-18 mm., midpetaline band hirsute outside. Stamen included-5, unequal, 8-11mm long; anther lobed oblong ca. 1.9x1 mm, basifixed, filaments pilose at the base. Style included-1, ca 13 mm long. Stigma 2-lobed. Ovary gray densely hirsute, 2-loculed, 4-ovuled. Capsule galbose 5-7 mm in diam., densely hirsute. Seeds grayish brown, globose, 2.5-4 mm in diameter. Fl.: Sept-Oct. Frt.: Oct-Nov. (Fig. 23).

Type: Lectotype: Sloane, *Jam. Pl.* pl. 97, f. 1. 1696 (MO).

English name: Littlebell

Ecology: Found on dry and open place.

Chr. No.: 2n=30 (Fang & Staples, 1995).

Distribution: E. alt.: 80 m. Nepal, Taiwan, Indonesia, Japan, Malaysia, New Guinea, Philippines, Sri-Lanka, N. America.

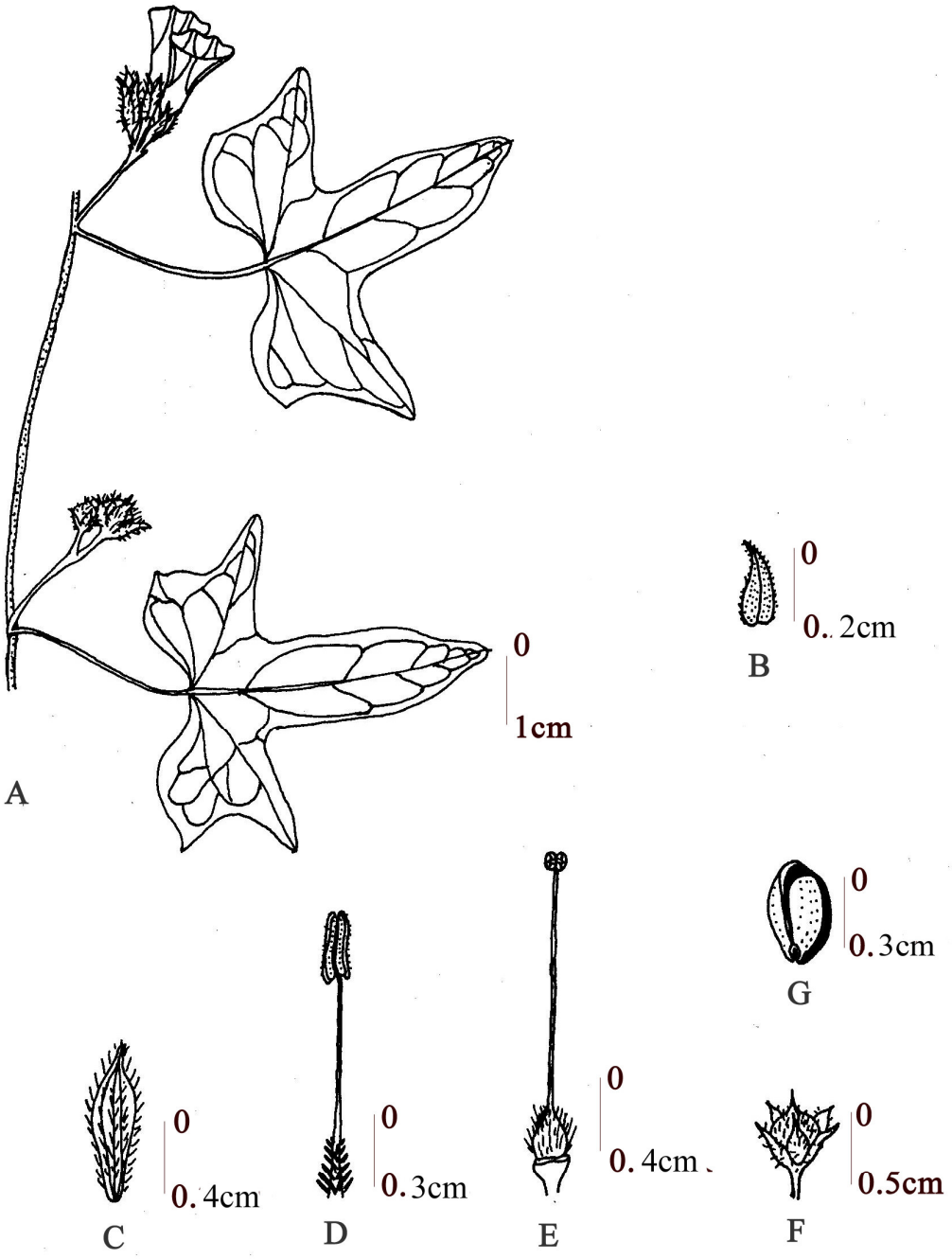
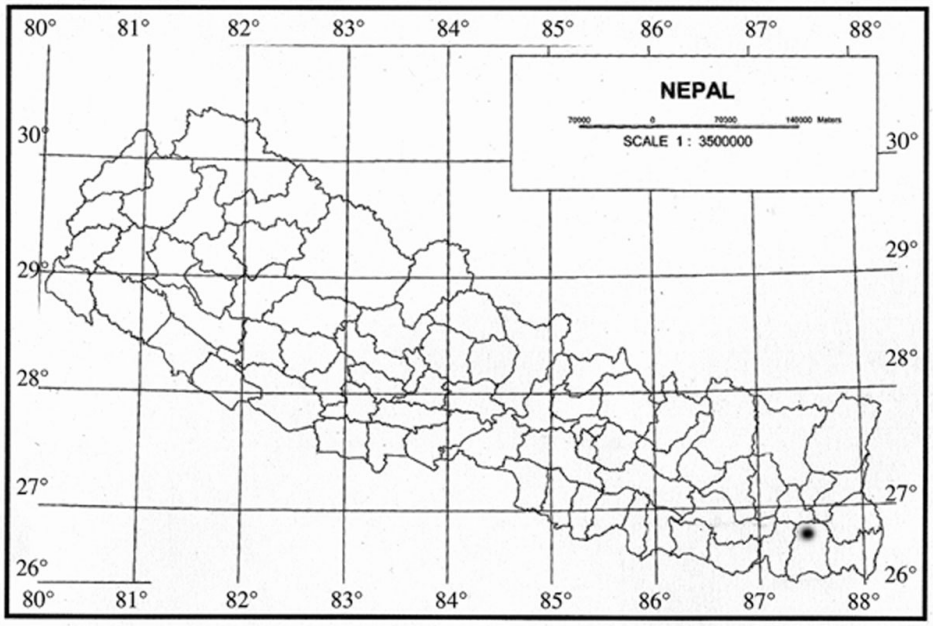


Fig. 23. Ipomoea triloba L. A. Habit sketch; B. Bract; C. Sepal; D. Stamen; E. Pistil; F. Fruit; G. Seed (S. Shrestha 215).

Species examined:

Eastern Nepal: Sanihat, **Biratnagar**, 80m, 8th Nov, 2008, S. Shrestha, 235 (TUCH).



Map 15. Distribution map of *Ipomoea triloba* L.

Notes:

The species *Ipomoa triloba* L. was reported from Eastern part of Nepal (Biratnagar, 80 m). I concludes that *I. triloba* L. is a new record for Nepal by vast literature survey and comparing digital images from different herbaria. The species was confirming by different literature as well as by Dr. D.F. Austin from Sonara Desert Musuem, who is popularly known as Dr. *Ipomoea*. The species showed little similarity with *I. batatas* in shape and color of the flowers. Both species have purple, funnelform flower. The species *I. triloba* was differ from *I. batatas* in integuments of the sepal and ovary. In case of *I. triloba*, the sepal was densely pubescent on margin and midrib while in *I. batatas* sepal was glabrous. Similarly the ovary in case of *I. triloba* was densely hirsute but in *I. batatas* ovary was glabrous and shining. While going through the root system than in *I. batatas*, tuberous root was found while tap root was found in *I. triloba*.

3.3 Distribution

3.3.1 Distribution of genus *Ipomoea* in Nepal.

Hara *et al.* (1982) and Press *et al*. (2000) have been reported 14 and 15 taxa of the genus of *Ipomeoa* from Eastern, Central and Western region of the country with altitudinal range in between 100-2400 m respectively.

Present study confirms the distribution of *Ipomoea* species throughout the Eastern, Central and Western region of the country with altitude ranges from 80 to 2400m. The horizontal and veritical distribution of species of the genus *Ipomoea* based on field study and literature survey is given below:

Table 1: Horizontal and Vertical distribution of genus *Ipomoea* of Nepal.

SN	Name of the Species	Vertical Distribution based on		E	C	W
		Press *et al*. 2000.	herbarium specimens.			
1	*Ipomoea alba*				*	
2	*Ipomoea aquatica*	200-280m.	80-230m.	* ☻ ©		* ☻ ©
3	*Ipomoea batatas*	100-220m.	1000-1250m.	*©	* ☻	☻
4	*Ipomoea cairica*	200m.	80-900m.	* ☻ ©	☻ ©	☻
5	*Ipomoea carnea* subsp. *fistulosa*	100-400m.	60-1200m.	* ☻ ©	* ☻ ©	* ☻
6	*Ipomoea eriocarpa*.	610-760m.	660m.		* ☻	
7	*Ipomoea hederifolia*	300m.	550-900m.	*©	☻	
8	*Ipomoea indica*	-	90-1050m	©	©	
9	*Ipomoea mauritiana*	-	550m	©		
10	*Ipomoea muricata*	910-1400m.	250-2300m.	☻	*©	*
11	*Ipomoea nil*	760-2000m.	1000-1667m.	☻ ©	*©	*
12	*Ipomoea obscura*	625m.	550m	*©		
13	*Ipomoea pes-tigridis*	460-1200m	200-1100m	* ☻	* ☻	* ☻
14	*Ipomoea purpurea*	910-2400m.	900-2140m.	* ©	* ☻ ©	*©
15	*Ipomoea quamoclit*	460-1100m.	250-1200m	*© ☻	*© ☻	☻ *
16	*Ipomoea triloba*	-	80 m	©		

* = Distribution based on literature.

☻ = Distribution based on herbarium studied.

© = Distribution based on personal collection.

3.3.1.1 Horizontal Distribution of genus *Ipomoe*a in Nepal

Most of the species of the genus *Ipomoea* were reported from Eastern and Central parts of the Nepal, while least species were recorded from Western Nepal. The species which were found only in East Nepal during study and from Press *et al*. (2000) were *I. obscura, I. hederifolia* and *I. batatas.* But the herbarium specimens deposited in TUCH and KATH, were found that *I. batatas* and *I. hederifolia* has been reported from Western and Central Nepal respectively. The species *I. mauritiana* was collected from the Easten part of the Nepal by auther and this species was recorded by Siwakoti (1995) at the first time in Nepal from Dharan (Eastern Nepal). The species which was found only in Central Nepal are *I. eriocarpa* and *I. alba,* which were not recorded and collected from other parts of the country.

Present study adds the two new record of *Ipomoea* for Nepal. One species viz. *I. indica* (Burman, f) Merr. was colleted from Eastern and Central Nepal (S. Shrestha 213, fig. 15). Similarly another species *I. triloba* L. was reported from Eastern Nepal (S. Shrestha, 235, fig. 23).

The plants species and herbarium species of *I. aquatica* have been reported only from Eastern and Western Nepal. Similarly the *I. muricata* has been collected and reported form Central and Western Nepal. The species which were recorded from Eastern, Central and Western part of the country were *I. purpurea, I. carnea* subsp. *fistulosa*, *I. nil, I. quamoclit* and *I. pes-tigridis*.

3.3.1.2 Vertical Distribution of the genus *Ipomoea* in Nepal

Altitudinal distribution of the species of *Ipomoea* ranges from 100 to 2400 m. (Hara *et al*. 1982 and Press *et al.* 2000). Distribution based on herbarium collected and distributed ranges from 80 to 2140 m. Most of the species of *Ipomoea* were found in the tropical region of Nepal viz. *I. alba, I. aqautica, I. obscura, I. cairica, I. eriocarpa, I. mauritiana, I. hederifolia* and *I. triloba* which lies in between 80–900 m, however some species like *I. pes-tigridis*, *I. nil, I. purpurea, I. indica, I. quamoclit, I. indica, I. batatas* and *I. carnea* subsp. *fistulosa* were collected and reported from tropical to sub-tropical region of the country which lies in between the altitude of 250–1150 m and the a species *I. purpurea* was reported from temperate region of the country which was found upto 2140 m.

3.4 Phenology

Phenology of the plants shows the calendar of flowering and fruiting period. In the current study, the phenological study was based on the field study, survey of the herbarium specimens and literatures. The flowering and fruiting period of various species of *Ipomoea* is presented in the following table.

Table 2: Phenology of genus *Ipomoea.*

S.N.	Name of the Species	Flowering	Fruiting
1	*Ipomoea alba*	Oct-Dec.	Oct-Dec.
2	*Ipomoea aquatica*	Sept.-Oct.	Nov-Dec.
3	*Ipomoea batatas*	Sept.-Oct.	Oct.-Nov.
4	*Ipomoea cairica*	Aug.-Oct.	Nov-Dec.
5	*Ipomoea carnea* subsp. *fistulosa*	Jul.-Jan.	Feb.-Mar.
6	*Ipomoea eriocarpa*	Sept.-Oct.	Oct.-Nov.
7	*Ipomoea hederifolia*	Sept.-Oct.	Nov-Dec.
8	*Ipomoea indica*	Feb.-oct.	Oct.-Nov.
9	*Ipomoea mauritiana*	Aug.-Oct.	Sept.-Oct.
10	*Ipomoea muricata*	Jul.-Sep.	Oct.-Nov.
11	*Ipomoea nil*	Apr.-Oct.	Oct.-Nov.
12	*Ipomoea obscura*	Aug.-Oct.	Nov-Dec.
13	*Ipomoea pes-tigridis*	Aug-Dec.	Aug-Dec.
14	*Ipomoea purpurea*	May.-Nov.	Nov.-Jan.
15	*Ipomoea quamoclit*	May.-Jul.	Aug.-ept.
16	*Ipomoea triloba*	Sep.-Oct.	Oct.-Nov.

Flowering period of the most of the species of *Ipomoea* were during rainy and summer season. During the study, it was concluding that the flowering times of the most of the species depend upon the climate and intensity of Sun light. On the sunny day the flower blooms between 6 to 11:30 A.M., after this time the colour of the flower become faded and corolla became shrink, due to which the flower of *Ipomoea* is popularly known as 'Morning glory'. When the climate was cloudy then, it blooms till evening. But in case of *I. alba* and *I. muricata*, the flowering period of the plant was at evening so, it is also known by the name 'moon flower'. Regarding the phenology, the flowering period was usually February to October and fruiting period was from October to January. Most of the species of *Ipomoea* were annual, so it was difficult of find the species in late December to till January except *I. carnea* subsp. f*istulosa* and *I. cairica* which are flowering almost all of the year.

3.5 Anatomical study

3.5.1 Stomatal Study

In the present study, the stomata of most of the species of *Ipomoea* were found to be Rubiaceous or Paracytic i.e. stomata were surrounded by two epidermal cells which were parallel to the guard cells (Pic. 2-3). Present study conclude that in species *I. nil*, the stomatal frequency was the highest (318.42 µm) followed by *I. obscura* (227.44 µm), *I. mauritiana* (227.44 µm) and *I. muricata* (219.86 µm). The lowest stomatal frequency was found in *I. purpurea* (30.32 µm). Regarding the size of the guard cells, the largest size of the guard cells was recorded in *I. cairica* (31.45 µm) and the smallest size of the guard cell was in *I. nil* and *I. pes-tigridis* (25.63 µm). The breadth was the highest in *I. cairica* (23.38 µm) and the smallest in *I. nil* (16.77µm).

Table 3: Stomatal study of the various species of the genus *Ipomoea*.

SN	Name of the species	Ave. No of Stomata (S)	Ave. No of Epidermal Cell (E)	Stomata Index (SI) Sx100/ (E+S)	Frequency per mm^2 (F=S/A)	Stomatal size (µm)	
						Guard cells	Stomata
1	*Ipomoea purpurea*	4	33	10.81	30.32	27.96x20.38	16.77x4.66
2	*Ipomoea Indica*	10	36	21.73	75.81	28.89x20.50	17.24x3.26
3	*Ipomoea carnea* subsp. *fistulosa*	16	49	24.61	121.30	30.29x20.97	12.81x5.24
4	*Ipomoea hederifolia*	16	33	32.65	121.30	27.96x19.57	19.10x4.19
5	*Ipomoea quamoclit*	18	53	25.35	136.46	27.49x17.24	16.89x4.07
6	*Ipomoea aquatica*	22	48	31.42	166.79	26.56x17.24	13.98x6.52
7	*Ipomoea batatas*	23	34	40.35	174.37	27.96x20.03	14.91x4.89
8	*Ipomoea cairica*	23	35	39.65	174.37	31.45x23.38	16.89x6.99
9	*Ipomoea triloba*	23	40	36.50	174.37	26.56x18.64	14.44x4.42
10	*Ipomoea pes-tigridis*	28	38	42.42	212.28	25.63x20.97	11.65x4.19
11	*Ipomoea muricata*	29	37	43.93	219.86	28.54x18.05	15.14x4.42
12	*Ipomoea mauritiana*	30	37	44.77	227.44	28.89x20.97	15.51x4.19
13	*Ipomoea obscura*	30	49	37.97	227.44	26.21x20.38	14.56x5.24
14	*Ipomoea nil*	42	52	44.68	318.42	26.21x20.38	14.56x5.24

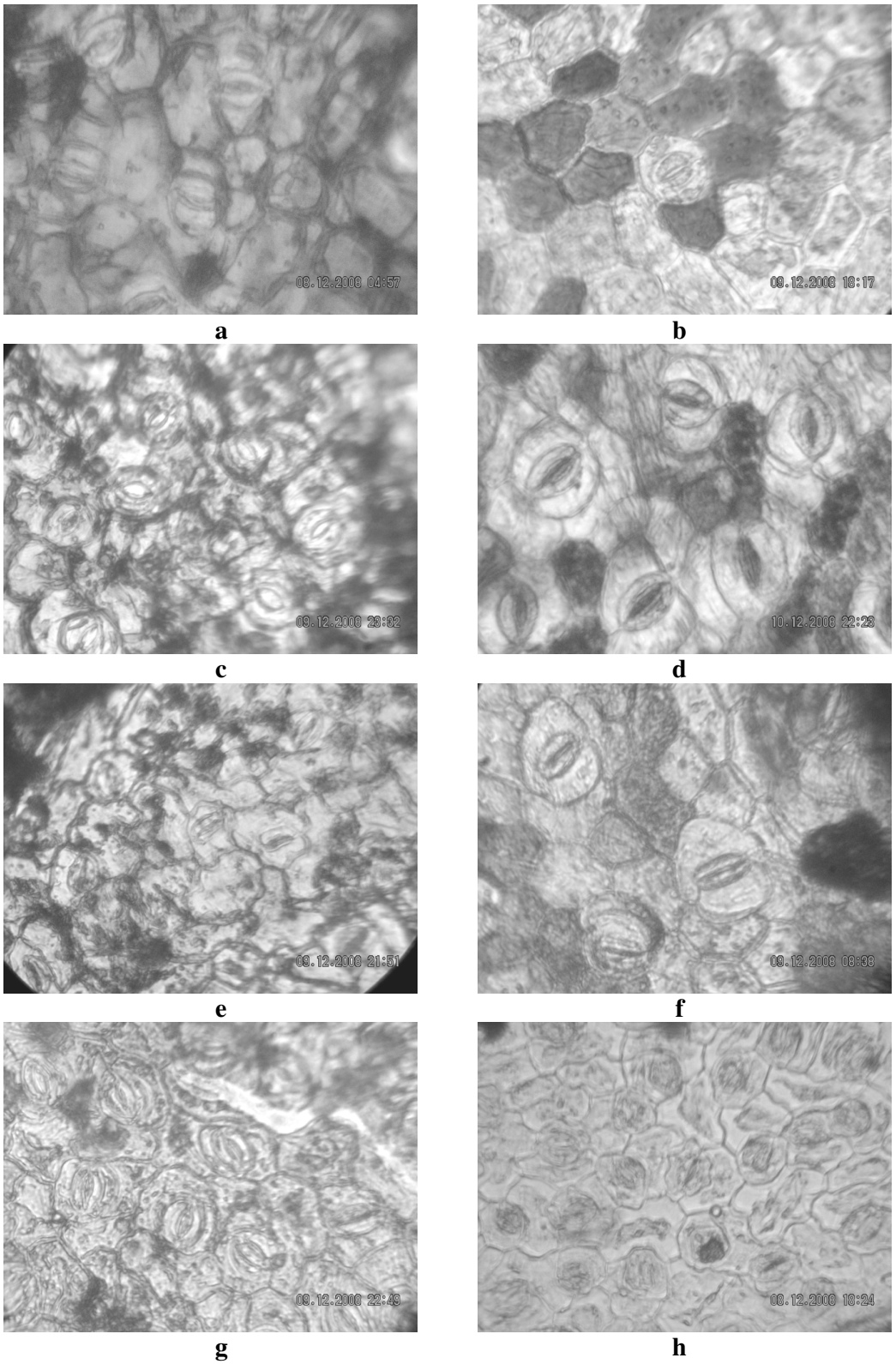
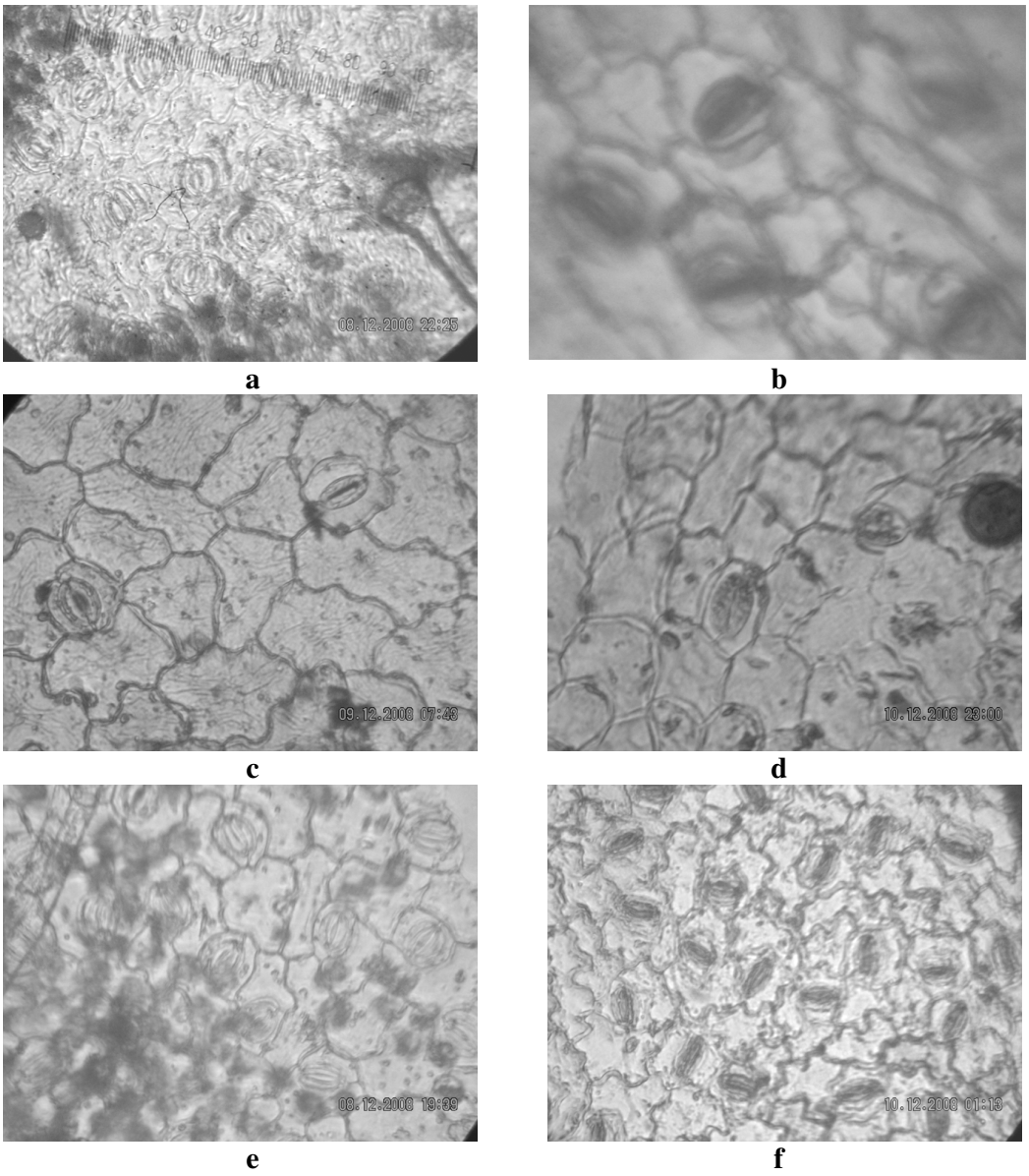


Plate 1. Paracytic type of Stomata: (a) *Ipomoea aquatica* Forsskal**; (b)** *I. batatus* (L.) Lam.; **(c)** *I. cairica* (L.) Sweet; **(d)** *I. carnea* Jacquin subsp. *fistulosa* (Mart.ex Choisy). D.F. Austin; **(e)** *I. hederifolia* L.; **(f)** *I. indica* (Burman, f.) Merrill; **(g)** *I. marutiana* Jacq; **(h)** *I. nil* (L.) Roth.



a **b** **c** **d** **e** **f**

Plate 2. Paracytic type of Stomata: (a) *Ipomoea obscura* (L.) Ker Gawl; **(b)** *I. pestigridis* L.; **(c)** *I. purpurea* (L.) Roth; **(d)** *I. quamaclit* L.; **(e)** *I. triloba* L; **(f)** *I. turbinata* Lag.

3.5.2 Stem anatomy

Stem anatomy of all 14 available species of *Ipomoea* was studied in the present study. There were no significant variations in stem anatomy within the members of the genus *Ipomoea*. The cork, as the outermost layer, was usually superficial in origin. Just below the cork, polygonal or barrel shaped single layer epidermis was present with lignifed outer wall in most of the species. The epidermis was followed by polygonal or oval collenchymatous cortex, the thickness of which was 7-9 layers in *I. aquatica*, *I. cairica, I. mauritiana* and *I. quamoclit*; 4-5 layers in *I. batatas, I. triloba, I. obscura* and *I. muricata*; 12-16 layers in *I. carnea* subsp. *fistulosa*; and 7-10 layers in *I. indica, I. purpurea* and *I. nil*. The secretory cells filled with milky content when fresh, but the latter becoming colourless, yellow or brown when dried, was scattered in the cortical region of almost all the species (Plate 3, 5 and 5).

Endodermis was single layer with barrel shaped parenchymatous cells, which sepereted the cortex and steler region. Just below the endodermis discontinuous ring of sclerenchymatous pericycle was present. The pericycle was single cell thick in most of the species, but in *I. batatas, I. indica, I. mauritiana, I. nil, I. obscura, I. pes-tigridis* and *I. purpurea* the pericycle was 2-3 cells in thickness. In most of the studied species of *Ipomoea*, the secondary growth was already took places. The primary phloem was much reduced (with few layers), which was followed by actively growing few cell thick cambium ring. Secondary phloem was devoid of sclerenchyma.

The xylem consisted of vessels traversed by narrow rays. The vessels of the primary xylem were smaller and arranged in radial rows and were exarch (i.e. protoxylem towards the peripheri and metaxylem towards the center). The vessels of the secondary xylem were very much larger and were concentrated on certain arcs of the xylem cylinder. However, the number of secondary xylem vessels and their aggregations varied between species. Secondary xylem vessels were scattered and solitary in *I. aquatica, I. carnea* subsp. *fistulosa, I. triloba, I. obscura, I. purpurea* and *I. quamoclit*. In these species the secondary xylem vessels were distributed among the thick walled elements of the fibrous ground mass of the xylem. The secondary xylem vessels were found in groups of 4-10 at certain region of xylem cylinder (specially at the arcs) in *I. batatas, I. cairica, I. hederifolia, I. indica, I. mauritiana, I. nil*, *I. pes-tigridis* and *I. muricata*. The size of the secondary xylem vessels varied from species to species. The largest size of the seconday xylem vessels were found in *I. mauritiana* (208.8 µm) and smallest size of the secondary xylem vessels were found in *I. obscura* and *I. carnea* subsp. *fistulosa* (72 µm).

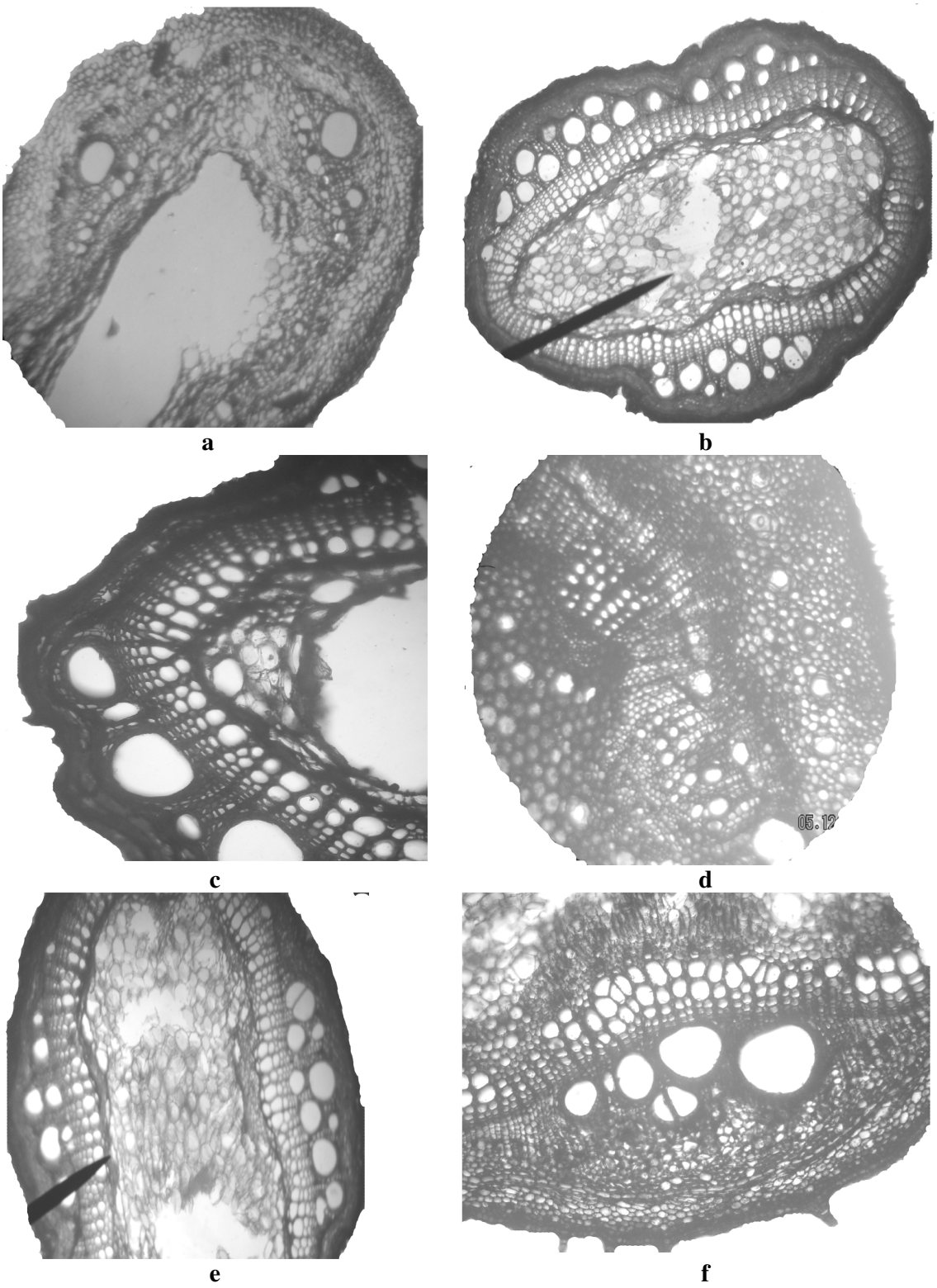


Plate 3. T.S. of Stem : (a) *Ipomoea aquatica* Forsskal; **(b)** *I. batatas* (L.) Lam; **(c)** *I. cairica* (L.) Sweet; **(d)** *I. carnea* Jacquin subsp. *fistulosa* (Mart. Ex Choisy). D.F. Austin; **(e)** *I. hederifolia* L ; **(f)** *I. indica* (Burman f.) Merrill

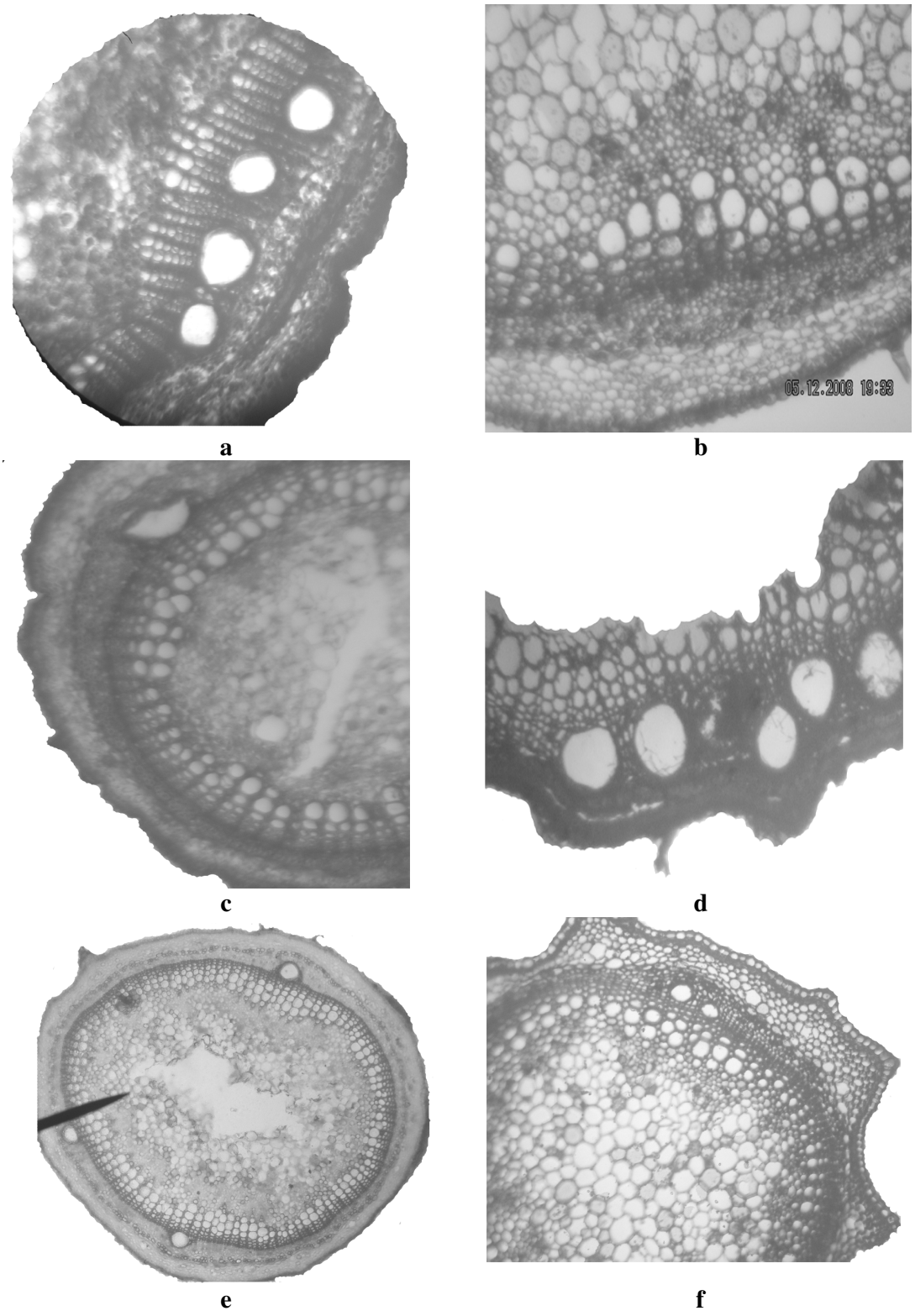
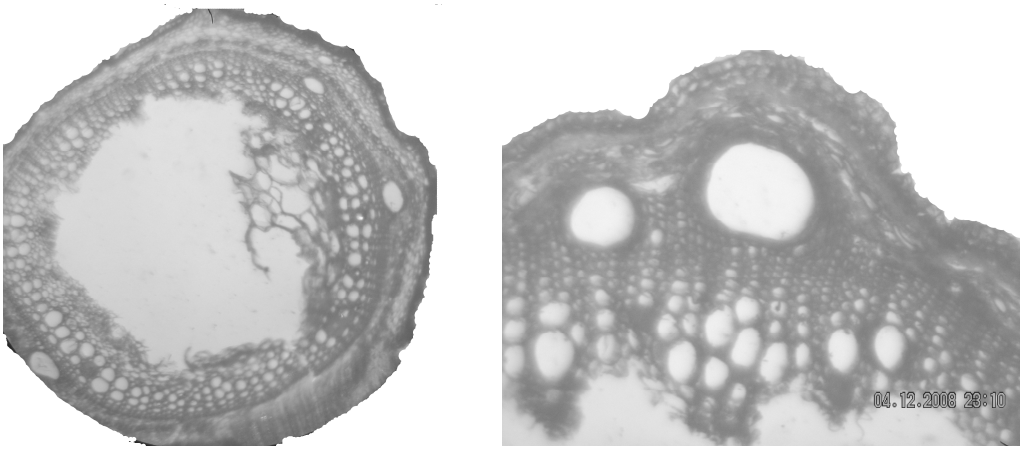


Plate 4. T.S. of Stem: (a) *Ipomoea mauritiana* Jacq; **(b)** *I. nil* (L.) Roth.; **(c)** *I. obscura* (L.) Ker Gawl; **(d)** *I. pestigridis*; **(e)** *I. purpurea* (L.) Roth; **(f)** *I. quamaclit* L.



a **b**

Plate 5. T.S. of Stem: (a) *Ipomoea triloba* L. and **(b)** *I. muricata* Lag

Table 4: Size of the Secondary Vessels of the various species of *Ipomoea* L.

SN	Name of the Species	Vessel Size (µm)	SN	Name of the Species	Vessel size (µm)
1	*Ipomoea aquatica*	115.2	8	*Ipomoea muricata*	180
2	*Ipomoea batatas*	115.2	9	*Ipomoea nil*	86.4
3	*Ipomoea cairica*	122.4	10	*Ipomoea obscura*	72
4	*Ipomoea carnea* subsp. *fistulosa*	72	11	*Ipomoea pes-tigridis*	122.4
5	*Ipomoea hederifolia*	93.6	12	*Ipomoea purpurea*	86.4
6	*Ipomoea inidca*	180	13	*Ipomoea quamoclit*	80.4
7	*Ipomoea mauritiana*	208.8	14	*Ipomoea triloba*	90

The most characteristic feature of *Ipomoea* was the presence of intraxylary phloem. This anamolous feature was also reported in other members of the family Convolvulaceae (except cuscuta) as described by Maire in 1913. The intraxylary phloem (secondary formed inner phloem) was arranged in radial rows in the inner part of the vascular bundle. Such phloems, however, did not form a continuous layer around the vascular cylinder. The innermost part of the stem i.e. pith was large and was made up of rounded or oval shaped parenchymatous cells which were filled with milky, yellow or brown secretory cells. The secretory cells in the pith region were either solitary or arranged in long rows. Parenchymatous cells with clearly visible food storage starch grains were also found in the pith region of most of the studied species.

3.6 Palynological study

3.6.1 Morphology of pollengrans of the genus *Ipomoea*

Present study accomplished the pollen analysis of 14 taxa of the genus *Ipomoea*. The result found that the pollen grains of all the studied species belonged to the "*Ipomoea* type" as described by Erdtman (1952). The pollengrains were echinate, pantoporate with a reticulate exine pattern. The pores were surrounded by extraporal regions and the spine forms a hexagonal area around each extraporal region. The spines were present more or less at the junction of each arm of the hexagon (plate 7:**g**).

The shapes of the pollen grains were spheroidal or globose (Plate 6 & 7). In all the observed pollen grains, the polarity of pollen grains was isopolar, in which the two polar hemispheres were the same. The sculpturing of the pollen grains was echinate, having spinelike outer wall with bulbous base. The aperature was pantoporate in which Pori occur globally on the surface of the pollen grain. The symmetry of all the observed pollen grains were found to be radially symmetric i.e., with two or more plane of symmetry and the pollen is placed under the category of sub-tectate type.

Among the 14 species of *Ipomoea*, the largest pollen was recorded in *I. quamoclit* (150.84 µm) and the smallest size of the pollen was found in *I. aquatica* (60.92 µm). The spine of the pollen was largest in *I. mauritiana* (11.65 µm long) and smallest in *I. aquatica* (4.98 µm) among the 14 species. The outer surface of the pollen was covered with numerous pores. The largest size of the pore was found in *I. carnea* subsp *fistulosa* (13.11 µm) and the smallest pore was found in *I. cairica* (3.48 µm) (Table: 4).

Table 4. Palynological study of *Ipomoea.*

SN	Name of the species	Size of the Pollen (µm)		Size of the spine (µm)	Diameter of the pore(µm)	Aperature
		With spine	Without spine			
1	*Ipomoea aquatica*	60.92	55.94	4.98	3.65	Pantoporate
2	*Ipomoea cairica*	63.19	57.67	5.52	3.48	Pantoporate
3	*Ipomoea pes-tigridis*	74.88	65.28	9.6	4.4	Pantoporate
4	*Ipomoea obscura*	75.31	64.60	10.71	5.59	Pantoporate
5	*Ipomoea triloba*.	77	67.92	9.08	6.99	Pantoporate
6	*Ipomoea mauritiana*	81.58	69.93	11.65	8.43	Pantoporate
7	*Ipomoea batatas*	93.54	87.24	6.30	7.30	Pantoporate
8	*Ipomoea nil*	95.87	87.91	7.96	4.98	Pantoporate
9	*Ipomoea indica*	96.37	86.58	9.79	4.64	Pantoporate
10	*Ipomoea purpurea*	102.73	94.57	8.16	6.07	Pantoporate
11	*Ipomoea carnea subsp. fistulosa*	105.13	97.23	7.9	13.11	Pantoporate
12	*Ipomoea hederifolia*.	110.86	102.56	8.3	5.97	Pantoporate
13	*Ipomoea muricata*	113.13	106.56	6.57	7.96	Pantoporate
14	*Ipomoea quamoclit*	150.84	142.05	8.79	8.26	Pantoporate

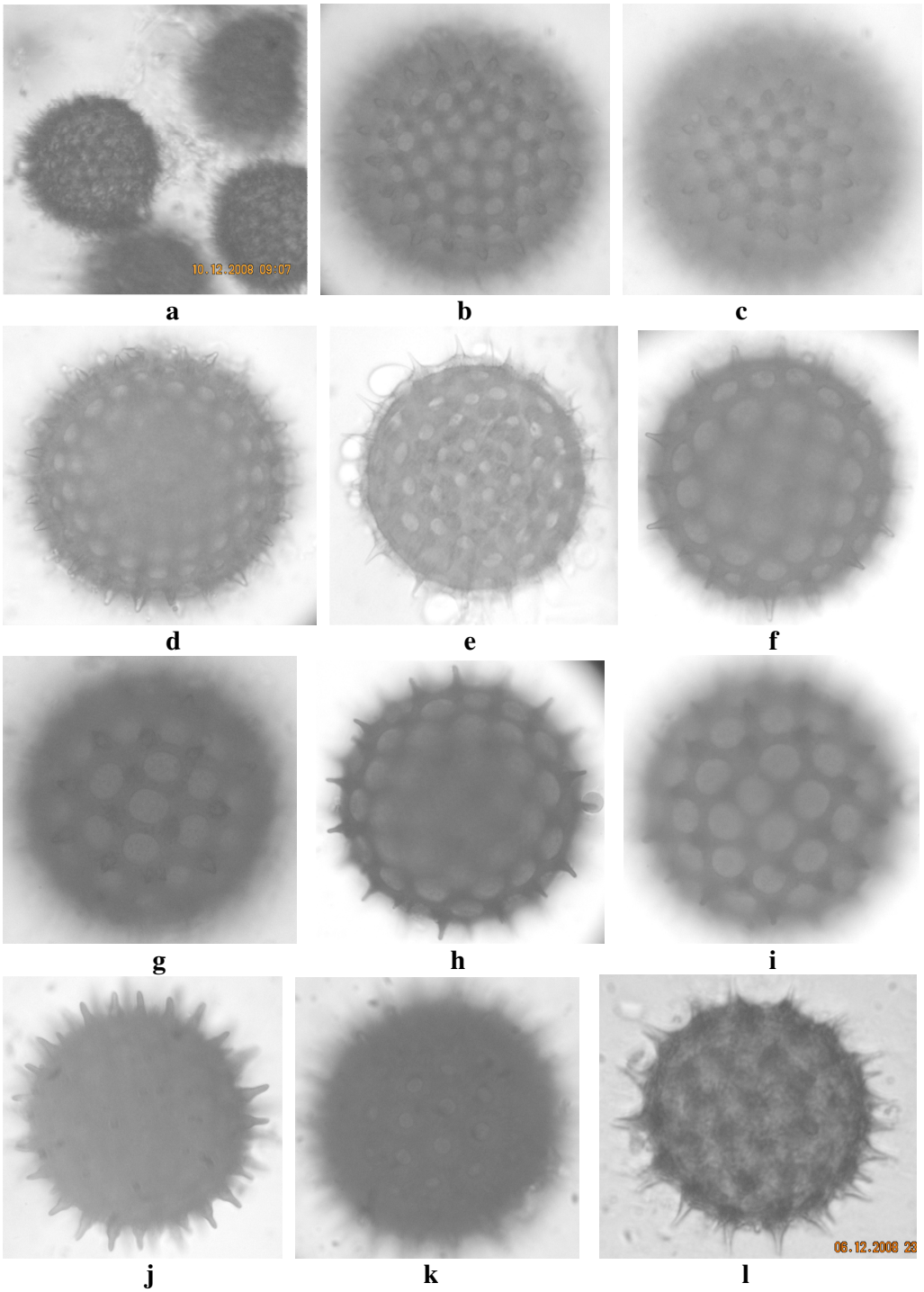


Plate 6: Pollen-grains : (a) *Ipomoea aquatica* Forsskal; **(b, c, d)** *I. batatus* (L.) Lam,; **(e)** *I. cairica* (L.) Sweet.; **(f, g)** *I. carnea* Jacquin subsp. *fistulosa* (Mart. Ex Choisy). D.F. Austin; **(h, i)** *I. hederifolia* L.**; (j, k)** *I. indica* (Burman f.) Merrill. And **(l)** *I. marutiana* Jacq.

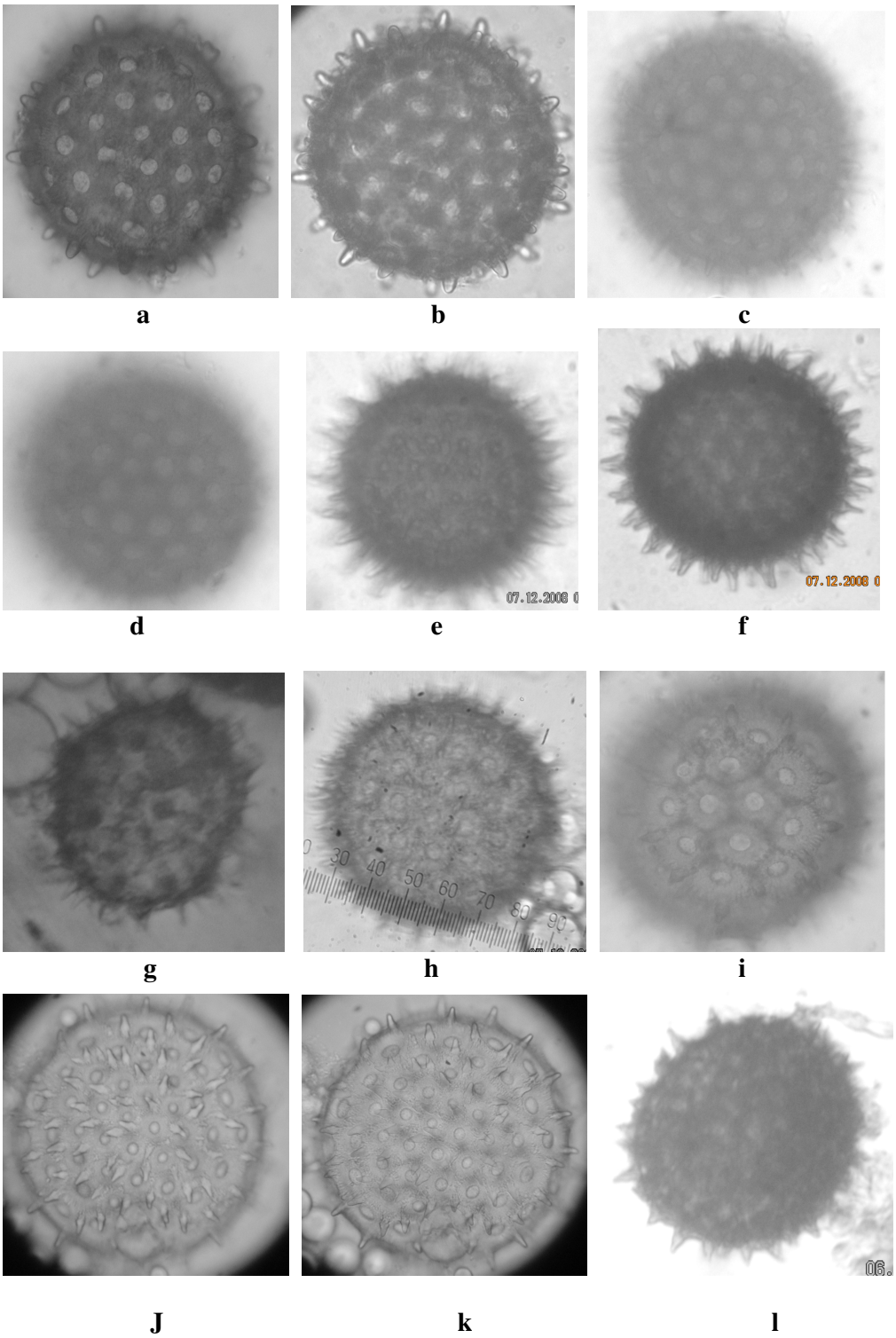


Plate 7: Pollen-grains: (a, b) *I. muricata* L.; **(c, d)** *I. nil* (L.) Roth.; **(e, f)** *I. obscura* (L.) Ker Gawl; **(g)** *I. pes-tigridis* L.; **(h, i)** *I. purpurea* (L.) Roth; **(j, k)** *I. quamaclit* L.; **(l)** *I. triloba* L.

3.7 Cluster analysis

The cluster dendrogram showing relationships among the species of *Ipomoea* is presented in Fig 24.

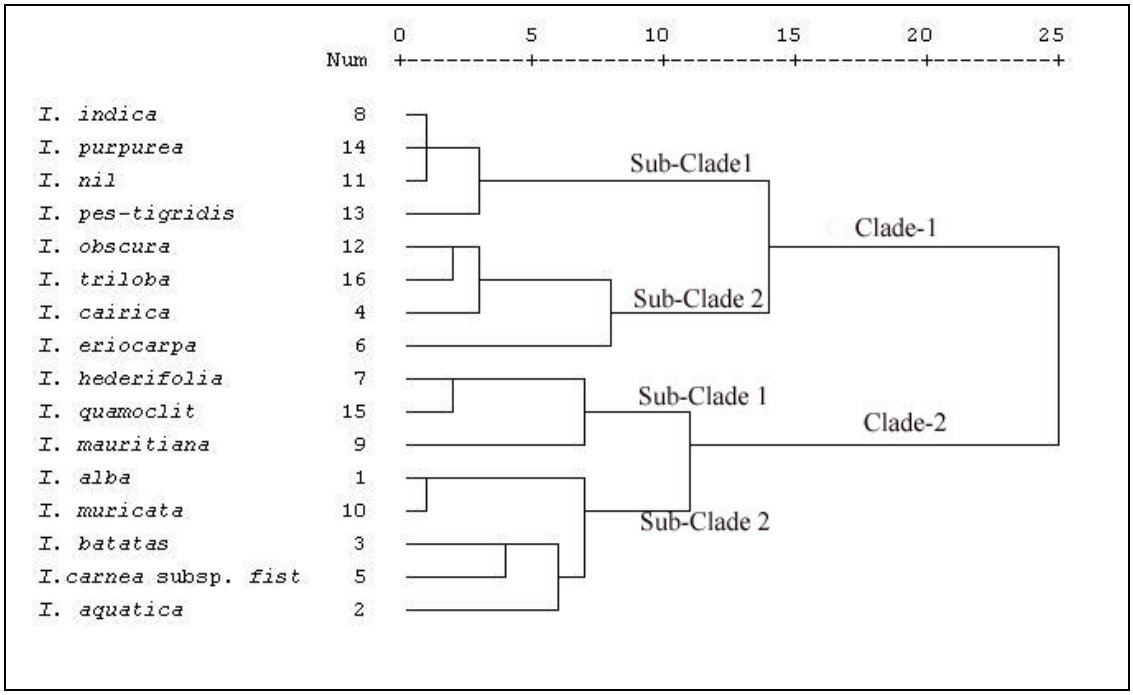


Fig. 24. relationship between the species of the genus *Ipomoea* (Cluster Dendrogram).

The result obtained from the cluster dendrogram shows that, the species of *Ipomeoa* are divided into two clade, clade-1 and clade-2. Out of 16 species, 8 species are belonging to clade 1 and remaning 8 species are belonging to calde 2. The Clade-1 further divided into two sub-clade, each of which gives the separate group. Sub-clade 1 contain four species among them *I. indica*, *I. purpurea* and *I. nil* shows close morphological similarity then that of *I. pes-tigridis*. Similarly in sub-clade 2, first two species, *I. obscura* and *I. triloba* shows close morphological similarity with each other and little similarity with *I. cairica* than that of *I. eriocarpa*.

The clade-2 also divided into, sub-clade 1 and sub-clade 2. In sub-clade 1, *I. hederifolia* and *I. quamoclit* are closely related with each other while *I. mauritiana* separate from former two species due to some morphological disimilarities. Similarly, the dendrogram shows that in sub-clade 2, *I. alba* and *I. batatas* are closely related with *I. muricata* and *I. carnea* subsp. *fistulosa* respectively while, *I. aquatica* shows little similarity with *I. batatas* and *I. carnea* subsp. *fistulosa* and less similarity with *I. alba* and *I. muricata*.

Chapter 4

DISCUSSION AND CONCLUSION

4.1 Discussion

The genus *Ipomoea* with ca. 600 species is the largest genus in the family Convolvulaceae, commonly called by the name "Morning glory". The genus occurs throughout the tropical and subtropical regions of the world and comprises annual and perennial herbaceous plants, lianas, shrubs and small trees; most of the species are twining climbing plants (Miller *et al*. 1999).

In contrast to Nepal the genus comprises the 14 species and one subspecies throughout the tropical, subtropical and temperate region of the country (Press *et al.* 2000). Present study concludes the presence of 15 species and one subspecies of the genus *Ipomoea* including two new records of species of *Ipomoea* for Nepal, viz. *I. triloba*. and *I. indica.* The species *I. triloba* was recorded and collected from East Nepal (Biratnagar, 80m). Similarly *I. indica* was colleted from Eastern (Biratnagar, 80m) and Central (Kathmandu, 900-1250m) Nepal.

The genus *Ipomoea* is usually terrestrial. They are found in open land, mostly on hedge and disturbed or dry habitat (*I. alba, I. pes-tigridis, I. purpurea, I. nil, I. obscura, I. batatas, I. triloba* and *I. eriocapra*); moist or shady habitat along with other species (*I. indica, I. cairica, I. mauritiana, I. muricata, I. hederifolia, I. carnea* subsp. *fistulosa* and *I. quamoclit*) and one species viz *I. aquatica* is aquatic in habitat and also found in marshy land.

The study shows that most of the species of the genus *Ipomoea* are annual, climbing, prostrate or twining herbs except three species viz. *I. carnea* subsp. *fistulosa* which is perennial stout, erect, shrub, and other two species *I. mauritiana* and *I. cairica* are perennial climbing herbs.

The roots of all species are tap root system except in *I. batatas* and *I. mauritiana* in which tuberous root are found. The stem is glabrous, terrete, minutely hairy to retrosely hairy. In *I. aquatica* and *I. batatas* the roots are developed at the nodes of the stem. During study, the adventitious roots were found at the node of the stem in *I. nil* and *I. purpurea,* when it exhibit as a twinner in open and bare land. The species *I. muricata* is clearly distinct from other species by its muricate stem and in *I. cairica*, the stem is glabrous in young while getting mature, stem becomes verruculose.

It is found that the leaves of most of the species are petiolated, simple, entire, lobed, or pinnately or palmately divided, alternate and exstipulate but in *I. cairica* and *I. quamoclit* leafy pseudostipules are found at the base of the petiole. In most of the literature the pseudostipules are described only for *I. cairica* but not for *I. quamoclit*. From present study it is conclude that in *I. quamoclit* pseudostipules are common and present at the base of petiole.

The leaves of the species of *Ipomoea* show variation in their shape, size and integuments characters and number of lateral veins. The petiole ranges from 5 mm to 19 cm. The smallest petiole is found in *I. quamoclit* (5-40 mm) and the longest is found in *I. purpurea* (ca. 19 cm). The shape and size of the leaf varies from species to species and in most of the species single plant bears more than one type of leaf so it creates confusion while studying and identifying the taxa. During study it was found that the plants growing in shady places bear large and dark green leaves and the plants which grow in sunny places, the shape of the leaves were smaller and light in color. The shape of the leaves vary from ovate, ovate-oblong, ovate-lanceolate, circular-ovate, broadly-ovate, linear, sparsely lobed, slightly or deeply 3-lobed and palmately 5-7 lobed. The smallest size of the leaf is recorded in *I. obscura* (2-6 x 1.5-5.5 cm) and the largest in *I. carnea* subsp. *fistulosa* (18-33 x 8.5-17 cm). The lamina of the leaves is glabrous, slightly pubescent to densely hirsute on both surfaces. The leaf base is cordate in almost all of the species but in *I. aquatica, I. batatas, I. cairica, I. carnea* subsp. *fistulosa, I. hederifolia* and *I. pes-tigridis* the base of the leaves are varies from hastate, saggitate to cordate; truncate to shallowly cordate or attenuate.

The inflorescence of the genus is found to be axillary, solitary or 1 to many flowered cyme. In *I. hederifolia* the inflorescence is unique among all species, in which first branch of peduncle is dichasial with alar flower and other monocahsical in arrangement.

The bracts are found on the base of the pedicel. It is deciduous or early deciduous, sub persistent or persistent. The largest bract is found in *I. indica*, in which outer most bract is larger, linear ca. 2.5 cm, inner is 1.5-2.2 cm. The bracts in most of the species are small and ranges from 1.5-8 x 0.5-4.5 mm.

It is found that the color of the flowers vary from species to species. Among them *I. purpurea* shows variation in color of the flower, which varies from red, white, blue, pink and purple.

The calyx is found to be most important reproductive character for taxonomic treatment of some species of *Ipomoea* (*Ipomoea nil, I. indica* and *I. purpurea*). The apex of the sepal is acute in almost all of the species while *I. mauritiana* apex is obtuse and in *I. carnea* subsp. *fistulosa* apex is found to be bifid sometimes. The species like *I. nil* and *I. indica*, the apex is very long narrowly acuminate. So these species are distinguished by the character of pubiscent found on the lamina of the sepal. In *I. indica*, the basal part of sepal is covered with soft, appressed hairs; like wise in *I. nil*, the sepal is covered with dense yellowish bristle with swollen base and the sepals are strongly reflexed in fruits. The variation is also found in lobe of the stigma, which are 3-lobed in *I. indica, I. nil, I. purpurea* and *I. quamoclit*, while in other species the 2-lobed stigma are common.

In Nepal, the species of the genus *Ipomoea* is distributed from Eastern to Western regions, ranging from tropical to temperate region of the country (Press *et al*. 2000). Most of the species are reported from Eastern and Central parts of the Nepal while least species are

recorded from western Nepal. Altitudinal distribution of *Ipomoea* ranges from 100 to 2400 m (Hara *et al.*1982 and Press *et al.* 2000). While, altitudinal distribution based on herbarium collected and distributed ranges from 80 to 2300 m.

Regarding the distribution, the *I. batatas* is found to be new distribution in Western Nepal, *I. cairica* is new distribution in Central and Western Nepal, *I. hederifolia* is new distribution in Central Nepal. *I. nil* and *I. muricata* is new distribution in Eastern Nepal. Hara *et al.* (1982) and Press *et al*. (2000) recorded *I. nil* from Central and Western Nepal only but in present study the I reported vast population of this species from Eastern Nepal. The species which are found only in Eastern Nepal are *I. mauritiana*, *I. obscura* and *I. triloba* these species are not found in other parts of the country. The species which is found only in Central Nepal are *I. alba* and *I. eriocarpa*, there is no record of this species in Eastern as well as in Western part of country. The species *I. aquatica* have been reported only from Eastern and Western Nepal. There was no record of *I. aquatica* from Central Nepal. Similarly the *I. muricata* has been collected and reported form Central and Western Nepal (Press *et al*. 2000) but herbarium specimens deposited in KATH was found to be reported from Eastern Nepal.

Regarding the phenology, the flowering period is usually in February to October and fruiting period is in October to January. The phenology is agreed in some extent with "Flora of Bhutan". During the study, it was concluding that the flowering time of the most of the species was depending upon the climate and intensity of Sun light. On the sunny day the flower is blooms between 6 to 11:30 A.M., after this time the colour of the flower become faded and corolla became shrink, due to which the flower of *Ipomoea* is popularly known as "Morning glory". When the climate was cloudy then, it blooms till evening. But in case of *I. alba* and *I. muricata*, the flowering period of the plant was at evening so these species are commonly known as 'moon flower'.

The use of anatomical character in taxonomy has been regarded as taxonomically important characters. It is just a valuable as morphological ones, and must not be neglected. Among the many anatomical characters, stomatal character is also very important in taxonomy. The arrangement of the surrounding epidermal cells or subsidiary cells in stomata is the most valuable character. Twenty seven types of stomata have been recognized by Dicher (1974) and Stace (1989) has added four more type of stomata in vascular plants. The occurrence of these types is often valuable at the higher taxonomic levels (Stace, 1989). The stomata type may remain the same within a genus or even in a family but the number of stomata, size and frequency of stomata often varies within genus and even species.

The micromorphological study of stomata shows that there is only one type of stomata i.e. Paracytic or Rubiaceous type as described by Matcalf and Chalk (1950) and indicate there is no significant qualitative variation in the arrangement of subsidiary cells within the species of the genus *Ipomoea*. But the quantitative difference such as size, number and frequency of

stomata; size and shape of the epidermal cells are observed within the species. The stomatal density often changes in response for changing atmospheric level of carbondioxide and they may also vary according to amount of rainfall in different localities and amount of light that the plant gets from the environment (Case, 2003). Present study reported the highest stomatal frequency in *I. nil* (318.42 µm) and the lowest in *I. purpurea* (30.32 µm). Regarding the size of the guard cells, the largest size of the guard cells is recorded in *I. cairica* (31.45 µm) and the smallest size in *I. nil* (25.63 µm). The breadth is the highest in *I. cairica* (23.38 µm) and the smallest in *I. nil* (16.77 µm).

The transverse section of the stem showed considerable variation in the size of the secondary formed xylem vessels as described by Matcalf and Chalk (1950), which are arranged either in solitary or in group in the xylem cylinder. The largest size of the secondary xylem vessels are found in *I. mauritiana* (208.8 µm) and the smallest in *I. obscura* and *I. carnea* subsp. *fistulosa* (72 µm).

Regarding the palynological study, one of the first palynological studies on the Convolvulaceae was made by Hallier (1893). He endeavored to make a natural system of classification on the basis of external morphology and anatomy. However he accorded importance to the gross pollen morphological characters and divided the family into two groups: "Psiloconiae" and "Echinoconiae." The pollen grains in the "Psiloconiae" were either psillate or possessed a granulated surface, e.g., *Convolvulus, Cuscuta, Evolvulus, Jacquemontia, Operculina,* etc. The "Echinoconiae" group consisted of genera such as *Argyreia, Ipomoea,* etc., where the pollen grains possessed spines. He reported the presence of tri-tetra-penta-hexa-pantocolpate and panto-porate grains in this family. The Convolvulaceae is an eurypalynous (Erdtman, 1952) family. The family possesses four main types of pollen grains based on number and distribution of apertures, they are: tricolpate, penta-hexa-colpate, dodecacolpate and pantoporate types (Sengupta, 1972).

Present study revels that pollen grains are spheroidal or globose, isopolar, pentoporate with echinate exine pattern as described by Erdtman (1952). There is no any specific variation in pollen grain among the species but quantitative variation i.e. size of the pollen grains; size of the spine and size of the pore are recorded in all studied species. The largest pollen is found in *I. quamoclit* (150.84 µm) and the smallest size of the pollen is in *I. aquatica* (60.92 µm). The largest size of the spine is found in *I. mauritiana* (11.65 µm) and the smallest in *I. aquatica* (98 µm). The outer surface of the pollen is covered with numerous pore ranges from 100-200 pores as described by Yoneda (1998-2004). The largest size of the pore is found in species *I. carnea* subsp. *fistulosa* (13.11 µm) and the smallest pore is found in *I. cairica* (3.48 µm).

The cluster analysis of studied species of the genus *Ipomoea* helps to generate the basic idea about the relationship between the species. Cluster dendrogram shows that the species of

Ipomoea are divided into two main clade. In clade 1, the species viz. *I. purpurea*, *I. nil* and *I. indica* shows very close similarity within species due to similarity in characters like, hirsute stem, appresssed trichome, 3-lobed stigma, pubescent bract, 4 celled ovule etc. *I. pes-tigridis* split away from former species due to dissimilarity in morphological characters like pubescent ovary and 2 lobed stigma possessed by *I. pes-tigridis*. Similarly in other group, *I. obscura* and *I. triloba* shows close similarity within each other due to presence of similar character like small flower, pubescent stem, sepal and bract, etc. while *I. cairica* and *I. eriocarpa* show less similarity with each other and other member of this group. In clade 2, due to presence of exserted anther and pistil, salverform corolla, glabrous stem, *I. quamoclit* and *I. hederifolia* shows close morphological relationship while *I. mauritiana* moves away from these two species due to dissimilarity in character like included anther and pistil, funnelform corolla; due to presence of 4-celled ovary, glabrous stem, similar size of petiole, leaf, bract and sepal this species placed in same group with *I. quamoclit* and *I. hederifolia*. While in next group, *I. alba* shows close similarity with *I. muricata* because most of the characters are similar to each other. Similarly *I. batatas* shows close relationship with *I. carnea* subsp. *fistulosa* by sharing similar character of glabrous stem and leaf; shape of the flower, integuments of sepal, bract, ovary etc. while *I. aquatica* shows less similarity with other members of this group.

The relationship obtained from present cluster analysis is differing from classification proposed by Hooker (1985). It is may be due to the morphological variation gained by the species during long period of time as well as environmental changes faced by the earth. The species *Ipomoea pes-tigridis* which was placed under subgenus Euipomoea by Hooker is now placed under subgenus Pharbitis, similarly *I. aquatica* and *I. carnea* subsp. *fistulosa* is now placed under subgenus Batatas and *I. mauritiana* which was placed under subgenus Batatas by Hooker is now placed under subgenus Quamoclit.

4.1.1 Two New Records of *Ipomoea* species for Nepal

From the present study, 2 new records of *Ipomoea* species has been added in Nepal Flora. These two new records for Nepal Flora include *Ipomoea indica* (Burman f.) Merr. and *I. triloba* L.

The new recorded species *I. indica* was collected from Kathmandu and Biratnagar; however, in rest of the collection sites visited by author, the species were not found. It was found in open and shady habitat. It looks like *I. nil* and *I. purpurea* but through examination of these species showed that the integuments of the sepal, size of the corolla and leaf shape were different from that of the two species. The plants were large climber than that of *I. nil* and *I. purpurea*, shape of the leaf was ovate, entire to slightly 3-lobed with apprised hairs. The main distinguishing characters of *I. indica* from *I. nil* and *I. purpurea* was the shape and

integument of the sepal. In *I. indica* the sepal was lanceolate with long acuminate apex with soft shining white pilose or pubescent on back with slender trichomes. But in *I. nil*, the sepal was gradually narrowed, long acute tips sub-erect or straight with densely yellowish hirsute on base and apex and the sepal of the *I. purpurea* was short, slightly narrow green tips shorter to slightly longer than body, with densely pilose at the base. The corolla size of *I. indica* was larger then that of the *I. nil* and *I. purpurea*. Flower was bright blue or bluish purple, aging reddish purple or red in *I. indica* while in *I. nil* the colour of the flower was pale to bright blue with whitish tube, turning red to reddish-purple and in *I. purpurea* the color of the flower was vary from red, blue, white, pink to purple.

Another new record *I. triloba* was collected from Biratnagar (80m). It was found along the hedge. It was somewhat similar with *I. batatas* in size of flower but sepal was appressed pilose in *I. triloba* while in *I. batatas* the sepal was glabrous. In *I. batatas* the root was tuberous while in *I. triloba* root was tap root system. The leaf was cordate, orbicular to trilobed in *I. triloba* while in *I. batatas* the leaf was hastate, sagitate or palmately lobed. The ovary was glabrous in *I. batatas* while in *I. triloba* the ovary was densely hirsute. Both these species of *Ipomoea* was confirmed by the comparative study of different literature, herbarium specimens deposited in BM and finally by Dr. Austin (Arizona-Sonora Desert Museum).

A one specimen of *Ipomoea* which was collected from Dharan (Budasubba,550m, Shrestha, S. 265) was found in moist, shady habitat, which had pure white flower with soft, glabrous stem with devoid of adventitious lateral roots at the node of the stem and leaf was thin membranous. This species shows few similarity with *I. aquatica* in shape and size of the flower; shape and size of the sepal, number of locule but differ in habitat, structure of stem, softness of leaves and color of the flower. But due to lack of proper literature and herbarium specimens it could not be thoroughly studied. Dr. Austin suggested that species may be *I. aquatica* so it needs further study.

4.1.2 Nomenclatural Change

During the study, some nomenclatural change of the Nepalese species has been observed. Nomenclature of *Ipomoea carnea* Jacq. has changed to *I. carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin. Similarly, the name *I. turbinata* Lag. has changed into *I. muricata* (L.) Jacq. The name *I. muricata* was previously used as the synonym of *I. turbinata*. But from the investigation of the publication date for Jacquin's "*Plantae Rariorum Horti Caesari Schoenbrunnensis"* by several authors it is clarified the nomenclature for these tropical purple flower morning glories is *I. muricata,* and this is the correct name while the name *I. turbinata* is a basionym for this species (Staples *et al*., 2005). So the name *I. muricata* must be included in the Flora of Nepal and the name *I. turbinata* should be kept as synonym.

4.2 Conclusion

Hara *et al.* (1982) recorded 13 species of *Ipomoea* and Press *et al.* (2000) recorded 14 species of *Ipomoea* and one subspecies (*I. alba, I. aquatica, I. arachonosperma, I. batatas, I. cairica, I. carnea* subsp. *fistulosa, I. eriocarpa, I. hederifolia, I. nil, I. obscura, I. pes-tigridis, I. purpurea, I. quamoclit, I. tuberculata* and *I. turbinata*). Present study confirms the presence of 15 species of *Ipomoea* viz. *I. alba*, *I. aquatica, I. batatas, I. cairica, I. eriocarpa, I. hederifolia, I. mauritiana, I. muricata*, *I. indica, I. nil, I. obscura, I. pes-tigridis, I. purpurea, I. quamoclit* and *I. triloba* and one subspecies *I. carnea* subsp *fistulosa* among them *I. indica* and *I. triloba* are two new record for Nepal.

Morphological characters are found to be very important characters for identification of the taxa at interspecific level. The characters include shape and integuments of the sepals, shape of leaves, position of the stamen in flower, number of the stigma's lobe, integuments of the ovary and fruits are useful for the separation of the species.

So far, most of the studied specimens were based on the author's personal collection from Tehrathum. Dhankuta, Dhran, Itahari, Biratnagar, Lahan, Chitwan, Hetauda, Rampur, Kamthmandu, Bhaktapur, Pokhara, Tanahun and Butwal, covering more then 14 districts. These specimens along with photograph of herbarium specimens from different herbaria and different literatures supported the present study.

Rubiaceous or paracytic types of stomata are found in all studied species of genus *Ipomoea*. The cross section of stem character is found to be similar in most of the species. So, there is no any such qualitative and significant variations are observed from anatomical study.

The Palynological study is very important for the taxonomical point of view. Pantoporate, spheroidal or globose type of pollen grains with echinate i.e. having spine like exine pattern are most commonly reported in all species of *Ipomoea*. Regarding the distribution, most of the species of *Ipomoea* are reported from Eastern and Central parts of the Nepal, while least species are recorded from Western Nepal. The species *I. obscura, I. mauritiana* and *I. triloba* are only recorded in Eastern Nepal and the species *I. alba* and *I. eriocarpa* are only recorded in Central Nepal. Vertical distribution of the species ranges from tropical to temperate region of the country. They are found between 80-2400 m. Most of the species are recorded in tropical and subtropical region and least are recorded from temperate region.

Phenological study shows that the flowering periods of the most of the species are usually from February to October and fruiting period is from October to January. The species *I. cairica* and *I. carnea* subsp. *fistulosa* are found to be flowering in most of the year. Similarly, cluster analysis seems to be one of the particular methods of hypothesizing relationship among species of *Ipomoea*. During the study, the dendrogram (cluster analysis) helped in separating the species of *Ipomoea* based on the morphological characters.

Some nomenclatural changes have been observed during the study. The species *I. carnea* Jacq. should be kept as synonym of *I. carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin. The name of *I. turbinata* Lag. has changed to *I. muricata* (L.) Jacq.

Among 14 species of *Ipomoea*, detail morphological, anatomical and palynological study of *I. pes-tigridis* was carried out from the herbarium specimen available from KATH. The collections cover 12 species and one subspecies from Eastern, Central and Western Nepal. Due to unsuitable condition of flowering season and lack of time and resources, the plants could not be collected from the most of the part of the country. Therefore there should be new species or new records of species of *Ipomoea* if exploration is carried out extensively throughout Nepal.

Present study could not cover the detail study of *I. alba* and *I. eriocarpa* even these are deposited in KATH because of lacking of most of the plant parts. Therefore, the description of these species is based on secondary sources (literatures). The species *I. arachnosperma* Welw and *I. tuberculata* Ker Gawl. are only recorded in Nepal Flora but proper description as well as the herbarium specimens are not found to be deposited in Nepal herbaria so, these two species are not included in present study. During the study, examination of herbarium specimens deposited in the herbaria of Nepal (KATH and TUCH) and digital images of herbarium specimens of Royal Botanical Garden (E), MO and BM were done for revisionary work.

4.3 Recommendations

There are possibilities of finding new species in Nepal. Western region of Nepal is relatively less explored than the Eastern and Central region. Therefore exploration on the Western region of Nepal is necessary for a more detailed study of *Ipomoea* in Nepal.

Due to lack of printed and online taxonomic literatures, many difficulties were faced during identification and nomenclature of the species. The libraries at Central Department of Botany, National Herbarium and Plant Laboratories and Tribhuvan University are deficient in recent literatures and information. So, it is important that these libraries be housed with the relevant literatures. Taxonomy is closely related with other fields of science like anatomy, cytology, palynology, photochemistry etc. However due to lack of proper instruments in the Department, detailed study could not be done. Thus modern instruments required for revision work must be available in the Department.

Protologue text, i.e. the original description of the species, first publication in international taxonomic journals, is the key source for the proper identification of taxa. Because of unavailability of the standard taxonomic journals and various international publications, great difficulty was faced while obtaining the protologue texts. Our libraries should be updated and new publications containing standard taxonomic journals should be included in the library so that future generation willing to work in this field may not suffer.

The flower of *Ipomoea* is very delicate. Thus preservation of flower requires great care. The flowers should be preserved as soon as they are plucked from the plant by wrapping between tissue paper. This method of pressing flowers not only preserves the colour of the flower but also keeps the parts of the flower intact.

There are some species which are reported only in Flora of Nepal Database and Checklist. However, the herbarium specimens are not deposited in Herbaria of Nepal and are beyond the reach of Nepalese researchers. This creates great difficulty in revision work. So herbarium specimens of all the species reported in Nepal should be made accessible to Nepalese researchers also.

No proper information on the TYPE specimens could be found which directly affected the study. Therefore there must be some mechanism so that at least there could be easy access to the TYPE specimens. There is also prime need to update the checklist of flowering plants of Nepal as there have been many changes in the recorded species.

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APPENDIX

APPENDIX 1. CLUSTER ANALYSIS

Table 5: Character coding for Cluster Analysis

S.N.	Characters	Character States
1.	Roots	0 = Tap root, 1 = Tuberous
2.	Habit	0 = Perennial, 1 = Annual
3.	Stem	0 = Pubescent, 1 = Glabrous, 2 = Muricate
4.	Trichome	0 = Appressed, 1 = Spreading, 2 = Glabours
5.	Petiole Length	0 = < 10 cm, 1 = > 10 cm
6.	Leaf Shape	0 = Ovate-oblong, 1 = Ovate-lanceolate, 2 = Elliptic, 3 = Circular, 4 = Linear
7.	Leaf Size	0 = ≤ 10 cm, 1 = > 10 cm
8.	Inflorescence	0 = Pedunculate, 1 = Sessile
9.	Sepal Equality	0 = Unequal, 1 = Equal
10.	Sepal Apex	0 = Acuminate, 1 = Acute, 2 = Linear acuminate, 3 = Awned, 4 = Obtuse
11.	Sepal Integuments	0 = Glabrous, 1 = Scarious, 2 = Hirsute
12.	Sepal Length	0 = < 10 mm, 1 = > 10 mm
13.	Bract Integuments	0 = Glabrous, 1 = Scarious, 2 = Hirsute
14.	Bract Length	0 = ≤ 5mm, 1 = > 5 mm
15.	Corolla Shape	0 = Funnelform, 1 = Salverform, 2 = Companulate
16.	Anther and Pistil Position	0 = Included, 1 = Exserted
17.	Stigma Lobe	0 = 2 lobed, 1 = 3 lobed
18.	Ovary	0 = Glabrous, 1 = Pubescent
19.	Ovules	0 = 2 celled, 1 = 3 celled, 2 = 4 celled
20	Seeds	0 = Glabrous, 1 = Tomentose, 2 = Pubescent

APPENDIX 2.

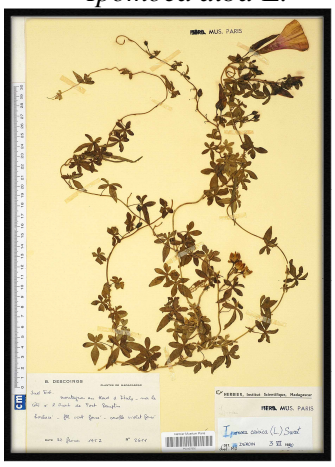
Table 6: Data Matrix

OTUs	**Characters**																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ipomoea alba	0	1	2	2	1	0	1	0	0	3	0	1	0	0	1	1	0	0	0	0
I aquatica	1	1	1	2	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	2
I. batatas	0	1	1	2	1	1	0	0	0	1	1	1	0	0	0	0	0	0	2	0
I.cairica	0	0	1	2	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1
I.carnea subsp. fistulosa	0	0	1	2	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	2
I. eriocarpa	0	1	0	0	0	1	0	1	1	0	2	0	0	1	2	0	0	1	0	0
I.hederifolia	0	1	1	2	0	0	0	0	0	3	0	0	0	1	1	0	0	1	2	1
I.indica	0	1	0	1	1	0	1	0	0	2	2	1	2	1	0	0	1	0	1	0
I.mauritiana	1	0	1	2	1	2	1	0	1	4	0	1	0	0	0	0	0	0	2	3
I.muricata	0	1	2	2	1	0	1	0	0	3	0	0	0	0	1	0	0	0	0	0
I.nil	0	1	0	1	1	0	1	0	0	2	2	1	2	1	0	0	1	0	1	2
I.obscura	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1
I.pes-tigridis	0	1	0	1	1	2	0	0	0	1	2	1	2	1	0	0	0	0	0	1
I.purpurea	0	1	0	1	1	0	1	0	0	1	2	1	2	1	0	0	1	0	1	1
I.quamoclit	0	1	1	2	0	4	1	0	0	1	0	0	0	0	1	1	1	0	2	1
I.triloba	0	1	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0

Ipomoea alba L.

I. aquatica Forsskal

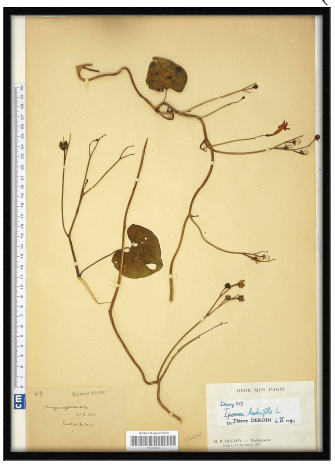
I. batatas (L.) Lam.



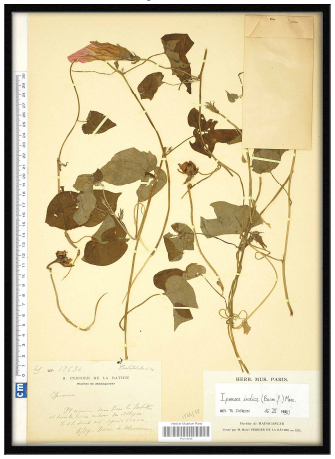
I. cairica (L.) Sweet

I. carnea Jacq.subsp.*fisulosa* (Mart.ex choisy) D.F.Austin

I. eriocarpa R.Br.



I. hederifolia L.



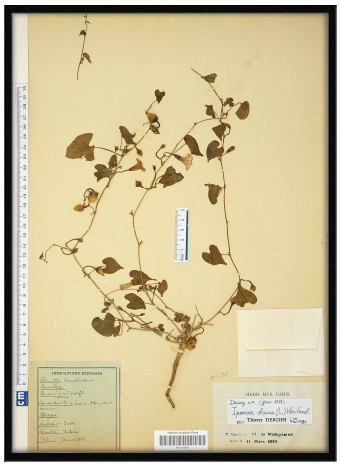
I. inidca (Burmann,f.) Merrill

I. marutiana Jacq.

Photograph of Type specimens of *Ipomoea* L. (Source: www. Eflora.com).

I. muricata (L.) Jacq.

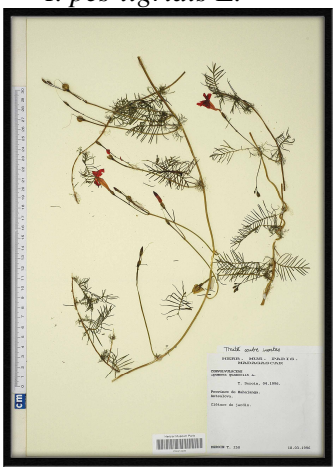
I. nil (L) Roth



I. obscura (L.) Ker. Gawl.

I. pes-tigridis L.

I .purpurea (Burmann, f.) Merr.



I. quamoclit L.

I. triloba L.

Photograph of Type specimens of *Ipomoea* L. (Source: www. Eflora.com).

Photograph of *Ipomoea* species. **Photo by: Saugat Shrestha**

Ipomoea aquatica Forsskal

Ipomoea aquatica Forsskal

Ipomoea batatas (L.) Lam,.

Ipomoea cairica (L.) Sweet.

Ipomoea carnea Jacq. subsp *fistulosa* (Mart. ex Choisy). D.F. Austin

Ipomoea hederifolia L

Ipomoea indica (Burman f.) Merrill.

Ipomoea marutiana Jacq

Ipomoea muricata L.

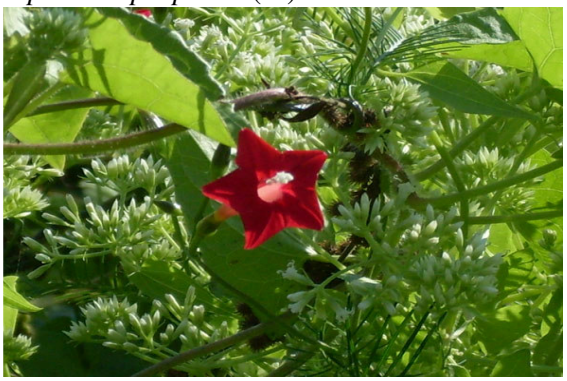
Ipomoea nil (L.) Roth.

Ipomoea obscura (L.) Ker Gawl.

Ipomoea pes-tigridis L.(eflora.com)

Ipomoea purpurea (L.) Roth.

Ipomoea purpurea (L.) Roth.



Ipomoea quamoclit L.

Ipomoea triloba L.

Checklist of *Ipomoea* L. in Nepal

IPOMOEA L. Sp. Pl. 159. 1753 & Gen. Pl. ed. **5**. 76. 1754

Ipomoea alba L. Sp. Pl. 161. 1753
Ipomoea bona-nox L. = *Ipomoea alba* L.

Ipomoea aquatica Fl. Aegypt.-Arab. 44 (1775).
Ipomoea subdentata Miquel = *Ipomoea aquatica* Fl.

Ipomoea batatas (L.) Lam. Tabl. Encycl. **1**: 465. 1793.
Convolvulus batatas L. = *Ipomoea batatas* (L.) Lam.

Ipomoea cairica (L.) Sweet. Hort. Brit. 287. 1827.
Ipomoea pentaphyla. Hook. = *Ipomoea cairica* (L.) Sweet.
Convolvulus cairicus L. = *Ipomoea cairica* (L.) Sweet
Ipomoea palmata Forssk. = *Ipomoea cairica* (L.) Sweet
Convolvulus tuberculatus Desr. = *Ipomoea cairica* (L.) Sweet
Ipomoea tuberculata (Desr.) Roem. & Schult. = *Ipomoea cairica* (L.) Sweet

Ipomoea carnea Jacquin Enum. Pl. Carib 13. 1760.
Ipomoea carnea Jacq. subsp. **fistulosa** (Mart. ex Choisy). D.F. Austin, Taxon **26**: 237. 1977.
Ipomoea fistulosa Mart. ex Choisy = *Ipomoea carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy). D.F. Austin
Ipomoea crassicaulis (Benth.) B. L. Robinson = *Ipomoea carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy). D.F.

Ipomoea eriocarpa R. Br. Prodr. 484. 1810.

Ipomoea hederifolia L., Syst. Nat. ed **10**: 925. 1759.
Ipomoea angulata Lam. = *Ipomoea hederifolia* L
Ipomoea phoenicea Roxb. = *Ipomoea hederifolia* L
Ipomoea coccinea Auct. = *Ipomoea hederifolia* L
Convolvulus hederifolius (Linnaeus) Sprengel = *Ipomoea hederifolia* L**.**
Quamoclit hederifolia (Linnaeus) G. Don = *Ipomoea hederifolia* L

Ipomoea indica (Burman f.) Merr. Int. Rumph. Herb. Amb. 445. 1917.
Convolvulus acuminatus Vahl = *Ipomoea indica* (Burman f.) Merr.
Convolvulus indicus Burman = *Ipomoea indica* (Burman f.) Merr.
Ipomoea acuminata (Vahl) Roemer & Schultes = *Ipomoea indica* (Burman f.) Merr.
Ipomoea cathartica Poiret, = *Ipomoea indica* (Burman f.) Merr.

Ipomoea indica (Burman) Merrill, var. *acuminata* (Vahl) Fosberg, = *Ipomoea indica* (Burman f.) Merr.

Ipomoea mauritiana Jacq. Fang & Staples in Fl. China **16**: 310. 1995.

Ipomoea muricata (L.) Jacq. Hort. Schoenb, 3(2): 40. T. 323. 1793(1803).
Ipomoea turbinata Lag. = *Ipomoea muricata* (L.) Jacq.
Convolvulus muricatus L. = *Ipomoea muricata* (L.) Jacq.
Calonyction muricatum (L.) G. Don = *Ipomoea muricata* (L.) Jacq.

Ipomoea nil (L.) Roth. Cal. Bot. **1**: 36. 1797.
Convolvulus nil L. = *Ipomoea nil* (L.) Roth.
Ipomoea hederaceus auct. = *Ipomoea nil* (L.) Roth
Pharbitis nil (L.) Choisy = *Ipomoea nil* (L.) Roth.

Ipomoea obscura (L.) Ker Gawl. in Edwards Bot. Reg. **3**: t. 239. 1817.
Convolvulus obscurus Linnaeus = *Ipomoea obscura* (L.) Ker Gawl.

Ipomoea pes-tigridis L. Sp. Pl. 162. 1753.

Ipomoea purpurea (L.) Roth EFPN **3**: 107. 1982.
Convolvulus purpureus L. = *Ipomoea purpurea* (L.) Roth
Pharbitis purpureus (L.) Voight = *Ipomoea purpurea* (L.) Roth

Ipomoea quamoclit L**.** Sp. Pl. 159. 1753.

Ipomoea triloba L. Sp. Pl. **1**: 161. 1753.