TAXONOMIC STUDY OF GENUS FIMBRISTYLIS VAHL. (CYPERACEAE) IN NEPAL

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

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Exam Roll No.: Bot. 530/074

T.U. Regd. No.: 5-2-50-123-2013

Batch: 2074/2076

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2023

DECLARATION

I, Shittal Aryal, hereby declare that this dissertation entitled **"Taxonomic Study of Genus Fimbristylis Vahl. (Cyperaceae) in Nepal"** is my original work, and all other sources of the information used are duly acknowledged. I have not submitted it or any of its parts to any other universities for any academic award.

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LETTER OF RECOMMENDATION

This is to certify that the dissertation work "**TAXONOMIC STUDY OF GENUS FIMBRISRYLIS Vahl. (CYPERACEAE) IN NEPAL**" has been completed by Ms. **Shittal Aryal** under my supervision. This entire research was accomplished on the basis of the candidate's original work. To the best of my knowledge the work has not been submitted for consideration for any other academic degree. It is hereby recommended for the acceptance of this dissertation as part of the requirement for a Master's degree in botany at the institute of Science and Technology, Tribhuvan University, Kathmandu Nepal.

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LETTER OF APPROVAL

The M.Sc. dissertation entitled "**Taxonomy of Genus Fimbristylis Vahl. (Cyperaceae) in Nepal**" submitted to the Central Department Botany, Tribhuvan University by Shittal Aryal has been accepted for the partial fulfillment of the requirement of Master of Science in Botany (Systematics and Biodiversity Conservation).

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ACKNOWLEDGEMENT

I would like to express my deepest gratitude and sincere appreciation to my supervisor Prof. Dr. Sangeeta Rajbhandary, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal for her kind supervision, encouragement, continuous support, guidance, inspiration, and valuable suggestions during my research work. Her unwavering dedication and commitment towards my academic pursuits have been instrumental in shaping my research journey and have played a pivotal role in my growth as a researcher.

I would also like to express my heartfelt thanks to Prof. Dr. Ram Kailash Prasad Yadav, Head of Department, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal, for his administration and moral support. I am grateful to all the administrative and support staff for their direct and indirect assistance.

Furthermore, I would like to express my gratitude to my respected teachers, Prof. Dr. Suresh Kumar Ghimire and Asso. Prof. Dr. Deepak Raj Pant of Systematics and Biodiversity Conservation Unit, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal, for their valuable suggestions and allowing me to examine herbarium specimens deposited at TUCH.

I am also deeply grateful to the Department of Plant Resources, Thapathali, for providing the research grant as per the concept carried out by Global Taxonomic Initiative (GTI), during this research.

I extend my sincere gratitude to the staff at National Herbarium and Plant Laboratories (KATH), Lalitpur, for their generous assistance and support throughout my research. Their cooperation in allowing me to examine the herbarium specimens deposited there was invaluable, and this study would not have been possible without their continuous help.

I would like to express my sincere appreciation to my seniors Mr. Prabin Bhandari for sharing his collections, Ms. Manisha Timalsina, Ms. Kajol Basukala for generously sharing their experiences, ideas, and knowledge, which played a crucial role in accomplishing this work. Their guidance and support were invaluable and have helped me a lot.

I am deeply grateful to my friends Mr. Yogendra Bikram Poudel and Mr. Kiran Panthi for their unwavering support during fieldwork and for sharing their collection, which significantly contributed to the success of this project. Also, I would like to thank my

friends Niruta Marpa, Manisha Nagarkoti, Rashika kafle, Tej Chaudhary, Pushpa Poudel for their support during my research work.

I would like to express my deepest gratitude and love to my family members for their continuous support and encouragement throughout my journey. Their constant love and support have been a source of strength and motivation.

Once again, I would like to express my sincere appreciation to all those who have contributed to my research journey and helped me in countless ways.

Date: March 2023 **Shittal Aryal**

ABBREVIATIONS AND ACRONYMS

Ann. Check. Fl. Pl. Nepal	Annotated Checklist of flowering plants of Nepal
APG	Angiosperm Phylogeny Group
QGIS	Quantum Geographic Information System
BM	The Natural History Museum, London, UK
C	University of Copenhagen Herbarium
C	Central
ca.	Circa (Approximate)
CAL	Central National Herbarium, Calcutta
Cat. Nep. Fl. Pl.	Catalogue of Nepalese Flowering Plants
CDB	Central Department of Botany
cm	Centimetre
Contr. Bot. India	Contributions to the Botany of India
DPR	Department of Plant Resources
E	Royal Botanic Garden Edinburgh Herbarium
E	Eastern Nepal
Ed.	Edition
Eds.	Editors
Enum. Pl.	Enumeratio Plantarum
Enum. Fl. Pl. Nep.	An Enumeration of the flowering plants of Nepal
et al.	et alia or and others
Fig.	Figure
Fl. Bhu.	Flora of Bhutan
Fl. Br. Ind.	Flora of British India
Fl. China	Flora of China
Fl. E. Him.	Flora of Eastern Himalaya
Fl. Ind.	Flora Indica
Fl. Kath. Val.	Flora of Kathmandu Valley
Gen. Pl.	Genera Plantarum
Hand. Fl. Pl. Nepal	Handbook of Flowering Plants of Nepal
J. Jap. Bot.	Journal of Japanese Botany
K	Royal Botanic Garden, Kew, UK
KATH	National Herbarium and Plant Laboratories, Nepal
Kew Bull.	Kew Bulletin

L	The Nationaal Herbarium Nederland (NHN)
m	meter
Mant. Pl	Mantissa Plantarum
mm	millimeter
NE	North-East
No.	Number
Nov. Pl. Sp	Novae plantarum species praesertim Indiae orientalis
Observ. Bot.	Observationes Botanicae
P.	Page
Pl. Jav. Rar.	Plantae Javanicar Rariores
Prodr. Fl. Nepal	Prodromous Florae Nepalensis
Rep. Bot. Soc. Exch. Club Brit. Isles	Report/ Botanical Society and Exchange Club of the British Isles
S	Southern
SE	South-East
S.N.	Serial number
Sp.	Species
s. s	Sensu strico (strict sense, in a narrow sense)
Sp. Pl.	Species plantarum
Subsp.	Subspecies
TI	University Museum, University of Tokyo, Japan
TUCH	Tribhuvan University Central Herbarium, Nepal
Var.	Variety
Vol.	Volume
W	Western Nepal

ABSTRACT

The genus *Fimbristylis* Vahl (Cyperaceae Juss.) is composed of about 300 taxa and there are significant taxonomic issues with both *Fimbristylis* and the tribe Abildgaardieae, and there is no agreement on the boundaries and morphological delimitation of these taxa or the species therein. No comprehensive and detailed taxonomic work has been done on the genus *Fimbristylis*. Altogether 23 species of *Fimbristylis* are recorded in Nepal. The present study was conducted to carry out the detailed taxonomic treatment of this genus based on morphology, distribution and phenology. The study was conducted from the specimens deposited at KATH, TUCH and Online herbarium: BM, E, K and TI, along with the personal collections as far as possible. Out of 23 species of *Fimbristylis*, 18 species are described based on the study of live plants and herbarium specimens, the remaining five are described based on the study of herbarium specimens deposited at different herbaria and review of relevant literatures.

Abildgardia, Bulbostylis and Fimbristylis genera are frequently picked out together because they are highly similar to one another and can only be distinguished by "minor" characteristics, which are frequently visible only under a powerful lens. *Fimbristylis* is distinguished by the lack of perianth bristles in the flower and lack of a persistent style base on the nut. The genus *Fimbristylis* has various economic importance as it provides food, fodder, medicines, fibres used in making hats, handbag, basket, cushion and mats. They also have environmental uses as soil improvers whereas some are considered as agricultural weeds. Taxonomic keys were prepared for the quick identification of the species. With the help of IBM SPSS version 23.0 Hierarchical cluster analysis was done where Dendogram was prepared using morphological character and character states where two main clusters were formed based on presence and absence of leaf blades. Similarly different sub clusters were formed based on various morphological characters, which shows the close and distant relationship among the species. Based on the herbarium and personal collection the species are distributed from 70m – 3200m. Both vegetative and reproductive characters play a crucial role in delimitation of the taxa. The taxa are delimited based on the characteristics of root, culms, leaves, inflorescence type, spikelets, glumes, style, stigma number and nutlets.

LIST OF FIGURES

LIST OF PHOTOPLATES

LIST OF DISTRIBUTION MAP

LIST OF TABLES

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Background

Systematics is defined as a science that incorporates and encompasses classical taxonomy, the description, identification, nomenclature, and categorization of organisms, and its main objective is the reconstruction of the phylogeny, or evolutionary history of life. Systematics is a fundamental branch of biology that focuses on the classification and study of the diversity of living organisms, as well as the evolutionary relationships among them (Simpson, 2010). This discipline is concerned with understanding the patterns of variation and similarities among organisms and using that information to reconstruct their evolutionary history and classify them into taxonomic groups. Systematics utilizes a range of methods and techniques to achieve these goals, including morphology, genetics, molecular biology, biogeography, and ecology. By examining and comparing the physical and genetic traits of different organisms, systematists can infer their relationships and construct a tree-like diagram called a phylogenetic tree, which represents the evolutionary history of life on earth.

A taxonomic review is a novel analysis of the patterns of variation within a certain taxon, usually confined to a comparison of morphological and geographic information for a particular group of plants. Revisions are summarizing reevaluations that present new information with new interpretations that have been incorporated with prior knowledge. It includes keys, a list of synonyms, new combinations, new names, and re-descriptions or diagnoses of little-known species. Therefore, revision is frequently based on morphological and geographic evidence as well as information from literature reviews and other supportive evidences from field data, anatomy, cytology, paleobotany, phytochemistry, ecology, palynology, seed (Siwakoti and Rajbhandary, 2015). The revisionary work also aids in the writing of flora since it provides comprehensive details on any taxon in a certain geographic region.

Cyperaceae

Poales is the largest order of flowering plants among the monocotyledons, which includes families such as grasses, bromeliads, and sedges. Cyperaceae is one of the well-defined and uncontroversial families within Poales. The family name is

derived from the genus Cyperus, which comes from the Greek word "kupeiros," meaning sedge. It was officially described by De Jussieu in 1789. Cyperaceae is a family of graminoid monocotyledonous flowering plants, commonly known as sedges. The family comprises over 5,500 species, mainly found in tropical humid and semi-humid regions (Goetghebeur 1998). The discovery rate of new taxa within Cyperaceae is still high, as evidenced by the numerous studies published since 2010 with descriptions of new species and genera (Hinchliff etal.2010; Huyghetal.2010; Muasya et al. 2012) and even new genera (Muasya et al. 2012; Gilmour et al. 2013). The classification of the family Cyperaceae is based on the structure of the spikelet and the inflorescence, along with other factors. However, the interpretation can be complicated due to the small size of the spikelet and the complex structure of the inflorescence. Some subfamilies, tribes, and taxa are still up for debate. C. B. Clarke (1893) conducted the first systematic study of sedges in India and classified 449 species under 28 genera in the Flora of British India.

***Fimbristylis* Vahl.**

The genus *Fimbristylis* Vahl (Cyperaceae Juss.) is composed of about 300 taxa and is found in the tropics, subtropics, and temperate zones of both the southern and northern hemispheres with SE Asia serving as its primary distribution hub (Govaerts et al. 2007; Govaerts, 2010, Zhang et al., 2010). It belongs to the tribe Abildgaardieae, which is mainly composed of about 480 species that are primarily found in tropical or subtropical areas (Ghamkhar et al. 2007). There are significant taxonomic issues with both *Fimbristylis* and the tribe Abildgaardieae, and there is no agreement on the boundaries and morphological delimitation of these taxa or the species therein (Reutemann et al. 2009).

Fimbristylis (Vahl.) are herbs, annual or perennials, rhizomatous or stoloniferous. **Culms** 3- 5 angled, irregular angled or compressed, slender or erect, solitary or tufted, glaborous or pubescent. Leaves basal / sub-basal, sometimes reduced to a bladeless sheath. **Ligule** if present compact fringe of white or brown hairs. **Leaf blade** linear or filiform, flat, sometimes absent. **Inflorescence** terminal, simple, compound or decompound anthela. **Spikelets** solitary or compressed, terete or flattened, ovoid, ellipsoid, lanceolate, globose to sub globose, with few to many flowered. **Glumes** spirally arranged or distichously arranged, glabrous or pubescent, basal distichous and apical spirally imbricate, smooth, single veined to many veined, keeled or not keeled. **Stamens** 1- 3. **Style** not persistent on nutlet,

often flattened basally, ciliated or glabrous. **Stigmas** 2 or 3. **Nutlet** biconvex or 3-sided, sometimes stipitate, reticulate, smooth or verruculose.

1.2 Justification of the study

Systematic study is crucial for understanding and documenting the diversity of plant life in each region. In Nepal, the practice of collecting and depositing plant specimens in herbaria has been a long-standing tradition, allowing taxonomists to study and describe new species, update nomenclature, and create national lists of plant taxa. However, despite the importance of sedges in the ecosystem, there has been limited taxonomic research conducted on the genus *Fimbristylis* and the tribe Abildgaardieae due to the difficulty of studying them.

This lack of comprehensive taxonomic work has resulted in unresolved taxonomic issues and disagreement on the classification of these taxa and species. Therefore, conducting a thorough taxonomic study on *Fimbristylis* will contribute significantly to the field of taxonomy research and help with enumeration and writing of floras. Additionally, depositing voucher specimens at KATH and TUCH will provide valuable resources for future research. In this study, the gross morphology, distribution, and phenology of *Fimbristylis* is considered to assess their status and relationships. Such information is critical for accurately identifying and classifying plant species, which is essential for understanding their ecological roles and conserving them in the face of environmental threats.

1.3 Objectives

The general objective of present study is the taxonomic study of *Fimbristylis* Vahl., in Nepal, and specific objectives are:

- To prepare identification keys, description, illustration, and distribution map of the species.
- To find the character similarity between taxa by using cluster analysis.

1.4 Limitations

Major limitations of this study are:

- The Covid-19 pandemic and resulting lockdowns have posed significant challenges to conduct planned field work.
- Small plant size, spikelets and small microscopic flowers challenges proper study of floral characters.

- The lack of laboratory instruments to study proper microscopic character of seeds, pollen, ovary gives incomplete information about specimens.
- Morphological characteristics alone may not provide a complete understanding of the phylogenetic relationships between different taxa.
- Non- availability of herbarium specimen and lack of information on TYPE specimen.

CHAPTER 2: LITERATURE REVIEW

2.1 History of Subfamilial classification of Cyperaceae

In 1806 Vahl established the genus *Fimbristylis* in the family Cyperaceae by separating the species from the genus *Scirpus* that have spiral glumes and a flat, ciliate, distigmatic, deciduous style with an expanded base. For species with the same type of floral structure but distichous glumes, he created the genus *Abildgaardia*, leaving the tristigmatic species in the genus *Scirpus*. However, some species have spikelets with glumes that are partially distichous and partially spiral. Further, Tristigmatic and distigmatic flowers are frequently found in the same species, even in the same spikelet. Therefore, the way the glumes are arranged, and the number of stigmas are not particularly useful features for defining these genera. Additionally, Robert Brown (1810) believed that the deciduous style articulated with the nut is the feature of the genus *Fimbristylis* that is most distinctive. Based on this, he shifted numerous tristigmatic species, previously classified under *Scirpus*, to the genus *Fimbristylis*. Lestiboudois (1819) created a new genus *Trichelostylis* based on the tristigmatic character. Other researchers treated this as a synonym of *Fimbristylis*, though Nees tried to revive that genus. Asa Grey, Bentham, and Koyama combined the genera *Bulbostylis* and *Fimbristylis*, yet there is a distinct morphological distinction between these two genera. Even though cytologically both are the same, having the same basic chromosome number and identical chromosome size, van der Vekan's (1965) embryological research on the species of both genera have also demonstrated this. The other names given to this genus earlier include *Iria* (L.C. Rich.) Hedwig. f. (1806), *Echinolytrum* Desv. (1808), *Pogonostylis* Bert. (1833), *Microspora* Boeck. (1860) and Actinoschoenus Benth. (1883). *Fimbristylis* is distinguished by the absence of perianth bristles in the flower and a persistent style base on the nut. Additionally, these characteristics set it apart from closely similar genera *Eleocharis* and *Bulbostylis* respectively. According to Kern (1974), this genus belongs to the tribe Cypereae of subfamily Cyperoideae, But Koyama (1985) placed it to the Fimbristylideae tribe. Later, *Fimbristylis* was placed in tribe Abildgaardieae by Goetghebeur (1998).

Approximately 10% of sedge species belong to the Cyperaceae tribe Abildgaardieae, which is a diverse and predominantly tropical lineage. This tribe includes genera such as *Crosslandia, Fimbristylis, Abildgaardia, Bulbostylis,*

Nemum, Nelmesia, and Tylocarya, and accounts for around 560 out of the 5,600 Cyperaceae species (Govaerts et al., 2020). The Abildgaardieae is the third largest Cyperaceae species group, following Cariceae (approximately 2,000 spp.) and Cypereae (around 1,130 spp.) (Govaerts et al., 2020). These species exhibit a wide range of ecological and morphological characteristics and are often dominant in many tropical habitats. The lineage also contains multiple origins of the C4 photosynthetic pathway, many species, some with a pantropical distribution, and apparently independent radiations in tropical regions of South America, Africa, Asia, and Australia (Besnard et al., 2009; Muasya, Goetghebeur et al. , 2020).

2.2 Systematics and phylogeny

The Cyperaceae family, which includes 109 genera and over 5,500 species, is the third-largest monocotyledonous family (Govaerts et al., 2007; Muasya et al., 1998) and has been identified as monophyletic and sister to Juncaceae (Goetghebeur, 1998; Bruhl, 1995). The Cyperaceae's fourth-largest genus, Genus *Fimbristylis* Vahl., contains 306 species that are found in both tropical and temperate regions of the world (World checklist of Monocots, 2006; Bruhl & Wilson, 2007). *Abildgaardia* and *Fimbristylis* are shown in molecular phylogenetic analyses of the family Cyperaceae to be more closely related to one another than any other genera, and it is claimed that there are not enough features to properly construct the phylogenetic tree (Muasya et al., 2009; Simpson et al., 2007; Ghamkhar et al., 2007). Although the tribe Fimbristylideae Vahl (=Abildgaardieae Lye) is determined to be sister to the tribes Fuireneae and Eleocharideae, no phylogenetic theories at the generic level have yet been developed (Vrijdaghs et al., 2009). Additionally, there aren't many phylogenetic analyses based on morphological data since sedges have a problem identifying an adequate number of phylogenetically valuable characters due to reduced and comparable characters (Simpson, 1993; Bruhl, 1995; Goetghebeur, 1998; Mausya et al., 2009; Naczi, 2009). As inflorescence diversification plays a crucial role in understanding the relationship between different taxa, it appears appropriate to consider it from a new viewpoint (Tucker & Grimes, 1999). To define inflorescences in flowering plants in this context, the typology-based system created by Troll (1964) and Weberling (1989) has been shown to be a useful tool (Rua, 1999).

The monophyly of Abildgaardieae is well supported, as is the monophyly of both clades in this tribe: the *Bulbostylis* and *Fimbristylis* clades (Muasya et al., 2009; Hinchliff & Roalson, 2013; Spalink et al., 2016; Semmouri et al., 2019). According to Besnard et al. (2009) and Muasya et al. (2014), it supports the two origins of the C4 photosynthetic pathway in the *Abildgaardieae.* The shift to C4 seems to have taken place along the branch leading to the *Bulbostylis* clade and along the branch leading to the clade including Abildgaardia and *Fimbristylis*. The other lineages of Abildgaardieae rely on the C3 photosynthetic pathway. The newly discovered genus *Zulustylis* (Muasya et al., 2020), based on two species originally placed in *Fimbristylis* (Gordon-Gray, 1971), is sister to the rest of the *Fimbristylis* clade. Next, a clade from Australia that includes the genera *Arthrostylis* and *Trachystylis* is related to a clade that also includes the genera *Actinoschoenus* s.s., *Abildgaardia*, and *Fimbristylis*. *Actinoschoenus, Arthrostylis*, and *Trachystylis* (together with Trichoschoenus) were initially considered to constitute a separate tribe known as "Arthrostylideae" (Goetghebeur, 1986; Bruhl, 1995). Later, they were moved to Schoeneae (Goetghebeur, 1998) before being moved again by Muasya et al. (2009) to Abildgaardieae. There are two clades of "Arthrostylideae" genera: (i) an Australian species clade that includes *Arthrostylis, Trachystylis,* and a new genus, *Scleroschoenus*, that was published by K.L. Wilson, J.J. Bruhl, and R.L. Barrett to replace several recently described species in Actinoschoenus (Rye et al., 2015); and (ii) a clade of Actinoschoenus s.s. These species-poor lineages with the Fimbristylis Clade are distinguished by (i) the C3 photosynthetic pathway and (ii) Carex or Schoenus type embryos, in comparison to the remaining lineages, which use the C4 photosynthetic route and have embryos with the *Abildgaardia, Fimbristylis, and Tylocarya* type embryos (Semmouri et al., 2019; Larridon et al., 2021). Abildgaardia has had a variety of treatments, however Larridon et al. (2021) define it as a distinct genus that is a sister to *Fimbristylis*. Data on embryo morphology and phylogenetic analysis support the establishment of the genus *Abildgaardia*, which differs from Fimbristylis by possessing an embryo of the *Abildgaardia* type (Semmouri et al., 2019). It has been established that Crosslandia W.Fitzg. is nested within *Fimbristylis* (Hinchliff & Roalson, 2013; Spalink et al., 2016; Semmouri et al., 2019, Roalson et al., 2019, Larridon et al.,

2021), and a new combination has been published to shift it within *Fimbristylis* (Roalson et al., 2019).

2.3 Delimitation of genera *Fimbristylis*

The delimitation of the genera *Fimbristylis, Abildgardia,* and *Bulbostylis* can be challenging due to their high degree of morphological similarity. These genera are all members of the Cyperaceae family and share several features such as many-flowered spikelets, bisexual florets, glumes wrapped around their own flower, and the absence of perianth. Additionally, they also have annellately thickened papillae on stigmata and a thickened style base.

However, to differentiate between these genera, embryological traits are given significant attention in current generic circumscriptions. Based on embryotype, *Bulbostylis, Abildgardia,* and *Fimbristylis* can be easily distinguished from one another. However, observing this character can be difficult, and the commonly used morphological and embryological characteristics may not always correlate directly. Therefore, identifying and distinguishing these genera may require a combination of different approaches and techniques.

Reutemann et al. (2009) conducted a taxonomic study and found that *Fimbristylis* can be distinguished from *Abildgaardia* and *Bulbostylis* based on several morphological characteristics. Firstly, *Fimbristylis* has a terminal inflorescence, while *Abildgaardia* and *Bulbostylis* have lateral inflorescences. Secondly, *Fimbristylis* has a glabrous rachilla and bracts that are shorter than the spikelet, whereas *Abildgaardia* and *Bulbostylis* have pubescent rachillas and longer bracts that exceed the spikelet. Thirdly, the achenes of *Fimbristylis* are distinctly trigonous with an acute or acuminate apex, while those of *Abildgaardia* and *Bulbostylis* are lenticular or slightly trigonous with a rounded apex. Finally, *Fimbristylis* has solid stems, while *Abildgaardia* and *Bulbostylis* have hollow stems. However, it is important to note that the delimitation of these genera is not always straightforward and may require the use of multiple characteristics in combination with molecular data for accurate identification.

2.4 Taxonomy of Himalayan *Fimbristylis*

The Himalayan ranges encircle the globe for about 3000 kilometers from west to east and occupy more than ten degrees of North latitude (27-38~ N). From roughly

300 meters to more than 5000 meters, the altitude ranges widely, as do the weather conditions. Physical conditions vary both temporally and spatially, leading to significantly varied phytogeographic stocks that exhibit a high level of endemism. By the end of the eighteenth century, European naturalists began organizing trips to the Himalaya because of their fascination with these differences, and knowledge of the Himalayan plants began to build. Perhaps the first botanist to collect plants from the Himalaya was Thomas Hardwick, who visited Garhwal (central Himalaya) in 1796; Hamilton was the first to explore Nepal (1802–1803); Govan was the first to gather plants from Punjab; Victor Jacquemont was the first to study the plants of Kashmir (1831); and Sir Joseph Hooker and Thomas Thompson conducted the first botanical explorations in the Eastern Himalaya. (Gupta, 1981).

The Cyperaceae are a family of graminoid (grass-like), monocotyledonous flowering plants known as sedges. With about 5,500 species recorded in around 90 genera, the family is enormous, with *Carex*, the genus of "true sedges," having the most species with over 2,000. These species are widely dispersed, with tropical South America and Asia serving as the group's hubs of diversity. Although sedges can thrive in practically every environment, many of them are connected to wetlands or to poor soils.

Hooker (1894) recorded 58 species of *Fimbristylis* from British India. Grierson and Long (2001) described 17 species of *Fimbristylis* with proper taxonomic treatments from Bhutan including Sikkim and Darjeeeling. Zhang et al. (2010) described 53 species of *Fimbristylis* from China with proper taxonomic tratement and Illustrations. 14 species of *Fimbristylis* were described by Kukkonen (2001) from Pakistan.

In Nepal, plant research is mainly concentrated on the mid-hills and high Himalayas, whereas the Tarai (lowlands) is mostly neglected. The distribution of Cyperaceae in Nepal ranges from the tropical Tarai to the Alpine Himalaya (Rajbhandari and Rai, 2017; Shrestha et al., 2018). 213 species in 17 genera have so far been recorded in Nepal (Rajbhandari and Rai, 2017; Shrestha et al., 2018). Press et al. (2000), recorded 16 species of *Fimbristylis* from Nepal. But Rajbhandari and Rai (2017) recorded 18 species of *Fimbristylis* based on available herbarium records and provided information on distribution of the species within the country, along with their synonyms. Also, the same 18 species

of *Fimbristylis* have been listed by Shrestha et.al. (2018). The two additional species of *Fimbristylis* which were added by Rajbhandari and Rai. (2017) and Shrestha et.al. (2018) are *Fimbristylis cymosa var. spathacea* and *Fimbristylis fuscinux*. Recently Shrestha et al. (2022) listed 23 species of *Fimbristylis*, five new records of *Fimbristylis* species were added. Five new records of *Fimbristylis* species were listed on "Taxonomic notes on Cyperaceae of Nepal: new records of a genus, six species and other noteworthy species" Bhandari et al. (2021), which are *F. acuminata, F. ferruginea, F. nutans, F. salbundia* and *F. thomsonii.* So altogether 23 species of *Fimbristylis* were well described and treated taxonomically in this dissertation.

List of *Fimbristylis* species recorded from Nepal are:

Fimbristylis acuminata Vahl.

Fimbristylis aestivalis (Retz.) Vahl

Fimbristylis bisumbellata (Forssk.) Bubani

Fimbristylis complanata (Retz.) Link

Fimbristylis cymosa var. *spathacea* (Roth) T. Koyama

Fimbristylis dichotoma (L.) Vahl

Fimbristylis falcata (Vahl) Kunth

Fimbristylis ferruginea (L.) Vahl

Fimbristylis fimbristyloides (F. Muell.) Druce

Fimbristylis fusca (Nees) C. B. Clarke

Fimbristylis fuscinux C. B. Clarke

Fimbristylis littoralis Gaudich

Fimbristylis nutans (Retz.) Vahl

Fimbristylis ovata (Burm. f.) Kern

Fimbristylis pierotii Miq.

Fimbristylis quinquangularis (Vahl) Kunth

Fimbristylis rigidula Nees.

Fimbristylis salbundia (Nees) Kunth

Fimbristylis schoenoides (Retz.) Vahl

Fimbristylis squarrosa Vahl.

Fimbristylis stolonifera C.B. Clarke

Fimbristylis thomsonii Boeckeler

Fimbristylis umbellaris (Lam.) Vahl.

2.5 Economic Importance

The genus *Fimbristylis* has various economic importance as it provides food, fodder, medicines, fibres used in making hats, handbag, basket, cushion and mats and also they have environmental uses as soil improvers whereas some are considered as agricultural weeds. *Fimbristylis aestivalis* is used as medicine during inflammation (Burkill 1935). *Fimbristylis complanata* is used as fibres in basketry. *Fimbristylis dichotoma* is used as animal food grazed by cattle, especially the young plant (Kern 1974). The fibres of *F. dichotoma* are used for inferior matting (Burkill 1935; Burkill 1985; kern 1974). *F. dichotoma* is also used as medicine to treat Skin/subcutaneous cellular tissue disorders (Tournon et al. 1986). *F. dichotoma* is also used as soil improvers as they are ploughed in as green manures (Burkill 1935; Burkill 1985). *Fimbristylis falcata* are used as medicines to cure infection and infestatations, also rhizomes is used by santals to relieve dysentery (Cauis and Banby 1935). *Fimbristylis ferruginea* culms are beaten to soften fibres and plaited into screens for huts (Burkill 1985), also the crushed rhizome used as aphrodisiac by Shipibo-Conibo (Tournon et al. 1986). *Fimbristylis ferruginea* is also used as medicine to cure infections/infestations, its leaves are used for poulticing in fever (Burkill 1935). *Fimbristylis ovata* is used as medicine for muscular-skeletal system disorders, also the flowering culms plaited foe bangles on wrists to relieve rheumatism (Burkill 1985). *Fimbristylis squarrosa* is used as medicine in respiratory system disorders, decoction of the plant is applied to obtain relief from sore throat (Manandhar 1989). Similarly, *Fimbristylis umbellaris* is used as excellent raw material for floor mats, handbag, cushions, hats (Burkill 1935; kern 1974), it is also used as medicine to cure blood system disorders, medicine for splenomegaly (Altschul 1973).

CHAPTER 3: MATERIALS AND METHODS

3.1 Taxonimic study

3.1.1 Protologue and literature review

A protologue combines all the components of the original material with the newly published taxon name, including its description, definition, diagnosis, phylogenetic definition, registration number, designation of type specimen, illustration, synonyms, bibliography, and so on. For accurate nomenclature and species identification, type specimens and protologues are essential, hence protologue of all *Fimbristylis* species were studied.

The literature review serves as the basis of the overall work because it contains all the crucial data regarding the taxon. It aids in defining the taxon under study. It is the secondary process which provides a conceptual framework, thereby clarifying the main taxonomic issues. Various taxonomic litereratures like Zhang et al. (2010), Grierson and Long (2001), Hooker (1973), Jafri (1972) and online databases such as Catalogue of Life (www.catalogueoflife.org), IPNI (www.ipni.org), Plants of the World Online (powo.science.kew.org), Tropicos (www.tropicos.org/home) and World Flora Online (www.worldfloraonline.org) were reviewed.

3.1.2 Literature based character matrix.

Character matrix was created after reviewing the protologue texts and various literatures since they aid in differentiating taxonomic characters and organizing the herbarium specimens into distinct groups based on those characters.

3.1.3 Collection and preparation of Herbarium Specimens

During the study, fresh and herbarium specimens that were deposited at TUCH and KATH were inspected and appropriately photographed. Additionally, the majority of characters from both the vegetative and reproductive parts were observed.

Using the appropriate equipment, such as a plant press, field notebook, digger, secateurs, blotting paper, GPS, tag, newspaper, hand lens, map, camera, etc., plant specimens were collected from various regions of the country. High-quality plants that had inflorescence were collected along with the photograph of the plant's habit. The field note (Collection number, date of collection, common name, local name, locality, District name, slope, aspect, latitude & longitude,

altitude, habit & habitat, phenology and the diagnostic feature of the plant) of all the collected species was recorded in the field and tagging and numbering was done for each individual collected.

Plants were pressed and dried right away after collection. Before pressing, specimens were cleaned. Decayed components were taken out and pressed against the center of blotting paper or newspaper. Large specimens were pressed in the shapes of a V, N, or W. After pressing, the specimens were dried by natural drying method. There was no need for artificial heating since my species was a sedge. By often changing the papers, natural drying was achieved. Dried and perfect plant specimens were mounted on herbarium paper of the standard size (45 cm x 30 cm), and a label containing the field note's details was attached to the sheet's lower right corner.

3.1.4 Identification of the species

The species were identified using printed or online identification keys as well as standard literature including Flora of British India (1897), Flora of Pakistan (1982), Flora of China (2006), and Flora of Bhutan (2000). It was also possible to identify the specimens by matching them to those deposited at TUCH (Tribhuvan University, Central Herbarium) and KATH (National Herbarium and Plant Laboratories, Nepal). The terminology for the study was followed from the book Harris and Harris (2000).

3.1.5 Morphological Study

Gross morphological (both macro and micro) features, such as vegetative and reproductive features like roots, stems, leaves, and flowers, were investigated. With the aid of a stereomicroscope, a compound microscope, and a dissecting microscope, a morphological analysis based on herbarium specimens and fresh specimens was carried out. By soaking the herbarium specimen in lukewarm water to soften it and restore its original shape, morphological study was done on the specimen. The mature parts were mostly used for measurements.

Roots

Roots were observed carefully to delimit the annual and perennial species. Nature of Rhizome and stolon were also studied.

Culm

Culms shape size and color were properly studied for the delimitation of *Fimbristylis* species.

Leaf sheath

The shape, size, color, nature (Pubescent or glabrous) of leaf sheath were studied.

Ligule

Absence and presence of ligule were studied with the help of hand lenses. Enlarged view was observed from stereomicroscope, along with the proper photographs as far as possible.

Inflorescence

Inflorescence type, shape, size was studied along with the rays and spikelet. Inflorescence is the major character for identification. Number, size, presence/ absence of Involucral bracts also were studied for the delimitation of taxa.

Spikelet

Spikelet was the most important character for delimitation of species. They were observed by hand lens in the field and in lab they were properly studied by stereomicroscope. The shape, size, color, and nature of spikelet were studied with good photograph.

Glume

Shape, size, nature and color along with the number of veins were studied on glume.

Nutlet

Nutlet also play a vital role in delimitation of species. Shape, size, and color along with texture were studied on nutlet with the help of stereo microscope.

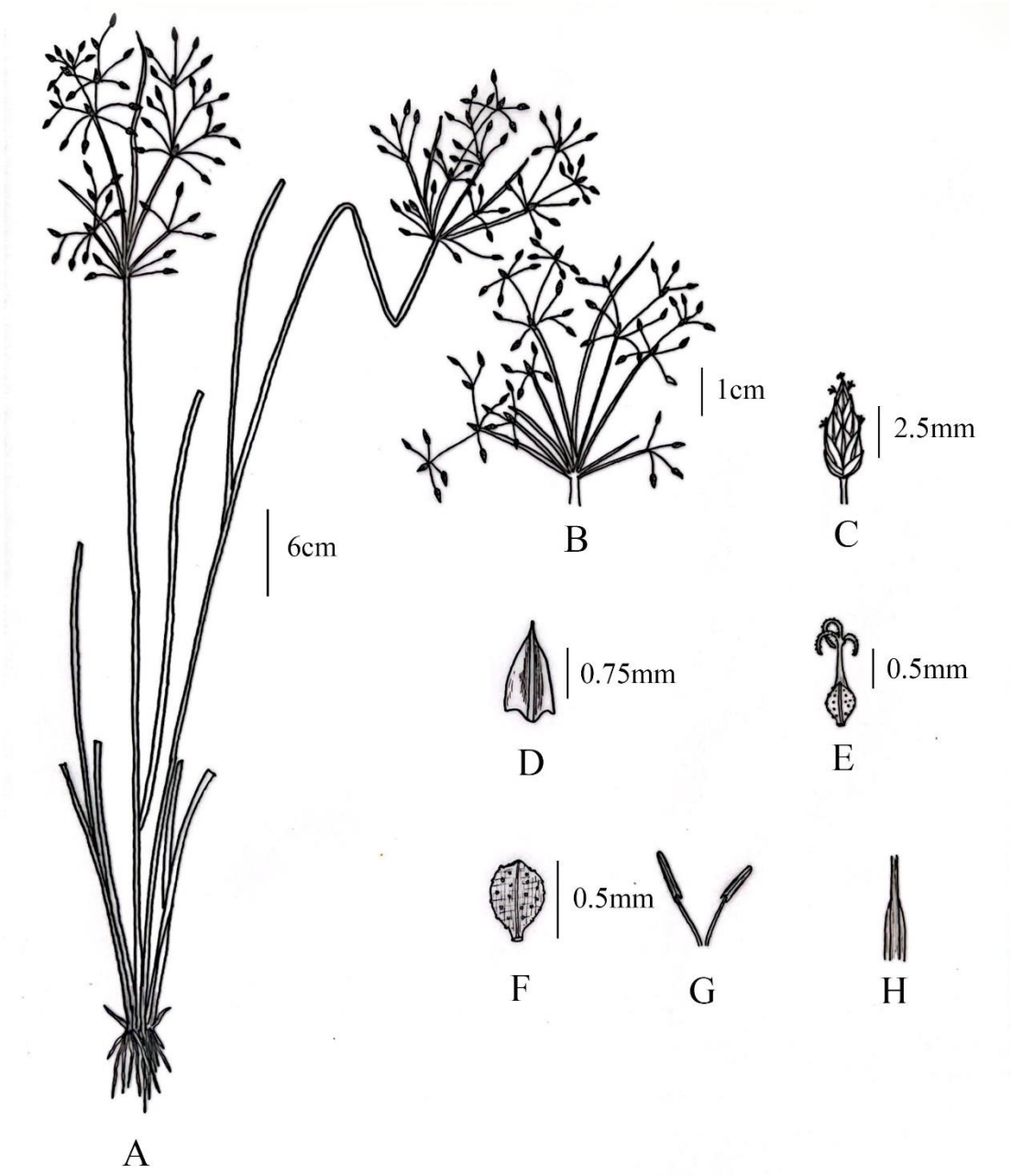


Figure 1. Illustration of *Fimbristylis quinquangularis* showing the way of measuring dimensions of floral parts. **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet, **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet, **G**. Stamens and **H**. Ligule.

3.1.6 Illustration

With the use of a pencil, free-hand diagrams of habit sketches, roots, stems, leaves, inflorescences, flowers, and nutlets were created. Finally, the inking was done at last. And digital photos were taken with the help of a scanner.

3.1.7 Construction of Identification Keys

Artificial identifying keys were created on the basis of micro and macromorphological features using the "Bracketed format."

3.1.8 Photographs and preparation of distribution Map

Both collected and herbarium specimens vegetative and reproductive parts were photographed. Using GIS software and the coordinate points, a distribution map for each species in the study was created.

3.2 Cluster analysis

Cluster analysis based on gross morphological traits, such as vegetative and reproductive characteristics, both qualitative and quantitative traits, was conducted to identify similarities across the species. Altogether 40 characters were used to perform cluster analysis of 23 species of *Fimbristylis.* All the selected characters were given equal weightage. Dendogram was constructed with the use of both two state and multistate coding. Using IBM SPSS 23.0 for windows, the squared hierarchical clustering was done. Clustering method was done by using between groups linkage option.

3.3 Phenology

The timeline of a plant's life cycle is known as phenology. It is the plant species' periodic behavior in response to changing environmental conditions. For plants, this includes fruiting, flowering, dispersing seeds, etc. Based on the species that were collected, herbarium specimens that were collected at KATH, TUCH & TI, and different literature, a record of flowering and fruiting was kept.

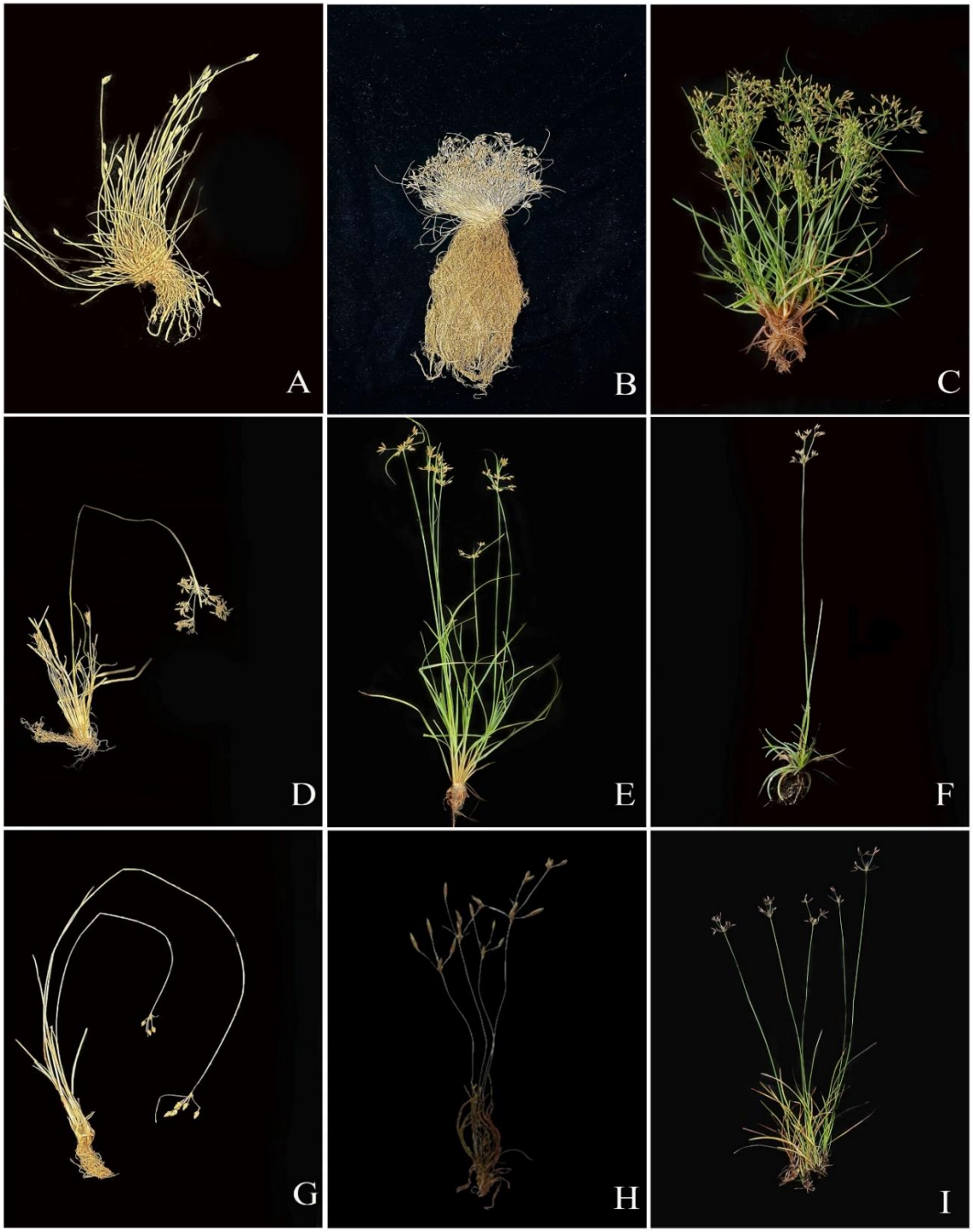
CHAPTER 4: RESULT

4.1 Range of morphological characters in genus *Fimbristylis* Vahl.

The morphology of the genus *Fimbristylis* has been studied from the fresh materials collected personally from different places of Nepal, herbarium specimens deposited at KATH and TUCH, digital photographs and different available literatures. The ranges of gross morphological characters of species of genus *Fimbristylis* found in Nepal are as follows:

4.1.1 Life forms

Both annual and perennial life forms are present. Among 23 species most of the species are perennial and only six species are annual. *Fimbristylis acuminata, F. aestivalis, F. bisumbellata, F. fimbristyloides, F. quinquangularis* and *F. squarrosa* are annual species, whereas *F. dichotoma* and *F. schoenoides* are annual or short-lived perennials. Similarly, the rest of the species *F. complanata, F. cymosa var. spathacea, F. falcata, F. ferruginea, F. fusca, F. fuscinux, F. littolaris, F. nutans, F. ovata, F. pierotii, F. rigidula, F. salbundia, F. stolonifera, F. thomsonii and F. umbellaris* are perennials. (Photoplate No.1 & 2 and appendix 2)



Photoplate No. 1: Variation of life forms in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I.** *F. fusca*

Photoplate No. 2: Variation of life forms in *Fimbristylis* **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

4.1.2 Roots and rhizome

Rhizome and root hairs are present in perennial species of *Fimbristylis* and the annual species of *Fimbristylis* have fibrous roots. The rhizome and stolons are often clothed with old remains of leaf sheath and scales. Out of 23 species *Fimbristylis acuminata, F. aestivalis, F. bisumbellata, F. fimbristyloides, F. quinquangularis, F. squarrosa* are annual herbs with fibrous root whereas *F. dichotoma and F. schoenoides* are annual or short-lived perennials and rest of 17 are perennials with rhizome. The rhizomes are usually small and woody, but in a few species creeping stolons are present. Stolons are only present on perennial species *F. stolonifera and F. pierotii*. Similarly, the rest of the species *F. complanata, F. cymosa var. spathacea, F. falcata, F. ferruginea, F. fusca, F. fuscinux, F. littolaris, F. nutans, F. ovata, F. rigidula, F. salbundia, F. thomsonii and F. umbellaris* are perennials with rhizome. (Appendix 2)

4.1.3 Culm

The stems are known as culms. Culms are tufted in most of the species of *Fimbristylis* and solitary only in few species. The size also varies from 5 cm to more than 1 meter, where *F. quinquangularis* exceeds more than 100cm and *F. squarrosa* is the smallest one which ranged only 5-7cm. culms are also variable from 3 angled to 5 angled and sometimes compressed and irregular angled. *F. littoralis* is differentiated from other species by having 4 angled culms whereas *F. fimbristyloides, F. fusca, F. quinquangularis and F. salbundia* have 5- angled culms. *Fimbristylis aestivalis, F. bisumbellata, F. complanata, F. cymosa var. spathacea, F. falcata, F. pierotii, F. thomsonii* have 3 angled culms and rest of the species have compressed and irregular angled culms. (Appendix 2)

4.1.4 Leaves

In *Fimbristylis* the leaves are divided into leaf sheath and leaf blade

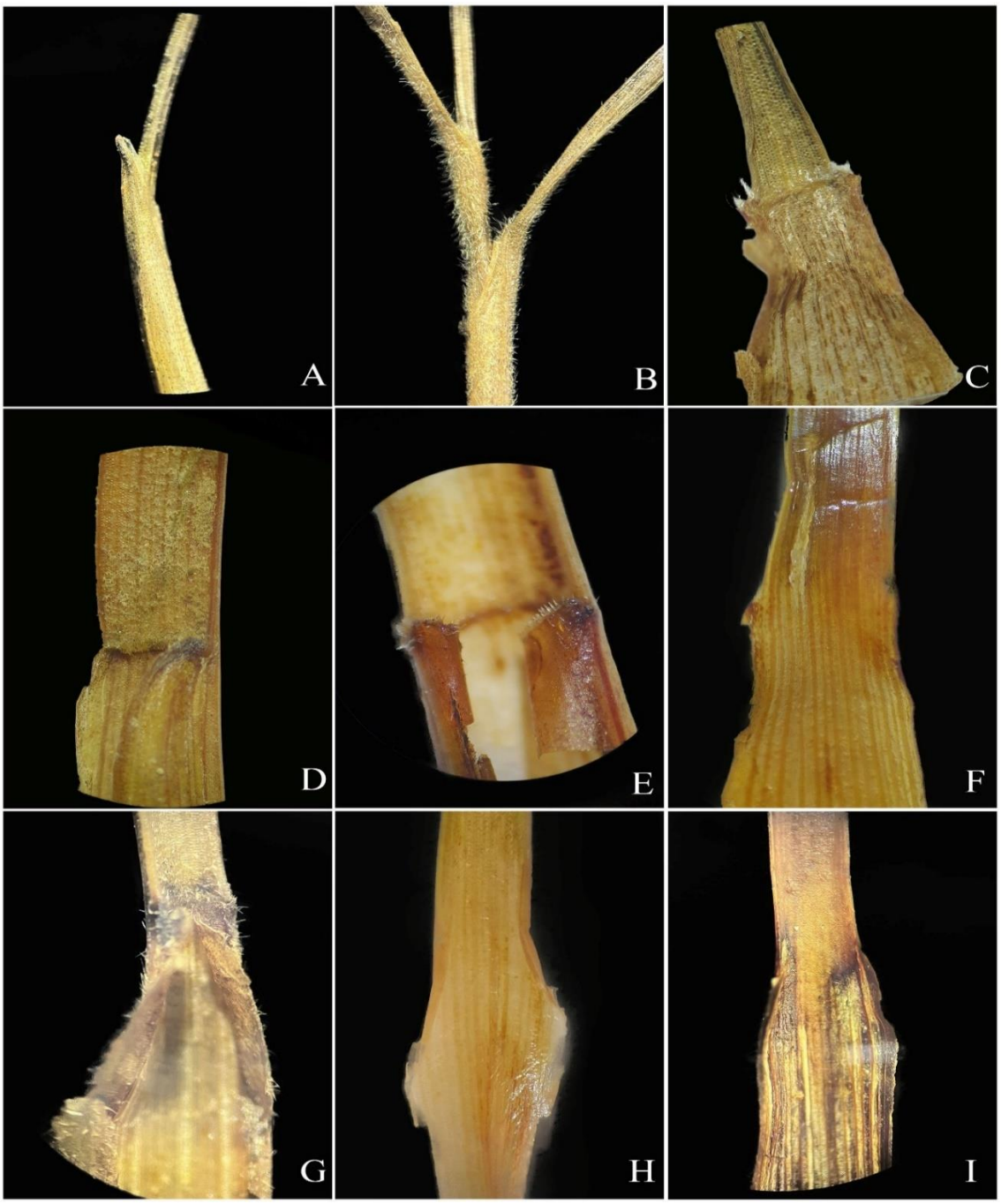
Leaf sheath

The color of leaf sheath varies from pale yellow, pale green to dark brown. Leaf sheath is open in *F. aestivalis, F. bisumbellata, F. cymosa var. spathacea, F. dichotoma, F. falcata, F. fimbristyloides, F. fusca, F. quinquangularis, F. schoenoides, F. squarrosa, F. stolonifera* and *F. thomsonii* and closed in *F. acuminata, F. complanata, F. ferruginea, F. littoralis, F. nutans, F. ovata, F. rigidula* and *F. salbundia*. The leaf sheath is glabrous and membranous in *F.*

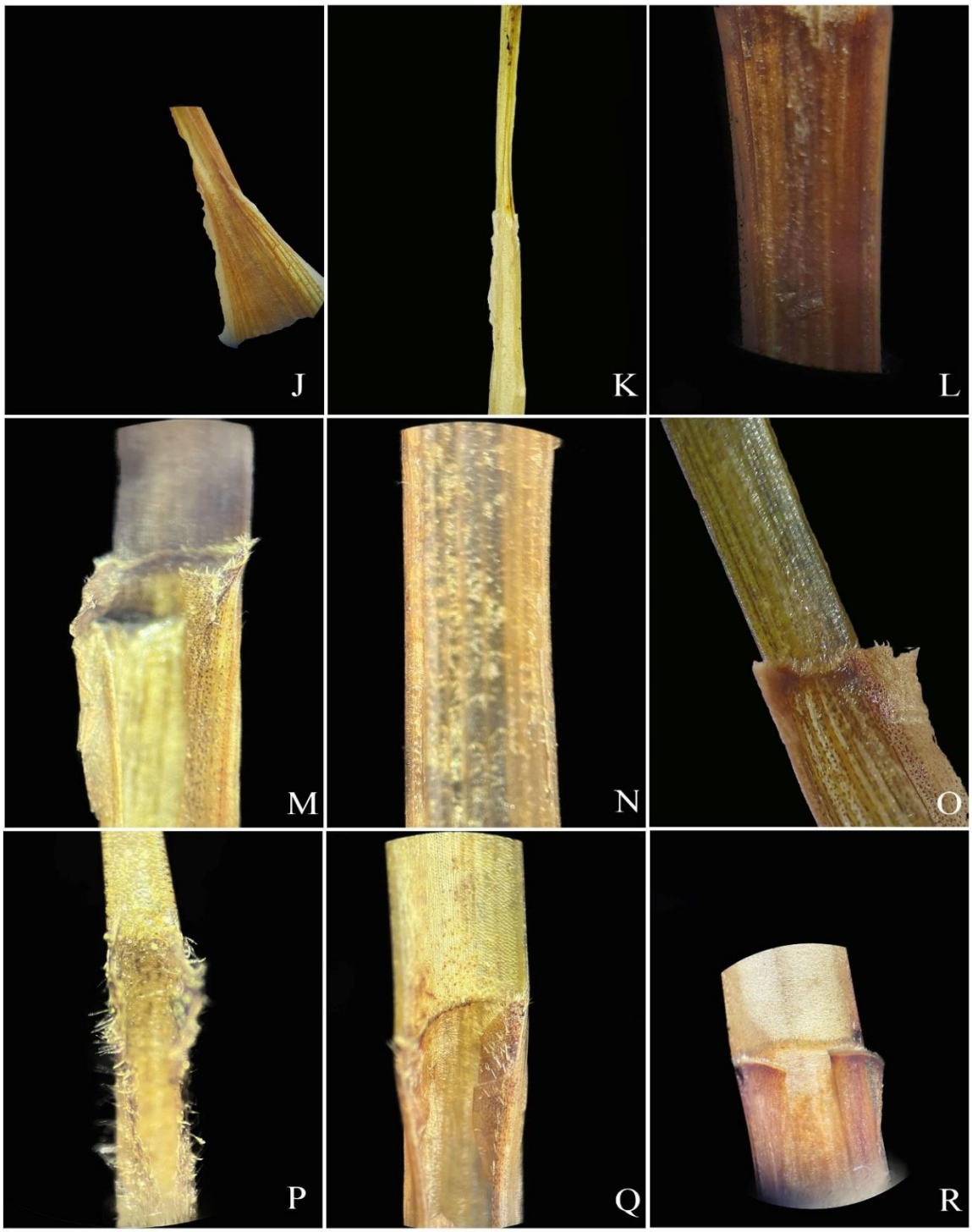
acuminata, F. complanata, F. cymosa var. spathacea, F. dichotoma, F. falcata, F. ferruginea, F. fimbristyloides, F. fusca, F. littoralis, F. nutans, F. ovata, F. pierotii, F. quinquangularis, F. rigidula, F. salbundia, F. schoenoides, F. stolonifera and *F. thomsonii*. It is pubescent in *F. aestivalis, F. bisumbellata* and *F. squarrosa* . Its size varies from 0.5 – 20cm, where the smallest size is present in *F. squarrosa* while the largest size is present in *F. salbundia*. The mouth of leaf sheath varies from straight, oblique to truncate. The leaf sheath of most of the species poses brown colored specks. (Photoplate 3 & 4 and appendix 3)

Ligule

Ligule is present in only 9 species of *Fimbristylis* Vahl. which are *F. bisumbellata, F. complanata, F. dichotoma, F. ferruginea, F.rigidula, F. schoenoides, F. squarrosa, F. stolonifera and F. thomsonii* whereas absent in *F. acuminata, F. aestivalis, F. cymosa var. spathacea, F. falcata, F. fimbristyloides, F. fusca, F. fuscinux, F. littoralis, F. nutans, F. ovata, F. pierotii, F. quinquangularis, F. salbundia* and *F. umbellaris*. (Photoplate 3 & 4 and appendix 3)



Photoplate No. 3: Variation of Leaf sheath and ligules in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I.** *F. fusca*



Photoplate No. 4: Variation of Leaf sheath and ligules in *Fimbristylis*. **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

Leaf blade

Leaf blades helped for the identification of the species. So. this was one of the major characteristics for the identification of the species.

Shape: The shape of leaf varies from filiform – linear flat.

Size: The size of leaf varies from 2- 70cm × 0.5mm- 4mm wide.

Surface: The leaf surface is glabrous in most of the species, only a few species have pubescent leaf surface. Leaf surface contains brown color specks when mature in most of the species.

Margin: The margin is scabrous or serrated in almost all species.

Most of the species have basal leaves and few species have basal and sub basal leaves, whereas in some species leaves are reduced to bladeless basal leaf sheaths. In *F. acuminata, F. salbundia* and *F. nutans* leaves are reduced to a bladeless sheath. The leaf blade size varies from 2cm- 70cm, where *F. squarrosa* have the smallest leaf size whereas *F. quinquangularis* have the largest one. In the majority of the species leaf blades are linear to linear flat whereas leaf blades are filiform in *F. aestivalis and F. squarrosa*. Similarly, *F. fimbristyloides* is distinguished from other species due to the presence of curved leaf blades. In leaf blades, the apex in majority of species was acute with serrated margin where*as F. bisumbellata and F. schoenoides* had obtuse, *F. fuscinux* had subobtuse- apiculate and *F. littoralis* had attenuated leaf apex. The leafblade surface is glabrous in *F. bisumbellata, F. complanata, F. cymosa var. spathacea, F. dichotoma, F. falcata, F. ferruginea, F. fimbristyloides, F. fuscinux, F. littoralis, F. ovata, F. pierotii, F. quinquangularis, F. rigidula, F. schoenoides, F. stolonifera, F. thomsonii* and *F. umbellaris* but pubescent only in *F. aestivalis, F. fusca and F. squarrosa*. The margin is serrated or scabrous in almost all the species but flat and incurved in *F. pierotii* and involute in *F. squarrosa.* (Appendix 4).

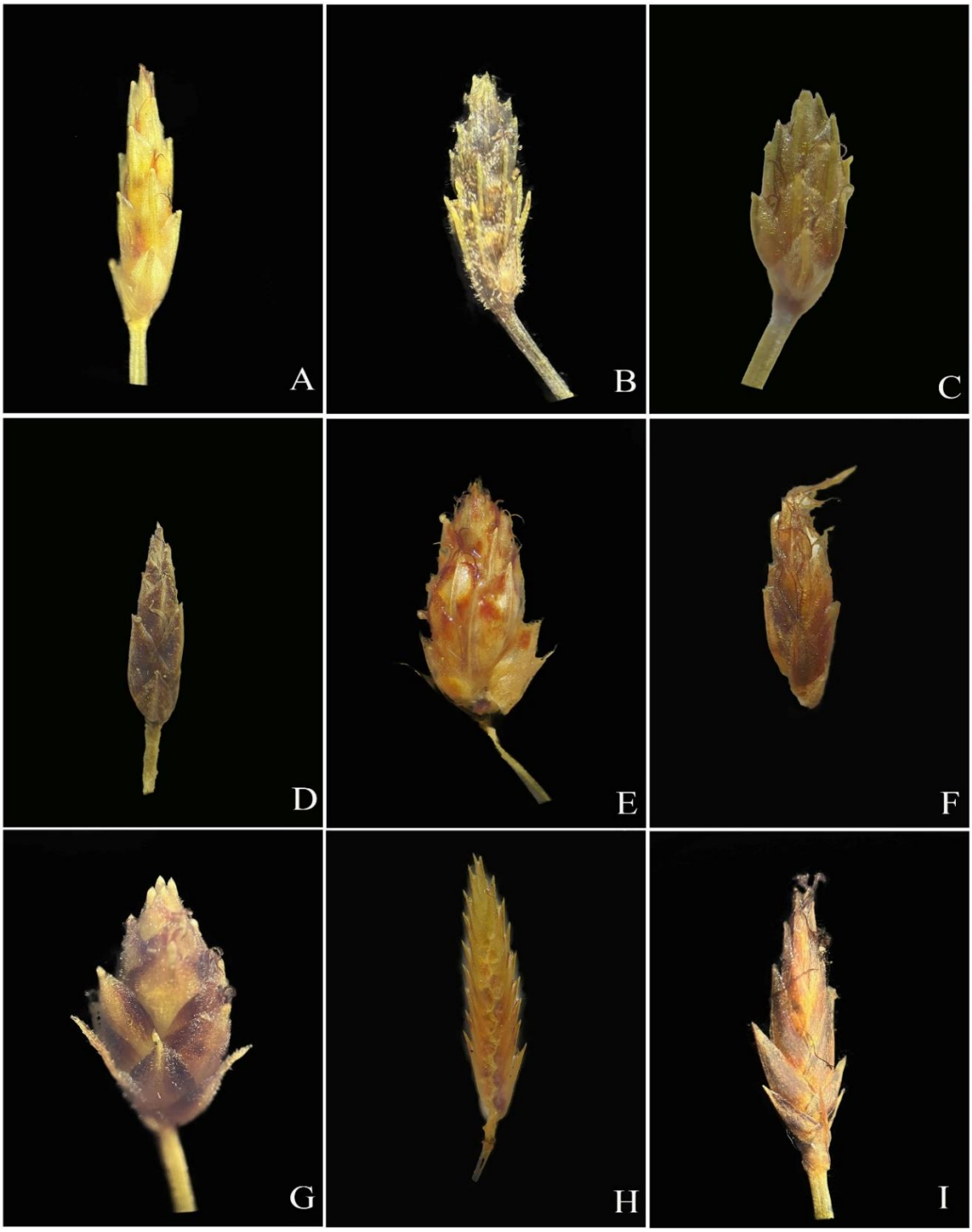
4.1.5 Inflorescence

Inflorescence in *Fimbristylis* is terminal, simple, compound, sub compound or decompound anthela with varying numbers of rays. The rays are of unequal length. Inflorescence is usually combinations of bracts, rays, and spikelets. Three species of *Fimbristylis, F. acuminata, F ovata and F. nutans* have single terminal inflorescence which helps to delimit them from other species, 4 species of *Fimbristylis, F. fimbristyloides, F. ferruginea, F. pierotii, F. schoenoides* have simple anthela while rest of the 16 species (*Fimbristylis aestivalis, F. bisumbellata, F. complanata, F. cymosa var. spathacea, F. dichotoma, F. falcata, F. fusca, F. fuscinux, F. littoralis, F. quinquangularis, F. rigidula, F. salbundia, F. squarrosa, F. stolonifera, F. thomsonii and F. umbellaris*) have compound to decompound anthela. The rays number varies from 2-6, with unequal length. Involucral bracts are of two different types in *Fimbristylis*, one is glume like and other is leaf like. *F. aestivalis, F. bisumbellata, F. complanata, F. cymosa* var. *spathacea, F. dichotoma, F. falcata, F. ferruginea, F. fimbristyloides, F. fusca, F. fuscinux, F. littoralis, F. quinquangularis, F. rigidula, F. salbundia, F. schoenoides, F. squarrosa, F. stolonifera, F. thomsonii and F. umbellaris* have leaf-like involucral bracts of unequal size and only 3 species, *F. ovata, F. pierotti and F. nutans* have glume-like involucral bracts whereas Involucral bracts is absent only in *F. acuminata*. (Appendix 5 & 6)

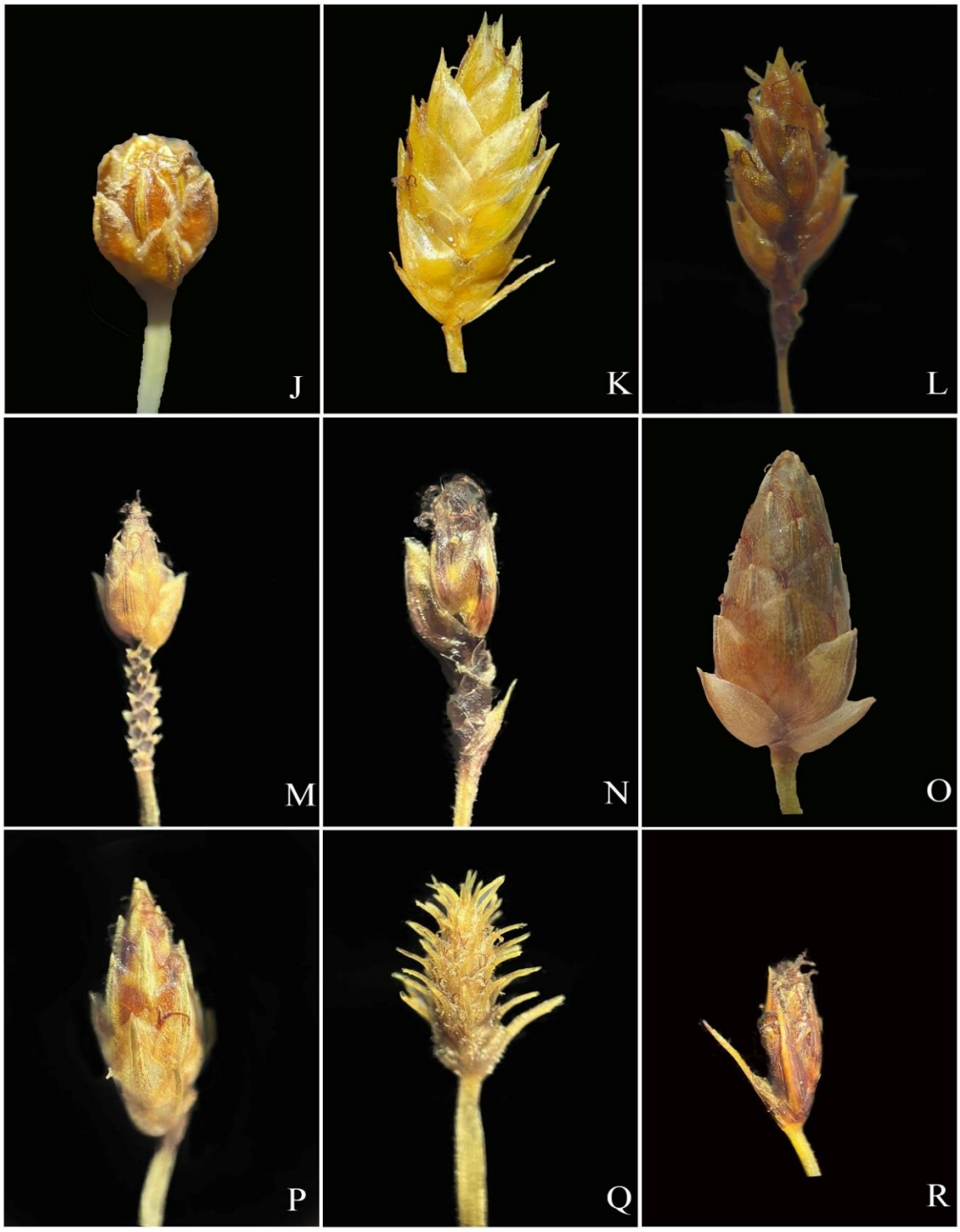
4.1.6 Spikelet

Spikelet was also the main character in *Fimbristylis* which helped in the identification and delimitation of the species. Spikelet in sedges vary in their shape, size and color which is shown in photoplate no. 5 and 6. The size of spikelet varies from 1.5mm -19mm, where *F. aestivalis, F. bisumbellata and F. littoralis* have the smallest spikelets and *F. fuscinux* have the largest one. The majority of the species of *Fimbristylis* have solitary spikelets but spikelets are only clustered in *F. falcata* and sometimes clustered in *F. cymosa var. spathacea*. The shape of spikelet is lanceolate only in 3 species *F. acuminata, F. fimbristyloides and F. fusca*. While oblong - ovoid spikelet is present in *F. aestivalis, F. bisumbellata, F. cymosa var. spathaceae, F. stolonifera* whereas ovoid - ellipsoid is present in *F. dichotoma, F. falcata, F. ovata, F. quinquangularis, F. rigidula. F. pierotii and F, thomsonii* have oblong, ellipsoid or ovoid shape of spikelets. Similarly, *F.*

complanata, F. ferruginea, F. squarrosa, F. schoenoides, F. salbundia have ovoid spikelets. And only *F. littoralis and F. umbellaris* have globose spikelets whereas *F. nutans* have oblong - elliptic type of spikelet. The color of spikelet is usually yellow to different shades of brown. This wide range of variations in shape and size of spikelets helped in the identification of species. (Photoplate 5 & 6 and Appendix 6)



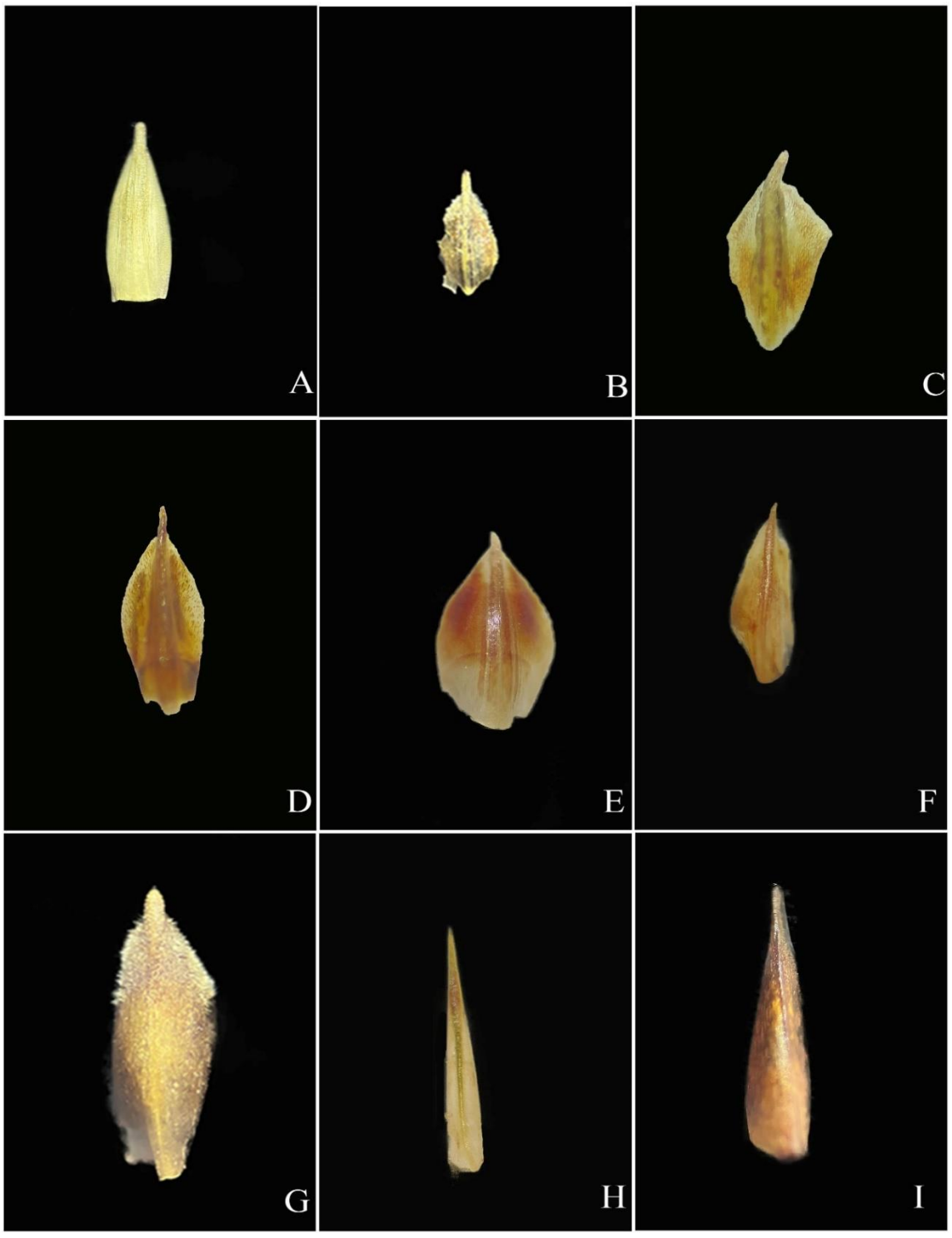
Photoplate No. 5: Variation of spikelets in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I**. *F. fusca*



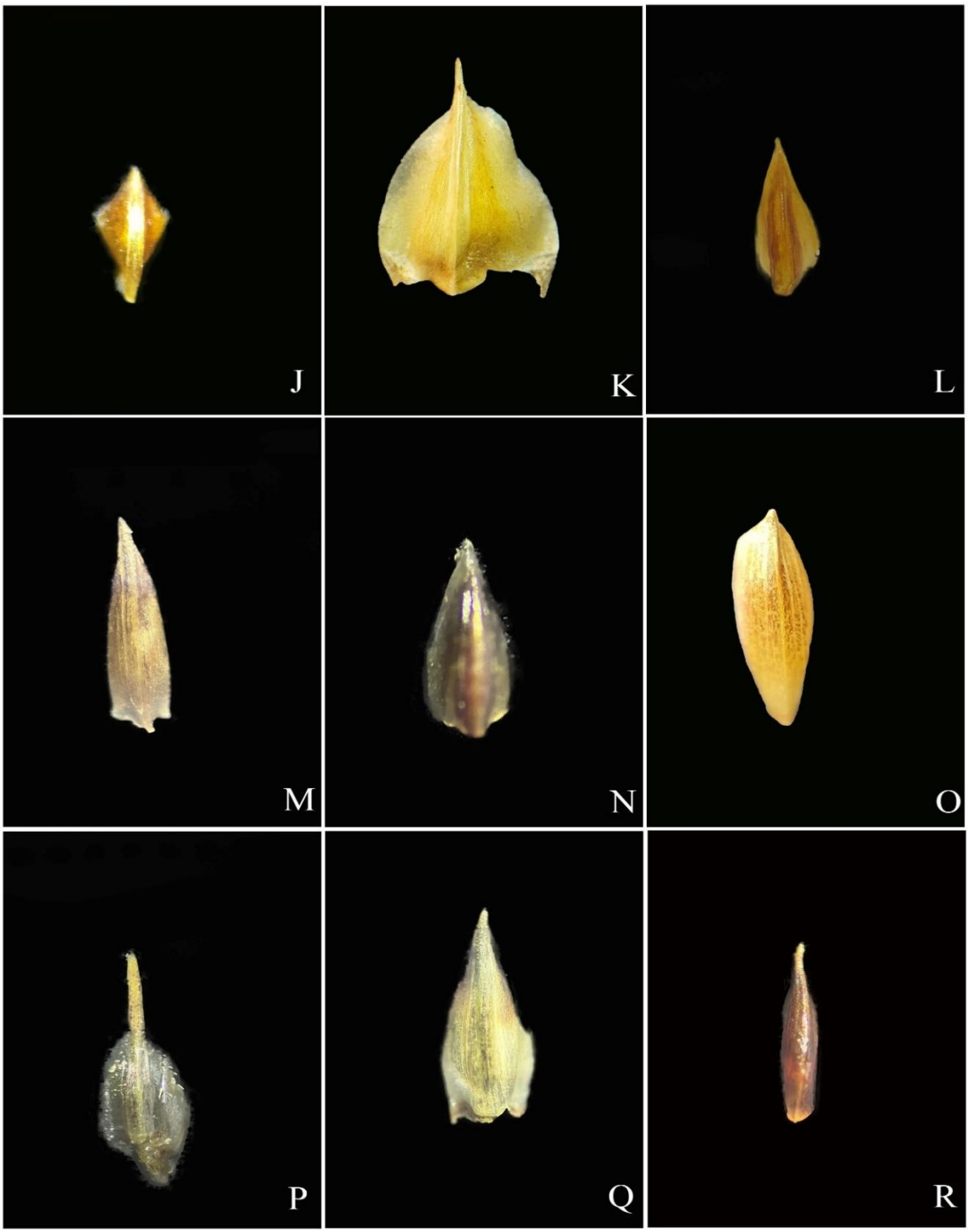
Photoplate No. 6: Variation of spikelets in *Fimbristylis*. **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

4.1.7 Glume

Glumes are membranous bract surrounding the florets. The unique traits of glumes that distinguish species include variation in numbers, arrangement, size, shape, color, venation, and apex. The arrangement of glumes is spiral in 20 species (*F. acuminata, F. aestivalis, F. bisumbellata, F. complanata, F. cymosa var spathaecea, F. dichotoma, F. falcata, F. fuscinux, F. ferruginea, F. littoralis, F. nutans, F. pierotii, F. rigidula, F. quinquangularis, F. rigidula, F. salbundia, F. squarrosa, F. stolonifera, F. schoenoides, F. thomsonii* and *F. umbellaris*) of *Fimbristylis* but glumes are distichously arranged only in 3 species which are *F. fimbristyloides, F. fusca and F. ovata*. The size of glumes also varies from 1.2-5mm. The shape of glume is lanceolate in *F. fimbristyloides and F. fusca.* Ovate – elliptic glumes is found on *F. acuminata* and *F. umbellaris*, ovoid – elliptic glume shape is found in *F. salbundia,* oblong- elliptic in *F. nutans*, oblong to ovate in *F. stolonifera*, whereas majority of species have ovate glumes, ovate glumes is found *in F. aestivalis, F. bisumbellata, F. complanata, F. cymosa var. spathaceae, F.dichotoma, F. falcata, F. ferruginea, F. fuscinux, F. littoralis, F.ovata, F. pierotii, F. quinquangularis, F. rigidula, F.squarrosa, F. thomsonii* and *F. schoenoides*. The apex of glume is apiculate in *F. fusca, F. ferruginea and F. nutans* and mucronate in *F. acuminata, F. aestivalis, F. dichotoma, F. fuscinux, F. ovata* ,attenuate in *F. bisumbellata, F. falcata* and *F. schoenoides,* acute in *F. complanata, F. fimbristyloides, F. salbundia* and *F. thomsonii,* acute – obtuse in *F. littoralis*, Obtuse – subacute in *F. pierotii,* and acuminate in *F. rigidula and F. stolonifera*, obtuse and awned in *F. squarrosa,* obtuse and apiculate in *F. quinquangularis*, obtuse – mucronate in *F. umbellaris* whereas acuminate in *F. rigidula*. The color varies from pale yellow, green to different shades of brown. The majority of species have keeled glumes with single to more than 15 veins, only *F. cymosa var. spathacea, F. dichotoma F. ferruginea* and *F. schoenoides* glumes are not keeled. Similarly, *F. ferruginea* and *F. aestivalis and F. squarrosa* have densely pubescent glumes while the rest of the species have glaborous glume surface which is the important characteristics to delimit from other species. (Photoplate 7 & 8 and Appendix 7)



Photoplate No. 7: Variation of glume in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I**. *F. fusca*



Photoplate No. 8: Variation of glume in *Fimbristylis*. **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

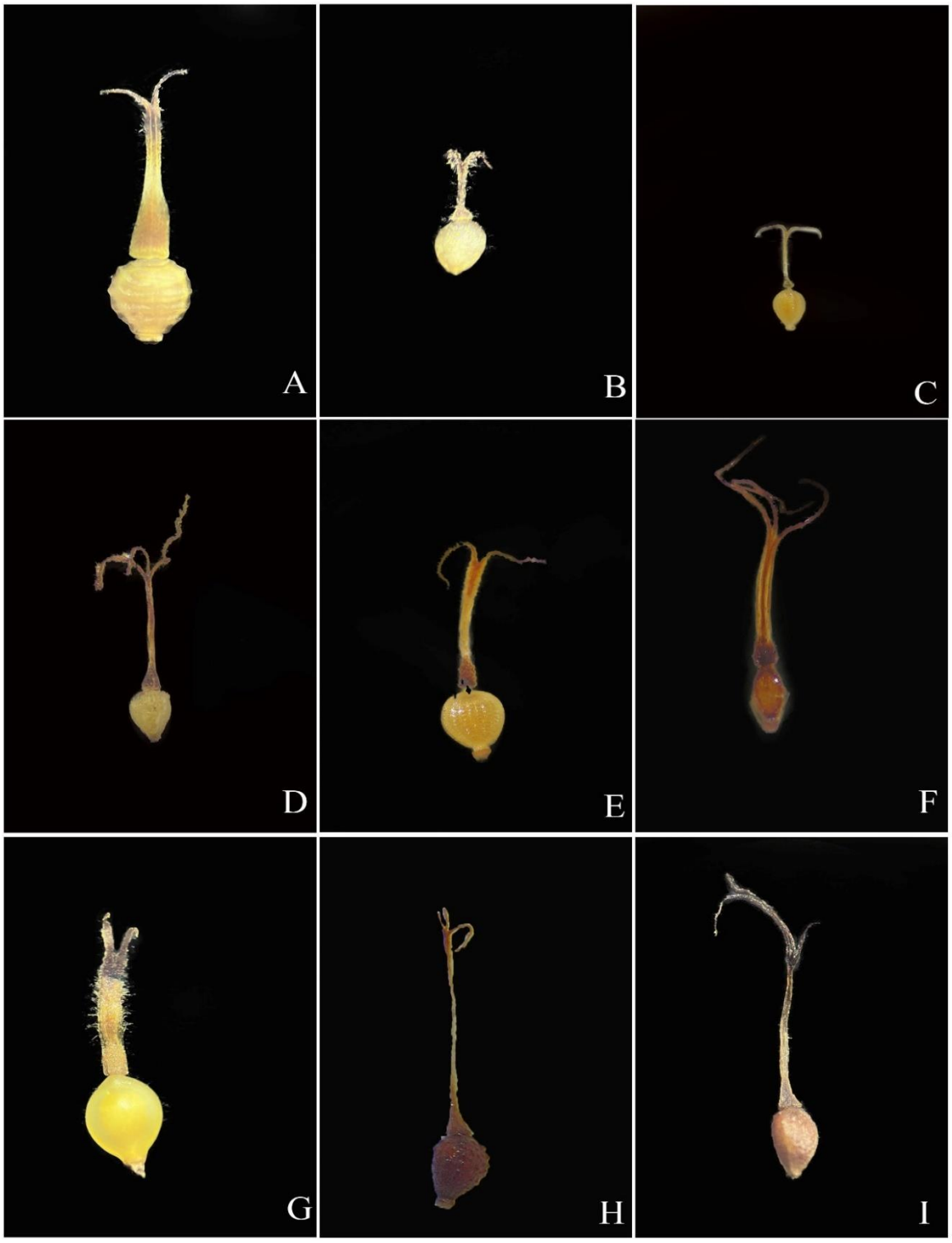
4.1.8 Flowers

Stamen

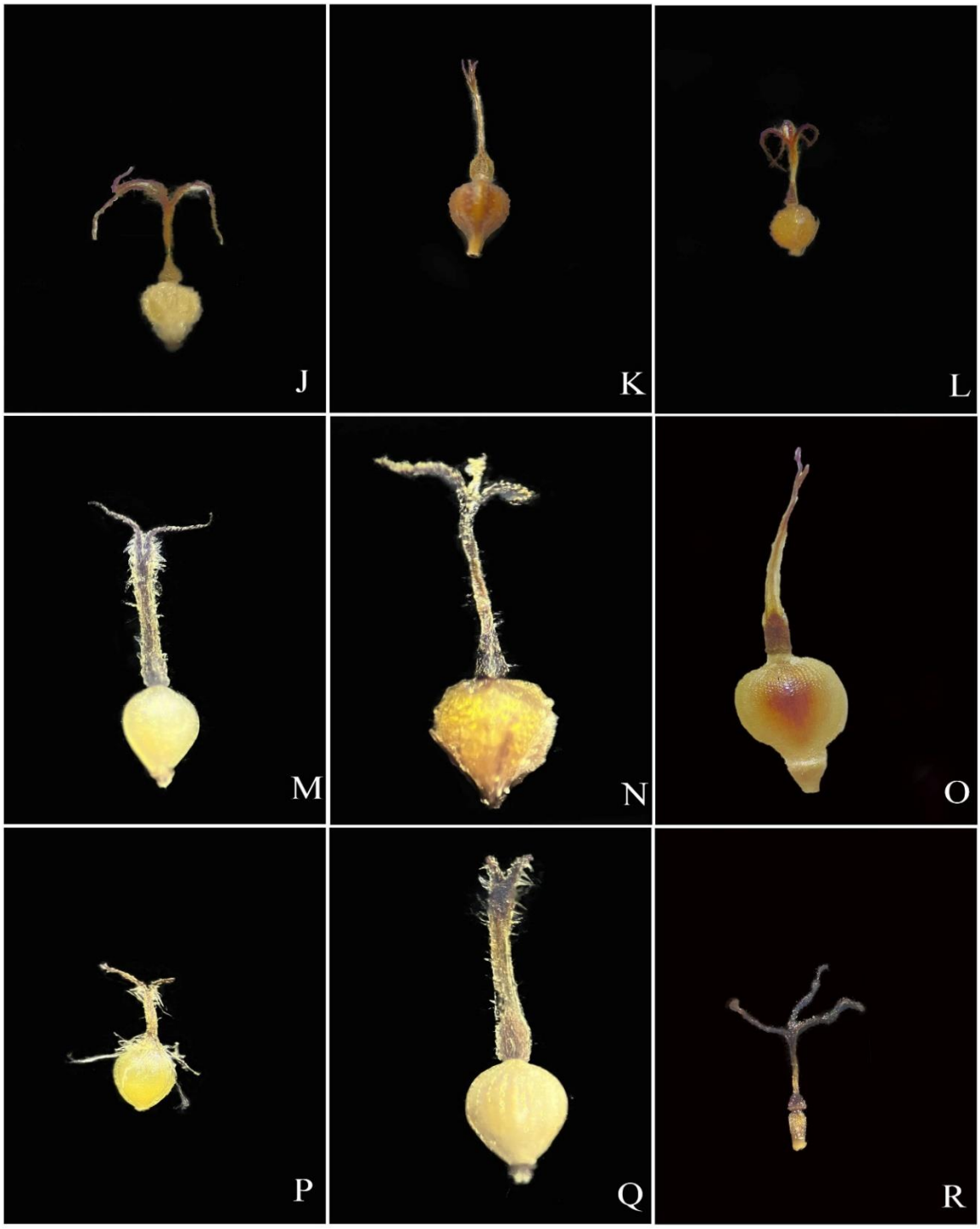
Stamens numbers also vary from 1-3 on *Fimbristylis* species. The number of stamen was 1 *in F.aestivalis, F. dichotoma and F. squarrosa* , 2 in *F. acuminata, F. bisumbellata, F. littoralis* and 3 in most of the species *F. complanata, F. falcata, F. fimbristyloides, F. fusca, F. feruuginea, F. ovata, F. pierotii, F. stolonifera, F. salbundia, F. schoenoides , F. thomsonii* and *F. nutans*. Similarly, 2 or 3 *in F. cymosa var. spathaceae, F. fuscinux, F. rigidula* and *F. umbellaris* and 1 or 2 in *F. quinquangularis*. (Appendix 8)

Carpels

The gynoecium consists of a single compound pistil of usually 2 or 3 carpels. The details are shown in Photoplate No. 9 and 10. The style is not persistent on nutlet, also flattened basally in majority of the species. The style is ciliated in *F. acuminata, F. aestivalis, F. bisumbellata, F. dichotoma, F. ferruginea, F.nutans, F. ovata, F. quinquangularis, F. rigidula, F. schoenoides, F. squarrosa* and *F. stolonifera* but not ciliated in rest of the species (*F. complanata, F. cymosa* var. *spathacea, F. falcata, F. fimbristyloides, F. fusca, F. fuscinux, F. littoralis, F. pierotii, F. salbundia, F. thomsonii* and *F. umbellaris*). The number of stigmas varies from 2 (*F. acuminata, F. aestivalis, F. bisumbellata, F. dichotoma, F. ferruginea, F. fuscinux, F. nutans, F. rigidula, F. schoenoides, F. squarrosa* and *F. stolonifera*) to 3 (*F. complanata, F. falcata, F. fimbristyloides, F. fusca, F. littoralis, F. ovata, F. pierotii, F. quinquangularis, F. salbundia and F. thomsonii*). In species like *F. cymosa. var spathacea* and *F. umbellaris* the stigmas number is variable (2-3). (Photoplates No. 9 &10 and Appendix 8)



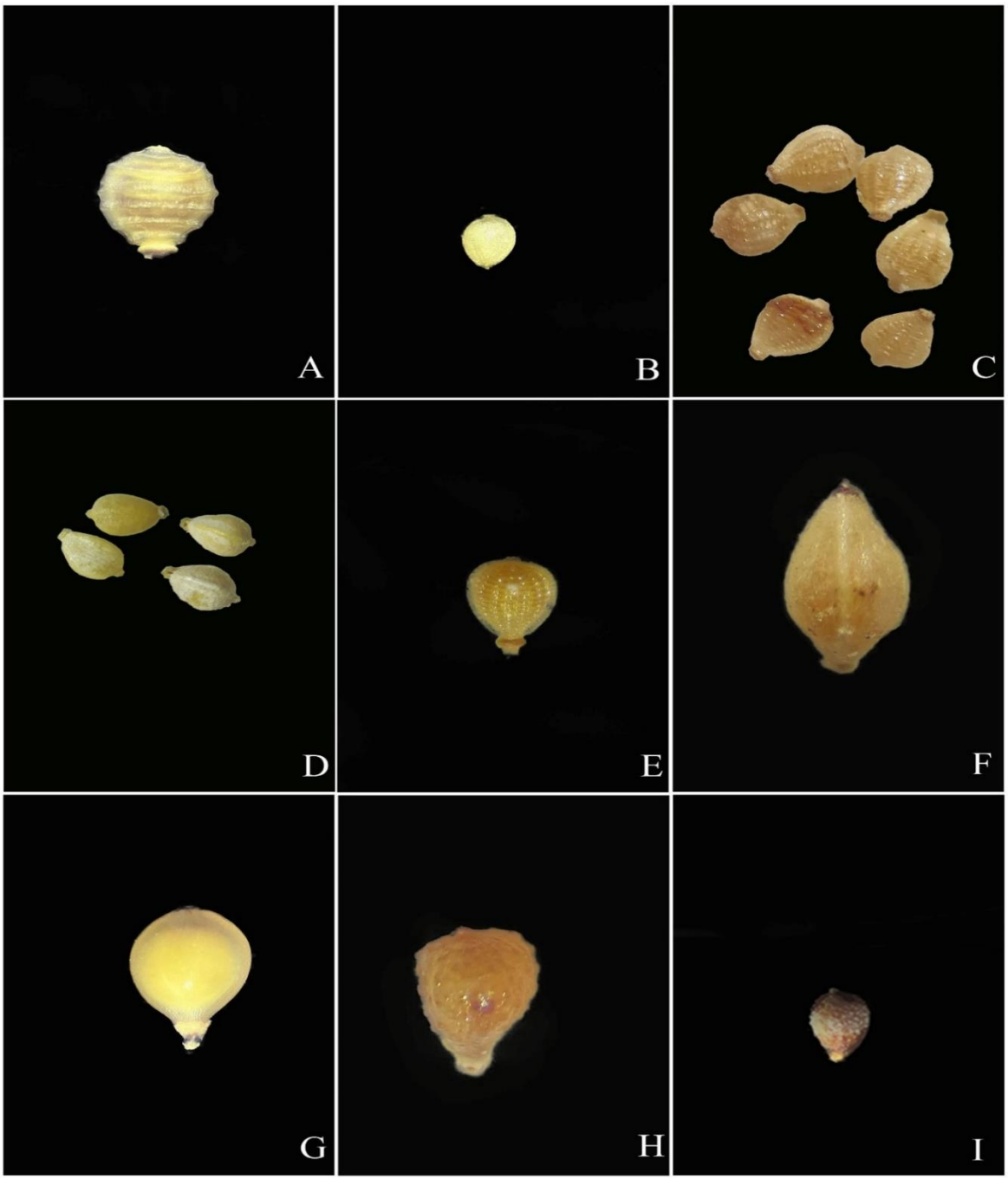
Photoplate No. 9: Variation of Pistil in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I**. *F. fusca*



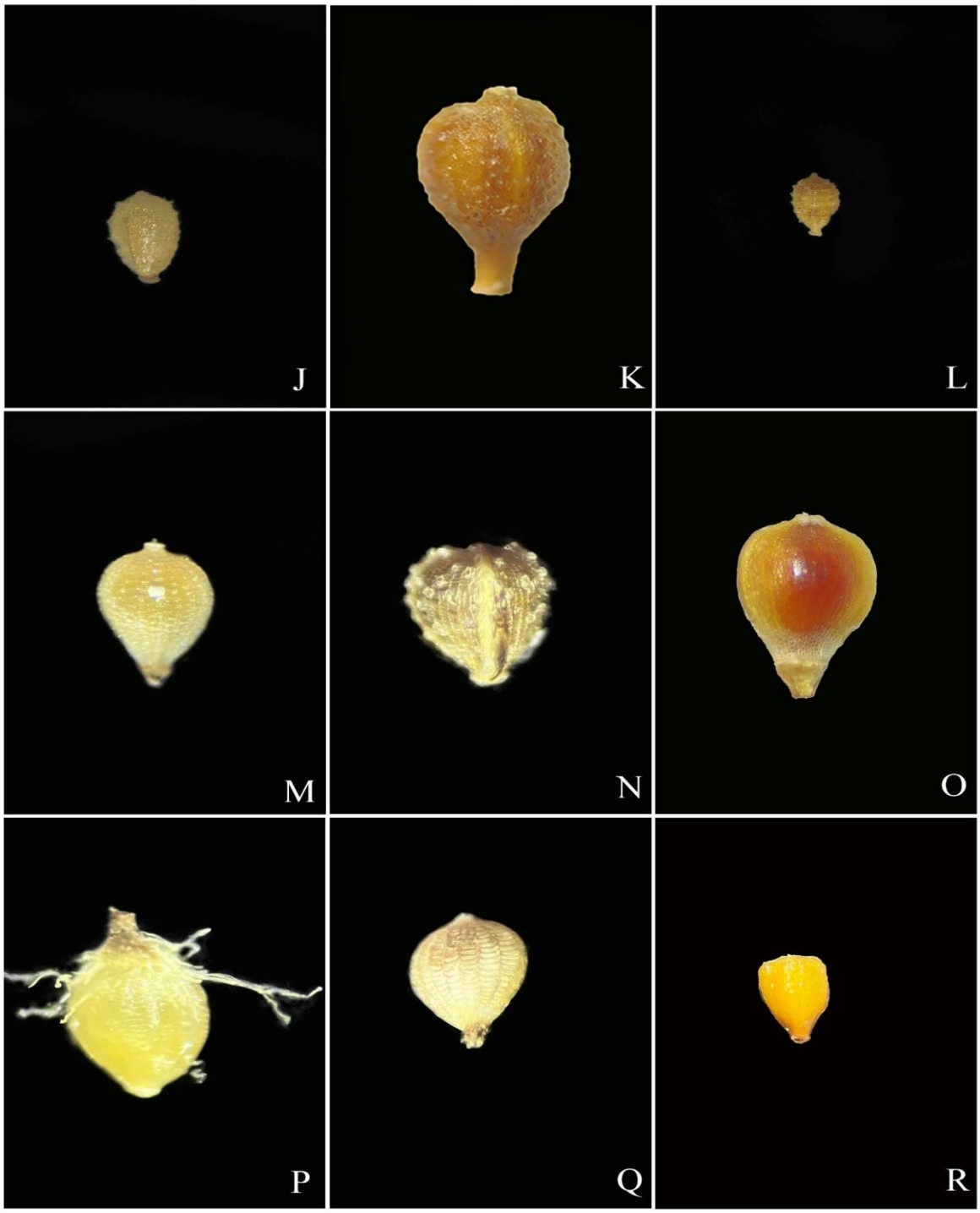
Photoplate No. 10: Variation of Pistil in *Fimbristylis*. **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

Nutlet/ Achene

The most studied nutlets characteristic for delimitation of species are shape, texture, colour and size. The Nut are sessile or subsessile, stipitate and sometimes non stipitate. The size of nutlet varies from 0.5-2.5mm. The majority of species have biconvex nutlet whereas the species with 3 stigmas which are *F. complanata, F. falcata, F. fimbristyloides, F. fusca, F. littoralis, F. ovata, F. littoralis, F. quinquangularis, F. salbundia* and *F. umbellaris* have trigonous nutlet. Reticulation is present in nutlets of most of the species while only *F. aestivalis, F. fuscinux, F. feruuginea, F. squarrosa* have smooth Nutlet. The color of the nutlets varies from pale white to different brown shades. And the majority of species have a very short stipe at the base of nutlet, but the stipe is indistinct in *F. aestivalis, F. falcata, F. fusca, F. littoralis, F. salbundia, F. squarrosa* and *F. nutans.* Out of 23 species *F. acuminata, F. aestivalis, F. bisumbellata, F. complanata, F. dichotoma, F. falcata, F. ferruginea, F. fuscinux, F. schoenoides, F. squarrosa* and *F. stolonifera* have non- verruculose nutlet while the rest species have verruculose nutlet. (Photoplate 11 & 12 and Appendix 9)



Photoplate No. 11: Variation of Nutlet in *Fimbristylis*. **A**. *F. acuminata*, **B**. *F. aestivalis* **C**. *F. bisumbellata*, **D**. *F. complanata*, **E**. *F. dichotoma*, **F**. *F. falcata*, **G**. *F. ferruginea*, **H**. *F. fimbristyloides*, **I**. *F. fusca*



Photoplate No. 12: Variation of Nutlet in *Fimbristylis*. **J**. *F. littoralis*, **K**. *F. ovata* **L**. *F. quinquangularis*, **M**. *F. rigidula*, **N**. *F. salbundia*, **O**. *F. schoenoides*, **P**. *F.squarrosa*, **Q**. *F. stolonifera*, **R**. *F. thomsonii*

4.2 Taxonomic Treatment

The detailed taxonomic treatment of the genus and the species was prepared with necessary illustrations, descriptions, phoytographs and keys. The primary source of information has been derived from field and the herbarium of the species of the genera *Fimbristylis* Vahl. and Secondary sources of information (different flora and Digital images) were used for the species whose herbarium were not available.

Cyperaceae

Annuals or perennials; rhizomatous or stoloniferous, sometimes tuberiferous or with bulbils. Culms simple, often 3-angled. Leaves alternate, in 3 ranks, mostly basal and sub basal, with blade and leaf sheath, sometimes blade absent, ligule present or absent. Leaf blades are usually linear, glabrous but apex and margin barbed. Involucral bracts 1 to many, leaflike or glume like. Infloresence a spike, multiple spike or large compound, type umbellate, paniculate, spicate, corymb etc, crateriform anthelodium. Flower bisexual or unisexual, sometimes dioecious; with or without bristle like perianth. Glumes spirally or distichously arranged. Stamens 1-3, rarely more and stigmas 2-3. Fruit nut-like.

Key to the Genus

1a. Culms solid ……..…….2

1b. culms hollow……3

2a. style base not persistent on nutlet…..…….….. **Fimbristylis**

2b. style base persistent on nutlet……..…3

3a. Leaf sheath apex with long white hairs; style base mostly enlarged and persistent; style glabrous ……**Bulbostylis**

3b. Leaf sheath apex without long white hairs, style base enlarged and mostly deciduous; style ciliated, hispidulous, rarely glabrous……..… **Abildgaardia**

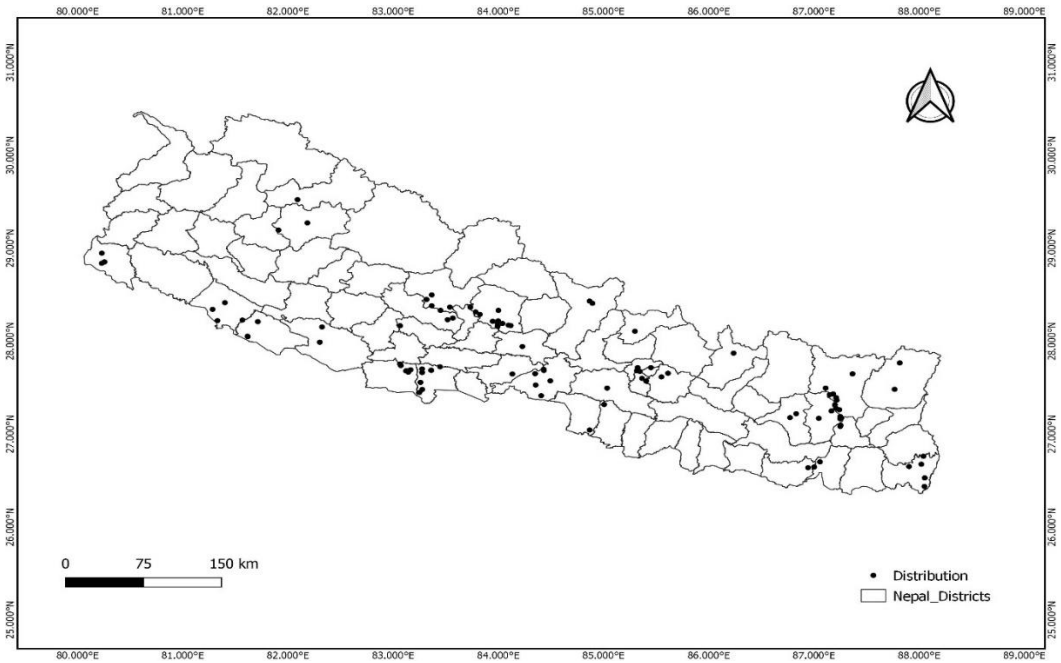
Genus *Fimbristylis* Vahl.

Herbs, annual or perennials, rhizomatous or stoloniferous. Culms 3- 5 angled, irregular angled or compressed, slender or erect, solitary or tufted, glaborous or pubescent. Leaves basal / sub-basal, sometimes reduced to a bladeless sheath. Ligule if present compact fringe of hairs. Leaf blades are linear or filiform, rarely ensiform, flat, sometimes absent or reduced to a bladeless sheath. Involucral bracts 1 to few leaf like or glume like, shorter to longer than inflorescence.

Inflorescence terminal, simple, compound or decompound anthela. Spikelets solitary or compressed, terete or flattened, ovoid, ellipsoid, lanceolate, globose to sub globose, few to many flowered. Glumes spirally arranged or distichously arranged, glabrous or pubescent, smooth, single veined to many veined, keeled or not keeled, mucronate or not. Stamens 1- 3 in numbers. Style not persistent on nutlet, often flattened basally, ciliated or glabrous. Stigmas 2 or 3, ciliated or not ciliated. Nutlet biconvex or trigonous, sometimes stipitate, reticulate, smooth or verruculose.

Distribution oF *Fimbristylis* in Nepal

The genus *Fimbristylis* is distributed in Tropical and sub-tropical regions of the world, with some extending into warmer parts of temperate regions. Based on the personal collections and herbariums deposited on KATH and TUCH the distribution pattern of *Fimbristylis* species was studied. *Fimbristylis* species are distributed from western Nepal to Eastern Nepal and Central Nepal, but some species are restricted to only one regions. *F. complanata, F. ovata, F.dichotoma* and *F. littoralis* are the widely distributed species of *Fimbristylis*, because they were recorded from Central, Western and Eastern Nepal. They also have a wide range of distribution from tropical to sub alpine region (70m-3200m).



Map 1: Distribution map of all species of *Fimbristylis* found in Nepal.

Key to the species

1a. Style 3-fid……..……..……..……2

1b. Style 2-fid ……..……..……...……...……12

2a. Glumes distichously arranged ……..……..…….3

2b. Glumes spirally arranged …..…….…….5

3a. Inflorescence a single terminal spikelet. Involucral bract glume like…**F. ovata**

3b. Inflorescence of 4-8 spikelets. Involucral bracts leaf like…….….4

4a. Rhizome absent. Leaf blades slightly curved……..…….**F. fimbristyloides**

4b. Rhizome present. Leaf blades linear……..……..**F. fusca**

5a. Leaf-sheath ligulate, with a fringe of short hairs……6

5b. Leaf-sheath eligulate……..7

6a. Spikelet less than 2mm wide. Nut smooth……..**F. complanata**

6b. Spikelet more than 2 mm wide. Nut verruculose…….…….**F. thomsonii**

7a. Spikelets in tight cluster……...……...……. **F. falcata**

7b. Spikelets solitary……...……..…….8

8a. Culms 3-angled……...…….9

8b. Culms 4 or 5 angled……..…….10

9a. Plant stoloniferous. Leaf blades present…….……..……**F. pierotii**

9b. Plant not stoloniferous. Leaf blades on vegetative shoot only……...**F. umbellaris**

10a. Culms 4- angled. Spikelets globose…...……**F. littoralis**

10b. Culms 5- angled. Spikelet ovoid- ellipsoid…….…11

11a. Leaves with blades. …….……..…..……**F. quinquangularis**

11b. leaves reduced to a bladeless sheath……**F. salbundia**

12a. Spikelets only 1-3 in numbers……..13

12b. Spikelets more than 3 in numbers …… ……..….15

13a. Leaf blades present, Nutlet smooth……..…….....……**F. schoenoides**

13b. Leaves reduced to a bladeless sheath. Nutlet reticulated……..…14

14a. Involucral bracts glume like. Spikelet slightly nodding……..…….**F. nutans**

14b. Involucral bracts absent. Spikelet erect……..……**F. acuminata**

15a. Leaves eligulate……16

15b. Leaves ligulate…….20

16a. Plant annuals. Rhizome absent…….…..…….17

16b. Plant perennials. Rhizome present…….……..18

17a. Leaf sheath open. Style with long pendant white hairs covering the nutlet……...……..……..**F. squarrosa**

17b. Leaf sheath close. Style sparsely ciliated only at upper half…..... **F. aestivalis**

18a. Rhizome long, creeping. Culms usually solitary…….……**F. rigidula**

18b. Rhizome short, not creeping. Culms densely tufted……19

19a. Leaf blades flat, apex subobtuse, spikelets solitary, narrowly ovoid…….....**F. fuscinux**

19b. Leaf blades or canaliculate, spikelets solitary or clustered, globose…….…..**F. cymosa** var. **spathacea**

20a. Stolons present……..……..……..**F. stolonifera**

20b. Stolons absent……..……21

21a. Glumes densely pubescent apically. Nut smooth…..……**F. ferruginea**

21b. Glumes glabrous. Nut with reticulation……..…….22

22a. Spikelet 1-1.5mm wide. Glumes keeled……**F. bisumbellata**

22b. Spikelet 2-4mm wide. Glumes not keeled……..……...**F. dichotoma**

Description of the species

1. **Fimbristylis acuminata** Vahl. Enum. Pl. 2: 285. 1805

   Type specimen: India, konig s.n. (Holotye: C)

   Annual herbs, fibrous root present, roots yellowish ;1-4cm long. Culms erect, 10-25cm long, compressed, sparsely tufted, glabrous. Leaves reduced to a tubular bladeless sheath. Leaf blade absent. Leaf sheath pale yellow with rusty colored specks, with truncate apex, closed, 1-4cm long, glabrous. Involucral bract absent. Inflorescence a single terminal spikelet. Spikelet solitary, lanceolate, 5-10 × 2-3mm, whitish green in color, slightly nodding. Glume, ovate- elliptic, spirally arranged, pale green, papery in texture with few brown colored specks, 3-4 × 1.5-2.5mm, with 10-12veins forming an abaxial keel, apex obtuse slightly mucronate; with ca. 0.3mm mucro. Stamens 2. Style 2- 2.5mm long, basally flattened, ciliate apically. Stigmas 2, 1-1.5mm long, ciliate. Nutlet obovoid, biconvex, 1.5-2 mm with 5-7 transverse wavy reticulation, very short stipe ca. 0.2mm also present, non- verruculose. (Figure 2 and Photoplate 13).

   Distributional Range: Nepal (C&E) (Map 2), E Himalaya, S Asia, E Asia, SE Asia and Australasia.

   Elevation: 70- 700 m

   Ecology: grows in flood plains, riverbanks and semi dry paddy fields.

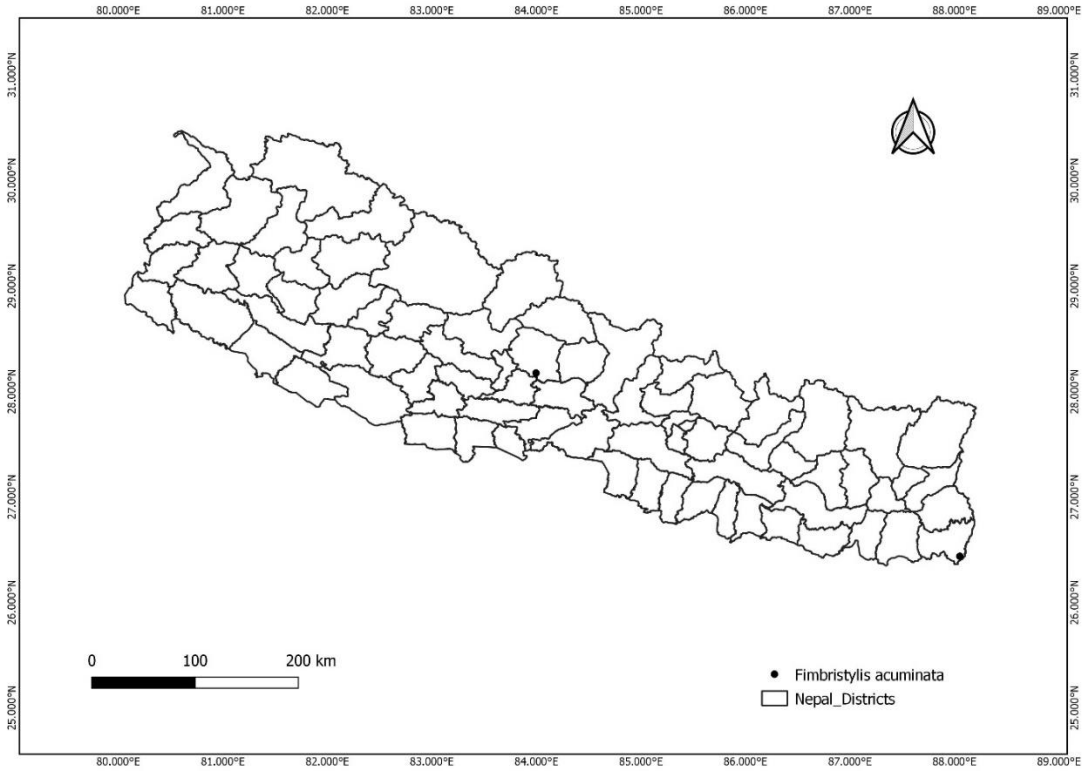
   Flowering and fruiting: July- December

   Voucher specimen: Province No.1, Jhapa District, Bhadrapur Municipality, Jalthal, 12 Sept.2021, Y.B. Poudel and K. Panthi JF947(TUCH).

   Specimen examined:

   Central Nepal: Gandaki province, Kaski District, Sitapaila, Pokhara, 11th Oct 2020, P. Bhandari & A. Bhandari (KATH, TUCH)

   East Nepal: Province No1, Jhapa District, kachankawal RM, Baniyani, 4th Dec 2020, S. Chaudhary (KATH).



Map 2. Distribution of *Fimbristylis acuminata* in Nepal Based on herbarium records.

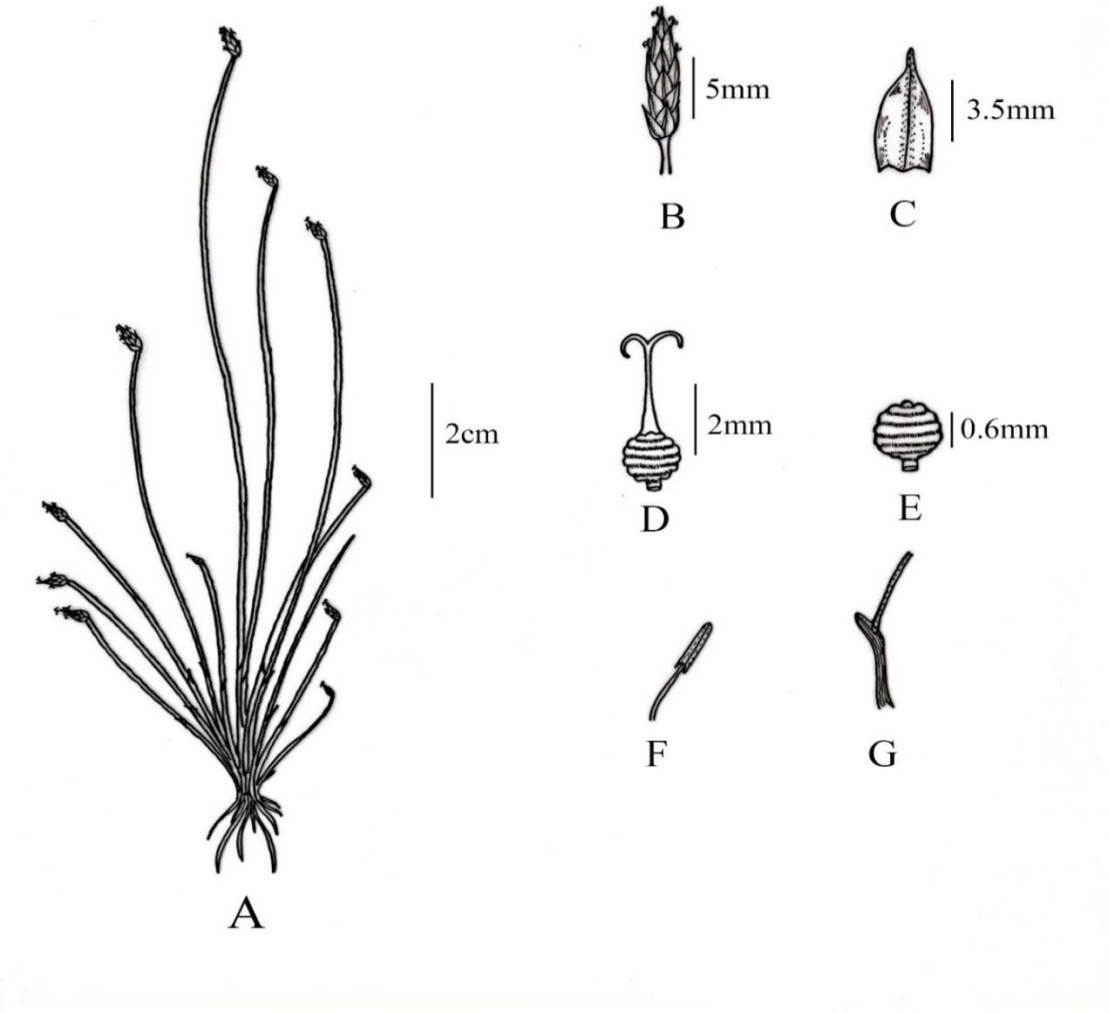


Figure 2: *Fimbristylis acuminata*. **A**. Habit sketch, **B**. Spikelet **C**. Glume, **D**. Fruiting pistil, **E**. Nutlet and **F**. Stamen G. Leafsheath. (Based on Y.B. Poudel and K. Panthi JF947(TUCH)).

2. **Fimbristylis aestivalis** (Retz.) Vahl, Enum. Pl. 2: 288 (1805). Koyama in Hara et al., Enum Flow. Pl. Nepal 1: 110 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 94 (2010).

   Scirpus aestivalis Retz., Obs. Bot. 4: 12 (1786)

   Type Specimen: Sri Lanka, konig s.n. (Lectotype:L)

   Annual herbs, fibrous root present, roots 10-14cm long, light brown in color. Culms erect, slender 6-15cm, densely tufted, 3-angled, smooth, glabrous with few leaves at the base. Leaves shorter to longer than the culm. Leaves eligulate; leaf sheath yellowish brown in color, closed, 5-15mm long, densely pubescent with white color hairs. Leaf blades filiform 3- 20cm × 0.5-1mm, apex acute with very few scattered hairs on margin, both surfaces sparsely hairy, covered with brown colored specks. Involucral bracts 3-5, leaf-like, 0.5-3cm long, shorter to longer than inflorescense, acute apex, both surfaces sparsely hairy. Inflorescense a compound anthela, 0.5-2.5cm × 0.5-3cm, rays 3-5 in numbers, 5-15mm long, with many spikelets. Spikelets solitary, oblong- ovoid, 1.5-3.5 × 1-1.5mm. Glumes reddish brown, spirally arranged narrowly ovate, 1-1.5mm × 0.5-1mm, 3-veined, keeled, mucronate; ca. 0.2-0.3mm mucro, densely pubescent. Stamen 1. Style ca. 0.5mm, ciliate apically, flattened basally. Stigmas 2, ca. 0.5mm in size and densely ciliated. Nutlet whitish yellow, obovoid, biconvex, c.a. 0.5mm, smooth, non- stipitate. (Figure 3 and Photoplate 14).

   Distribution range: Nepal (C & E) (Map3), E Himalaya, Assam-Burma, S Asia, E Asia, SE Asia, N Asia, Australasia.

   Elevation: 85- 1600m

   Ecology: Riverbanks

   Local Name: Masino Jwano Jhar

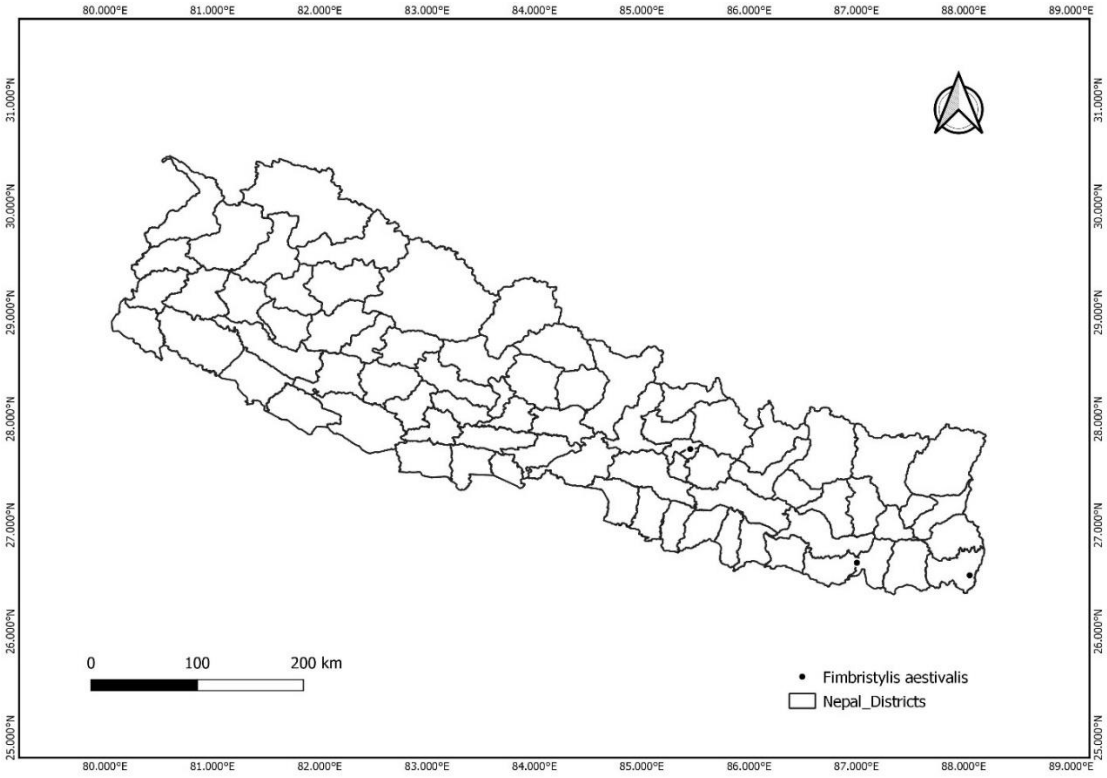
   Flowering and fruiting: March- August

   Voucher specimen: Province No. 1, Jhapa District, Range Danda, Haldibari, 84m, 31st Aug 2021, Y.B. Poudel and K. Panthi JKY1(TUCH).

   Specimen examined:

   Central Nepal: Bagmati Province, Sankhu, Kathmandu, 1530m, 14th March 1975, D.P. Joshi and K.R. Rajbhandari 75/597 (KATH).

   East Nepal: Province No. 1, Koshi-tappu, Sunsari, 65m, May 3rd 2005, K.R. Bhattarai and N. Acharya (KATH).



Map 3: Distribution of *Fimbristylis aestivalis* in Nepal Based on herbarium records.

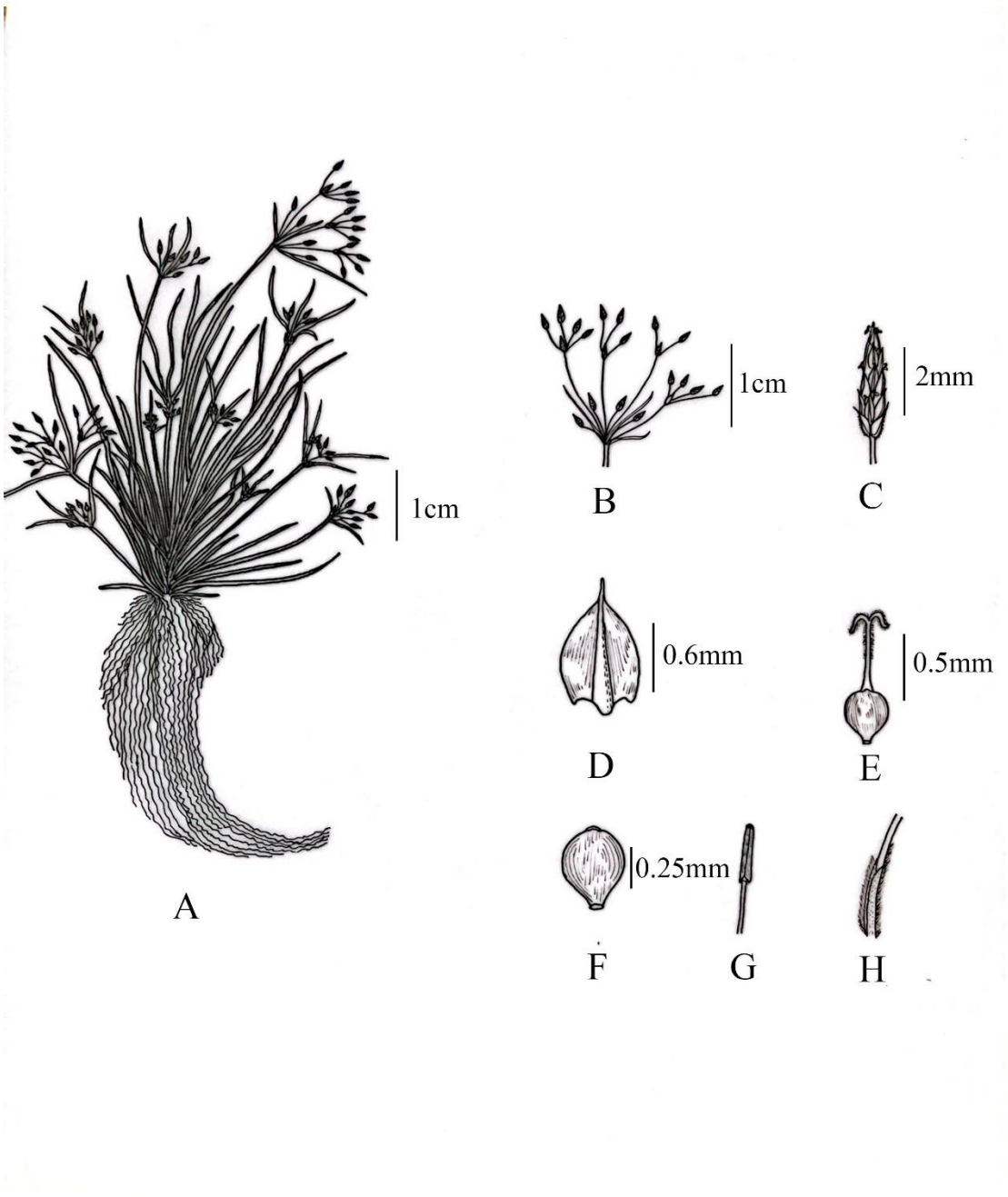


Figure 3. *Fimbristylis aestivalis*. **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. Stamens H. Leafsheath. (Based on Y.B. Poudel and K. Panthi JKY1(TUCH)).

3. **Fimbristylis bisumbellata** (Forssk.) Bubani, Dodecanthea, 30 (1850). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111(1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 94 (2010).

   Scirpus bisumbellatus Forssk., Fl. Aegypt. -Arab. 15 (1775)

   Type specimen:

   Annual herbs, fibrous root present, roots 4-8cm long, yellowish brown in color. Culms erect, densely tufted, 10 to 20cm, smooth, 3-angled, glabrous, with few leaves at base. Leaves shorter than the culm. Leaves ligulate; Leaf sheath pale brown in color, open, 1-2cm long, papery with rust-colored specks, pubescent. Leaf blades linear, 30-70mm × 0.5-1.5mm wide, apex obtuse, margin apically serrate, glabrous, sometimes sparsely hairy. Involucral bracts 2-3 in numbers, leaf-like, 1-3cm long, shorter, or equal to the inflorescence, apex obtuse, margin ciliate. Inflorescence a compound or decompound anthela, 2- 4cm × 3- 4cm with many spikelets, rays 4-6 in numbers; rays 1-2cm long. Spikelets solitary, oblong-ovoid, 2-4mm × 1-1.5mm, apex acute. Glume pale yellow or white in color, spirally arranged, broadly ovate,1.5-2mm × 0.5-1mm, apex attenuate, membranous, 3-veined forming an abaxial keel, papery texture, glabrous. Stamen 2. Style ca.1mm, ciliated, basally flattened. Stigmas 2, ca. 0.5mm long, ciliated. Nutlet yellowish white, biconvex, shiny, ca. 0.5mm, transverse oblong reticulation, non- verruculose, very short stipe present. (Figure 4 and Photoplate 15)

   Distributinal Range: Nepal (C&E) (Map 4), Assam- Burma, S Asia, E Asia, SE Asia, N Asia, SW Asia, Europe, Africa and Australasia.

   Elevation: 100-1100m

   Ecology: Roadside and Open grasslands

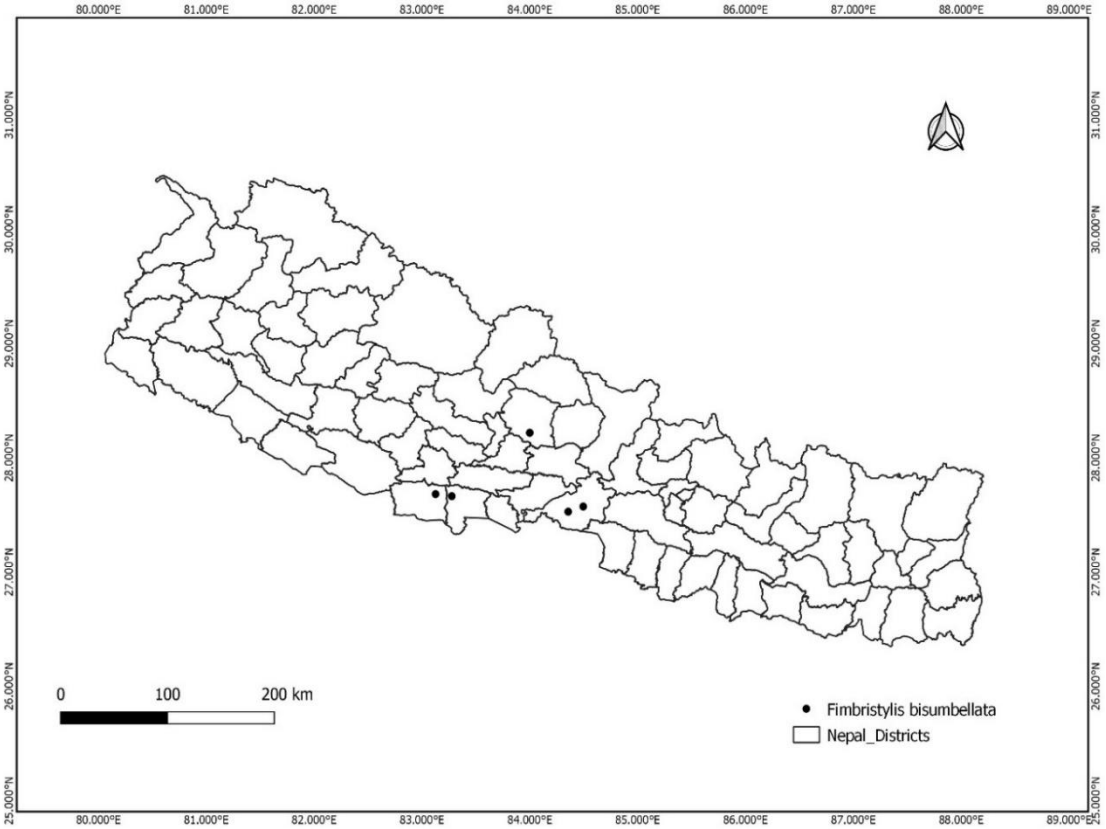
   Flowering and fruiting: March- November

   Voucher specimen: Bagmati province, Chitwan District, Rapti riverbank, 150m, 23 Aug 2021, S. Aryal and Y.B. Poudel CH7 (TUCH); Lumbini Province, Kapilbastu District, koili Bangai, 118m, 15 sept 2020, S. Aryal, Y.B Poudel and P. Poudel LD12 (TUCH); Lumbini Province, Rupandehi District, Ramapur, 106m, 23 July 2021, S. Aryal, Y.B. Poudel and K. Panthi KY5 (TUCH).

   Specimen examined:

   Eastern Nepal: Province No.1, Sankhuwasabha District, Sitalpati, 3500ft., 29 March 1952, O. Polunin, W.R. Sykes & H.J. Willams 660 (KATH).

Central Nepal: Gandaki Province, Kaski District, Ranipauwa, 9 July 1986, N.P. Manandhar 11376 (KATH); Bagmati province, Chitawan District, Narayani, 150m, 21 November 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha, M. Shiwakoti DNEP2 B37 (KATH).



Map 4: Distribution of *Fimbristylis bisumbellata* in Nepal Based on herbarium records.

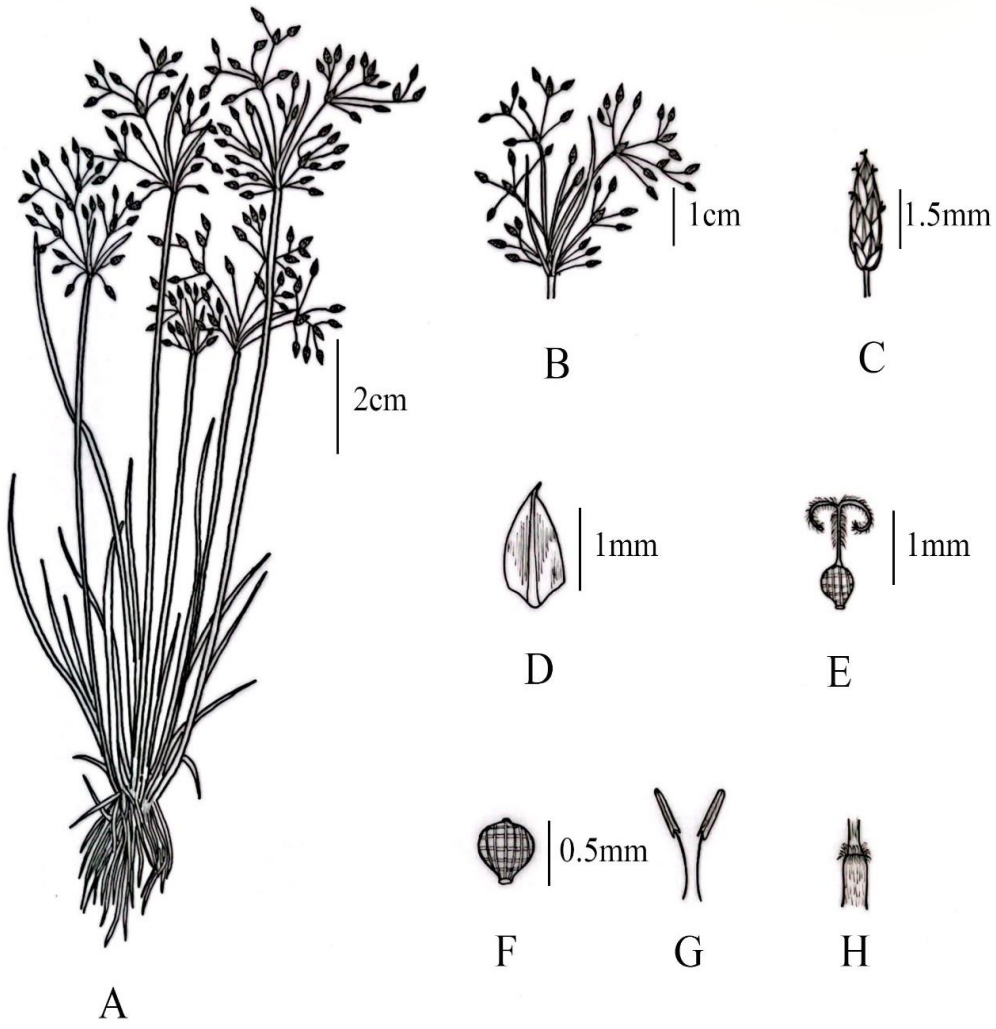


Figure 4: *Fimbristylis bisumbellata*. **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. Stamens H. Leafsheath. (Based on S. Aryal and Y.B. Poudel CH7 (TUCH)).

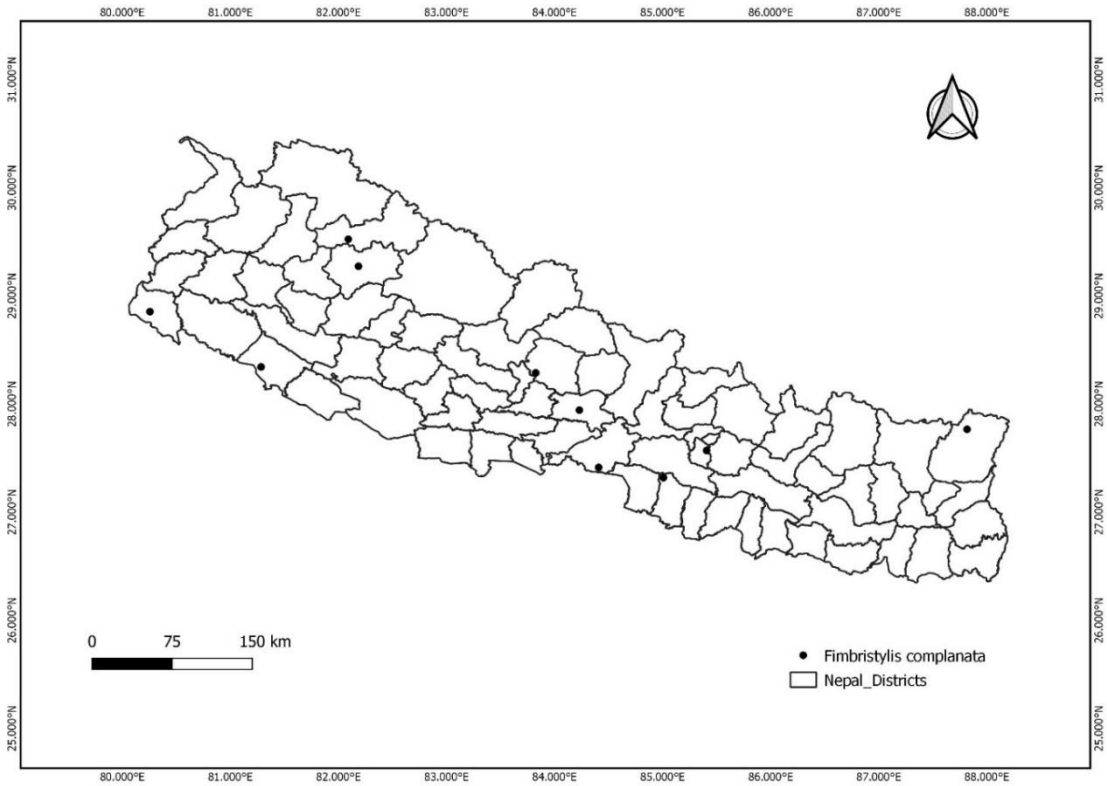
4. **Fimbristylis complanata** (Retz.) Link, Hort. Berol. 1: 292 (1827). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1:95 (2010).
Scirpus complanatus Retz., Obs. Bot. 5: 14(1788)

Perennial herbs, rhizome present; very short ca. 1cm, pale yellow in color. Culms erect, 35 to 60cm in height, densely tufted, 3 angled, with many leaves at base. Leaves shorter usually half the length of culm. Leaves ligulate; Leaf sheath yellowish white in color, closed, 2-4cm long, bilaterally compressed, mouth obliquely split, glabrous, abaxially membranous. Leaf blade flat, 4-15cm × 2-4mm, apex acute, margin finely serrate, rough in texture, covered with papillae. Involucral bracts 2-3in number, leaf-like, 1-3cm × 1-2mm, shorter than inflorescence, acute apex, margin serrate, bractlets present. Inflorescence a compound anthela with many spikelets, 3-6 × 2-5cm, rays 3-5in numbers, 1.5-4cm long. Spikelets solitary, oblong, 6-8mm × 1.5-2mm. Glumes dark brown in color, spirally arranged, ovoid, 2.5- 3mm × 1- 1.2mm , with single vein excurrent into a mucro, keeled, apex acute- apiculate, glabrous. Stamen 3. Style 1-1.5mm, not ciliated, flattened basally. Stigmas 3, 1.5- 2mm long, densely ciliated. Nutlet whitish, shiny, obovoid, trigonous, ca. 1.5mm, with transverse oblong reticulation, non- verruculose, very short stipe. (Figure 5 and Photoplate 16).

Distribution: Nepal (W, C& E), E Himalaya, Tibetean Plateau, S Asia, E Asia, SE Asia, SW Asia, N America, S America and Australasia.
Elevation: 100- 3200m
Ecology: Grassland and Marshy areas
Flowering and fruiting: August- November
Voucher specimen: Gandaki province, Tanahu district, Damauli, 850m, 15 Aug 2020, Y.B. Poudel T1(TUCH).
Specimen examined:
Eastern Nepal: Madhesh province, Bara District, North of Tinnambarpur, 470m, 11 Oct 1995, M. Mikage, T. Kajita and K. Yonekura 9552867(KATH); Province No.1, Tamur Valley, Wallungchung Gola, 8500ft, 20 July 1956, J.D.A. Stainton 1072(KATH).

Central Nepal: Gandaki province, Kaski District, Vicinity of Tamage, 1510m, 11 Aug 1999, M.Mikage, M. Yoshimitsu, A. Kaneda, C. Mouri, S. Tatsukawa, Y. Asada and M. Senoo 9964089 (KATH); Gandaki province, Myagdi District, Beni 840m, Singa 910m, Tatopani 920m, Bholamza 950m, Shimarchaur 950m, Babichor 960m, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9682134 (KATH); Gandaki province, Lamjung, Near Jagat, 8500ft. 5 July1954, Stainton, Skyes and Williams 3371(KATH); Bagmati Province, Phulchoki, 2400m, 19 Sept 1970, H. Kanai and C. Chuma 672889(KATH).

Western Nepal: Karnali province, Birendranagar, Bandar Bhariya, 600 ft., 20 November 1975, L.R. Sharma and Party 823 (KATH); Karnali province, Rara, 2900m, 10 Aug 1981, N.P. Manandhar and D.P. Joshi 8037 (KATH); Karnali Province, Jumla, 2800m, 10 Sept 1973, Eirarnon, Skirlog and Wetterhan 3904 (KATH); Sudurpaschim Province, Kanchanpur, Suklaphanta Wildlife Reserve, 600ft, 25 Aug 1975, D. Schaaf 28 (KATH).



Map 5: Distribution of *Fimbristylis complanata* in Nepal Based on herbarium record.

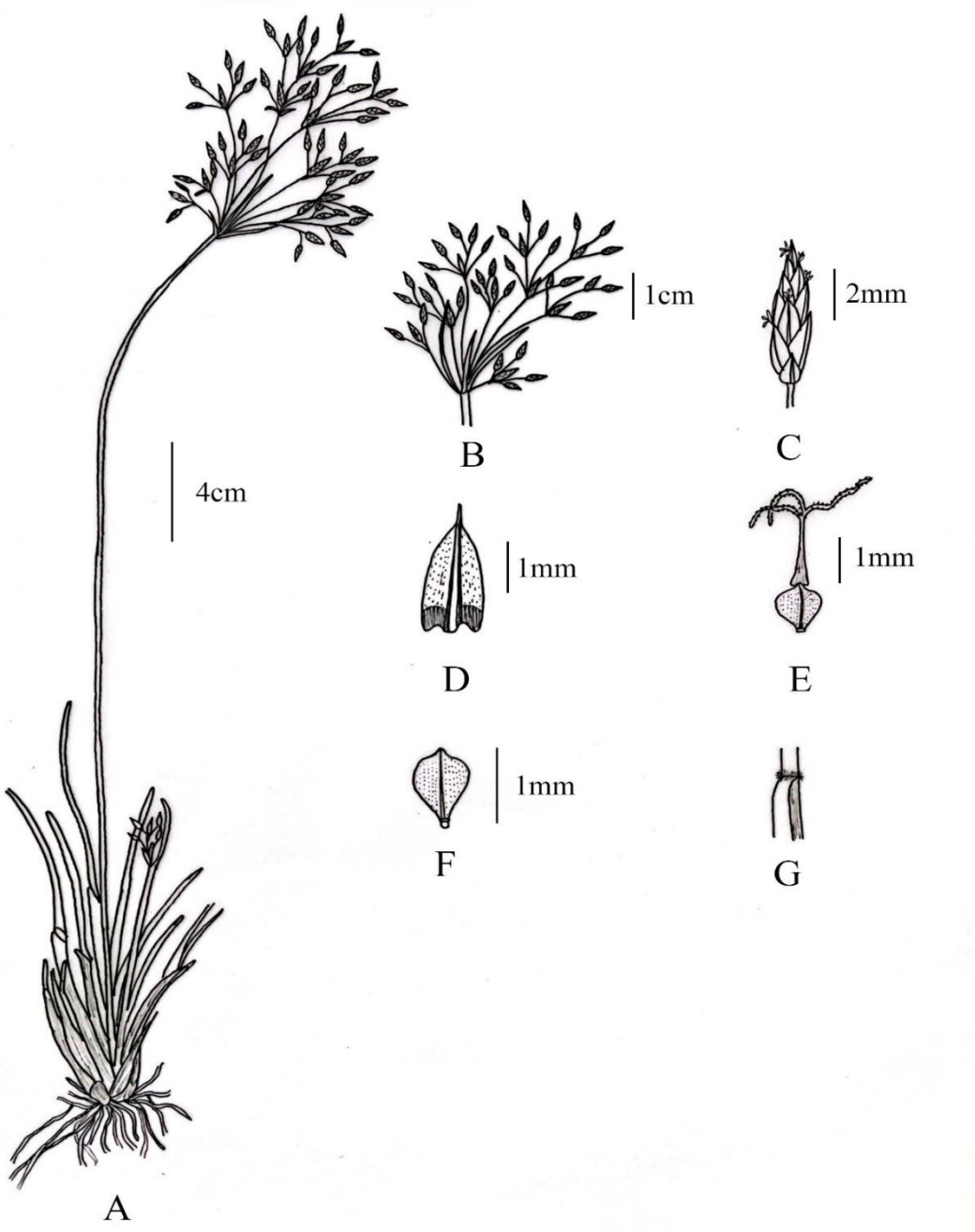


Figure 5: *Fimbristylis complanata*. **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. Leafsheath. (Based on Y.B. Poudel T1(TUCH)).

5. **Fimbristylis cymosa** var. **spathacea** (Roth) T. Koyama, J. Jap. Bot. 46(3): 66 (1971)

Fimbristylis spathacea Roth, Nov. Pl. Sp.: 24 (1821)

Fimbristylis wightiana Nees in Wight, Contr. Bot. India: 99 (1834)

Type specimen: Australia, Brown s.n. (Holotype:BM)

Perennial herbs, rhizome short. Culms erect, tufted, 10-60cm tall, tufted, 3-angled, not thick at the base. Leaves less than half length of culms. Leaves eligulate; leaf sheath pale brown in color, shiny, open, 1-2.5cm long. Leaf blade rigid, flat, 1-3mm wide, apex acute, margin serrated. Involucral bracts 1-3 in numbers, leaf-like, shorter than inflorescence. Inflorescence simple or compound anthela with several rays. Spikelets solitary or sometimes clustered (2-3 spikelets), ovoid, 3-5 ×1.5-2.mm, densely many flowered, apex obtuse. Glumes brown, ovate to broadly ovate, spirally arranged, 1.2-2mm, memebranous, abaxially 3-veined, margin broadly hyaline, apex obtuse. Stamens 2 or 3. Style1-1.2mm, not ciliated, basally slightly flattened. Stigmas 2 or 3, ciliated. Nutlet dark brown- black in color, obovoid, biconvex, rarely 3-sided, ca. 1mm, slightly verruculose, faint square or transversely oblong reticulation but sub-smooth sometimes. (Figure 6).

Distribution range: Africa, Nepal (WC) (Map 6), S Asia, E Asia, SE Asia.

Altitude: 300- 800m

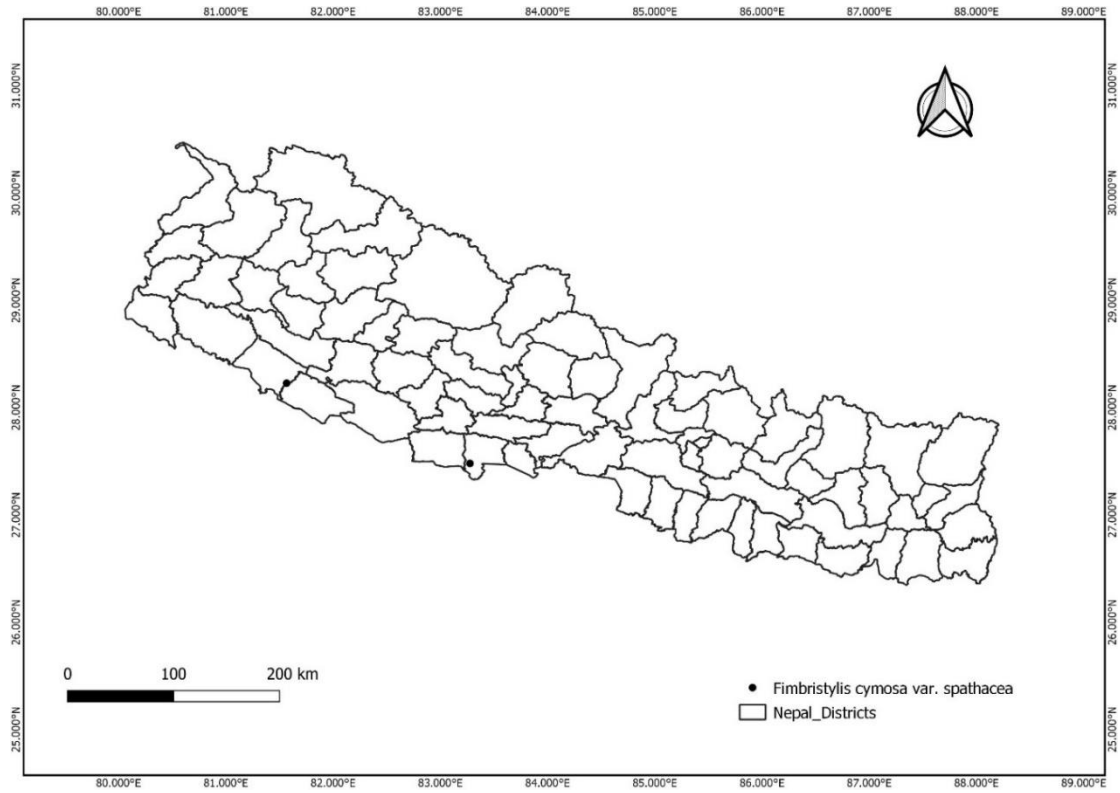
Ecology: Moist Place

Flowering and fruiting: June- October

Specimen examined:

Western Nepal: Karnali Province, Lakhana, 600ft, Shrawn 10 2039, U.R. Poudyal, 4201(KATH)

Central Nepal: Lumbini province, Lumbini, 26 June 1973, N.P. Manandhar and party, 2901(KATH)



Map 6: Distribution of *Fimbristylis cymosa var. spathacea* in Nepal Based on herbarium records.

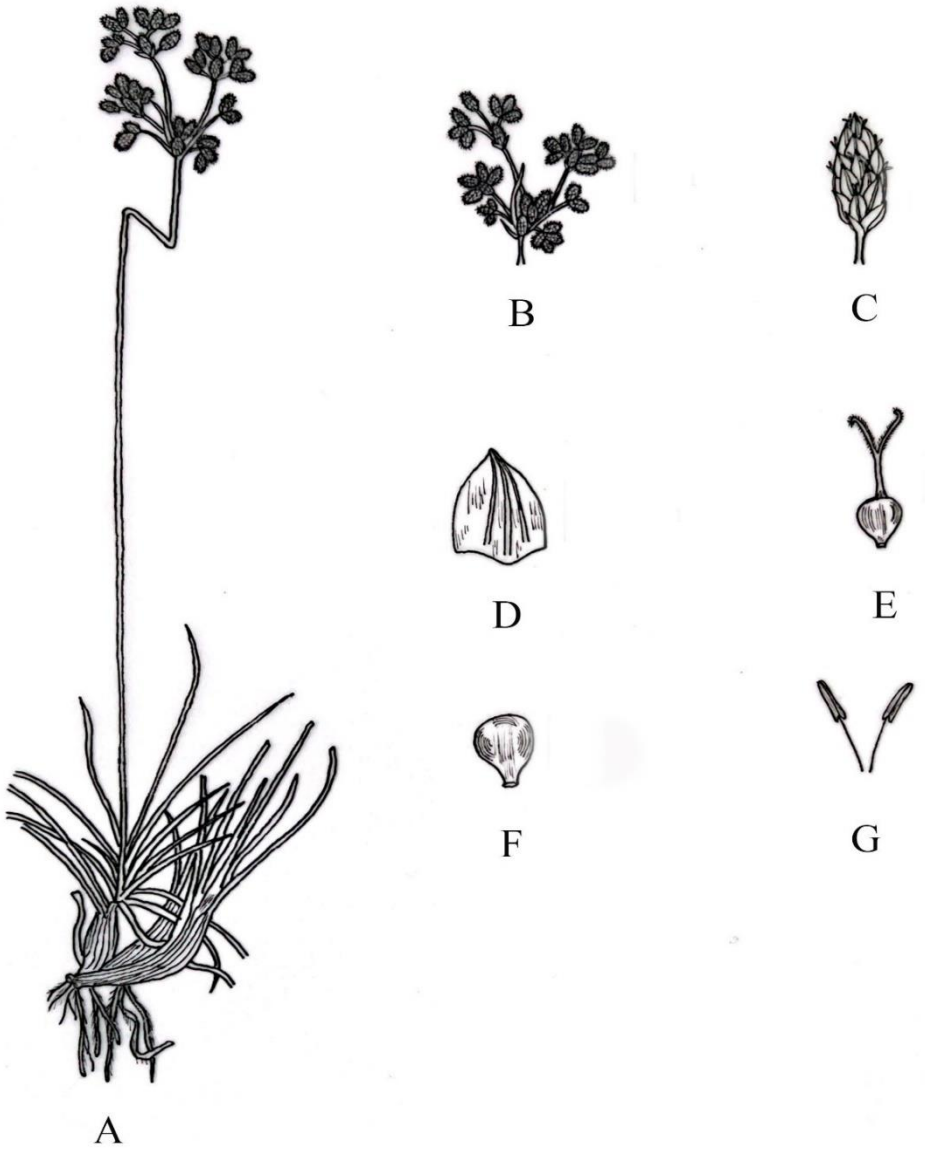


Figure 6: *Fimbristylis cymosa var. spathacea* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens. (Based on Flora of China).

6. **Fimbristylis dichotoma** (L.) Vahl. Enum. Pl. 2: 287 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1:95 (2010).

   Scirpus dichotomus L., Sp. Pl. 1. 50 (1753).

   Fimbristylis diphylla (Retz.) Vahl, Enum. Pl. 2: 289 (1806).

   Scirpus diphyllus Retz., Observ. Bot. 5: 15 (1788).

   Type specimen: Herb. Hermann 2: 63 (Lectotype: BM)

   Annual or short-lived perennial herbs, rhizome short. Culms tufted, erect, 5 to 100cm, compressed, grooved, glabrous. Leaves shorter or sometimes longer than culms. Leaves ligulate. Leaf sheath dark brown shiny, margin hyaline, surface glabrous, opened, 1- 4cm long. Leaf blade linear, flat, 0.5-2.5 mm wide, apex acute, margin minutely serrate, surface glabrous. Involucral bracts leaf-like, 3-4 in numbers, shorter to longer than inflorescence, 1-4 cm long, apex acute, margin serrate, surface glabrous. Inflorescence a simple or compound anthela, 2- 10 × 3-7 cm, with 3-4 rays; rays 1-4cm long. Spikelets soliary, ovoid- ellipsoid, 6-14 × 2-3mm, many flowered. Glume reddish brown in upper part and pale brown in lower part, ovate, 2- 4.2mm, shiny, 3- veined, midvein excurrent into a mucro; mucron ca. 0.1 mm, not keeled, margin hyaline, surface glabrous; lower glumes often empty. Stamen 1. Style 2mm long, apically densely ciliated and basally sparsely ciliated, flattened basally. Stigmas 2, shorter than style ca. 1mm long, ciliated. Nutlet obovoid or globose, biconvex, creamy -yellowish shiny, 1-1.3mm with very short basal brown colored stipe, with 8-24 vertical reticulation, margin thickened, non- verruculose. (Figure 7 and Photoplate 17).

   Keys to subspecies

   Spikelets 4.5-8.5mm. 5-11 vertical rows on Nutlet…….....**F. subsp. dichotoma**

   Spikelets 8-14mm. 15-24 vertical rows on Nutlet……..**F. Subsp. podocarpa**

   Fimbristylis dichotoma subsp. **dichotoma**

   Culms 5- 60cm. Leaves shorter to sometimes longer than culms. Leaf blade linear, 1-2.5mm wide. Inflorescence a compound or simple anthela. Spikelets 4.5- 8.5mm. Glumes 2-2.5 mm. Nutlet obovoid, 0.6- 1.2mm, with 5-11 vertical rows of transversely oblong cells, non-verruculose.

Distribution: Nepal (W, C & E), Asia, Africa, N America, S America and Australasia.

Elevation: 100-3000m

Ecology: Roadsides and cultivated paddy fields.

Local Name: Paani Mothe

Flowering and fruiting: May- Nov

Voucher specimen: Lumbini Province, Kapilbastu District, koili Bangai, 118m, 15 sept 2020, S. Aryal, Y.B Poudel and P. Poudel LD6 (TUCH); Lumbini Province, Rupandehi District, Ramapur, 106m, 23 July 2021, S. Aryal, Y.B. Poudel and K. Panthi KY5 (TUCH); Lumbini Province, Rupandehi District, Ranibagiya, 121m, 24 Aug 2020, S. Aryal MG5 (TUCH).

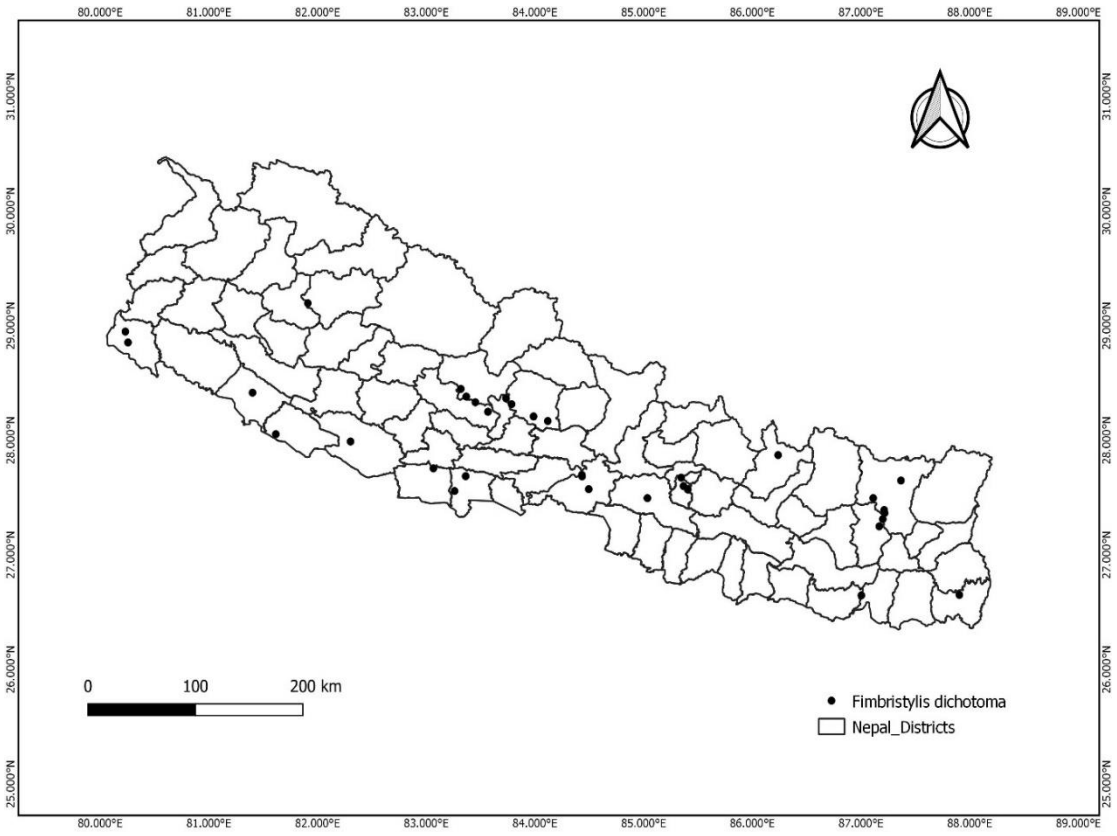
Specimen examined:

Central Nepal: Bagmati province, Makwanpur District, Bhainse- Managaon, 1000m, 23 June 1970, H. kanai and P.R. Shakya 671947(KATH); Gandaki Province, Kaski District, Birethanti(1100m)- Tikhedhunga(1600m)- Ulleri(2100m)- Banthanti(2200m), 25 July 1996, T. Hoshino, M. Amano, H. Koba, N. Miyoshi, K.R. Rajbhandari, M. Sato, P. Shrestha and S. Takatsuki 9668012(KATH); Bagmati Province, Dolakha District, Simigaon- Gyalcha Kharka, 2100m, 31 Aug 1983, K.R. Rajbhandari 9560(KATH); Gandaki Province, Myagdi District, Beni(840m)- Singa(910m)- Tatopani(920m)- Bholamza(950m)- Babichor(960m), 2 Sept 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9682318(KATH); Gandaki Province, Baglung and Myagdi District, Baglung(860m)- Ramechour(820m)- Beni(840m), 1 sep 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9682032(KATH); Gandaki Province, Myagdi District, Babichor- Dharapani, 960- 1550m, 3 Sept 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9685095(KATH); Gandaki Province, Myagdi District, Dharapani- Muri, 1550-1850m, 4 Sept 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9687105(KATH); Gandaki Province, kaski District, Pokhara, 920m, 9 July 1985, N.P. Manandhar 10416(KATH); Bagmati Province, Chitawan District, Narayanghat, 700ft, 4 Jan 1977, V.L. Gurung, B. Roy and M. Basukala 563/77A(KATH); Gandaki Province, Lamjung District, Ghalegaun, 720m, 17 May 1973, P.R. Shakya and T.K. Bajracharya 2104(KATH); Bagmati

Province, Kathmandu District, Near Koteshwor, 1311m, 17 Nov 1977, N.P. Manandhar 584(KATH); Bagmati Province, Lalitpur District, Gothe Hill, Phulchowki, 1828m,30 Aug 1967, R.K. Manandhar and Party 7367(KATH); Bagmati Province, Lalitpur district, Godawari, 1500m, 4 Mar 1982, K.R. Rajbhandari 198210(KATH).

Western Nepal: Sudur Paschim province, kanchanpur District, Suklaphanta Wild life Reservior, 600ft, 21 Aug 1974, D. Schaaf 20(KATH); Lumbini province, Nepalgunj, 2000ft, 15 July 1975, K.J. Malla 71(KATH); Karnali Province, Kalikot District, Nagma, 2000m, 13 Aug 1981, N.P. Manandhar and D.P. Joshi 8246(KATH); Lumbini province, Dang District, Phedi, 440m, 27 Aug 1982, N.P. Manandhar and N.K. Bhattarai 8458(KATH); Sudur Paschim province, Kanchanpur District, Betkot Tal, 496m, 9 June 2015, G.D. Bhatt and D.R. Kandel 4(KATH); Lumbini Province, Bardia District, Royal Bardia National Park, 300m, 5 Oct 1996, M. Mikage, Hukum. P. Acharya, Kamal. K. Shrestha and A. Takahashi 9689086(KATH)

Eastern Nepal: Province No. 1, Jhapa District, Surunga- Sanichare, 200- 250m, 7 June 1974, P. Pradhan, M.M. Amatya and R. Shrestha 140/74(KATH); Province No. 1, Sunsari District, Koshitappu, 65m, 5 May 2005, N. Acharya and K.R. Bhattarai 200502(KATH); Province No. 1, Sankhuwasabha District, khahare – Tumlingtar, 280- 400m, 26 July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, M. Sugita, H. Yagi, M.N. Subedi and H. Ikeda 20163(KATH); Province No. 1, Sankhuwasabha District, Arun River, Chokkrang Bridge, 1090m, 14 Oct 1991, D.G. Long, R.J.D. McBeath, D.R. McKean, D.A.H. Rae, N.K. Bhattarai and Emak 8 (KATH); Province No. 1, Sankhuwasabha District, Khandbari- Manebhanjyang, 1100m, 13 Sept 1989, K.R. Rajbhandari 13529(KATH); Province No. 1, Sankhuwasabha District, Tumlingtar, 400m, 5 Oct 1989, K.R. Rajbhandari 13959(KATH); Province No. 1, Sankhuwasabha District, Nagitar, 1900m, 28 Sept 1989, K.R. Rajbhandari 13904(KATH); Province No. 1, Sankhuwasabha District, Tumlingtar- Khandbari, 600m , 11 Sept 1989, K.R. Rajbhandari 13514(KATH).



Map 7: Distribution of *Fimbristylis dichotoma* in Nepal Based on herbarium records.

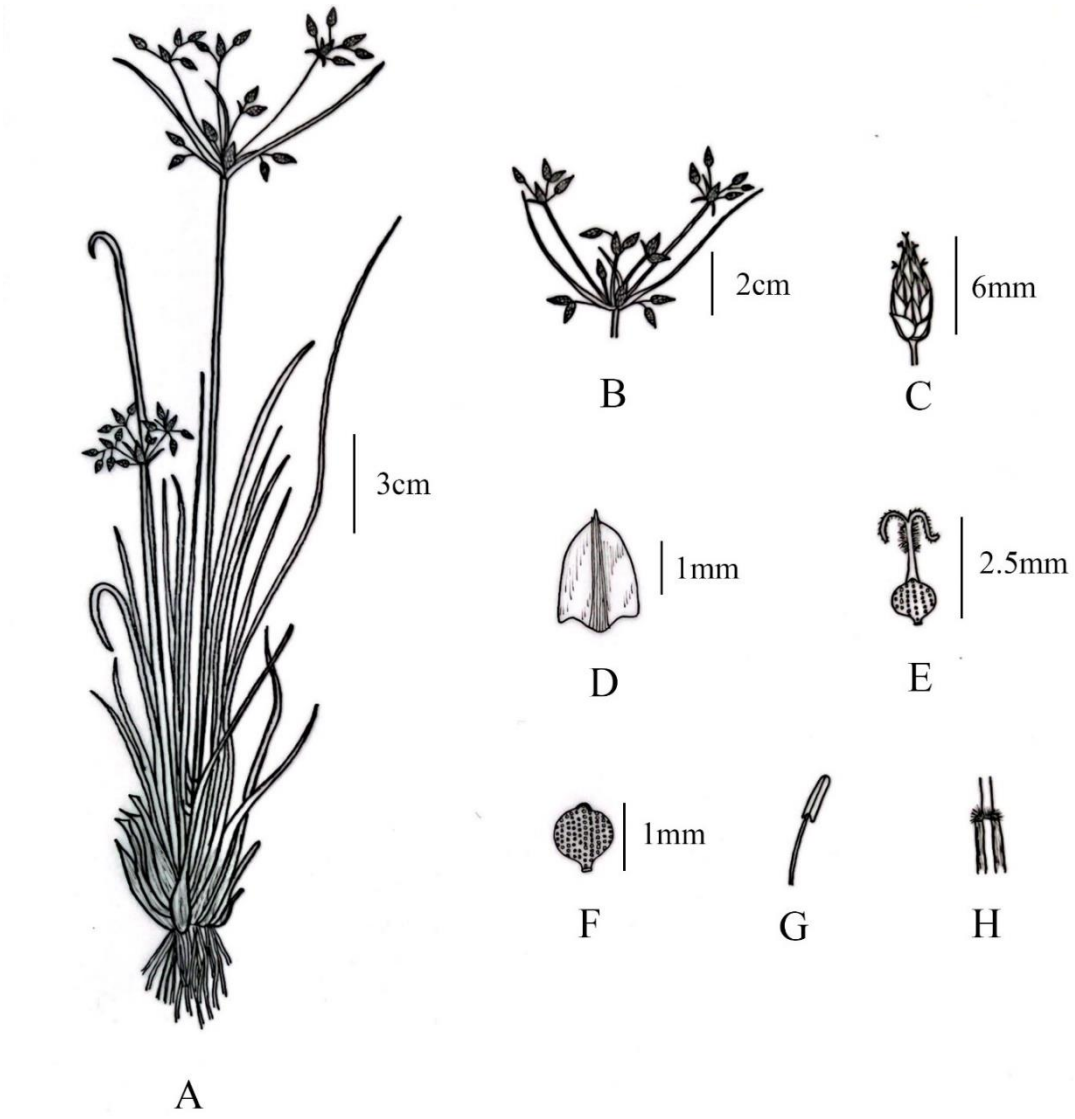


Figure 7. *Fimbristylis dichotoma* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath, (Based on S. Aryal MG5 (TUCH)).

Fimbristylis dichotoma (L.) Vahl **subsp. podocarpa** (Nees) T. Koyama, Micronesica 1: 87 (1964). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Fimbristylis podocarpa Nees in Wight, Contr. Bot. India, 98 (1834).

Culms 5- 100cm. Leaves shorter than culms. Leaf blade narrowly linear, 0.5-2 mm wide, both surface pubescent. Inflorescence a compound or simple anthela. Spikelets 0.8-1.4 mm. Glumes 3.8- 4.2mm. Nutlet obovoid/ globose 1.2mm, with 15-24 vertical rows of transversely oblong- rectangular cells, non-verruculose.

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

Elevation: 80-200m

Ecology: open places, grasslands

Local Name: Paani Mothe

Flowering and fruiting: May- Nov

7. **Fimbristylis falcata** (Vahl) Kunth, Enum. Pl. 2: 239 (1837). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

   Scirpus falcatus Vahl, Enum pl. 2: 275 (1806)

   Fimbristylis junciformis (Nees) Kunth, Enum. Pl. 2: 239 (1837)

   Perennial, rhizome present, 2-4cm long, reddish brown in color covered with remains of old leaves and scales. Culms erect, 10- 35cm in height, not tufted, with basal leaves, glabrous, terete, somewhat triangular at base. Leaves ¼- 1/3 shorter than the culm length. Leaves eligulate; leaf sheath brown in color, 1-2.5cm long, opened, glabrous, margin hyaline. Leaf blade linear, 50- 150 ×1-2mm, apex acute, leathery in texture, margin finely serrate, glabrous. Involucral bracts 3-5 in number, 5-10mm × 0.5-1mm, leaf like, usually shorter than inflorescence, apex acute, margin finely serrate. Inflorescence decompound anthela, 2-5cm x 2-3cm with 4-6 rays, 1-3cm long. Spikelet not solitary, present in cluster of 2-4, ellipsoid- ovoid, sessile, 5-6 ×1-1.5mm. Glume pale brown in color, ovate, spirally arranged, 3-4 × 0.5-1mm, membranous, 3-veined with green mid vein, apex attenuate, keeled, glabrous. Stamens 3. Style 1.5- 2mm long, not ciliated, basally flattened. Stigmas 3, 1- 1.5mm long, sparsely ciliated. Nutlet yellowish

creamy – dark brown when mature, obovoid, trigonous, 1- 1.5mm, minutely reticulate, non- verruculose, stipe indistinct. (Figure 8 and Photoplate 18)

Distribution range: Nepal (W & C) (Map8), W Himalaya, E Himalaya, S Asia, SE Asia, and Africa.

Elevation: 200-1200m

Ecology: wet playgrounds, Riverbanks.

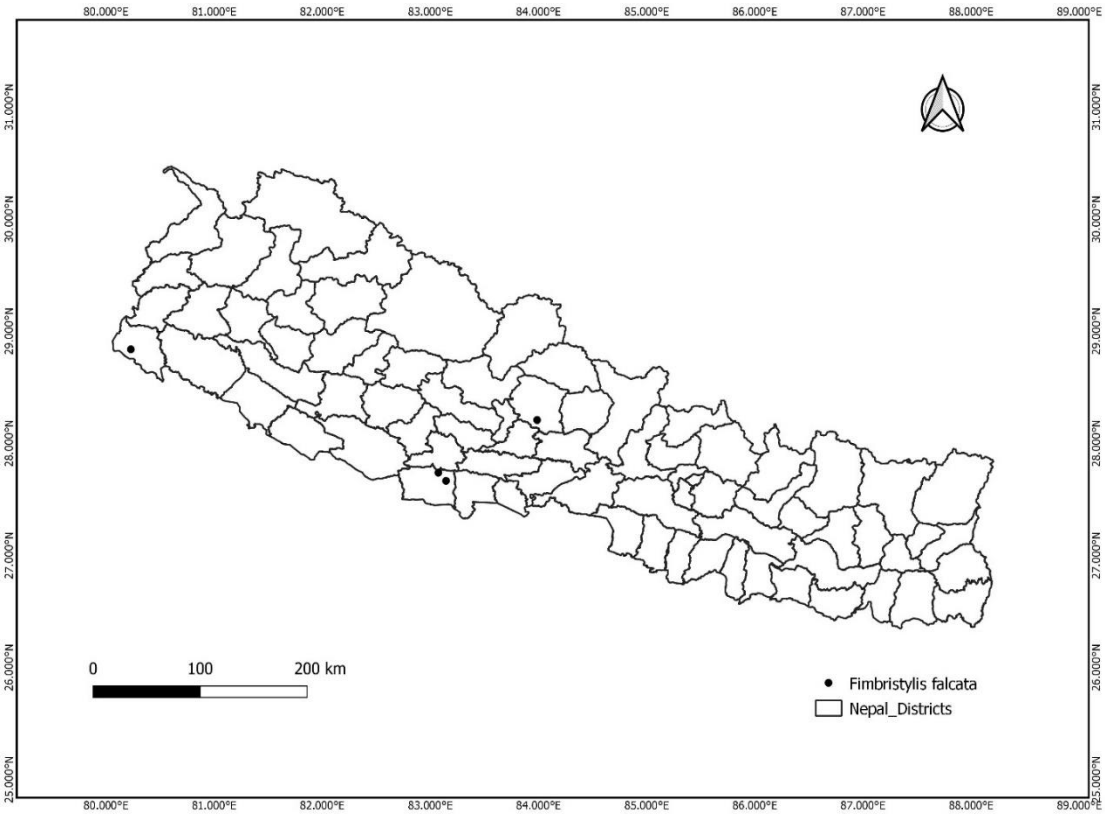
Flowering and fruiting: April- September

Voucher specimen: Lumbini province, Kapilvastu District, Banganga, 135m, 15 July 2020, S. Aryal and Y.B. Poudel. CN1(TUCH); Lumbini Province, Kapilvastu District, Banganga, Behind Jaleshwor Dham, 119m, 1 Aug 2020, S. Aryal and Y.B. Poudel 2CN8 (TUCH).

Specimen examined:

Central Nepal: Gandaki province, kaski District, Pokhara, 3500ft, 20 June 1954, Stainton, Skyes and Williams 5844(KATH); Gandaki province, Kaski District, Pokhara, 920m, 24 June 1986, N.P. Manandhar, L.P. Kattel 10818(KATH).

Western Nepal: Sudur Paschim province, kanchanpur District, Suklaphanta Wild life Reserve, 600ft, 30 June 1974, D. Schaaf 34(KATH)



Map 8: Distribution of *Fimbristylis falcata* in Nepal Based on herbarium records.

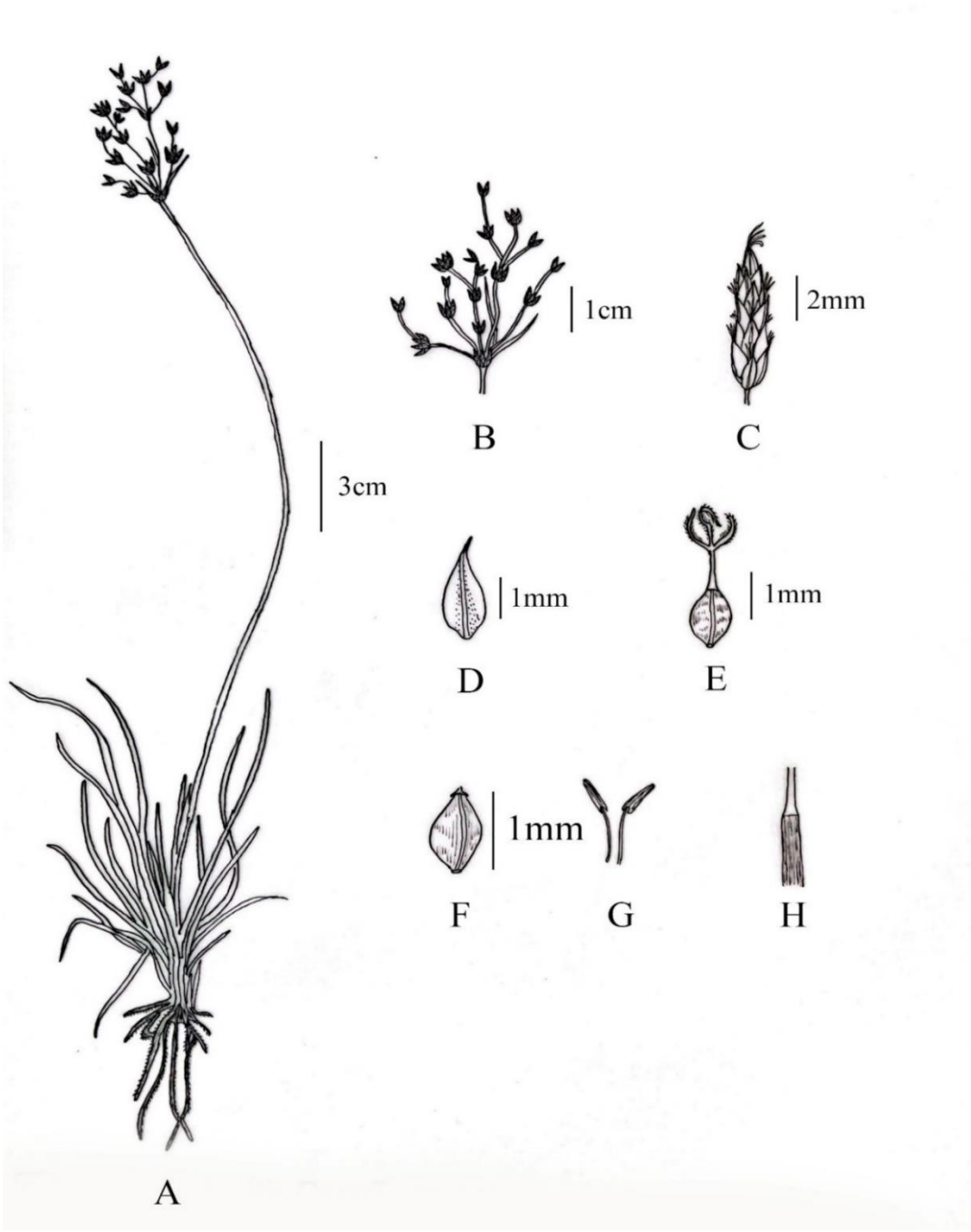


Figure 8: *Fimbristylis falcata* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal and Y.B. Poudel. CN1 (TUCH)).

8. **Fimbristylis ferruginea** (L.) Vahl, Enum Pl. 2: 291. 1805.

Scirpus ferrugineus L., Sp. Pl. 1: 50. 1753

Type specimen: JAMAICA, Collecter Unknown s.n. [Herb. Van Royen], [lectotype, designated by Adams in Cafferty and Jarvis 2004, pg.180 (L0052731 image!)].

Perennial, rhizome present, 1-4 cm long dark brown in color. Culms erect, slender, 30- 50cm tall, tufted, irregularly angled, compressed, glabrous, bladeless sheath present. Leaves shorter to sometime equaling the culm. Leaves ligulate; leaf sheath light brown in color, closed, glabrous, 4-10cm long. Leaf blades linear, 100-180mm × 1.5-2mm wide, apex acute, margin serrate, both surfaces glabrous, rusty brown specks present on leaf blade. Involucral bract 2 or 3 in number, leaflike, 30-50 × 1-1.5mm, longer than inflorescence, apex acute, glabrous on both surfaces, margin serrate. Inflorescence terminal with 4-6 solitary spikelets, 2-4 ×1.5-3cm, rays 3-4 in numbers, 0.5-3cm long. Spikelets solitary, ovoid, 4-9 ×2-3.5mm, light brown in color. Glumes reddish brown, broadly ovoid, spirally arranged, 3.5-5× 2-3mm, densely pubescent apically, apex apiculate, faint midrib, not keeled. Stamens 3. Style 1- 1.5mm long, ciliate apically, not flattened basally. Stigmas 2, sparsely ciliated, slightly shorter or equaling style, ca.1mm. Nutlet creamy, shiny, biconvex, obovoid, ca.1.5mm with smooth surface, stipitate; stipe ca. 0.2mm long. (Figure 9 and Photoplate 19).

Distribution range: Nepal (C & E) (Map 9), E Himalaya, Asaam- Burma, S Asia, SE Asia, SW Asia, C Asia, SW Europe, Africa, Tropical America and Australasia.

Elevation: 70-700 m

Ecology: Flood plains, Riverbanks and semi dry Paddy fields

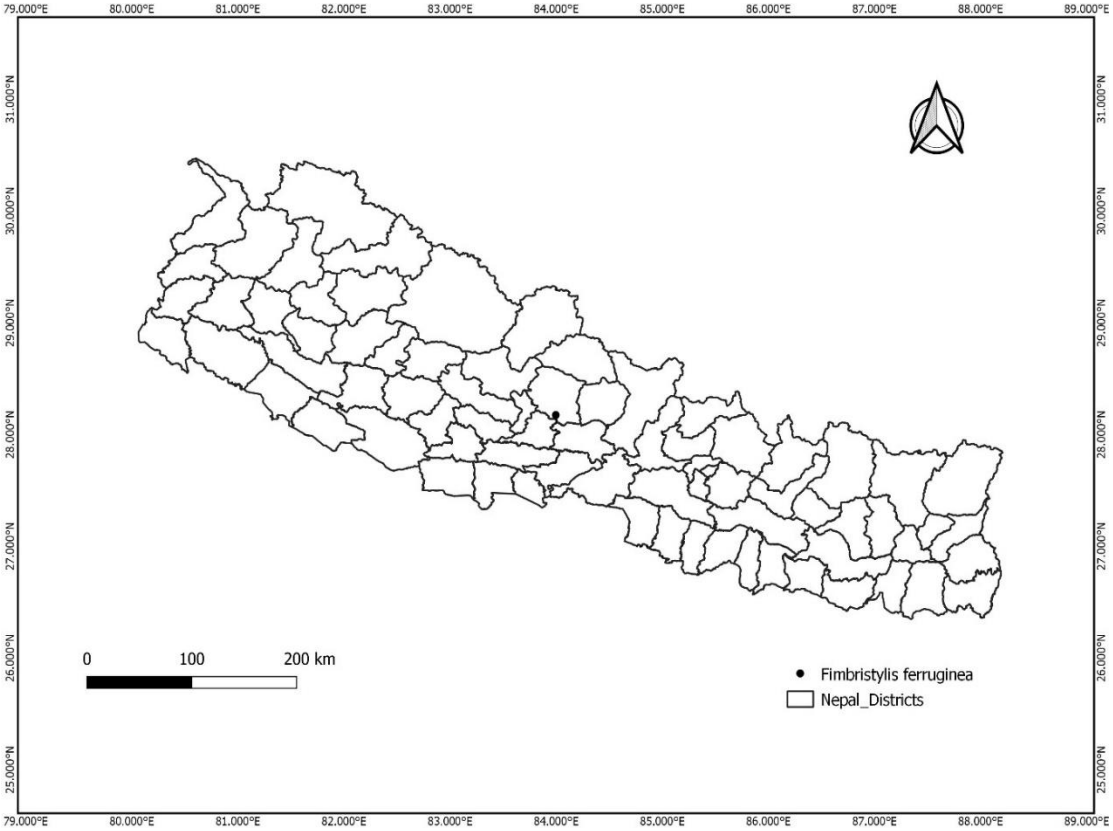
Flowering and fruiting: Aug- Dec

Voucher specimen: Gandaki Province, Kaski District, Sitapaila Pokhara, 676m, 11 Oct 2020, P. Bhandari and A. Bhandari 20101101 (KATH, TUCH)

Specimen examined:

Central Nepal: Gandaki Province, Kaski District, Sitapaila Pokhara, 676m, 11 Oct 2020, P. Bhandari and A. Bhandari 20101101 (KATH, TUCH)

Eastern Nepal: Province No.1, Jhapa District, Kanchankawal RM, Baniyani, 70m, 4 Dec 2020, S. Chaudhary 20120406 (KATH).



Map 9: Distribution of *Fimbristylis ferruginea* in Nepal Based on herbarium records.

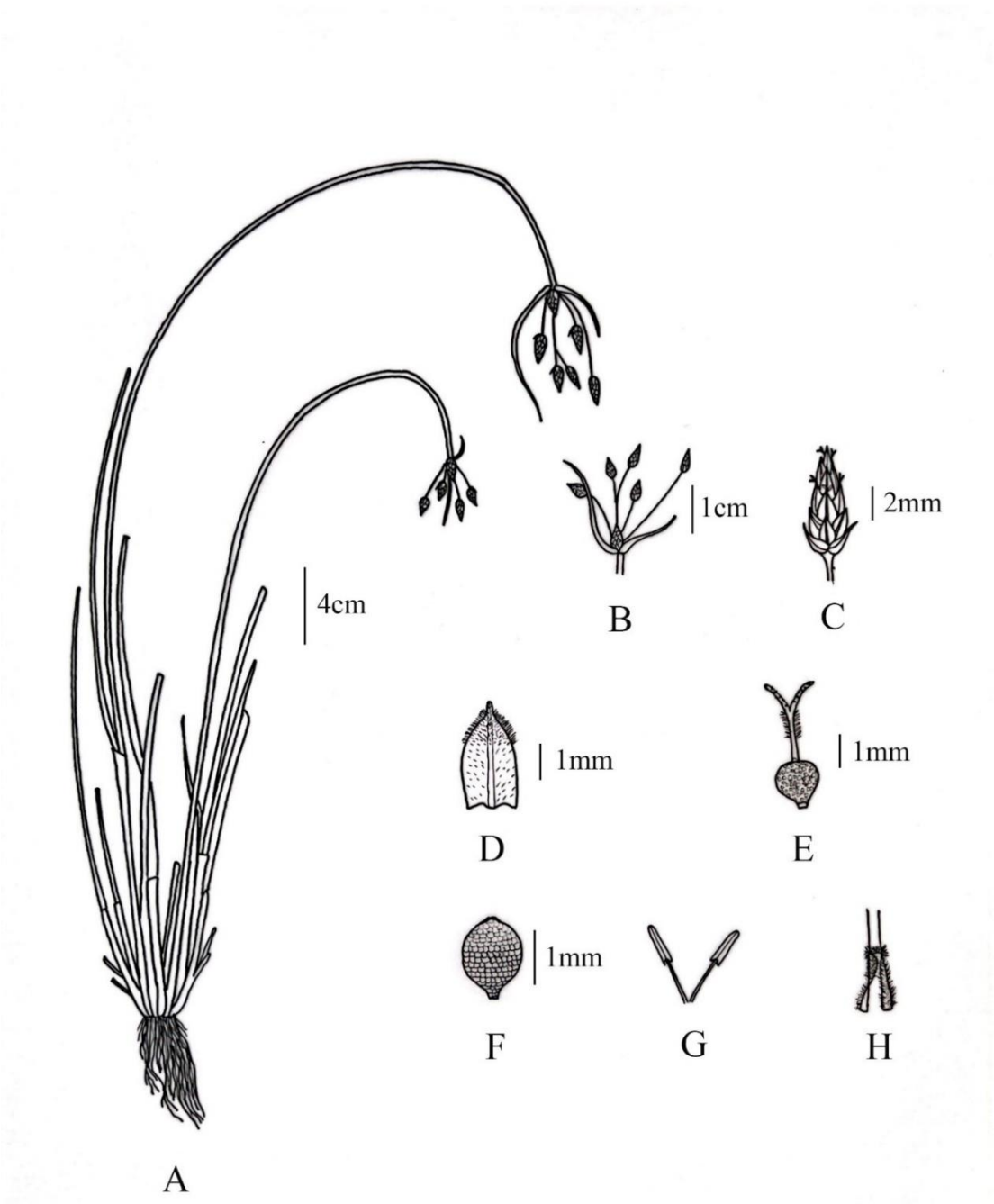


Figure 9: *Fimbristylis ferruginea* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on P. Bhandari and A. Bhandari 20101101 (KATH, TUCH))

9. **Fimbristylis fimbristyloides** (F. Mueller) Druce, Rep. Bot. Soc. Exch. Club Brit. Isles 4: 623 (1917). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Abildgaardia fimbristyloides F. Mueller, Fragem. 8: 273 (1874)

Type specimen: Sabah, Gibbs, L.S. (Holotype:K)

Annual herbs, roots pale brown; 1- 1.5cm long. Culms, slender, 10- 15cm tall, tufted with basal leaves, glabrous. Leaves shorter than the culms. Leaves eligulate; leaf sheath greenish – brown in color, opened, membranous, 1-2 cm long, glabrous, papery texture. Leaf blade basal, curved, 1-1.5mm wide, apex acute, margin serrate, surface glabrous. Involucral bracts 2-4 in number, leaf like, 0-5- 1.5cm long, less than 1mm wide, shorter than inflorescence, apex acuminate, margin serrate, glabrous. Inflorescence a simple anthela, rays 2- 3 in numbers, 1- 3.5 cm long with 4-6 spikelets, glabrous. Spikelets solitary, lanceolate, 5- 15 × 1.5mm wide. Glume pale yellow in color, lanceolate, distichously arranged, 3- 3.5 × 1- 1.5mm, apex acute, mucronate minutely; mucron ca. 0.5mm, single veined forming a slight abaxial keel, margin hyaline, surface glabrous. Stamens 3. Style 2.5- 3mm long, not ciliated, basally flattened. Stigmas 3 shorter than style, 1- 1.2mm long, not ciliated. Nutlet dark brown when mature, broadly obovate, trigonous, 1- 1.2mm, verruculose, shortly stipitate. (Figure 10 and Photoplate 20)

Distribution range: Nepal (C & E) (Map 10), E Himalaya, Assam- Burma, S Asia, E Asia, SE Asia and Australasia.

Elevation: 500- 2300m

Ecology: wet ground, grassy slopes

Flowering and fruiting: Aug- Oct

Specimen examined:

Central Nepal: Gandaki Province, Myagdi District, Dharapani(1550m)- Takum(1650m)- Sibang(1750m)- Dhara Khola(1640m)- Muri(1620m), 4 Sept 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, A. Takahashi and K. Yonekura 9682202(KATH)

Eastern Nepal: Province No.1, Sankhuwasabha District, Arun Valley, Ridge Between Khandbari and Bhotebas, 1680m, 18 Sept 1991, D.G. Long, R.J.D. McBeath, D.A.H. Rae and N.K. Bhattarai 29(KATH). Province No.1, Illam District, Rong, 340m, 16 oct 2020, S. Poudel and B.B. Shrestha.

Map 10: Distribution of *Fimbristylis fimbristyloides* based on herbarium records.

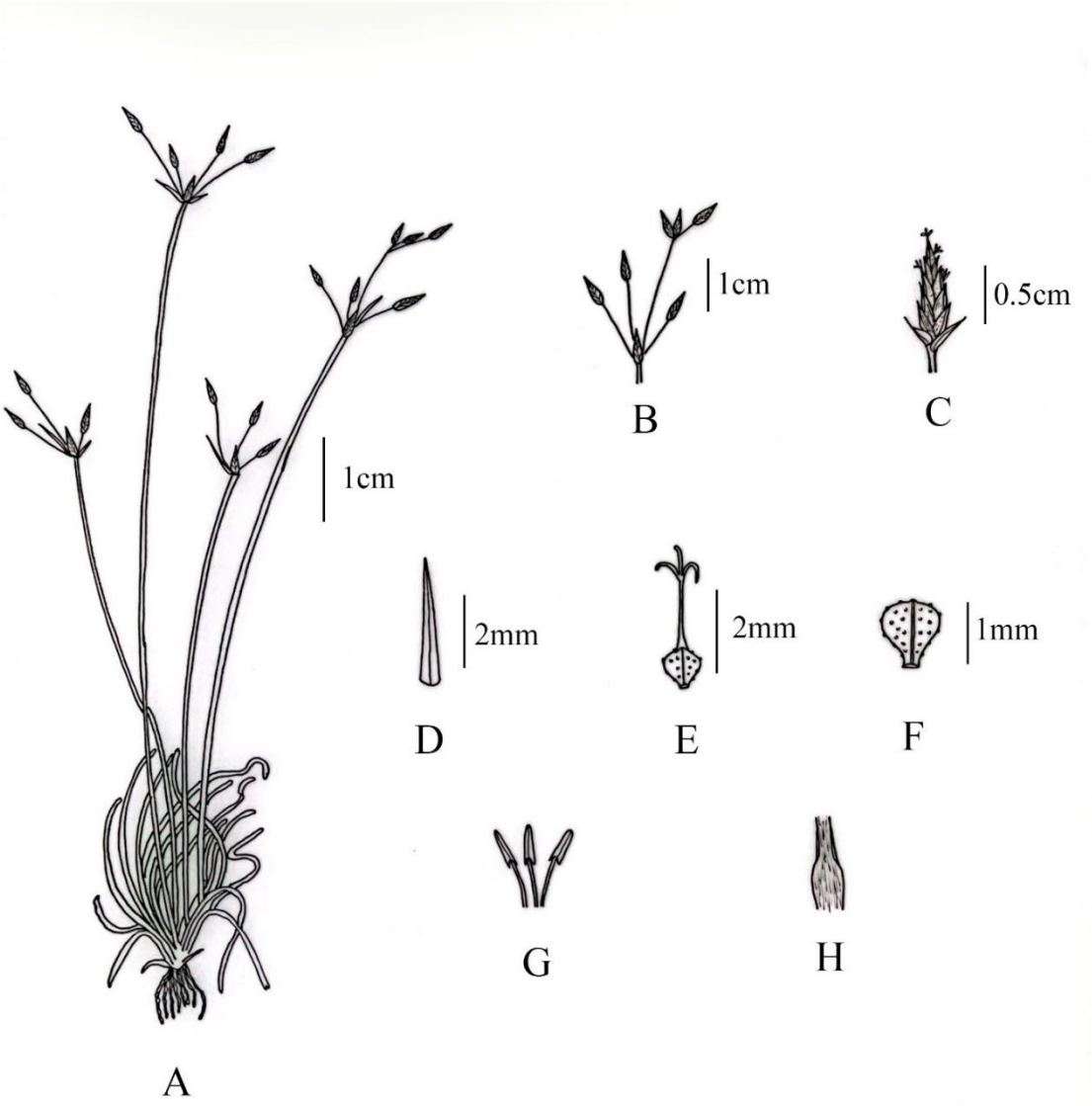


Figure 10: *Fimbristylis fimbristyloides* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Poudel and B.B. Shrestha)

10. **Fimbristylis fusca** (Nees) Benth. ex C. B. Clarke in Hooker, Fl. Brit. India 6: 649 (1893). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

    Abildgaardia fusca Nees in wight, Contr. Bot. India: 95 (1834).

    Type specimen: Nepalia, 1821, Wallich 3530 (Lectotype: E)

    Perennial, rhizomatous, rhizome short, dark brown in color, 1-1.5cm long. Culms erect, 30- 50cm, tufted, 5-angled, green in colour, glabrous with basal leaves. Leaves shorter than culm. Leaves eligulate; leaf sheath dark brown in color, 1.5-4cm long, membranous, glabrous on both surfaces, opened. Leaf blade linear, 5-25 X 0.5-1mm, apex acute, margin serrate, both surface pubescent. Involucral bracts 2-4 in number, leaf-like, 1-5 cm long, less than 1mm wide, usually shorter than inflorescence, apex acuminate, both surfaces hairy. Inflorescenc a compound anthela, with 3-4 rays; rays 1.5cm – 3.5cm long, hairy. Spikelet solitary, lanceolate, 5-10 X 1-3mm. Glumes dark brown in color, distichously arranged, lanceolate, 3-5mm, with single vein forming an abaxial keel, apiculate apex, glabrous surface, lower 2-3 glumes empty. Stamens 3. Style 4-5mm, not ciliated, basally flattened. Stigmas 3, 1.5- 2mm long, sparsely ciliated. Nutlet dark brown, trigonous, obovoid, almost sessile ca. 1mm, verruculose, stipe indistinct. (Figure 11 and Photoplate 21)

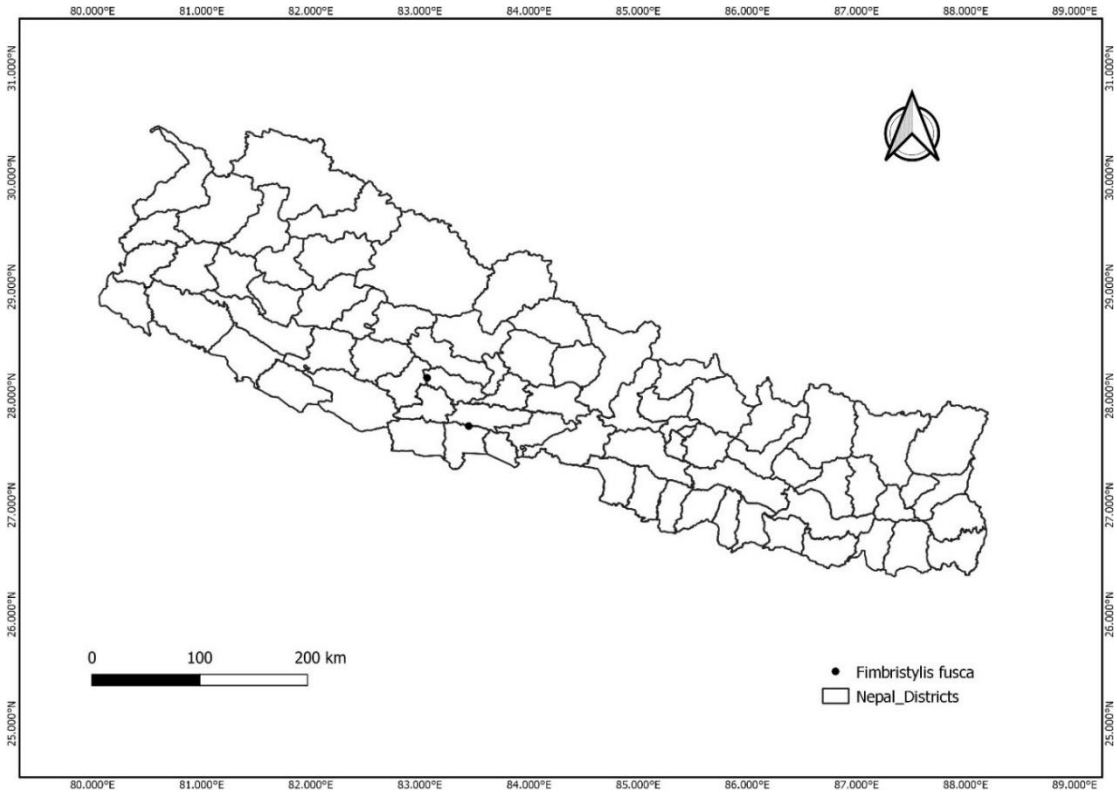
    Distribution range: Nepal(C) (Map 11), Assam- Burma, E Asia, SE Asia and Australasia.

    Elevation: 300- 1500m

    Ecology: Grassy slopes

    Flowering and fruiting: June- September

    Voucher specimen: Lumbini province, Gulmi district, Madane,1100m, 25 Aug 2021, K. Panthi G1(TUCH); Lumbini Province, Palpa District, Nuwakot, 900m, 3 sept 2021, S. Aryal and Y.B. Poudel PN2 (TUCH).



Map 11: Distribution of *Fimbristylis fusca* in Nepal based on herbarium records.

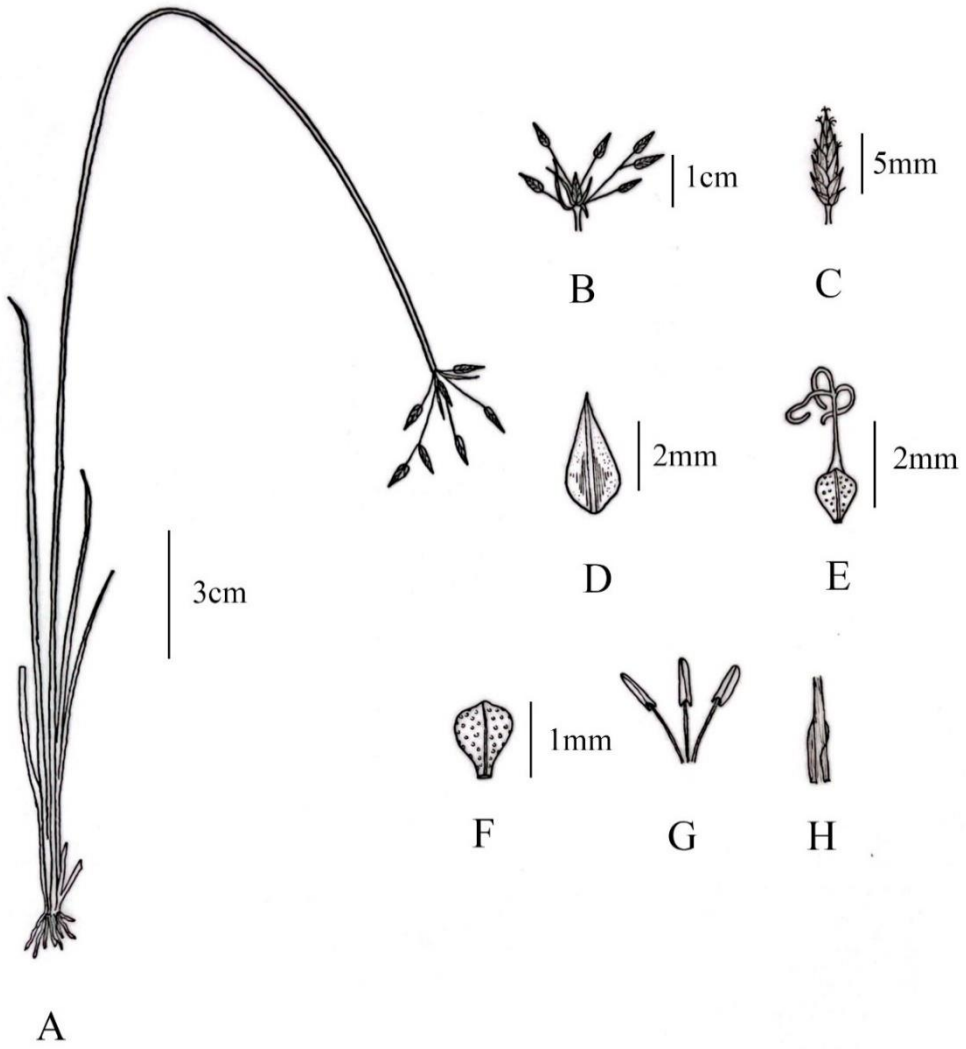


Figure 11: *Fimbristylis fusca* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal and Y.B. Poudel PN2 (TUCH)).

11. **Fimbristylis littoralis** Gaudich., Voy. Uranie 10: 413 (1829). Rajbhandari in Rajbhandari & baral, Cat. Nep. Fl. Pl. 1: 95 (2010)

Fimbristylis miliacea auct. Non (L.) Vahl: Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Type specimen: Indonesia, Gaudichaud s.n. (Holotype: P)

Perennial, rhizome short, 1-3cm long, dark brown in color. Culms erect and tufted 30- 80cm long, 4-angled with 2-3 leaf sheath on each culm, glabrous. Leaves shorter to longer than the culms. Leaves eligulate; leaf sheath pale brown in color, 1.5-10cm long, closed, compressed bilaterally, attenuate apically, with rusty marks. Leaf blade ensiform, 15- 45cm × 1.5-2mm wide, bilaterally compressed with sheath, margin finely serrate, apex attenuate. Involucral bracts 2-5in number, leaf like, 1.5- 4cm long, setaceous, apex attenuate, margin rusty. Inflorescence a compound or decompund anthela, 3-9 ×2-4cm with more than 30 spikelets, rays 2-4 in number, 1.5-5cm long. Spikelet solitary, globose, 1.5-3 × 1.5-2mm, with round apex. Glume dark brown, spirally arranged 1-1.5mm × 1mm, 3veined, keeled, apex acute- obtuse, midvein green, lateral veins light brown, glabrous. Stamen 2. Style ca.1mm, not ciliated, basally slightly flattened. Stigmas 3, densely ciliated, longer than style, 1- 1.5mm. Nutlet yellowish white, trigonous, ca. 1mm, obovoid, shiny, sparsely verruculose, with transversely oblong reticulation, stipe indistinct. (Figure 12 and Photoplate 22)

Distribution range: Nepal (W, C& E) (Map 12), E Himalaya, Assam- Burma, S Asia, E Asia, SE Asia, SW Asia, Africa, N America, S America and Australasia.

Elevation: 100-1700m

Ecology: Waterlogged area around paddy field, Foot trail sides of paddy field.

Local Name: Jwane jhaar

Flowering and fruiting: May- November

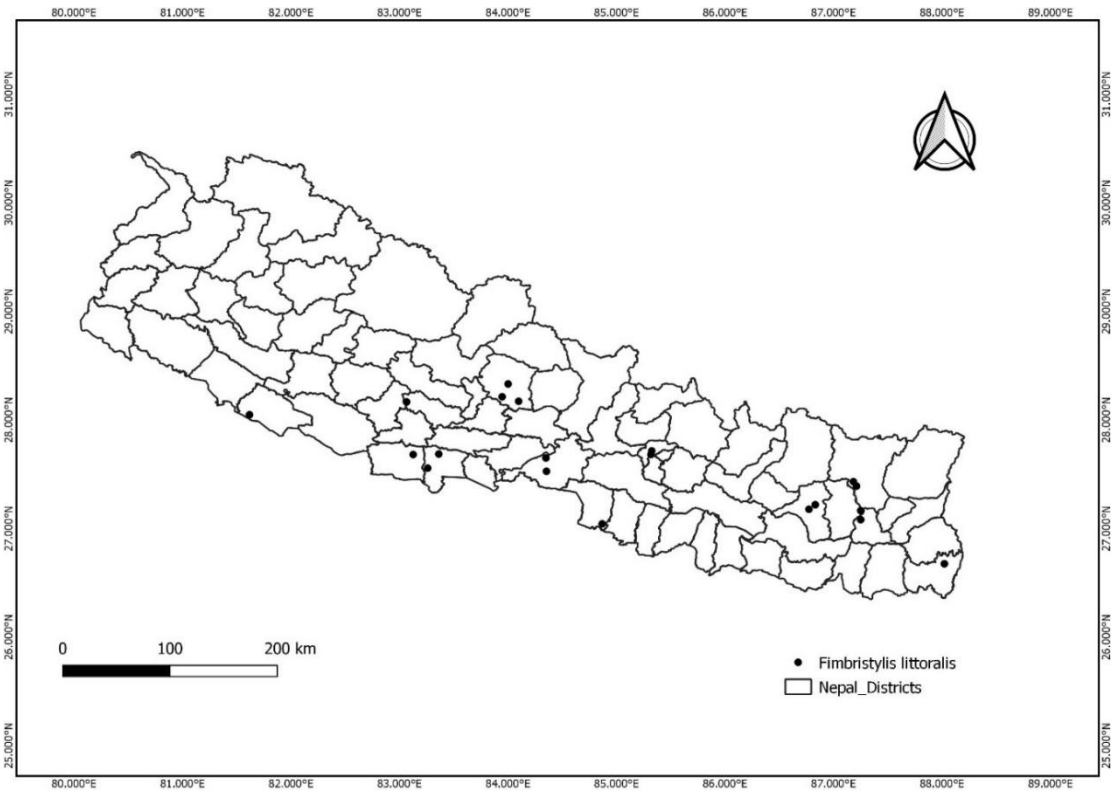
Voucher specimen: Lumbini Province, Rupandehi District, kharmendipur, Gaidahawa, 102m, 3 August 2020, S. Aryal and Y.B. Poudel 4CN2 (TUCH); Lumbini province, Rupandehi District, Ranibagiya, 121m, 24 Aug 2020, S. Aryal MG3 (TUCH); Lumbini Province, Kapilvastu District, Koili Bangai,118m, 15 sept 2020, S. Aryal and Y.B. Poudel LD10(TUCH).

Specimen examined:

Central Nepal: Bagmati Province, Kathmandu District, 60km west of Kathmandu District, 900m, 25 Aug 1989, C Grey- Wilson, Sue Zmarzty, Mike Sinnott, David Long, Ron McBeath, Henry Noltie and Mahendra Subedi 11(KATH); Bagmati Province, Chitawan District, Narayani, 300m, 18 Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha and M. Shiwakoti DNEP2 A9(KATH); Bagmati Province, Kathmandu District, On the bank of Bishnumati River near Balaju, 17 Noiv, 1977, N.P. Manandhar 579(KATH); Gandaki Province, Kaski District, Kaseri, 880m, 29 June 1986, N.P. Manandhar and L.P. Kattel 11090(KATH); Bagmati province, Chitawan District, Rampur, 350m, 4 Aug 1992, N. Joshi and I. Shrestha 155(KATH); Gandaki Province, Kaski District, Near Phewa Tal, Pokhara, 755m, 15 Nov 1985, N.P. Manandhar 10441(KATH); Madhesh Province, Parsa District, ca. 3km North of Birgunj Town Center, 70m, 25 Nov 2004, C.A. Pendry, K.K. Shrestha, S. Dahal, A. Giri, A.G. Miller, N. Pandey, M.R. Pullan, L.R. Shakya, S. Shrestha and M. Shiwakoti DNEP2 B134(KATH).

Eastern Nepal: Province No.1, Jhapa District, Suroonga- Sanichare, 200- 250m, 7 June 1974, P. Pradhan, M.M. Amatya and R. Shrestha 131/74(KATH); Province No.1, Sankhuwasabha District, Arun Valley, Ridge Between Khandbari and Bhotebas, 1550m, 18 Sept 1991, D.G. Long, R.J.D. McBeath, D.A.H. Rae and N.K. Bhattarai 25(KATH); Province No.1, Dhankuta District, Gholikharka-Ramrista (1230m- 230m), 24 July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi and H. Ikeda 90(KATH); Madhesh Province, Siraha District, Salhesh Phulbari, 115m, 14 June 2016, G.D. Bhatt and S. Khatri 2016606(KATH); ; Province No.1, Dhankuta-Sankhuwasabha District, Ramrista (230m)- Leguwa(230m)- Chanua(250m)- Bhaileni(370m)- Pileni(260m)- Khahare(280m), 25 July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi and H. Ikeda 20124(KATH); Province No.1, Khotang District, Khani Danda(1380m)-Shera khalle(1660m)- Diktel(1620m)- Miya Khola(1050m)- Dorpa Churi Danda(1460m), 29 0ct 1995, M. Mikage, T. Kajita, F. Kiuchi, N. Kondo, R. Lacoul, M. Suzuki and K. Yonekura 9558166(KATH); Province No.1, Sankhuwasabha District, Khandbari- Manebhanjyang, 1100m, 13 Sept 1989, K.R. Rajbhandari 13528(KATH).

Western Nepal: Lumbini province, Dang District, Surje gaon, 180m, 17 sept 1975, L.R. Sharma 263(KATH); Lumbini Province, Nepalgunj District, Nepalgunj, 180m, 24 Oct 1972, N.P. Manandhar 8045(KATH); Lumbini Province, Nepalgunj District, Surje gaon, 180m, Nepalgunj, 17 sept 1975, L.R. Sharma 268(KATH).



Map 12: Distribution of *Fimbristylis littoralis* in Nepal Based on herbarium records.

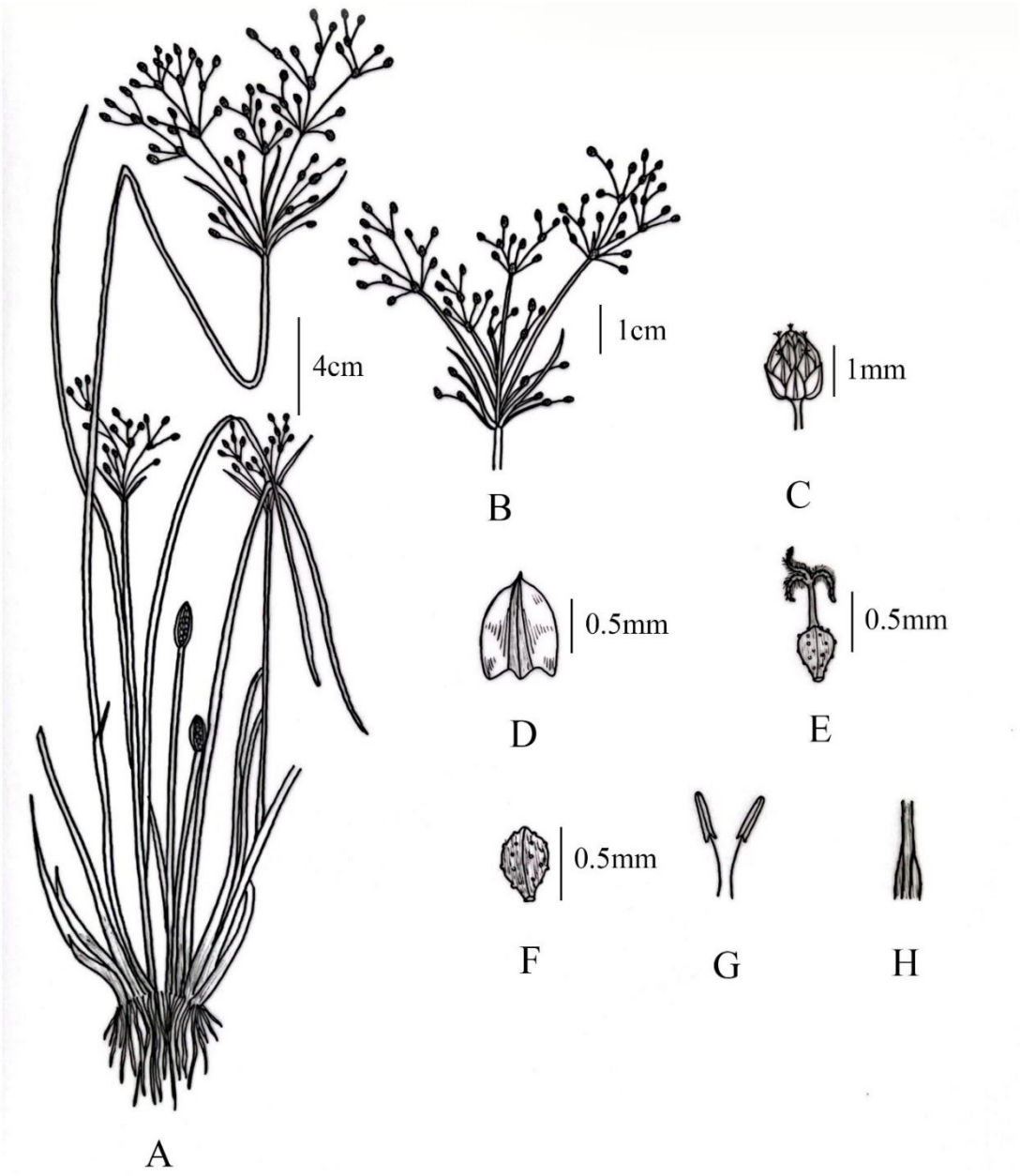


Figure 12: *Fimbristylis littoralis* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal MG3 (TUCH)).

12. Fimbristylis nutans (Retz.) Vahl, Enum. Pl. 2: 285. 1805

Scirpus nutans Retz. Observ. Bot. 4: 12. 1786.

Type specimen: Malaysia, Malacca, J.G. Konig s.n. (Lectotype, designated by Fischer 1932, pg. 69: LD)

Perennial herbs, rhizomatous; rhizome short. Culms erect, 50-60cm long, densely tufted, smooth, sub- cylindric, glabrous. Leaves reduced to a bladeless sheath; leaf blades absent. Ligule absent. Leaf sheath tubular, 3-8cm long, closed, light brown in color, glabrous, apex obliquely truncate. Involucral bract single, glume- like, 3.5mm long, apex mucronate. Inflorescence reduced to a single terminal spikelet. Spikelet slightly nodding, ovoid, 5- 10 × 2-4mm. Glumes rusty brown in color, oblong- elliptic, spirally arranged, 2-4 × 1.5-3mm, papery, margin membranous, apex apiculate, surface glabrous, keeled. Stamens 3. Style 3.5mm long, flattened basally, sparsely ciliate apically. Stigmas 2, short. Nutlet biconvex, white, obovate, 1.5mm, with transverse wavy reticulation, verruculose margin, basal stipe indistinct. (Figure 13)

Distribution: Nepal(C) (Map 13), Assam- Burma, S. Asia, E. Asia, SE Asia and Australasia.

Ecology: Grows in marshy areas, edges of lake, sometimes forming a floating island of vegetation, associated with Eleocharis species and Fimbristylis species.

Elevation:700m elevation

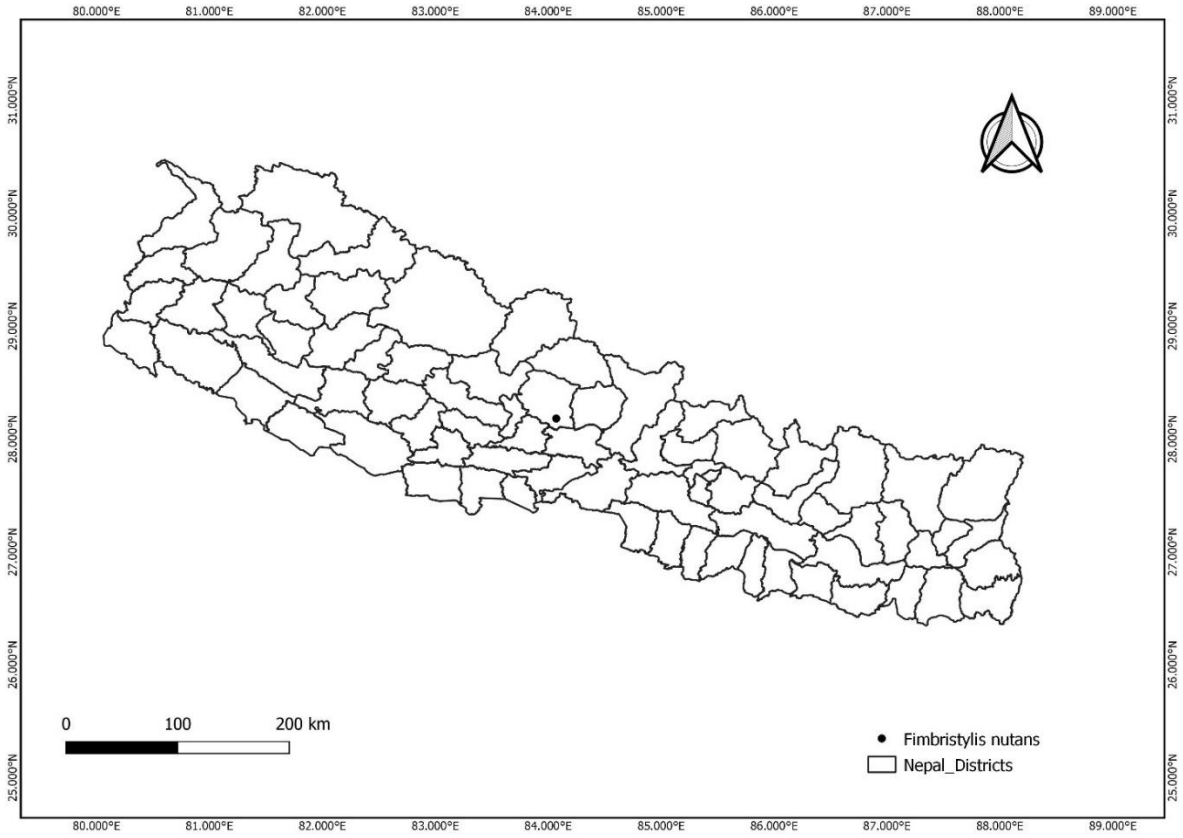
Flowering and fruiting:

Flowering: July- August

Fruiting: September- October

Specimen examined:

Central Nepal: Gandaki Province, Kaski, Pokhara valley, Dipang Lake, 700m, 17 September 2019, P. Bhandari & V. Adhikari (KATH)



Map 13. Distribution of *Fimbristylis nutans* in Nepal Based on Herbarium record

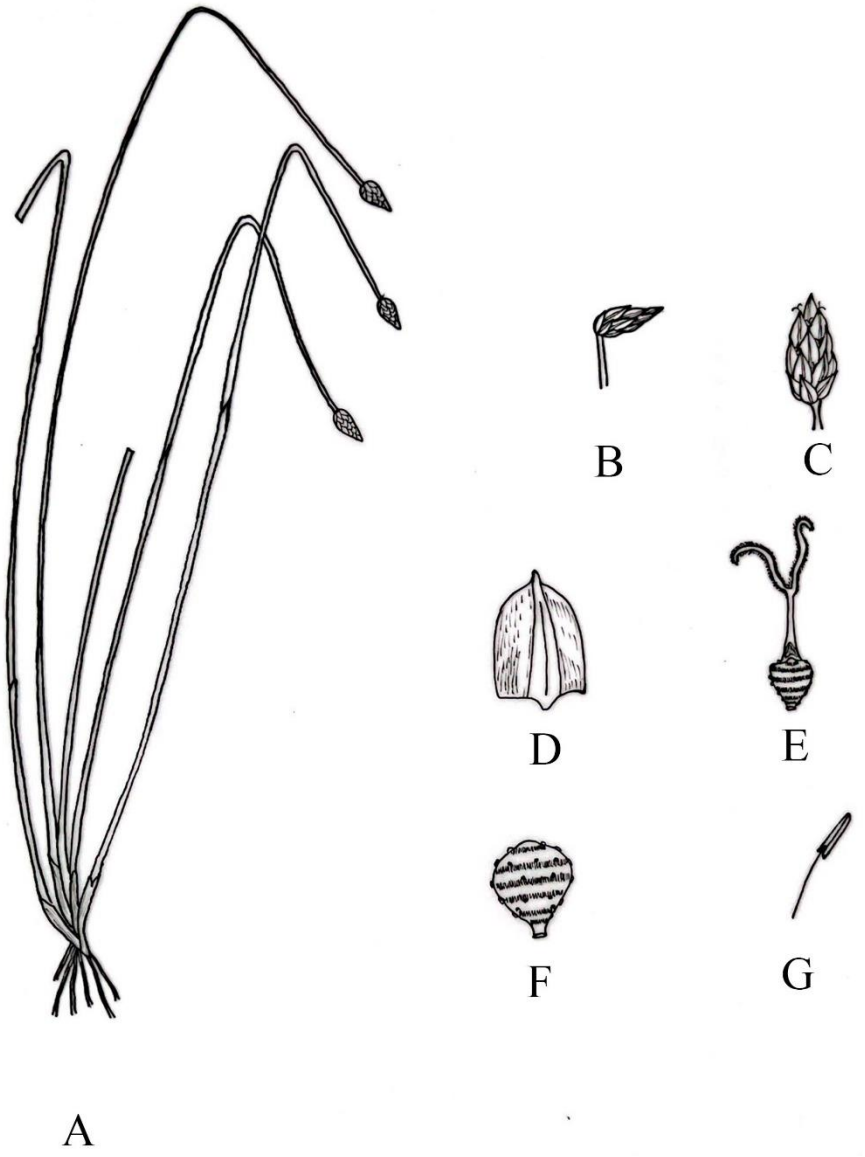


Figure 13: *Fimbristylis nutans* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. Stamen (Based on P. Bhandari & V. Adhikari (KATH)).

13. **Fimbristylis ovata** (Burm. f.) Kern, Blumea 15: 126 (1976). Koyama in Hara et. Al., Enum. Flow. PL. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

Carex ovata Burm. f., Fl. Ind. 194(1768)

Cyperus monostachyos L., Mant. Pl. 2: 180 (1771)

Fimbristylis monostachya (L.) Hassk., Pl. Jav. Rar. 61 (1848)

Type specimen: Indonesia, Java, Burman s.n. (Holotype: B)

Perennials herbs, rhizomatous; rhizome 0.5-1cm long. Culms slender, densely tufted 10 to 35cm, compressed and grooved, glabrous. Leaves basal, half the length of culms. Leaves eligulate; leaf sheath whitish- pale green in color, closed, 3-5cm long, shiny, papery, glaborous; leaf blade linear, 50-200mm × 0.8-1mm, apex acute, margin serrate, both surfaces glabrous. Involucral bracts 1-2, glume like, 2-3 × 1.8- 2.2mm, hyaline, green midrib with apex awned; awn 2-3mm long. Inflorescense a single terminal erect spikelet. Spikelet solitary, ovoid – ellipsoid, flattened, 8-10 × 3-5mm. Glume yellowish green in color, ovate, distichously arranged, 4-5 × 2-3 mm, 3-veined forming an abaxial keel, margin hyaline, mucronate; mucro ca.1mm, glabrous. stamens 3. Style 2-3mm long, densely ciliated, flattened basally. Stigmas 3, ca. 1mm long, ciliated. Nutlet shiny white-brown in color, obovoid, trigonous, ca.2-2.5mm, verruculose with a short ca. 0.5mm stipe. (Figure 14 and Photoplate 23)

Distribution range: Nepal (CEW) (Map 14), Africa, S. W. Asia, E Himalaya, S Asia, E Asia, Assam- Burma, SE Asia.

Altitude: 100- 1400m

Ecology: River side rocky area, open Grasslands

Flowering and fruiting: June- September

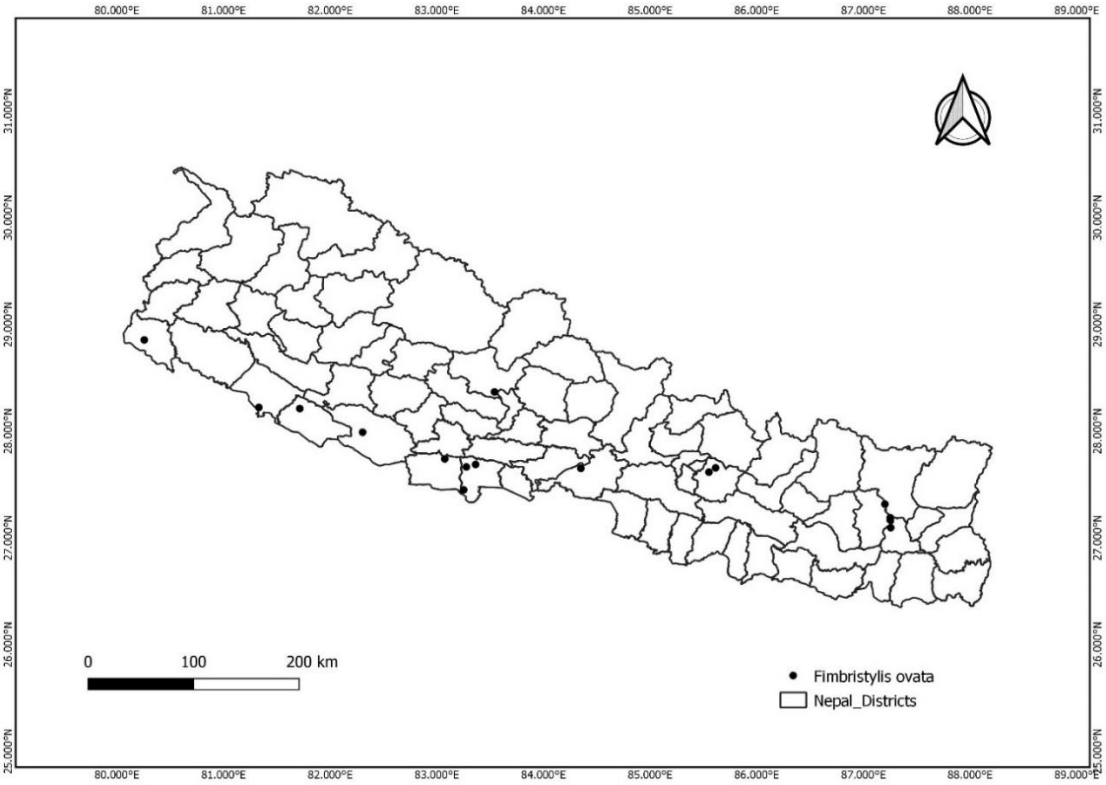
Voucher specimen: Lumbini Province, Kapilvastu District, Banganga, 135m, 15 July 2020, S. Aryal and Y.B. Poudel 2CN2(TUCH); Lumbini Province, Rupandehi District, Ramapur, 106m, 23July 2021, S. Aryal, Y.B. Poudel And K. Panthi KY9 (TUCH).

Specimen examined:

Central Nepal: Lumbini Province, Rupandehi District, Lumbini, 150m, 26 June 1973, N.P. Manandhar and Party 2907(KATH); Bagmati Province, Kavrepalanchowk District, Baluwa V.D.C., Dumreghari Leasehold Forest, 22 July 2001, S.R. Baral 1112(KATH); Bagmati Province, Kavrepalanchowk District, Dhotra Panchkhal V.D.C., 18 July 2002, S.R. Baral and P.P. Kurmi 1222(KATH); Bagmati Province, Chitawan District, Rampur, 320m, 3 Aug 1992, N. Joshi and I. Shrestha 149(KATH); Gandaki province, Myagdi District, Beni , Rice terrace banks, 2800ft, 4 Sept 1954, Stainton, Skyes and Williams 4152(KATH).

Western Nepal: Lumbini Province Bardiya District, Gulariya, 187m, 18 Aug 1976, L.P. Sharma 1087(KATH); Lumbini Province, Nepalgunj District, Kohalpur, 600ft, 22 Magh 2030, R.J. Shah 8167(KATH); Lumbini Province, Dang District, Aambas, 27 Aug 1982, N.P. Manandhar 8456(KATH); Sudur Paschim Province, Kanchanpur District, Suklaphanta Wildlife Reservior, 600ft, 25 Aug 1975, D. Schaaf 30(KATH)

Eastern Nepal: Province No.1, Dhankuta District, Baireni Bagar(320m)- Kyawa Khola(290m)- Chanuwa(280m)- Leguwa Shibaratri(330m)- Mongmaya Khola(330m)- Diyale(760m), 1 Sept 1998, S. Noshiro, K. Kobayashi, Y. Omori, K. Shinozaki and H. Tsukaya 9810218(KATH); Province No.1, Sankhuwasabha District, Tumlingtar(440m)- Katle Bhanjyang(410m)- Sabha Khola(310m)- Khahare(410m)- Pikuwa Khola(320m)- Surtibari(320m)- Baireni Bagar(320m), 31 Aug 1998, S. Noshiro, K. Kobayashi, Y. Omori, K. Shinozaki and H. Tsukaya 9810211(KATH); Province No.1, Dhankuta- Sankhuwasabha District, Ramrista (230m)- Leguwa(230m)- Chanua(250m)- Bhaileni(370m)- Pileni(260m)- Khahare(280m), 25 July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi and H. Ikeda 20143(KATH)



Map 14: Distribution of *Fimbristylis ovata* in Nepal Based on herbarium records.

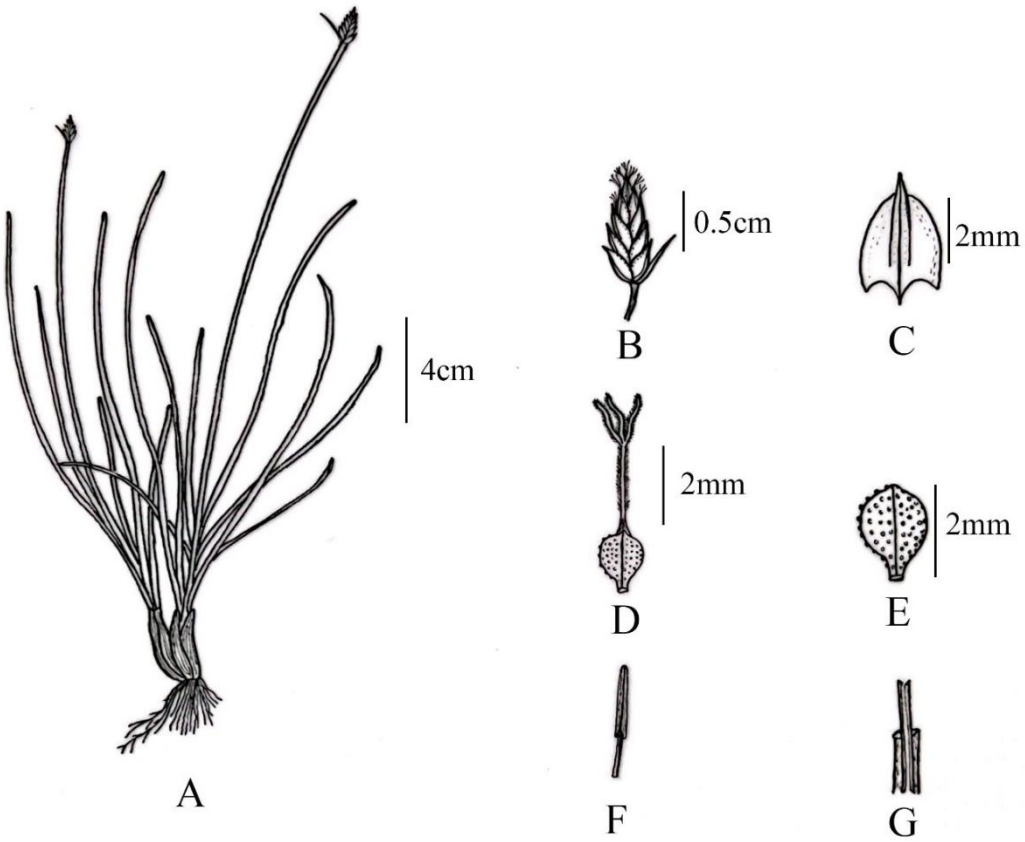


Figure 14: *Fimbristylis ovata* **A**. Habit sketch, **B**. Spikelet **C**. Glume, **D**. Fruiting pistil, **E**. Nutlet and **F**. Stamen **G**. Leafsheath. (Based on S. Aryal and Y.B. Poudel 2CN2(TUCH)).

14. **Fimbristylis pierotii** Miq., Ann. Mus. Bot. Lugduno- Batavi 2: 145 (1865). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Fimbristylis Pinetorum Merr. Philipp. J. Sci., C 9: 2666. 1914

Type specimen: Japan. Pierot s.n. (Isotype: L)

Perennial herbs. Rhizome short, creeping, covered with scales, up to 2mm in diameter. Culms slender, solitary, 3-angled, 13-40cm tall, apical part scarbous, glabrous. Leaves shorter to nearly equaling culms. Leaves eligulate; leaf sheath rust colored, memebranous at the adaxial side, glaborous, mouth obliquely split. Leaf blade 1- 2mm wide, margin incurved or flat, finely serrated, apex acute, glabrous. Involucral bracts glume like, 1-3 in number, shorter than inflorescence, with awned apex. Inflorescence a simple anthela, 1.5- 2.5cm long. Spikelets solitary oblong, ellipsoid, or ovoid, 6-10 x 2.5-4mm, 9- flowered, apex acute. Glumes dark brown, spirally arranged, ovate- broadly ovate, ca. 4mm long, 3-veined forming an abaxial keel, apex obtuse to sub-acute, margin hyaline, basal two glumes with a short apical mucron. Stamens 3. Style not ciliated, basally flattened. Stigmas 3, ciliated, nearly equaling style. Nutlet brown, broadly obovoid, trigonous, ca. 1mm, verruculose, non-stipitate. (Figure 15).

Distribution range: Nepal (C) (Map 15), W Himalaya, E Himalaya, E Asia and SE Asia.

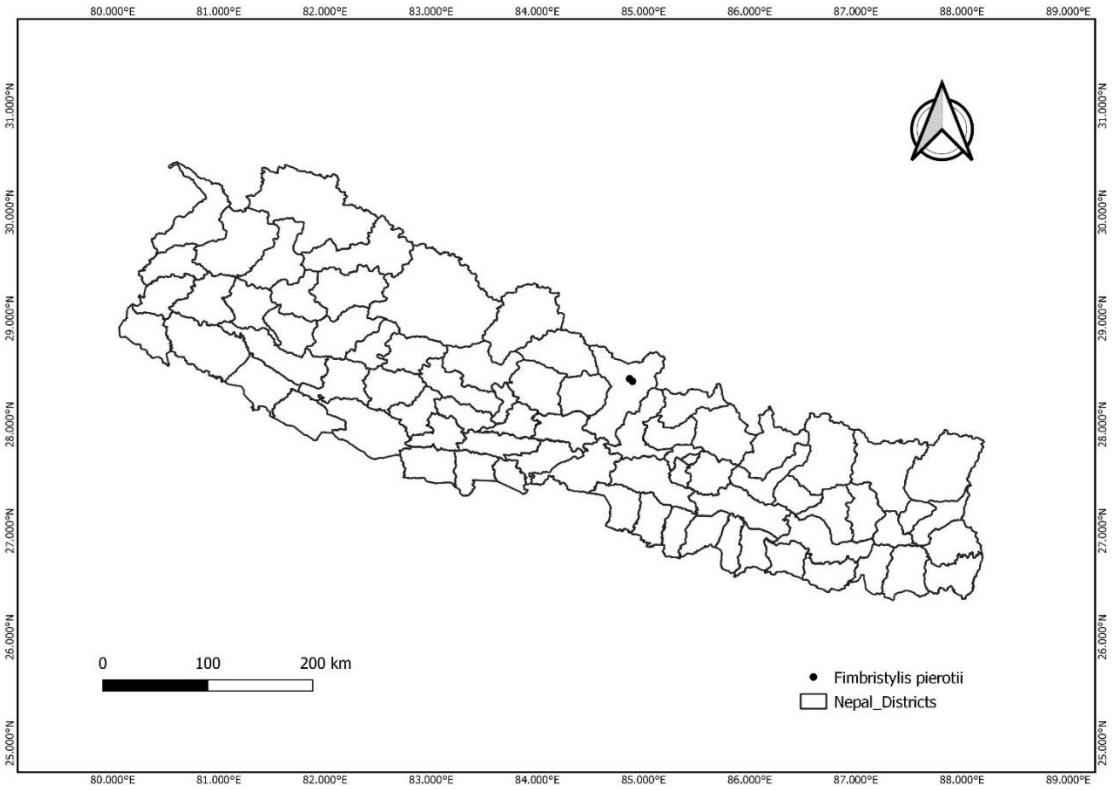
Elevation: 700- 2400m

Ecology: Wet ground

Flowering and fruiting: May- september

Specimen examined:

Central Nepal: Gandaki Province**,** Gorkha district, Ekle Ghar, 1620m, 2 Aug 1994, M. Suzuki, N. Acharya, N. Fujii, L. Joshi, T. Kajita, N. Kondo, M. Mikage, S. Noshiro & K. Yoda 9485240 (KATH)



Map 15: Distribution of *Fimbristylis pierotii* in Nepal based on herbarium record

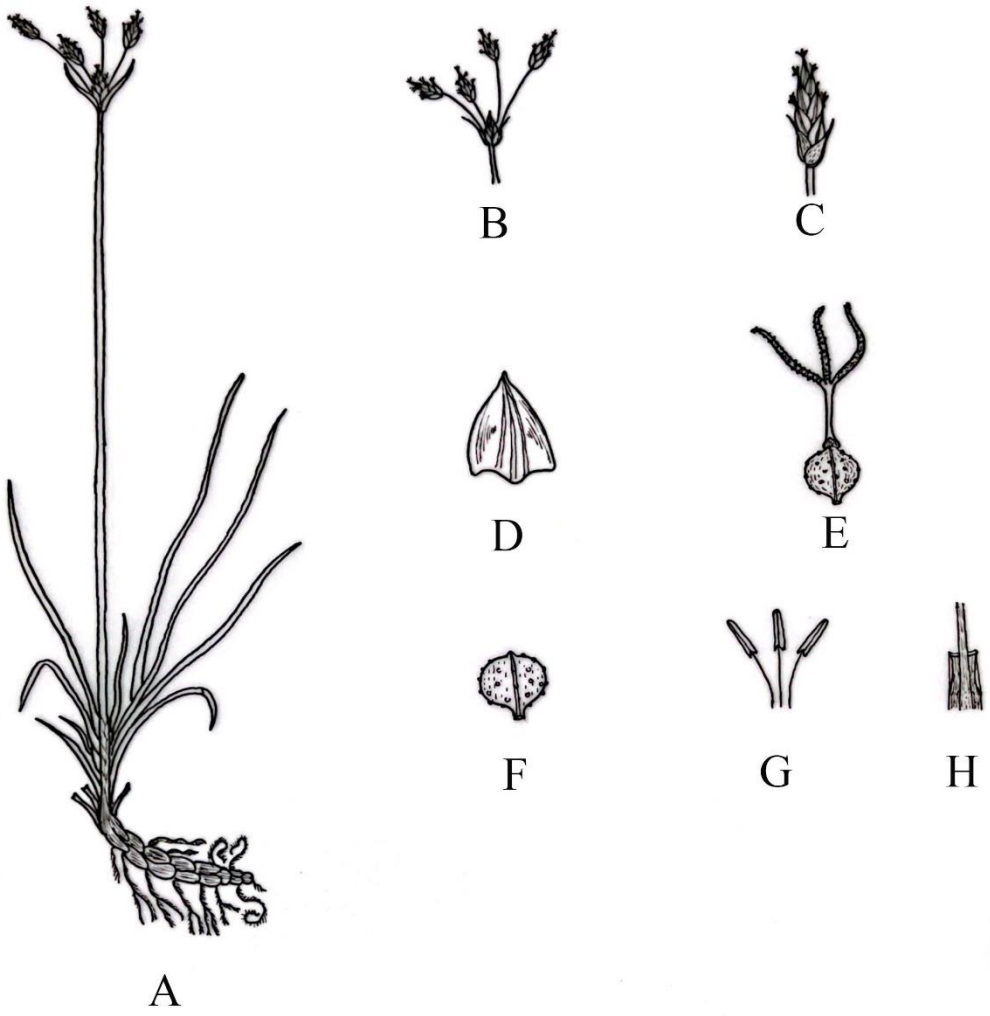


Figure 15: *Fimbristylis pierotii* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on Flora of China).

15. **Fimbristylis quinquangularis** (Vahl) Kunth, Enum. Pl. 2: 229 (1837). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari et al., Cat. Nep. Fl. Pl. Suppl. 1: 20 (2015).

Scirpus quinquangularis Vahl, Enum. Pl. 2: 279 (1805)

Type specimen:

Annual, fibrous root present, dark brown in color, 1- 4cm long. Culms erect, 50-100cm, densely tufted, 5-angled, glabrous with some bladeless sheath at base. Leaves shorter or sometimes equaling the culms. Leaves eligulate; leaf sheath pale brown in color, basal sheath up to 15cm, mouth oblique, pale brown in color, opened, glabrous; upper sheath closed. Leaf blades 30- 70 cm × 2-3mm, present only on vegetative shoots, shorter or sometimes equaling the inflorescence, with acute apex and serrulate margin, glabrous on both surfaces. Involucral bracts 3- 4 in numbers, leaf-like, 0.5-3cm long, shorter than inflorescence, apex acute and margin serrate, glabrous. Inflorescence a decompound anthela, 3-7 ×3-4cm with 3-4 rays and more than 40 spikelets; rays 2-4cm long. Spikelets solitary, ovoid-ellipsoid, brown, 3-5 × 1-1.5mm. Glume light brown, ovate, spirally arranged, 1.5- 2 × 1mm, 3-veined, apex acute, keeled. Stamen 1 or 2. Style ca. 0.8mm, base slightly flattened, apically sparsely ciliate. Stigmas 3, ciliated, equaling or sometimes longer than style. Nutlet yellow – light brown, obovoid, trigonous, ca. 0.5mm, densely verruculose with transverse linear reticulation, stipitate, with ca.0.1mm stipe. (Figure 16 and Photoplate 24)

Distribution range: Nepal (C & E) (Map 16), E Himalaya, Tibetean Plateau, Asaam- Burma, S Asia, E Asia, SE Asia, C Asia, SW Asia, Africa and Australasia

Elevation: 80- 200m

Ecology: Paddy field, Foot trails, Roadside areas

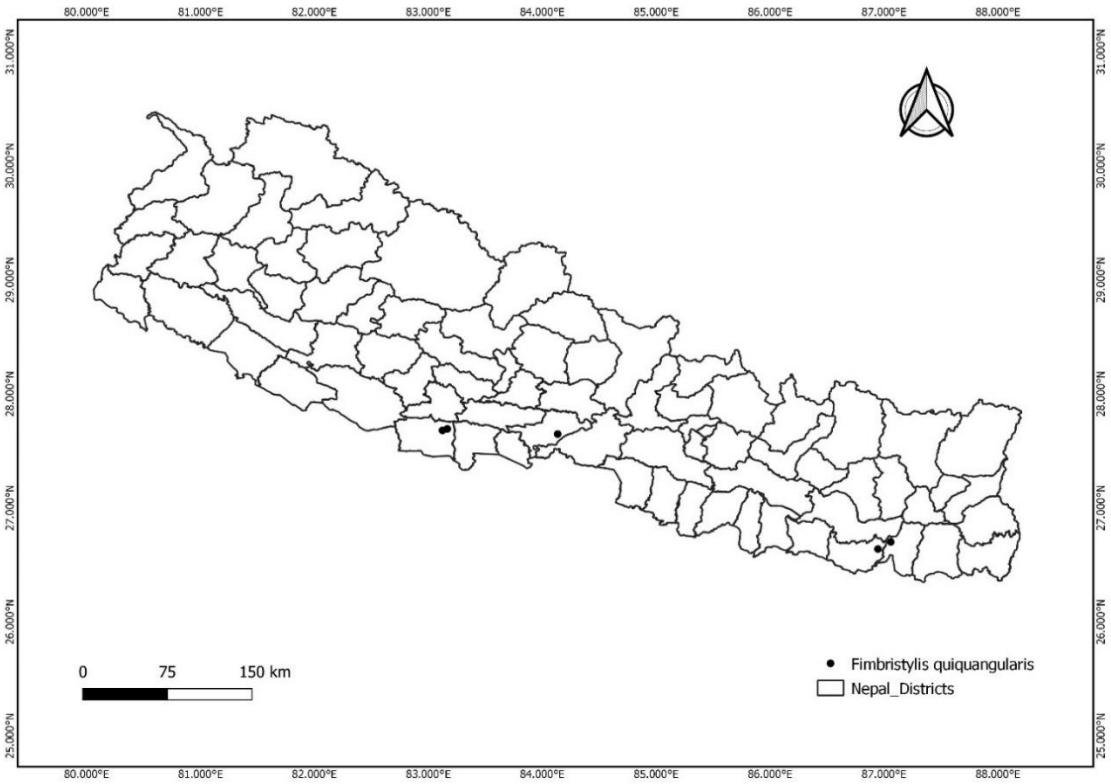
Local Name: Jwane Jhar

Flowering and fruiting: Aug- Oct

Voucher specimen: Lumbini Province, Kapilvastu District, Banganga, 143m, 15 sept 2020, S. Aryal and Y.B. Poudel LD5(TUCH); Lumbini Province, Kapilvastu District, Koilibangai, 118m, 2 Aug 20202, S. Aryal, Y.B. Poudel, P. Poudel 3CN8 (TUCH): Lumbini Province, Nawalpur District, Kawasoti, 180m, 23 Aug 2021, S. Aryal and Y.B. Poudel CH2(TUCH).

Specimen examined:

Eastern Nepal: Province No.1 and Madhesh Province, Sunsari District and Saptari District, Koshitappu Wildlife Reserve, Simana – Kanchanpur, 65m, 22 Oct 1995, M. Mikage, T. Kajita, N. Kondo, M. Suzuki and K. Yonekura 9552952(KATH).



Map 16: Distribution of *Fimbristylis quiquangularis* in Nepal Based on herbarium records.

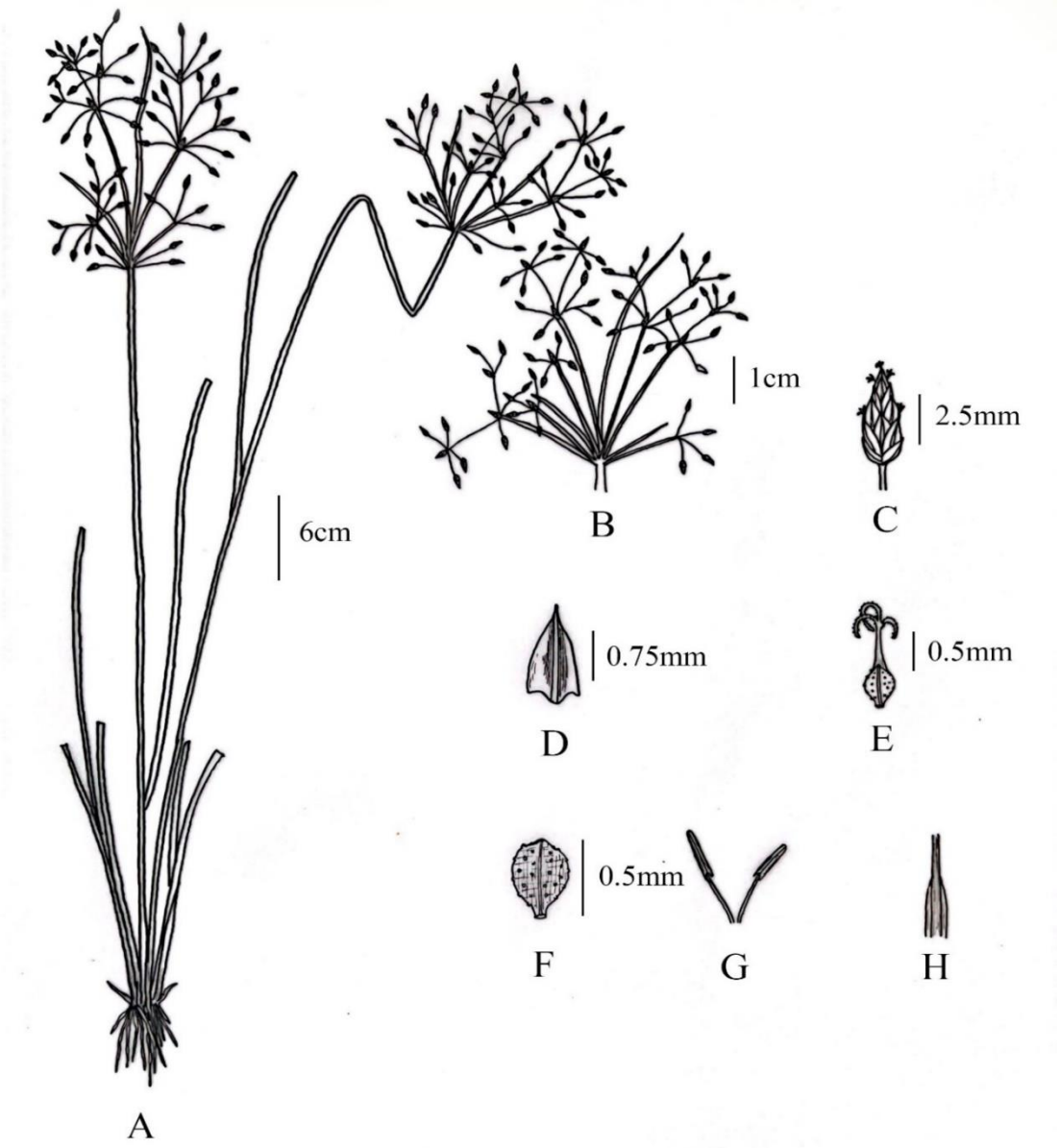


Figure 16: *Fimbristylis quinquangularis* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal and Y.B. Poudel LD5(TUCH)).

16. **Fimbristylis rigidula** Nees in Wight, Contr. Bot. India: 99 (1834). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978).

Fimbristylis hanceana Boeckeler, Linnaea 38(4): 394. 1874

Type specimen: Nepalia, Wallich 3519 (Lectotype: CAL)

Perennial, rhizome thick, woody and shortly creeping, blackish brown in color, 1-2cm long, covered with remains of old leaf sheaths. Culms erect, 10- 30cm, not tufted, solitary, grooved, basally swollen, covered with old leaf sheaths. Leaves shorter than culm. Ligule present; leaf sheath 2-3cm long, closed, glabrous with rusty marks. Leaf blade linear, 50- 120 ×1.5-2mm, grayish green, apex acute, margin minutely serrate, surface glabrous. Involucral bracts leaf like 3- 5in numbers, 1-2 ×0.5-1cm, shorter and sometimes longer than inflorescence, apex obtuse, margin serrate, surface covered with black and brown specks, glabrous. Inflorescence simple or sometimes compound, 1- 1.5cm long, rays 3-6 in numbers, 0.5-1.5cm. Spikelets solitary, ovoid-ellipsoid, 4-7 × 2-3mm. Glume dark brown in color, ovate-broadly ovate, spirally arranged, 2-3 × 1-1.5mm, apex acuminate, 3-veined, also with many lateral veins, margin hyaline, keeled, glabrous. Basal glumes empty. Stamens 2-3. Style 2-3mm, long and compressed, basally flattened, apically densely ciliate. Stigmas 2, half the length of style ca. 1mm, sparsely ciliated. Nutlet obovoid, biconvex, ca.1mm, creamy white in color, with fine hexagonal reticulation, non- verruculose, very short stipe present. (Figure 17 and Photoplate 25)

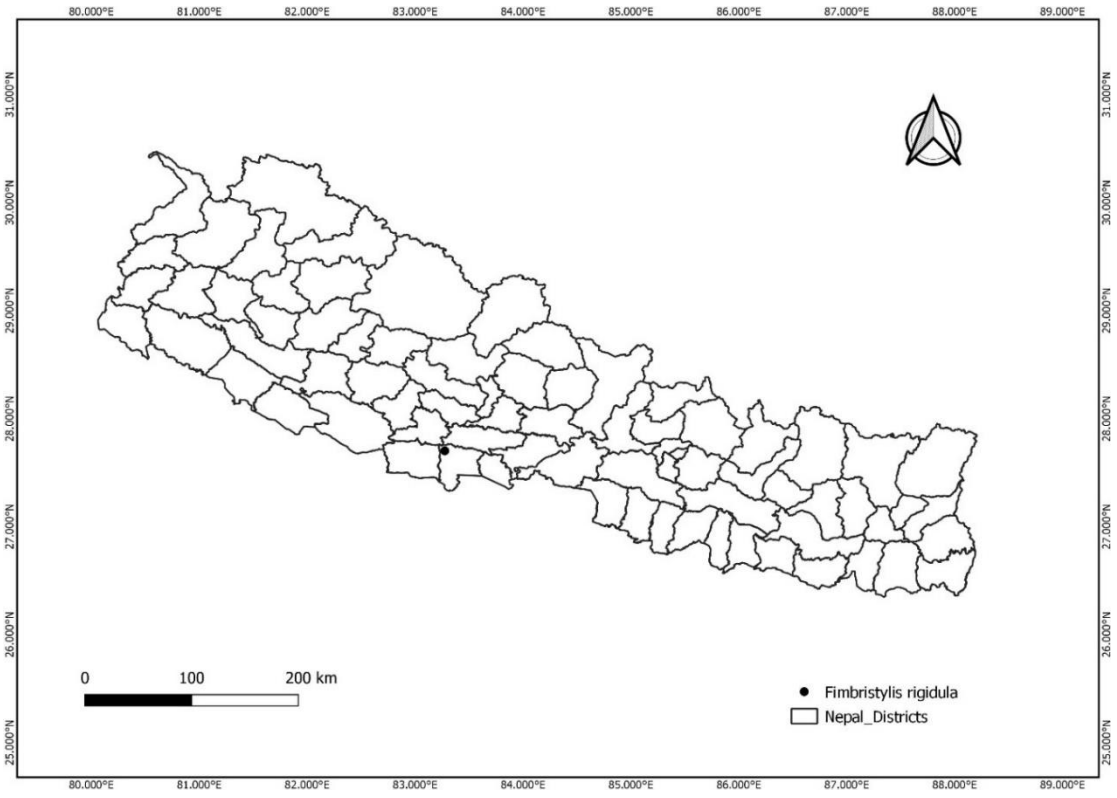
Distribution range: Nepal (C) (Map 17), Assam- Burma, S Asia, E Asia, E Himalaya, SE Asia

Elevation: 100-1200m

Ecology: Open Grasslands

Flowering and fruiting: Feb- July

Voucher specimen: Lumbini Province, Rupandehi District, Ramapur, 106m, 23 July 2021, S. Aryal, Y.B Poudel and K. Panthi KY1(TUCH).



Map 17: Distribution of *Fimbristylis rigidula* in Nepal Based on herbarium records.

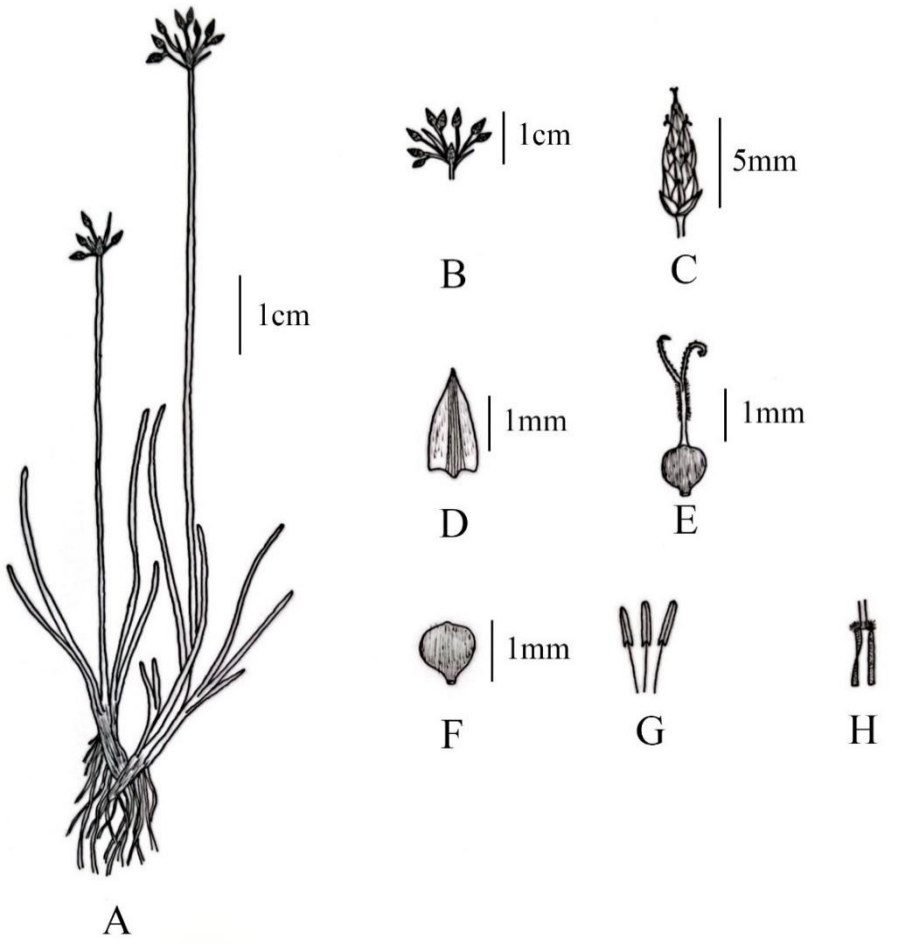


Figure 17: *Fimbristylis rigidula* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal, Y.B Poudel and K. Panthi KY1(TUCH)).

17. Fimbristylis salbundia (Nees) Kunth, Enum Pl. 2: 230. 1837.

Trichelostylis salbundia Nees, Contr. Bot. India 105. 1834

Type specimen: Silhet, N. Wallich 3526 (Lectotype: K)

Perennial, rhizome present, dark brown in color, short ca. 0.5-1cm. Culms erect, not tufted, 30-70cm long, 5- angled, glabrous. Leaves reduced to a bladeless sheath. Leaves eligulate; leaf sheath up to 20cm, pale brown in color, glabrous, tubular, closed, lanceolate apex. Involucral bracts 2 -3 in numbers, leaf-like, 0.5-1cm long, acute apex, margin slightly involute and sparsely spiny, glabrous. Inflorescence a compound anthela, 2-5 × 2-4cm with 2-4rays, rays 1-2cm long, glabrous. Spikelet solitary, dark brown in color, ovoid, 3-5 ×1.5-2.5mm. Glumes light brown in color, 1.5-2mm × 1-1.5mm, elliptic- ovoid, spirally arranged, many flowered, 3-veined, with dark brown mid rib forming an abaxial keel, apex acute, margin hyaline, glabrous. Stamens 3. Style 1- 1.5mm, basally flattened, not ciliated. Stigmas 3 as long as style, ca. 1.5mm, ciliated. Nutlet broadly obovoid, trigonous, dark brown in color, ca.1mm, with 7-8 oblong reticulation on each side, estipitate, sparsely verruculose, stipe indistinct. (Figure 18 and Photoplate 26)

Distribution range: Nepal (W &C) (Map 18), Assam- Burma, S Asia, E Asia and SE Asia

Elevation: 700- 900 m

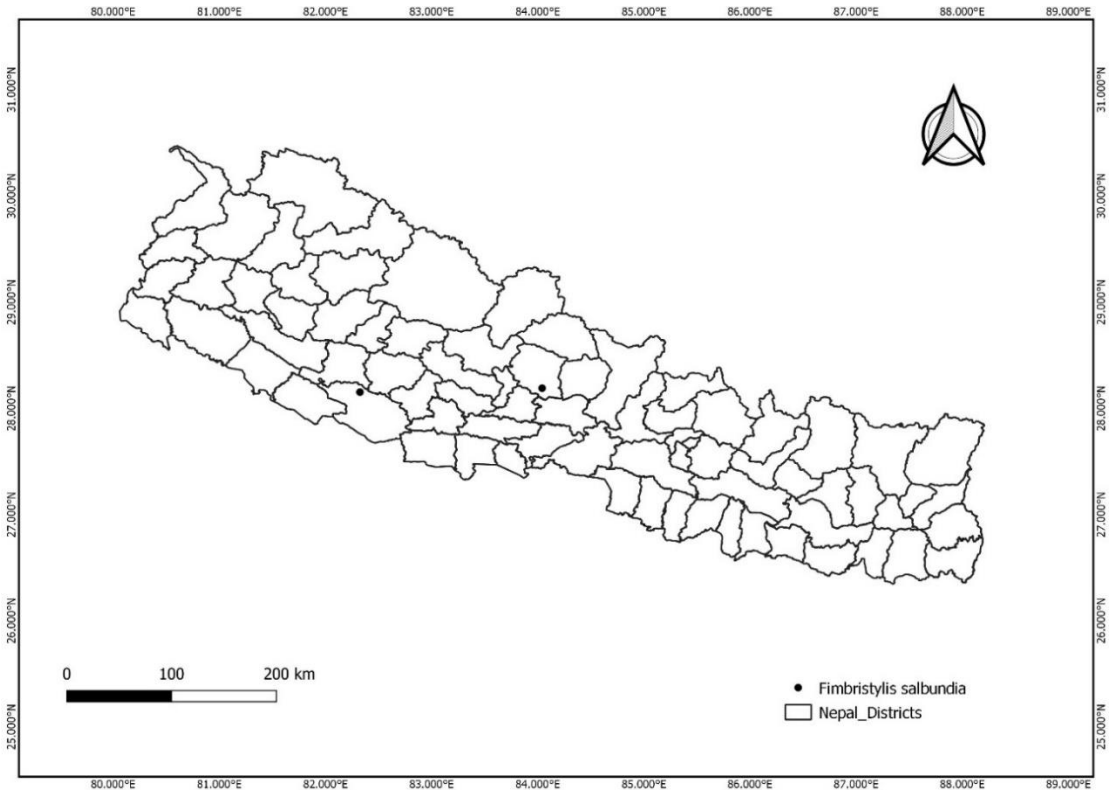
Ecology: Grows in Marshy areas

Flowering and fruiting: July- December

Voucher specimen: Gandaki Province, Kaski District, Pokhara, Gunde Lake, 760m, 30 Dec 2020, P. Bhandari and N.L. Bhandari 20123005 (KATH, TUCH).

Specimen examined:

Central Nepal: Lumbini Province, Dang District, Damargaun, Angare, 835m, 17 Dec 2020, B. Subedi 20121704 (KATH); Gandaki Province, kaski District, Pokhara, Gunde Lake, 760m, 30 Dec 2020, P. Bhandari and N.L. Bhandari 20123005 (KATH, TUCH).



Map 18: Distribution of *Fimbristylis salbundia* in Nepal based on herbarium records.

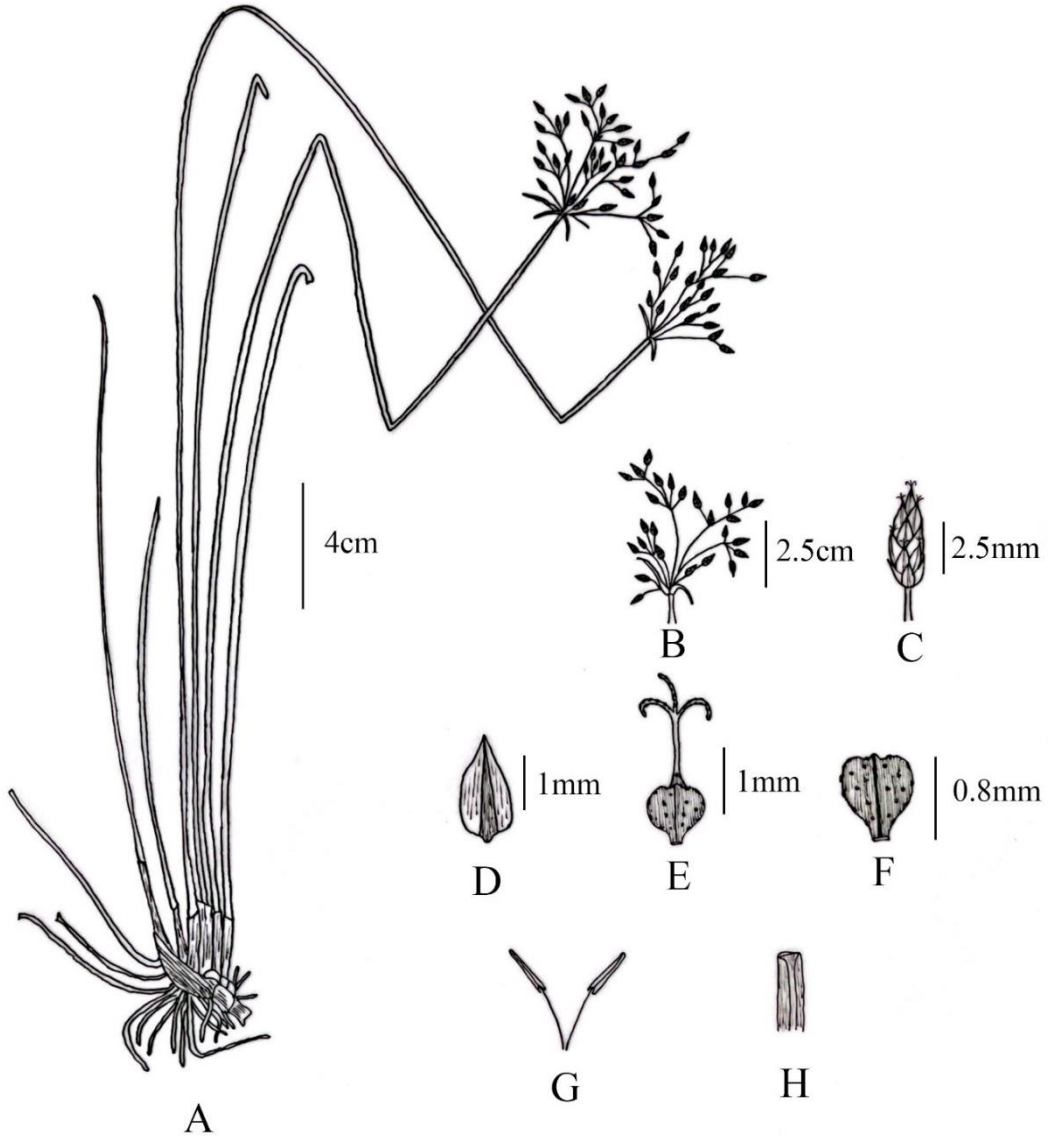


Figure 18: *Fimbristylis salbundia* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on P. Bhandari and N.L. Bhandari 20123005 (KATH, TUCH)).

18. **Fimbristylis schoenoides (Retz.)** Vahl, Enum. Pl. 2: 286 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Scirpus schoenoides Retz., Obs. Bot. 5: 14 (1788)

Type specimen: India, Koenig s.n. (Holotype: C)

Annual or short-lived perennial herbs, very short rhizome present, pale reddish in color. Culms erect, 10 to 30cm, tufted, deeply grooved, irregular angled. Leaves shorter than culms, ca. ½ of the culm length. Leaves ligulate; leaf sheath 2-4cm long, light yellow in color, glabrous, opened, margin entire. Leaf blade linear,10-25cm × 0.5- 1.2mm, apex obtuse, margin densely serrated, slightly involute, both surface glabrous. Involucral bracts 1 or 2, leaf like, longer than inflorescence, linear up to 4cm. Inflorescence a simple anthela, terminal with 1- 2 or 3 spikelets. Spikelets yellowish white, solitary, ovoid, 5-7 × 2.5-3.5mm. Glume yellowish white, 3- 4 × 1.2-1.5mm, spirally arranged, membranous, not keeled, glabrous, apex attenuate, glumes with brown short lines on abaxial side. Stamen 3. Style 1.5- 2mm, basally flattened, apically ciliate. Stigmas 2, shorter than style ca. 1mm, ciliated. Nutlet shiny yellowish brown when mature, globose to subglobose, ca. 1.5mm, biconvex with hexagonal reticulation, non- verruculose, stipitate; stipe 0.2- 0.3 mm long. (Figure 19 and Photoplate 27)

Distribution range: Nepal (C & E) (Map 19), E. Himalaya, Assam- Burma, S Asia, E Asia, SE Asia, Africa and Australasia

Elevation: 98m- 1800m

Ecology: Around paddy fields

Flowering and fruiting: May- Oct

Voucher specimen: Lumbini Province, Rupandehi District, kharmendipur, Gaidahawa, 98m, 3 August 2020, S. Aryal and Y.B. Poudel 4CN4 (TUCH); Lumbini province, Rupandehi District, Ranibagiya, 121m, 24 Aug 2020, S. Aryal MG5 (TUCH). Lumbini Province, Rupandehi District, Ramapur, 106m, 23 July 2021, S. Aryal, Y.B Poudel and K. Panthi KY4(TUCH).

Specimen examined:

Central Nepal: Gandaki province, Baglung and Myagdi District, Baglung (960m)- Ratnechour (820m)- Beni(840m), 1 Sept 1996, , M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9682067(KATH); Gandaki province, Myagdi District, Dharapani(1550m)- Takum(1650m)- Sibang(1750m)- Dharakhola(1640m)- Muri(1820m), 4 Sep 1996, M. Mikage, R. Hirano, N. Kondo, R. Lacoul, C. Mohri, A. Takahashi and K. Yonekura 9687107 (KATH); Gandaki Province, Parbat District, Between Khaniyaghat and Benari, Near Kushma, 696m, 27 Sept 1976, C.H. Tabata, K.R. Rajbhandari and K. Tsuchiya 3978(KATH).

Eastern Nepal: Province No.1, Sunsari District, Koshitappu, ca.60m, 5 May 2005, N. Acharya and K.R. Bhattarai 200529(KATH);); Province No.1, Sankhuwasabha District, Arun Valley, Ridge Between Khandbari and Bhotebas, 1550m, 18 Sept 1991, D.G. Long, R.J.D. McBeath, D.R. McKean, D.A.H. Rae and N.K. Bhattarai 27(KATH); Province No.1, Sankhuwasabha District, Arun River at Chokkrang Bridge near Syiksilla, 14 Oct 1991, D.G. Long, R.J.D. McBeath, D.R. McKean, D.A.H. Rae and N.K. Bhattarai 804(KATH); Province No.1, Bhojpur District, Bungling, 440m, 14 Sept. 1989, K.R. Rajbhandari 13570(KATH); Province No.1, Sankhuwasabha District Kyawa Khola- Sabha khola , 320m, 14 Aug 1997, S. Noshiro, N. Acharya, Y. Ibaragi, K. Kobayashi and T. Kurosawa 9770081(KATH); Province No.1, Taplejung District, Tamur River near Chhiruwa, 1350m, 3 Sept. 1989, C.G. Wilson, S. Zmarzty, M. Sinnott, D. Long, R. McBeath, H. Noltie and M. Subedi 185(KATH)

Map 19: Distribution of *Fimbristylis schoenoides* in Nepal based on herbarium records.

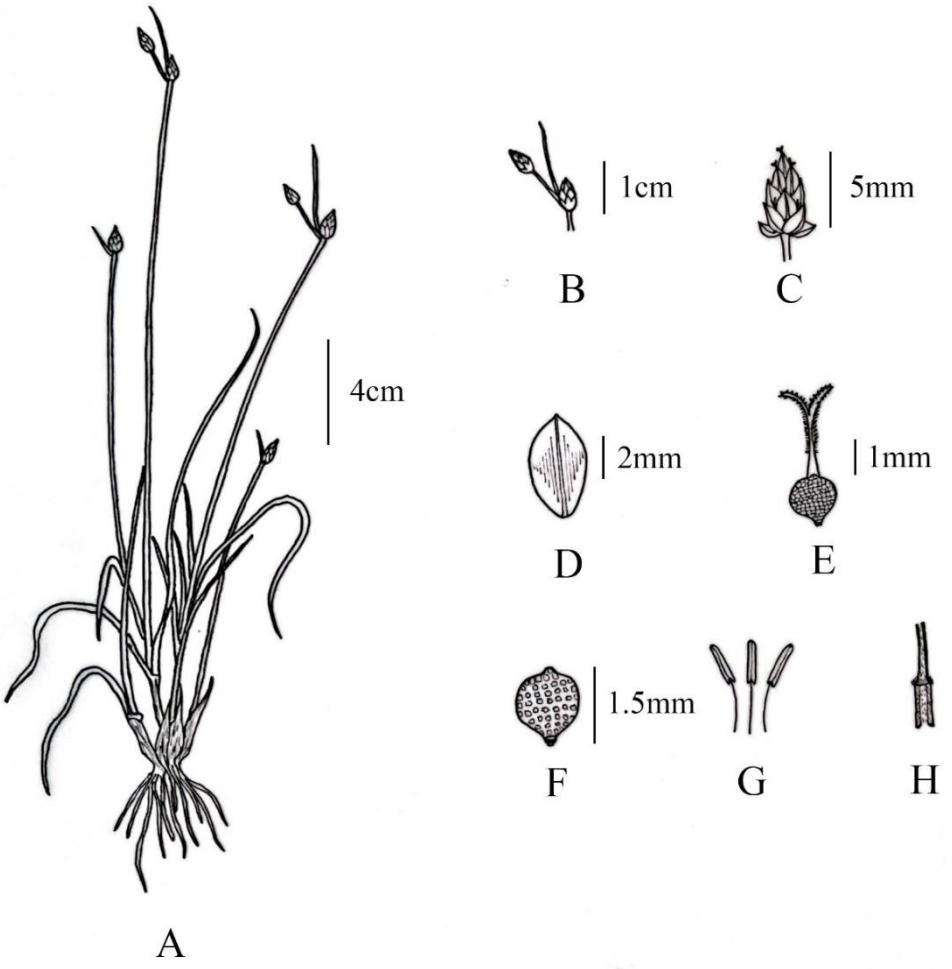


Figure 19: *Fimbristylis schoenoides* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H.** Leafsheath. (Based on S. Aryal MG5 (TUCH))

19. Fimbristylis squarrosa Vahl, Enum. Pl. 2: 289 (1805). Komaya in Hara et al., Enum. Flow. Pl. Nepal. 1: 112 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Fimbristylis comata Nees in Wight, Contrib. Bot. Ind.: 102 (1834)

Type specimen: America, Loefling s.n. (Holotype: C)

Annual, fibrous root present, 4-5cm long, dark brown in color. Culms slender, densely tufted, compressed, 5-7cm long, glabrous with few leaves at base. Leaves shorter or equaling the culm. Leaves ligulate; leaf sheath light brown in color, 0.5 -1cm long, opened, densely pubescent with white color hairs. Leaf blades filiform 2-5cm × ≤ 1mm wide, apex acute, margin involute, both surface pubescent. Involucral bracts 2-4, leaf-like, 5-20mm long, shorter to longer than inflorescence, apex acute, margin entire. Inflorescence a compound anthela, 1-1.5cm × 1-1.5cm with 3-6 rays; rays 0.5-1cm long. Spikelet solitary, ovoid, 1.5-5 × 1-2.5mm, 8-10 flowered. Glumes pale brown, 2.5-3.5mm × 0.5-1mm, spirally arranged, keeled, ovate-oblong, with 1mm long awn, sparsely pubescent. Stamen 1. Style 0.8-1mm apically hairy, basally flattened, with long pendant white hairs densely covering the top of nutlet. Stigmas 2, ciliated, ca. 0.5mm. Nutlet yellowish white, smooth, biconvex, 0.5-1mm, non- verruculose, stipe indistinct. (Figure 20 and Photoplate 28)

Distribution range: Nepal(E) (Map 20), W Himalaya, E Himalaya, Tibetean Plateau,Assam- Burma, S. Asia, E. Asia, , SE Asia, SW Asia and Australasia.

Elevation: 80-1500m

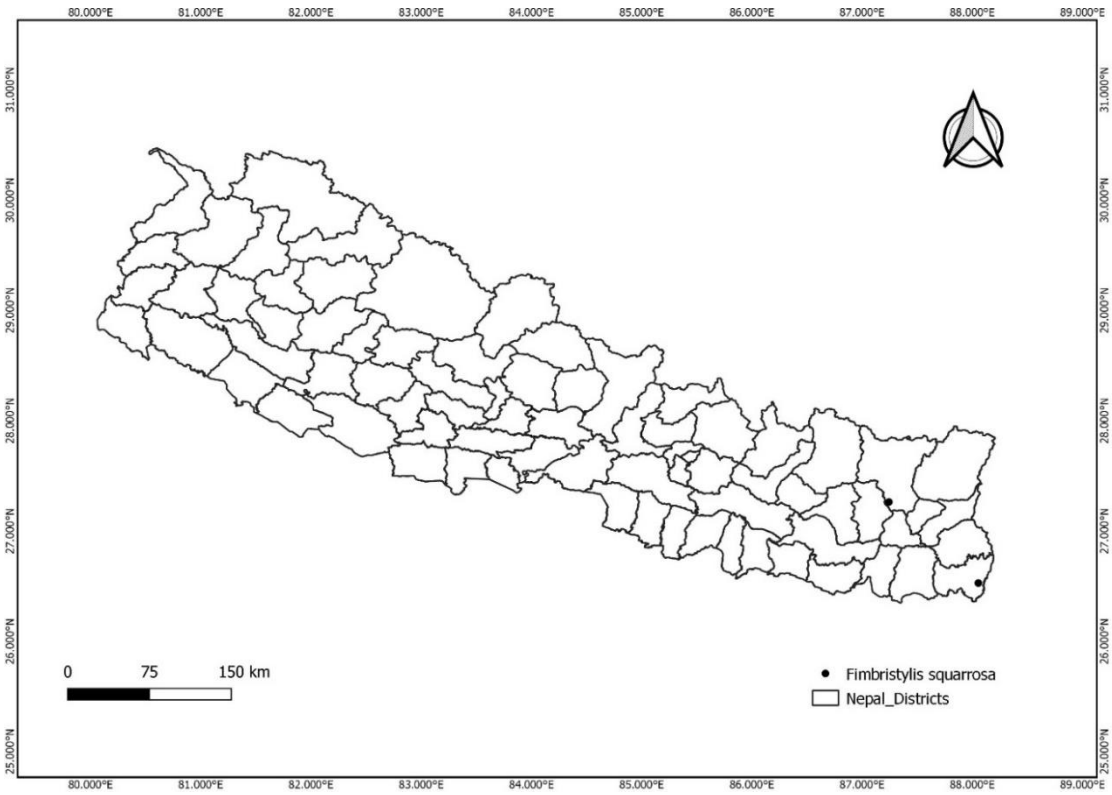
Ecology: Riverbank

Flowering and fruiting: August- October

Voucher specimen: Province No. 1, Jhapa District, Range Danda, Haldibari, 84m, 31st Aug 2021, Y.B. Poudel and K. Panthi JKY2(TUCH).

Specimen examined:

East Nepal: Province No.1, Sankhuwasabha district, Num N. of Chainpur, Arun valley, 4000ft., April 26, 1956, J.D.A. Stainton 141(KATH).



Map 20: Distribution of *Fimbristylis squarrosa* in Nepal Based on herbarium records.

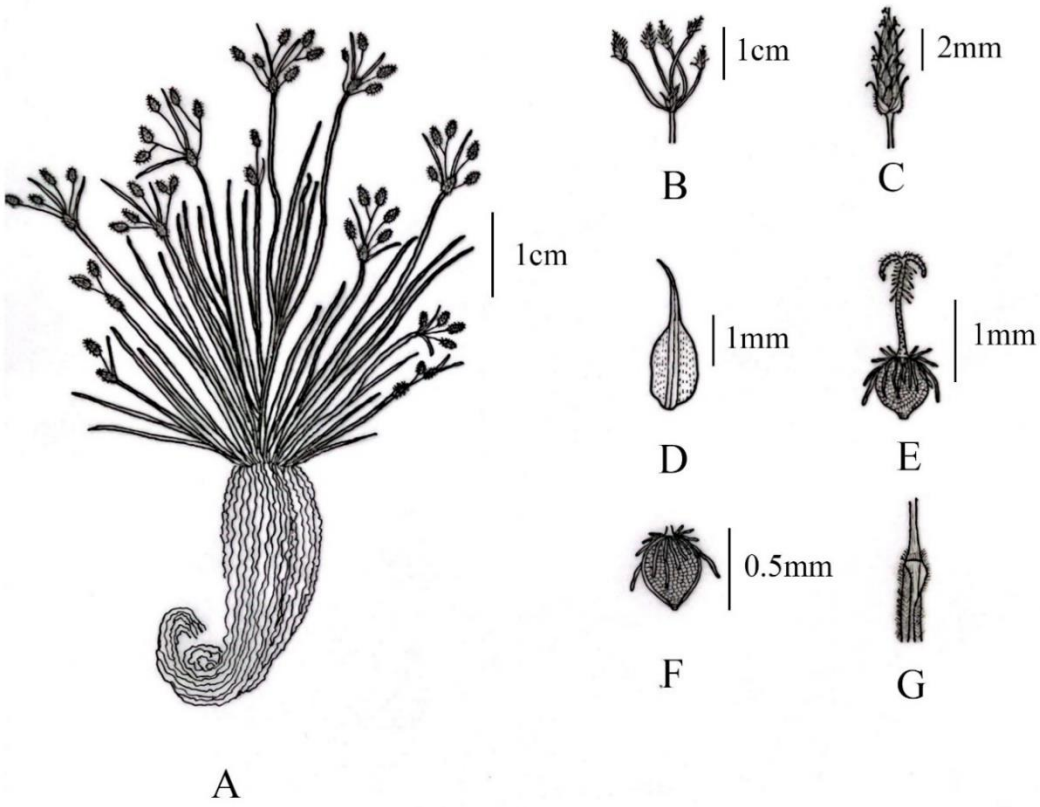


Figure 20: *Fimbristylis squarrosa* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. Leafsheath. (Based on Y.B. Poudel and K. Panthi JKY2(TUCH)).

20. **Fimbristylis stolonifera** C. B. Clarke in Hooker, Fl. Brit. India 6: 637 (1893). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978).

Type specimen: Nepalia, 1821, N. Wallich 3503A (Lectotype: K)

Perennial, Stolon present, slender and creeping covered with brown colored scales and old leaf sheaths, 2-4cm long. Culms erect, 30- 50cm long, tufted. Leaves shorter than culms. Leaves ligulate; leaf sheath pale yellow in color, 3-5cm long, glabrous with rusty marks, opened, hyaline. Leaf blade linear, 12-30 cm × 1-3mm, apex acute- obtuse, upper margin serrate, with black colored venation. Involucral bracts 3-5in numbers, leaf like, 2-7cm x 1-1.5mm wide, lower one longer or equaling the inflorescence, apex acute, margin serrate. Inflorescence simple or sub-compound anthela, 5-7 x 3-4cm, with 3-6number of rays; rays 2-3cm long. Spikelets solitary, oblong- narrowly ovoid, 3-5mm ×2-3mm with spirally arranged glumes. Glume greenish brown, 2.5-3 × 1-1.5mm, midrib green and shiny, apex acuminate, margin hyaline, glabrous, keeled. Stamens 3. style 1.5-2mm, densely ciliated, basally slightly flattened. Stigmas 2, shorter than style ca. 0.5-1mm, ciliated. Nutlet shiny, creamy white in color, obovoid, biconvex, ca.1mm with about 12 vertical rows per cell, non-verruculose, stipitate; stipe very short ca. 0.2mm. (Figure 21 and Photoplate 29)

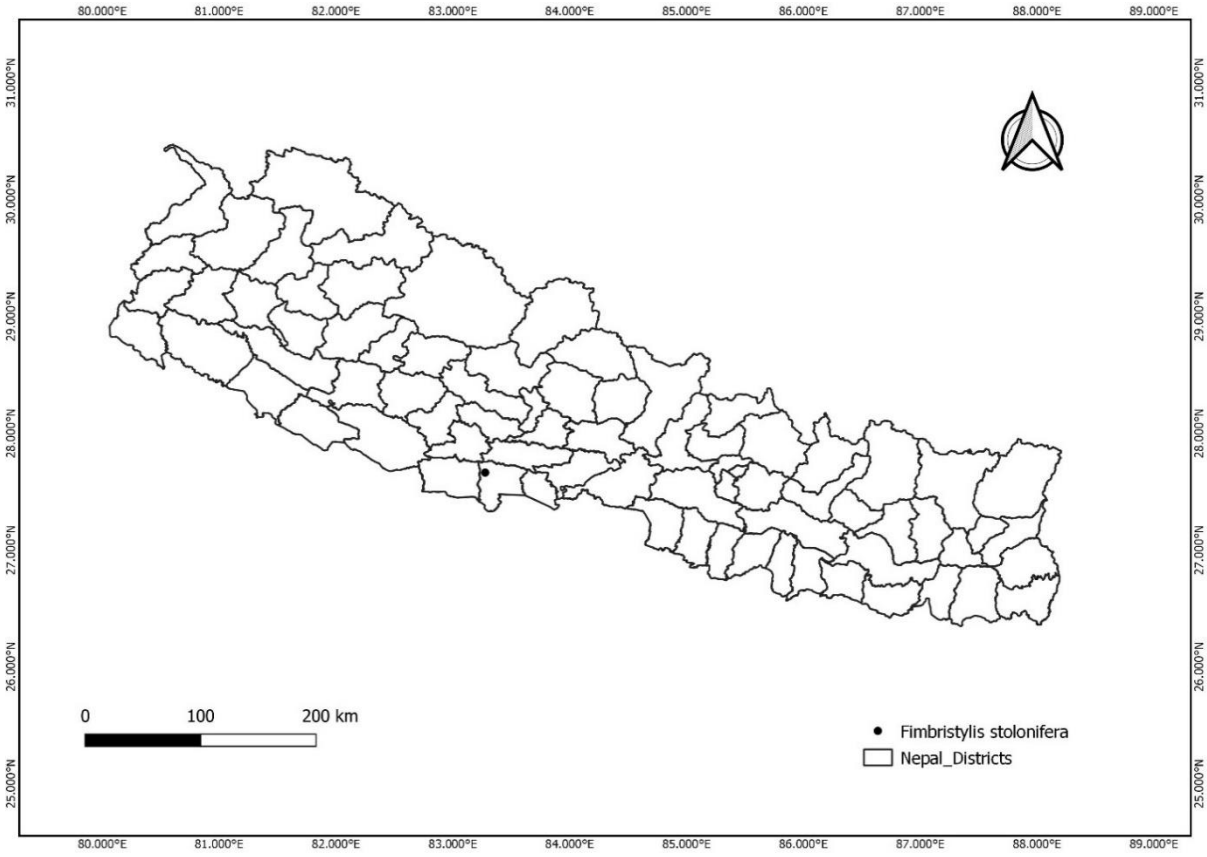
Distribution range: Nepal(C) (Map 21), E Himalaya, Assam- Burma, S Asia and E Asia.

Elevation: 100-2900m

Ecology: Marshy area

Flowering and fruiting: June- Sept

Voucher specimen: Lumbini Province, Rupandehi District, Ramapur, 106m, 23 July 2021, S. Aryal, Y.B Poudel and K. Panthi KY2(TUCH).



Map 21: Distribution of *Fimbristylis stolonifera* in Nepal Based on herbarium records

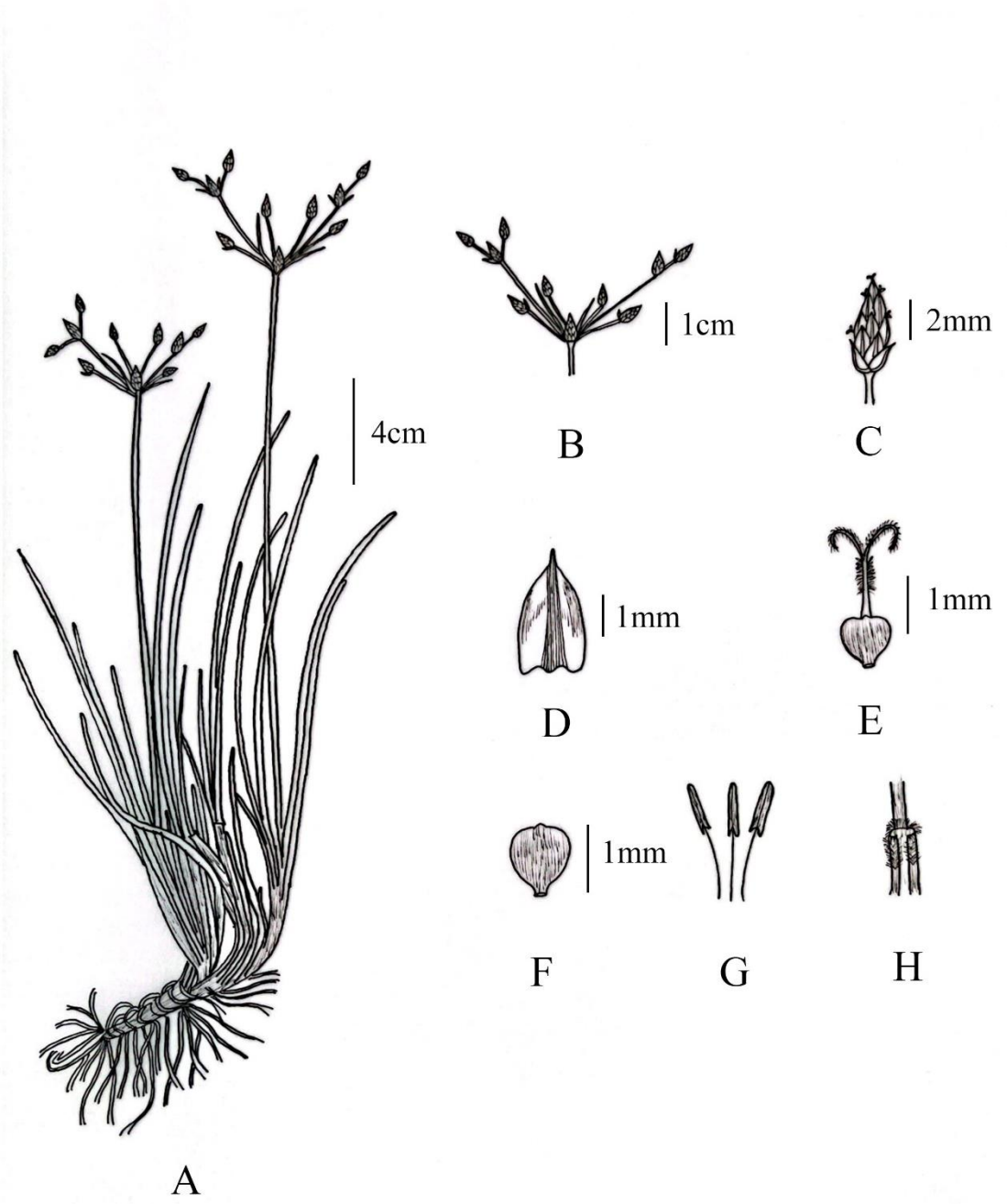


Figure 21: *Fimbristylis stolonifera* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H**. Leafsheath. (Based on S. Aryal, Y.B Poudel and K. Panthi KY2(TUCH)).

21. **Fimbristylis thomsonii** Boeckeler, Linnaea 37(1): 37. 1871

Type Specimen: India, Mount khasia, J.D. Hooker & T. Thomson 12 (Lectotype, designated by Dey and Halder 2015, pg. 230, 231: P)

Perennial herbs, rhizome present; rhizome 3-5cm long. Culms erect 20-25cm, not tufted, green in color, flatly 3-angled with many leaves at the base, glabrous. Leaves are shorter than culm. Leaves ligulate; leaf sheath pale brown, 2-5cm long, opened, glabrous on both side, bladeless sheath absent. Leaf blades flat, 5-15 × 2-3mm wide, apex acute, margin serrate, surface glabrous. Involucral bracts 2 or 3 leaf like, 1-3cm long, shorter than inflorescence, with acuminate apex. Inflorescence a compound anthela, 4-6 × 3-5cm, with 3-4 rays with more than 20 spikelets; rays 1-4cm long, slightly compressed. Spikelets solitary, elliptic, oblong to ovoid, 4-6 ×1.5-2.5mm, 8-10 flowered, reddish brown in color. Glumes reddish brown in color, ovate, boat shaped, spirally arranged, 3-4 × 2mm, keeled, mid-vein excurrent into a mucro; mucron 0.2mm, surface glabrous. Stamens 3. Style 2mm long, base flattened, not ciliated. Stigmas 3, as long as style ca. 2mm, sparsely ciliated. Nutlet yellowish shiny, trigonous, 1-1.2mm, with transversely oblong reticulation, verruculose, basal stipe very short. (Figure 22 and Photoplate 30)

Distribution: Nepal(C) (Map 22), E Himalaya, Assam- Burma, S Asia, E Asia and SE Asia.

Altitude: 1020m

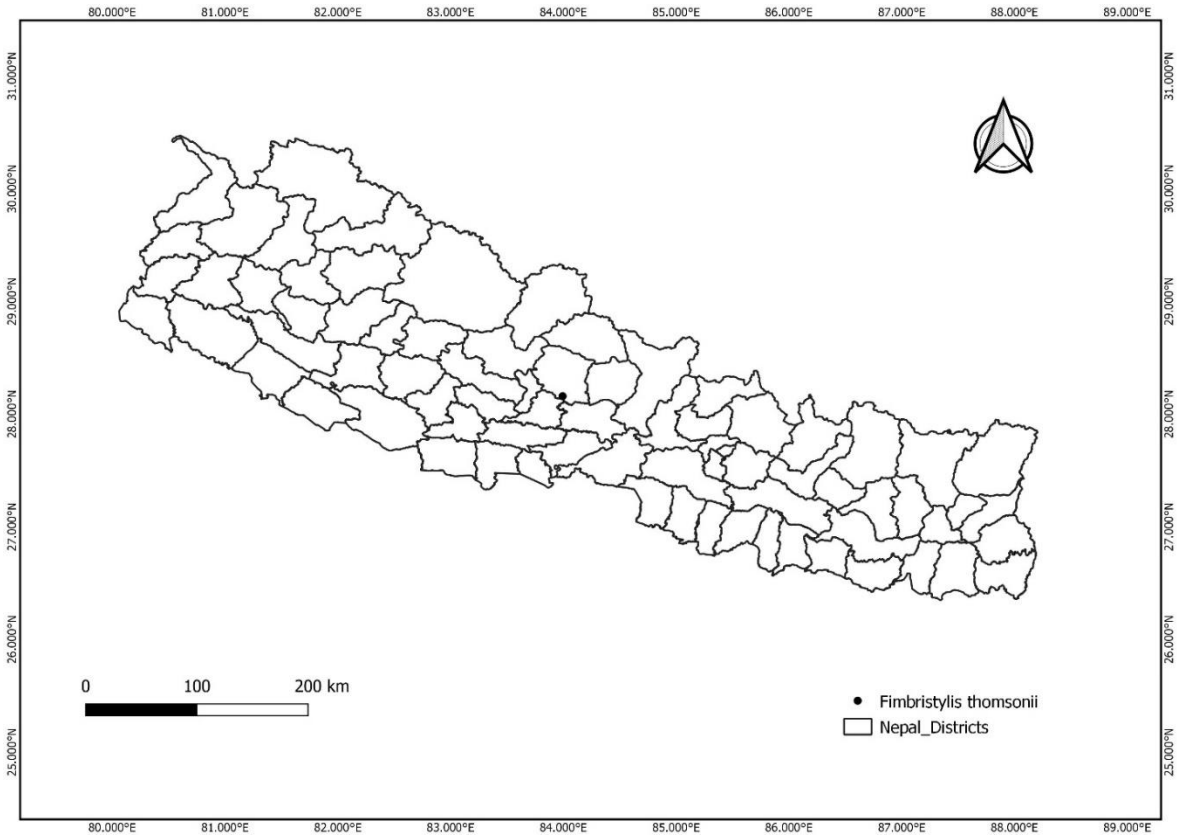
Ecology: Grows in grassland near *Schima- Castanopsis* forest

Flowering and fruiting: April

Voucher specimen: Gandaki Province, Kaski District, Pokhara, Kharchyang-Aghihare Community Forest, Bhirswara, 1020m, 25 April 2020, P. Bhandari & A. Bhandari KAS28 (KATH).

Specimen examined:

Central Nepal: Gandaki Province, Kaski District, Pokhara, Kharchyang-Aghihare Community Forest, Bhirswara, 1020m, 25 April 2020, P. Bhandari & A. Bhandari KAS28 (KATH).



Map 22: Distribution of *Fimbristylis thomsonii* in Nepal Based on herbarium records.

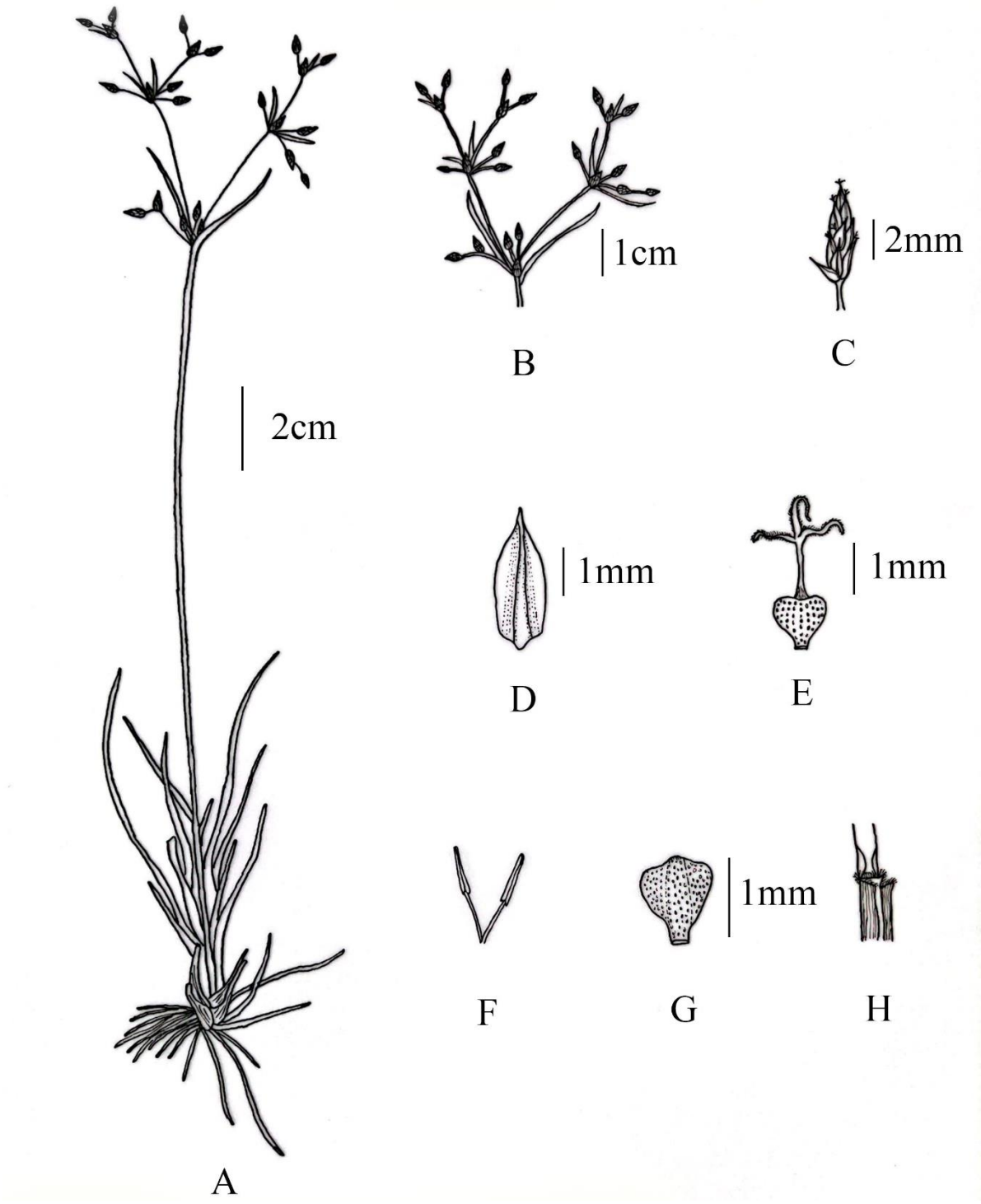


Figure 22: *Fimbristylis thomsonii* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens **H**. Leafsheath. (Based on P. Bhandari & A. Bhandari KAS28 (KATH)).

22. **Fimbristylis umbellaris** (Lam.) Vahl, Enum. Pl. 2: 291 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978). Rajbhandari in Rajbhandari & Baral. Cat. Nep. Fl. Pl. 1:96 (2010).

Scirpus umbellaris Lam., Tabl. Encycl. 1: 141 (1791)

Fimbristylis globulosa (Retz.) Kunth, Enum. Pl. 2: 231 (1837)

Scirpus globulosus Retz., Obs. Bot. 6: 19 (1791)

Type specimen:

Perennial herbs, rhizomatous; rhizome short, horizontal, covered with brown colored scales. Culms densely tufted, 17- 90 cm tall, obtusely 3- angled, smooth or striate, glabrous with 2 or 3 bladeless sheaths at base. Ligule reduced to a circle of hair or absent. Leaves of vegetative shoot shortly bladed. Leave sheath cylindric, 2- 19 cm, mouth obliquely truncate. Leaf blade linear, 7- 25cm x 1- 2mm. Involucral bract 2 or 3, leaf-like, narrowly lanceolate to lanceolate, longest 5- 11 mm, margin scarbid. Inflorescence simple or compound anthela, 1.5- 10 x 1.3 – 7cm , primary rays 2 – 10 , unequal , 0.7 – 5cm. spikelets solitary, 3- 40 per inflorescence , ovoid, broadly ovoid, broadly ellipsoid, or globose- ellipsoid, 3-8 x 3-4mm, densely many flowered. Glumes numerous, 1.8 -2.7 x 1- 1.5mm, spirally arranged, yellowish rust colored or brown, ovate to ovate- elliptic, membranous, 3-veined, scarcely keeled, apex obtuse to mucronate. Stamens 2 or 3. Style glabrous, basally flattened. Stigmas 2 or 3. Nutlet yellowish, obovoid to obovoid- globose, 0.8 -1mm, 3-sided to sometimes slightly compressed, rarely sparsely verruculose, shortly stipitate or sessile. (Figure 23)

Distribution: Nepal(C) (Map23), Assam-Burma, S Asia, E Asia and SE Asia.

Ecology: Marshy places, Wet ground

Altitude: 1500- 1600m

Nepali name: Gudmothe

Flowering and fruiting: June- October

Specimen examined:

Central Nepal: Rasuwa district, Dhunche- Syabrubensi, 1550m, 26th June 1970, H. Kanai & P. R. Shakya 672033 (KATH).

Map 23: Distribution of *Fimbristylis umbellaris* in Nepal based on herbarium records.

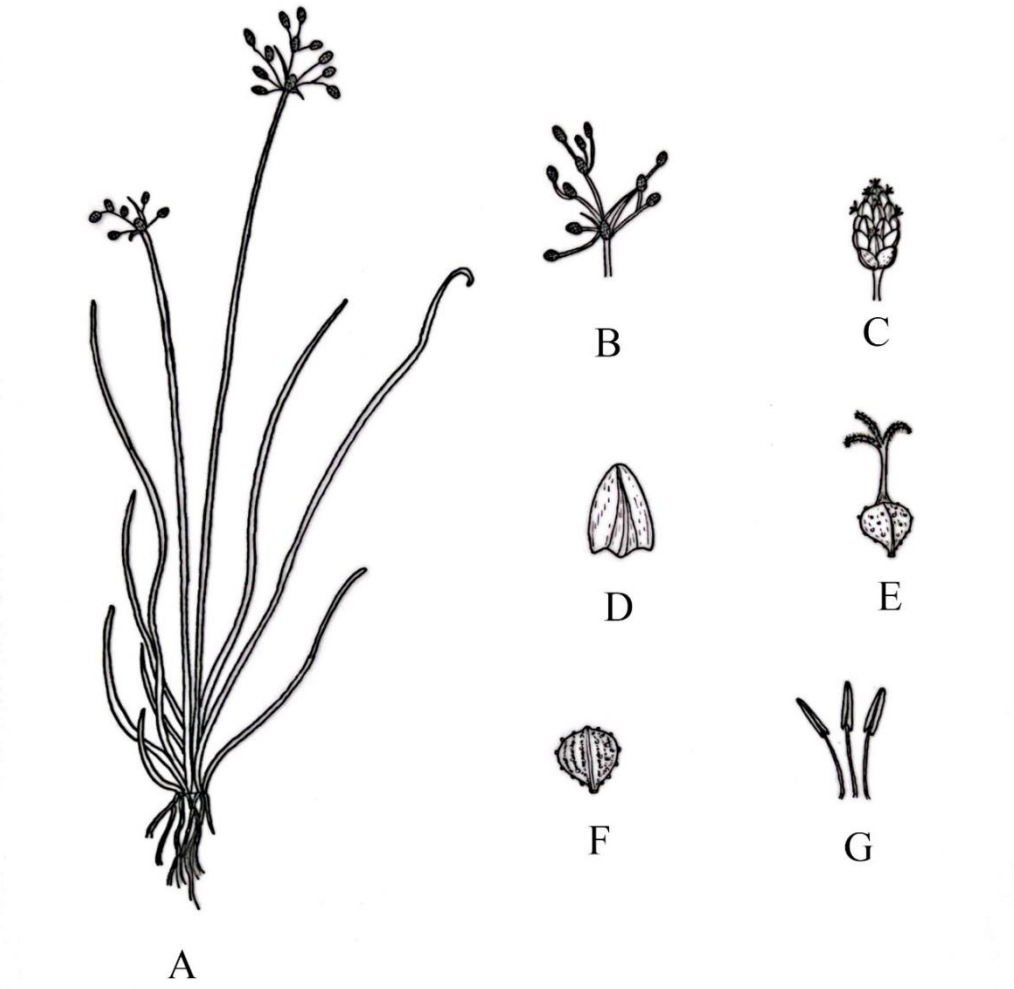


Figure 23: *Fimbristylis umbellaris* **A**. Habit sketch, **B**. Inflorescence, **C**. Spikelet **D**. Glume, **E**. Fruiting pistil, **F**. Nutlet and **G**. stamens. (Based on Flora of China).

Species studied from secondary literature.

23. **Fimbristylis fuscinux** C. B. Clarke in Hooker, Fl. Brit. India 6: 638 (1893). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

Perennial herbs, rhizome short, covered with old remain leaf sheaths. Culms erect, 20- 80cm, tufted, compressed- slightly quadrangular, smooth, glabrous. Leaves basal and sub- basal, half the length of culms. Leaves eligulate. Leaf blade linear, flat, ca. 2mm wide, apex subobtuse - apiculate, membranous. Involucral bracts leaf like, 2- 2.7cm long, shorter to longer than inflorescence. Inflorescence a compound anthela, 5.2 – 18 × 2- 9.5cm, with 3-4 rays, 3- 11cm long. Spikelets solitary, narrowly ovoid, 3.6 – 19 × 2.5 – 3.5mm. Glumes pale brown, spirally arranged, ovate, subacute, 1.6-2 × 1.2 – 1.5mm mucronate, keeled, midrib green, 3- veined, margin hyaline. Stamens 2-3 in numbers. Style ca. 0.8mm, not-ciliated, dark brown, slightly flattened towards base. Stigmas 2, nearly equaling style. Nutlet cream or brownish black in color, biconvex, 1- 1.3 × 1mm, broadly ovate, smooth, sparsely reticulated, non- verruculose.

Distribution range: Nepal, Assam- Burma, S Asia, E Asia and SE Asia.

Altitude: 500- 600m

Ecology: Open damp places along the track

Flowering and fruiting: August - October

4.3 Hierarchical cluster Analysis

A general technique to cluster analysis called hierarchical cluster analysis (or hierarchical clustering) aims to group together items or records that are close to one another. Discrete traits and character states that vary within a species were used in this study to analyse the relationships between the species. Altogether 40 characters were taken for the cluster analysis. With the help of IBM (SPSS, version 23.0) all the characters and character states were analysed. After the analysis, Dendogram was obtained where the species show the close relationship are shown together and species with different characteristics are present in different clusters. The character and character states are shown in Table no.1.

Table no.1 Character and character state coding for Hierarchical cluster analysis

S.N.	Characters	Coding
1	Habitat	0= Annual, 1=perennial, 2= Annual or perennials
2	Root	0= fibrous, 1= rhizomatous
3	Culms	0= solitary or not tufted, 1= tufted
4	Culms size	0= less than 50cm, 1= 50cm or more than 50cm
5	Culms angle	0= 3-sided, 1= 4 or 5-sided, 2= irregular or compressed
6	Culms base	0= with basal leaves, 1= bladeless leaf sheath
7	Leaf sheath	0=open, 1= closed
8	Leaf sheath type	0= ligulate, 1= eligulate
9	Leaf sheath size	0= less than 5cm, 1= 5cm or more
10	Leaf blade size	0= less than 10cm, 1= 10cm or more, 2= absent
11	Leaf blade apex	0= acute, 1= obtuse, 2= attenuate, 3= absent
12	Leaf blade margin	0= serrate, 1= smooth, 2= absent
13	Involucral bract	0= leaf like, 1= glume like, 2= absent
14	Involucral bract numbers	0= less than 4, 1= more than 4, 2= absent
15	Inflorescence type	0= simple anthela, 1= compound, 2= decompound anthela
16	Spikelet	0= single terminal, 1= less than 4 in numbers, 2= more than 4 in numbers
17	Spikelet size	0= less than 0.5cm, 1= 0.5cm or more
18	Spikelet texture	0 = glabrous, 1= pubescent
19	Glume arrangement	0= spirally arranged, 1= distichously arranged

20	Glume size	0= less than 3mm, 1= 3 mm or more
21	Glume color	0= yellowish white,1= pale green, 2= light or dark brown
22	Glume shape	0= ovate, 1=ovate/oblong - elliptic, 2= elliptic, 3= lanceolate
23	Glume apex	0= acute, 1= obtuse, 2= attenuate,3= apiculate,4= acuminate
24	Glume margin	0= hyaline, 1= not hyaline
25	Glume surface	0= glabrous, 1= pubescent
26	Glume veins	0= less than 3, 1= 3 or more than 3
27	Glum apex extension	0= mucro, 1= awn, 2= both absent
28	Glume base	0=keeled, 1= not keeled
29	Stamen number	0= less than 3, 1= 3 in numbers
30	Style size	0= less than 1mm, 1= 1mm or more
31	Style surface	0= glabrous, 1= pubescent
32	Stigmas number	0= 2 in numbers, 1= 3 in numbers, 2= 2 or 3 in numbers
33	Stigmas surface	0= cilated, 1= not ciliated
34	Stigmas size	0= less than 1mm, 1= 1mm or more than 1mm
35	Nutlet color	0= whitish – light yellow 1= dark brown- blackish
36	Nutlet shape	0= ovoid, 1= obovoid, 2=globose/subglobose, 3= elliptic
37	Nutlet length	0= less than 1mm, 1= 1mm or more
38	Nutlet texture	0= reticulate, 1= smooth
39	Nutlet surface	0= verruculose, 1= non- verruculose
40	Nutlet base	0= stipitate, 1= non stipitate

Dendogram

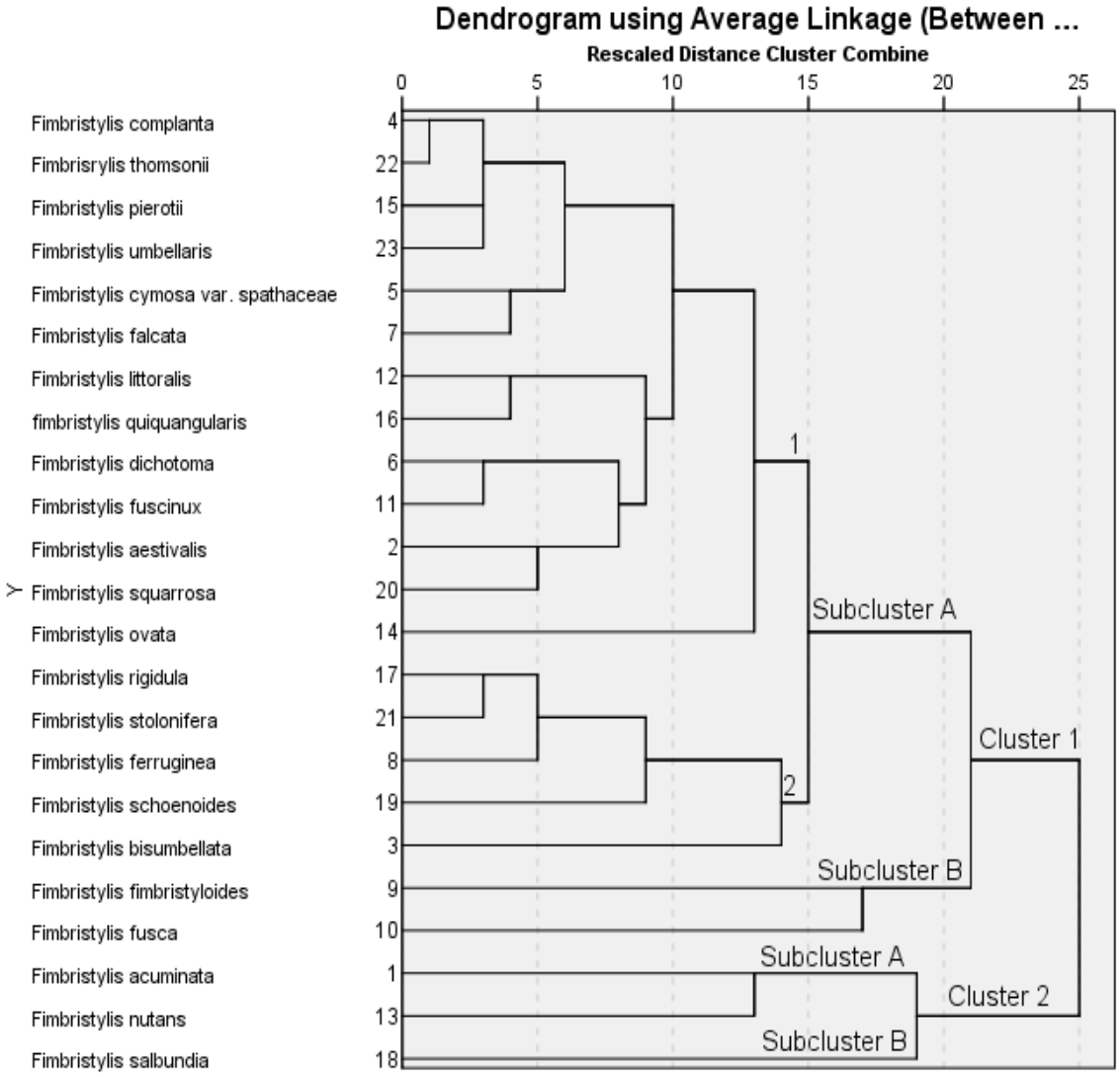


Figure 24: Dendogram showing the similarity among the species of *Fimbristylis*

From the above dendogram two main clusters are formed which are cluster one with 20 species (*F. aestivalis, F. bisumbellata, F. complanata, F. cymosa var. spathacea, F. dichotoma, F. falcata, F. ferruginea, F. fimbristyloides, F. fusca, F. fuscinux, F. Littoralis, F. ovata, F. pierotii, F. rigidula, F. schoenoides, F. squarrosa, F. stolonifera, F. thomsonii and F. umbellaris*) and cluster 2 with only 3 species which are are *F acuminata, F nutans and F, salbundia.* Leaf blades are the major characters for the formation of these two clusters. Leaf blades are

present in all 20 species of *Fimbristylis* whereas absent only in 3 species *F. acuminata, F. nutans and F. salbundia.*

In cluster two, two sub clusters are formed where *F. acuminata* and *F. nutans* lies on one cluster (Sub- cluster A) whereas *F. salbundia* lies in next cluster (Sub-cluster B), here the subcluster are formed on the basis of number of spikelets where *F. acuminata* and *F. nutans* have single solitary spikelet whereas *F. salbundia* have compound anthela with more than 20 spikelets.

In cluster one two sub clusters are formed where 18 species lies in one cluster (Sub- cluster A) and two species (*F. Fimbristyloides* and *F. fusca*) lies in one cluster (Sub- cluster B), here these two species are separated from others due to the presence of distichously arranged glumes and lanceolate glume shape . Again the subcluster is divided into two clusters where one Cluster consists of 13 species and next cluster consists of 5 species which are *F. rigidula, F. stolonifera, F. ferruginea, F. schoenoides and F. bisumbellata*, .these 5 species are shown closely related than rest of the 13 species because of ligulate leaf sheath, shape of glumes, size of style, same number of stigmas, surface of stigmas, color of nutlet, whereas surface of nutlet.

Out of those 13 species *F. complanata* is shown closely related to *F. thomsonii* due to presence of flat leaf blades, 3 stigmas, non- verruculose nutlet. *F. littoralis, F, quinquangularis* are closely related to each other due to presence of 4 and 5 angled culms. *F. falcata and F. cymosa* var *spathacea* are closely related due to the presence of clustered spikelets. Similarly *F. squarrosa* is shown closely related to *F. aestivalis* due to presence of pubescent leaf sheath and pubescent glumes and the main character that delimit them are the presence of long pendent hairs on style covering the nutlet on *F. squarrosa*.

4.4 Distribution pattern of genus *Fimbristylis* Vahl. in Nepal

Distribution Pattern of Fimbristylis were studied on the basis of Herbarium specimen deposited in KATH and TUCH and also from the personal collections. Most of the species of Fimbristylis are distributed in Central, Eastern or western regions. Only *F. squarrosa* is found to be restricted only in Eastern region. Out of 23 species *F. complanata, F. dichotoma, F. littoralis* and *F. ovata* are widely distributed species. Majority of species are found on central region which are *F. bisumbellata, F. ferruginea, F. fusca, F. nutans, F. pierotii, F. rigidula, F.*

stolonifera, F. thomsonii and *F. umbellaris*. Whereas 5 species *F. acuminata, F. aestivalis, F. fimbristyloides, F. quinquangularis* and *F. schoenoides* are found in the Central and Eastern region. And only *F. cymosa* var. *spathacea, F. Falcata* and *F. salbundia* are found in the central western region.

Table no.2: Distribution Pattern of *Fimbristylis* Vahl. species

Distribution pattern of Fimbristylis	**Species**
Widely distributed	*F. complanata, F. dichotoma, F. littoralis, F. ovata,*
Central species	*F. bisumbellata, F. ferruginea, F. fusca, F. nutans, F. pierotii, F. rigidula, F. stolonifera, F. thomsonii, F. umbellaris*
Eastern species	*F. squarrosa*
Central Eastern species	*F. acuminata. F. aestivalis, F. fimbristyloides, F. quinquangularis, F. schoenoides,*
Central Western species	*F. cymosa var. spathacea, F. falcata, F. salbundia*

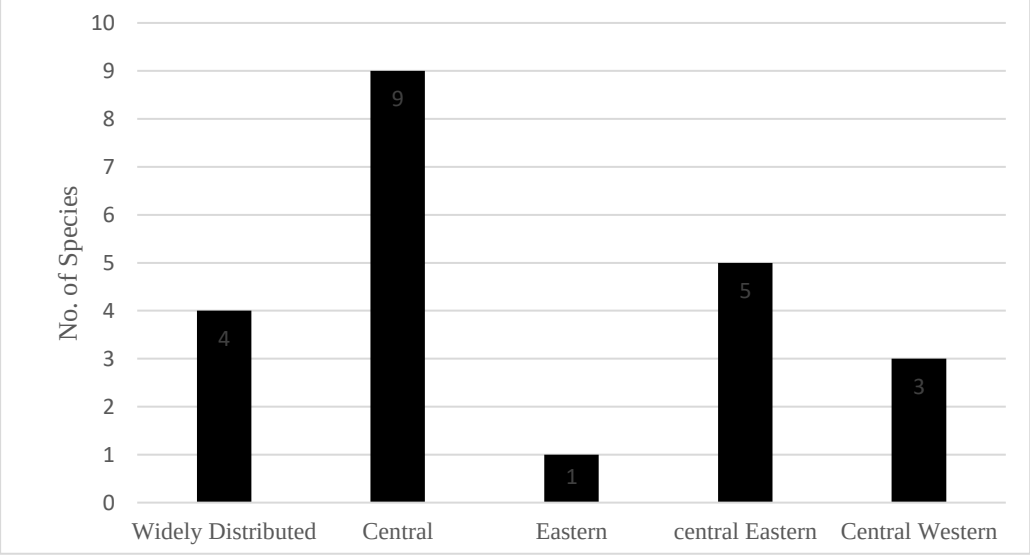


Fig 25: Distribution pattern of species of genus *Fimbristylis* Vahl. in Nepal.

4.5 Phenology: Flowering and Fruiting

Phenology is the science that measures the timing of life cycle events for all organisms. It is difficult to know the exact time of flowering and fruiting but the overall estimation was done on the basis of herbarium specimen deposited at KATH and TUCH and also from the personal collection. The phenological period starts in February and ends in December. August and September were the peak months in which most of the species were found. In January no species were recorded. The longest period of flowering and fruiting was found in *F. bisumbellata* which lasts for 9months whereas shortest on *F. thomsonii*.

Table No. 3: Flowering and fruiting month of 23 species of *Fimbristylis* Vahl.

Name of species	Flowering To Fruiting Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F. acuminata	Jul- Dec							■	■	■	■	■	■
F. aestivalis	Mar - Aug			■	■	■	■	■	■				
F. bisumbellata	Mar- Nov			■	■	■	■	■	■	■	■	■	
F. complanata	Aug- Nov								■	■	■	■	
F. cymosa var. spathacea	Jun- Oct						■	■	■	■	■		
F. dichotoma	May-Nov					■	■	■	■	■	■	■	
F. falcata	Apr- sept				■	■	■	■	■	■			
F. ferruginea	Jul- Dec							■	■	■	■	■	■
F. fimbristyloides	Aug- Oct								■	■	■		
F. fusca	Jun- sept						■	■	■	■			
F. fuscinux	Aug- Oct								■	■	■		
F. littoralis	May-Nov					■	■	■	■	■	■	■	
F. nutans	Jul- Oct							■	■	■	■		

F. ovata	Jun- Sep												
F. pierotii	May-Sep												
F. quinquangularis	Aug- Oct												
F.rigidula	Feb- Jul												
F. salbundia	Jul- Dec												
F.schoenoides	May- Oct												
F. squarrosa	Aug- Oct												
F. stolonifera	Jun- Sept												
F. thomsonii	April												
F. umbellaris	Jun- Oct												

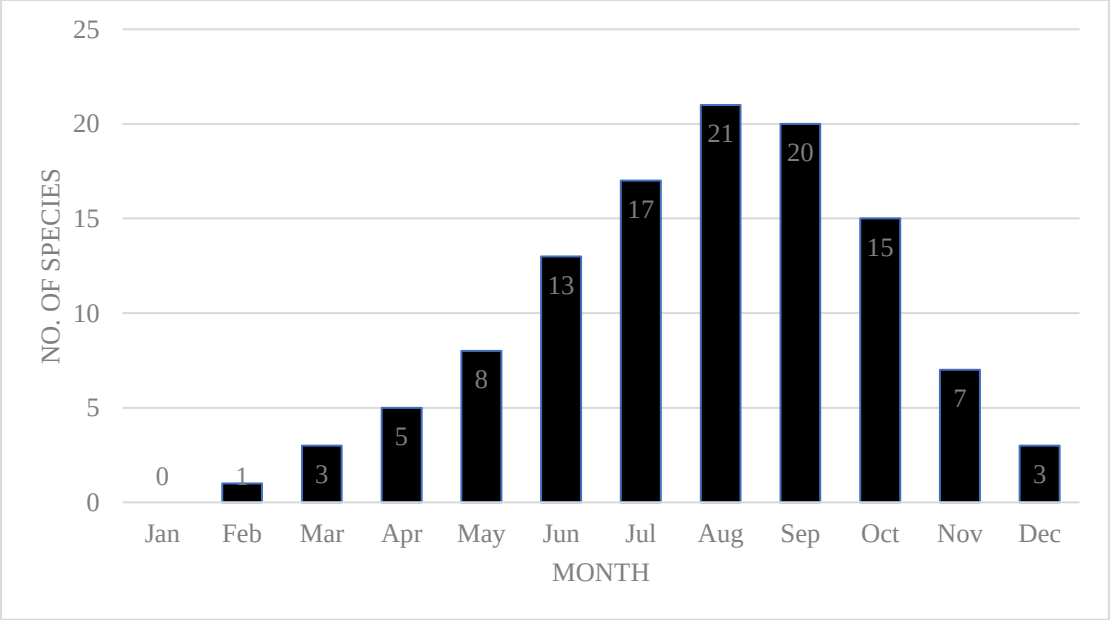


Fig No. 26: Number of Flowering and fruiting species at different months

CHAPTER 5: DISCUSSION

5.1 Taxonomy of genus Fimbristylis vahl.

Press et al. (2000) enumerated 16 species of *Fimbristylis*, Rajbhandari and Rai (2017), and Shrestha et al. (2018) listed 18 species from Nepal. Recently Shrestha et al. (2022) listed 23 species of *Fimbristylis* from Nepal. On this study 23 species of *Fimbristylis* are described. Among 23 species, 18 species are described based on the study of live plants and herbarium specimens. The remaining five are described based on the study of herbarium specimens deposited at different herbaria and review of relevant literatures.

The genus *Fimbristylis* is closely related to the genera *Abildgaardiia, Bulbostylis, Crosslandia*, *Nelmesia or Nemum* (Bruhl 1995, Goetghebeur 1998). However, based on the morphology, the genus *Fimbristylis* can be easily distinguished from other related genera by characters like nut forms, spikelets per inflorescence and glume forms. such as achene size and ornamentation, embryo form, floral scale form, having inflorescences with many spikelets, and deciduous style-base (Tucker 1987, Goetghebeur 1998). In this study the taxa are delimited based on the characteristics of culms, leaves, inflorescence type, spikelets, glumes, stigma number and nutlets. Similarly, Zhang et al. (2010), Grierson and Long (2001) and Hooker (1894) also emphasized these all characteristics for the delimitation of the taxa.

5.2 Vegetative characters

Both annual and perennial life forms are present in *Fimbristylis*. Among 23 species, 15 species are perennial with rhizome or stolons, and six species namely, *Fimbristylis acuminata, F. aestivalis, F. bisumbellata, F. fimbristyloides, F. quinquangularis* and *F. squarrosa* are annuals. *F. dichotoma* and *F. schoenoides* are annuals or short-lived perennials. But Zhang et al. (2010) considered *F. acuminata, F. liitoralis, F. quinquangularis* and *F. nutans* as annuals or short-lived perennials. Similarly, Grierson and Long (2001) described *F. littoralis* as an annual species and *F. bisumbellata* as perennial species. *F. stolonifera* is distinct from other taxa as it possesses stolons.

Culms is tufted in majority of the species and solitary only in *F. rigidula* and *F. pierotii.* Culms angle or cross-section also helps in the delimitation of the species. It varies from 3-angle to 5-angled, and sometimes compressed/irregular angled. *F. littoralis* is differentiated from other species by having 4-angled culms, whereas *F. fimbristyloides,*

F. fusca, F. quinquangularis and F. salbundia have 5- angled culms. This result is similar to that of Zhang et al. (2010) and Grierson and Long (2001).

The presence and absence of leaf blades also helps in delimitation of the taxa. In *F. acuminata, F. salbundia* and *F. nutans* leaves are reduced to a bladeless sheath, which is the major characteristic to distinguish them from other taxa. The presence of curved leaf blades is the major characteristic of *F. fimbristyloides* to delimit it from other taxa. Leaf apex and margin do not play an important role in delimitation of taxa.

5.3 Reproductive Characters

Inflorescence plays a crucial role in delimitation of the taxa. Single terminal spikelet is the characteristic feature of *F. acuminata, F ovata and F. nutans*. Similarly, *F. fimbristyloides, F. ferruginea, F. pierotii, F. schoenoides* are characterized by their simple anthela. Glume-like involucral bract is present only in *F. ovata, F. pierotti and F. nutans*, and the rest 19 species have leaf-like involucral bracts of unequal sizes. Involucral bract is absent only in *F. acuminata*. These characters show the similarity with Zhang et al. (2010) and Grierson and Long (2001), Kral (2003).

Spikelets also play a major role in delimitation of the species. *F. falcata* having clustered spikelets can be easily distinguished from other taxa. Similarly, *F. cymosa var. spathacea* is also considered to have clustered spikelets sometimes. Thus, these are the unique traits of these two species. Hooker (1894) also emphasized solitary and clustered spikelets for the delimitation of the taxa. Spikelets in sedges vary in their shape, size, and color. Lanceolate spikelet shape of *F. acuminata, F. fimbristyloides and F. fusca* also helps in delimitation of the taxa. But the size of spikelet of *F. fimbristyloides* does not show similarity with the study of Zhang et al. (2010) and Grierson and Long (2001).

Apex, shape, size, color, and nature of glume is variable in *Fimbristylis* species. Glumes are arranged spirally, distichously or sub distichously. Arrangement of glumes is also one of the major characteristics for the delimitation of the taxa. Zhang et al. (2010) and Grierson and Long (2001) also emphasized the arrangement of glumes for the delimitation of taxa. The glumes are arranged spirally in 20 species and distichously arranged only in three species (*F. acuminata, F. fimbristyloides* and *F. fusca*). Zhang et al. (2010) considered *F. ovata* to have sub-distichous arrangement of glumes, but it is found to have distichous arrangement on this study. The shape and color do not play an important role in delimitation of the taxa. The glume is keeled in 15 species and not

keeled only in 8 species (Appendix 6). This character is also used for delimitating the taxa from one another, and construction of identification keys by Zhang et al. (2010).

Stamens number does not play an important role in delimitation of the taxa as it varies between 1 to 3. The pistil form is another important characteristic for the delimitation of the taxa. The number of stigmas is the major characteristic of *Fimbristylis* for the delimitation of taxa. Zhang et al. (2010), Grierson and Long (2001), Hooker (1894) and Kral (2003), Kukkonen (2001) also used the number of stigmas as the main character for the delimitation of taxa. The stigmas and style may be ciliated or non- ciliated.

Nutlet color, size, shape, and texture also varies between the *Fimbristylis* species. Nutlet shape and texture is mainly used for the delimitation of taxa. The majority of species have biconvex nutlet whereas the species with 3 stigmas (*F. complanata, F. falcata, F. fimbristyloides, F. fusca, F. littoralis, F. ovata, F. littoralis, F. quinquangularis, F. salbundia* and *F. umbellaris*) have trigonous nutlet. 12 species of *Fimbristylis* have verruculose nutlet whereas 11 have non- verruculose nutlet. Out of 23 species, only 4 species namely, *F. aestivalis, F. fuscinux, F. feruuginea* and *F. squarrosa* have smooth nutlet and rest of the species have reticulated nutlet. These characters of nutlet are also used for delimiting the taxa.

Grierson and Long (2001) recorded 17 species of *Fimbristylis* from Bhutan, including Sikkim and Darjeeling. Among them, 14 species are also recorded from Nepal (*F. acuminata, F. aestivalis, F. bisumbellata, F. complanata, F. dichotoma, F. falcata, F. fimbristyloides, F. fuscinux, F. littoralis, F. ovata, F. rigidula, F. schoenoides, F. stolonoifera* and *F. thomsonii*). They used morphological characters like number of stigmas, arrangement of glumes, number of spikelets, presence/ absence of leaf blades, presence/ absence of ligules and presence/ absence of rhizome and stolons for delimiting the taxa. In our study, all these characteristics are considered for the delimitation of the taxa and the taxonomic description of species is found to be similar.

Similarly, Zhang et al. (2010) recorded 53 species of *Fimbristylis* from China. Among them 20 species are also recoded from Nepal. In this flora the delimitation of taxa was done based on glumes arrangement, number of spikelets, number of stigmas, presence/ absence of leaf blades, presence/ absence of rhizome and stolons, solitary/ tufted culms. In the present study all these characteristics are used for delimitation of taxa.

Hooker (1894) recorded 58 species of *Fimbristylis* from British India. Among them 14 species are also recorded in Nepal. In this Flora taxa are divided in four sections, where

section one is Eleocharoides (stem with one spikelet), section two is Dichelostylis (style 2-fid), section three is Trichelostylis (style 3- fid), and section four is Abildgaardia (lower glume distichous). Further, section two and section three are divided into two series where series A consists of taxa with solitary spikelets and series B consists of taxa with clustered spikelets. So here spikelets and glumes character are used for delimiting the taxa.

Malla et al. (1986) recorded only two species of *Fimbristylis* (*F. complanata* and *F. dichotoma*) from Kathmandu, which are delimited based on branching of style and nutlet shape. The short description shows similarity to the present study.

5.4 Distribution

The distribution of *Fimbristylis* is documented across the entire country, from Eastern region to western region. Out of 23 species, *F. complanata, F. dichotoma, F. littoralis* and *F. ovata* are widely distributed species and are found in all regions i.e., western, central and eastern Nepal. The majority of species are recorded from central Nepal, which are *F. bisumbellata, F. ferruginea, F. fusca, F. nutans, F. pierotii, F. rigidula, F. stolonifera, F. thomsonii* and *F. umbellaris*. This study was also based mainly on the central region. Whereas five species *F. acuminata, F. aestivalis, F. fimbristyloides, F. quinquangularis* and *F. schoenoides* are recorded only from central and eastern Nepal. *F. cymosa* var. *spathacea, F. falcata* and *F. salbundia* are only recorded from central and western Nepal. *F. squarrosa* is the only species that is restricted only in the eastern Nepal. The distribution pattern of *Fimbristylis* was studied based on herbarium specimen deposited at KATH and TUCH, and from personal collections. Majority of collections are done from central Nepal. The vertical distribution of genus ranges from tropical to sub-alpine zone (70-3200 m), where *F. acuminata* is found to be reported from lowest elevation (70- 700 m) and *F. complanata* is found to be recorded from highest elevation (800-3200 m). Most species are reported from tropical to sub-tropical zones.

5.5 Hierarchical Cluster Analysis

Based on the Dendogram obtained, two main clusters have been created, where cluster one consists of 20 species and cluster 2 consists of only 3 species. These three species are separated from the rest of the 20 species due to the presence of bladeless leaf sheath and leaf blades are present in rest of the 20 species of cluster 1.

Two subclusters are formed in cluster two based on number of spikelets and inflorescence type where *F. acuminata* and *F. nutans* are present in one subcluster due to the simple type of inflorescence with single terminal spikelets and *F. salbundia* is present in another sub- cluster due to the presence of compound anthela with many spikelets.

Similarly, cluster one is also divided to two sub clusters where 18 species are present in one subcluster and two species are present in another sub-clusters, here these two species are separated from rest 18 species due to the glume shape and arrangement cause lanceolate shape and distichous arrangement of glume is present in these two species which are *F. fimbristyloides* and *F. fusca*.

Again, subcluster A is further divided into two, here *F. complanata* is shown closely related to *F. thomsonii* due to presence of flat leaf blades, 3 stigmas, non- verruculose nutlet. *F. littoralis, F. quinquangularis* are closely related to each other due to the presence of 4 - 5 angled culms. *F. falcata* and *F. cymosa* var. *spathacea* are closely related due to the presence of clustered spikelets. Similarly, *F. squarrosa* is shown closely related to *F. aestivalis* presence of pubescent leaf sheath and pubescent glumes, main character that delimit them are the presence of long pendent hairs on style covering the nutlet of *F. squarrosa*. So, the presence/absence of leaf blades, leaf shape, culms angle, spikelets numbers, glumes shape and arrangement, style surface are the major characteristics to delimit taxa from one another.

5.6 Phenology: Flowering and fruiting

The reproductive phenology of *Fimbristylis* starts in February and ends in December. August and September were the peak months in which most of the species were found. In January, no species were recorded flowering and fruiting. The longest period of flowering and fruiting was recorded in *F. bisumbellata*, which lasts for about nine months whereas, shortest on *F. thomsonii* (April). In most species, the fruiting period ends before November.

5.7 Nomenclature changes

Press et al. (2000), recorded 16 species of *Fimbristylis* from Nepal. But, Rajbhandari and Rai (2017) recorded 18 species of *Fimbristylis* based on available herbarium records, and provided information on distribution of the species within the country, along with their synonyms. Also, the same 18 species of *Fimbristylis* have been listed by Shrestha et.al. (2018). The two additional species of *Fimbristylis* which were added

by Rajbhandari and Rai, (2017) and Shrestha et al. (2018) are *Fimbristylis cymosa* var. *spathacea* and *Fimbristylis fuscinux*. Also, *Fimbristylis miliacea* listed by Press et al. (2000) is now considered as *Fimbristylis littoralis*. Recently Shrestha et al. (2022) listed 23 species of *Fimbristylis*, five new records of *Fimbristylis* species were added. Five new records of *Fimbristylis* species were listed on "Taxonomic notes on Cyperaceae of Nepal: new records of a genus, six species and other noteworthy species" Bhandari et al. (2021), which are *F. acuminata, F. ferruginea, F. nutans, F. salbundia* and *F. thomsonii*. So altogether 23 species of *Fimbristylis* were well described and treated taxonomically in this dissertation.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The present study recognized 23 species of *Fimbristylis* from Nepal. Out of which 22 species were studied by examining the personal collections as well as herbarium deposited in KATH and TUCH whereas only one species with the help of different secondary literatures due to lack of herbarium species in KATH and TUCH.

As already described many morphological, both vegetative and reproductive characters play a crucial role in delimitation of the taxa. In present taxonomic work characters like roots(type and texture), culms (height, texture, shape, solitary or tufted), ligule (presence / absence), leaf blades (shape, size , texture, surface, margin, apex), leaf sheath (presence/ absence), Inflorescence(terminal, compound or decompound), rays (size and numbers), Involucral bracts (size, shape, apex, numbers, texture, surface), spikelets (shape, size, numbers, color), glumes (shape, size, color, arrangement, number of veins , apex, surface), stamens (number), stigma(number, size, ciliated or not), style (size, shape, ciliated or not), nutlet (shape, size, color, texture, stipitate or not, reticulated or smooth) were studied. With the help of the above characteristics taxonomic keys were prepared for the easy identification of the taxa.

The hierarchical cluster analysis helped in analysing the relationship between the species based on the morphological characters, where the species having common characteristics shows the close relationship whereas species with different characteristics shows the distant relationship.

6.2 Recommendations

The present study is based on the collections from Eastern and Central Nepal, and the herbariums deposited in KATH and TUCH. As very few research is done in monocots, more emphasis should be given to this type of work. So, if significant explorations are made in Nepal, it is possible to discover new species.

1. Finding protologue and type specimens has become challenging due to a lack of printed and online taxonomic literature, thus libraries should be maintained and new publications with standard taxonomic journals should be included.

2. Many of the specimens deposited at KATH and TUCH lack detailed information on their labels, thus labels that include most of the information about the herbarium specimens should be kept up to date.
3. Some of the specimens that foreign collectors have reported from Nepal have been stored in herbaria abroad, and even their duplicate are not found in Nepal. To ensure that the specimens that left the nation have a duplicate in Nepal, it is recommended that the plant quarantine office and the department of plant resources cooperate with the country's herbaria.
4. Many species of *Fimbristylis* are considered to have medicinal values but they are only considered as weeds and destroyed so awareness is necessary for proper utilization of these species.
5. Incorporating advanced tools can greatly improve revisionary work in botany and help integrate key components such as anatomy, palynology, cytology, and phytochemistry.

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APPENDICES

Appendix 1: Vertical and Distribution of *Fimbristylis* Vahl. in Nepal

S.N.	Name of Species	Altitudinal range	Distribution in Nepal
1	*F. acuminata*	70-700m	C&E
2	*F. aestivalis*	85-1600m	C&E
3	*F. bisumbellata*	100-1100m	Central
4	*F. complanata*	100-3200m	W,C&E
5	*F. cymosa var. spathacea*	300-800m	W&C
6	*F. dichotoma*	100-3000m	W,C&E
7	*F. falcata*	200-1200m	W&C
8	*F. ferruginea*	70-700m	Central
9	*F. fimbristyloides*	500-2300m	C&E
10	*F. fusca*	300-1500m	Central
11	*F. fuscinux*	500-600m	-
12	*F. littoralis*	100-1700m	W,C&E
13	*F. nutans*	700m	Central
14	*F. ovata*	100-1400m	W,C&E
15	*F. pierotii*	700-2400m	Central
16	*F. quinquangularis*	80-200m	C&E
17	*F. rigidula*	100-1200m	Central
18	*F. salbundia*	700-900m	W&C
19	*F. schoenoides*	98-1200m	C&E
20	*F. squarrosa*	80-1500m	Eastern
21	*F. stolonifera*	100-2900m	Central
22	*F. thomsonii*	1020m	Central
23	*F. umbellaris*	1500-1600m	Central

Appendix 2: Comparative study of Life forms, Plant height and culms angle

S.N.	Name of Species	Life form	Plant height	Culm angle
1	*F. acuminata*	Annual	10-25cm	Compressed
2	*F. aestivalis*	Annual	6-15cm	3 angled
3	*F. bisumbellata*	Annual	10-20cm	3 angled
4	*F. cymosa var. spathacea*	Perennial	10-60cm	3 angled
5	*F. complanata*	Perennial	35-60cm	3 angled
6	*F. dichotoma*	Annual Or Short Lived Perennials	5-100cm	Compressed
7	*F. falcata*	Perennial	10-35cm	3-angled at base
8	*F. ferruginea*	Perennial	30-50cm	Irregular angled
9	*F. fimbristyloides*	Annual	10-15cm	5 angled
10	*F. fusca*	Perennial	30-50cm	5 angled
11	*F. fuscinux*	Perennial	20-80cm	Compressed-quadrangular
12	*F. littoralis*	Perennial	30-80cm	4- angled
13	*F. nutans*	Perennial	50-60cm	Sub- cylindric
14	*F. ovata*	Perennial	10-35cm	Compressed
15	*F. pierotii*	Perennial	13-35cm	Flatly 3- angled
16	*F. quinquangularis*	Annual	50- 100cm	5- angled
17	*F. rigidula*	Perennial	10- 30cm	Compressed
18	*F. salbundia*	Perennial	30-70cm	5-angled
19	*F. schoenoides*	Annual or Short Lived Perennials	10-30cm	Irregular angled
20	*F. squarrosa*	Annual	5-7cm	Compressed
21	*F. stolonifera*	Perennial	30-50cm	Compressed
22	*F. thomsonii*	Perennial	20-25cm	Flatly 3- angled
23	*F. umbellaris*	Perennial	50-60cm	Sub- cylindric

Appendix 3: Comparative study of Leaf sheath size, Leaf sheath color and Ligule

S.N.	Name of species	Leaf sheath size	Leaf sheath color	ligule
1	*F. acuminata*	1-4cm	Pale yellow with rusty specks	absent
2	*F. aestivalis*	5-15mm	Yellowish brown	Absent
3	*F. bisumbellata*	1-2cm	Pale brown	Present
4	*F. cymosa var. spathacea*	1-2.5cm	Pale brown	Absent
5	*F. complanata*	2-4cm	Yellowish white	Present
6	*F. dichotoma*	1-4cm	Dark brown	Present
7	*F. falcata*	1-2.5cm	brown	Absent
8	*F. ferruginea*	4-10cm	Light brown	Present
9	*F. fimbristyloides*	1-2cm	Greenish brown	Absent
10	*F. fusca*	1.5-4cm	Dark brown	Absent
11	*F. fuscinux*	-	-	Absent
12	*F. littoralis*	1.5-10cm	Pale brown	Absent
13	*F. nutans*	3-8cm	Light brown	Absent
14	*F. ovata*	3-5cm	Pale green	Absent
15	*F. pierotii*	-	Rust colored	Absent
16	*F. quinquangularis*	upto 15cm	Pale brown	Absent
17	*F. rigidula*	2-3cm	Pale brown	Present
18	*F. salbundia*	Upto 20cm	Pale brown	Absent
19	*F. schoenoides*	2-4cm	Light yellow	Present
20	*F. squarrosa*	0.5-1cm	Light brown	Present
21	*F. stolonifera*	3-5cm	Pale yellow	Present
22	*F. thomsonii*	2-5cm	Pale brown	Present
23	*F. umbellaris*	2-19cm	Brown	Circle of hairs/ absent

Appendix 4: Comparative study of Leaf blade size, apex, margin and shape

S.N.	Name of species	Leaf blade size	apex	margin	Shape
1	*F. acuminata*	absent	absent	absent	Absent
2	*F. aestivalis*	30-200 ×0.5-1mm	acute	serrated	Filiform
3	*F. bisumbellata*	30-70 × 0.5-1mm	obtuse	serrated	Linear
4	*F. cymosa var. spathacea*	1-4mm wide	acute	serrated	Flat
5	*F. complanata*	40-150 × 2-4mm	acute	serrated	Flat
6	*F. dichotoma*	0.5-2.5 mm wide	acute	Minutely serrated	Linear, Flat
7	*F. falcata*	50-150 × 1-2mm	acute	serrated	Linear
8	*F. ferruginea*	100-180 × 1.5-2mm	acute	Serrated	Linear
9	*F. fimbristyloides*	1-1.5mm wide	acute	serrated	Curved
10	*F. fusca*	5-25 × 0.5-1mm	acute	serrated	Linear
11	*F. fuscinux*	-	Subobtuse-apiculate	-	Flat
12	*F. littoralis*	150-450 ×1.5-2mm	attenuate	Finely serrated	Ensiform
13	*F. nutans*	absent	absent	absent	Absent
14	*F. ovata*	50-200 × 0.8-1mm	acute	serrated	Linear
15	*F. pierotii*	1.2-2mm wide	acute	Flat-incurved	Linear
16	*F. quinquangularis*	300-700 × 2-3mm	acute	serrated	Linear
17	*F. rigidula*	50-120 × 1.5-2mm	acute	serrate	Linear
18	*F. salbundia*	absent	absent	absent	Absent
19	*F. schoenoides*	100-250 × 0.5-1.2mm	obtuse	Involute and serrated	Linear
20	*F. squarrosa*	20-50 × ≤1mm	acute	involute	Filiform
21	*F. stolonifera*	120-300 ×1-3mm	acute	serrated	Linear
22	*F. thomsonii*	50-150 ×2-3mm	acute	serrated	Flat
23	*F. umbellaris*	70-250 ×1-2mm	-	-	linear

Appendix 5: Comparative study of Involucral bract type, size and numbers

S.N.	Name of species	Involucral bracts type	Involucral bracts size	Involucral bract number
1	*F. acuminata*	absent	absent	Absent
2	*F. aestivalis*	Leaf like	0.5-3cm	3-5 in numbers
3	*F. bisumbellata*	Leaf like	1-3cm long	2-3 in numbers
4	*F. cymosa var. spathacea*	Leaf like	-	1-3 in numbers
5	*F. complanata*	Leaf like	1-3cm	2-3 in numbers
6	*F. dichotoma*	Leaf like	1-4cm	3-4 in numbers
7	*F. falcata*	Leaf like	5-10mm	3-5 in numbers
8	*F. ferruginea*	Leaf like	3-5cm	2 or 3 in numbers
9	*F. fimbristyloides*	Leaf like	0.5-1.5cm	2-4 in numbers
10	*F. fusca*	Leaf like	1-5cm long	2-4 in numbers
11	*F. fuscinux*	Leaf like	2-2.7cm	-
12	*F. littoralis*	Leaf like	1.5-4cm	2-5 in numbers
13	*F. nutans*	Glume like	3.5mm long	Single
14	*F. ovata*	Glume like	2-3mm	1-2 in numbers
15	*F. pierotii*	Glume like	-	1-3 in numbers
16	*F. quinquangularis*	Leaf like	0.5-3cm	3-4 in numbers
17	*F. rigidula*	Leaf like	1-2 cm	3-5 in numbers
18	*F. salbundia*	Leaf like	0.5-1cm	2-3 in numbers
19	*F. schoenoides*	Leaf like	Upto 4cm	1 or 2 in numbers
20	*F. squarrosa*	Leaf like	5 to 20mm	2-4 in numbers
21	*F. stolonifera*	Leaf like	2-7cm	3-5 in numbers
22	*F. thomsonii*	Leaf like	1-3cm	2 or 3 in numbers
23	*F. umbellaris*	Leaf like	5-11mm	2 or 3 in numbers

Appendix 6: Comparative study of Inflorescence type, shape and size

S.N.	Name of species	Inflorescence type	Spikelet shape	Spikelet size
1	*F. acuminata*	Single terminal	lanceolate	5-10 × 2-3mm
2	*F. aestivalis*	Compound anthela	Oblong- ovoid	1.5-3.5 ×1-1.5mm
3	*F. bisumbellata*	Compound or decompound anthela	Oblong- ovoid	2-4 × 1- 1.5mm
4	*F. cymosa var. spathacea*	Simple or compound anthela	Oblong- ovoid	3-6 × 1.5-2mm
5	*F. complanata*	Compound anthela	oblong	3-6 × 2-5cm
6	*F. dichotoma*	compound /rarely simple anthela	Ovoid- ellipsoid	6-14 × 2-3mm
7	*F. falcata*	Decompound anthela	Ellipsoid- ovoid	5-6 ×1-1.5mm
8	*F. ferruginea*	simple	ovoid	4-9 × 2-3.5mm
9	*F. fimbristyloides*	simple	lanceolate	5-15 × 1.5mm
10	*F. fusca*	Compound anthela	lanceolate	5-10 × 1-3mm
11	*F. fuscinux*	Compound anthela	Narrowly ovoid	3.6-19 × 2.5-3.5mm
12	*F. littoralis*	Compound or decompound anthela	globose	1.5-3 ×1.5-2mm
13	*F. nutans*	Single terminal	Nodding, ovoid	5-10 × 2-4mm
14	*F. ovata*	Single terminmal	Ovoid- ellipsoid	8-10 × 3-5mm
15	*F. pierotii*	Simple anthela	Oblong, ellipsoid or ovoid	6-10 × 2.5-4mm
16	*F. quinquangularis*	Decompound anthela	Ovoid- ellipsoid	3-5 × 1-1.5mm
17	*F. rigidula*	Simple anthela	Ovoid- ellipsoid	4-7 × 2-3mm
18	*F. salbundia*	Compound anthela	ovoid	3-5 × 1.5-2.5mm
19	*F. schoenoides*	Simple anthela	ovoid	5-7 × 2.5-3.5mm
20	*F. squarrosa*	Compound anthela	ovoid	1.5-5 × 1-2.5mm
21	*F. stolonifera*	Simple or sub compound anthela	Oblong- ovoid	3-5mm × 2-3mm
22	*F. thomsonii*	Compound anthela	Elliptic, oblong to ovoid	4-6mm × 1.5-2.5mm
23	*F. umbellaris*	Simple or compound anthela	Globose- ellipsoid	3-8 × 3-4mm

Appendix7: Comparative study of Glume color, shape, size, arrangement, veins, base and texture

S. N.	Name of species	Glume color	Glume shape	Glume size	arrangement	No.of veins	Keeled or Not	Glume surface
1	*F. acuminata*	Pale green	Ovate-elliptic	3-4 × 1.5-2.5mm	Spirally arranged	10-12 veins	keeled	Glabrous
2	*F. aestivalis*	Reddish brown	Narrowly ovate	1-1.5 ×0.5-1mm	Spirally arranged	3 veined	keeled	Densely pubescent
3	*F. bisumbellata*	Pale yellow or white	Broadly ovate	1.5-2 × 0.5-1mm	Spirally arranged	3 veined	keeled	Glabrous
4	*F. cymosa var. spathacea*	brown	Ovate-broadly ovate	1.2-2mm	Spirally arranged	3 veined	Not keeled	Glabrous
5	*F. complanata*	Dark brown	ovoid	2.5-3mm	Spirally arranged	Single veined	keeled	Glabrous
6	*F. dichotoma*	Reddish brown	ovate	2-4.2mm	Spirally arranged	3 veined	keeled	Glabrous
7	*F. falcata*	Pale brown	ovate	3-4 × 0.5-1mm	Spirally arranged	3 veined	Keeled	glabrous
8	*F. ferruginea*	Reddish brown	Broadly ovoid	3.5-5 ×2-3mm	Spirally arranged	Faint single vein	Not keeled	Densely pubescent spically
9	*F. fimbristyloides*	Pale yellow	lanceolate	3-3.5× 1-1.5mm	Distichously arranged	Single vein	Slightly keeled	Glabrous
10	*F. fusca*	Dark brown	lanceolate	3-5mm	Distichously arranged	Single vein	keeled	Glabrous
11	*F. fuscinux*	Pale brown	ovate	1.6-2 ×1.2-1.5mm	Spirally arranged	3 veined	keeled	Glabrous
12	*F. littoralis*	Dark brown	ovoid	1-1.5 × 1mm	Spirally arranged	3 veined	keeled	Glabrous
13	*F. nutans*	Rusty brown	Oblong-elliptic	2-4 ×1.5-3mm	Spirally arranged	Faint veins	Keeled	Glabrous

14	*F. ovata*	Yellowish green	ovate	4-5 × 2-3mm	Distichously arranged	3 veined	keeled	glabrous
15	*F. pierotii*	Chestnut brown	Broadly ovate	Ca.4 mm	Spirally arranged	3 veined	keeled	Glabrous
16	*F. quinquangularis*	Light brown	ovate	1.5-2 ×1mm	Spirally arranged	3 veined	keeled	Glabrous
17	*F. rigidula*	Dark brown	ovate	2-3 ×1-1.5mm	Spirally arranged	3 veined	keeled	Glabrous
18	*F. salbundia*	Light brown	Elliptic- ovoid	1.5-2 ×1-1.5mm	Spirally arranged	3 veined	keeled	Glabrous
19	*F. schoenoides*	Yellowish white	ovate	3-4 × 1.2-1.5mm	Spirally arranged	membranous	Not keeled	Glabrous
20	*F. squarrosa*	Pale brown	Ovate-oblong	2.5-3× 0.5-1mm	Spirally arranged	3 veined	keeled	Glabrous
21	*F. stolonifera*	Greenish brown	ovate	2.5-3× 1-1.5mm	Spirally arranged	5-7 veined	keeled	Glabrous
22	*F. thomsonii*	Reddish brown	ovate	3-4 ×2mm	Spirally arranged		keeled	Glabrous
23	*F. umbellaris*	Yellow rust colored	Ovate-elliptic	1.8-2.7×1-1.5mm	Spirally arranged	3 veined	Scarcely keeled	Glabrous

Appendix 8: Comparative study of stamen, style and stigmas

S.N.	Name of species	Stamen numbers	Style size	surface	stigmas numbers	Stigmas size	Stigmas surface
1	*F. acuminata*	2	2-2.5mm	ciliated	2	1-1.5mm	ciliated
2	*F. aestivalis*	1	Ca.0.5mm	ciliated	2	Ca. 0.5mm	Ciliated
3	*F. bisumbellata*	2	Ca.1mm	ciliated	2	Ca.0.5mm	Ciliated
4	*F. complanata*	3	1-1.5mm	Not ciliated	3	1.5-2mm	Ciliated
5	*F. cymosa var. spathacea*	2 or 3	1-1.2mm	Not ciliated	2 or 3	-	Ciliated
6	*F. dichotoma*	1	2mm	ciliated	2	Ca.1mm	Ciliated
7	*F. falcata*	3	1.5-2mm	Not ciliated	3	1-1.5mm	Sparsely ciliated
8	*F. ferruginea*	3	1-1.5mm	ciliated	2	Ca.1mm	Sparsely ciliated
9	*F. fimbristyloides*	3	2.5-3mm	Not ciliated	3	1-1.2mm	Not ciliated
10	*F. fusca*	3	4-5mm	Not ciliated	3	1.5-2mm	Sparsely ciliated
11	*F. fuscinux*	2-3	Ca. 0.8mm	Not ciliated	2	Ca. 0.8mm	-
12	*F. littoralis*	2	Ca.1mm	Not ciliated	2	Ca.1mm	Not ciliated
13	*F. nutans*	3	3.5mm	Sparsely ciliated	2	short	Ciliated
14	*F. ovata*	2	2-3mm	ciliated	3	Ca.1mm	Ciliated
15	*F. pierotii*	3	-	Not ciliated	3	-	Ciliated
16	*F. quinquangularis*	1 or 2	Ca.0.8mm	Sparsely ciliated	3	Ca. 1mm	Ciliated
17	*F. rigidula*	2-3	2-3mm	Densely ciliated	2	Ca.1mm	Sparsely ciliated
18	*F. salbundia*	3	1-1.5mm	Not ciliated	3	Ca.1.5mm	Ciliated
19	*F. schoenoides*	3	1.5-2mm	Apically ciliated	2	Ca.1mm	Ciliated
20	*F. squarrosa*	1	0.8-1mm	Apically ciliated	2	Ca.0.5mm	Ciliated
21	*F. stolonifera*	3	1.5-2mm	Densely ciliated	2	Ca. 0.5-1mm	Ciliated
22	*F. thomsonii*	3	2mm	Not ciliated	3	Ca.2mm	Sparsely ciliated
23	*F. umbellaris*	2 or 3	-	Not ciliated	2 or 3	-	-

Appendix9: Comparative study of Nutlet color, size, shape and texture

S.N.	Name of Species	Nutlet color	Nutlet size	Nutlet	Nutlet texture and surface
1	*F. acuminata*	yellowish	1.5-2mm	Biconvex	Reticulate and non-verruculose
2	*F. aestivalis*	Whitish yellow	Ca. 0.5mm	Biconvex	Smooth and non-verruculose
3	*F. bisumbellata*	Yellowish white shiny	Ca. 0.5mm	biconvex	Reticulate and non-verruculose
4	*F. complanata*	Whitish shiny	Ca.1.5mm	trigonous	Reticulate and non-verruculose
5	*F. cymosa var. spathacea*	Dark brown-black	Ca.0.7-1mm	biconvex	Reticulate and indistinctly verruculose
6	*F. dichotoma*	Creamy-yellowish shiny	1-2 mm	biconvex	Reticulate and non-verruculose
7	*F. falcata*	Yellowish creamy- dark brown	1-1.5mm	trigonous	Obscurely reticulate and non- v erruculose
8	*F. ferruginea*	Creamy, shiny	Ca.1.5mm	biconvex	Smooth non-verruculose
9	*F. fimbristyloides*	Dark brown	1-1.2mm	trigonous	Reticulate and verruculose
10	*F. fusca*	Dark brown	Ca.1mm	trigonous	Reticulate and verruculose
11	*F. fuscinux*	Cream or black color	Ca.1-1.3mm	biconvex	Smooth non-verruculose
12	*F. littoralis*	Yellowish white	Ca.1mm	trigonous	Reticulate and sparsely verruculose
13	*F. nutans*	white	Ca.1.5mm	biconvex	Reticulate and verruculose
14	*F. ovata*	Shiny white-brown	Ca. 2-2.5mm	trigonous	Smooth and verruculose
15	*F. pierotii*	brown	Ca.1mm	trigonous	Finely verruculose
16	*F. quinquangularis*	Yellow- light brown	Ca. 0.5mm	trigonous	Reticulate and verruculose
17	*F. rigidula*	Creamy white	Ca.1mm	biconvex	Reticulate and verruculose
18	*F. salbundia*	Dark brown	Ca.1mm	trigonous	Reticulate and sparsely verruculose
19	*F. schoenoides*	Shiny yellowish brown	Ca.1.5mm	biconvex	Reticulate and non verruculose

20	*F. squarrosa*	Yellowish white	0.5-1mm	biconvex	Smooth non verruculose
21	*F. stolonifera*	Creamy white	Ca.1mm	binconvex	Reticulate and non-verruculose
22	*F. thomsonii*	Yellowish shiny	1-1.2mm	trigonous	Reticulate and verruculose
23	*F. umbellaris*	yellowish	0.8-1mm	Trigonous or compressed	Reticulate and sparsely verruculose

CHECKLIST

Fimbristylis acuminata Vahl. Enum. Pl. 2: 285. 1805

Type specimen: India, konig s.n. (Holotye: C)

Distributional Range: Nepal (C&E) (Map 2), E Himalaya, S Asia, E Asia, SE Asia and Australasia.

Elevation: 70- 700 m

Ecology: grows in flood plains, riverbanks and semi dry paddy fields.

Flowering and fruiting: July- December

Fimbristylis aestivalis (Retz.) Vahl, Enum. Pl. 2: 288 (1805). Koyama in Hara et al., Enum Flow. Pl. Nepal 1: 110 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 94 (2010).

Scirpus aestivalis Retz., Obs. Bot. 4: 12 (1786)

Type Specimen: Sri Lanka, konig s.n. (Lectotype:L)

Distribution range: Nepal (C & E) (Map3), E Himalaya, Assam-Burma, S Asia, E Asia, SE Asia, N Asia, Australasia.

Elevation: 85- 1600m

Ecology: Riverbanks

Local Name: Masino Jwano Jhar

Flowering and fruiting: March- August

Fimbristylis bisumbellata (Forssk.) Bubani, Dodecanthea, 30 (1850). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111(1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 94 (2010).

Scirpus bisumbellatus Forssk., Fl. Aegypt. -Arab. 15 (1775)

Distributinal Range: Nepal (C&E) (Map 4), Assam- Burma, S Asia, E Asia, SE Asia, N Asia, SW Asia, Europe, Africa and Australasia.

Elevation: 100-1100m

Ecology: Roadside and Open grasslands

Flowering and fruiting: March- November

Fimbristylis complanata (Retz.) Link, Hort. Berol. 1: 292 (1827). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1:95 (2010).

Scirpus complanatus Retz., Obs. Bot. 5: 14(1788)

Distribution: Nepal (W, C& E), E Himalaya, Tibetean Plateau, S Asia, E Asia, SE Asia, SW Asia, N America, S America and Australasia.

Elevation: 100- 3200m

Ecology: Grassland and Marshy areas

Flowering and fruiting: August- November

Fimbristylis cymosa var. spathacea (Roth) T. Koyama, J. Jap. Bot. 46(3): 66 (1971)

Fimbristylis spathacea Roth, Nov. Pl. Sp.: 24 (1821)

Fimbristylis wightiana Nees in Wight, Contr. Bot. India: 99 (1834)

Type specimen: Australia, Brown s.n. (Holotype:BM)

Distribution range: Africa, Nepal (WC) (Map 6), S Asia, E Asia, SE Asia.

Altitude: 300- 800m

Ecology: Moist Place

Flowering and fruiting: June- October

Fimbristylis dichotoma (L.) Vahl. Enum. Pl. 2: 287 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1:95 (2010).

Scirpus dichotomus L., Sp. Pl. 1. 50 (1753).

Fimbristylis diphylla (Retz.) Vahl, Enum. Pl. 2: 289 (1806).

Scirpus diphyllus Retz., Observ. Bot. 5: 15 (1788).

Fimbristylis dichotoma (L.) Vahl subsp. **dichotoma**

Distribution: Nepal (W, C & E), Asia, Africa, N America, S America and Australasia.

Elevation: 100-3000m

Ecology: Roadsides and cultivated paddy fields.

Local Name: Paani Mothe

Flowering and fruiting: May- Nov

Fimbristylis dichotoma (L.) Vahl **subsp. podocarpa** (Nees) T. Koyama, Micronesica 1: 87 (1964). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Fimbristylis podocarpa Nees in Wight, Contr. Bot. India, 98 (1834).

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

Elevation: 80-200m

Ecology: open places, grasslands

Local Name: Paani Mothe

Flowering and fruiting: May- Nov

Fimbristylis falcata (Vahl) Kunth, Enum. Pl. 2: 239 (1837). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

Scirpus falcatus Vahl, Enum pl. 2: 275 (1806)

Fimbristylis junciformis (Nees) Kunth, Enum. Pl. 2: 239 (1837)

Distribution range: Nepal (W & C) (Map8), W Himalaya, E Himalaya, S Asia, SE Asia, and Africa.

Elevation: 200-1200m

Ecology: wet playgrounds, Riverbanks.

Flowering and fruiting: April- September

Fimbristylis ferruginea (L.) Vahl, Enum Pl. 2: 291. 1805.

Scirpus ferrugineus L., Sp. Pl. 1: 50. 1753

Type: JAMAICA, Collecter Unknown s.n. [Herb. Van Royen], [lectotype, designated by Adams in Cafferty and Jarvis 2004, pg.180 (L0052731 image!)].

Distribution range: Nepal (C & E) (Map 9), E Himalaya, Asaam- Burma, S Asia, SE Asia, SW Asia, C Asia, SW Europe, Africa, Tropical America and Australasia.

Elevation: 70-700 m

Ecology: Flood plains, Riverbanks and semi dry Paddy fields

Flowering and fruiting: Aug- Dec

Fimbristylis fimbristyloides (F. Mueller) Druce, Rep. Bot. Soc. Exch. Club Brit. Isles 4: 623 (1917). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Abildgaardia fimbristyloides F. Mueller, Fragem. 8: 273 (1874)

Type specimen: Sabah, Gibbs, L.S. (Holotype:K)

Distribution range: Nepal (C & E) (Map 10), E Himalaya, Assam- Burma, S Asia, E Asia, SE Asia and Australasia.

Elevation: 500- 2300m

Ecology: wet ground, grassy slopes

Flowering and fruiting: Aug- Oct

Fimbristylis fusca (Nees) Benth. ex C. B. Clarke in Hooker, Fl. Brit. India 6: 649 (1893). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

Abildgaardia fusca Nees in wight, Contr. Bot. India: 95 (1834).

Type specimen: Nepalia, 1821, Wallich 3530 (Lectotype: E)

Distribution range: Nepal(C) (Map 11), Assam- Burma, E Asia, SE Asia and Australasia.

Elevation: 300- 1500m

Ecology: Grassy slopes

Flowering and fruiting: June- September

Fimbristylis littoralis Gaudich., Voy. Uranie 10: 413 (1829). Rajbhandari in Rajbhandari & baral, Cat. Nep. Fl. Pl. 1: 95 (2010)

Fimbristylis miliacea auct. Non (L.) Vahl: Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978).

Type specimen: Indonesia, Gaudichaud s.n. (Holotype: P)

Distribution range: Nepal (W, C& E) (Map 12), E Himalaya, Assam- Burma, S Asia, E Asia, SE Asia, SW Asia, Africa, N America, S America and Australasia.

Elevation: 100-1700m

Ecology: Water logged area around paddy field, Foot trail sides of paddy field.

Local Name: Jwane jhaar

Fimbristylis nutans (Retz.) Vahl, Enum. Pl. 2: 285. 1805

Scirpus nutans Retz. Observ. Bot. 4: 12. 1786.

Type specimen: Malaysia, Malacca, J.G. Konig s.n. (Lectotype, designated by Fischer 1932, pg. 69: LD)

Distribution: Nepal(C) (Map 13), Assam- Burma, S. Asia, E. Asia, SE Asia and Australasia.

Ecology: Grows in marshy areas, edges of lake, sometimes forming a floating island of vegetation, associated with Eleocharis species and Fimbristylis species.

Elevation:700m elevation

Flowering and fruiting:

Flowering: July- August

Fruiting: September- October

Fimbristylis ovata (Burm. f.) Kern, Blumea 15: 126 (1976). Koyama in Hara et. Al., Enum. Flow. PL. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 95 (2010).

Carex ovata Burm. f., Fl. Ind. 194(1768)

Cyperus monostachyos L., Mant. Pl. 2: 180 (1771)

Fimbristylis monostachya (L.) Hassk., Pl. Jav. Rar. 61 (1848)

Type specimen: Indonesia, Java, Burman s.n. (Holotype: B)

Distribution range: Nepal (CEW) (Map 14), Africa, S. W. Asia, E Himalaya, S Asia, E Asia, Assam- Burma, SE Asia.

Altitude: 100- 1400m

Ecology: River side rocky area, open Grasslands

Flowering and fruiting: June- September

Fimbristylis pierotii Miq., Ann. Mus. Bot. Lugduno- Batavi 2: 145 (1865). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Fimbristylis Pinetorum Merr. Philipp. J. Sci., C 9: 2666. 1914

Type specimen: Japan. Pierot s.n. (Isotype: L)

Distribution range: Nepal (C) (Map 15), W Himalaya, E Himalaya, E Asia and SE Asia.

Elevation: 700- 2400m

Ecology: Wet ground

Flowering and fruiting: May- September

Fimbristylis quinquangularis (Vahl) Kunth, Enum. Pl. 2: 229 (1837). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 111 (1978). Rajbhandari et al., Cat. Nep. Fl. Pl. Suppl. 1: 20 (2015).

Scirpus quinquangularis Vahl, Enum. Pl. 2: 279 (1805)

Distribution range: Nepal (C & E) (Map 16), E Himalaya, Tibetean Plateau, Asaam-Burma, S Asia, E Asia, SE Asia, C Asia, SW Asia, Africa and Australasia

Elevation: 80- 200m

Ecology: Paddy field, Foot trails, Roadside areas

Local Name: Jwane Jhar

Flowering and fruiting: Aug- Oct

Fimbristylis rigidula Nees in Wight, Contr. Bot. India: 99 (1834). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978).

Fimbristylis hanceana Boeckeler, Linnaea 38(4): 394. 1874

Type specimen: Nepalia, Wallich 3519 (Lectotype: CAL)

Distribution range: Nepal (C) (Map 17), Assam- Burma, S Asia, E Asia, E Himalaya, SE Asia

Elevation: 100-1200m

Ecology: Open Grasslands

Flowering and fruiting: Feb- July

Fimbristylis salbundia (Nees) Kunth, Enum Pl. 2: 230. 1837.

Trichelostylis salbundia Nees, Contr. Bot. India 105. 1834

Type specimen: Silhet, N. Wallich 3526 (Lectotype: K)

Distribution range: Nepal (W &C) (Map 18), Assam- Burma, S Asia, E Asia and SE Asia

Elevation: 700- 900 m

Ecology: Grows in Marshy areas

Flowering and fruiting: July- December

Fimbristylis schoenoides (Retz.) Vahl, Enum. Pl. 2: 286 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Scirpus schoenoides Retz., Obs. Bot. 5: 14 (1788)

Type specimen: India, Koenig s.n. (Holotype: C)

Distribution range: Nepal (C & E) (Map 19), E. Himalaya, Assam- Burma, S Asia, E Asia, SE Asia, Africa and Australasia

Elevation: 98m- 1800m

Ecology: Around paddy fields

Flowering and fruiting: May- Oct

Fimbristylis squarrosa Vahl, Enum. Pl. 2: 289 (1805). Komaya in Hara et al., Enum. Flow. Pl. Nepal. 1: 112 (1978). Rajbhandari in Rajbhandari & Baral, Cat. Nep. Fl. Pl. 1: 96 (2010).

Fimbristylis comata Nees in Wight, Contrib. Bot. Ind.: 102 (1834)

Type specimen: America, Loefling s.n. (Holotype: C)

Distribution range: Nepal(E) (Map 20), W Himalaya, E Himalaya, Tibetean Plateau,Assam- Burma, S. Asia, E. Asia, , SE Asia, SW Asia and Australasia.

Elevation: 80-1500m

Ecology: Riverbank

Flowering and fruiting: August- October

Fimbristylis stolonifera C. B. Clarke in Hooker, Fl. Brit. India 6: 637 (1893). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978).

Type specimen: Nepalia, 1821, N. Wallich 3503A (Lectotype: K)

Distribution range: Nepal(C) (Map 21), E Himalaya, Assam- Burma, S Asia and E Asia.

Elevation: 100-2900m

Ecology: Marshy area

Flowering and fruiting: June- Sept

Fimbristylis thomsonii Boeckeler, Linnaea 37(1): 37. 1871

Type Specimen: India, Mount khasia, J.D. Hooker & T. Thomson 12 (Lectotype, designated by Dey and Halder 2015, pg. 230, 231: P)

Distribution: Nepal(C) (Map 22), E Himalaya, Assam- Burma, S Asia, E Asia and SE Asia.

Altitude: 1020m

Ecology: Grows in grassland near *Schima- Castanopsis* forest

Flowering and fruiting: April

Fimbristylis umbellaris (Lam.) Vahl, Enum. Pl. 2: 291 (1805). Koyama in Hara et al., Enum. Flow. Pl. Nepal 1: 112 (1978). Rajbhandari in Rajbhandari & Baral. Cat. Nep. Fl. Pl. 1:96 (2010).

Scirpus umbellaris Lam., Tabl. Encycl. 1: 141 (1791)

Fimbristylis globulosa (Retz.) Kunth, Enum. Pl. 2: 231 (1837)

Scirpus globulosus Retz., Obs. Bot. 6: 19 (1791)

Distribution: Nepal(C) (Map23), Assam-Burma, S Asia, E Asia and SE Asia.

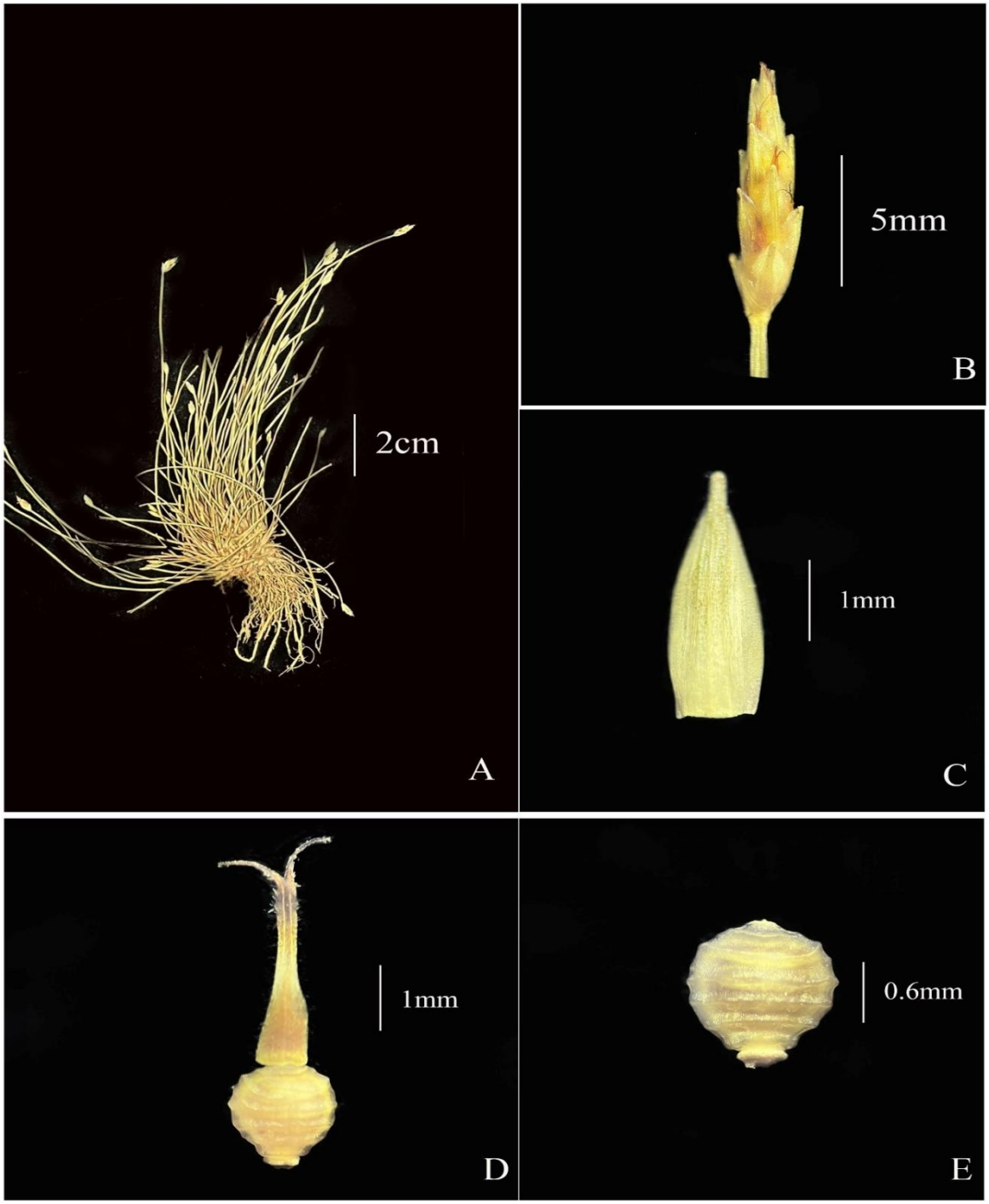
Ecology: Marshy places, Wet ground

Altitude: 1500- 1600m

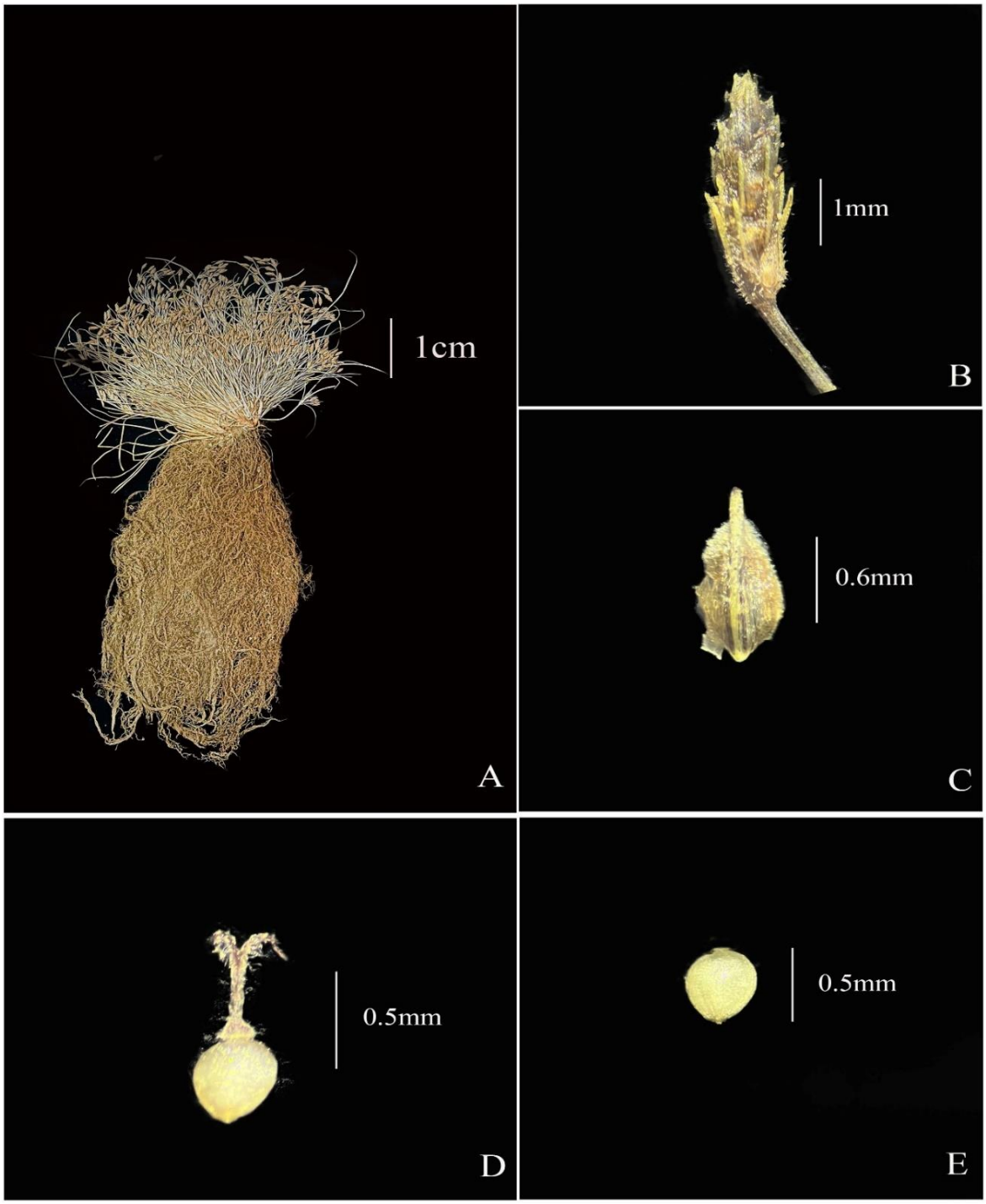
Nepali name: Gudmothe

Flowering and fruiting: June- October

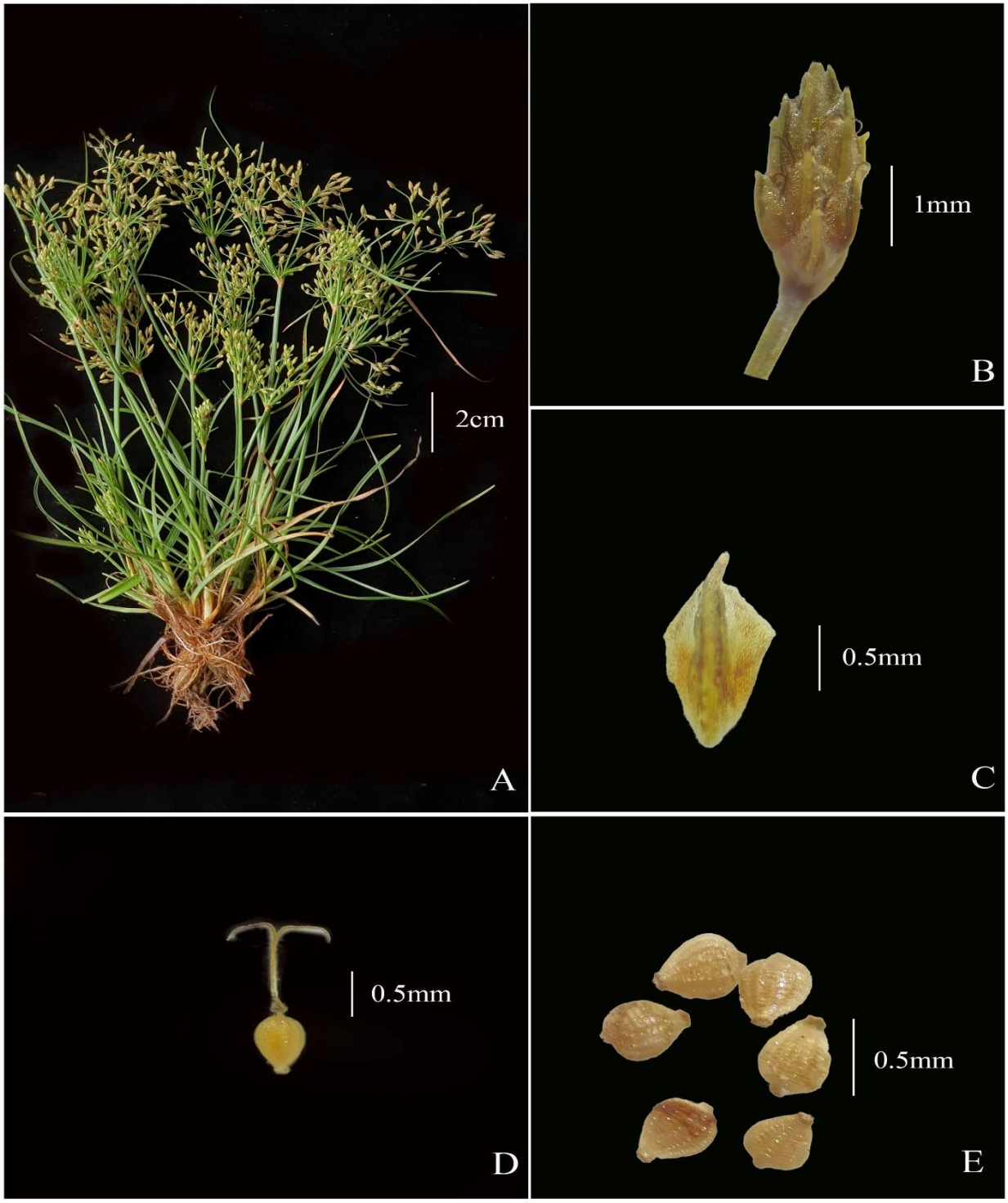
PHOTOPLATES



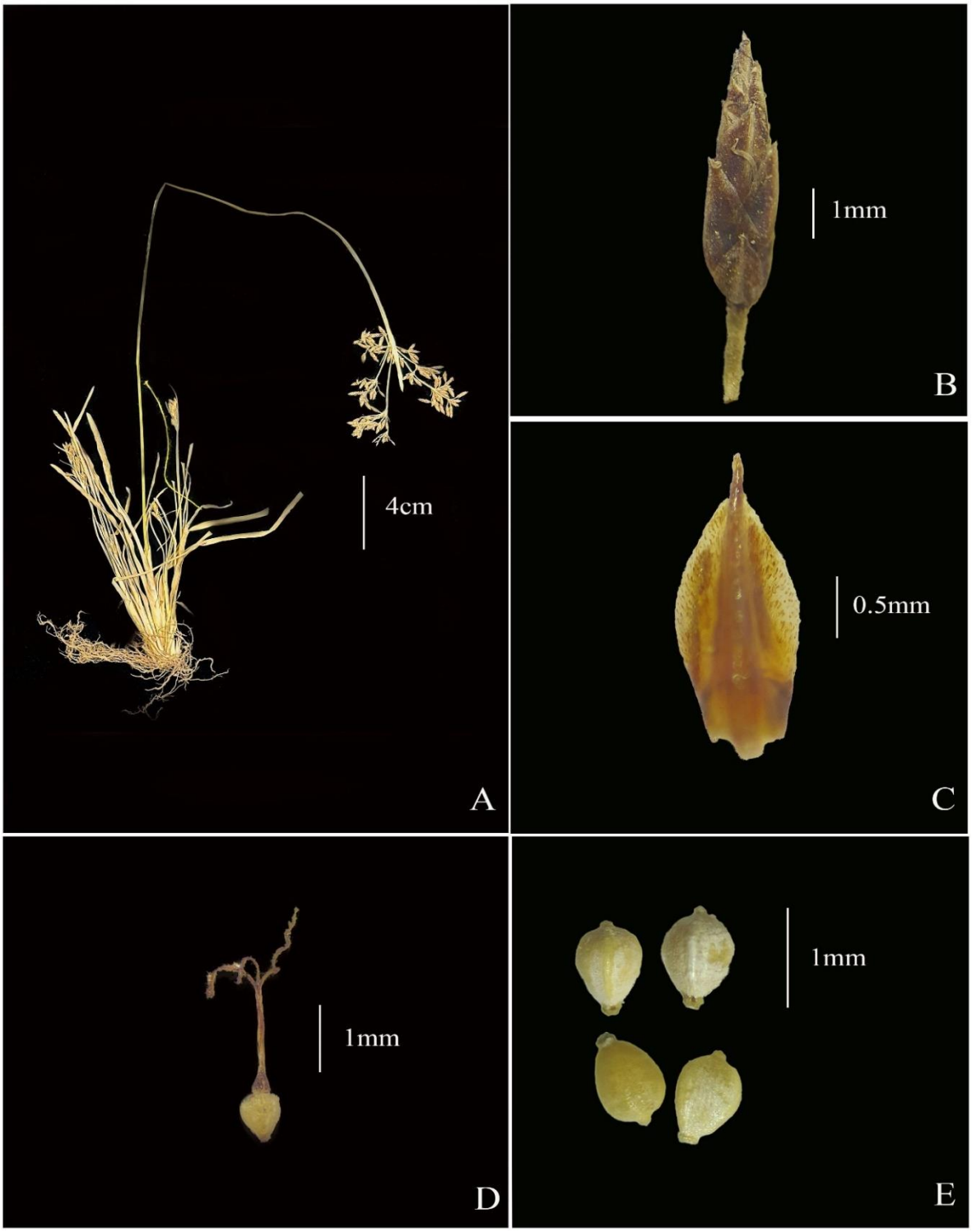
Photoplate No. 13: *Fimbristylis acuminata* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet.



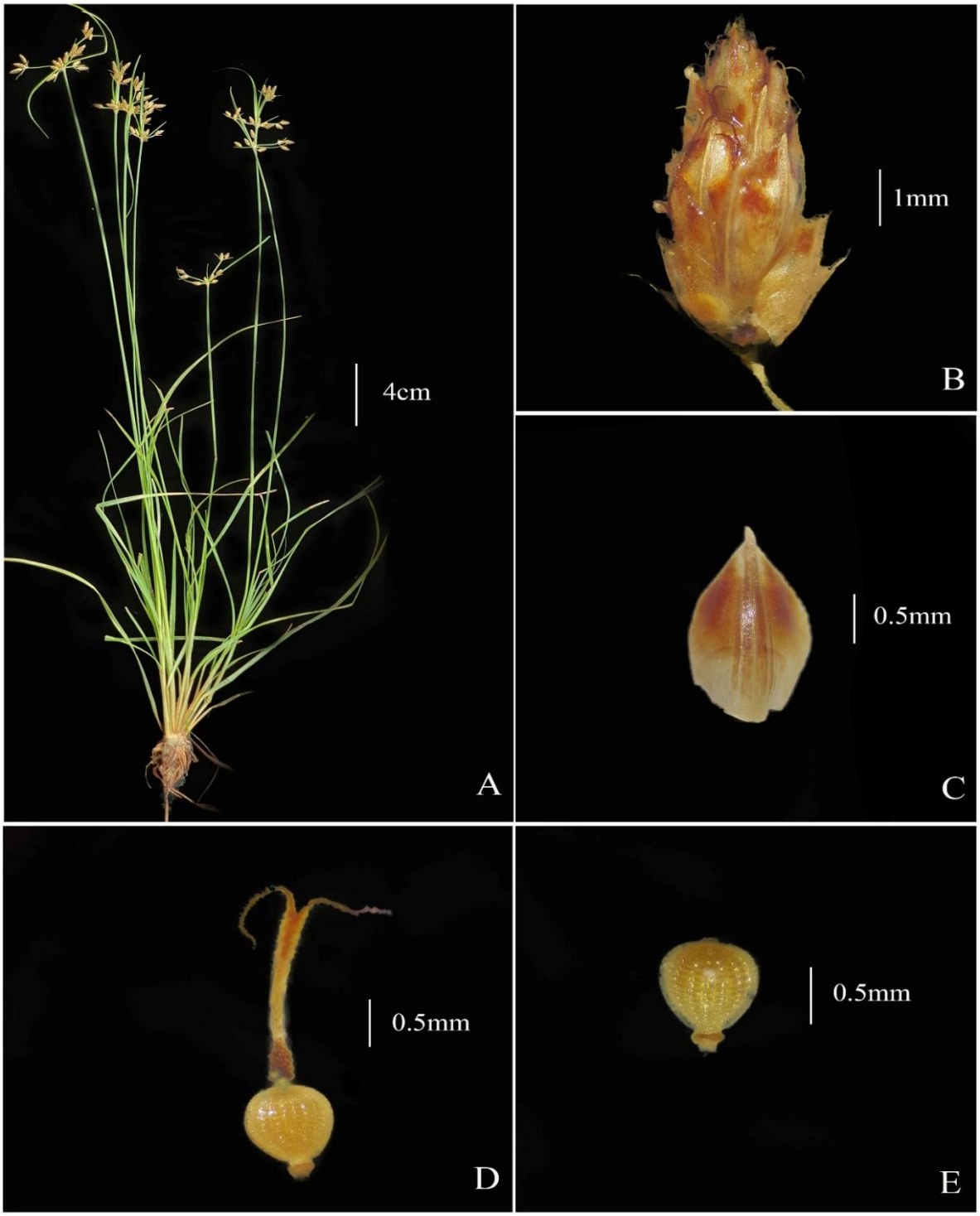
Photoplate No. 14: *Fimbristylis aestivalis* **A**. Habit sketch, **B**. Spikelet **C**. Glume, **D**. Fruiting pistil, **E**. Nutlet.



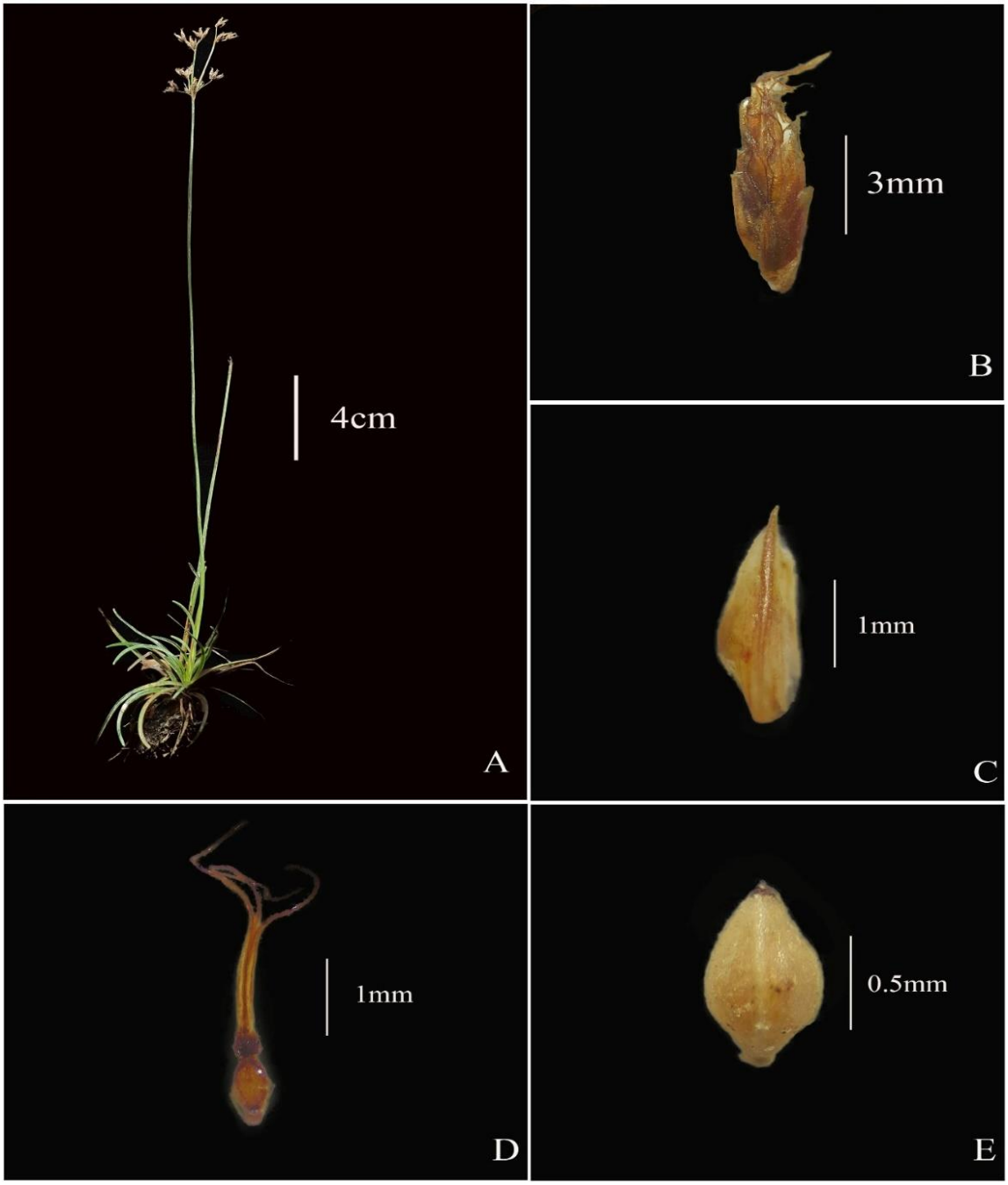
Photoplate No.15: *Fimbristylis bisumbellata* **A**. Habit sketch, **B**. Spikelet **D**. Fruiting pistil, **E**. Nutlet



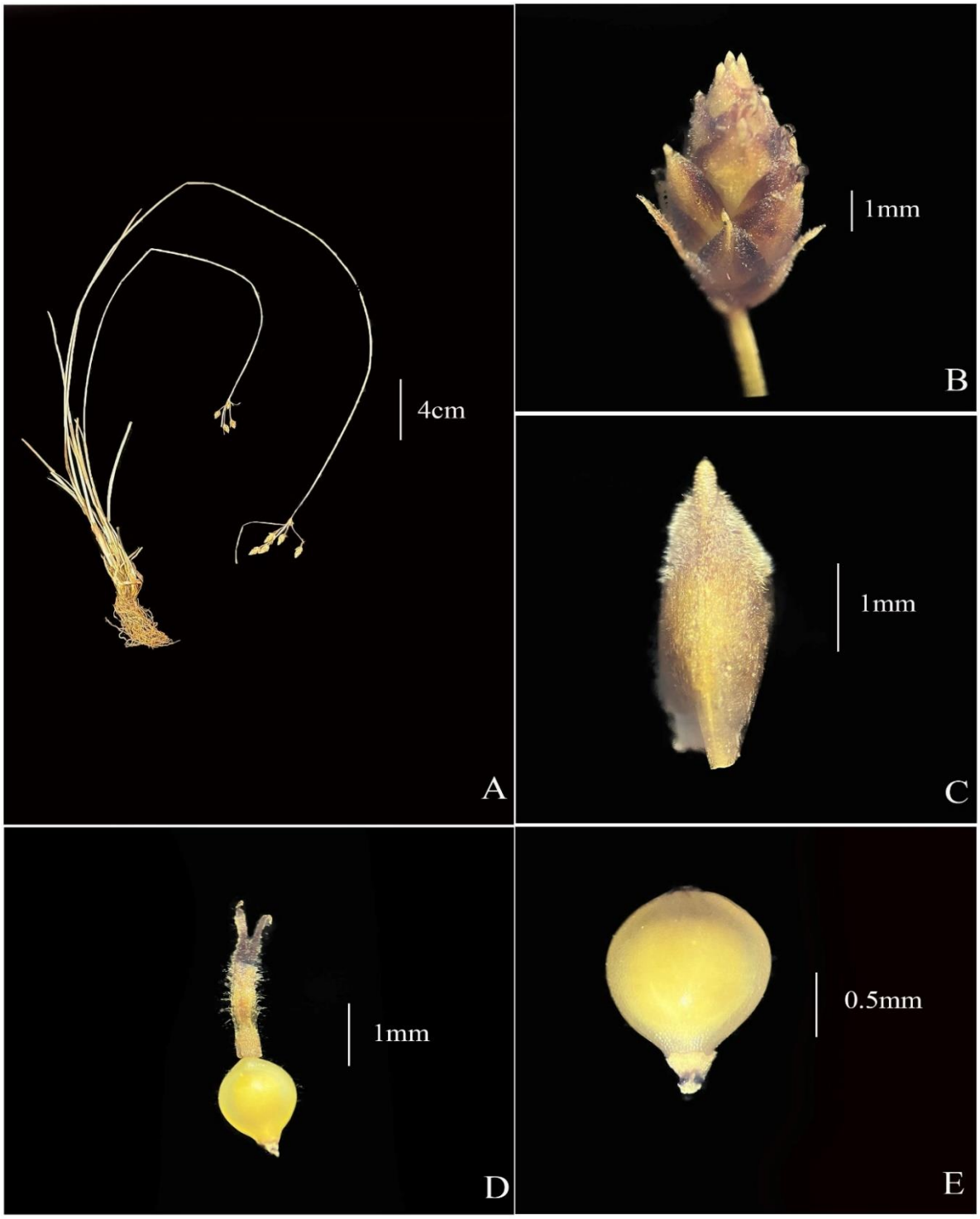
Photoplate No. 16: *Fimbristylis complanata* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



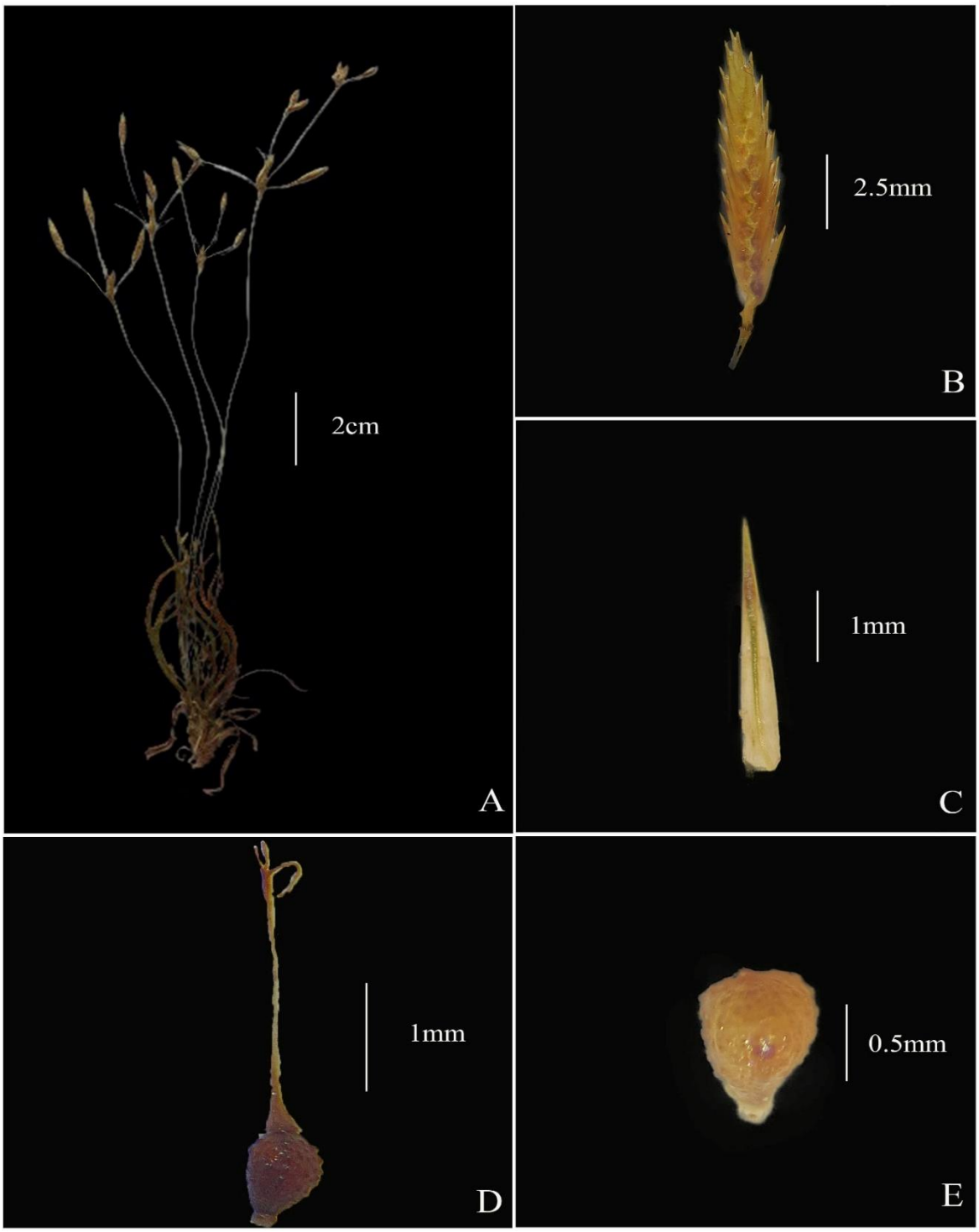
Photoplate No. 17: *Fimbristylis dichotoma* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet.



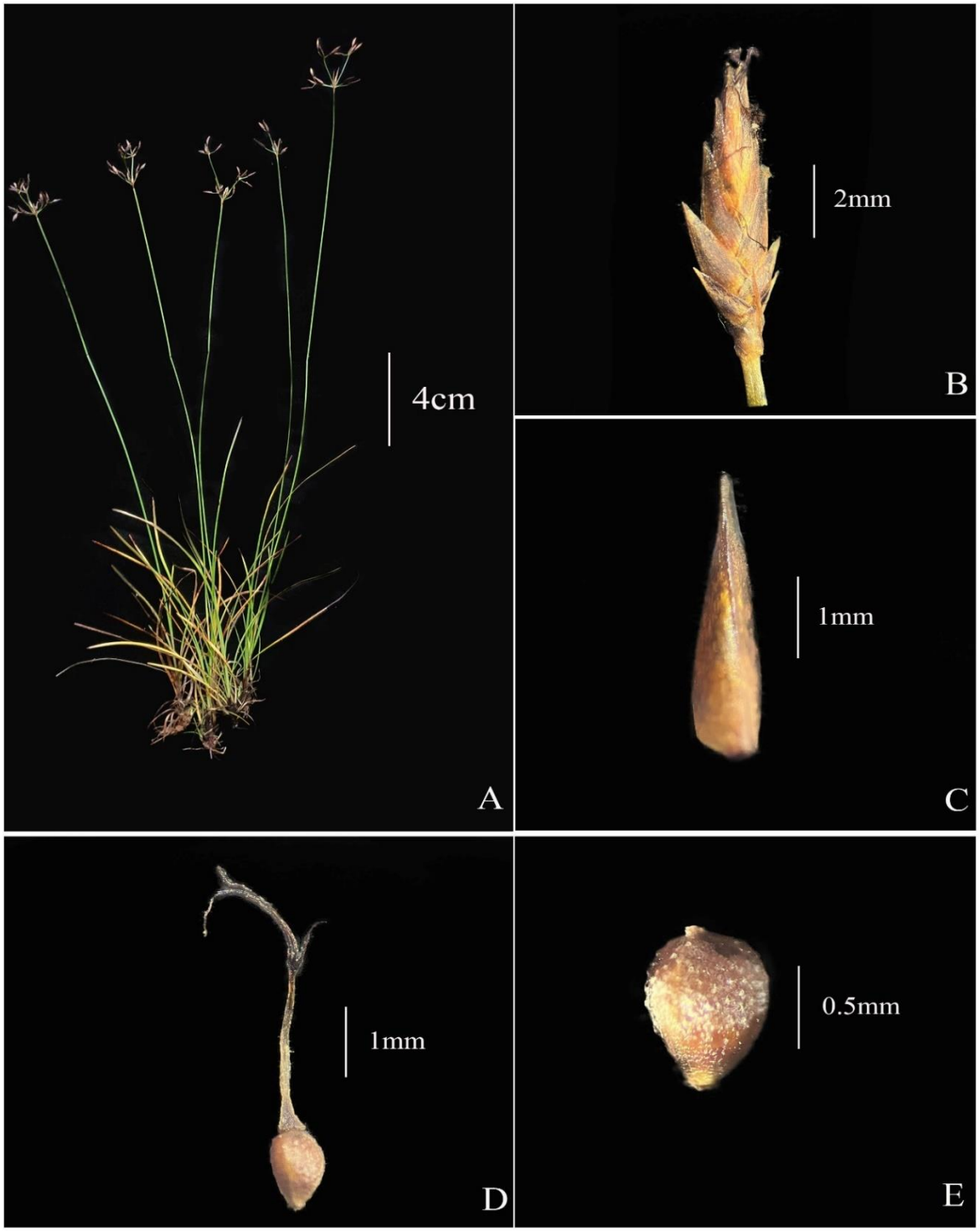
Photoplate No. 18: *Fimbristylis falcata* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



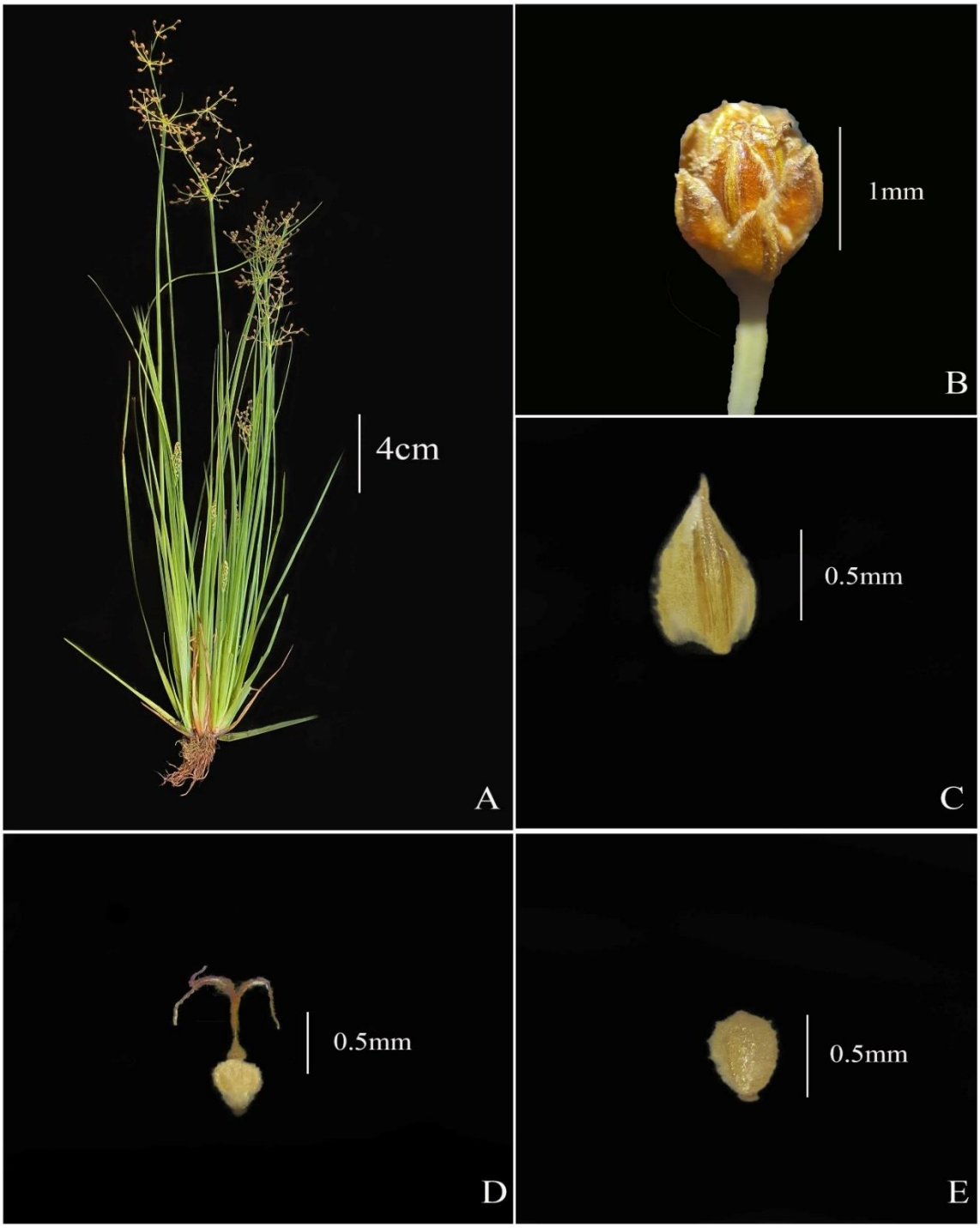
Photoplate No. 19: *Fimbristylis ferruginea* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



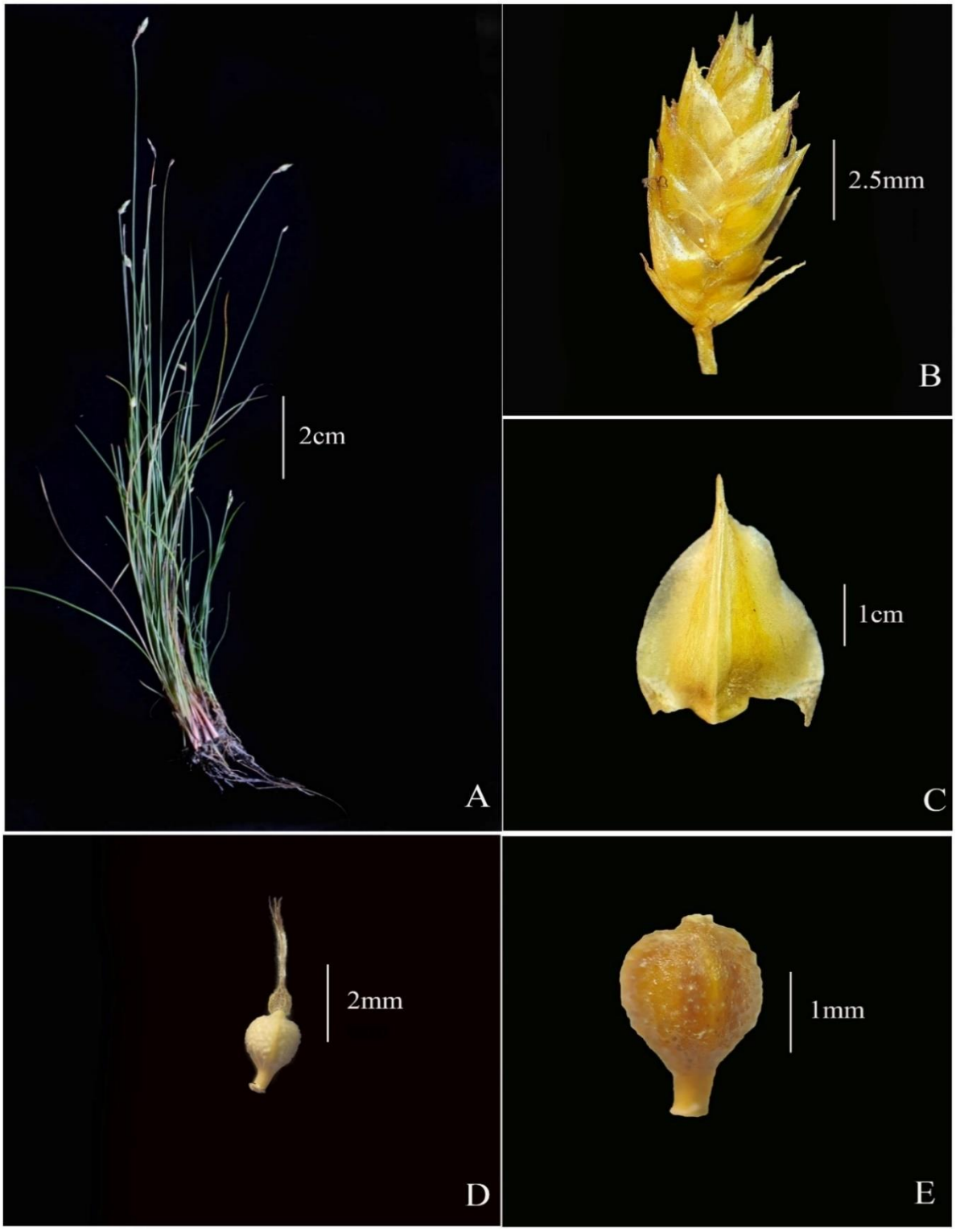
Photoplate No. 20: *Fimbristylis fimbristyloides* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



Photoplate No. 21: *Fimbristylis fusca* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet

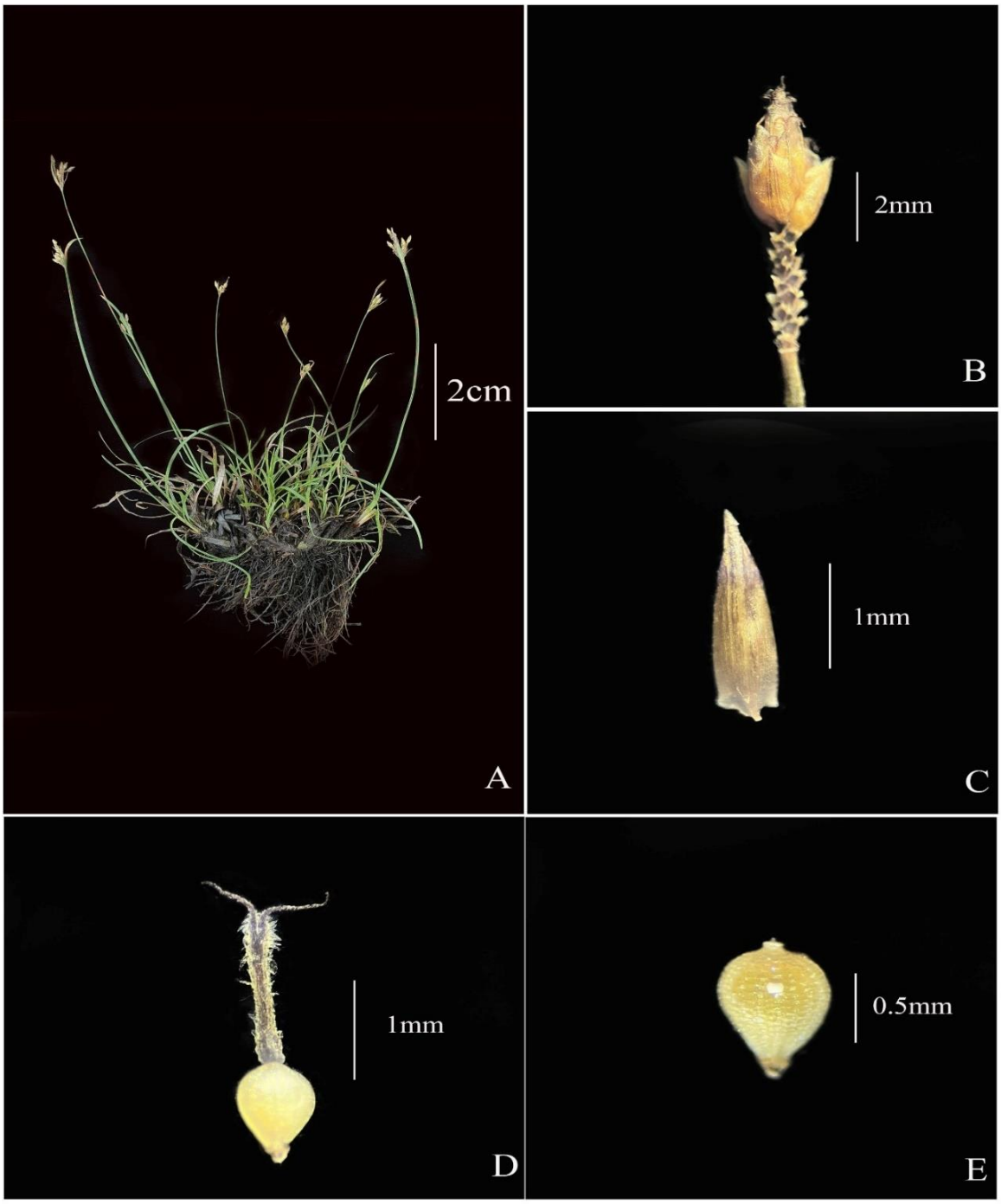


Photoplate No. 22: *Fimbristylis littoralis* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet

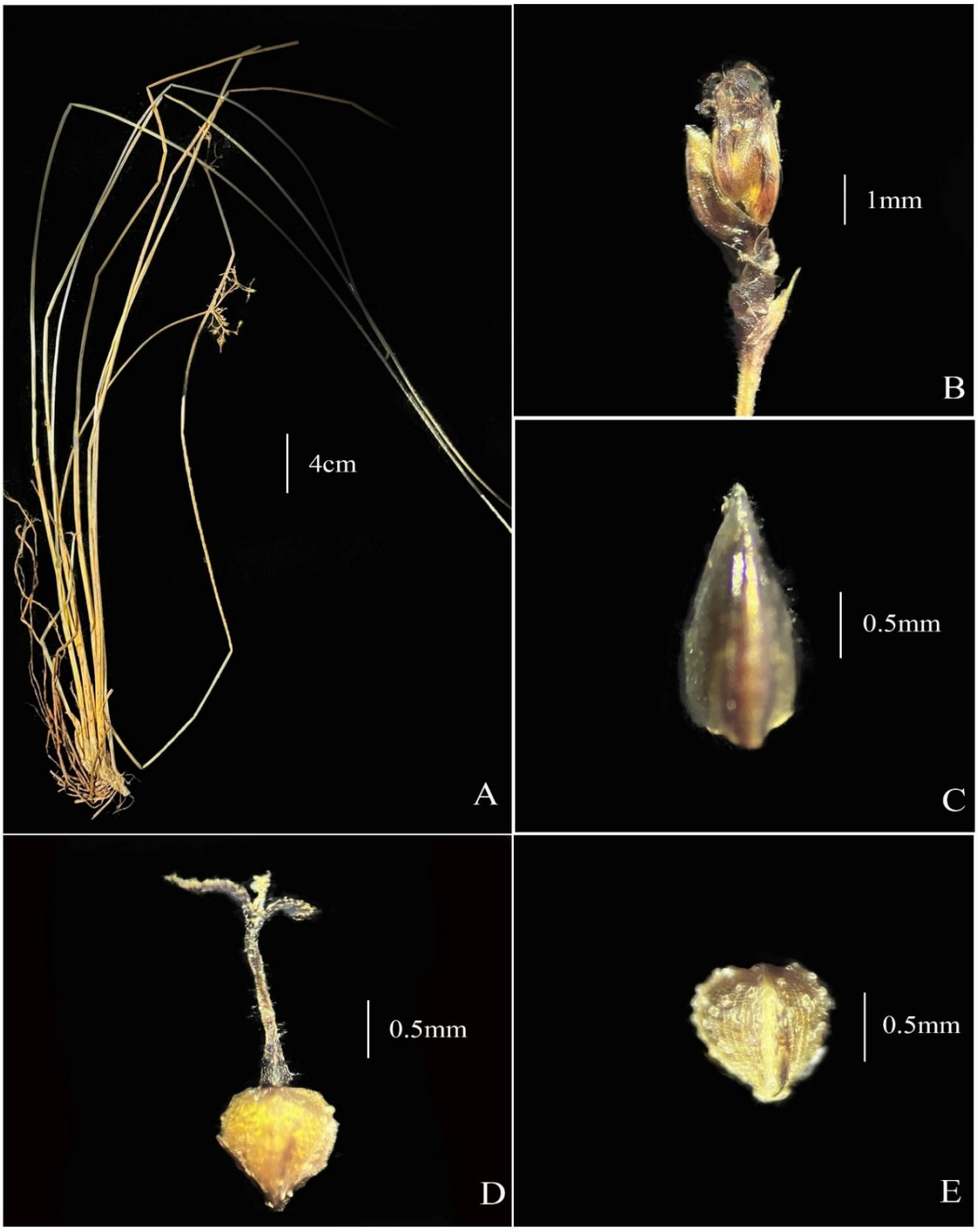


Photoplate No. 23: *Fimbristylis ovata* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet

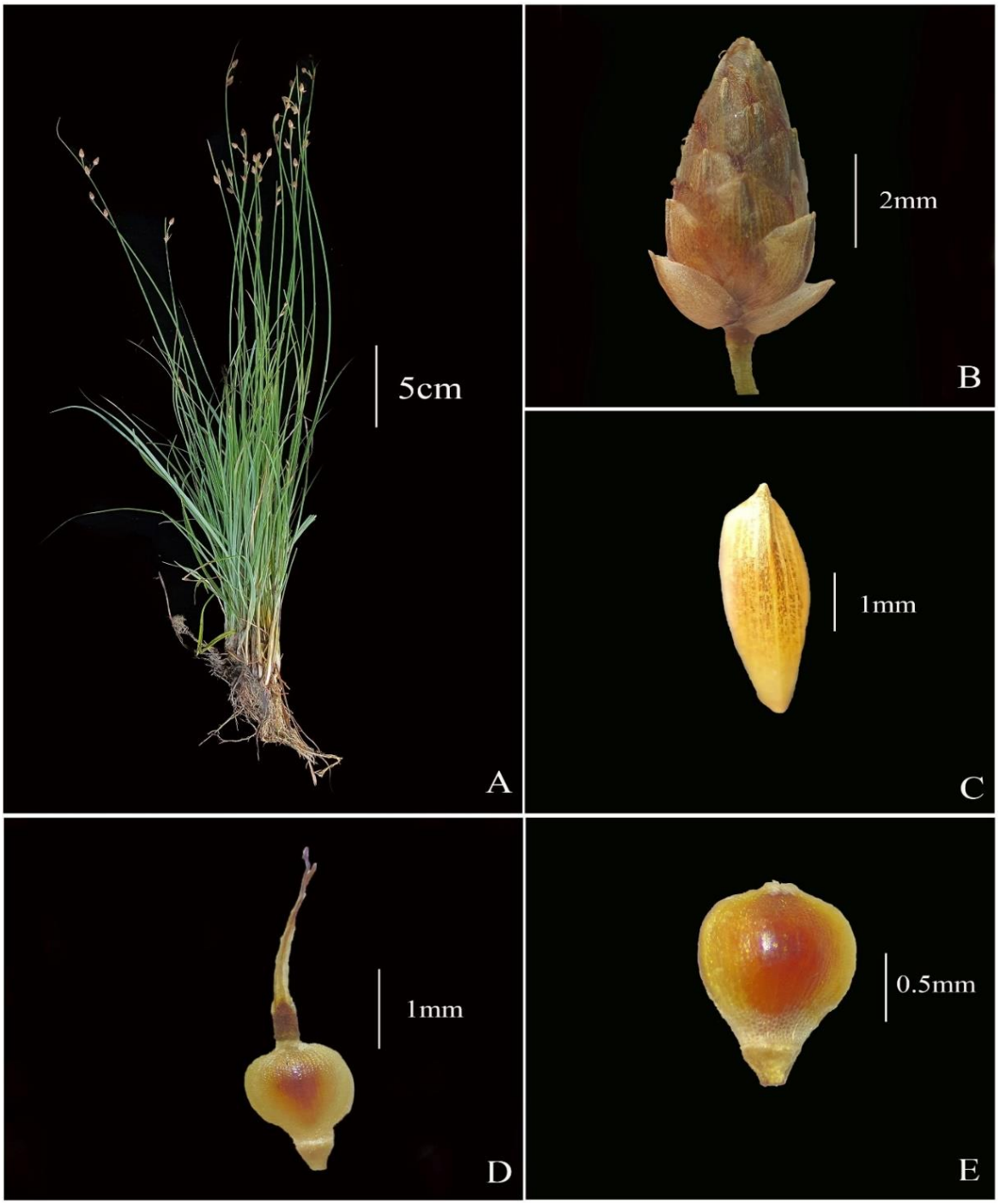
Photoplate No. 24: *Fimbristylis quinquangularis* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet.



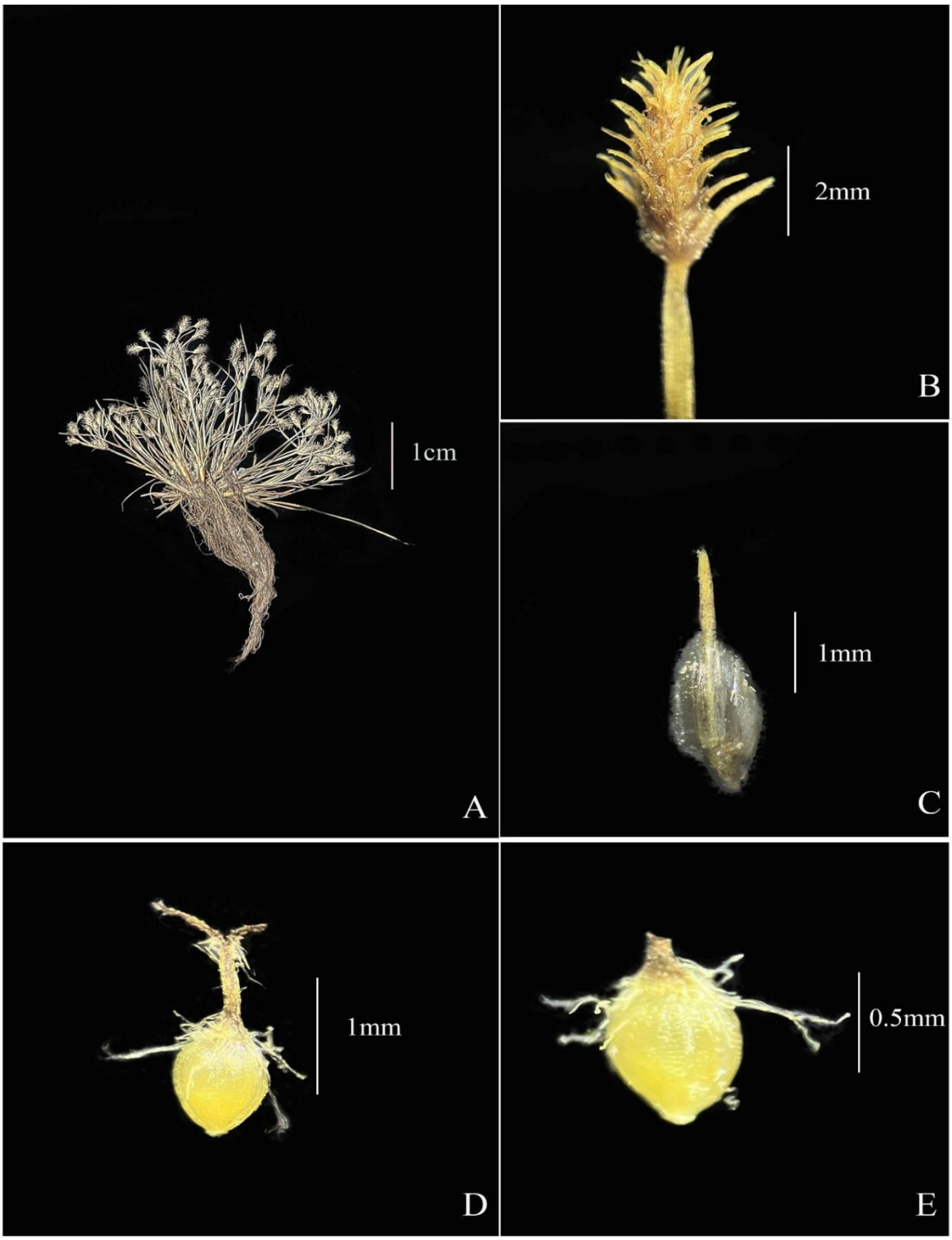
Photoplate No. 25: *Fimbristylis rigidula* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



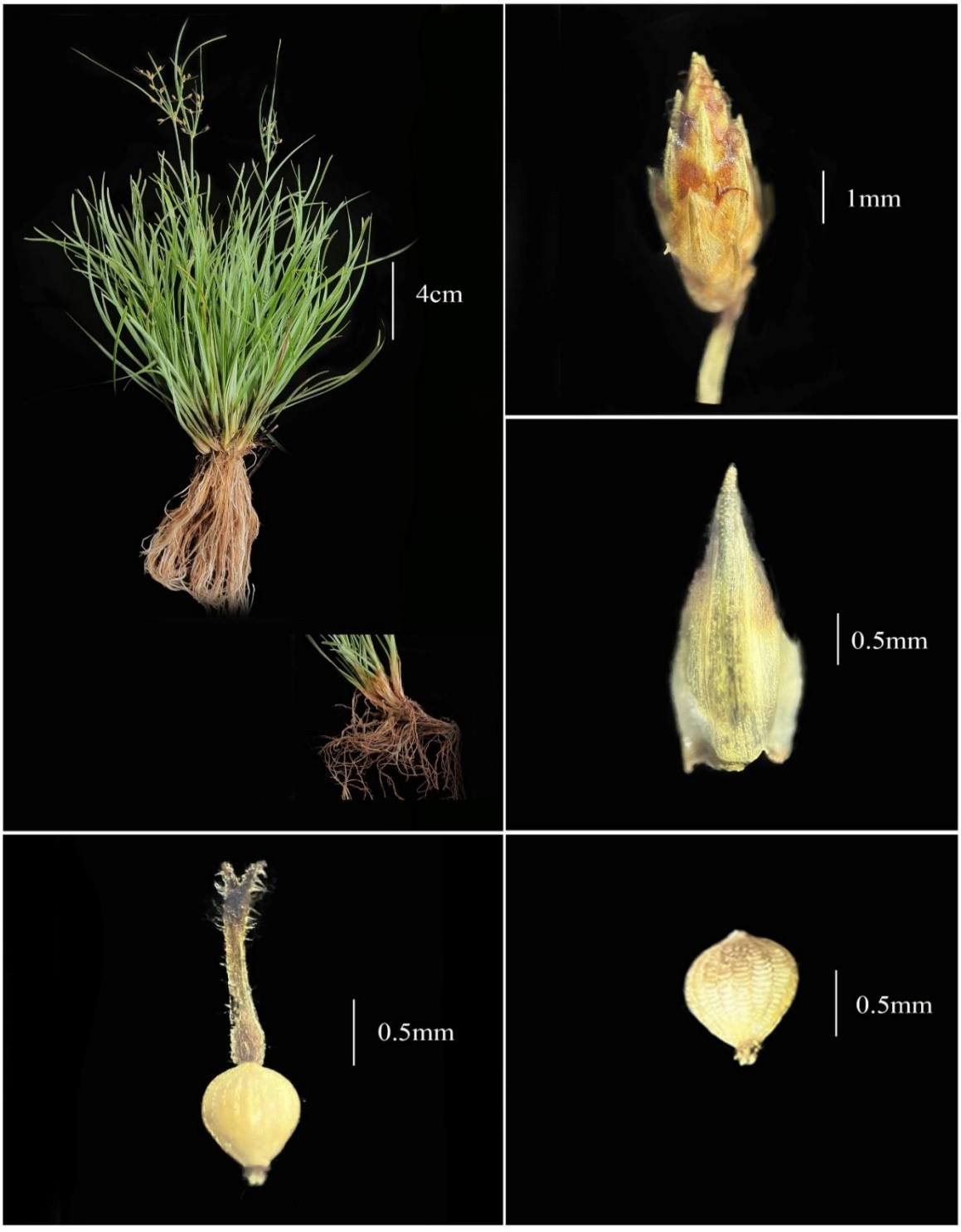
Photoplate No. 26: *Fimbristylis salbundia* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



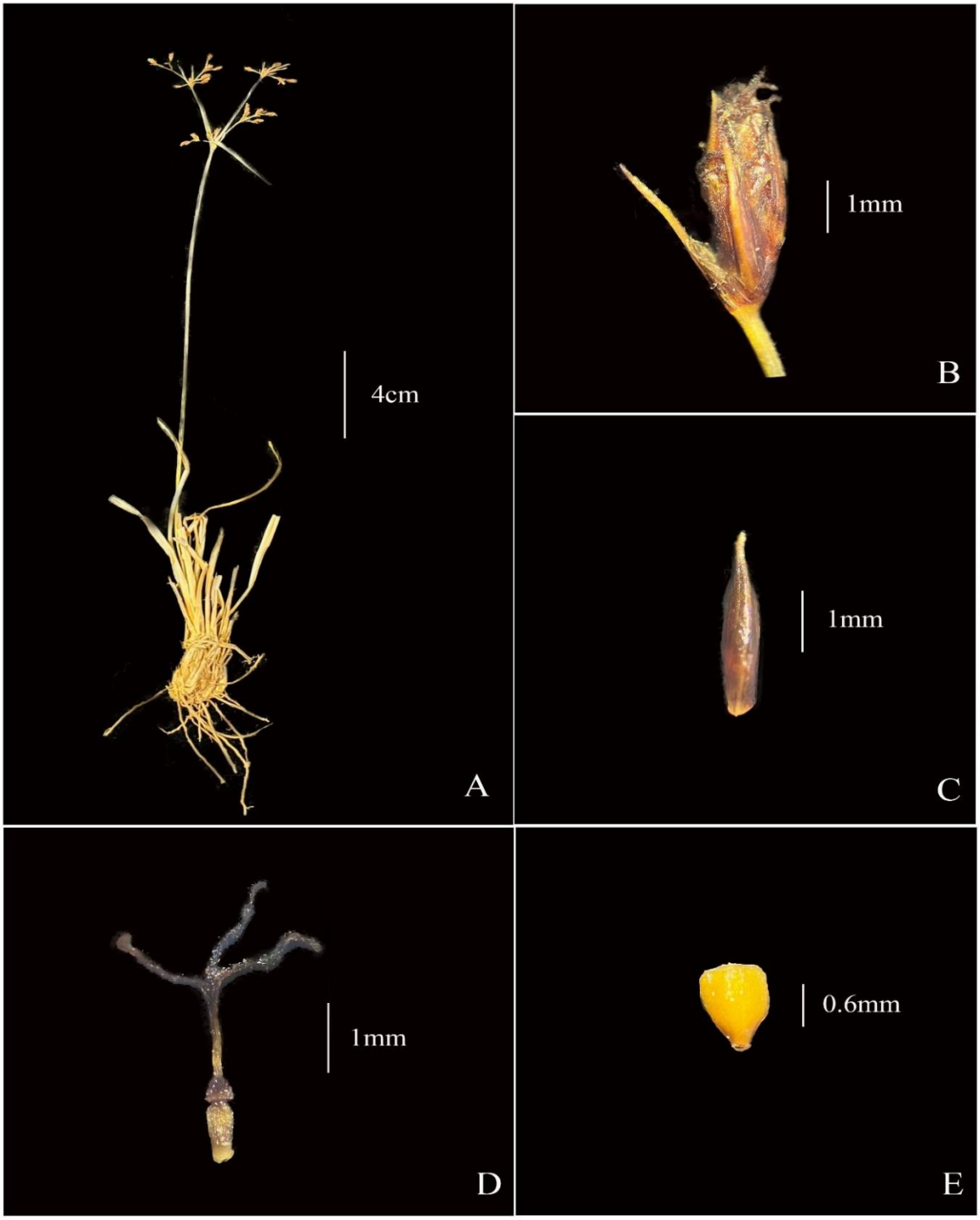
Photoplate No. 27: *Fimbristylis schoenoides* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



Photoplate No. 28: *Fimbristylis squarrosa* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



Photoplate No. 29: *Fimbristylis stolonifera* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet



Photoplate No. 30: *Fimbristylis thomsonii* **A**. Habit sketch, **B**. Spikelet **C**. Glume **D**. Fruiting pistil, **E**. Nutlet