TAXONOMY AND REPRODUCTIVE BIOLOGY OF THE FAMILY LILIACEAE OF BANGLADESH.

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TO
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By

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Dedicated
To My
Beloved Parents, Husband
And
Respected Teachers

DECLARATION

*I hereby declare that the work presented in this thesis entitled "**Taxonomy and Reproductive Biology of the family Liliaceae of Bangladesh**" is the result of my own investigation. I further declare that this thesis has not been submitted in any previous application for the award of any other academic degree in any university. All sources of information have been specifically acknowledged by referring to the authors.*

February, 2018

Sumona Afroz
Author

CERTIFICATE

*This is to certify that the research work presented in this dissertation entitled "**Taxonomy and Reproductive Biology of the family Liliaceae of Bangladesh**" is the outcome of the original work carried out by **Sumona Afroz** in the Plant Taxonomy, Ethnobotany and Herbal Medicine Laboratory, Department of Botany, University of Dhaka under my supervision.*

This is further certified that the style and contents of this dissertation is approved for submission in fulfillment of the requirements for the degree of Doctor of Philosophy in Botany (Plant Taxonomy).

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Abstract

The family Liliaceae A.L. de Jussieu has been revised for Bangladesh and a total of 43 species under 20 genera have been recorded. A complete taxonomic account of the family is therefore prepared for the flora. The taxonomic history and currently accepted classification of the family Liliaceae is presented and discussed.

Artificial dichotomous bracketed keys to the genera and species (wherever necessary) have been provided for easy identification of the taxa. Updated nomenclature i.e. valid names, synonyms, local names and English names where available, and descriptions have been furnished under each taxon including photographs. Flowering and fruiting periods and distribution have also been added. The germplasm of most of the taxa have been collected from different parts of the country and planted in the experimental plots of the Dhaka University Botanical Garden.

Out of 43 species, 21 species are wild and 22 are cultivated. Among the wild species *Asparagus racemosus* Willd., *A. densiflorus* (Kunth) J.P. Jessop and *A. setaceous* (Kunth) J.P. Jessop are climbers. *Hypoxis aurea* Lour., *Asparagus setaceous* (Kunth) J.P. Jessop, *Asphodelus tenuifolius* Cavan and *Crinum stenophyllum* Baker were previously recorded but we did not find any live specimens in the wild. Some species are restricted to certain area like *Urginea indica* (Roxb.) Kunth in Cox's Bazar district near Himchari and *Allium tuberosum* Rottler *ex* Spreng. in Belaichari of Rangamati district.

Chlorophytum nepalense (Lindley) Baker was collected from Runctia Sal forest under Sherpur district in 2008 and planted in the Dhaka University Botanical Garden. This species has been recorded as new for the flora of Bangladesh. Despite repeated field trips were made in that area for further collection, no specimen of *Chlorophytum nepalense* were found and therefore this species could be claimed as very rare or possibly extinct in Bangladesh.

Hymenocallis littoralis (Jacq.) Salisb., an ornamental herb collected from Sonargaon and Char Kukri Mukri was not recorded previously, hence it is a new record for Bangladesh. Some other species, viz. *Allium chinense* G. Don, *Asparagus densiflorus* (Kunth) J.P. Jessop, *A. officinalis* L., *Chlorophytum comosum* R.Br., *Crinum amabile* Donn, *C. jagus* (Thomps.) Dandy, *Eucharis grandiflora* Planch. & Linden, *Eucrosia bicolor* Ker-Gawl., *Hippeastrum puniceum* (Lamk.) Voss, *Proiphys amboinensis* (L.) Herb., *Zephyranthes atamasco* (Linn.) Herb. are usually cultivated in the gardens, were not recorded in any literature published previously for this region.

Reproductive Biological data of important 14 species under 11 genera are presented and discussed. Among these species *Allium tuberosum* Rottler *ex* Spreng., *Asparagus racemosus* Willd., *Chlorophytum nepalense* (Lindley) Baker and *Urginea indica* (Roxb.) Kunth are cross pollinated. Pollination occurred by ant or bee belonging to the family Formicidae or Apidae. Most of the species are self pollinated. *Hemerocallis fulva* L. produced no fruit and *Pancratium triflorum* Roxb. produced fruit but not matured. *Asparagus racemosus* Willd. and *Haemanthus multiflorus* Martyn *ex* Willd. produced very poor number fruits in comparison to the number of flowers bloomed.

Out of studied 14 species of Liliaceae, 10 species were propagated through seeds. Seeds were not germinated in *Curculigo orchioides* Gaertn. and *Scadoxus multiflorus* Raf. Two species e.g. *Hemerocallis fulva* L. and *Pancratium triflorum* Roxb. produced no fruit. Minimum time taken for seed germination is 3-4 days in *Zephyranthes* spp., whereas maximum 1 year in *Crinum amoenum* Roxb. Propagation through bulb or rhizome transfer was not possible in *Asparagus racemosus* Willd., *Chlorophytum nepalense* (Lindley) Baker and *Zephyranthes tubispatha* (L'Her.) Herb. whereas rest 11 species propagated through bulb or rhizome.

Minimum time taken for scape initiation to fruit maturation were 16 days in *Zephyranthes* spp. and maximum about 80 days in *Gloriosa superba* L. from initiation of aerial stem. Maximum about 100 flowers borne on a scape in *Scadoxus multiflorus* Raf., whereas single flower in *Gloriosa superba* L. and *Zephyranthes* spp.

Asparagus racemosus Willd. and *Haemanthus multiflorus* Martyn *ex* Willd. produced single seed, while *Gloriosa superba* L. contains about 50-75 seeds in each fruit. Production of fruits and seeds were very poor compare to number of flowers in *Allium tuberosum* Rottler *ex* Spreng., *Asparagus racemosus* Willd. and *Scadoxus multiflorus* Raf.

CHAPTER 1

INTRODUCTION

1.1: Introduction to Plant Taxonomy

Plant taxonomy, the theory and practice of plant classification, is probably the oldest branch of science. This branch of science was originated in the prehistoric time when primitive people tried to group their surrounding plants according to their economic uses.

As plant names are the key to literature and grouping into different taxa can be possible only when their identity are revealed and named for the sake of convenience and communication of ideas about them, at present plant taxonomy includes identification, and nomenclature, apart from their classification.

Although in its initial stage taxonomy was mainly based on the gross morphological features of plants, now many other scientific information is used from other branches of botany like anatomy, palynology, cytology, ecology, molecular biology, reproductive biology etc. Therefore plant taxonomy is now a very dynamic and synthetic science and is the basic to all other branches of biological sciences.

In developed countries, trained plant taxonomists are available in large number, taxonomy reached at the experimental (biosystematic) phase or even at encyclopedia stage. In Bangladesh, we are still running through pioneer (exploratory) phase to the consolidation (compilation of revision, flora or monograph) phase. However, very few preliminary works on DNA barcoding are also available, but this is still insignificant. After 1947, there were very few plant taxonomists to work on higher plants. Professor M. Salar Khan was the only trained plant taxonomist to proceed in this line. At present there are many plant taxonomists working in the University of Dhaka, University of Chittagong, Jahangirnagar University and Bangladesh National Herbarium and they are adding significant contribution. We are still in the pioneer and consolidation phases mostly producing flora of smaller areas or revision of smaller or well known families.

Bangladesh, though a small country of about 1,47,570 square kilometer area, has vast floral elements of diversified characters and rich in its flora. There is an estimate of 5,000 species of flowering plants (Khan and Alam, 1977) in Bangladesh; many of them are unexplored or lacking information of their specific exact location. Ahmed *et al.* (2007-2009) in their 28 volumes of "Encyclopedia of Flora and Fauna of Bangladesh" described 158 families under Magnoliopsida (dicot) and 41 families under Liliopsida (monocot). Dr. Arthur Cronquist (1981) recognized 65 monocot families, out of which 41 families are recognized and described from Bangladesh area indicating richness of our floral elements.

For better taxonomic knowledge and to make complete inventory of plant wealth of the country each and every family should be revised properly and scientifically. Only a few families including Apocynceae, Zingiberaceae, Orchidaceae, Rubiaceae, Araceae are properly revised for the country, most of the families yet to be revised. Out of many whichare yet to be revised Liliaceae is one of the moderately large family and are important both economically as well as taxonomically.

1.2: Poor Representation of the Family Lliaceae

The family Liliaceae family is poorly represented in most of the herbaria, because

- Certain genera cannot be located easily in the field for most of the time of the year because they become devoid of aerial parts and survive only by the underground stem. So it is difficult to locate them in the field e.g. *Gloriosa.*
- In few genera, the flowers and the leaves do not appear simultaneously. So, collection of both flowers and leaf at the same time in a specimen is difficult e.g. *Hippeastrum.*
- Short flowering period in many taxa e.g. *Urginea.*
- Many species are succulent. So, special technique is required for its preparation and preservation in the herbarium e.g. *Crinum, Scadoxus* etc.

1.3: Reasons for Choosing Liliaceae for the Present Work

Liliaceae has been chosen for the present work because

- Studies on Liliaceae family in Bangladesh are fragmentary and scattered. No comprehensive work on this family was undertaken before in Bangladesh.
- Liliaceae family is an important source of spices, viz. *Allium cepa* (Piyaz), *A. sativum* (Rasun) and vegetables like *Asparagus officinalis* (Asparagus).
- Most of the species have medicinal or ornamental value e.g. *Asparagus racemosus, Urginea indica, Gloriosa superba, Scadoxus multiflorus, Hemerocallis fulva, Pancratium triflorum* etc.
- Some species (*Asparagus* sp., *Crinum* sp.) gradually becoming disappeared due to forest clearings.

1.4: Aims and Objectives

The present investigations have been undertaken with the following aims and objectives:

1. To collect specimens from all over Bangladesh.
2. To prepare an artificial analytical key for easy identification of the species.
3. To resolve nomenclatural problems.
4. To identify different economically important species.
5. To revise the family for Bangladesh.
6. To carry out experimental study on reproductive biology and other methodology of propagation of some selected species of Liliaceae.

1.5: Materials and Methods

The present work is mainly based on the fresh materials collected by the author. However, some species have also been taken into account from the Dhaka University Salar Khan Herbarium (DUSH) and Bangladesh National Herbarium (DACB).

Collected plants of this family were kept under plantation in the Botanical Garden of theUniversity of Dhaka. Collection includes the species growing in the wild and also cultivated in the gardens as well as in the crop fields.

Collected fresh specimens were studied and fresh flowers were collected for dissection. After dissection, detail floral parts have been studied for identification of the species.

The species which could not be collected fresh were studied from the herbarium specimens. The family, genera, and species descriptions are given in an alphabetical order.

The collected specimens were identified with the consultation of standard literature and comparing with herbarium specimens deposited in the Dhaka University Salar Khan Herbarium (DUSH), Bangladesh National Herbarium (DACB), Chittagong University Herbarium (HCU), Bangladesh Council of Scientific and Industrial Research Herbarium (BCSIRH), Chittagong, Jahangirnagar University Herbarium and Rajshahi University Herbarium.

The descriptions were compared with Hooker (1892), Jackson (1895), Prain (1903), Dassanayake and Clayton (1981), Deb (1983), Raven and Zhengyi (2000), Jessop (1979) and Utech (2002).

Some other literatures and journals have been consulted to determine up to date nomenclature. Internet information have also been collected and added in some cases.

Key to genera and key to species, wherever necessary have also been added.

Study methods for petiole anatomy and reproductive biology are furnished under respective chapters.

CHAPTER 2

HISTORICAL BACKGROUND OF LILIACEAE

2.1: General Background

Liliaceae, the Lily family, is a moderately large family that consists of about 280 genera and nearly 4000 species. It is widespread throughout the world, but most abundant and varied in fairly dry, temperate to subtropical regions (Cronquist, 1981). The family is named after *Lilium*, the type genus (Simpson, 2006). *Lilium* is Latin for 'lily' and which came from the Greek word *leírion* (lily flower "a classic symbol of purity"). Liliaceae are generally bulbous geophytes, but also possess other forms of enlarged underground stem. This family contains many members with economic importance.

Though a general account of Liliaceae occurring in the Indian subcontinent is given by Hooker (1892) and for the then Bengal by Prain (1903), specific localities for the species have rarely been cited. Datta and Mitra (1953) published a general record of angiospermic plants occurring in the present Dhaka and its surroundings under the caption "Common plants in and around Dacca" where they recorded 5 genera and 5 species under Amaryllidaceae and 6 genera and 4 species under Liliaceae.

No detailed taxonomic work on this family was done before in this country. It is realized that a thorough taxonomic revision of this family for Bangladesh is necessary and it should be done immediately. Hence, this work was undertaken. This is the first attempt on the comprehensive study of the family Liliaceae in Bangladesh.

There is no question that the evidence available today (Angiosperm Phylogeny Group, 1998; Rudall *et al*., 1995; Wilson and Morrison, 2000) strongly supports extensive dismemberment of Arthur Cronquist's (1981, 1988, 1993) very broadly circumscribed Liliaceae. Not fewer than 30 segregate families have been recognized, though there is not universal acceptance of all of them, and in some cases their ordinal associations are not yet settled. As defined by Cronquist (1981), the Liliaceae contained "about 280 genera and nearly 4000 species." In a much more restricted, recent sense, the family was considered to include only 11 genera and perhaps 545 species (Thorne, 2000).

Thorne (2000) recognized two subfamilies, of which the Medeoloideae (*Medeola* and *Clintonia*) have sometimes been segregated as the Medeolaceae (Takhtajan, 1997). Kubitzki (1998), Judd (1999), Thorne (2000), and Patterson and Givnish (2002) have recognized Calochortaceae separated from Liliaceae. As circumscribed by Patterson and Givnish (2002), the family includes *Calochortus*, *Prosartes, Scoliopus, Streptopus*, and *Tricyrtis* Wallich. Takhtajan (1997) distributed these genera among three segregated families: Calochortaceae, Scoliopaceae and Tricyrtidaceae. *Hesperocallis* is currently treated as the sole representative of the segregate family Hesperocallidaceae (Traub, 1972; Takhtajan, 1997). Karyologically and embryologically, *Hesperocallis* is the nearest to *Hosta* (Hostaceae) and the Agavaceae (Cave, 1948; 1970), and even though their base chromosome numbers are different [x = 24 in *Hesperocallis* and x = 30 in *Hosta* and Agavaceae (Whitaker, 1934; Satô, 1935; Sen, 1975; Maekawa and Kaneko, 1968; Tamura, 1995)], they share a strongly bimodal karyotype. In addition, the pollen grains of *Hosta plantaginea* and *Hesperocallis* have similar unibaculate muri (Alvarez and Köhler, 1987). *Hosta* has long been associated with *Hemerocallis* and *Leucocrinum* in the liliaceous tribe Hemerocallideae. However, recent molecular and morphological evidence (Chase *et al.,* 1996; Rudall *et al*., 1995) supports separating the genera *Hemerocallis* in the Hemerocallidaceae, *Leucocrinum* in the Anthericaceae (Conran, 1998a), and *Hosta* in a monotypic Hostaceae (Kubitzki, 1998; Takhtajan, 1997). In the past, several taxonomic affinities have been suggested for *Androstephium, Bloomeria, Brodiaea, Dichelostemma, Milla, Muilla, Triteleia,* and *Triteleiopsis* (Liliaceae, Amaryllidaceae, Alliaceae), but most recently they have been placed in the resurrected family Themidaceae based on molecular and anatomical evidence (Fay and Chase, 1996; Pires *et al.,* 2001). The Liliaceae include numerous important ornamentals such *as Amaryllis, Hemerocallis, Hosta, Lilium, Narcissus,* and *Tulipa*. The family is a dominant component in the temperate spring flora, which includes both native and introduced species. Many of the introductions, or cultivars derived from them, are from ecologically equivalent, temperate zones and their naturalization potential is high. *Asparagus* and *Allium* have edible species of major economic importance, while many other genera (e.g., *Convallaria, Ornithogalum, Veratrum, Zigadenus*) are highly toxic due to the presence of various alkaloids and cardenolides (Burrows and Tyrl, 2001). They include: *Colchicum autumnale* Linnaeus, *Gagea fistulosa* Ker-Gawl., *G. villosa* (M. Bieberstein) Duby, *Gloriosa superba* Linnaeus, *Kniphofia uvaria* (Linnaeus) Oken, *Liriope muscari* (Decaisne) L. H. Bailey, *L. spicatum* Loureiro, *Lycoris radiata*

(L'Heritier) Herbert, *L. squamigera* Maximowicz, *Ophiopogon jaburan* (Siebold) Loddiges, *Sternbergia lutea* (Linnaeus) Ker-Gawl. *ex* Sprengel, and *Tricyrtis hirta* (Thunberg) Hooker (Utech, 2002).

2.2: Taxonomic History and Classification

Dahlgren and Clifford (1982) gave a historical account of monocotyledon classification. Table 1 indicates the classification of Liliaceae (including Amaryllidaceae) from 1853 to 1983.

Table 1. Previous classifications of Liliaceae including Amaryllidaceae (Dahlgren and Clifford, 1982).

Author (year)	**Classification**
Lindley (1853)	*Class* Endogens *Narcissales*: Amaryllidaceae *Liliales*: Liliaceae (*sensu lato*)
Bentham *et* Hooker (1883)	Series II. *Epigynae*: Amaryllidaceae Series III. *Coronariae*: Liliaceae
Van Tieghem (1891)	Order Liliinees: Family Liliacees Order Iridinees: Amaryllidees
Engler (1892), Rendle (1930)	Order *Liliflorae*: Liliaceae, Amaryllidaceae
Wettstein (1901)	Order *Liliflorae*: Liliaceae *sensu lato*, Amaryllidaceae
Lotsy (1911)	Family *Liliflorae*: Liliaceae (split into smaller groups), Amaryllidaceae
Haillier (1903, 1905, 1912)	Order *Liliflorae*: Liliaceae, Amaryllidaceae
Bessey (1915)	Class *Alterniflorae* (Monocotyledons) Subclass *Strobiloideae* - *Liliales*: Liliaceae Subclass *Cotyloideae* - *Iridales*: Amaryllidaceae
Ankermann (1927)	Liliaceae: Amaryllidaceae
Calestani (1933)	Series I. *Lirianthae* 3. Scillinae: Liliaceae, Amaryllidaceae
Skottsberg (1940)	Order *Liliflorae*: Liliaceae (*sensu lato*), Amaryllidaceae

Hutchinson (1934)	Order *Liliales*: Liliaceae Order *Amaryllidales*: Amaryllidaceae
Soo (1953, 1961, 1975)	Series E: 43. Liliflorae - Liliales
Novak (1954)	*Liliales*: 1. Liliinae: Liliaceae, Amaryllidaceae
Deyl (1955)	*Liliales*: Amaryllidaceae, Liliaceae
Kimura (1956)	II. *Syncarpae* *II. 1 Subsyncarpae* B. *Liliflorae*: 7. *Liliales*: Liliaceae *II: 2 Coenocarpae* G. *Epigynae*: 24. *Amaryllidales*: Amaryllidaceae
Takhtajan (1959, 1969)	Class LILIATAE (=Monocotyledones) Subclass LILIIDAE: Superorder Lilianae *Liliales*: Liliaceae, Amaryllidaceae
Emberger (1960)	*Phylum IV. Liliflores* *Liliales*: Liliaceae, Amaryllidaceae
Hamann (1961)	Order *Liliales*: Liliaceae, Amaryllidaceae
Faulks (1964)	13. *Liliales*: Liliaceae 17. *Amaryllidales*: Amaryllidaceae
Melchior (1964)	Order 2. *Liliflorae*: Liliaceae *sensu lato*, Amaryllidaceae
Cronquist (1968)	Class LILIATAE (Monocotyledoneae) Subclass LILIIDAE: *Liliales*: Liliaceae (incl. Amaryllidaceae)
Thorne (1968, 1976)	Superorder Liliflorae *Liliales*: Liliaceae (with the subfamily Amaryllidoideae)
Huber (1969, 1977)	*Asparagales*: Amaryllidaceae *Liliales*: Liliaceae
Stebbins (1974)	Subclass MONOCOTYLEDONES Superorder Liliidae: *Liliales*: Liliaceae (incl. Amaryllidaceae)
Dahlgren (1975)	*Lilianae* *Asparagales*: Amaryllidaceae *Liliales*: Liliaceae

Ehrendorfer (1978)	Class MONOCOTYLEDONAE Subclass LILIIDAE: *Lilianae*: *Liliales*: Liliaceae, Amaryllidaceae
Dahlgren and Clifford (1982)	Superorder LILIFLORAE
Dahlgren and Rasmussen (1983)	Order Asparagales: Amaryllidaceae Order Liliales: Liliaceae

It is clear from the above stated taxonomic treatments that many taxonomists described Amaryllidaceae and Liliaceae separately under the same order or under separate orders. However Cronquist (1981) merged Amaryllidaceae under Liliaceae. The same treatment is followed in the present study.

2.3: Affinities of Liliaceae

The family Liliaceae consists of many diverse groups, so many authors splitted this family into several segregate families like Asparagaceae, Trilliaceae, Amaryllidaceae, Hypoxidaceae, Alliaceae etc. However, the mutual affinity among all the members is also widely recognized.

The family has close affinity to Juncaceae as in both the seeds have albumen but differs from Juncaceae in petaloid perianth. The family, on account of marked variabilities in cytological, embryological and anatomical structures, appears to be polyphyletic in origin. Its origin from Helobieae or its ancestor may be assumed from floral structures and helobial endosperm formation in some of the genera of Liliaceae as *Petrosavia*, *Protolirion*. The helobian origin is further supported by the flower construction of *Helonias* which is similar to the members of Juncaceae. Liliaceae is regarded as a typical monocot family and represents the basic monocot stock from which many families have arisen. Hutchinson has excluded many genera which are included later by many botanists in the family Liliaceae. He included *Allium, Agapanthus* in the family Amaryllidaceae of his order Amaryllidales; *Yucca, Dracaena, Sanseviera, Phormium* in the family Agavaceae of his order Agavales; *Xanthorrhoea* in the family Xanthorrhoeaceae of his order Agavales. He also included *Smilax* in the family Smilacaceae and *Ruscus* in Ruscaceae in his order Liliales. (http://www.biologydiscussion.com/botany/monocotyledons/liliaceae-characters-distribution-and-types/48562).

Liliaceae resembles very much Amaryllidaceae except in the character of **superior ovary**. Juncaceae also bears a close affinity to Liliaceae. It is considered to be polyphyletic in origin from the stand point of cytological variabilities, embryological and anatomical structures. Liliaceae is also supposed to have been derived from Helobieae or its ancestor based on the floral structures of a few genera belonging to Liliaceae, such as, *Petrosava, Protolirion*, etc. which possess semi-free carpels.

Amaryllidaceae is allied to Dioscoreaceae but the latter is distinguished by its habit: climbing plants with net-veined leaves and small, often unisexual flowers. Iridaceae, while resembling Amaryllidaceae is the inferior ovary, is distinguished from the latter as well as other epigynous petaloid families in having only three stamens (Mukherji, 1972).

2.4: Geographical Distribution

It is a well known fact that plant species are not homogenously distributed, each species depends on the existence of a specific set of environmental conditions for its long-term survival (Gaston and Blackburn, 2000).

The members of the family Liliaceae are widespread throughout the world, but most common in temperate to subtropical regions, especially East Asia and North America in the Northern hemisphere. The centre of diversity is from southwest Asia to China (Simpson, 2006). Their distribution is diverse, mainly in plains, steppes, and alpine meadows, but also in deciduous forests, Mediterranean scrub and arctic tundra.

2.5: Importance

The family is very important because of the following facts. The following statements will further substantiate the importance of the family.

Taxonomic importance

As many species are medicinally very important, their proper taxonomic identification is a prerequisite before they are used as medicine. There are also many endangered and rare species which need proper investigation regarding identification, distribution and abundance, and on ensure to reestablish them.

Medicinal importance

Many members of this family are well known for their medicinal properties. List of medicinal plants under the family includes species of *Asparagus*, *Gloriosa, Curculigo*, *Allium, Asphodelus, Crinum, Urginea* and *Scadoxus*.

Aesthetic importance

Many members of the family are familiar garden plants or ornamentals including species of *Hippeastrum, Tulipa, Aspidistra, Lilium, Narcissus, Chinodoxa, Eucharis, Proiphys, Gloriosa, Hemerocallis, Asparagus, Zephyranthes, Scadoxus, Crinum* etc.

Other importance

Spices: *Allium* (*Allium cepa, A. sativum*).

Wraping materials: *Curculigo latifolia.*

Making hats: *Molineria recurvata*.

Flour: *Curculigo orchioides.*

Poisonous: *Crinum asiaticum, C. amoenum, Gloriosa superba, Scadoxus multiflorus, Zephyranthes candida, Z. carinata.*

Rodent control: *Urginea indica*.

Vegetables: *Allium cepa, A. sativum, A. tuberosum, Asparagus officinalis*.

2.6: Exploration History and Previous Records

The earliest plant collections from the Indian subcontinent, including the areas now in Bangladesh, were made by a number of Botanists and collectors.

Nicolai Laurentii Burmanni (1768) recorded 20 species under 12 genera as hexandria monogynia in Flora Indica.

William Roxburgh (1814) with the collaboration of Buchanan Hamilton, Smith, Carey and Hardwick first recorded the species of the family Liliaceae from the area of present Bangladesh. He recorded 74 species under 17 genera in Hortus Bengalensis (1814) where 6 species under 5 genera recorded from Chittagong, Sylhet and Bengal. Later he added 43 species under 13 genera in the manuscript of Flora Indica (1832).

Francis Hamilton and David Don (1825) recorded 6 species under 10 genera as Asparageae, 6 species under 10 genera as Liliaceae, single species under Hemerocallideae, Hypoxideae and Melanthaceae in Prodromus Florae Nepalensis.

William Withering (1845) recorded 26 species under 12 genera in Systematic Arrangement of British Plants. He recorded the species as monogynia under the class hexandria.

Botanical exploration in eastern India including intensive collection from Sylhet, the Sundarbans and Chittagong, were made by Joseph Dalton Hooker (1817-1911) and his companion Thomas Thomson. Hooker's travels were systematically recorded in his Himalayan journals published in 1855 where he gave a graphic description of the flora encountered on his journey. Hooker was a pioneer in the study of the phytogeography of the Indian subcontinent, and suggested for the first time, the floristic areas of the region. With the cooperation of a number of eminent botanists, he published his monumental work in 7 volumes entitled "Flora of British India" (1872-1897). Hooker intensively studied the family Liliaceae in detailed, and in the 6th volume of his colossal work the Flora of British India (1892), he described 189 species under 39 genera for the whole British India. He merged the family Smilacaceae and Dracaenaceae with Liliaceae but kept the order Amaryllideae apart from Liliaceae. He described 4 genera and 25 species under the order Amaryllideae and the rest are under Liliaceae.

Alexander Kyd Nairne (1894) listed single species under the family Hypoxidaceae, 4 species and 3 genera under the order Amaryllideae, 12 species and 9 genera under the order Liliaceae in his book entitled 'The Flowering Plants of Western India'.

Sir David Prain, the author of Bengal Plants (1903) and the Flora of Sundribuns (1903a) during the period of his service as a curator of the herbarium (1887-1898) at Calcutta Botanical Gardens, he explored both west and east Bangal. In his 2nd volume of Bengal Plants, he recorded 13 species and 1 variety under 7 genera as Amaryllidaceae and 22 species under 13 genera as Liliaceae including Smilacaceae and Dracaenaceae.

Robert Lawrence Heinig (1925), another British botanist arrived India in 1895 and served as a Forester at Chittagong and Sundarbans from 1920 to 1924. He explored throughout Chittagong and Chittagong Hill Tracts and collected huge information on the forest flora. He compiled and published his works entitled 'A List of Plants of Chittagong Collectorate and Hill Tracts' in 1925. In his work he listed 14 species and 9 genera under the family Liliaceae.

John Macqueen Cowan, another Scottish botanist, published The Flora of Chakaria Sundarbans (1928) when it was thriving littoral forest. He also explored Chittagong and collected lots of plants from the area. In his Flora of Chakaria Sundarbans, he recorded 10 species under 5 genera as Amaryllidaceae and 9 species under 3 genera as Liliaceae including Smilacaceae.

Asa Gray (1908) recorded 33 genera, 103 species and 15 variety under the family Liliaceae and 14 species under 8 genera as Amaryllidaceae in 'Gray's New Manual of Botany: a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada'.

In 1944, two Indian botanist, Rabindra Mohan Datta and Jatindra Nath Mitra visited Dhaka and they collected plants in the neighbouring place of Dhaka (Dacca) city. In the publication Common Plants in and Around Dacca (1953), they recorded 5 species under 5 genera in the family Liliaceae and 7 species under 7 genera in the family Amaryllidaceae.

James Sinclair (1955), Scottish botanist worked extensively at Cox's Bazar and surrounding areas. He published 'The Flora of Cox's Bazar' where he recorded 2 species under Amaryllidaceae and 6 species under Liliaceae.

Jatindra Nath Mitra (1958) published Flowering Plants of Eastern India where he accumulated 101 species 3 variety under 36 genera in the family Liliaceae and 24 species and 1 variety under 11 genera in the family Amaryllidaceae.

Debendra Bijoy Deb (1983), an Indian botanist described 7 species and 7 genera under Liliaceae in his book Flora of Tripura State.

Dwijendra Narayan Bakshi (1984) listed 3 species and 1 variety under 4 genera in the family Liliaceae and 5 species under 3 genera as Amaryllidaceae in Flora of Murshidabad District.

Nayar (1984-85) recorded 7 genera under the family Amaryllidaceae and 30 genera under the family Liliaceae in two volumes of Key Works to the Taxonomy of Flowering Plants of India.

Bentham *et* Hooker (1983) recorded 64 genera under 5 tribe in the family Liliaceae and 187 genera under 20 tribe as Amaryllidaceae in their popular book Genera Plantarum.

Karthikeyan *et al.* (1989) described 24 species and 6 variety under 5 genera in the family Amaryllidaceae and 209 species, 3 sub species and 47 variety under 44 genera as Liliaceae in Flora of India.

Khan *et al.* (1994) recorded 2 species under the family Liliaceae in Assessment of Biodiversity of Teknaf Game Reserve in Bangladesh Focussing on Economically Important Plant Species.

Noltie (1994) arranged 6 species under single genus as Asparagaceae, 5 species under 3 genera as Hypoxidaceae, 2 species under a genus as Phormiaceae, single species under Hemerocallidaceae, only single genus under Asphodelaceae, 7 species under 4 genera as Anthericaceae, 7 species under 6 genera as Amaryllidaceae, single species under Colchicaceae and 17 species under 6 genera as the family Liliaceae in his publication Flora of Bhutan.

Mia and Khan (1995) described 2 species in the First List of Angiospermic Taxa of Bangladesh not Included in Hooker's 'Flora of British India' and Prain's 'Bengal Plants' under Liliaceae.

Hajra and Verma (1996) listed 5 species under 4 genera in Amaryllidaceae, 4 species under single genus in Hypoxidaceae, 8 variety, 5 sub species and 82 species under 36 genera as Liliaceae in Flora of Sikkim.

Rahman and Hassan (1995) and Uddin *et al.* (1998) recorded single species each under Liliaceae from Gazipur and Kaptai of Bangladesh while prepared angiospermic flora of two specific areas.

Raven and Zhengyi (2000) recorded 32 species and 5 variety under 10 genera in Amaryllidaceae and 741 species, 2 subspecies and 81 variety under 57 genera as Liliaceae in Flora of China.

Utech (2002) reported in the Flora of North America 478 species under 70 genera in the family Liliaceae.

Khan *et al.* (2002) described 3 species with their uses under the family Liliaceae in Ethnobotanical Survey in Rema-Kalenga Wildlife Sanctuary (Habiganj) in Bangladesh where Uddin *et al.* (2002) recorded 6 species under the family Liliaceae in An Annotated Checklist of Angiospermic Flora of Rema-Kalenga Wildlife Sanctuary (Habiganj) in Bangladesh-I. Liliopsida (Monocots).

Recently Siddiqui *et al.* (2007) recorded 26 species under 13 genera in the Encyclopedia of Flora and Fauna of Bangladesh. They described the family Liliaceae including Amaryllidaceae.

Rashid and Chowdhury (2013) recorded 1 species under the family Liliaceae in Bangladesh Journal of Plant Taxonomy entitled Additions to the Angiosperm Flora in the Sitapahar Reserve Forest of Kaptai, Rangamati, Bangladesh.

Sajib *et al.* (2014) also listed 3 species from Subarnachar Upazila, Noakhali under Liliopsida.

CHAPTER 3

INTRODUCTION TO THE STUDY AREA

The study of the family Liliaceae has been carried out throughout Banglades. Therefore this chapter includes a brief introduction to Bangladesh, exploration history, distribution of the Liliaceae species occurring in the flora of Bangladesh.

A brief note on the geographical position and topography, geology and soils, climate, vegetation and phytogeographic regions of Bangladesh is provided below in separate headings.

3.1: Geographical Position and Topography

Bangladesh, a small country in the South-east Asia with an area of 1,47,570 square kilometers, lies between 20°34′ and 26°38′ north latitude and 88°01′ and 92°41′ east longitude (Bangladesh Statistical Pocket Book 2006). The country is almost completely surrounded by India, with a short frontier with Myanmar in the south-east and the Bay of Bengal in the south (Fig.1).

Ahmed (2008) described Socio-Biological profile of Bangladesh in the Encyclopedia of Flora and Fauna of Bangladesh. He described the present land profile of Bangladesh as follows:

Arable land	63% of total land area that is, 72 milion hectare = 72,000 sq km
Forest	7% of total land area that is, 1.3 milion hectare = 10,300 sq km
Wetland	(Haors, Beels, Ditches) 20% of total land area = 29,000 sq km
Housing	4.4% of total land area, 0.15 milion hectare = 7,500 sq km

The country is bordered on the west, north, and east by a 2,400 kilometer land frontier with India and, in the southeast, by a short land and water frontier (193 kilometers) with Myanmar. On the south is a highly irregular deltaic coastline of about 600 kilometers, fissured by many rivers and streams flowing into the Bay of Bengal. The territorial waters of Bangladesh extend 12 nautical miles, and the exclusive economic zone of the country is 200 nautical miles.

The physiography of Bangladesh is characterized by two distinctive features: a broad deltaic plain subject to frequent flooding, and a small hilly region crossed by swiftly flowing rivers.

It is the world's largest deltaic plain and comprised of a vast area of plain land excepting a few hills in the north-east and south-east. Plain land has extensive inland depressions. Innumerable rivers and canals criss-crossed the low-lying areas. The tidal plain is in the south (Khan, 1977).

Geology and soils

Bangladesh is formed of the major part of Bengal Basin covered with Holocene and Neocene sediments. The Neocene sediments occur in the northern, north-eastern and eastern part where they are also folded. Pleistocene sediments occupy the Madhupur tract (the greater Dhaka, Tangail and Mymensingh), the Barind (part of Rajshahi), Rangpur and Dinajpur districts and the Lalmai elevation (Comilla district). The rest of the country comprises recent to sub-recent alluvial deposits carried by the three mighty rivers, the Padma (Ganges), the Jamuna (Brahmaputra) and the Meghna (Ismail & Mia, 1972).

The soils of the country may be classified into five major divisions (Ismail and Mia, 1972):

a. *Hill soil:* Covers the hilly region of the Chittagong, Chittagong Hill Tracts and Sylhet.

b. *High terrace soil:* Covers most of the Pleistocene and piedmont deposits with laterite characteristics.

c. *Alluvial soil:* Covers most of the flood plains excluding the Sundarbans and the depressed basins.

d. *Fresh water swamp soil:* A number of depressed basins are found in the district of greater Mymensingh and Sylhet which are inundated by fresh water during the monsoon that gradually dry out during the dry winter season. These depressed basins are known as 'Haor'.

e. *Tidal swamp soil:* Mainly covers the costal areas of south-western part of the country.

A small tract of higher land occurs in Sylhet, Mymensingh, Chittagong, Cox's Bazar and Chittagong Hill Tracts (CHT) regions.

Climate

Bangladesh is located in the tropical monsoon region and its climate is characterised by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. The most striking feature of its climate is the reversal of the wind circulation between summer and winter, which is an integral part of the circulation system of the South Asian subcontinent. From the climatic point of view, three distinct seasons can be recognised in Bangladesh-the cool dry season from November through February, the pre-monsoon hot season from March through May, and the rainy monsoon season which lasts from June through October. The month of March may also be considered as the spring season, and the period from mid-October through mid-November may be called the autumn season (Islam, 2003).

According to Bangladesh Statistical Pocket Book 2017, average climatic variations are given in Table 2.

Table 2. Average climatic variations.

Season	Temperature		Rainfall	Relative Humidity
	Maximum	Minimum		
Pre Monsoon	32.6°C	22.4°C	453 mm	74%
Monsoon	31.5°C	25.5°C	1733 mm	86%
Post Monsoon	30.5°C	21.4°C	210 mm	80%
Winter	26.5°C	13.9°C	44 mm	73%
Annual	30.4°C	21.2°C	203 mm	78%

a. *Temperature*

According to Bangladesh Statistical Pocket Book 2017, maximum and minimum temperature is recorded during 2016 of selected stations (Table 3).

Plate 1. Map of Bangladesh showing geographical position and administrative districts.

Table 3. Annual average maximum and minimum temperature during 2016 of selected stations.

Selected stations	**Maximum Temperature (annual average)**	**Minimum Temperature (annual average)**
Dhaka	30.7°C	21.8°C
Chittagong	30.3°C	21.7°C
Rangamati	30.6°C	21.0°C
Comilla	30.3°C	20.9°C
Sylhet	30.0°C	19.6°C
Barisal	30.6°C	21.3°C
Khulna	31.2°C	21.7°C
Dinajpur	29.9°C	19.9°C
Rajshahi	31.2°C	20.5°C
Rangpur	29.5°C	20.1°C

b. *Rainfall*

According to Bangladesh Statistical Pocket Book 2017, average annual rainfall is recorded during 2016 of selected stations (Table 4).

Table 4. Average annual rainfall during 2016 of selected stations.

Selected stations	**Annual average rainfall**
Dhaka	177 mm
Chittagong	243 mm
Rangamati	212 mm
Comilla	174 mm
Sylhet	344 mm
Barisal	175 mm
Khulna	150 mm
Dinajpur	170 mm
Rajshahi	121 mm
Rangpur	192 mm

c. *Relative humidity*

The relative humidity remains over 82% during June to September throughout the country, but in other parts of the year it sometimes goes down below 71%.

Vegetation

The vegetation of Bangladesh is one of the richest in tropical Asia. It is also affected by its climate, topography and soil. Vegetation of Bangladesh can be presented under the following headings according to Khan (1977):

1. *The Gangetic Plain*

The Gangetic plain constitutes the major part of the country with perfectly flat plain build up by the alluvial deposits laid down by the major rivers with their numerous tributaries and distributaries. The land is usually very fertile and about 60% of the area under crop cultivation, mostly rice and jute. The scattered villages in this plain are concealed by the dense foliage of a wide variety of trees, bushy shrubs,, twining shrubs over bushes, and clumps of bamboos and bananas. The plain is also characterized by the presence of *beels, jheels* and *haors* which are tracts wholly under water during the rains and only partially dry in the winter when rice cultivation is done.

2. *The Sundarbans*

It is a littoral forest and considered as the largest mangrove tract in the world. It covers the southern part of the greater Khulna (Satkhira, Khulna and Bagerhat) extending upto Patuakhali through Barguna district and facing the Bay of Bengal in the south, and is intersected by a network of innumerable small rivers and channels (*Khals*). Among the Mangrove species are a few climbers, epiphytes specially orchids, ferns and mosses. It is interesting to note that although grasses are plentiful, Sundarbans is devoid of bamboos.

3. *Chittagong Hill Tracts*

Chittagong Hill Tracts (Bandarban, Khagrachari and Rangamati) is bounded on the north by Tripura state of India, on the south by Akyab region of Myanmar and on the east by the Lushai Hills of India. This forest can be classified into a) tropical semi-evergreen, b) deciduous, c) bamboo brakes and d) grassland.

4. *Chittagong Forests*

The hilly terrain of Chittagong (including Cox's Bazar) is exceedingly irregular with a series of ridges and valleys in all directions. In the north, north-easterly, and easterly slopes, and in the deep valleys, the forest tend to be semi-evergreen but truly deciduous towards the south, south-west and westerly slopes. Towards the south a series of low flat islands skirt the coast with the mangrove vegetation especially in the delta of the Matamohuri river (Chakaria sundarban) and on the western bank of the river Naf. The littoral forest of Chakaria Sundarbans is in a rather degenerated condition due to erosion and constant tree felling. Floristically and geographically the region of Chittagong and the Hill Tracts is more related to Indo-China than to any part of the Indian subcontinent.

5. *Dhaka-Tangail-Mymensingh Sal Forest*

This covers the central part of Tangail, Mymensingh and Gazipur districts. The forest is dense at Madhupur in Tangail district. The dominant tree of the forest is *Shorea robusta* Gaertn. f. (*Sal*) often associated with a number of other deciduous trees. The under-growth along with shrubby climbers is rich in Zingers and grasses. The forest is dense at Madhupur in Tangail district. The forest consists of several hundred separate blocks of trees interrupted by depressions where vegetation is cleared for cultivation of paddy.

6. *Vegetation of Sylhet*

Sylhet (including Sunamganj, Habiganj and Moulvi Bazar) consists of low hills of 30-60 m covered with tees of deciduous types with some evergreen trees distributed in a number of scattered tracts. Impenetrable thorny thickets of canes and dwarf fan-palm (*Licuala* sp.) are formed here and there. There is a prevalence of epiphytes including orchids, ferns and mosses.

7. *Flora of Northern and Western Districts*

The drier part of the country is composed of deciduous forest predominantly with sal. Throughout the region *Acacia nilotica ssp. indica* (*Babla*), and *Acacia catechu* (*Khair*) grow well. There are mango and litchi groves at Rajshahi, Dinajpur and Kushtia districts yielding best quality fruits in Bangladesh.

8. *The Lalmai Elevation*

This elevation (6-12m), which is at the south-west of Comilla town, is now characterized by the presence of scrub jungles with a few natural patches of *Sal* forests.

CHAPTER 4

ASSESSMENT OF CHARACTERS

The concept of character is fundamental to the science of taxonomy. In general, a character is 'any attribute (or descriptive phase) referring to form, structure or behaviour which the taxonomists separate from the whole organism for a paricular purpose such as comparison or interpretation" (Radford *et al.*, 1974).

4.2: Morphological Characters of Liliaceae

1. Habit: Herbs e.g. *Allium*, rarely wiry shrubs e.g. *Asparagus* or climber e.g. *Gloriosa*.

Plate 2. Different habits: a. *Allium*; b. *Asparagus*; c. *Gloriosa*.

2. Root: Fibrous adventitious e.g. *Scadoxus*, sometimes tuberous e.g. *Asparagus*.

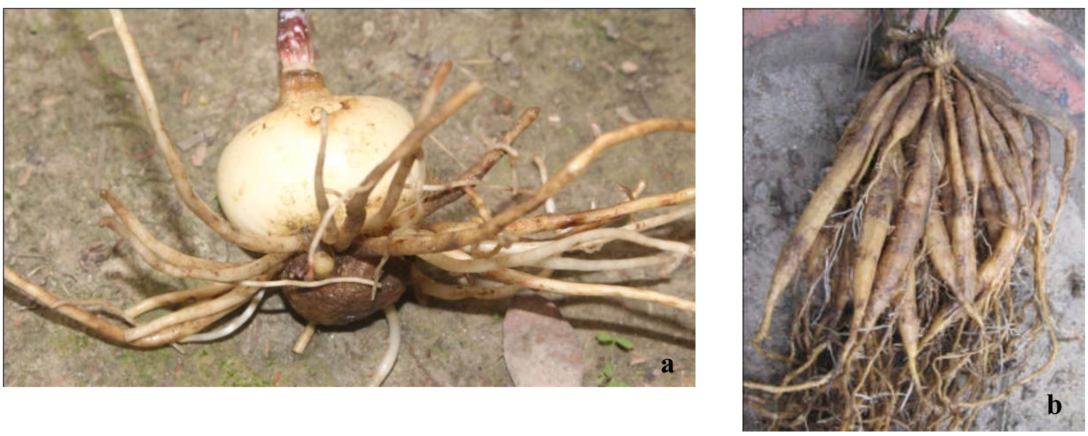


Plate 3. Different types of roots: a. *Scadoxus*; b. *Asparagus*.

3. Stem: Rhizome e.g. *Hemerocallis*, bulb e.g. *Crinum, Pancratium* or corm e.g. *Erythronium*.

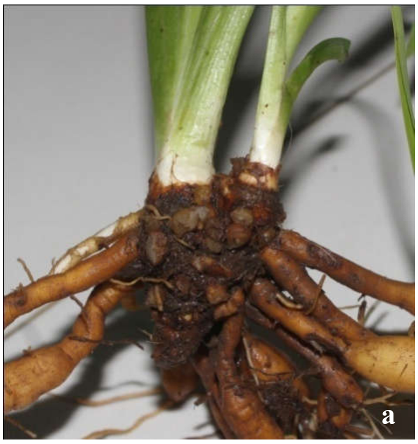


Plate 4. Different types of stem: a. *Scadoxus*; b. *Pancratium*.

4. Leaves: Simple, basal e.g. *Crinum, Pancratium*, or petiolate e.g. *Proiphys*, *Curculigo, Eucharis*, sometimes much-reduced e.g. *Asparagus*.

Plate 5. Leaf diversity: a. *Pancratium*; b. *Proiphys*; c. *Asparagus*.

5. Inflorescence: Raceme e.g. *Asparagus*, solitary e.g. *Gloriosa*, spike e.g. *Molineria,* panicle e.g. *Chlorophytum* or involucrate cymose umbel e.g. *Allium, Haemanthus*.

Plate 6. Inflorescence diversity: a. *Asparagus*; b. *Gloriosa*; c. *Molineria*; d. *Chlorophytum*; e. *Allium*)

6. Bracts and bracteoles: Bracts present e.g. *Molineria,* or not *Gloriosa*, usually small, scarious, sometimes spathe-like when umbellate e.g. *Crinum*; bracteoles present e.g. *Crinum* or not e.g. *Gloriosa*, linear e.g. *Crinum* or lanceolate e.g. *Pancratium*.

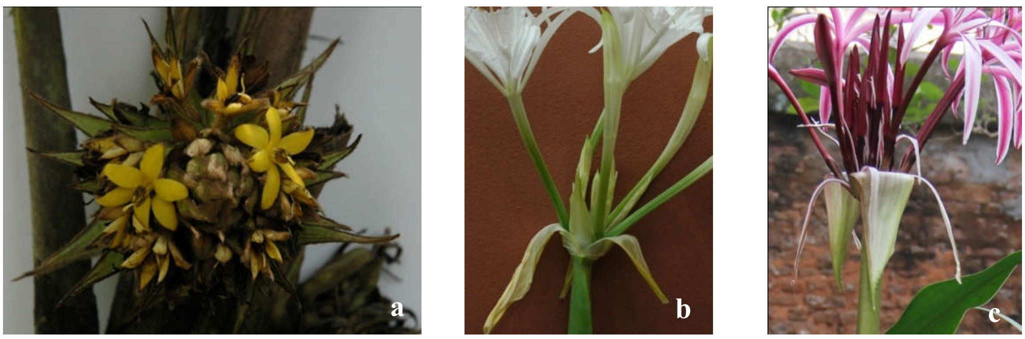


Plate 7. Bract and bracteole diversity: a. *Molineria*; b. *Pancratium*; c. *Crinum*.

7. Flowers: Usually regular e.g. *Crinum* rarely irregular. Perianth is either homochlamydeous (all tepals equal, e.g. *Allium*) or dichlamydeous (two separate and different whorls, e.g. *Hippeastrum*) and may be united into a tube e.g. *Crinum*.

Plate 8. Different types of flowers: a. *Allium*; b. *Hippeastrum*; c. *Crinum.*

8. Staminal Corona: Present e.g. *Pancratium, Hymenocallis* or not *Chlorophytum*.

Plate 9. Presence of staminal corona: a. *Pancratium*; b. *Chlorophytum*.

9. Androecium: Stamens 6, all free and distinct, adnate to the perianth tube or connate by their filaments; anthers linear e.g. *Gloriosa*, or oblong e.g. *Allium*, usually free or rarely fused e.g. *Molineria*, dorsifixed e.g. *Crinum* or basifixed e.g. *Chlorophytum*.

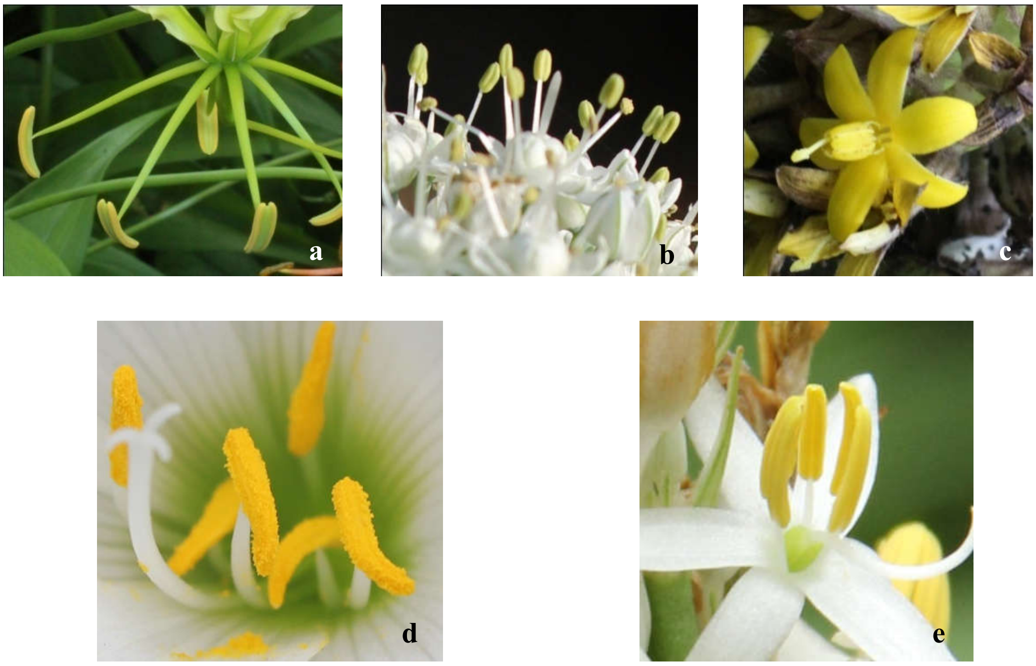


Plate 10. Anthers diversity: a. *Gloriosa*; b. *Allium*; c. *Molineria*; d. *Zephyranthes*; e. *Chlorophytum*.

10. Gynoecium: Carpels 3 rarely 2 or 4, united, ovary superior e.g. *Asparagus*, or inferior e.g. *Crinum*, ovules few-many, stigma 3-4 lobed, ovules 1-several or numerous in each locule.

Plate 11. Different ovary position: a. *Asparagus*; b. *Crinum*.

11. Placentation: Usually axile e.g. *Zephyranthes*, rarely basal e.g. *Allium* or parietal e.g. *Scoliopus*.

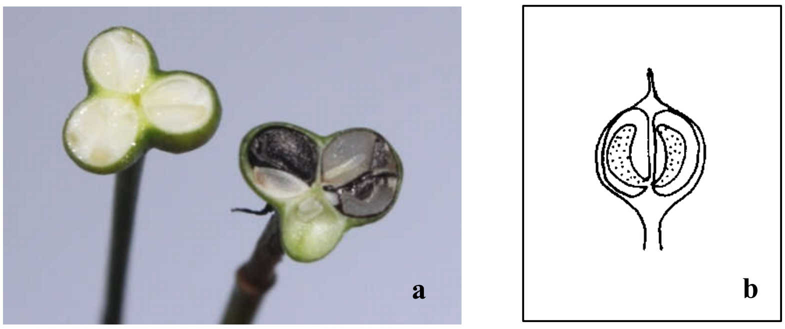


Plate 12. Different types of placentation: a. *Zephyranthes*; b. *Allium*.

12. Fruit: Fruit usually a loculicidal e.g. *Zephyranthes*, or septicidal e.g. *Gloriosa* capsule, less often a berry e.g. *Molineria*.

Plate 13. Different types of fruits: a. *Zephyranthes*; b. *Gloriosa*; c. *Molineria*.

13. Seed: Seeds 1-many, globose, often flat, thin e.g. *Urginea*, or sometimes thick e.g. *Gloriosa*, embryo more or less linear, with a terminal cotyledon and lateral plumule.

Plate 14. Different types of seeds: a. *Urginea*; b. *Gloriosa*.

4.2: Anatomical Characters

Anatomical characters have been employed for systematic purposes well over a hundred years. Anatomy of the vegetative organs of flowering plants can be taxonomically useful in the following ways: the identification of fragmentary material, the preliminary identification of herbarium specimens, and as an aid toward establishing the interrelationship of taxa at and above the species level.

Petiole Anatomy

Introduction

In recent years, anatomical characters including the petiole characters have been widely used in solving taxonomic problems in vascular plants (Akcin *et al.*, 2011).

Materials and Methods

Out of total 43 Liliaceae species in Bangladesh, 7 species are petiolate and the rest are sessile.

Transverse hand sections of one third lower part of petiole were made and stained with safranin. The stained sections were then mounted on slides with glycerin and studied under light microscope.

Results and Discussion

1. *Curculigo orchioides* Gaertn. **(Plate 15)**

In transverse section the adaxial side of the petiole is deeply grooved with two more or less acute lateral projections, whereas the abaxial side is almost round. Epidermis consists of a single layer isodiametric cells with thick cuticles. Hypodermis is 3 layers chlorenchymatous cells irregularly arranged. First layer under epidermis is regularly arranged but next lower 2 layers are like spongy mesophyll. The 10-12 vascular bundles of variable size are encircled by 2-3 layers of sclerenchyma. Smaller vascular bundles consist of less developed xylem and phloem surrounded by a bundle sheath.

2. *Eucharis grandiflora* Planch. & Linden **(Plate 16)**

In transverse section the adaxial side of the petiole is slightly grooved with two obtuse lateral projections, whereas the abaxial side is almost round. Epidermis consists of a single layer more or less barrel shaped cells with thick cuticles. Hypodermis is 3-4 layers chlorenchymatous cells. The 32-34 vascular bundles are arranged symmetrically round the periphery of whole petiole at the same distance from centre. Vascular bundles are not distinct and surrounded by a single layer irregularly arranged parenchymatous cells. Only single xylem vessel is distinct and the phloem cells are not distinct.

3. *Eucrosia bicolor* Ker-Gawl. **(Plate 17)**

In transverse section the adaxial side of the petiole is slightly grooved with two obtuse lateral projections, whereas the abaxial side is almost round. Epidermis consists of a single layer more or less barrel shaped cells with cuticles. Hypodermis is 1-2 layers chlorenchymatous cells. The 15-17 vascular bundles are arranged symmetrically round the periphery of whole petiole at the same distance from centre. Vascular bundles surrounded by a single layer irregularly arranged parenchymatous cells. Two or three xylem vessel is distinct.

4. *Molineria recurvata* (Dryand.) Herb. **(Plate 18)**

In transverse section the adaxial side of the petiole is deeply grooved with more or less acute lateral projections, whereas the abaxial side is almost round. Epidermis consists of a single layer isodiametric cells with thick cuticles. Hypodermis is 2-3 layers chlorenchymatous cells. The 24-26 vascular bundles of variable size are encircled by 2-3 layers of sclerenchyma. Smaller vascular bundles are arranged near the periphery consist of less developed xylem and phloem surrounded by a bundle sheath whereas large vascular bundles distributed throughout the cortex with periphery consist of well developed xylem and phloem.

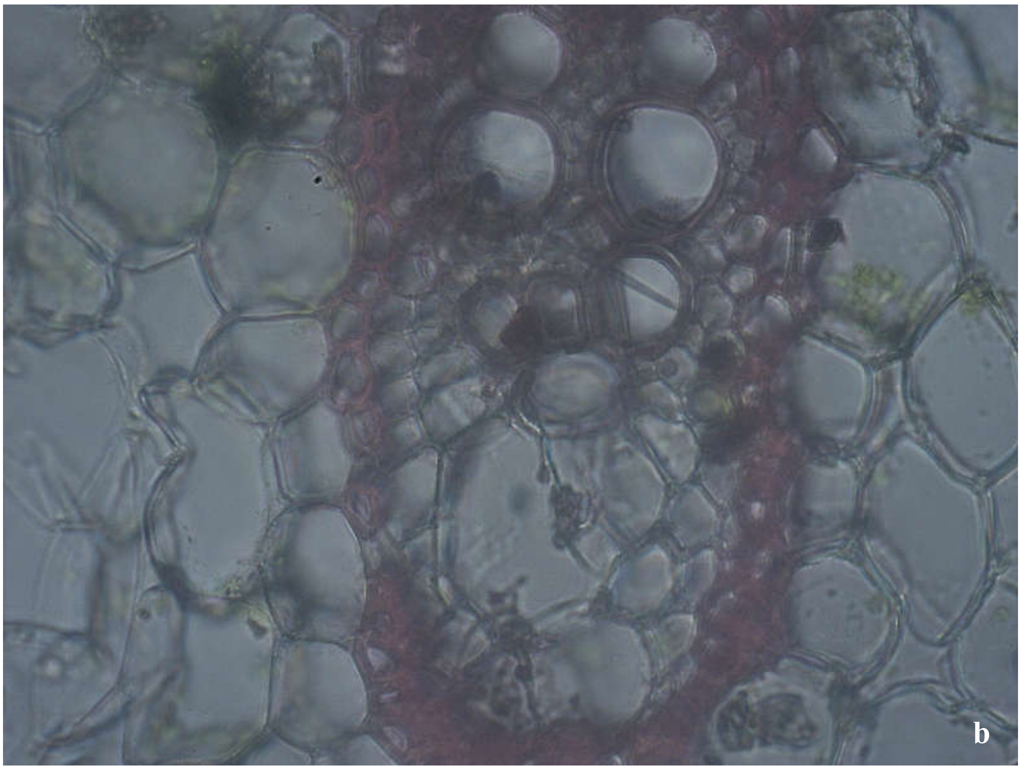
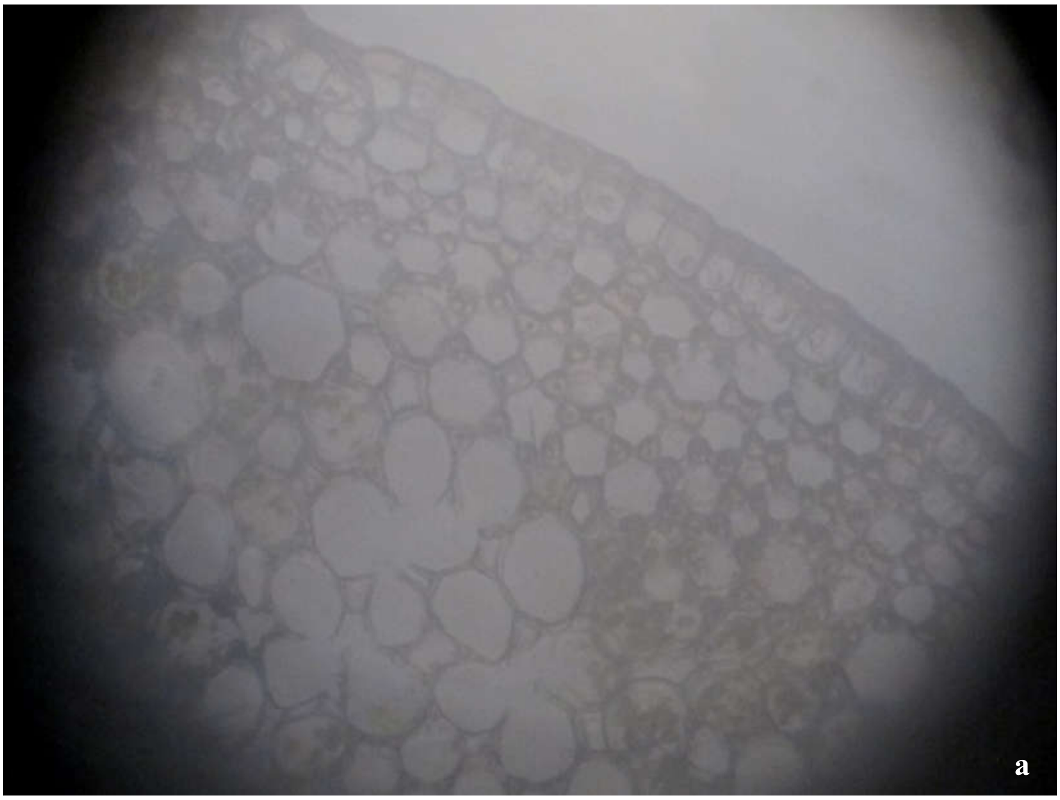


Plate 15. Petiole anatomy of *Curculigo orchioides* Gaertn., a) T.S. of petiole (×10); b) Single vascular bundle (×40).



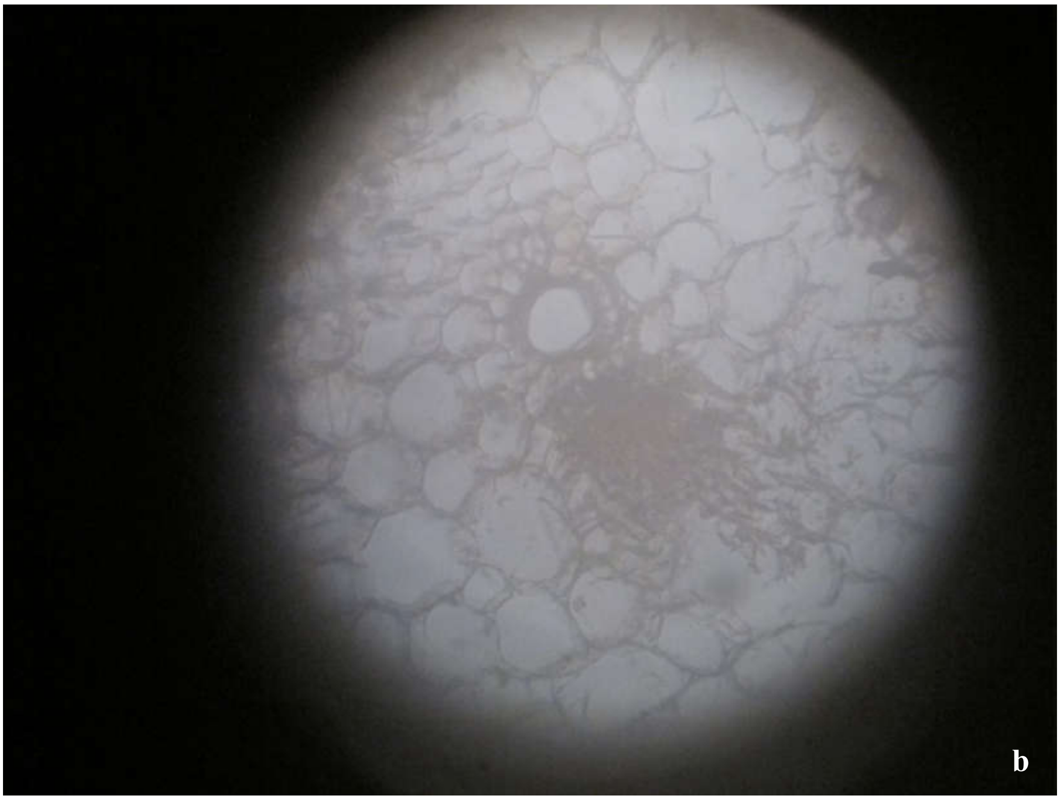


Plate 16. Petiole anatomy of *Eucharis grandiflora* Planch. & Linden, a) T.S. of petiole (×40); b) Single vascular bundle (×40).

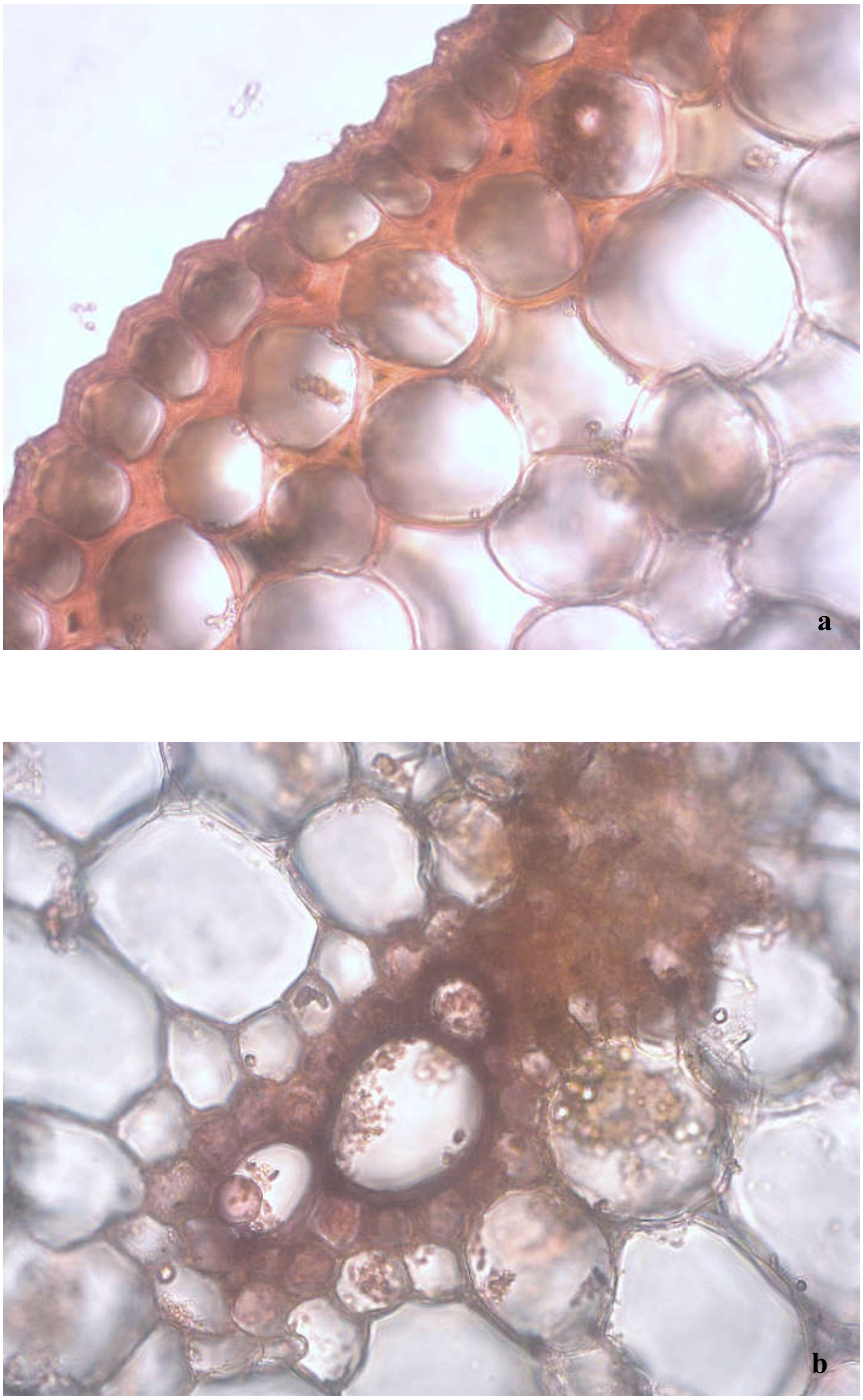


Plate 17. Petiole anatomy of *Eucrosia bicolor* Ker-Gawl., a) T.S. of petiole (×40), b) Single vascular bundle (×40).

5. *Molineria salarkhanii* S.N. Uddin & M.A. Hassan **(Plate 19)**

In transverse section the adaxial side of the petiole is deeply grooved with more or less acute lateral projections, whereas the abaxial side is almost round. Epidermis consists of a single layer isodiametric cells with thick cuticles. Hypodermis is 3-4 layers chlorenchymatous cells whereas first layer under epidermis bear some sclerenchyma cells. The 34-36 vascular bundles of variable size are encircled by 3-4 layers of sclerenchyma. Smaller vascular bundles within hypodermis consist of less developed xylem and phloem surrounded by a bundle sheath whereas large vascular bundles distributed throughout the cortex with periphery consist of well developed xylem and phloem.

Results of a aomparative petiole anatomical features of 5 species are shown in Table 5.

Table 5. Comparative petiole anatomical features of 5 species studied.

Sl. No.	**Taxa**	**Shape of petiole (T.S.)**	**No. of vascular bundle**
1.	*Curculigo orchioides* Gaertn.	V shaped	10-12
2.	*Eucharis grandiflora* Planch. & Linden	Heart shaped	32-34
3.	*Eucrosia bicolor* Ker-Gawl.	Heart shaped	15-17
4.	*Molineria recurvata* (Dryand.) Herb.	V shaped	24-26
5.	*Molineria salarkhanii* S.N. Uddin & M.A. Hassan	V shaped	34-36

From the above experiment it is evident that though petiole shape of *Curculigo orchioides, Molineria recurvata* and *Molineria salarkhanii* are same, but the number of vascular bundle is different in these species. So these 3 species can also be identified by the number of vascular bundles in their petiole. In *Eucharis grandiflora* and *Eucrosia bicolor*, petiole shape is same but vascular bundle number is different. It is clear that important anatomical character i.e. petiole anatomy can be used for identification of different species.

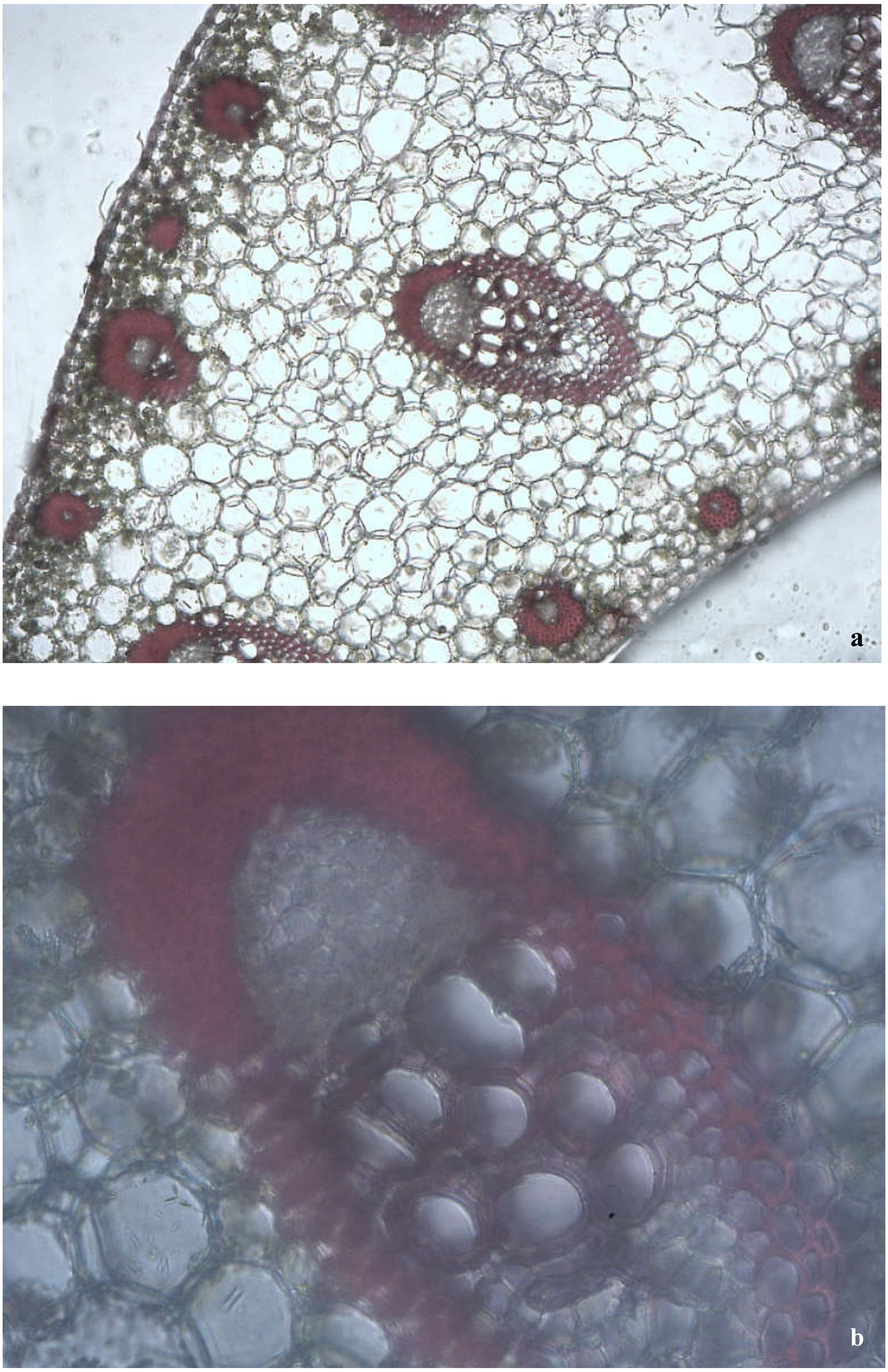


Plate 18. Petiole anatomy of *Molineria recurvata* (Dryand.) Herb., a) T.S. of petiole (×10); b) Single vascular bundle (×40).

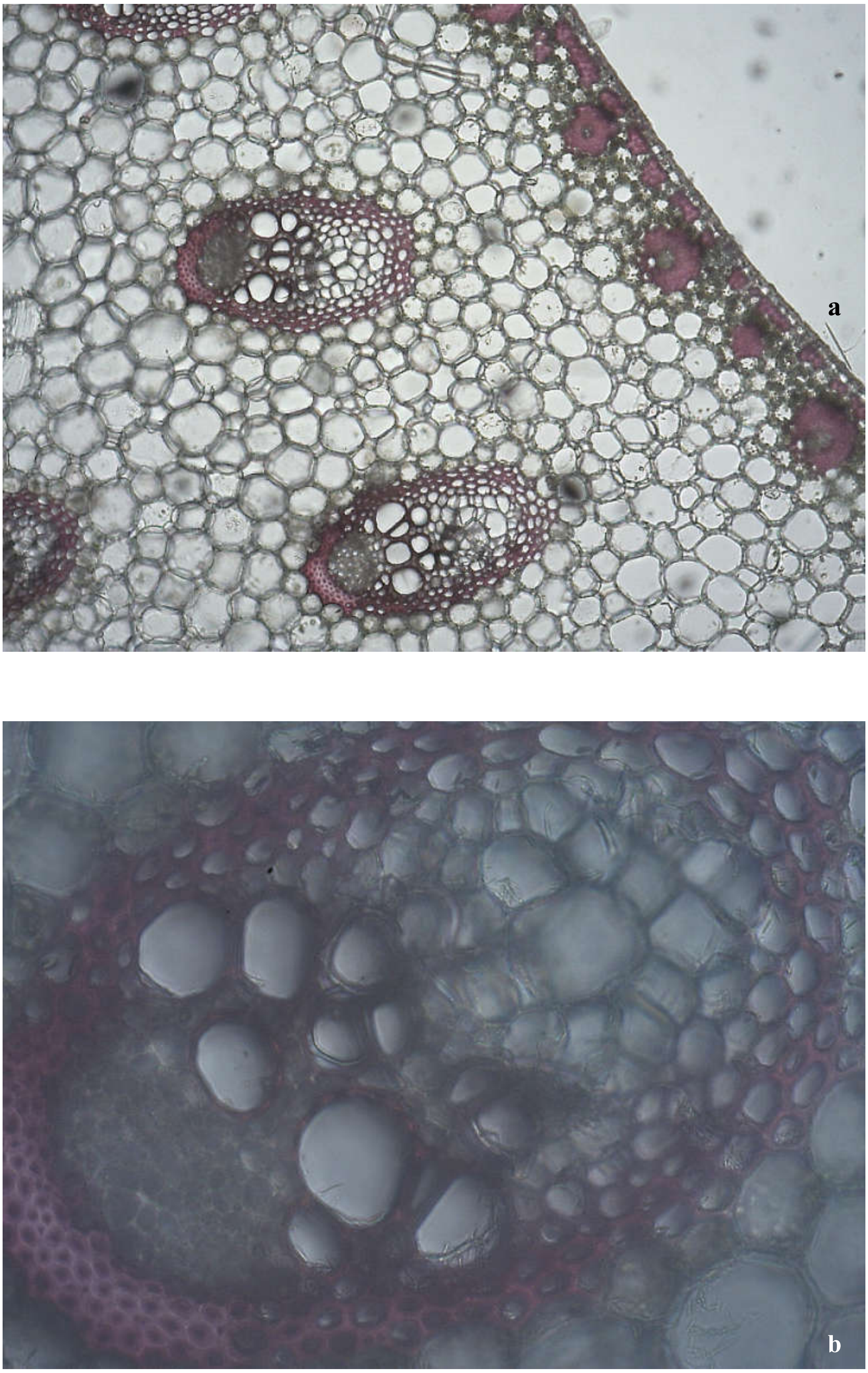


Plate 19. Petiole anatomy of *Molineria salarkhanii* S.N. Uddin & M.A. Hassan, a) T.S. of petiole (×10); b) Single vascular bundle (×40).

4.3: Palynogoical Characters

Morphological characteristics of pollen grains also can be useful characters in studies of plant taxonomy because many pollen traits are influenced by the strong selective forces involved in various reproductive processes, including pollination, dispersal, and germination (Erdtman, 1952; Moore *et al.,* 1991; Nowicke and Skvarla, 1979; Stuessy, 1990).

A total of 14 species have been studied under this experiment focussed on mainly pollen shape and viability. Three types of pollen shape e.g. oval, round and spherical found in these species. Out of 14 species, 6 oval, 4 round and the rest 4 have spherical pollen grains. Out of 3 *Crinum* species *C. asiaticum* posses elliptical pollen grains whereas other 2 species have round. The species *C. asiaticum* can be easily identified from *C. amabile* and *C. latifolium* using shape of pollen.

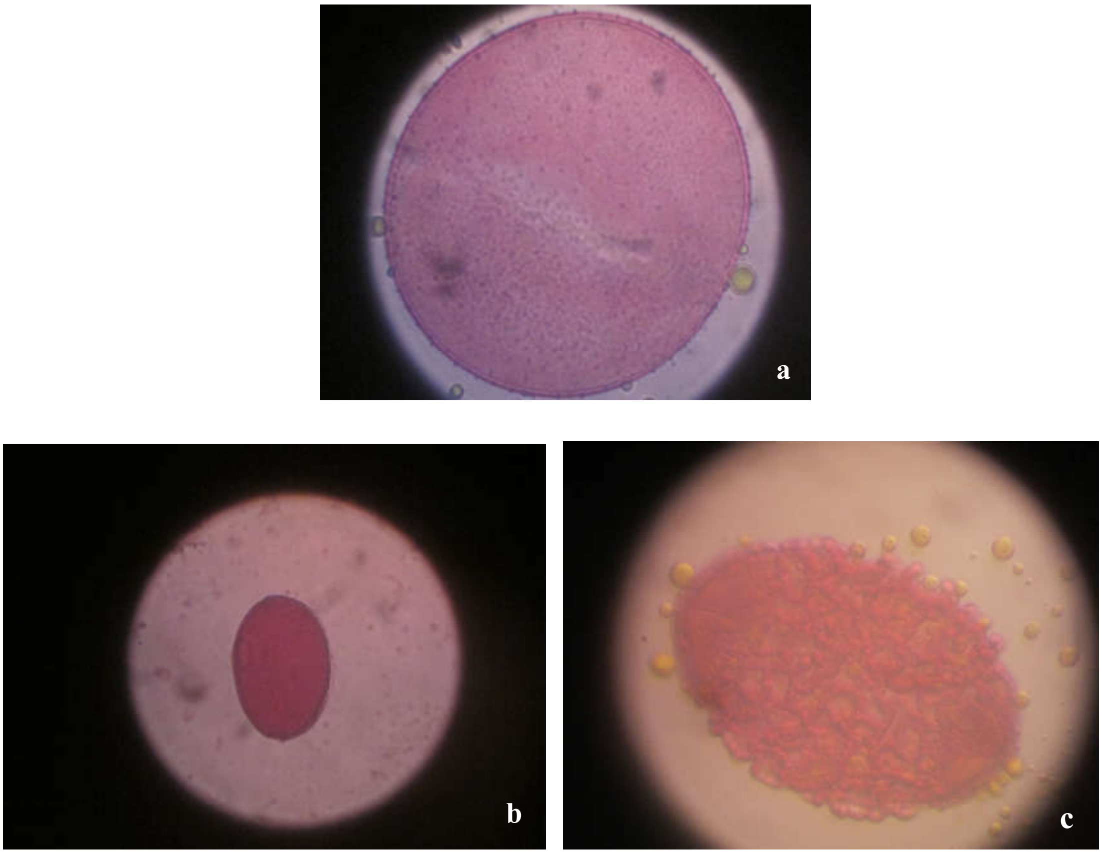


Plate 20. Pollen grains (×40): a) *Crinum amabile* Donn (Round);
b) *Curculigo orchioides* Gaertn. (Oval);
c) *Hymenocallis littoralis* (Jacq.) Salisb. (Elliptical).

CHAPTER 5

TAXONOMIC TREATMENT OF LILIACEAE

5.1: Diagnostic Characteristics

- Roots fibrous. Leaves with parallel veins.
- Stem usually a bulb, corm or rhizome.
- Leaves mostly linear and grass-like.
- Flowers actinomorphic, usually bisexual.
- Perianth 2 whorls of 3 tepals.
- Stamens 6 in two whorls.
- Carpels 3, united.
- Fruit usually a capsule or berry.

5.2: General Characters

Herbs or shrubs, sometimes vines (*Asparagus*), perennial, mostly geophytic, scapose or caulescent, sometimes woody, elongate, tuberous rhizomes or scaly or tunicated bulbs or corms. Leaves simple, basal and/or cauline, alternate, opposite, or whorled, herbaceous (scalelike in *Asparagus*), sometimes sheathing; blade typically narrow and parallel-veined, occasionally broad and/or reticulate-veined. Inflorescences racemose, spicate, paniculate, cymose, umbellate, or with flowers single or paired in leaf axils; bracts present or absent, 1-several, sometimes involucrate or sheathing; bracteoles present or absent, linear to linear-lanceolate. Flowers usually bisexual, sometimes bisexual and unisexual (*Curculigo*), or unisexual only, usually pedicellate, occasionally sessile. Perianth actinomorphic or zygomorphic, often very showy; usually corollalike, 6-merous, rarely 4- or 8-merous, in 2 whorls; segments free (tepals) or united, distinct or less often connate proximally forming tube that may also bear a corona, usually petaloid, more or less equal in 2 whorls of 3, or those of outer whorl narrower, greener, more sepaloid. Stamens 6, rarely 3, 4 or 8, sometimes 3 fertile and 3 staminodial, free or adnate to perianth; filaments or adnate to perianth, rarely connate into a corona.

Anthers basifixed with latrorse dehiscence or dorsifixed, versatile, and with introse or extrorse dehiscence, cordate to linear. Carpels usually connate for most or all of their length, rarely only at base; ovary superior to inferior, (2-)3(-4)-locular, often with septal nectaries, ovules usually several or many per locule; styles 1 or 3(-4); stigmas several and distinct or 1, capitate; ovules usually anatropous. Fruits capsular and loculicidal or septicidal, membranaceous to leathery, or baccate, or dry and indehiscent. Seeds 1-many, often flat and wind-distributed, sometimes thicker.

5.3: Key to the Genera

1.	Inflorescence surrounded by involucral bracts or spathes	**2**
-	Inflorescence not surrounded by involucral bracts	**11**
2.	Scape 1-flowered. Involucre basally tubular and apically 2-notched	**Zephyranthes**
-	Scape more than 1-flowered	**3**
3.	Flowers with staminal corona	**8**
-	Flowers without staminal corona	**4**
4.	Leaves without petiole; corona soft	**5**
-	Leaves with petiole; corona hard and waxy	**6**
5.	Less than 10 ovules per locule and they are globose	**Hymenocallis**
-	Numerous ovules present per lucule and they are flattened	**Pancratium**
6.	Stamens declinate, long filaments form a cup containing nectaries at the base	**Eucrosia**
-	Stamens not declinate	**7**
7.	Corona 6-partite. Scape not less than 15-flowered	**Proiphys**
-	Corona united. Scape up to 10-flowered	**Eucharis**
8.	Fruit a berry. Inflorescence a brush-like heads; flowering before leaves	**Scadoxus**
-	Fruit a capsule	**9**
9.	Scape hollow, arising with or just after the leaves	**Hippeastrum**
-	Scape solid	**10**
10.	Bulbs covered with tunic, leaves not ensiform, flowers not salver-shaped	**Allium**
-	Bulbs not covered with tunic, leaves ensiform, flowers salver-shaped	**Crinum**
11.	Leaves reduced to minute scales, often spinescent, bearing in their axils tufts of leaf-like cladodes	**Asparagus**

-	Leaves simple, foliate	**12**
12.	Inflorescence branched	**13**
-	Inflorescence unbranched	**15**
13.	Fruit a capsule	**14**
-	Fruit a berry. Leaves distichous, panicle branched, pedicel articulate apically; rhizome generally branched	**Dianella**
14.	Leaves base sheathing, scape more than 10-flowered	**Chlorophytum**
-	Leaves base not sheathing, scape up to 8-flowered	**Hemerocallis**
15.	Fruit indehiscent. Rootstocks tuberous a coated corm	**Molineria**
-	Fruit dehiscent	**16**
16.	Aerial annual stem climbing, leafy; leaves with tendril-like tips	**Gloriosa**
-	Aerial annual stem or scapes erect, leafless	**17**
17.	Inflorescence 1 or 2 flowered. Leaves sessile; flowers solitary, scape shorter than the leaves, perianth persistent	**Hypoxis**
-	Inflorescence many flowered	**18**
18.	Leaves plicate, fruit a berry, usually beaked	**Curculigo**
-	Leaves not plicate, fruit a capsule	**19**
19.	Flowers hypogynous, perianth campanulate, seeds many, plants not wooly	**Urginea**
-	Flowers epigynous, perianth not campanulate, seed usually 1, plants often wooly	**Asphodelus**

5.4: Taxonomic Enumeration

Genus 1: **ALLIUM** [Tourn.] Linn., Syst. ed. 1 (1735). Benth. and Hook. f., Gen. Pl. 3: 802 (1883); L., Sp. Pl.: 294 (1753).

Anguinum Fourr. in Ann., Soc. Linn. Ley. N. S. 17: 160 (1869); *Ascalonicum* Renaul., Fl. Dep. Orn. 33 (1800); *Cepa* Tourn. *ex* Linn., Gen. ed. 1: 103 (1737); *Codonoprasum* Reichb., Conosp. 66 (1828); *Geboscon* Fafin., Cat. 14 (1824); *Moenchia* Medic., Act. Acad. Pal. Phys. 6: 343 (1790); *Molium* Fourr. in Ann., Soc. Linn. Ley. N. S. 17: 159 (1869); *Moly* Boerh. *ex* Moenc., Meth. 286 (1794); *Nectaroscordum* Lindl., Bot. Reg. t. 1912 (1836); *Ophioscorodon* Wallr., Sched. Crit. 129 (1822).

Herbs, perennial, scapose, from tunicate bulbs, with onion odor and taste. Bulbs solitary or clustered, dividing at base, or on rhizomes, reforming annually; outer coats generally brown or gray, smooth, fibrous, or with cellular reticulation (generally important in identification); inner coats membranous. Leaves radical and scapose; blade usually linear, terete, channeled, or flat (carinate in *A. sativum*, *A. praecox, A. tuberosum, A. rotundum, A. neapolitanum, A. triquetrum, A. unifolium, and A. lacunosum*), straight or ± falcate (coiled or circinate in *A. nevadense* and *A. atrorubens*), broader in *A. victorialis* and *A. tricoccum*, not petiolate (except in *A. tricoccum* and *A. victorialis*). Scape usually persistent, hollow or solid, terete or flattened. Inflorescences umbellate, flowering centripetally (centrifugally in *A. schoenoprasum*), sometimes replaced totally or partially by bulbils, subtended by spathe bracts; bracts conspicuous, more or less fused, equaling pedicel except in some introduced species, membranous. Flowers erect (pendent in *A. triquetrum*); tepals 6, in 2 similar whorls, more or less distinct, petallike, usually becoming dry and persisting. Stamens 6, epipetalous; filaments free or connate below, anthers oblong or linear, generally glabrous (A. *rotundum* and *A. hoffmanii* papillose to ciliate proximally); anthers and pollen variously colored. Ovary superior, 3-lobed, sometimes crested with processes, 3-locular, usually 2 ovules per locule (6-8 in *A. nigrum*), crest processes 3 or 6, smooth except in *A. haematochiton, A. sharsmithiae,* and *A. lacunosum*; style 1; stigma capitate to 3-lobed. Pedicel erect or spreading (lax in *A. triquetrum*). Fruits a loculicidal capsule. Seeds black, compressed or nearly flat, obovoid, finely cellular-reticulate, cells smooth or minutely roughened, with 1-8 papillae.

About 700 species, mostly in northern hemisphere, mainly in Asia, some species in Africa, and Central and South America. The genus *Allium* is represented in the flora of Bangladesh by 4 species.

Key to the species

1.	Leaves fistular, heads dense	**2**
-	Leaves not fistular, flat	**3**
2.	Leaves 3-5 angled in cross section	**A. chinense**
-	Leaves rounded in cross section	**A. cepa**
3.	Spathe deciduous, umbels with many bulblets and few flowers	**A. sativum**
-	Spathe persistent, umbels with only flowers	**A. tuberosum**

1. Allium cepa L., Sp. Pl. ed. 1: 300 (1753). Roxb., Fl. Ind. 2: 142 (1824); Hook. f., Fl. Brit. Ind. 6: 337 (1892); Haines, Bot. Bih. Or. 1095 (1924). **(Fig. 1, Plate 21)**

English names: Onion, Bulb Onion, Common Onion.

Local name: *Peyaj*.

Description: Annual herb. Stem underground and modified into a small disc, generally known as bulb, c 4.5 × 3.8 cm. Leaves radical, simple, long cylindrical, fistular and sub-distichous, c 30.0 × 0.4 cm, dark green in colour. Flowers arranged in a terminal umbel, inflorescence borne on a long leafless scape and enclosed by membranous bract, bract c 1.5 × 1.8 cm, ovate-lanceolate, split 3-4 parts during anthesis. Scape c 47 cm long, hollow, more than 20 flowered. Flowers pedicellate, pedicel c 1.2 cm long, complete, bisexual. Perianth segments 6 or 8, free, c 0.4 × 0.3 cm, sub-calycine, free, white with mid green line. Stamens 6 or 8, inserted at the base of the perianth lobes, filaments free, c 0.4 cm long, somewhat dilated below, anthers oblong, c 0.2 cm long, introrse, greenish-grey. Carpels 3, ovary 3 or 4-celled, globose, c 0.4 cm long, green, glabrous, style and stigma one, placentation basal. Fruit a membranous, loculicidal capsule. Seeds compressed, black.

Flowering and fruiting: February-June.

Specimens examined: Dhaka: D.U. Bot. Garden, 11.01.2007, Sumona 6; 19.3.2007, Sumona 9; 23.4.1940, Atul p. 30.3.1948 (DUSH). **Munshiganj**: Sirajdikhan, 19.03.2016, Sumona 98 (DUSH).

Chromosome number: 2n = 16 (Kumar and Subramaniam, 1986).

Habitat: Cultivated in fertile land.

Distribution: Probably originated in central Asia, now only known from cultivation, and is being cultivated in most of the countries of the world. In Bangladesh, Onion is cultivated all over the country.

Economic uses/values/harmful aspects: The whole immature plant, the leaves and also the peduncles are used as *Sak* or vegetable. The main usable parts are the fleshy scaly-leaf bases, wrongly known as bulb. These are used as a vegetable, and can also be used raw. Bulbs are also used as a spice. The principal constituent of onion is an essential oil containing various sulphur compounds. Onion is anti-rheumatic, diuretic

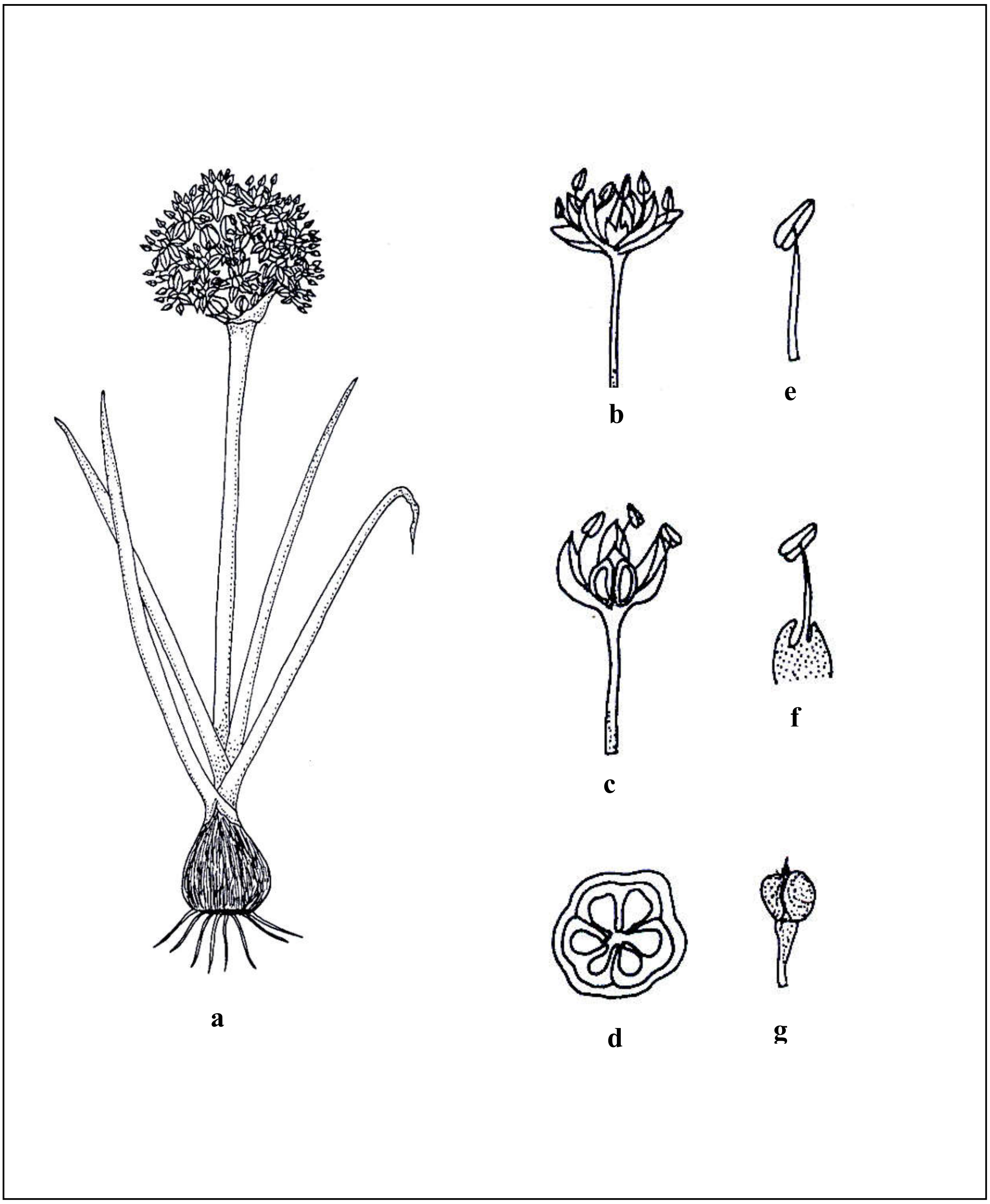


Fig. 1. *Allium cepa* L., a) Habit (×0.2); b) Flower (×2); c) L.S. of a flower (×2); d) T.S. of ovary (×5); e) Outer stamen (×5); f) Inner stamen (×5); g) Gynoecium (×2).

Plate 21. *Allium cepa* L., a) Habit: part of a cultivated field; b) Inflorescence.

and antibacterial. It reduces the insulin requirement of diabetic patients and decreases serum cholesterol. It is regarded as a stimulant and aphrodisiac (Ghani, 2003). In general, onion is used for prickling, cooking, and frying (Siemonsma and Piluek, 1994). It is also used in traditional medicine to treat boils, wounds, stings and felons externally, and internally to relieve coughs, bronchitis, asthma, gastro-intestinal disorders (de Padua *et al*., 1999). The seeds are fattening; useful in caries of the teeth and urinary discharges (Kirtikar *et al*., 1935).

Ethnobotanical information: Onion is considered as a hair-growth promoter and therefore fresh juice (of fleshy scaly leaves) or mixed with oil (coconut or sesame) is rubbed on the head.

Propagation: By seeds, seed-grown bulblets and bulbs. On germination the cotyledon functions as a haustorial organ, becoming green and photosynthetic and characteristically forming a sharp bend or knee on the soil. A primary root is produced by the seedling, all other roots are adventitous. After the seedling has established, approximately one new leaf is produced per week. When the plant has reached a certain stage of growth, and when the daylength is long enough and temperatures sufficiently high, a bulb is formed (Siemonsma and Piluek, 1994).

2. **Allium chinense** G. Don, Mem. Wern. Nat. Hist. Soc. 6: 83 (1827).

(Plate 22)

English names: Baker's Garlic, Chinese Onion, Chinese Scallion, Oriental Onion, Japanese scallion.

Local name: *Jaldong*.

Description: Bulbs clustered, narrowly ovoid to ellipsoid, 1-4 cm in diameter, tunic white, sometimes tinged with red, membranous, entire. Leaves hollow, distichous, cylindrical, subequaling scape, 20-50 × 0.1-0.5 cm, 3 to 5-angled, fistulose. Scape solid, lateral, terete, 20-40 cm long, covered with leaf sheaths only at base. Spathe 2-valved, persistent. Umbel nearly hemispheric, laxly flowered, flowers campanulate. Pedicels subequal, 2-4 × as long as perianth, bracteolate. Perianth pale purple to dull purple; segments broadly elliptic to suborbicular, 0.4-0.6 × 0.3-0.4 cm; inner ones slightly longer than outer. Filaments equal, c 1.5, as long as perianth segments,

Plate 22. *Allium chinense* G. Don, a) Habit: grown in a pot; b) Fleshy scaly leaves, bulbs and roots.

connate at base and adnate to perianth segments; outer ones subulate; inner ones broadened at base, 1-toothed on each side. Ovary obovoid-globose, with concave nectaries covered by hoodlike projections at base. Style exserted.

Flowering and fruiting: October-November.

Specimen examined: Dhaka: D.U. Bot. Garden (originally collected from Baligaon, Kamalganj, Maulvi Bazar), 04.07.2016, Sumona 105 (DUSH).

Chromosome number: 2n = 24, 32 (Kumar and Subramaniam, 1986).

Habitat: Moderately high land with light loamy soil is preferable for its cultivation.

Distribution: Native to China and Korea, and cultivated in many other countries. It is naturalized in other parts of Asia as well as in North America. In Bangladesh it is cultivated in Moulvi Bazar district.

Economic uses/values/harmful aspects: Bulbs are used raw or fried mixed with other vegetables in Indonesia. The bulbs are widely used as sweet and sour pickles after steeping in salt for several days. In Japan, they are used mainly in pickles as side dishes, often eaten with Japanese curry. Flowers and young seedpods are also edible raw, used as a garnish on salads (Lim, 2015).

Ethnobotanical information: In China, the juice of the plant is used as a moth repellent. The whole plant is said to repel insects and moles (Riotte, 1978). In Bangladesh, leaf of this species is used as a substitute of Garlic.

Propagation: Propagation is done by bulb separation.

3. Allium sativum L., Sp. Pl. 1: 296 (1753). Roxb., Fl. Ind. 2: 142 (1824); Hook. f., Fl. Brit. Ind. 6: 337 (1892); Haines, Bot. Bih. Or. 1094 (1924).

(Plate 23)

English name: Garlic.

Local name: *Rasun*.

Description: An erect herb. Stem very small, disc-like, botanically known as bulb, with many adventitious roots at the base, aerial pseudo-stem is formed by sheathing leaf bases. Leaves simple, radical, 4-10 in number when full-grown, distichous, glabrous,

Plate 23. *Allium sativum* L., a) Habit; b) Different type garlics.

blade linear, up to 50 cm long. Flowers in umbel inflorescence on a solid scape, tepals 6 in two whorls, polytepalous, greenish-white. Stamens 6, exserted. Carpels 3, united, ovary 3-celled, placentation basal; style short; stigma pointed. Fruits seedless.

Flowering and fruiting: February-April.

Specimen examined: Munshiganj: Sirajdikhan, 19.03.2016, Sumona 99 (DUSH).

Chromosome number: 2n = 16, 18 (Kumar and Subramaniam, 1986).

Habitat: Moderately high land with light loamy soil is preferable for its cultivation (P^H 6-7 or higher).

Distribution: Garlic is believed to have originated from Central Asia (Tien Shan) where its wild ancestor *A. longicuspis* Regd. is endemic. At present garlic is grown all over the world at latitudes between 5-50° in both hemispheres, but is most popular in the Mediterranean and in China (Siemonsma and Piluek, 1994). It is cultivated throughout Bangladesh during the winter. Its leading producers include China, Egypt, India, South Korea, Spain, Thailand and Turkey. In Bangladesh, Garlic is cultivated all over the country.

Economic uses/values/harmful aspects: Garlic is an important spice crop used for various culinary purposes and conventional Unani and Ayurvedic treatments. It contains a sulphur-based compound named Allin, which helps to reduce the cholesterol concentration in human blood. Of the many beneficial effects of garlic, inhibition of the growth of cancer is remarkable. Garlic is used as a stimulant, carminative, anthelmintic, hypoglycaemic, diuretic, aphrodisiac, tonic, alterative and hypotensive. It is also used in wounds, leprosy, cough, piles, rheumatism and diabetes (Ghani, 2003). In many Asian countries it is popular in the preparation of chutneys, pickles, curry powders, curried vegetables and tomato ketchup. The cloves are used as condiment and flavouring agent (Deb, 1983). Garlic is valued worldwide as a 'Panacea' to cure an array of diseases and to strengthen the body (de Padua *et al*., 1999).
The cloves are ground with other ingredients and fed or made into plaster for haemorrhagic septicaemia, and bandaged on the legs of cattle for foot and mouth disease. The fried garlic is fed to goats for flatulence (Alam, 2000).

Ethnobotanical information: For indigestion and abdominal pain one clove of garlic with salt is taken by the rural people in Bangladesh. For rheumatic pain crushed garlic heated in mustard oil is rubbed on affected body parts. To alleviate discomforts of the running nose, this oil is also rubbed on the head, feet and palm. There is a general belief that if cooked food is sent to a distant place that may take a long time to reach its destination placement of a few cloves of garlic on the food cover would prevent rapid spoilage.

Propagation: Propagation is done by cloves.

4. **Allium tuberosum** Rottler *ex* Spreng., Syst. Veg. 2: 38 (1825).

(Fig. 2, Plate 24)

Synonyms: *Allium argyi* H. Léve., Nouv. Contrib. Liliac. & C. Chine 16 (1906); *A. chinense* Maxim., Prim. Fl. Amur. 284 (1859), not G. Don (1827); *A. clarkei* Hook. f., Fl. Brit. Ind. 6(18): 344 (1992); *A. roxburghii* Kunth, Emun. Pl. 4: 454 (1843); *A. sulvia* Buch.-Ham. *ex* D. Don, Prod. Fl. Nepal. 53 (1825); *A. uliginosum* G. Don, Mem. Wern. Nat. Hist. Soic. 6: 60 (1827), not Ledebour (1830); *A. yesoense* Nakai, Bot. Mag. 36: 117 (1922).

English names: Chinese Chive, Oriental Garlic.

Local name: *Jangli Peyaj*.

Description: Bulbs clustered, 1-3, borne on stout, more or less horizontal rhizome, elongate, cylindric or conic, 0.5-1.5 × 0.7-2.0 cm, outer coats enclosing 1 or more bulbs, dull yellow to yellowish brown, reticulate, inner coats white. Leaves withering from tip by anthesis, 2-5; blade solid, flat, carinate abaxially, 20-40 × 0.2-0.6 cm, margins entire. Scape persistent, solitary, erect, terete, 30-50 × 0.1-0.3 cm. Inflorescence umbel, persistent, erect, loose, 20 to 50-flowered, hemispheric-globose, spathe bracts 3 to 7-veined, persistent, 1-3, lanceolate-ovate, shorter than pedicel, apex acuminate. Flowers substellate; tepals spreading, white with green or brownish midveins, lanceolate to elliptic, more or less equal, withering and exposing capsule; outer ones oblong-ovate to oblong-lanceolate, 0.4-0.8 × 0.2-0.3 cm; inner ones oblong-obovate, 4-8 × 0.2-0.3 cm. Stamens included; anthers purple. Ovary crestless; style linear, more or less equaling stamens; stigma capitate, unlobed; pedicel 1.0-3.0 cm long. Seed coat shining; cells smooth, irregularly shaped, with more or less sinuous walls.

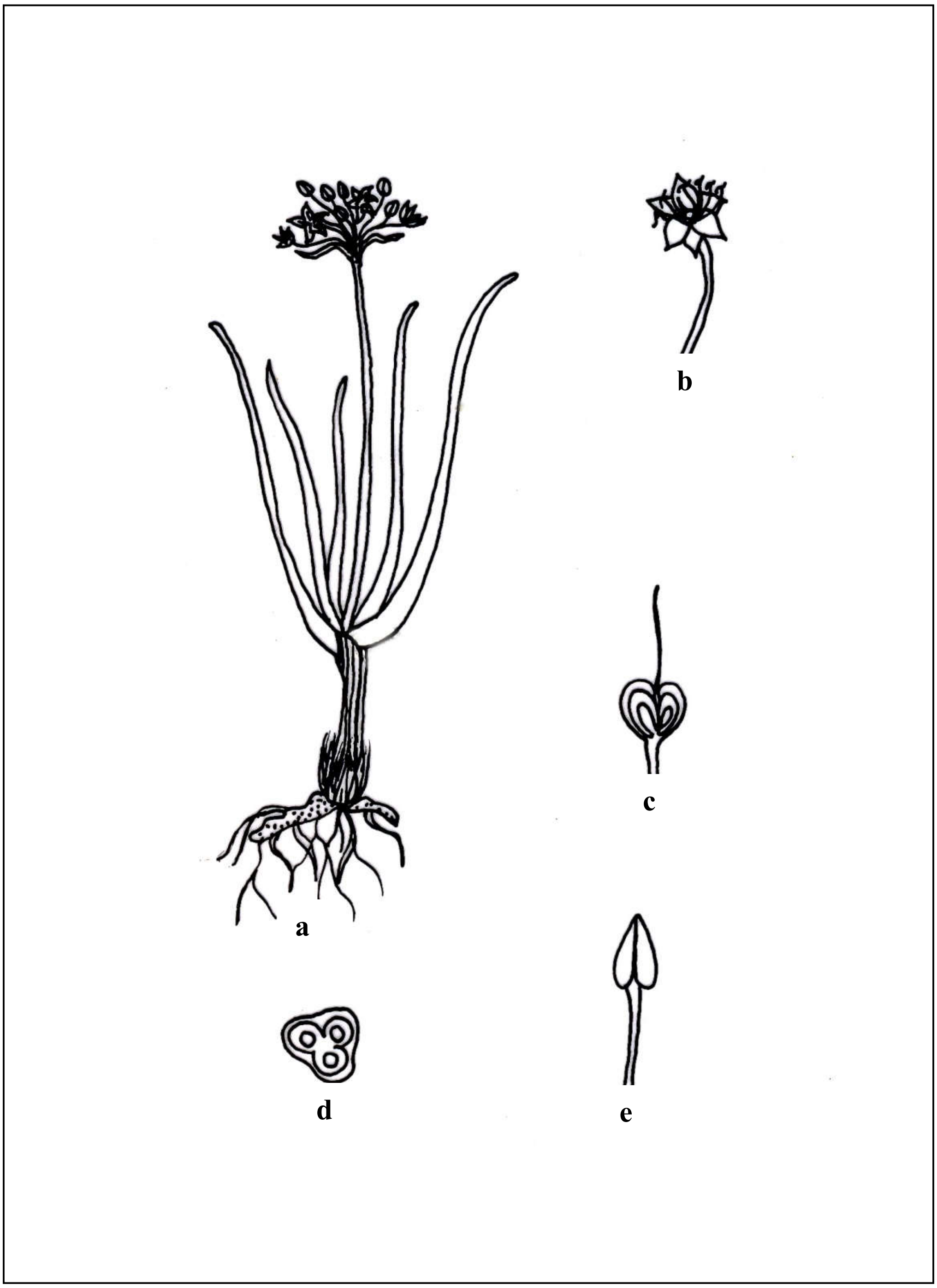


Fig. 2. *Allium tuberosum* Rottler *ex* Spreng., a) Habit (×0.3); b) Flower (×1); c) L.S. of gynoecium (×5); d) T.S. of ovary (×5); e) Stamen (×5).

Plate 24. *Allium tuberosum* Rottler *ex* Spreng., a) Habit; b) Rhizome with bulb.

Flowering and fruiting: July-September.

Specimens examined: Dhaka: D.U. Bot. Garden (originally collected from Chittagong), 20.04.2013, Sumona 78; 22.08.2013, Sumona 82 (DUSH).

Chromosome number: 2n = 16, 24, 32 (Kumar and Subramaniam, 1986).

Habitat: Roadsides and hilly area.

Distribution: *Allium tuberosum* is cultivated in China, Siberia, and North America, and is reported to be established in New England. It may escape anywhere the species is cultivated. In Bangladesh, it is found in Rangamati district and cultivated in BCSIR Laboratory Garden, Chittagong.

Economic uses/values/harmful aspects: The flavour of the leaves of *A. tuberosum* is subtle, like very mild garlic, while the narrow bulbs are strong and sharp when eaten raw. The leaves are used similarly to the way chives or green onions are used, and are especially useful to add mild garlic flavor in uncooked dishes where raw garlic would be too overpowering. They can be added to salads, egg dishes, soups, or stews, but should be added at the end of cooking in hot dishes as too much heat destroys the mild flavour. It is used in stir fries and other dishes in several oriental cuisines, especially Korean. The flowers are also edible, so can be used as a garnish or added to salads.

Propagation: Propagated by both seeds and bulb separation.

Genus 2: **ASPARAGUS** Tourn. *ex* Linn., Syst. ed. 1 (1735) and Gen. ed. 1: 93 (1737). Benth. & Hook. f., Gen. Pl. 3: 765 (1883); L., Sp. Pl.: 313 (1753) and Gen. Pl. ed. 5: 147 (1754).

Asparagopsis Kunth, Abh. Akad. Berl. 35 (1842); *Elide* Medic., Phil. Bot. 2: 71 (1791); *Hecatris* Salisb., Gen. Pl. Fragm. 66 (1866); *Myrsiphyllum* Willd., Ges. Nat. Fr. Berl. Mag. 2: 25 (1808).

Herbs, shrubs or vines, perennial, from rhizomes, usually with fusiform tubers, often with fernlike appearance. Stem erect, straggling or climbing, terete, grooved or angled. Roots many, clustered. Leaves small, scale-like, membranous or sometimes spiny with hardened base, subtending cladophylls. Inflorescences axillary or terminal, racemose or umbellate, paired or solitary; racemes short. Flowers bisexual or unisexual; pedicels jointed. Perianth greenish, white or yellowish, campanulate to rotate. Tepals 6, distinct or shortly connate basally, equal. Stamens 6, distinct, equal; filaments free, anthers versatile, oblong, 2-locular, dehiscence introrse. Ovary superior, 3-locular, septal nectaries present; style 3-branched distally. Fruits baccate, red or purplish black, globose, often with tepals persisting at base. Seeds 1-6, black, globose to angular.

About 300 species: introduced; Europe, Asia, Africa; some widely introduced, expected elsewhere. The genus *Asparagus* is represented in the flora of Bangladesh by 6 species.

Key to the species

1.	Inflorescence an axillary raceme, flowers bisexual	**2**
-	Inflorescence a solitary flower or a cluster of flowers, flowers bisexual or unisexual	**5**
2.	Stem suberect. Cladodes in fascicles of 5-20, ascending, erect or recurved	**3**
-	Stem climbing. Cladodes in fascicles of (1)-3-6(-8), flat	**4**
3.	Cladodes not terete, rather triquetrous	**A. acerosus**
-	Cladodes terete	**A. adscendens**
4.	Spines 1.5-2.0 cm on the main stem and 0.5-1.0 cm on branches; branch ± rectangular. Lower half of the articulated pedicel longer than the bract	**A. racemosus**
-	Spines 3-5 mm on the main stem and indistinct on branches. Lower half of the articulated pedicel shorter than the bract	**A. densiflorus**
5.	Stem climbing. Pedicel articulated about the middle or below	**A. setaceous**
-	Stem erect. Pedicel articulated above the middle	**A. officinalis**

1. Asparagus acerosus Roxb., Fl. Ind. 2: 150 (1832).

(Fig. 3)

English name: Asparagus.

Local name: *Shatamuli*.

Description: A perennial, sub-scandent undershrub, stem smooth, branchlets very slender with stiff ascending angles, spines short and slightly recurved. Cladodes 3-6 nate, c 4.0 × 0.1 cm, sub-erect, strict, triquetrous, acuminate. Racemes short, solitary or

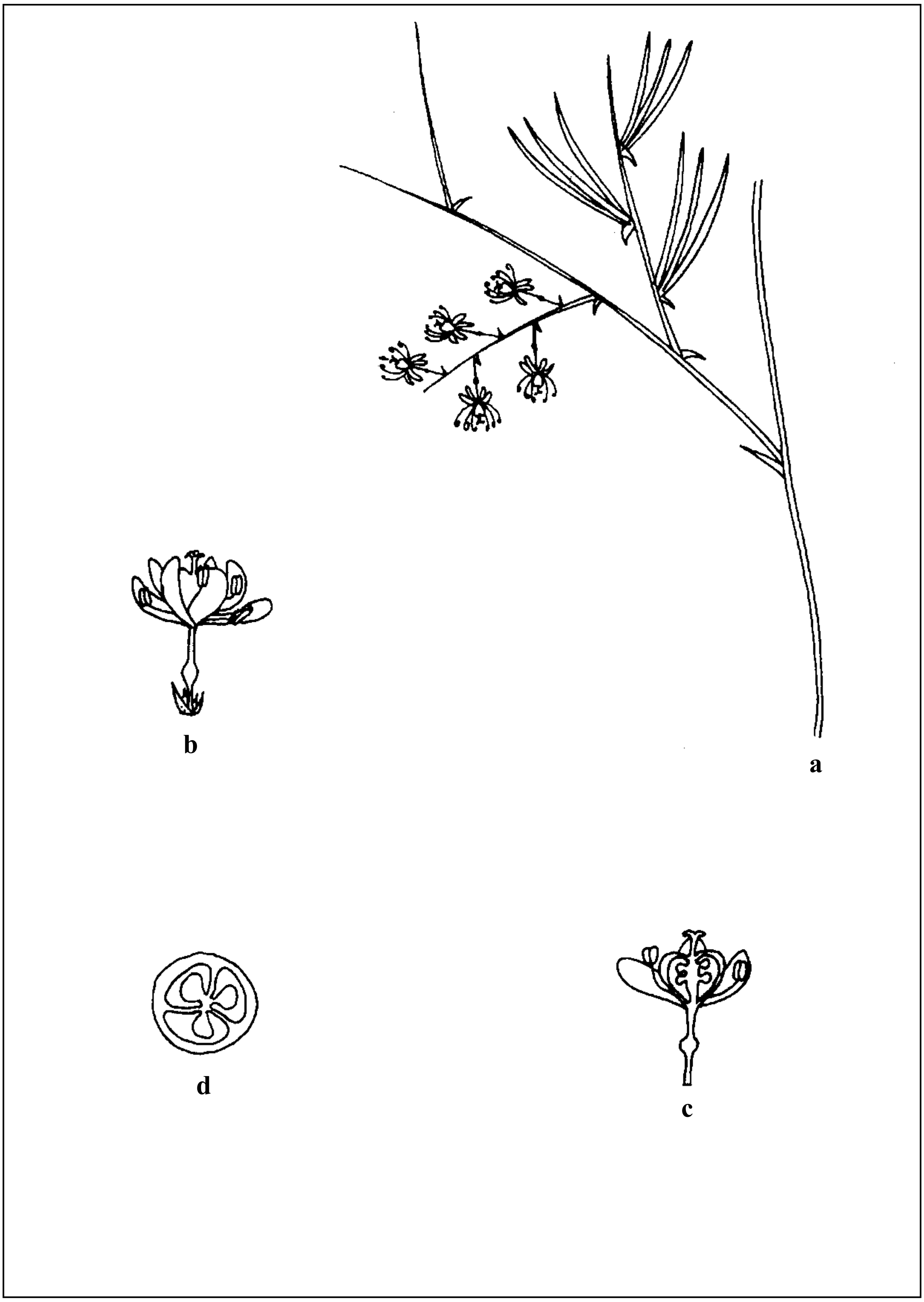


Fig. 3. *Asparagus acerosus* Roxb., a) Habit (×1); b) Flower (×6); c) L.S. of a flower (×6); d) T.S. of ovary (×10).

2-nate. Flowers bisexual, hypogynous, pedicellate, pedicel c 1.9 mm long. Perianth segments 6, c 2.5 × 1.0 mm, white, fragrant. Stamens 6, adnate to the base of the tepals, filaments white, c 2 mm long, anthers minute, c 0.9 × 0.5 mm, sub-globose. Carpels 3, syncarpous, ovary 3-gonous, 3-chambered, c 1.1 mm long, placentation axile, ovules many in each chamber. Fruit a berry, 4-6 mm in diameter, 1-seeded.

Flowering and fruiting: November-March.

Specimens examined: Dhaka: Nayerhat, 07.01.1973, M.S. Khan & A.M. Huq K. 263; Chandra Forest, 29.12.1978, M.S. Mia 21; Green Road, Dhanmondi, 22.12.1982, Mia 892; D.U. Staff Quarters, 24.11.1986, M.R. Khan; Baldha Garden, 17.02.1988, Rezia, Huq & Mia R.K. 249 (DACB). **Tangail**: Madhupur, 26.12.1987, A.M. Huq 51; Madhupur, 22.12.1982, Mia 892; Madhupur, 28.2.1987, Huq *et al.* 8215 (DACB); Madhupur, 29.6.1969, Alo Rani 306; Asiya 118; Panna 115 (DUSH). **Rangamati**: Snigdha Roy, 2005 R-62 (DACB).

Habitat: Hilly areas.

Distribution: Myanmar and North Australia. In Bangladesh the species was collected from Dhaka, Tangail and Rangamati districts.

Economic uses/values/harmful aspects: Tuberous roots of this plant may have use similar to that of *A. racemosus*.

Propagation: By seeds and rootstocks.

2. **Asparagus adscendens** Roxb., Fl. Ind. 2: 153 (1832).

English name: Asparagus.
Local name: *Shatamuli*.

Description: A dioecious evergreen shrub with white tuberous roots. Stem tall, stout, sub-erect, terete, smooth, branchlets grooved, ascending, angled, spines 1.3-2.0 cm long, stout, straight. Cladodes 6-20 nate, 1.3-5.0 cm long, slender, filiform, terete, sub-erect or curved. Inflorescence of racemes, many-flowered, bracts minute. Flowers pedicellate, c 2.5 cm in diameter, jointed above or below the middle, bracts minute. Perianth segments 6. Stamens 6. Carpels 3, syncarpous, ovary 3-celled, placentation axile. Fruit a berry, 1-seeded.

Specimen examined: Gazipur: *Sal* forest, 10.12.1944, Balwant Singh, 22.05.1946 (DUSH).

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: *Sal* forests and well-drained moist soils in semi-shady condition.

Distribution: Iran, Afghanistan, India (Uttar Pradesh) and in the Himalayan region. In Bangladesh, it was collected only from Gazipur *Sal* forests in 1944.

Economic uses/values/harmful aspects: Tuberous root is a source of nutritious starch. The roots are said to be demulcent, diaphoretic, galactogogue and stimulant and are useful in the treatment of diarrhoea, dysentery and general debility (Kirtikar *et al.*, 1935).

Propagation: By seeds.

3. Asparagus densiflorus (Kunth) J.P. Jessop, Bothalia 9: 51 (1966).

(Fig. 4, Plate 25)

Synonyms: *Asparagopsis densiflora* Kunth, Enum. Pl. 5: 96 (1850); *Asparagus sprengeri* Regel., Act. Hort. Petrop. 11: 302 (1890); *Asparagus aethiopicus* L., Mant. 1 (1767); *Protasparagus densiflorus* (Kunth) A.A. Oberm., Fl. S. Afr. 5(3): 49 (1992).

English names: Sprenger Asparagus, Basket Asparagus, Asparagus-fern, Lace-fern, Emerald-fern.

Description: Evergreen perennial herb. Tuber more or less globose, c 4 × 2 cm. Stem stiff or spreading-arching to 20 cm long. Larger branches usually bearing minute axillary spines, spines c 0.4 cm long. Cladodes scale-like, linear, light green, c 1.7 × 0.1 cm, 2-9 clustered at branch nodes. Inflorescences arise from the main branch, c 5 to 9-flowered. Flowers small, bell-shaped, greenish-white, fragrant, perianth segments 6, c 0.2 × 0.1 cm; pedicel c 0.2 cm long, atriculate at middle. Stamens 6, anthers oblong, c 0.1 cm long, orange, filament c 0.15 cm long, white. Carpels 3, syncarpous, ovary globose, c 0.3 cm long, ovules many, stigma minute, placentation axile. Fruit a bright-red berry, oval, about 0.8 cm in diameter, fruit 1-3 seeded.

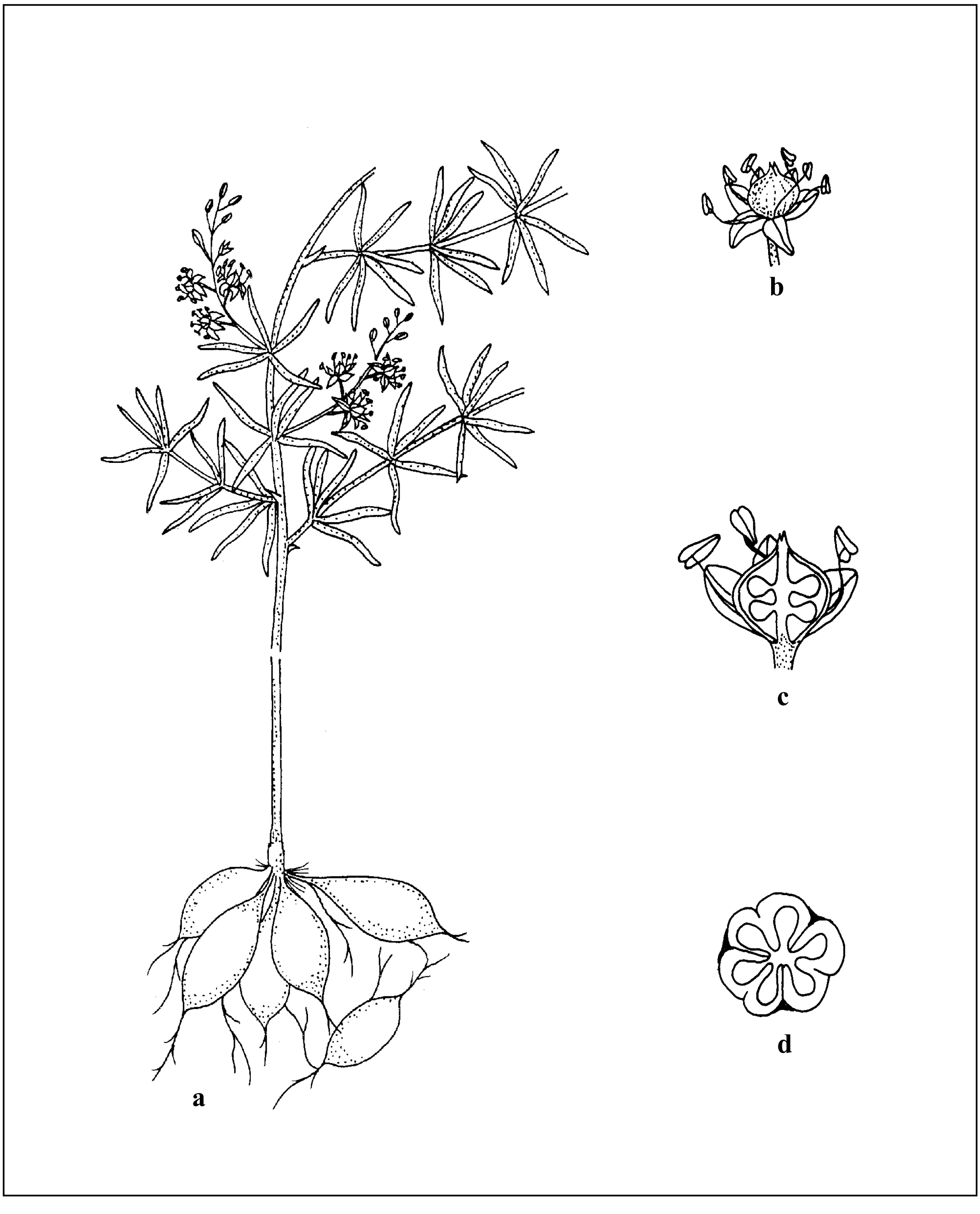


Fig. 4. *Asparagus densiflorus* (Kunth) J.P. Jessop, a) Habit (×1); b) Flower (×3); c) L.S. of a flower (×6); d) T.S. of ovary (×8).

Plate 25. *Asparagus densiflorus* (Kunth) J.P. Jessop, a) Habit; b) Tuberous roots.

Flowering and fruiting: February-April.

Specimens examined: Dhaka: Baldha Garden, 23.03.2007, Sumona 11; Baldha Garden 26.04.2007, Sumona 23 (DUSH).

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: Waste places and also cultivated in gardens.

Distribution: Native to South Africa, widely grown as an ornamental for its fern-like foliage (Whistler, 2000), introduced in many countries. In Bangladesh, it was reported from Baldha Garden where it was planted before.

Economic uses/values/harmful aspects: Eating of berries may cause gastrointestinal problems, skin irritation with redness, swelling and blisters following contact with plant sap.

Propagation: By seeds.

4. **Asparagus officinalis** L., Sp. Pl. 1: 313 (1753).

(Fig. 5, Plate 26)

English names: Garden Asparagus, Common Asparagus.
Local name: *Asparagus.*

Description: Herbs, erect, 1.0-2.5 meter tall; rhizomes fibrous. Stems annual, densely branched distally; branches finely dissected, ascending to perpendicular, unarmed; cladophylls in clusters of (2-)4-15(-25) per node, filiform, straight or curved, 1-3 cm long. Leaves scalelike, 0.3-0.4 cm; blade lanceolate, base hardened. Inflorescences in axillary racemes, 1 to 3-flowered. Flowers of both sexes solitary of in clusters of 2-4; pedicel 0.8-1.2 cm long, jointed at or above middle. Male flowers: perianth yellowish green, campanulate, 0.5-0.6 cm; filaments adnate to perianth segments for about half of their length; anthers 0.1-0.1 cm long. Female flowers: perianth c 0.3 cm long. Berries red, 0.6-1.0 cm in diameter, 2- or 3-seeded.

Flowering and fruiting: May-August.

Specimen examined: Dhaka: D.U. Bot. Garden, 25.09.2016, Sumona 109 (DUSH).

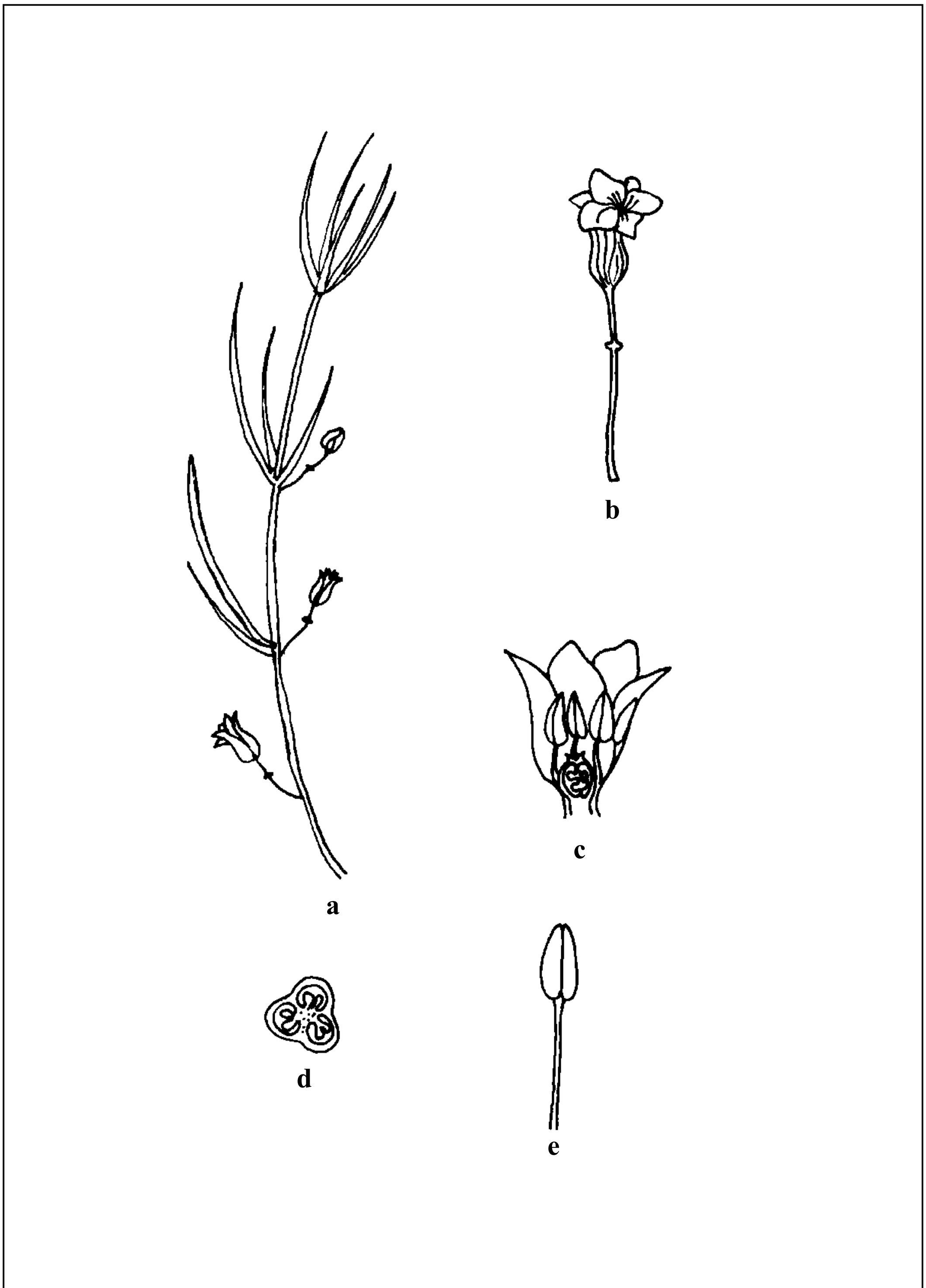


Fig. 5. *Asparagus officinalis* L., a) Habit (×1); b) Flower (×5); c) L.S. of a flower (×10); d) T.S. of ovary (×10); e) Stamen (×10).

Plate 26. *Asparagus officinalis* L., a) Habit; b) Leaves; c) New arising shoot (edible); d) Flowers.

Chromosome number: 2n = 20, 40, (Kumar and Subramaniam, 1986).

Habitat: Fields, fencerows, roadsides. Cultivated since ancient Greek times.

Distribution: Europe, Asia, Africa. Naturalized in temperate regions worldwide.

Economic uses/values/harmful aspects: Eaten as a vegetable, *Asparagus officinalis* has been widely cultivated for its young shoots since ancient Greek times. The species is naturalized in many temperate climates. Mature asparagus can cause poisoning in cattle. Young plants can cause dermatitis, and the red berries are suspected of poisoning humans. The species is dioecious, and homomorphic sex chromosomes have been identified (Utech, 2002).

Ethnobotanical information: Not known.

Propagation: By dividing the crowns.

5. Asparagus racemosus Willd., Sp. Pl. 2: 152 (1799). Hook. f., Fl. Brit. Ind. 6: 317 (1892); Haines, Bot. Bih. Or. 1089 (1924); Fischer in Gamble, Fl. Pres. Madras. 1517 (1928) and Rec. Bot. Surv. Ind. 12(2): 146 (1938).

(Fig. 6, Plate 27)

Synonyms: *Asparagus dubius* Decne, Nouv. Ann. Mus. Paris 3: 363 (1834); *Asparagopsis decaisnei* Kunth, En. Pl. 5: 103 (1850); *Asparagopsis javanica* Kunth, En. Pl. 5: 100 (1850); *Asparagopsis schoberioides* Kunth, En. Pl. 5: 70 (1850).

English name: Asparagus.

Local names: *Shatamuli, Satmuli, Shaktichara* (Chakma), *Mimong Tamache* (Garo).

Description: A perennial, slender, scandent shrub like plant with reflexed spines, root tuberous, many together. Leaves scale-like, minute, cladodes present in scale-like leaf axils. Cladode 2-6 nate, acicular, triquetrous, falcate, finely acuminate, 1.0-2.5 cm long. Inflorescence a raceme, solitary or fascicled, simple or branched. Flowers bisexual, greenish-white at iniciation then light pink and lastly dark maroon in colour, sweet scented, bracteate, bract minute, c 0.3×0.1 cm, off white in colour, pedicellate, pedicel c 0.4 cm long, green. Perianth segments 6, spreading, obovate, c 0.4×0.1 cm, off white with vertical green line. Stamens 6, adnate to the base of the perianth lobes, filaments free, c 0.2 cm long, anthers minute, oblong, purplish. Carpels 3, syncarpous, ovary

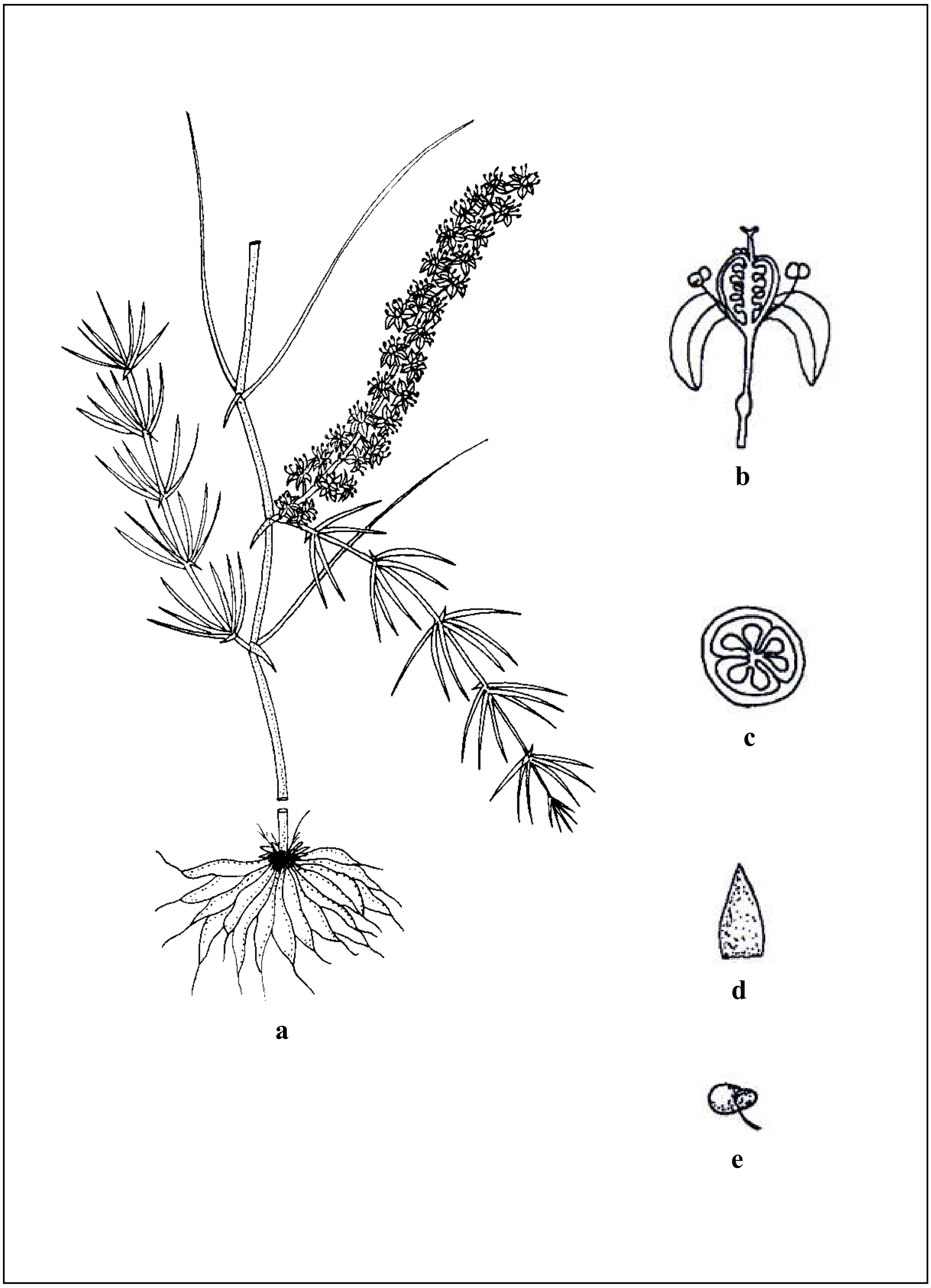


Fig. 6. *Asparagus racemosus* Willd., a) Habit (×0.5); b) L.S. of a flower (×5); c) T.S. of ovary (×10); d) Bract (×5); e) Fruit (×1).

Plate 27. *Asparagus racemosus* Willd., a) Habit; b) Cluster of tuberous roots.

superior, c 0.2 cm long, trigonous, 3-celled, 2-several ovules in each cell, stigma 3-fid, placentation axile. Fruit a berry, globose, c 0.5-0.8 cm in diameter, green, turn red when ripe.

Flowering and fruiting: November-March.

Specimens examined: Dhaka: Baldha Garden, 17.02.1988, Rezia Khatun 249 (DACB). D.U. Bot. Garden, 05.02.1983, M.A. Hassan 501; Science Library, 04.02.2006, Sumona 1; Science Library, 01.01.2012, Sumona 72; Ekushey Hall, 02.12.2006, Sumona 4; D.U. Bot. Garden, 21.05.2007, Sumona 34 (DUSH). **Gazipur**: Savar, Jahangirnagar University, 05.01.2009, Sumona 61(DUSH). **Sunamganj**: Pashua Haor, 23.05.1992, Khan *et al.* K. 8669 (DACB). **Tangail**: Madhupur Forest, 05.08.1976, Huq, Rahman & Khan K. 4173 (DACB). **Chittagong**: Bariadhala, 17.11.1986, A.M. Huq & M.K. Mia H. 7992; Sandwip, Horishpur, Hazipara, 10.02.1988, Mia & Mahfuz M. 1522 (DACB); Chunati Wildlife Sanctuary, 25.02.1999, Rahman *et al*. 4029 (HCU). **Sylhet**: Chattak, 05.01.1978, Huq & Rahman H. 3662 (DACB). **Patuakhali**: Mirzaganj, Subidkhali, 20.11.2004, M. Sultana 567; Dumki, Srirampur, 17.05.2005, M. Sultana 899; Patuakhali Sadar, Laukathi, 15.05.2006, M. Sultana 1262 (DUSH). **Cox's Bazar**: Whykeong Range, Raikeong, 11.09.1999, Rahman *et al.* 5916 (HCU). **Rangamati**: Belaichari, 23.07.1999, Rahman *et al.* 5101 (HCU).

Chromosome number: 2n = 20, 22, 30, 40, 48 (Kumar and Subramaniam, 1986).

Habitat: Scrub jungles.

Distribution: Throughout tropical and subtropical India, including Sri Lanka, Pakistan, Nepal, Bhutan, Malaysia, Australia and tropical Africa. In Bangladesh, this species is common in the *Sal* forests of Dhaka, Gazipur, Mymensingh and Sherpur districts.

Economic uses/values/harmful aspects: Tuberous roots are used as aphrodisiac, alterative, tonic, demulcent and diuretic. Ethanolic extracts of aerial parts possess anti-cancer properties (Ghani, 2003). The plant is ground with other ingredients, made into pills, and fed to cattle for diarrhoea (Alam, 2000). Tubers are used as a vegetable (Deb, 1983). The root is useful in diseases of the kidney and the liver, scalding urine, gleet, gonorrhoea (Kirtikar *et al*., 1935).

Ethnobotanical information: Tuberous root paste mixed with sesame oil or coconut oil is used as a hair tonic. Root taken with milk is useful in gonorrhoea.

Propagation: By seeds and tuberous root with crown.

6. **Asparagus setaceous** (Kunth) J.P. Jessop, Bothalia 9: 51 (1966).

(Fig. 7, Plate 28)

Synonyms: *Asparagopsis setacea* Kunth, Enum. Pl. 5: 82 (1850); *Asparagus plumosus* Baker, Journ. Linn. Soc. 14: 613 (1875).

English names: Climbing Asparagus-fern, Lace-fern.

Local name: *Fern Asparagus*.

Description: A woody vine, scrambling or climbing to 5 m long, smooth, much branched, branches spreading horizontally, branchlets and cladodes arranged in one plane, like a fern frond. Cladodes in fascicles of 10-15 per node, very slender, 4-10 × 0.5 mm. Leaves membranous, 1-2 mm long, blade forming a short spine with reflexed apex, mostly on the main stem. Inflorescence terminally umbellate, 1-4 flowered. Flowers bisexual, short pedicellate, pedicel c 3.9 mm long. Perianth of 6 tepals, c 3.0 × 1.2 mm, campanulate, spreading, white, fragrant. Stamens 6, filaments c 1.5 mm long, anthers oblong, c 1.0 × 0.5 mm. Carpels 3, united, ovary superior, 3-celled, c 3 × 3 mm, stigma 3-fid, style minute, style with stigma c 1 mm long, placentation axile. Fruit a berry, purplish-black, 5-6 mm in diameter. Seeds 1-3 per berry.

Flowering and fruiting: February-June.

Specimens examined: Dhaka: D.U. Bot. Garden, 05.07.2016, Sumona 106; Nazimuddin Road, 20.1.1956, Shaliqehan p. 25.9.1945 (DUSH); Baldha Garden, 17.2.1988, Rezia *et al.* 249 (DACB). **Patuakhali**: Dumki, Srirampur, 17.05.2005, M. Sultana 900 (DUSH).

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: Waste places.

Distribution: Native to South Africa, introduced in many countries including Bangladesh.

Economic uses/values/harmful aspects: Commonly cultivated for its fern-like frond.

Ethnobotanical information: Foliage is used for decorative purposes by florists.

Propagation: By seeds.

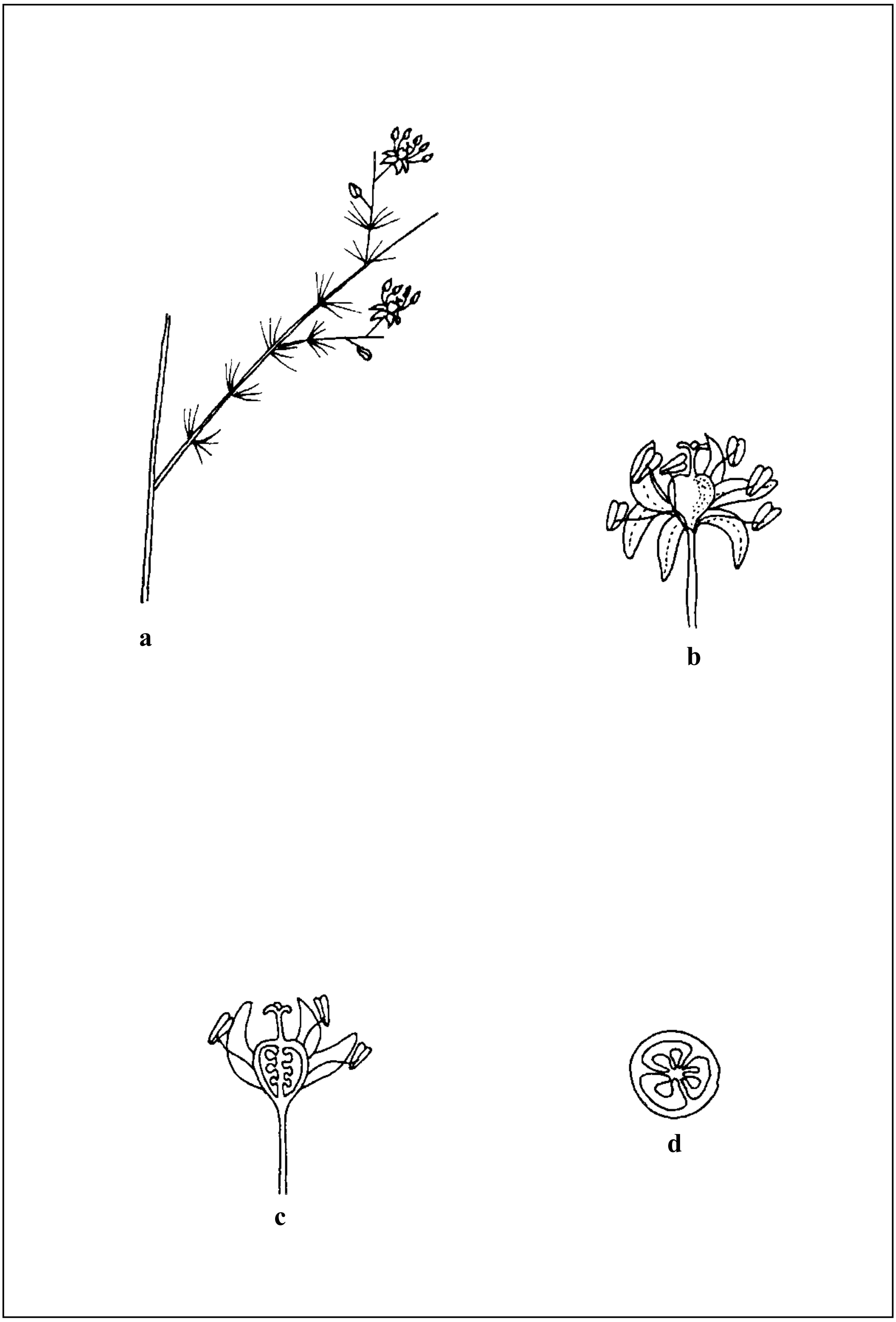


Fig. 7. *Asparagus setaceus* (Kunth) J.P. Jessop, a) Habit (×0.5); b) Flower (×3); c) L.S. of a flower (×3); d) T.S. of ovary (×5).

Plate 28. *Asparagus setaceous* (Kunth) J.P. Jessop, Habit.

Genus 3: **ASPHODELUS** [Tourn.] Linn., Syst. ed. 1 (1735). Benth. and Hook. f., Gen. Pl. 3: 782 (1883); L., Sp. Pl.: 309 (1753) and Gen. Pl. ed. 5: 146 (1754).

Asphodeloides Moench, Meth. 634 (1794); *Clausonia* Pomel, Mat. Fl. Atl. 1 (1874); *Gethosyne* Salisb., Gen. Pl. Fragm. 72 (1866); *Ophioprason* Salisb., Gen. Pl. Fragm. 72 (1866); *Verinea* Pomel, Mat. Fl. Atl. 1 (1874).

Annual or perennial herbs, scapose, from swollen rhizomes. Leaves numerous, basal; blade linear, triquetrous, cylindrical or flat, base membranous, sheathing, margins entire. Scape hollow or solid. Inflorescences racemose or paniculate, many-flowered, bracteate; bracts persistent, narrowly lanceolate, scarious. Flower solitary in the bracts, bisexual, epigynous, erect to spreading, distinct or barely connate basally, equal, each with single prominent vein; pedicel articulate. Perianth segments 6, white, 6-partite, segments united below into a perianth tube. Stamens 6, distinct, subequal or equal, shorter than tepals; filaments dilated at the base and covering the ovary, anthers dorsifixed, versatile. Carpels 3, united into a 3-celled ovary, style filiform, stigma slightly 3-lobed, ovary with 2-collateral ovules in each cell. Fruit a capsule, usually 1-seeded, globose, hard, loculicidal. Seeds 3 or 6, black, angled or winged.

About 12 species: South west Europe, north Africa, south west Asia (India); widely introduced elsewhere. The genus *Asphodelus* is represented in the flora of Bangladesh by single species.

1. **Asphodelus tenuifolius** Cavan, Anal. Cienc. Nat. 3: 46, t. 27 (1801). Hook. f., Fl. Brit. Ind. 6: 332 (1892); Haines, Bot. Bih. Or. 1097 (1924).

(Fig. 8)

Synonyms: *Asphodelus fistulosus* L., Sp. Pl. 309 (1753); *Asphodelus parviflorus* Wight, Ic. t. 2062 (1853).

English name: Narrow-leaved Asphodelus.

Description: An annual herb. Leaves radical, slender, semi-terete, fistular, 15-30 cm long, acuminate. Scape glabrous or papillosely scaberulous, 4-8 cm long, terete, simple

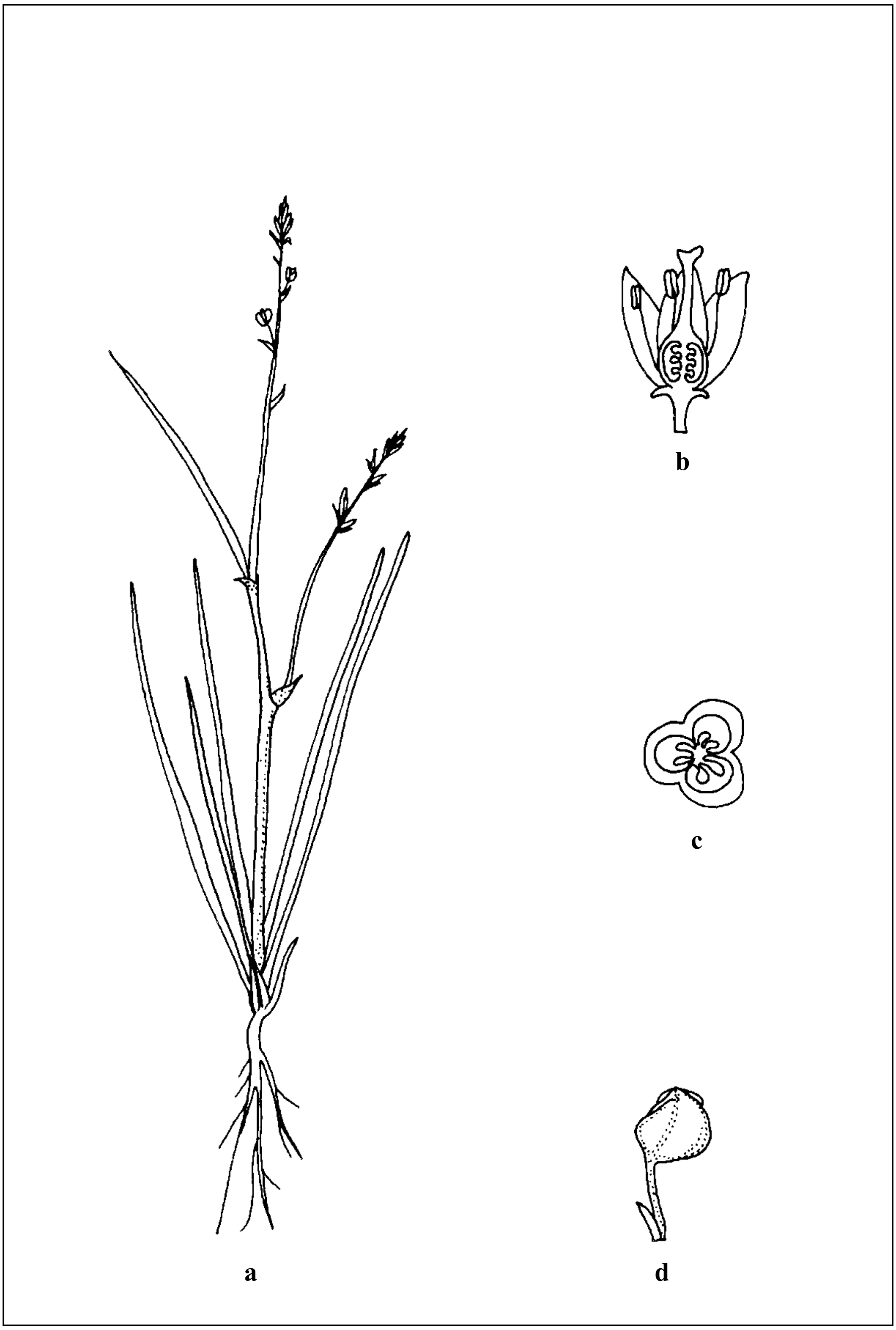


Fig. 8. *Asphodelus tenuifolius* Cavan, a) Habit (×0.5); b) L.S. of a flower (×3); c) T.S. of ovary (×5); d) Fruit (×2).

or branched. Flowers small, in racemose inflorescence, bracteate, bisexual, actinomorphic, pedicellate, pedicels jointed below the middle. Perianth segments 6, petaloid, white with a brownish costa. Stamens 6, filaments fusiform towards the tip, shorter than the perianth lobes. Carpels 3, united into a 3-celled ovary, ovules 2 in each cell, stigma 3-lobed. Fruit a capsule, globose, valves deeply wrinkled. Seeds trigonous, with 3-4 dorsal ridges and as many lateral pits.

Flowering and fruiting: May-July.

Specimens examined: Kushtia: 24.04.1957, M.Q. Kabir 52; 06.06.1970, Nazim 184 (DUSH); 02.01.1976, Chuadanga, Huq, Rahman and Mia 1758 (DACB). **Narayanganj**: Postogola, 21.05.1970, M.A. Rahman 133 (DUSH). **Rajshahi**: Biraldah, 05.02.1973, Huq 778 (DACB).

Chromosome number: 2n = 28, 30 (Kumar and Subramaniam, 1986).

Habitat: Plain lands.

Distribution: North Africa, south west Europe, south west Asia, Pakistan and India. In Bangladesh, the species was collected in 1976 and after that this species was not recorded any parts of the country, hence the species might be endangered in the country.

Economic uses/values/harmful aspects: The seed is diuretic; applied externally to ulcers and inflamed parts (Kirtikar *et al.*, 1935). The plant is eaten raw as well as in cooked form, particularly during famine (Ali and Qaiser, 2005).

Propagation: By seeds.

Genus 4: **CHLOROPHYTUM** Ker-Gawl., Bot. Mag. 27: t. 1071 (1807).

Perennial herbs, rhizomatous. Rhizome often short, inconspicuous, sometimes thick, elongate. Roots usually slightly fleshy. Leaves basal, subdistichous or fasciculate, sessile or petiolate, conduplicate. Inflorescence a terminal raceme or panicle, bract small. Scape axillary, proximately with bract-like cauline leaves. Flowers bisexual, pedicel articulate. Perianth segments 6, usually white, free, persistent or marcescent. Stamens 6, inserted at the base of tepals; filaments filiform, usually slightly widened near middle, anthers nearly basifixed. Ovary 3-loculed, ovules 1 to several per locule;

style slender; stigma small. Fruit a capsule, acutely 3-angled, loculicidal. Seeds black coated, flattened.

About 300 species: mainly in tropical areas of Africa, Asia and Australia, also in South America. The genus *Chlorophytum* is represented in the flora of Bangladesh by 2 species.

Key to the Species

1.	Leaves evergreen, strictly distichous; margin not crisped; anthers white	**C. laxum**
-	Leaves not evergreen and not strictly distichous; margin laxly crisped; anthers orange	**C. nepalense**

1. **Chlorophytum laxum** R. Br., Prodr. 277 (1810); Hook. f. in Trimen, Handb. Fl. Ceylon 4: 290 (1898). **(Fig. 9, Plate 29)**

Synonyms: *Chlorophytum laxum* R. Br. (as *'laxiflorum'*) Baker, J. Linn. Soc. Bot. 15: 328 (1876); *Phalangium laxum* (R. Br.) F. Muell., Fragm. 7: 71 (1869); *Anthericum parviflorum* (Wight) Bentham, Fl. Hongk. 373 (1861); *Chlorophytum parviflorum* (Wight) Dalzell, Hooker's J. Bot. Kew Gard. Misc. 2: 141. 1850; *Phalangium parviflorum* Wight, Ic. Pl. Ind. Orient. [Wight] t. 2039 (1853).

English names: Spider Plant, Ribbon Plant, Spider Ivy, Airplane Plant.

Description: Perennial herb, c 25 cm tall with fibrous roots some of which swell out to form tubers 1-12 cm long, 0.5-1 cm thick. Leaves 6-12 or more, 10-30 × 0.5-1 cm, distichous, spreading, the outer strongly recurved, linear, acute, acuminate, more or less flat or conduplicate, rather rigid, costate, with sheathing base, chanelled above, keeled and shallowly ribbed beneath, scabrous at margins, bright green beneath, slightly paler beneath. Peduncle slender, 2-2.5 cm long, inflorescence 5-30 cm long, flexuous, deflexed after anthesis. Bracts 2-10 mm long, scattered, lanceolate, acuminate, reddish green, membranous, turning scarious when dry. Flowers in distant fascicles in axils of bracts 1-2 cm apart, opening successively in each fascicles. Pedicel 4-5 mm long,

Fig. 9. *Chlorophytum laxum* R. Br., a) Habit (×0.3); b) Flower (×0.5); c) L.S. of gynoecium (×3); d) T.S. of ovary (×5); e) Stamen (×3); f) Bract (×0.5).

Plate 29. *Chlorophytum laxum* R. Br., a) Habit; b) Flower.

jointed below the middle, decurving and elongating to c 10 mm in the fruit. Perianth white or pale greenish white, segments acute, 4-5 mm long, outer segments lanceolate, c 1.5 mm broad, inner narrowly oavte, c 2 mm broad. Filaments 1.5-2.5 mm long, subequal and outer longer, white, subulate. Anthers c 0.75 mm long, greenish, connective with a small lobe at its tip. Ovary trigonous, depressed at apex, green. Style c 1.5 mm long, simple, white. Stigma punctiform, shallowly 3-lobed, papillose. Capsule 3-8 mm broad, broadly obcordate, trigonous, with 3 very short wings. Seeds 1-4 in each locules, c 2 mm broad, compressed, hard, black, covered with minute tubercles.

Flowering and fruiting: October-April.

Specimen examined: Dhaka: D.U. Bot. Garden, 06.09.2015, Sumona 96 (DUSH).

Chromosome number: 2n = 16 (Raven and Zhengyi, 2000).

Habitat: Partly shaded area.

Distribution: India, Indonesia, Malesia. Cultivated in many countries including Bangladesh.

Economic uses/values/harmful aspects: The plant is basically use for treatment of piles and as astringent. The tuberous roots are being used as a well-known tonic and an aphrodisiac. Roots are used for the treatment of diarrhea, dysentery, also used as demulcent and galactogogue. The tuber pest of *Chlorophytum laxum* is use for treatment of insect bite and snake bites (Kale and Thakare, 2013).

Propagation: By rhizome division.

2. **Chlorophytum nepalense** (Lindley) Baker, Journ. Linn. Soc. 15: 330 (1876). **(Fig. 10, Plate 30)**

Synonyms: *Phalangium nepalensis* Lindley, Trans. Hort. Soc. Lond. 6: 277 (1826); *Chlorophytum khasianum* Hook. f., Fl. Brit. Ind. 6: 334 (1892).

English name: Chlorophytum.

Local names: *Khiranglo, Nigalisak* (India).

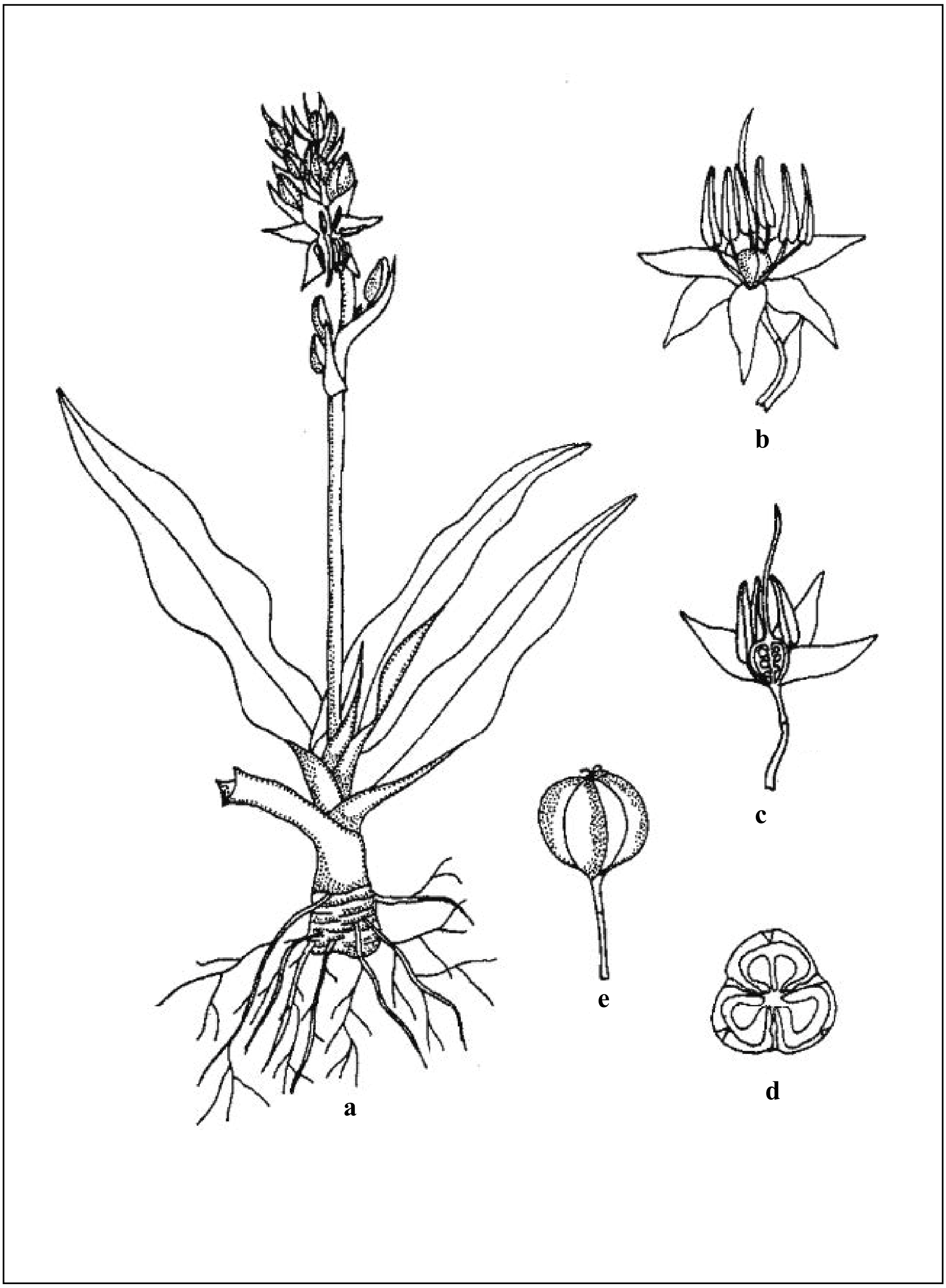


Fig. 10. *Chlorophytum nepalense* (Lindley) Baker, a) Habit (×0.5); b) Flower (×2); c) L.S. of a flower (×2); d) T.S. of ovary (×10); e) Fruit (×2).

Plate 30. *Chlorophytum nepalense* (Lindley) Baker, a) Habit; b) Tuberous roots.

Description: Root fibrous, cylindric and tuberous, nearly clustered. Rhizome often short, inconspicuous. Leaves ensiform, sessile, flat, convolute, often distichous, c 19.5 × 4.2 cm, acute-acuminate, linear-lanceolate, entire, margin laxly crisped, glabrous, green. Inflorescence an irregular terminal raceme, scape solid, simple or shortly branched, terete or slightly compressed, green, c 20.5 cm long, flowering portion c 6 cm long. Flowers bracteate, each bract contains four buds, bracts c 0.8 × 0.4 cm, lanceolate, green, glabrous. Pedicels c 0.8 cm long, erect, white, jointed above the middle, perianth segments 6, 3 + 3, inner three c 0.8 × 0.3 cm, outer three c 1.0 × 0.2 cm, linear-lanceolate, acute to obtuse, white, glabrous. Stamens 6, exserted, filaments c 0.3 cm long, white, anthers c 0.6 cm long, yellow, basifixed, dehiscence longitudinal, not recurved or revolute after flowering. Ovary c 0.25 × 0.2 cm, green, trigonous, glabrous. Carpels 3, syncarpous, ovules many in each chamber, style c 1.1 cm long, white, stigma minute, c 0.1 cm long, 3-fid, glabrous. Fruit a capsule, trigonous, c 0.8 × 0.9 cm, with 0.1 cm 3-fid stigma. Seeds two-several per valve, c 0.3 × 0.2 cm, black, opaque.

Flowering and fruiting: March-July.

Specimens examined: Sherpur: Runctia *Sal* forest, 16.05.2008, Ershad Tutul 205; D.U Bot Garden (originally collected from Runctia *Sal* forest), 28.07.2013, Sumona 80 (DUSH).

Chromosome number: 2n = 56 (Naik, 1977).

Habitat: Scrub jungles.

Distribution: Native to Nepal and distributed in Myanmar, India, China and Bhutan. In Bangladesh the species was only recorded from Runctia *Sal* Forest of Sherpur district (Afroz *et al*., 2008).

Economic uses/values/harmful aspects: *Chlorophytum nepalense* used as wild vegetables by local communities like Chhetri, Tamang Bankaria and khasi of Nepal and North Eastern India (Kale and Thakare, 2013).

Propagation: By seeds.

***Note*:** The species is very close to the other species *Chlorophytum tuberosum* (Roxb.) Baker, but the difference is pedicels jointed above the middle in C. *nepalense* whereas under the middle in *C. tuberosum*.

Genus 5: **CRINUM** L., Gen. Pl. ed. 1: 97 (1737) and Sp. Pl. 291 (1753). Benth. and Hook. f., Gen. Pl. 3: 726 (1883).

Crinopsis Herb., Amaryll. 270 (1837); *Erigona* Salisb., Gen. Pl. Fragm. 115 (1866); *Liriamus* Rafin., Fl. Tell. 4: 23 (1836); *Scadianus* Rafin., Atl. Journ. 164 (1833); *Taenais* Salisb., Gen. Pl. Fragm. 115 (1856); *Tanghekolli* Adans. Fam. 2: 57 (1763).

Perennial herbs with tunicated bulbs, usually produced at the apex into a short or long false stem. Leaves long, lorate or ensiform, spirally arranged, sessile, with smooth or scabrous edges. Peduncle compressed, solid. Flowers large, fragrant, umbellate, short-pedicelled or sessile, spathes 2, lanceolate, scarious; bracteoles many, linear. Perianth funnel-shaped or almost salver-shaped, tube long, straight or incurved, perianth segments 6, linear-lanceolate or narrowly oblong, red to white, often striped, streaked, or overlaid with red abaxially. Stamens 6, adnate to the throat of the perianth tube; filaments free, filiform, declinate or diverging. Anthers linear or oblong-linear, dorsifixed. Carpels 3, syncarpous. Ovary inferior, 3-celled, ovules few in each locules, biseriate; style long, filiform, more or less declinate; stigma small, sub-capitate. Fruit a capsule, sub-globose or obovoid, membranous or coriaceous, bursting irregularly. Seeds few, large, green, rounded or irregularly compressed.

About 130 species: tropical and warm regions worldwide, mostly in Africa. The genus *Crinum* is represented in the flora of Bangladesh by 8 species.

Key to the species

1.	Perianth lobes linear	**2**
-	Perianth lobes oblong or lanceolate	**5**
2.	Umbels more than 15-flowered	**3**
-	Umbels up to 15-flowered	**4**
3.	Scape purplish, shorter than the leaves	**C. amabile**
-	Scape green, longer than the leaves	**C. asiaticum**
4.	Bulbs with a fusiform, stoloniferous base	**C. defixum**
-	Bulbs not stoloniferous	**C. stenophyllum**
5.	Perianth tube erect, stamens spreading	**6**
-	Perianth tube upcurved, stamens declinate	**7**

6.	Leaves acuminate, scabrous; perianth lobes shorter than the tube	**C. amoenum**
-	Leaves obtuse or sub-acute; perianth lobes longer than the tube	**C. pratense**
7.	Leaf margin scabrous, perianth vertically reddish on the back	**C. latifolium**
-	Leaf margin smooth, perianth white	**C. jagus**

1. **Crinum amabile** Donn, Hort. Cantabring. ed. 6: 82 (1811).

(Fig. 11, Plate 31)

Synonym: *Crinum augustum* Roxb., Fl. Ind. 2: 136 (1832).

English names: Purple Spider Lily, Pink Crinum lily, Pink Giant Spider Lily, Giant Spider Lily, Tiger Lily.

Local name: *Sukhdarshan*.

Description: A perennial herb with a large tunicated bulb, bulb c 40 × 12 cm with long stem, roots c 15 cm long. Leaves long, c 60-170 × 7-20 cm, lorate, entire, acute, glabrous, green in colour. Scape solid, c 60-130 cm long, purplish, 20-50 flowered umbel, green, glabrous, arise from the side of the stem. Flowers large, actinomorphic, bisexual, epigynous, purple, fragrant at night, pedicellate, pedicel c 3.7 cm long. Spathes 2, 15-25 × 7.0-12.5 cm, lanceolate, purplish-green or purple, bracteoles many, linear, c 10.2 × 0.5 cm, white in colour. Perianth segments 6, c 17 × 3 cm, purple, lower parts forming a long, slightly curved tube, tube c 13 cm long, purple. Stamens 6, adnate to the throat of the perianth tube, filaments filiform, c 9 cm long, purplish, anthers linear, 1.5-2.5 cm long, dorsifixed, yellow. Carpels 3, syncarpous, ovary inferior, c 1.8 cm long, 3-celled, purple, style single, filiform, c 22 cm long, stigma sub-capitate, placentation axile. Fruit not formed.

Flowering and fruiting: Throughout the year.

Specimens examined: Dhaka: D.U. Bot. Garden, 15.11.2006, Sumona 3; Cantonment, Shaheed Anwar Girls College, 15.11.2006, 06.10.2016, Sumona 105 (DUSH).

Chromosome number: 2n = 33 (Lubna *et al.*, 2004).

Habitat: Mainly cultivated in gardens.

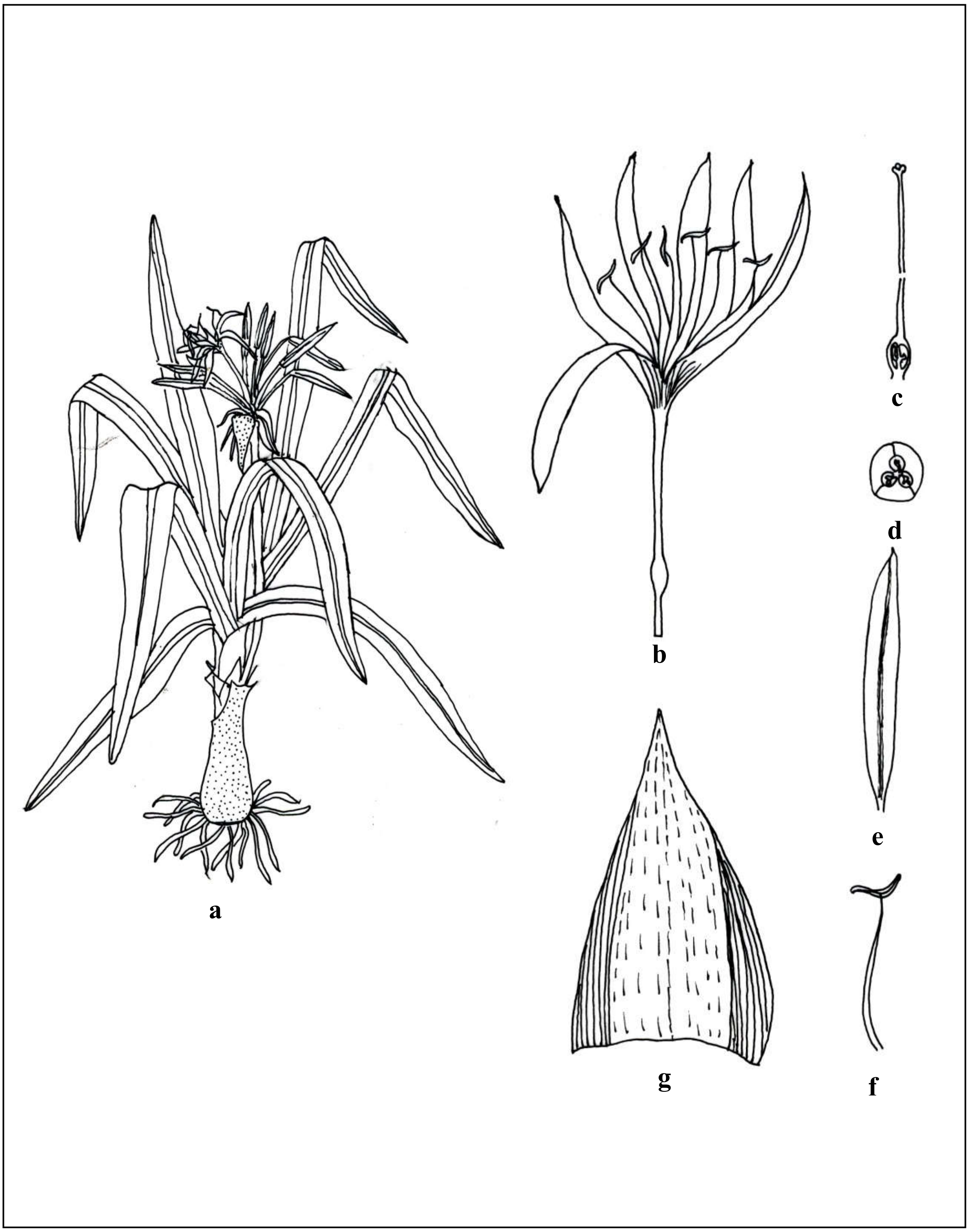


Fig. 11. *Crinum amabile* Donn, a) Habit (×0.1); b) Flower (×0.16); c) L.S. of gynoecium (×0.25); d). T.S. of ovary (×2); e) Tepal (×0.16); f) Stamen (×0.25); g) Bract (× 0.3).

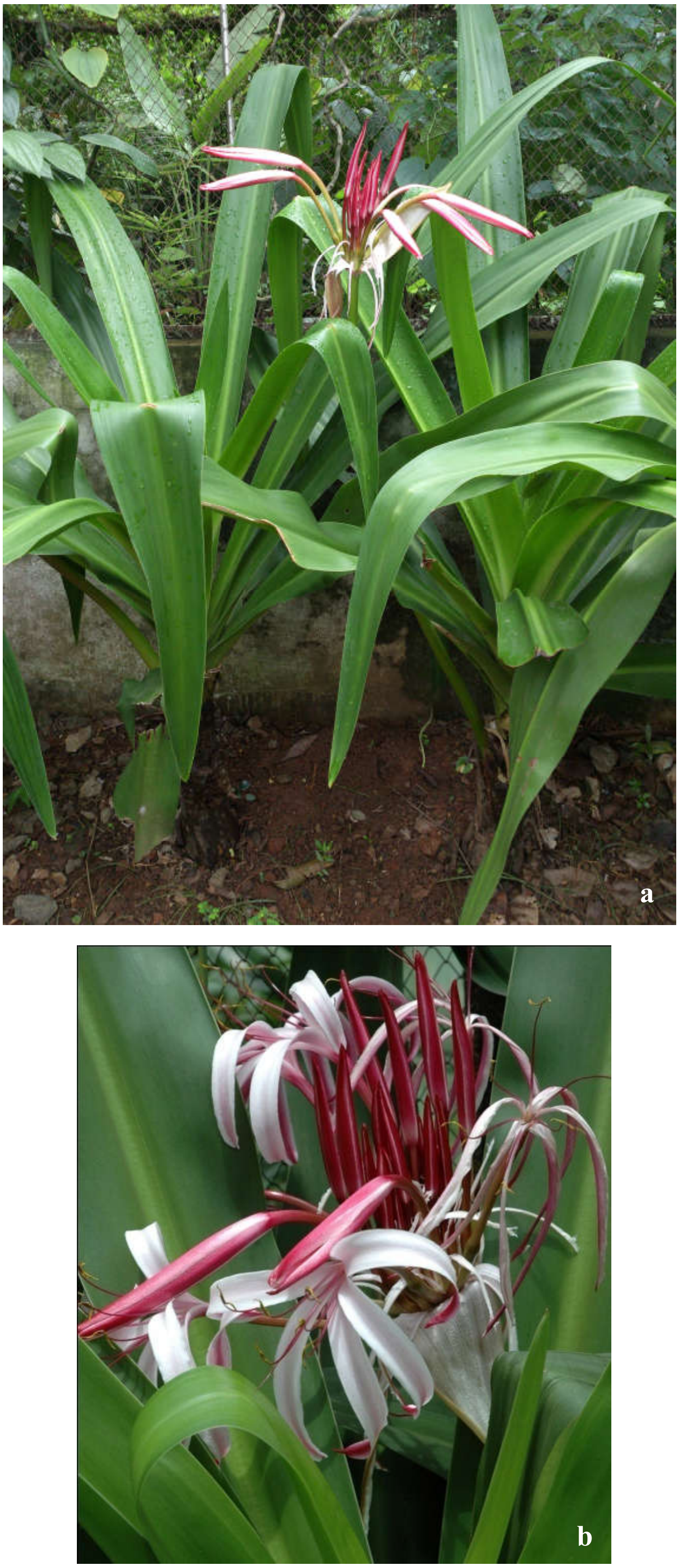


Plate 31. *Crinum amabile* Donn, a) Habit; b) Flowers.

Distribution: South Africa, Tropical regions of Asia. In Bangladesh, the species is cultivated in some private institutions and roadsides.

Economic uses/values/harmful aspects: Planted in the gardens.

Propagation: By bulb separation.

2. Crinum amoenum Roxb., Hort. Beng. 23 (1814). Fl. Ind. 2: 127 (1832). **(Fig. 12, Plate 32)**

Synonyms: *Crinum himalense* Royle, Ill. Bot. Himal. Mts. (1839); *Crinum verecundum* Carey *ex* M. Roem., Fam. Nat. Syn. Monogr. 75 (1847).

English names: Himalayan Crinum, Tiger Lily.

Local name: *Gang Kachu*.

Description: A bulbous perennial herb, bulb globose, 5.0-7.5 cm in diameter. Leaves long, 45-60 × 2.5-4.0 cm, bright-green, sub-erect, ensiform, tapering from the base to the tip, acuminate, margin sub-scabrous. Scape 30-60 cm long, rather slender, sub-cylindric, greenish-purple. Inflorescence of 6-12 flowered umbels, spathes 2, c 5 cm long, lanceolate, bracteoles many. Flowers sub-sessile. Perianth tube green, 7.5-10.0 cm long, lobes 5.0-7.5 cm long, linear-lanceolate, longer than the filaments, white. Stamens 6, filaments red, c 6 cm long, shorter than the perianth lobes, anthers oblong, dorsifixed. Carpels 3, ovary 3-celled, inferior, c 1.6 cm long, placentation axile. Fruit a capsule. Seeds 1-5, irregularly round.

Flowering and fruiting: May-August.

Specimens examined: Dhaka: Baldha Garden, 26.05.2007, Sumona 38; Uttara, 24.05.2007, Sumona 36 (DUSH). **Patuakhali**: Galachipa, Rangabali, 23.03.2006, M. Sultana 1208; Patuakhali Sadar, Laukathi, 15.05.2006, M. Sultana 1268 (DUSH). **Chittagong**: Chunati, Goalmara, 28.06.1997, Rahman *et al.* 663B (HCU). **Cox's Bazar**: Teknaf, Upazila Sadar, 25.05.2014, Sumona 88 (DUSH).

Chromosome number: 2n = 18, 22 (Kumar and Subramaniam, 1986).

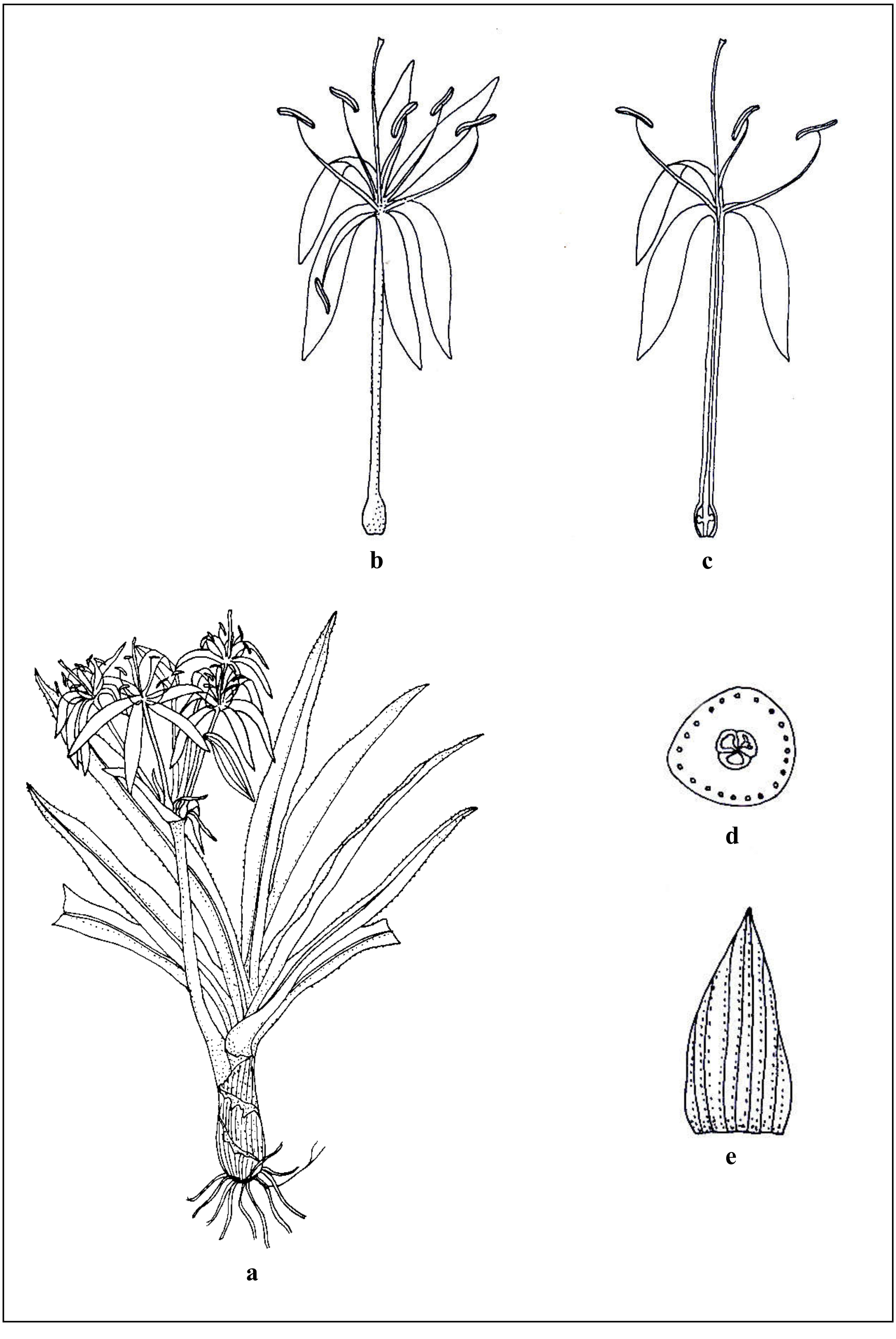


Fig. 12. *Crinum amoenum* Roxb., a) Habit (×0.2); b) Flower (×0.5); c) L.S. of a flower (×0.5); d) T.S. of ovary (×4); e) Bract (×1).

Plate 32. *Crinum amoenum* Roxb., a) Habit; b) Bulb.

Habitat: Hilly areas near streams, up to an altitude of 1800 m.

Distribution: Tropical Himalayas, India (Sikkim and Khasia Hills), Nepal and Myanmar. It was reported from the Sylhet region of present-day Bangladesh (Hooker, 1892). It is distributed in Dhaka, Patuakhali, Cox's Bazar and Chittagong districts.

Economic uses/values/harmful aspects: Planted in the gardens.

Propagation: By seeds and sucker formation.

3. **Crinum asiaticum** L., Sp. Pl.: 292 (1753).

(Fig. 13, Plate 33)

Synonyms: *Amaryllis carnosa* Herb. Ham. *ex* Hook.f., Fl. Brit. Ind. 6(18): 280 (1892); *Crinum albiflorum* Noronha, Verh. Batav. Genootsch. Kunst. 5(Art. 4): 12 (1790); *Crinum angustifolium* Herb. *ex* Steud., Nomencl. Bot. ed. 2. 1: 438 1(840); *Crinum bancanum* Kurz, Tijdschr. Nederl. Ind. 27: 231 (1864); *Crinum bracteatum* Willd., Sp. Pl., ed. 4. 2(1): 47 (1799); *Crinum hornemannianum* M.Roem., Fam. Nat. Syn. Monogr. 71 (1847); *Crinum macrocarpum* Carey *ex* Kunth, Enum. Pl. 5: 553 (1850); *Crinum northianum* Baker, Gard. Chron. I. 671 (1882); *Crinum plicatum* Livings. *ex* Hook., Bot. Mag. 56: t. 2908 (1829); *Crinum rumphii* Merr., Interpr. Rumph. Herb. Amboin. 141 (1917); *Crinum sumatranum* Roxb., Fl. Ind. 2: 131 (1832); *Crinum umbellatum* Carey *ex* Herb., Bot. Mag. 47: sub t. 2121, p. 7 (1820); *Crinum woolliamsii* L.S.Hannibal, Herbert. 43(1): 14 (1987); *Crinum toxicarium* Roxb., Fl. Ind. 2: 134 (1832).

English names: Poison Bulb, Giant Crinum Lily, Crinum Lily.

Local names: *Bara Kanur, Nagdal, Kachori, Sukhdarshan, Gaerhonar-pata*.

Description: A perennial herb with a large tunicated bulb. Leaves long, 36-48 × 3-5 in, lorate, margin entire, acute, wavy, glabrous, green in colour. Scape solid, 15-50 flowered umbels, green, glabrous. Flowers large, actinomorphic, bisexual, epigynous, white, fragrant at night, pedicellate, pedicel c 3.3 cm long. Bracts 2, c 6.5 × 3.2 cm, ovate-lanceolate, acute, greenish-white, bracteoles many, linear, white in colour. Perianth segments 6, c 8 × 1 cm, white, lower parts forming a long, straight tube, tube

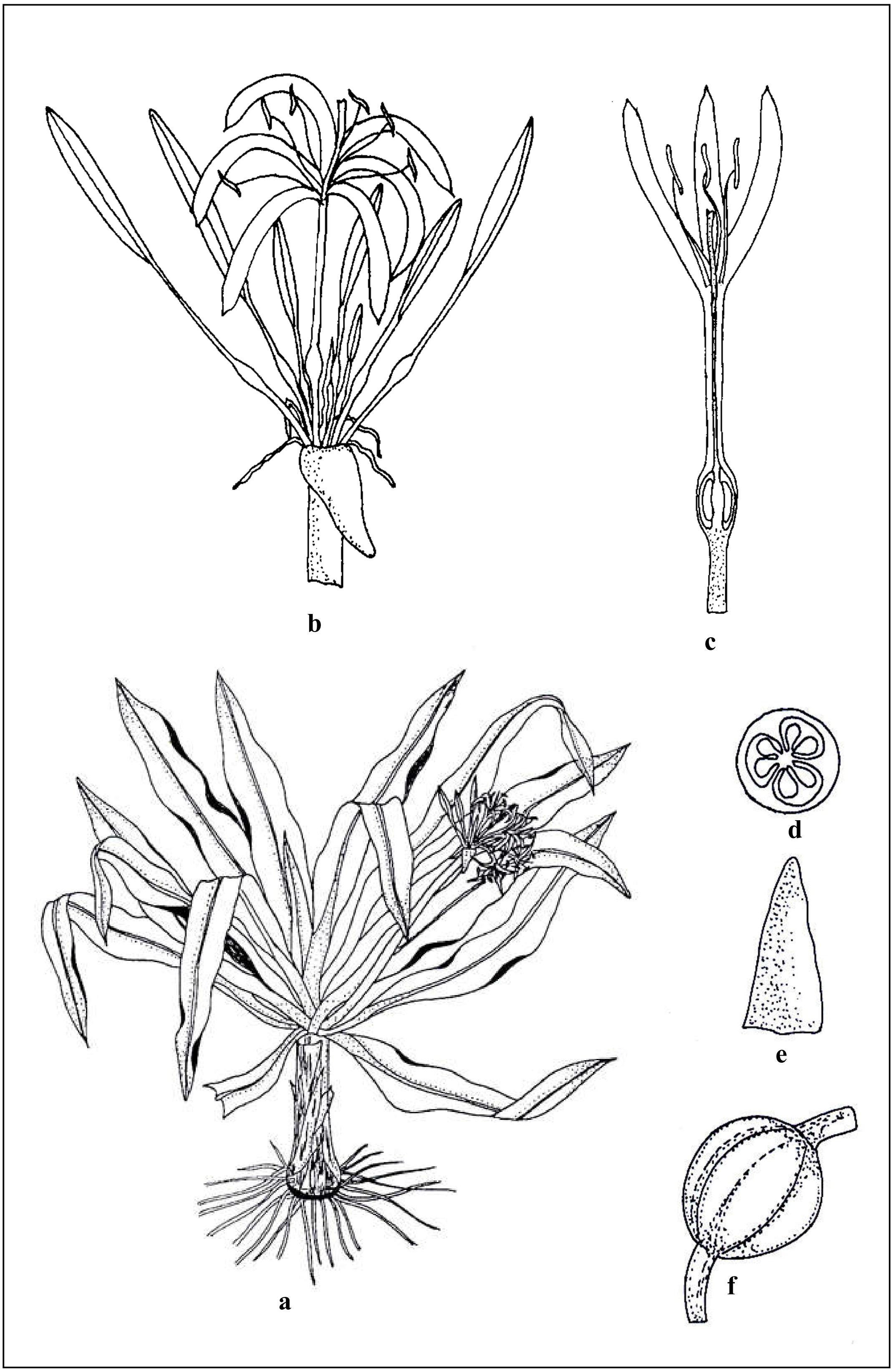


Fig. 13. *Crinum asiaticum* L., a) Habit (×0.1); b) Inflorescence (×0.3); c) L.S of a flower (×0.3); d) T.S. of ovary (×6); e) Bract (×0.5); f) Fruit (×1).

Plate 33. *Crinum asiaticum* L., a) Habit; b) Bulb; c) Fruits.

erect, greenish, c 7.5 cm long, equalling the linear lobes, lobes revolute. Stamens 6, adnate to the throat of the perianth tube, filaments filiform, c 4.6 cm long, purplish in upper half and white in lower half, anthers linear, 1.5-2.5 cm long, dorsifixed, yellow. Carpels 3, syncarpous, green, ovary inferior, c 1.5 cm long, 3-celled, placentation axile, style single, filiform, stigma sub-capitate. Fruit a capsule, c 3.0 × 1.5 cm, sub-globose, beaked, green, bursting irregularly. Seeds round, concave.

Flowering and fruiting: March-November.

Specimens examined: Dhaka: D.U. Bot. Garden, 08.08.2007, Sumona 43; D.U. Bot. Garden, 01.07.1968, Mozahar 155; 05.09.1994, M.M. Khan 89; Uttara, 12.07.2007, Sumona 41 (DUSH). **Jhalakathi**: Chankati, 03.03.1987, Huq and Mia 6667 (DACB). **Khulna**: Sundarban, Manderbaria, 21.08.2002, S. Nasir Uddin N-1386(1); Sundarban, Kotka, 24.08.2010, Sumona 65; Kotka, 21.09.2011 Sumona 71; (DACB). **Mymensingh**: Bhaluka, 03.07.2001, M.S. Hossain 229; Ishwarganj, 05.07.2001, M.S. Hossain 261 (DACB). **Bhola**: Char Kukri Mukri, 07.12.2015, M. Zashim Uddin (DUSH). **Patuakhali**: Kalapara, Nilganj, 11.03.1999, M. Sultana 320; Patuakhali Sadar, Lohalia, 14.05.2005, M. Sultana 714; Kalapara, Gongamoti, 07.01.2006, M. Sultana 935; Kalapara, 08.08.2013, Sumona 81 (DUSH).

Chromosome number: 2n = 22 (Kumar and Subramaniam, 1986).

Habitat: Coastal areas, also cultivated in gardens.

Distribution: Throughout the tropical parts of India, Sri Lanka and Nepal. In Bangladesh, it is common in the Sundarbans and coastal areas of Chittagong, and also planted in gardens.

Economic uses/values/harmful aspects: Widely planted in the gardens for its beautiful flowers. The bulb contains the alkaloids lycorine, crinidine and hamayne (Ghani, 2003). The bitter bulb is tonic, laxative, expectorant, used in biliousness and strangury and other urinary complaints. Fresh root is emetic, nauseant and diaphoretic. Seeds are purgative, diuretic, emmenagogue and tonic. Leaves are expectorant, applied to skin diseases and to reduce inflammation (Sinha, 1996). Tuber is useful in bronchitis and diseases of the chest and lungs, gonorrhoea, night blindness and defective vision, disease of the spleen, urinary conceretions, lumbago, anuria, toothache and snake-bite (Kirtikar *et al*., 1935).

Ethnobotanical information: Leaf juice is used in earache.

Propagation: By bulbs and seeds.

4. Crinum defixum Ker-Gawl., Quart. Journn. Sci. 3: 105 (1817). Hook. f., Fl. Brit. Ind. 6: 28 (1892); Prain, Beng. Pl. 1061 (1903); Cooke, Fl. Pres. Bomb. 2: 749 (1908); Haines, Bot. Bih. Or. 1108 (1924).

(Fig. 14, Plate 34)

Synonyms: *Crinum asiaticum* Roxb., Hort. Beng. 23 (1814); *Crinum viviparum* (Lamk.) R. Ansari & V.J. Nair, J. Econ. Taxon. Bot. 11(1): 205 (1988).

English names: Poison Bulb, Crinum Lily.

Local name: *Sukhdarshan*.

Description: Very stout bulbous herb, bulb with a fusiform stoloniferous base, neck cylindric. Leaves 30-80 × 2-3 cm, linear or linear-lanceolate, concave, smooth, entire, obtuse. Scape 35-50 cm long, usually shorter than the leaves, compressed, smooth. Spathe 2-leaved, bracteoles filiform. Flowers in umbels, umbel usually 6-15 flowered, bisexual, large, shortly pedicellate. Perianth white, tube cylindric, 6.0-7.5 cm long, segments 6, linear, nearly as long as the tube. Stamens 6, adnate to the throat of the perianth tube, spreading, recurved, filaments white or pink, shorter than the perianth lobes, anthers oblong, brown, versatile. Carpels 3, syncarpous, ovary inferior, 3-celled, style erect, exserted, stigma simple. Fruit a capsule, ellipsoid, c 2.5 cm long, 1-2 seeded. Seeds large, rugose.

Flowering and fruiting: May-August.

Specimens examined: Bhola: Char Kukri Mukri, 07.12.2015, M. Zashim Uddin (DUSH). **Patuakhali**: Bhupal, Kalaiya, 13.03.1973, M. S. Khan K-2843; Patuakhali Sadar, Lohalia, 18.11.2004, M. Sultana 462; Mirzaganj, Subidkhali, 20.11.2004, M. Sultana 565; Galachipa, Basbunia, 01.03.2005, M. Sultana 619; Galachipa, Panpotti, 18.12.2010, M. Sultana 1860 (DUSH).

Chromosome number: 2n = 22 (Alam *et al*., 1998); 50, 60 (Kumar and Subramaniam, 1986).

Habitat: Swampy river banks and gardens where it is commonly cultivated.

Distribution: Throughout tropical India and Sri Lanka. In Bangladesh, it is well represented in forests and many gardens.

Economic uses/values/harmful aspects: Commonly cultivated in the gardens for its beautiful large fragrant flowers. Bulb is nauseant, emollient, emetic and diaphoretic.

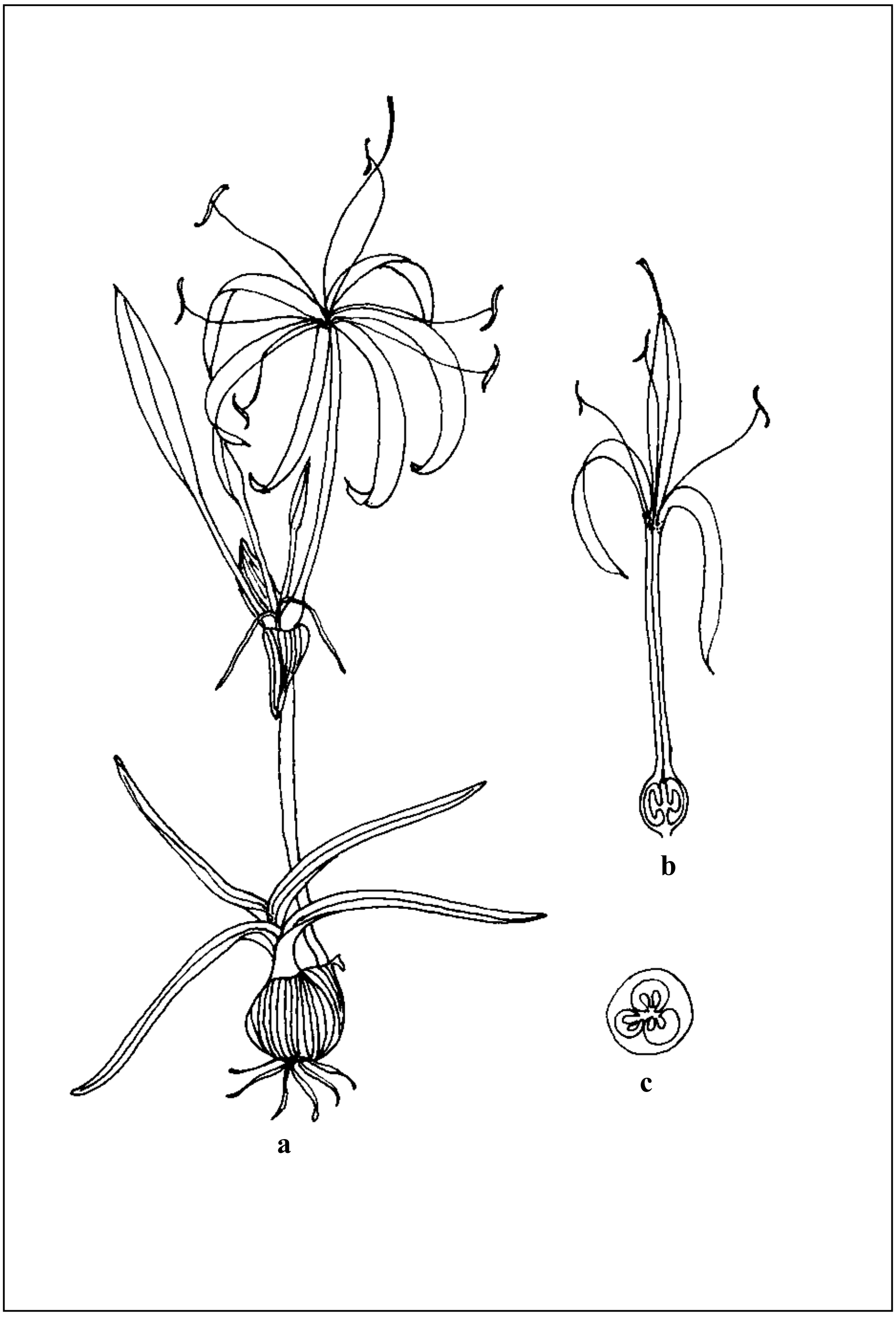


Fig. 14. *Crinum defixum* Ker-Gawl., a) Habit (×0.2); b) L.S. of a flower (×0.5); c) T.S of ovary (×0.3).

Plate 34. *Crinum defixum* Ker-Gawl., Habit.

The plant is toxic to cattle (Sinha, 1996).

Bulb is emollient and emetic; in small doses it is a nausant and diaphoretic. The bulb and stolon are very much used for the treatment of burns, whitlow, and carbuncle. In otitis a few drops of juice of the leaves are instilled in to the ear. In Rema Kalenga, bulbs are used for the treatment of stomach complaints of cow (http://www.mpbd.info/plants/crinum-defixum.php).

Propagation: By bulbs.

5. **Crinum jagus** (Thomps.) Dandy, Journ. Bot. Lond. 77: 64 (1939).

(Fig. 15, Plate 35)

Synonyms: *Amaryllis jagus* Thomps., Bot. Displ. t. 6 (1798); *Crinum giganteum* Andr., Bot. Rep. t. 169 (1810).

English name: Giant Crinum.

Local name: *Sukhdarshan*.

Description: A bulbous perennial herb, bulb globose, 12.5-15.0 cm in diameter with c 7 cm long neck. Leaves many, 60-90 × 7-12 cm, lorate or lanceolate, margin entire, wavy, acute or obtuse. Scape 30-90 cm long, green, spathes 2, greenish-white, ovate-lanceolate, c 9.7 × 5.9 cm, obtuse, bracteoles 4-8, linear-lanceolate, c 8.0 × 0.7 cm, greenish-white. Inflorescence of 4-8 flowered umbels, short-pedicelled or sessile. Perianth segments 6, c 11.5 × 4.0 cm, ovate-lanceolate, fragrant, white, lobes as long as or shorter than the tube, tube c 19 cm long, green. Stamens 6, filaments adnate to the throat of the perianth tube, 6-8 cm long, shorter than the perianth lobes, curved, white, anthers oblong, c 1.5 × 0.2 cm, dorsifixed, versatile, spiral after bursting. Carpels 3, syncarpous, ovary inferior, c 2.5 × 1.5 cm, placentation axile, style with stigma c 9.5 cm long, green, 3-celled. Fruit a sub-globose capsule. Seeds not found.

Flowering and fruiting: April-July.

Specimens examined: Dhaka: Science Library, 03.05.2007, Sumona 25; Charukala Campus, 26.05.2007, Somona 39; D.U. Bot. Garden (originally collected from Char Kukri Mukri), 10.05.2017, Sumona 106 (DUSH).

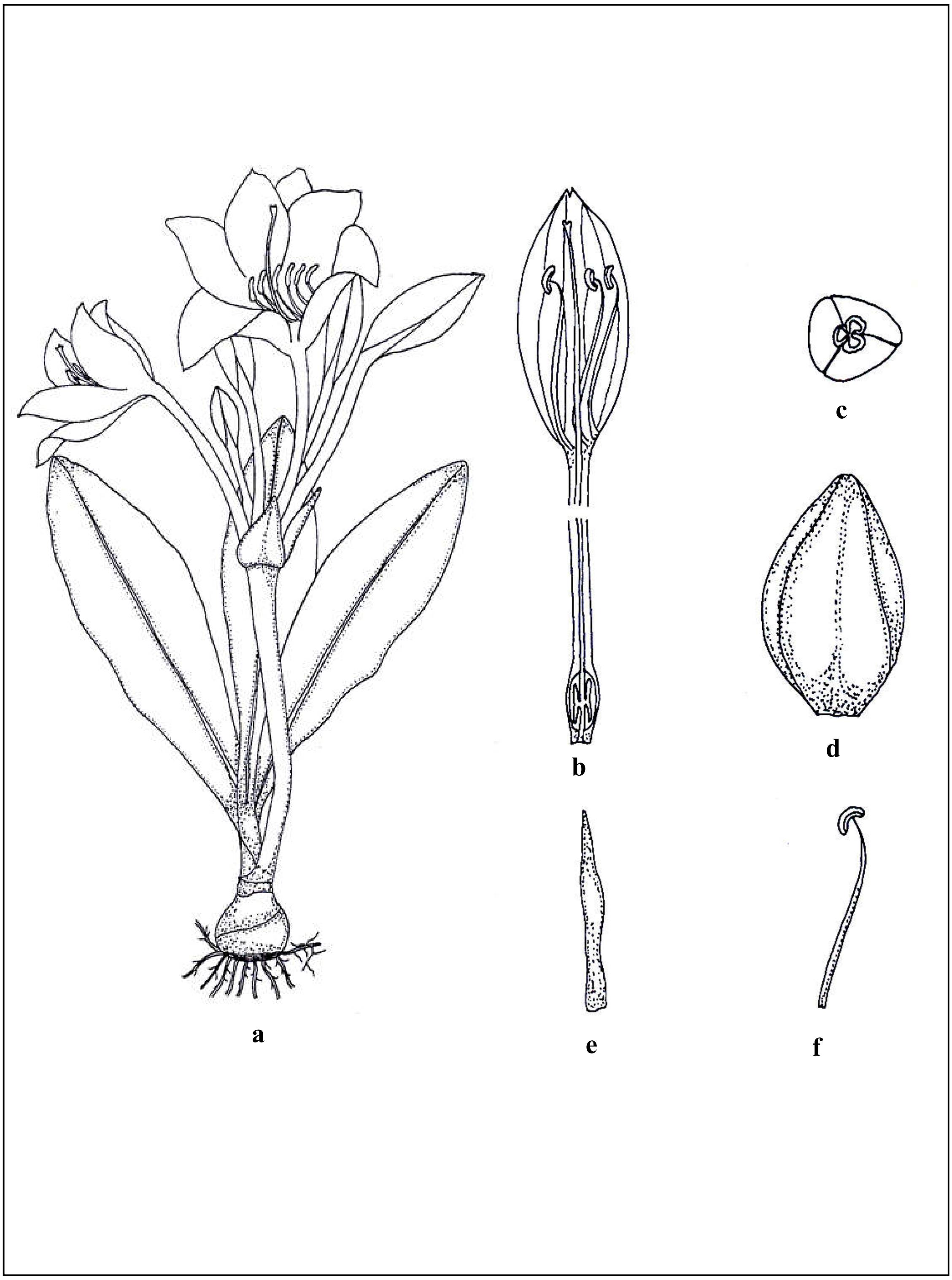


Fig. 15. *Crinum jagus* (Thomps.) Dandy, a) Habit (×0.05); b) L.S. of a flower (×0.1); c) T.S. of ovary (×2); d) Bract (×0.1); e) Bracteole (×0.1); f) Stamen (×0.1).

Plate 35. *Crinum jagus* (Thomps.) Dandy, a) Habit; b) Flowers.

Chromosome number: 2n = 33 (Kumar and Subramaniam, 1986).

Habitat: Soil rich in organic matter.

Distribution: Throughout Sri Lanka, India and Myanmar, also in Malaysia and Africa. In Bangladesh, it is found in different gardens.

Economic uses/values/harmful aspects: Cultivated in the gardens for its large beautiful flowers.

Ethnobotanical information: Crushed and roasted bulbs are used in rheumatism. Leaf juice is used in earache (Sinha, 1996).

Propagation: By bulbs.

6. **Crinum latifolium** L., Sp. Pl.: 291 (1753).

(Fig. 16, Plate 36)

Synonyms: *Crinum ornatum* Herb., Amaryll. 262 (1837); *Crinum moluccanum* Roxb., Fl. Ind. 2: 140 (1859); *Crinum zeylanicum* L., Syst. ed. 12 (1767).

English name: Pink Striped Trumpet Lily.

Local name: *Sukhdarshan*.

Description: A bulbous perennial herb, bulb globose, 12.5-15.0 cm in diameter with a short neck. Leaves many, 60-90 × 7-12 cm, lorate, margin sub-scabrid. Scape 60-90 cm long, greenish-purplea or yellowish-green, spathes 2, reddish-green or purple, lanceolate. Inflorescence of 6-12 flowered umbels, short-pedicelled. Perianth segments 6, c 12.2 × 3.0 cm, perianth tube curved, c 7 cm long, lobes 7-15 cm long, as long as or shorter than the tube, elliptic-oblong or elliptic-lanceolate, fragrant, white, more or less streaked or tinged with red towards the centre, sometimes red-purple, nearly all over the back. Stamens 6, declinate, filaments adnate to the throat of the perianth tube, 6-8 cm long, shorter than the perianth lobes, anthers oblong, 1.3-2.0 cm long, grey, dorsifixed, versatile. Carpels 3, syncarpous, ovary inferior, 3-celled, c 1 cm long, placentation axile. Fruit a sub-globose capsule, c 4.5 × 3.0 cm, pinkish-maroon in colour.

Flowering and fruiting: May-September.

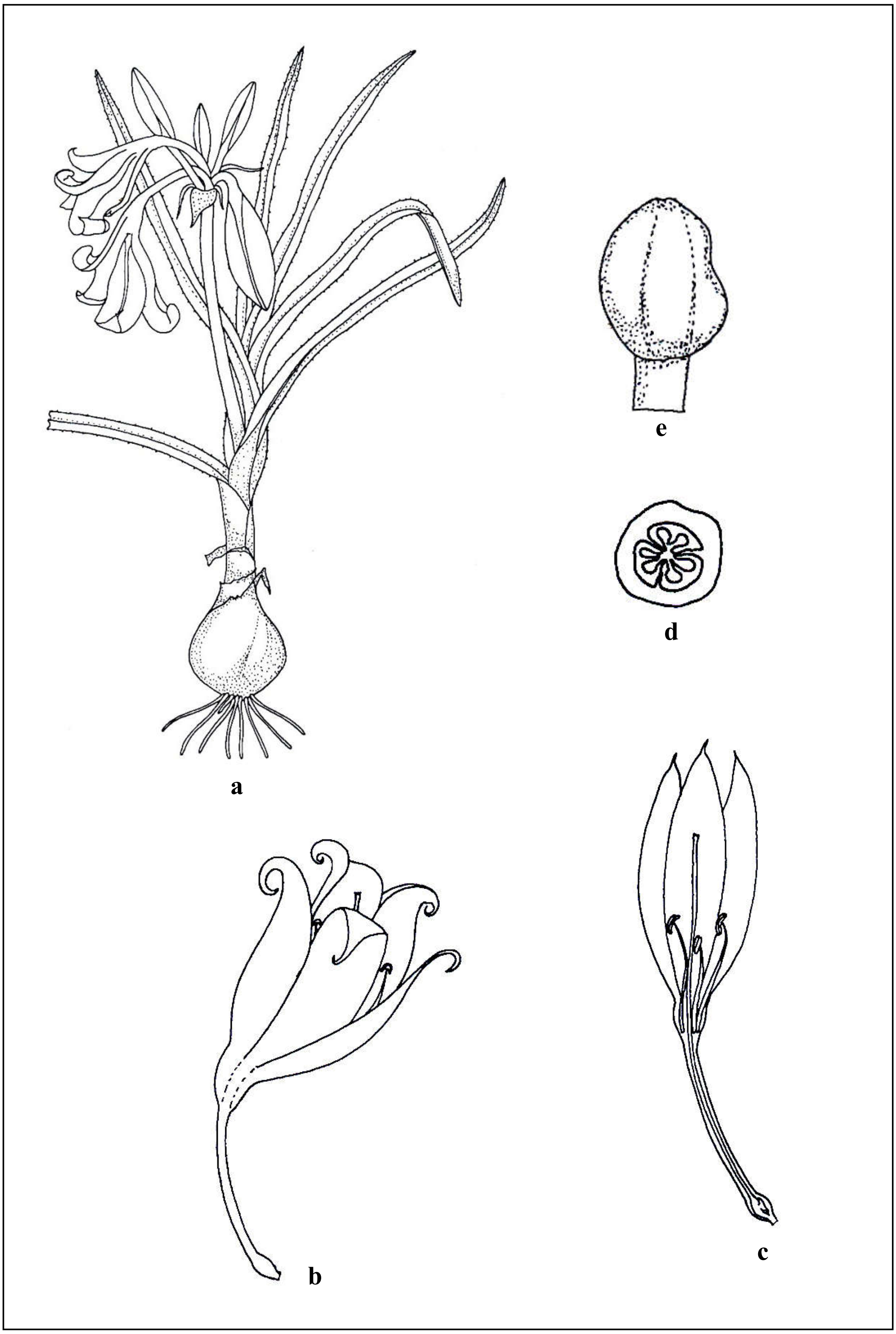


Fig. 16. *Crinum latifolium* L., a) Habit (×0.12); b) Flower (×0.25); c) L.S. of a flower (×0.25); d) T.S. of ovary (×3); e) Fruit (×1).

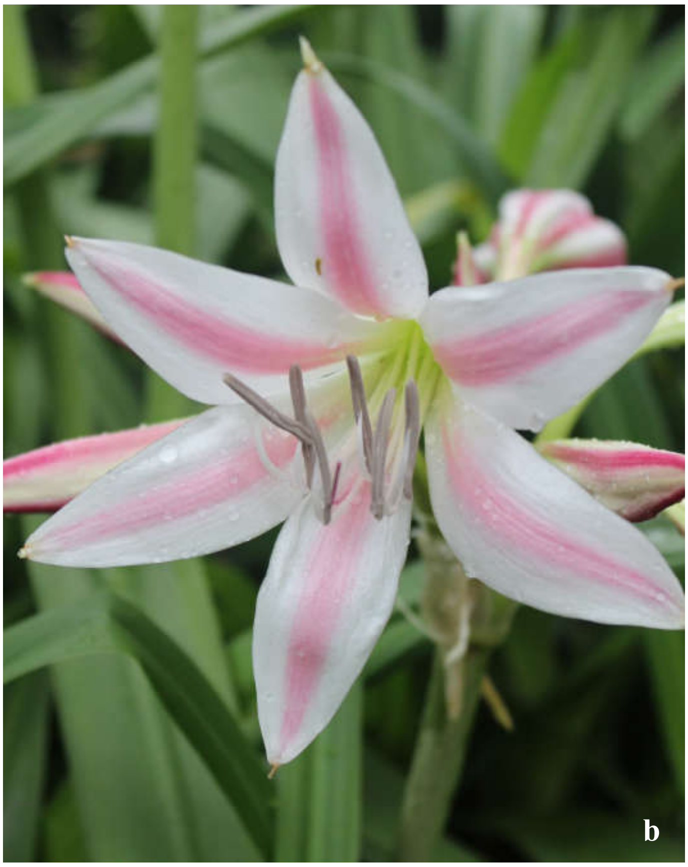


Plate 36. *Crinum latifolium* L., a) Habit; b) Flower.

Specimens examined: Dhaka: Science Library, 19.09.2007, Sumona 44; 20.08.2012 Somona 74; D.U. Bot. Garden, 28.04.2007, Somona 24; 20.08.2012, Sumona 75 (DUSH).

Chromosome number: 2n = 22, 33 (Kumar and Subramaniam, 1986).

Habitat: Soil rich in organic matter.

Distribution: Native to tropical Asia. Throughout Sri Lanka, India and Myanmar, also in Malaysia and Africa. In Bangladesh, it is found in different gardens.

Economic uses/values/harmful aspects: The bulbs are extremely acidic. In India, when roasted, they are used as a rubifacient in rheumatism, or crushed on piles and abscesses to cause suppuration. The juice of the leaves is used for earache (van Valkenburg and Bunyapraphatsara, 2002). Food plant of Lily moth, whose brightly spotted caterphillars feed on the plant. Bulbs are used in traditional medicine (Kehimkar, 2000).

Ethnobotanical information: Crushed and roasted bulbs are used in rheumatism. Leaf juice is used in earache (Sinha, 1996).

Propagation: By bulbs.

7. Crinum pratense Herb., Amaryll.: 256 (1837). Hook. f., Fl. Brit. Ind. 6: 282 (1892); Prain, Beng. Pl. 1061 (1903); Cooke, Fl. Pres. Bomb. 750 (1908).

Synonyms: *Crinum longifolium* Roxb., Fl. Ind. 2: 130 (1832); *Crinum lorifolium* Roxb. *ex* Ker-Gawl., J. Sci. Arts 3(5): 110 (1817).

Local names: *Sukhdarshan, Bon Peyaj*.

Description: A bulbous perennial herb, bulb ovoid or spherical, 10-13 cm in diameter, neck 5-7 cm across. Leaves 45-90 cm long, linear, channelled, sub-erect or declinate, entire, obtuse. Scape 30 cm or more long, compressed, decumbent. Spathe 5.0-7.5 cm long, deltoid-lanceolate. Flowers in umbels, white, fragrant, short-pedicelled, bisexual, epigynous. Perianth tube 7.5-10.0 cm long, perianth lobes lanceolate. Stamens 6, adnate to the throat of the perianth tube, filaments filiform, red, anthers oblong, dorsifixed, bursting longitudinally. Carpels 3, syncarpous, ovary inferior, 3-celled, style single, stigma simple. Fruit a capsule.

Flowering and fruiting: May-August.

Specimen examidned: Dhaka: D.U. Bot. Garden (Collected from Chanbari beat Rema-Kalenga Sanctuary in Habiganj), 01.06.2000, Zashim Uddin 835 (DACB).

Chromosome number: 2n = 22 (Alam *et al*., 1998).

Habitat: Plain lands. On the bank of channel (Uddin and Hassan, 2004).

Distribution: Plains of India and Myanmar. In Bangladesh, it is planted in household gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs.

8. **Crinum stenophyllum** Baker, Gard. Chron. 1: 786 (1881); Handb. Amaryl. 75 (1888).

Description: Leaves 90 × 0.6-1.0 cm, linear, flaccid. Scape very slender, 2-edged. Inflorescence umbel, 4-6 flowered. Spathes c 5 cm, lanceolate, pedicel 0.6 cm long. Perianth tube 7-10 cm long, very slender, lobes half as long or longer.

Distribution: Myanmar. In Bangladesh, the species was only reported from Sylhet district (Hooker, 1892). Since than there was no collection report which indicates that the species may no longer be present in Bangladesh.

Genus 6: **CURCULIGO** Gaertn., Fruct. 1: 63, t. 16 (1788). Benth. and Hook. f., Gen. Pl. 3: 717 (1883).

Aurota Rafin., Fl. Tell. 3: 61 (1836); *Empodium* Salisb., Gen. Pl. Fragm. 43 (1866); *Fabricia* Thunb. in J.C. Fabric., Reise nach Norw. 23 (1779); *Forbesia* Eckl., Verz. Pfl. Samml. 4 (1827); *Molineria* Colla, Hort. Repub. App. 2: 331 (1826).

Perennial herbs with tuberous rhizomes. Leaves radical, elongated, linear-lanceolate, plicate, leathery or papery. Inflorescences racemose, spicate, or subcapitate. Flowers often unisexual, solitary or in racemose inflorescence, scape short or long, often subterranean. Perianth often yellow, rotate, 6-partite, usually produced above the ovary as a solid stipe; segments spreading, subequal, sometimes basally connate into a tube.

Stamens 6, adnate to the base of the perianth segments, filaments short, sometimes subequaling anther. Carpels 3, ovary usually hairy, 3-celled, produced upwards into a long beak or stipe, ovules 2 to many, style columnar, slender; stigmas 3. Fruit a berry, indehiscent, more or less beaked. Seeds sub-globose, small, often striped.

About 20 species: tropical and subtropical regions worldwide. The genus *Curculigo* is represented in the flora of Bangladesh by 2 species.

Key to the species

1.	Large stout herbs, leaves large, lanceolate, plicate; flowers on scapes projecting beyond the leaf-sheaths	**C. latifolia**
-	Slender herbs, leaves small, linear; flowers in distichous spikes on scapes, hidden by the leaf-sheaths	**C. orchoides**

1. **Curculigo latifolia** [Dryand.] Ait., Hort. Kew. ed. 2, 2: 253 (1811). Hook. f., Fl. Brit. Ind. 6: 337 (1892).

(Fig. 17, Plate 37)

Synonyms: *Curculigo sumatrana* Roxb., Fl. Ind. 2: 146 (1832); *Molineria latifolia* (Dryand.) Herb. *ex* Kurz, Tijds. Ned. Ind. 27: 232 (1864).

English name: Lumbah.

Description: A large stout herb, up to 40 cm high. Rootstock covered with dense roots. Leaves petiolate, petiole 7-13 cm long, lamina 20-35 × 6.5-10.5 cm, broadly lanceolate, acuminate, entire, upper surface glabrous, green, lower surface pale, finely pubescent. Inflorescence from the leaf axil, racemose, peduncled. Bracts c 3.5 × 0.5 cm, cuspidate, irregularly stellately hairy. Flowers unisexual (male) and bisexual. Male flowers: bract c 1.3 cm long, pedicel c 7 mm long. Outer tepal c 7 × 2 mm, broadly lanceolate, acuminate, villous, yellow. Inner tepal c 6.0 × 1.5 mm, elliptic to linear, acuminate, pubescent with the main vein, yellow. Stamens 6, c 5 mm long, anthers c 2 × 1 mm, flat, dorsifixed, longitudinally dehiscence, filaments c 3 mm long. Bisexual flowers:

Fig. 17. *Curculigo latifolia* [Dryand.] Ait., a) Habit (×.0.25); b) Flower (×2); c) L.S. of a flower (×2); d) T.S. of ovary (×4); e) Bract (×1).

Plate 37. *Curculigo latifolia* [Dryand.] Ait., Habit.

lowermost in the inflorescence, epigynous, actinomorphic, bract c 3 cm long, pedicel c 2 cm long, outer tepal c 1.0 × 0.4 cm, broadly lanceolate, acuminate, villous, yellow, inner tepal c 1.0 × 0.3 cm, elliptic to linear, acuminate, pubescent along the main vein, yellow. Stamens 6, c 7 mm long, anthers c 3 × 1 mm, flat, dorsifixed with longitudinal dehiscence, filaments c 4 mm long. Ovary c 0.4 × 0.5 cm, ovate, hairy, 3 chambered, each locule with 2 ovules, stigma irregularly globose, style c 1 cm long. Fruits are not seen.

Flowering and fruiting: May-October.

Specimens examined: Sylhet: Rema-kalenga range, 24.05.1999, Zashim Uddun 719 (DACB). **Mymensingh**: Nandail, 08.07.2001, M.S. Hossain 313 (DACB).

Habitat: Shady places in the rain forest.

Distribution: India, Myanmar, Thailand, Indonesia, Malaysia and the Philippines (Brink and Escobin, 2003). In Bangladesh, it is found in Habiganj and Chittagong districts (Uddin *et al*., 1999).

Economic uses/values/harmful aspects: The fruit is edible and the leaves are used for making fishing nets (Deb, 1983). The seeds are edible. In Borneo, they are used to make ropes, twines, sarongs, rice bags and garments. The cloth made from the fibre is known as 'lemba' cloth. The leaves are rolled into strings. In Indonesia and Malaysia they also serve to wrap fruits, vegetables and other goods for transport (Brink and Escobin, 2003).

Ethnobotanical information: The leaves are used as a wrapping material.

Propagation: Propagated by stolons and seeds.

2. **Curculigo orchioides** Gaertn., Fruct. 1: 63, t. 16 (1788). Hook. f., Fl. Brit. Ind. 6: 279 (1892); Haines, Bot. Bih. Or. 1812 (1924).

(Fig. 18, Plate 38)

Synonym: *Curculigo brevifolia* [Dryand.] Ait., Hort. Kew. ed. 2, 2: 253 (1811).

English name: Yellow Ground Star.

Local names: *Talmuli, Kalo Musali* (India).

Description: A slender herb with tuberous or elongated rootstock. Leaves radical, 15-50 × 1.2-2.5 cm, petioled or subsessile, linear-lanceolate, membranous, plicate, glabrous. Scape c 3 cm long, clavate, flattened, hidden by the leaf sheaths. Flowers distichous, the lowest bisexual, all the rest male. Bracts lanceolate, c 3.0 × 0.4 cm, hairy. Perianth segments 6, 1.3-2.0 cm long, lanceolate, pubescent. Stamens 6, filaments c 0.3 cm long, anthers oblong, c 0.3 × 0.1 cm, dorsifixed. Carpels 3, ovary inferior, c 0.2 cm long, 3-celled, stigma capitat, ovules 6-8 per cell. Fruits berry, oblong, c 1.2 cm long, 1-4 seeded, beak slender. Seeds black, shining.

Flowering and fruiting: June-August.

Specimens examined: Gazipur: Savar, Jahangirnagar University, 20.08.2014, Sumona 90 (DUSH). **Chittagong**: Sitakund, 24.6.1979, Mia and Rahman 158; Botiary Road, 20.09.1987, M.A. Rahman & Mosharaf (DACB); 03.10.1940, S.K. Sen p. 11.09.1945 (DUSH). **Chittagong Hill Tracts**: Pablakhali Forest area, 29.04.1977, Huq & Rahman H-3272 (DACB). **Cox's Bazar**: Goalmara beat, 4.8.1990, Khan, Huq and Alam 8426 (DACB). **Sylhet**: Astagram, 21.4.1985, Huq and Mia 7032; Habiganj, 17.04.1985, A.M. Huq & M.K. Mia H-6915 (DACB). **Bandarban**: Kechua, 22.08.1987, Khan, Huq and Mia 7788 (DACB). **Dinajpur**: Birganj Singra (*Sal* forest), 25.08.1998, Mia *et al.* 4242 (DACB). **Nawabganj**: Shibiganj, 03.09.2009, Rezia, Momtaz, Bushra & Harun R.K.-3818; Sonamasjid area, 02.09.2002, Rezia, Momtaz, Bushra & Haroon RK-3742 (DACB). **Sherpur**: Gazni *Sal* Forest, 30.04.2015, Sumona 95 (DUSH). **Tangail**: Madhupur, 17.09.1980, Mia & Rahman M-269 (DACB). **Thakurgaon**: Pirganj Salgani Forest, 06.08.1998, Khan, Haroon, Nasir & Zashim K-10043 (DACB). **Patuakhali**: Kalapara, Kuakata, 04.02.2007, M. Sultana 1621 (DUSH).

Chromosome number: 2n = 18, 36 (Kumar and Subramaniam, 1986).

Habitat: Highland soils, up to an altitude of 200 m; on the hill top.

Distribution: Subtropical Himalayas of Pakistan and India (Khasia Hills, Tripura and Manipur) to Combodia, Vietnam and Laos, Southern China, Taiwan, Southern Japan to Thailand, Java Island of Indonesia. In Bangladesh, it is found throughout the country.

Economic uses/values/harmful aspects: The root is powdered and eaten as flour (Deb, 1983). The rhizome is prescribed in piles, jaundice, asthma, diarrhoea and gonorrhoea and considered as a demulcent tonic, used as a poultice for itches and skin diseases (Sinha, 1996). In India, rhizome is used to induce abortion. Powdered rhizomes are normally used in decoction, but are also sometimes given with an equal quantity of sugar in a glass of milk (de Padua *et al.*, 1999).

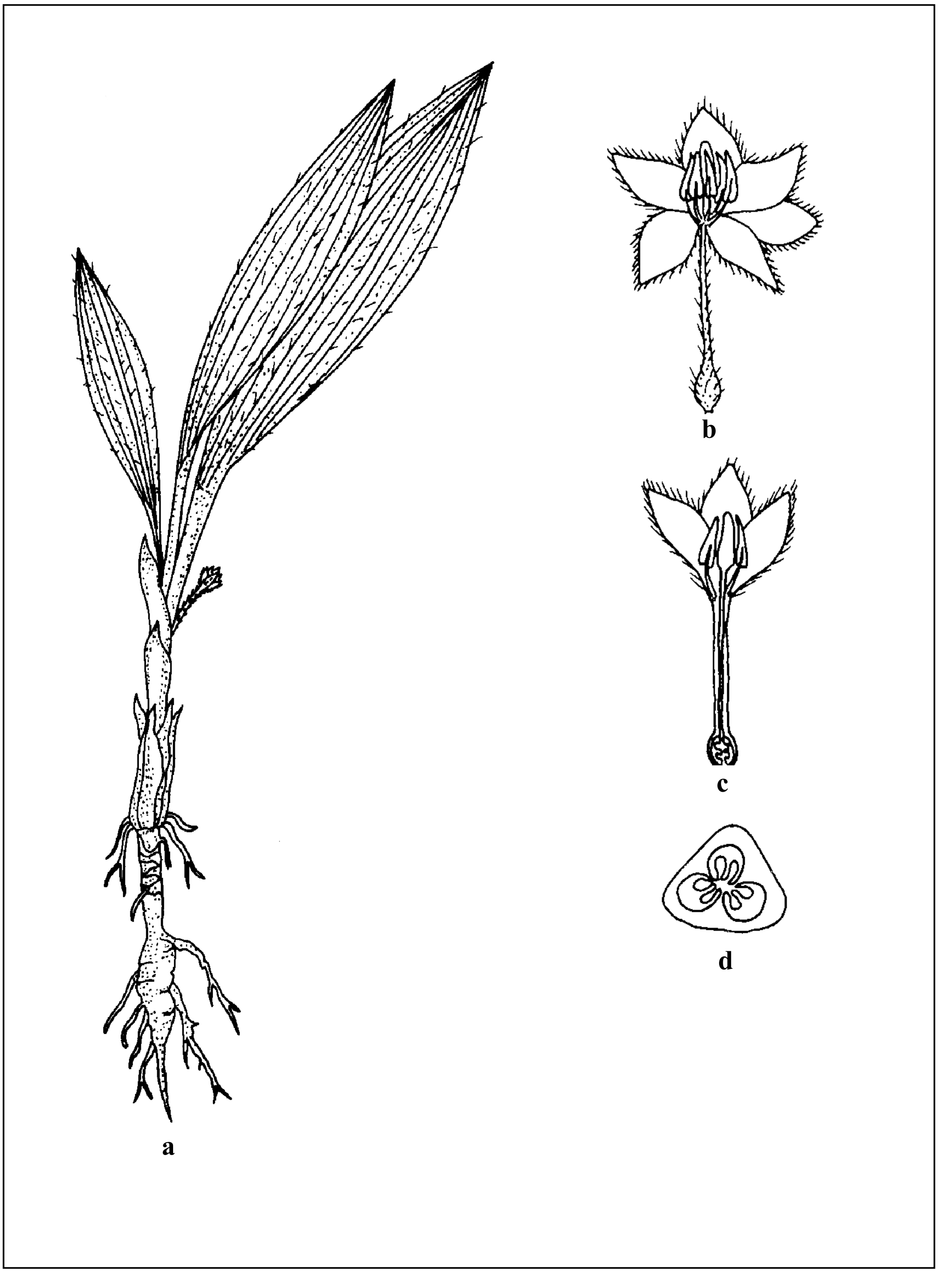


Fig. 18. *Curculigo orchioides* Gaertn., a) Habit (×1); b) Flower (×2); c) L.S. of a flower (×2); d) T.S. of ovary (×10).

Plate 38. *Curculigo orchioides* Gaertn., a) Habit; b) Flower.

Ethnobotanical information: In Bangladesh, the rootstocks are used by the tribal people of Habiganj area to treat jaundice (Uddin and Hassan, 2004).

Propagation: Propagated by rootstocks.

Genus 7: **DIANELLA** Lamarck, Encycl. 2: 276 (1786); Lamarck *ex* Jussieu, Gen. Pl. 41 (1789).

Herbs, perennial, evergreen, scapose, mat-forming, from stout, creeping, scaly rhizomes with fibrous, tuberous roots. Leaves basal, radical, distichous, crowded, sheathing, firm to subcoriaceous; blade linear to broadly ensiform, basal sheaths connate into short tubes, margins entire or serrulate, apex obtuse. Scape elongate, 0.5–2.0 m. Inflorescences panicle, laxly branched, usually large, with several to many racemes or smaller panicles. Bracts small. Flowers nodding to ascending; tepals 6, persistent, withering, distinct, subequal, narrowly oblong to ovate, 3–7-veined; pedicel slender, articulate distally. Stamens 6, distinct; filaments barely adnate to tepal bases, thickened distally; anthers basifixed, dehiscence extrorse, opening by terminal pores that become longitudinal slits. Ovary superior, 3-locular, ovules 4--8 per locule, septal nectaries present; style filiform; stigma minute, capitate. Fruits rather long-persistent, baccate, blue to bluish purple, ovoid-globose. Seeds black, lustrous, ovate, somewhat flattened.

About 20 species: mainly in tropical Asia, introduced; tropical Africa, Asia, Australia, and Polynesia. The genus *Dianella* is represented in the flora of Bangladesh by a single species.

1. **Dianella ensifolia** (L.) DC. in Redouté, Liliac. 1(1): pl. 1 (1802).

(Fig. 19, Plate 39)

Synonyms: *Dianella nemorosa* Lamk., Encycl. 2: 276 (1786). *Dracaena ensata* Thunb., Diss. Bot. Drac. 4 (1808). *Dianella montana* Blume, En. Pl. Jav. 1: 12 (1827). *Dianella odorata* (Rump.) Blume, En. Pl. Jav. 1: 13 (1827). *Dianella revoluta* (non R. Br.) Schauer, Nov. Act. Ac. Nat. 19 (1843). *Dianella bancana* Miq., Fl. Ind. Bat. Suppl. 610 (1861). *Dianella caerulea* Merr., Philip. J. Sc. (Bot.) 2: 266 (1907). *Dianella robusta*

Elmer, Leafl. Philip. Bot. 5: 806 (1913). *Dianella bambusifolia* Hall.f., Nova Guinea 8: 995, t. 182 (1914). *Dianella parviflora* Ridl., J. Fed. Mal. St. Mus. 6: 186 (1915). *Dianella pullei* Krause, Nova Guinea 14: 175 (1924). *Dianella ledermannii* Krause, Bot. Jahrb. 59: 553 (1925). *Dianella levis* C. T. White, Proc. Linn. Soc. N. S. W. 51: 298 (1926). *Dianella sparsiflora* Schlittler, Mitt. Bot. Mus. Un. Zürich 163: 262 (1940). *Dianella ensata* (Thunb.) Henderson, Taxon 26: 136 (1977).

English names: Sword Leaf Dianella, Cerulean flax-lily, Umbrella Dracaena.

Description: A perennial erect or decumbent herb, stem up to 1.5 m high, rigid, usually unbranched, rarely with a few branches, rhizome horizontal, moderately branched. Leaves basal, scattered along the stem or in a terminal rosette, distichous, with a sheathing lower part, lamina linear or linear-lanceolate (sometimes absent in lower leaves), 30-90 × 1-3 cm, above the base keeled, margins smooth or scabrid, firmly appressed to one another and fused to form an isobilateral portion, midrib on the lower surface with minute serrations or prickles, veinlets conspicuous and numerous. Inflorescence a terminal panicle, 30-70 cm long, cuneiform, usually exceeding the leaves, lax or with short terminal branches often 1-2 cm long, bearing up to 30 flowers. Lower bracts usually narrowly lanceolate and bilaterally compressed above the basal sheath like the leaves, bracts subtending pedicels 0.1-0.4 cm long or rarely absent. Pedicels 0.4-1.5 cm long. Flowers inodorous, perianth segments 6, blue, yellow, lilac or white, spreading, 4-9 mm long, inner three reflexed. Filaments often more than half as long as the perianth segments, filiform or narrowly linear, white or yellow with a yellow or orange, glabrous swelling below the anther, anthers linear, 2-porose. Ovary green, three locular, 0.1-0.2 cm long, ovules 4 in each locule, style green, white or blue. Fruit shiny blue or dark purple, 6-10 mm in diameter, each cell 1-3- or more seeded. Seeds ovoid, subacute, 0.3-0.4 cm long.

Flowering and fruiting: Throughout the year.

Specimens examined: Dhaka: Art Institute, 31.03.2012, Sumona 73 (DUSH); Ramna Park, 19.02.1981, M. Halim 928; Dhanmondi, 06.08.1991, Rezia Khatun 694 (DACB). **Sylhet**: Habiganj: Satchari forest, 19.04.1985, A. M. Huq and M. K. Mia H-7003 (DACB). **Moulvi Bazar**: Lawachara, Srimangal, 02.02.2009, Sarder Nasir Uddin N-3282; Lawachera National Park, 12-05-2009, Sardar Nasir Uddin N-4820; Kamalganj, 08.03.2011, Sardar Nasir Uddin N-4437 (DACB). **Rangamati**: Ram Pahar, Kaptai, 20.04.2006, Sarder Nasir Uddin N-2825 (DACB).

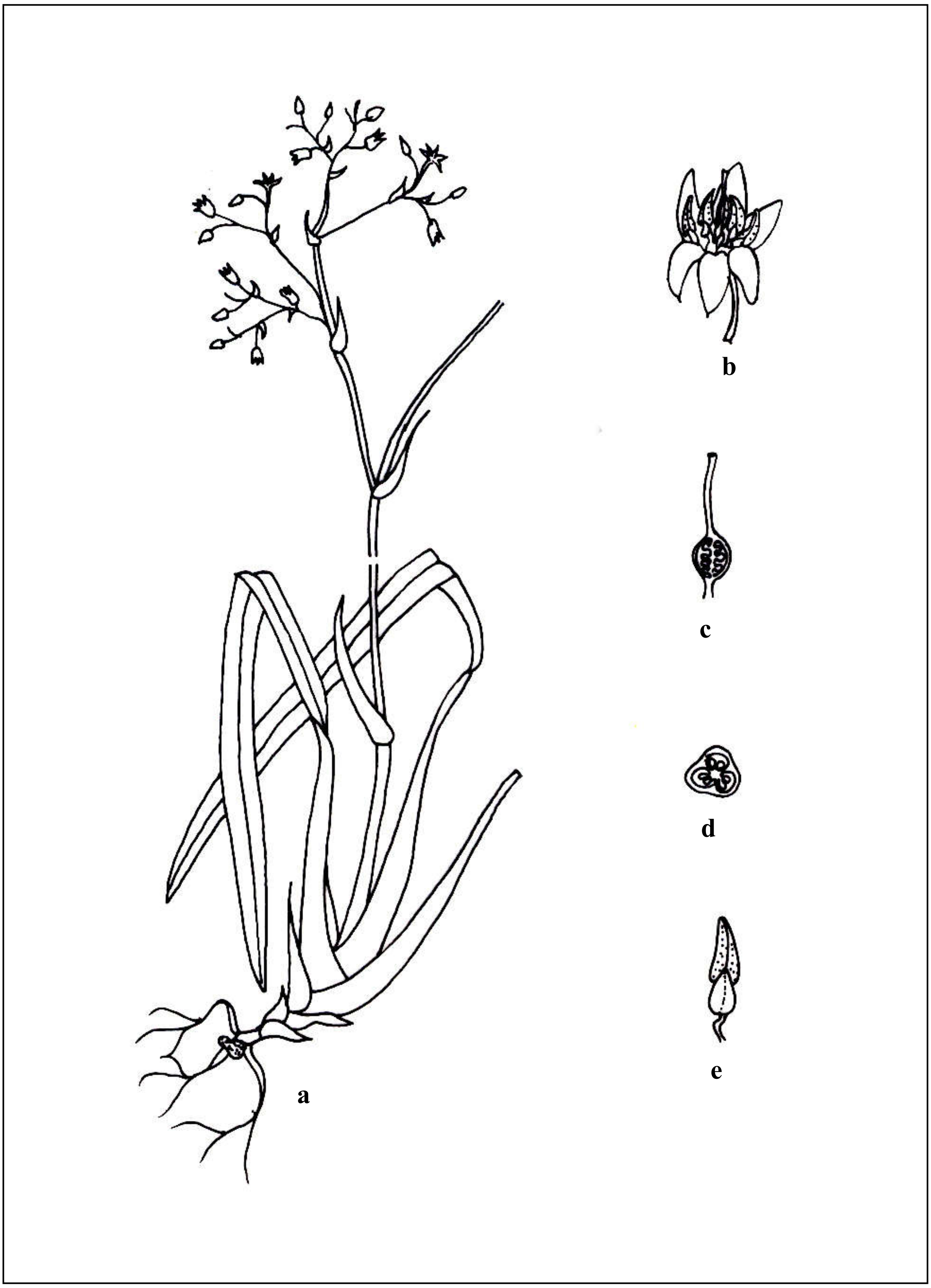


Fig. 19. *Dianella ensifolia* (L.) DC., a) Habit (×0.33); b) Flower (×2); c) L.S. of gynoecium (×4); d) T.S. of ovary (×4); e) Stamen (×4).

Plate 39. *Dianella ensifolia* (L.) DC., a) Herbarium specimen; b) Inflorescence.

Chromosome number: 2n = 16, 32 (Kumar and Subramaniam, 1986).

Habitat: A highly adaptable species, occurring in habitats ranging from open grasslands to primary forests, from sea level to over 3000 m altitude (Jessop, 1979).

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: Propagated by seeds and rhizomes.

Note: The species was recorded new from Bangladesh (Uddin and Hassan, 2009).

Genus 8: **EUCHARIS** Planch. & Linden, Cat. no. 8: 3 (1853) *et* in Fl. des Serres, Ser. 8: 107 (1852-1853). Benth. and Hook. f., Gen. Pl. 3: 731 (1883).

Mathieua Klotz. in Otto and Dietr., Allg. Gartenz. 21: 337 (1853).

Bulbous plant, bulb 2-6 cm in diameter. Leaves long petiolate, 20-55 cm long and 10-20 cm broad. Inflorescence umbel, 2-10 flowered. Scape erect, 40-80 cm long. Flowers fragrant, waxy, having central prominent cup or corona which sometimes tinged with green.

About 15-20 species: Neotropical, native to Central America and South America, from Guatemala south to Bolivia. Some species have become naturalized in Mexico, the West Indies, and scattered tropical islands. The genus *Eucharis* is represented in the flora of Bangladesh by a single species.

1. **Eucharis grandiflora** Planch. & Linden, Fl. des. Serr. Ser. 1, 9: 255 (1853-1854).

(Fig. 20, Plate 40)

Synonym: *Eucharis amazonica* Lind., Ill. Hort. 28: 30 (1881).

English name: Amazon Lily.

Description: Bulbous perennial herb, bulb c 5 × 6 cm. Leaves simple, petiolate, petiole c 12 × 1 cm, 2-ridged, green, glabrous, blade 30 × 14 cm, acute, entire, slightly wavy, midrib conspicuous. Inflorescence 2-6 flowered umbel, scape solid, c 30 cm long,

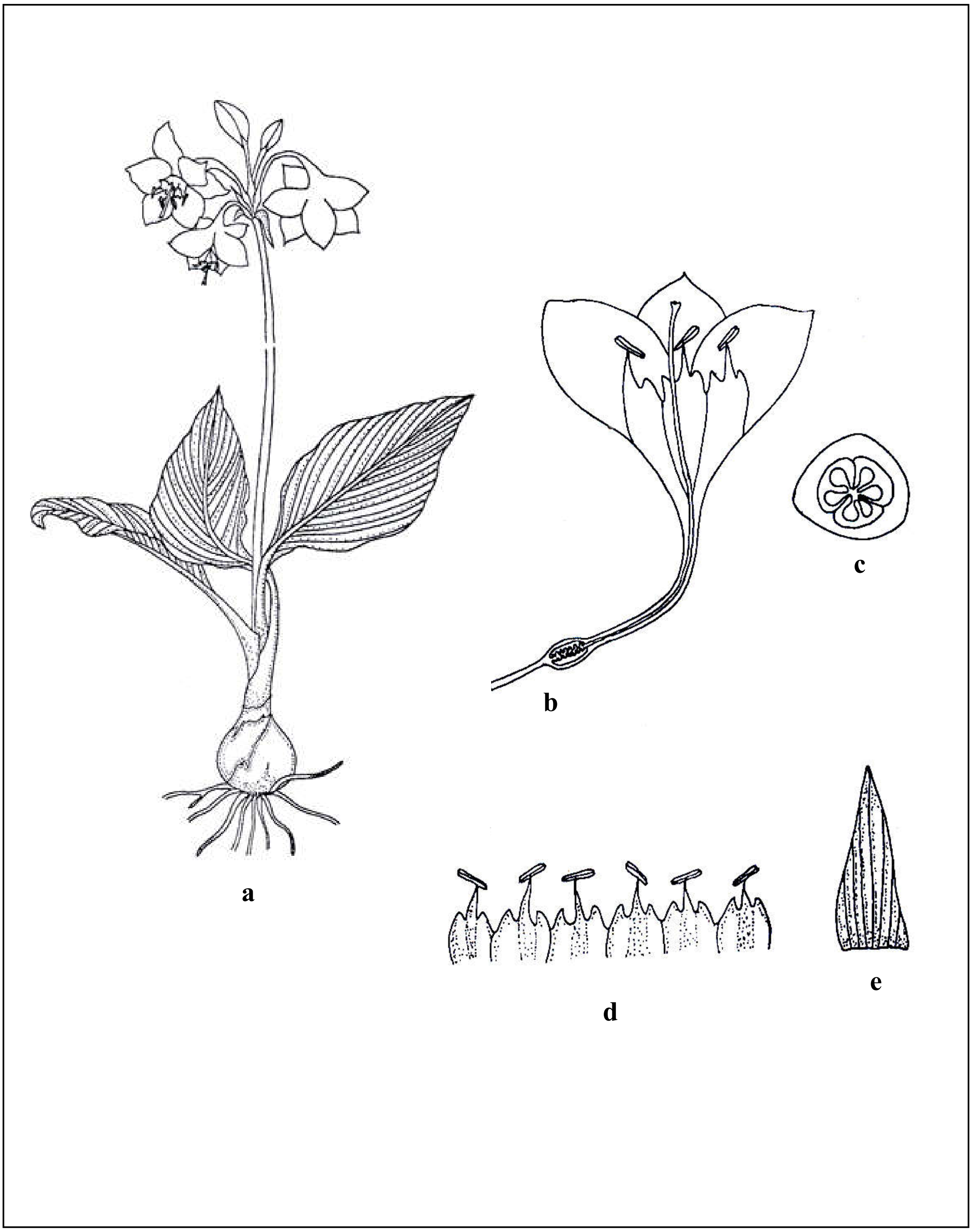


Fig. 20. *Eucharis grandiflora* Planch. & Linden, a) Habit (×0.25); b) L.S. of a flower (×1); c) T.S. of ovary (×4); d) Dissected staminal corona (×1); e) Bract (×1).

Plate 40. *Eucharis grandiflora* Planch. & Linden, Habit.

green. Flowers pedicellate, pedicel c 1.5 cm long, green, curved. Spathes 2, c 4.0 × 1.5 cm, lanceolate. Perianth segments 6, c 4.5 × 2.3 cm, white, inner 3 obtuse, outer 3 acute, waxy, perianth tube c 4.7 cm, white, curved, throat c 1.5 cm in diameter. Stamens 6, filaments c 0.8 cm long, united below and form a broad, erose, staminal cup, c 1 cm long, anthers oblong, c 0.7 cm long, dorsifixed, greyish-brown in colour. Carpels 3, syncarpous, ovary c 1.0 × 0.5 cm, green, 3 chambered, placentation axile, ovules many, stigma 3-fid, white.

Flowering and fruiting: May-July.

Specimen examined: Dhaka: Science Library, 06.06.2007, Sumona 40 (DUSH).

Chromosome number: 2n = 44, 68 (Kumar and Subramaniam, 1986).

Habitat: Shady places where it is cultivated.

Distribution: Native to Columbia and Peru (Dassanayake and Clayton, 1981). Australia and America. In Bangladesh, it is grown in many gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs.

Genus 9: **EUCROSIA** Ker-Gawl., Bot. Reg. 3: t. 20 (1817).

Bulbs perennial, tunicate, solitary or offsetting vigorously. Leaves deciduous, petioles long, blades elliptical or ovate, up to 25 cm wide; may or may not be present when flowers produced. Inflorescence is an umbel, 6–30 weakly to strongly zygomorphic flowers, tubular at the base, green, yellow or red in colour. Scape terete, glaucous. Bracts 2, ovate-lanceolate, valvate-imbricate; bracteoles narrower and smaller. Flowers protandrous, without fragrance, pedicellate, each subtended by a linear bracteole; perianth showy, zygomorphic, consisting of 6 subequal tepals in two series which are connate basally into a tube, true hypanthium rarely present, tube generally half or one fifth of the length of the tepals, rarely longer. Stamens declinate, long-exserted, much exceding the perianth in length, variously connate basally or rarely free, bi- or triseriate, one usually 0.3-0.5 cm shorter than the other 5, filaments long, in most species form a cup containing nectaries at the base. Anther dorsifixed, versatile, introrse. Style filiform, longer than the filaments, declinate at first, ascendant when receptive; stigma capitate, minute, papillae unicellular. Ovary ellipsoid, trilocular, septal nectaries present, placentation axile, ovules c 20-25 per locule, compressed. Fruit a glaucous, turbinate, 3-loculed capsule, turning brown at dehiscence; pedicel elongating in fruit. Seeds numerous, flat, obliquely winged.

About 8 species: native to Ecuador and Peru. The genus *Eucrosia* is represented in the flora of Bangladesh by single species.

1. **Eucrosia bicolor** Ker-Gawl., Bot. Reg. 3: t. 207 (1817).

(Fig. 21, Plate 41)

Synonym: *Eocrosia lehmannii* Hieron., Not. Kon. Bot. Gart. Berlin 1: 33 (1895).

English name: Peruvian Lily, Two-coloured Eucrosia.

Description: Perennial herb. Bulb globose, c 3.5-4.5 cm in diameter; neck 1.5-5.0 cm long, 1.0-1.2 cm thick, tunics light brown. Leaves 1-2 (1 sometimes present with scape); petiole shorter than the lamina, about 9-10 cm long; lamina elliptic, 17-24 × 5-11 cm, short acuminate, basally attenuate, bright green adaxially, pale green abaxially, the abaxial cuticle striate, margins slightly undulate. Scape 50-60 × 0.7-1.0 cm; bracts 2.5-4.0 cm long, lanceolate, greenish white. Flowers 5-10, funnelform-campanulate, strongly zygomorphic, somewhat ascendent; pedicels sub-erect, 1.5-3.8 cm long; perianth 3.0-3.5 cm long; limb spreading to 1.0-1.6 cm wide; tube subcylindrical, slightly gibbous, 0.7-1.0 cm long, c 0.6 cm wide for most of its length, constricted at the base to 0.3 cm wide, green proximally, yellow medially, distally concolorous with the tepals, declined from the pedicel, slightly cernuous distally; true hypanthium present between the apex of the ovary and the base of tube, cylindrical, c 0.4 cm long, green. Tepals deep red with few green stains, yellow at the apex and lightly along the midrib, 2 more or less ascendent, 4 spreading laterally of which 2 are lower and somewhat declinate; outer tepals lanceolate, 2.5-2.6 cm × 0.5-0.6 cm, the uppermost slightly galeate, minutely apiculate, the apiculum yellow; inner tepals narrowly elliptic, 2.4-2.5 × 0.6-0.7 cm, obtuse. Stamens long-declinate, emerging between the 2 lowest

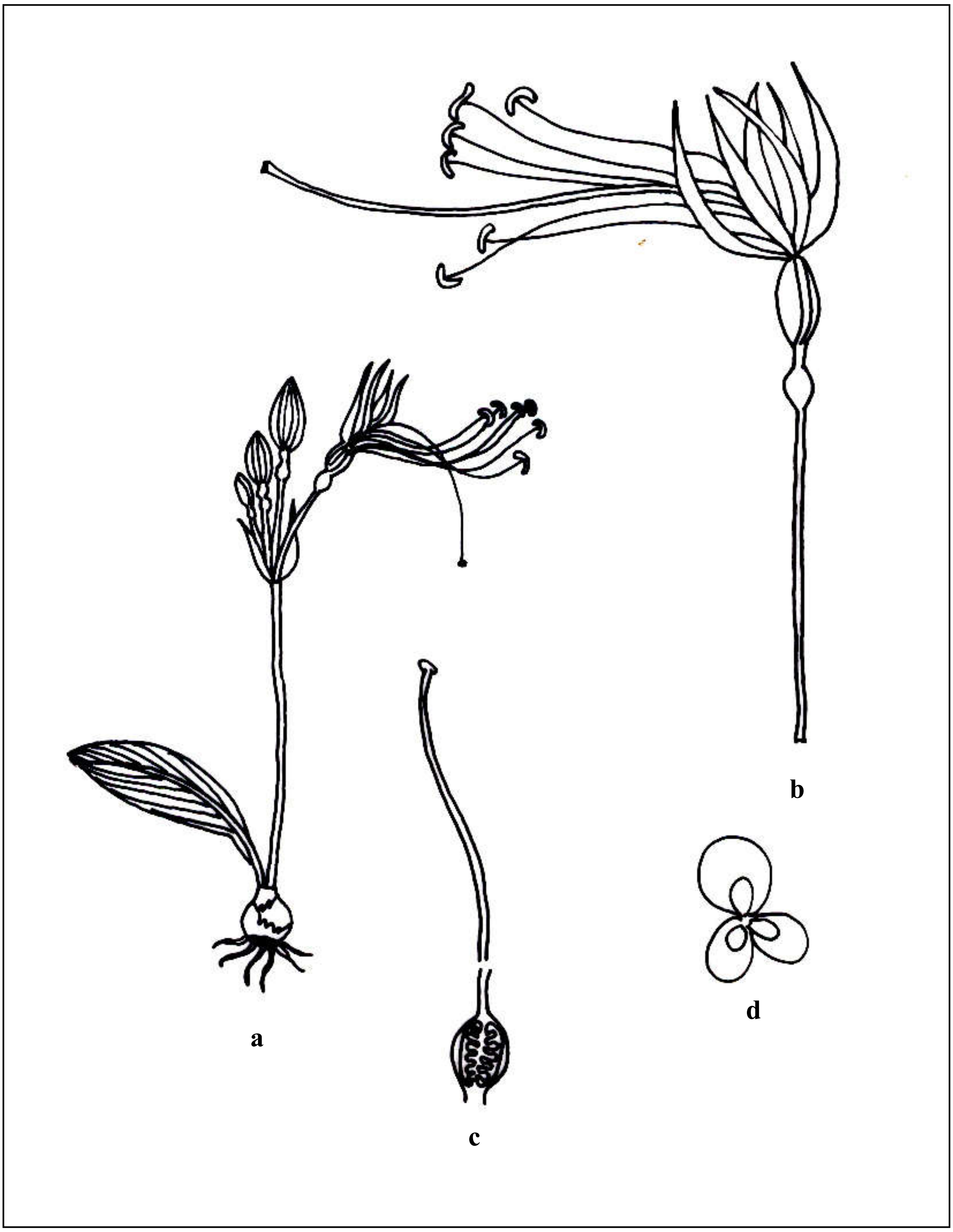


Fig. 21. *Eucrosia bicolor* Ker-Gawl., a) Habit (×2); b) Flower (×1); c) L.S. of gynoecium (×2); d) T.S. of ovary (×5).

Plate 41. *Eucrosia bicolor* Ker-Gawl., a) Habit; b) Inflorescence.

tepals before the flower opens completely, yellow or red, basally connate into an irregularly cleft staminal cup with a deep oblong, dorsal sinus; cup sharply declined from the perianth throat, 0.5-0.6 cm long dorsally, 2.0-2.3 cm long ventrally. Filaments 3-seriate, 2.3-5.5, 2.5-6.0 and 2.7-6.5 cm long, usually ascendent in their distal one forth; style at first straight, then curved downwords and lastly bent up like the filaments. Anthers 0.5-0.6 cm long, oblong, green; pollen yellow. Style 3-8 cm long, yellow; stigma 0.1-0.1 cm wide. Ovary ellipsoid, c 0.6 × 3.5 cm, green; ovules 20 or more per locule. Capsule c 2.6 × 1.6 cm, pedicel c 4.5 cm long. Seeds c 0.1 × 0.5 cm.

Flowering and fruiting: April-June.

Specimen examined: Dhaka: D.U Bot. Garden, 30.03.32014, Sumona 87 (DUSH).

Chromosome number: 2n = 46 (Meerow, 1987).

Habitat: Shady places where it is cultivated.

Distribution: Native to Peru and Ecuador. In Bangladesh, it is cultivated in personal gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs.

Genus 10: **GLORIOSA** L., Syst. ed. 1 (1735) and Sp. Pl.: 305 (1753). Benth. and Hook. f., Gen. Pl. 3: 830 (1883).

Clinostylis Hochst., Fl. 27: 26 (1844); *Mendoni* Adans., Fam. 2: 48, 576 (1763); *Methonica* Juss., Gen. 48 (1789).

Perennial herbs with stout, tuberous, naked rootstocks. Aerial stem climbing and leafy. Leaves cauline, alternate, opposite or 3-nately whorled, lanceolate, costate, tip elongated into a spiral tendril. Flower solitary, axillary with a long, reflexed pedicel. Perianth segments 6, free, showy, subequal, narrow, usually spreading or reflexed, often crisped, persistent. Stamens 6, inserted at base of tepals; filaments filiform, anthers linear, versatile, extrorse. Carpels 3, united, ovary 3-loculed, ovules many per locule; style filiform, stigma 3-fid, adaxially stigmatic. Fruit a capsule, septicidal. Seeds globose to sub-globose, testa bright red, spongy.

About 5 species: South and tropical Africa, tropical Asia. The genus *Gloriosa* is represented in the flora of Bangladesh by single species.

1. Gloriosa superba L., Sp. Pl.: 305 (1753). Hook. f., Fl. Brit. Ind. 6: 358 (1892); Prain, Beng. Pl. 1073 (1903); Heinig, Enum. 1340 (1907); Haines, Bot. Bih. Or. 1093 (1924); Fischer in Gamble, Fl. Pres. Madras. 1519 (1928). **(Fig. 22, Plate 42)**

Synonym: *Gloriosa simplex* D. Don, Prod. Fl. Nep. 51 (1825).

English names: Flame Lily, Superb Lily, Malabar Glory Lily, Climbing Lily.

Local names: *Ulatchandal*, *Bishlanguli*, *Bilambuli*, *Agnishikha*, *Kalihari*.

Description: A climbing herb. Underground rootstock perennial, solid, white, fleshy, covered with a thin brown layer, mature rootstock 15-30 × 2.5-3.8 cm, pointed at each end, bifurcately branched. Aerial stem green, glabrous, up to 1 m or more long, given off from the angles of the young tubers. Leaves sessile or nearly so, 7.5-15.0 × 0.2-4.5 cm, scattered or opposite, lanceolate, acuminate, tip ending in a tendril-like spiral, base cordate, venation parallel. Flowers large, axillary, solitary, pedicel 6-14 cm long, the tip deflexed. Perianth segments 6 (rarely 8), c 8.7 × 1.6 cm, linear-lanceolate with crisply waved margins, greenish at first, then turning yellow, and in sequence to orange, scarlet and finally crimson. Stamens 6 (rarely 8), filaments 3-5 cm long, spreading, anthers c 1.3 cm long, the arms about 0.6 cm long, versatile, pollen grain oval, yellow in colour. Pistil tricarpellate with ovary usually superior, 3-loculed, placentation axile, style c 6.3 cm long, stigma generally 3-lobed (rarely 4). Fruit a capsule, capsule c 7.0 × 2.5 cm, linear-oblong, first green, crimson when mature, septicidal, each chamber contain 15-17 seeds. Seeds sub-globose, crimson, c 0.5 × 0.4 cm.

Flowering and fruiting: July-November.

Specimens examined: Dhaka: D.U. Bot. Garden, 25.09.2007, Somona 47; Govt. Nursery, 11.10.1970, M.A. Rahman 268; Savar, Jahangirnagar University, 24.08.2013, Sumona 84; 21.09.2013, Sumona 86; Baldha Garden, 16.08.1966 Zeyauddin 223 (DUSH); 17.06.2000, Ali Hossain (DACB); Nayerhat, Chandra, 10.06.1985, A.M. Huq 7106; Sakhipur, 20.10.1978, Reaz; Baldha Garden, 30.06.1978, Mahbuba Halim 174

Fig. 22. *Gloriosa superba* L., a) Habit (×0.3); b) L.S. of a flower (×0.5); c) T.S. of ovary (×4); d) Fruit (×0.5).

Plate 42. *Gloriosa superba* L., a) Habit; b) Rhizome with bulb.

(DACB). **Chittagong**: Chittagong Town Area, 14.08.1997, Rahman *et al*. 1732 (HCU). **Cox's Bazar**: Ukhiya, Madhuchara, 20.08.1997, Rahman *et al*. 1752 (HCU). **Gazipur**: Zoydebpur, 28.06.1969, Subhash Chandra Ghosh 88 (DUSH). **Dinajpur**: Biral (Mayer pukur), 28.08.1998, Mia *et al.* 4392 (DACB). **Chapai Nawabganj**: Godagari, Panchananpur, 04.09.2002, Rezia, Momtaz, Bushra & Haroon R.K.-3882 (DACB). **Jessore**: Keshabpur, 30.08.1983, Huq, Mia & Mahbuba H-6026 (DACB). **Patuakhali**: Kalapara, Kuakata, 24.07.1998, M. Sultana 119; Galachipa, Panpotti, 18.12.2010, M. Sultana 1862 (DUSH).

Chromosome number: 2n = 22, 88, 90 (Kumar and Subramanim, 1986).

Habitat: High waste land, forest borders, also grows on the coastal zones (Ahmed, 1997). The plant generally grows wild in the high lands, hill slopes and is also planted in the gardens as an ornamental plant.

Distribution: Common throughout the tropical regions of the world, such as tropical Africa, India (the Himalayas to Assam), Sri Lanka, Myanmar, Vietnam and Malay Peninsula. In Bangladesh, this plant is available in Dhaka, Chittagong, Cox's Bazar, Dinajpur, Chapai Nawabganj, Jessore and Patuakhali districts.

Economic uses/values/harmful aspects: Plant contains the alkaloid colchicine as a major constituent. The root is given in bowel complaints; the starch obtained from the root is taken by mouth in gonorrhoea. Tuber is astringent, expectorant, used in the treatment of bleeding piles and for quenching thirst. Tubers contain the bitter substance superbine and the alkaloid colchicine, which in large doses are poisonous, but in small doses (5-10 grains) are used as stomachic, antiperiodic, alterative and purgative. Its warm poultice is locally applied in rheumatism. It is a gastrointestinal irritant and may cause vomiting. Alkaloid colchicine is used for the remedy of gout.

In patients who have taken an overdose of bulbs, death occurs as a result of respiratory depression and cardiovascular collapse (de Padua *et al*., 1999).

Ethnobotanical information: The Lodha tribal people of India give dried tuber powder in a medicinal dose with cow milk to women as a contraceptive. They also prescribe the tuber paste as a cure for maggot-infested wounds. The Santal tribal people apply fresh tuber paste as a plaster on swellings caused by sprain. The paste is applied also in parasitic infestations of the skin. Juice obtained from the leaves is used to eradicate hair lice. The fresh tuber paste is used for poisoning hunting arrows (Pal and Jain, 1998).

Propagation: By tubers and also by seeds.

Genus 11: **HEMEROCALLIS** L., Syst. ed. 1 (1735) and Sp. Pl. 324 (1753). Benth. and Hook. f., Gen. Pl. 3: 773 (1883).

Herbs, perennial, scapose, clump-forming, rhizomatous, from fibrous or fleshy contractile roots often enlarged at ends; rhizomes spreading. Leaves many, basal, sessile, 2-ranked, bases sheathing; blade long-linear, keeled, apex acuminate. Inflorescences 2, in terminal helicoid cyme, or solitary. Flowers large, slightly irregular, sub-erect, orange-yellow, on a few-flowered panicle. Perianth funnel-shaped, 6-partite, tepals connate at the base, forming a tube, tip recurved, the inner 3 much larger. Stamens 6, inserted to the mouth of the perianth tube, exserted; filaments filiform, curved upward, distinct, unequal; anthers linear-oblong, dorsifixed, 2-locular, dehiscence introrse. Carpels 3, syncarpous, ovary superior, green, 3-loculed, conic, septal nectaries present, ovules many in each locule; style filiform, declinate, stigma capitate. Fruit a capsule, leathery, triquetrous, loculicidal. Seeds rarely produced (sterile) or many.

About 30 species: introduced; temperate zones worldwide; temperate East Asia. The genus *Hemerocallis* is represented in the flora of Bangladesh by single species.

1. **Hemerocallis fulva** L., Sp. Pl. ed. 2: 462 (1764). Hook. f., Fl. Brit. Ind. 6: 326 (1892); Prain, Beng. Pl. 1078 (1903); Heinig, Enum. 1336 (1907); Haines, Bot. Bih. Or. 1092 (1924). **(Fig. 23, Plate 43)**

Synonyms: *Hemerocallis disticha* Donn, Hort. Cantab. ed. 6: 93 (1811), *Hemerocallis longituba* Miq. in Ann., Mas. Bot. Lugd. Bat. 3: 152 (1867).

English names: Orange Day Lily, Common Day Lily.

Local name: *Komola Lily*.

Description: A showy herb with a short rootstock and fleshy root-fibres. Leaves very long, 30-60 × 2.5-3.5 cm, semi-erect, acute, sub-glaucous beneath. Scape 60-90 cm

Fig. 23. *Hemerocallis fulva* L., Habit (×0.5).

Plate 43. *Hemerocallis fulva* L., Habit.

long, branched, green, semi-erect, acute, 6-12 flowered. Flowers large, short-pedicellate, pedicel c 1.7 cm long, bracteate, bracts small and membranous. Perianth funnel-shaped, tepals 6 in 2 series, c 10.0 × 2.3 cm, connate at the base in a yellow tube, tube c 2 cm long, inner segments much larger and broader than outer segments, margins undulate with reticulate nerves, outer segments orange-yellow, oblong, acute. Stamens 6, inserted to the mouth of the perianth tube, exserted, filaments filiform, anthers linear-oblong, versatile. Carpels 3, united, ovary single, 3-celled, style 1, stigma capitate, ovule many in each cell of the ovary. Fruit a loculicidal capsule. Seeds angled, black and shining.

Flowering and fruiting: June-July.

Specimens examined: Dhaka: D.U. Bot. Garden, 12.05.2007, Sumona 33; D.U. Bot. Garden, 28.05.1968, Mazahar 133 (DUSH); D.U. Bot. Garden, 30.06.1970, Huq 81 (DACB).

Chromosome number: 2n = 22, 32, 33, 44, 48 (Kumar and Subramaniam, 1986).

Habitat: Hilly regions and well-drained garden soils.

Distribution: Native of China and naturalized in the Himalaya (common in the Kulu valley), and in some parts of W. and C. Nepal (Polunin and Stainton, 1984). South Europe, North Asia to Japan, the Himalayas and Khasia Hills, cultivated throughout the Indian subcontinent (Hooker, 1892). In Bangladesh, this species is widely cultivated in gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By rootstocks.

Notes: Two types viz. single and double flower plants are found. Double flower bearing species may be an ornamental hybrid where stamens are modified into tepals and not found true ovary.

Genus 12: **HIPPEASTRUM** Herb., App. Bot. Reg. 31 (1821). Benth. and Hook. f., Gen. Pl. 3: 724 (1883).

Aulica Rafin., Fl. Tell. 4: 10 (1836); *Aschamia* Salisb., Gen. Pl. Fragm. 134 (1866); *Chonais* Salisb., Gen. Pl. Fragm. 135 (1866); *Eusarcops* Rafin., Fl. Tell. 4: 11 (1836); *Habranthus* Herb., Amaryll. 156 (1837); *Lais* Salisb., Gen. Pl. Fragm. 134 (1866); *Leopoldia* Herb., Bot. Mag. sub t. 2113, in nota (1819); *Myostemma* Salisb., Gen. Pl. Fragm. 135 (1866); *Omphalissa* Salisb., Gen. Pl. Fragm. 134 (1866); *Phycella* Lindl., Bot. Reg. sub t. 928 (1825); *Rhodolirion* Phil., Linn. 29: 65 (1857-1858); *Rhodophilala* Presl, Bot. Bemer. 115 (1844); *Trisacarpis* Rafin., Fl. Tell. 4: 11 (1836).

Herbs with subterranean bulbs. Bulbs 5-12 cm in diameter. Leaves few, basal, long lasting; blade liguliform, fleshy, parallel-veined, margins entire, apex tapering, 30-90 cm long. Inflorescences umbellate, funnel-shaped flowers are borne on leafless scapes; semi erect, strap-shaped, light to mid green or gray-green, basal leaves developed with or just after the flowers, many large flowered, bracteate; bracts 2, scarious, colourful hybrids (incorrectly known as *Amaryllis*, a separate south African genus), have been breed for cultivation in containers. These are 5 types: single, double, miniature, cybister and trumpet. These usually produce 4-6 flowers, scape 30-75 cm long, hollow, open funnel-shaped flowers, more or less declinate, 10-20 cm across, and strap-shaped, deep green leaves. Tepals 6 in 2 whorls of 3, outer slightly shorter than inner. Stamens 6, filaments curved, inserted on perianth tube, declinate, subequal; stigma capitate; ovary inferior, ellipsoid. Fruit a capsule, slits vertically, seeds black, wedge-shaped, each locule contains 20 seeds across. In frost prone areas, grow as house plants or in a warm green house or conservatory. In warmer areas, grow in a border or in containers outdoors. All parts may cause mild stomach upset if ingested. Many forms have been developed by hybridization. Fruits capsular, dehiscence loculicidal. Seeds few to many.

About 75 species: Central America, West Indies, South America, West Africa. The genus *Hippestrum* is represented in the flora of Bangladesh by single species.

1. **Hippeastrum puniceum** (Lamk.) Voss, Vilm. Blumen. ed. 3. 1: 1033 (1895). **(Fig. 24, Plate 44)**

Synonym: *Amaryllis punicea* Lamk. in J. Lamk. *et al*., Encycl. 1: 122 (1783).

English names: Barbados Lily, Easter Lily, Cacao Lily, Cocoa Lily, Amaryllis Lily.

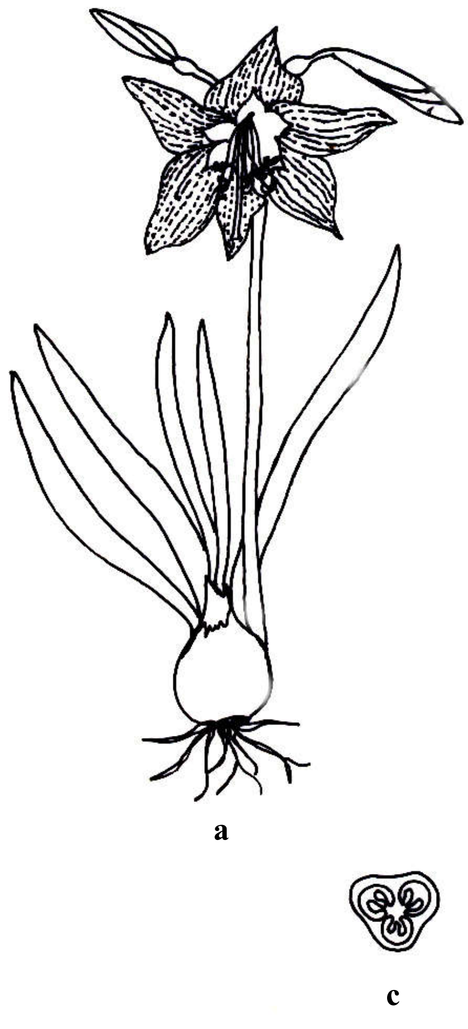


Fig. 24. *Hippeastrum puniceum* (Lamk.) Voss, a) Habit (×0.2); b) L.S. of gynoecium (×0.1); c) T.S. of ovary (×0.2); d) Stamen (×0.1).

Plate 44. *Hippeastrum puniceum* (Lamk.) Voss, Habit.

Local name: *Lily*.

Description: Bulbs 6-10 cm in diameter. Leaves 6-8, distichous, strap shaped, appearing just after flowering, 50 × 3-5 cm. Scape about 1 m long, hollow, round. Inflorescences 2 to 4-flowered; bracts 5 cm long. Flowers slightly zygomorphic; perianth reddish to salmon, with whitish midstripe on adaxial surface of each outer tepal, tube 3 cm long; outer tepals lanceolate to subrhombic, 12 cm or more, apex acuminatenate. Capsules ellipsoid to ovoid, 2 cm long. Seeds black, compressed-globose or subglobose.

Flowering and fruiting: March-May.

Specimen examined: Dhaka: D.U. Bot. Garden, 05.10.2014, Sumona 93 (DUSH).

Chromosome number: 2n = 22, 33, 44 (Hang *et al*., 2015).

Habitat: Well-drained garden soils.

Distribution: Mexico, West Indies, Central and South America (Utech, 2002). In Bangladesh, this species is cultivated in many gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs.

Genus 13: **HYMENOCALLIS** Salisbury, Trans. Hort. Soc. London. 1: 338 (1812).

Herbs, perennial, scapose, from bulbs. Bulb 1, ovoid or globose, tunicate, often extending into neck of clasping, distichous leaf bases. Leaves 2-16, deciduous or evergreen, sessile, rarely petiolate; blade narrowly to widely liguliform or oblanceolate, rarely ovate to elliptic. Inflorescences umbellate, bracteate, each flower with subtending, often narrowly lanceolate bract. Bracts 2-3, triangular, ovate, or lanceolate. Flowers 1-16, usually sessile, erect or slightly diverging, large and starlike, fragrant. Perianth connate basally into short or long tube, surmounted by conspicuous staminal corona; tepals extending from base of corona, free portions reflexed or ascending, often distally recurved, linear. Stamens adnate basally into showy funnelform or rotate corona, margins between free portions of filaments often dentate or lacerate, portions of filaments inserted on margin of corona, erect to incurved, filiform. Anthers versatile, introrse, pollen yellow, often golden, or orange. Ovary inferior, globose, ovoid, oblong, or pyriform; ovules 2-10 per locule; style exserted beyond stamens, deflexed laterally, filiform; stigma capitate. Fruits capsular, green, subglobose to elongate, 3-locular, large, leathery. Seeds large, green, fleshy.

About 50 species: South east and south central United States, West Indies, Central America, and South America. The genus *Hymenocallis* is represented in the flora of Bangladesh by single species.

1. **Hymenocallis littoralis** (Jacq.) Salisb., Trans. Hort. Soc. Lond. 1: 338 (1812). **(Fig. 25, Plate 45)**

Synonyms: *Pancratium littorale* Jacq., Select. Stirp. Amer. Hist.: 99 (1763); *Hymenocallis adnata* Herbert, Amaryll.: 215 (1837); *Hymenocallis tenuiflora* Herbert, Amaryll.: 215 (1837); *Pancratium illyricum* auct. *non* L.: Blanco, Fl. Filip. ed. 3: 316 (1877); *Pancratium maritimum* auct. *non* L.: Blanco, Fl. Filip. ed. 3: 316 (1877).

English names: Beach Spider Lily, Spider Lily.

Local name: *Bokful*.

Description: A perennial bulbous herb, bulb c 4-5 cm across, neck cylindric. Leaves radical, up to 90 × 7 cm, linear, distichous. Scape up to 80 cm long, compressed, bracts few-many, linear or lanceolate, hyaline. Inflorescence in 6-12 flowered umbel, flowers fragrant. Perianth segments 6, white, tube up to 14 × 0.6 cm, greenish, lobes 6, up to 13 cm long, narrow, white. Stamens 6, at the throat of the perianth, staminal cup white, c 3.5 cm long with 4 cm mouth, filaments above the cup c 6 cm long, green, anthers c 2 cm long, linear, versatile. Carpels 3, syncarpous, ovary 3-celled, c 1.5 × 0.7 cm, inferior, green, ovules 4-5 in each locules; style above the cup c 10 cm long, green, stigma slightly 3-lobed. Fruit a capsule, sub-globose, 3-angled, loculicidal. Seeds angled, black. Fruit and seed normally not formed.

Flowering and fruiting: June-August.

Specimens examined: Dhaka: DU Bot. Garden, 20.02.1980, Mahbuba Halim 740 (DACB). **Narayanganj**: Sonargaon, Amgaon, 25.08.2011, Sumona 69; **Bhola**: Char Kukri Mukri, 02.07.2014, Sumona 89 (DUSH).

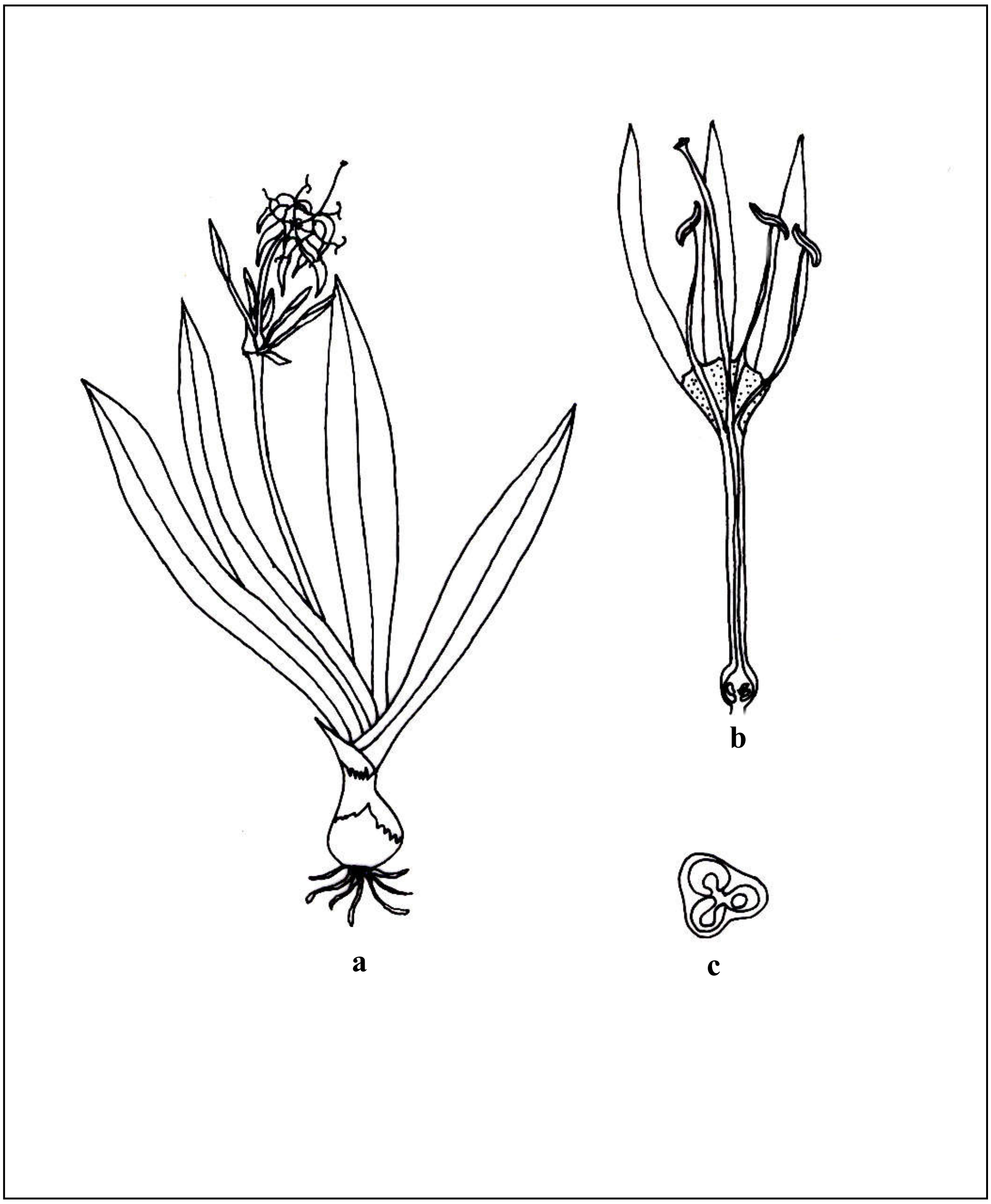


Fig. 25. *Hymenocallis littoralis* (Jacq.) Salisb., a) Habit (×0.1); b) L.S. of a flower (×0.5); c) T.S. of ovary (×2).

Plate 45. *Hymenocallis littoralis* (Jacq.) Salisb., a) Habit; b) Bulb.

Chromosome number: 2n = 46 (Jee and Vijayavalli, 1999).

Habitat: Well-drained soils.

Distribution: South to Central America; cultivated and naturalized in tropical Africa, tropical Asia, Malesia and the Pacific Islands (Jessop, 1979). In Bangladesh, this species is found in Narayanganj district and cultivated in many gardens.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs.

Genus 14: **HYPOXIS** L., Syst. ed. 10: 986 (1759). Benth. and Hook. f., Gen. Pl. 3: 717 (1883).

Franquevillea Zoll. *ex* Miq., Fl. Ind. Bal. 3: 586 (1855); *Ianthe* Salisb., Gen. Pl. Fragm. 44 (1866); *Niobea* Willd. *ex* Schult. f., Syst. 7: 762 (1880); *Spiloxene* Salisb., Gen. Pl. Fragm. 44 (1866).

Herbs, perennial, scapose, glabrous or sparsely to densely pubescent, often pilose, pubescence including at least some irregularly stellate trichomes, rhizomatous or cormose. Stems subterranean, usually vertical, fleshy. Leaves grasslike; blade linear to setaceous. Scape usually shorter than leaves. Inflorescences depauperate racemes or umbels, borne singly in leaf axils, bracteate. Flowers solitary, umbell or racemose. Perianth segments 6, rotate, sessile on the top of the ovary, persistent, often greenish abaxially, yellow adaxially, outer usually more or less pilose abaxially. Stamens 6, adnate to the base of the perianth segments, filaments short, anthers erect, dorsifixed, spreading, shortly connate at bases. Carpels 3, syncarpous, ovary inferior, usually densely pubescent to pilose, sometimes glabrate, 3-celled, style short, stigmas 3, erect, distinct or connate, ovules two seriate. Fruit a capsule, cirucumscissile below the top or 3-valved. Seeds sub-globose, (5-)10-50 per capsule.

About 100 species: mainly Southern Hemisphere. The genus *Hypoxis* is represented in the flora of Bangladesh by single species.

1. Hypoxis aurea Lour., Fl. Cochinch.: 200 (1790). Hook. f., Fl. Brit. Ind. 6: 278 (1892); Haines, Bot. Bih. Or. 1113 (1924).

Synonyms: *Hypoxis minor* D. Don, Prod. Fl. Nep. 53 (1825), *Curculigo graminifolia* Nimmo, J. Grah. Cat. Pl. Bomb. 215 (1839), *Hypoxis franquevillii* Miq., Fl. Ind. Bat. 3: 586 (1858).

English names: Golden Star Grass, Yellow Star Grass.

Local name: *Bhui Khajur* (India).

Description: Small perennial herb with globose or elongated rootstock, crowned with fibrous remains of old leaves. Leaves radical, narrowly linear, 10-30 cm long, strongly nerved, sub-coriaceous, keeled. Scape 2-flowered, filiform, hairy. Flowers yellow, bisexual. Perianth rotate, 6-partite, persistent, sessile on the top of the inferior ovary. Stamens 6, adnate to the base of the perianth segments, filaments short, anthers erect, dorsifixed. Carpels 3, syncarpous, ovary 3-celled, inferior, style short, stigmas 3, placentation axile. Fruit a capsule. Seeds sub-globose, black, tuberculate.

Flowering and fruiting: May-August.

Chromosome number: 2n = 54 (Kumar and Subramaniam, 1986).

Habitat: Grassy slopes or grazed ground (Polunin and Stainton, 1984). Hilly areas, up to an altitude of 2000 m.

Distribution: Subtropical Himalayas from Kashmir eastwards to Sikkim and Khasia Hills, Myanmar, Indonesia, China and Japan. Also the Western Ghats from Concan southwards, Bihar and Bengal (includes present-day Bangladesh).

Economic uses/values/harmful aspects: Used as tonic, aphrodisiac, panacea similar to ginsengs (Walter *et al.*, 2003).

Propagation: Propagated by rootstocks.

Note: I could not found any specimen of the species even in any herbarium specimen.

Genus 15: **MOLINERIA** Colla, Hort. Repub. App. 2: 333, t. 18 (1826).

Curculigo sect. *Molineria* Benth. (1883).

Rootstocks tuberous, or a coated corm. Leaves radical, petioled, scape short or long, flowers in spicate, racemed or subcapitate inflorescence. Perianth limb sessile or very shortly stipitate above the ovary. Stamens 6. Ovary 3-celled. Fruit indehiscent. Seeds black.

Native to Southeast Asia, China, the Indian Subcontinent, Papuasia, and Queensland. The genus *Molineria* is represented in the flora of Bangladesh by 2 species.

Key to the species

1.	Fruit globose, scape more than 6 cm long	**M. recurvata**
-	Fruit ellipsoid, scape up to 5 cm long	**M. salarkhanii**

1. **Molineria recurvata** (Dryand.) Herb., Amaryl.: 84 (1834).

(Fig. 26, Plate 46)

Synonyms: *Leucojum capitulatum* Lour., Fl. Cochinch. 199 (1790), *Curculigo recurvata* [Dryand.] Ait., Hort. Kew. ed. 2, 2: 253 (1811), *Curculigo capitulata* (Lour.) O. Kuntze, Rev. Gen. 703 (1891), *Curculigo glabra* Merr., Philip. Journ. Sci. 2: 267 (1907).

English name: Palm Grass.

Local name: *Satipata*.

Description: A stout herb with tuberous rootstock, c 16.0 × 5.5 cm, brownish-black. Leaves very variable, 30-90 × 7-15 cm, lanceolate, plicate, acuminate, entire, glabrous or with nerves beneath hairy, recurved, petiole channelled, 30-60 cm long, hairy below, sub-glabrous above. Scapes 7-30 cm long, stout or slender, villous, compressed, bracts lanceolate, c 2.4 × 1.0 cm, villous. Flowers yellow, pedicellate, pedicel c 1.1 cm long, in dense bracteate heads, 5-10 cm across. Perianth segments 6, c 0.7 × 0.4 cm, outer segments villous on the back, rotate, sessile, yellow. Stamens 6, filaments short, adnate to the base of the perianth segments, anthers cohering, c 0.5 cm long, yellow. Carpels 3, epigynous, syncarpous, ovary 3-celled, c 0.2 cm long, villous, placentation axile, stigma small. Fruit a berry, 6-8 mm in diameter, one chamber contain more than 20 seeds. Seeds black.

Flowering and fruiting: July-September.

Specimens examined: Dhaka: D.U. Bot. Garden, 05.09.2006, Sumona 2; 10.02.2007, Sumona 8; D.U. Bot. Garden (originally collected from Chittagong, Himchari), 03.07.2016 Sumona 104 (DUSH). **Cox's Bazar**: Teknaf, 16.06.1991, Khan *et al.* 8475 (DACB); 25.03.1973, M.M. Islam 792 (DUSH); Himchari National Park, Bara Chara, 27.08.1996, Rahman *et al*. 364a (HCU). **Rangamati**: Kaptai, 24.04.1997, Khan *et al.* 9835, Kaptai Range, 24-04-1997, Khan, Yusuf, Alam & Nasir K-9835; Bilaichari, Farua Reserve Forest, 14.10.2008, Sarder Nasir Uddin *et al*. N-3009; Sitarghat, Sitapahar, Kaptai, 24.09.2008, Sarder Nasir Uddin N-1514 (DACB); Kaptai, Sitapahar, 22.04.1997, Rahman *et al.* 1013 (HCU); Ghagra Road, 27.06.1997, Rahman *et al*. 1125 (HCU); Kaptai, Rampahar, 14.05.1999, Rahman *et al*. 4851 (HCU). **Mymensingh**: Haluaghat, 23.05.89, Mia 2034 (DACB). **Maulvi Bazar**: Lawachera, 15.08.76, Khan *et al.* 4227; Lawachera National Park, Kamalganj, 18.08.2009, Sarder Nasir Uddin N-3941 (DACB). **Chittagong Hill Tracts**: Ghagra, 27.04.1976, Huq, Rahman & Mia H-2456 (DACB). **Sylhet**: Habiganj, Satchari, 24.04.1997, A.M. Huq & M.K. Mia H-6934 (DACB). **Bandarban**: Lama, 04.12.1997, Rahman *et al*. 2469 (HCU). **Chittagong**: Chunati, 09.06.1997, Rahman *et al.* 1054a (HCU). **Khagrachari**: Alutila, Bengalkati Chara, 27.06.1997, Rahman *et al*. 1181A (HCU).

Chromosome number: 2n = 18 (Kumar and Subramaniam, 1986; under the name *Curculigo capitulata*).

Habitat: On the hill slope.

Distribution: South Asia through south-east Asia to Taiwan, Australia and the Pacific Islands. In Malesia, it occurs in Peninsular Malaysia, Singapore, Indonesia, the Philippines, New Guinea and Manus Island (Brink and Escobin, 2003). In Bangladesh, it occurs in Dhaka, Cox's Bazar, Rangamati, Mymensingh, Maulvi Bazar, Chittagong Hill Tracts, Sylhet, Bandarban, Chittagong and Khagrachari districts.

Economic uses/values/harmful aspects: Used as traditional medicine to treat kinds of diseases such as impotence, limb limpness, gastrointestinal and heart diseases (Nie *et al.*, 2013).

Fig. 26. *Molineria recurvata* (Dryand.) Herb., a) Habit (×0.1); b) Inflorescence (×0.5); c) Flower (×2); d) L.S. of a flower (×3); e) T.S. of ovary (×10); f) Bract (×1); g) Fruit (×1).

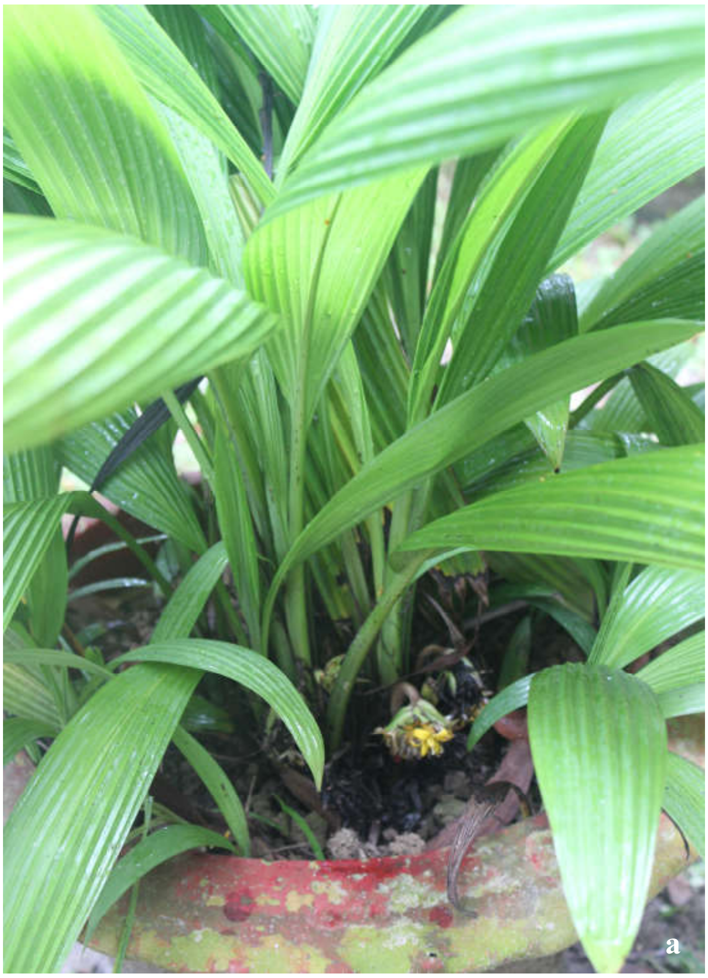


Plate 46. *Molineria recurvata* (Dryand.) Herb., a) Habit; b) Inflorescence.

Ethnobotanical information: Leaves are used to make hats (Uddin and Hassan, 2004).

Propagation: Propagated by rootstocks.

2. **Molineria salarkhanii** S.N. Uddin & M.A. Hassan [sp. nov. (Ph.D. thesis unpublished 2012)]. **(Fig. 27, Plate 47)**

Description: A stout herb with tuberous rootstock, brownish-black. Leaves lanceolate, plicate, acuminate, entire, glabrous or with nerves beneath hairy, recurved, petiole channelled, hairy below, sub-glabrous above. Scape stout or slender, villous, compressed, up to 5 cm long. Fruit a berry, ellipsoid, striated.

Flowering and fruiting: July-September.

Specimens examined: Rangamati: Rampahar, Kaptai, 30.05.2008, Sarder Nasir Uddin N-2955 (DACB). **Sylhet**: Rema-Kalenga range, Collected from Rema-Kalenga Sanctuary in Habiganj, 24.5.1999 (DACB).

Habitat: On the hill slope.

Propagation: Propagated by rootstocks.

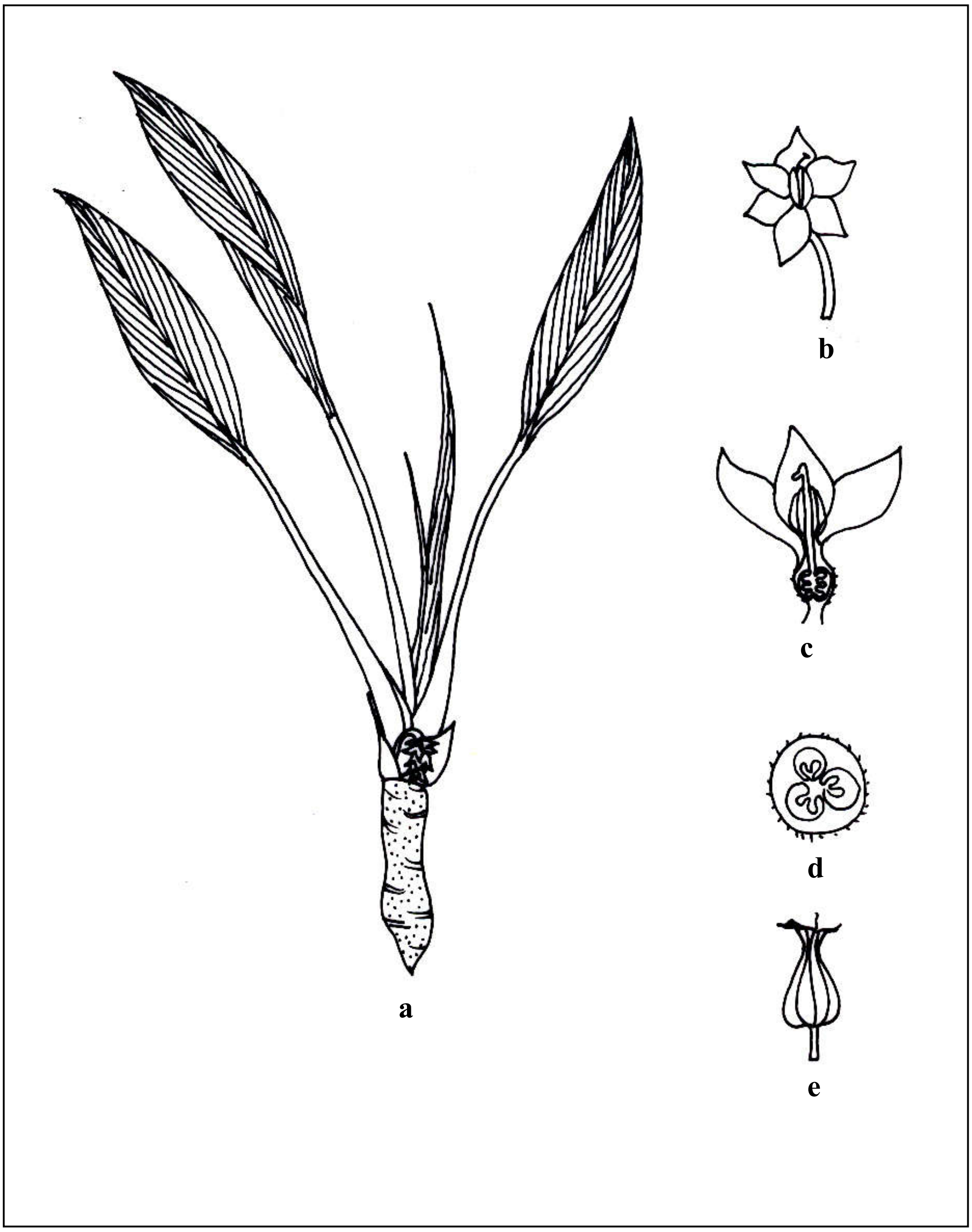


Fig. 27. *Molineria salarkhanii* S.N. Uddin & M.A. Hassan, a) Habit (×0.1); b) Flower (×2); c) L.S. of a flower (×3); d) T.S. of ovary (×10); e) Fruit (×1).

Plate 47. *Molineria salarkhanii* S.N. Uddin & M.A. Hassan, a) Habit; b) Inflorescence.

Genus 16: **PANCRATIUM** Dill. *ex* Linn., Syst. ed. 1 (1735). Benth. and Hook. f., Gen. Pl. 3: 733 (1883); L., Sp. Pl.: 290 (1753).

Almyra Salisb., Trans. Hort. Soc. 1: 336 (1812); *Bollaea* Parl., Bull. Soc. Bot. Fr. 5: 509 (1858); *Halmyra* Herb., Amaryll. 202 (1837); *Troxistemon* Rafin., Fl. Tell. 4: 23 (1836); *Zouchia* Rafin., Fl. Tell. 4: 22 (1836).

Bulbous perennial herbs. Leaves basal, linear or lanceolate, sessile. Scape long, solid. Inflorescences umbellate, 1 to many flowered. Flowers large, umbelled or solitary. Spathes 1-4, membranous, bracts few, linear or lanceolate, hyaline. Perianth funnel-shaped, spreading, linear or lanceolate, lobes narrow. Stamens 6, on the throat of the perianth, filaments connate into a cup for most of their length but apically free; anthers linear, versatile. Ovary with many ovules, ovules flattened. Carpels 3, syncarpous, style filiform; stigma capitate, sometimes somewhat 3-lobed to branched, small. Fruit a capsule, 3-angled, loculicidal. Seeds black or brown, wedge-shaped, hard.

About 15 species: Mediterranean region to tropical Africa and Asia. The genus *Pancratium* is represented in the flora of Bangladesh by 3 species.

Key to the species

1.	Staminal cup not bi-fid between the filaments	**P. biflorum**
-	Staminal cup bi-fid between the filaments	**2**
2.	Scape equal or longer than the leaves	**P. verecundum**
-	Scape shorter than the leaves	**P. triflorum**

1. **Pancratium biflorum** Roxb., Fl. Ind. 2: 125 (1832).

(Fig. 28, Plate 48)

Synonym: *Pancratium longiflorum* Buch.-Ham. *ex* Roxb., Fl. Ind. 2: 125 (1832).

Description: A perennial bulbous herb, bulb with a long neck. Leaves radical, up to 120 × 7 cm, linear, midrib prominent from the underside, margin entire, apex acute. Scape compressed, slightly shorter than the leaves, spathes 3-4. Inflorescence an 4-8 flowered umbel. Flower short pedicelled, bisexual, epigynous. Perianth segments 6, united below to form a long trigonous tube, throat not dilated, tube up to 12 cm long, lobes narrow, slightly shorter than the tube, c 0.5 cm wide. Stamens 6, with a white, erose, funnel-shaped staminal-cup, not toothed between each pair of filaments. Carpels 3, united into an inferior 3-celled ovary, style longer than the filaments, stigma short. Fruit a capsule (usually does not produce), 3-angled, loculicidal.

Flowering and fruiting: May-September.

Specimen examined: Dhaka: Baldha Garden, 23.3.2007, Sumona 12 (DUSH).

Chromosome number: 2n = 22 (Kumar and Subramaniam, 1986; under the name *P. longiflorum*).

Habitat: Gardens, where it is planted.

Distribution: Southern India, Sri Lanka. In Bangladesh, it is found in many gardens.

Economic uses/values/harmful aspects: Planted in gardens as an ornamental plant.

Propagation: By bulbs.

Fig. 28. *Pancratium biflorum* Roxb., a) Habit (×0.1); b) Inflorescence (×0.33); c) L.S. of a flower (×0.33); d) T.S. of ovary (×5).

Plate 48. *Pancratium biflorum* Roxb., a) Habit; b) Inflorescence.

2. **Pancratium triflorum** Roxb., Fl. Ind. 2: 126 (1824).

(Fig. 29, Plate 49)

Synonyms: *Pancratium malabathricum* Herb., Amaryll. 202, 206 (1837), *Crinum pauciflorum* Miq. *ex* Hook. f., Fl. Brit. Ind. 6: 285 (1892).

Description: Bulb globose, c 9.0 ×6.5 cm. Leaves 20 × 3 cm, linear-oblong, acute. Scape c 16.0 × 1.5 cm, compressed, flowers 4, white, slightly fragrant. Spathe 1, c 5 cm long, acute, ovate, papery thin, white, bracteoles narrow. Perianth segments 6, c 4.5 × 1.0 cm, tube c 14 cm long, white, greenish below, dilated, staminal cup above 2.0 cm long with large bifid teeth between the filaments. Stamens 6, shorter than the perianth, filaments longer than the teeth of the cup, anthers yellow. Style longer than stamen but shorter than perianth, stigma yellow.

Flowering and fruiting: April-May.

Specimens examined: **Dhaka**: D.U. Bot. Garden (originally collected from Chittagong), 27.08.2010, Sumona 66; D.U. Bot. Garden (originally collected from Gazni forest, Sherpur), 21.03.2010, Sumona 62 (DUSH). **Bandarban**: Khagrachari, 06.04.2004, M. Yusuf 1602 (BCSIR Lab.).

Chromosome number: 2n = 22, 23, 44, 48, 56 (Kumar and Subramaniam, 1986).

Distribution: Sri Lanka, Deccan Peninsula. In Bangladesh, it occurs in Bandarban, Chittagong and Gazipur districts.

Economic uses/values/harmful aspects: Planted in gardens as an ornamental plant.

Habitat: Hilly areas.

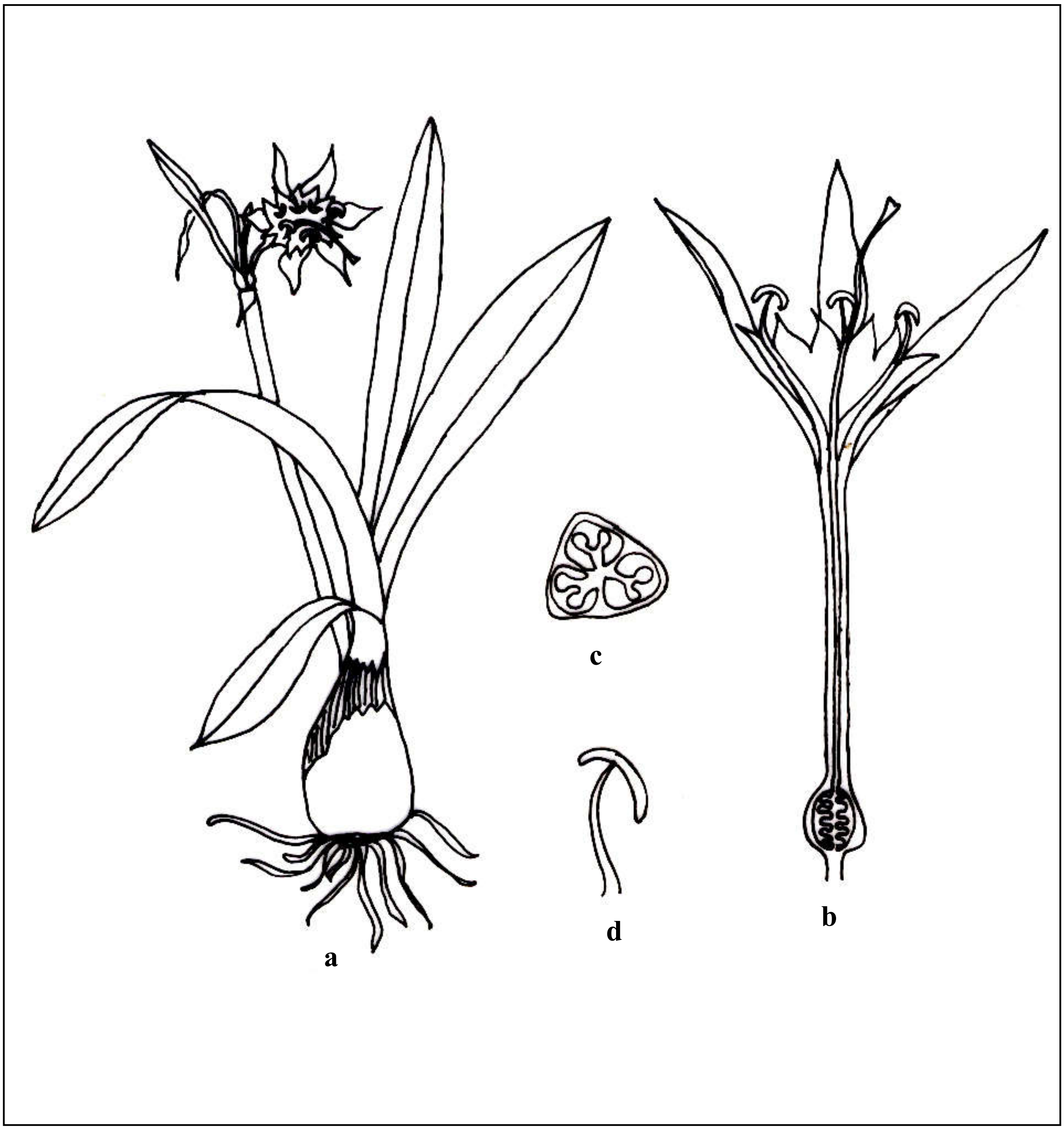


Fig. 29. *Pancratium triflorum* Roxb., a) Habit (×0.5); b) L.S. of a flower (×1); c) T.S. of ovary (×2); d) Stamen (×2).

Plate 49. *Pancratium triflorum* Roxb., a) Habit; b) Flower; c) Bulb.

3. **Pancratium verecundum** Ait., Hort. Kew. 1: 412 (1810).

(Fig. 30, Plate 50)

English name: Spider Lily.

Local names: *Gor-rashun, Bakphul*.

Description: A perennial bulbous herb, bulb c 4-5 cm across, neck cylindric. Leaves radical, up to 90 × 7 cm, linear, scape up to 80 cm long, compressed, bracts few-many, linear or lanceolate, hyaline. Inflorescence in 6-30 flowered umbel. Perianth segments 6, white, tube up to 12 cm long and 0.5 cm wide, greenish, lobes 6, up to 13 cm long, narrow, white. Stamens 6, at the throat of the perianth, staminal cup white, c 3.5 cm long with 4 cm mouth, 2-fid between each pair of the filaments, filaments above the cup c 6 cm long, white, anthers c 2 cm long, linear, versatile. Carpels 3, syncarpous, ovary 3-celled, c 1.5 × 0.7 cm, inferior, green, style above the cup c 10 cm long, stigma slightly 3-lobed. Fruit a capsule, sub-globose, 3-angled, loculicidal. Seeds angled, black, very rarely formed.

Flowering and fruiting: March-July.

Specimens examined: Dhaka: Curzon Hall Area, 02.06.2013, Sumona 79; **Patuakhali**: Patuakhali Sadar, Charpara, 16.05.2006, M. Sultana 1294; Galachipa, Amkhola, 01.02.2007, M. Sultana 1464 (DUSH).

Chromosome number: 2n = 44, 44+1 (Kumar and Subramaniam, 1986).

Habitat: Hilly areas.

Distribution: Foot of the Himalayas, from the Punjab eastwards to Sikkim and Assam (India). In Bangladesh, it occurs in waste places and also cultivated in many gardens.

Economic uses/values/harmful aspects: Planted in the gardens as an ornamental herb.

Ethnobotanical information: Children eat the sweet nectar that accumulates in the perianth tube.

Propagation: Propagated by bulbs.

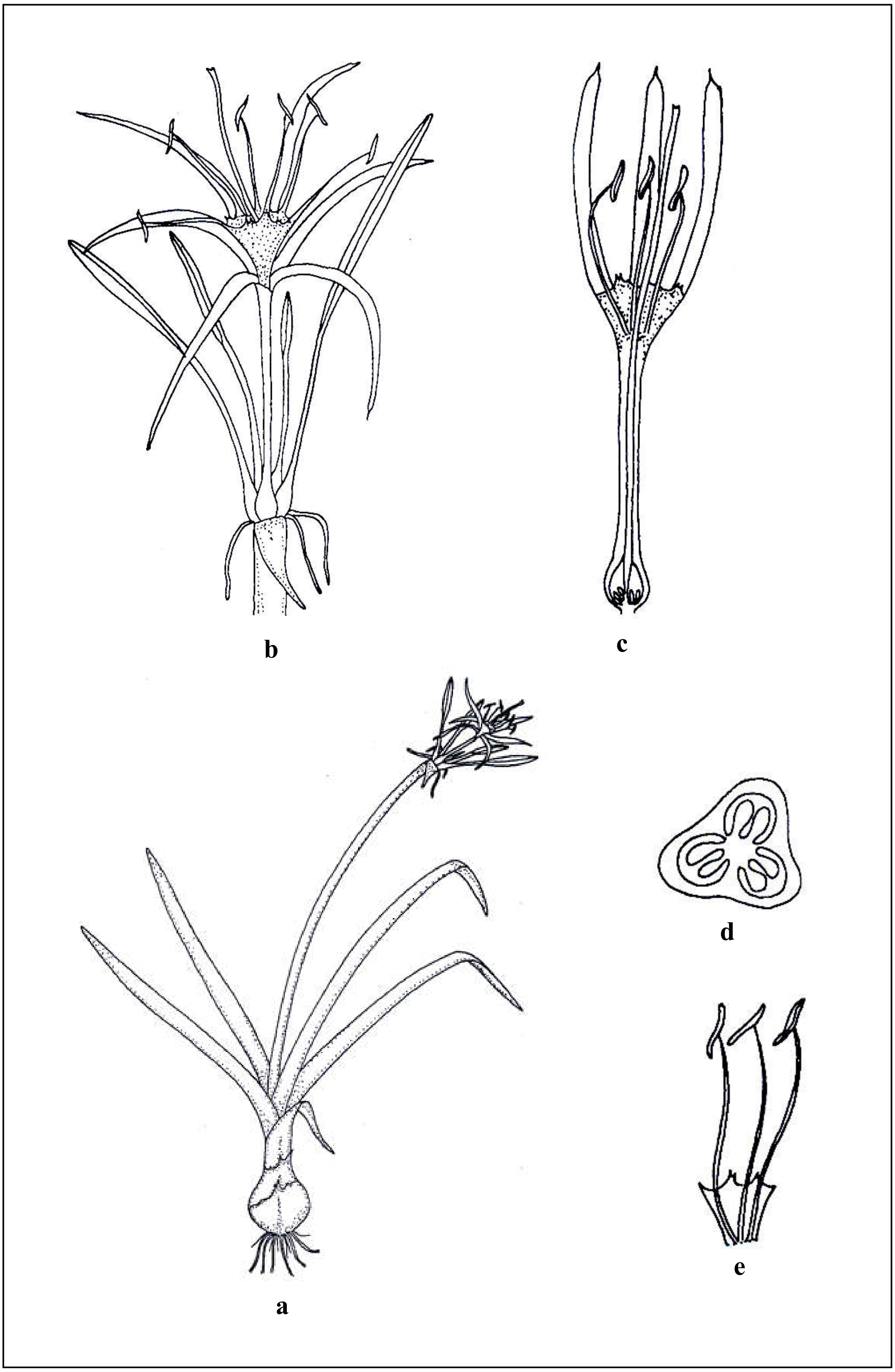


Fig. 30. *Pancratium verecundum* Ait., a) Habit (×0.1); b) Inflorescence (×0.5); c) L.S. of a flower (×0.5); d) T.S. of ovary (×4); e) Three stamens with stamina corona (×0.5).

Plate 50. *Pancratium verecundum* Ait., a) Habit; b) Inflorescence.

Genus 17: **PROIPHYS** Herb., App. [Bot. Reg.] 42 (1821).
Eurycles Salisb., Trans. Hort. Soc. 1: 337 (1812).

Perennial herbs, bulbs tunicated, more or less globose or sub-globose. Leaves simple, alternate, spiral or distichous, long petioled, channelled above, or sessile, sheathing at base. Inflorescence terminal, umbel, scape erect, unbranched, involucral bracts 2-4, ovate-lanceolate. Flowers pedicellate, 7-45 cm long, regular, 3-merous, perigone tube present. Perianth segments 6, with a conspicuous corona like an extra inner whorl, isomerous, jointed, white. Stamens 6, adnate, free, arranged in two whorls, filaments appendiculate, anthers dorsifixed or rarely basifixed, versatile, introrse. Carpels 3, stigma 1-3 lobed, capitate, ovary uni or plurilocular, placentation axile. The fruits often germinate on the plant and new plant can be grown from these, seeds fleshy, 1-several in number.

About 3 species: Extending beyond Australia to South-East Asia. The genus *Proiphys* is represented in the flora of Bangladesh by a single species.

1. **Proiphys amboinensis** (L.) Herb., App. [Bot. Reg. 7] 42 (1821).

(Fig. 31, Plate 51)

Synonyms: *Eurycles sylvestris* Salisb., Trans. Hort. Soc. 1: 337 (1812), *Pancratium amboinensis* L., Sp. Pl. 291 (1753), *Eurycles amboinensis* (L.) Lindl. in Loud., Enc. Pl. 242 (1829).

English names: Cardwell Lily, Northern Christmas Lily.

Description: Herb with tunicated bulb, bulb c 9 × 5 cm, globose. Leaves simple, petiolate, petiole c 30 cm long, cordate-reniform, acute, entire, lamina strongly nerved, c 21 × 26 cm, green, glabrous, base sheathing. Inflorescence 20 or more flowered umbel. Scape solid, round, c 38 cm long. Flowers bisexual, pedicellate, pedicel c 2.8 cm long, green. Spathes 3, c 8.5 × 2.5 cm, ovate-lanceolate, greenish-white, bracteoles many, c 6.0 × 1.5 cm, ovate-lanceolate. Perianth segments 6, c 3.7 × 1.5 cm, united at base, white, waxy, tube c 3.5 cm long, round, glabrous, green. Stamens 6, form a white staminal-cup, staminal cup 6 partite, c 1 cm long, filaments white, c 2.6 cm long,

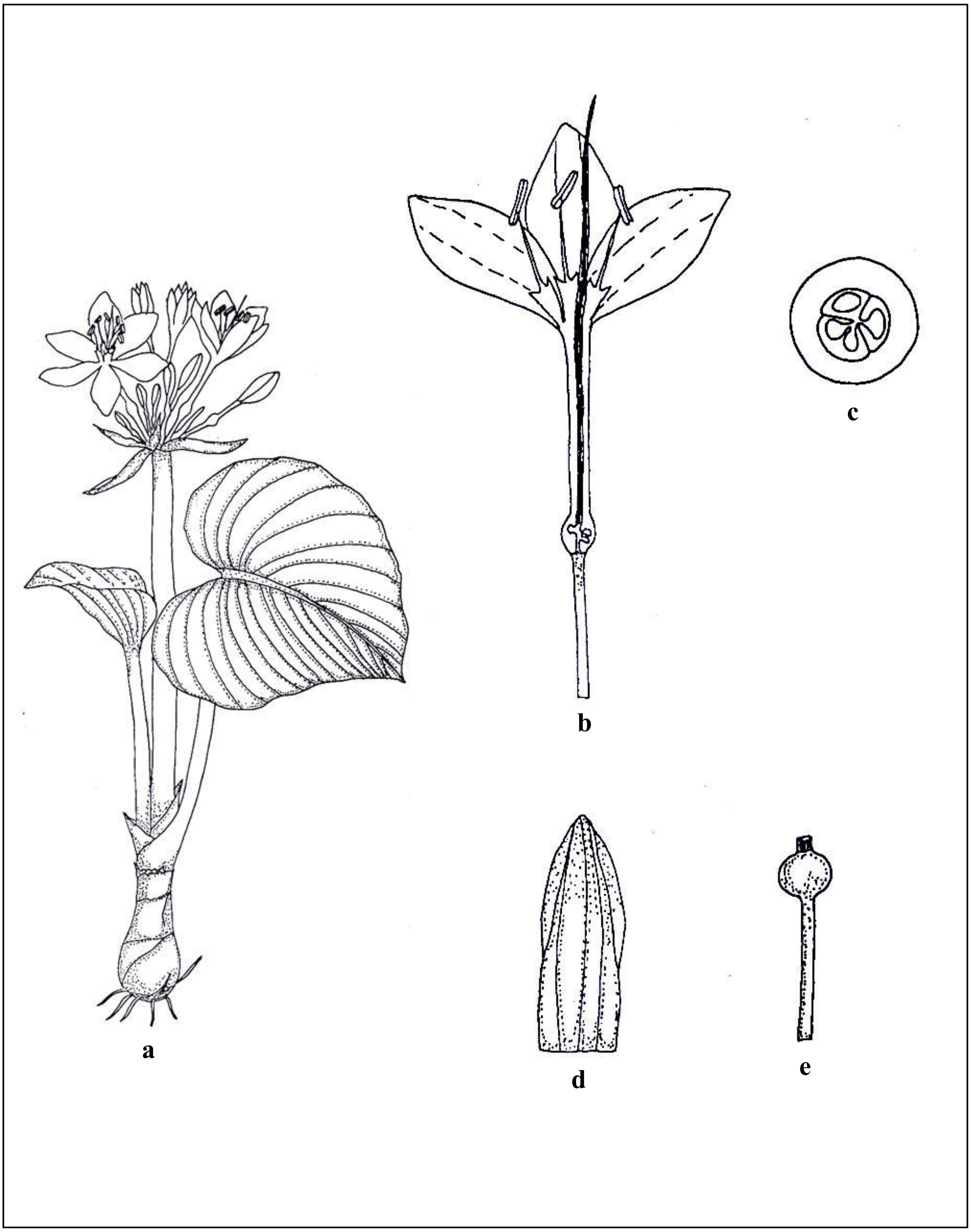


Fig. 31. *Proiphys amboinensis* Herb., a) Habit (×0.12); b) L.S. of a flower (×1); c) T.S. of ovary (×4); d) Bract (×0.5); e) Fruit (×1).

Plate 51. *Proiphys amboinensis* Herb., a) Habit; b) Bulb; c) Flower; d) Fruits.

anthers c 0.6 cm long, linear, dorsifixed, orange in colour. Carpels 3, syncarpous, ovary c 0.5 cm long, globose, green, stigma 1, white, glabrous, style filiform, placentation axile, ovules many, arranged irregularly in placenta. Fruit a globose berry, c 0.8 cm with 0.3 cm beak, dark green in colour.

Flowering and fruiting: April-August.

Specimens examined: Dhaka: D.U. Bot. Garden, 05.05.2007, Sumona 28; Science Library, 10.05.2007, Sumona 31; D.U. Bot. Garden, 25.05.1968, Mozahar 129; Govt. Nursery, 26.04.1946, Sukhdeo p. 25.06.1946 (DUSH).

Chromosome number: 2n = 20 (Fedorov, 1969, under the name of *Eurycles sylvestris*).

Habitat: Shady places.

Distribution: Native of Malesia, widely cultivated in tropical countries (Dassanayake and Clayton, 1981).

Economic uses/values/harmful aspects: Planted in gardens as an ornamental plant.

Propagation: By bulbs and may be seeds.

Genus 18: **SCADOXUS** Raf., Fl. Tellur. 4: 19 (1838).

Perennial herbs, rhizomatous or globose bulb with rhizomatous parts. Leaves radical and simple, appearing along with or after the appearance of scape, not distinctly distichous, herbaceous in texture, distinct middle nerves, glabrous. Petioles forming a false stem or pseudostem, which may be purple-spotted; lamina lanceolate to ovate, The leafless flowering stem (scape) is also sometimes purple-spotted. Inflorescence is usually an umbellate cyme. Flowers small, joined at the base to form a tube, more or less upright, narrow, actinomorphic, bisexual, epigynous. Perianth segments petaloid. Stamens 6, epiphyllous. Carpels 3, syncarpous. Fruit a globose berry, orange to red when ripe.

About 9 species: tropical Arabia and Africa as far south as Namibia and East Cape. The genus *Scadoxus* is represented in the flora of Bangladesh by a single species.

1. **Scadoxus multiflorus** Raf., Fl. Tellur. 4: 19 (1838).

(Fig. 32, Plate 52)

Synonym: *Haemanthus multiflorus* Martyn *ex* Willd., Sp. Pl. 2: 25 (1799).

English names: May Flower, Blood Lily, African Blood Lily, Powder-Puff Lily, Fireball Lily, Torch Lily, Football Lily, Catherine Wheel.

Local names: *Agni-golock, Ball-phu*, *May Ball*.

Description: A bulbous perennial herb with long neck, neck greenish-white with red-maroon spots, bulb tunicated, c 3.5 × 3.0 cm, off-white in colour. Leaves radical, simple, lanceolate, c 28 × 10 cm, entire, acute, parallel veined, leaf base sheathing, leaves appear just after the appearance of scape, not distinctly distichous, herbaceous in texture, distinct middle nerves, always glabrous. Petioles forming a false stem or pseudostem, which is purple-spotted. Inflorescence an umbellate cyme with numerous flowers grown at the tip of a leafless scape, full-bloomed flowers form a globulous head which lasts only for a week. Scape c 35 × 1.3 cm, greenish-purple, spathes 4, lanceolate, c 6 × 1 cm, bracteoles many, c 4.0 × 0.1 cm, linear. Flowers actinomorphic, bisexual, pedicellate, pedicel c 3.8 cm long, greenish-red, epigynous. Perianth segments 3+3, petaloid, c 2.9 × 0.2 cm, united below into a tube, reddish-pink, glabrous, tube c 1 cm long. Stamens 6, epiphyllous, filaments long, c 3.1 cm long, anthers linear, c 0.4 cm long, dorsifixed, introrse. Carpels 3, syncarpous, ovary 3-celled, inferior, c 0.3 cm long, green, placentation axile, style c 4 cm long from the top of the tube. Fruit a berry, globose, red when ripe.

Flowering and fruiting: May-June (flowers usually in May).

Specimens examined: Dhaka: D.U. Bot. Garden, 05.05.2007, Sumona 27; 17.05.2010 Sumona 64; D.U. Bot. Garden, 28.05.1968, Mozahar 131 (DUSH).

Chromosome number: 2n = 16, 18 (Kumar and Subramaniam, 1986).

Habitat: Well-drained moist soils in the p^H range 5.6-8.5 receiving moderate levels of sunshine.

Distribution: This plant is originated from tropical and southern Africa (Bateman *et al*., 2004). Planted in gardens in warmer regions of the world. In Bangladesh, it is found in many household gardens.

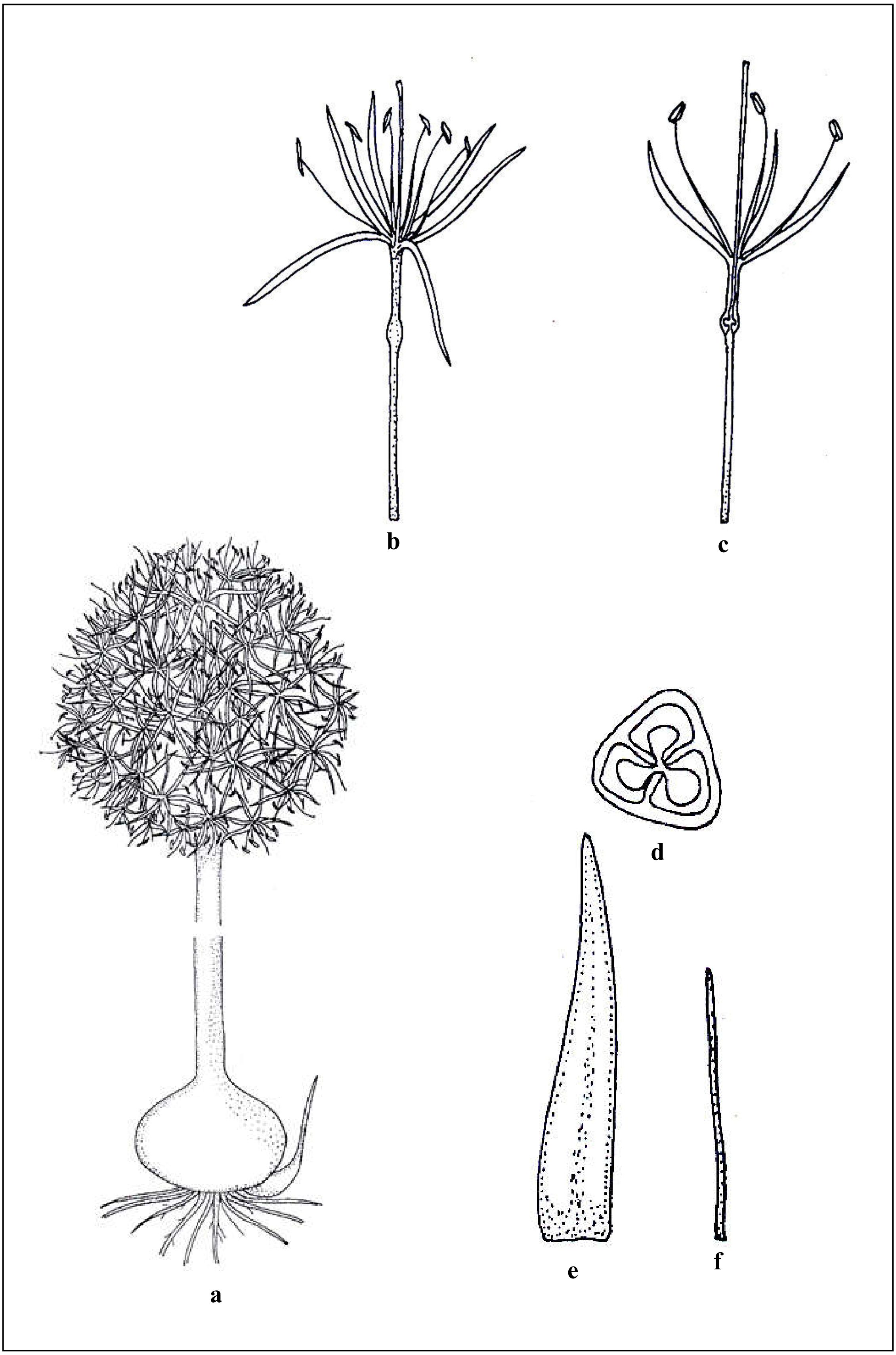


Fig. 32. *Scadoxus multiflorus* Raf., a) Habit (× 0.25); b) Flower (×1); c) L.S. of a flower (×1); d) T.S. of ovary (×7); e) Bract (×1); f) Bracteole (×1).

Plate 52. *Scadoxus multiflorus* Raf., a) Habit; b) Bulb with bulblets.

Economic uses/values/harmful aspects: It is one of the finest of all flowering plants, cultivated as an ornamental or garden plant. The bulb is poisonous, if ingested it can cause salivation, nausea, vomiting and diarrhoea. It contains lycorine and other alkaloids. The plant is attractive to bees, butterflies and/or birds. In some African countries, the bulbs are used as a fish poison. They are known to be lethal to livestock, mainly goats and sheep's grazing on them.

Ethnobotanical information: In South Africa, the bulbs pickled in vinegar, is used by the farmers as an expectorant to treat asthma and as a diuretic to treat dropsy.

Propagation: By separated offsets from its large onion-like bulbs.

Note**:** In Bangladesh, the species was wrongly identified under the name *Haemanthus multiflorus* Martyn *ex* Wild. but the correct name of the species is *Scadoxus multiflorus* Raf. There are some distinct differences between these two genera (Table 6) which specify the correct name the species grown in our country.

Table 6. Differences between the genera *Haemanthus* and *Scadoxus* according to the key given by Friis and Nordal (1976).

Characteristics	***Haemanthus***	***Scadoxus***
Stem	bifarious bulb	rhizomes or globose bulb with rhizomatous parts
Leaves	distichous, usually thick and fleshy, no distinct middle nerve, sometimes hairy	not distinctly distichous, herbaceous in texture, distinct middle nerves, always glabrous
Distribution	South Africa and Namibia	tropical Arabia and Africa as far south as Namibia and East Cape
Chromosome number	2n = 16	2n = 18

Genus 19: **URGINEA** Steinh., Ann. Sc. Nat. Ser. 2, t. 14, 1: 322 (1834). Benth. and Hook. f., Gen. Pl. 3: 810 (1883).

Fusifilum Rafin., Fl. Tell. 2: 27 (1836); *Montassa* Salisb., Gen. Pl. Fragm. 36 (1866); *Physodia* Salisb., Gen. Pl. Fragm. 37 (1866); *Pilasia* Rafin., Fl. Tell. 3: 53 (1836); *Squilla* Steinh. in Ann., Sc. Nat. Ser. 2, 6: 276 (1836); *Sypharissa* Salisb., Gen. Pl. Fragm. 37 (1866); *Tenicroa* Rafin., Fl. Tell. 3: 52 (1836).

Bulbous perennial herbs, bulbs tunicated, outer scales white, scarious, inner fleshy. Leaves few, basal, radical, sessile. Scapes terete, glabrous, with terminal racemes. Inflorescences racemose or cymose, 1-many-flowered, sometimes bracteate; bracts none or 1, subtending each flower. Flowers bisexual, hypogynous, bracteate, campanulate. Perianth segments 6, free to the base, outspreading. Stamens 6, filaments free, adnate to the base of the perianth segments. Carpels 3, united, ovary sessile, style single, stigma usually 3-lobed. Fruit a capsule, oblong or globose. Seeds many, much compressed.

About 50 species: introduced; Eurasia, especially Mediterranean area and south west Asia; south Africa. The genus *Urginea* is represented in the flora of Bangladesh by single species.

1. **Urginea indica** (Roxb.) Kunth, Enum. Pl. 4: 333 (1843).

(Fig. 33, Plate 53)

Synonyms: *Scilla indica* Roxb., Fl. Ind. 2: 147 (1832), *Scilla coromandeliana* Roxb., Fl. Ind. 2: 147 (1832), *Scilla cundaria* Ham. in Wall., Cat. no. 5062 (1832), *Scilla denudata* Ham. in Wall., Cat. no. 5062 (1832), *Urginea coromandeliana* (Roxb.) Hook. f., Fl. Brit. Ind. 6: 347 (1892), *Urginea senegalensis* Kunth, Enum. Pl. 4: 334 (1843), *Urginea wightiana* Hook. f., Fl. Brit. Ind. 6: 347 (1892).

English names: Sea Onion, Indian Squill, Wild Onion.

Local names: *Jongli Peyaj, Kanda, Shamudra Peyaj, Bon Peyaj, Go Rashun*.

Description: A perennial bulbous herb, bulb 2.5-8.0 × 3-9 cm, globose, white to yellowish-white. Leaves radical, appearing after flowering, many, linear, up to 60 × 2 cm, parallel-veined, dying out in the winter (December-January). Scape appearing before leaves, erect, up to 1 m tall, raceme 12-60 cm long, solid, fleshy, brownish-

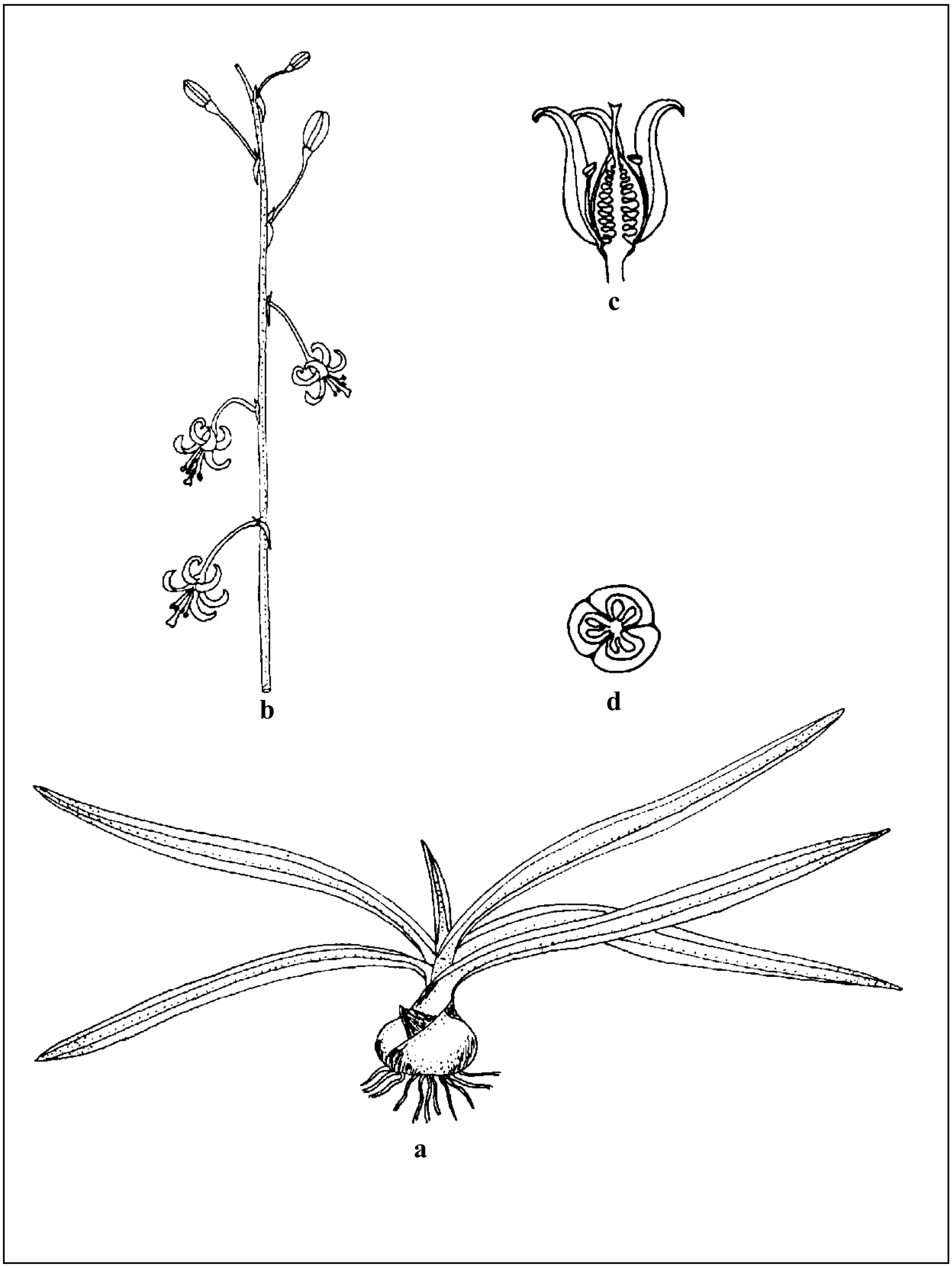


Fig. 33. *Urginea indica* (Roxb.) Kunth, a) Habit (×0.3); b) Inflorescence (×1); c) L.S. of a flower (×2); d) T.S. of ovary (×6).

Plate 53. *Urginea indica* (Roxb.) Kunth, a) Vegetative habit; b) Reproductive habit.

maroon, distantly flowered. Flowers hypogynous, bisexual, bracteate, bract c 0.6 × 0.3 cm, rough, pedicellate, pedicels up to 6 cm long, 3-5 flowers open in a day, last only for a night, opening in night and closing in the next morning. Perianth of 6 tepals, tepals free, greenish-white with green mid-nerve, oblong-lanceolate, c 0.9 × 0.3 cm, tips rounded. Stamens 6, filaments flattened at the base, c 0.5 cm long, off white in colour, anthers dorsifixed, c 0.4 cm long, 2-celled. Carpels 3, united into a single ovary, ovary ovoid or oblong, c 0.8 cm long, 3-celled, style one, c 0.3 cm long, stigma 3-lobed, capitate. Fruit a capsule, c 1.5 × 0.5 cm, brownish-yellow. Seeds few in each chamber, up to 7 × 4 mm, black, very light, compressed.

Flowering and fruiting: February-May.

Specimens examined: Dhaka: D.U. Bot. Garden (originally collected from Cox's Bazar), 06.04.2007, Sumona 20 (DUSH). **Cox's Bazar**: Teknaf, Ukhia, Sonapara, 31.03.2016, Sumona 100 (DUSH).

Chromosome number: 2n = 20, 30 (Fedorov, 1969).

Habitat: It grows in dry habitats, specially sandy grounds near sea beaches.

Distribution: India, Nepal, Myanmar, Africa and Bangladesh. In Bangladesh, only found in the coastal area from Cox's Bazar to Teknaf.

Economic uses/values/harmful aspects: Bulb is used as an important cardiac drug, as a powerful expectorant in the treatment of coughs, chronic bronchitis and asthma. Bulbs also possess anti-cancer properties (Ghani, 2003) and contain scillaren A, scillaren B, scillaridin A, Quercetin, etc. *Urginea indica* commonly called Indian squill is considered to have medicinal value and is largely used as an expectorant, cardiac stimulant, in treating rheumatism, dropsy, edema, gout, asthama and as an anticancer and antifungal agents (Kameshwari *et al*., 2012). The bulb ground with other ingredients, and fed to cows for both diarrhoea and poisoning. It is also made into a plaster for haemorrhagic septicaemia (Alam, 2000). The bulb is useful in paralysis, skin disease, disease of the nose, internal pains, scabies (Kirtikar *et al*., 1935). Powder of the bulb is a good adhesive containing mucilage and hence used in calico printing (Deb and Dasgupta, 1981).

Propagation: By bulbs or seeds.

Genus 20: **ZEPHYRANTHES** Herb., App. [Bot. Reg.] 36 (1821). Benth. and Hook. f., Gen. Pl. 3: 723 (1883).

Argyropsis M. Roem., Syn. Ensat. 125 (1847); *Arviela* Salisb., Gen. Pl. Fragm. 135 (1866); *Habranthus* Herb., Bot. Mag. t. 2464 (1824); *Mesochloa*, *Plectronema* and *Pogonema* Rafin., Fl. Tell. 4: 10 (1836); *Pyrolirion* Herb., App. [Bot. Reg.] 37 (1821).

Small herb with tunicate bulbs, perennial, bulbs black or brown, tunicate, ovoid or globose, sometimes with long neck. Leaves simple, sessile, erect or recumbent, with overlapping sheathing bases; blade linear or lorate, rarely exceeding 1 cm wide, smooth, appearing with or after the flowers. Scape hollow. Inflorescence 1-flowered (rarely 2-flowered in Z. drummondii), spathaceous, otherwise ebracteate; spathe proximally tubular. Flowers solitary, erect to declinate, actinomorphic, usually at the top of the long scape. Perianth subrotate to funnel-shaped to salverform, connate basally into tube, tube short or long, dilated upward, tepals 6 (rarely up to 8), in 2 series of 3 each, united at the base, subequal. Stamens 6 (rarely up to 8), of 2 different lengths, adnate to the perianth base; filaments long, erect, inserted just above perianth tube; anthers linear, dorsifixed, usually parallel with floral axis. Carpels 3, united, ovary inferior, 3-celled, ovules many, style long, filiform; stigma capitate or 3-lobed with lobes linear. Fruit a sub-globose or depressed capsule, thin-walled, loculicidally 3-valved, subglobose or ± oblate. Seeds oblong, black.

About 70 species: south east and south central United States, Mexico, West Indies, Central America, South America. The genus *Zephyranthes* is represented in the flora of Bangladesh by 4 species.

Key to the species

1.	Leaves terete, spathe covering the ovary	**Z. candida**
-	Leaves flat, spathe not covering the ovary	**2**
2.	Spathe not 2-fid. Flowers yellow	**Z. tubispatha**
-	Spathe 2-fid	**3**
3.	Outer 3 tepals obtuse, pink colour	**Z. grandiflora**
-	Outer 3 tepals acute, white but turn pink at maturity	**Z. atamasco**

1. Zephyranthes atamasco (Linn.) Herb., App. Reg. 36 (1821).

(Fig. 34, Plate 54)

Synonyms: *Amaryllis atamasco* L., Sp. Pl. 1: 292 (1753); *Amaryllis atamasco* Blanco, Fl. Filip. 254 (1837).

English names: Atamasco Lily, Fairy Lily, Rain Lily, Easter Lily, Zephar Lily.

Local name: *Sada Ghashphul*.

Description: A perennial bulbous herb, bulb ovoid, c 2.5 cm in diameter, neck 2.5-5.0 cm long. Leaves long, linear, up to 15 cm long, bright green. Flowers terminal, solitary, bisexual, peduncle c 21 cm long, hollow. Spathe simple, c 3.0 × 0.6 cm, hyaline, tubular, 2-notched. Perianth segments 6, c 5 × 2 cm, arranged in two rows, inner 3 smaller than the outer 3, white but lower 2 cm green in colour, changes from pure white to pink as it ages. Stamens 6, outer 3 large, c 2.5 cm long, inner 3 small, c 1.7 cm long, anthers linear, yellowish-orange in colour. Carpels 3, united, ovary inferior, c 0.4 cm long, 3-celled, placentation axile, style slender, stigma 3-notched, c 4 cm long with stigma. Fruit a capsule, sub-globose.

Flowering and fruiting: April-May.

Specimens examined: Dhaka: D.U. Bot. Garden, 11.04.2007, Sumona 21; 10.09.2013, Sumona 85 (DUSH).

Chromosome number: 2n = 12, 24 (Kumar and Subramaniam, 1986).

Habitat: Gardens, where it is widely cultivated.

Distribution: Native to south-east America, naturalized in Southern North America (Missouri and Virginia to Florida), widely cultivated in many countries including Bangladesh.

Economic uses/values/harmful aspects: Widely cultivated as an ornamental plant in gardens. All parts are toxic especially bulb, may be fatal if eaten.

Propagation: By division of bulbs.

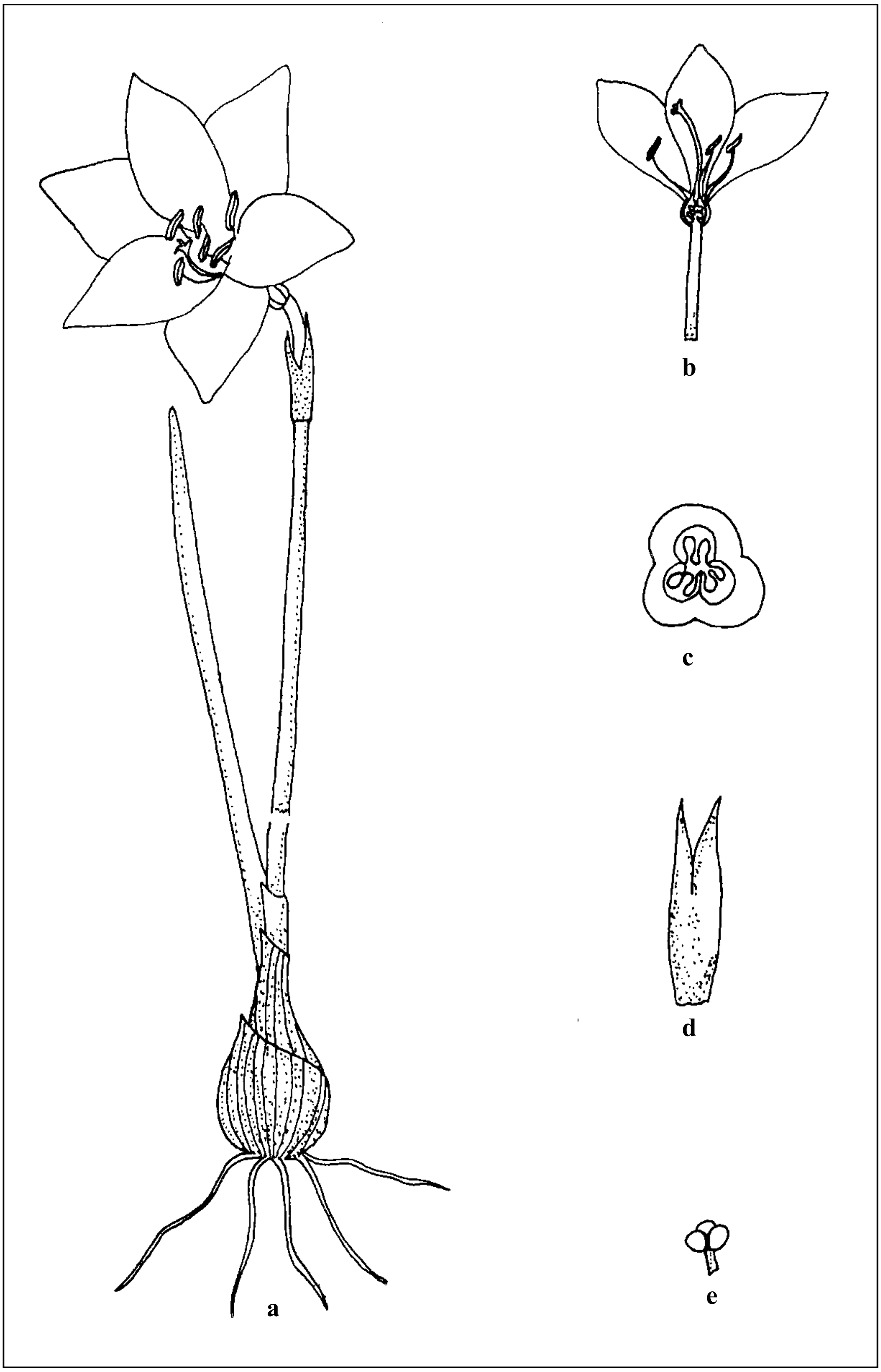


Fig. 34. *Zephyranthes atamasco* (Linn.) Herb., a) Habit (×1); b) L.S. of a flower (×0.5); c) T.S. of ovary (×4); d) Bract (×1); e) Fruit (×1).

Plate 54. *Zephyranthes atamasco* (Linn.) Herb., Habit.

2. **Zephyranthes candida** (Lindl.) Herb., Bot. Mag. 53: t. 2607 (1826).

(Fig. 35, Plate 55)

Synonym: *Amaryllis candida* Lindl. (1823).

English name: Fairy Lily.

Local name: *Sada Ghash-phul*.

Description: A perennial clump-forming bulbous plant, bulb tunicated, ovoid, c 2.5 cm in diameter, neck 2.5-5.0 cm long. Leaves simple, terete, linear, up to 35 cm long and 0.5 cm in diameter, hollow, obtuse, glabrous, dark green in colour. Inflorescence solitary on terminal leafless scape. Flowers pedunculate, peduncle c 26 cm long, bisexual, incomplete, actinomorphic, epigynous, white, spathe like bract present at the top of a long scape covered the ovary, bract c 3 × 1 cm, brown in colour, lanceolate, glabrous. Tepals 6, c 3.7 × 1.5 cm, free, ovate-lanceolate, white. Stamens 6, free, about half as long as the perianth, anthers c 0.9 cm long, oblong, dorsifixed, yellow, length of filaments and anthers are more or less same, filaments white, glabrous. Carpels 3, syncarpous, ovary inferior, c 0.5 × 0.3 cm, 3-celled, style slender, c 1.7 cm long with stigma, ovules many, stigma 3-notched, placentation axile. Fruit a capsule, sub-globose, c 0.8 × 1.2 cm, yellowish-green, each fruit contain 16-25 seeds. Seeds angular, flattened, testa black.

Flowering and fruiting: August-November.

Specimens examined: Dhaka: Science library, 20.09.2007, Sumona 46; Nazrul Institute, 20.08.2011, Sumona 68 (DUSH).

Chromosome number: 2n = 19, 20, 36, 38, 40, 41, 48, 50 (Kumar and Subramaniam, 1986).

Habitat: Gardens, where it is widely cultivated.

Distribution: Originated from Argentina, Uruguay (Bateman *et al*., 2004). Native to South America, naturalized in South China, widely cultivated in many countries including Bangladesh.

Economic uses/values/harmful aspects: Widely cultivated as an ornamental plant in gardens, containers or as a landscape plant.

Propagation: By division of clumps of bulbs or by seeds.

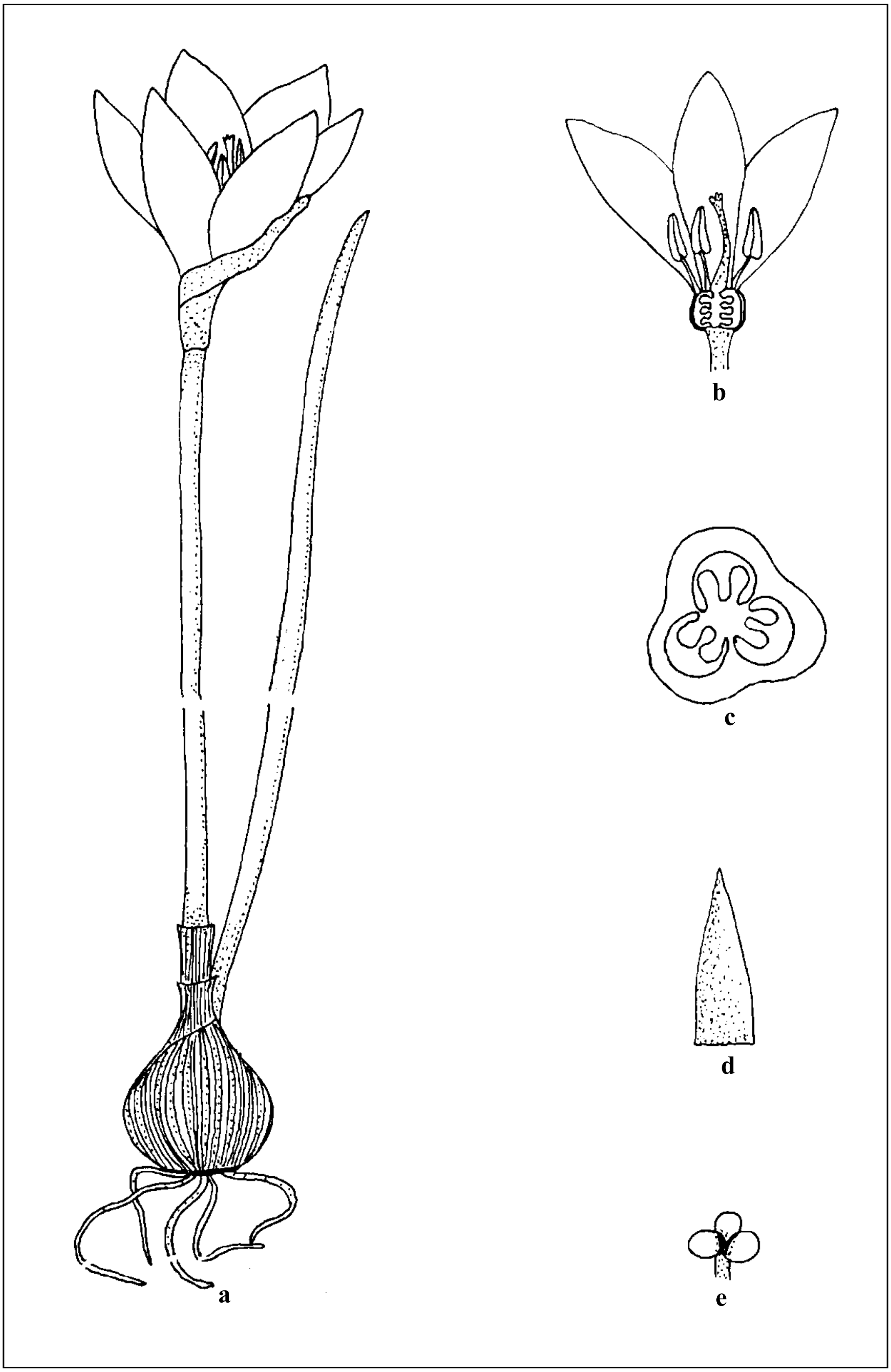


Fig. 35. *Zephyranthes candida* (Lindl.) Herb., a) Habit (×1); b) L.S. of a flower (×1); c) T.S. of ovary (×8); d) Bract (×1); e) Fruit (×1).

Plate 55. *Zephyranthes candida* (Lindl.) Herb., a) Habit; b) Bulb.

3. **Zephyranthes carinata** Herb., Bot. Mag. t. 2594 (1825).

(Fig. 36, Plate 56)

Synonyms: *Zephyranthes rosea* Lindl., Bot. Reg. t. 821 (1824); *Zephyranthes grandiflora* Lindl., Bot. Reg. t. 902 (1825).

English names: Pink Rain Lily, Fairy Lily, Zephar Lily, Pink Storm Lily.

Local name: *Golapi Ghash-phul*.

Description: A bulbous, clump forming perennial herb, bulb tunicated, up to 2 cm across. Leaves simple, exstipulate, linear, obtuse, entire, glabrous, green, up to 35.0 × 0.8 cm, appearing with flowers. Inflorescence solitary on terminal leafless scape. Scape c 18 cm long, light green, produce a single maroon lipstick-like bud on a top, flowers about 7.5 cm long, spreading about 7.5 cm across. The flowers last a few days, closing up at night. Spathe simple, c 2.0 × 0.6 cm, hyaline, tubular, 2-notched. Perianth segments 6 (rarely up to 8), funnel-shaped, rose or pink coloured, 2-4 cm long, sub-elliptic to oblong-lanceolate. Stamens 6, sometimes 7-8, adnate to the throat of the perianth, filaments up to 2 cm long, white, anthers linear, yellow, narrow, dorsifixed. Carpels 3, syncarpous, ovary 3-celled, ovules many in each cell, style filiform, c 2.5 cm long, placentation axile, stigma deeply 3-4 fid. Fruit a capsule, c 0.5 × 0.5 cm, dark green, each fruit contain 6-10 seeds. Seeds black.

Flowering and fruiting: June-October. Blooming soon after a heavy rainfall.

Specimens examined: Dhaka: D.U. Bot. Garden, 19.09.2007, Sumona 45; D.U. Bot. Garden, 24.08.2014, Sumona 92; Nazrul Institute, 20.08.2012, Sumona 76 (DUSH).

Chromosome number: 2n = 24, 36, 48 (Kumar and Subramaniam, 1986).

Habitat: Well-drained soils.

Distribution: Native of Central America and Mexico. Warmer parts of America, widely cultivated in many countries with a warm climate. In Bangladesh, it is widely grown in many gardens.

Economic uses/values/harmful aspects: The species is valued as an ornamental plant, along walkway or at the front of a sunny border.

Propagation: Propagated by bulbs or seeds.

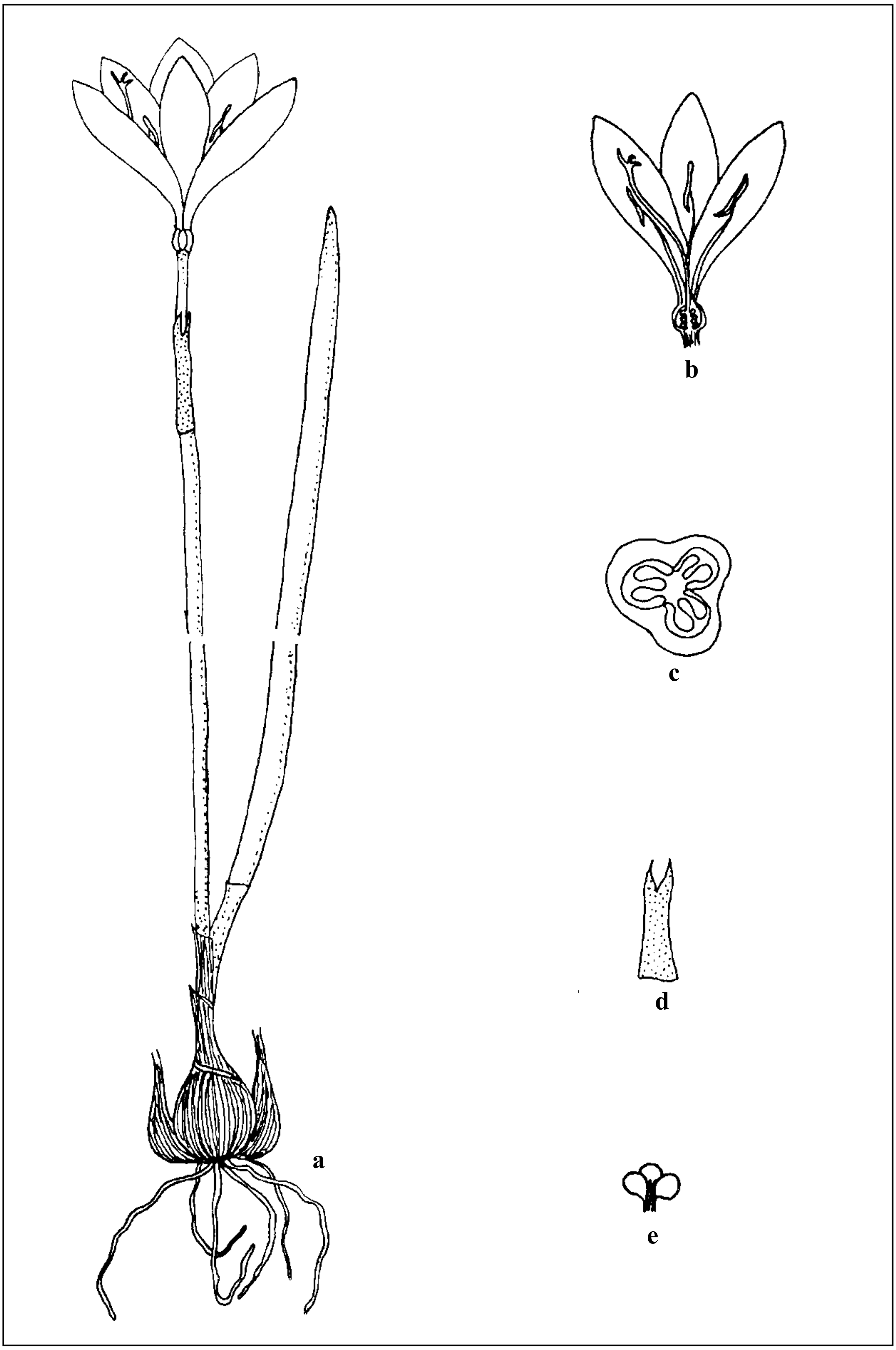


Fig. 36. *Zephyranthes carinata* Herb., a) Habit (×1); b) L.S. of a flower (×1); c) T.S. of ovary (×10); d) Bract (×1); e) Fruit (×1).

Plate 56. *Zephyranthes carinata* Herb., a) Habit; b) Bulb.

4. Zephyranthes tubispatha (L'Her.) Herb. *ex* Traub, Taxon 7: 110 (1958). **(Fig. 37, Plate 57)**

Synonyms: *Amaryllis tubispatha* L'Her., Sert. Angl. 9 (1789), *Zephyranthes nervosa* Herb., Amaryll. 172 (1837).

English names: Zephar Lily, Fairy Lily, Rain Lily.

Local name: *Holde Ghash-phul*.

Description: A small perennial herb with underground tunicated bulb, bulb c 1.5 × 1.0 cm, grows singly. Leaves simple, linear, c 30 cm long and 3 mm broad, green, entire, obtuse, appearing along with the flowers. Flowers solitary, pedunculate, bract spathe-like, c 2.3 cm long, situated at the top of a long (up to 28 cm) fistular scape. Perianth segments 6, connate below, free above, funnel-shaped, c 3.7 cm long, yellow in colour. Stamens 6, anthers linear, dorsifixed, c 0.7 cm long, orange, bursting longitudinally, filaments c 1.4 cm long. Carpels 3, syncarpous, ovary 3-celled, c 0.5 cm long, ovules many, placentation axile, style 1, c 2 cm long, white, stigma short, 3-lobed. Fruit a sub-globose capsule, loculicidally 3-valved, yellowish-green, c 0.8 × 1.0 cm, each fruit contain 16-20 seeds. Seeds oblong, black, angled.

Flowering and fruiting: June-September.

Specimens examined: Dhaka: D.U. Bot. Garden, 26.05.2007, Sumona 37; D.U. Bot. Garden, 10.04.1968, Mozahar 101 (DUSH); Uttara, Sector-3, 18.08.1998, M. Salar Khan K-10115; DU Bot. Garden, 30.06.1970, A.M. Huq 78 (DACB).

Chromosome number: 2n = 24, 25 (Kumar and Subramaniam, 1986).

Habitat: Well-drained soils, grassy ground of hilly areas.

Distribution: Native of Peru, tropical America and the West Indies. The species is planted in gardens and has been naturalized in many countries including Bangladesh.

Economic uses/values/harmful aspects: An ornamental herb.

Propagation: By bulbs and seeds.

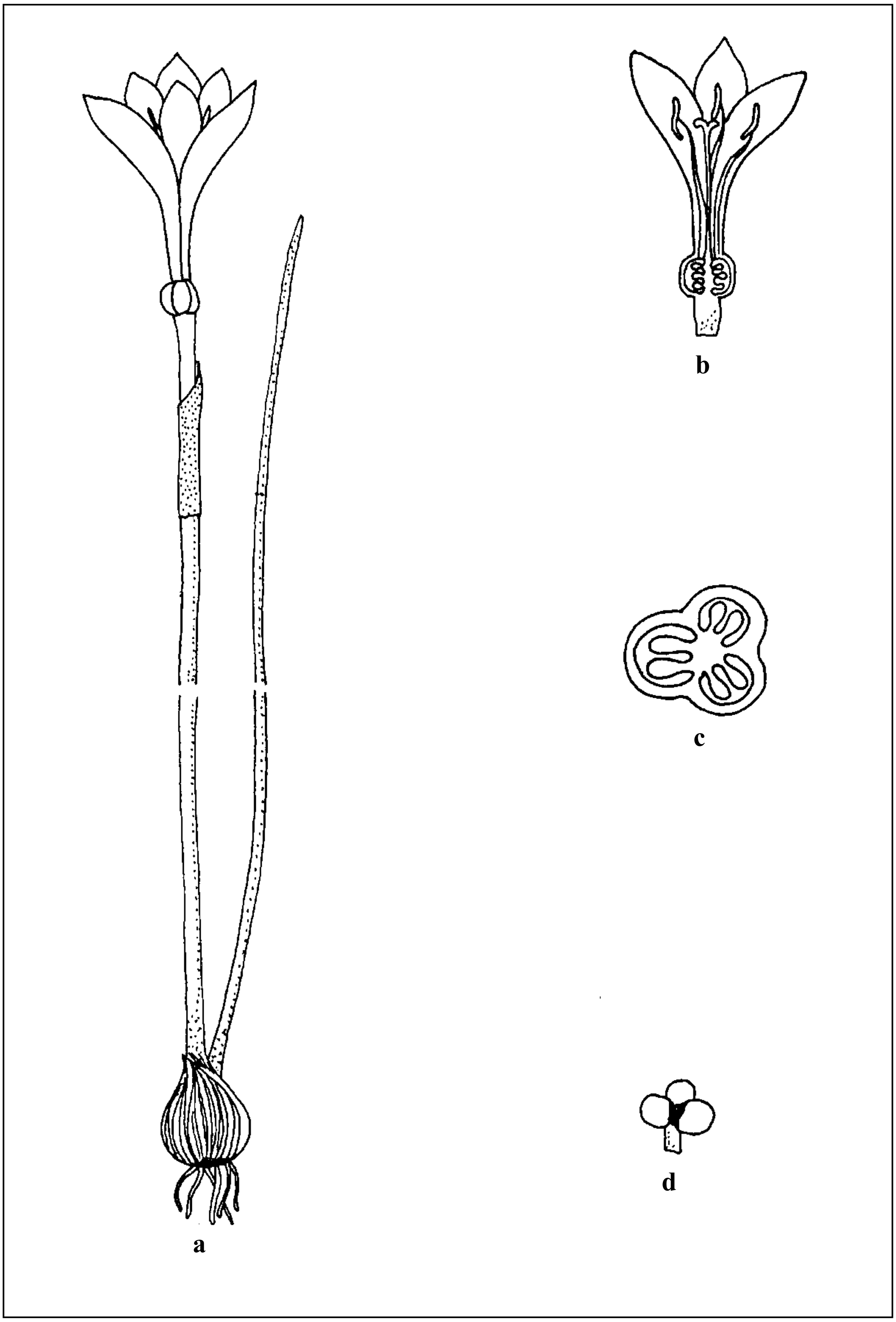


Fig. 37. *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub., a) Habit (×1); b) L.S. of a flower (×1); c) T.S. of ovary (×8); d) Fruit (×1).

Plate 57. *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub., a) Habit; b) Bulbs.

CHAPTER 6

REPRODUCTIVE BIOLOGY

6.1: Introduction to Reproductive Biology

Reproduction is one of the most important characteristics of living organisms and hence it is an important biological process. By this process living organisms produce more individuals of their own kind.

Reproductive biology refers to a collective term applied to all of the many mechanisms, agents, and adaptations involved in the reproductive process of a species. In higher plants, for example, reproductive biology includes floral structure, mode and/or agents of pollination, self or cross-incompatibility, various types of sterility, time and season of flowering, and similar characteristics. Reproductive biology is fundamental to an understanding of the dynamics of any natural population.

Learning the basic mechanics of plant reproductive biology is very important in understanding how to maximize the yield and quality of produced seed. The inherent biological processes of the flower and its sexual parts are often the first place a seed grower looks to when a particular seed crop is not performing adequately, i.e. the quality and quantity of seed is below expectations.

There are two modes of plant reproduction: asexual reproduction and sexual reproduction. Sexual reproduction in plants consists of alternating, multicellular haploid and diploid generations. In angiosperms, the female gametophyte is the embryo sac and the male gametophyte is the pollen. The haploid egg and sperm fuse to form diploid zygotes, from which new sporophytes develop. In asexual reproduction, offspring are produced without meiosis or fusion of gametes and the plant multiplies through tubers, bulbs, corms and other vegetative parts. Sometimes a third mode of reproduction, apomixis, may be distinguished. Apomixis is the formation of new individuals from the sexual organs of a plant, without fertilization (Fryxell, 1957).

Learning the basic flower parts and the various types of flowers will allow monitoring crucial steps in the reproductive process like pollen formation, pollen shed, embryo and seed formation, seed development and maturity. This will enable to troubleshoot any potential problems that may occur in the crops, helping to determine whether the poor performance of any particular seed crop is due to environmental, cultural, or varietal factors that can potentially avoided in subsequent growing seasons.

To understand the mechanism of reproductive biology one should have the basic knowledge on the following concepts:

Panmixis: The interbreeding of all the actively reproducing members of a population in such a way that mating is at random, i.e., each individual has the same probability of mating with any other individual.

Outbreeding (Cross-breeding): A breeding system in which sexual reproduction involves the mating and union of gametes of different individuals (requires cross-pollination in seed plants). The common mode of sexual reproduction in higher animals. In plants outbreeding may be obligate or facultative. The necessity or tendency for outbreeding may be reinforced by dioecism, self-incompatibility, self-sterility, heterostyly and other mechanisms. It is usually aided by wind, insect, or other pollinating agents. Outbreeding may imply mating between individuals which are less closely related than would occur with random mating.

Inbreeding: A breeding system in which sexual reproduction involves the mating and union of gametes of individuals which are more closely related than would occur with random mating. Selfing, sib-mating, and back-crossing (e.g., parent-offspring matings) are examples of close inbreeding. Self-pollination is rather frequent in plants, especially among annuals. It may be obligate (e.g., cleistogamy) or facultative and is often aided by floral adaptations which enhance the opportunities for selfing.

Heterozygosity and Homozygosity: Applied to the presence of a pair of dis-similar or identical homologous alleles (or chromosomes) respectively in the individual, but also used to characterize the relative numbers of such gene pairs in populations. Strict outbreeding produces and maintains relatively high degrees of heterozygosity; strict inbreeding produces and maintains homozygosity.

Inbreeding Depression and Hybrid Vigour: The inbreeding of normally crossbred organisms usually causes depressed vigour and viability because of the increased homozygosity of deleterious genes; outbreeding of normally inbred organisms (and of experimental inbred lines) often results in hybrid vigour. Wide crosses, i.e., between species or genera, sometimes produce extremely vigorous hybrids, but more often the hybrids are relatively weak and infertile.

Heterosis: Superiority of heterozygous genotypes in one or more characters over the corresponding homozygotes, the phenotypic result of gene interaction in the heterozygotes.

Self-Incompatibility: Genetically controlled physiological interactions which prevent or inhibit (partial self-incompatibility) the completion of self-pollination and/or self-fertilization in certain perfect flowered or monoecious plants (e.g., species of *Nicotiana, Hemerocallis, Trifolium*) and thus promote cross-breeding. The same genotypic combinations which cause self-incompatibility also cause cross-incompatibility reactions when they occur in separate individuals which may be otherwise unrelated.

Heterostyly: Combined morphological, physiological, and genetic mechanism in certain angiosperms which promotes cross-breeding. Flowers of two, sometimes three kinds which differ in the relative positions of the styles (and anthers) are produced by separate individuals. Successful pollination and fertilization usually occurs only between flowers which differ, e.g., long styled by short styled or the converse, thus cross-pollination is ensured.

Apomixis: The substitution of some form of asexual reproduction for the sexual process amphimixis in an organism derived from sexually reproducing ancestors. Apomixis should not be confused with amixis, the asexual forms of reproduction which are common in procaryotic organisms.

Clone: All the members of a population of cells or organisms derived asexually from a single individual by vegetative (mitotic) reproduction.

Agamospermy: Includes those forms of apomixis in which seeds are produce by one of a wide variety of asexual processes. Agamospermy does not necessarily produce clones because meiotic segregation and recombination can occur in certain kinds of agamospermy.

Agamic Complex: Complex of hybrid and polyploid forms reproducing by agamospermy so that each original form comes to be represented by an apomictic population. These are extremely difficult taxonomically because each 'population' is actually the extension of a single individual of hybrid origin.

Hybrid: In taxonomy, the result of a cross between two taxa, often inter-specific. In genetics, the result of a cross between any two individuals or races which differ genetically (Radford *et al.*, 1974).

6.2: Reproductive Biology and Plant Taxonomy and Systematics

When we find both inbreeding and out crossing in two closely related species, in a single species, or even in a single plant, it is quite likely that some floral dimorphism will be correlated with the two pollination types. Under reduced pollinator selection the self-pollinated flowers may be smaller, less showy, and have smaller anthers. The ultimate in this type of dimorphism occurs in those plants, such as violets and henbit, which normally produce both open, showy, cross-pollinated chasmogamous flowers and on the same plant also produce small, often drab cleistogamous flowers that never open but self-pollinate within the closed floral envelop. The cleistogamous flowers of henbit (*Lamium amplexicaule*; Lamiaceae), a small winter annual weed of lawns and waste places, are usually produced in the late winter or early spring and are followed shortly by, or even intermixed with, the more showy chasmogamous flowers. In the common purple violet (*Viola papilionacea*; Violaceae), a herbaceous perennial of woodland clearings and open areas, the fragrant and showy chasmogamous flowers appear early in the spring when the days are short and the cleistogamous flowers follow with the longer days of summer as the new crop of leaves mature. Such plants as the violet and henbit thus have very effective mechanisms to insure both outbreeding and inbreeding as a normal part of each reproductive cycle.

However, even in species that are predominantly self-pollinated, there usually remains the capacity for occasional outcrossing and a renewal of heterozygosity. A series of population studies of predominantly self-pollinated species of cultivated plants such as wheat, oats, and lima beans, has shown that normal outcrossing in these closely inbred plants may range from 1-12%. In addition, the heterozygotes appear to be more vigorous and fertile than the homozygotes. This further indicates that self-pollination is a derived type of reproductive process that, under certain current conditions, has a higher selective value than outcrossing despite demonstrated heterosis.

The extend to which pollinators and reproductive methods may modify floral structures within a single family is well illustrated by Verne Grant's studies (1965) on pollination in the Polemoniaceae (where plants in individual species in various genera either self-pollinated or are pollinated by a series of flies, bees, butterflies, birds and bats) and the work of Leppik (1964) on floral evolution in the Ranunculaceae. In each instance floral modifications can be correlated with the type of pollinators, thus indicating something of the role of pollinating mechanisms, and pollinators, in both interspecific isolation and speciation. Some of the more common insect polinator-flower relationships pointed out by van der Pijl (1960-61) and by Faegri and van der Pijl (1966) has been summarized by Baker and Hurd (1968).

The evolutionary, and taxonomic consequences of the various floral adaptations or modifications associated with xenogamy, autogamy, dioecism, heterostyly, apomixis, cleistogamy and other aspects of sexual or asexual reproduction provide an interesting, and almost unlimited, field of biological study for those interested in 'getting behind the scenes' in systematic work where data are accumulated and attempts are made to answer the question 'why' in regard to certain types and patterns of plant variation upon which we base many of our taxonomic conclusions.

6.3: Reproductive Biology Study Methods

Careful field observations will usually indicate pollinator type and specificity as well as the sequence of anthesis within a single flower, an inflorescence, or for an entire plant. The functional details of flowers structure are also often best studied in the field although laboratory observations are obviously required for the details of floral morphology which can be observed fresh (for ultraviolet patterns not otherwise apparent), cleared (for venation patterns and other anatomical detail) or otherwise prepared (for chemical analysis or electron microscope observation). Pollen studies (size, viability, morphology) are easily organized into blocks of laboratory activity, as are the cytological studied that are necessary part of any detailed reproductive biology research. However, compatibility studies, tests for apomixis, and experimental hybridization require experimental field plots or suitable greenhouse space (Radford *et al.*, 1974).

6.4: Study of Floral Structure

For each species at least 10 flowers were observed, dissected and studied carefully to know detailed floral structures and their mode of arrangement.

6.5: Mode of Pollination Study

To understand the pollination mechanism, bagging experiments were carried out. Bags of appropriate size of fine muslin cloth were used for bagging the inflorescence of individual plants at a stage when all flowers of the raceme were in unopened condition. During bagging an inflorescence, open flowers, if any, were manually removed so that only unopened buds remained. Bagged inflorescences were kept under frequent observations for fruit formation which were compared with that of the plants kept under control (Hassan and Khan, 1996).

10 flowers tagged but otherwise left open/un-bagged as a control to determine normal seed set.

10 flowers baged, tied in bud, or otherwise protected, and then self-pollinated to test for self-compatibility, which would be indicated by full fruit set.

10 flowers baged and left alone to test for self-pollination; normal fruit set indicates self-pollination and self-fertility (or apomixis).

10 flowers baged and emasculated to test for apomixis; fruit set under these conditions would indicate apomixis (Radford *et al.*, 1974).

In case of cross-pollination, insects that visited the flowers were collected and examined where available. The identification of insects was made as per direction of Dr. Md. Abul Bashar, Entomologist, department of Zoology, University of Dhaka.

6.6: Study of Seed Germination

The germination response pattern of seed is an important phenomenon in plant life history strategy (Mayer and Poljakoff-Mayber, 1989).

1. Collection of seeds: Seeds were collected from mature fruits for germination experiment and preserved under laboratory condition. Times taken for maturation of fruits from flowers initiation and maturation of seeds from immature fruits were calculated. Comparatively large, dark colour and thick seeds were considered as matured. Gerry and Wilson (1995) states that the number of days for germination is positively related to seed size, the largest seeds germinated faster than the smaller seeds. The results obtained from the present study support the hypothesis of Gerry and Wilson (1995).

2. Sowing of seeds: Earthen pots of 10 inch in diameter filled up with a mixture of soil and compost (2:1) were used for seed sowing (Plate-58). At least 5 (usually 10 in most cases) mature seeds for each species were tested for germination. Mature seeds were sown at the same date after one month interval of the year. Watering was done regularly to record dormancy and viability, suitable time for germination, percentage and type of germination. Germination defined as shoot emergence from seeds was

Preparation of Soil for Seed Sowing

Plate 58. Preparation of soil for seed sowing, a) 1:2 soil and compost; b) mixing soil and compost; c) Earthen pot and mixed composed soil; d) Sowing seeds.

checked regularly. Percent of germination was calculated by the numbers of seeds germinated in relation to total initial seed number sown. The time of 1-leaved stage was determined and measurement of seedlings in this stage was calculated.

i) Long time taken to germinate indicate some dormancy period.
ii) High rate of germination indicates suitable time for sowing.
iii) No seed germination indicating loss of viability of seeds in normal storage system.

Knowledge on reproductive biology helps a taxonomist to

i) delimit taxa,
ii) understand complexity of the gradation of characters within the range of a species,
iii) determine a hybrid,
iv) understand why a species is becoming rare or endangered, and finally
v) suggest proper methods of regeneration and reestablishment of a rare species, that is an effective conservation method.

6.7: Materials and Methods

Out of 43 species, the following 14 species have been selected for study based on seed formation by the plant, medicinal value and availability of plant specimens.

1. *Allium tuberosum* Rottler *ex* Spreng.
2. *Asparagus racemosus* Willd.
3. *Chlorophytum nepalense* (Lindley) Baker
4. *Crinum amoenum* Roxb.
5. *Curculigo orchioides* Gaertn.
6. *Gloriosa superba* L.
7. *Hemerocallis fulva* L.
8. *Pancratium triflorum* Roxb.
9. *Scadoxus multiflorus* Raf.
10. *Urginea indica* (Roxb.) Kunth
11. *Zephyranthes atamasco* (Linn.) Herb.
12. *Zephyranthes candida* (Lindl.) Herb.
13. *Zephyranthes carinata* Herb.
14. *Zephyranthes tubispatha* (L'Her.) Herb.

The study of reproductive biology has been done at the Botanical Garden under Department of Botany, University of Dhaka. Selected species have been collected from different places of the country and cultivated in Botanical Garden, Dhaka University. A minimum of 5 flowers have been selected in each treatment. Mature seeds have been collected at appropriate time. Where seeds did not form, other suitable parts have been tried for vegetative propagation. Data were recorded under various flowering characters which are important for breeding viz., duration and habit of flowering, raceme development, anthesis and dehiscence, mode of pollination and fruit development. The mode of pollination was observed by fruit setting within bagged and open flower condition. Vegetative propagation (reproduction) is quite common among the family Liliaceae and can take place by the formation of new plants from bulbs, rhizomes, tubers, stolons and root divisions which become repeated from the parent plant. Therefore, propagation by vegetative parts is also tried where it was necessary. Collected seeds from mature fruits were sown at regular intervals to record dormancy period (if any), time taken to germinate and optimum period of the year for successful germination. Development from scape initiation to fruit maturation were also studied.

6.8: Soil Analysis

Two types of soil (normal garden soil and compost) were used for seed germination experiments (Plate-58). Physical and chemical soil properties of these two types of soil have been carried out for comparative study under the Laboratory of Ecology, Department of Botany.

Determination of soil p^H

Soil p^H was recorded in the laboratory within 24 hours after collection from the field. Soil p^H was determined in suspension with distilled water (2:1, v:w). 10 g soil was taken in a beaker and then 20 ml distilled water was added to make a suspension by shaking well. The suspension was kept for a while for settling down of the particles. The p^H meter (Hanna p^H meter, p^He^P) was calibrated with known p^H. Then, the pH values were recorded for each of the soil sample.

Determination of soil moisture content

For the determination of soil moisture content, 10g fresh soil was taken into a cup made with aluminum foil and then kept in an oven at 60^0C temperatures for 24 hours. Soil moisture content was determined by the following formula:

Soil moisture content (%) $=\frac{F-D}{D} \times 100$

Where, F= Weight of fresh soil

D= Weight of dry soil

Determination of soil conductivity

Soil conductivity was recorded in the laboratory within 24 hours after collection from the field. Soil conductivity was determined in suspension with distilled water (5:1, v: w). 10 gm soil was taken in a beaker and then 50 ml distilled water was added to make a suspension by shaking well. The suspension was kept for a while for settling down of the particles. The conductivity meter was calibrated with known conductivity. Then, the conductivity values were recorded for each of the soil sample.

Determination of soil organic carbon

Organic carbon of the soil was determined by Walkley and Black method (Black, 1965). For determination of soil organic carbon, 2.0 g soil which was passed through 2 mm sieve was weighted and transferred to a 500 ml clean dry conical flask. 10 ml of normal potassium dichromate solution was added. Then 10 ml conc. H_2SO_4 was added and mixed thoroughly. The flask was allowed to cool on a sheet of asbestos with occasional shaking for half an hour. After changing the colour into green, an additional 10 ml $K_2Cr_2O_7$ was added.

After half an hour when the flask was cool, approximately 150 ml distilled water, 10 ml phosphoric acid and 0.2 g of sodium fluoride was added. Then 3 ml of diphenylamine indicator was added. The colour of the solution was deep violet. The excess of chromic acid left in the flask was titrated with the help of normal ferrous sulfate solution. Lastly the colour of the solution was changed to deep bottle green. A blank experiment was done in the same way with all reagents except soil.

Calculation

1000 ml of N $K_2Cr_2O_7$ = 1000 ml of N C = 3 g of C

(eq. wt. of C = 12/4= 3)

Or, 1 ml of N $K_2Cr_2O_7$ solution = 0.003 g of C

$$\% \text{ of organic carbon} = \frac{(B-T)\times f \times 0.003\times 100}{W}$$

Where,

B = Amount in ml of N $FeSO_4$ solution required in this experiment

T = Amount in ml of N $FeSO_4$ solution required in experiment with soil

f = Strength of N $FeSO_4$ solution (from blank experiment)

W = Weight of soil taken

Determination of available nitrogen of soil

Available nitrogen in soil was determined by following the Kjeldahl method (Black, 1965). For determination of available nitrogen, 5g soil was taken in a 100 ml plastic bottle. 50 ml 1N KCl solution was added to it and shaken and then it was left for 1 hour. Then the samples were filtered with Whatman filter paper. Then, 10 ml of extract was distilled with 10 ml of 10%NaOH using micro Kjeldahldistillation apparatus. 0.2 g devarda's alloy was added into the funnel where sample and 10% NaOH were given. The distillate was collected in 10 ml 2% H_3BO_3 until the volume was about 50 ml. About 60 ml volume of distillate (ammonium borate) was collected in a 125 ml conical flask containing 10 ml of boric acid with mixed indicator. Then, the distillate was titrated against the standard H_2SO_4. The end point was indicated by pink color of the solution. A blank experiment was done simultaneously using all the chemicals except soil.

Calculation

1000 ml 1N H_2SO_4 = 1000 ml normal nitrogen = 14 g nitrogen.

Or 1 ml of 1N H_2SO_4 = 0.014 g N

$$\% \text{ of available nitrogen} = \frac{(T-B)\times f \times .014\times 100\times 50}{W\times \text{volume of extract used}}$$

Where,

B = Amount in ml of N/100 H_2SO_4 required in titration of the blank experiment

T = Amount in ml of N/100 H_2SO_4 required in titration of the experiment with soil

f = Normality factor of N/100 H_2SO_4 (=0.0112 N)

W = Weight of soil

Determination of phosphorus content of soil

For the determination of soil phosphorus content, 2gm finely powdered soil was taken in a beaker. 10 ml HNO_3 was added to it and dried. Then 5 ml $HClO_4$ was added to it and dried again. Little amount of soil was added and filtrated. 4 ml of this solution was taken into a 25 ml volumetric flask. 5 ml coloring reagent was added and finally made volume up to 25 ml in volumetric flask with distilled water.

A blank experiment was done simultaneously using all the chemicals except soil. 5 standard solutions were prepared by using all chemicals and phosphorus of known concentration 0, 0.5, 1.0, 1.5, 2.5 instead of soil. Absorbance was determined using a spectrophotometer at 440 nm. By using the absorbance of 5 concentrations standard curves was drawn and from this standard curve concentration of sample phosphorus was determined.

Calculation

Percentage of P was calculated by using following formula:

$$\% \text{ P} = \frac{\text{PPM} \times 25 \times 50 \times 100}{\text{Vol. taken for color} \times \text{wt of soil} \times 10^6}$$

The present study evident that all physico-chemical properties, especially moisture content, of compost soil are higher than garden soil (Table 7).

Table 7. Mean values of soil properties.

Parameters	Garden soil	Compost soil
pH	6.68	6.78
Conductivity (µs/cm)	87.9	89.3
Moisture (%)	12.99	65.29
Organic Carbon (%)	1.85	2.22
Available Nitrogen (%)	0.005	0.015
Total Phosphorus (%)	0.10	0.17

6.9: Experiments and Results

Allium tuberosum Rottler *ex* Spreng.

The species is ornamental as well as medicinal. Used as vegetable for garlic like flavour. The whole plant is antibacterial and anti-emetic that improves kidney function. The leaves and the bulbs are applied to bites, cuts and wounds.

POLLINATION

The present stydy revealed that *Allium tuberosum* Rottler *ex* Spreng. produced no fruit under bagged condition although in the same period of time fruits were recorded in the un-bagged plants specify cross-pollination (Table 8).

Table 8. Bagging experiment of *Allium tuberosum* Rottler *ex* Spreng. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	05-09-2013	10	-	-	Cross-pollinated
Un-bagged Plant	05-09-2013	10	+	20	
Emasculated flowers	05-09-2013	10	-	-	

Pollen transfer may be occurred by two kinds of pollinators under the family Formicidae and Apidae. **(Plate 59)**

Plate 59. *Allium tuberosum* Rottler *ex* Spreng., a-b) Pollinators.

Plate 60. *Allium tuberosum* Rottler *ex* Spreng., a) Fruit burst; b) Seeds; c-d) Seedlings.

SEED GERMINATION

Results of the present study in *Allium tuberosum* Rottler *ex* Spreng. evident that minimum 6 days required for seed germination after sowing (average 7 days). Percentage of seed germination is highest in the month of October-November (Table 9).

Table 9. Seed germination experiment of *Allium tuberosum* Rottler *ex* Spreng.

(Plate 60)

Date of seed collection	Date of seed sown	No. of seeds sown	Date of germination	No. of seed germinated	Time taken for germination (days)
19-10-2013	19-10-2013	10	26-10-2013	5 (50%)	7
	19-11-2013	10	27-11-2013	5 (50%)	8
	19-12-2013	10	25-12-2013	3 (30%)	6
	19-01-2014	10	27-12-2013	1 (10%)	7
	19-02-2014	10	-	-	-
	19-03-2014	10	-	-	-
	19-04-2014	10	-	-	-

No dormancy period present. Seeds lost their viability completely after four months since not a single seed was germinated after that period.

DEVELOPMENT

The flowers opening in *Allium tuberosum* Rottler *ex* Spreng. start c 21 days after arising the scape and fruit formation starts about 7 days after flowering (Table 10).

Table 10. Development from scape initiation to fruit maturation of *Allium tuberosum* Rottler *ex* Spreng.

(Plate 61)

Serial No.	Date	No. of flower/s open	No. of fruits formed	No. of fruits ripe
1.	10-08-2014	**Scape arising start**		
2.	31-08-2014	3		

3.	01-09-2014	4		
4.	02-09-2014	2		
5.	03-09-2014	3		
6.	04-09-2014	4		
7.	05-09-2014	4		
8.	06-09-2014	2		
9.	07-09-2014	4	3	
10.	08-09-2014	5	2	
11.	09-09-2014	2	-	
12.	10-09-2014	2	2	
13.	11-09-2014	3	1	
14.	12-09-2014	4	2	
15.	13-09-2014	1	1	
16.	14-09-2014	2	3	
17.	15-09-2014	1	6	
18.	16-09-2014	-	3	
19.	17-09-2014	2	4	
20.	18-09-2014	-	3	
21.	19-09-2014	1	4	
22.	20-09-2014		3	
23.	21-09-2014		3	
24.	29-09-2014			3
25.	30-09-2014			3
26.	01-10-2014			1
27.	02-10-2014			3
28.	03-10-2014			1
29.	04-10-2014			2
30.	05-10-2014			5
31.	06-10-2014			3
32.	07-10-2014			5
33.	08-10-2014			4
34.	09-10-2014			3
35.	10-10-2014			3
Total	**35 days**	**49 flowers**	**40 fruits formed**	**36 fruits riped**

About 30-50 mature fruits formed per scape from c 40-60 flowers. Each fruit contain 1-6 seeds.

Seeds per fruit in *Allium tuberosum* Rottler *ex* Spreng. were counted and arranged from lower to higher in Table 11.

Table 11. Total number of seeds per scape in *Allium tuberosum* Rottler *ex* Spreng.

Sl. No.	**No. of fruits**	**No. of seed/s per fruit**	**Total no. of seeds**
1.	4	1	$1 \times 4 = 4$
2.	6	2	$2 \times 6 = 12$
3.	5	3	$3 \times 5 = 15$
4.	8	4	$4 \times 8 = 32$
5.	10	5	$5 \times 10 = 50$
6.	3	6	$6 \times 3 = 18$
Total	**36**		**131**

VEGETATIVE PROPAGATION

Results of propagation experiment in *Allium tuberosum* Rottler *ex* Spreng. are depicted in Table 12.

Table 12. Propagation experiment of *Allium tuberosum* Rottler *ex* Spreng.

(Plate 62)

Date of bulb transfer	**Size of bulb (cm)**	**Date of seed sown**	**Date of flowering**		**Average time for flowering**	
			From bulb	**From seed**	**From bulb**	**From seed**
09-10-09	1.3×0.7		04-09-11		c 2 years	
		09-10-09		10-09-13		c 4 years

From the Table 12 it is concluded that seed propagation is more time consuming than bulb transfer. Plants propagated from seeds take c 4 years to bloom where c 2 years from bulb (attached with rhizome) separation.

Plate 61. *Allium tuberosum* Rottler *ex* Spreng., a) Buds within spathe; b) Flowers; c) Fruits formation; d) Fruit burst.

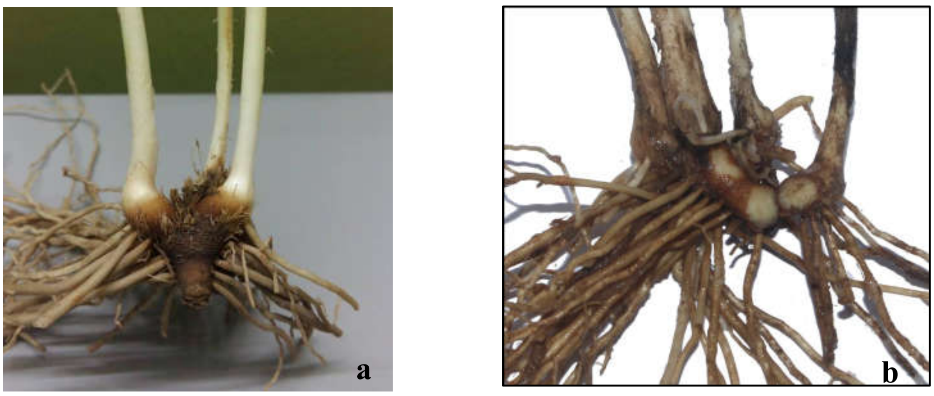


Plate 62. *Allium tuberosum* Rottler *ex* Spreng., a-b) Bulbs with rhizome.

Asparagus racemosus Willd.

Medicinally important plant. Ethanolic extracts of aerial parts possess anti-cancer properties. Tuberous roots are used in diseases of the kidney and the liver, scalding urine, gleet, gonorrhoea etc.

POLLINATION

The present study revealed that *Asparagus racemosus* Willd. produced no fruit under bagged condition although in the same period of time fruits were recorded in the un-bagged plants specify cross-pollinated (Table 13).

Table 13. Bagging experiment of *Asparagus racemosus* Willd. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	20-12-2010	18	-	-	Cross-pollinated
Un-bagged Plant	20-12-2010	18	+	6	
Emasculated flowers	20-12-2010	18	-	-	

Pollen transfer may be occurred by one kind of Bee under the family Apidae. **(Plate 63)**

SEED GERMINATION

The present study in *Asparagus racemosus* Willd. evident that seeds taken minimum time c 15 days after sowing for germination. Percentage of seed germination is highest in the month of April-May when sown after collection (Table 14).

Plate 63. *Asparagus racemosus* Willd. Pollinator.

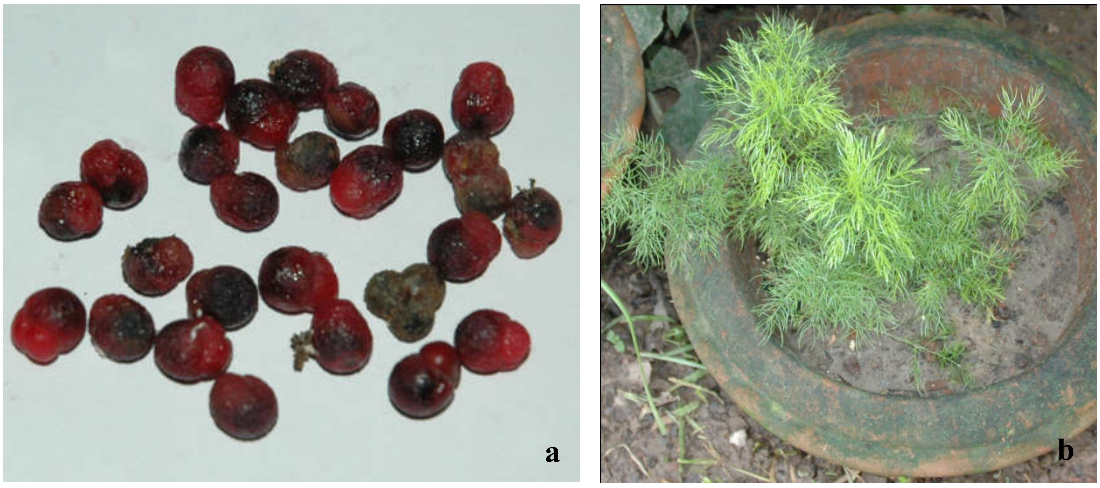


Plate 64. *Asparagus racemosus* Willd., a) Seeds; b) Seedlings.

Table 14. Seed germination experiment in *Asparagus racemosus* Willd.

(Plate 64)

Sl. No.	Date of seed collection	Date of seed sown	No. of seeds	Date of germination	No of seed germinated	Time taken for germination (days)
1.	09-04-2009	09-04-2009	10	24-04-2009	5 (100%)	15
2.		09-05-2009	10	24-05-2009	5 (50%)	15
3.		09-06-2009	10	30-06-2009	1 (10%)	21
4.		09-07-2009	10	28-07-2009	1 (10%)	18
5.		09-08-2009	10	-	-	-
6.		09-09-2009	10	-	-	-
7.		09-10-2009	10	-	-	-
8.		09-11-2009	10	-	-	-
9.		09-12-2009	10	-	-	-
10.		09-01-2010	10	-	-	-

Seeds lost their viability after four months. The type of seeds germination is Hypogeal.

DEVELOPMENT

Results of development from scape initiation to fruit maturation in *Asparagus racemosus* Willd. is depicted in Table 15.

Table 15. Development from scape initiation to fruit maturation of *Asparagus racemosus* Willd.

(Plate 65)

Serial No.	Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s matured
1.	06-12-2013	**Scape arising start**		
2.	14-12-2013	8		
3.	15-12-2013	22		
4.	16-12-2013	20		
5.	17-12-2013	8		
6.	22-12-2013		6	
7.	23-12-2013		4	
8.	27-12-2013		(2 fall)	
9.	29-12-2013		(2 fall)	
10.	02-02-2014			6
11.	05-02-2014			2
Total	**59 days**	**58 flowers**	**10 fruits**	**8 fruits**

Plate 65. *Asparagus racemosus* Willd., a) Buds; b) Flowers (greenish white); c) Flowers (light pink); d) Flowers (maroon); e) Unripe fruits; f) Ripe fruits.

From Table 15 it is stated that the flowers opening take c 8 days after scape initiation. Fruit formation takes about 16 days after flowering. Fruit maturation takes c 50 days after fruit formation. Flowers are gradually greenish-white at initiation, then light pink and lastly dark-maroon in colour. Flowers of this species opened for 10-15 days without closing and turned to fall or become fruits. Number of fruit formation is very poor in compare to the number of flowers.

Tuberous root formation of *Asparagus racemosus* Willd. has been observed after seed germination. Tuber formation was observed after one month interval. Results of tuberous root formation are summarized in Table 16.

Table 16. Tuberous root formation of *Asparagus racemosus* Willd.

(Plate 66)

Date of seed germination	**Date of tuber formation**	**No. of tuber formation**	**Size of tuber**	**No. of aerial shoots**	**Length of aerial shoots**
24-04-2009	10-07-2009	1	1.2 × 0.2 cm	1	12 cm
	25-07-2009	2	1.5 × 0.3 cm 1.6 × 0.3 cm	3	12-17 cm
	25-08-2009	4	2.5 × 0.4 cm 3.0 × 0.3 cm 1.7 × 0.4 cm 1.4 × 0.4 cm	4	10-27 cm
	25-09-2009	6	2.5 × 0.4 to 3.3 × 0.6 cm	5	
	25-10-2009	8	3.0 × 0.4 to 4.0 × 0.6 cm	6	
	25-11-2009	10	3.0 × 0.4 to 4.6 × 0.8 cm	6	
	25-12-2009	12	3.2 × 0.5 to 4.8 × 1.0 cm	6	
	25-01-2009	14	3.3 × 0.6 to 5.5 × 1.5 cm	6	
	25-02-2010	16	3.3 × 0.6 to 6.0 × 1.5 cm	1 climbing stem appear	
	19-03-2013	40	3.3 × 0.6 to 6.0 × 1.5 cm	4 climbing stem appear	

Plate 66. *Asparagus racemosus* Willd., a) Single tuberous root after 76 days; b) Four tuberous roots; c) Forty tuberous roots after 4 years.

From the Table 16 it is concise that first small tuberous root is noticed after 76 days of seed germination. About 40 tuberous roots formed after c 4 years. Length of a large size tuberous root is c 6.0 centimeter. It is the tuberous roots which are used as drugs.

VEGETATIVE PROPAGATION

The present study shows that seed propagation is the only way to propagate of *Asparagus racemosus* Willd. while tuber transfer is not possible (Table 17).

Table 17. Results of propagation experiment of *Asparagus racemosus* Willd.

Date of tuber transfer	**Size of tubers (cm)**	**Date of seed sown**	**Date of flowering**		**Average time for flowering**	
			From tuber	**From seed**	**From tuber**	**From seed**
09-04-2009	16.0 × 1.5 16.2 × 1.6 16.9 × 2.0		-		-	
		09-04-09		09-12-13		4 years

Tiller transfer may be possible.

Chlorophytum nepalense (Lindley) Baker

Taxonomically very important species. The species is perhaps by this time become extinct from Bangladesh territory.

POLLINATION

The present study revealed that *Chlorophytum nepalense* (Lindley) Baker produced no fruit under bagged condition although in the same period of time fruits were recorded in the un-bagged plants indicating that the species is cross-pollinated (Table 18).

Plate 67. *Chlorophytum nepalense* (Lindley) Baker, a) Bagging condition; b) Pollinator.

Table 18. Bagging experiment of *Chlorophytum nepalense* (Lindley) Baker ('+' indicates positive fruit setting, '-' indicates no fruit setting).

(Plate 67)

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	06-04-2010	30	-	-	Cross-pollinated
Un-bagged Plant	06-04-2010	30	+	5	
Emasculated flowers	06-04-2010	30	-	-	

Pollen transfer may be occurred by one kind of ant (Fam. Apidae).

SEED GERMINATION

Seeds taken minimum time c 17 days after sowing for germination in *Chlorophytum nepalense* (Lindley) Baker and percentage of seed germination is highest in the month of June (Table 19).

Table 19. Seed germination experiment of *Chlorophytum nepalense* (Lindley) Baker

(Plate 68)

Sl. No.	**Date of seed collection**	**Date of seed sown**	**No. of seeds**	**Date of germination**	**No of seed germinated**	**Time taken for germination (days)**
1.	07-07-09	14-07-09	5	-	-	
2.	07-07-09	25-07-09	5	-	-	
3.	18-07-09	25-08-09	5	-	-	
4.	18-07-09	20-09-09	5	-	-	
5.	18-07-09	18-10-09	5	-	-	
6.	25-07-09	11-11-09	5	-	-	
7.	27-07-09	14-05-10	5	04-06-10	3 (60%)	c 20
8.	27-07-09	21-06-10	5	08-07-10	2 (40%)	17
9.	27-07-09	23-07-10	5	-	-	
10.	28-08-09	23-08-10	5	-	-	

Plate 68. *Chlorophytum nepalense* (Lindley) Baker, a) Seeds with fruit coats; b) Seedlings.

From the Table 19 it is evident that seeds have near about 11 month's dormancy period in *Chlorophytum nepalense* (Lindley) Baker and after 12 months lost their viability.

DEVELOPMENT

The plant was first collected in the month of March 2008 with 3 opened flowers. Two flowers were dissected for correct identification purposes and remain did not set fruit. In March 2009, scape arising started and the last fruit burst in the month of August. An exception of flowering season was seen in 2010. Scape arising started in the month of September 2010 and the last fruit burst in the month of November. In 05-11-2009 one new bulb arises from the side of rhizome and many tuberous roots were also seen. In 03-12-2009 all leaves defoliated and in 14-12-2009 the plant totally rotten. Some seeds were collected from that plant and got 3 new plants in June and 2 in July 2010 through seeds. Among them 3 plants survive till December 2014 while 2 died. First flowering of the new three plants occurred in 2012 and similarly 2013.

Results of development from scape initiation to fruit maturation in *Chlorophytum nepalense* (Lindley) Baker are presented in Table 20.

Table 20. Development from scape initiation to fruit maturation of *Chlorophytum nepalense* (Lindley) Baker

(Plate 69)

Sl. No.	Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s burst
1.	25-03-09 (Wed)	Scape arising start		
2.	08-04-09 (Wed)	1		
3.	09-04-09 (Thu)	2		
4.	11-04-09 (Sat)	1		
5.	13-04-09 (Mon)	4		
6.	16-04-09 (Thu)	3		
7.	20-04-09 (Mon)	2		
8.	21-04-09 (Tue)	2		
9.	22-04-09 (Wed)	8		
10.	25-04-09 (Sat)	6		
11.	27-04-09 (Mon)	7		
12.	28-04-09 (Tue)	2		
13.	29-04-09 (Wed)	3	4	

Sl. No.	Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s burst
14.	30-04-09 (Thu)	4	-	
15.	02-05-09 (Sat)	-	1	
16.	03-05-09 (Sun)	2	-	
17.	04-05-09 (Mon)	-	-	
18.	05-05-09 (Tue)	1	-	
19.	06-05-09 (Wed)	2	-	
20.	08-05-09 (Thu)	-	-	
21.	09-05-09 (Sat)	2	1	
22.	10-05-09 (Sun)	-	-	
23.	12-05-09 (Tue)	1	4	
24.	13-05-09 (Wed)	-	2	
25.	15-05-09 (Thu)	-		
26.	16-05-09 (Sat)	-	3	
27.	17-05-09 (Sun)	2		
28.	18-05-09 (Mon)	1		
29.	21-05-09 (Thu)	3		
30.	26-05-09 (Tue)	1		
31.	06-07-09 (Sun)			1
32.	07-07-09 (Mon)			2
33.	09-07-09 (Wed)			1
34.	10-07-09 (Fri)			1
35.	15-07-09 (Wed)			1
36.	22-07-09 (Thu)			1
37.	25-07-09 (Sat)			1
38.	27-07-09 (Mon)			4
39.	28-07-09 (Tue)			1
40.	03-08-09 (Tue)			1
41.	06-08-09 (Thu)			1
Total	**131 days**	**60 flowers**	**15 fruits**	**15 fruits**

From this experiment, it is revealed that flowers opening start c 12 days after arising the scape and fruit formation starts about 21 days after flowering. About 10-15 mature fruits formed per scape from c 30-60 flowers.

Plate 69. *Chlorophytum nepalense* (Lindley) Baker, a) Tuberous roots with axial bulb; b) Scape initiation; c) Fruit formation with flowers; d) Mature fruits; e) Fruits burst.

Seeds per fruit of *Chlorophytum nepalense* (Lindley) Baker were counted and arranged from lower to higher in Table 21. Each fruit contain 1-11 seeds but most of the fruit have 7 seeds.

Table 21. Total number of seeds per scape of *Chlorophytum nepalense* (Lindley) Baker

Sl. No.	No. of fruit/s	No. of seeds per fruit	Total no. of seeds
1.	1	1	1 × 1 = 1
2.	1	2	2 × 1 = 2
3.	1	3	3 × 1 = 3
4.	2	4	4 × 2 = 8
5.	2	5	5 × 2 = 10
6.	1	6	6 × 1 = 6
7.	4	7	7 × 4 = 28
8.	1	8	8 × 1 = 8
9.	1	9	9 × 1 = 9
10.	1	11	11 × 1 = 11
Total	**15**		**86**

Experiments on development for that three new plants of *Chlorophytum nepalense* (Lindley) Baker reproduced by seeds have been carried out to specify a part of its life cycle specially flowering and fruiting period.

Plant-1

Results of development from scape initiation to fruit formation in *Chlorophytum nepalense* (Plant-1) are summarized in Table 22.

Table 22. Development from scape initiation to fruit formation of *Chlorophytum nepalense* (Lindley) Baker (Plant-1)

Sl. No.	Date	No. of flower/s opened	No. of fruit/s formed
1.	27-04-2013	**Scape arising start**	
2.	06-05-2013	1	
3.	07-05-2013	2	

Sl. No.	Date	No. of flower/s opened	No. of fruit/s formed
4.	11-05-2013	4	1
5.	13-05-2013	6	1
6.	14-05-2013	8	4
7.	15-05-2013	6	6
8.	16-05-2013	3	4
9.	18-05-2013	6	4
10.	19-05-2013	4	3
11.	21-05-2013	6	2
12.	22-05-2013	5	2
13.	23-05-2013	6	2
14.	26-05-2013	2	2
15.	29-05-2013	2	1
16.	01-06-2013		1
17.	02-06-2013		1
Total	**35 days**	**61 flowers**	**34 fruits**

Seeds per fruit and total number of seeds per scape of *Chlorophytum nepalense* in Plant-1 were counted and arranged in Table 21.

Table 23. Total number of seeds per scape of *Chlorophytum nepalense* (Lindley) Baker (Plant-1)

Date of fruits ripe & collection	Number of fruit/s	Total number of seeds
16-07-2013	4	38
18-07-2013	6	55
20-07-2013	5	11
21-07-2013	9	71
27-07-2013	3	31
28-07-2013	5	20
29-07-2013	2	7
Total	**34**	**233**

Plant-2

Results of development from scape initiation to fruit formation in *Chlorophytum nepalense* (Plant-2) are summarized in Table 24.

Table 24. Development from scape initiation to fruit formation of *Chlorophytum nepalense* (Lindley) Baker (Plant-2)

Sl. No.	Date	No. of flower/s opened	No. of fruit/s formed
18.	10-05-2013	**Scape arising start**	
19.	21-05-2013	1	
20.	22-05-2013	2	
21.	23-05-2013	6	
22.	24-05-2013	4	
23.	25-05-2013	2	
24.	26-05-2013	5	6
25.	27-05-2013	6	4
26.	28-05-2013	4	2
27.	29-05-2013	2	3
28.	30-05-2013	5	2
29.	01-06-2013	3	1
30.	02-06-2013	6	3
31.	03-06-2013	2	2
32.	04-06-2013	1	1
33.	05-06-2013	4	1
34.	06-06-2013	2	2
35.	08-06-2013	1	1
36.	09-06-2013		2
37.	10-06-2013		1
38.	15-06-2013		2 fruits not matured
Total	**35 days**	**56 flowers**	**29 fruits**

Seeds per fruit and total number of seeds per scape of *Chlorophytum nepalense* in Plant-2 were counted and arranged in Table 25.

Table 25. Total number of seeds per scape of *Chlorophytum nepalense* (Lindley) Baker (Plant-2)

Date of fruits ripe & collection	Number of fruit/s	Total number of seeds
02-07-2013	3 fruits rotten for heavy rain	
14-07-2013	1	5
16-07-2013	5	52
18-07-2013	3	34
21-07-2013	2	19
25-07-2013	6	56
27-07-2013	4	39
30-07-2013	3	14
08-08-2013	2	6
Total seeds	**26**	**225**

Plant-3

Results of development from scape initiation to fruit formation in *Chlorophytum nepalense* (Plant-3) are summarized in Table 26.

Table 26. Development from scape initiation to fruit formation per scape in *Chlorophytum nepalense* (Lindley) Baker (Plant-3)

Sl. No.	Date	No. of flower/s	No. of fruit/s formed
1.	28-04-2013	**Scape arising start**	
2.	07-05-2013	1	
3.	08-05-2013	3	
4.	09-05-2013	2	
5.	10-05-2013	6	
6.	11-05-2013	7	
7.	12-05-2013	4	
8.	13-05-2013	5	1
9.	14-05-2013	3	-
10.	15-05-2013	1	2
11.	16-05-2013	1	1
12.	17-05-2013	6	1

13.	18-05-2013	2	2
14.	19-05-2013	7	-
15.	20-05-2013	5	2
16.	21-05-2013	1	1
17.	25-05-2013	1	2
18.	29-05-2013	4	1
19.	30-05-2013	2	4
20.	01-06-2013		5
21.	02-06-2013		5
22.	08-06-2013		1
Total	**40 days**	**61 flowers**	**28 fruits**

Seeds per fruit and total number of seeds per scape of *Chlorophytum nepalense* in Plant-1 were counted and arranged in Table 27.

Table 27. Total number of seeds per scape of *Chlorophytum nepalense* (Lindley) Baker (Plant-3)

Date of fruit ripe & collection	Number of fruit/s	Number of seeds
28-07-2013	2	20
29-07-2013	4	42
30-07-2013	2 fruits not matured	
30-07-2013	6	38
31-07-2013	2	5
02-08-2013	4	15
04-08-2013	3	9
07-08-2013	5	7
Total seeds	**26**	**136**

From these experiments, it is exposed that flowers taken about 9 days for opening after scape initiation and fruit formation taken about 7 days after flowering. About 25-35 mature fruits formed per scape from c 50-70 flowers means about fifty percent opened flowers set fruit and other fifty percent does not. Each fruit contain 2-12 seeds but most of the fruits have 9 seeds. Comparatively first forming fruits (lower part of the scape) bear more seeds than the later forming fruits (upper part of the scape). Number of seeds per fruit decreased from lower to higher part of the scape. Total 594 seeds from 86 fruits have been collected from those three plants. The species taken 90-100 days from scape initiation to seeds maturation.

Crinum amoenum Roxb.

The species is ornamental and seeds poisonous if ingested.

POLLINATION

The present study revealed that *Crinum amoenum* Roxb. is self-pollinated. Fruit formation taken minimum time c 12 days after flowering (Table 28).

Table 28. Bagging experiment of *Crinum amoenum* Roxb.
('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	27-05-2014	17	+	3	Self-pollinated
Un-bagged Plant	27-05-2014	17	+	4	
Emasculated flowers	27-05-2014	17	-	-	

SEED GERMINATION

Seeds of *Crinum amoenum* Roxb. taken minimum c 1 year after sowing for germination. Percentage of seed germination is highest in the month of June (Table 29).

Table 29. Seed germination experiment of *Crinum amoenum* Roxb.

(Plate 70)

Date of seed collection	**Date of seed sown**	**No. of seed sown**	**Date of seed germinated**	**No of seed germinated**	**Time taken for germination**
24-06-2010	25-06-2010	10	12-06-11	2 (20%)	c 1 year
			15-06-11	7 (70%)	c 1 year

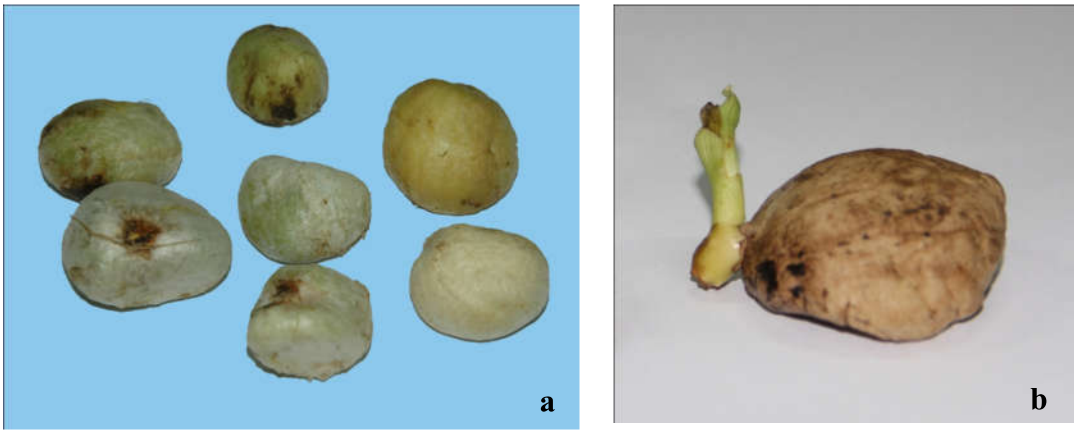


Plate 70. *Crinum amoenum* Roxb., a) Seeds; b) Seedling.

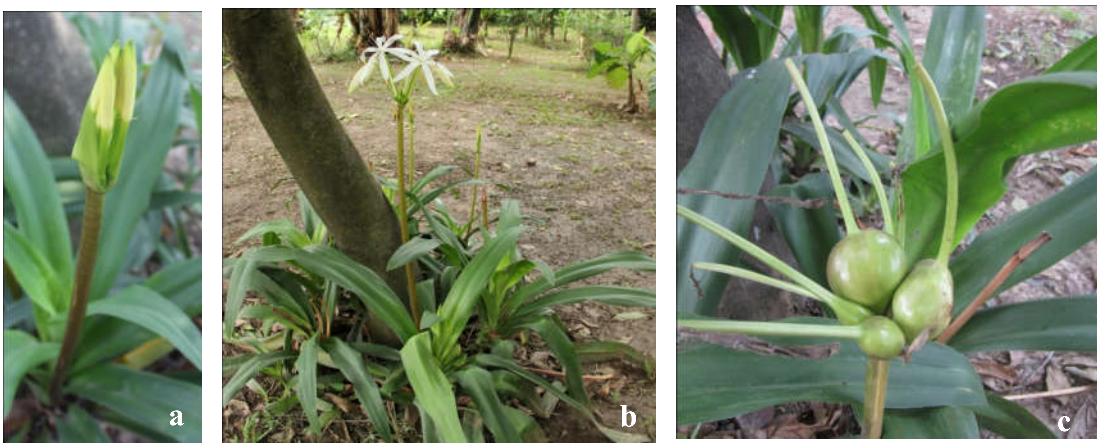


Plate 71. *Crinum amoenum* Roxb., a) Flower buds; b) Flowers; c) Fruits.

From Table 29 it is revealed that the seeds have near about 11 months dormancy period.

DEVELOPMENT

Flowers opening in *Crinum amoenum* Roxb. taken 13-15 days after initiation of the scape. Fruit formation taken 6-10 days after flowering (Table 30).

Table 30. Development from scape initiation to fruit maturation of *Crinum amoenum* Roxb.

(Plate 71)

Serial No.	Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s matured
1.	17-05-2014	**Scape arising start**		
2.	30-05-2014	1		
3.	31-05-2014	7		
4.	01-06-2014	8		
5.	02-06-2014	7		
6.	11-06-2014	-	2	
7.	12-06-2014	-	1	
8.	13-06-2014	-	1	
9.	24-06-2014			2
10.	27-06-2014			1
11.	28-06-2014			1

Fruit maturation takes 25-30 days after formation. 2-5 fruits formed from 6-9 flowers, each fruit contain 1-5 seeds.

VEGETATIVE PROPAGATION

The present study shows that seed propagation of *Crinum amoenum* Roxb. is more time consuming than sucker formation (Table 31).

Plate 72. *Crinum amoenum* Roxb., Sucker formation.

Table 31. Propagation experiment of *Crinum amoenum* Roxb.

(Plate 72)

Date of bulb transfer	**Size of bulb (cm)**	**Date of seed sown**	**Date of flowering**		**Average time for flowering**	
			From sucker	**From seed**	**From sucker**	**From seed**
26-05-2009	5.0 × 5.4		02-06-11		2 years	
		25-06-2010		05-06-14		4 years

Plants propagated from seeds take 4-5 years to bloom where 2 years for sucker formation.

Curculigo orchioides Gaertn.

Medicinally important plant. Rhizome is prescribed in piles, jaundice, asthma, diarrhoea and gonorrhoea and considered as a demulcent tonic, used as a poultice for itches and skin diseases (Sinha, 1996). In India, rhizome is used to induce abortion.

POLLINATION

Results of bagging experiment in *Curculigo orchioides* Gaertn. is shown in Table 32.

Table 32. Bagging experiment of *Curculigo orchioides* Gaertn. ('+' indicates positive fruit setting, '-' indicates negative fruit setting).

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	27-04-2010	17	+	1	self-pollinated
Un-bagged Plant	27-04-2010	17	+	1	
Emasculated flowers	27-04-2010	17	-	-	

From Table 32 it is revealed that *Curculigo orchioides* Gaertn. is self-pollinated. Fruit formation taken minimum time c 12 days after flowering.

SEED GERMINATION

The present study depicted that deeds of *Curculigo orchioides* Gaertn. were not germinated (Table 33).

Table 33. Seed germination experiment of *Curculigo orchioides* Gaertn.

Date of seed collection	Date of seed sown	No. of seed sown	Date of seed germinated	No of seed germinated	Days taken for germination
02-10-2009	02-10-09	10	-	-	-
	02-11-09	10	-	-	-
	02-12-10	10	-	-	-
	02-01-10	10	-	-	-
	02-02-10	10	-	-	-
	02-03-10	10	-	-	-
	02-04-10	10	-	-	-
	02-05-10	10	-	-	-
	02-06-10	10	-	-	-
	02-07-10	10	-	-	-

Perhaps seeds did not have full developed embryo. However, embryological studies have not been done.

DEVELOPMENT

The present study depicted that flowers opening in *Curculigo orchioides* Gaertn. taken 9-12 days after scape initiation. Fruit formation taken 12-15 days after flowering (Table 34).

Plate 73. *Curculigo orchioides* Gaertn., a) Flowers; b) Fruits; c) Seeds within fruit.

Table 34. Development from scape initiation to fruit maturation of *Curculigo orchioides* Gaertn.

(Plate 73)

Serial No.	**Date**	**No. of flower/s open**	**No. of fruit/s formed**	**No. of fruit/s matured**
1.	21-04-2010	**Scape arising start**		
2.	30-04-2010	1		
3.	02-04-2010	1		
4.	05-04-2010	2		
5.	12-05-2010	-	1	
6.	08-06-2010	-		1

Fruit maturation taken 25-30 days after formation. 1-2 fruits formed from 2-4 flowers. Each fruit contain 1-15 seeds (average 7).

VEGETATIVE PROPAGATION

Curculigo orchioides Gaertn. propagated only by the separation of rhizome with aerial shoots. Propagation by seed germination is not possible.

Gloriosa superba L.

Medicinally important plant. Plant contains the alkaloid colchicine as a major constituent. Alkaloid colchicine is used for the remedy of gout. In patients who have taken an overdose of bulbs, death occurs as a result of resperatory depression and cardiovascular collapse (de Padua *et al*., 1999). In the Indian Systems of Medicine, the tubers are used against snake bites and reported the abortifacient action.

POLLINATION

The present study revealed that *Gloriosa superba* L. is self-pollinated. Flowers large, at a time only one flower bagged. Fruit formation taken minimum time c 16 days after flowering (Table 35).

Plate 74. *Gloriosa superba* L., a) Bagging condition; b) Seeds; c) Seedlings.

Table 35. Bagging experiment of *Gloriosa superba* L. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

(Plate 74)

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	16-07-2009	20	+	1	Self-pollinated
Un-bagged Plant	16-07-2009	20	+	1	
Emasculated flowers	16-07-2009	20	-	-	

SEED GERMINATION

Minimum 31 days required for seed germination in *Gloriosa superba* L. after sowing. Percentage of seed germination is highest when sown immediately after collection. Suitable germination period of these species is May-June (Table 36).

Table 36. Seed germination experiment of *Gloriosa superba* L.

(Plate 74)

Date of seed collection	**Date of seed sown**	**No. of seed sown**	**Date of seed germinated**	**No of seed germinated**	**Days taken for germination**
02-11-2009	02-11-09	10	20-05-10	9 (90%)	198
	02-12-09	10	23-05-10	7 (70%)	171
	02-01-10	10	21-05-10	4 (40%)	139
	02-02-10	10	26-05-10	5 (50%)	114
	02-03-10	10	02-06-10	7 (70%)	90
	02-04-10	10	02-06-10	3 (30%)	60
	02-05-10	10	03-06-10	2 (20%)	31
	02-06-10	10	-	-	-
	02-07-10	10	-	-	-

Days required and percentage of germination both gradually reduced because of long dormancy period as well as gradually losing viability. The species has about five months dormancy period and after seven months seeds of this plant lost its total viability. The type of seeds germination is Hypogeal.

DEVELOPMENT

Flowers opening in *Gloriosa superba* L. start c 7 days after arising the flower bud. Fruit formation starts about 14 days after flowering (Table 37).

Table 37. Development from flower bud initiation to fruit maturation of *Gloriosa superba* L.

(Plate 75)

Categories	**Date**
Date of bud arising start	07-09-2014
Date of flower opened	14-09-2014
Date of fruit formation	28-09-2014
Date of fruit maturation	26-11-2014

Fruits were matured about after 60 days. Each fruit contain 50-75 seeds. In November, aerial parts of this plant became dry and survive by the underground tubers. Aerial shoots from underground tubers usually comes up in late April and after sprouting flowering starts within c 60 days.

VEGETATIVE PROPAGATION

Seed propagation of *Gloriosa superba* L. is more time consuming than tuber transfer. Plants propagated from seeds take 3-4 years to bloom where only one year is taken from tuber transfer (Table 38).

Table 38. Propagation experiment of *Gloriosa superba* L.

(Plate 76)

Date of tuber transfer	**Size of tuber (cm)**	**Date of seed sown**	**Date of flowering**		**Average time for flowering**	
			From tuber	**From seed**	**From tuber**	**From seed**
02-11-09	4.6 × 1.0		20-07-10		1 year	
		02-11-09		15-07-12		3 years

Plate 75. *Gloriosa superba* L., a) Buds; b) Flower before open; c) Flower open at initiation; d) Flower (crimson); e) Fruit; f) Fruit burst.

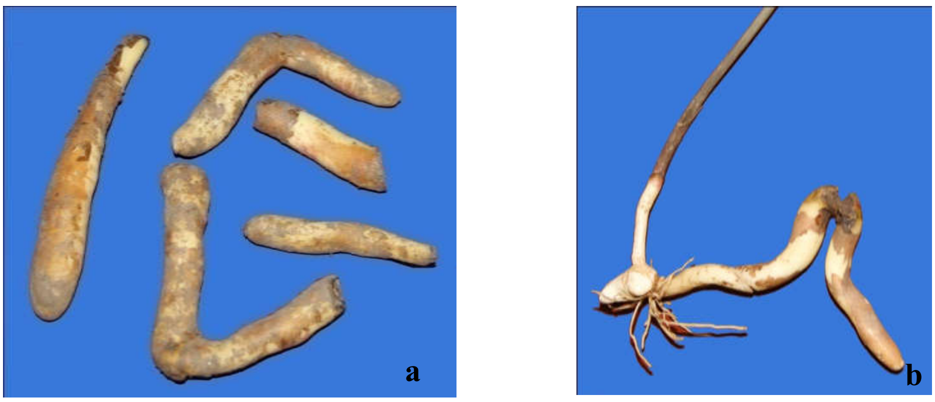


Plate 76. *Gloriosa superba* L., a) V or L shaped tuberous roots; b) Tuberous root with aerial shoot.

Hemerocallis fulva L.

Ornamental plant. Found in most of the gardens. It is a summer flower.

DEVELOPMENT

Results of development from scape initiation to flowers maturation of *Hemerocallis fulva* L. is presented in Table 39.

Table 39. Development from scape initiation to flowers maturation of *Hemerocallis fulva* L.

(Plate 77)

Category	**Date**
Scape arising start	09-06-2012
First flower open	24-06-2012

First flower opened after 14 days of arising the scape. Fruit formation not occurred.

VEGETATIVE PROPAGATION

Plants of *Hemerocallis fulva* L. were regenerated through daughter rhizome with tuberous roots from mother rhizome (Table 40).

Table 40. Propagation experiment of *Hemerocallis fulva* L. through separation of rhizome

(Plate 78)

Date of rhizome separation	**Length of rhizome (cm)**	**Date of flowering**	**Time taken of flowering (years)**
28-03-2012	2.5 × 1.5	10-07-2015	c 3 years

40-45 days taken for re-establish of new plant after separating daughter rhizomes. Fruits were not formed, the only way to regenerate the species through rhizome separation and about 3 years taken to bloom from rhizome separation.

Plate 77. *Hemerocallis fulva* L., a) Flower buds; b) Flowers.

Plate 78. *Hemerocallis fulva* L., a) Clump of plants; b) Rhizomes; c) Divided rhizomes; d) Young plant.

Pancratium triflorum Roxb.

Ornamental plant. Leaves and rhizome are used as cardiotonic, diuretic, and expectorant.

POLLINATION

The present study revealed that *Pancratium triflorum* Roxb. is self-pollinated (Table 41).

Table 41. Bagging experiment of *Pancratium triflorum* Roxb. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	18-03-2013	10	+	1	Self-pollinated
Un-bagged Plant	18-03-2013	10	+	2	
Emasculated flowers	18-03-2013	10	-	-	

Fruit formation taken minimum time c 5 days after flowering. Fruit setting were very rare. Fruits were fall before maturity. No seed was produced.

DEVELOPMENT

Flowers opening in *Pancratium triflorum* Roxb. taken c 12 days after scape initiation. Fruit formation taken about 5 days after flowering (Table 42).

Table 42. Development from scape initiation to flower maturation of *Pancratium triflorum* Roxb.

(Plate 79)

Category	**Date**
Scape arising start	09-03-2013
First flower open	21-03-2013
First fruit formation	26-03-2013

Rarely 1-2 fruits formed from 1-4 flowers.

Plate 79. *Pancratium triflorum* Roxb., a) Flower buds; b) Flower; c) Immature fruits.

Plate 80. *Pancratium triflorum* Roxb., a) Bulb with bulblets; b-c) Two bulblets.

VEGETATIVE PROPAGATION

The present study shows that only vegetative propagation method of *Pancratium triflorum* Roxb. is through separation of bulb.

Table 43. Propagation experiment of *Pancratium triflorum* Roxb.

(Plate 80)

Date of bulb separation	Length of bulb (cm)	Date of flowering	Time taken for flowering
02-06-2013	3.0 × 1.0	22-03-2015	c 2 years

Plants propagated from bulb separation takes c 2 years to bloom.

Scadoxus multiflorus Raf.

(*Haemanthus multiflorus* Martyn. *ex* Wild.)

It is one of the finest of all flowering plants, cultivated as an ornamental or garden plant. The bulb is poisonous, if ingested it can cause vomiting and diarrhoea. In some African countries, the bulbs are used as a fish poison. They are known to be lethal to livestock, mainly goats and sheep's grazing on them.

POLLINATION

Results of Bagging experiment in *Scadoxus multiflorus* Raf. is shown in Table 44.

Table 44. Bagging experiment of *Scadoxus multiflorus* Raf. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	07-05-2013	17	+	1	Self-pollinated
Un-bagged Plant	07-05-2013	17	+	2	
Emasculated flowers	07-05-2013	17	-	-	

From Table 44 it is revealed that *Scadoxus multiflorus* Raf. is self-pollinated.

SEED GERMINATION

Production of fruits and seeds were very few in comparison with number of flowers. The seeds are fleshy and not germinated. Seed germination experiment is done. No seed was germinated.

DEVELOPMENT

Flowers opening in *Scadoxus multiflorus* Raf. taken c 20 days after arising the scape. Fruit formation taken about 10 days after flowering. 2-3 fruits formed from c 70-100 flowers (Table 45).

Table 45. Development from scape initiation to fruit maturation of *Scadoxus multiflorus* Raf.

(Plate 81)

Serial No.	Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s matured
1.	20-04-2013	**Scape arising start**		
2.	10-05-2013	6		
3.	17-05-2013	80		
4.	22-05-2013		1	
5.	24-05-2013		1	
6.	16-07-2013			1
7.	19-07-2013			1

Fruit maturation takes 50-55 days after formation. Fruits are gradually deep green, then yellow and lastly dark red in colour when fully matured.

Scadoxus multiflorus Raf. blooms only by last week of April and by the end of May it is gone. The fruit is little fleshy, red in colour. Only few flowers developed fruit. The flower lasts for about a week. The fresh leaves appear after the flowering. The leaves died off in winter and the bulbs were dormant.

Plate 81. *Scadoxus multiflorus* Raf., a) Scape initiation; b) Spathe burst; c) Flower buds; d) Flowers open start; e) Flowers; f) Fruits; g) Ripe fruits.

Plate 82. *Scadoxus multiflorus* Raf., a) Bulb with bulblets; b) New arising plant from bulblet.

VEGETATIVE PROPAGATION

Propagation in *Scadoxus multiflorus* Raf. through separation of bulb is the only way to regenerate the species (Table 46).

Table 46. Propagation of *Scadoxus multiflorus* Raf. through bulb separation

(Plate 82)

Date of bulb separation	Size of bulb (cm)	Date of flowering	Time taken of flowering
25-06-2012	1.6 × 1.2	15-05-2015	c 3 years

About 3 years taken for flowering from about 1.6 × 1.2 cm size of daughter bulb transfer.

Urginea indica (Roxb.) Kunth

Important medicinal plant. Bulbs possess anti-cancer properties (Moshiuzzaman *et al.*, 2002). Used in the treatment of coughs, chronic bronchitis, asthma, paralysis, skin disease, disease of the nose, internal pains and scabies. The species is now very rare and become restricted to a very small area in Teknaf.

POLLINATION

The present study revealed that *Urginea indica* (Roxb.) Kunth produced no fruit under bagged condition although in the same period of time fruits were recorded in the un-bagged plants specify cross-pollinated (Table 47).

Table 47. Bagging experiment of *Urginea indica* (Roxb.) Kunth
('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	18-03-2010	18	-	-	Cross-

Un-bagged Plant	18-03-2010	18	+	2	pollinated (probably)
Emasculated flowers	18-03-2010	18	-	-	

Fruit setting were recorded only in the year of 2009 where observation occurred till to date and recently fruit setting were recorded again in April 2017 but most of the seeds were not germinated.

SEED GERMINATION

Seeds of *Urginea indica* (Roxb.) Kunth taken c 6 days after sowing for germination. Best time for seed germination is just after collection of seeds. Most of the seeds do not fully mature (Table 48).

Table 48. Seed germination experiment in *Urginea indica* (Roxb.) Kunth

(Plate 83)

Sl. No.	Date of seed collection	Date of seed sown	No. of seeds	Date of germination	No of seed germinated	Time taken for germination (days)
1.	10-04-2009	10-04-2009	7	17-04-2090	2 (29%)	6
2.	17-04-2017	17-04-2017	6	-	-	-

Percentage of seed germination cannot be counted cause of rare fruit setting. The species have no dormancy period and after 1 month seeds of this plant lost its viability. The type of seeds germination is Hypogeal.

DEVELOPMENT

The present study evident that flowers opening in *Urginea indica* (Roxb.) Kunth taken c 14 days after arising the scape. Fruit formation taken about 6 days after flowering (Table 49).

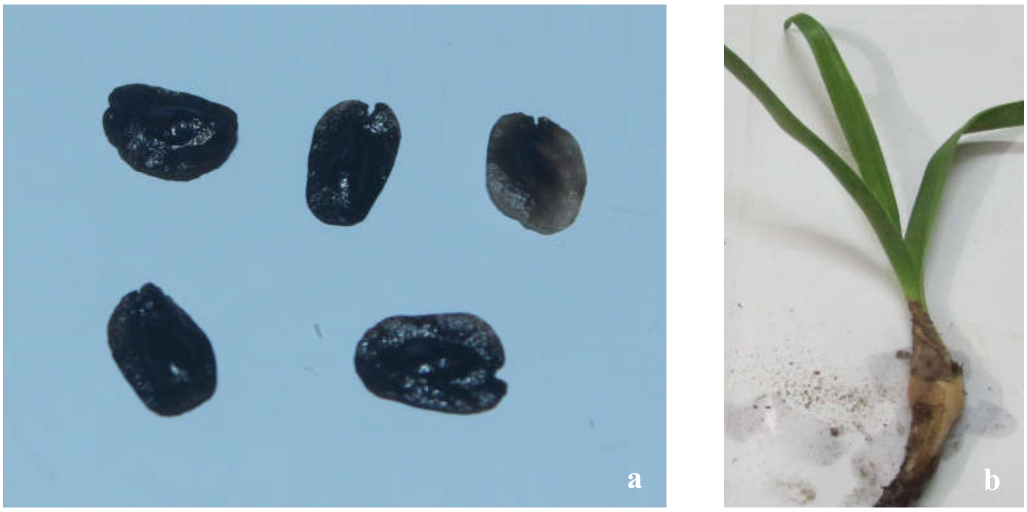


Plate 83. *Urginea indica* (Roxb.) Kunth, a) Seeds; b) Seedlings.

Plate 84. *Urginea indica* (Roxb.) Kunth, a) Scape initiation; b) Buds; c) Flowers; d) Fruits; e) Fruit burst.

Table 49. Development from scape initiation to fruit maturation of *Urginea indica* (Roxb.) Kunth

(Plate 84)

Date	No. of flower/s open	No. of fruit/s formed	No. of fruit/s burst
11-03-2009	**Scape arising start**		
25-03-2009	3		
26-03-2009	4		
27-03-2009	3		
28-03-2009	2		
01-04-2009		2	
02-04-2009		1	
10-04-2009			2
11-04-2009			1

Rarely 2-3 fruits formed from 6-17 flowers. Each fruit contain 2-3 seeds.

VEGETATIVE PROPAGATION

Results of vegetative propagation experiment of *Urginea indica* (Roxb.) Kunth are depicted in Table 50.

Table 50. Propagation experiment of *Urginea indica* (Roxb.) Kunth

(Plate 85)

Date of bulb transfer	Size of bulb (cm)	Date of seed sown	Date of flowering		Average time for flowering	
			From bulb	From seed	From bulb	From seed
29-03-2009	1.5 × 0.8		05-03-2012		3 years	
		10-04-2009		01-03-2013		4 years

Propagation through bulb is more suitable than seeds. Plants propagated from seeds take c 4 years to bloom.

Plate 85. *Urginea indica* (Roxb.) Kunth, a) Two bulbs within fleshy scales; b) Two bulbs; c) Bulb with bulblets; d) Two bulblets.

Zephyranthes atamasco (Linn.) Herb.

(Plate 86)

POLLINATION

The present study revealed that *Zephyranthes atamasco* (Linn.) Herb. is self-pollinated (Table 51).

Table 51. Bagging experiment of *Zephyranthes atamasco* (Linn.) Herb.
('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	07-05-2013	5	+	1	Self-pollinated
Un-bagged Plant	07-05-2013	5	+	1	
Emasculated flowers	07-05-2013	5	-	-	

SEED GERMINATION

The present study evident that rate of seed germination is very low. There is no dormancy period (Table 52).

Table 52. Seed germination experiment in *Zephyranthes atamasco* (Linn.) Herb.

Date of seed collection	Date of seed sown	No. of seed sown	Date of seed germinated	No of seed germinated	Days taken for germination
15-05-07	15-05-07	10	20-05-07	2 (20%)	5
	15-06-07	10	-	- (0%)	-
	15-07-07	10	-	- (0%)	-
	15-08-07	10	-	- (0%)	-
	15-09-07	10	-	- (0%)	-

Viability remains only for one month. Only 5 days taken to germinate.

Plate 86. *Zephyranthes atamasco* (Linn.) Herb., a) Flower; b) Flowers closed (turn pink).

VEGETATIVE PROPAGATION

The present study evident that propagation in *Zephyranthes atamasco* (Linn.) Herb. through bulb is more suitable than seeds (Table 53).

Table 53. Propagation experiment of *Zephyranthes atamasco* (Linn.) Herb.

Date of bulb transfer	Size of bulb (cm)	Date of seed sown	Date of flowering		Average time for flowering	
			From bulb	From seed	From bulb	From seed
15-05-06	0.5 × 0.3		08-05-08		2 years	
		15-05-06		19-05-09		3 years

Plants propagated from seeds take c 3 years to bloom whereas c 2 years from bulb separation.

Zephyranthes candida (Lindl.) Herb.

(Plate 87)

POLLINATION

The present study revealed that *Zephyranthes candida* (Lindl.) Herb. is self-pollinated (Table 54).

Table 54. Bagging experiment of *Zephyranthes candida* (Lindl.) Herb. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	10-08-2012	4	+	1	Self-pollinated
Un-bagged Plant	10-08-2012	4	+	1	
Emasculated flowers	10-08-2012	4	-	-	

SEED GERMINATION

Results of seed germination experiment in *Zephyranthes candida* (Lindl.) Herb. are summerized in Table 55.

Table 55. Seed germination experiment in *Zephyranthes candida* (Lindl.) Herb.

Date of seed collection	Date of seed sown	No. of seed sown	Date of seed germinated	No of seed germinated	Days taken for germination
25-08-07	25-08-07	10	28-08-07	10 (100%)	3
	25-09-07	10	28-09-07	10 (100%)	3
	25-10-07	10	29-10-07	10 (100%)	4
	25-11-07	10	-	- (0%)	-
	25-12-07	10	-	- (0%)	-

From Table 55 it is evident that no dormancy period exist. Seeds lost complete viability after three months. Rate of germination is very high.

VEGETATIVE PROPAGATION

Propagation in *Zephyranthes candida* (Lindl.) Herb. through bulb is more suitable than seeds (Table 56).

Table 56. Propagation experiment of *Zephyranthes candida* (Lindl.) Herb.

Date of bulb transfer	Size of bulb (cm)	Date of seed sown	Date of flowering		Average time for flowering	
			From bulb	From seed	From bulb	From seed
25-08-06	0.6 × 0.4		20-07-08		2 years	
		25-08-06		08-09-09		3 years

Plants propagated from seeds take c 3 years to bloom whereas c 2 years from bulb separation.

Plate 87. *Zephyranthes candida* (Lindl.) Herb., a) Flower; b) Fruits; c) Fruit burst; d) Seeds; e) Seedlings; f) Bulb with bulblet.

Zephyranthes carinata Herb.

(Plate 88)

POLLINATION

The present study revealed that *Zephyranthes carinata* Herb. is self-pollinated (Table 57).

Table 57. Bagging experiment of *Zephyranthes carinata* Herb. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	Bagging and emasculation date	Days counted	Fruit set	No. of fruit set	Pollination type
Bagged Plant	15-07-2012	5	+	1	Self-pollinated
Un-bagged Plant	15-07-2012	5	+	1	
Emasculated flowers	15-07-2012	5	-	-	

SEED GERMINATION

Results of seed germination experiment in *Zephyranthes carinata* Herb. are shown in Table 58.

Table 58. Seed germination experiment in *Zephyranthes carinata* Herb.

Date of seed collection	Date of seed sown	No. of seed sown	Date of seed germinated	No of seed germinated	Days taken for germination
25-07-07	25-07-07	10	28-07-07	10 (100%)	3
	25-08-07	10	29-08-07	8 (80%)	4
	25-09-07	10	29-09-07	6 (60%)	4
	25-10-07	10	-	- (0%)	-
	25-11-07	10	-	- (0%)	-

No dormancy period exist. Complete loss of viability after three months. After maturation viability gradually decreases.

Plate 88. *Zephyranthes carinata* Herb., a) Bulb with bulblet; b) Flower buds, c) Flower; d) Fruits; e) Fruit burst; f) Seeds; g) Seedlings.

VEGETATIVE PROPAGATION

The present study evident that propagation through bulb is more suitable than through seeds (Table 59).

Table 59. Propagation experiment of *Zephyranthes carinata* Herb.

Date of bulb transfer	Size of bulb (cm)	Date of seed sown	Date of flowering		Average time for flowering	
			From bulb	From seed	From bulb	From seed
20-07-06	0.5 × 0.4		15-07-08		2 years	
		20-07-06		10-08-09		3 years

Plants propagated from seeds take c 3 years whereas c 2 years from bulb separation to bloom.

After a heavy rainfall, seeds of *Zephyranthes candida* and *Z. carinata* got germinated while still inside the capsules. In the process of germination, the hypocotyle elongated and came out of the seed forming a loop and developed narrow, straight epicotyle. This type of germination may be termed as **pseudo-vivipary (Plate 89)**. The normal type of germination in these species is hypogeal. Further studies are needed to investigate the cases of **pseudo-vivipary** in these species.

Zephyranthes tubispatha (L'Her.) Herb. *ex* Traub.

(Plate 90)

POLLINATION

The present study revealed that *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub. is self-pollinated (Table 60).

Plate 89. a) Pseudo-vivipary in *Zephyranthes carinata* Herb.; b-c) Pseudo-vivipary in *Zephyranthes candida* (Lindl.) Herb.

Table 60. Bagging experiment of *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub. ('+' indicates positive fruit setting, '-' indicates no fruit setting).

Category	**Bagging and emasculation date**	**Days counted**	**Fruit set**	**No. of fruit set**	**Pollination type**
Bagged Plant	15-07-2012	3	+	1	Self-pollinated
Un-bagged Plant	15-07-2012	3	+	1	
Emasculated flowers	15-07-2012	3	-	-	

GERMINATION:

The present study evident that no dormancy period present in *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub. (Table 61).

Table 61. Seed germination experiment in *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub.

Date of seed collection	**Date of seed sown**	**No. of seed sown**	**Date of seed germinated**	**No of seed germinated**	**Days taken for germination**
23-07-07	23-07-07	10	26-07-07	10 (100%)	3
	23-08-07	10	27-08-07	10 (100%)	4
	23-09-07	10	27-09-07	8 (80%)	4
	23-10-07	10	-	- (0%)	-
	23-11-07	10	-	- (0%)	-

Loss of viability after three months. Germination rate is very high when sown just after seed collection.

VEGETATIVE PROPAGATION

The present study revealed that no bulblet is formed in this species, so propagation through seeds is the only way of regeneration (Table 62).

Plate 90. *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub., a) Bulb; b) Flower bud; c) Flower; d) Fruits; e) Fruit burst; f) Seeds; g) Seedlings.

Table 62. Propagation experiment of *Zephyranthes tubispatha* (L'Her.) Herb. *ex* Traub.

Date of bulb transfer	**Size of bulb**	**Date of seed sown**	**Date of flowering**		**Average time for flowering**	
			From bulb	**From seed**	**From bulb**	**From seed**
-	-	06-08-06	-	18-08-09	-	3 years

CHAPTER 7

PALYNOLOGICAL STUDIES

7.1: Introduction

In angiosperm, pollen is an important (obligate) part of sexual reproduction. In usual method no seed is to be formed without viable pollen. Hence pollen viability test is very important in reproductive biology experiments.

The need for assessing viability of pollen used in artificial pollination and in breeding experiments (Stone *et al*., 1995) is also important in the understanding of sterility problems and hybridization programs (Gupta and Murty, 1985), fruit breeding programs (Oberle and Watson, 1953), and evolutionary ecology (Thomson *et al*., 1994).

Pollen of Amaryllidaceae has been studied in detail by Meerow (1987, 1989) and Meerow & Dehgan (1988). Amaryllidaceae pollen grains are small to very large (largest equatorial axis 14-158 urn). Small grains (usually <30 um) are found in the Galantheae (*Galanthus*, *Leucojum* p.p.). Very large pollen (> 100 um) occurs only in *Hymenocallis* p.p. Tetragonal tetrads are known in *Stenomesson elwesii* (Meerow *et al.*, 1986).

The apertural system is monosulcate or dicolpate. Sulci are nearly as long as the longest equatorial axis, or extend slightly on the proximal grain side. The position of the colpi in dicolpate pollen with respect to the distal and proximal poles is unknown. Exine stratification is generally distinct. Electron micrographs show a columellate, tec-tate or semitectate sexine in monosulcate pollen. Ornamentation is reticulate or sparsely scabrate-microechinate, rarely psilate/punctate (Galantheae) to verrucate/fossulate (*Eucrosia*). The lumina in reticulate patterns are small to very large (up to c 10 urn in *Hymenocallis*). Usually lumen size decreases towards the aperture, and often it is distinctly less at the apocolpial ends of a grain. In several *Hymenocallis* species these parts ('auriculae') have ornamentation quite different and clearly separated from that of the main part of the grain (Ravikumar & Nair, 1982; Meerow & Dehgan, 1985).

Two main pollen types may be distinguished in the family: 1) monosulcate reticulate pollen, and 2) dicolpate scabrate-microechinate pollen. Infratectum structure might be another important feature separating both types. The latter characterizes all genera of the Amaryllideae (sensu Dahlgren *et al.*, 1985; Snijman, 1991), and *Pauridia* of the Hypoxidoideae (Thompson, 1979; Simpson, 1983). The former type is found in all other Amaryllidaceae. The two colpi in Amaryllideae pollen are on opposite grain sides, whereas in Pauridia pollen they are situated in the same hemisphere. Also the nature of the scabrate ornamentation is different in Pauridia. Other Hypoxidoideae have monosulcate, finely reticulate pollen, more or less the same as in most Amaryllidoideae and many other monocots (Kalkman *et al.*, 1993).

7.2: Materials and Methods

In all cases, fresh pollen has been collected and studied. Flowers were collected from the field, and brought to the laboratory. Pollen was only taken from recently opened anthers. A drop of acetocarmine was taken into the slide. An anther was removed from the flower with the help of a forcep and then touched into the acetocarmine placed on a slide. A cover slip was placed over the acetocarmine solution very carefully and then observed under light microscope. Viable pollen takes acetocarmine and the shape were regular whereas non viable pollen not coloured with acetocarmine and were very irregular in shape. Number of pollen viability has been calculated in the following methods:

$$\frac{\text{Number of viable pollen}}{\text{Total number of pollen}} \times 100$$

7.3: Pollen Viability of Some Liliaceae Species

(Plates 91-95)

Table 63. Pollen viability of available Liliaceae species

Sl. No.	Species Names	Percentage of pollen viability
1.	*Allium tuberosum* Rottler *ex* Spreng.	90%
2.	*Asparagus officinalis* L.	99%
3.	*Chlorophytum laxum* R. Br.	96%
4.	*Crinum amabile* Donn	20%
5.	*Crinum asiaticum* L.	99%
6.	*Crinum latifolium* L.	100%
7.	*Curculigo orchioides* Gaertn.	98%
8.	*Gloriosa superba* L.	100%
9.	*Hymenocallis littoralis* (Jacq.) Salisb.	95%
10.	*Molineria salarkhanii* S.N. Uddin & M.A. Hassan	98%
11.	*Pancratium triflorum* Roxb.	99%
12.	*Zephyranthes candida* (Lindl.) Herb.	100%
13.	*Zephyranthes carinata* Herb.	98%
14.	*Zephyranthes tubispatha* (L'Her.) Herb.	100%

From this experiment it becomes clear that out of fourteen species studied for pollen viability thirteen has 90%-100% viable pollen except *Crinum amabile* having only 20% of viable pollen. This plant does not form any fruit.

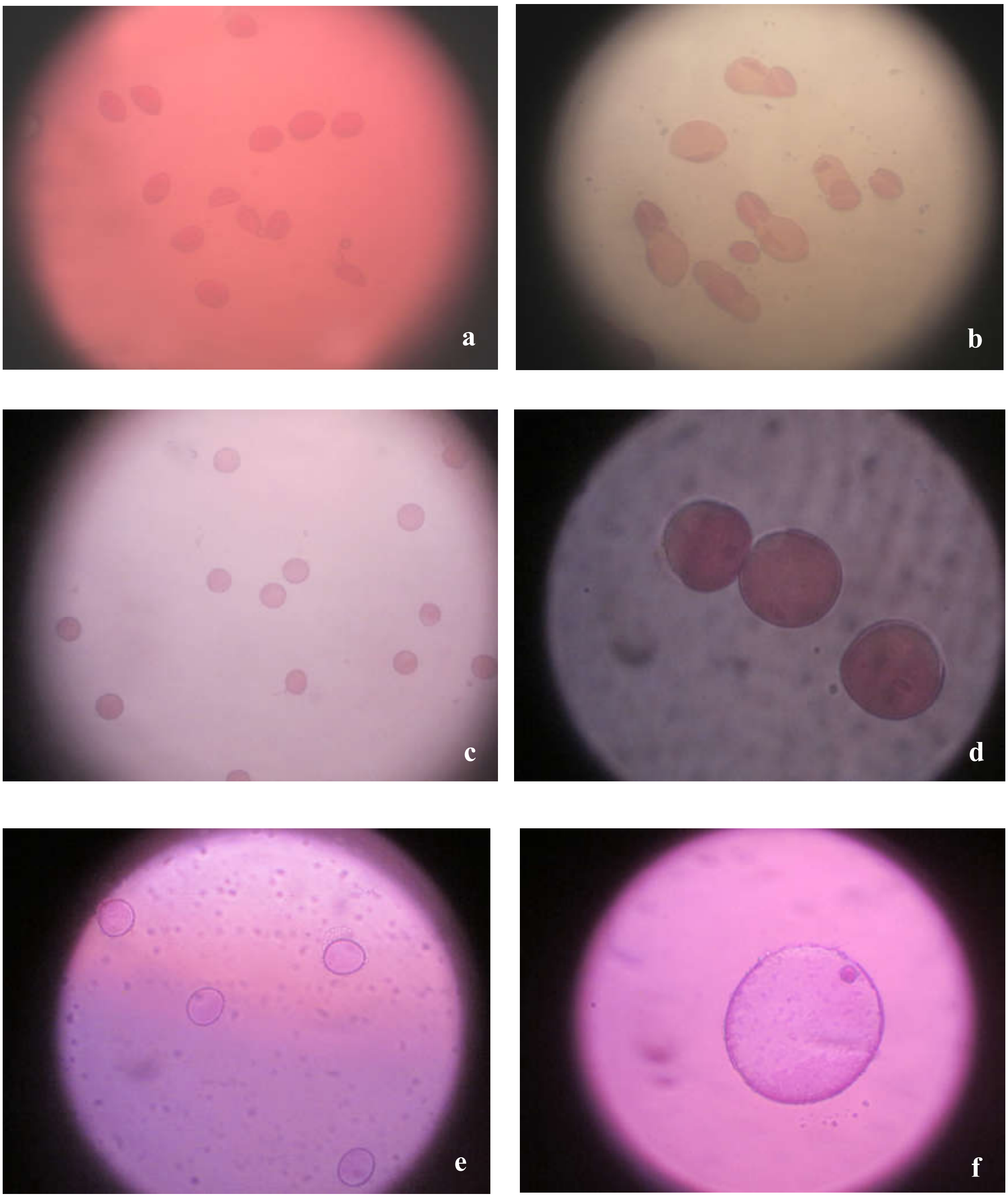


Plate 91. Pollen viability, a-b) *Allium tuberosum* Rottler *ex* Spreng. (×10, ×40);
c-d) *Asparagus officinalis* L. (×10, ×40);
e-f) *Chlorophytum laxum* R. Br.(×10, ×40).

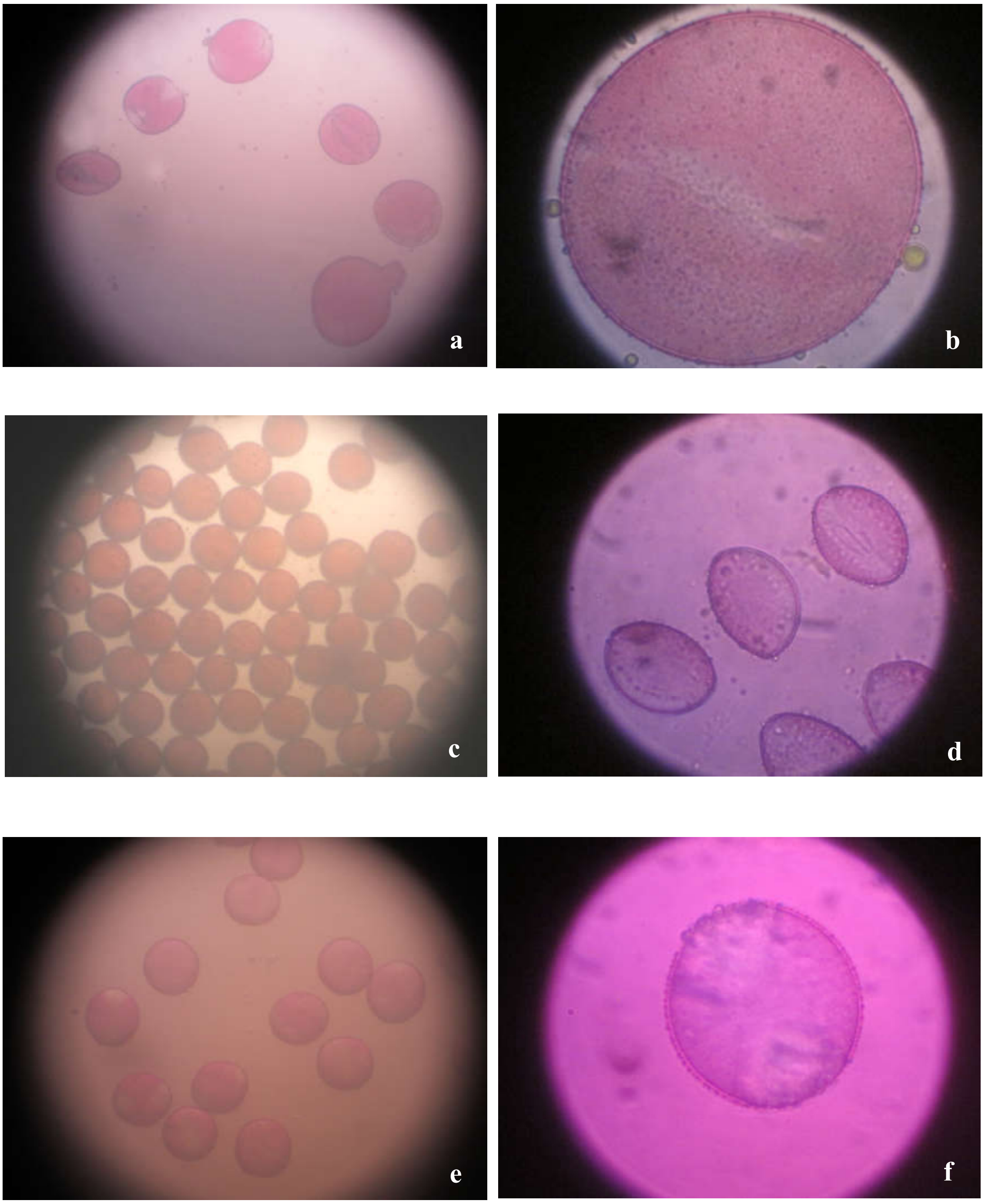


Plate 92. Pollen viability, a-b) *Crinum amabile* Donn (×10, ×40);
c-d) *Crinum asiaticum* L. (×10, ×40);
e-f) *Crinum latifolium* L. (×10, ×40).

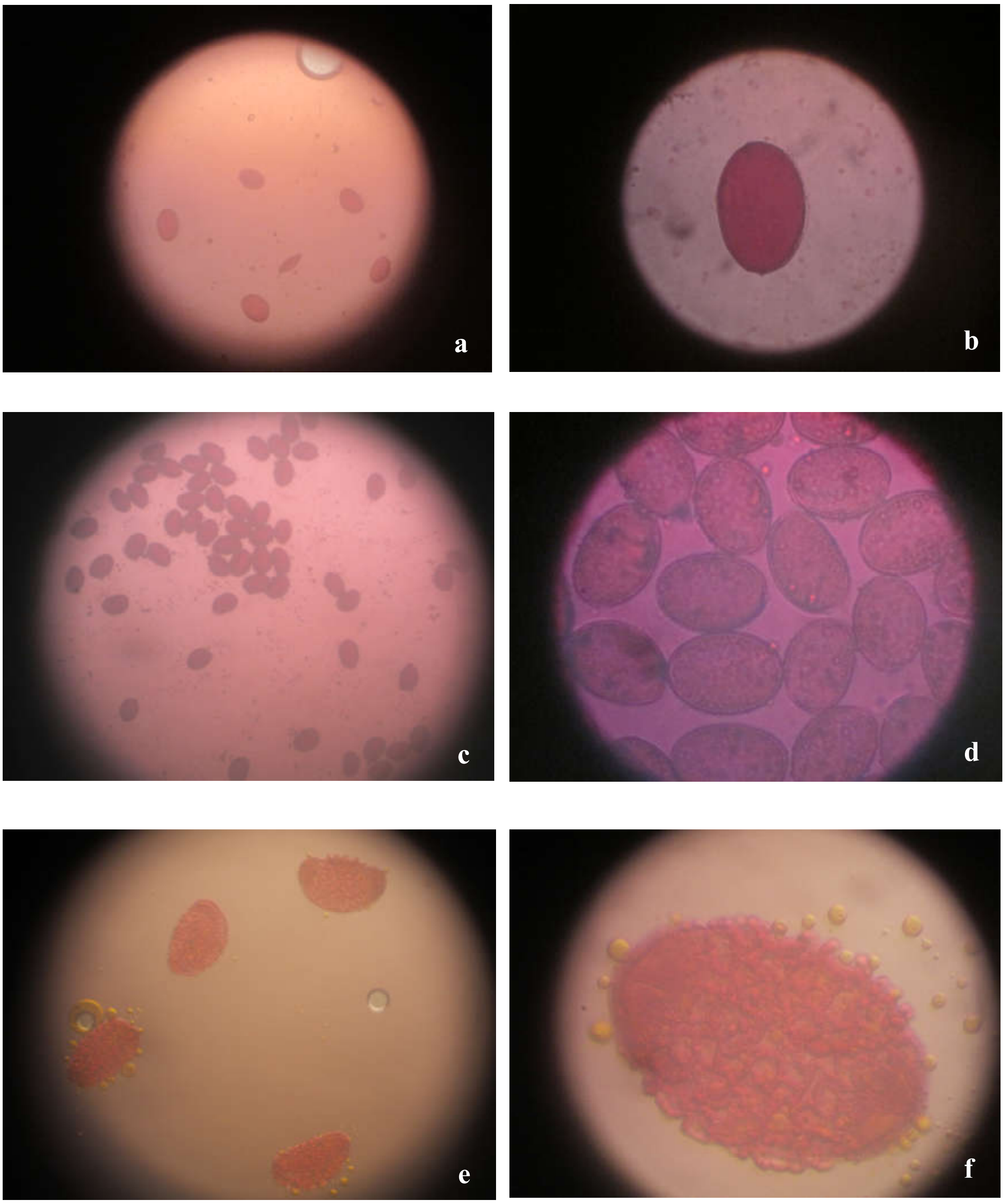


Plate 93. Pollen viability, a-b) *Curculigo orchioides* Gaertn. (×10, ×40);
c-d) *Gloriosa superba* L. (×10, ×40);
e-f) *Hymenocallis littoralis* (Jacq.) Salisb. (×10, ×40).

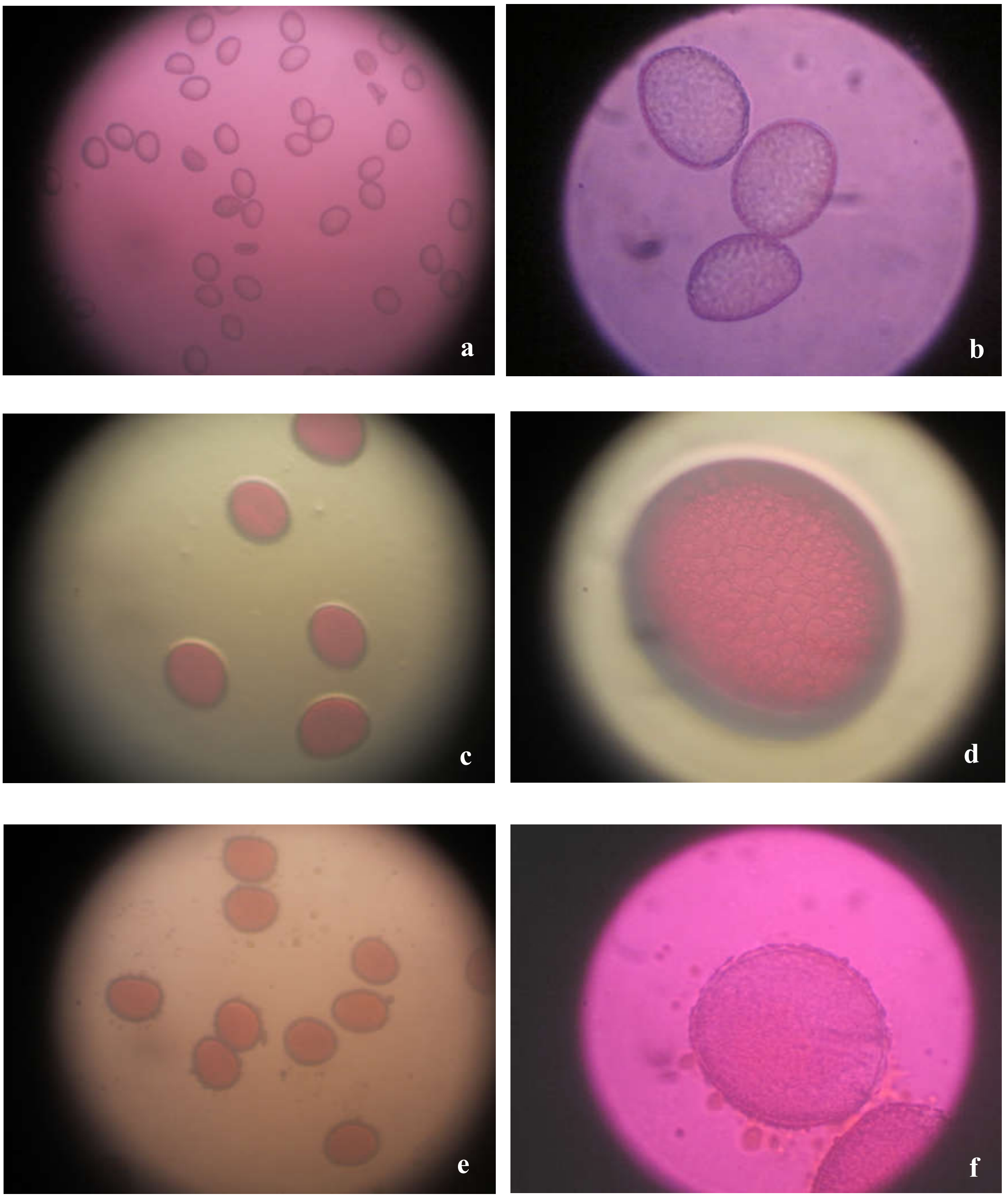


Plate 94. Pollen viability, a-b) *Molineria salarkhanii* S.N. Uddin & M.A. Hassan (×10, ×40); c-d) *Pancratium triflorum* Roxb. (×10, ×40); e-f) *Zephyranthes candida* (Lindl.) Herb. (×10, ×40).

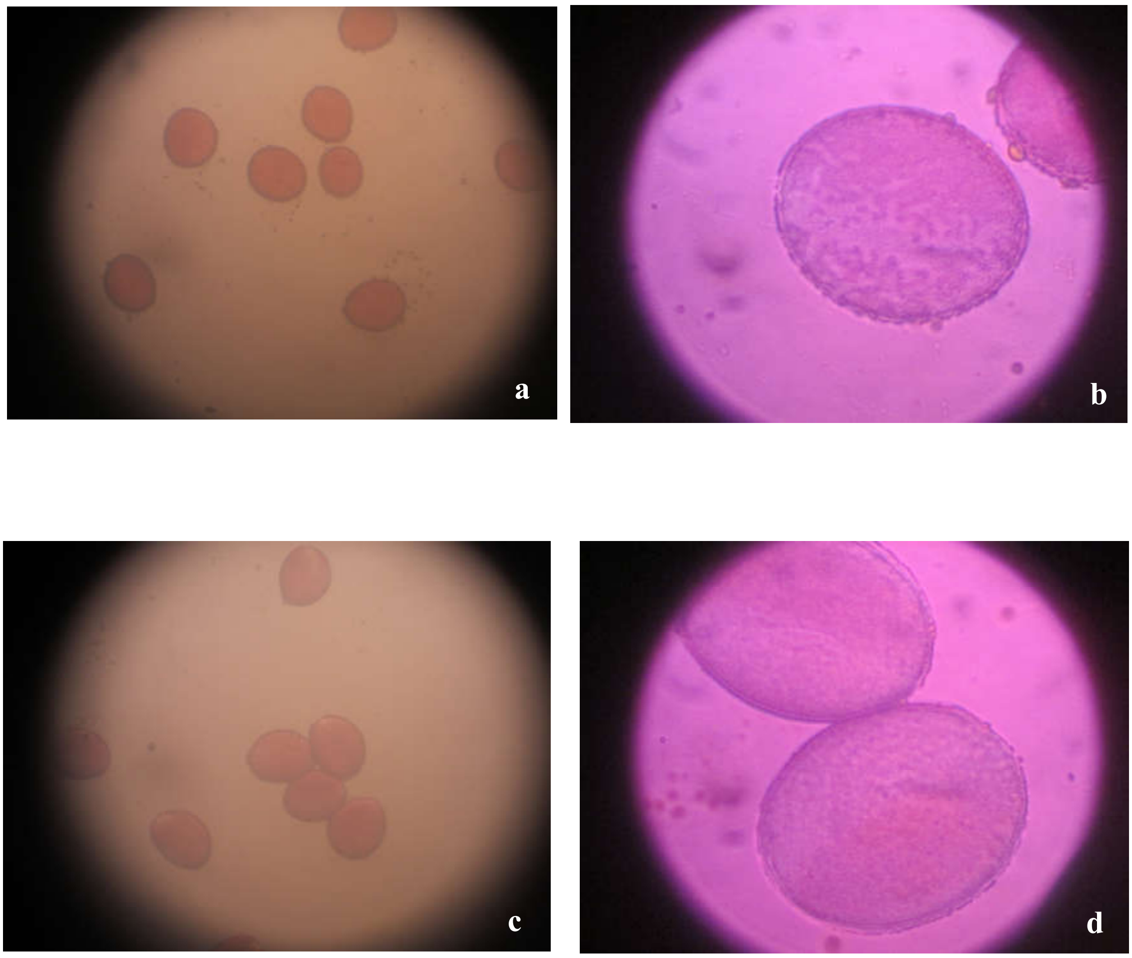


Plate 95. Pollen viability, a-b) *Zephyranthes carinata* Herb. (×10, ×40);
c-d) *Zephyranthes tubispatha* (L'Her.) Herb. (×10, ×40).

7.4: Pollen Pistil Interaction

Introduction

The pollen-pistil interaction is composed of a number of successive events leading to the recognition and acceptance or rejection of the gametes (Heslop-Harrison, 1975; Knox *et al*., 1976; Dumas and Guade, 1981; Dickinson and Roberts, 1986). In compatible pollination, after landing the pollen grains and adhere to the stigma surface. This adhesion depends on the nature of both pollen grains and stigma surfaces. After adhesion, hydration takes place. During this phase pollen grains acquire water from the stigma which cause rehydration and activation of pollen grains. Next step the pollen grains germinate on the stigma by proliferating the swollen appendix through the germinal aperture. The tube initials develops into pollen tubes which penetrate the stigmatic cell layers and elongate within a specialized tissue in the style called the transmitting tissue, eventually reaching the ovary and where they enter the ovules and penetrate the embryo sacs. The pollen tubes tip burst in the embryo sac to release the male germinal cells for fertilization (Cheung, 1995).

In incompatible pollination pollen tube may be arrested at the stigma or anywhere along the pathway of pollen tube elongation. Pollen has a high to support its activity during germination and tube growth (Steer and Steer, 1989). Pistil tissues are believed to provide physical and chemical supports and directional guidance to the pollen tube growth process (Knox, 1984).

The present investigation was planned to study the pollen-pistil interaction following self-, cross- and open pollinations among the same species with the help of fluorescent microscopy.

Materials and Methods

The following materials were used in the present investigations:

1. *Allium tuberosum* Rottler *ex* Spreng.

2. *Hymenocallis littoralis* (Jacq.) Salisb.

The plants were raised in the Botanical Garden of Dhaka University.

Controlled pollinations were made with the anthers of freshly opened flowers. For self- and cross-pollinations the appropriate flower buds were emasculated one day before pollinations. Pollinations were made on the stigma between 7:30 to 10:00 am.

In self-pollination, open pollinated flowers were removed from the plants on the day before pollination and thus the plants containing fresh buds. Pollination was made with freshly dehisced anthers by touching them on the same flower stigma with the help of fine forceps between 7:30 to 10:00 am.

In cross pollination, conventional methods were followed. To avoid contamination emasculation was done before the anthesis. The anthers were removed carefully by the twisting the pointed forceps from the desired freshly opened flower of the plant and rubbed against the stigma of the emasculated flower. A tag was tied around peduncle to identify the pollinated buds.

To study the pollen-pistil interaction, pollinated pistils were collected at different intervals of time (12 hours, 24 hours, and 48 hours) from the time of pollination. The pistils were collected and fixed in the vials containing aceto-alcohol solution (1:3 v/v).

To determine pollen germination for both self- and cross-pollinations, collected pistils were kept in 1N NaOH and incubated at 55-60°C for 10-15 minutes for softening. After cooling the materials were washed for three times with distilled water to make them free from NaOH. For staining the materials were kept in 0.1% (w/v) decolourized aniline blue solution for 8-10 minutes. The staining materials were mounted in a 50% (v/v) aqueous solution of glycerol prior to examine under a Nikon (Optiphot) microscope fitted with epi-flurescence UV illumination system having filter combination of UV-2A and BV-2A.

Results

1. *Allium tuberosum* Rottler *ex* Spreng. **(Plate 96)**

In this species, most of the pollen grains were found to germinate and produced pollen tube within 24-30 hours from the time of pollination in both self- and cross-pollination. In case of open pollination, some pistil bears pollen with pollen tubes but some pistils were found without pollen tube. This result proved that the species is strictly cross pollinated which were previously described. Pollen tubes were not found when pistils were collected before 24 hours from the time of pollination.

2. *Hymenocallis littoralis* (Jacq.) Salisb. **(Plate 97)**

The species produced no fruit in our country. In this species, pollen was not germinated and pollen tubes were not found in both self-, cross- and open pollination. In this investigation it is concluded that the species have pre fertilization incompatibility and may be fruits were not produced for that reason.

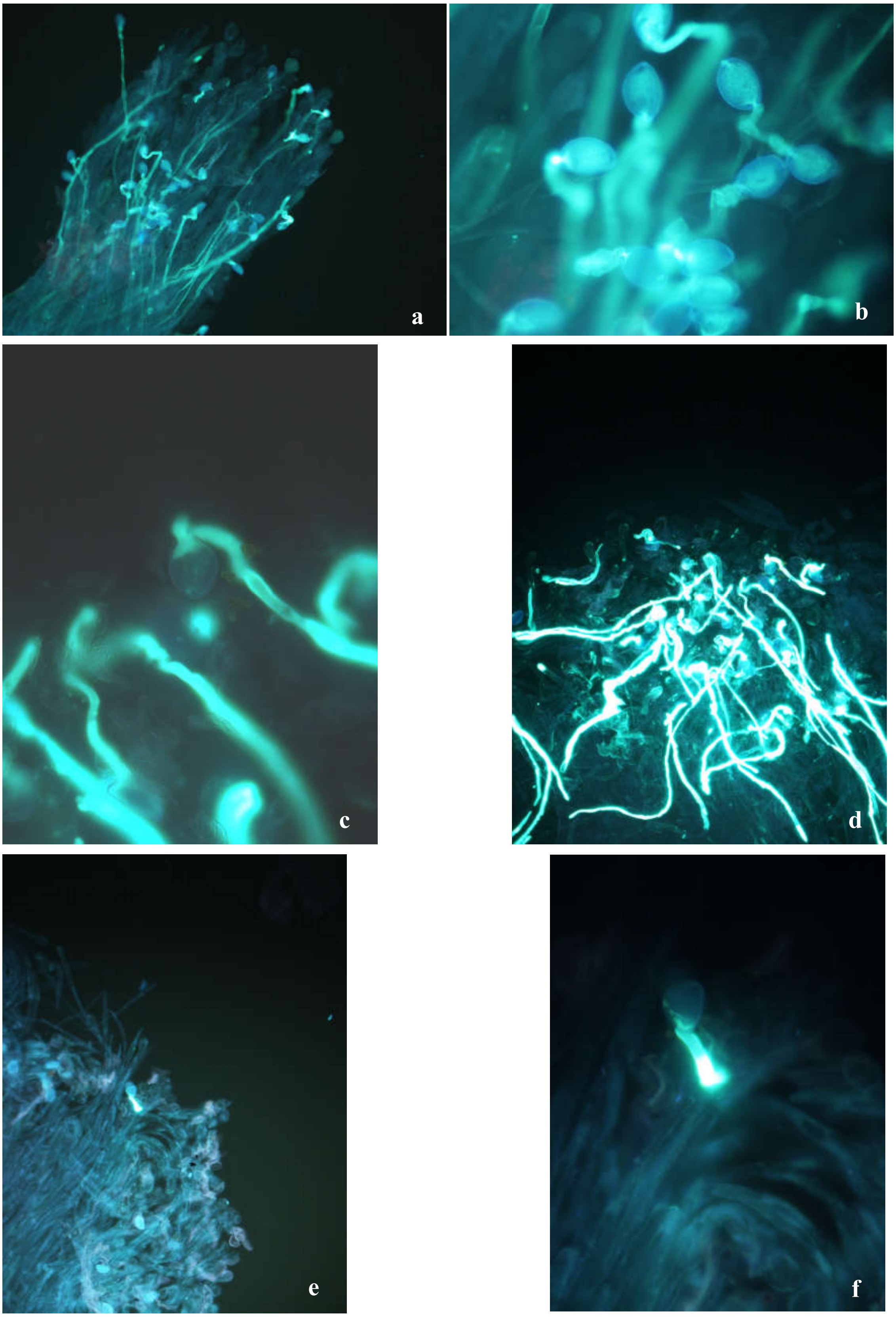


Plate 96. Pollen pistil interaction of *Allium tuberosum* Rottler *ex* Spreng., a-b) Natural pollination (×10, ×40); c-d) Self pollination (×10, ×40); e-f) Cross pollination (×10, ×40).

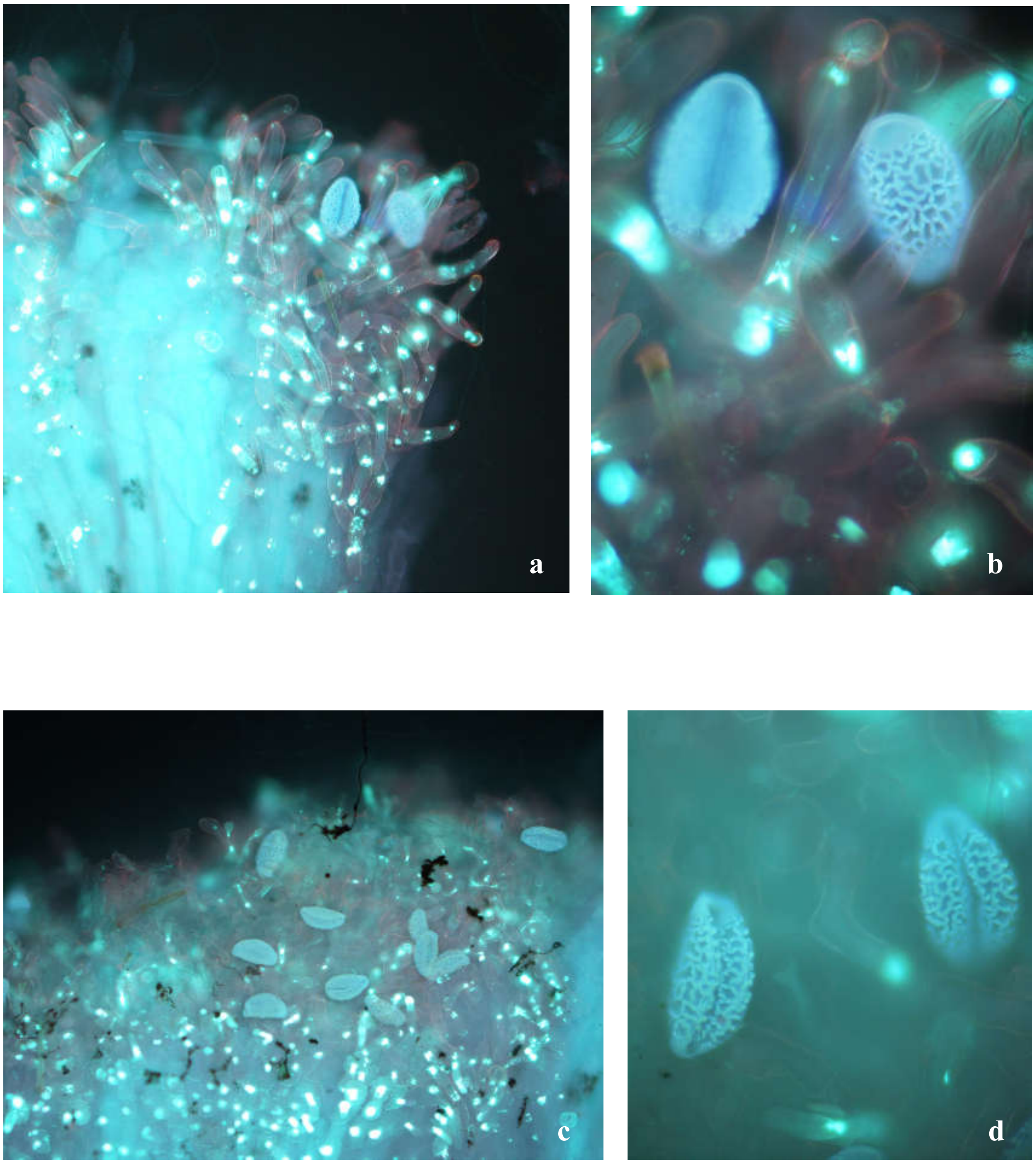


Plate 97. Pollen pistil interaction of *Hymenocallis littoralis* (Jacq.) Salisb., a-b) Self pollination (×10, ×40); c-d) Cross pollination (×10, ×40).

CHAPTER 8

DISCUSSION

The family Liliaceae A.L. de Jussieu has been revised for Bangladesh and a total of 43 species under 20 genera have been recorded. A complete taxonomic account of the family is therefore prepared for the flora. The taxonomic history and currently accepted classification of the family Liliaceae are presented and discussed.

Artificial dichotomous bracketed keys to the genera and species have been provided for easy identification of the taxa. Updated nomenclature i.e. valid names, synonyms, local names and English names where available, and descriptions have been furnished under each taxon including photographs. Flowering and fruiting periods and distribution have also been added. The germplasm of most of the taxa have been collected from different parts of the country and planted in the experimental plots of the Dhaka University Botanical Garden for further studies, viz. *Allium chinense* G. Don, *A. tuberosum* Rottler *ex* Spreng., *Asparagus racemosus* Willd., *A. officinalis* L., *Chlorophytum laxum* R. Br., *Crinum amabile* Donn, *C. amoenum* Roxb., *C. asiaticum* L., *C. jagus* (Thomps.) Dandy, *C. latifolium* L., *Curculigo orchioides* Gaertn., *Dianella ensifolia* (L.) DC., *Eucrosia bicolor* Ker-Gawl., *Gloriosa superba* L., *Hemerocallis fulva* L., *Hippeastrum puniceum* (Lamk.) Voss, *Molineria recurvata* (Dryand.) Herb., *M. salarkhanii* S.N. Uddin & M.A. Hassan, *Pancratium triflorum* Roxb., *P. verecundum* Ait., *Proiphys amboinensis* (L.) Herb., *Scadoxus multiflorus* Raf., *Urginea indica* (Roxb.) Kunth, *Zephyranthes atamasco* (Linn.) Herb., *Z. candida* (Lindl.) Herb., *Z. carinata* Herb., *Z. tubispatha* (L'Her.) Herb. etc.

The genus *Crinum* appears to be the largest in the study area represented by eight species, globally the genus is represented by 130 species (Verdoorn, 1973). Most of the other genera viz. *Asphodelus* [Tourn.] Linn., *Dianella* Lamk., *Eucharis* Planch. & Linden, *Eucrosia* Ker-Gawl., *Gloriosa* L., *Hemerocallis* L., *Hippeastrum* Herb., *Hypoxis* L., *Proiphys* Herb., *Scadoxus* Raf. and *Urginea* Steinh. each represented by a single species.

Out of 43 species, 21 species are wild and 22 are cultivated. Among the wild species *Asparagus racemosus* Willd.*, A. densiflorus* (Kunth) J.P. Jessop and *A. setaceous* (Kunth) J.P. Jessop are climbers. *Hypoxis aurea* Lour.*, Asparagus setaceous* (Kunth) J.P. Jessop, *Asphodelus tenuifolius* Cavan and *Crinum stenophyllum* Baker are previously recorded from this area but during our survey we did not find any live specimens of them in the wild. Both intensive and extensive survey throughout the country is needed to find out their live specimens. If found anywhere, the place should be taken under controll to conserve them.

Some species are restricted to certain small area like *Urginea indica* (Roxb.) Kunth in Cox's Bazar district near Himchari and *Allium tuberosum* Rottler *ex* Spreng. in Belaichari of Rangamati district. To conserve these two species immediate in-situ as well as *ex-situ* conservation methods should be adopted. The Forest Department and the local administration should come forward in this regard.

Chlorophytum nepalense (Lindley) Baker was collected only from Runctia *Sal* forest under Sherpur district in 2008 and planted in the Dhaka University Botanical Garden. Despite repeated field trips made in that area for further collection, no specimen of *Chlorophytum nepalense* were found and therefore this species might be claimed as very rare or extinct in Bangladesh. Photograph of the species may be supplied to forest personnel of that area indicating its vegetative and flowering time which may help its rediscovery.

Most of the species in this family are ornamental, e.g. *Crinum* L., *Eucrosia* Ker-Gawl., *Scadoxus* Raf., *Hemerocallis* L., *Hippeastrum* Herb., *Proiphys* Herb. and *Zephyranthes* Herb. These plants are profusely cultivated in most of the gardens. Medicinally important species belong to the genera are *Asparagus* Tourn. *ex* Linn., *Chlorophytum* Ker-Gawl., *Gloriosa* L., *Curculigo* Gaertn., *Allium* [Tourn.] Linn., *Asphodelus* [Tourn.] Linn., *Crinum* L., and *Urginea* Steinh. Some species are used as vegetable, e.g. *Asparagus officinalis* and some are also used as spices, e.g. *Allium cepa, A. chinense* and *A. sativum*. These are also medicinal and are used in herbal as well as homoeo medicines. So their conservation and cultivation are needed. Their best genotypes should be experimentally selected and referred for cultivation.

Chlorophytum nepalense (Lindley) Baker, a very rare species, was only recorded from Runctia *Sal* forest and confirmed as a new record for Bangladesh. *Chlorophytum nepalense* (Lindley) Baker develops tuberous roots, which are more or less similar to *Chlorophytum tuberosum* (Roxb.) Baker. However, *C. nepalense* differs from *C. tuberosum* in pedicel jointed above the middle in *C. nepalense*, whereas below the middle in *C. tuberosum*. Some other species, viz. *Allium chinense* G. Don, *Asparagus densiflorus* (Kunth) J.P. Jessop, *A. officinalis* L., *Chlorophytum laxum* R. Br., *Crinum amabile* Donn, *C. jagus* (Thomps.) Dandy, *Eucharis grandiflora* Planch. & Linden, *Eucrosia bicolor* Ker-Gawl., *Hippeastrum puniceum* (Lamk.) Voss, *Proiphys amboinensis* (L.) Herb., *Zephyranthes atamasco* (Linn.) Herb. are usually cultivated in the gardens, were not reported in any literature published previously for this region.

Hymenocallis littoralis (Jacq.) Salisb., was not recorded before from any part of the country. Hence it might be a new record for Bangladesh.

Scadoxus multiflorus Raf. was wrongly identified since long time under the name *Haemanthus multiflorus* Martyn *ex* Willd. but existing species is *Scadoxus multiflorus* Raf. *Scadoxus* differs from *Haemanthus* in stem and leaf characters as well as in somatic chromosome number.

In many established and authentic books, placentation of *Allium* is stated as axile but the present author, found basal placentation in the species of *Allium* instead of axile. Therefore, species of *Allium,* as studied here, have basal placentation, not axile. However, it is true that an ovary with basal placentation when cut near its base seems to superficially axile placentation (not actually).

Characters of studied 43 species are summarized on in Table 64.

Reproductive biology data are important for cultivation of important taxa, for conservation and to identify seedlings of rare and important plants in the wild. This is also important to understand variation complexity resulted from breeding systems. Reproductive biological studies include floral study, pollination, seed germination, propagation etc. A comparative account of reproductive characters of 14 species are presented in Table 65.

Table 64. Summary of characters of 43 species recognized.

Name of the species	Stem	Leaf	Inflorescence	Scape	Anther	Ovary	Fruit	Seed	Uses	Wild/ Cultivated
Allium cepa L.	bulb	fistular sub-distichous	umbel	hollow	oblong	superior	capsule	flat	madicine spice	Cultivated
Allium chinense G. Don	bulb	fistular distichous	umbel	solid	oblong	superior	capsule	flat	vegetable	Cultivated
Allium sativum L.	bulb	not fistular distichous	umbel	solid	oblong	superior	capsule	flat	madicine spices	Cultivated
Allium tuberosum Rottler *ex* Spreng.	bulb with rhizome	not fistular spiral	umbel	solid	oblong	superior	capsule	flat	salad	Wild
Asparagus acerosus Roxb.	rhizome	cladodes	raceme	solid	oblong	superior	berry	round	madicine	Wild
Asparagus adscendens Roxb.	rhizome	cladodes	raceme	solid	oblong	superior	berry	round	madicine	Wild
Asparagus densiflorus (Kunth) J.P. Jessop	rhizome	cladodes	raceme	solid	oblong	superior	berry	round	ornamental	Cultivated
Asparagus officinalis L.	rhizome	cladodes	solitary	-	oblong	superior	berry	round	vegetable	Cultivated
Asparagus racemosus Willd.	rhizome	cladodes	raceme	solid	oblong	superior	berry	round	madicine	Cultivated
Asparagus setaceus (Kunth) J.P. Jessop	rhizome	cladodes	raceme	solid	oblong	superior	berry	round	ornamental	Cultivated
Asphodelus tenuifolius Cavan	rhizome	fistular	raceme	solid	oblong	superior	capsule	trigonous	madicine	Wild
Chlorophytum laxum R. Br.	rhizome	not fistular distichous	raceme	solid	oblong	superior	capsule	flat	ornamental	Cultivated
Chlorophytum nepalense (Lindley) Baker	rhizome	not fistular spiral	panicle	solid	oblong	superior	capsule	flat	madicine	Wild

Table 64 contd.

Name of the species	**Stem**	**Leaf**	**Inflorescence**	**Scape**	**Anther**	**Ovary**	**Fruit**	**Seed**	**Uses**	**Wild/ Cultivated**
Crinum amabile Donn	bulb	not fistular	umbel	solid	linear	inferior	-	-	ornamental	Cultivated
Crinum amoenum Roxb.	bulb	spiral	umbel	solid	oblong	inferior	capsule	irregularly round	ornamental	Cultivated
Crinum asiaticum L.	bulb	not fistular	umbel	solid	linear	inferior	capsule	round concave	medicine ornamental	Wild
Crinum defixum Ker-Gawl.	bulb	spiral	umbel	solid	oblong	inferior	capsule	irregularly round	medicine ornamental	Wild
Crinum jagus (Thomps.) Dandy	bulb	not fistular	umbel	solid	oblong	inferior	capsule	irregularly round	ornamental	Cultivated
Crinum latifolium L.	bulb	spiral	umbel	solid	oblong	inferior	capsule	irregularly round	medicine ornamental	Wild
Crinum pratense Herb.	bulb	not fistular	umbel	solid	oblong	inferior	capsule	irregularly round	ornamental	Wild
Crinum stenophyllum Baker	bulb	spiral	umbel	solid		inferior	-	-	ornamental	Wild
Curculigo latifolia [Dryand.] Ait.	rhizome	plicate	raceme	solid	oblong	inferior	-	-	edible, making bags	Wild
Curculigo orchioides Gaertn.	rhizome	plicate	raceme	solid	oblong	inferior	bery	striped with small projection	medicine	Wild
Dianella ensifolia (L.) DC.	rhizome	not fistular distichous	panicle	solid	linear	superior	bery	flat, ovoid	ornamental	Wild
Eucharis grandiflora Planch. & Linden	bulb	not fistular spiral	umbel	solid	oblong	inferior	-	-	ornamental	Cultivated
Eucrosia bicolor Ker-Gawl.	bulb	not fistular spiral	umbel	solid	oblong	inferior	capsule	flat	ornamental	Cultivated
Gloriosa superba L.	tuberous rootstock	whorled	axillary	-	linear	superior	capsule	sub-globose	medicine ornamental	Wild
Hemerocallis fulva L.	rhizome	distichous	cyme	solid	linear-	inferior	capsule	flat	ornamental	Cultivated

Table 64 contd.

Name of the species	Stem	Leaf	Inflorescence	Scape	Anther	Ovary	Fruit	Seed	Uses	Wild/ Cultivated
					oblong					
Hippeastrum puniceum (Lamk.) Voss	bulb	distichous	umbel	hollow	oblong	inferior	capsule	flat	ornamental	Cultivated
Hymenocallis littoralis (Jacq.) Salisb.	bulb	not fistular spiral	umbel	solid	linear	inferior	capsule	flat	ornamental	Wild
Hypoxis aurea Lour.	rhizome	sub-distichous	raceme	solid	sagittate	inferior	capsule	sub-globose	medicine	Wild
Molineria recurvata (Dryand.) Herb.	tuberous rootstock	plicate	head like raceme	solid	linear, fused	inferior	berry	round	madicine	Wild
Molineria salarkhanii S.N. Uddin & M.A. Hassan	tuberous rootstock	plicate	head like raceme	solid	linear, fused	inferior	berry	round	-	Wild
Pancratium biflorum Roxb.	bulb	sub-distichous	umbel	solid	linear	inferior	capsule	flat	ornamental	Cultivated
Pancratium triflorum Roxb.	bulb	distichous	umbel	solid	linear	inferior	capsule	flat	ornamental	Wild
Pancratium verecundum Ait.	bulb	sub-distichous	umbel	solid	linear	inferior	capsule	flat	ornamental	Wild
Proiphys amboinensis (L.) Herb.	bulb	not fistular spiral	umbel	solid	linear	inferior	berry	-	ornamental	Cultivated
Scadoxus multiflorus Raf.	bulb	not fistular spiral	umbel	solid	linear	inferior	berry	round, fleshy	medicine ornamental	Cultivated
Urginea indica (Roxb.) Kunth	bulb	not fistular spiral	raceme	solid	oblong	superior	capsule	flat	medicine	Wild
Zephyranthes atamasco (Linn.) Herb.	bulb	fistular fascicled	solitary	hollow	linear	inferior	capsule	flat	ornamental	Cultivated
Zephyranthes candida (Lindl.) Herb.	bulb	not fistular fascicled	solitary	hollow	oblong	inferior	capsule	flat	ornamental	Cultivated
Zephyranthes carinata Herb.	bulb	not fistular fascicled	solitary	hollow	linear	inferior	capsule	flat	ornamental	Cultivated
Zephyranthes tubispatha (L'Her.) Herb.	bulb	not fistular fascicled	solitary	hollow	linear	inferior	capsule	flat	ornamental	Cultivated

Table 65. Reproductive characteristics of studied 14 species.

Species Name	**Pollination types**	**Time taken for seed germination**	**Time taken for scape initiation to first flowering (Days)**	**Time taken for fruit formation after flowering (Days)**	**Time taken for fruit maturation after formation (Days)**	**No. of flowers per scape**	**No. of fruits per scape**	**No. of seed/s per fruit**	**Time taken for flowering from seed germination (Years)**	**Time taken for flowering from bulb or rhizome transfer (Years)**
Allium tuberosum Rottler *ex* Spreng.	Cross	6-8 days	21	7	21	40-60	30-50	1-6	4	2
Asparagus racemosus Willd.	Cross	15-21 days	8	16	50	30-60	1-6	1	4	Not possible
Chlorophytum nepalense (Lindley) Baker	Cross	17-20 days	9	7	67	50-70	25-35	2-12	2	Not possible
Crinum amoenum Roxb.	Self	1 year	13-15	6-10	25-30	6-9	2-5	1-5	4-5	2
Curculigo orchioides Gaertn.	Self	Not germinated	9-12	12-15	25-30	2-4	1-2	1-15	Seeds not germinated	2-3
Gloriosa superba L.	Self	31-198 days	7	14	58	1	1	50-75	3-4	1
Hemerocallis fulva L.	No fruit formation	Produced no fruit	14	Produced no fruit	-	Produced no fruit	-	-	Produced no fruit	3
Pancratium triflorum Roxb.	Self	Fruit not matured	12	5	Fruit not matured	2-4	1-2	Fruit not matured	Produced no seed	2

Table 65 contd.

Species Name	Pollination types	Time taken for seed germination	Time taken for scape initiation to first flowering (Days)	Time taken for fruit formation after flowering (Days)	Time taken for fruit maturation after formation (Days)	No. of flowers per scape	No. of fruits per scape	No. of seed/s per fruit	Time taken for flowering from seed germination (Years)	Time taken for flowering from bulb or rhizome transfer (Years)
Scadoxus multiflorus Raf.	Self	Not germinated	15-20	10-12	50-55	70-100	2-3	1	Seeds not germinated	3
Urginea indica (Roxb.) Kunth	Cross	6 days	15	6	9	6-17	2-3	2-3	4-5	3
Zephyranthes atamasco (Linn.) Herb.	Self	5 days	8	4	7	1	1	2-8	3	2
Zephyranthes candida (Lindl.) Herb.	Self	3-4 days	7	3	6	1	1	6-20	3	2
Zephyranthes carinata Herb.	Self	3-4 days	8	4	7	1	1	6-20	3	2
Zephyranthes tubispatha (L'Her.) Herb.	Self	3-4 days	7	3	6	1	1	8-20	3	Not possible

From Table 65 it is clear that out of 14 species studied, 4 species, viz. *Allium tuberosum* Rottler *ex* Spreng., *Asparagus racemosus* Willd., *Chlorophytum nepalense* (Lindley) Baker and *Urginea indica* (Roxb.) Kunth are cross pollinated, whereas the rest are self pollinated excluding a single species did not produce fruit (e.g. *Hemerocallis fulva*).

Minimum time taken for seed germination is 3-4 days in *Zephyranthes* spp., whereas maximum 1 year in *Crinum amoenum* Roxb. Seeds were not germinated in *Curculigo orchioides* Gaertn. Shrestha *et al.* (2011) showed that the dormancy period in *Curculigo orchioides* Gaertn. remains 11-12 months.

Asparagus racemosus Willd. and *Scadoxus multiflorus* Raf. produced single seed, while *Gloriosa superba* L. contains about 50-75 seeds in each fruit. Production of fruits and seeds were very poor compare to number of flowers in *Allium tuberosum* Rottler *ex* Spreng., *Asparagus racemosus* Willd. and *Scadoxus multiflorus* Raf.

In the present study *Hemerocallis fulva* L. and *Hymenocallis littoralis* (Jacq.) Salisb., no fruit formation occurred but these species reproducd vegetatively. Previous studies also showed that these two species did not produce any fruit (Rhoads *et al*., 2007; Duke, 1992; Hubbard, 1987). Therefore our study was supported by earlier studies.

Minimum time taken for scape initiation to fruit maturation were 16 days in *Zephyranthes* spp. and maximum about 80 days in *Gloriosa superba* L. Maximum about 100 flowers borne on a scape in *Scadoxus multiflorus* Raf., whereas single flower in *Gloriosa superba* L. and *Zephyranthes* spp.

The present study revealed that great variation in pollination of *Gloriosa superba* L. Padmapriya *et al.* (2015) stated that attractively coloured flowers favours cross pollination. Only large insects like bumble bees and birds like *Nectarinia zeylanica* and *Nectarinia asiatica* with long beaks have been reported to be pollinators for this species. However this study showed self pollination in *Gloriosa superba* L. found inconsistance with those of Padmapriya *et al.* (2015) and Schmelzer and Gurib-Fakim (2008).

References

Afroz, S., Tutul, E., Uddin, M.Z. and Hassan, M.A. 2008. *Chlorophytum nepalense* (Lindley) Baker (Liliaceae) - A New Angiospermic Record for Bangladesh. Bangladesh J. Bot. **37**(2): 193-194.

Ahmed, N. 1997. Wild Flowers of Bangladesh. The University Press Limited, Dhaka, Bangladesh. p. 124.

Ahmed, Z.U. 2008. Bangladesh-Land of Unique Socio-Biological Profile. In: Ahmed, Z.U., Hassan, M.A., Begum, Z.N.T., Khondker, M., Kabir, S.M.H., Ahmed, M. and Ahmed, A.T.A. (eds.). Encyclopedia of Flora and Fauna of Bangladesh, Vol. 1. Bangladesh Profile. Asiatic Society of Bangladesh, Dhaka. pp. 1-8.

Ahmed, Z.U., Hassan, M.A., Begum, Z.N.T., Khondker, M., Kabir, S.M.H., Ahmed, M. and Ahmed, A.T.A. (eds.) 2007-09. Encyclopedia of Flora and Fauna of Bangladesh, Vols. 1-28. Asiatic Society of Bangladesh, Dhaka.

Akcin, O.R., Ozyurt, M.S. and Senel, G. 2011. Petiole anatomy of some Lamiaceae taxa, Pak. J. Bot. **43**(3): 1437-1443.

Alam, M.B. 2000. Medicinal Plants for Livestock and Poultry in Disaster Prone Areas like Chilmari, Bangladesh. SUMUL, Bangladesh. 104 pp.

Alam, S.S., Sharmin, S.A., Sarker, R.H. and Zaman, M.A. 1998. Karyotype analysis with differential bandings in *Crinum pratense* and *C. defixum*. Cytologia **63**: 223-227.

Ali S.I. and Qaiser, M. 2005. Flora of Pakistan. Vol. 211. Missouri Botanical Garden Press, p. 4.

Alvarez, A. and Köhler, E. 1987. Morphologia del pollen de las Agavaceae y algunos generos afincs. Grana **26**: 25-46.

Angiosperm Phylogeny Group 1998. An ordinal classification for the families of flowering plants, Annals of the Missouri Botanical Garden **85**(4): 531-553.

Ankermann, F. 1927. Die Phylogenie der Monocotyledonen. Bot. Arch. **19**: 51-60.

Baker, H.G. and Hurd, P.J. 1968. Intrafloral ecology. Annual Review of Entomology. **13**: 385-414.

Bakshi, D.N.G. 1984. Flora of Murshidabad District. Scientific Publishers, Jodhpur, India. 440 pp.

Bateman, H., Kelpac, A., Moody, M., Sweeney, B. and Tomnay, S. 2004. The Essential Flower Gardening Encyclopedia. Fog City Press, the U.S.A. 608 pp.

Bentham, G. *et* Hooker, J.D. 1983. Genera Plantarum. Vol. III, Part 2. L. Reeve & Co. Ltd., London. 1258 pp.

Bessey, C.E. 1915. The Phylogenetic Taxonomy of Flowering Plants. Ann. Miss. Bot. Gard. **2**: 109-164.

Black, C.A. 1965. Methods of soil and plant analysis. Part I and II. American Society of Agronomy.

Brink, M. and Escobin, R.P. (eds.). 2003. Plant Resources of South-East Asia No. 17. Fibre Plants. Backhuys Publishers, Leiden, the Netherlands. 456 pp.

Burmanni, N.L. 1768. Flora Indica. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. pp. 79-84.

Burrows, G.E. and Tyrl, R.J. 2001. Toxic Plants of North America. Iowa State University Press, Ames. IA 539: 541.

Calestani, C. 1933. Le origini e la classifizione delle angiosperme. Archo. Bot. Sist. Fito-geogr. Gene. **9**: 274-311.

Cav, M.S. 1948. Sporogenesis and embryo sac development of *Hesperocallis* and *Leucocrinum* in relation to their systematic position. Am. J. Bot. **35**: 343-349.

Cav, M.S. 1970. Chromosomes of California Liliaceae. Univ. Calif. Publ. Bot. **57**: 1-48.

Chase, M.W., Rudall, P.J. and Conran, J.G. 1996. New circumscriptions of asparagoid lilies: genera formerly included in Anthericaceae. Kew. Bull. **51**: 667-680.

Cheung, A.Y. 1995. Pollen-pistil interactions in compatible pollination. Proc. Natl. Acad. Sci. USA. **92**: 3077-3080.

Conran, J.G. 1998a. Anthericaceae. In: Kubitzki, K. (ed.). The families and genera of vascular plants. III, Springer, Berlin, Heidelberg, New York. pp. 114-121.

Cowan, J.M. 1928a. The Flora of Chakaria Sundarbans. Rec. Bot. Surv. Ind. **11**(2): 119-225.

Cronquist, A. 1968. The Evolution and Classification of Flowering Plants. H. Mifflin, Boston.

Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York. 1262 pp.

Cronquist, A. 1988. The Evolution and Classification of Flowering Plants. 2nd ed. The New York Botanical Garden, New York. 555 pp.

Cronquist, A. 1993. Angiosperms. Encyclopedia Brittaanica **13**: 603-765.

Dahlgren, R.M.T. 1975. A system of classification of the angiosperms to be used to demonstrate the distribution of characters. Bot. Notiser **128**:119-147.

Dahlgren, R.M.T. and Clifford, H.T. 1982. The monocotyledons. A comparative study. Academic Press, London.

Dahlgren, R.M.T. and Rasmussen, F.N. 1983. Monocotyledon Evolution. Characters and phylogenetic estimation. Evol. Biol. **16**: 255-395.

Dahlgren, R.M.T., Clifford, H.T. and Yeo, P.F. 1985. The families of the Monocotyledons: 199.

Dassanayake, M.D., and Clayton, W.D. 1981. A Revised Handbook to the Flora of Ceylon, Oxford & IBH Co. Ltd., Calcutta. **14**: 25-26.

Datta, R.M. and Mitra, J.N. 1953. Common plants in and around Dacca. Bul. Bot. Soc. Beng. **7**(1&2): 102-105.

de Padua, L.S., Bunyapraphatsara, N. and Lemmens, R.H.M.J. (eds.). 1999. Plant Resources of South-East Asia No. 12. Medicinal and Poisonous Plants 1. Backhuys Publishers, Leiden, the Netherlands. 711 pp.

Deb, D.B. 1983. The Flora of Tripura State. Vol. 2, Today and Tomorrow's Printers and Publishers, New Delhi, India. 601 pp.

Deb, D.B. and Dasgupta, S. 1981. Fascicles of Flora of India, Fascicle 7, Botanical Survey of India, Calcutta. 23 pp.

Deyl, M. 1955. The evolution of plants and the taxonomy of monocotyledons. Act. Mus. Nat. Prag. XI B, No. 6, Bot. No. **3**: 1-143.

Dickinson, H.G. and Roberts, I.N. 1986. Cell surface receptors in the pollen-stigma interaction of *Brassica oleracea*. In: hormones, receptors and cellular interaction in plants. pp. 255-279.

Duke, J.A. 1992. Handbook of Edible Weeds: Herbal Reference Library. CRC Press, New York.

Dumas, C. and Guade, T. 1981. Stigma pollen recognition and pollen hydration. Phytomorphol. **31**: 191-201.

Ehrendorfer, F. 1978. In: von Denffer D., Ehrendorfer, F., Magdefrau, K., Ziegler, H. (eds.). Lehrbuch der Botanik. G. Fischer, Stuttgart. pp. 835-841.

Emberger, L. 1960. Les vegetaux vascularies. In: M. Chadefaut and L. Emberger (eds.). Traite de Botanique, Masson, Paris. pp. 1-1539.

Engler, A. 1892. Die Systematische Anordnung monocotyledoneen Angiospermen. Abh. Preuss. Akad. Wiss. Berlin. 55 pp.

Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist and Wiksell, Stockholm, Sweden.

Faegri, K. and van der Pijl, L. 1966. The principles of pollination ecology. Pergamon, Oxford.

Faulks, P.J. 1964. The Systematization of the Angiosperms. Moredale, London.

Fay, M.F. and Chase, M.W. 1996. Resurrection of Themidaceae from the Brodiaea alliance, and recircumscription of Alliaceae, Amaryllidaceae and Agapanthoideae. Taxon **45**: 441-451.

Fedorov, A.A. 1969. Chromosome Numbers of Flowering Plants. Academy of Sciences of USSR, Moscow. 926 pp.

Friis, I., Nordal, I. 1976. Studies on the genus *Haemanthus* (Amaryllidaceae) IV. Division of the genus into *Haemanthus* s. str. and *Scadoxus* with notes on *Haemanthus* s. str. Norw. J. Bot. **23**: 63-77.

Fryxell, P.A. 1957. Mode of Reproduction of Higher Plants. Botanical Review **23**:135-233.

Gaston, K.J. and Blackburn, T.M. 2000. Pattern and process in Macroecology. Wiley-Blackwell, Oxford, UK.

Gerry, A.K. and Wilson, S.D. 1995. The influence of initialize on the competitive responses of six plant species. Ecology **76**: 272-279.

Ghani, A. 2003. Medicinal Plants of Bangladesh. Asiatic Society of Bangladesh, Dhaka. 460 pp.

Gray, A. 1908. Robinson, B.L. and Fernald, M.L. (eds.). Gray's new manual of botany: a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. 7^{th} ed., American book company, New York, pp. 279-300.

Gupta M., Murty, Y.S. 1985. Viability and longevity of pollen in *Vicia faba* L. Acta Bot. Indica **13**: 292-294.

Hajra, P.K. and Verma, D.M. 1996. Flora of Sikkim: Monocotyledons. Volume 1, Botanical Survey of India, New Delhi, India. 336 pp.

Hallier, H. 1903. Uber den Umfang, die gliederung und die Verwandtschaft der familie der Hamamelidaceen. Beih. Bot. Zen. Zentralbl **14**: 247-260.

Hallier, H. 1905. Ein Zweiter Entwurf des Naturlichen (Phylogenetischen) Systems der Blutenpflanzen. Vorlaufige Mitteilung. Ber. Dtsch. Bot. Ges. **23**: 85-91.

Hallier, H. 1912. L'origine *et* le systeme phyletique das Angiosperms exposes a l'aide de leur arbre genealogique. Arch. Neerl. Sci. Exact Nat. Ser. 3B **1**: 146-234.

Hamann, U. 1961. Merkmalabestand und Verwandtschaftsbeziehungen de Farinosae. Ein Beitrag zum Syatem der Monokotyledonen. Willdenowia **4**: 1-178.

Hamilton, F. and Don, D. 1825. Prodromus Florae Nepalensis. Veneunt Apud J. Gale, Bruton Street, London. 256 pp.

Hang, T.T.M., Phuong, P.T.M., Dung, T.T.M. and Miyajima, I. 2015. Preliminary chromosome studies on *Hippeastrum* species from Vietnam. J. Fac. Agr. Kyushu Univ. **60**(1): 51-55.

Hassan, M.A. and Khan, M.S. 1996. Pollination mechanism in *Polygonum* L. (*s. l.*). Bangladesh J. Plant Taxon. **3**(1): 67-70.

Heinig, R.L. 1925. List of Plants of Chittagong Hill Tracts. The Bengal Government Branch Press, Darjeeling, pp. 1-84.

Heslop-Harrison, J. 1975. Incompatibility and the pollen stigma interaction. Ann. Rev. Plant Physiol. **17**: 403-425.

Hooker, J.D. 1872-1997. The Flora of British India. Vols. 1-7, L. Reeve and Co. Ltd., Kent, England.

Hooker, J.D. 1892. The Flora of British India. L. Reeve and Co. Ltd., Kent, England. **6**: 277-362.

Huber, H. 1969. Die Samenmerkmale und Verwandtschaftsverhaltnisse der Liliifloren. Mitt. Bot. Staatssamml. Munchen **8**: 219-538.

Huber, H. 1977. The treatment of the monocotyledons in an evolutionary system of classification. Plant Syst. Evol. Suppl. **1**: 285-298.

Hutchinson, J. 1934. The Families of Flowering Pants. Vol. 2. London, 243 pp.

Islam, S. 2003. Banglapaedia: National Encyclopaedia of Bangladesh. Vol. 3. Asiatic Society of Bangladesh, Nimtali, Dhaka. p. 45.

Ismail, M. and Mia, M.K. 1972. Ecology of Bangladesh Vegetation 1. Bot. Surv. Bangladesh, BARC, Dhaka.

Jackson, B.D. 1895 (rep. 1946). Index Kewensis (An Enumeration of the Genera and Species of Flowering Plants). 2 Vols. Clardon press, Oxford.

Jee, G. and Vijayavalli, B. 1999. Karyomorphology of eight taxa of *Hymenocallis* from South India. Caryologia **52**(1-2) 59-64.

Jessop, J.P. 1979. Liliaceae. In: van Steenis, C.G.G.J. (ed.), Flora Malesiana, Ser. 1, Vol. 9, Part 1. Noordhoff International Publishing, Leiden, the Netherlands, pp. 189-235.

Judd, W.S. 1999. Plant Systematics: A Phylogenetic Approach. Sunderland, Mass Sinauer Associates, 464 pp.

Kale, K. and Thakare, P. 2013. Genus *Chlorophytum* Ker-Gawl.: Medicinally important plant from Ancient Indian literature (Ayurveda), Int. J. Ayur. & Herb. Medicine **3**(3): (1201-1211).

Kalkman, C., Geerinck, D.J.L., Buijsen, J.R.M. and Duyfjes, B.E.E. 1993. Flora Malesiana, Vo. 11, Part 2. Rijksherbarium. 192 pp.

Kameshwari, M.N.S., Lakshman, A.B. and Paramasivam, G. 2012. Biosystematics studies on medicinal plant *Urginea indica* Kunth. Liliaceae - A review. Int. J. Pharm. & Life Sci. **3**(1): 1394-1406.

Karthikeyan, S., Jain, S.K., Nayar, M.P. and Sanjappa, M. 1989. Flora of India. Ser. 4. Botanical Survey of India, Pune, India. pp. 3-4, 88-102.

Kehimkar, I. 2000. Common Indian Wild Flowers. Bombay Natural history Society. Oxford University Press, Calcutta. 141 pp.

Khan, M.S. 1977. The vegetation of Bangladesh. In: Ali, S.I. and Gaffar, A. (eds.). Plant Life of South Asia. pp. 185-192.

Khan, M.S. and Alam, M.K. 1977. Commelinaceae. In: Khan, M.S. (ed.), Flora of Bangladesh. Fascicle No. 4. Bangladesh National Herbarium, Bangladesh Agricultural Research Council, Dhaka.

Khan, M.S., Hassan, M.A. and Uddin, M.Z. 2002. Ethnobotanical survey in Rema-Kalenga Wildlife Sanctuary (Habiganj) in Bangladesh. Bangladesh J. Plant Taxon. **9**(1): 51-60.

Khan, M.S., Rahman, M.M., Huq, A.M., Mia, M.M.K. and Hassan, M.A. 1994. Assessment of biodiversity of Teknaf Game Reserve in Bangladesh focusing on economically and ecologically important plant species. Bangladesh J. Plant Taxon. **1**(1): 21-33.

Kimura, Y. 1956. Systeme *et* phylogene des monocotyledones. Notul. Syst (Paris) **15**: 137-149.

Kirtikar, K.R., Basu, B.D. and An, I.C.S. 1935. (2nd ed.) Indian Medicinal Plants. Vol. 4, (reprint ed. 1994). Bishen Singh Mahendra Pal Singh, Dehra Dun, India. pp. 2465-2528.

Knox, R.B. 1984. Pollen pistil interactions. In: Cellular interactions. Encycl. Plant Physiol. **17**: 508-608.

Knox, R.B., Clarke, A.E., Harison, S., Smith, P. and Merchaloins, J.J. 1976. Cell Recognition in Plants: Determinants of the stigma surface and their pollen interactions. Proc. Natl. Acad. Sci. USA. **73**: 2788-2792.

Kubitzki, K. 1998. The Families and Genera of Vascular Plants. Flowering Plants, Monocotyledons: Lilianae (except Orchidaceae). Vol. 3, Springer-Verlag Berlin Heidelberg, New York, 478 pp.

Kumar, V. and Subramaniam, B. 1986. Chromosome Atlas of Flowering Plants of the Indian Subcontinent. Vol. II, Botanical Survey of India, Calcutta. 464 pp.

Lim, T.K. 2015. Edible Medicinal and Non Medicinal Plants: Vol. 9, Modified Stems, Roots, Bulbs, Springer Dordrecht Heidelberg, New York, London. 1036 pp.

Lindley, J. 1853. The Vegetable Kingdom; The structure, classification, and uses of plants. 3rd edition. Bradbury & Evans Printers, London.

Lippik, E.E. 1964. Floral Evolution in the Ranunculaceae. Iowa State Jour. Sci. **39**: 1-101.

Lotsy, P.J. 1911. Vortrage Uber Botanische Stammesgeschichte, Vol. 3, 1. Jena: G. Fischer.

Lubna, A., Begum, R., Noor, S.S., Zaman, M.A. and Alam, S.S. 2004. Reversible flurescent chromosome banding in three *Crinum* spp. (Amaryllidaceae). Cytologia **69**(1): 69-74.

Maekawa, F. and Kaneko, K. 1968. Evolution of Karyotype in *Hosta* (Liliaceae). J. Jpn. Bot. **43**: 132-140.

Mayer, A.M. and Poljakoff-Mayber, A. 1989. The germination of seeds. Pergamon Press, New York.

Meerow, A.W. 1987. A Monograph of *Eucrosia*. System. Bot. **12**(4): 460-492.

Meerow, A.W. 1989. Systematics of the Amazon lilies, *Eucharis* and *Caliphruria* (Amaryllidaceae). Ann. Missouri Bot. Gard.**76**: 136-220.

Meerow, A.W. and Dehgan, B. 1985. The articulate pollen grain of *Hymenocallis quitoensis* Herb. (Amaryllidaceae) and its systematic implications. Amer. J. Bot. **72**: 540-547.

Meerow, A.W. and Dehgan, B. 1988. Pollen morphology of the Eucharideae (Amaryllidaceae). Amer. J. Bot. **75**: 1857-1870.

Meerow, A.W., Dehgan, N.B. and Dehgan, B. 1986. Pollen tetrad in *Stenomesson elwesii* (Amaryllidaceae). Amer. J. Bot. **73**: 1642-1644.

Melchior, H. (ed.) 1964. Engler's Syllabus der Pflanzenfamilien (ed. 12), 2: Angiospermae, Berlin.

Mia, M.M.K. and Khan, B. 1995. First list of angiospermic taxa of Bangladesh not included in Hooker's Flora of British India and Prain's Bengal Plants. Bangladesh J. Plant Taxon. **2**(1&2): 24-45.

Mitra, J.N. 1958. Flowering Plants of Eastern India. Vol. I-Monocotyledons, The World Press Pvt. Ltd., Calcutta, India. 387 pp.

Moore, P.D., Webb, J.A. and Collinson, M.E. 1991. Pollen Analysis, 2nd ed. Blackwell Scientific Publications, Oxford, U.K.

Moshiuzzaman, M., Nahar, N. and Begum, S.A. 2002. Bioactivity and Chemical Studies of *Urginea indica* Kunth (Liliaceae) and *Scoparia dulcis* Linn. (Scrophulariaceae). Ph.D Thesis. Dept. of Chemistry, University of Dhaka. pp. i-iii; 16-19.

Mukherji, H. 1972. Plant Groups (8th edition). Books & Allied Pvt. Ltd., Calcutta, India. 1084 pp.

Naik, V.N. 1977. Cytotaxonomic studies of six Indian species of *Chlorophytum*. Bot. Journ. Linn. Soc. **74**: 297-308.

Nairne, A.K. 1894. The Flowering Plants of Western India. W.H. Allen & Co. Ltd., London. 401 pp.

Nayar, M.P. 1984. Key Works to the Taxonomy of Flowering Plants of India. Vol. 1, Botanical Survey of India, Calcutta. 462 pp.

Nayar, M.P. 1985. Key Works to the Taxonomy of Flowering Plants of India. Vol. 3, Botanical Survey of India, Calcutta. 169 pp.

Nie, Y., Dong, X., He, Y., Yuan, T., Han, T., Rahman, K., Qin, L. and Zhang, Q. 2013. Medicinal plants of genus *Curculigo*: Traditional uses and a phytochemical and ethnopharmacological review. Journ. Ethnopharm. **147**(3): 547-563.

Noltie, H.J. 1994. Flora of Bhutan. Vol. 3. Part 1, Royal Botanic Garden, Edinburgh. 456 pp.

Novak, F.A. 1954. System Angiosperm. Preslia **26**: 337-364.

Nowicke, J.W. and. Skvarla, J.J. 1979. Pollen morphology: The potential influence in higher order systematics. Ann. Missouri Bot. Gard. **66**: 633-700.

Oberle G.D. and Watson, R. 1953. The use of 2,3,5-triphenyl tetrazolium chloride in viability test of fruit pollen. Am. Soc. Hortic. Sci. **61**: 299-303.

Padmapriya, S., Rajamani K. and Sathiyamurthy V.A. 2015. Glory Lily (*Gloriosa superba* L.) - A Review. Inter. Journ. Curr. Pharmac. Rev. Research **7**(1): 43-49.

Pal, D.C. and Jain, S.K. 1998. Tribal Medicine. Naya Prokash, Calcutta, India. p. 126.

Patterson, T.B. and Givnish, T.J. 2002. Phylogeny, Concerted Convergence, and Phylogenetic Niche Conservatism in the Core Liliales: Insights from *Rbc*l and *Ndh*f sequence data. Evolution **56**: 233-252.

Pires, J.C., Fay, M.F., Davis, W.S., Hufford, L. Rova, J. Chase, M.W. and Sytsma, K.J. 2001. Molecular and morphological phylogenetic analyses of Themidaceae (Asparagales). Kew. Bull. **56**: 601-626.

Polunin, O. and Stainton, A. 1984. Flowers of the Himalaya. Oxford University Press, New Delhi. 580 pp.

Prain, D. 1903. (Ind. Rep. 1981). Bengal Plants. Vol. 2. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. 1319 pp.

Prain, D. 1903a. The Flora of Sundribuns. Record of the Botanical Survey of India **144**: 312-313.

Radford, A.E., Dickison, W.C., Massey, J.R. and Bell, C.R. 1974. Vascular Plant Systematics. Harper and Row Publishers, New York. London. 891 pp.

Rahman, M.O. and Hassan, M.A. 1995. Angiospermic flora of Bhawal National Park, Gazipur (Bangladesh). Bangladesh J. Plant Taxon. **2**(1&2): 47-79.

Rashid, M.H. and Chowdhury, M.A.I. 2013. Additions to the Angiosperm Flora in the Sitapahar Reserve Forest of Kaptai, Rangamati, Bangladesh. Bangladesh J. Plant Taxon. **20**(2): 255-257.

Raven, P. and Zhengyi, W. (eds.) 2000. Flora of China. Flagillariaceae through Marantaceae. Vol. 24, Beijing Science Press. 431 pp.

Ravikumar, C. and Nair, P.K.K. 1982. Pollen morphological analysis of *Hymenocallis littoralis* Salisb. and *H. pedalis* - SEM and Light Microscopic study. J. Palynol. **18**: 43-54.

Rendle, A.B. 1930. The Classification of Flowering Plants. 2nd edition. Cambridge University Press, Cambridge.

Rhoads, A.F. and Timothy A.B. 2007. The Plants of Pennsylvania. An Illustrated Manual, 2nd edition. University of Pennsylvania Press,Philadelphia, PA.

Riotte, L. 1978. Companion Planting for Successful Gardening, Garden Way, Vermont, the USA.

Roxburgh, W. 1814. Hortus Bengalensis. Mission Press, Serampore. pp. 23-25.

Roxburgh, W. 1832. Flora Indica. Vol. 2. W. Thacker & Co., Calcutta, and Parbury, Allen & Co., London. 791 pp.

Rudall, P.J., Cribb, P.J., Cutler, D.F and Humphries, C.J. 1995. Monocotyledons: Systematics and Evolution. Volume 2, Royal Botanic Gardens, Kew.

Sajib, N.H., Uddin, S.B. and Islam, M.M. 2014. Angiospermic Plant Diversity of Subarnachar Upazila in Noakhali, Bangladesh. J. Asiat. Soc. Bangladesh, Sci. **40**(1): 39-60.

Satô, D. 1935. Analysis of karyotype in *Yucca*, *Agave* and related genera. Jap. J. Genetics **11**: 272-278.

Schmelzer, G.H. and Gurib-Fakim, K. (eds.) 2008. Plant Resources of Tropical Africa 11(1). Medicinal Plants 1. PROTA Foundation, Wageningen, the Netherlands. 791 pp.

Sen, S. 1975. Cytotaxonomy of Liliales. Feddes, Rep. **86**: 255-305.

Shrestha, B.B., Jha, P.K. and Kandel, D.R. 2011. Reproductive ecology and conservation prospects of a threatened medicinal plant *Curculigo orchioides* Gaertn. in Nepal. Trop. Ecol. **52**(1): 91-101.

Siddique, K.U., Islam, M.A., Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., Khondker, M, Rahman, M.M., Kabir, S.M.H., Ahmad, A.T.A., Rahman, A.K.A. and Haque, E.U. (eds.) 2007. Encyclopedia of Flora and Fauna of Bangladesh. Vol. 11, Angiosperms: Monocotyledons (Agavaceae-Najadaceae). Asiatic Society of Bangladesh, Dhaka. 399 pp.

Siemonsma, J.S. and Piluek, K. (eds.) 1994. Plant Resources of South-East Asia No. 8. Vegetables. Backhuys Publishers, Leiden, the Netherlands. 412 pp.

Simpson, G.M. 2006. Plant Systematics. Elsevier Academic Press, London, UK.

Simpson, M.G. 1983. Pollen ultrastructure of the Haemodoraceae and its taxonomic significance. Grana **22**: 79-103.

Sinclair, J. 1955. The flora of Cox's Bazar, East Pakistan. Bull. Bot. Soc. Beng. **9**(2): 84-116.

Sinha, S.C. 1996. Medicinal Plants of Manipur. Mass and Sinha, Manipur Cultural Integration Conference Palace Compound, Imphal, India. 238 pp.

Skottsberg, C. 1940. Vexternas Liv. Vol. 5. Kungl. Vet. Acad. Handl. Stockholm.

Snijman, D.A. 1991. *Kamiesbergia*, a new monotypic genus of the Amaryllideae-Strumariinae (Amaryllidaceae) from the north-western Cape. Bothalia **21**: 125-128.

Soo, C.R. de 1953. Die Modernen Grundsatze der Phylogenie. Acta Biol. Acad. Sci. Hungarica **4**: 257-306.

Soo, C.R. de 1961. Systematische Ubersicht der Pannonischen Pflanzen. 3: Act. Bot. Acad. Sci. Hung. **7**: 425-450.

Soo, C.R. de 1975. A Review of the new classification system of flowering plants. (Angiospermatophyta, Magnoliophyta). Taxon **24**: 585-592.

Stebbins, G. L. 1974. Flowering Plants- Evolution above the Species Level, Belknap Press, Harverd University Press, Cambridge, Mass.

Steer, M.W. and Steer, J.L. 1989. Pollen tube tip growth. New Phytol. **111**: 323-358.

Stone, J.L., Thomson, J.D., Dent-Acosta, S.J. 1995. Assessment of pollen viability in hand-pollination experiments: a review. Am. J. Bot. **82**:1186-1197.

Stuessy, T.F. 1990. Plant Taxonomy. Columbia Univ. Press, New York.

Takhtajan, A. 1959. Die Evolution der Angiospermen. Fischer, Jena.

Takhtajan, A. 1969. Flowering plants: Origin and dispersal. Oliver & Boyd, Edinburgh.

Takhtajan, A. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.

Tamura, M.N. 1995. A karyological review of the orders Asparagales and Liliales (Monocotyledonae). Feddes Repertorium **106**: 83-111.

Thompson, M.F. 1979. Studies in the Hypoxidaceae. III. The genus *Pauridia*. Bothalia **12**: 621-625.

Thomson, J.D., Rigney, L.P., Karoly, K.M. and Thomson, B.A. 1994. Pollen viability, vigor, and competitive ability in *Erythronium grandiflorum* (Liliaceae). Am. J. Bot. **81**:1257-1266.

Thorne, R.F. 1968. Synopsis of a putatively phylogenetic classification of the flowering plants. Aliso **6**(4): 57-66.

Thorne, R.F. 1976. A phylogenetic classification of the angiospermae. Evol. Biol. **9**: 35-106.

Thorne, R.F. 2000. The Classification and Geography of the Flowering Plants: Dicotyledons of the Class Angiospermae (Subclasses Magnoliidae, Ranunculidae, Caryophyllidae, Dilleniidae, Rosidae, Asteridae, and Lamiidae), Botanical Review, **66**(4): 441-647.

Traub, H.P. 1972. The Order Alliales. Pl. Life **28**: 129-138.

Uddin M.Z. and Hassan M.A. 2004. Flora of Rema-Kalenga Wildlife Sanctuary. IUCN-Bangladesh Country Office, Dhaka, Bangladesh. 122 pp.

Uddin, M.Z., Hassan, M.A. and Khan, M.S. 2002. An annotated checklist of angiospermic flora of Rema-Kalenga wildlife sanctuary (Habiganj) in Bangladesh-1. Liliopsida (Monocots). Bangladesh J. Plant Taxon. **9**(2): 57-66.

Uddin, M.Z., Khan, M.S. and Hassan, M.A. 1999. *Curculigo latifolia* Dryand. (Hypoxidaceae)-A new angiospermic record for Bangladesh. Bangladesh J. Pl. Taxon. **6**(2): 105-107.

Uddin, S.N. and Hassan, M.A. 2009. *Dianella ensifolia* (L.) DC. (Liliaceae) - A new angiospermic record for Bangladesh. Bangladesh J. Plant Taxon. **16**(2): 181-184.

Uddin, S.N., Khan, M.S., Hassan, M.A. and Alam, M.K. 1998. An annotated checklist of angiospermic flora of Sita Pahar at Kaptai in Bangladesh. Bangladesh J. Plant Taxon. **5**(1): 13-46.

Utech, F.H. 2002. Flora of North America: North of Mexico. Vol. 26, Flora of North America Editorial Committee (eds.), Oxford University Press, New York. 752 pp.

van der Pijl, L. 1960-61. Ecological aspects of flower evolution I, II. **14**: 403-416; **15**: 44-59.

Van Tieghem, P. 1891. Traite de Botanique. 2nd edition. Savy, Paris.

van Valkenburg, J.L.C.H. and Bunyapraphatsara, N. (eds.). 2002. Plant Resources of South-East Asia No. 12. Medicinal and Poisonous Plants 2. Backhuys Publishers, Leiden, the Netherlands. 782 pp.

Verdoorn, I.C. 1973. The Genus *Crinum* in Southern Africa. Bolhalia **11**(1&2): 27-52.

Walter, H.L., Memory P.F.E.L. 2003. Medical Botany: Plants Affecting Human Health. Wiley & Sons, 812 pp.

Wettstein, R.R. 1901. Handbuch der Systematischen Botanik. Leipzig and Wien: F. Deuticke.

Whistler, W.A. 2000. Tropical Ornamentals: a guide. Timber Press, Portland, Oregon. p. 72.

Whitaker*,* T.W. *1934*. Chromosome constitution in certain monocotyledons. J. Arnold Arb. **15**: 135-142.

Wilson, K.L. and Morrison, D.A. 2000. Monocots: Systematics and Evolution. Csiro Publishing, 728 pp.

Withering, W. 1845. Systematic Arrangement of British Plants (6th edition). Charterhouse Square, London. 437 pp.

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