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PREFACE

Aquatic angiosperms are very remarkable forms of plant life, mainly on account of the fact that due to the aquatic habitat, in which they spend most of their lives, they are practically unaffected by climatic and seasonal changes, or at least much less affected than land plants. For this reason it is possible to study such plants more or less throughout the year. Botanists will find in such aquatic plants a great source of interest, for they show rather striking adaptations to their liquid medium.

Dr Subramanyam, the author of this monograph, has spent many years in the detailed study of these plants; we see in this book the results of his careful work on the same. From discussions I have had with the author, I have learnt of the great difficulty he has had in the selection of his plants for detailed study; it is clear that a very large number of our monsoon plants could be justly called aquatic plants, for they grow during the monsoon when the soil is not only water-logged, but also often covered with a considerable layer of free water. On purpose many of the monsoon plants have had to be omitted from this book in order to keep it from becoming unduly bulky.

This book, then, covers only some of the plants more widely spread all over India, plants usually growing out of the monsoon season. The book, it is hoped, will be of help to botanists all over the country who may wish to study such plants in 'fair weather'.

The descriptions and diagrams are at times somewhat different from those appearing in printed floras; this is due to the fact that the author has collected and examined his plants in the living condition, and described them and made his diagrams from the same living plants. The book, therefore, is not just a compilation or re-hashing of previously published information, but forms an interesting contribution to our knowledge of the flora of India from first hand personal knowledge and study. When examining the diagrams of various plants I have been delighted to see that at least some plates carry an appropriate scale for the plant and for its individual parts,

a detail to which many other publications seem to pay scanty attention, but which will be of real help to students. The author has made efforts to straighten the nomenclature of his plants; he has succeeded not only in this but also in establishing the correct identity of some plants, which all along had been consistently misidentified by Indian botanists.

My good wishes go to the author and to the book. At the same time may I express the hope that we shall see more contributions by the author of the standard of the present monograph.

H. SANTAPAU
Chief Botanist
Botanical Survey of India

Calcutta
September 17, 1961

AUTHOR'S NOTE

The Botanical Monographs Committee of the Council of Scientific and Industrial Research, impressed by the wealth of aquatic vegetation in India, felt the need for a suitable hand-book on the subject. So, when this work was assigned to me by Dr M. S. Randhawa and Professor P. Maheshwari, I accepted it willingly and gladly because I knew I had plenty of opportunities to study the plants both in nature in the course of my botanical tours and in the various herbaria of the country.

This monograph deals with the better known aquatic angiosperms of India; in addition to descriptions of families, genera, and species with appropriate keys, information is given on anatomy, embryology, chromosome numbers, pollination mechanism, ecology and medicinal uses. The illustrations, as far as possible, are drawn from fresh materials; but information available from other sources has also been incorporated.

The help rendered by some of my friends, colleagues and associates in the Botanical Survey of India, in the compilation of the monograph, has been considerable. The illustrations have been drawn by Messrs L. P. Sikdar, S. N. Roy and S. Chandrasekhar; Professors J. Venkateswarlu and B. G. L. Swamy provided me with illustrations of *Hydrocera* and *Nechamandra* respectively; Miss S. K. Rajeshwari and Mr R. L. Mitra helped me to gather data on distribution; Mr N. P. Balakrishnan secured pertinent information on nomenclature and read the manuscript; Mr B. V. Shetty, in particular, was helpful in various ways throughout the progress of this work. To all of them, I wish to express my profound appreciation for their ready assistance.

I am very grateful to Dr J. C. Sen Gupta, former Chief Botanist, Botanical Survey of India, for his keen interest, encouragement and for the facilities provided. To Rev. Father H. Santapau, Chief Botanist, Botanical Survey of India, I am much indebted for the stimulating discussions, valuable suggestions and constructive criticisms; his guidance, particularly in solving the nomenclatural riddles, has been invaluable. I owe a special debt of gratitude to Professor P. Maheshwari who has been mainly responsible for initiating me in botanical research.

That the book appears in its present form is due to the Publications Directorate of the C. S. I. R., and my sincere thanks are due to them for their excellent co-operation.

It is my sincere hope that the book will be of interest not only to field botanists but also to research workers and other students of botany. Let me, however, conclude by quoting a few remarks by Charles H. Curtis, in his book on Orchids: "I cannot expect that no errors of any kind occur, but trust mistakes are few, and that readers will tolerate them, remembering that . . . it is easier to be critical than correct." Corrections and suggestions will be most welcome.

Botanical Survey of India
Calcutta
September 9, 1961

K. SUBRAMANYAM

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AQUATIC ANGIOSPERMS

INTRODUCTION

India is a country where the most varied types of vegetation can be found, the Himalayas to the north show alpine vegetation; the best parts of the Western and Eastern Ghats and parts of Assam are covered with evergreen rain forests; deciduous forests may be seen in other parts of India, forests that through direct and constant human interference may finally be reduced to mere scrub jungles; in Rajasthan and parts of Kutch we may even see the desert in all its gaunt nakedness. All these types of vegetation are intimately connected with temperature, altitude and rainfall (not to speak of human destructive activities). Scattered, however, all over the country, and practically independent of climate and altitude we have even in parts otherwise bare of vegetation lakes and ponds of various kinds, in which aquatic plants may find a more or less precarious footing. Towards the mouths of many of our rivers we have mangrove forests, forming a very special community of their own, adapted to the very hard conditions of their existence. The present monograph deals with plants of lakes, ponds and pools; on purpose it does not deal with mangrove plants.

Paradoxically enough, it is not easy to define aquatic plants, at least in a manner that may be applied without fear of contradiction; the difficulty comes from the existence of numerous borderline species. Muenscher (1944) considered aquatic plants as "those species which normally stand in water and must grow for at least a part of their life cycle in water, either completely submersed or emersed". Similar view has been more recently expressed by Reid (1961) who defined water plants as "those whose seeds germinate in either the

water phase or the substrate of a body of water, and which must spend part of their cycle in water. This ecological grouping includes plants which grow completely submerged (except when flowering) as well as a variety of emergent types".

The present monograph describes and illustrates some of the better known aquatic flowering plants, commonly found scattered over most of the Indian subcontinent growing in fresh water; a few marine species, that are fairly common along our coasts, are also included. All in all, this monograph deals with 117 taxa belonging to 32 families. To the knowledgeable botanist, it will at once be obvious that this list is far from complete; the author has had to take the commoner plants for discussion and leave rarer species to the specialists.

Materials for this book have been gathered by the author out in the open in numerous field trips, over most parts of the country; in addition, the more important herbaria of the Indian Union, such as the Central National Herbarium, Calcutta, the Regional Herbaria of the Botanical Survey of India, and the herbaria of several universities and that of the Forest Research Institute, Dehra Dun have been carefully searched for information. The descriptions and accompanying diagrams have been drawn, as far as possible, from fresh living materials; they may at times differ somewhat from the usual printed descriptions found in most of our floras; however, the author can vouch for the accuracy of the information contained in this book, as being based entirely on his own observations on living plants.

The book begins with a key giving the diagnostic characters of the various families included in the monograph; the keys for genera and species are likewise given under their respective families. As for the nomenclature, the names which in the writer's opinion are correct according to our present knowledge have been adopted; basionyms and commoner synonyms are also usually given, at any rate such names as are to be found in the *Flora of British India* (referred to as FBI) and other standard books. Recent investigations on anatomy and embryology and also ecological notes, if any, are added for each taxon. While describing these features due importance is given to the work carried out in India. Wherever adequate data are available from studies on the comparative embryology of angiosperms, these are taken into consideration for a discussion of the systematic position of the particular family. Short notes on important economic uses are also given.

For the sake of completeness, an appendix gives a list of chromosome numbers, as far as they are known, for the taxa mentioned in the book.

KEY TO THE FAMILIES

1. Leaves net-veined, simple or compound; stem bundles in a ring when viewed in cross-section; cotyledons usually two . . . . . *DICOTYLEDONS*
   2. Perianth lobes always spirally arranged, numerous . . . . . *Nymphaeaceae*
   2. Perianth lobes cyclically arranged, definite.
      3. Pistil 1-ovuled; fruit 1-seeded.
         4. Fruit a large spiny nut . . . . . *Trapaceae*
         4. Fruit an achene or utricle.
            5. Leaves with stipular sheaths . . . . *Polygonaceae*
            5. Leaves without stipules or sheath.
               6. Leaves whorled . . . . . *Ceratophyllaceae*
               6. Leaves opposite . . . . . *Amaranthaceae*
      3. Pistil with 2 or more ovules; fruit a capsule or separating into 2–4 nutlets or indehiscent.
         7. Plants attached to rocks by disc-like processes, appearing like algae or bryophytes . . . . . *Podostemaceae*
         7. Plants not attached to rocks.
            8. Petals free or wanting.
               9. Ovary superior.
                  10. Posterior sepal spurred . . . *Balsaminaceae*
                  10. Posterior sepal not spurred.
                     11. Fruit a capsule or legume.
                        12. Fruit a capsule.
                           13. Leaves alternate or basal; placenta parietal . . . . . *Cruciferae*
                           13. Leaves opposite or whorled; placenta axile . . . . . *Elatinaceae*
                        12. Fruit a legume . . . . *Leguminosae*
                     11. Fruit separating into 3–4 nutlets.
                        14. Leaves opposite, simple, entire . . . . . *Callitrichaceae*
                        14. Leaves whorled or alternate, dissected . . . . . *Haloragaceae*
               9. Ovary inferior . . . . . *Onagraceae*
            8. Petals united.
               15. Corolla regular.
                  16. Placentation axile; ovules 4 . *Convolvulaceae*
                  16. Placentation parietal; ovules many.
                     17. Leaves cordate; flowers white or yellow . . . . . *Gentianaceae*

17. Leaves not cordate; flowers bright blue . . . . . *Hydrophyllaceae*

15. Corolla irregular, often 2-lipped.

18. Leaves with bladders . *Lentibulariaceae*

18. Leaves without bladders.

19. Capsule 2–many seeded with retinacula . . . . . *Acanthaceae*

19. Capsule many seeded without retinacula . . . . . *Scrophulariaceae*

1. Leaves parallel-veined, simple (except in a few forms with fleshy spadix as in Araceae); stem bundles scattered when viewed in cross-section; cotyledon one . . . . *MONOCOTYLEDONS*

20. Stems not developed; plant reduced to a small, undifferentiated, flat, globose or tubular, floating frond . . *Lemnaceae*

20. Stems well developed; plants rooted, submersed or emersed.

21. Ovary superior.

22. Pistil solitary, simple or compound.

23. Ovary 1-celled or appearing so.

24. Flowers solitary in the axils of leaves *Najadaceae*

24. Flowers in clusters.

25. Flowers not in the axils of dry chaffy bracts.

26. Inflorescence a cylindrical spike, not covered by a spathe . . . . . *Typhaceae*

26. Inflorescence a spadix, covered by a spathe . . . . . *Araceae*

25. Flowers (composed of spikelets) in the axils of dry chaffy bracts.

27. Leaves 3-ranked; stem triangular, solid; leaf sheaths closed, without a ligule . . . . . *Cyperaceae*

27. Leaves 2-ranked; stem terete, fistular except at nodes; leaf sheaths always split, usually with a ligule . . . . *Gramineae*

23. Ovary 2- or 3-celled.

28. Flowers with a showy perianth; leaves broad . . . . . *Pontederiaceae*

28. Flowers not showy, arranged in heads; leaves grass-like . . . . . *Eriocaulaceae*

22. Pistils several, free or basally united.

29. Pistils 1-ovuled.

30. Perianth showy, 2-seriate with the outer tepals sepaloid . . . . . *Alismataceae*

30. Perianth inconspicuous, 1-seriate with 4–6 herbaceous or membranous tepals . *Potamogetonaceae*
29. Pistils 2-many ovuled.
31. Flowers in spike-like inflorescences; ovules basal . . . . . *Aponogetonaceae*
31. Flowers solitary or in involucrate umbels; ovules superficial . . . . . *Butomaceae*
21. Ovary inferior . . . . . *Hydrocharitaceae*

NYMPHAEACEAE

Perennial aquatic herbs with creeping, stout, branching rootstocks. Leaves alternate, cordate or peltate, sometimes very large, floating or emersed, with margins involute in vernation. Flowers axillary, solitary, usually large and showy on a naked scape; sepals and petals 3 to numerous; stamens 3 to many, inserted on a fleshy torus or rarely enclosing the gynoecium; carpels 3 or more, free or united, or irregularly sunk in the pits of the torus. Fruit a many-seeded berry or of 1- or 2-seeded nuts embedded in the receptacle; seeds naked or arillate.

KEY TO GENERA

Carpels several, fused into a compound pistil; seeds many; plants more or less armed.
Plants slightly armed; leaves cordate; smooth; flowers hypogynous . . . . . *Nymphaea*
Plants much armed; leaves peltate, prickly beneath; flowers epigynous . . . . . *Euryale*
Carpels free, sunk in the turbinate torus; plants unarmed . . . . . *Nelumbo*

Nymphaea L.

Large perennial herbs with creeping rhizomes. Leaves alternate, blade floating, orbicular, entire or sinuate-toothed, with main veins radiating from the top of the slender petiole and much branched. Flowers solitary, hypogynous, floating, on long axillary peduncles; sepals 4; petals numerous, white or coloured; stamens many, filaments petaloid, anthers linear and introrse; carpels many, uniseriate, sunk in the fleshy torus forming a plurilocular ovary crowned by the radiating stigmas; ovules numerous, superficial. Fruit a spongy berry with several seeds enclosed in a sac-like aril.

KEY TO SPECIES

Leaves entire or sinuate, glabrous on both sides; flowers blue, white, rose or purple . . . . . *N. stellata*
Leaves sharply sinuate-toothed, densely pubescent beneath; flowers white or red . . . . . *N. nouchali*

Nymphaea stellata Willd. Sp. Pl. 2: 1153, 1799; FBI. 1: 114, 1872; Conrad in Publ. Carneg. Instn 4: 140, 1905. (Fig. 1).

Common throughout the warmer parts of India and South Andamans in tanks and ponds; flowering throughout the year. Used for ornamental purposes and as a cardiotonic.

Nymphaea nouchali Burm. f. Fl. Ind. 120, 1768; Merrill in Philipp. J. Sci. 19: 350, 1921. *N. pubescens* Willd. Sp. Pl. 2: 1154, 1799; Conard, 198. *N. rubra* Roxb. ex Salisb. Parad. Lond. 1: sub t. 14, 1805. *N. lotus* Hook. f. & Thoms. FBI. 1: 114, 1872 (non Linn. 1753). *N. lotus* var. *pubescens* Hook. f. & Thoms. (Pl. I; Fig. 2).

Common in fresh-water tanks and pools all over the warmer parts of India and North Andamans; flowering almost throughout the year, particularly during the rains. Used for ornamental purposes; powdered rhizome used for piles, dysentery and dyspepsia. In certain regions of India the rhizomes, petioles and peduncles are collected and eaten (Santapau, 1960). According to Cooke (1958), the seeds are eaten in times of scarcity.

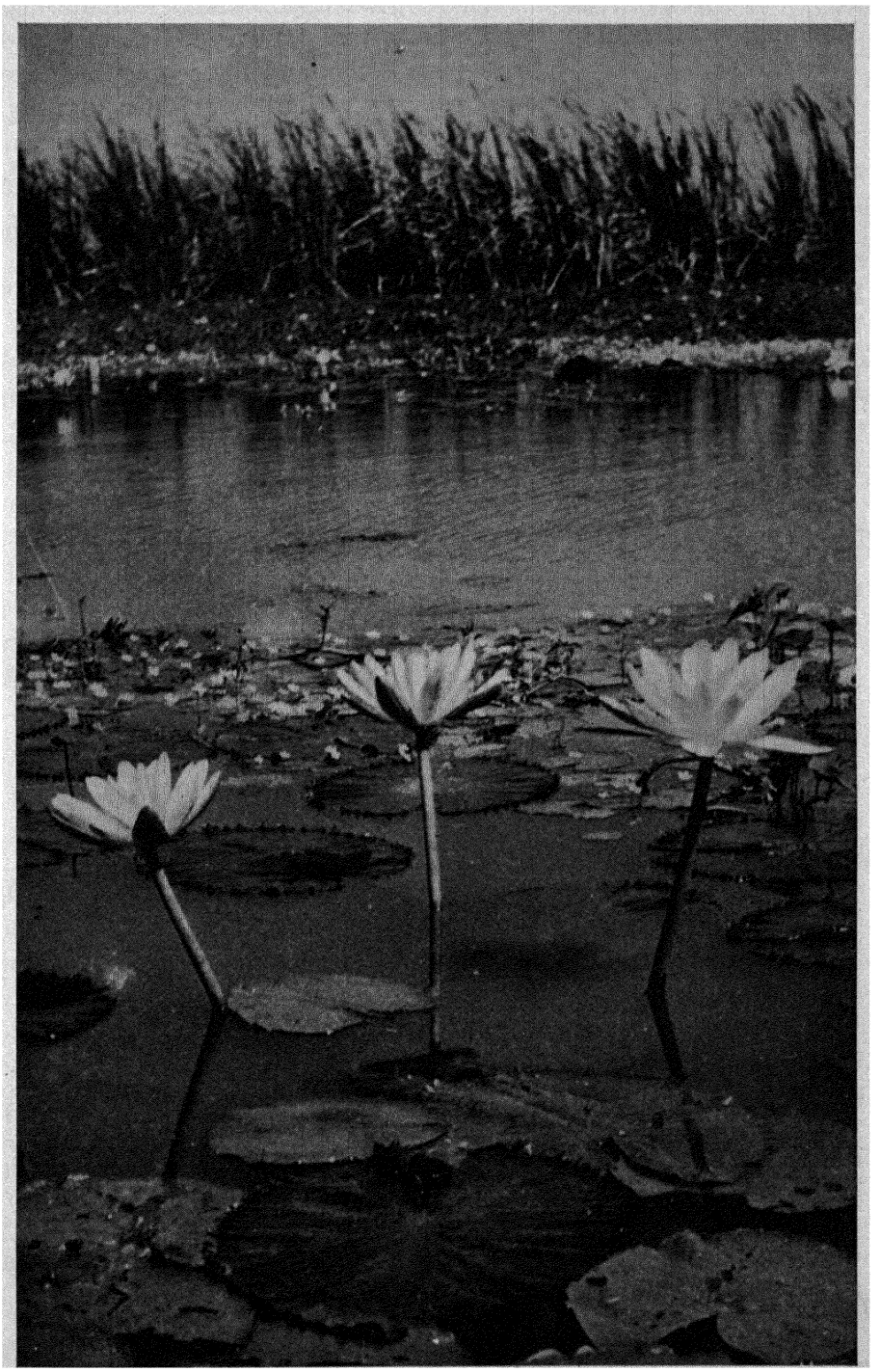
Note: Because of the great variations noticed in the different varieties and forms of the species of *Nymphaea,* their taxonomy is complicated. The six species considered by Roxburgh (1832) have been rightly reduced by Hooker (1872) to just two viz. *N. lotus* and *N. stellata.* Biswas and Calder (1955) have discussed this problem (see also Conard, 1905).

Euryale Salisb.

A perennial, densely prickly, aquatic herb with a thick, short rootstock. Leaves floating, orbicular, corrugate. Flowers blue, violet or red, epigynous, partially submerged; sepals 4, inserted on the edge of torus; petals numerous, shorter than the sepals; stamens numerous, grouped in fascicles of eight; ovary 8-celled, sunk in the dilated top of the torus; stigma discoid, depressed, concave; ovules few, borne on parietal placentae. Fruit a spongy berry, crowned by the persistent sepals and covered with stout prickles; seeds 8–20 with pulpy aril; testa thick; endosperm mealy; embryo small.

Euryale ferox Salisb. in Kon. & Sims. Ann. Bot. 2: 73, 1806; FBI. 1: 115, 1872. (Fig. 3).

Pl. I



NYMPHAEA NOUCHALI—KOLLERU LAKE, ANDHRA PRADESH

Found in fresh-water tanks and lakes in Kashmir, Alwar in Rajasthan, Uttar Pradesh, Bihar, West Bengal, Assam, Tripura and Manipur. In Bengal it begins to grow from January to February and fruits in May–June. The fruits are edible and the seeds which are of the size of a pea or a cherry are roasted and eaten. On roasting, the seed coat swells and bursts and can be easily peeled off. The seed flour is used as arrowroot; it is nutritious and easily digested. The seeds are also used as a tonic and deobstruent.

Nelumbo Adans.

Large perennial herbs with a stout, creeping, underground rhizome. Leaves alternate, when mature raised high above the water surface, orbiculate, peltate, 0.3–0.9 m. in diameter, margin upturned, prominently veined from the centre. Flowers large, pinkish-red, white or rarely yellow; sepals 4–5, caducous; petals and stamens numerous, many-seriate, caducous; anthers linear with the connective prolonged into a clubbed, pearl-white appendage; carpels several, surrounded by and embedded in cavities of the broad, turbinate, spongy torus; stylodium very short, exserted, stigma terminal, peltate. Ripe carpels nut-like, pericarp bony, smooth; seed pendulous, testa spongy; endosperm absent; embryo large with thick, fleshy cotyledons enclosing the folded plumule.

Nelumbo nucifera Gaertn. Fruct. 1: 73, t. 19, f. 2, 1788. *Nelumbium speciosum* Willd. Sp. Pl. 2: 1258, 1799; FBI. 1: 116, 1872. (Fig. 4).

This is the Sacred Lotus of India, common throughout in ponds, tanks and lakes. It flowers profusely before and after the rains. The beautiful red or white flowers are used for decorative and religious purposes and are considered sacred by Hindus. The flowers are recommended as a cardiac tonic and in fever and diseases of liver; the seeds form a cooling medicine for skin diseases; the rhizomes in the powdered form are prescribed for piles. The leaf, pedicel and embryo contain an alkaloid nelumbine. The carpels, popularly known as seeds, are eaten in various parts of the country and this has been one of the causes for the gradual disappearance of the plants.

CRUCIFERAE

A large family of terrestrial plants with only a few aquatics. Herbaceous plants having alternate or radical, exstipulate leaves with pungent smell. Inflorescence a raceme. Flowers regular, perfect;

sepals 4, free, imbricate, caducous; petals 4, cruciform; stamens 6, tetradynamous; disc with four glands opposite the sepals; ovary superior, 2-loculed, the locules separated by the replum; ovules many, 2-seriate on the two parietal placentae; style short, stigma entire or 2-lobed. Fruit a siliqua or silicle; seeds with folded embryo, without endosperm.

Nasturtium R. Br.

Perennials with spreading or creeping stems rooting at the nodes. Leaves alternate, pinnately compound, with elliptical, nearly entire leaflets. Inflorescence racemose. Flowers small, white with slender pedicels; sepals spreading, not pouched at base; petals cuneate; stamens 2, 4 or 6. Pod a linear cylindric siliqua, curved upward; replum thin; seeds many, small; cotyledons accumbent.

Nasturtium officinale R. Br. in Ait. Hort. Kew. Ed. ii. 4: 111, 1812; FBI. 1: 133, 1872. (Fig. 5).

A delicate, glabrous, aquatic herb with pinnate leaves and white flowers. It occurs in Delhi State, Nilgiri Hills and other hill stations and also in Punjab. Probably an introduced plant. Antiscorbutic and stimulant.

ELATINACEAE

Small, aquatic or terrestrial, herbaceous annuals or small shrubs with creeping or erect stems. Leaves opposite or whorled, stipulate, entire or serrate, gland-dotted. Flowers small, axillary, solitary or in small axillary cymes, hermaphrodite; sepals and petals 2–5, free, imbricate; stamens as many as or twice the number of petals, hypogynous, free with versatile anthers; ovary superior, 2–5 celled with numerous anatropous ovules on axile placentae; styles 2–5, stigmas capitate. Fruit a septicidal capsule with several seeds; seeds straight or curved, often rugose; endosperm scanty or absent; embryo cylindric or curved; cotyledons small.

KEY TO GENERA

Leaves entire; small aquatic herbs with solitary, axillary flowers; sepals 3, obtuse . . . . . *Elatine*

Leaves serrate or crenate; stout aquatic or terrestrial herbs or undershrubs with clustered flowers; sepals 5, acute . . . . . *Bergia*

Elatine L.

Small or minute, tender, aquatic, creeping herbs rooting at nodes. Leaves opposite or whorled. Flowers minute, axillary, sessile or nearly so, usually one at each node; sepals 2–4, membranous, free, obtuse; petals 2–4; stamens 2–8, separate; ovary globose, 2–4 celled, with as many styles or sessile stigmas. Capsule membranous, septicidal with many straight or curved seeds with ridges or pits on the seed coat.

Elatine triandra Schk. Bot. Handb. 1: 345, fig. 109 b, f. 2 (*sensu lato*), 1808. *E. americana* Arn. in Edinb. J. Nat. & Geogr. Sc. 1: 431, 1830; FBI. 1: 250, 1874.

A delicate, prostrate herb with sessile flowers and stamens longer than the sepals. It occurs in the Nilgiris, Courtallam and Chingleput and flowers in July.

Bergia L.

Terrestrial or aquatic herbs, annuals or undershrubs with decumbent, diffusely branched stems. Leaves opposite, stipulate, usually serrate. Flowers in dense axillary fascicles or rarely solitary, minute; sepals 5, acute with membranous margins; ovary ovoid. Capsule 3–5 celled, septicidal or septifragal.

Bergia capensis L. Mant. 2: 241, 1771. *B. verticillata* Willd. Sp. Pl. 2: 770, 1799; FBI. 1: 252, 1874. (Fig. 6).

An annual, ascending, glabrous, rather succulent, aquatic herb, 15–30 cm. high with branches decumbent. It occurs on the margins of tanks in Delhi, Uttar Pradesh, Bombay, Konkan and South India. The stem and branches are pink and translucent. The leaves are simple, opposite, elliptic-lanceolate, serrate; petioles short; stipules triangular-acute, caducous. The flowers are minute and occur in sessile or subsessile axillary clusters. The period of flowering ranges from September to January.

D'Almeida (1942) has studied the physiological anatomy of this plant and has noticed certain interesting features in its root system. The primary root is short-lived. It is soon replaced by a group of adventitious roots which develop from the lower nodes. In plants that grow partially or completely submerged, the roots show a differentiation into two kinds—ground roots or mud roots and water roots. The ground roots which are buried in the mud are stout and white; they bear few, slender, thread-like branches. Root-hairs are present and these are not confined, as in most ordinary roots, to a small

region above the root-cap, but are spread all over the main roots and branches. The water roots arise from the submerged nodes and float freely in water; they are thin, profusely branched, plumose, devoid of root-hairs and frequently green in colour.

There is marked difference in the anatomical structure of water roots and ground roots. In the water root, beneath the epidermis which is composed of thin walled tubular cells there is a hypoderma of about three layers of parenchyma and inside this the cortical lacunae are separated by radial filaments composed of more or less rounded or oval cells. Chloroplasts are present in the cells of the cortex abutting on the lacunae. The stele is very narrow. The profuse branching of the water roots increases the absorptive surface and establishes intimate contact with the surrounding medium, thus facilitating better absorption. The presence of chloroplasts in these roots indicates that the roots are also photosynthetic in function.

The cortex in the ground root is much wider. Beneath the epidermis, there is a hypoderma of two layers of parenchymatous cells. The rest of the cortex is made up of radial filaments of elongated cells. These filaments are separated from one another by wide, radially running gaps or spaces. The ground roots, in addition to their usual function of fixation and absorption, serve as reservoirs of air and help in respiration. Thus, the differences in the external and internal structures between water and ground roots are closely related to their respective conditions of life.

BALSAMINACEAE

Plants herbaceous (sometimes aquatic as in *Hydrocera*) or suffrutescent, often succulent, rarely epiphytic. Leaves alternate, opposite or in whorls of threes, usually exstipulate, pinnately veined. Inflorescence solitary or several together on axillary peduncles. Flowers hermaphrodite, zygomorphic, often resupinate, spurred and pentamerous; sepals usually 5, free, imbricate, often petaloid, the posticous very large and sac-like and gradually prolonged backward into a tubular nectiferous spur; petals 5, imbricate, alternating with the sepals, distinct or connate and appearing as if 3, the lower ones larger than the upper ones; stamens 5, the filaments flattened and closely covering the ovary like a hood or sheath, anthers 2-celled, coherent or subconnate; ovary superior, 5-carpelled and loculed; ovules anatropous, pendulous, 1 to many on axile placentae; style short, stigmas 1–5. Fruit capsular, elastically dehiscent or drupe with a bony pyrene.

Hydrocera Bl.

Erect, glabrous, aquatic herbs. Stem 5-angular and fistular in the internodal region. Leaves exstipulate, alternate, linear, serrate, with a glandular leaf base. Inflorescence axillary, cymose. Flowers bracteate, zygomorphic, on short 2-flowered peduncles; sepals 5, petaloid, imbricate, the two outer lateral flat, becoming anterior due to resupination, the posterior produced into a short, hollow spur; petals 5, free, the two outer posterior longer, concave, coloured; disc absent; stamens 5, filaments short, broad and united towards the connective, anthers connate around the pistil; gynoecium 5-carpellary, superior, bent towards the spur; ovary 5-celled; ovules 2–3 in each cell, borne on axile placentae; stigmas 5, sessile and persisting in fruit. Fruit purplish-red, truncate at base and with a short bent beak of persisting stigmas, capsular, dehiscing septicidally leaving the seeds attached to the column but separating later; seeds solitary in each cell, curved, corrugated; endosperm absent; cotyledons thick; radicle short, superior.

Hydrocera triflora (L.) Wt. & Arn. Prodr. 140, 1834, FBI. 1: 483, 1875. *Impatiens triflora* L. Sp. Pl. 938, 1753. (Fig. 7).

An annual, aquatic, branched herb with fistular floating stems bearing long fibrous roots and reaching a height of about one metre. The linear-lanceolate leaves have glandular leaf bases. The purplish-red fruit is capsular, dehiscing septicidally. It occurs commonly in Uttar Pradesh, West Bengal, Naga Hills and S. India in small ponds and tanks. In certain parts of Andhra Pradesh the flowers are sometimes used for dyeing finger nails.

Some of its interesting embryological features (Venkateswarlu & Lakshminarayana, 1957) are: development of trabecular partitions from tapetal cells, thus dividing the sporogenous cells into several groups; Allium type of embryo sac and a cellular endosperm which develops a large, multinucleate haustorium protruding through the micropyle.

LEGUMINOSAE

The aquatic taxa of this family are herbaceous or shrubby. Leaves stipulate, alternate, compound. Inflorescence axillary, leaf opposed or terminal racemes or panicles. Flowers usually zygomorphic or rarely actinomorphic; sepals 5 or fewer, united or free; petals 5 or fewer, free, unequal; stamens usually 10, rarely fewer, sometimes indefinite, filaments variously combined or free; ovary superior,

usually monocarpellary with ovules borne on the ventral suture. Fruit a legume.

KEY TO SUBFAMILIES

Flowers zygomorphic; petals imbricate, free; stamens definite	*Papilionoideae*
Flowers actinomorphic; petals valvate, united above the base; stamens definite or indefinite .	*Mimosoideae*

PAPILIONOIDEAE

Herbs, shrubs, or trees (rarely aquatic). Leaves alternate, simple or digitately or pinnately compound, rarely bipinnate, sometimes ending in tendrils. Flowers zygomorphic, hermaphrodite; calyx gamosepalous, 5-toothed or 5-lobed, more or less connate or bilabiate, the 2 upper opposed to the 3 lower, rarely spathaceous; corolla papilionaceous, descendingly imbricate, petals 5, free or adnate to the staminal tube, the posterior standard outside in the bud, the 2 lateral wings intermediate and the 2 lower forming keel inside and usually cohering by their lower margins; stamens 10, diadelphous (usually 9 in one bundle and the remaining one opposite the standard) or monadelphous or free; ovary superior, monocarpellary. Fruit a legume; embryo with an inflexed radicle, cotyledons accumbent.

Aeschynomene L.

Erect herb or undershrub, usually found along borders of ponds and lakes. Leaves imparipinnate; leaflets small, very numerous, close, linear, sensitive; stipules setaceous or lanceolate; stipels absent. Flowers yellow, often purple-striate, in axillary or rarely terminal, simple or compound racemes; calyx deeply 2-lipped; corolla papilionaceous, standard orbicular, wings obliquely obovate, keel petals oblong or falcate; stamens diadelphous, in 2 bundles of 5 each, anthers uniform; ovary stipitate, 2–many ovuled; style filiform, incurved, stigma terminal. Pod a long stipitate lomentum, flattened, breaking into 1-seeded bits; seeds sub-reniform.

KEY TO SPECIES

Stems slender, woody; flowers small, peduncles viscid; sepals and smaller petals smooth; pod up to 3.5 cm. long, smooth or papillose on the faces .	*A. indica*
Stems stout, pith-like; flowers large, peduncles not viscid; sepals and larger petals hispid; pod up to 6.5 cm. long, echinulate opposite the seeds	*A. aspera*

Aeschynomene indica L. Sp. Pl. 713, 1753; FBI. 2: 151, 1876. (Fig. 8).

It is widely distributed in India and South Andamans, ascending up to 1,600 m. It flowers and fruits practically throughout the year. An inferior quality pith is obtained from the stem.

Arora (1954) has recorded the presence of well developed bacterial nodules on the roots as well as the stem of *Aeschynomene indica*. The nodules arise close to the place of emergence of the lateral roots, and the ruptured tissue in this region constitutes the path of infection. While the root nodules are endogenous and arise in the pericycle, the stem nodules originate in the cortex. The nodule is differentiated into an infected bacteroid region and an uninfected portion. A single vascular strand differentiates at the base of the nodule and gives off six to eight branches which taper unequally to the apex. The vascular tissues of the nodule mature from the base outwards. The xylem and phloem are arranged collaterally. An endodermis with Caspary bands surrounds each vascular strand. Degeneration of the nodule is accompanied by the formation of a layer of suberized cells at its base which in turn forms a protective seal when the nodule is sloughed off.

Aeschynomene aspera L. Sp. Pl. 713, 1753; FBI. 2: 152, 1876. (Fig. 9).

A tall, robust, sparsely branched, perennial shrub, reaching a height of 1.5–3 m. with spongy floating stem which sometimes attains a diameter of nearly 5 cm. It is common in Maharashtra, Delhi, Uttar Pradesh, Bihar, Orissa, West Bengal, Assam and South India, growing along margins of tanks and lakes and usually flowers and fruits in winter months. The leaflets are sensitive and show nyctinastic movements. Most of the stem is made up of light soft pith which has good insulating properties. The pith is largely used in making sun hats. It is also used for making toys, artificial flowers and models. In the laboratory the pith is used for embedding plant materials for cutting free-hand sections. It also finds use in the manufacture of swimming jackets and life-belts.

MIMOSOIDEAE

Trees or shrubs, sometimes climbing, rarely herbs, few aquatics. Leaves bipinnate or less commonly simply pinnate. Flowers small, regular, 4–5 merous, hermaphrodite, sometimes polygamous, generally in heads or spikes; bracts small, at the base of or on the peduncle, usually deciduous; bracteoles absent or very small and usually deciduous; calyx more or less campanulate with usually 5,

sometimes 3, 4 or 6 valvate lobes, united or free; petals as many as the sepals, valvate, free or connate in a lobed corolla; stamens definite or indefinite; if definite as many as or twice the sepals and petals; if indefinite many, free or monadelphous; ovary superior, monocarpellary. Pod dehiscent or indehiscent, sometimes a lomentum; seeds occasionally arillate, endospermous or nonendospermous; cotyledons flat.

Neptunia Lour.

Annual or perennial aquatic herbs or undershrubs with erect, prostrate or floating stems, rooting at the nodes. Leaves with persistent stipules, bipinnate; pinnules many, small, sensitive. Flowers small, sessile, with minute bracts, ebracteolate, arranged in oblong or globose, peduncled, axillary heads; upper flowers in the head are hermaphrodite, below which are the male and the lowest are the neuter flowers with flattened staminodes; calyx small, campanulate, 5-toothed; corolla 5, valvate, petals free or campanulate; stamens 10, exserted, filaments slender, anthers gland-crested; ovary superior, stalked, many ovuled; style filiform, stigma terminal, club-shaped, concave. Fruit a flat, membranous, compressed, oblong, bivalved pod; seeds transversely compressed with a filiform funicle.

Neptunia oleracea Lour. Fl. Cochinch. 654, 1790; FBI. 2: 285, 1878. (Fig. 10).

It is distributed throughout the warmer parts of India and flowers in the wet season and also during winter. The zig-zag branches of the stem bear fibrous roots at the nodes and spongy bladder-like swellings or floats on the internodes. These floats are composed of aerenchymatous tissue which helps the plant in its floatation. The aerenchyma originates from the phellogen in the outer part of the cortex and consists of cells with cellulose walls and living contents. The plant is refrigerant and astringent (Chopra *et al.*, 1956).

HALORAGACEAE*

Herbs, often aquatic with submersed, creeping or emersed stems. Leaves exstipulate, opposite or whorled, sometimes alternate, when submerged often pectinately pinnatifid. Flowers sessile, in the axils of leaves or bracts, hermaphrodite or unisexual, solitary or fascicled, small and often much reduced; calyx fused with the ovary, lobes

* There seems to be no justification for the adoption of the names Halorrhagaceae or Haloragidaceae, as done by many authors (Taxon **8** : 175, 1959).

usually 4, very short or wanting; petals 4, valvate or slightly imbricate, sometimes reduced or wanting; stamens 4 or 8, anthers 2-celled, dehiscing longitudinally and laterally; ovary consisting of 4 carpels, 1–4 celled, each with a single pendulous ovule; styles as many as the locules with sessile, plumose stigmas. Fruit small, drupaceous, indehiscent or separating into carpels; seeds pendulous, 4 or rarely 1, with fleshy endosperm.

Myriophyllum L.

Perennial, glabrous, aquatic herbs with slender, sparingly branched, floating stems mostly rooting freely at the lower nodes. Leaves opposite or whorled, variable, the floating ones usually linear, serrate, the submerged ones pectinately pinnatifid. Flowers very small, hermaphrodite or monoecious, sessile in the axils of the upper emersed leaves or in nearly naked spikes raised above the surface of water. Male flowers very shortly pedicelled or sessile, female sessile; calyx in male minute, 2–4, sometimes absent; in female adnate to the ovary, four toothed, minute; corolla of 2 or 4 petals in male flowers, concave, sessile; absent in female; stamens 4 or 8; ovary inferior, of 4, rarely 2 fused carpels; ovules solitary, pendulous; styles short, plumose. Fruit 4-furrowed, separating into 4 or 2 cocci, each with a row of tubercles or murications on the back ; embryo straight or curved.

KEY TO SPECIES

1. Fruits tubercled, carpel backs acute, keeled.
   2. Leaves linear-lanceolate, toothed upwards, apex acute; stigma fimbriate . . . . . *M. tuberculatum*
   2. Leaves linear-spathulate, rarely toothed, apex obtuse; stigma not fimbriate . . . *M. spathulatum*
1. Fruits muricate, carpel backs obtuse, rounded.
   3. Floral leaves entire or dentate-serrate, never pectinate.
      4. Fruiting carpels columnar, furrows very narrow, hardly noticeable.
         5. Floral leaves less than 0.5 cm. long; fruit *c.* 2 mm. long . . . . . *M. spicatum*
         5. Floral leaves more than 1 cm. long; fruit *c.* 1 mm. long . . . . . *M. intermedium*
      4. Fruiting carpels arranged stellately, separated by wide furrows . . . . . *M. indicum*
   3. Floral leaves pectinate-pinnatifid . . . . *M. verticillatum*

Myriophyllum tuberculatum Roxb. Fl. Ind. 1: 451, 1832; FBI. 2: 432, 1878; Schindl. in Engl. Pflanzenr. 23: 96, f. 28 A–C, 1905.

A perennial aquatic herb with pink flowers and fimbriate stigmas. It commonly occurs in fresh-water lakes, tanks and puddles in West Bengal, Orissa and Mysore. It flowers and fruits throughout the year.

Myriophyllum spathulatum Blatt. & Hallb. in J. Indian Bot. 2: 44, t. 1, 1921. (Fig. 11).

A perennial, aquatic, glabrous herb with spathulate floral leaves, white flowers and green, non-fimbriate stigmas. It is reported from Khandala, Mahabaleshwar in Western Ghats and has also been collected from Mohli in Saugor District of Madhya Pradesh and flowers and fruits in November and December. As reported by Blatter and Hallberg (l.c.), it was noticed that the pericarp of the fruit is completely smooth but the seeds are tubercled. In live plants when the mature fruits are wet they appear smooth and rounded at the back, but when the plants and fruits dry, the loose pericarp jacket contracts and the tubercles of the seeds are prominently seen outside and the carpel back becomes acute and keeled.

Myriophyllum spicatum L. Sp. Pl. 992, 1753; FBI. 2: 433, 1878; Schindl. 90.

A perennial aquatic herb with large oblong-ovoid fruits, occurring in Kashmir, northern boundary of Punjab and in Uttar Pradesh at about 500–2,000 m.

Myriophyllum intermedium DC. Prodr. 3: 69, 1828; FBI. 2: 433, 1878; Schindl. 96. (Fig. 12).

Aquatic herb, sometimes floating, with short submerged leaves, more often rooted in mud with only the upper leaves apparent. It occurs in eastern parts of Madhya Pradesh, Western Ghats, especially in Nilgiris, in wet places and ponds above 1,500 m. and flowers in June and December.

Myriophyllum indicum Willd. Sp. Pl. 4: 407, 1805; FBI. 2: 433, 1878; Schindl. 93, f. 28 D.

A floating aquatic herb with very long stems and many submerged leaves and occurs in ponds, lakes and canals in Kashmir, Uttar Pradesh, Bihar, West Bengal, Assam, Agartala, Manipur and East Coast from Ganjam southwards. It flowers and fruits throughout the year.

Myriophyllum verticillatum L. Sp. Pl. 992, 1753; FBI. 2: 433, 1878; Schindl. 87, f. 28 E–J.

A glabrous, floating, aquatic herb with the floral leaves pectinate-pinnatifid. It occurs in Kashmir at about 2,000 m. and flowers and fruits from June to August.

CALLITRICHACEAE

Small, monoecious, aquatic, perennial or annual herbs. Leaves opposite, entire, linear or obovate-spathulate, the upper ones often rosulate. Flowers minute, naked, axillary, usually monoecious, solitary or sometimes one male and one female together in the same axil; bracteoles white, membranous, caducous; stamen 1, forming male flower; pistil in the female flower consists of a bicarpellary ovary; each cell of the ovary becomes divided by a false septum and there is a single, pendulous, anatropous ovule in each of the four loculi; styles 2, long, subulate, placed transversely like the carpels. Fruit coriaceous, indehiscent, the four carpels combined into 2 pairs, separating at length, when ripe, into 1-seeded sections; seeds pendulous with fleshy endosperm; cotyledons short, radicle superior.

Callitriche L.

The only genus with the characteristics of the family.

Callitriche stagnalis Scop. Fl. Carniol. 2: 251, 1772; Hegelm. Monogr. Callitriche 58, 1864; FBI. 2: 434, 1878. (Fig. 13).

A small, flaccid herb, rooting at the nodes, with carpels narrowly winged at the margins. It occurs from the Himalayas to the Deccan and in Western Ghats, Nilgiri and Pulney Hills in ponds and wet places at an altitude of 2,100–3,000 m. It flowers and fruits in the month of February.

The systematic position of Callitrichaceae is interesting. This family includes a single genus, *Callitriche* with about 30 species of slender, semi-aquatic plants, extremely reduced in both vegetative and floral structures. The exact position of *Callitriche* has been considered doubtful. According to Bentham and Hooker, Brown, De Candolle, Hegelmaier and Hutchinson, it is related to the Haloragaceae. Clarke (1865) felt that it should be placed under the Caryophyllaceae; and Baillon (1858), owing to the reduction in flower structure, included *Callitriche* in the Euphorbiaceae. Pax and Hoffmann (1931) felt that it should be assigned to a separate family Callitrichaceae, close to the Euphorbiaceae.

The embryological characters in *Callitriche* make these assignments very unlikely. Jörgensen (1923, 1925) showed the existence

of a tenuinucellate ovule, a massive single integument and a cellular endosperm which forms well developed micropylar and chalazal haustoria. These features which are so characteristic of the Tubiflorae, together with the four-lobed nature of the ovary, have suggested a relationship with the Verbenaceae. The recent study of Souèges (1952) has fully confirmed this and shown that even the embryo development in *Callitriche* and *Verbena* is essentially similar.

ONAGRACEAE

Herbs, rarely undershrubs, sometimes aquatic. Leaves alternate or opposite, exstipulate, entire or dentate. Flowers hermaphrodite, axillary and solitary or in spikes or racemes borne towards the ends of the branches, regular or sometimes irregular; calyx fused with the ovary and terminating into 2–5 valvate lobes; petals epigynous, 4–5, alternate with the calyx lobes, rarely wanting; stamens as many as, or twice as many as the petals and sepals and attached to the top of the calyx-tube; ovary inferior, usually 4-celled with 1 or many ovules in each cell, pendulous or half ascending, placentae axile; style subulate, stigma capitate or 2–4 lobed. Fruit a linear capsule, 4-celled, dehiscing from the apex loculicidally; seeds usually many, obovoid or ellipsoid; without endosperm.

Jussiaea L.

A prostrate or creeping aquatic herb or undershrub. Leaves alternate, usually entire. Flowers yellow or white, axillary, solitary; pedicels with 2 bracteoles; calyx-tube narrow, scarcely produced above the ovary, lobes 4–6, acute, persistent; petals 4–6, epigynous, alternate with the calyx lobes; stamens twice as many as the petals and inserted with them; ovary inferior, 4–5 celled, ovules anatropous, many, axile, borne in several vertical rows at the inner angle of each cell; style simple, short, stigma 4–5 lobed. Fruit a linear, terete or angled, 4–5 celled capsule, dehiscing septicidally, crowned by the disk and calyx lobes; seeds numerous, small with reticulated, crustaceous testa; cotyledons oblong.

Jussiaea repens L. Sp. Pl. 388, 1753; FBI. 2: 587, 1879. (Fig. 14).

A common water plant, creeping on the surface of water and floating by means of white, spongy, aerenchymatous, breathing roots formed in whorls at the nodes of the main stem. It occurs throughout India in fresh-water lakes and ponds and flowers and fruits from

October to June. The herb is used for curing ulcers and skin diseases.

A characteristic feature of this (Khan, 1942) and other taxa of Onagraceae is the development of a four nucleate embryo sac of the monosporic Oenothera type.

TRAPACEAE

Aquatic floating herbs. Leaves dimorphic; the submerged leaves opposite, root-like, pinnatipartite with filiform segments; the floating ones rosulate, rhomboidal; the petiole with a spongy aerenchymatous swelling near its apex. Flowers hermaphrodite, axillary, solitary, peduncled, projecting above the water surface; calyx-tube short, the limb 4-parted, adnate to the lower part of the ovary; calyx lobes 4, 2 or all becoming spines on the fruit; petals 4, sessile, white, inserted on the margin of the epigynous, cup-shaped, sinuous, coronary disc which has a dentate margin; stamens 4 with elongated, dorsifixed, divergent anthers inserted with the petals; ovary semi-inferior, 2-celled with a conical apex; ovule anatropous, pendulous, solitary in each cell, borne on axile placenta; style subulate, stigma capitate. Fruit a large, bony nut with four angles, 2 or all of which spinose, indehiscent, with a short cylindric beak at the top through which the radicle protrudes; seed 1; cotyledons very unequal, radicle incurved; endosperm absent.

Trapa L.

Aquatic annuals with rosette leaves having rhombic blades coarsely serrate, the upper surface glossy and the lower pubescent. Nut with 2 or 4 sharp spines or prongs, surrounded by receptacle and calyx except near the summit, which is open and encircled by a crown of bristles. The mature nuts sink to the bottom and after shedding the outer layer have a black or metallic appearance; the stout spines then show the backwardly pointed barbs at their apices; seed angular, cordate, without endosperm; embryo with very unequal cotyledons, one in the form of a small scale and the other large and fleshy with starch reserves.

KEY TO SPECIES

Leaves very villous beneath; nut with 2 strong, well developed, scabrous thorns . . . . . *T. bispinosa*

Leaves less villous beneath; nut with 4 dagger-like thorns, often unequal . . . . . *T. maximowiczii*

Trapa bispinosa Roxb.* Fl. Ind. 1: 449, 1820; FBI. 2: 590, 1879, *pro parte*. (Fig. 15).

The water-chestnut is a very ancient plant as is borne out by the extensive fossil remains of the nut in the tertiary era. It has long stems, bearing pectinate leaves beneath and curious rhomboid rosulate leaves with swollen petioles on the surface of water. The stoloniferous stem has well developed lacunae both in the pith and the cortex. There is very little mechanical tissue. The tip of the stem reaches the surface of water and this is possible because of the swollen petioles of the upper rhombic leaves which are arranged in a rosette. The leaves are transversely heliotropic.

There is no primary root. The submerged stem bears two types of adventitious roots. Those near the base of the stem fix the plant to the muddy substrate. The rest are free-floating fibrous roots, borne in pairs below the leaf bases. They are branched and have a feathery appearance and are unusual in being green and photosynthetic. Cross sections of these show a tetrarch stele with alternating xylem and phloem and an exarch protoxylem.

The flowers are white and open above the surface of water in the afternoon; but after pollination the pedicel bends down so that the flower is submerged and fruit formation takes place in this condition. The 2-thorned fruit, which is a one-seeded nut, is eaten either raw or cooked, the edible portion being the starchy cotyledon. The pericarp is stony having two upwardly projecting thorns which are modified sepals. The fruit is non-endospermic. There are two cotyledons of which one is extremely reduced and the other is full of starchy material. It occurs throughout India in lakes, tanks and ponds and is extensively cultivated. It flowers during the rainy season, fruits later and these ripen in the cold season.

Trapa maximowiczii Korsh. Act. Hort. Petrop. 12: 336, 1892. *T. quadrispinosa* auct., non Roxb. Fl. Ind. 1: 430, 1832.

A rather uncommon plant with leaves less villous beneath. The leaf-blade towards the base is black-brown or has two dark spots. The corolla is pale lilac and anthers yellow. The fruit is tipped by the conical hardened style. The surface of the fruit is smooth and the four thorns which are often unequal are straight or curved with their apices barbed. It occurs in Agartala and southern regions of Bihar.

The genus *Trapa* has been placed variously by different systematists. Bentham and Hooker (1883), Rendle (1952) and

* *T. natans* L. syn. *T. quadrispinosa* Roxb. has been recorded from Kashmir (FBI. 2: 590, 1879).

Hutchinson (1959) placed it in the family Onagraceae. However, as early as 1898, Raimann had erected a new family Hydrocaryaceae to accommodate the genus *Trapa*. Wettstein (1935) supported this view while Pulle (1938) suggested that in the absence of any genus named *Hydrocarya*, the family name should be changed to Trapaceae. The embryological features of *Trapa* (Ram, 1956) have provided very convincing data for its removal from Onagraceae and assignment to a new family Trapaceae (Pulle, l.c.). There are many pronounced dissimilarities between the embryological characters of *Trapa* and Onagraceae. In *Trapa* the ovary is semi-inferior and bilocular with a single pendulous ovule in each chamber; the pollen grains are pyramidal with three multifolded meridional crests; the chalazal megaspore invariably functions and the embryo sac is of the Polygonum type; endosperm is absent; the embryo conforms to the Solanad type, has two extremely unequal cotyledons and a well developed suspensor and suspensor collar. On the other hand, in the Onagraceae the ovary is inferior, mostly tetralocular with many ovules in each chamber; pollen grains are basin-shaped, surrounded and bound together in long strings by 'fibrils' (Beer, 1906); usually the micropylar megaspore develops and the embryo sac is of the Oenothera type; the endosperm is nuclear and the embryogeny corresponds to the Onagrad type; the cotyledons are equal and the suspensor is short and inconspicuous.

Eames (1953) has expressed the view that on anatomical evidence also *Trapa* does not belong to the Onagraceae and is not even closely related to it. Sphaeraphides occur commonly and the vascular bundles lack a cambium.

Morphologically *Trapa* differs from the members of the Onagraceae in having floating leaves with inflated petioles; uniseriate, multicellular hairs on the petioles, pedicels and lower surface of the leaves; branched assimilatory roots; a single whorl of stamens; and two to four upwardly directed spines on the one seeded fruits.

It is, therefore, evident that embryology, anatomy and morphology of *Trapa* fully justify its removal from the Onagraceae and its inclusion in the newly erected family, the Trapaceae.

GENTIANACEAE

Glabrous herbaceous plants, sometimes aquatic. Leaves alternate, sometimes opposite, simple, exstipulate, entire, sometimes trifoliolate. Inflorescence in terminal cymes or clusters, or axillary and clustered, or solitary. Flowers usually regular, sometimes irregular, hermaphrodite, tetra or pentamerous, rarely bracteate;

calyx inferior, 4 or 5, imbricate; corolla funnel-shaped or rotate, twisted to the right or induplicate-valvate as in *Nymphoides;* stamens epipetalous, as many as the petals, alternate with them, inserted in the corolla-tube or at its mouth, filaments linear, sometimes dilated below, oblong anthers dehisce longitudinally or sometimes by apical pores; disc annular or 5 glands at the base of the ovary or absent; ovary superior, bicarpellary, syncarpous, 1-celled with numerous ovules on parietal placentae, rarely the placentae intrude and meet; style simple, short or linear, stigma entire or 2-lobed. Fruit a membranous septicidal capsule, rarely a fleshy berry; seeds numerous, small, sometimes winged; testa membranous or crustaceous; endosperm copious; embryo small.

Nymphoides* Hill

Perennial aquatic herbs, floating or creeping. Stems erect or runner-like or resembling petioles. Leaves alternate or sub-opposite, elliptic or ovate, deeply cordate, entire or obscurely sinuate. Flowers white or yellow, on peduncles clustered at the nodes or on the apparent petioles close below the leaf-blades; calyx 4–5, the sepals oblong or lanceolate, slightly connate; corolla rotate, 4–5 lobed, the tube sometimes glandular opposite the lobes, petals induplicate-valvate in bud, ciliate, fimbriate or with a longitudinal fold down their middle; stamens 4–5, adnate to the corolla-tube, filaments linear, short, anthers hastate-oblong, versatile; ovary superior, 1-celled, placentae 2, parietal, not intruded; style short, stigma 2-lobed. Fruit a globose or ovoid or ellipsoid capsule, subindehiscent; seeds many, discoid, smooth or tuberculate or finely reticulate, sometimes winged; endospermous; cotyledons very small, radicle cylindric.

KEY TO SPECIES

Stems rooting at nodes.

Corolla lobes entire, with a longitudinal fold down the middle and glands below it on the tube, white; seeds few, large, with prominent, small, slightly glochidiate tubercles . . . *N. cristatum*

Corolla lobes long, fimbriate, densely papillose, not folded down the middle, white with

* In our Indian floras this genus goes under the name *Limnanthemum* Gmel. (1770) but this must make way for *Nymphoides* Hill (1756) on account of priority. O. Kuntze attributed *Nymphoides* to Ludwig (1737); Ludwig's name is clearly illegitimate, being pre-1753. The fact that J. Hill does not consistently follow bionomial system of nomenclature, does not invalidate generic names described in Hill's *British Herbal.*

yellow centre; seeds many, small, smooth or sometimes minutely tuberculate . . . . *N. indicum*

Stems not rooting at the nodes.

Leaves all orbicular, deeply cordate; corolla yellow; seeds large, microscopically puberulous, minutely reticulate, prominently tuberculate, almost spherical . . . . . *N. aurantiacum*

Leaves radical, spathulate-orbicular or orbicular-cordate; corolla white; seeds minutely puberulous and tuberculate, lenticular . . . . . *N. parvifolium*

Nymphoides cristatum (Roxb.) O. Kuntze, Rev. Gen. Pl. 429, 1891 *Menyanthes cristata* Roxb. Pl. Cor. 2: 3, t. 105, 1798. *Limnanthemum cristatum* Griseb. Gen. & Spec. Gent. 342, 1839; FBI. 4:131, 1883. (Fig. 16).

A rather small plant with orbicular, deeply cordate, often purplish floating leaves up to 3 cm. in diam. The white delicate flowers project above water and the corolla-tube has a ring of white hairs round the throat. The seeds are few in number with prominent, small, slightly glochidiate tubercles, scabrous. It is very common throughout India and is gregarious in habit, generally growing near the margins of tanks and lakes. It usually flowers and fruits in the winter season.

In this species polystely occurs in the cortical region of the stolons and in the petioles of the leaves (Majumdar, 1938).

Nymphoides indicum (L.) O. Kuntze, Rev. Gen. Pl. 429, 1891. *Menyanthes indica* L. Sp. Pl. 145, 1753. *Limnanthemum indicum* (L.) Griseb. emend. Thw. Enum. Pl. Zeyl. 205, 1860 ; FBI. 4: 131, 1883. (Pl. II; Fig. 17).

A large plant with orbicular, deeply cordate, floating leaves up to 30 cm. in diam. The pedicels are long, numerous, unequal and densely fascicled at the nodes. The white corolla is yellowish within and the petals are fimbriated and densely papillose. The seeds are many, small and smooth or minutely tuberculate. It is very common throughout India and North Andamans and shows the same habit as the former species. It flowers and fruits from November to March. The plants are used as a substitute for chiretta (*Swertia chirayita* Karst.) in fever and jaundice (Chopra *et al.*, 1956).

Nymphoides aurantiacum (Dalz.) O. Kuntze, Rev. Gen. Pl. 2: 429, 1891. *Limnanthemum aurantiacum* Dalz. in Hook. Kew Journ. 2: 136, 1850; FBI. 4: 132, 1883.

Pl. II



NYMPHOIDES INDICUM—UMRED TANK, NAGPUR

A straggling plant with elongate stems bearing leaves and flowers at intervals. Pedicels are few and commonly two of them arise from each node. The yellow flowers and the glabrous, minutely reticulate, prominently tuberculate, finely puberulous seeds are very characteristic. It occurs in Western Deccan Peninsula from Bombay southwards. It flowers and fruits in November and December.

Nymphoides parvifolium (Griseb.) O. Kuntze, Rev. Gen. Pl. 2: 429, 1891. *Limnanthemum parvifolium* Griseb. in DC. Prodr. 9: 141, 1845; FBI. 4: 132, 1883.

A delicate plant with many radical leaves and long slender stems with small floating leaves under 2.5 cm. in diam. The corolla is white and the seeds are minutely puberulous and tuberculate. It occurs in Assam and Western Deccan Peninsula along the coast-lands. It generally flowers and fruits in November and December.

HYDROPHYLLACEAE

Annual or perennial herbs. Leaves alternate, rarely opposite, entire, exstipulate. Flowers regular, hermaphrodite, in helicoid cymes, sometimes in spikes or racemes; calyx inferior, 5-partite, imbricate; corolla 5-lobed, tubular or funnel-shaped, the lobes imbricate, rarely contorted; stamens 5, inserted on the corolla-tube and alternate with the petals, filaments filiform, often dilated at the base, anthers ovate-oblong or linear; disc hypogynous or absent; ovary superior, bicarpellary, syncarpous, typically unilocular with 2 parietal intruding placentae, sometimes meeting in the centre making the ovary appear bilocular; ovules numerous; styles 1 or 2, stigmas capitate. Fruit a globose or ovoid, loculicidal or septicidal capsule or dehiscing irregularly; seeds minute; endosperm fleshy, embryo minute.

Hydrolea L.

Smooth, procumbent or creeping herbs. Leaves alternate, lanceolate, entire, smooth. Flowers blue, viscidly hairy, bracteate, in short terminal racemes or cymes; calyx 5-partite, the lobes lanceolate, hairy, exceeding the capsules; corolla rotate or campanulate, 5-lobed, imbricate; stamens 5, filaments filiform, sometimes dilated at base, anthers sagittate; ovary superior, 2-celled with many ovules borne on the fleshy axile placentae; styles 2, distinct, spreading, stigmas capitate. Fruit a globose or ovoid, septicidal capsule; seeds minute, irregularly wrinkled.

Hydrolea zeylanica (L.) Vahl, Symb. Bot. 2: 46, 1791; FBI. 4: 133, 1883. *Nama zeylanica* L. Sp. Pl. 226, 1753. (Fig. 18).

An annual herb, rooting at nodes, with bright blue flowers and lanceolate leaves. The calyx is glandular pubescent and the capsule is thin and transparent. It occurs commonly throughout India on the margins of tanks, water courses and in wet rice fields. It flowers during the cold weather from November to March. The leaves are considered to possess antiseptic properties and are used as a poultice for callous ulcers (Chopra *et al.*, 1956).

CONVOLVULACEAE

Herbs or shrubs, often twining, rarely trees. Leaves alternate, exstipulate. Inflorescence cymose or rarely solitary. Flowers regular, hermaphrodite, often showy, pentamerous (rarely tetramerous), hypogynous; calyx free, deeply 5-lobed, persistent, the sepals often unequal and sometimes accrescent; corolla made up of five petals, campanulate or funnel-shaped or subrotate, entire or shortly lobed, often plicate in bud; stamens 5, on the corolla-tube, filaments usually slender, sometimes enlarged at base, anthers linear or oblong, dorsifixed, dehiscing longitudinally; disc annular, around the base of the ovary; ovary superior, bicarpellary, syncarpous, 2-celled or 4-celled by the formation of a false vertical septum; ovules 2 or less commonly 1 or 4 in each cell, sessile, erect, anatropous; style filiform, simple or forked, stigma capitate or 2-lobed. Fruit, a berry or capsule dehiscing by two valves or circumscissile or dehiscing irregularly; seeds 4 or 2, rarely 1, erect; endosperm scanty or absent; cotyledons generally plaited.

Ipomoea L.

Twining or prostrate herbs, rarely shrubby or erect. Leaves alternate, entire, lobed or divided. Flowers solitary or in cymes; bracts various; calyx of 5 equal or unequal sepals, ovate or linear, often enlarged in fruit; corolla campanulate or funnel-shaped, the limb plicate, very slightly lobed; stamens 5, epipetalous, unequal, usually included, filaments filiform or dilated below and often hairy, anthers oblong, straight or twisted; pollen grains spinulose; ovary superior, 2-(rarely 4) celled, usually 4-ovuled; style filiform, stigma capitate, 2-globose. Fruit 4–6 valved capsule, rarely indehiscent; seeds usually 4, velvety or woolly; cotyledons bilobed, crumpled.

Ipomoea aquatica Forsk. Fl. Aeg.-Arab. 44, 1775; FBI. 4: 210, 1883. (Fig. 19).

Annual or biennial, pretty water plant with hollow stems. The cymes are few flowered and the pinkish corolla is darker in the throat. It is common throughout India and South Andamans and is found along the sides of puddles, tanks, small lakes and streams. It flowers in the cold months from November to March. The young leaves, shoots and roots are eaten. The juice of the leaves acts as a mild purgative and is supposed to purify blood.

SCROPHULARIACEAE

Herbs or shrubs, usually terrestrial, some aquatic. Leaves opposite, alternate or whorled, exstipulate. Inflorescence centripetal or composite. Flowers hermaphrodite, usually zygomorphic, hypogynous; calyx of 4–5 persistent, connate sepals; corolla more or less bilabiate, sometimes personate, 4–5 lobed, imbricate; stamens 4, didynamous, epipetalous, with or without a staminode, rarely 5 or even 2, anthers various, 1- or 2-celled, the cells distinct or more or less confluent, disc annular, cupular or glandular; ovary superior, bicarpellary, syncarpous, 2-celled; ovules many, anatropous, rarely amphitropous, sometimes few in each cell, borne on axile placentae; style simple, stigma dilated, 2-lobed or 2-lamellate. Fruit a capsule; placentae on a free central axis or attached to the margins of the valves; seeds small, various in shape; endosperm present; embryo straight or curved.

KEY TO GENERA

Stamens 4 . . . . . *Limnophila*
Stamens 2 . . . . . *Dopatrium*

Limnophila R. Br.

Water or marsh plants, glabrous or pubescent, often aromatic. Leaves with transparent dots, opposite or whorled, toothed or incised, or if submerged, with capillaceo-multifid lobes. The foliage of the taxa varies according to the depth and extent of the water-level. Flowers axillary, sessile or pedicelled, solitary or passing into terminal spikes or racemes; bracts leafy, bracteoles small or absent; calyx 5-partite, subequal, the posterior larger; corolla bilabiate, tube cylindric, upper lip suberect, entire or 2-lobed, lower spreading, 3-lobed; stamens 4, didynamous, included, anther-cells usually separate, stalked; ovary 2-celled with many ovules on axile placentae; style slender, deflexed at tip, stigma shortly bilamellate. Fruit an

ovoid or globose capsule, often acute, dehiscing both loculicidally and septicidally, the placentiferous dissepiment separating with the valves and usually winged with the remains of the septa; seeds many, angular, truncate, reticulate.

KEY TO SPECIES

1. Leaves pinnately nerved, not ribbed, no whorls of pinnatifid or multifid lower leaves; calyx usually striate.
   2. Flowers sessile in close axillary heads . . *L. rugosa*
   2. Flowers pedicelled in axillary or terminal, many flowered racemes . . . . . *L. aromatica*
1. Leaves 3–5 ribbed from the base, lower leaves usually pinnatifid or multifid; calyx not striate.
   3. Flowers sessile or nearly so.
      4. Flowers solitary, axillary . . . . *L. heterophylla*
      4. Flowers in terminal or axillary, often divaricately branched spikes . . . *L. aquatica*
   3. Flowers with pedicels longer than calyx . *L. indica*

Limnophila rugosa (Roth) Merrill, Interp. Herb. Amb. 466, 1917; Pennell, Scroph. West. Himal. 26, 1943; Chatterjee & Bharadwaja, Bull. bot. Soc. Beng. 9: 137, 1955. *Herpestis rugosa* Roth, Nov. Pl. Sp. 290, 1821. *Limnophila roxburghii* G. Don, Gen. Syst. 4: 543, 1838; FBI. 4: 265, 1884.

A stout aromatic annual herb, up to 30 cm. high, creeping and rooting at the base, bearing bluish-purple, sessile flowers with yellow mouth, clustered in small, nearly sessile heads. It occurs in watery places as a common weed in Northern India, Assam, Tripura, West Bengal, Bihar, Orissa, Central India, Bombay and in Godavari District of Andhra Pradesh. It flowers in September and October. The infusion of the leaves is used as a diuretic and as a tonic (Chopra *et al.*, 1956).

Limnophila aromatica (Lamk.) Merrill, Interp. Herb. Amb. 466, 1917; Santapau, J. Bombay nat. Hist. Soc. 49: 33, 1950. *Ambulia aromatica* Lamk. Encycl. 1: 128, 1783. *Limnophila gratissima* Blume, Bijdr. 749, 1826; FBI. 4: 268, 1884.

A tall glabrous plant, decumbent at base and rooting at the lower nodes, then erect; the leaves of this plant are mostly in whorls of 3 and sharply serrate; the purple, bracteate flowers are usually borne in terminal racemose panicles. It occurs commonly in watery places of Southern Bihar, West Bengal, Deccan Peninsula, West

Coast Districts, Western Ghats and Anamalais at 600 m. It flowers and fruits in the rainy season and winter months from June to January. The juice of the plant is antiseptic; also used as a cooling medicine in fever and given to women who are nursing, when the milk is sour (Chopra *et al.*, 1956).

Limnophila heterophylla Benth. Scroph. Ind. 25, 1835; FBI. 4: 270, 1884. *Columnea heterophylla* Roxb. Fl. Ind. 3: 97, 1832.

A rather tall erect herb with leaves of all the three forms; the erect stem which bears many capillary leaves below the water-level often arises from the nodes of a long under water horizontal stem. It is common throughout India and is found in small puddles, ponds and rice fields. It usually flowers and fruits from September to December.

Limnophila aquatica (Willd.) Santapau, J. Bombay nat. Hist. Soc. 49: 33, 1950. *Stemodia aquatica* Willd. Sp. Pl. 3: 346, 1800. *Limnophila polystachya* Benth. Scroph. Ind. 26, 1835; FBI. 4: 269, 1884. (Fig. 20).

A water plant with the upper parts erect and easily recognised by the racemes of small white flowers in terminal panicles. It occurs in Maharashtra, Mysore and other places in South India and flowers and fruits in winter months from December to March.

Limnophila indica (L.) Druce, in Rep. Bot. Exch. Cl. Brit. Isles 3: 420, 1914; Pennell, Scroph. West. Himal. 26, 1943; Chatterjee & Bharadwaja, Bull. bot. Soc. Beng. 9: 138, 1955. *Hottonia indica* L. Syst. Nat. 919, 1759. *Limnophila gratioloides* R. Br. Prodr. 442, 1810; FBI. 4: 271, 1884. *Limnophila racemosa* Benth. Scroph. Ind. 26, 1835; FBI. l.c. (Fig. 21).

An aquatic herb with slender or much branched stems from the base, growing up to 30 cm., rooting from the lower striate nodes. The upper leaves are whorled, sometimes opposite, prominently 3–5 nerved, serrate and the lower are often capillaceo-multifid and flaccid. The white or pinkish flowers are solitary, axillary or borne in terminal racemes. This is a widely distributed species in India and South Andamans and commonly occurs in ponds, lakes and rice fields and usually flowers during the rainy and cold seasons. The plant is considered as an antiseptic and when made into a liniment with coconut oil is used in elephantiasis. The juice of the plant is rubbed over the body in pestilent fevers; it is also given internally with ginger, cummin and other aromatics in dysentery (Chopra *et al.*, 1956).

This taxon is extremely variable in its vegetative characters (see

Santapau, p. 34, 1950). According to Chatterjee and Bharadwaja (1955), varieties *intermedia* Benth. and *elongata* Benth. are only ecoforms of *Limnophila indica* Druce.

Dopatrium Buch.-Ham.

Annual, slender, glabrous herbs. Leaves few, opposite, the lower pairs small, the upper minute, remote. Flowers small, solitary, axillary, violet; bracteoles absent; calyx small, 5-partite, lobes narrow, imbricate; corolla bilabiate, the slender tube dilated to a broad throat, the outer upper lip short, 2-fid; lower broad, spreading, 3-lobed; 2 upper stamens perfect, included, filaments filiform, anther-cells parallel, distinct, equal, lower pair reduced to minute staminodes; ovary superior, 2-celled with many ovules borne on axile placentae; style short, stigma 2, lanceolate. Fruit a small, globose or oblong, loculicidal capsule, the valves placentiferous; seeds many, very small, reticulately pitted or tuberculate.

KEY TO SPECIES

Fruiting pedicels absent or under 1.2 cm., erect; stems much branched from the base with fleshy erect branches up to 30 cm. high; corolla very small, 5 mm. long . . . . . *D. junceum*

Fruiting pedicels up to 2.5 cm. long, horizontally spreading; stems erect, usually single or at most 2–3 from the base, up to 45 cm. high; corolla 12 mm. long . . . . . *D. lobelioides*

Dopatrium junceum (Roxb.) Buch.-Ham. ex Benth. Scroph. Ind. 31, 1835; FBI. 4: 274, 1884; Chatterjee & Bharadwaja, Bull. bot. Soc. Beng. 9: 135, 1955. *Gratiola juncea* Roxb. Pl. Cor. 2: 16, t. 129, 1798.

An erect, very slender, fleshy herb with pink flowers. It is common throughout India and occurs in ponds, wet places, rice fields and extends even up to an altitude of 1,200 m. It flowers and fruits during the rainy and cold seasons.

Dopatrium lobelioides (Retz.) Benth. Scroph. Ind. 31, 1835; FBI. 4: 274, 1884. *Gratiola lobelioides* Retz. Obs. 4: 7, 1786. (Fig. 22).

A rather tall, slender, fleshy herb with comparatively larger flowers. It occurs commonly during the rainy season in South Deccan and near Madras in tanks and wet places. It flowers and fruits from September to January.

LENTIBULARIACEAE

Herbs, aquatic or in wet places, often insectivorous. Leaves rosulate or when submerged, capillaceo-multifid, sometimes obsolete. Scape many flowered, raceme or spike. Flowers zygomorphic, hermaphrodite; bracts small or absent, bracteoles 2 or ebracteolate; calyx inferior, 2–5 lobed or partite, persistent; corolla 2-lipped, spurred, the upper lip usually smaller, entire or emarginate, the lower usually much larger, 3–5 lobed; stamens 2, attached to the base of the corolla, alternate with the lobes of the lower lip, filaments broad, curved, anthers 2-celled, ovate, dorsifixed, the cells transversely confluent, longitudinally dehiscing; ovary globose, superior, bicarpellary, 1-celled; ovules very many on a free central placenta; style short, stigma unequally 2-lobed. Fruit a capsule, 2–4 valved or irregularly breaking up or sometimes circumscissile; seeds many, minute, without endosperm.

Utricularia L.

Submerged or floating, rootless aquatics or growing on wet ground and rocks, rooting among other plants; sometimes twining. Many of the leaf segments of most species produce small bladders furnished with a little trap door and usually with several minute bristles at the orifice. These bladders capture small aquatic animalcules. In some of the floating taxa the scape is provided with a whorl of spongy floats. Leaves, in floating species, are multifid with capillary segments, alternate or rarely whorled; in erect or twining species the leaves are entire.

Because of the absence of true roots even in the seedling stages, the branches and leaves may be modified in various ways to serve as anchoring or absorbing organs. In some taxa the stems are almost entirely subterranean, colourless and rhizome-like from which root-like segments are produced and some of them in turn bear bladders. These produce erect branches with a few reduced leaves. Other taxa produce long, creeping, entirely free-floating or submerged stems which are usually horizontal and sparsely branched; such stems are covered with finely dissected leaves which are bladder-bearing.

The flowers are borne on simple or branched scapes, racemose; in a few species the flowers are cleistogamous; pedicels bracteate, often bibracteolate; calyx 2-partite, lobes entire or nearly so, often accrescent; corolla bilabiate, the upper lip entire or emarginate, the lower larger, lobed and spurred at the base, the spur straight or curved, the palate of the lower lip often projecting so as to nearly

close the throat, often bearded; stamens 2, filaments broad, anthers ovate, 2- or sub-1-celled; ovary superior, 1-celled, the numerous ovules borne on a free central placenta. Seeds of various shapes, mostly characteristic for each taxa, minute, the testa reticulate or scrobiculate or even glochidiate.

KEY TO SPECIES

Peduncles with a whorl of spongy floats below the inflorescence; pedicels short; seeds tabular prismatic, with 4–6 usually sharp angles and slightly winged margins . . . . . *U. stellaris*

Peduncles without a whorl of spongy floats; pedicels long.

Peduncles and pedicels stout; submerged leaves very many, long; seeds prismatic with sharp angles and slightly winged margins; flowers rather large, usually 3–8 . . . . . *U. flexuosa*

Peduncles and pedicels slender; submerged leaves very short, lobes capillary; seeds lenticular with a broad, dentate, corky wing; flowers small, 1–3 . *U. exoleta*

Utricularia stellaris L. f. Suppl. 86, 1781; FBI. 4: 328, 1884. (Fig. 23).

A water plant with yellow flowers, only the inflorescence showing above the surface, held up by broadly ellipsoid or ovoid, reticulately veined floats which have a tuft of filiform external pinnules at their apices. The submerged leaves are often arranged in whorls of four; they are pinnately cut into numerous, slender, pectinate segments and each pinna is usually provided near the base with a small, globular, ovoid bladder with a truncate mouth. The thickened pedicels are usually deflexed in fruit. The globose capsules are circumscissile. It occurs commonly throughout India in stagnant fresh-water ponds and lakes. It usually flowers during and after the rainy season and fruits later.

In **U. stellaris** L. f. var. **inflexa** Cl. the corolla is white with violet stripes and the spur is as frequently pubescent and as little curved as in the typical species.

Utricularia flexuosa Vahl, Enum. 1: 198, 1805; FBI. 4: 329, 1884. (Fig. 24).

A water plant with yellow flowers and bladders similar to the former taxon, but with longer peduncles, larger flowers and pedicels deflexed after flowering; in exceptional instances, floats are seen in this species as well. It occurs throughout India in tanks, lakes, rice

fields and wet places and flowers and fruits in the cold season from October to February.

The presence of floats which is a characteristic feature of the inflorescence of *Utricularia stellaris* are not usually seen in *U. flexuosa*. In exceptional cases, however, they are seen in the latter taxon as well and Deva (1953) has given a very good account of the anatomy of these floats. According to him, when such floats are present, they are much larger and measure 20 mm. in length and 4 mm. in diameter, while those of *U. stellaris* are only 8 mm. long and 3.5 mm. in diameter. They are branched at the tip and the branches are further divided into fine capillary segments. Their number may vary from one to half a dozen on an inflorescence and are irregular in arrangement.

The float in a transverse section is circular. Multicellular glandular hairs are present scattered on the epidermis. The stalk of the hair is two-celled and the gland consists of two elongated cells or several enlarged cells. The cortex consists of a ring of air-chambers and constitutes the main bulk of the float. On the outer side they are limited by the epidermis. The partitions separating the air-chambers are one cell thick. In the centre there is a narrow stele with a pith and only two layers of cells between the chambers and stele. The vascular bundles are arranged in a ring. A noteworthy feature of the bundles is the dissociation of xylem and phloem from each other at various levels. Consequently, a transverse section shows the two tissues forming separate bundles in addition to others showing the usual conjoint condition. The conducting elements are very much reduced and the cambium is absent. These features and the presence of air-chambers are associated with aquatic habit. In the branches of the floats the vascular elements, pith, and the air-chambers of the cortex go on diminishing. Finally, the entire stele in the centre is just represented by a single xylem cell associated with few phloem-like cells. This is surrounded by only two layers of cells, of which the outer represents the epidermis.

There is some controversy regarding the morphological nature of the floats. Barnhart (1916) feels that they are modified leaves. Haines (1922), Rendle (1952) and Lloyd (1942) also regard them as leaves. Arber (1920), on the other hand, has regarded them as shoots. The anatomical study of Deva (l.c.) shows that the stele in the floats is like that of the stem and hence, the floats are of the nature of modified shoots.

The structure and mechanism of the bladders in *Utricularia flexuosa* have been clearly described by Ekambaram (1916, 1918 and 1926). In this taxon the bladders are highly specialised structures

for capturing the animalcules. Each bladder is an egg-shaped structure with a flat end. The flat end, which is horse-shoe shaped, has a thick ridge or 'collar' which surrounds the mouth that leads into the cavity inside. The ridge is produced at the two ends of the base of the horse-shoe into two stout projections from which branched hairs or 'antennae' arise. The mouth is closed by a trap door or valve which is attached to the ridge along the base of the horse-shoe and opens only towards the inside. If pushed from inside, the door presses against the thick ridge and is thus prevented from being opened towards outside. The device makes it easy for an animalcule to enter the bladder but it cannot get out when it finds unpleasant inside. In the living bladder the valve is tightly closed against the ridge. It is dome-shaped with the apex of the dome lying very near the bend of the horse-shoe. From the apex arise four or six long pointed hairs arranged in two sets. The hairs stretch towards the base and project slightly from the valve. The major portion of the upper surface of the valve is clothed with club-shaped glandular hairs.

Three different groups of hairs are present on the bladder. First we have the antennae and the hairs forming a fringe round the ridge of the mouth. The antennae are long, multicellular, branched hairs placed one at each end of the base of the horse-shoe formed by the ridge round the mouth. Each has a stout base formed by a projection of the tissue of the ridge and consists of parenchymatous cells. The outer walls of the hair are thick and the main hair as well as the branches have pointed ends. The hairs surrounding the ridge are also pointed and multicellular. Ekambaram (1918), from their position and structure, has inferred that these hairs afford protection to the bladder.

The second group are the irritable hairs situated at the apex of the dome formed by the valve. The hairs are placed in two sets, each set consisting usually of three hairs. They are nearly as long as the valve and project at an angle of 45° from the surface of the valve towards the base of the horse-shoe. These are the hairs that receive and transmit the stimulus which is caused by contact with any animalcule that rubs against them and finally brings about the opening of the valve and the sucking in of the animalcule. Each hair consists of six or seven cells arranged one above the other. The basal cell is large and projects beyond the surface of the valve. Above this there are two to three elongated cells, then a very short cell and two more long cells which gradually taper to a point. The short cell lies about half way along the length of the hair and the hair itself appears jointed above it, as the transverse wall separating the upper two cells is very

much thickened. The other cross walls are all thin. All the cells have prominent nuclei and their outer walls are uniformly thickened. While the bigger cells have scanty cytoplasm, the short cell is filled with dense contents. When the valve is dissected out, one or more of these hairs are bent and the flexure invariably occurs at the short cell. In this connection, the structure of the outer wall of the short cell is interesting. It consists of two parts, a thin elastic and translucent inner membrane and a thick brittle and more refractive outer one. In the bent hairs, the brittle outer part is found broken and the broken ends are found protruding into the cell, while the inner membrane remains intact. Very near the base of the irritable hairs there are two or four very short hairs. The head cells of these short hairs have a curious shape, resembling the turgid guard-cells of a stoma.

The third group of hairs form a dense clothing over the portion of the ridge between the antennae and part of the upper surface of the valve. Each hair consists of a long or short stalk with an oblong or oval head. In addition to this there are also short stalked hairs with spherical heads scattered all over the surface of the walls of the bladder. These hairs have a secretory function.

The parts of the bladder concerned in capturing the prey are the valve, the ridge round the mouth and the walls of the bladder. The valve is attached all along the base and a little way along the sides of the horse-shoe formed by the ridge round the mouth. On irritation, the valve turns its shape from a convex dome-shaped structure into a concave boat-shaped one. The structure of the valve is well-suited to bring about this change of shape. The valve is uniformly made up of two layers of cells, but is divisible into two parts on account of the difference in the size and shape of the cells. There is, firstly, a large portion extending from the line of attachment to the place of origin of the irritable hairs and secondly, a smaller portion constituting the margin. The larger portion is mainly responsible for the change of the convex valve into a concave one. At the region where the valve is attached, a projection of the ridge is formed by the arching of the wall of the bladder. It is the arch thus formed that is instrumental in bringing about changes in the position of the valve. The structure of the arch is different from the wall of the bladder. The wall of the bladder consists of three layers of cells. In the innermost layer which consists of large and small cells, the cell walls are thickened and slightly lignified. Further, the smaller cells bear quadrifid or quadripartite glandular hairs which help in the absorption of the dead and decaying animalcule entrapped in the bladder. The outer two layers consist of thin-walled cells. The inner layer may act as a resistant

layer, being less extensible and the outer two may be active in bringing about the change in shape.

The trap mechanism of the bladder is interesting. It is seen that the bladders are usually found in two states, some with concave and others with convex sides. If an animalcule swims very near the mouth of the empty bladder with concave walls and touches only the irritable hairs projecting from the apex of the valve, it will be found that on touching the hairs, the concave sides of the bladder shoot out, becoming convex and at the same time, water along with the animalcule is sucked into the bladder. This entire process is extremely quick and it is impossible to observe directly anything more of what happens than the shooting of the walls and the filling up of the bladder with water. But under special conditions, it was found that, on irritation, the dome-shaped valve becomes boat-shaped with the irritable hairs lying in the hollow and at the same time, the valve is drawn down into the cavity of the bladder leaving the mouth fully open. According to Ekambaram (1918), the valve is made to assume a dome-shape by a differential change of dimensions in the cells of the two layers of the larger portion and that this dome is stretched out and made more rigid by the behaviour of the marginal tissue. Simultaneously with these changes, the walls shoot out and the water along with the animalcule is sucked in. With the immediate passing off of the effect of irritation, the valve returns to its original position, assumes the dome-shape and bars the exit of the organism entrapped. When once entrapped, the animalcules die and decay inside the bladder and the decaying materials are absorbed by the special hairs or the quadrifids on the wall of the bladder and sent into the plant for its nourishment.

In a very thorough account, Khan (1954) has reported some very interesting features on the embryology of *Utricularia flexuosa*. The salient embryological features are: the differentiation of the placental nutritive tissue; the extra micropylar growth of the embryo sac; and the Scutellaria type of endosperm which develops aggressive haustoria. During the growth of the ovule there differentiates a group of cells near its base constituting the placental nutritive tissue. These cells have dense protoplasmic contents and are organised into a compact morbid mass which forms a distinctive feature of the free central placenta whether in transverse or in longitudinal section. In older stages each mass is surrounded by a sheath of two or three layers of cells. The upper bulbous portion of the embryo sac protrudes beyond the ovule, becomes thus extra-micropylar and its apex is now buried in the placental nutritive tissue. Thus, this extra-ovular embryo sac is supplied with food material by the specially organised

nutritive tissue of the placenta. The endosperm is of the Scutellaria type and prominent micropylar and chalazal haustoria are differentiated. The aggressive micropylar haustorium penetrates deep into the placental nutritive tissue, whose cells break down and their nuclei enter the haustorium. As many as 150 placental nuclei get incorporated into this haustorium. The aggressive, 2-nucleate, chalazal endosperm haustorium occasionally contains three nuclei.

Utricularia exoleta R. Br. Prodr. 430, 1810; FBI. 4: 329, 1884. (Fig. 25).

A small floating aquatic plant, occurring throughout India. The leaves are very small and sparingly lobed. They bear bladders which are obliquely ovoid with a truncate mouth at the apex furnished with slender, long, branched hairs. The yellow flowers with orange streaks have a rather long spur. According to R. Brown (l.c.) "Scape 1–2 flowered, lower lip undivided; upper lip entire and semi-trilobed, spur ascendent, emarginate. Rather close to *U. minor* L."

ACANTHACEAE

Herbs or shrubs. Leaves opposite, exstipulate, entire, usually lineolate, with prominent raphides. Inflorescence in cymes, racemes or spikes, rarely solitary. Flowers bracteate, bracteolate, hermaphrodite, usually zygomorphic; calyx 5-partite, rarely 4-partite, sometimes small and multifid; corolla bilabiate, or subequally 5-lobed, the petals imbricate or twisted in bud; stamens 4 or 2, epipetalous on the corolla tube, sometimes the 5th represented by a staminode, anthers 2- or 1-celled, the cells often remote and sometimes bearded; disc often conspicuous; ovary superior, bicarpellary, syncarpous, bilocular with 1 or more anatropous ovules in each cell arranged in one or two series; style simple, filiform, stigma notched or 2-lobed, the lobes often unequal. Fruit a loculicidal capsule, the valves often elastically recurved, the septum splitting; seeds usually hard, attached, except in a few genera, to upcurved subacute retinacula developed from funiculi, ovoid or compressed, testa smooth or rugose or clothed with appressed hairs which are often elastic and spread out when wetted; endosperm scanty or absent; cotyledons usually flattened and next to the hilum.

KEY TO GENERA

Retinacula minute, straight; lower leaves often toothed or pinnatifid; inflorescence not thorny .	*Cardanthera*
Retinacula hooked; leaves entire; inflorescence thorny	*Asteracantha*

Cardanthera Buch.-Ham.

Aromatic, often viscid herbs. Leaves opposite, often lineolate, upper toothed, rarely entire, the lower often pinnatifid, or if submerged, pectinate. Flowers in spikes or axillary whorls or 1–3 in the leaf-axils; bracts and bracteoles often suppressed; sepals 5, narrow, often unequal; petals 5, connate into a tube, bilabiate, with a transversely plaited palate; stamens 4, didynamous, anthers of the posterior pair often smaller, cells parallel; ovary narrow, 2-celled; ovules many; style slender, sparsely hairy. Fruit a narrow sessile capsule; seeds many, ovoid, small; retinacula minute, conical, straight.

Cardanthera difformis (L. f.) Druce in Rep. Bot. Exch. Cl. Brit. Isles 1916 Suppl. II: 612, 1917. *Ruellia difformis* L. f. Suppl. 289, 1781. *Cardanthera triflora* Buch.-Ham. ex Benth. in Benth. & Hook. Gen. Pl. 2: 1074, 1876; FBI. 4: 405, 1884.

Annual decumbent herb, rooting at the base. The lower leaves are pectinate and membranous. The flowers are borne in axillary whorls. It is very common along the margin of water in West Bengal and extends up to Assam.

Asteracantha Nees

A stout herb of wet places; the numerous stems bear long, sharp, axillary thorns on the nodes. Leaves narrow, lanceolate, lineolate, in whorls of six, the outer leaves of each whorl larger. Flowers in sessile axillary whorls, surrounded by the slightly recurved thorns; bracts leafy, bracteoles linear-lanceolate; calyx deeply 4-partite, the upper lobe the largest; corolla bilabiate, the upper 2- and the lower 3-lobed with 2 crested folds on the palate, tube cylindric below, enlarged above; stamens 4, didynamous, anthers 2-celled, equal, the cells parallel; ovary 2-celled, ovules 4 in each cell; style pubescent, stigma simple. Fruit a linear-oblong capsule; seeds 4–8 on hard retinacula, flat and white hairy when wet.

Asteracantha longifolia (L.) Nees in Wall. Pl. As. Rar. 3: 90, 1832; Santapau, Univ. Bombay Bot. Mem. 2: 17, 1951. *Barleria longifolia* L. Cent. Pl. 2: 22, 1756. *Hygrophila spinosa* T. Anders. in Thw. Enum. Pl. Zeyl. 225, 1860; FBI. 4: 408, 1884. (Fig. 26).

A tall, hispid herb with blue-purple flowers with six thorns arranged in a whorl. It occurs commonly throughout India along the margins of tanks, rice fields and wet places. It flowers from October to February and fruits from November onwards. The leaves,

roots and seeds are used as a diuretic and employed for jaundice, dropsy, rheumatism and diseases of the urino-genital tract (Chopra *et al.*, 1956).

The arrangement of leaves, thorns and flowers at each node has been described by Rangaswamy (1941). The axillary buds in the axils of the two linear-lanceolate, subsessile, opposite leaves become more often transformed into thorns than develop into branches. Each of these two thorns bears at its base, one on either side, two more leaves shorter than the first two. So, for the two thorns there are four more smaller leaves and these four in turn bear in their axils more thorns which are slightly shorter than the first two thorns. At the base of each one of these four thorns two more leaves arise and the buds in the axils of the latter develop into flowers. Thus, there are actually three whorls of leaves arising one above the other as do the floral leaves in a flower, the lowermost whorl consisting of the two big opposite leaves; from the axil of each of these two big leaves, there appear three thorns, six leaves and four flowers. Since the uppermost or the innermost whorl of small leaves bear flowers exactly in their axils, these leaves can be regarded as bracts. All these parts are sessile and are crowded at the base to form a cluster. Thus, the two larger and four smaller thorns clustered at each node represent the modified axillary branches of the first and second order respectively.

AMARANTHACEAE

Herbs, rarely shrubs, erect or climbing. Leaves exstipulate, opposite or alternate, simple. Inflorescence terminal or axillary, simple or panicled spikes, cymes or clusters. Flowers usually hermaphrodite, rarely polygamous or dioecious, with hyaline or scarious bracts and bracteoles; perianth dry, calycine, persistent, usually of 5 free or slightly connate, hyaline or scarious, imbricate segments; stamens 1–5, antitepalous, filaments free or connate below in a membranous hypogynous cup, often alternating with membranous staminodes, anthers dorsifixed, 1- or 2-celled; ovary superior, 1-celled, ovoid, ellipsoid or globose; ovules 1 or more, amphitropous, erect or suspended from basal funicles; style simple with capitellate stigma, sometimes 2–3 fid with acute stigmas, or 2 or 3 papillosely stigmatic on the lower face. Fruit an ovoid membranous utricle, rarely a berry or a capsule breaking irregularly or circumscissile; seed erect or inverted, orbicular, ovate or reniform, compressed; testa crustaceous; tegmen, if present, membranous; embryo horse-shoe shaped or annular, surrounding a floury endosperm; perisperm present.

Alternanthera Forsk.

Usually prostrate or decumbent herbs. Leaves usually opposite. Flowers hermaphrodite, small, white, in axillary often clustered heads; bract and bracteoles scarious; perianth of 5 calycine tepals, unequal, the two lateral innermost, concave; stamens 2–5, filaments short, connate into a short cup with or without intervening staminodes, anthers 1-celled; ovary orbicular or ovoid; ovule solitary, pendulous from a long basal funicle; style short, stigma subsessile, capitellate. Fruit a compressed, ovoid, orbicular or obcordate utricle, the margins often thickened or winged; seed lenticular; testa crustaceous; embryo annular, surrounding the floury endosperm; cotyledons narrow, radicle superior.

Alternanthera sessilis (L.) DC. in Cat. Hort. Monspel. 77, 1813; FBI. 4: 731, 1885. *Gomphrena sessilis* L. Sp. Pl. 225, 1753.

A common prostrate herb and occurs throughout India and South Andamans in small ponds or in wet places. The leaves are lanceolate, oblanceolate or linear-oblong and the small white flowers are borne in axillary clusters. There are three stamens and the fruit is a broad, obcordate utricle. It flowers and fruits throughout the year.

POLYGONACEAE

Herbs, rarely shrubs, sometimes climbing, with jointed stems. Leaves alternate, rarely opposite, entire, serrulate or rarely lobed; stipules fused into sheaths (ocreae), scarious or membranous, clasping the stem above the leaf base. Inflorescence racemose or cymose. Flowers with pedicels usually articulate, hermaphrodite, rarely polygamous, regular, solitary in small bracteate clusters; perianth simple, calycine or corolline, tepals 3–6, free or connate, imbricate in bud; stamens 5–8, rarely more or fewer, antitepalous, anthers 2-celled; disc annular, glandular or absent; ovary superior, free, 1-celled; ovule solitary, orthotropous, sessile or on distinct funicle; styles 3 or 2, rarely 4, stigmas capitate, peltate or fimbriate. Fruit a small, hard, usually trigonous or lenticular nut, enclosed in the perianth; seed erect, testa membranous; endosperm floury, sometimes ruminate; embryo various, radicle superior.

Polygonum L.

Perennial or annual herbs or shrubs with stems swollen at the nodes, erect or with creeping rootstocks. Nodes covered by the thin,

cylindrical, stipular sheaths. Leaves alternate, entire, rarely lobed; stipules membranous, connate into a tubular ocrea. Bracts and bracteoles membranous, obovate. Flowers hermaphrodite, small or minute, axillary or terminal, the clusters sessile or in spiciform, capitate or panicled racemes; pedicels short, usually jointed under the perianth; perianth green or coloured, 4–5, rarely 3-cleft, the two outer sepals smallest; stamens 5–8, rarely 1–4, perigynous, filaments filiform, often dilated at base or alternate with the lobes of an annular or glandular disc; ovary compressed or trigonous; styles 2 or 3, free or slightly connate below, stigmas usually capitellate. Fruit a lenticular or trigonous nutlet, more or less included in the persistent perianth; pericarp usually hard and shining; seed endospermous; embryo lateral or excentric, radicle long, cotyledons small.

KEY TO SPECIES

Nutlets orbicular, biconvex.
- Bracts hispid and ciliate on the margins; ocreae strigose.
  - Leaves long-petioled, ovate or ovate-cordate, covered with short, grey hairs . . . . . *P. orientale*
  - Leaves short-petioled, lanceolate, silky pubescent . . . . . *P. pulchrum*
- Bracts glabrous, not ciliate on the margins; ocreae glabrous . . . . . *P. glabrum*

Nutlets trigonous . . . . . *P. barbatum*

Polygonum orientale L. Sp. Pl. 362, 1753; FBI. 5: 30, 1886.

Annual, suberect, branching, hairy herb or undershrub with long petioled, ovate or ovate-cordate, acuminate leaves. The flowers are white, red or green. It occurs in ditches, lakes and flooded areas from Assam westwards up to Jammu and in Madras ascending up to 1,500 m. It usually flowers in the beginning of the rainy season. The plant is a good tonic and used for healing wounds (Chopra *et al.*, 1956).

Mitra (1945) and Mitra and Majumdar (1952) by their anatomical studies have explained the exact morphology of the ocreaceous stipule. According to them, in *Polygonum orientale* the leaf primordium receives one median and many lateral traces and the node is multilacunar. From the axis, the base becomes free as a tubular sheath and it continues its free upward growth till the laterals deviate from their vertical courses and bend to follow a united horizontal course towards the central region of the sheathing base. During the united

horizontal course the laterals give out branches, and these branches maintain further upward growth of the sheath as the free upper tubular portion (stipule). The base thus forms a mantle enclosing the axial core in the internode. The ocrea is really the sheath plus the stipule.

Polygonum pulchrum Bl. Bijdr. 530, 1826. *P. tomentosum* Willd. Sp. Pl. 2: 447, 1799 (non Schrank Baier. Fl. 1: 669, 1789); FBI. 5: 30, 1886.

A thick, herbaceous plant with prostrate stems rooting at the nodes and the branches erect and hairy. The flowers are white and the thick, shining, crustaceous nutlets are dark brown. It occurs in ditches and small lakes in West Bengal, Assam, North and South Andamans and in South India it is found in Northern Circars, Deccan and extends from Bombay to Kerala.

Polygonum glabrum Willd. Sp. Pl. 2: 447, 1799; FBI. 5: 34, 1886. (Fig. 27).

An erect, glabrous, annual herb rooting from lower nodes and reaching up to 1.5 m. in height. The leaves are very slender with pink or white flowers borne in long paniculate racemes. It occurs throughout India in small ponds, lakes and ditches. The plant is used as a febrifuge and the infusion of leaves in colic pain (Chopra *et al.*, 1956).

Polygonum barbatum L. Sp. Pl. 362, 1753; FBI. 5: 37, 1886. (Fig. 28).

An erect annual with conspicuous long fimbriate ciliae on the ocreae. The leaves are lanceolate and the flowers white. It occurs throughout the hotter parts of India from Assam to Indus, South India, Laccadives and North and South Andamans. The roots are used as an astringent and as a cooling agent; the seeds are used to relieve gripping pains of colic (Chopra *et al.*, 1956).

PODOSTEMACEAE

Perennial aquatic herbs, submerged and closely attached to rocks by hairs or haptera in rushing water and torrential hill streams; the flowers appear and seeds germinate at the close of the rainy season when exposed by the receding of the water-level. The primary axis in the early stages gives rise to a thallus, which is actually the part of the plant that creeps on the rocks. Secondary shoots appear from the thallus, and may be found as rosettes of leaves or as growing or branching leaf-bearing axis. Leaves very simple and delicate, caducous, changing to bracts and finally ending in a spathe or cupule

which encloses the young flower. Flowers hermaphrodite, small and either regular, trimerous with a perianth or zygomorphic, trimerous without one; stamens 3, hypogynous in regular flowers, alternate with the tepals; in zygomorphic flowers usually 2, monadelphous and usually with 2 staminodes; anthers introrse, 2-celled; ovary superior, 2–3 celled, septa delicate, placenta thick; ovules numerous, anatropous; stigmas 2–3. Fruit a pedicellate capsule, smooth or ribbed, septitragal; seeds usually numerous (in *Farmeria* 2 or 4); testa mucilaginous; endosperm absent; embryo straight.

As the level of water recedes in the streams, the flowers are produced. The fruits, when well developed, burst and discharge the seeds. The minute seeds rest on the rocks and with the advent of the rains and under favourable conditions develop into individual plants.

KEY TO GENERA

1. Flowers regular; tepals 3, free or united; spathe absent.
   2. Roots thread-like, creeping, long, slender, often branched, free-floating; shoots with linear scattered leaves . . . . . *Indotristicha*
   2. Roots thalloid, frondose, closely attached to rocks; shoots with two kinds of linear leaves densely conferted at the tip of the shoots . *Terniola*
1. Flowers zygomorphic, naked, the young buds covered or encircled by a spathe.
   3. Capsule not oblique, isolobous . . . *Dicraea*
   3. Capsule oblique, anisolobous.
      4. Capsule smooth.
         5. Flowers with tepals . . . . . *Hydrobryopsis*
         5. Flowers without tepals, naked.
            6. Thallus fucoid; leaves distichous *Griffithella*
            6. Thallus crustaceous; leaves 4-ranked . . . . . *Willisia*
      4. Capsule ribbed.
         7. Fruit 2–4 seeded . . . . *Farmeria*
         7. Fruit many seeded.
            8. Thallus crustaceous . . *Zeylanidium*
            8. Thallus filiform . . . *Podostemon*

Indotristicha van Royen

Submerged herbs with the habit of *Fontinalis* and other aquatic mosses, the roots creeping and filamentous; secondary shoots many,

often more or less paired on opposite sides, floating freely in water. When well developed often long, many-flowered and frequently branched; branches of two kinds, long ones with the structure of the main axis and short ones consisting of a delicate axis with many small leaves tristichously arranged. Flowers terminal, on pedicels subtended by 2–3 large or several ordinary leaves, the upper ones often more or less united; stamens 3 and a cupule-like organ is formed by connate leaves at the base of the pedicel; pedicel and ovary with deciduous cortex which shrivels after flowering; the small flowers usually emerging through the water at the beginning of the dry season.

Indotristicha ramosissima (Wt.) van Royen in Acta Bot. Neerl. 8: 474, 1959. *Dalzellia ramosissima* Wt. Ic. Pl. Ind. Or. 5: 35, 1852; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 33, ff. 16A, 24, 1930, as *D. ramosissima* (Wt.) Warm. *Terniola ramosissima* (Wt.) Wedd. in DC. Prodr. 17: 47, 1873; FBI. 5: 63, 1886. *Tristicha ramosissima* (Wt.) Willis in Ann. R. bot. Gdns Peradeniya 1(3): 208, 1902 and 1(4): 293–306, ff. 5–9, 1902. (Fig. 29).

It occurs in Western Ghats, rivers of South Canara, Malabar, Cochin and Travancore and also in Anamalai Hills up to 1,200 m. It is a floating plant with very long, much branched stems and narrow, linear leaves in tufts round the single pedicellate flower. There are 3 stamens and the three long filamentous stigmas are hairy.

Terniola Tul.

Herbs with frondose thalli, growing on smooth rocks in rapid streams and waterfalls. They are submerged during the monsoon, flowering in the dry season when exposed. The suborbicular or stellate thallus is closely attached by root-hairs. Leaves numerous, simple, entire, acute, green or red, occurring either on the upper surface and edges of the thallus or in closely-packed rosettes on its older parts. Flowers terminal, on the growing points of the margins of the thallus, solitary, on pedicels emerging from terminal axial leaf cupules; the pedicel which during flowering is 2–5 mm. in length elongates into an erect, elastic structure after flowering and measures nearly 3 cm. in length; stamens 3, alternating with tepals; anthers 2-celled, dehiscing longitudinally. Capsule ellipsoid or obovoid, 9-ribbed, 3-celled, septifragal, valves incurved after dehiscence.

Terniola zeylanica (Gardn.) Tul. Archives Mus. hist. nat. Paris 6: 190–192, t. 13, f. 3, 1852; FBI. 5: 62, 1886; van Royen 475. *Tristicha zeylanica* Gardn. Calc. J. nat. Hist. 7: 177, 1846. *Lawia*

zeylanica Tul. in Ann. Sc. nat. Ser. 3, 11: 112, 1849, emend Willis in Ann. R. bot. Gdns Peradeniya 1(3): 213, 1902. Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 34, f. 26, 1930.

It occurs in Western Ghats, South Canara at Sullia and Beltangadi, Kerala at Kottayam and Quilon and Tambraparni river in Tinnevelly district of Madras State. The thallus of this frondose plant closely adheres to the substratum and branches freely. The capsule is about 2 mm. long, ellipsoid.

Terniola zeylanica Tul. var. **konkanica** (Willis) Santapau in Rec. bot. Surv. India 16: 202, 1960. *Lawia zeylanica* Tul. var. *konkanica* Willis, 216, 1902.

The thallus is 15–25 cm. with flabelliform lobes and crowded growing points. The capsule is 1.5–2.5 mm. long, obovoid and light brown. This species occurs in streams in and around Khandala, in Khadshi river, near Bhorkus, west of Poona, in Thul Ghat near Igatpuri of Western Ghats and on wet rocks in the rivers of Angul in Orissa.

Dicraea Tul.

Submerged herbs with the habit of *Fucus* and other seaweeds. Thallus various, usually free-floating from an attached base, exogenously branched, with marginal ultimately 1-flowered secondary shoots. Leaves usually subulate. Flowers zygomorphic, enclosed in spathes splitting irregularly at the tip and subtended by 2–8 (usually 4), fleshy, scaly bracts; stamens 2 or 1, with staminodes on either side of the common axis; ovary smooth, ripening into 8- (or rarely 8–12) ribbed, isolobous fruit with many seeds.

KEY TO SPECIES

Thallus narrow, ribbon-like, flattened, attached at base, free-floating above, up to 30 cm. long; pedicels about 2 cm. long	*D. dichotoma*
Thallus broad, algiform, freely branched, creeping or floating from an attached base, up to 45 cm. long; pedicels up to 4 cm. long . . .	*D. stylosa*

Dicraea dichotoma (Gardn.) Tul. in Ann. Sc. nat. Ser. 3, 11: 101, 1849; Willis in Ann. R. bot. Gdns Peradeniya 1(3): 220, 1902; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 51, 1930. *Podostemon dichotomus* Gardn. in Calc. J. nat. Hist. 7: 185, 1847; FBI. 5: 64, 1886. (Fig. 30).

It occurs in Western Ghats, Nilgiris and hills of Malabar up to 2,500 m. on rocks in rapid waters. The thallus is narrow and usually zigzag.

Dicraea stylosa Wt. Ic. t. 1917, f. 2, 1852; Willis, 225; Engl., 51, f. 42. *Podostemon stylosus* Benth. in Benth. & Hook. Gen. Pl. 3: 112, 1880; FBI. 5: 64, 1886. (Fig. 31).

It is reported from Western Ghats, South Canara to Travancore, Nilgiris and Anamalais up to 1,500 m. The thallus is broad, seaweed-like and the bracts are helmet-shaped.

Hydrobryopsis Engl.

Small, green, herbaceous plants closely attached to the rocks. Thallus branched, 3–10 mm. wide, the pinnules arising in acropetal order. Flowering shoots numerous on the fringe of the thallus, each in the axil of the branches of 5–6 bracts of which the upper helmet-shaped and bigger. Spathe boat-shaped, open on upper side, occasionally uneven; tepals 2, linear, as long as the ovary; stamens 2, on the gynoecium or anthropod of the same length; ovary smooth, style linear, almost the length of the ovary. Capsule sessile, ball-shaped, smooth, obliquely dehiscing, anisolobous.

Hydrobryopsis sessile (Willis) Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 60, f. 53A–C, 1930. *Hydrobryum sessile* Willis in Ann. R. bot. Gdns Peradeniya 1(3): 239, 1902.

A very curious little plant with distichous bracts bearing the sessile fruit; occurs in streams of Western Ghats, South Canara at Beltangadi and at Visakhapatnam in Andhra Pradesh.

Griffithella Warm.

Minute herb attached to rocks in running streams. Thallus fucoid, algiform, highly polymorphic; secondary shoots marginal or on central parts, small with included axis in vegetative condition, ultimately slightly exserted. Leaves distichous. Flowers naked, zygomorphic, emerging from an ascending tubular or funnel-shaped spathe irregularly split at the tip; stamens 2, monadelphous, staminodes 2, at the sides of the filament-sheath; ovary very oblique; stigmas 2, simple, subulate or more or less lobed, with small papillae. Capsule quite smooth, nearly spherical, unequally lobed, splitting obliquely into a larger persistent and smaller deciduous lobe.

Griffithella hookeriana (Tul.) Warm. in Danske Vid. Selsk. Skr. Ser. 6, 11: 13, 1901; Willis in Ann. R. bot. Gdns Peradeniya 1(3):

233, 1902; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 61, f. 54A–E, 1930. *Mniopsis hookeriana* Tul. in Ann. Sc. nat. Ser. 3, 11: 105, 1849. *Podostemon hookerianus* (Tul.) Wedd. in DC. Prodr. 17: 74, 1873; FBI. 5: 65, 1886. (Fig. 32).

It is reported from Western Ghats from Bombay to South Canara at Beltangadi and Sullia. A curious lichen-like plant.

Willisia Warm.

Small, tufted herb with erect, imbricate shoots. Thallus small, crustaceous, fleshy, closely attached to rocks; secondary shoots crowded, erect, forming a dense tuft, the shoots with imbricate, 4-ranked, scaly leaves; in addition during the vegetative condition one or more shoots are found with leaves not imbricate but long and filiform and non-floriferous. Leaves of floriferous shoots decussate and triquetrous. Flowers naked, zygomorphic, sessile, terminal, the spathes bifid at tip; stamens 2, monadelphous, with two staminodes; ovary ellipsoid; stigmas 2, subulate, smooth. Capsule smooth, with a slight rib in the centre of each valve, anisolobous, one valve deciduous, the other persistent on a bifid stalk.

Willisia selaginoides (Bedd.) Warm. ex Willis in Ann. R. bot. Gdns Peradeniya 1(3): 235, 1902; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 51, f. 41A–D, 1930. *Mniopsis selaginoides* Bedd. in Madr. J. Sc. Ser. 3, 11: 105, 1849. *Podostemon selaginoides* (Bedd.) Benth. in Benth. & Hook. Gen. Pl. 3: 113, 1880; FBI. 5: 68, 1886.

It occurs in Western Ghats at Anamalais up to 1,000 m. An interesting species with shoots resembling *Lycopodium selago,* attached to rocks in the form of tufts.

Farmeria Willis

Dendrically branching herbs, adherent to smooth rocks in rapid waters. Thallus ribbon-like, closely attached, regularly branched; secondary shoots as in *Hydrobryum* but behind the branches of thallus instead of in anterior axils. Bracts prostrate, thicker on upper side, usually 1, scaly, with deciduous tips; spathe splitting on upper side; stamen 1; ovary more or less globose, with thickened placenta and 2–4 ovules on the under side, lower loculus more or less abortive; stigmas large, subulate. Fruit small, ribbed, dehiscent, anisolobous, the upper lobe larger, 2–4 seeded.

Farmeria indica Willis in Ann. R. bot. Gdns Peradeniya 1(3): 248, 1902; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 68, 1930; Gamble, Fl. Pres. Madras 2: 839, 1957.

It occurs in Western Ghats and in Tambraparni river in Tinnevelly. A plant with thread-like thallus. The four-seeded fruit is shortly stalked, ribbed and dehiscent.

Zeylanidium Tul.

Small, green, thalloid, crustaceous or ribbon-like, branched plants closely attached to rocks; vegetative shoots with narrow leaves 1–10 cm. long. Flowering shoots lie parallel with 4–8 helmet-shaped bracts having thread-like caducous ends. Spathe boat-shaped, open at the top in the form of a slit; tepals 2, linear on both sides of the staminal column; stamens 2, rarely 1, as long as the gynoecium; ovary ellipsoidal or globose; style awl- or wedge-shaped. Capsule 8-ribbed, stalked, dehiscent obliquely, anisolobous, the broad valve persistent, the small one deciduous.

KEY TO SPECIES

Thallus crustaceous.
Stamens short . . . . . *Z. olivaceum*
Stamens very long . . . . . *Z. johnsonii*
Thallus ribbon-like, branched; stamens of varying length . . . . . *Z. lichenoides*

Zeylanidium olivaceum (Gardn.) Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 62, f. 55A–K, 1930. *Podostemon olivaceum* Gardn. in Calc. J. nat. Hist. 7: 181, 1846; FBI. 5: 66, 1886. *Hydrobryum olivaceum* Tul. in Ann. Sc. nat. Ser. 3, 11: 104, 1849; Willis in Ann. R. bot. Gdns Peradeniya 1(3): 239, 1902. (Fig. 33).

A common small plant easily distinguishable by its crustaceous thallus and erect, clearly ribbed fruit. It occurs in Kottayam and Quilon of Kerala State. The form **anamalaiense** of this taxon is reported from Anamalai Hills, Western Ghats at 1,000 m.; another form of this is **griseum** and it occurs in Nilgiris in the Pykara river at about 1,600 m.

Zeylanidium johnsonii (Wt.) Engl. 62. *Mniopsis johnsonii* Wt. Ic. t. 1919, f. 5, 1852. *Podostemon johnsonii* (Wt.) Wedd. in DC. Prodr. 17: 75, 1873; FBI. 5: 66, 1886. *Hydrobryum johnsonii* (Wt.) Willis, 241. (Fig. 34).

It occurs in Western Ghats, in mountain streams in Malabar.

Zeylanidium lichenoides (Kurz) Engl. 62. *Hydrobryum lichenoides* Kurz in J. Asiat. Soc. Beng. 42: 103, 1873; Willis, 242.

Podostemon microcarpus Wedd. in DC. Prodr. 17: 76, 1873; FBI. 5: 66, 1886.

A common, very variable species occurring in Assam, Western Ghats, Visakhapatnam, in hill streams near Jeypore in Orissa, streams of South Canara, Travancore and Anamalai Hills at 1,000 m. It flowers and fruits in January and February.

Zeylanidium lichenoides (Kurz) Engl. var. **khandalense** (Willis) Santapau in Rec. bot. Surv. India 16: 203, 1960. *Hydrobryum lichenoides* Kurz var. *khandalense* Willis, 245, 1902.

The pedicels are 2–5 mm. long. It occurs in Thul Ghat near Igatpuri and Khandala, Western Ghats.

Zeylanidium lichenoides (Kurz) Engl. var. **bhorense** (Willis) Santapau, 203. *Hydrobryum lichenoides* Kurz var. *bhorense* Willis, 245.

The pedicels are 5–8 mm. long. It is reported from Thul Ghat and Khandala.

Podostemon Michx.

Annual or perennial, submerged herbs in rapid mountain streams. Thallus thread- or ribbon-like; secondary shoots ascending, several-flowered, with long subulate leaves and no scaly bracts. Flowers zygomorphic, naked, terminal with a tubular or funnel-shaped crest; spathe rupturing irregularly at the tip; stamens 2 or 1, monadelphous, with a staminode on each side of the common axis and sometimes at the fork of the partial filaments; ovary ellipsoid, 2-celled; style short, stigmas 2, simple, subulate, with small papillae. Fruit unequally lobed, 8-ribbed, one valve persistent with 3 decurrent ribs, the other deciduous.

KEY TO SPECIES

Stamens usually 2; flowers not cleistogamous; ovary not winged	*P. subulatus*
Stamen 1; flowers cleistogamous; ovary with 6 broad wings	*P. barberi*

Podostemon subulatus Gardn. in Calc. J. not. Hist. 7: 184, 1846; FBI. 5: 65, 1886; Willis in Ann. R. bot. Gdns Peradeniya 1(3): 229, 1902; Engl. in Engl. & Prantl, Nat. Pflanzenfam. 18a: 63, 1930. (Fig. 35).

It occurs in Western Ghats at Anamalai Hills. The long, slender, subulate leaves attached to the rocks in tufts are very characteristic.

Podostemon barberi Willis, 230; Engler, 63.

It occurs in Western Ghats, the hills of South Canara at Beltangadi and Bastar District of Madhya Pradesh.

From the point of embryology the Podostemaceae are particularly interesting. The embryological studies of Razi (1949) on two Indian species of Podostemaceae have revealed the following noteworthy features: the pollen grains are single or united in dyads; embryo sac development follows the reduced Allium type; antipodals are usually lacking in the small mature embryo sac; there is a single polar nucleus (or cell); a pseudoembryo sac is formed; endosperm is absent right from the beginning; the basal cell of the two-celled proembryo becomes vesicular, coenocytic and forms a haustorium. The loss of endosperm, the formation of the pseudoembryo sac and the divergent type of embryo sac can be explained as derivative characters which are in all probability due to the special mode of life of these plants. Further, it is seen that the Podostemaceae resemble the Crassulaceae in having a secretory type of anther tapetum, binucleate pollen grain, presence of starch grains in both pollen and embryo sac and in the haustorial behaviour of the basal vesicular cell of the embryo. In addition to these features *Crassula aquatica,* a member of the Crassulaceae, has a mode of life somewhat similar to that of Podostemaceae. It has the most reduced endosperm in the Crassulaceae and this may well form a transitional stage leading to the complete suppression of this tissue in the Podostemaceae. It may also be pointed out here that on the basis of embryological features Maheshwari (1945) has concluded that it is "almost certain that the Podostemaceae are much reduced apetalous derivatives of the Crassulaceae".

CERATOPHYLLACEAE

Slender, submerged, aquatic herbs, rootless, olive-green to green in colour, with a slender main axis and slender lateral branches. The lower end of the stem is frequently imbedded in soft mud and usually without chlorophyll. Leaves in whorls, dichotomously cleft into slender, often stiff, brittle, filiform, minutely toothed lobes, much crowded towards the apex by the appearance of a 'coon tail'; stipules absent. Plants with reduced staminate and pistillate inflorescences on different nodes, rarely on the same node. Flowers minute, monoecious, solitary, axillary, sessile; perianth (or involucre) of both sexes of 10–15 narrow, subvalvate, 2-fid segments; stamens 10–20, spirally arranged on a flat receptacle, filaments very short, anthers extrorse, connective projecting, truncate or 2–3 toothed at the apex ; ovary

superior, sessile, ovoid, 1-celled; ovule 1, pendulous; style subulate, stigmatic on one side. Fruit a small, coriaceous, ovoid or ellipsoid, somewhat compressed nutlet terminating in the persistent long style and furnished on either side with long subulate spur projecting from a little above the base, sometimes narrowly winged; seed exalbuminous; embryo straight, plumule many leaved; cotyledons thick, radicle short, inferior. The family consists of only one genus.

Ceratophyllum L.

Aquatic herbs entirely submerged, branching, a single branch produced at a node. Roots lacking (even in the embryo) but leafy branches sometimes modified as 'rhizoids'. Leaves whorled, 6–10 at a node, rather rigid, 1–4 dichotomously dissected, with two rows of minute teeth along the upper side of the ultimate segments, tipped by two bristles, usually with a purplish hair of tannin-filled cells in between. Flowers usually solitary in the axil of one leaf of a whorl; perianth segments 8–12 cleft, arranged in the form of an involucre; staminate flowers with an involucre of 10–15 perianth segments, slightly united at the base, each tipped with a purplish hair, with a convex receptacle and 10–20 extrorse, 4-locular stamens with short filaments bearing large, sessile, oblong-linear, often 2-cuspidate anthers; pollen large, nearly smooth, thin-walled, acolpate; the filament ends in a connective with terminal expansion or cusp which acts as a float when the mature anthers become detached and rise to the water surface; after dehiscence of the anther the pollen sink and come in contact with the submerged pistillate flower; pistillate flower with a solitary pistil surrounded by an involucre of 10–15 bristle pointed segments; occasionally an involucre may contain, in addition to the normally developed pistil, 1 or more reduced lateral pistils, each with its own whorl of segments indicating a much reduced compound inflorescence; ovary ovate, 1-locular, with an unitegmic, pendulous ovule; style filiform, oblique and stigma has a lateral pocket. Fruit a laterally compressed achene, 5–7 mm. long, with persistent involucre and tipped by the indurate persistent style (or its base) and often with additional 2 basal spines and also lateral marginal spines in some species; seed fills the cavity of the fruit and the nucellar tissue forms the seed coat; embryo large, cotyledons thick, ovate and the well developed plumule shows several nodes with simple or forked leaves; hypocotyl and radicle lacking; endosperm scanty or absent.

Ceratophyllum demersum L. Sp. Pl. 992, 1753; FBI. 5: 639, 1888. (Fig. 36).

A fragile, alga-like herb 15–90 cm. long with leaves 1.2–2.5 cm. long. The fruit *c.* 0.5 mm. long, smooth, muricate or minutely tubercled. It occurs throughout India and Andaman Islands in shallow ponds, tanks, lakes and other stagnant waters; flowers from January to March and fruits later. The plant is used as a cooling agent, for biliousness and scorpion-sting (Chopra *et al.*, 1956). The achenes are eaten by wild ducks.

The plants of this genus are completely adapted to an aquatic mode of life. They lack cuticle, stomata and roots; the radicle does not enlarge or elongate during seed germination and the roots are absent in the seedling. Even in the embryo, the anchoring function is taken over by the leafy branches which grow into the mud. Both xylem and phloem are reduced, mechanical cells are lacking and about a third of the plant is occupied by air-spaces. The pollination of the highly reduced flowers is sub-aquatic. The achenes which have a hard, durable covering are often found in muck soils at the bottom of dry ponds and lakes.

The plants grow upright in the early growing season, the lower part of the stem serving as an anchor and also for absorption of nutrients. Later in the season many of the plants grow more or less floating near the surface of the water, intertangled with filamentous algae. During winter the tips of the branches may become much shortened, thickened and break off; these in turn sink to the bottom to act as "winter-buds", also called "squamulae intravaginales", which can grow into a new plant.

Occasionally it forms an association with *Hydrilla verticillata,* another submerged plant.

HYDROCHARITACEAE

Aquatic herbs in fresh or salt waters, usually submerged. Leaves undivided, clustered at nodes of rhizomes or a few with leafy stems. Flowers regular, monoecious or dioecious, polygamous or rarely hermaphrodite, enclosed in an entire or 2-leaved spathe; male flowers 1 to many, female flowers solitary; calyx of 3 green or petaloid sepals; petals 3, membranous or wanting; in pistillate flowers the perianth is fused into a tube which in turn is adnate to the wall of the compound pistil; stamens 3–12, anthers 2-celled ; ovary inferior, 1-celled, placentae parietal, intruded and sometimes almost meeting; ovules numerous, borne on parietal or superficial placentae; style or style-arms 3–12. Fruit globose or ovoid, membranous or fleshy, ripening under water, indehiscent, rarely dehiscent; seeds few or many, nonendospermous; embryo various.

KEY TO GENERA

1. Fresh-water herbs; leaves tufted, whorled, opposite or alternate.
   2. Stems branched, leafy.
      3. Leaves mostly whorled; stamens 3; style undivided . . . . . *Hydrilla*
      3. Leaves mostly alternate; stamens 2; style notched . . . . . *Nechamandra*
   2. Stemless or with stolons; leaves radical.
      4. Leaves without a distinct petiole, linear, grass-like; flowers very slender; spathe not winged.
         5. Perianth single; peduncle of female spathe spirally coiled . . . . . *Vallisneria*
         5. Perianth in 2 whorls; peduncle not coiled . . . . . *Blyxa*
      4. Leaves distinctly petioled, mostly broad, not grass-like.
         6. Flowers unisexual; ovary beakless; fruit not winged . . . . . *Hydrocharis*
         6. Flowers hermaphrodite; ovary beaked; fruit winged . . . . . *Ottelia*
1. Salt-water herbs, submerged.
   7. Leaves under 15 cm. long, ovate or oblong, in pairs from the axil of a scale; male spathe 1-flowered; perianth single . . . . . *Halophila*
   7. Leaves 60–90 cm. long, narrowly linear, 2–3 enclosed in a basal sheath; male spathe many-flowered; perianth double . . . . *Enhalus*

Hydrilla Rich.

Leafy, caulescent aquatic herbs, usually submerged. Leaves linear to lanceolate, rarely elliptic, midrib conspicuous, 3–4-nately whorled or the lower opposite, entire or toothed. Flowers regular, monoecious or dioecious; male flowers minute, shortly pedicelled, solitary, in a subsessile subglobose muricate spathe; sepals 3, ovate to orbicular, convex, green, imbricate; petals 3, oblong or cuneiform, imbricate; stamens 3, alternating with petals, anthers reniform, erect, latrorsely dehiscent; female flowers sessile, solitary in a cylindrical, top bifid, membranous spathe; sepals 3, imbricate, convex, petals 3, imbricate; ovary inferior, shorter than the spathe, cylindric to

narrowly conical, 1-celled; beak filiform; ovules many, anatropous; styles 2–3, alternipetalous, linear, entire, stigmas fimbriate. Fruit subulate, smooth or muricate; seeds 2–6, minute, oblong-elliptic; testa shortly produced at both ends.

Hydrilla verticillata (L. f.) Royle, Ill. Bot. Himal. t. 376, 1839; FBI. 5: 659, 1888; Hartog in Fl. Males. I, 5: 385, f. 1, 1957. *Serpicula verticillata* L. f. Suppl. 416, 1781. (Fig. 37).

A slender, submerged weed up to 45 cm. long with fibrous roots and is common throughout India in still, fresh-water ponds, puddles, tanks and lakes. It flowers during the cold season from October to January. When abundantly found it is used as a manure. It is eaten by some fishes and as it is a good oxygenator, it is suitable for aquaria. The plants grow quickly and reproduce both vegetatively and by seeds. The loosened shoots develop into new plants by attaching themselves in the mud by fine filiform adventitious roots. Subterranean shoots with swollen tips, called 'turions' are also formed. These are densely clothed with fleshy, acute or acuminate, scale-like leaves and serve as organs of vegetative propagation.

Ernst-Schwarzenbach (1945) has studied thoroughly the anthesis and mechanism of pollination in this taxon. In the male spathe the pedicel breaks and the mature bud, after pushing the two tips of the spathal apex, rises to the surface of water. It is provided with a small part of the pedicel and the drifting bud makes an angle of 45° with the water surface. After floating for about an hour, the bud opens and anthesis sets in. During anthesis the sepals and petals retract and finally a stamen detaches itself abruptly from the hollow sepal, assumes a horizontal position and immediately dehisces, discharging its pollen around it in a sector of 120°. Now the pollen grains are situated around the opened flower. When all the anthers have dehisced the flower which was oblique in position becomes erect. The detachment of male flowers and their rise to the surface takes place only after a preceding bright day.

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The female flower in the submerged condition resembles a closed inversed bell on whose bottom the short styles are inserted. The peduncle gradually elongates and as the flower reaches the water surface the perianth lobes retreat, forming a wide funnel immersed in the water surface. Inside the funnel the surface tissue is dry. The styles are, therefore, not wetted and they project dry into the air at the bottom of the inversed perianth bell. The perianth lobes appear to be limp; their turgescense capacity is lesser than the powers involved by surface tension. Because of this, the flower closes temporarily

with the tepals embracing an air bubble above the dry styles. It opens again when the wave has passed.

Because of this remarkable mechanism, Ernst-Schwarzenbach (l.c.) concludes that the pollen is not carried to the styles by means of water, but must be transmitted directly by aerial transport to the styles.

Nechamandra Planch.

Submerged, fresh-water perennial herbs. Leaves alternate, gramineous, amplexicaul, acute, minutely serrulate, many-nerved, striate and pellucid. Flowers dioecious; male minute, numerous and densely crowded in an axillary, sessile, ovoid, 2-fid spathe; perianth consists of an outer whorl of 3 tepals, enclosing 2 small tepals arranged antero-posteriorly; stamens 2, divergent, anthers ovate; female spathe tubular, apex bifid; perianth tube filiformly attenuated above into a neck; limb 3-partite, coronate; ovary inferior, ovate-lanceolate, gradually attenuated, slightly unequal, 1-celled; ovules many, orthotropous, attached irregularly on the parietal placentae; stigmas 3, cuneate, bilobed. Fruit an ovoid, indehiscent utricle included in the spathe; seeds numerous, ascending, oblong, scrobiculate.

Nechamandra alternifolia (Roxb.) Thw. Enum. Pl. Zeyl. 332, 1864 *Vallisneria alternifolia* Roxb. Fl. Ind. 3: 750, 1832. *Lagarosiphon roxburghii* (Planch.) Benth. in Benth. & Hook. f. Gen. Pl. 3: 451, 1880; FBI. 5: 659, 1888. (Fig. 38).

A common, submerged, dioecious, aquatic herb occurring throughout India in ponds, tanks and lakes. It flowers and fruits in the winter months from October to February. The elongated, rather filiform stems ascend through the water to various lengths. The sessile leaves are linear-lanceolate, acute and often twisted. The ovoid male spathes are axillary, sessile, paired, 2-valved and when they open, the minute male florets are set free; they are seen as specks floating on the surface of water in a close gregarious manner. The tepals of male flower are reflexed and the anthers of the two stamens dehisce transversely. The solitary, axillary, sessile female flowers have three spreading, orbicular, concave tepals. The ovary is long and the 6-lobed stigma is finely papillose on the receptive surface.

Vallisneria L.

Submerged, tufted, stemless, stoloniferous, glabrous, dioecious, fresh-water herbs with fibrous roots. Leaves radical, linear, ribbon-

shaped, sheathing at base with longitudinal air-chambers; apex obtuse, margin faintly dentate or entire; veins 3–9, parallel, connected by cross-veins, only the midrib reaching the apex, the other nerves gradually joining together near the top. Flowers dioecious, on long or short scapes; male spathe shortly peduncled, ovoid, 3-lobed, containing many pedicelled flowers which break off and rise to the surface; sepals 3, ovate or oblong-ovate, convex; petals absent; stamens 1–3, anthers didymous; pistillode wanting; female spathe connate, tubular, 2-cleft, borne at the apex of a long, slender scape, floating on the water, becoming spirally contracted after anthesis; sepals 3, ovate or oblong-ovate; petals 3, minute, scarious; staminodes in female 3, each 2-fid; ovary inferior, narrow, linear, cylindric, not produced upwards, 1-celled with 3 parietal placentae; styles 3, split into broad stigmatic lobes, hairy on their inner surface. Fruit linear, 5–10 cm. long, included in the spathe; seeds numerous, oblong to fusiform, imbedded in a gelatinous mass; testa membranous.

Vallisneria spiralis L. Sp. Pl. 1015, 1753; FBI. 5: 660, 1888. (Fig. 39).

A common weed rooting at the bottom of pools, tanks and lakes and occurs throughout India and middle Andamans. It has rather narrow, entire leaves (up to 1 m.) with only 5 nerves. In the female flower the spathe covers only the base of the ovary. The sepals are acute and styles fringed. It flowers and fruits from October to March. The plant is used as a stomachic and for leucorrhoea (Chopra *et al.*, 1956). It is also cultivated in aquaria.

Kausik (1939) has made very interesting observations on pollination and its influences on the behaviour of the pistillate flower in *Vallisneria spiralis*.

The staminate flower is about 0.6 mm. across the recurved sepals which are three in number; of these one is smaller. There are two stamens with slender filaments spreading apart at right angles. Each stamen bears distally, when the anther has dehisced, a mass of large pollen grains. The two masses of pollen grains of a given flower project beyond the margins of the sepals so that the pollen grains may immediately come in contact with the stigmas of the pistillate flower. In addition to the two stamens, the staminate flower has a rudimentary petal and a small staminodium placed on opposite sides. The pistillate flower has a slender inferior ovary measuring 12–14 mm. in length at the time of pollination. The spathe invests the ovary almost up to the base of the spreading sepals and later in the developing fruit forms only a partial basal investment. Three rudimentary petals are found inside the sepals and attached at the base of the style. No

staminodes are seen. There are three stigmas, each of which is bifid with two leaf-like fleshy expansions curling slightly outside. These stigmatic lobes now lie between the sepals and expose their inner surfaces which are densely clothed with stigmatic hairs.

The pistillate flower develops under water and is brought to the surface at the time of pollination by the elongated slender scape. The latter, because of its great length, places the pistillate flower in a slanting position on the surface of water. The floral parts are exposed on the surface and on account of their weight, the surface film forms a slight cup-like depression about each pistillate flower. At this time staminate flowers, floating on the surface, are moved along by currents or wind and may reach these depressions, when they tumble down and strike against the stigmatic lobes of the pistillate flowers. In this act a quantity of pollen is immediately shed on the stigmatic lobes; the pollen grains are as large as 50 microns and are found sticking to the receptive stigmatic surfaces. Frequently, the water is disturbed by the formation of strong waves; on such occasions the pistillate flowers may suffer a temporary submergence, and the associate staminate flowers generally lose their contact with the stigmas and drift away. But with the passing of the wave, the pistillate flowers are again exposed in the surface depressions. The transfer of pollen to the stigmatic lobes proceeds favourably during the short intervals when the surface of water is fairly quiet between successive waves.

Attention has now to be drawn to the peculiar behaviour of the pistillate flowers, prior to and after pollination. The pistillate flower develops under water and when its ovules are in the megasporocyte stage it is a little over 2 mm. long, with a very short stalk measuring about a millimeter. The stalk gradually increases in length until it brings the pistillate flower to the surface of water. The increase in length is largely due to an elongation of the individual cells of the scape. Kausik (l.c.) found that the cells had increased by about 40 to 50 times their original length. When the pistillate flower has reached the surface of water it is nearly erect but later gradually assumes a more or less horizontal position by the further increase in the length of the scape. The stigmatic lobes spread out in about two to four hours and pollination is effected under favourable circumstances in about four to six hours. After pollination the scape of the pistillate flower undergoes a special torsion which is first evident at the base of the ovary. This is followed by the formation of a number of coils in the scape. These coils then draw closer and tighter and the pistillate flower retreats under water where the fruit is developed.

Blyxa Thouars

Submerged, stoloniferous, tufted, monoecious or dioecious, scapigerous herbs. Leaves linear, spirally arranged, radical or along a 15–60 cm. long stem, base sheathing or semiamplexicaulous, entire or minutely dentate, attenuate; nerves parallel, midrib prominent. Spathe sessile or peduncled, tubular, with 6 longitudinal ribs, bifid at the tip, 1-flowered, or in male spathes of dioecious plants with up to 10 flowers; peduncle flattened or terete in cross-section. Flowers uni- or bisexual, female and hermaphrodite ones sessile, male ones pedicelled; sepals 3, linear or linear-lanceolate, green, persistent; petals 3, linear, longer than the sepals, white, flaccid, fringed; stamens 3–9, 1 or more rudimentary, filaments capillary, anthers linear or lanceolate, erect, bilocular, latrorsely dehiscent; pistillodes 3, slender; staminodes in female absent or minute; ovary inferior, linear, slender beaked, with 3 parietal placentae; styles 3, linear, connate at the base, stigmas 3, filiform. Fruit linear or linear-lanceolate, wall membranous, included in the narrow, ribbed spathe; seeds 10 or more, elliptic or fusiform, 1–2 mm.; testa glabrous, membranous, smooth or with 3–8 longitudinal rows of more or less conspicuous tubercles or spines often tailed at both ends.

KEY TO SPECIES

Flowers bisexual; stamens 3.	
Seeds with 8 rows of more or less tubercled ribs, without filiform processes	*B. auberti*
Seeds with 8 rows of blunt spines, with a 1–5 mm. long filiform tail at both ends . .	*B. echinosperma*
Flowers unisexual; stamens 9	*B. octandra*

Blyxa auberti Rich. Mém. Inst. Paris 12, 2: 19–23, 77, t. 4, 1812; Hartog, 390, f. 5 & f. 6d-d'. *B. griffithii* Planch. ex Hook. f. FBI 5: 661, 1888. *B. ceylanica* Hook. f. FBI. 5: 661, 1888. *B. oryzetorum* Hook. f. FBI. 5: 661, 1888. (Fig. 40).

A monoecious, acaulescent plant with radical leaves sheathing at the base. The 1-flowered spathe is up to 10 cm. in length and has obtuse tips. Seeds are many, elliptic to ovate, 1–2 mm.; the testa has 8 longitudinal rows of distinctly tubercled ribs. It occurs commonly in stagnant water of pools and small lakes in Kashmir, Madhya Pradesh, Bihar, West Bengal, Assam and South India. It flowers and fruits in December and January.

Blyxa echinosperma (Clarke) Hook. f. FBI. 5: 661, 1888; Hartog, 391, f. 6a. *Hydrotrophus echinospermus* Clarke in J. Linn. Soc. Bot.

14: 8, t. 1, 1875. *B. lancifolia* Hook. f. FBI. 5: 661, 1888. *B. talboti* Hook. f. FBI. 5: 661, 1888.

The testa of the seed has 8 longitudinal rows of blunt spines connected by scarious membranes, with a 1–5 mm. long filiform tail at both ends. It occurs in deep water tanks of Madhya Pradesh, West Bengal, Assam and South India and generally flowers and fruits from December to February.

Blyxa octandra (Roxb.) Planch. ex Thw. Enum. Pl. Zeyl. 332, 1864, *excl. specim.*; Hartog, 392, f. 6b. *Vallisneria octandra* Roxb. Pl. Cor. 2: 34, t. 165, 1802. *B. roxburghii* Rich. Mém. Inst. Paris 12, 2: 23–24, 77, t. 5, 1812; FBI. 5: 660, 1888. (Fig. 41).

A dioecious, acaulescent, aquatic herb with radical leaves sheathing and narrowed at the base. The female spathe is 1-flowered. The male spathe encloses 5–10 flowers and each has 9 stamens. The seeds are oblong-elliptic, have no tails, with one end attenuate and the other end obtuse; the testa has 8 longitudinal rows of more or less long (*c.* 0.5 mm.), curved spines. It occurs almost throughout India in shallow water and in shaded small streams in dense masses and flowers and fruits from December to January.

Hydrocharis L.

Floating, glabrous, monoecious, aquatic plants; stolons arising from the leaf axils. Leaves floating or emerging out of water, ovate to suborbicular, entire, apex rounded or acute, more or less cordate or reniform at base; nerves curved, parallel, joining the marginal nerve, connected by straight, parallel cross-veins; petiole near the base with 1 or 2 ligulate, transparent, scarious stipules. Spathal segments lanceolate, membranous, unisexual; the male spathe pedunculed, containing 1–4 flowers; female spathe sessile, 1-flowered; pedicels of male flowers short; sepals 3, elliptic, obtuse, white or greenish white, persistent; petals 3, larger than the sepals, broad-ovate, with broadly rounded apex and cuneate persistent base, shortly unguiculate, membranous; stamens 9–12, anthers bilocular, latrorsely dehiscent, dorsifixed; ovary elliptic, nearly 6-celled, placenta parietal; styles 6, flat, bifid. Fruit berry-like, elliptic to globose, with 6 ribs bursting irregularly at the apex; seeds many, elliptic, attached to six sharp keels or placentae; testa pulpy, full of spiral vessels; embryo ovoid.

Hydrocharis dubia (Bl.) Blacker, Handb. Fl. Java 1: 64, 1925; Hartog, 394, ff. 8–9. *Pontederia dubia* Bl. En. Pl. Jav. 1: 33, 1827. *Hydrocharis morsus-ranae* F. v. M. Fragm. 6: 199, 1868 (non L.); Hook. f. in FBI. 5: 662, 1888. (Fig. 42).

Free-floating or grows in shallow water rooting at the bottom in pools and tanks. It occurs in West Bengal, North Bihar and in the north-eastern regions of Uttar Pradesh and Kashmir. It flowers and fruits in winter during November and December.

Ottelia Pers.

Submerged, monoecious or dioecious, glabrous, fresh-water herbs. Leaves radical, crowded, the submerged ones different and narrower than the floating, linear, lanceolate, broad-ovate, suborbicular, cordate or reniform, apex rounded, acute or apiculate, base cuneate, truncate or cordate; nerves 3–11, parallel, straight or curved, connected by fine parallel cross-veins forming a characteristic pattern, midrib sometimes prominent; petiole sheathing at the base, often gradually merging into the blade, the length of the petiole depends on depth of water. Spathe peduncled, elliptic or ovate with 6 more or less prominent ribs or 2–10 wings; female and hermaphrodite ones 1-flowered, male ones many flowered. Flowers uni- or bisexual, female and hermaphrodite ones sessile, male ones pedicelled; sepals 3, linear, oblong or ovate, green with scarious margin, persistent; petals 3, oblong, broad-ovate to orbicular, twice or thrice as long as the sepals, white or coloured; stamens 6–15 in three to five whorls, often unequal, some often rudimentary, filaments filiform, flattened, anthers linear or oblong, latrorsely dehiscent; ovary oblong or fusiform, narrowed at the top, incompletely divided by superficial placentae into 6 cells; ovules numerous, scattered on the placentae and walls; styles 6–15, bifid; in the male flowers 3 stylodia are present. Fruit oblong, apex attenuate, pericarp thickened; seeds many, minute, oblong or fusiform, with rather thick testa.

Ottelia alismoides (L.) Pers. Syn. Pl. 1: 400, 1805 ; FBI. 5: 662, 1882; Hartog, 398, ff. 10–11. *Stratiotes alismoides* L. Sp. Pl. 1: 535, 1753. (Fig. 43).

A common, flaccid, submerged annual in slow streams and stagnant pools at low altitude. It occurs throughout India and flowers and fruits all round the year. The leaves are of two kinds; the submerged leaves are shortly petioled and usually narrow or oblong and tapering to the base; the floating ones are oblong or orbicular, cordate or rounded at the base and then narrowed into the angled petiole, up to 18 cm. in diam.; 7–11 nerved, margins undulate. The petals are obovate or orbicular and have fleshy basal appendages. The pollen grains are densely set with numerous minute tubercles.

In very shallow water the tops of the leaves are emerged and in

deeper water only the flower just peeps over the surface during anthesis. According to Ernst-Schwarzenbach (1956), the flowers often do not reach the surface of water, in which case self-pollination takes place in the closed, submerged flowers. In some cases these flowers may open later.

In this species polystely is noticed in the peduncle and leaf-stalk, and endodermis and pericycle surround each meristele (Majumdar, 1938).

Halophila Thouars

Monoecious or dioecious, submerged, marine plants. Stems creeping, ramified, rooting at the nodes with one, rarely more unramified roots closely beset with fine root-hairs. At the nodes there are two scales, one embracing the stem, the other embracing a lateral, often undeveloped shoot which bears the leaves which rarely have 2 scales below their base. Leaves opposite, sessile or petiolate, linear, lanceolate, oblong-elliptic or ovate, entire or serrulate, rarely hairy; nerves 3, a midrib and on both sides an intramarginal nerve, connected by cross-veins; between the leaves a new shoot appears which again bears scales and one or more pairs of leaves and the inflorescence. Spathe sessile, composed of 2 membranous free bracts, one overlapping the other, elliptic, obovate or suborbicular, acute, rounded to emarginate or indented, keeled, keel sometimes serrulate. Flowers unisexual, solitary, rarely one or more male and one female flower in one spathe; male flower pedicelled, perianth segments 3, imbricate; stamens 3, alternating with the tepals, anthers nearly sessile, linear-oblong, 2–4 celled, dehiscing extrorsely; pollen grains in long chains or filamentous; pistillode absent; female flower sessile or nearly so; ovary elliptic or ovate, 1-celled; ovules many on 2 parietal placentae; apex of ovary with a long beak crowned by the three reduced tepals; styles linear, 2, 3 or 5, filiform, papillose all over. Fruit ovate, rostrate, 1-celled, wall membranous, included in the spathe; seeds few to many, globose or subglobose, testa membranous; embryo thick, with the spiral cotyledon in a cavity at the side.

Halophila ovalis (R. Br.) Hook. f. Fl. Tasm. 2: 45, 1858; Hartog, 408, f. 16. *Caulinia ovalis* R. Br. Prod. 1: 339, 1810. *H. ovata* Aschers. Sitz. Ber. Ges. Naturf. Freunde 1868: 3, 1868 (non Gaud.); Hook. f. in FBI. 5: 663, 1888. (Fig. 44).

A dioecious, slender, creeping herb with linear-oblong to ovate, penninerved leaves, up to 7.5 cm. long and 1 cm. wide. While the male flowers are pedicelled, the female ones are usually sessile. It

usually occurs in sheltered localities along the sandy coasts and in back-waters; sometimes the plants may be almost buried in the muddy bottoms. They grow gregariously on coral-reefs along the coasts of Krusadi Island, Pamban, Cape Comorin and also in Ennore, Nellore, Chinnaganjam, Chilka, Calcutta salt lakes, Andamans and Nicobar Islands. It flowers during September and October. It is sometimes used as a manure in coconut and other plantations.

The male gametophyte of *Halophila ovalis* has been studied by Kausik and Rao (1942) and their observations on the formation of the filamentous pollen grains are interesting. During the development of the anther, the walls of the tapetal cells break down and their contents form a periplasmodium which is much less intrusive than in other taxa of this family. The microsporocytes are rather long and narrow and form a number of regularly arranged linear rows in each anther locule. This linear arrangement is seen later also in older anthers when the meiotic divisions in the mother cells are completed and still later when the pollen grains are maturing. The divisions take place transversely in each mother cell, so that the resulting microspores are found in a row, and not according to the tetrahedral or isobilateral types met with usually in angiosperms. Further, the linear tetrads of microspores formed by the mother cells in each row remain together without separating and thus there are several chains or filaments of microspores in each locule of the anther. In these filaments clear spaces are seen at regular intervals and these indicate the limits of individual tetrad of microspores formed by any one mother cell. A number of such chains of microspores in the form of a bundle are found in each anther locule and the whole bundle escapes as such when the thin anther wall dehisces. In the fully developed pollen grains which are ready to be shed, the gametophyte consists of a tube nucleus and two small male cells. The bundles of pollen grains united together in chains float on the surface of water, where they get caught amidst the exposed stigmatic lobes of the pistillate flowers.

Enhalus Rich.

Submerged, dioecious, rhizomatous, coarse, marine herbs; root-stock crinite with the remains of old leaves. Leaves few, 2–6, ribbon-like, together enclosed by a basal, flattened, membranous, transparent sheath, apex inequilateral, faintly serrulate when young; nerves many, parallel, air-chambers numerous, septated. Male inflorescence a peduncled spathe consisting of 2 connate blades, the margins of the outer one enclosing the inner blade; flowers small, numerous,

pedicelled, on a central stipe, get detached just before anthesis and the mature buds rise to the level of the water; sepals 3; petals 3, broadly elliptic; stamens 3, alternipetalous, anthers oblong, subsessile, 2-locular, latrorsely dehiscing; pollen grains large. Female inflorescence much larger, 1-flowered, long-peduncled ; spathe consisting of 2 nearly free blades, one embracing the other with both margins, persistent; sepals 3, oblong, imbricate; petals 3, longer, linear, subvalvate, wrinkled; staminodes absent; ovary rostrate, composed of 6 carpels, 1-locular, the 6 parietal placentae far intruding and forming 6 cavities; styles 6, each forked from the base, arms slender, fimbriate. Fruit ovate, acuminate, indehiscent, spathe persistent; seeds 8–14, obconical, angular, containing starch; the embryo with a large suspensor cell; the integuments stretch so much during post-fertilization stages that they equal the growing embryo; when the fruit ripens and bursts, the testa breaks off around the hypocotyl and remains as a ragged, easily loosened cap on the top of the cotyledon.

Enhalus acoroides (L. f.) Rich. ex Steud. Nom. Bot. 1: 554, 1840; Hartog, 402, f. 13. *Stratiotes acoroides* L. f. Suppl. 268, 1781. *Enhalus koenigii* Rich. Mém. Inst. Paris 12: 64, 78, 1812; FBI. 5: 663, 1888. (Fig. 45).

A submerged marine herb growing gregariously along shallow sheltered sea coasts, covering large areas and forming a closed vegetation on sandy and muddy bottoms. It is reported from South Andamans and South India along the sea coasts of Pamban, Krusadi Island and Cape Comorin, particularly in the inter-tidal regions. The leaves are 60–90 cm. long, 1–2 cm. wide with the strigose female spathes growing up to 5 cm. long. At low tide the leaves lie flat and nearly exposed on the bottom of shallow pools along the sea-shore and are all directed seaward by the off-flow of the water. The leaves are mostly covered with a thin film of mud particles and in the Krusadi specimens there is usually a thick epiphytic growth of the brown alga *Ectocarpus*. It flowers and fruits from September to November. A common associate of *Enhalus acoroides* is *Halophila ovalis*. A durable fibre for fishing nets is produced from this plant.

The morphology of the gynoecium of *Enhalus acoroides* requires some explanation. Svedelius (1904) regarded that the gynoecium of this taxon is "composed of six carpels which form a unilocular ovary divided into six cavities" and that the "parietal placentae project to the middle of the ovary and are, as in so many of the Hydrocharitaceae, split quite into two lamellae". Troll (1931) has shown that the gynoecium in this and other Hydrocharitaceae is really apocarpous and that it appears to be syncarpous only apparently. He

designates such a gynoecium as pseudo-coenocarpous. Further, he states that in the attainment of this condition the floral receptacle, which is said to be cup-like, is fused with the dorsal portions of the otherwise free carpels. On the other hand, Kausik (1940b) by anatomical study suggests that the outer wall of the gynoecium is made up of the fused basal portions of the two sets of floral leaves, for, the nine peripheral bundles which are seen at the base of gynoecium are really the combined sepal-petal traces. The receptacular tissue ends below the level at which these bundles and the main vascular supplies of the carpels are formed. The outer floral whorls are adnate to the carpels over a considerable distance and are free only above the gynoecium, which thereby has become not only pseudo-coenocarpous but also inferior.

Svedelius (1904) studied the life-history of *Enhalus acoroides,* especially in relation to the phenomenon of pollination; and Kausik (1941) studied the structure and development of the staminate flower and male gametophyte of this taxon and compared its pollination with some other members of the family. According to Svedelius (l.c.), the small male flowers, which occur in great numbers, open already in the spathe and during this development the pedicels break. Kausik (l.c.) observed that when the floral parts are passing through the stages of development, the narrow lower part of the flower which forms the pedicel increases rapidly in length and becomes slender. Later, when the flower is almost mature and is about to be released from the inflorescence, a definite cross zone of regularly arranged cells is seen in the upper part of the pedicel immediately below the base of the flower. This region is devoid of tannin-containing cells which are particularly conspicuous elsewhere in the pedicel and also in the floral parts. The detachment of the flower is effected later at this cross zone. The flowers are liberated only during diurnal, low-spring-tide, after opening of the spathe. At maturity, the staminate flowers get detached from the axis of the inflorescence and rise to the surface of water owing to the buoyancy caused by a bubble of air enclosed between the floral parts. On the surface of water the sepals and petals snap back and become reflexed so that the three erect stamens are completely exposed. According to Kausik (l.c.), the pollen grains are three celled at the shedding stage. They also contain large quantities of starch grains which are scattered throughout the cytoplasm and Svedelius (l.c.) notes that these make the grains heavier so that they sink in sea-water. Through their waxy cuticle the petals are hydrophobous, consequently they crowd together in swarms which move with surface currents and wind.

The papillate epidermal cells of the recurved petals and anthers,

and minute folds seen in their walls probably help to prevent wetting of these floral parts. In addition, they may also be of advantage in lodging the staminate flowers securely in the folds of the petals of the pistillate flowers.

Svedelius (l.c.) attributed the release of the male flowers to the decrease of air-pressure within the ripe bud during the retreat of the sea-water with spring ebb.

At the anthesis stage of the female flower, the peduncle being sufficiently long, the flower floats on the surface of water during low-tide. By means of the lobes of the spathe the flower is kept floating in a horizontal position. The petals are then extended and float on the surface without being wetted due to the waxy cuticle. Further, the petals are long and delicate with a number of folds. Kausik (l.c.) regards that they are thus admirably suited for catching and retaining the staminate flowers for pollination even when considerable disturbances are present on the surface of water. By the hydrophobous property of the petals the female flowers 'attract' the free male flowers, and it is often seen that a drifting female flower is surrounded by numerous male flowers. Still, pollination cannot take place, because the styles are covered by the perianth leaves and the anthers rise above the water level. As the water rises during flood, the female flowers are submerged; as a result of the surface tension, the petals close together catching or sucking in the male flowers adhering to the margins of the petals.

How pollination takes place within the female flowers has not been observed. Svedelius (l.c.) assumed that the anthers drop their pollen; these, as they are sinking down, can scarcely escape falling upon the styles, which now stand vertically and in a circle owing to the changed position underneath the level of the water.

The explanation given by Ernst-Schwarzenbach (1945) on the pollination mechanism appears to be more plausible. She assumes the presence of an air-bubble in the submerged female flower due to the hydrophobous quality of the petals covering the styles. Then the pollen is transferred by the toppled male flowers within the air-bubble without touching the water.

Kausik (1940a) has also made some very interesting observations on the seed of *Enhalus acoroides*. The fruit develops suspended in sea-water at varying levels below the surface. The outer surface of the fruit is densely clothed over by numerous stiff bristles and the tissue within is soft and fleshy. Embedded within the soft tissue are a few large seeds placed loosely within the cavities. When the fruit bursts, the seeds are exposed and come in direct contact with the surrounding sea-water. Since the outer integument has numerous

air-filled cavities, the buoyancy of the seed is increased and it does not immediately sink in water. Later, however, the thin seed coat comes off as a loose cap by becoming ruptured at the base and the embryo thus becomes naked. The seed coat remains for some time as a ragged, easily loosening cap on the top of the cotyledon.

The naked embryo is conical in shape with a large cotyledon containing plenty of starch filled cells. The radicle occupies the flat portion of the embryo and is nonfunctional in subsequent stages. The plumule is well developed and shows a number of young leaves arising in quick succession. At the base of the plumule and a little to the side is formed a second root which later comes out during germination of the embryo in the soil. In connection with the young leaves of the plumule there are certain axillary scale-like structures called squamulae.

The heavy embryos of *Enhalus* which leave the seed coat sink in the sea-water immediately. They become buried in the soil where they at once begin to grow further. Thus the embryo is liberated from the fruit and this represents a distinct form of vivipary.

PONTEDERIACEAE

Fresh-water, palustrial, perennial herbs, rooting in mud, erect or floating. Stem erect or floating or solid, with numerous air-chambers which are also present in the petioles. Leaves rosulate or alternate, emersed, floating or submerged, broad or narrow, curvi-nerved when emersed; petioles sheathing at the base. Flowers hermaphrodite, ephemerous, mostly in racemiform, spiciform, sub-umbelliform inflorescences which are subtended by 1–2 spathe-like or tubular leaf-sheaths; bracts minute or absent. Flowers often simultaneously or centrifugally expanding; perianth inferior, choriphyllous or gamophyllous, 6-merous, actinomorphic or zygomorphic, blue or lilac, after anthesis marcescent and tightly including the ovary or the fruit; stamens 6 or 3, rarely 1, on the base, in the tube or in the throat of the perianth, often unequal, filament free, anthers 2-celled, erect or versatile, cells bursting longitudinally, rarely poricidal; ovary superior, sessile, 3-celled with axile placentae or 1-celled with 3 parietal placentae; ovule 1 to many on each placenta, when 1, pendulous from the apex of each cell; style slender, stigma entire or minutely 3-lobed. Fruit a membranous, loculicidal, 3-valved capsule; seeds small, ovoid or ellipsoid, longitudinally ribbed; embryo central, terete, straight, hardly shorter than the copious, mealy endosperm.

KEY TO GENERA

Flowers distinctly pedicelled; perianth actinomorphic, almost choriphyllous, posterior tepal without a discolourous blotch; one stamen longer, filaments horned on one side, glabrous	*Monochoria*
Flowers sessile; perianth strongly zygomorphic, distinctly gamophyllous, posterior tepal with a discolourous blotch; stamens 6, three much longer than others, filaments not horned (at least those of longer stamens), hairy	*Eichhornia*

Monochoria Presl

Glabrous, palustrial, fresh-water herbs; rootstock suberect or creeping; each stem bearing at its top a single, acute, densely curvinervate leaf, the petiole of which forms a prolongation of the stem. Leaves long-petioled, radical, hastate, ovate or subreniform. Inflorescence racemiform or subumbelliform which is at first hidden within the broad sheath of the cauline leaf; it then bursts forth, next bends forward and finally after anthesis becomes quite deflexed. It arises at the base, opposite the sheath of the floral leaf, with a large bract. Flowers terminal, solitary, subsessile or shortly stalked, centrifugal; tepals 6, lilac blue with a green median nerve, free almost to the very base, spreading during anthesis, afterwards spirally contorted, 3 inner broader, median nerve of tepals thickened after anthesis; stamens 6, on the base of the perianth, subequal or unequal, 5 with smaller yellow anthers, the sixth with a longer filament, mostly provided with a lateral obliquely erect tooth or horn, its anther mostly larger, blue, all anthers basifixed, opening by a terminal pore-like slit; ovary 3-celled, ovules many in each cell; style filiform, stigma subentire or minutely 3-lobed. Fruit a membranous capsule, exploding loculicidally into 3 valves which are torn from the pedicel and flung away together with the many ovoid, longitudinally ribbed seeds.

KEY TO SPECIES

Rootstock creeping, branched; leaves triangular-ovate, usually with a sagittate or hastate or very rarely with a cordate base, 7–25 × 4–20 cm., basal lobes divergent, mostly with an acuminate or narrowed apex; racemes 15–60 flowered; flowers pale blue, succedaneous in groups; perianth 15–18 mm. long; plant 30–100 cm. high, generally robust	*M. hastata*

Rootstock suberect or oblique, usually very short; leaves varying from broadly ovate to ovate-oblong from an obtuse, rounded, truncate or a cordate base, but never sagittate or hastate; basal lobes, if present, broadly rounded; racemes 3–25 flowered; flowers dark blue, mostly simultaneously expanded or nearly so; perianth 11–15 mm. long; plant 5–50 cm. high *M. vaginalis*

Monochoria hastata (L.) Solms in DC. Mon. Phan. 4: 523, 1883; Backer in Fl. Males. I, 4: 258, f. 1, 1951. *Pontederia hastata* L. Sp. Pl. 288, 1753. *Monochoria hastaefolia* Presl, Rel. Haenk. 1: 128, 1827; FBI. 6: 362, 1892. (Fig. 46).

A robust aquatic herb with erect or obliquely erect stems bearing pale blue flowers. It occurs throughout India in fresh-water pools, margins of tanks, canals and sometimes in paddy fields. It usually flowers and fruits during and after the rainy season. The plants are used as a tonic and cooling agent. The juice of the leaves is used for curing boils (Chopra *et al.*, 1956). Except the roots, all other parts of the plant furnish a relished dish.

Very remarkable lateral endosperm haustoria are reported in this taxon by Banerji and Halder (1942). The early stages of endosperm development follow the Helobial type. The chalazal endosperm chamber remains small and has only about half a dozen nuclei or even less. But the micropylar chamber shows active nuclear divisions and soon gives rise to two tubular outgrowths (one on each side of the chalazal chamber) which grow downward and invade the tissues of the chalaza. Subsequently, the main body of the chamber also elongates and fuses with the two haustoria to form a continuous mass of endosperm cells with the chalazal chamber still recognisable at the base.

Monochoria vaginalis (Burm. f.) Presl ex Kunth, En. 4: 134, 1843; FBI. 6: 363, 1892; Hochreut. in Candollea 2: 324, 1925; Backer in Fl. Males. I, 4: 256, 598, 1951. *Pontederia vaginalis* Burm. f. Fl. Ind. 80, 1768. (Fig. 47).

It is common throughout India and South Andamans in tanks, shallow pools, flooded paddy fields and swampy or inundated localities. The erect or obliquely erect stems bear leaves of variable shape. The lilac blue flowers open simultaneously and all wither in the afternoon of the same day. The tiny, oblong brown seeds have *c.* 10 thin longitudinal ribs with fine transverse striae between them. It usually flowers and fruits during the rainy season. The juice of the leaves and the roots is used for medicinal purposes. The root is

chewed for toothache and the bark is eaten with sugar for asthma (Chopra *et al.*, 1956).

Eichhornia Kunth

Aquatic herbs, growth sympodial, floating or creeping, rooting at the nodes. Leaves rosulate or alternate, often long-petioled, broadly ovate-rhomboid or linear-lanceolate. Inflorescence terminal, peduncled, spiciform, many flowered, erect during anthesis, afterwards deflexed. Perianth zygomorphic or subactinomorphic, lilac blue, often with a yellow blotch, 6-fid, macrescent after anthesis; stamens inserted in the throat of the corolla or deeper, decurved, unequal, often 3 longer, 3 shorter, anthers subequal and inserted near the base; ovary sessile, 3-celled; cells many ovuled; style filiform, stigma slightly swollen or shortly 3–6 lobed. Fruit a membranous, ovoid-oblong or linear capsule; seeds ovoid, many ribbed.

Eichhornia crassipes (Mart.) Solms in DC. Mon. Phan. 4: 527, 1883; Fischer in Fl. Pres. Madras 3: 1069, 1957; Backer in Fl. Males. I, 4: 259, ff. 2–3, 1951. *Pontederia crassipes* Mart. Nov. Gen. Sp. 9, t. 4, 1823. (Fig. 48).

This plant, commonly known as water-hyacinth, is a native of Brazil. It has become a serious pest in Bengal and Assam and has gradually spread throughout India. It inhabits stagnant or slow-moving fresh-water such as broad rivers near their banks, lakes, canals, railway ditches, pools and tanks. Because of its luxuriant growth and extremely rapid multiplication, the plant becomes a very troublesome weed, covering entirely the surface of the water, crowding out all other plants, choking water courses and greatly hampering navigation and fishing.

It is a floating herb with a very short leafy main stem which in turn sends down a large bunch of long fibrous roots into the shallow water, sometimes penetrating the soil on reaching the bottom. These roots are pinkish violet due to the presence of anthocyanin. The leaves are radical, rosulate, emerged. The spongy petioles are inflated near the middle portion into bladder-like structures which show internally large air-chambers which aid the plant to float. The inflorescences, which are 15–30 cm. in length, are enclosed by irregular mucilaginous sheaths. The spike bears 8–35, beautiful lilac or pale violet, funnel-shaped, trimorphic, heterostyled flowers. The perianth tube is 1.5–1.75 cm. long with a green base and a pale top which is slightly curved at apex; the tepals are ovate to oblong or obovate, lilac; the posterior tepal has a bright yellow, blue-bordered, median

blotch, 3–3.5 cm. long. The stamens are curved and the filaments are glandular hairy. When the flowers wither, the spike bends into water. The capsule gets detached from the spike, bursts and the seeds sink to the bottom of the tank where they lie buried in the mud. When the tank gets shallow in summer, the wading birds disperse the seeds from tank to tank.

Studies on the mode of pollination and seed formation in water-hyacinth have been made by Agharkar and Banerji (1930). According to them, the flowers open as a rule in the morning, soon after sunrise; on cloudy and humid days, however, they open later. The stigma stands high above the stamens in the bud stage. After the opening of the flowers, the stigma occupies a position lower than the three upper anthers. The three lower anthers are situated at the mouth of the corolla tube. The flowers are mesostylous. The dry pollen grains which are ellipsoid imbibe water very rapidly and become ovoid. From the structure of the flower and the relative positions of the stamens and stigma the flower appears to be entomophilous. Under natural conditions only about 35 per cent of the flowers are pollinated. Bagging experiments have shown that self-pollination also occurs in this plant to a considerable extent. Germination of the pollen grain on the stigma takes place within an hour after pollination. The style is traversed by three longitudinal canals. The pollen tube traverses the style through these canals. The axis of the inflorescence bends downward considerably after flowering and brings the flowers under water whenever a free water surface is available. Seed formation takes place only in inflorescences which are submerged in water. Among external factors, humidity and temperature appear to have a great influence on seed production.

The seedlings germinate during the rainy season from June to July and if the conditions are suitable, develop into full-fledged plants; later, within a period of three to four months they bear flowers in September or October. Prolific vegetative growth is mainly responsible for its rapid propagation.

Observations on the germination of seeds of the water-hyacinth in Orissa have been made by Parija (1934). According to him, the embryo is fully formed at the time when the seeds are shed from the bursting capsule into the water. The seeds are minute with an oval base and tapering apex. The hard seed coat is thrown out into longitudinal ridges, 12 to 15 in number. The seeds remain dormant at least for one season, i.e. from November to June and retain their viability for several years. The dormancy is caused by the hard seed coat which offers mechanical resistance and prevents the entry of oxygen into the seed. When the seed coat gets loosened, either by

alternate wilting or by chemical action, germination is facilitated by the entry of oxygen. The embryo is surrounded by a copious endosperm. During germination the cotyledon emerges first through the micropyle as a knob-like protruberance. At its apex there is a slightly raised circular ring having dots on its surface. The projected apex is the radicle which later on grows as the root and the dots on the ring are the papillose unicellular root hairs. The root hairs appear to prevent the washing away of the seedlings and also protect the delicate radicle from being broken. Further, they anchor the cotyledon to soil and when it is properly fixed, the radicle tip grows by penetrating into the soil and thus establishes the plant. Perhaps, they also serve as temporary absorbing organs for the plant in the initial stages until the radicle becomes active.

The cotyledon grows out first and if even after the limit of its length is reached and the radicle is not in a suitable soil to grow, the hypocotyl becomes intercalated carrying the radicle to a suitable depth, when its growth begins. During this time the cotyledon is green and probably supplements the plastic material in the seed. However, a hypocotyl is lacking in seedlings growing in very damp mud, as in such cases the radicle, because of favourable surroundings, becomes active. The first leaf grows out when the radicle has become fixed in the soil. Once the seedling is established, linear leaves come out in succession and form a rosette. There is no distinction between leaf blade and petiole at this stage. In the leaves of the mature plant the petioles become swollen.

The plants are used as a manure and for fattening pigs.

Various methods have been attempted for eradicating this noxious weed. Some workers have recommended the removal of seedlings from tanks, a suggestion of little practical value as the seedlings of water-hyacinth cannot be easily distinguished from its associates. Others like Biswas and Calder (1955), therefore, suggested that the plants should be bodily removed, dried and burnt. The plants should be lifted up with their rootstocks during March to May and must be burnt to ashes during the last week of May or early in June before the advent of the rains. Another suggestion was to effect a change in the edaphic factors of the plant's environment and poison the plants with suitable chemicals. Recent investigations on this problem have indicated that of the chemicals 2, 4-dichlorophenoxyacetic acid is the most effective for killing and sinking the water-hyacinth. In U.S.A., as a result of large scale spraying of this chemical, the spread of the plant has been successfully checked and similar measure should prove effective in other countries also.

TYPHACEAE

Aquatic or marsh herbs with perennial, creeping rhizome covered with distichous leaves. Leaves mostly radical, linear, erect or floating, sheathing below. Flowers monoecious, minute, in terminal superposed dense cylindric spikes, the upper male and the lower female flowers, often intermixed with slender clavate bracts, sterile female flowers or simple or branched hairs; perianth absent; stamens 2–7, usually 3, rarely 1, filaments usually connate, tip of connective thickened, sometimes produced, anthers 4-celled, erect, basifixed; ovary borne on a slender, usually densely hairy gynophore or in the axil of a membranous spathulate bract, 1-celled, fusiform, narrowed into a slender persistent style; stigma filiform or clavate; ovule solitary, pendulous from near the apex. Sterile female flowers on a long axis with a clavate pistillode. Fruit minute, membranous or drupaceous, fusiform, detached with the gynophore, dehiscing by an apical lid; seed often adnate to the wall; endosperm fleshy or floury; embryo axile, cylindric.

Typha L.

Perennial, palustrial or aquatic herbs with a creeping rhizome; stems erect, solid, submerged at the base. Leaves biseriate, partly radical or subradical, elongate-linear, rather thick and spongy, blunt-margined, their sheathing bases secreting slime on their inner side. Flowers numerous, very closely packed in 2 or less often 3, superposed, contiguous or more or less remote, terete, unisexual spikes; upper spike male; the 1–2 lower female; all spikes at the base with a foliaceous bract which is caducous long before anthesis. Male flowers with 3 flat hairs together surrounding 2–5 stamens; anthers basifixed, linear, 2-celled, connective shortly produced, cells back to back, bursting longitudinally; pollen grains free or cohering in tetrads; rachis of female spathe closely studded with thick cylindrical excrescences and between these and their basal parts, it is beset with flowers containing a fertile ovary; higher part of the excrescences bearing rudimentary ovaries; female flowers with or without a very narrow bracteole; bracteole with a more or less broadened, often dentate-acuminate apex either entirely hidden by the flowers or their apices visible externally; ovary borne on a very thin gynophore which bears long hairs on its base, fusiform, 1-celled; style distinct, thin, stigma broadened, unilateral, linear or spathulate. Fruit small, fusiform or elongate-ovoid, falling off together with its stalk from the pilose axis of the spike, finally bursting by a longitudinal slit; seed

pendulous, striate; endosperm starchy; embryo narrow, straight, nearly as long as the seed.

Typha angustata Bory & Chaub. Exp. Sc. Mores. II, 1: 338, 1832; FBI. 6: 489, 1893; Graebner in Pflanzenr. 2: 14, f. 4F, 1900.

A robust plant growing up to 4 m. high and is common throughout India in ponds, lakes, slow running rivers and streams and marshy regions from sea level to 700 m. The leaves attain a length of nearly 3 m. and are 0.5–2.5 cm. wide. They are semi-terete above the sheath. The male and female spikes are separated by a considerable interval which is up to 30 cm. long, 0.6–2.3 cm. in diameter, and is brown in colour. The male flowers are slender and paler than the female ones which are mixed with clavate sterile pistillodes. It appears to flower throughout the year. The leaves are used for thatching purposes and for preparing mats and screens. According to Cooke (1958), a curious yellow cake called *Bur* is prepared out of the flowers and is eaten by all classes of people living in Sind. The rootstock is used as an astringent and diuretic (Chopra *et al.*, 1956).

ARACEAE

Tuberous or rhizomatous, sometimes climbing by aerial roots, or aquatic (rarely floating) herbs or shrubs with watery, milky or acrid sap. Leaves in herbaceous species solitary, clustered or radical, in shrubby and arboreal species alternate, often fleshy or coriaceous, simple, entire or lobed or variously compound, petioles sheathing. Inflorescence a spadix subtended by a herbaceous spathe (sometimes absent). Flowers hermaphrodite, monoecious or dioecious, sessile or shortly pedicelled; neutral flowers often present; perianth absent, when present, of 2–6 parts; stamens 1–6, free or united into a synandrium, usually opening by a terminal pore; ovary superior, syncarpous, entire, rarely lobed, 1–3 celled, rarely more celled; ovules 1–many in each cell, style absent, when present short or long. Fruit usually a berry; seeds 1–many, embedded in mucilaginous pulp; endosperm present or absent; embryo large.

KEY TO GENERA

Floating herb; leaves in a close spiral, cuneate . . *Pistia*
Attached herbs; leaves radical, grass-like . . . *Cryptocoryne*

Pistia L.

Floating, aquatic, gregarious, stoloniferous herb with a short stem bearing a rosette of leaves and numerous branching, adventitious

roots; vegetative propagation by offsets. Leaves sessile in a close spiral, together forming a cup, leaf blade simple, ovate to obovate-cuneate, densely pubescent, 3–15 cm. long, each surrounded at its base by a membranous sheath. Spathe 2–4 cm. long, shortly peduncled, tubular at its base, but free and spreading above into an ovate, concave limb, slightly constricted above the middle; spadix fused to the median line of the spathe, free at its distal end. Flowers unisexual, without a perianth; the carpellate flower is solitary on the lower part of the spadix and the staminate whorled above; stamens 2–8, connate, appearing to terminate the spadix; staminate flowers subtended by a membranous collar surrounding the free portion of the spadix, this in turn subtended by a short-stalked, cordate, membranous flap; gynoecium unicarpellate with a 1-locular ovary containing numerous anatropous ovules on a marginal placenta; the carpel is obliquely adnate to the spadix, the apex free and forming a conical style, stigma discoid. Fruit green, ovoid to ellipsoid, crowned by the persistent style; seeds few to many, oblong or obovoid; testa thick and rugose; endosperm abundant, floury; embryo minute, cuneiform.

Pistia stratiotes L. Sp. Pl. 963, 1753; FBI. 6: 497, 1893; Engl. in Pflanzenr. 73: 259, ff. 63–64, 1920; Wilson in J. Arnold Arb. 41: 62, f. 5, 1960. (Fig. 49).

It is found floating in ponds, tanks and old wells and occurs throughout India up to a height of about 1,000 m. It flowers in the hot season and the flowering period extends up to the rainy months; fruits appearing after the rains. According to Chopra *et al.* (1956), the plants are used to destroy bugs and the roots as a laxative and diuretic. The leaves are made into poultice and applied to haemorrhoids. The juice of the leaves is boiled in coconut oil and the preparation used externally in chronic skin diseases. The leaves are mixed with rosewater and sugar and given for asthma and cough and with rice and coconut milk for dysentery. The ashes are applied to the ringworm of the scalp.

Pistia is of considerable biological importance not only because of its weedy nature, which frequently results in the clogging of waterways, but also because it may represent the evolutionary line through which the Lemnaceae developed. The development of the embryo sac follows the Polygonum type.

Cryptocoryne Fisch.

Aquatic or riverain herbs with a creeping rootstock; stem short or absent. Leaves grass-like, radical, spathe often partly

subterranean or submerged, margins connate into a tube below with a transverse septum forming an almost closed chamber for the spadix and then expanding into a usually narrow, often contorted limb. Spadix very slender, adnate at the tip to the septum of the spathe; male and female flowers separated by a bare region of the spadix; perianth absent; male flowers numerous forming a cylinder; stamens 1–2, anthers sessile, cells 2, conical, with perforate tips; pollen vermiform; ovaries in a single whorl of 4–7 at the base of the spadix, connate, 1-celled, mixed with a few neuters; styles short, recurved; ovules many, erect, orthotropous. Fruit a fleshy berry, consisting of connate 2-valved carpels; seeds many, oblong; testa rugose; albumen copious; embryo axile.

Cryptocoryne retrospiralis Fisch. ex Wydler in Linnaea 5: 428, 1830; FBI. 6: 493, 1893; Engl. in Pflanzenr. 73: 246, f. 62, 1920. (Fig. 50).

An aquatic herb with somewhat fleshy fibrous roots. The spathe is nearly as long as the leaves, dull-green outside, streaked with dark purple within; the glabrous limb of the spathe is closely twisted. It occurs in Uttar Pradesh, Bihar, West Bengal, Assam, Madhya Pradesh, Maharashtra and South India and is usually found as a submerged herb along the beds or banks of rivers. It flowers in hot weather and fruits later.

LEMNACEAE

Small or minute, gregarious aquatic plants, floating on or below the surface of water, consisting of a highly reduced, fleshy or membranous plant body (frond), lacking distinct stems and leaves, and either rootless or with one or many capillary roots. Reproduction is primarily vegetative and a single plant may multiply by budding to several millions in one season. Propagation also takes place by hibernating bulbils. Plants monoecious, the minute flowers naked or enclosed in a membranous spathe within marginal reproductive pouches or in pouches on the upper surface of the frond. Perianth absent; staminate flower consisting of a single stamen borne singly or in pairs; anthers 2-locular; carpellate flowers solitary, consisting of a single carpel; ovary sessile, 1-celled with one or two basal ovules; style short, stigma truncate or funnel-shaped. Fruit a flask-shaped, 1-7 seeded utricle; testa coriaceous; albumen fleshy or absent; embryo cylindric, axile.

KEY TO GENERA

Fronds flat above with 2 marginal reproductive pouches; segments with 1–many roots; inflorescence of 2 staminate and 1 carpellate flower surrounded by a membranous spathe.
  Fronds with 2 or more roots; conspicuously 5–18 nerved . . . . . *Spirodela*
  Fronds bearing a single root; obscurely 1-3 nerved . *Lemna*
Plants minute, subglobose with a single marginal reproductive pouch; segments rootless; inflorescence of 1 staminate and 1 carpellate flower without a spathe and borne on the upper surface . . . . . *Wolffia*

Spirodela Schleid.

Plants solitary or in groups of 2–5. Frond round or obovate, thick, purple beneath and green above, with 5–18 palmately arranged nerves radiating from the node (centrum). Roots 2–16 to each frond. Each frond with 2 marginal reproductive pouches at the basal region. Inflorescence of 1 carpellate and 2 (rarely 3) staminate flowers, enclosed within a membranous spathe; stamens 2-locular, dehiscing longitudinally; gynoecium with a unilocular ovary and 1 campylotropous or 2 anatropous ovules. Utricle with winged margins.

Spirodela polyrhiza (L.) Schleid. in Linnaea 13: 392, 1839; Hegelmaier in Bot. Jb. 21: 284, 1895; Wilson in J. Arnold Arb. 41: 66, 1960. *Lemna polyrhiza* L. Sp. Pl. 970, 1753; FBI. 6: 557, 1893.

It is abundant throughout India in still waters, ascending up to a height of 1,800 m. It flowers and fruits between February and April.

Spirodela, the least reduced of the Lemnaceae, has been compared to *Pistia* of Araceae. In a morphological study of *Spirodela polyrhiza,* Jacobs (1947) interpreted the lower flap of the reproductive pouch as "bracts which were derived by phylogenetic reduction from leaves." The plant was considered to be a "greatly reduced type of rosette in which the vertical axis has been reduced to three highly compacted nodes." Brooks (1940) has pointed that the flowers of the plant are always produced in the larger, usually left-hand reproductive pouch, while the smaller, right-hand reproductive pouch produces only vegetative buds. This led him to interpret the right-hand pouch as being formed by the prophyllum and the basal part of the foliage leaf and the left-hand flowering pouch by the bract and foliage leaf. Occasionally this arrangement is reserved.

Spirodela, in addition to possessing numerous roots, differs from the other genera of the Lemnaceae by the presence of vascular tissue in the roots, the formation of two ovules in the ovary (though *Lemna gibba* L. is described as having as many as 7 ovules) and by the Polygonum type of embryo sac.

Lemna L.

Fronds solitary or in groups of 2–5, each frond with 1–3 nerves and a single capillary root without vascular tissue. Marginal reproductive pouches 2, of unequal size, at the basal region of each frond the flowers, when produced, always appear in the smaller pouch, the vegetative buds in both. Inflorescence of 1 carpellate and 2 staminate flowers surrounded by a membranous spathe; stamen solitary, filament filiform, anther 2-celled, globose, dehiscing transversely; gynoecium with 1-loculed ovary and 1 campylotropous ovule. A vascular bundle runs from the frond to the base of the flower and there diverges into three traces, one to the pistil and one to each stamen. Utricle ovoid and smooth.

Lemna paucicostata Hegelm.* Lemnac. 138, t. 8, 1868; FBI. 6: 556, 1893.

It is a very small, scale-like floating aquatic plant. The fronds are asymmetric, nearly flat on both surfaces and are 2–7 mm. long. The single root has an appendaged root-sheath and an acute root cap. It is common in tanks, ponds, old wells and other still waters and occurs in various parts of India and Nicobar Islands. It flowers and fruits between May and January.

According to S. C. Maheshwari (1956), the seeds of *Lemna paucicostata* float in water and the operculum is pushed off by the suspensor, although still remaining attached to it. The cotyledonary sheath on the other side undergoes considerable growth and expansion and as a result a pouch-like chamber is formed. The suspensor forms the floor of this chamber, while the newly grown cotyledonary sheath forms the roof. In between these two structures emerges the first frond together with the rudiments of its daughter frond attached at the base. The fronds bend horizontally and soon outgrow the suspensor. In the early stages the growing frond obtains its nutrition partly from the chlorophyllous cotyledonary sheath and partly from the endosperm. The major part of the embryo remains inside the seed and acts as a mediator through which food materials are

* Some authors consider this species to be a synonym of *L. perpusilla* Torrey, Fl. N. York 1: 245, 1843.

transported from the endosperm to the frond. Later, the frond becomes separated and establishes its independent existence. It shows a marginal meristem, characteristic of laminar growth, and there is no apical or terminal growth. Another point worthy of mention is that there is no radicle or root during the intraseminal growth of the embryo.

Wolffia Horkel ex Schleid.

Fronds very minute, solitary or in pairs, globose or ellipsoid, without roots or veins. It has a single, funnel-shaped, basal vegetative pouch from which arise the young fronds which soon become detached. Flowers in a groove on the upper surface of the frond, naked; spathe absent; male flower consists of a single stamen with a 2-loculed anther; female flower represented by a single carpel containing a solitary orthotropous ovule; style short, stigma depressed. Utricle spherical and smooth.

Wolffia arrhiza (L.) Wimm. Fl. Schles. 140, 1857; FBI. 6: 557, 1893. *Lemna arrhiza* L. Mant. 2: 294, 1767.

These are the smallest and simplest (by reduction) of the flowering plants, resembling small dots or grains floating on still water in the form of thick, green, granular mass. It occurs throughout India and flowers and fruits between June and October.

Recent studies on the flower and embryo development (S. C. Maheshwari, 1954) indicate that the anther is 2- rather than 1-loculed as has been previously reported.

In *Wolffia* the carpel matures before the stamen and pollination probably is affected through the agency of wind or rain. The pollen grains germinate on the stigma and the pollen tube grows along the wall of the hollow stylar canal. A characteristic feature is the formation of an operculum (S. C. Maheshwari, l.c.) which appears like a stopper at the micropylar end of the seed. It originates from the apical cells of the inner integument, which show conspicuous enlargement even before fertilization. During the development of the embryo, cells of both the layers elongate, divide anticlinally and become lignified. The outer integument fits close to the operculum and from outside, gives the seed a more or less streamlined appearance. In the mature seed, except at the apex, the nucellus degenerates even before megasporogenesis. The persisting cells form a nucellar cap which is completely covered by the operculum. The disorganized remains of the nucellar cap may be seen even in the mature seed.

The frond of the Lemnaceae has been interpreted as a stem

functioning as a leaf, as a modified leaf and as a structure partly foliar and partly axial. Arber (1919) compared the structure of *Pistia* with *Spirodela* and considered the lemnaceous frond to be axial at the base and foliar at the distal region. She interpreted the distal part of the frond as a "petiolar phyllode" and considered the pockets of *Spirodela* on the lower side as being formed by "wings of the leaf-sheath, terminating into two minute ligular flaps" and on the upper side by the axis. Goebel's (1921) interpretation of the frond is based on the idea that the main shoot never develops in the seedling—the distal portion represents a cotyledon, the proximal, a hypocotyl; the side members (daughter fronds) continue to repeat this pattern. Here the "tendency to asymmetry" is stressed as an important characteristic of the family. Brooks (1940) who expressed a somewhat different view interpreted the plant body of *Spirodela* as a single sympodial branch bearing a prophyllum, a leaf and a bract and terminating in an inflorescence, all somewhat reduced and fused to each other. Lawalrée (1943) considers the complexity of Lemneae as derived from the simple, embryo-like Wolffieae. The resemblance of the young embryo of *Lemna minor* to an adult *Wolffia* frond (Lawalrée, 1952) is advanced as an evidence in support of this; but most workers derive the Wolffieae by further reduction from the Lemnaceae pattern. Recently, Hillman (1961) has stated "that any hypothesis reading the Lemnaceae as a series advancing with increased complexity has to explain away the increasing vascularization in the direction Wolffieae to Lemneae, a trend of no evident selective value given the environment and size of the plants".

The anatomy of the frond and root (Hegelmaier, 1868; Lawalrée, 1943; see also Hillman, 1961) is interesting. The frond in Lemneae is mainly composed of chlorenchymatous cells, often separated by large intercellular spaces filled with air or other gases which provide buoyancy. Certain cells in *Lemna* and *Spirodela* are filled with needle-like raphides. The upper epidermis differs considerably from the lower, being highly cutinized and unwettable. *Spirodela* and some species of *Lemna* have large amounts of anthocyanin pigments in the cells of the frond. Both these genera have greatly reduced vascular bundles. These typically have one xylem element above and one sieve element, with two companion cells, below. The xylem elements are elongated cells with spiral or ring thickenings; they usually occur in a single file and are surrounded by other elongated but parenchymatous cells. A large bundle runs from the node towards the proximal end of the frond. In *Spirodela polyrhiza* the proximal end of the bundle is clearly free from the end of the frond for a short distance, so that bundle and frond together form an

asymmetrically peltate structure. At the node, several bundles diverge into the distal portion of the frond, forming the veins or "nerves". No such system is present in the Wolffieae, except occasionally as very small traces in the filament.

In both *Spirodela* and *Lemna* the slender adventitious roots arise at the node just beneath the lower epidermis. Often the epidermis forms a short sheath about the upper few millimeters of root or roots and a prominent root-cap is usually developed. In transverse section the roots show a reduced vascular strand, as in a frond nerve, surrounded by a ring of elongated cells. These are in turn surrounded by larger, more isodiametric vertical cells which include symmetrically arranged air-spaces, which in turn are surrounded by an epidermis. Many root cells contain chloroplasts and these are apparently active photosynthetically. Root-hairs are absent. Since the entire lower surface of Lemnaeae fronds can absorb nutrients from the medium and the plants can grow well under conditions which entirely prevent root elongation, the functional importance of the roots is difficult to evaluate. It has been suggested (Arber, 1920) that they serve chiefly as anchors to keep the fronds right side up, and to form the tangled masses which are of some significance in dispersal and protection from water motion. Thus, though the morphology and vegetative reproduction are peculiar, their anatomy, particularly the prominent air spaces and reduced vascular structures, resembles that of many aquatic angiosperms.

The flowers of *Spirodela* and *Lemna* are enclosed in a membranous spathe within the reproductive pouch. This spathe is absent in *Wolffia*. The flowers of a single plant mature at different times; when two staminate flowers and a carpellate flower are produced by the plant the sequence of their maturation is basipetal, the distal stamen matures first, then the carpel and finally the second stamen. This difference in the time of the maturation of the flowers doubtless promotes cross pollination. Further, the flask-shaped pistil has a stylar canal which opens at the stigma; a large pollination drop is exuded at maturity. Both pistil and stamens turn up above the water surface as they grow out of the reproductive pocket. Apparently, pollination may result from direct contact of the flowers since the plants float; it may also take place by the agency of insects and other small aquatic animals which are associated with these plants. The pollen grains are spherical, monocolpate and generally have spiny projections on the exine. These grains show some characters in common with certain types of the Araceae, while they are less similar to those of Najadaceae.

The family Lemnaceae is considered by most botanists (Engler,

1877; Arber, 1919; Hegelmaier, 1896; Hutchinson, 1959; Pulle, 1938; Rendle, 1953; Wettstein, 1935) to be allied to the family Araceae and it is thought that the Lemnaceae have arisen as a result of regressive evolution in the following sequence (see Lawrence, 1951): Araceae (*Pistia*)—*Spirodela*—*Lemna*—*Wolffia*. According to Lawalrée (1945), the family does not show a close affinity with the Araceae, but has been derived from the Helobiales.

The investigations of Gupta (1935) and the recent detailed studies on the embryology of Lemnaceae (S. C. Maheshwari, 1954, 1956, 1958) and Araceae (S. C. Maheshwari & Khanna, 1956) show that the Lemnaceae and Araceae resemble each other in the following features: successive divisions of the microspore mother cells; presence of a true periplasmodium; three-celled pollen grains (although in several aroids, mature pollen grains are two-celled); periclinal divisions in the nucellar epidermis; formation of a "nucellar cap"; cellular endosperm; occurrence of endosperm caecum at the chalazal end; development of an operculum. The only major feature where the two families differ concerns the development of the embryo sac. In the Lemnaceae the embryo sac is usually bisporic (Gupta, 1935; Lawalrée, 1952; S. C. Maheshwari, 1954), while in the Araceae the development is generally monosporic. However, even in the Lemnaceae, *Spirodela* has a monosporic eight-nucleate embryo sac (S. C. Maheshwari, 1958). In the Araceae also it may be recalled that in certain cases (*Homalonema alba* and *H. rubra*, Jüssen, 1928) bisporic embryo sacs have been reported. Further, the recent studies of S. C. Maheshwari (1958) have also shown that apart from the similarities between the Araceae and the Lemnaceae in both megasporogenesis and endosperm development, the genus *Spirodela* constitutes a connecting link between the aroids and duck-weeds.

The embryo sac in the Lemnaceae is bisporic, endosperm is cellular with a short chalazal haustorium and the early divisions in embryogeny are irregular. None of these features are shared by the Helobiales. In all the families of this order, except the Alismataceae and the Butomaceae, the embryo sac is monosporic. Even in Butomaceae, *Butomus umbellatus* has a monosporic embryo sac (Holmgren, 1913; Roper, 1952). The endosperm in the Helobiales is Helobial or Nuclear. The first division of the zygote results in the formation of a terminal cell and a basal cell of which the latter remains undivided and becomes hypertrophied. On the other hand, in both Lemnaceae and Araceae the endosperm is cellular with a short chalazal endosperm caecum and the mode of embryo development is also similar.

The recent embryological studies by S. C. Maheshwari (l.c.)

clearly indicate a close alliance between these two families and thus offer strong support to the assignment of the Lemnaceae to Spathiflorae along with the Araceae as first suggested by Engler (l.c.).

ALISMATACEAE

Annual or perennial aquatics and marsh plants, usually erect, sometimes floating, often with milky juice. Leaves basal and erect, sometimes floating, rarely all submerged, few reduced to phyllodes, lanceolate to sagittate, rarely broad-elliptic to ovate, entire, with a hydathode at the apex, curvinerved, nerves more or less parallel and gradually joining the marginal nerve, connected by ascending cross-veins; petiole sheathing, with air-chambers, often septate. Inflorescence mostly erect, racemose or paniculate; peduncle sometimes hollow, mostly with air-channels; bracts 3 (or 2) per whorl of flowers or branches. Flowers actinomorphic, bisexual or unisexual; sepals 3, imbricate, green, parallel-nerved, convex, persistent; petals 3, imbricate, white or faintly coloured, marcescent; stamens 3–many, free, in a whorl, filaments filiform or dilated, anthers latrorsely dehiscent; carpels superior, 3–6 or more, free, sessile or stipitate, on a flat or a raised receptacle; stylodium ventrally or terminally inserted on each carpel, persistent, stigma simple; ovule 1–many in each carpel, basal, campylotropous, rarely anatropous, micropyle extrorse. Fruit an achene, the achenes arranged in a head, free, rarely connate at the base; seeds small, oblong or horse-shoe shaped; testa membranous; embryo conduplicate; endosperm absent.

KEY TO GENERA

Carpels crowded on a minute receptacle; achenes swollen, round in cross-section.	
Leaves ovate to elliptic; flowers bisexual; achenes without air-chambers	*Caldesia*
Leaves broadly sagittate; flowers male and bisexual; achenes with 2 lateral air-chambers . .	*Limnophyton*
Carpels inserted on a large, globular or oblong receptacle; achenes more or less compressed . .	*Sagittaria*

Caldesia Parl.

Scapigerous aquatic herbs. Leaves broad-elliptic to broad-ovate, apex blunt, base cordate. Panicle pyramidal; branches and pedicels on the branches in whorls of 3, each branch and pedicel in the axil of an oblong-lanceolate bract. Flowers bisexual; sepals persistent; petals white; stamens 6 or more, filaments filiform; carpels few to

many on a minute receptacle, crowded, not in a whorl; stylodium ventrally inserted, slender. Achenes swollen, without lateral air-chambers; endocarp formed by large, radially arranged, sclerenchymatous cells; exocarp spongy or membranous; seed oblong; embryo horse-shoe shaped.

KEY TO SPECIES

Leaves not pellucid-punctate, veins connecting the nerves parallel and ascending at an angle; bracts scarious; sepals erect after anthesis; achenes elliptic, with 3–5 longitudinal smooth ribs on the dorsal side	*C. parnassifolia*
Leaves pellucid-punctate, veins connecting the nerves parallel and perpendicular to the nerves; bracts herbaceous; sepals reflexed and revolute after anthesis; achenes reniform, dorsally provided with 4 more or less warty or spiny ribs .	*C. oligococca*

Caldesia parnassifolia (Bassi ex L.) Parl. Fl. Ital. 3: 599, 1858; Hartog in Fl. Males. I, 5: 319, 1957. *Alisma parnassifolium* Bassi ex L. Syst. Nat. 3: 230, 1768. *A. reniforme* D. Don, Prodr. Fl. Nep. 22, 1825; FBI. 6: 560, 1893. (Fig. 51).

A glabrous aquatic herb with broad ovate to elliptic or suborbicular leaves floating on water. The flowers are white. It occurs in shallow water, in small ponds and tanks throughout the plains of India, sometimes ascending up to 1,500 m. in the hills. It flowers and fruits between May and September.

Caldesia oligococca (F. v. M.) Buchen. in Bot. Jb. 2: 479, 1882; Hartog, 320. *Alisma oligococcum* F. v. M. Fragm. 1: 23, 1858; FBI. 6: 560, 1893.

A scapigerous herb common in pools of Punjab, Uttar Pradesh, West Bengal and Kerala. The leaves are ovate with a deeply cordate base and pellucid-dotted. The flowers are white. The achenes are laterally compressed, kidney-shaped and have 4 longitudinal ribs on the dorsal side, densely set with blunt spiny warts which are interconnected by scarious membranes. The seeds are reddish brown. It flowers and fruits between June and October.

Limnophyton Miq.

Erect, succulent, aquatic herbs with milky juice. Basal leaves sagittate. Panicle pyramidal with branches and flowers in 3-bracteate whorls: lower whorls with bisexual flowers, upper ones male; sepals

Pl. III



LIMNOPHYTON OBTUSIFOLIUM—UMRED TANK, NAGPUR

reflexed after anthesis; petals white; filaments broadened towards the base; carpels 15 to many, crowded on a small receptacle. Achenes swollen, on a globose head; exocarp spongy, endocarp hardly sclerenchymatous; seed horse-shoe shaped.

Limnophyton obtusifolium (L.) Miq. Fl. Ind. Bat. 3: 242, 1855; FBI. 6: 560, 1893; Hartog, 324, f. 4. *Sagittaria obtusifolia* L. Sp. Pl. 993, 1753. (Pl. III; Fig. 52).

A robust aquatic herb with pellucid-punctate, broadly sagittate leaves. The flowers are white. The achenes are obovate, with a cuneate base 4–8 mm. long; they show a fine reticulation of scarious ribs and are short-beaked. Seeds 4 mm. long. It is common in fresh-water pools and tanks throughout India and flowers and fruits from April to August.

Sagittaria L.

Erect aquatic herbs. Emerged leaves sagittate or lanceolate, floating ones mostly cordate, submerged phyllodes linear. Inflorescence mostly a raceme, with 1–14 mostly 3-flowered whorls, each subtended by a whorl of 3, more or less connate bracts, sometimes a panicle. Flowers mostly unisexual, upper ones male, lower ones female or hermaphrodite; pedicels erect or ascending, those of female flowers often thickened and reflexed after anthesis; sepals reflexed in male flowers, in female flowers appressed, patent or reflexed; petals delicate, white or rarely pink, sometimes with a purple spot at the base; stamens 6 to many, filaments filiform, subulate or dilated; staminodes often present in female flowers; carpels many, laterally flattened, spirally arranged in a head on a large, globular receptacle; stylodium terminal, erect or obliquely directed inward, stigma papillose; ovule solitary, basal. Fruit a globose or oblong head of crowded, laterally compressed, beaked, winged, mostly membranous achenes: seeds erect, horse-shoe shaped; testa thin.

KEY TO SPECIES

Mature leaves hastate or sagittate, blade 5–21.5 cm. long, apex acute or acuminate, basal lobes usually diverging, narrower and often longer than the rest of the blade, tapering to a fine point; lower female flowers nearly sessile, with staminodes; upper male flowers with longer pedicels and about 24 stamens; hermaphrodite flowers rare; achenes obliquely ovate, apiculate, wing broad, entire or subcrenate . . . . . *S. sagittifolia*

Mature leaves broadly ovate, deeply cordate, apex rounded, 2.5–11.5 cm. long, 2.5–10 cm. wide, basal lobes rounded; petioles, scapes and pedicels often hairy; lower hermaphrodite flowers with 9–12 stamens, upper more numerous; male flowers with 6–12 stamens; achenes surrounded by a broad, blunt-spiny wing . . . . . *S. guayanensis* ssp. *lappula*

Sagittaria sagittifolia L. Sp. Pl. 2: 993, 1753; FBI. 6: 561, 1893.

A common, scapigerous, aquatic herb occurring throughout India in tanks and ponds. It flowers from February to May and fruits later. The basal lobes of the sagittate leaves end in a very acute, needle-like tip. The petals are white with a distinct basal purple claw. The sepals are appressed or spreading after anthesis. The achenes are flat and dorsally winged.

Sagittaria guayanensis H.B.K. ssp. **lappula** (D. Don) Bogin in Mem. N.Y. bot. Gdn 9: 192, f. 5, 1955; Hartog, 328, f. 6. *S. lappula* D. Don, Prodr. Fl. Nep. 22, 1825. *S. guayanensis* Hook. f. FBI. 6: 561, 1893, *pro parte,* non H.B.K.

A scapigerous herb occurring commonly in fresh-water tanks and pools throughout the plains of India. It flowers and fruits from August to November. The floating leaves are broadly ovate with a deeply cordate, obtuse base. The flowers are white. The flat achenes are surrounded by a broad, toothed wing.

The detailed embryological studies on the Alismataceae (Johri, 1935a, b, c; 1936a; Narasimha Murthy, 1933) and Butomaceae (Holmgren, 1913; Johri, 1936b; 1938a, b) show that there is a close affinity (Johri, 1936b; Maheshwari and Singh, 1943) between these two families. They resemble each other in the character of their pollen, in their more or less free carpels, in the absence of a wall cell in the ovule, in the presence of bisporic, six or five-nucleate embryo sac and in the horse-shoe shaped embryo. The chief difference between the Alismataceae and Butomaceae is in the arrangement of ovules. In the Alismataceae they are few in number and are borne on a marginal placenta, while in the Butomaceae their number is indefinite and they are borne superficially on the inner walls of the ovary.

BUTOMACEAE

Erect, glabrous, rhizomatous, terrestrial, aquatic-swamp herbs, laticiferous (except *Butomus*). Leaves radical, sheathing, elliptic, curvinerved, leaf-blades above water. Flowers umbellate (or

sometimes solitary), actinomorphic, hermaphrodite; sepals 3, imbricate, usually thin, fugacious; stamens 8–9 or many, rarely less, sometimes the outer ones staminodal, filaments flattened, free, anthers basifixed, 1-celled, opening lengthwise latrorsely; ovary apocarpous, superior; carpels 6–many, rarely less by reduction, whorled, sessile on a flat receptacle, free or cohering only at the base, dehiscing with an adaxial slit; ovules many, anatropous, scattered on reticulately branched placentae. Fruit of 6–7, membranous, many seeded follicles, at last dehiscing along the ventral side; seeds numerous, minute, smooth; embryo flat, horse-shoe shaped (elliptic-terete and straight in *Butomus*); endosperm absent.

Tenagocharis Hochst.

Erect annual herbs, 8–60 cm. tall, with milky juice. Leaves petioled, elliptic. Flowers in long-peduncled, 2–16-flowered, terminal or superposed, umbelliform inflorescences exceeding the leaves, hermaphrodite, pedicels triangular, bracts whorled; sepals herbaceous, persistent; petals membranous, deciduous; stamens 8–12, filaments filiform; carpels 6–9 (or less by reduction), whorled, sessile on a flat receptacle; stylodia short; ovules many, anatropous. Fruit of 6–7 erect, membranous follicles, with their tips exerted from the calyx; seeds numerous, broad-oblong, compressed, smooth; embryo conduplicate, horse-shoe shaped.

Tenagocharis latifolia (D. Don) Buchen. Abh. Naturw. Ver. Bremen 2: 2, 3, 6, 1868; van Steenis in Fl. Males. I, 5: 118, f. 1, 1954. *Butomus latifolius* D. Don, Prodr. Fl. Nep. 22, 1825. *Butomopsis lanceolata* Kunth, Enum. Pl. 3: 165, 1841; FBI. 6: 562, 1893. (Pl. IV; Fig. 53).

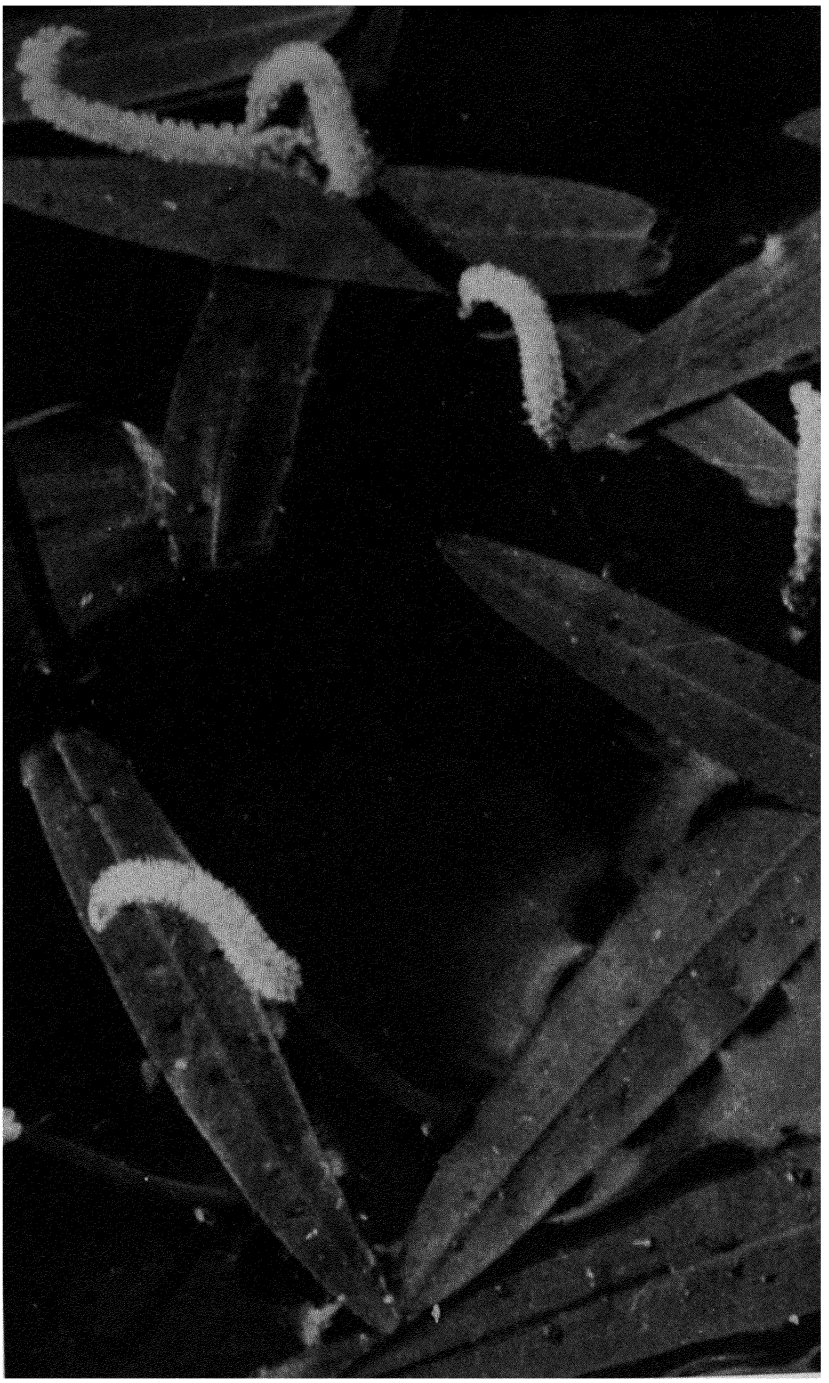
An aquatic herb occurring in ponds and lakes throughout India except in the states of Mysore, Madras and Kerala. It flowers and fruits from November to March. The leaves are oblanceolate, tipped by a hard blunt mucro which has a large hydathode on its underside. The umbels are many flowered (4–15) and the white flowers are borne on long, thin pedicels. The follicles, which have their adaxial walls membranous, are shortly beaked and slightly connate below. Seeds are hardly 5 mm. long, elliptic, shining and brown. Johri (1936b) observed in this taxon the occasional occurrence of pollen grains in the stylar canal and in one instance, germination of a pollen grain on an ovule inside the ovary was also noted by him.

Pl. IV



TENAGOCHARIS LATIFOLIA—UMRED TANK, NAGPUR

Pl. V



APONOGETON NATANS—TANK, JAVADI HILLS, MADRAS

APONOGETONACEAE

Submerged or floating, glabrous, laticiferous aquatic herbs; rhizome tuberous or stoloniferous; tubers usually globose with numerous fibrous roots. Leaves radical, rarely sessile, petioles with a sheathing base; leaf blade oblong to linear-lanceolate, membranous, floating or submerged, with 3–7 or more longitudinal nerves connected by numerous oblique transverse nervules. Peduncles long, emerging, bearing a simple or 2–4 branched spike without bracts, subtended by a caducous basal sheath (spathe). Flowers very small, actinomorphic, hermaphrodite, rarely dioecious, spicate-scapose, white, rose, purple, yellow or yellowish-green; perianth segments 1–3, membranous, equal or unequal, usually persistent; stamens in two whorls, 6 (or more), free, hypogynous, persistent, filament filiform or subulate, anthers small, basifixed, 2-celled, extrorse; pollen subglobose or ellipsoid; ovary superior, apocarpous; carpels 3–6, sessile, each 1-celled, narrowed into a slender, simple stylodium; ovules 1–8 (or more), anatropous, basal or 2-seriate on the ventral suture, ascending. Fruit of 3 or more inflated, coriaceous, beaked follicles, opening along ventral suture; seeds 1–8, erect, oblong or cylindric, without endosperm; testa herbaceous or fleshy, sometimes ribbed; embryo straight, elongate, compressed or cylindric.

Aponogeton L. f.

Scapigerous fresh-water herbs with tuberous rootstock crowned by a bunch of root-fibres. Leaves oblong, floating or submerged, rather membranous. Flowers hermaphrodite, on long scapes bearing solitary or geminate, often unilateral spikes, which when young are enclosed in a conical, quickly deciduous sheath; perianth of 1–3 equal or unequal tepals, pink, white or pale blue; stamens 6 or more, filaments subulate, unequal, persistent, anthers didymous; carpels 3–6; style short or absent, stigma discoid or decurrent, persistent. Fruit of 3 or more coriaceous follicles; seeds erect; testa thick or thin; embryo straight.

KEY TO SPECIES

Leaves mostly floating, oblong to linear-oblong to linear-lanceolate, acute or obtuse, base rounded or shallow-cordate, 15–20 cm. long, up to 5 cm. wide; spike 2.5–15 cm. long, usually dense flowered; tepals 2, obovate or suborbicular, 2 mm. long; stamens as long or longer; follicles 3, subglobose; seeds 1–8, 6–8 ribbed, striate . . . . . *A. natans*

Leaves all submerged, oblong to linear-oblong, rounded or subacute, base narrowed into the petiole, 17.5–50 cm. long, sometimes much longer, up to 3.8 cm. wide, margins undulate or crisped; spike 7.5–12.5 cm. long, usually lax-flowered; tepals 2, obovate-spathulate, 0.4 mm. long, much longer than the stamens; follicles 3, oblong, beaked; seeds 1–2, smooth . . . . . *A. crispum*

Aponogeton natans (L.) Engl. & Krause in Engl. Pflanzenr. 24: 22, 1906. *Saururus natans* L. Mant. 2: 227, 1767. *A. monostachyon* L. f. Suppl. 214, 1781; FBI. 6: 564, 1893. (Pl. V; Fig. 54).

An aquatic herb with edible stoloniferous rootstock. The flowers are white, pink or pale-blue with bluish purple anthers. It commonly occurs in tanks, pools, and lowland waters all over India and flowers throughout the year, particularly during the rainy season and fruits later.

Aponogeton crispum Thunb. Nov. Gen. 1: 73, 1781; FBI. 6: 564, 1893.

A perennial, stoloniferous aquatic herb with tuberous, edible rootstock. The flowers are white. It is found commonly in fresh-water tanks and pools in Central, South and North East India and West Bengal and flowers and fruits from July to December.

POTAMOGETONACEAE

Fresh-water or marine herbs, submerged or floating, often with creeping rootstocks. Leaves distichous, alternate or less often opposite, sessile or petioled, often vaginate at the base, stipulate. Flowers usually very small, emerged or submerged, solitary, spicate, or cymose, hermaphrodite or monoecious, actinomorphic, often borne in a spathe; perianth wanting or of 4 to 6, small, herbaceous or membranous, separate or fused segments; stamens 1–6 with extrorse, sessile anthers; pistil superior; carpels 1–6, free or rarely fused, 1-celled; stigma 1 or 2; ovule solitary, usually pendulous from the apex and orthotropous, rarely parietal and anatropous. Fruit of coriaceous, subwoody or membranous, 1-seeded drupelets; seeds without endosperm; embryo axile.

KEY TO GENERA*

1. Carpels several, free; plants of fresh or rarely brackish waters.

* According to Hutchinson (1959) *Potamogeton* is placed in the family Potamogetonaceae (*sensu stricto*), *Ruppia* in Ruppiaceae and *Zannichellia*, *Cymodocea* and *Diplanthera* in Zannichelliaceae.

2. Flowers perfect; stamens 2–4; leaves alternate.
   3. Stamens 4, with petal-like connectives; flowers in spikes; fruit sessile . . . . *Potamogeton*
   3. Stamens 2, without petal-like connectives; flowers not in spikes; fruit on a long stalk *Ruppia*
2. Flowers imperfect; stamen solitary; fruit short-stalked; leaves opposite . . . . . *Zannichellia*

1. Carpels solitary or fused into a compound pistil; flowers imperfect or rarely perfect; plants of marine waters.
   4. Anthers 2, inserted at the same level; stigmas 2 . . . . . *Cymodocea*
   4. Anthers 2, one inserted above the other; stigma 1 . . . . . *Diplanthera*

Potamogeton L.

Submerged or floating herbs with jointed, leafy stems bearing fibrous roots at lower nodes. Leaves submerged or floating, linear, lanceolate, oblong or sometimes round, petioled or sessile, rarely amplexicaul. Stipules membranous, more or less fused by the margins into a sheath or in a few species fused with the base of the blade. Flowers small, crowded in spikes; spikes sheathed by the stipules in the bud, raised to the surface on long peduncles or submerged with short axillary peduncles. Flowers ebracteate, perfect, hermaphrodite; perianth of 4 rounded, valvate, concave, greenish segments; stamens 4, opposite these segments; pollen globose; carpels 4, separate, sessile; with a short style or the stigma subsessile or decurrent, persistent. Fruit drupe-like when fresh, the drupelets more or less compressed, with bony, often keeled endocarp containing a solitary subreniform seed with coiled embryo.

Various interpretations have been put forward to explain the nature of the perianth-like parts in the flowers of *Potamogeton*. According to some, it is a sepaloid structure in the form of an expansion of the connective of the stamen. Others consider the flower as a reduced inflorescence of 4 staminate flowers, each consisting of one stamen and a bract, surrounding a pistillate flower of 4 carpels. According to this view, the spike would be a compound inflorescence. Studies on the vascular anatomy of the flowers (Uhl, 1947) do not afford evidence to the theory that the sepaloid structure has arisen from an expanded connective, but rather suggest that the so-called

perianth parts are in fact individual bracts subtending and adnate to the stamens and that the flower is fundamentally an inflorescence composed of staminate flowers and apetalous pistillate flowers.

KEY TO SPECIES

Upper or all the leaves floating, those floating petioled, none amplexicaul or semi-amplexicaul.

Leaves all broad and petioled; floating leaves sometimes opposite, thinly coriaceous, elliptic-lanceolate and acute or oblong or suborbicular and obtuse, base rounded or cuneate, 4–10 cm. long, 2.5–6 cm. wide; submerged leaves membranous, linear to elliptic-lanceolate, acute, up to 20 cm. long and 2.5 cm. wide, often undulate; petioles very long; stipules free, up to 3.5 cm. long; peduncles axillary or leaf-opposed, 2.5–15 cm. long; spikes 2.5–3.5 cm. long, dense-flowered; sepals 0.2–0.3 mm. long, oblique, suborbicular, clawed; drupelets long, oblique, shortly beaked . . . . . *P. nodosus*

Submerged leaves very narrowly linear or filiform without distinct petiole; floating leaves membranous, elliptic to ovate-oblong, acute, 1.3–2.5 cm. long; petioles usually shorter than the blade; stipules free, 1.2–2.5 cm. long; peduncles slender, axillary or leaf-opposed; spikes 0.7–1.3 cm. long, lax-flowered; sepals orbicular-ovate; drupelets semiglobose with a hooked beak, ribs often toothed and tubercled . *P. octandrus*

Leaves all submerged, without distinct petiole.

Stem rather stout, terete, laxly branched; leaves ovate-lanceolate, cordate, amplexicaul, obtuse, 2–4 cm. long, 1.3–2.5 cm. wide; stipules small caducous; peduncles axillary, rather stout, 2.5–5 cm. long; spikes dense-flowered, 1.3–2.5 cm. long; sepals elliptic-obovate, clawed; drupelets globose with a short curved beak, hardly keeled, smooth, 0.2 mm. long . . . . . *P. perfoliatus*

Stem filiform, copiously, distichously branched; leaves narrowly linear or filiform, acute, 2.5–15 cm. long, 0.2–0.3 mm. wide; stipules adnate to the leaf-sheath with free tips; peduncles slender,

axillary, elongate; flowers interruptedly whorled on a spike 0.6–3.3 cm. long; sepals suborbicular; drupelets dimidiate-obovate, shortly beaked, 0.2–0.3 mm. long . . . . . *P. pectinatus*

Potamogeton nodosus Poir. in Encycl. Meth. Bot. Suppl. 4: 535, 1816; Dandy in J. Linn. Soc. 50: 531, 1937. *P. indicus* Roxb. Fl. Ind. 1: 471, 1820 (non Roth ex Roem. & Schult. 1818); FBI. 6: 565, 1893.

Aquatic, submerged, rooted herb with upper or all leaves floating. It is common in fresh-water areas throughout the plains of India and South Andamans ascending up to 2,700 m. in Sikkim Himalayas. It flowers from January to July and fruits later.

Potamogeton octandrus Poir. in Encycl. Meth. Bot. Suppl. 4: 534, 1816; Dandy in J. Linn. Soc. 50: 517, 1937. *P. javanicus* Hassk. in Act. Soc. Sci. Ind.-Neerl. 1: 8, 26, 1856; FBI. 6: 566, 1893.

Aquatic herb with small, ovate-oblong or elliptic floating leaves and linear acuminate submerged leaves. The minute flowers are arranged in interrupted whorls. The drupelets are turgid with stout beaks. It occurs in tanks and pools throughout the plains of India, ascending in the Himalayas up to a height of 800 m. It flowers and fruits almost throughout the year.

Potamogeton perfoliatus L. Sp. Pl. 126, 1753; FBI. 6: 566, 1893; Aschers. & Graeb. in Pflanzenr. 31: 92, f. 21A-E, 1907; Dandy in J. Linn. Soc. 50: 536, 1937. (Fig. 55, 4–5).

An aquatic herb with a stout, dichotomously branched, terete stem bearing ovate-cordate, amplexicaul leaves. The spikes are densely flowered. The compressed drupelets have straight beaks. It occurs in tanks and pools of Central, North, West and South India and flowers and fruits throughout the year.

Potamogeton pectinatus L. Sp. Pl. 127, 1753; FBI. 6: 567, 1893; Aschers. & Graeb. in Pflanzenr. 31: 121, f. 28A–B, 1907; Dandy in J. Linn. Soc. 50: 513, 1937. (Fig. 55, 1–3).

Aquatic herb with profusely branched stems having filiform, acute, opaque, 1–3 nerved leaves. The flowers are few and arranged in distant whorls. The turgid drupelets are dimidiate-obovoid and have a very short beak. It is common in fresh-water pools and low-land water throughout the plains of India, sometimes ascending to higher altitudes. It flowers and fruits almost throughout the year.

Ruppia L.

Slender, much-branched herbs with creeping rootstocks submerged in brackish water. Leaves alternate or subopposite, filiform, with tapering apex and broad, sheathing base. Flowers minute, hermaphrodite, peduncled within the leaf sheath; peduncle elongating after flowering, straight or spirally coiled; perianth absent; stamens 2, subsessile, anthers 2-celled; carpels 4, becoming long-stipitate as they mature; stigma peltate; ovule pendulous. Fruits oblique, drupelets on long stipes, ovoid, obtuse or beaked, usually 4 in a cluster on a long peduncle which contracts and often becomes coiled; seeds pendulous, uncinate with a coiled macropodal embryo.

Ruppia maritima L. Sp. Pl. 127, 1753; Aschers. & Graeb. in Pflanzenr. 31: 142, 1907; McCann in J. Bombay nat. Hist. Soc. 45: 396, ff. 1–12, 1945. *R. rostellata* Koch. in Reichb. Ic. Pl. Crit. 2: 66, f. 174, 1824; FBI. 6: 568, 1893. (Fig. 56, 1–6).

A submerged aquatic herb common throughout India in brackish water. It forms tangled masses of filiform, leafy, flaccid stems and branches and flowers and fruits from January to May. The anthers, which are ellipsoid or suborbicular, dehisce through the centre and are borne on an extremely short filament which ends in a minute appendage. The pollen grains are long, kidney-shaped, buoyant, pale yellow and smooth. The pistils are stipitate, the stipe elongating to 25–30 mm., obovate-oblong, truncate, surmounted by a discoid, peltate, stigmatic canopy.

McCann (1945) has made some observations on the mode of pollination in this plant. There are four anthers in each cluster, two above and two below the female cluster. The anthers dehisce first and shed their pollen little by little. The pollen drifts upwards and on its way is arrested by the stigmatic canopy. It adheres to the margin of the canopy and under it; gradually it drifts round to the stigma, when pollination takes place. The pollen grains are seen singly or in sausage-like strings clinging to the canopy.

Zanichellia L.

Submerged, fresh or brackish water perennial herbs with slender, simple or cymosely branched leafy stems; rootstock slender. Leaves mostly opposite, linear or filiform, entire, with sheathing or free stipules. Flowers minute, monoecious, naked, axillary, both sexes enclosed together in a membranous deciduous spathe, 1 staminate and 2–5 pistillate flowers, often in the same axillary, cup-shaped involucre; staminate flower without a perianth; stamen solitary,

filament filiform, anther linear, 2–3 celled; female flower with a cupular, hyaline perianth; carpels 1–9, sessile or stipitate; style short or long, stigma peltate; ovule pendulous, orthotropous. Drupelets usually 4, stipitate, coriaceous, compressed, curved, toothed or entire along the margin; seeds pendulous, oblong; testa thin; embryo cylindric.

Zannichellia palustris L. ssp. **pedicellata** Wahlenberg & Rosén in Nov. Act. Upsal. 8: 227, 254, 1821; FBI. 6: 568, 1893. (Fig. 56, 7–9).

It occurs commonly in salt marshes and at times in fresh-water lagoons throughout India, sometimes ascending to higher altitudes. It is a highly variable species and four to five taxa are recognised. It usually flowers and fruits in the summer months from February to June.

Cymodocea Koenig

Submerged, dioecious marine herbs with rigid, perennial, creeping, jointed, branching rootstocks bearing the annual scars of fallen leaves. Leaves distichous, oblong, linear or terete with acute apex; stipular sheaths membranous, distinctly 2-auriculate and ligulate. Flowers axillary, solitary or in cymose clusters, enclosed in membranous sheaths; stamens 2, anthers elongate, connate, stipitate, with pollen in threads; carpels 2, subsessile, ovoid, compressed; style short, stigmas 2, subulate; ovule pendulous, orthotropous. Drupelets 2, ovoid, coriaceous or woody; seeds pendulous; embryo macropodal.

KEY TO SPECIES

Leaves flat; flowers solitary.

Leaf scars forming closed rings; leaves up to 20 cm. long, 0.5 cm. wide, usually entire, 7–13 nerved; sheaths compressed-cylindric, up to 6.3 cm. long and 0.5 cm. wide; drupelets with a coarse, acute, dentate keel . . . . . *C. rotundata*

Leaf scars forming open rings; leaves up to 20 cm. long, 1 cm. wide, minutely toothed, 11–19 nerved; sheaths obconic, 2.5–3.8 cm. long, up to 1 cm. wide at the mouth, much narrowed at the base . . . . . *C. serrulata*

Leaves fleshy, terete, grooved, tip 3-toothed, 7.5–15 cm. long, 1 mm. wide or less; sheaths narrowly obconic, up to 3.2 cm. long and 0.5 cm. wide at the mouth; flowers in terminal, dichotomously

branched cymes, 2.5–5 cm. long, each pair sessile on a short peduncle enclosed in a spathiform bract with a linear tail; bracts 0.5 cm. long . . . . *C. isoetifolia*

Cymodocea rotundata Aschers. & Schw. in Sitzb. Ges. Naturf. Fr. Berl. 84, 1870; Aschers. & Graeb. in Engl. Pflanzenr. 31: 147, 1907; Fischer in Fl. Pres. Madras 3: 1117, 1957.

It occurs in Pamban, Krusadi, Tuticorin in South India and South Andamans.

Cymodocea serrulata (R. Br.) Aschers. & Magn. in Sitzb. Ges. Naturf. Fr. Berl. 84, 1870; FBI. 6: 570, 1893; Aschers. & Graeb. 147. *Caulinia serrulata* R. Br. Prodr. 339, 1810.

It occurs in Pamban, Krusadi and Tuticorin in South India.

Cymodocea isoetifolia Aschers. in Sitzb. Ges. Naturf. Fr. Berl. 3, 1867; FBI. 6: 570, 1893. Aschers. & Graeb. 149.

It is reported from Pamban, Krusadi and Tuticorin in South India and from Andaman and Nicobar Islands.

Diplanthera Thouars

Submerged marine herbs; rootstock slender, branching, rigid, jointed, bearing the annual scars of fallen leaves. Leaves narrowly linear, apex with 2 minute lateral teeth, 3-nerved; sheaths cylindric, distinctly 2-auriculate and ligulate. Flowers axillary, monoecious; peduncles of male flowers long; anthers equal, sessile, one inserted above the other by about half its length; carpels included in the sheath with a single, subulate, exserted style. Drupelet subrotund-ovate, slightly compressed.

Diplanthera uninervis (Forsk.) Aschers. in Engl. & Prantl, Pflanzenfam. Nachtr. 37, 1897; Aschers. & Graeb. in Engl. Pflanzenr. 31: 152, 1907. *Zostera uninervis* Forsk. Fl. Aeg.-Arab. 159, 1775. *Cymodocea australis* Trim. Cat. Ceylon Pl. 99, 1885; FBI. 6: 570, 1893.

It occurs in the backwaters at Ennore near Madras and in Tuticorin.

NAJADACEAE

Slender, submerged, fresh or salt water herbs; stems rooting from the nodes, branched, filiform or muricate. Leaves alternate, opposite or ternate, linear, entire, either spiny-toothed or minutely spinulose-serrulate; base dilated, sheathing, sheaths truncate, rounded or

2-auriculate at the apex, margins more or less toothed. Flowers minute, axillary, solitary or a few together, monoecious, rarely dioecious, naked or enclosed in a tubular or inflated spathe; perianth absent or tubular and hyaline; stamen 1, adnate to the perianth, 1–4 celled; carpel 1, sessile; style cylindric, stigmas 2–4, slender; ovule solitary, basal, erect, anatropous. Achenes oblong or ellipsoid; seeds erect; testa very thin, arcolate; embryo straight, macropodal.

Najas L.

Submerged aquatic herbs growing in fresh or brackish water with branched, filiform, smooth or muricate stems rooting at the nodes. Leaves sessile, opposite, alternate or whorled, narrowly linear, sinuate-dentate or serrulate. Flowers minute, axillary, monoecious or dioecious; staminate flowers consisting of a single, sessile, 1- or 4-celled, apiculate or cuspidate anther, usually surrounded by 2 envelopes, one considered as a perianth and the other a spathe; spathe tubular or inflated, entire or 4-fid; perianth hyaline; pistillate flowers of a single sessile carpel, surrounded by either 1 or 2 envelopes; perianth absent or hyaline or adnate to the carpel. Fruit an oblong achene; seed erect; testa thin.

KEY TO SPECIES

1. Flowers of both sexes devoid of spathe; leaves 1.5–2.5 cm. long, 0.4–0.6 cm. wide, marginal spinules minute, numerous; auricles of the sheath elongate, about half the length of the sheath, toothed; flowers solitary or 2–4 together; male perianth ending directly above the anther in 2 ear-like lobes; fruit ellipsoid-oblong, attenuate at the apex; areoles minute, subquadrate or polygonal . . . . . *N. graminea*

1. At least the male flowers enclosed in a spathe.
   2. Flowers of both sexes in a spathe; shoots very slender; leaves 2–4 cm. long, 0.5 cm. or less wide, marginal spinules few, often as long as the width of the leaf; auricles of sheath variable, truncate or lobed, never elongate; spathe of male narrowed into an irregularly toothed mouth ending in 2 opposite, linear prolongations, 1–2-spined at the apex; perianth closely investing the anther; spathe of female with a neck 0.8–0.9 mm. in

length, mouth spinulose; fruit ellipsoid, enclosed in the persistent spathe; areoles quadrate . . . . . *N. indica*

2. Spathe absent from female flowers.
   3. Anthers 1-celled; shoots 4–26 cm. long; leaves tapering, 1.2–2.5 cm. long, 0.4–0.5 mm. wide, margins with a few broad-based, up-curved spinules; sheaths broad, usually truncately rounded with a few prominent teeth on the shoulders; spathe of male ellipsoid, elongate below, ending above the perianth in a short cylindrical neck; perianth closely investing the anther; fruit ellipsoid, 0.2–3.2 cm. long; areoles in the shape of ladder-like pits . . . . . *N. minor*
   3. Anthers 4-celled.
      4. Apex of the spathe cut into deep, irregular segments bearing 1 or more brown spinules; shoots dichotomously branched, up to 16.5 cm. long; leaves up to 2.5 cm. long and 1 mm. wide, spinules few, the dorsal keel sometimes spinulose; auricles of the sheath rather broad, the apex cut into 2–4 deep spiny teeth . . . . . *N. lacerata*
      4. Spathe ellipsoid, apex not lacerate; leaves 1.6–2.2 cm. long, 1 mm. wide, marginal spinules numerous; auricles of sheath often falcately curved, with a few teeth along the outer edge, inner edge entire; fruit 2.2 cm. long; areoles minute, quadrate . . . . . *N. falciculata*

Najas graminea Del. Fl. Aegypte 282, t. 50, f. 3, 1812; FBI. 6: 569, 1893; Rendle in Pflanzenr. 7: 18, f. 5Q–V, 1901.

A very slender, delicate, bright green aquatic plant of grass-like habit rooting at the nodes. The densely leaved lateral branches and tips of the main shoot results in a plumose habit of the plant. It is common throughout India and Nicobar Islands in stagnant fresh-water. It flowers and fruits from March to September.

Najas graminea Del. var. **minor** Rendle in Trans. Linn. Soc. 2. Ser. 5: 426, 1899 et in Pflanzenr. 18, 1901.

A smaller and more delicate herb with leaves 0.7–1.5 cm. long and shorter auricles of sheath; the fruit measures 1–2 mm. long. It occurs in Tuticorin, South India.

Najas indica (Willd.) Cham. in Linnaea 4: 501, 1829; Rendle, 10, f. 3R–T, 1901; Fischer in Fl. Pres. Madras 3: 1119, 1957. *Caulinia indica* Willd. in Mem. Acad. Berlin 1798: 89, t. 1, f. 3, 1801. *Najas minor* var. *indica* A. Br. in J. Bot. 2: 278, 1864, *pro parte.*

It occurs in Sambalpur, Orissa State and Tranquebar, Madras State.

Najas minor (Pers.) All. Fl. Pedem. 2: 221, 1785; FBI. 6: 569, 1893, *pro parte;* Rendle, 14, f. 4S–T, 1901. *Fluvialis minor* Pers. Syn. 2: 530, 1807.

A small, fragile, dichotomously branched aquatic herb about 3–25 cm. long. It occurs in ponds and lakes throughout India and North Andamans. It flowers and fruits during all seasons of the year.

Najas minor All. var. **spinosa** Rendle in Trans. Linn. Soc. 2. Ser. 5: 431, 1899 et in Pflanzenr. 15, 1901.

The leaves are very narrow and marginal spinules have almost the same length and width as the leaves; the fruit is 0.1–0.2 mm. long. It occurs in the Godavary district of Andhra State and in Madras and Tanjore.

Najas lacerata Rendle in Trans. Linn. Soc. 2. Ser. 5: 416, t. 41, f. 132, 1899 et in Pflanzenr. 15, f. 5E–F, 1901; Fischer in Fl. Pres. Madras 3: 1119, 1957.

It is reported to occur in Madras and Tinnevelly.

Najas falciculata A. Br. in J. Bot. 2: 278, 1864; FBI. 6: 569, 1893; Rendle, 15, 1901.

The stem is rigid and the auricles are falcately incurved, entire or the inner margin entire, the outer toothed. It occurs in Madras and Tuticorin.

ERIOCAULACEAE

Annual or perennial, scapigerous, marsh (less frequently aquatic) herbs. Stem usually simple, often very short. Leaves radical or in aquatic species, cauline, usually narrow and grass-like, 2–50 cm. long, flat or concave, glabrous, loosely cellular, often translucent. Roots white septate, often translucent. Heads depressed or convex, with staminate or pistillate flowers only or with both kinds intermixed, or with the staminate in the centre and the pistillate outside; receptacle

naked or pilose, flat, convex, hemispherical, conical or columnar. Flowers minute, unisexual, densely packed in a solitary, globose, hemispheric, subglobose or discoid head surrounded by an involucre of bracts, terminating a usually ribbed peduncle with a basal sheath; flowers solitary in the axils of bracts, the tips of which are often white-woolly on the outside; staminate flower stipitate; sepals 2- or 3-keeled, free or more or less connate or spathaceous and split down on one side, equal or often one smaller and differently shaped, sometimes winged on the back; petals 2–3, usually united into a cylindric or funnel-shaped, lobed or truncate tube, one lobe sometimes much larger than the rest, rarely free, each lobe usually bearing a black subapical gland; stamens 4 or 6 (rarely 3), usually in 2 series, filaments filiform, anthers 2- or 4-celled, usually black, sometimes white or yellow; pistillate flower sessile or stipitate; sepals usually free, rarely more or less connate, usually 2 or 3, rarely 1 or absent, often attached to some distance below the corolla; petals 2 or 3 (rarely wanting), free, narrow, usually pilose and bearing a black gland at the apex; ovary superior, sessile or shortly stipitate, 2–3 celled, cells 1-ovuled, style single, usually short, stigmas as many as the cells of the ovary, usually long, slender and single, sometimes 2-fid. Capsule deeply 3-lobed, membranous, lobes globose, loculicidal; seeds pendulous, minute, oblong or ellipsoid, brown; testa thin, often with rows of white papillae, smooth or reticulate and often more or less ribbed; endosperm farinaceous, embryo minute.

Eriocaulon L.

Stem when present always simple, usually very short or absent. Peduncles often twisted, glabrous or hairy. In male flowers, lobes of the corolla always present though often minute, one often enlarged and sometimes protruding beyond the floral bract, usually bearing an apical, black, rarely red, gland. In female flowers, petals usually 3, rarely less, always free. In many taxa the floral bracts and the sepals are furnished with peculiar white or yellowish, cylindrical, blunt, opaque hairs which resemble elongate papillae.

Eriocaulon setaceum L. Sp. Pl. 87, 1753; FBI. 6: 572, 1893; Fyson in J. Indian Bot. 2: 193, f. 1, 1921.

Water plants with only peduncles emerging. The submerged stems grow to a length of nearly 1 m. and bear many capillary, flexuous, 1-nerved leaves, 3–5 cm. long. The numerous umbellate peduncles arise on the apex of the stem and are 3.5–7.5 cm. long. The sheath which is up to 2.5 cm. long has an oblique mouth. The heads are subglobose, 0.3–0.5 mm. in diam., dark brown and glabrous

or pale-green and white-puberulous at the apex. The receptacle is villous. In the male flowers the calyx is spathaceous, split down on the front and the anthers are black. In the female flowers the 3 sepals are obovate and cymbiform; the petals are linear or linear-spathulate, pilose, usually with an apical black gland. It occurs in tanks and ponds along western regions of peninsular India, North Bengal, Assam, Agartala and Manipur. It flowers and fruits from August to September.

CYPERACEAE

Grass-like, annual or perennial herbs; roots fibrous; rhizomes short or long, often scaly or absent. Stems usually solid, more often three angled. Leaves grass-like, often tristichous, mostly linear, parallel-veined, usually crowded near the base of the stem or alternate; sheaths closed, rarely split; ligule absent or insignificant. Flowers 1 or 2-sexual, in the axils of glumes arranged distichously or spirally in spikelets which are solitary or variously disposed in heads or panicles; the bases of the branches of the inflorescence sometimes embraced by a sheath called cladophyllum; bracts usually like the leaves and a little broader; perianth absent or of 6 scales or bristles or an indefinite number of hairs; stamens 1–3, rarely more, anthers linear or oblong, basifixed, apex sometimes crested; ovary superior, 1-celled; ovule 1, basal, erect, anatropous; style short or long, 2–3 cleft, rarely entire or nearly so, branches slender, stigmatic. Fruit a compressed, lenticular or 3-angled, sometimes bony nut (or achene); seed free, erect; embryo minute, enclosed in the large, starchy endosperm.

KEY TO GENERA

Scales (glumes) of spikelets in 2 ranks; spikelets in a terminal cluster; perianth bristles wanting . . . . *Cyperus*

Scales (glumes) of spikelets in more than 2 ranks, spirally arranged; spikelets usually several in a terminal or lateral cluster; perianth bristles all setaceous, rarely absent . . . . . *Scirpus*

Cyperus L.

Annual or perennial, erect or floating herbs; stems mostly erect, simple, triangular, leafy at the base with one or more leaves at the top forming an involucre to the terminal umbel or head of spikelets. Leaves usually radical, flat or terete and channelled, rarely entirely reduced to sheaths. Inflorescence capitate or of simple or compound

umbels; peduncles of the umbel unequal, simple or branched, sheathed at base; bracts like the leaves, rarely reduced almost to scales, usually divaricate, sometimes one, erect. Spikelets linear or oblong, slender, usually compressed and flattened, seldom terete, few or many flowered; rachilla persistent, often winged, the wings interrupted and in pairs, opposite the nuts, sometimes united to the glumes; glumes usually distichous, deciduous, the 2 lowest empty, 4 to many succeeding ones bisexual, the uppermost 1–3 sterile or empty; perianth bristles wanting; stamens 3 or 2, rarely 1, anthers sometimes crested; style 3-fid, rarely undivided, deciduous, not tumid at the base nor articulated to the nut. Nut usually trigonous or lenticular, without beak.

KEY TO SPECIES

Plants floating in water; base or angles of the nut corky.

Style long, undivided or obscurely 2–3 toothed; stems slender, up to 45 cm. long; bracts 2.5–20 cm. long; spikelets numerous, congested in a single head; glumes broadly ovate, boat-shaped, rigid, acute or acuminate; nut half as long as the glume, ovoid, unequally 3-sided, base corky . . . . . *C. cephalotes*

Style short, branches 3, linear; stem robust, sharply 3-angular, up to 1 m. long; bracts several, up to 50 cm. long, margins usually scabrous; spikelets narrowly ovate to oblong, light or reddish-brown, umbellately or digitately clustered; glumes regularly imbricate, mucronate; nut $\frac{2}{3}$ the length of the glume, ellipsoid, angles corky . . . . . *C. platystylis*

Plants rooted; nut not corky.

Stems terete, stout, thickened below, transverse septa distinct when dry, up to 2 m. high; rootstock stout, woody, stoloniferous; leaves reduced to sheaths or sometimes with a short foliaceous limb; bracts 1–3, scale-like, triangular, acute, under 2.5 cm. long . . . . *C. articulatus*

Stems trigonous above, spongy below, septa not or hardly visible when dry; rhizome creeping, stout, woody; leaves reduced to sheaths or sometimes with a blade up to 15 cm. long; bracts developed . . . . . *C. corymbosus*

Cyperus cephalotes Vahl, Enum. 2: 311, 1806; FBI. 6: 597, 1893; Blatter & McCann in J. Bombay nat. Hist. Soc. 37: 257, 1935; Kükenthal in Engl. Pflanzenr. 101: 291, 1936.

A floating, glabrous herb with slender stolons and occurs commonly in tanks in Bihar, West Bengal, Assam, Manipur, Madras and Kerala. The glumes are closely packed, boat-shaped, green, more or less marked with red or chestnut colour. It flowers and fruits from May to January.

Cyperus platystylis R. Br. Prodr. 214, 1810; FBI. 6: 598, 1893; Blatter & McCann, 258; Kükenthal, 185, f. 21. (Fig. 57).

A glabrous herb floating in tanks. It occurs in West Bengal, Assam and Madras. The stolons are covered by ovate, acute, striate, pale-brown scales. The leaves and bracts are long; the umbels are compound and the numerous spikes are close together. It flowers and fruits from May to January.

Cyperus articulatus L. Sp. Pl. 44, 1753; FBI. 6: 611, 1893; Blatter & McCann, 269; Kükenthal, 77.

A tall glabrous sedge with a stout, woody, stoloniferous rootstock and erect robust stem growing up to a height of 2 m. The leaves are reduced to sheaths and they cover the base of the stem. The compound umbel bears a number of spikes and the bracts are very short, acute and scale-like. The nut is trigonous, acute at either end and black. It usually occurs in standing water in West Bengal, Tripura, Manipur, Gujarat and most of the States in peninsular India. It flowers and fruits throughout the year. The tuber is used as a tonic and stimulant (Chopra *et al.*, 1956).

Cyperus corymbosus Rottb. Descr. & Icon. 42, t. 7, f. 4, 1773; FBI 6: 612, 1893; Blatter & McCann, 270; Kükenthal, 80, f. 10. (Fig. 58).

A perennial herb with tuberous rootstock and an erect stem 1–2 m. high, which is sub-trigonous, bright green and glabrous. The umbels are decompound and the spikelets are alternate, subulate and bright brown. It occurs in ponds and tanks throughout India and flowers and fruits throughout the year. The stems of this species are used for making fine mats in the districts of Tinnevelly, Tanjore, Madurai, Tiruchirapally, South and North Arcot of Madras State and in West Bengal.

Scirpus L.

Glabrous herbs with triangular or terete stems. Leaves narrow, arising from the base of the stem, up to $\frac{2}{3}$ of its height, in submerged

species from all along the stem, sometimes altogether absent. Inflorescence terminal or lateral of 1 to many spikelets in clusters or umbels or corymbs; spikelets usually many flowered; glumes generally imbricate, rarely subdistichous below, 1–3, lowest empty, uppermost few tabescent, the intermediate 1–many with hermaphrodite flowers. Hypogynous bristles 0–7 (rarely 8 or 9), usually linear, sometimes broad, retrorsely scabrid, rarely plumose; stamens 1–3, anterior; ovary with a 2–3 fid style, base linear, or conic and continuous with the nut. Nut sessile or nearly so, plano-convex or lenticular, apex obtuse or acute, without apical button.

KEY TO SPECIES

Leaves arising from $\frac{1}{3}$ of the height of the stem or higher	*S. grossus*
Leaves radical or reduced to sheaths	*S. articulatus*

Scirpus grossus L. f. Suppl. 104, 1781; FBI. 6: 659, 1893; Blatter & McCann in J. Bombay nat. Hist. Soc. 37: 769, 1935.

A large, perennial, glabrous herb with a stout rootstock, sometimes stoloniferous. During the period of active growth the long stolons creep underground for some distance and ultimately the growing apex turns upward and produces a new plant. When the pond begins to dry (Mullan, 1945), the subterranean stolons swell at the ends and produce dark coloured, hard, globose tubers clothed with matted fibres. The swelling of the tuber is mainly due to the hypertrophy of the fundamental tissue of the stele in which the vascular bundles are embedded. The parenchymatous cells of this tissue increase in size and later get fully packed with starch grains. With the drying of the pond, the plants gradually die down to the surface of the soil but the tubers perennate, remaining dormant throughout the dry season and sprout in the next monsoon. The tuber on sprouting usually produces a stolon which runs to a short distance and gives rise to a new plant at its apex. At times, however, the new plant arises directly from the top of the tuber. Thus, the tubers serve as hibernating organs and help in tiding over seasons unfavourable to vegetative growth. The stem is stout, spongy below, sharply trigonous or 3-winged above, 1–3 m. high. The spikelets are ovoid, 0.4–0.8 mm. long and arranged in large, compound corymbs, on slender, scabrid, solitary peduncles. The glumes are ovate-oblong, chartaceous, apex entire, obtuse, apiculate, not awned, strongly keeled, dark brown, glabrous or puberulous, 0.2–0.3 mm. long. The 5–6, retrorsely hispid, hypogynous bristles are shorter or longer than the nut. The obovoid, trigonous nut is 1.7 cm. long, brown, smooth

with a conical apex. It occurs in still or running water, more or less throughout India, ascending up to 600 m. It flowers and fruits during August to December. The tubers are given in diarrhoea and vomiting (Chopra *et al.*, 1956).

Scirpus articulatus L. Sp. Pl. 47, 1753; FBI. 6: 656, 1893; Blatter & McCann in J. Bombay nat. Hist. Soc. 37: 767, 1935. (Fig. 59).

Perennial, glabrous, aquatic plants with densely tufted robust stems, light green, spongy, 15–150 cm. high. The inflorescence arises below the middle of the terete, transversely septate stem and the white septa are visible externally at intervals. The sheaths are lax with their mouth oblique and often open. The few to many sessile spikelets are borne in a dense lateral head, often arising some distance above the mouth of the sheath; they are ovoid to cylindric-oblong, 0.5–1.8 cm. long. The glumes are broadly ovate, concave, narrowed with an acute or subacute apex, apiculate, hardly keeled. Bristles are absent and the three stamens have linear, obtuse, yellow anthers; the style is 3-fid. The obovate nut is trigonous, concave along the sides, black, smooth or shows 16–20, more or less pronounced transverse wavy lines. It is common throughout India and South Andamans in pools and tanks. It flowers from January to May and fruits during winter.

GRAMINEAE

Erect, decumbent or creeping, sometimes floating herbs, or tall reeds, shrubs or trees or climbers, annual or perennial by means of rhizomes; roots adventitious, fibrous; stem simple or more commonly branched from the base, generally terete with hollow internodes. Leaves alternate, commonly 2-ranked, nearly always with a sheathing base split down on one side; at the upper end of the sheath where it is joined with the blade there is usually a membranous or hairy fringe, the ligule, which is rarely absent; blades usually long and narrow, rarely ovate, parallel-veined, sessile or sometimes petioled. Inflorescence terminal, rarely terminal and lateral, composed of panicled, racemose, simple or compound, spicate or capitate spikelets, rarely reduced to a single spikelet; sometimes dioecious; spikelets homogeneous or differing in sex and shape; 1-sexual or 2-sexual with all the florets 2-sexual or 2-sexual with male only or male and female in the same spikelet, spikelets with a shortened axis (rachilla) on which are attached few to many bracts (the glumes), the two lower of which, the empty glumes, are without flowers in their axils; the

succeeding ones, the lemmas or flowering glumes, each bear a solitary axillary flower and palea on a short stalk between the floret and the axis; the midrib of the glumes may project into a long bristle or awn beyond the body of the glume; in some forms the upper or lower lemmas may be reduced or sterile; usually there are 2, rarely 3, hyaline, minute scales called lodicules within the palea, representing the reduced perianth; stamens 3, rarely 6, 4, 2 or 1, occasionally more than 6, filaments slender, often very long, free, rarely united, anthers versatile with 2 parallel cells; ovary superior, 1-celled; styles 2, rarely 3 or 1, free or connate at the base, stigmas plumose; ovule solitary, erect, anatropous. Fruit a grain or caryopsis, free within the lemma and palea or adnate to either or both; seed erect, endosperm copious, floury; embryo minute or large, along one side at the base of and outside the endosperm.

KEY TO GENERA

1. Sexes in the same inflorescence, with few female flowers at the base and male above; female solitary within a closed, globose, stony bract . . *Coix*
1. Sexes mixed.
   2. Mature spikelets falling entire from or with their pedicels or with the contiguous joint of the rachis, all alike or differing in sex and structure, perfect ones with 2 heteromorphous florets, lower male or empty, upper bisexual.
      3. Inflorescence never an open or contracted cylindric panicle; fruiting lemmas acute, not mucronate; spikelets solitary, their sides contiguous . . . . . *Paspalidium*
      3. Inflorescence an open or a contracted, cylindric spiciform panicle; spikelets, at least the upper of each branch, supported by bristle-like branchlets, bristle solitary, much extended beyond the terminal spikelet . . . . . *Pseudoraphis*
   2. Mature spikelets breaking up, leaving the persistent or subpersistent glumes on the rachis or pedicels, or if falling entire, then not consisting of 2 heteromorphous florets.
      4. Glumes represented by an entire or 2-lobed rim; lemmas awnless . . . . . *Leersia*
      4. Glumes suppressed; lemmas awned . . *Hygroryza*

Coix L.

Annual or perennial, tall, erect or floating plants. Leaves flat. Inflorescence of fascicled, axillary and terminal, spiciform racemes consisting usually of one female spikelet completely enclosed in a globose or ovoid basal bract through which the rachis grows out and bears the male spikelets above; bract eventually stony and polished, sometimes continued into a leafy blade, rarely with a second bract above; male spikelets imbricate, in pairs or threes, one of them pedicelled; glumes subequal, herbaceous, the lower flat with 2 lateral winged keels, the upper boat-shaped with a median keel; florets 2, both staminate or the upper empty; lemmas similar, membranous, the upper shorter; paleas hyaline; lodicules 2, cuneate, fleshy; stamens 3; female spikelets enclosed in the bract with 2 bare pedicels; glumes hyaline-membranous and inflated below, contracted into an acute cartilaginous beak, the upper acutely keeled between 2 deep grooves; florets 2, the lower usually reduced to an empty lemma resembling the lower glume, upper lemma resembling the upper glume, with a broad palea; lodicules absent; stamens 3, rudimentary; style long, deeply 2-fid, exserted from the mouth of the sheathing bract. Grain subglobose or ellipsoid, enclosed in the bract; embryo long.

Coix aquatica Roxb. Fl. Ind. 3: 571, 1832; FBI. 7: 100, 1897; Bor, Grasses 264, 1960.

A perennial, floating or creeping plant and the jointed, rounded stems can reach a length of over 30 m. The leaves are linear, acute with hispid margins, 30–90 cm. long, 2.5–3.8 cm. wide, the lower ones linear-lanceolate, and the superior ones ensiform. The spikes are many flowered, terminal, peduncled, solitary or in pairs, drooping. The male flowers are of two types: the two lateral ones are sessile, the central pedicelled and all have two valved glumes with two flowers in each. The female flowers are solitary, situated at the base of the male spikes. The glumes are turbinate and perforated. There are 3 rudimentary staminodes and the style is 2-fid. The turbinate, smooth grain is of a dull pearl colour. Bor (1960) writes about this taxon thus: "This species has since Roxburgh's time been considered to be a variety of *C. gigantea* Roxb., and they are certainly very difficult to separate in the herbarium, but since the habit of each is different and each has a different chromosome number, I have decided that *Coix aquatica* Roxb. is worthy of specific rank". It occurs as a floating plant in lakes in lower Bengal, Bihar (Monghyr) and Orissa (Balasore). It flowers from September to November and fruits later. It grows gregariously and provides fodder for cattle.

Paspalidium Stapf

Perennial, terrestrial or semi-aquatic herbs; culms often spongy below. Leaves flat or involute. Inflorescence of few to many, spiciform, sessile or subsessile racemes secund on a common triquetrous rachis. Spikelets ovoid to ovate-lanceolate, turgid or more or less compressed; glumes dissimilar and unequal; the lower much smaller, turned away from the axis; lemmas dissimilar; lower similar to, but usually longer than the upper glume, margins inflexed, with or without a palea, containing a male floret; the upper elliptic, crustaceous with firm, involute margins, its palea 2-keeled, of the same texture, almost as long, containing a bisexual floret; lodicules 2; stamens 3; styles 2, free. Grain tightly enclosed in the more or less hardened lemma and palea.

Paspalidium geminatum (Forsk.) Stapf in Oliver, Fl. Trop. Afr. 9: 583, 1920; Bor, 333. *Panicum geminatum* Forsk. Fl. Aeg.-Arab. 18, 1775. *Panicum paspaloides* Pers. Syn. 1: 81, 1805; FBI. 7: 30, 1897. (Fig. 60).

An annual grass with prostrate stem floating below water and rooting at nodes. The leaves are 17.5–30 cm. long and 0.5–0.8 cm. wide. The rachis of the spikes is not produced into a sharp point. The upper glume which is nearly as long as the upper granular, smooth and shining lemma is broadly ovate and apiculate. It occurs in tanks and lakes throughout India and flowers and fruits all round the year. It forms a good fodder for cattle.

Pseudoraphis Griffith

Floating or marsh herbs, usually elongate, much branched and rooting at the lower, geniculate nodes. Leaves narrow, flat. Panicles terminal, contracted or effuse, the branchlets produced beyond the uppermost spikelet. Spikelets narrow, obscurely articulated on the short pedicels, persistent; glumes very unequal; the lower very small, thinly membranous; the upper as long as the spikelet or nearly so; lemmas smaller and rather firmer than the upper glume; the lower containing a male floret; the upper a bisexual or a female; paleas hyaline, cuneiform; lodicules 2, sometimes only 1 in female florets; stamens 3, rudimentary in female florets; styles 2, shortly united at the base. Grain linear-oblong, compressed, free within the subcoriaceous lower and the hyaline upper lemmas.

Pseudoraphis spinescens (R. Br.) Vickery in Proc. roy. Soc. Qd. 62: 69, 1952; Bor, 353. *Panicum spinescens* R. Br. Prodr. 103,

1810. *Chamaeraphis spinescens* (R. Br.) Poir. in Lamk. Encycl. 2: 189, 1811; FBI. 7: 62, 1897. (Fig. 61).

It is found rooting in shallow water and floating upon the water surface in pools, tanks and lakes. The culms are bearded at the nodes and the sessile spikelets are 4–6 mm. long. The lemma of the lower floret is acuminate-aristate. It is common in West Bengal, Bihar, Madhya Pradesh, Rajasthan, Gujarat and peninsular India and flowers and fruits throughout the year.

Leersia Sw.

Slender, perennial herbs. Leaves narrow, flat. Panicle contracted, usually flaccid. Spikelets imbricate, laterally compressed, 1-flowered. Glumes absent or reduced to an obscure, hyaline, entire or 2-lobed rim; lemma coriaceous or chartaceous, oblong, strongly 1-keeled; palea similar in texture and shape, nearly as long but narrower, 1-keeled, containing a bisexual floret; lodicules 2; stamens usually 6, sometimes 3 or fewer; styles 2, free. Grain oblong, compressed, free within the lemma and palea.

Leersia hexandra Sw. Prod. Veg. Ind. Occ. 21, 1788; FBI. 7: 94, 1897; Bor, 599, f. 68. (Fig. 62).

It occurs in tanks, lakes and marshes throughout India and up to an altitude of 2,100 m. The culms are up to 1.2 m. high and the leaves are usually 7.5–20.0 cm. long. The panicle is 5–12.5 cm. long and the spikelets, which are closely imbricate and 2.5–3.5(4) mm. long, are oblong, plano-convex and smooth on the sides. The lemma is obliquely oblong and the keels of lemma and palea are bristle-ciliate. This grass is very much liked by cattle. It flowers and fruits throughout the year.

Hygroryza Nees

Glabrous, floating herbs; culms spongy below, producing capillary roots at the nodes. Panicles short, broad; spikelets narrowly ciliate, 1-flowered, articulate on their pedicels but deciduous during late development. Glumes absent; lemma thinly chartaceous, narrowed into an awn; palea similar but narrower, awnless, containing a bisexual floret; lodicules 2, gibbous; stamens 6, anthers long, slender; styles 2, free. Grain narrowly oblong, free within the lemma and palea.

Hygroryza aristata (Retz.) Nees ex Wt. & Arn. in Edinb. New Phil. J. 15: 380, 1833; FBI. 7: 95, 1897; Bor, 597, f. 67. *Pharus aristatus* Retz. Obs. Bot. 5: 23, 1789. (Fig. 63).

This taxon is common in tanks, lakes and slow-moving streams in most of the states of India and forms floating masses of considerable extent. The floating culms measure 30 cm. or more and the erect branches are 5–20 cm. high. The leaves are subcoriaceous, ovate to narrowly ovate-oblong, base cordate, with inflated sheaths, 2.5–7.8 cm. long and 0.5–1.7 cm. wide. The panicles are 2.5–5 cm. long with few hermaphrodite, long-pedicelled spikelets. The glumes are absent and there is a single floret. The lemma is narrowly lanceolate, 0.6–0.7 mm. long, strongly 5-nerved and awned which in turn is 0.7–1.4 cm. long and scabrid. This grass is relished by cattle and the grains are said to be eaten by the poor people. The seeds are used as a cooling agent, an astringent to urinary tract and in biliousness (Chopra *et al.*, 1956). It flowers and fruits from October to April.

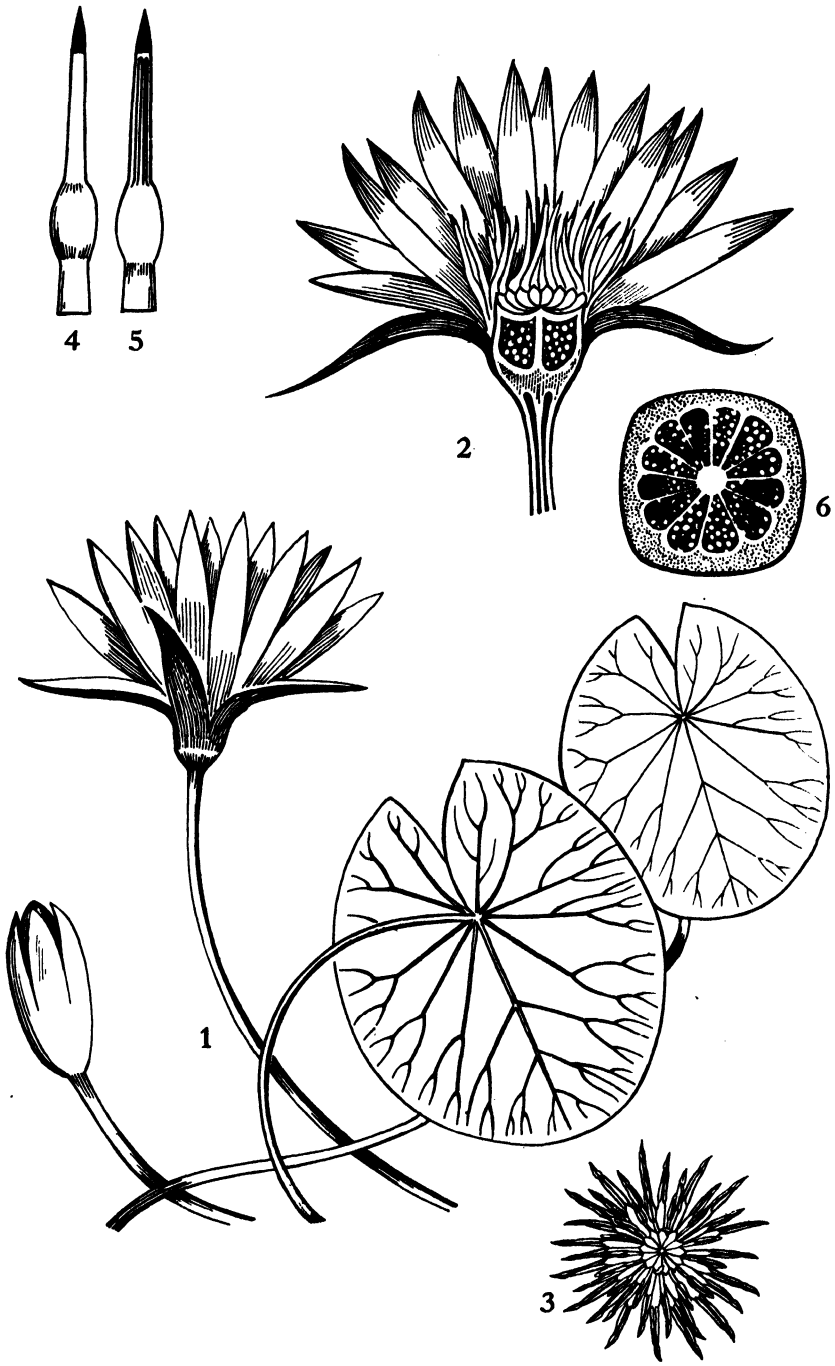


FIG. 1—*Nymphaea stellata* : 1, Leaves, bud and flower. 2, L.s. flower. 3, Top view of stamens and stigmatic lobes. 4 & 5, Stamens. 6, T.s. ovary

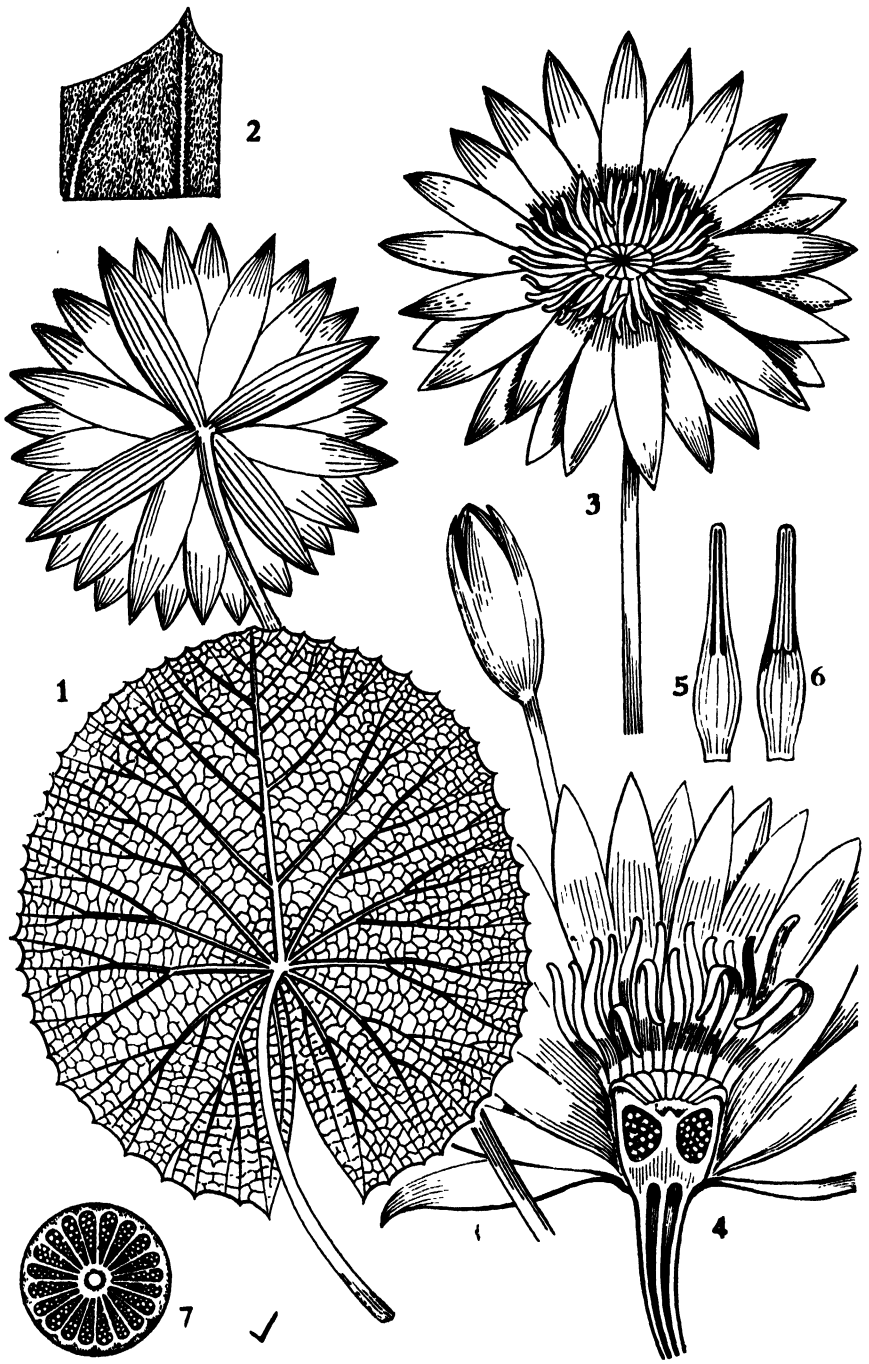


FIG. 2—*Nymphaea nouchali* : 1, Leaf and flower. 2, Portion of under surface of leaf showing pubescence. 3, Flower. 4, L.s. flower. 5 & 6, Stamens. 7, T.s. ovary

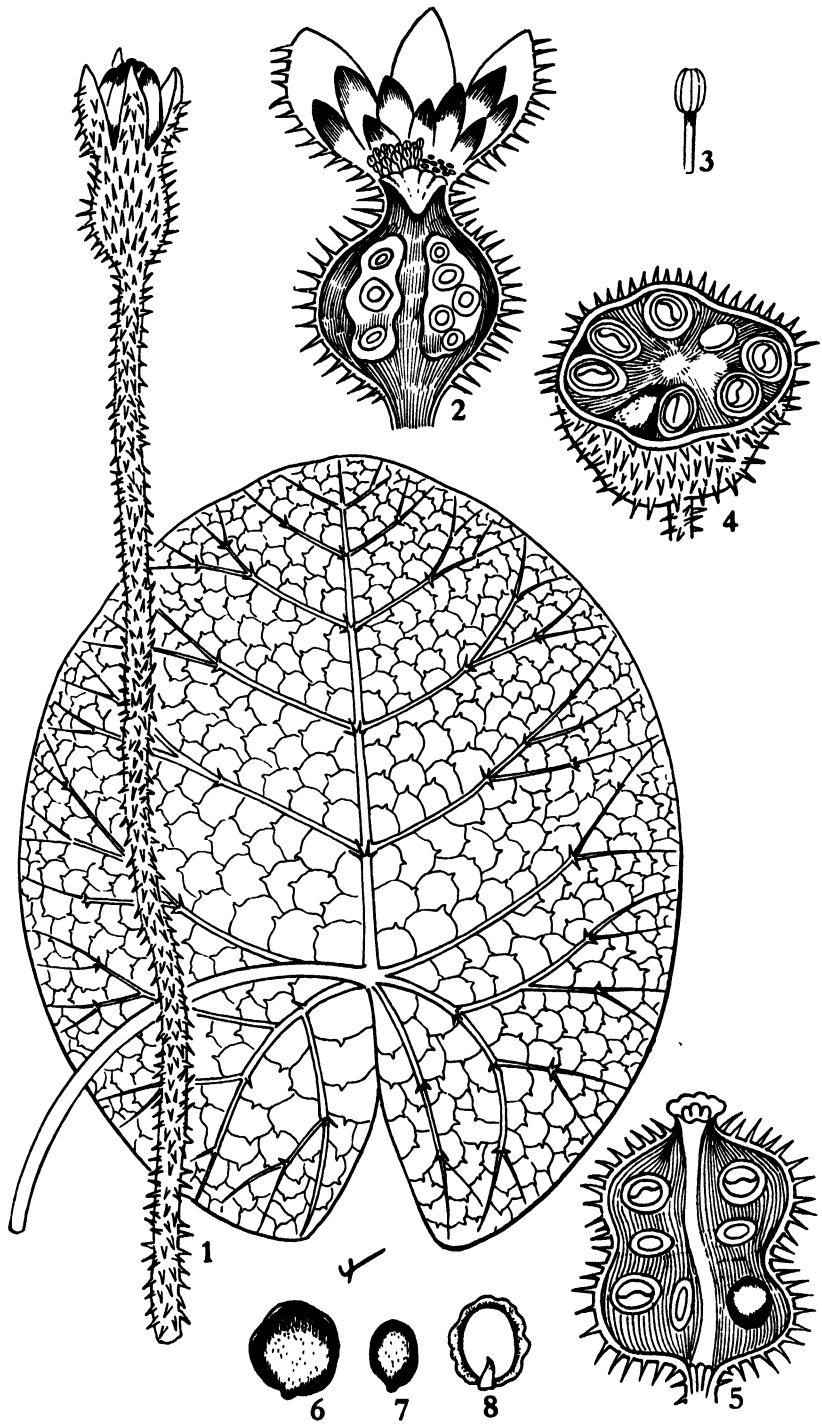


FIG. 3—*Euryale ferox* : 1, Leaf and flower. 2, L.s. flower. 3, Stamen. 4, T.s. fruit. 5, L.s. fruit. 6, 7 & 8, Seeds



FIG. 4—*Nelumbo nucifera* : 1, Leaves, bud and flower. 2, L.s. flower. 3 & 4, Stamens. 5, Turbinate torus. 6, L.s. torus. 7, Carpel. 8, L.s. carpel



FIG. 5—*Nasturtium officinale*: 1, Portion of plant. 2, Inflorescence and fruits. 3, Flower with one petal removed



FIG. 6—*Bergia capensis*: 1, Plant. 2, Portion of stem. 3, Leaf. 4, Flower. 5, L.s. flower. 6, Pistil

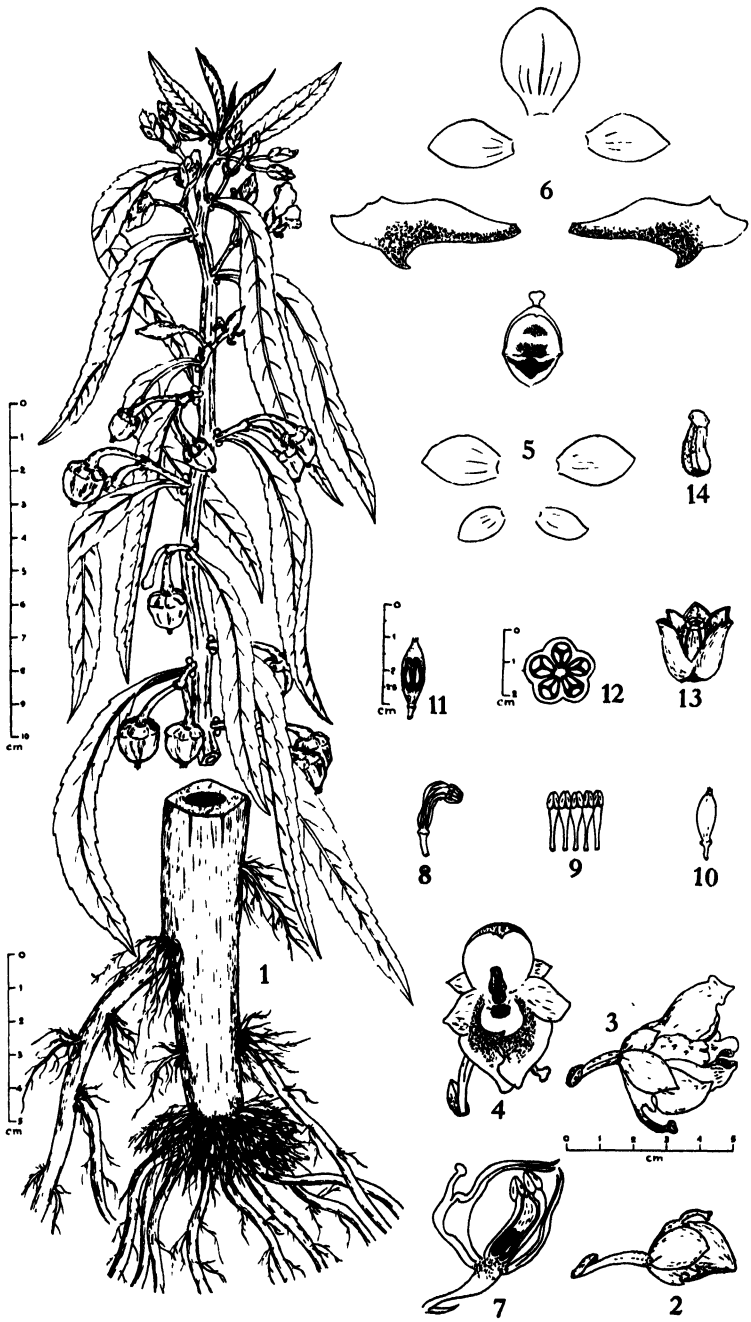


FIG. 7—*Hydrocera triflora* : 1, Basal portion and flowering shoot. 2, Flower bud. 3 & 4, Two views of flowers. 5, Sepals. 6, Petals. 7, L.s. flower. 8 & 9, Arrangement of stamens. 10, Pistil. 11, L.s. pistil. 12, T.s. ovary. 13, Dehiscing fruit. 14, Seed

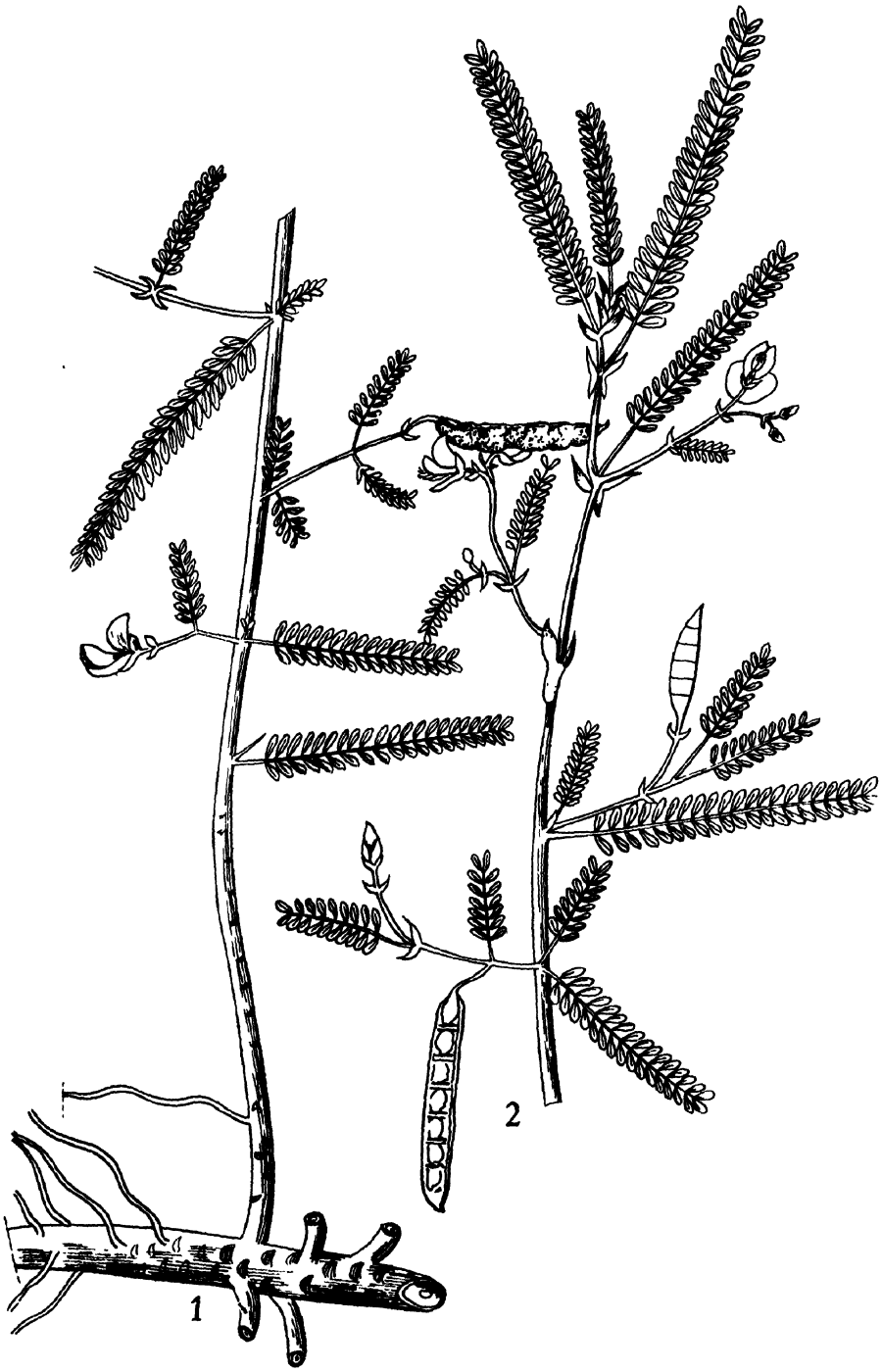


FIG. 8—*Aeschynomene indica* : 1, Basal portion of plant. 2, Twig with flowers and fruits

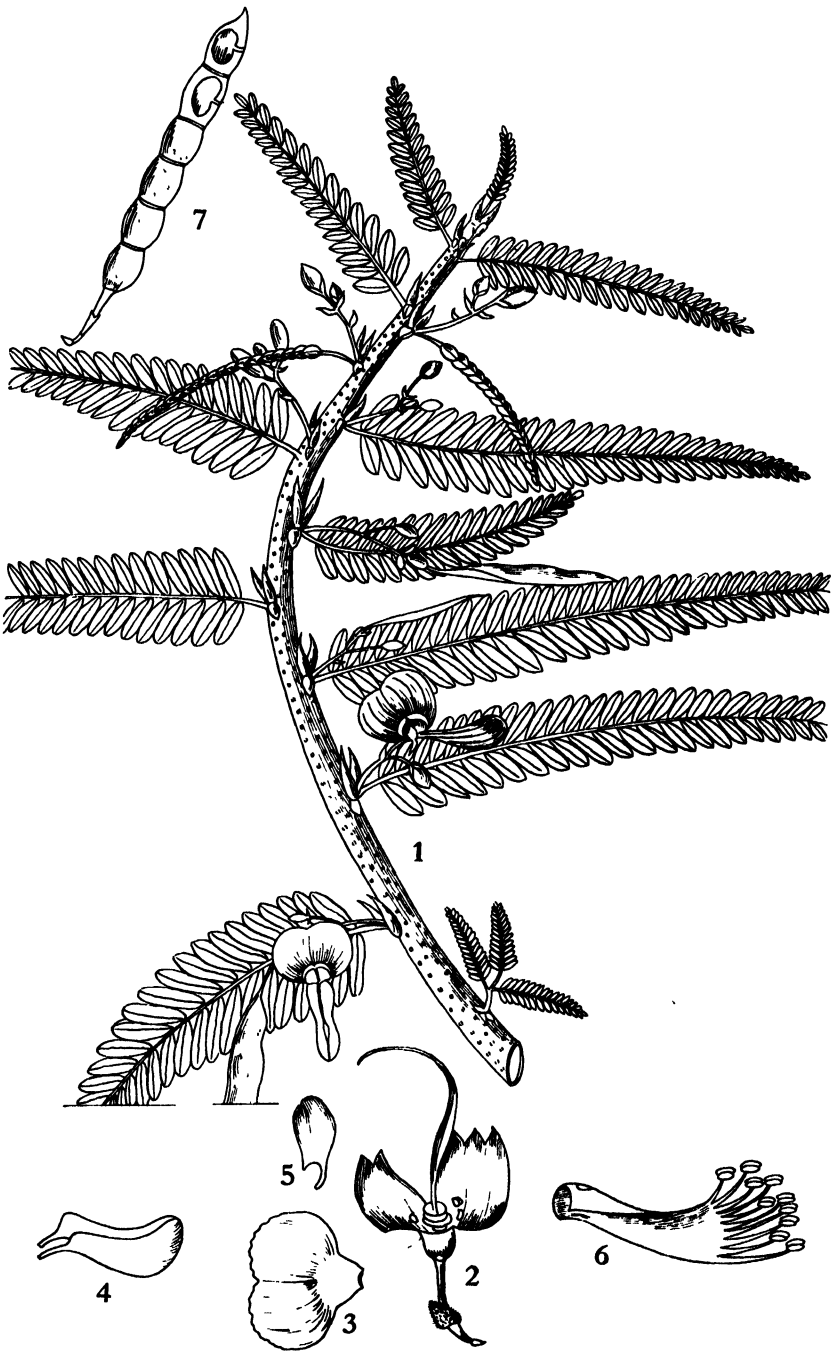


FIG. 9—*Aeschynomene aspera* : 1, Flowering shoot. 2 & 3, Flower with standard petal removed. 4, Wing petals. 5, Keel petal. 6, Stamens. 7, Legume

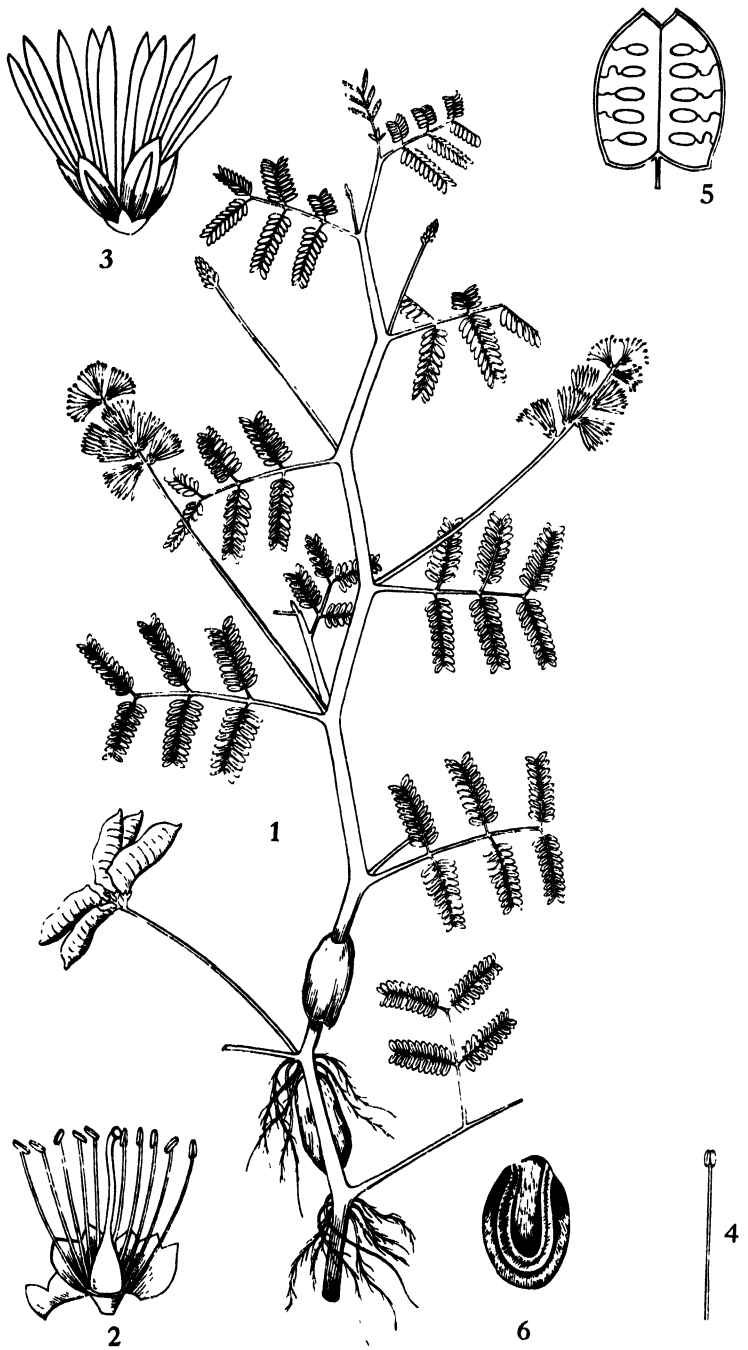


FIG. 10—*Neptunia oleracea* : 1, Flowering shoot. 2, Hermaphrodite flower. 3, Neuter flower with flattened staminodes. 4, Stamen. 5, Fruit opened along ventral suture. 6, Seed

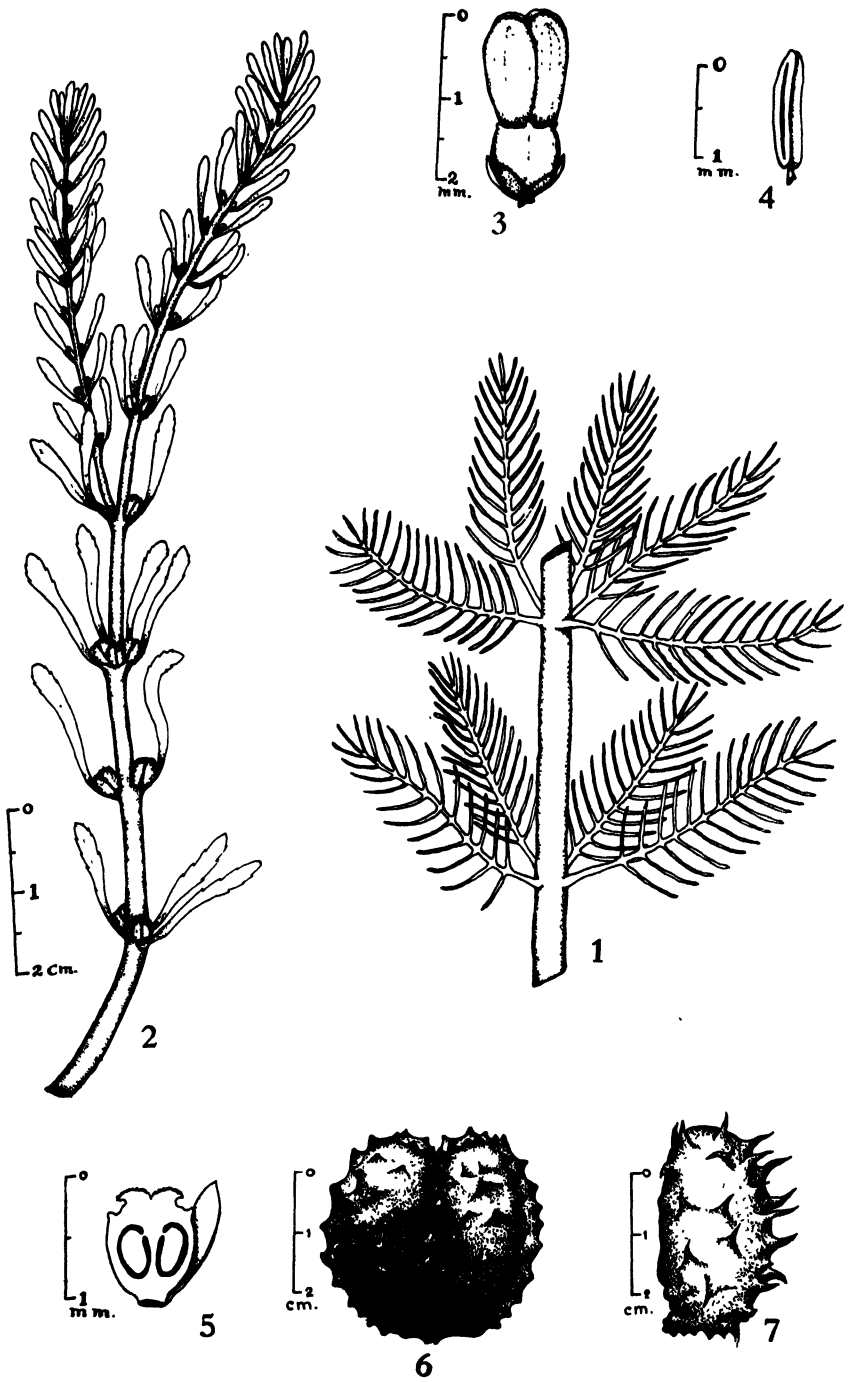


FIG. 11—*Myriophyllum spathulatum* : 1 & 2, Submerged and emerged portions of plant. 3, Flower. 4, Stamen. 5, L.s. pistil. 6, Dry fruit. 7, Seed

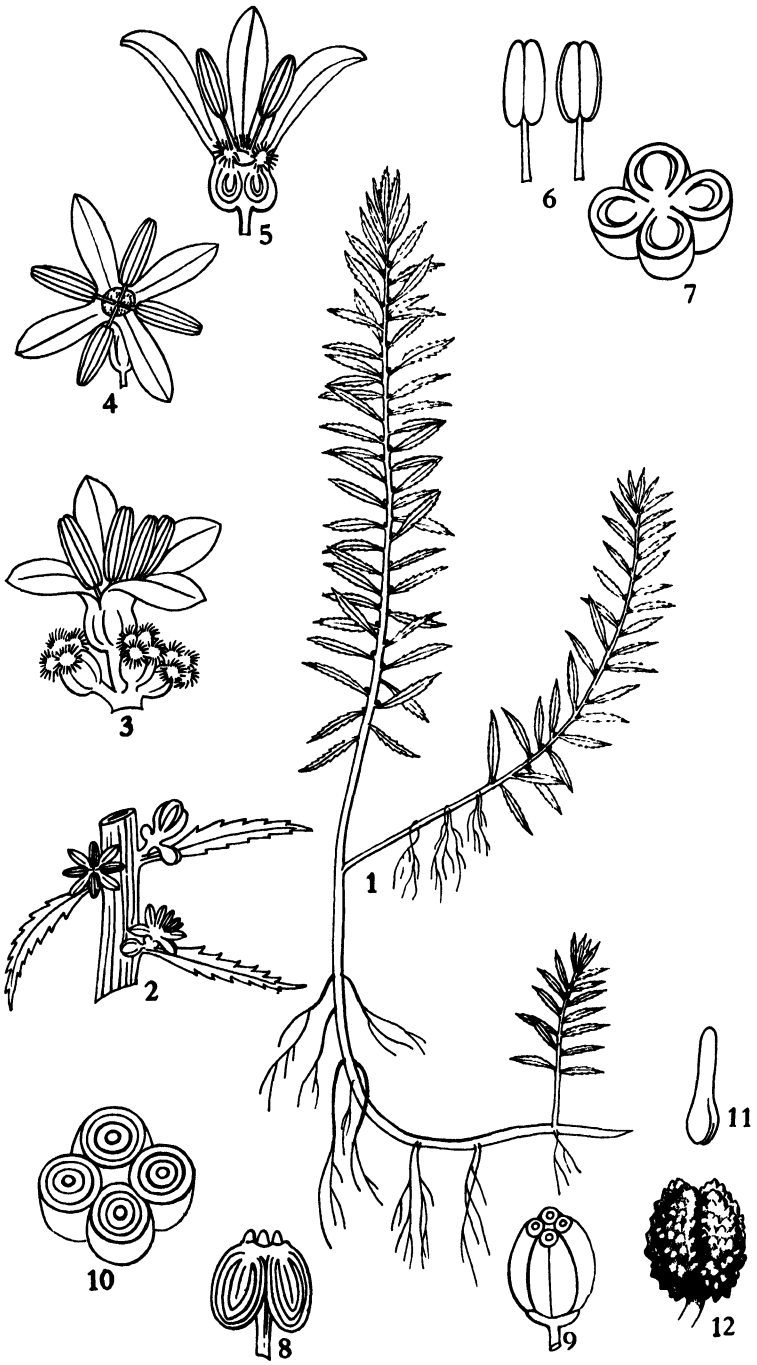


FIG. 12—*Myriophyllum intermedium*: 1, Plant. 2, Portion of plant. 3, Flower and fruits. 4, Flower. 5, L.s. flower. 6, Stamens. 7, T.s. ovary. 8, L.s. fruit. 9, Fruit. 10, T.s. fruit. 11, Embryo. 12, Dry fruit

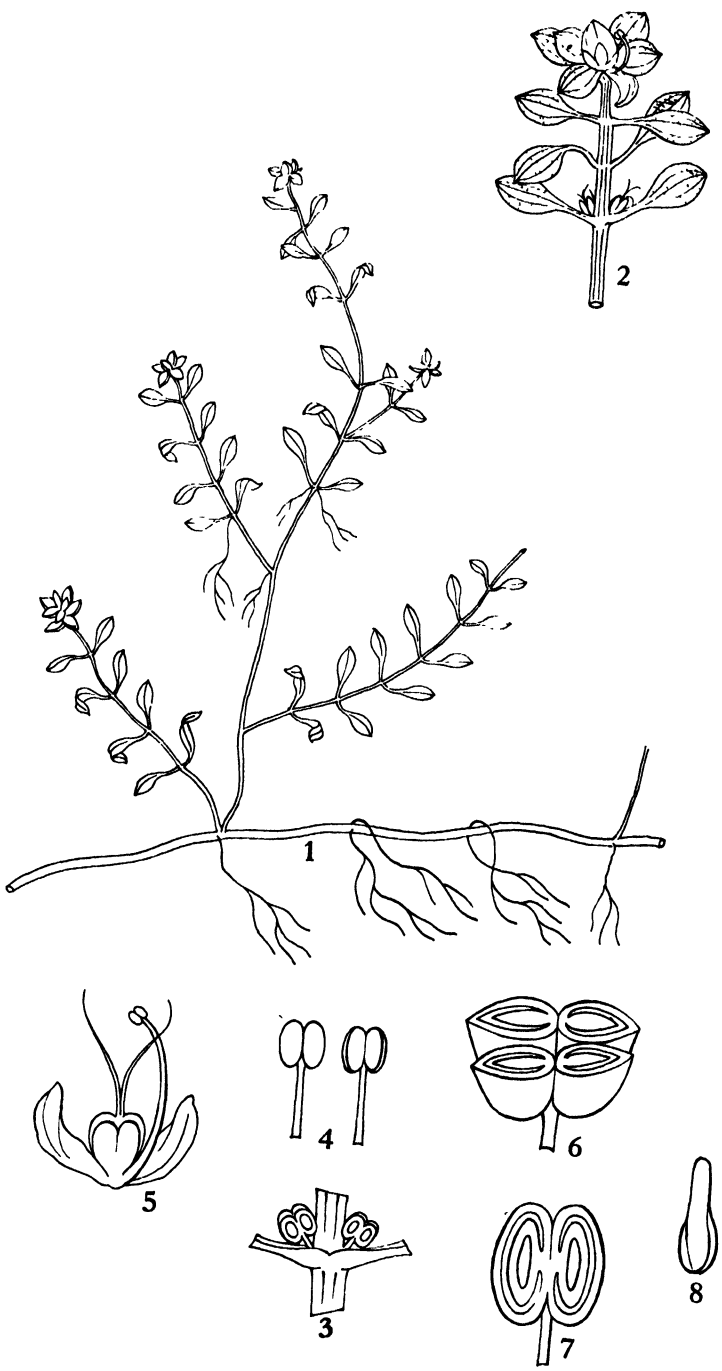


FIG. 13—*Callitriche stagnalis*: 1, Portion of plant. 2, Portion of branch enlarged. 3, Fruits at a node. 4, Stamens. 5, Flower. 6, T.s. fruit. 7, L.s. fruit. 8, Embryo

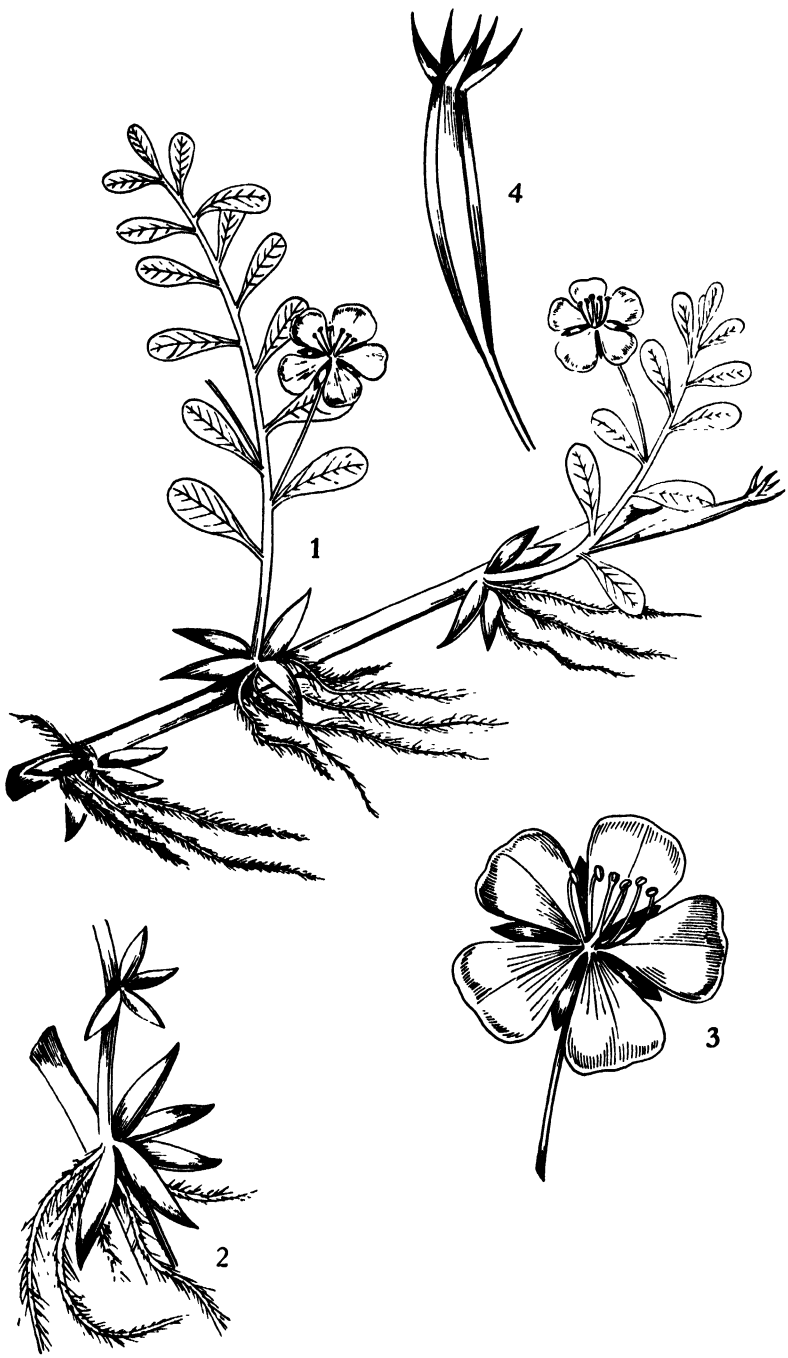


FIG. 14—*Jussiaea repens*: 1, Portion of shoot. 2, Portion of stem enlarged showing spongy breathing roots. 3, Flower. 4, Fruit

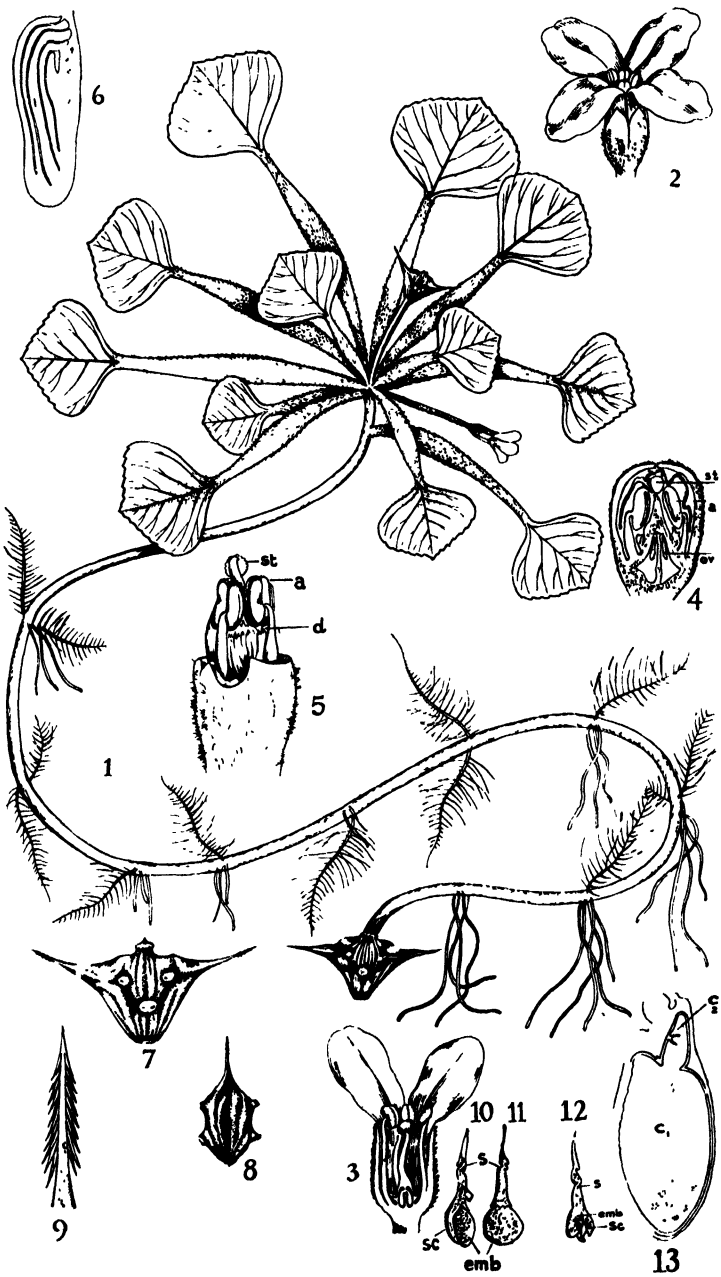


FIG. 15—*Trapa bispinosa* : 1, Plant. 2, Flower. 3, L.s. flower. 4, L.s. flower bud. 5, Flower bud with calyx and corolla removed ; dotted lines represent position of ovules. 6, L.s. anatropous ovule. 7 & 8, Fruits. 9, Upper portion of spine showing barbs. 10, 11 & 12, Embryos (emb) showing suspensor (s) and suspensor collar (sc). 13, L.s. seed showing the large embryo and the extremely unequal cotyledons (c_1 & c_2). a, Anther ; d, Disc ; ov, Ovule ; st, Stamen

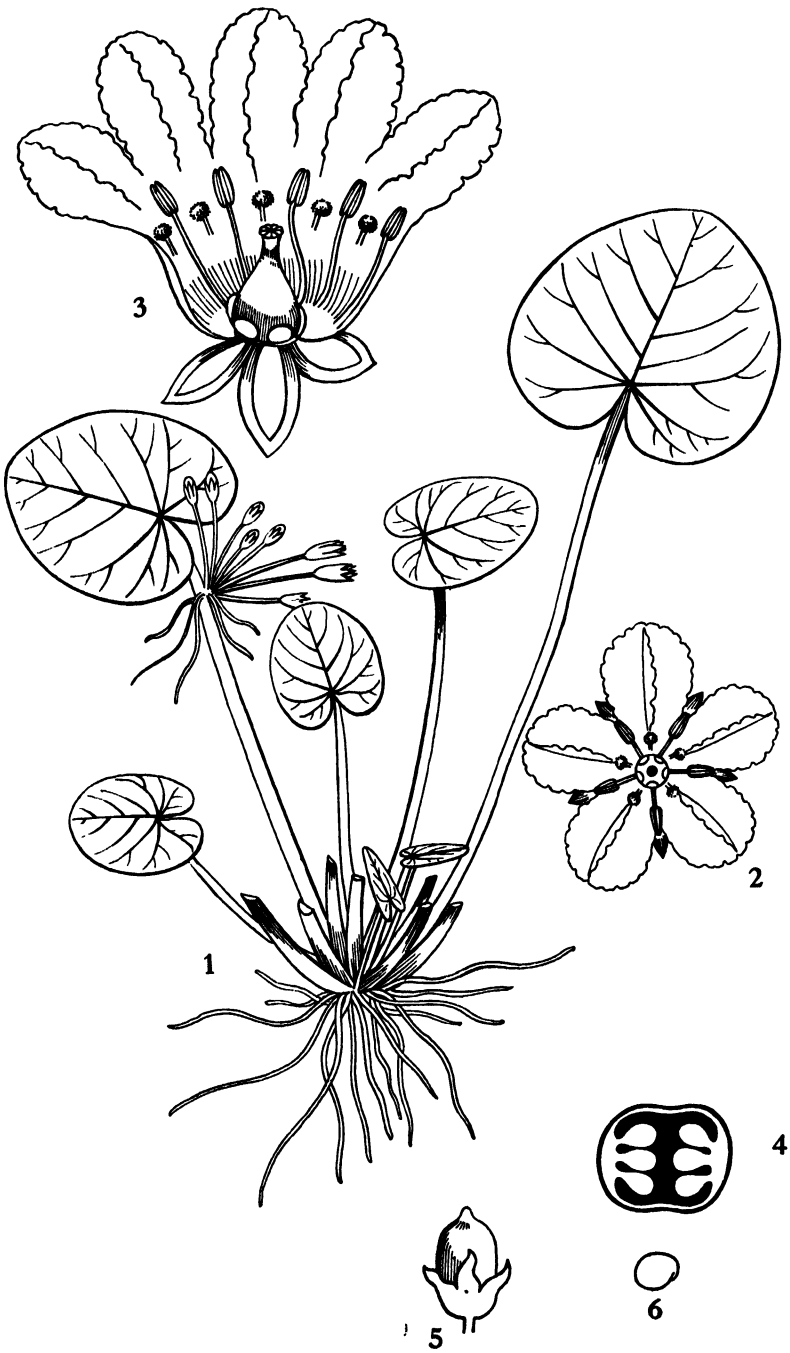


FIG. 16—*Nymphoides cristatum* : 1, Plant. 2, Top view of flower. 3, Flower with corolla opened. 4, T.s. ovary. 5, Fruit. 6, Seed

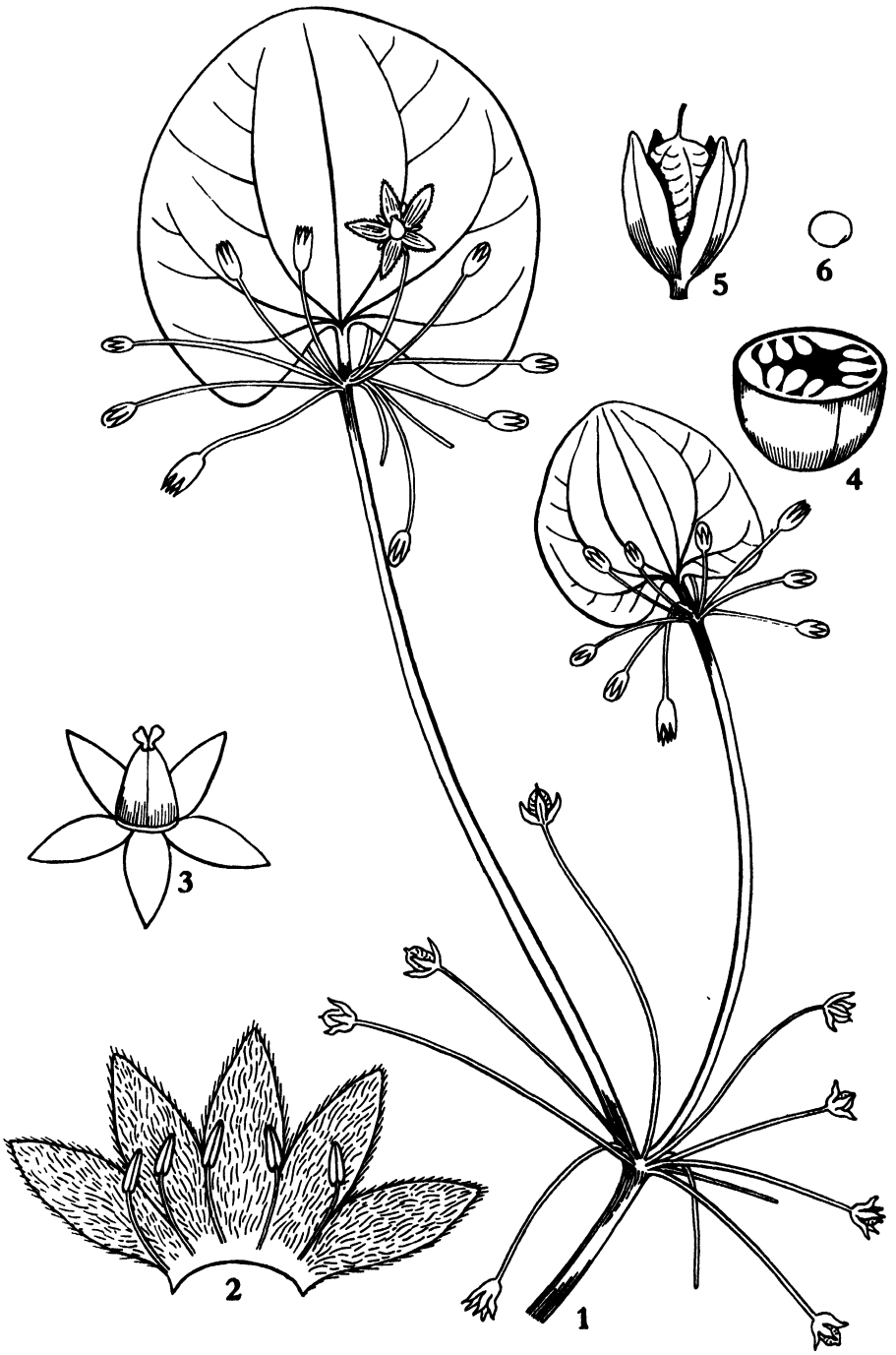


FIG. 17—*Nymphoides indicum* : 1, Portion of plant. 2, Corolla opened. 3, Pistil and persistent calyx. 4, T.s. ovary. 5, Fruit. 6, Seed



FIG. 18—*Hydrolea zeylanica*: 1, Portion of plant. 2 & 3, Flowers. 4, Pistil with persistent calyx. 5, T.s. ovary

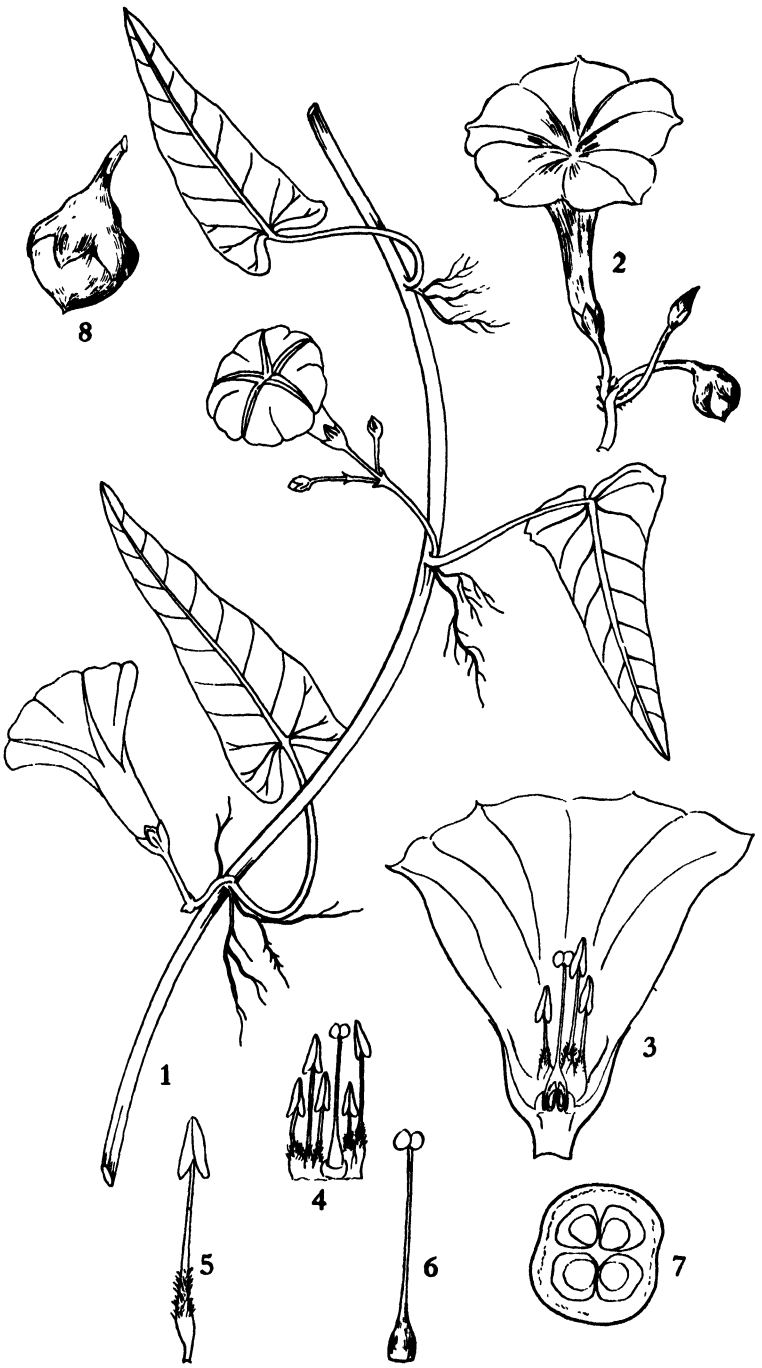


FIG. 19—*Ipomoea aquatica* : 1, Portion of plant. 2, Flower and buds. 3, L.s. flower. 4, Stamens of different lengths and pistil. 5, Stamen. 6, Pistil. 7, T.s. ovary. 8, Fruit

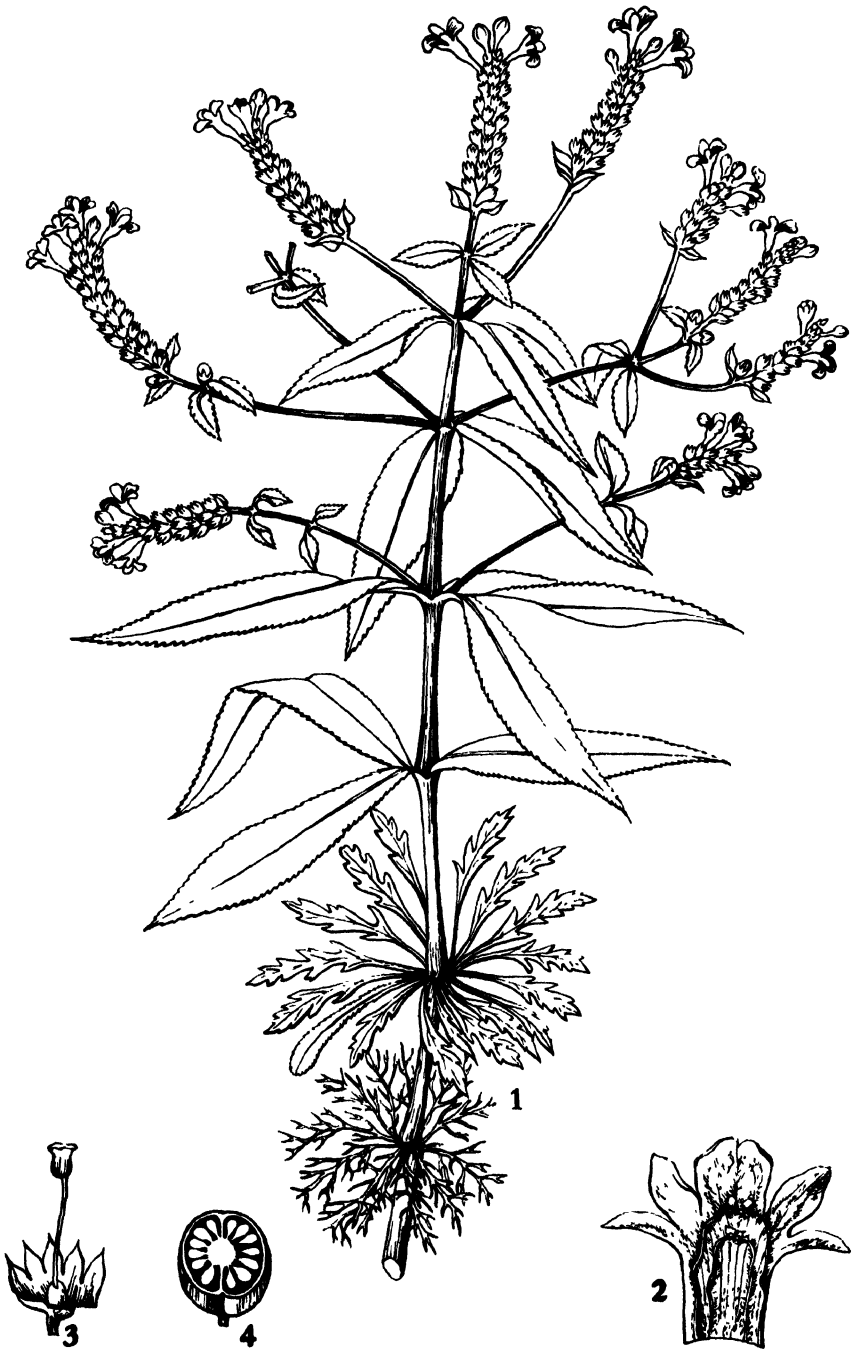


FIG. 20 –*Limnophila aquatica* : 1, Portion of plant. 2, Corolla opened to show stamens. 3, Pistil and calyx. 4, T.s. ovary

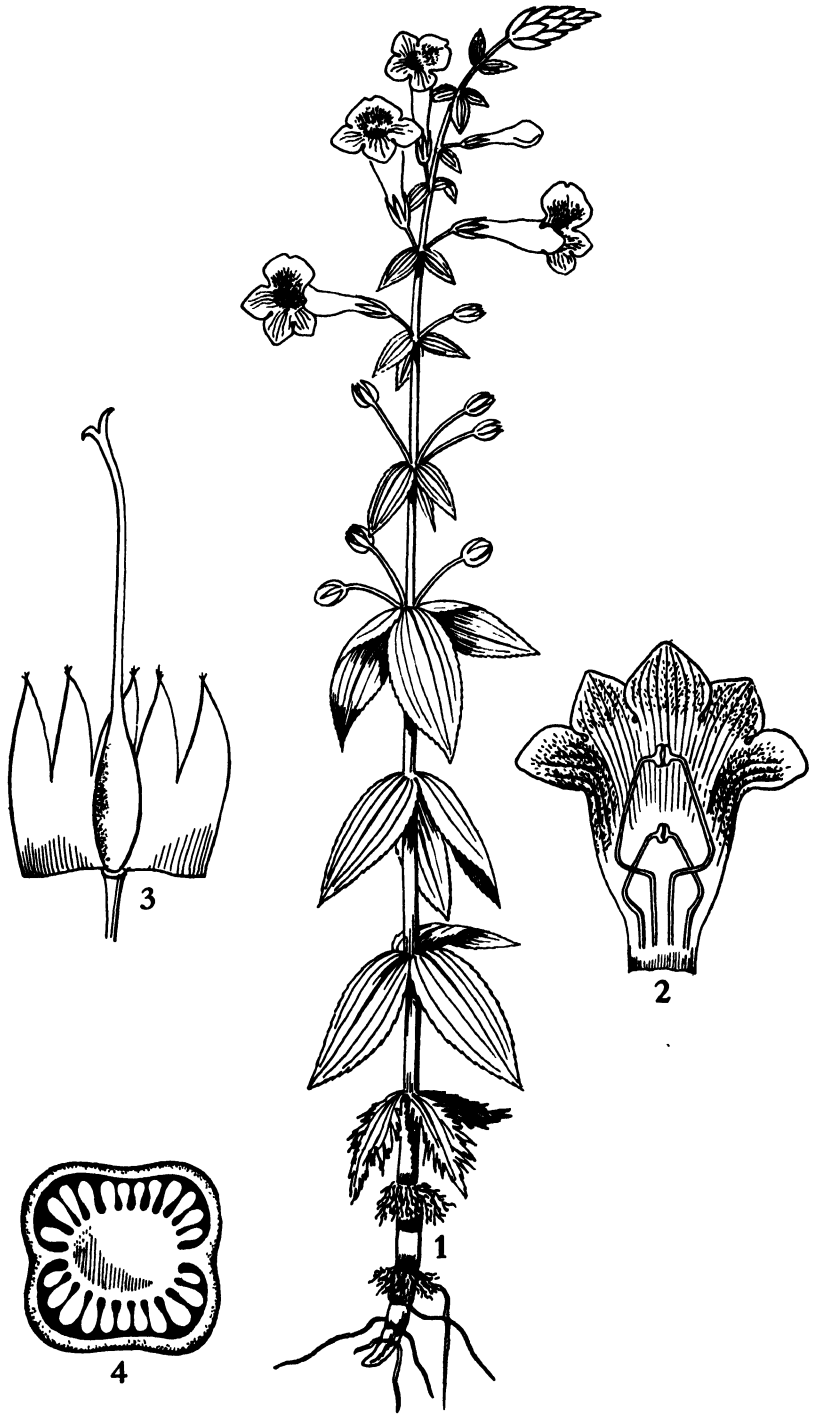


FIG. 21—*Limnophila indica* : 1, Plant. 2, Corolla opened to show stamens. 3, Pistil and calyx. 4, T.s. ovary



FIG. 22—*Dopatrium lobelioides*: 1, Plant. 2, Lower portion of plant enlarged. 3, Corolla opened to show stamens. 4, Stamen. 5, Pistil. 6, T.s. ovary. 7, Fruit

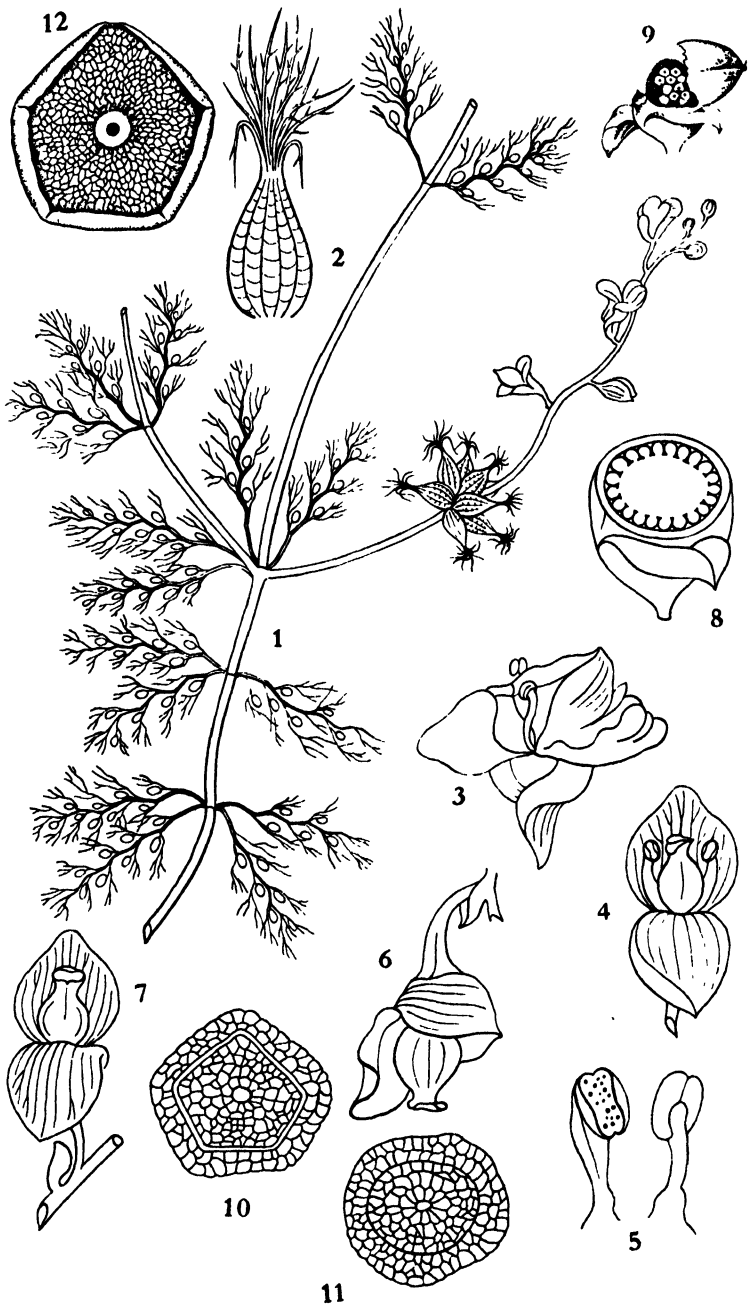


FIG. 23—*Utricularia stellaris :* 1, Part of plant showing bladders, leaf segments and whorl of spongy floats below the inflorescence. 2, Float with filiform pinnules. 3 & 4, Flowers. 5, Stamens. 6 & 7, Fruit with persistent calyx. 8, T.s. ovary. 9, Pyxidium. 10, 11 & 12, Tabular prismatic seeds

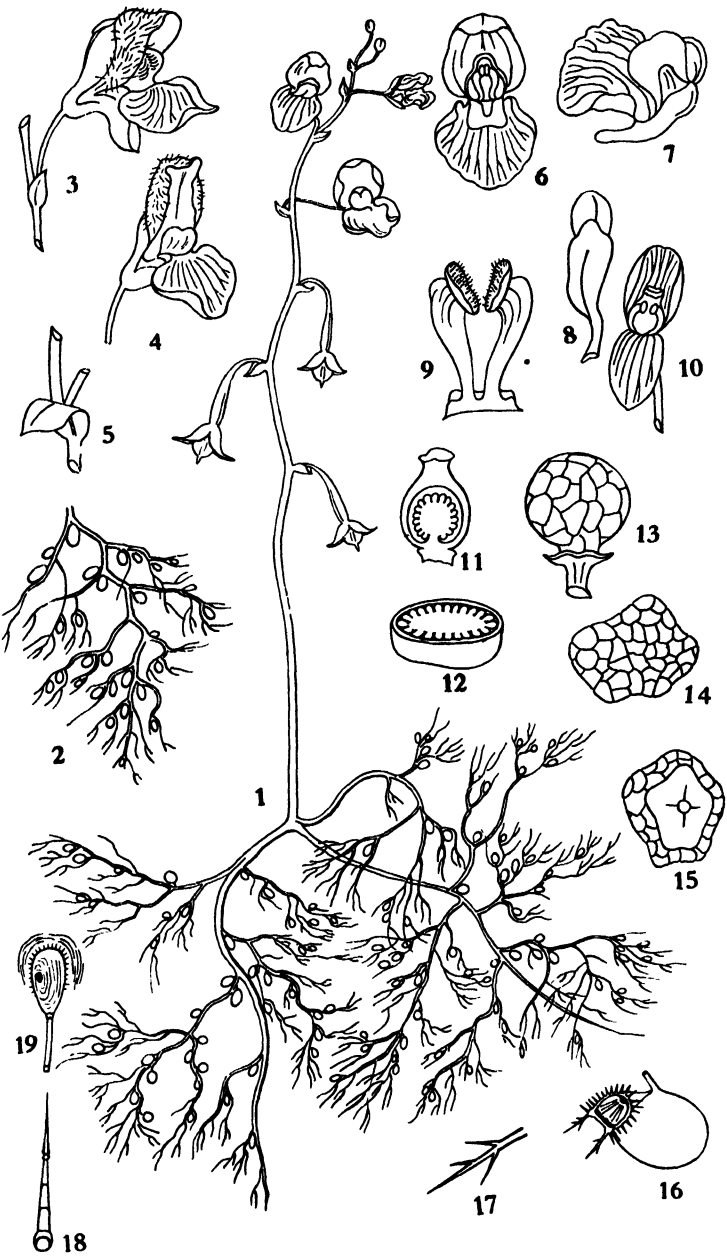


FIG. 24—*Utricularia flexuosa* : 1, Plant showing bladders, flowers and fruits. 2, Capillary leaves and bladders. 3 & 4, Flowers. 5, Scale leaf on inflorescence axis. 6 & 7, Views of corolla. 8 & 9, Stamens. 10, Stamens and pistil. 11, L.s. pistil. 12, T.s. ovary. 13, Arrangement of seeds on free central placenta. 14 & 15, Prismatic seeds. 16, Bladder. 17, Branched hair or antenna. 18, An irritable hair jointed at the short cell. 19, Secretory hair

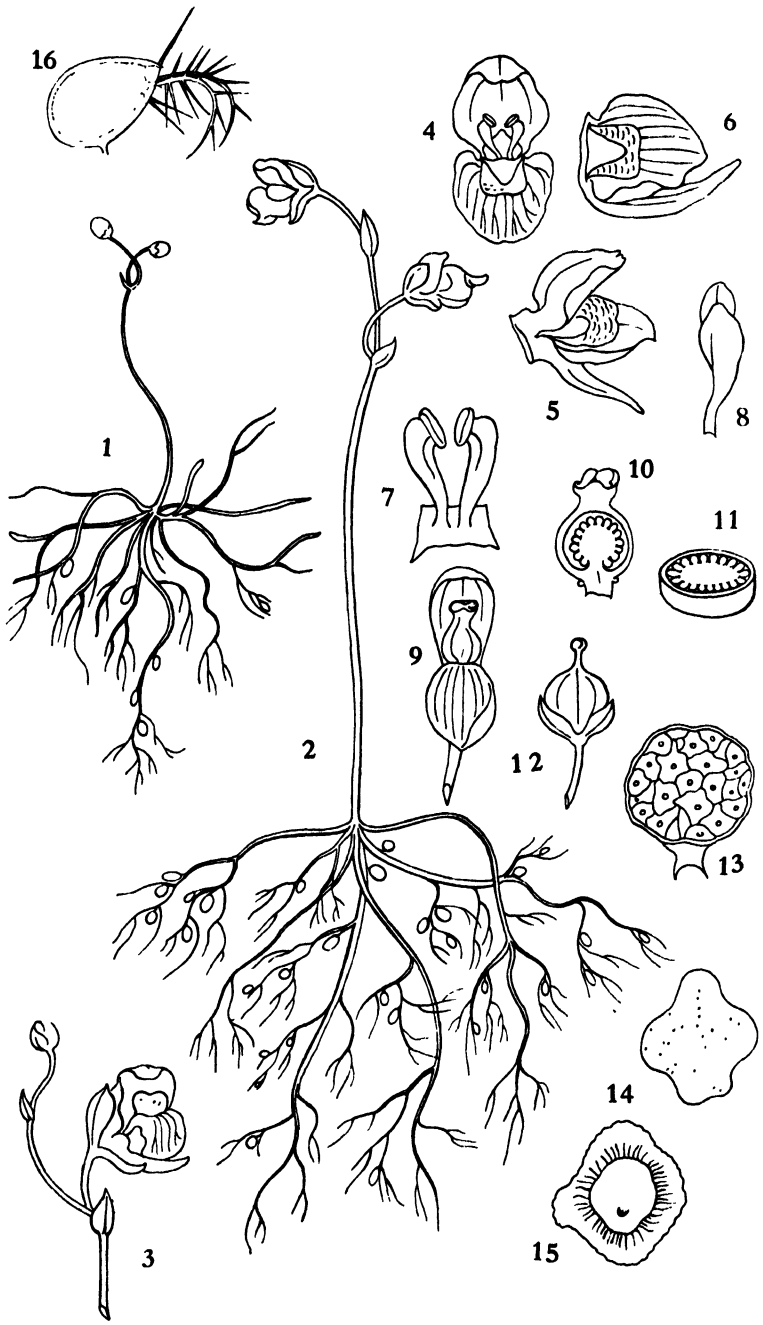


FIG. 25—*Utricularia exoleta*: 1 & 2, Plants showing bladders and flowers. 3, Bud and flower. 4, 5 & 6, Views of corolla. 7 & 8, Stamens. 9, Pistil and persistent calyx. 10, L.s. pistil. 11, T.s. ovary. 12, Fruit. 13, Seeds on free central placenta. 14 & 15, Lenticular seed with corky wing. 16, Bladder

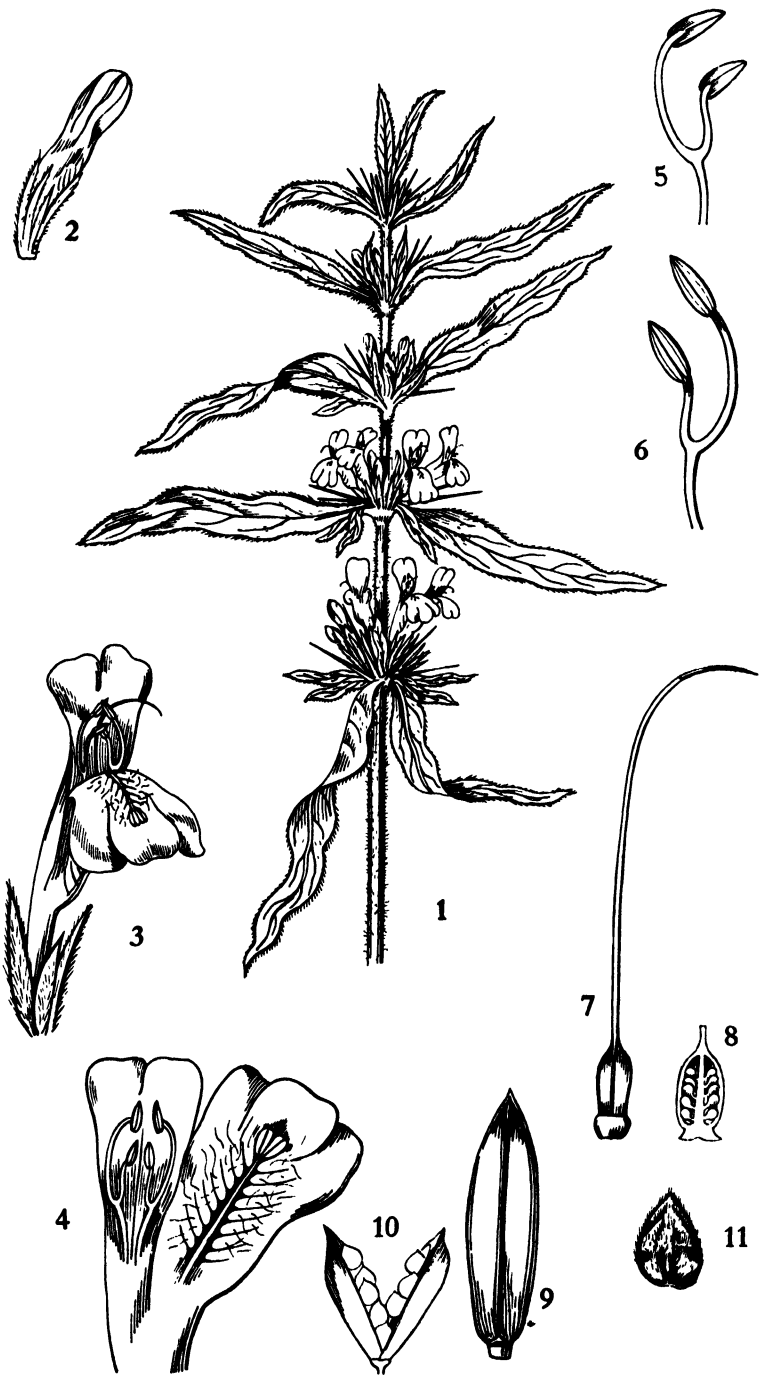


FIG. 26—*Asteracantha longifolia* : 1, Portion of plant. 2, Bud. 3, Flower. 4, Corolla opened. 5 & 6, Stamens. 7, Pistil. 8, L.s. ovary. 9, Capsule. 10, Dehiscing capsule. 11, Seed

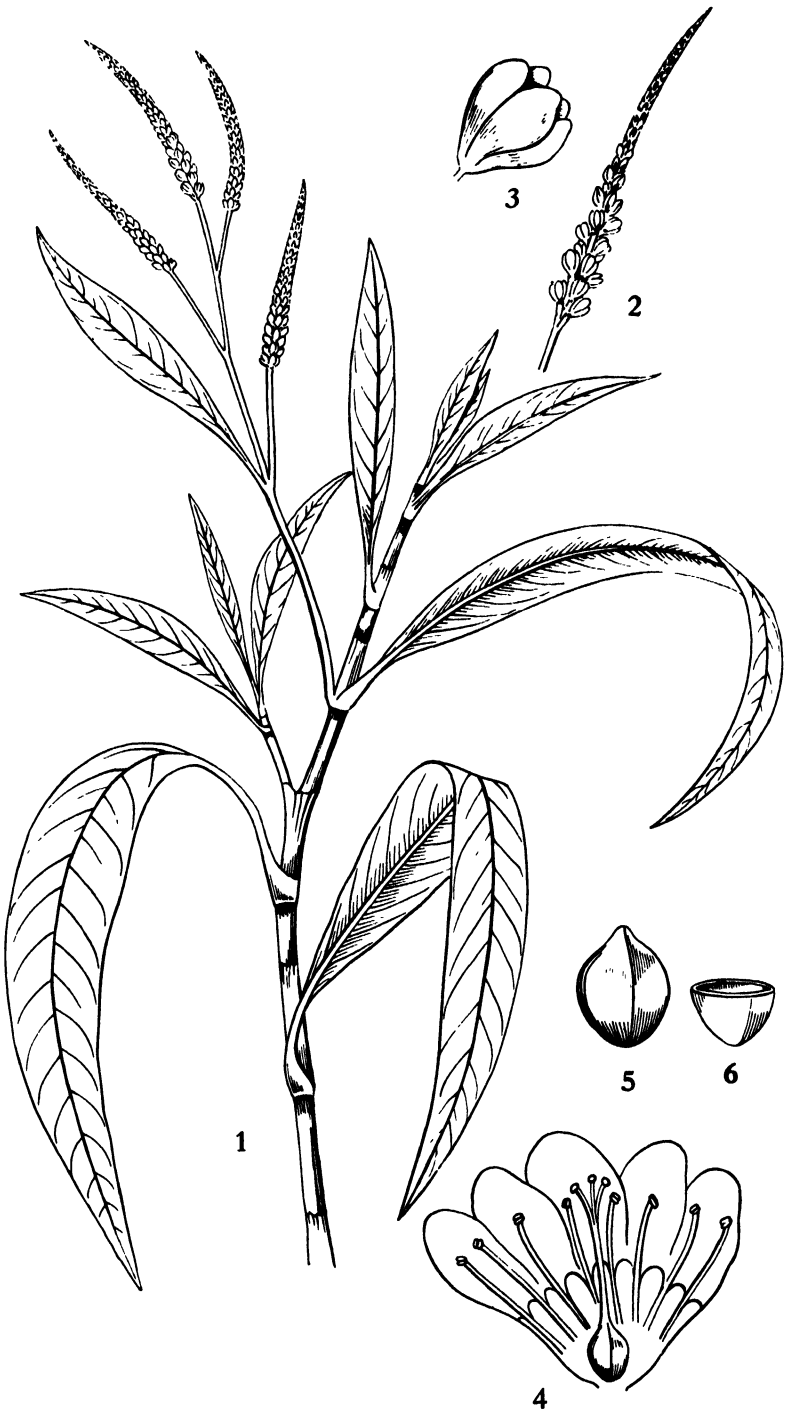


FIG. 27—*Polygonum glabrum*: 1, Portion of plant. 2, Inflorescence. 3, Flower. 4, Corolla opened. 5, Nutlet. 6, T.s. nutlet



FIG. 28—*Polygonum barbatum* : 1, Portion of plant. 2, Leaf and ocrea. 3, Inflorescence. 4 & 5, Bud and flowers. 6, Corolla opened. 7, Nutlet. 8, T.s. nutlet



FIG. 29—*Indotristicha ramosissima*: 1, Portion of plant. 2, Portion of branch enlarged. 3 & 4, Flowers. 5, Stamen. 6, Leaf. 7, Pistil. 8, T.s. ovary. 9 & 10, Seeds



FIG. 30—*Dicraea dichotoma* : 1, Plant. 2, Flower. 3, Stamen. 4, Sheathing leaves. 5, Pistil. 6, L.s. pistil. 7, T.s. ovary. 8, Seed



FIG. 31—*Dicraea stylosa* : 1, Portion of plant. 2, Leaves. 3, Flower bud. 4, 5 & 6, Young and old flowers. 7, Stamens on a common axis with staminodes on either side. 8, Stamen. 9, Pistil. 10, L.s. pistil. 11, T.s. ovary. 12, Seed. 13, Embryo

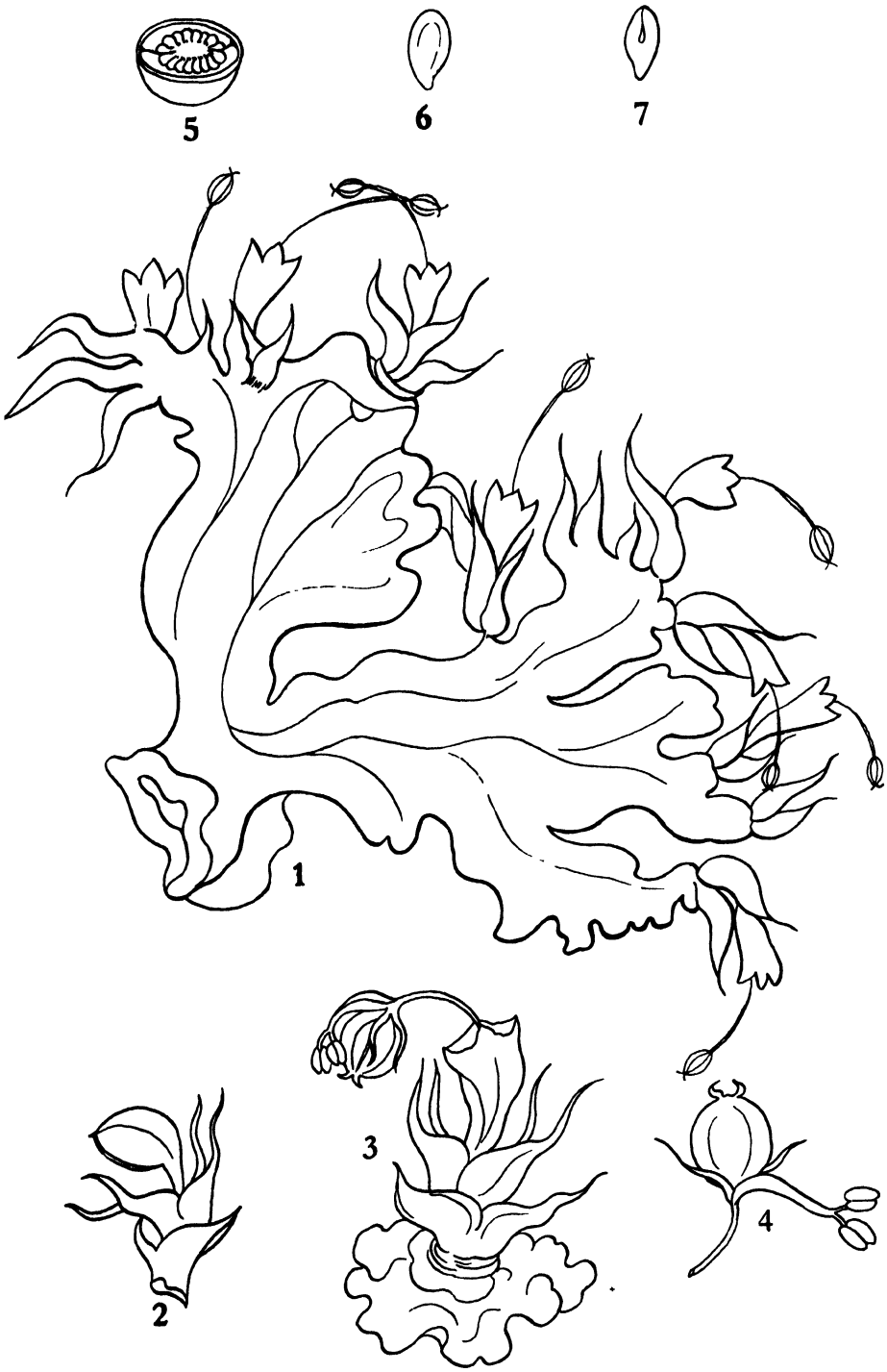


FIG. 32—*Griffithella hookeriana* : 1, Plant. 2 & 3, Portions of plant enlarged. 4, Flower. 5, T.s. ovary. 6, Seed. 7, Embryo

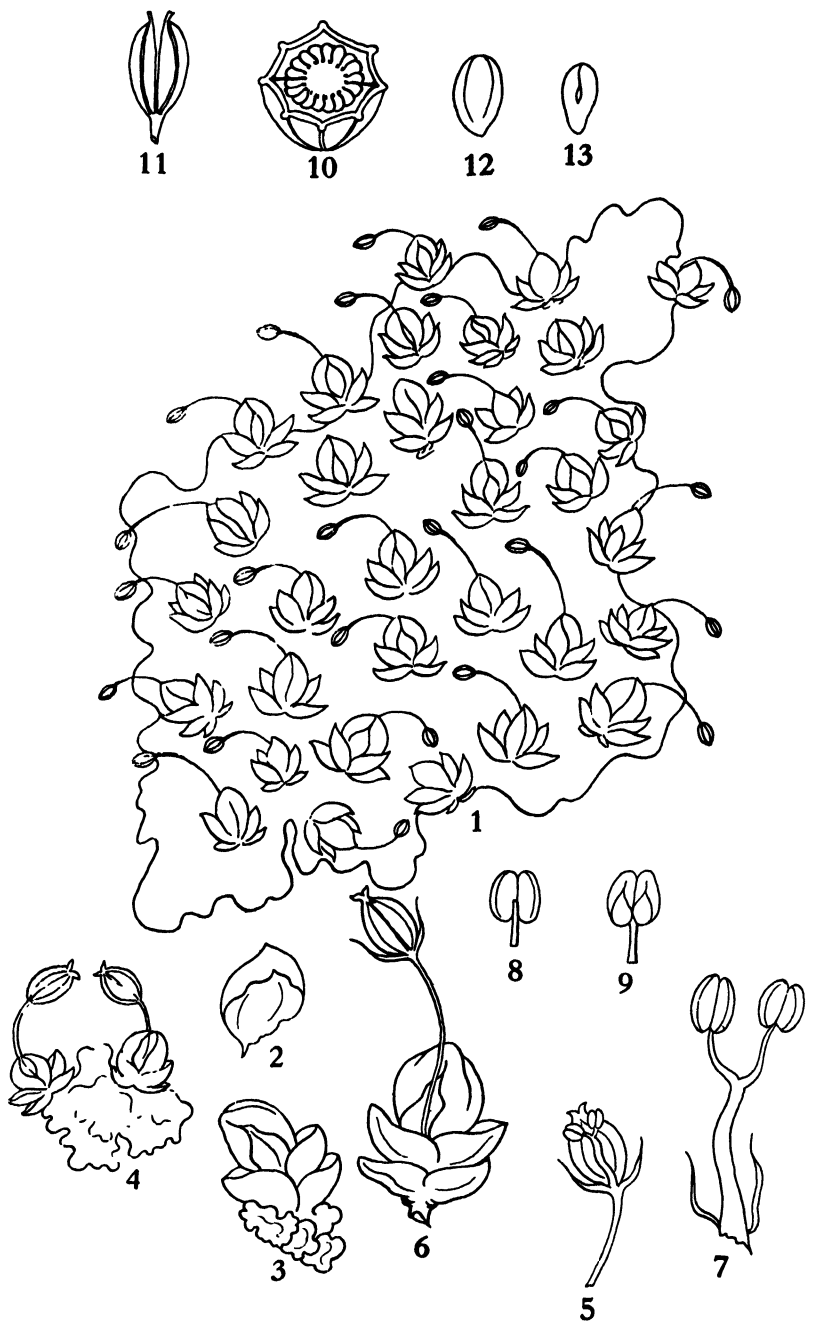


FIG. 33—*Zeylanidium olivaceum* : 1, Plant. 2, Leaf. 3, Flower bud. 4, 5 & 6, Young and old flowers. 7, Stamens on a common axis with staminodes on either side. 8 & 9, Stamens. 10, T.s. ovary. 11, Dehiscing capsule. 12, Seed. 13, Embryo

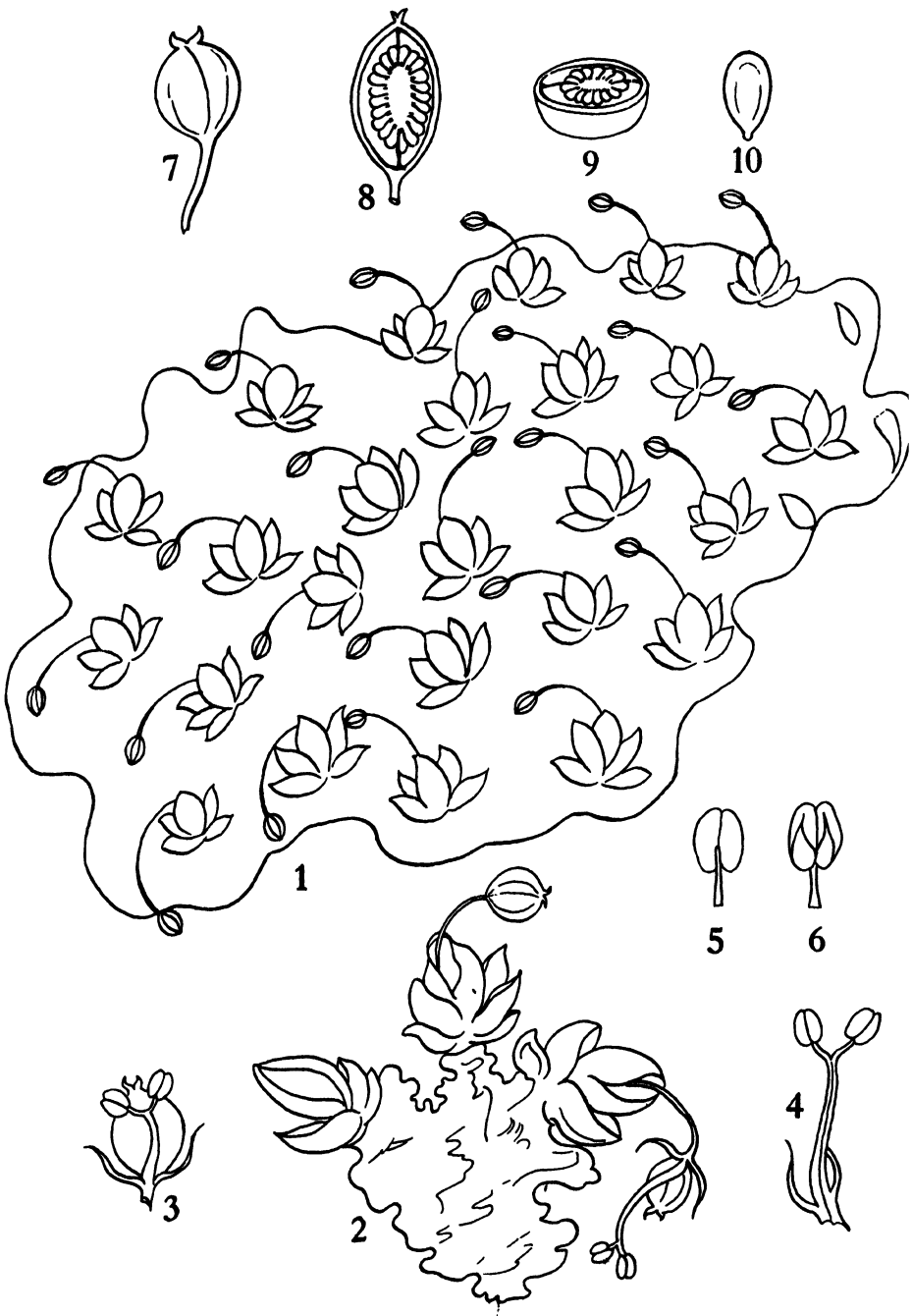


FIG. 34—*Zeylanidium johnsonii*. 1, Plant. 2, Portion of plant enlarged. 3, Flower. 4, Stamens on a common axis with staminodes on either side. 5 & 6, Stamens. 7, Pistil. 8, L.s. pistil. 9, T.s. ovary. 10, Seed



FIG. 35—*Podostemon subulatus*: 1, Portion of plant. 2, Flower. 3, Stamen. 4, Pistil. 5, L.s. pistil. 6 T.s. ovary. 7, Seed. 8, Embryo

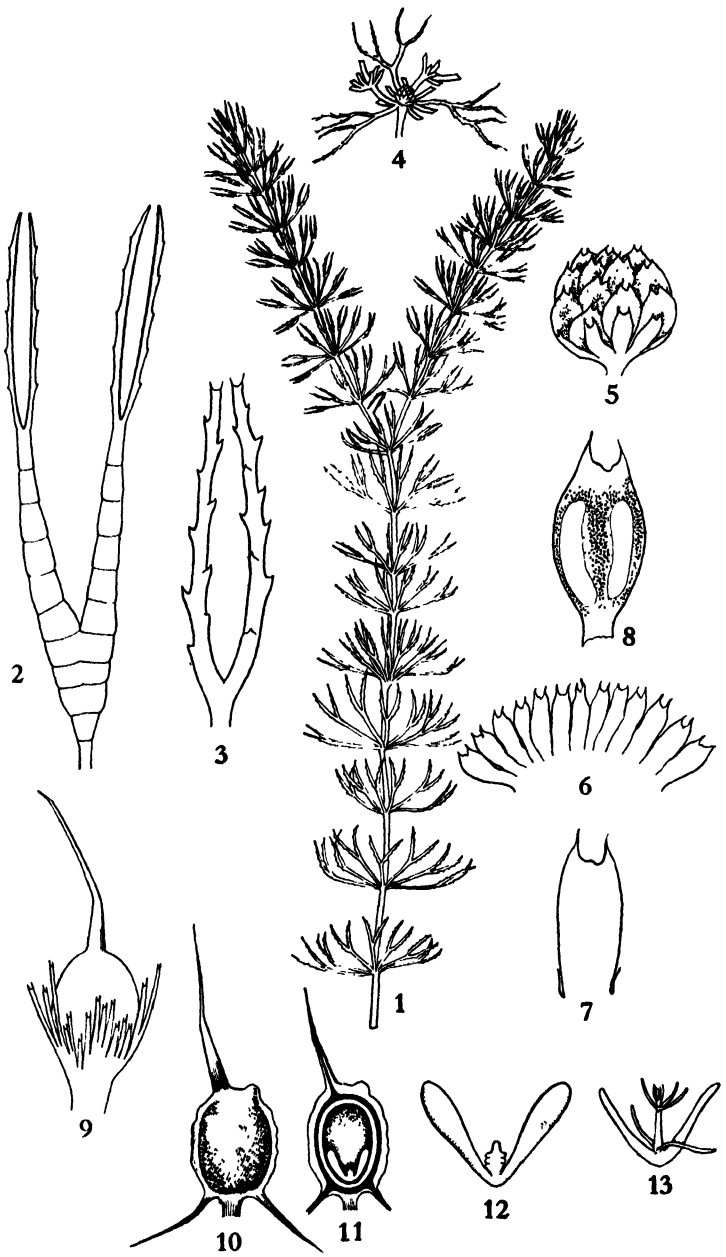


FIG. 36—*Ceratophyllum demersum* : 1, Portion of plant. 2, Leaf enlarged. 3, Upper portion of leaf enlarged. 4, Node showing position of male flower and leaves. 5, Male flower. 6, Perianth segments connate at base. 7, Perianth segment. 8, Stamen. 9, Female flower. 10, Mature achene. 11, L.s. achene. 12, Embryo. 13, Seedling

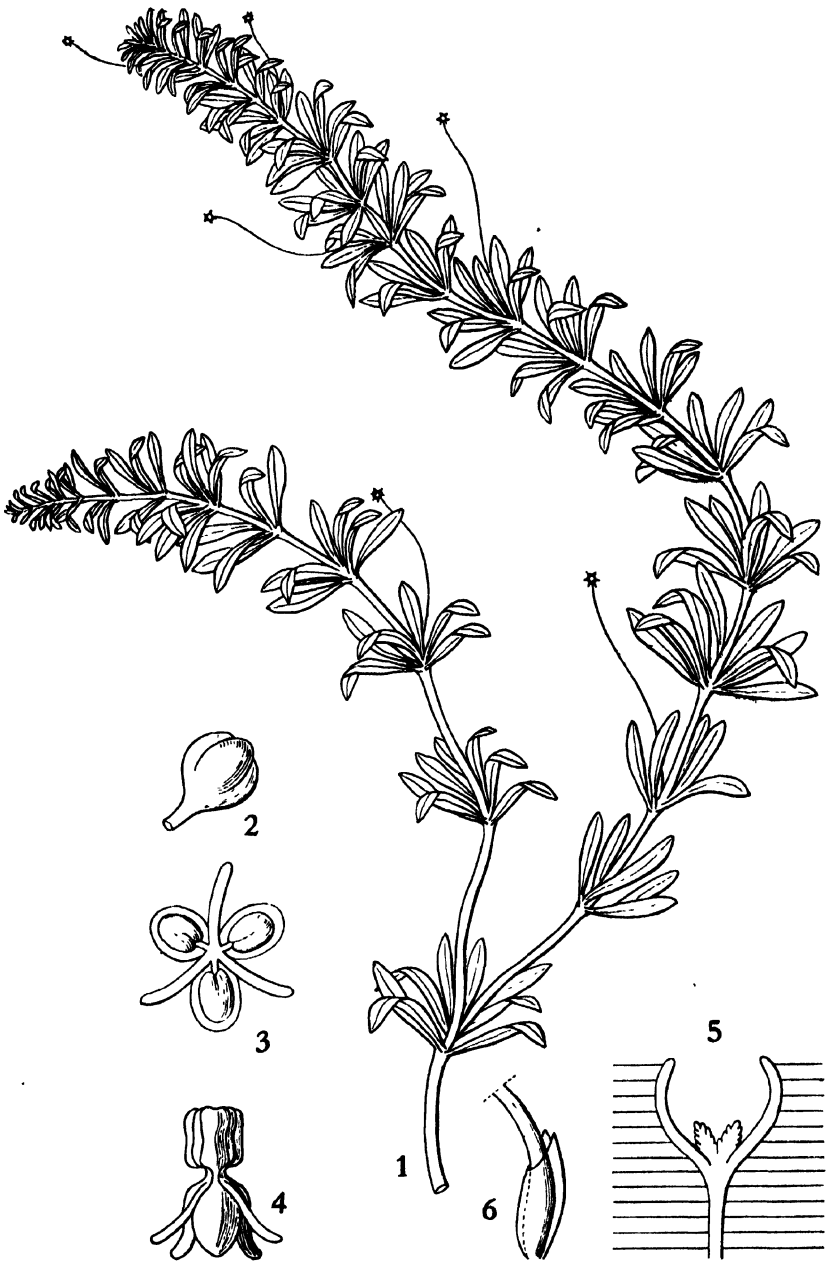


FIG. 37—*Hydrilla verticillata*: 1, Portion of female plant. 2, Male flower bud. 3, Male flower just before anthesis as seen from above. 4, Lateral view of male flower; note empty erect anthers. 5, Mature female flower (schematic vertical section) on the water surface. 6, Sheath and base of peduncle of female flower

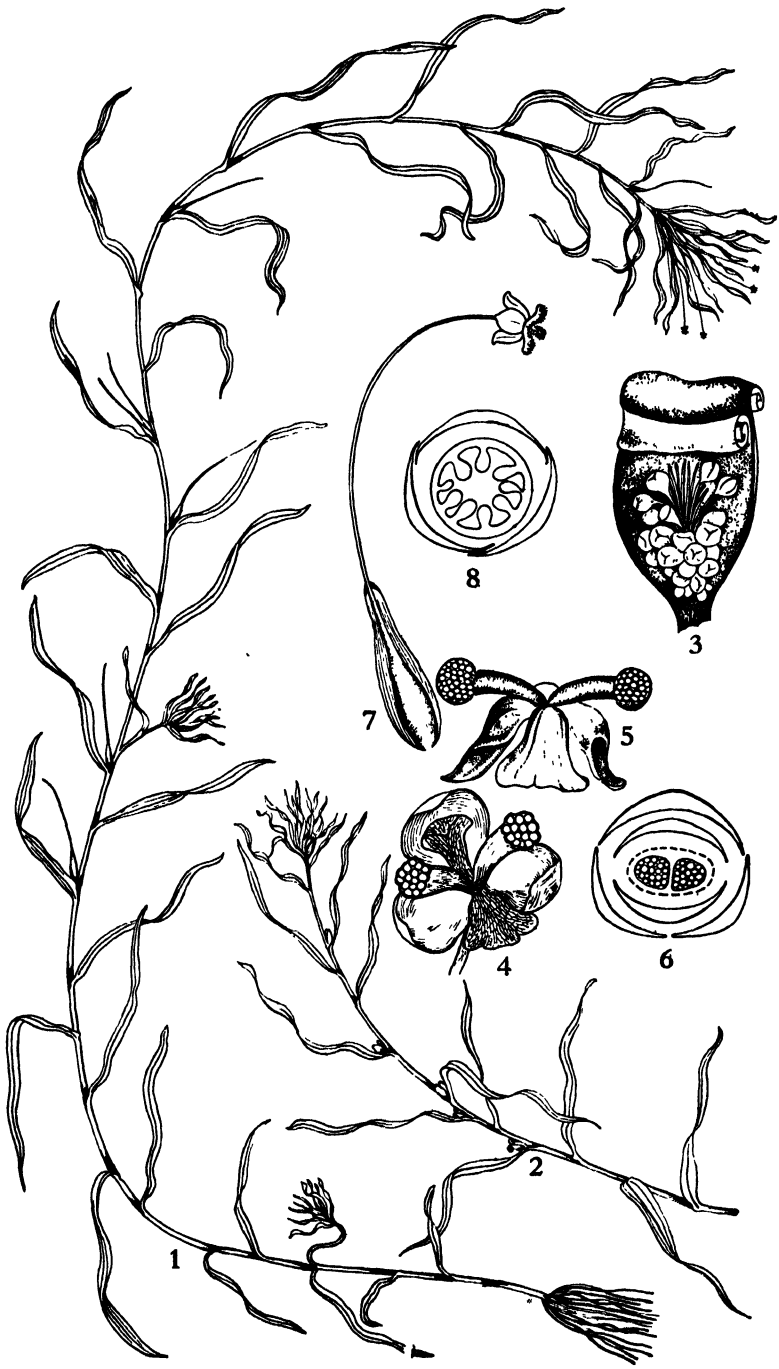


FIG. 38—*Nechamandra alternifolia*: 1, Female plant. 2, Portion of male plant. 3, Male inflorescence. 4 & 5, Young and old male flowers. 6, Floral diagram of male flower. 7, Female flower. 8, Floral diagram of female flower.

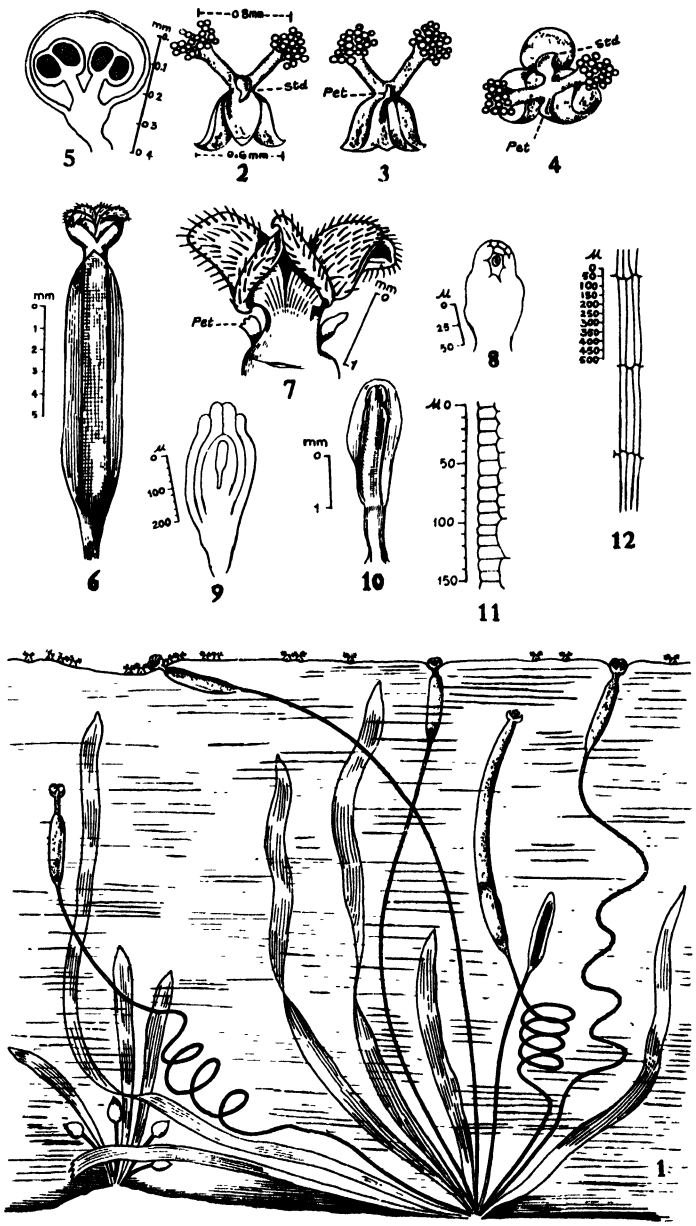


FIG. 39—*Vallisneria spiralis* : 1, Male and female plants under water ; note free floating staminate flowers and submerged pistillate flowers in various stages of development. 2, 3 & 4, Different views of staminate flowers. 5, L.s. unopened staminate flower. 6, Pistillate flower at the time of pollination. 7, Stigmatic lobes of the pistillate flower. 8, Young ovule at megaspore mother cell stage. 9, Young ovule showing embryo sac in outline. 10, Young pistillate flower. 11, Epidermal cells of the scape of flower shown in 7. 12, Epidermal cells of the scape of a pistillate flower at the time of pollination showing elongated cells. Pet, Rudimentary petal ; Std, Staminodium

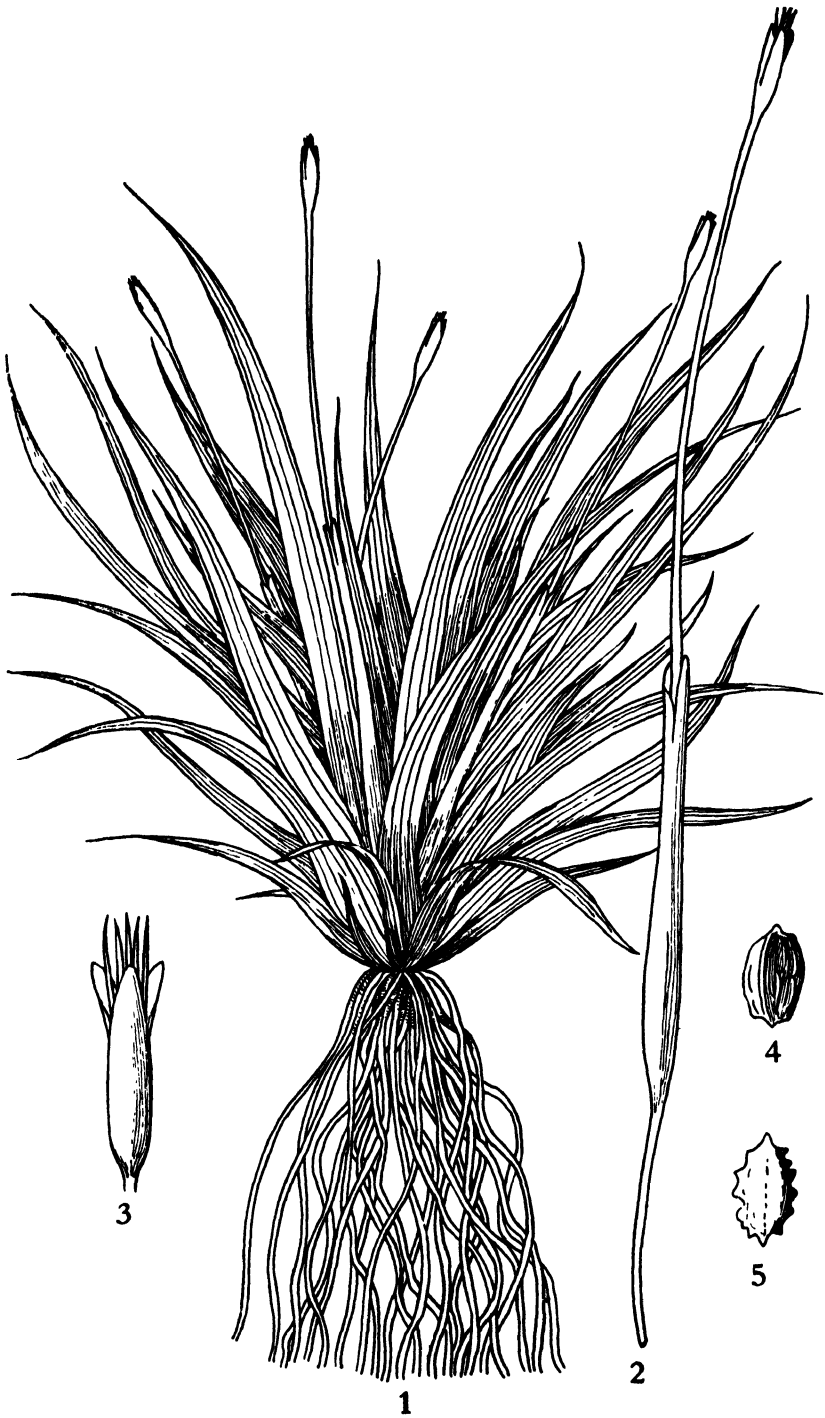


FIG. 40—*Blyxa auberti*: 1, Plant. 2, Flower with sheath. 3, Flower. 4 & 5, Seeds



FIG. 41—*Blyxa octandra*: 1, Plant. 2, Stamens. 3, Seed

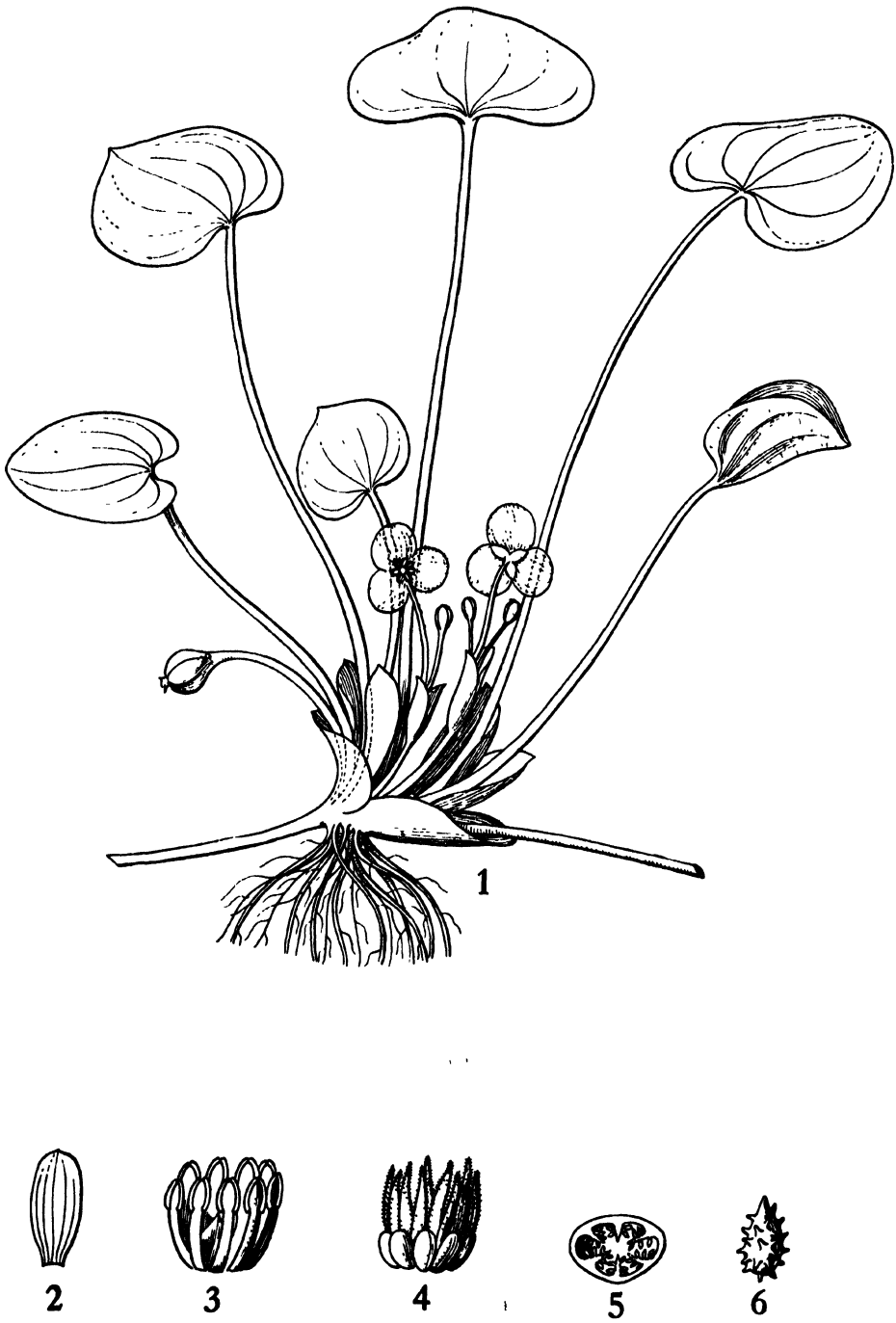


FIG. 42—*Hydrocharis dubia*: 1, Portion of plant with male flowers and fruit. 2, Sepal. 3, Stamens. 4, Ovary. 5, T.s. fruit. 6, Seed

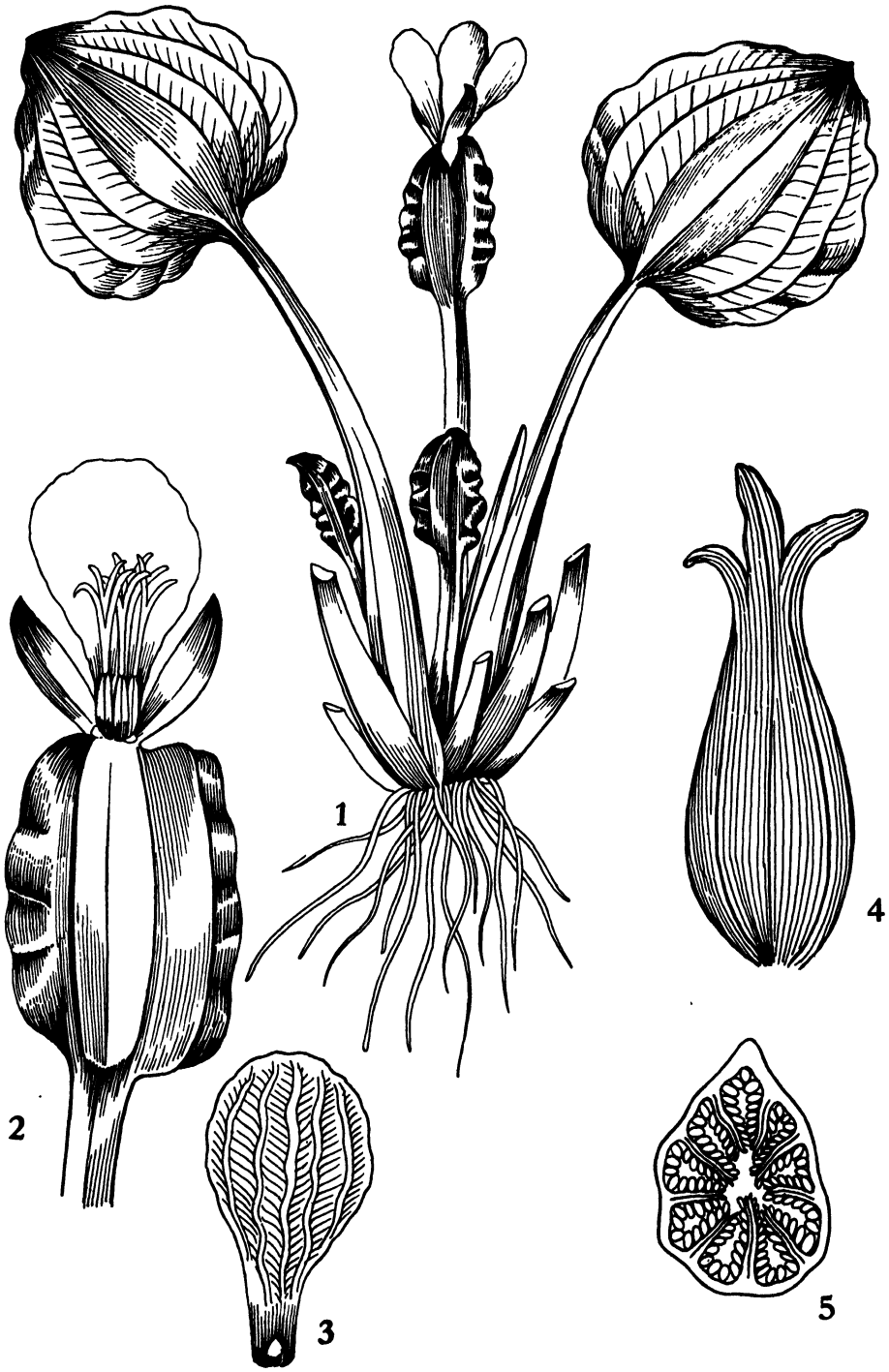


FIG. 43—*Ottelia alismoides* : 1, Plant. 2, Flower. 3, Petal. 4, Fruit. 5, T.s. fruit

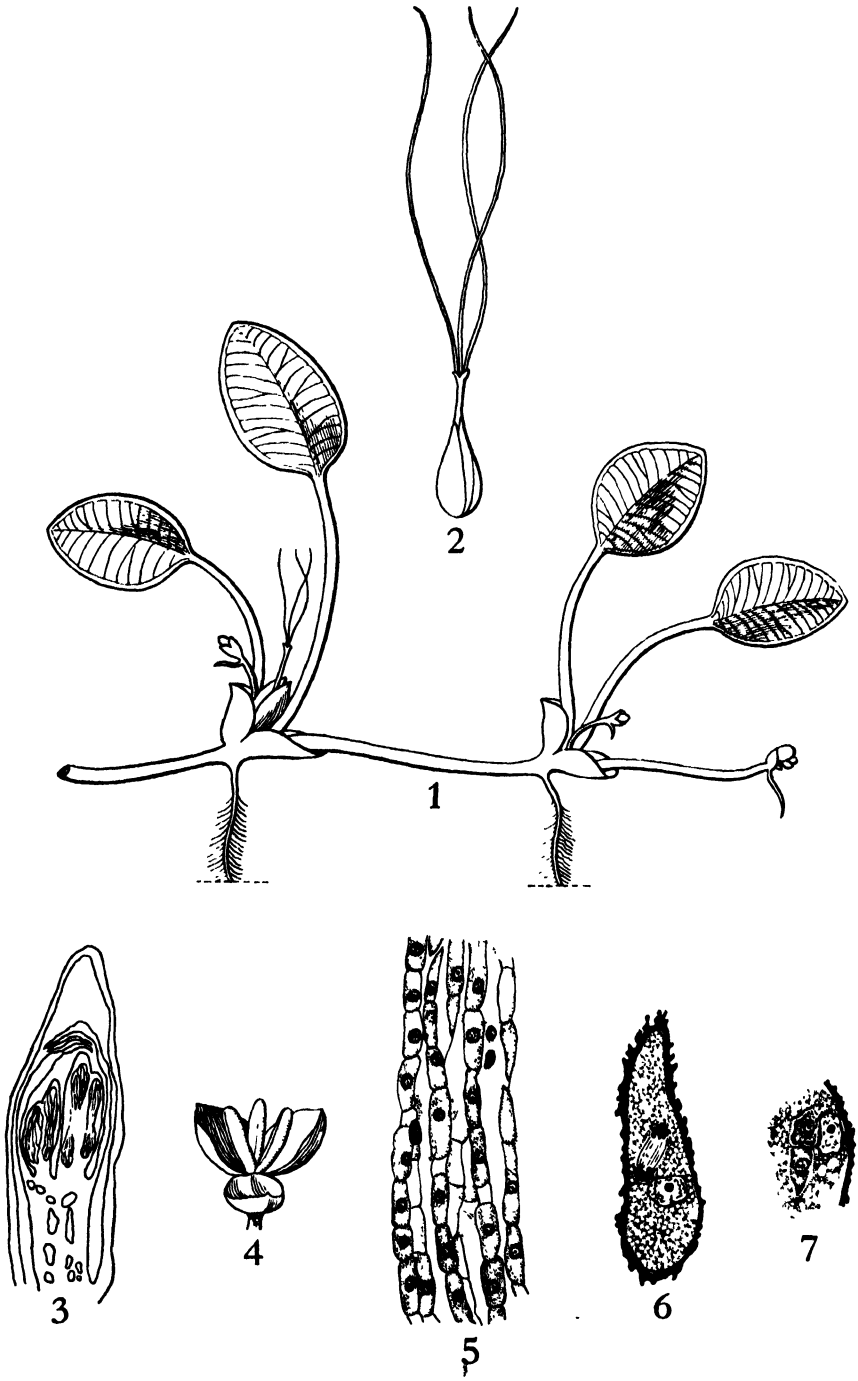


FIG. 44—*Halophila ovalis*: 1, Portion of plant. 2, Female flower. 3, L.s. young staminate flower. 4, Male flower. 5, Chains of microspores. 6, Pollen grain, showing division of generative cell. 7, Tube nucleus and male cells

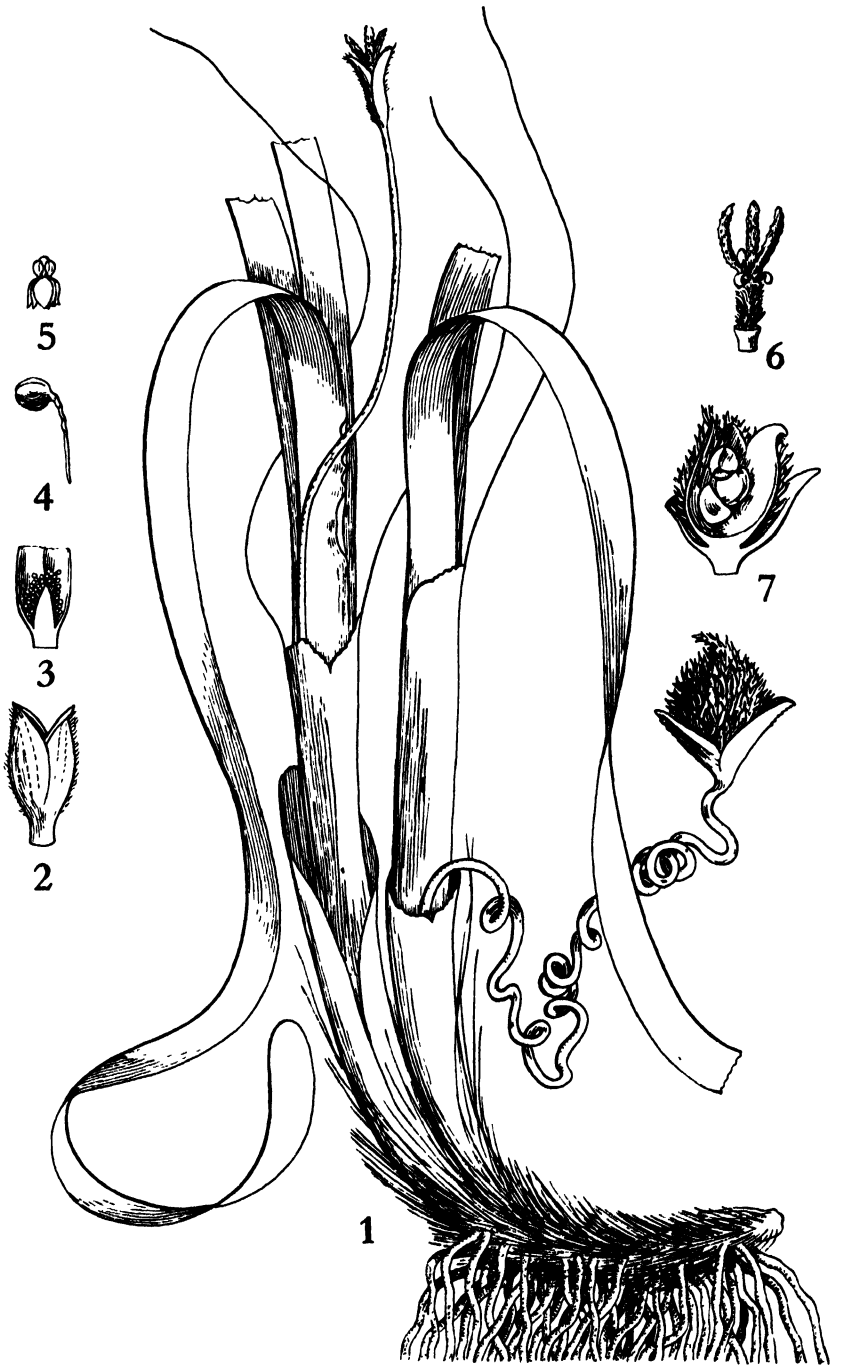


FIG. 45—*Enhalus acoroides*: 1, Plant. 2, Male spathe. 3, L s. male spathe with conical receptacle and indefinite male flower buds. 4, Male flower bud. 5, Opened male flower. 6, Female flower. 7, L.s. fruit with three seeds



FIG. 46—*Monochoria hastata* : 1, Plant. 2, Inflorescence. 3 & 4, Flowers. 5, Stamen. 6, Stamen with horned filament. 7, Pistil. 8, T.s. fruit

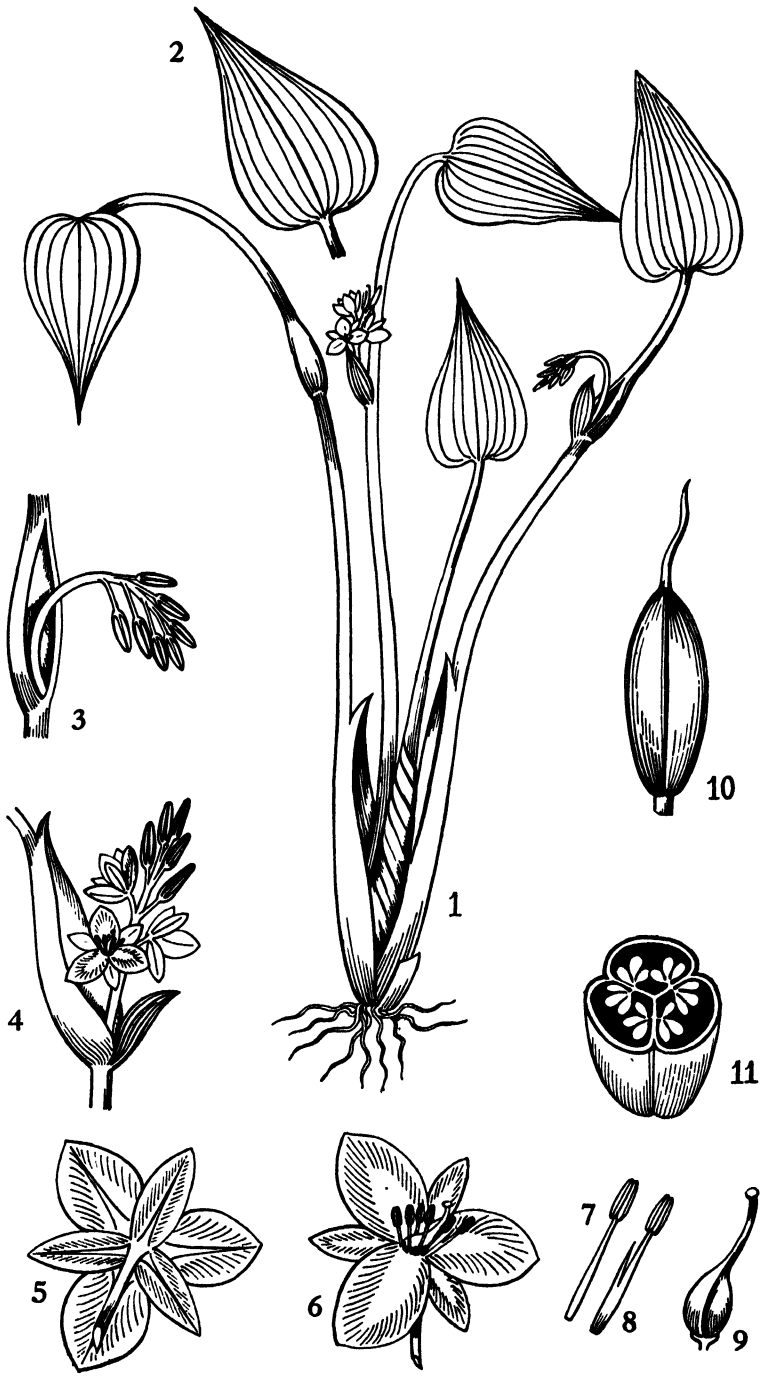


FIG. 47.—*Monochoria vaginalis* : 1, Plant. 2, Leaf. 3 & 4, Young and old inflorescences. 5 & 6, Flowers. 7, Stamen. 8, Stamen with horned filament. 9, Pistil. 10, Fruit. 11, T.s. fruit

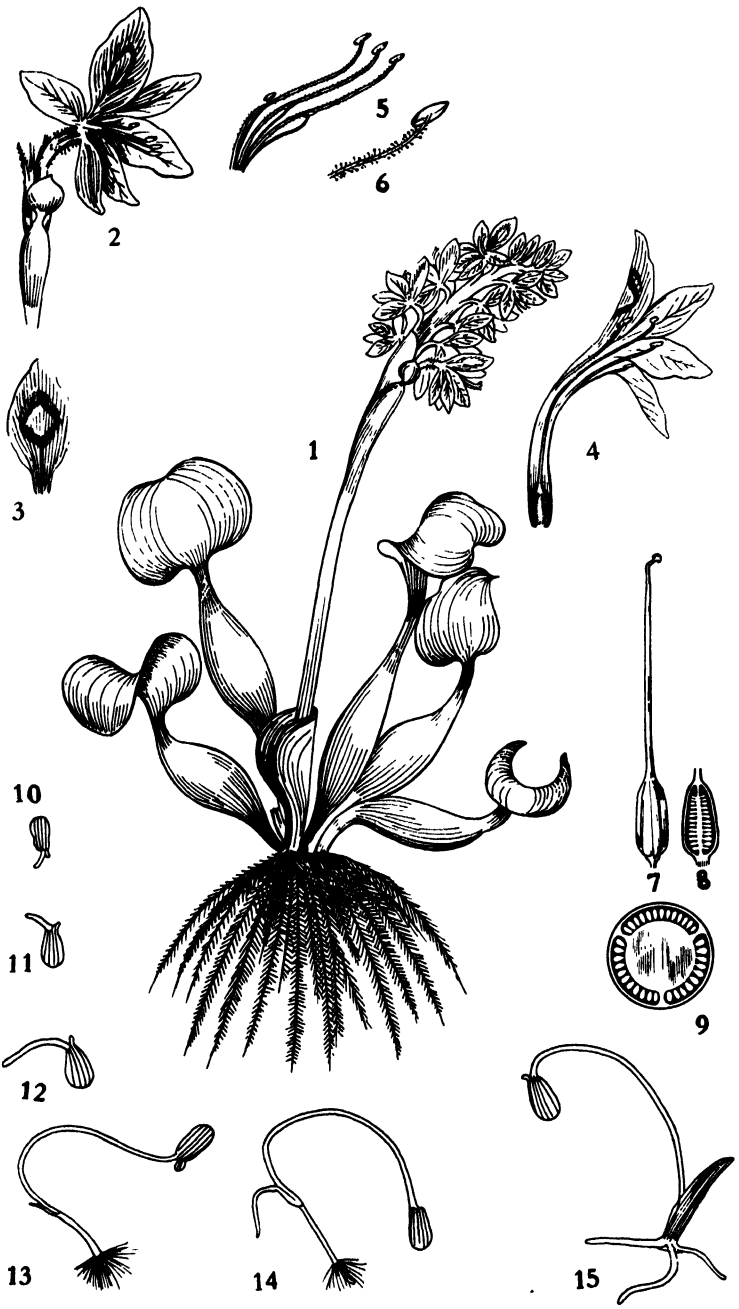


FIG. 48—*Eichhornia crassipes*: 1, Plant. 2, Flower. 3, Prominent upper tepal of inner whorl. 4, L.s. flower. 5, Three anterior exserted stamens with pubescent filaments and three included stamens with glabrous filaments. 6, Anterior stamen. 7, Pistil. 8, L.s. ovary. 9, T.s. ovary 10–15, Stages of seed germination

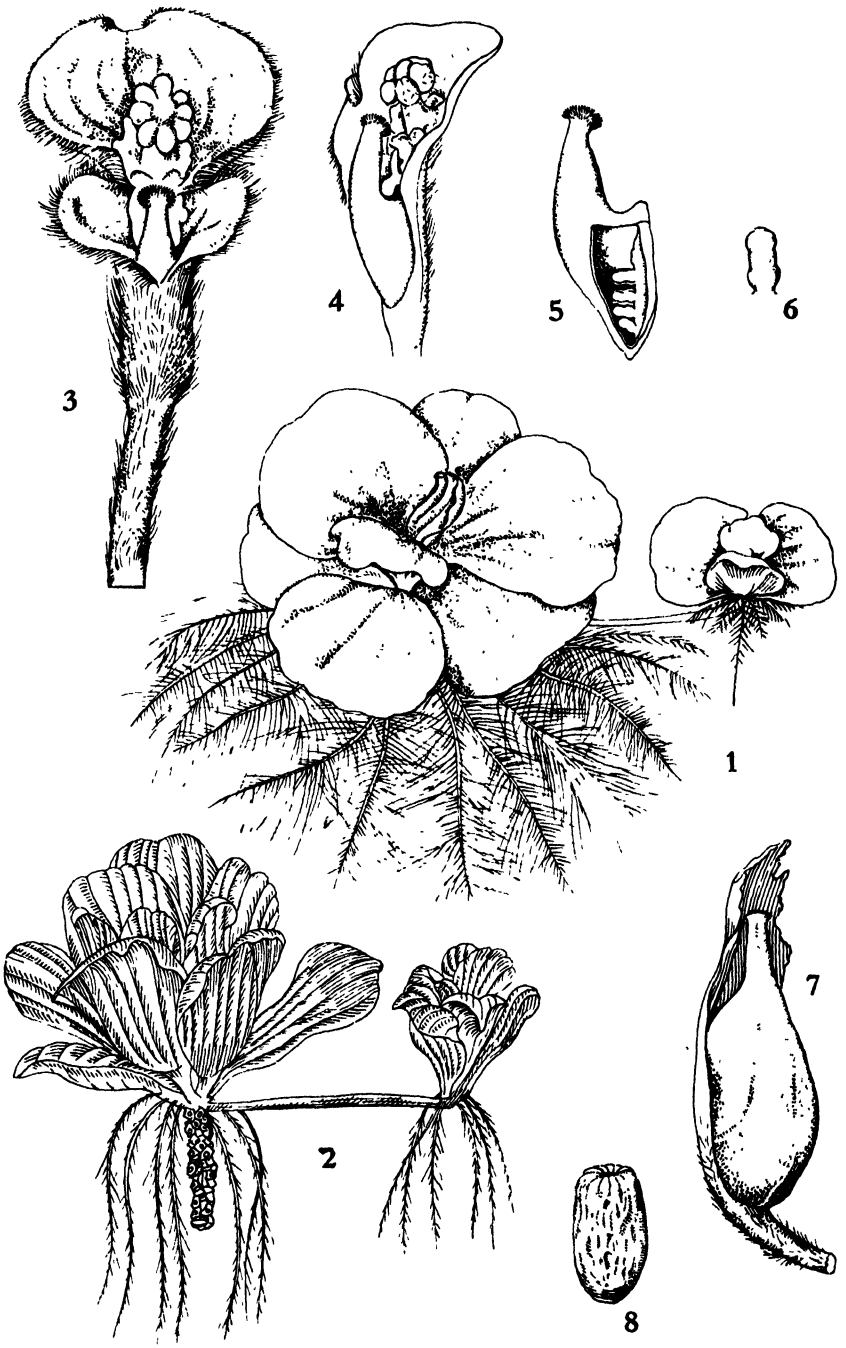


FIG. 49—*Pistia stratiotes*: 1, Plant. 2, Formation of an offset. 3, Spadix. 4, Portion of spathe removed to show flowers. 5, Portion of pistil dissected to show ovules. 6, Ovule. 7, Fruit. 8, Seed

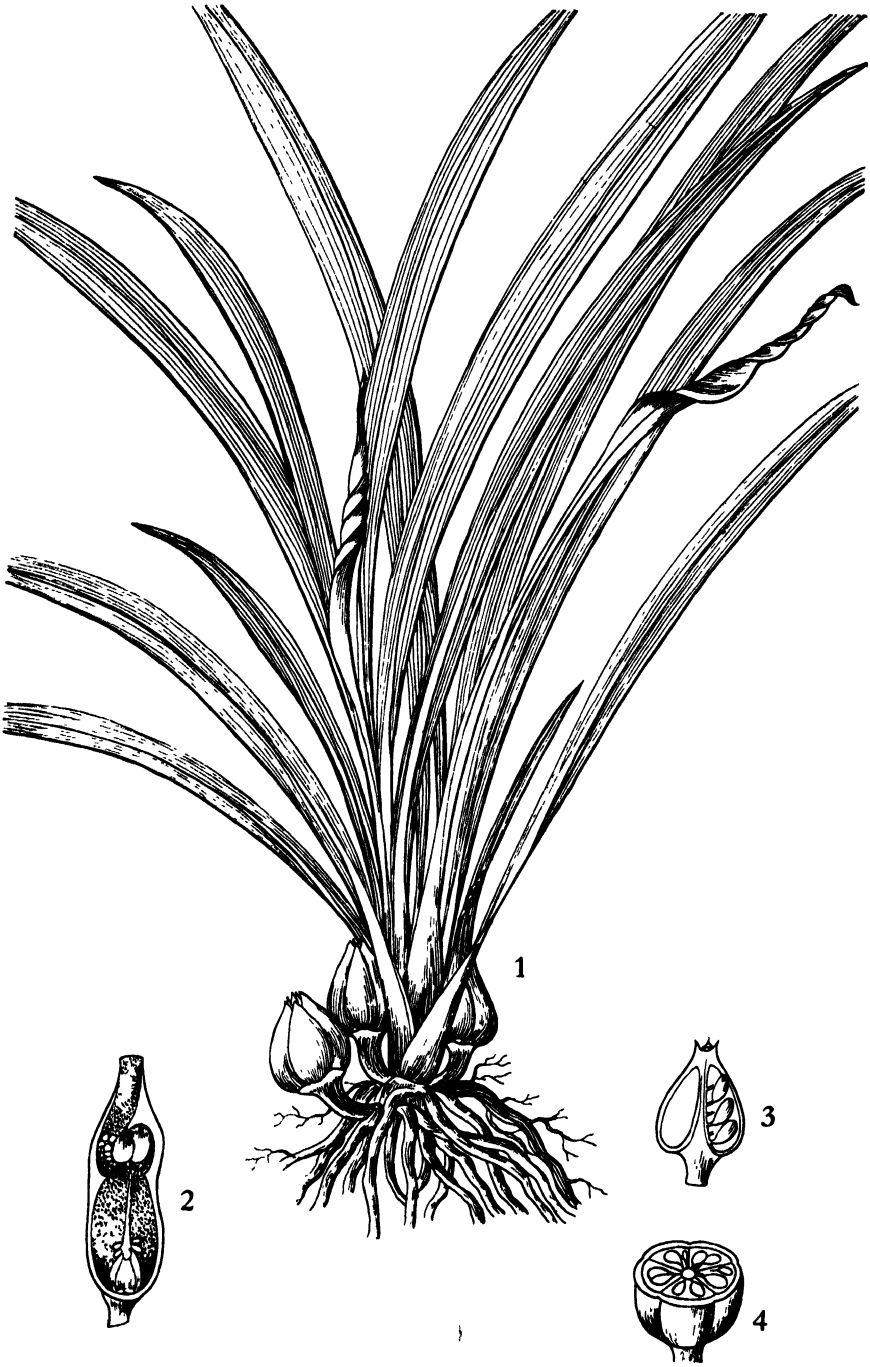


FIG. 50—*Cryptocoryne retrospiralis* : 1, Plant. 2, Portion of spathe removed to show inner parts. 3, L.s. ovary. 4, T.s. ovary

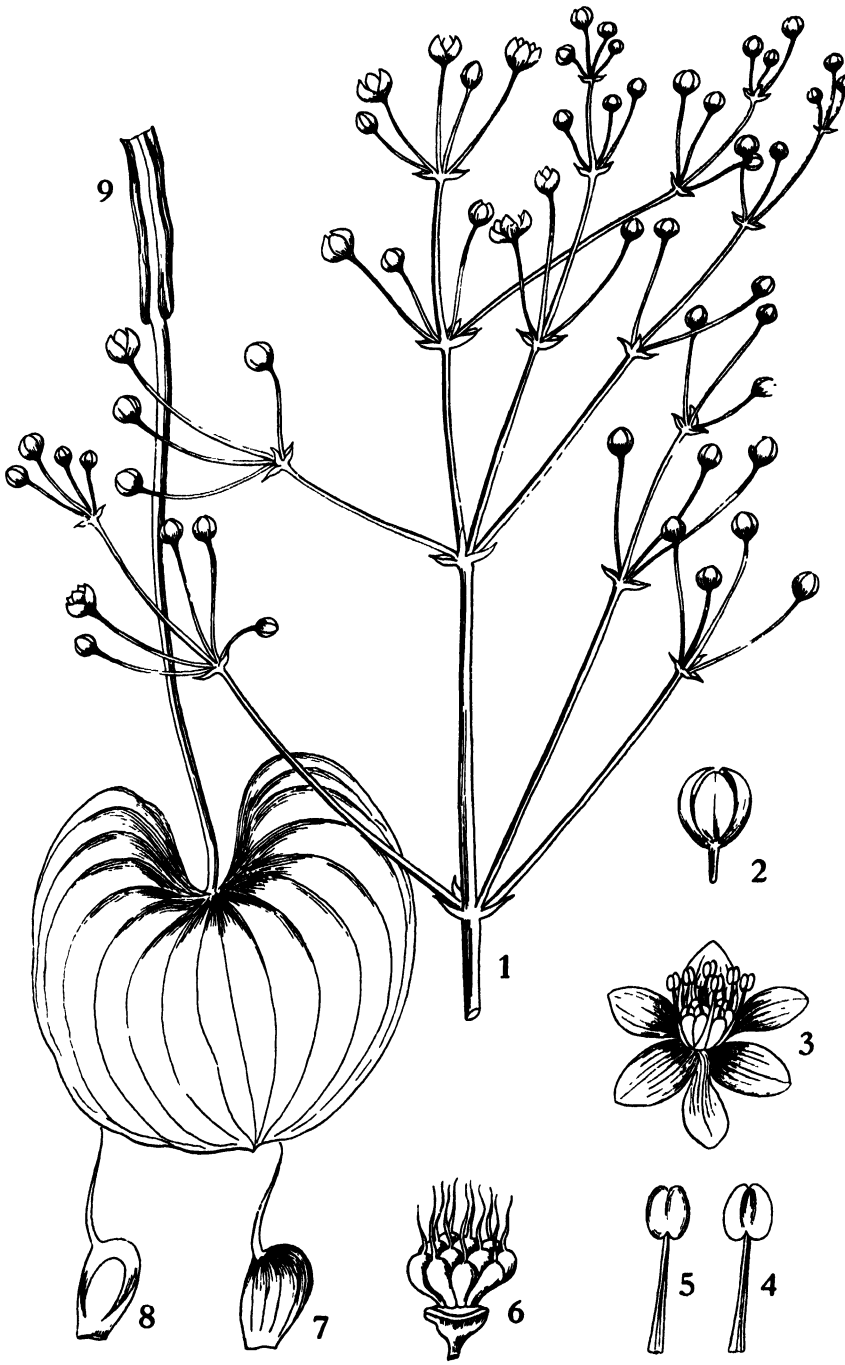


FIG. 51—*Caldesia parnassifolia* : 1, Panicle. 2, Bud. 3, Flower. 4 & 5, Stamens. 6, Carpels. 7, A carpel. 8, L.s. carpel. 9, Leaf



FIG. 52—*Limnophyton obtusifolium*: 1, Plant. 2, Leaf. 3, Flower. 4, Fruit



FIG. 53—*Tenagocharis latifolia* : 1, Plant. 2, Flower. 3, Sepal. 4, Petal. 5, Petal and stamen. 6, Stamen. 7, Carpel. 8, Follicle. 9, Seed

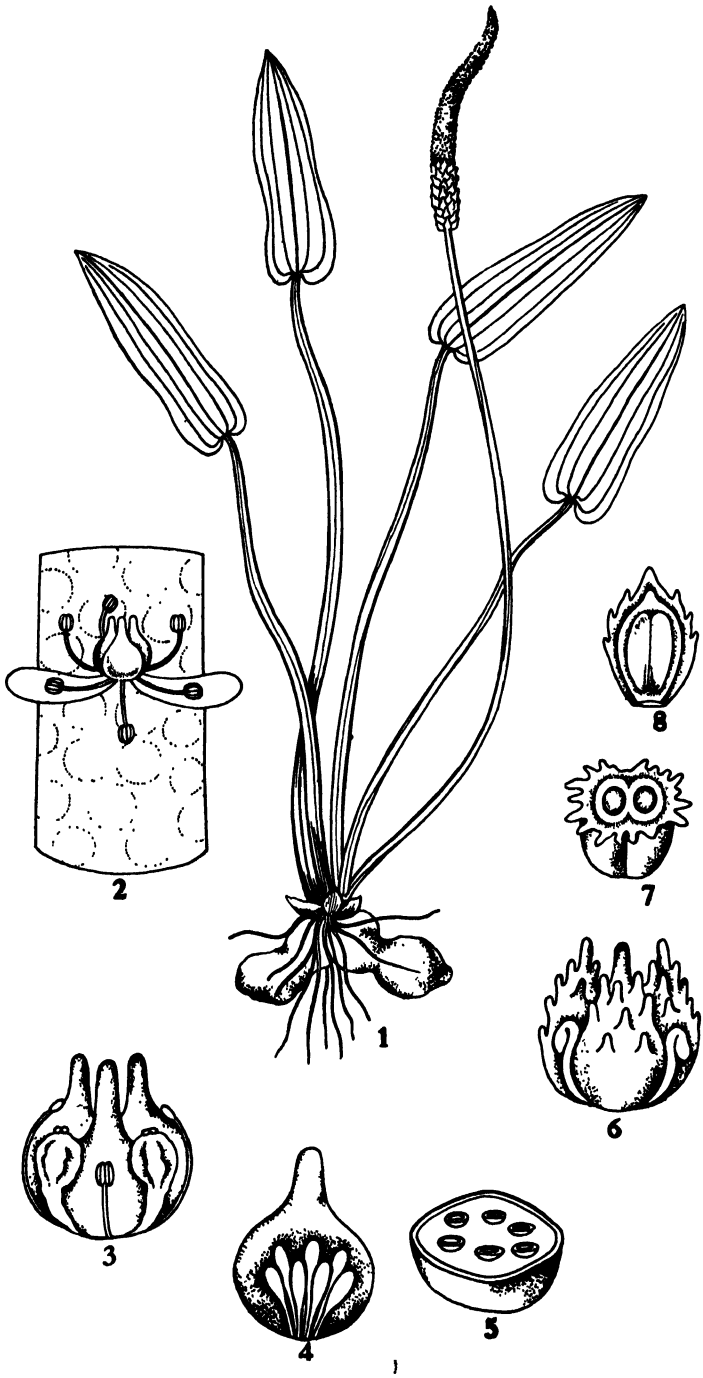


FIG. 54—*Aponogeton natans* : 1, Plant. 2, Portion of spike with a flower enlarged. 3, Flower. 4, L.s. carpel showing basally attached ovules. 5, T.s. carpel. 6, Three beaked follicles. 7, T.s. follicle. 8, L.s. follicle

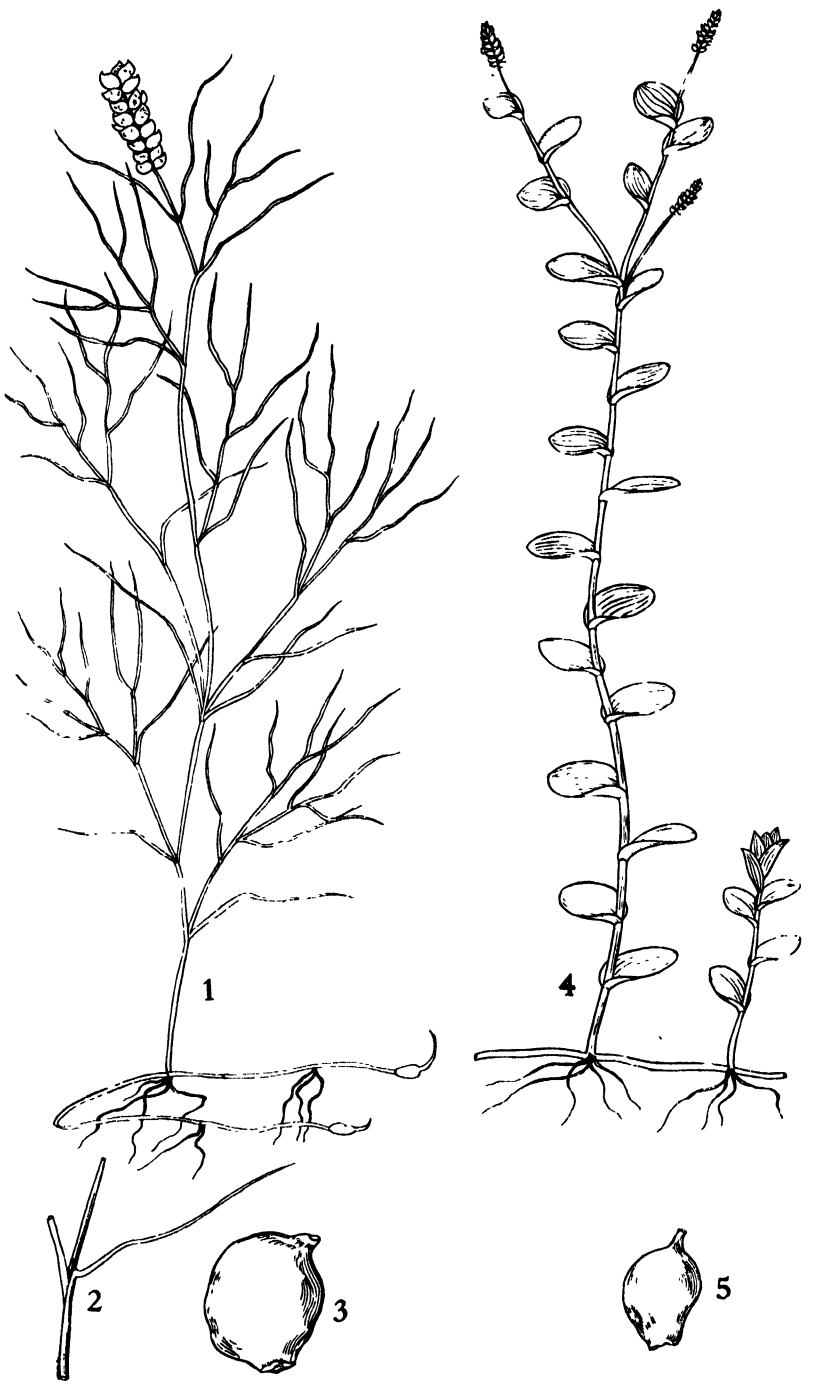


FIG. 55—*Potamogeton pectinatus :* 1, Plant with rootstocks and tubers. 2, Leaf with stipules fused with sheath. 3, Fruit. *Potamogeton perfoliatus :* 4, Plant. 5, Fruit

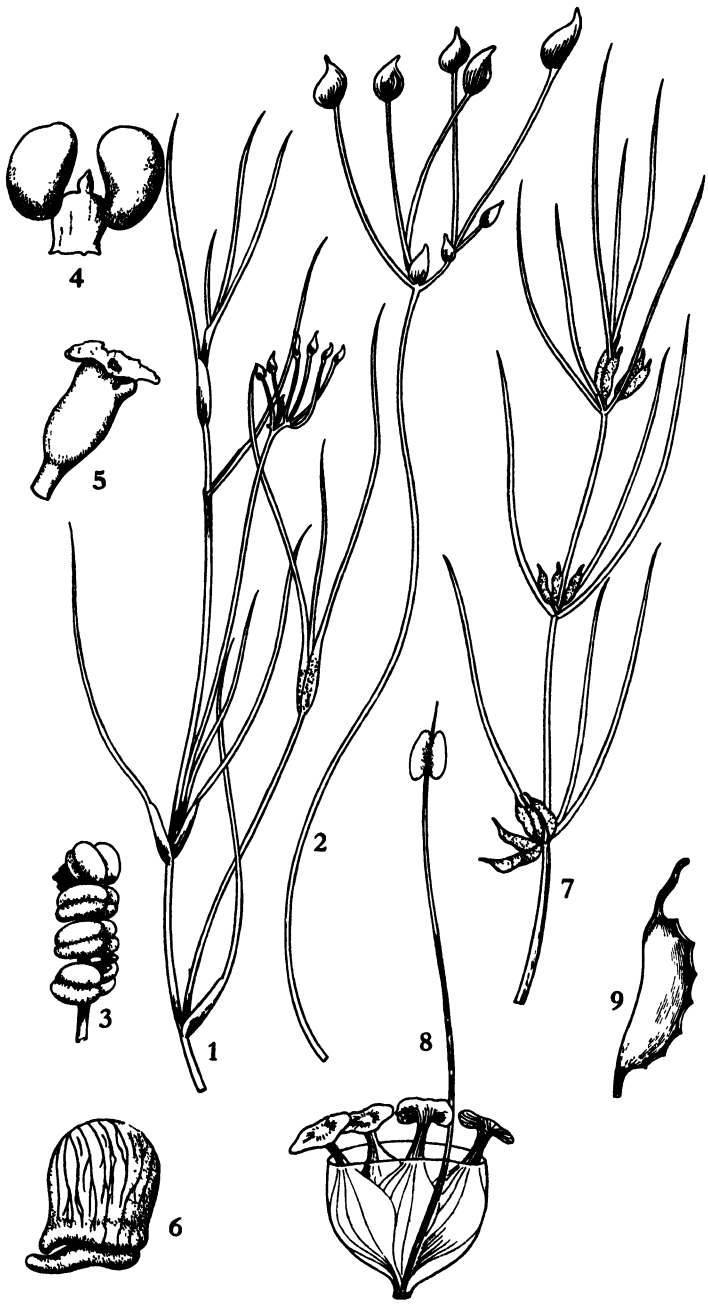


FIG. 56—*Ruppia maritima* : 1, Portion of plant. 2, Cluster of fruits. 3, Peduncle with two flowers, each with four stamens and four carpels. 4, Stamen. 5, Pistil. 6, Embryo. *Zannichellia palustris* ssp. *pedicellata* : 7, Branch with fruits. 8, Flower showing four carpels and one stamen. 9, Fruit

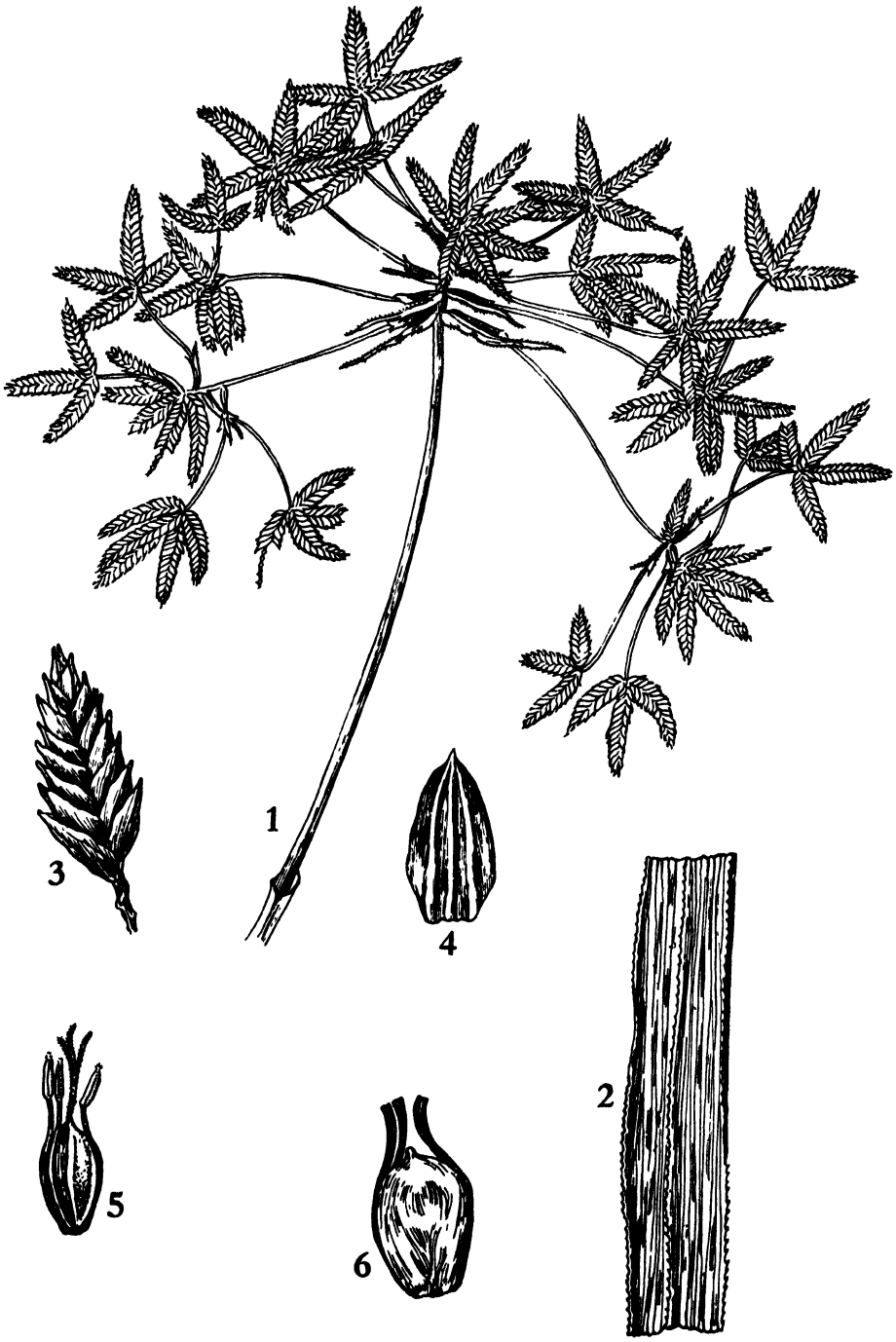


FIG. 57—*Cyperus platystylis*: 1, Inflorescence. 2, Portion of leaf. 3, Spikelet. 4, Glume, dorsal view. 5, Stamens and pistil. 6, Fruit



FIG. 58—*Cyperus corymbosus* : 1 & 2, Lower and upper portions of plant. 3, Portion of inflorescence. 4, Spikelet. 5, Glume. 6, Stamens and pistil

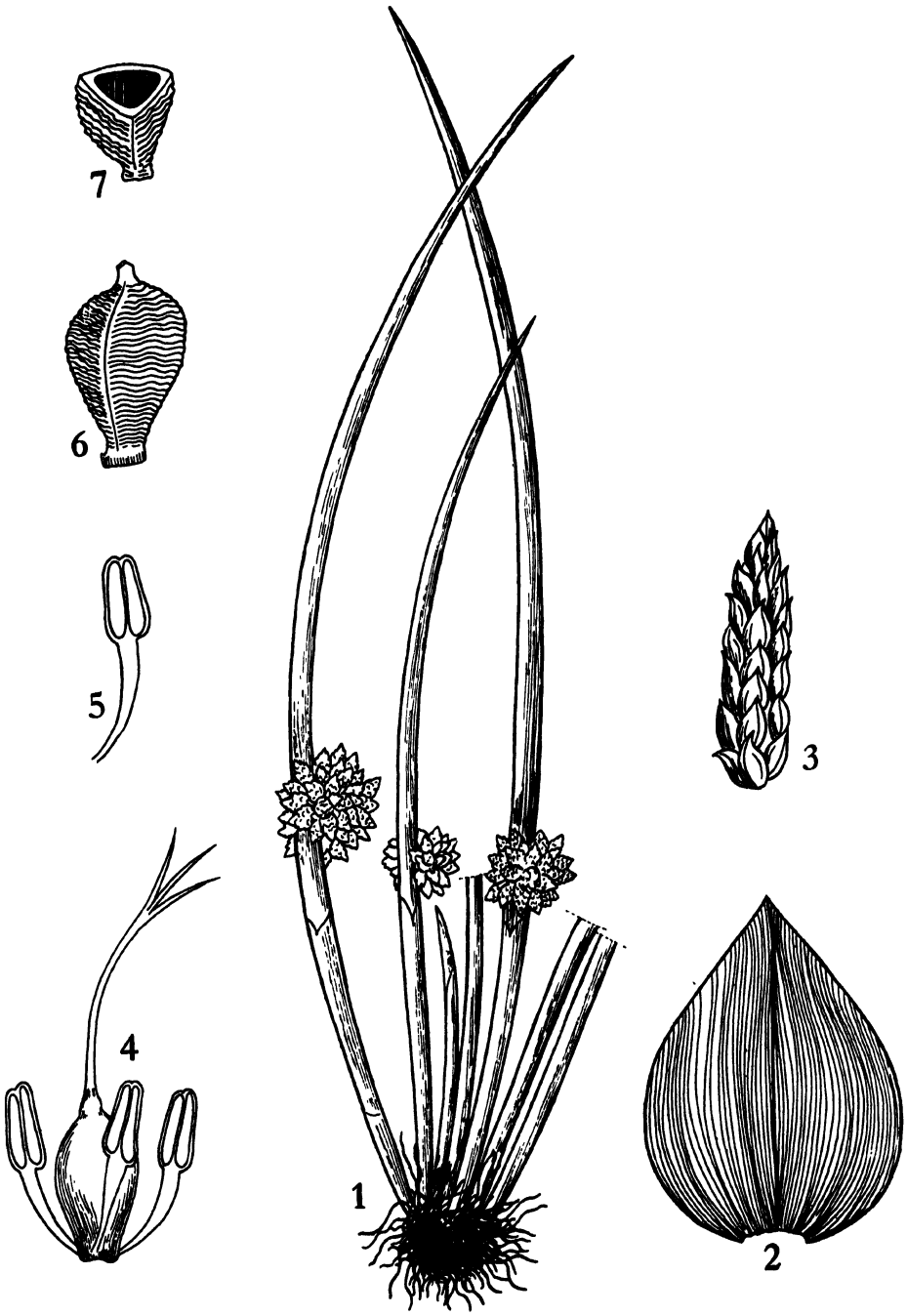


FIG. 59—*Scirpus articulatus*: 1, Plant. 2, Glume. 3, Spikelet. 4, Stamens and pistil. 5, Stamen. 6, Fruit. 7, T.s. fruit

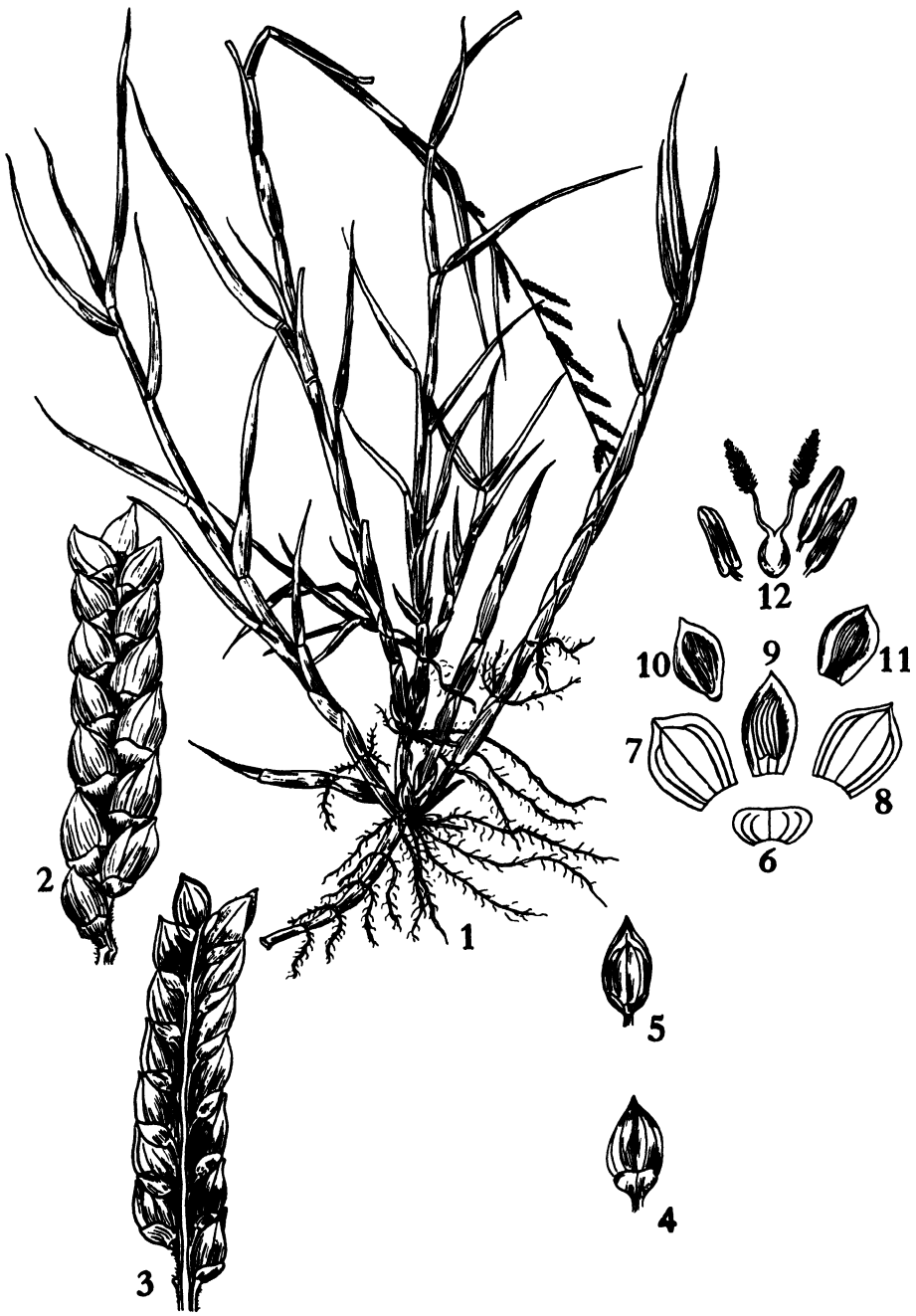


FIG. 60—*Paspalidium geminatum* : 1, Plant. 2 & 3, Front and back views of spikes. 4 & 5, Spikelets. 6, 7 & 8, First, second and third glumes respectively. 9, Palea of the third glume with stamens. 10 & 11, Fourth glume and its palea. 12, Stamens and pistil

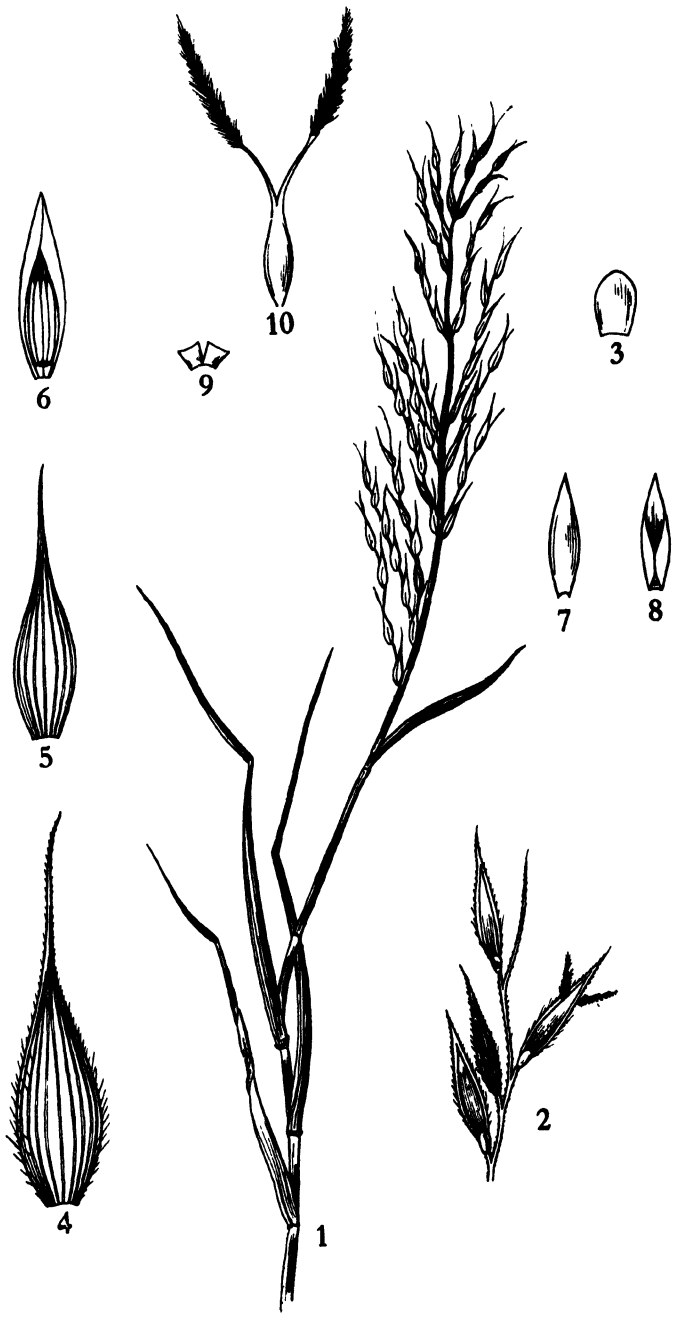


FIG. 61—*Pseudoraphis spinescens*: 1, Portion of plant with panicle. 2, Terminal portion of a spike showing bristle. 3, 4, 5 & 7, First, second, third and fourth glumes respectively. 6, Palea of third glume with its anthers and lodicules. 8, Palea of fourth glume. 9, Lodicules. 10, Pistil

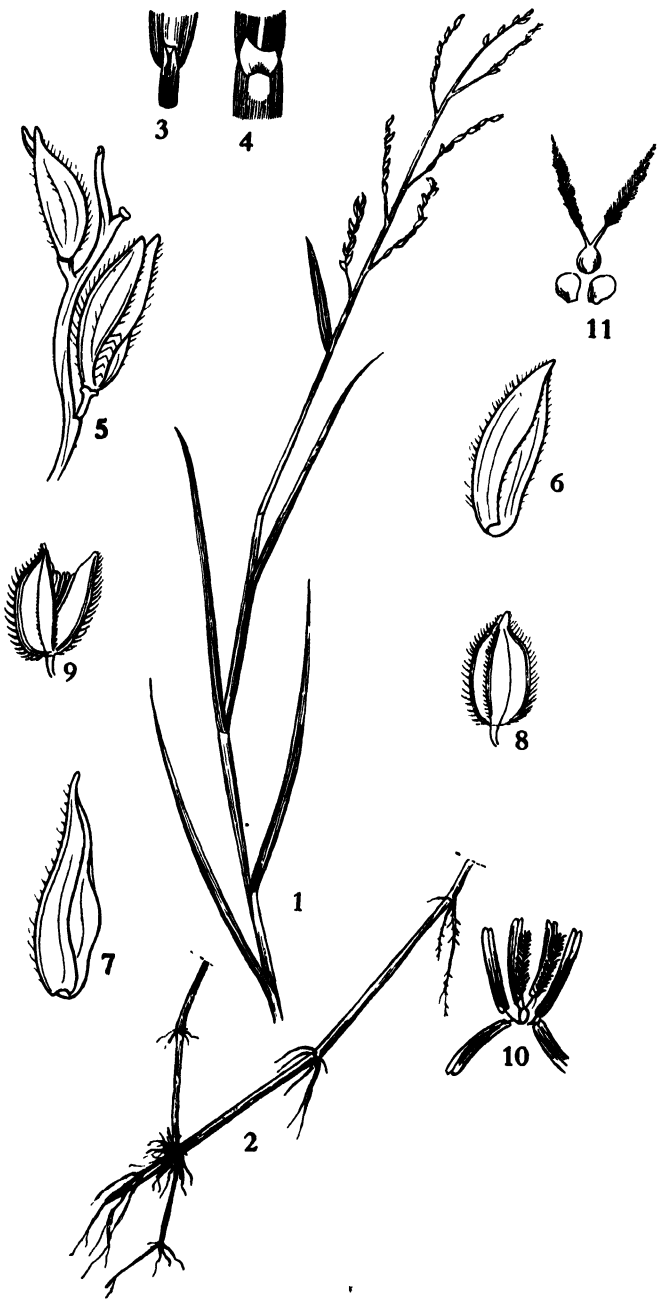


FIG. 62—*Leersia hexandra*: 1, Upper portion of plant. 2, Lower portion showing roots. 3 & 4, Portions of leaves. 5, Spikelets on rachis. 6, Floral glume. 7, Palea. 8 & 9, Spikelets. 10, Stamens and pistil. 11, Lodicules and pistil



FIG. 63—*Hygroryza aristata* : 1, Plant. 2, Part of leaf with ligule. 3, Spikelet opened. 4, Spikelet unopened. 5, Lemma without awn. 6, Palea. 7, Stamens, pistil and lodicules. 8, Grain showing embryo. 9, Grain showing linear hilum

LITERATURE CITED

AGHARKAR, S. P. & BANERJI, I. 1930. Studies in the pollination and seed formation of Water-Hyacinth (*Eichhornia speciosa* Kunth). *Agric. J. India* **35** : 286–296.

ARBER, A. 1919. The vegetative morphology of *Pistia* and the Lemnaceae. *Proc. roy. Soc. Lond.* **91B** : 96–103.

—— 1920. Water Plants A Study of Aquatic Angiosperms. University Press, Cambridge.

ARORA, N. 1954. Morphological development of the root and stem nodules of *Aeschynomene indica* L *Phytomorphology* **4** : 211–216.

BAILLON, H 1858. Recherches sur l'organogénie du *Callitriche* et sur ses rapports naturels. *Bull. Soc. bot. Fr.* **5** : 337–341.

BANERJI, I. & HALDER, S. 1942. A contribution to the morphology and cytology of *Monochoria hastaefolia* Presl. *Proc Indian Acad. Sci.* **16B** : 91–106.

BARNHART, J. H. 1916. Segregation of genera in Lentibulariaceae. *Mem. N. Y. bot. Gdn* **6** : 39–64.

BEER, R. 1906 On the development of the pollen grain and anther of some Onagraceae. *Beih. bot. Zbl.* **19A** : 286–313.

BENTHAM, G. & HOOKER, J. D. 1883. Genera Plantarum. III. London.

BISWAS, K. & CALDER, C. C. 1955. Hand-book of common water and marsh plants of India and Burma, 1936 (2nd edn). *Hlth Bull., Calcutta*, No 24.

BOR, N. L. 1960 Grasses of Burma, Ceylon, India and Pakistan (excluding Bambuseae) Pergamon Press, Oxford.

BROOKS, J S. 1940 The cytology and morphology of the Lemnaceae. Ph.D. Thesis, Cornell University.

CHATTERJEE, D. & BHARADWAJA, R. C. 1955. Revision of the Scrophulariaceae of the Upper Gangetic Plain and adjoining areas *Bull. bot. Soc. Bengal* **9** : 127–153.

CHOPRA, R N., NAYAR, S L & CHOPRA, I. C. 1956. Glossary of Indian Medicinal Plants. Council of Scientific & Industrial Research, New Delhi.

CLARKE, B. 1865. On the structure and affinities of Callitrichaceae. *J. Bot., Lond.* **3** : 36–39.

CONARD, H. S. 1905. The water lilies. a monograph of the genus *Nymphaea*. *Publ. Carneg. Instn* **4** : 1–279.

COOKE, T. 1958 The flora of the Presidency of Bombay. I & III. (Reprinted edn). Botanical Survey of India, Calcutta.

D' ALMEIDA, J. F. R. 1942. A contribution to the study of the biology and physiological anatomy of Indian marsh and aquatic plants. *J. Bombay nat. Hist. Soc* **43** : 92–96.

DEVA, R. C. 1953. The anatomy of the floats of *Utricularia flexuosa* Vahl. *J. Indian bot. Soc* **32** : 142–144.

EAMES, A. J. 1953. Floral anatomy as an aid in generic limitation. *Chron. bot.* **14** : 126–132.

EKAMBARAM, T. 1916. Irritability of the bladders in *Utricularia*. *Agric. J. India* **11** : 72–79.

—— 1918 *Utricularia flexuosa* Vahl. *Bot. Bull Pres. Coll., Madras* 1918: 1–22.

—— 1926. A note on the mechanism of the bladders of *Utricularia*. *J. Indian bot. Soc.* **4** : 73–74.

ENGLER, A. 1877. Vergleichende Untersuchungen uber die morphologischen Verhältnisse der Araceae II. Über Blattstellung und Sprossverhältnisse der Araceae. *Nova Acta Leop Carol. dtsch. Akad Naturf.* **39** : 159–232.

ERNST-SCHWARZENBACH, M. 1945. Zur Blutenbiologie einiger Hydrocharitaceen. *Ber. schweiz. bot. Ges.* **55** : 33–69.

—— 1956. Kleistogamie und Antherenbau in Jer Hydrocharitaceen—Gattung *Ottelia*. *Phytomorphology* **6** : 296–311.

GOEBEL, K. 1921. Zur Organographie der Lemnaceen. *Flora* **114** : 278–305.

GUPTA, B. L. 1935. Studies in the development of the pollen grains and embryo sac of *Wolffia arrhiza*. *Curr. Sci.* **4** : 104–105.

HAINES, H. H. 1922. The Botany of Bihar and Orissa. III & IV. London.

HEGELMAIER, F. 1868. Die Lemnaceen — eine monographische Untersuchung. Leipzig.

—— 1896. Systematische Übersicht der Lemnaceen. *Bot. Jb.* **21** : 268–305.

HILLMAN, W. S. 1961. The Lemnaceae or duckweeds. A review of the descriptive and experimental literature. *Bot. Rev.* **27** : 221–287.

HOLMGREN, J. 1913. Zur Entwicklungsgeschichte von *Butomus umbellatus* L. *Svensk bot. Tidskr.* **7** : 58–77.

HOOKER, J. D. *et al.* 1872–97. The Flora of British India. I–VII. L. Reeve & Co., London.

HUTCHINSON, J. 1959. The Families of Flowering Plants. I. Dicotyledons. Clarendon Press, Oxford.

—— 1959. The Families of Flowering Plants II. Monocotyledons. Clarendon Press, Oxford.

JACOBS, D. L. 1947. An ecological life-history of *Spirodela polyrrhiza* (greater duckweed) with emphasis on the turion phase. *Ecol. Monogr.* **17:** 437–469

JOHRI, B. M. 1935a. Studies in the family Alismaceae—I. *Limnophyton obtusifolium* Miq. *J. Indian bot. Soc.* **14** : 49–66

—— 1935b. Studies in the family Alismaceae—II *Sagittaria sagittifolia* L. *Proc. Indian Acad. Sci* **1B** : 340–348.

—— 1935c Studies in the family Alismaceae—III. *Sagittaria guayanensis* H B.K. and *Sagittaria latifolia* Willd. *Proc. Indian Acad. Sci.* **2B** : 33–48

—— 1936a Studies in the family Alismaceae—IV. *Alisma plantago* L. ; *Alisma plantago-aquatica* L. ; and *Sagittaria graminea* Mich. *Proc Indian Acad. Sci.* **4B** : 128–138

—— 1936b. The life-history of *Butomopsis lanceolata* Kunth. *Proc Indian Acad. Sci.* **4B** : 139–162.

—— 1938a. The embryo sac of *Limnocharis emarginata* L. *New Phytol* **37** : 279–285

—— 1938b The embryo sac of *Hydrocleis nymphoides* Buchen. *Beih. bot. Zbl.* **48A** : 165–172

JORGENSEN, C. A. 1923. Studies on Callitrichaceae. *Bot. Tidsskr.* **38** : 81–126.

—— 1925. Zur Frage der systematischen Stellung der Callitrichaceen. *Jb wiss. Bot.* **64** : 404–442.

JUSSEN, F. J. 1928. Die Haploidgeneration der Araceen und ihre Verwertung fur das System. *Bot. Jb.* **62** : 155–283.

KAUSIK, S. B. 1939. Pollination and its influences on the behaviour of the pistillate flower in *Vallisneria spiralis*. *Amer. J. Bot.* **26** : 207–211.

—— 1940a A contribution to the embryology of *Enalus acoroides* (L. fil) Steud *Proc. Indian Acad. Sci.* **11B** : 83–99.

—— 1940b. Vascular anatomy of the pistillate flower of *Enalus acoroides* (L. fil.) Steud. *Curr. Sci.* **9** : 182–184.

—— 1941. Structure and development of the staminate flower and the male gametophyte of *Enalus acoroides* (L. fil.) Steud. *Proc Indian Acad. Sci.* **14B** : 1–16.

—— & RAO, P. K. V. 1942. The male gametophyte of *Halophila ovata* Gaudich. *J. Mysore Univ.* **3** : 41–49.

KHAN, R. 1942. A contribution to the embryology of *Jussieua repens* Linn. *J. Indian bot. Soc.* **21** : 267–282.

—— 1954. A contribution to the embryology of *Utricularia flexuosa* Vahl. *Phytomorphology* **4** : 80–117.

LAWALRÉE, A. 1943. La multiplication végétative des Lemnacées, en particulier chez *Wolffia arrhiza*. *Cellule* **49** : 335–382.

—— 1945. La position systématique des Lemnaceae et leur classification. *Bull. Soc. Bot. Belg.* **77** : 27–38.

—— 1952. L'embryologie des Lemnaceae. Observation sur *Lemna minor* L. *Cellule* **54** : 303–326.

LAWRENCE, G. H. M. 1951. Taxonomy of Vascular Plants. Macmillan Co., New York
LLOYD, F. E. 1942. Carnivorous Plants. Waltham, Mass.

MAHESHWARI, P. 1945. The place of angiosperm embryology in research and teaching. *J. Indian bot. Soc.* **24** : 25–41.

—— & SINGH, B. 1943. Studies in the family Alismaceae—V. *Proc. nat. Inst. Sci. India* **9** : 311–322.

MAHESHWARI, S. C. 1954. The embryology of *Wolffia*. *Phytomorphology* **4** : 355–365.

—— 1956. The endosperm and embryo of *Lemna* and systematic position of the Lemnaceae. *Phytomorphology* **6** : 51–55.

—— 1958. *Spirodela polyrrhiza* : the link between the Aroids and duckweeds. *Nature, Lond.* **181** : 1745–1746

—— & KHANNA, P. P. 1956 The embryology of *Arisaema wallichianum* Hook. f. and the systematic position of the Araceae. *Phytomorphology* **6** : 379–388.

MAJUMDAR, G. P. 1938. A preliminary note on polystely in *Limnanthemum cristatum* and *Ottelia alismoides*. *Curr. Sci* **6** : 383–385.

MCCANN, C. 1945. Notes on the genus *Ruppia* (Ruppiaceae). *J Bombay nat. Hist. Soc.* **45** : 396–402.

MITRA, G. C. 1945. The origin, development and morphology of the ochrea in *Polygonum orientale* Linn. *J. Indian bot. Soc.* **24** : 191–200.

—— & MAJUMDAR, G. P. 1952 The leaf-base and the internode—their morphology *Paleobotanist* **1** : 351–367

MUENSCHER, W. C. 1944. Aquatic Plants of the United States. Comstock Publishing Co , New York.

MULLAN, D P. 1945. The biology and anatomy of *Scirpus grossus* L. f. *J Bombay nat. Hist. Soc.* **45** : 402–407.

NARASIMHA MURTHY, S. K. 1933. Cytological and morphological studies in *Limnophyton obtusifolium* Miq. *Half-yrly J Mysore Univ* **7** : 1–32

PARIJA, P. 1934. Physiological investigations on Water-Hyacinth (*Eichhornia crassipes*) in Orissa with notes on some other aquatic weeds. *Indian J. agric. Sci.* **4** : 399-429.

PAX, F & HOFFMANN, C. 1931. Callitrichaceae In Engler and Harms' Die natürlichen Pflanzenfamilien. **19C.** Leipzig.

PULLE, A. A. 1938. Compendium van de Terminologie, Nomenclatuur of Systematiek der Zaadplaten. Utrecht

RAIMANN, R. 1898 Hydrocaryaceae. In Engler and Prantl's Die naturlichen Pflanzenfamilien. III(7). Leipzig.

RAM, M. 1956. Floral morphology and embryology of *Trapa bispinosa* Roxb. with a discussion on the systematic position of the genus *Phytomorphology* **6** : 312–323.

RANGASWAMY, K 1941. Cyto-morphological studies in *Asteracantha longifolia* Nees (*Hygrophila spinosa* T. And.). *Proc. Indian Acad. Sci.* **14B** : 149–165.

RAZI, B. A. 1949. Embryological studies of two members of the Podostemaceae. *Bot. Gaz.* **111** : 211–218.

REID, G K 1961. Ecology of Inland Waters and Estuaries. Reinhold Publishing Corporation, New York.

RENDLE, A. B. 1952. The Classification of Flowering Plants. II. Dicotyledons. University Press, Cambridge.

—— 1953. The Classification of Flowering Plants. I. Gymnosperms and Monocotyledons. University Press, Cambridge.

ROPER, R B. 1952. The embryo sac of *Butomus umbellatus* L. *Phytomorphology* **2** : 61–74.

ROXBURGH, W. 1832. Flora Indica: or descriptions of Indian plants. II. Serampore.

SANTAPAU, H. 1950. Notes on the Scrophulariaceae of Bombay. *J. Bombay nat. Hist. Soc.* **49** : 25–49.

—— 1960. The flora of Khandala on the Western Ghats of India (2nd edn). *Rec. bot. Surv. India* **16**(1): 1–335.

SOUÈGES, R. 1952. L'albumen et l'embryon chez le *Callitriche vernalis* Kuntz. (*C. verna* L.). *C. R. Acad. Sci., Paris* **235** : 453–456.

SVEDELIUS, N. 1904. On the life-history of *Enalus acoroides*. *Ann. R. bot. Gdns Peradeniya* **2** : 267–297.

TROLL, W. 1931. Beiträge zur Morphologie des Gynaceums. 1. Über das Gynaeceum der Hydrocharitaceen. *Planta* **14** : 1–18.

UHL, N. W. 1947. Studies in the floral morphology and anatomy of certain members of the Helobiae. Ph.D. Thesis, Cornell University.

VENKATESWARLU, J & LAKSHMINARAYANA, L. 1957. A contribution to the embryology of *Hydrocera triflora* W. & A. *Phytomorphology* **7** : 194–203.

WETTSTEIN, R. 1935. Handbuch der systematischen Botanik. Leipzig.

APPENDIX

CHROMOSOME NUMBERS IN INDIAN AQUATIC PLANTS

Name of the family and taxon	Chromosome number 2n	Authority
NYMPHAEACEAE		
Nymphaea stellata Willd.	28	Langlet & Söderberg, 1927 ; Janaki Ammal, 1959
var. *versicolor* Hook. f. & Thoms.	84	Sundara Raghavan & Arora, 1958
Euryale ferox Salisb.	58	Langlet & Soderberg, 1927
Nelumbo nucifera Gaertn. (*Nelumbium speciosum* Willd.)	16	Langlet & Soderberg, 1927
CRUCIFERAE		
Nasturtium officinale R. Br	32	Howard & Manton, 1946
ELATINACEAE		
Elatine triandra Schk.	*c.* 40	Frisendahl, 1927
Bergia capensis L.	18	Raghavan & Srinivasan, 1940a
BALSAMINACEAE		
Hydrocera triflora (L.) Wt. & Arn. (*H. angustifolia* Bl.)	16	Schurhoff, 1931 ; Venkateswarlu & Lakshminarayana, 1957
LEGUMINOSAE		
Aeschynomene indica L.	40	Kawakami, 1930
HALORAGACEAE		
Myriophyllum spicatum L.	36	Löve & Löve, 1948
	28	Löve, 1954a ; Love & Löve, 1956
	42	Löve, 1961
M. verticillatum L.	28	Scheerer, 1940
	42	Harada, 1952
CALLITRICHACEAE		
Callitriche stagnalis Scop.	10,20	Jörgensen, 1923
	10	Sokolovskaja, 1932 ; Schotsman, 1954 ; Löve & Löve, 1956
ONAGRACEAE		
Jussiaea repens L.	16	Sinoto, 1928

Name of the family and taxon	Chromosome number 2n	Authority
GENTIANACEAE		
Nymphoides cristatum (Roxb.) O. Kuntze (*Limnanthemum cristatum* Griseb.)	18	Srinivasan, 1941 ; Mookerjea, 1951 ; Srivastava, 1955 ; Shetty & Saroja (Unpubl.)
N. indicum (L.) O. Kuntze [*Limnanthemum indicum* (L.) Griseb.]	18	Shetty & Saroja (Unpubl.)
CONVOLVULACEAE		
Ipomoea aquatica Forsk. (*I. reptans* Poir.)	30	Rao, 1947 ; Sharma & Datta, 1958
SCROPHULARIACEAE		
Limnophila indica (L.) Druce (*L. racemosa* Benth.)	34	Shetty & Saroja (Unpubl.)
Dopatrium lobelioides (Retz.) Benth.	14	Raghavan & Srinivasan, 1940b
LENTIBULARIACEAE		
Utricularia flexuosa Vahl	42	Siddiqi, 1959
ACANTHACEAE		
Asteracantha longifolia (L.) Nees (*Hygrophila spinosa* T. Anders.)	24	Sugiura, 1940
	32	Rangaswamy, 1941
POLYGONACEAE		
Polygonum orientale L.	22	Jaretzky, 1928 ; Doida, 1960
P. pulchrum Bl (*P. tomentosum* Willd.)	22	Love & Löve, 1942 ; Andersson (in Love & Love, 1942)
P. glabrum Willd.	66	Sundara Raghavan & Arora, 1958
CERATOPHYLLACEAE		
Ceratophyllum demersum L	*c.* 24	Langlet & Soderberg, 1927
HYDROCHARITACEAE		
Hydrilla verticillata (L. f.) Royle	16,24	Sinoto, 1929
	16	Rao, 1950
	24	Sharma & Bhattacharyya, 1956
Nechamandra alternifolia (Roxb.) Thw. [*Lagarosiphon roxburghii* (Planch.) Benth.]	100	Sharma & Bhattacharyya, 1956
Vallisneria spiralis L.	20	Jorgensen, 1927 ; Rangasamy, 1934 ; Rao, 1950
	30,40	Sharma & Bhattacharyya, 1956
Ottelia alismoides (L.) Pers.	72	Narasimha Murthy, 1935
	c. 40	Janaki Ammal (in Darlington & Janaki Ammal, 1945)
	22,66	Rao, 1950
	44	Islam, 1950
	52	Sharma & Bhattacharyya, 1956
Halophila ovalis (R. Br.) Hook. f. (*H. ovata* Aschers.)	18	Harada, 1951
Enhalus acoroides (L. f.) Rich. ex Steud.	14	Janaki Ammal (in Darlington & Wylie, 1955)
PONTEDERIACEAE		
Monochoria hastata (L.) Solms	28	Banerji & Halder, 1942 ; Majumdar, 1953
M. vaginalis (Burm. f.) Presl ex Kunth	52	Morinaga & Fukushima, 1931
Eichhornia crassipes (Mart.) Solms	32	Taylor, 1925 ; Sharma & Talukdar, 1961

Name of the family and taxon	Chromosome number 2n	Authority
TYPHACEAE		
Typha angustata Bory & Chaub.	30	Harada, 1947 ; Gunguly, 1959
ARACEAE		
Pistia stratiotes L.	28	Blackburn, 1933
LEMNACEAE		
Spirodela polyrhiza (L.) Schleid. (*Lemna polyrhiza* L.)	40	Blackburn, 1933 ; Ehrenberg, 1945
Wolffia arrhiza (L.) Wimm.	*c.* 50	Blackburn, 1933
	c. 44–46	Lawalrée, 1943
ALISMATACEAE		
Limnophyton obtusifolium (L.) Miq	24	Narasimha Murthy, 1933
Sagittaria sagittifolia L.	16	Liehr, 1916
	20	Nawa, 1928
	22	Lohammar, 1931 ; Vaarama, 1941 ; Love & Love, 1942 ; Brown, 1946 ; Love, 1954b
BUTOMACEAE		
Tenagocharis latifolia (D. Don) Buchen.	14	Rao, 1946, 1953
POTAMOGETONACEAE		
Potamogeton perfoliatus L.	*c.* 48	Wiśniewska, 1931
	52	Palmgren, 1939 , Harada, 1942 ; Felfoldy, 1947 ; Löve, 1954a,b ; Harada, 1956 ; Löve & Love, 1956
P. pectinatus L.	*c.* 78	Scheerer, 1939 ; Harada, 1942 ; Palmgren (in Löve & Love, 1942)
Ruppia maritima L.	16	Murbeck, 1902 ; Graves, 1908 ; Wulff, 1937
Zannichellia palustris L.	28	Scheerer, 1940 ; Tarnavschi, 1948 ; Löve & Love, 1956
	24	Harada, 1956
NAJADACEAE		
Najas graminea Del.	24	Harada, 1943
N. minor (Pers.) All.	12	Harada, 1943
	24	Chase, 1947
CYPERACEAE		
Scirpus articulatus L.	32	Sharma & Bal, 1956
GRAMINEAE		
Coix aquatica Roxb.	10	Mangelsdorf & Reeves, 1939 ; Janaki Ammal (in Darlington & Janaki Ammal, 1945) ; Venkateswarlu, 1958
Paspalidium geminatum (Forsk.) Stapf (*Panicum geminatum* Forsk.)	40	Brown, 1951
	18	Raman *et al.*, 1959
Leersia hexandra Sw.	48	Ramiah, 1935 ; Ramanujam, 1938 ; Brown, 1948
Hygroryza aristata (Retz.) Nees ex Wt. & Arn.	24	Hirayoshi, 1937

REFERENCES TO APPENDIX

BANERJI, I. & HALDER, S. 1942. *Proc. Indian Acad. Sci.* **16B** : 91.
BLACKBURN, K. B. 1933. *Proc. Univ. Durham phil. Soc.* **9** : 84.
BROWN, W. V. 1946. *Bot. Gaz.* **108** : 262.
—— 1948. *Amer. J. Bot.* **35** : 382.
—— 1951. *Bull. Torrey bot. Cl.* **78** : 292.
CHASE, S. S. 1947. *Amer. J. Bot.* **34** : 581.
DARLINGTON, C. D. & JANAKI AMMAL, E. K. 1945. Chromosome Atlas of Cultivated Plants. London.
—— & WYLIE, A P. 1955. Chromosome Atlas of Flowering Plants. London.
DOIDA, Y. 1960. *Bot. Mag., Tokyo* **73** : 337.
EHRENBERG, L. 1945. Cited in Love & Löve, 1948.
FELFOLDY, L. J. M. 1947. *Archiv. Biol Hung* **17** : 101.
FRISENDAHL, A. 1927. *Acta Hort. gothoburg* **3** : 99.
GRAVES, 1908. Cited in Love & Love, 1948.
GUNGULY, B. 1959. *Curr. Sci* **28** : 82.
HARADA, I. 1942. *Jap. J. Genet.* **18** : 92
—— 1943. *Jap. J. Genet.* **19** : 120.
—— 1947. *Cytologia, Tokyo* **14** : 214.
—— 1951. *Jap. J. Genet.* **26** : 226.
—— 1952. *Jap. J Genet.* **27** : 117.
—— 1956. *Cytologia, Tokyo* **21** : 306.
HIRAYOSHI, I. 1937. *Jap. J. Genet.* **13** : 215
HOWARD, H. W. & MANTON, I. 1946 *Ann. Bot , Lond.* **10** : 1
ISLAM, A. S. 1950 *J Indian bot. Soc* **29** : 79.
JANAKI AMMAL, E. K. 1959. *Bull. bot. Surv. India* **1** : 33.
JARETZKY, R. 1928. *Jb. wiss. Bot.* **69** : 357
JÖRGENSEN, C. A. 1923. *Bot. Tidsskr.* **38** : 81.
—— 1927. *J. Genet.* **18** : 63.
KAWAKAMI, I. 1930. *Bot Mag , Tokyo* **44** : 319
LANGLET, O. F. J. & SODERBERG, E. 1927. *Acta Hort. berg* **9** : 85.
LAWALRÉE, A. 1943. *Cellule* **49** : 335.
LIEHR, O. 1916. *Cohns Beitr. Biol. Pflanz.* **13** : 135.
LOHAMMAR, G. 1931. *Svensk bot. Tidskr.* **25** : 32.
LÖVE, A. 1954a. *Svensk bot. Tidskr.* **48** : 211.
—— 1954b. *Vegetatio, Haag* **5-6** : 212.
—— 1961. *Rhodora* **63** : 139.
—— & LÖVE, D. 1942. *Bot. Notiser* 1942. 19.
—— & —— 1948. Chromosome Numbers of Northern Plant Species. Reykjavik.
—— & —— 1956. *Acta Hort. gothoburg.* **20** : 65.
MAJUMDAR, A. 1953. *Caryologia* **5** : 306.
MANGELSDORF, P. C. & REEVES, R. G. 1939. *Bull. Tex. agric. Exp. Sta.* 574: 75.
MOOKERJEA, A. 1951. *Curr. Sci.* **20** : 328.
MORINAGA, T. & FUKUSHIMA, E. 1931. *Bot. Mag., Tokyo* **45** : 140.
MURBECK, S. 1902. Cited in Löve & Löve, 1948.
NARASIMHA MURTHY, S. K. 1933. *Halfyrly J. Mysore Univ.* **7** : 1.
—— 1935. *Proc. Indian Acad. Sci.* **2B** : 59.
NAWA, N. 1928. *Bot. Mag., Tokyo* **42** : 33.
PALMGREN, O. 1939. *Bot. Notiser* 1939: 246.
RAGHAVAN, T. S. & SRINIVASAN, V. K. 1940a. *J. Indian bot. Soc.* **19** : 283.
—— & —— 1940b. *Cytologia, Tokyo* **11** : 37.
RAMAN, V. S., CHANDRASEKHARAN, P. & KRISHNASWAMI, D. 1959. *Curr. Sci.* **28** : 453
RAMANUJAM, S. 1938. *Ann. Bot., Lond.* **2** : 107.
RAMIAH, K. 1935. *Proc. Ass. econ. Biol., Coimbatore* **3** : 51.
RANGASAMY, K. 1934. *J. Indian bot. Soc.* **13** : 129.
RANGASWAMY, K. 1941. *Proc. Indian Acad. Sci.* **14B** : 149.

RAO, N. S. 1947. *Curr. Sci.* **16** : 156.
RAO, Y. S. 1946. *Curr. Sci.* **15** : 175.
—— 1950. *Proc. Indian Sci. Congr.* 1950, pt. 3: 67.
—— 1953. *Proc. nat. Inst. Sci India* **19** : 563.
SCHEERER, H. 1939. Cited in Love & Löve, 1942.
—— 1940. *Planta* **30** : 716.
SCHOTSMAN, H. D. 1954. *Acta bot. neerl.* **3** : 313.
SCHÜRHOFF, P. N. 1931. *Bot. Jb.* **64** : 324.
SHARMA, A. K. & BAL, A. K. 1956. *Phyton* **6** : 7.
—— & BHATTACHARYYA, B. 1956. *Phyton* **6** : 121.
—— & DATTA, P. C. 1958. *Nucleus* **1** : 89.
—— & TALUKDAR, C. 1961. *Proc. Indian Sci. Congr.* 1961, pt. 3: 290.
SIDDIQI, O. H. 1959. *Sci. & Cult.* **25** : 319.
SINOTO, Y. 1928. *Proc. imp. Acad Japan* **4** : 231.
—— 1929. *Cytologia, Tokyo* **1** : 109.
SOKOLOVSKAJA, A. 1932. *Trud. petergof. est -nauch. Inst.* **8** : 149.
SRINIVASAN, A. R. 1941. *Proc. Indian Acad. Sci.* **14B** : 529.
SRIVASTAVA, M. G. 1955. *Sci. & Cult.* **21** : 215.
SUGIURA, T. 1940. *Cytologia, Tokyo* **10** : 324.
SUNDARA RAGHAVAN, R. & ARORA, C. M. 1958. *Proc. Indian Acad. Sci.* **47B** : 352.
TARNAVSCHI, I. T. 1948. *Bul. Grăd. bot. Cluj.* **28** : 1.
TAYLOR, W. R. 1925. *Amer. J. Bot.* **12** : 238.
VAARAMA, A. 1941. Cited in Löve & Löve, 1942.
VENKATESWARLU, J. 1958. *J Indian bot. Soc.* **37** : 329.
—— & LAKSHMINARAYANA, L. 1957. *Phytomorphology* **7** : 194
WIŚNIEWSKA, E. 1931. *Acta Soc. Bot. Polon.* **8** : 157.
WULFF, H. D. 1937. *Jb. wiss. Bot.* **84** : 812

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