Collecting and Preserving Aquatic Plants

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Introduction

The collection of aquatic plants is often done as part of ecological or impact studies, both as a record of conditions at a given time for comparison with later conditions, and as a necessity when the collectors are not able to identify the specimens in the field and need to send a specimen to an expert. These specimens are a valuable scientific record and their collection and subsequent handling should be done with care so that much of the time and expense that has gone into their collection is not wasted. Herbaria exist for the purpose of long term care and storage of the specimens and some standards have been set up for the care and storage of plant specimens. These standards should be followed so that the plants will become valuable scientific specimens for more than the specific purpose for which they were collected. In addition, their storage in a long term facility like an herbarium will make them accessible to subsequent researchers for other uses. Herbaria provide a permanent record of what was found and if identifications need to be rechecked the specimen is available. Even when the major thrust of the work is for biomass studies or tissue analyses, representative specimens must still be collected and saved as vouchers of what species were analysed or studied.

Identification

General Specimen Handling Procedures

General Notes

Plants are mounted on white card stock, about 11 by 16 inches and stored in Herbarium Cabinets made for this purpose. These cabinets have insect-proof tightly-sealed doors, and shelves which accommodate these standard-sized mounting boards. This uniformity facilitates exchange of specimens between institutions and a common design of storage cabinets and facilities. One should assume that a specimen is **permanent**. Treat it as such when you collect it and when you are processing and storing it, and when you are handling it at a later date. Many specimens in herbaria around the world are hundreds of years old and are of great value in documenting changes in the habitats of areas, and in the study of the ongoing process of plant evolution.

For terrestrial plants, where the plants are rigid and can be mounted dry, most good quality white card stock is acceptable. However most submerged plants do not have structural supporting tissues, they rely on the water for support (this is why they are virtually useless for compost), and they must be floated onto the card stock. Therefore a paper which is remains dimensionally stable under wetting and subsequent drying is required. Most ordinary papers will wrinkle upon drying after being soaked, even if they are kept pressed during the drying process. Ask your paper supplier for a card stock which does not react this way; they are available but their trade names change from time-to-time and supplier-to-supplier so no example can be given.

Collecting

Generally the whole plant should be collected. Some groups can not be identified to species without mature fruits or flowers; others need rhizomes of leaf axils or tips. Since the submerged portions of aquatic plants do not have to guard against loss of water from their tissues, they do not have waxy or water repellant cuticles like emergent plants. Do not leave them out in the sun even briefly as they will wither very quickly and become useless as specimens. Keep them in a bag or bucket of water at all times until you are ready to press them. Emergent plants should not be submerged but kept in a bag with a little water in the bottom to maintain a high humidity. It is best to keep each species in its own bag and all the bags from one lake or site together in one large bag, a garbage bag will do fine.

Some very small plants like the duckweeds do not make very satisfactory pressed and dried specimens, nor is it convenient to collect them into a bag. Small, 20 mL, screw cap vials make good collecting and preservation containers for these plants. Put a little water into the vial to keep the plants moist. Later fill the vial with a solution of 5% formalin, 25% water and 70% ethanol as a permanent preservative. This liquid may need to be replaced after about a month since it will extract chlorophyll and pigments from the plants and become quite dark or opaque. Isopropanol can be used instead of ethanol but ethanol is preferred.

Under some conditions it may be necessary to bring back frozen specimens from the field. Some species do not react very well to freezing and will not be suitable for permanent herbarium specimens. However the plants are indentifiable and provide distribution records. Put each specimen in its own bag; a tangled mass of frozen plants is difficult to separate without damage.

If you are returning from the field within a day you may bring plants back in their plastic bags and press them later. They will keep quite well overnight in the crisper section of a refrigerater if necessary. Do not keep them too long or the quality of the specimens deteriorates. In general plants should be pressed as soon as possible after they are collected for the best specimens.

A common technique for fruiting plants, where the seeds may be shed on drying, is to collect the seeds, which are often diagnostic, in small paper or cellophane pouches and attach these pouches to the finished herbarium sheet.

Mounting and Labelling

Specific details on mounting different species of aquatic plants are given below. Generally, for stiff, erect, emergent plants which are similar to terrestrial plants, and those aquatics which do not clump together when taken from the water, no special techniques are required. Lay the plants on the card stock with the roots in the bottom left corner and fold over the tops if they are too tall to fit. Do not cover the label area in the bottom right corner. Spread out leaves and flowers, turn some over so the bottoms can be seen, and try to make a neat and tidy specimen that covers the whole sheet. For small plants fill the sheet with more specimens from the same clump or clone, to show as much variability as possible.

Plants which are not rigid and erect, but clump together or are flaccid, need to be floated onto the card stock and arranged neatly to keep them from becoming a useless mat. Start by slowly lifting the bottom of the card stock out of the water at the root end and arranging and spreading the plant as you continue. Once a portion is out of the water it will stay in place. Some, but not all, plants will allow a limited amount of rearranging once they are out of the water. Hold the card stock with one corner down and let most of the excess water drain off. Floating may be done in motel bathtubs or shower stalls, in 14 by 20 inch photographic trays or in lakes and ponds. It will be difficult in lakes if there is any wind or waves. Do **not** take plants to a different lake to float them onto the card stock; you risk spreading weeds from lake to lake. Using a tray on a picnic table, at a site with running water, is an ideal mounting and pressing situation as is the tailgate of a truck with a canopy.

After mounting the aquatic plant on the card stock a piece of heavy blotting paper is placed on top of the specimen to help dry the plant quickly. These blotters are re-usable and are usually about 12 by 18 inches in size. The package of the card stock with the plant and the blotter is wrapped in a newsprint folder while in the drying press; this newsprint is also re-usable. It is usually 12 by 36 inches in size and folded in half to form a folder in which the mounted plant is placed. Field notes are often written on this newspaper but for aquatic plants, where the specimens stay on the card stock permanently, notes should be written on the top side of the card stock in the bottom right-hand corner where it will later be covered by the permanent label. This way the label data stays with the specimens. The size of this label is usually about 5 inches wide by 3 inches high; confine your field notes to a space smaller than this so the subsequent label will completely cover them. Write the notes on the card stock in pencil and do so **before** you float the plants onto the card. You will not be able to write on the card once it is wet.

The wrapped packages of plants on card stock with a blotter and a newsprint folder are put into a plant press with a piece of corrugated cardboard separating each package. This re-usable cardboard is usually 12 by 18 inches and all the corrugations should run in the same direction so that air flow through the press is facilitated. Quick drying under pressure is needed; drying should take place within several days to prevent fungal growth and rotting, and to preserve colours and shapes as much as possible. If you will be in a laboratory or herbarium the same day the plant presses may be dried in a proper plant drier or a forced draft oven at 40 degrees. In the field use motel hot air registers, baseboard heaters, or hair driers to move warm air through the corrugated cardboard. If the weather is dry put the plant press on the roof of the truck and allow air to blow through the corrugated cardboard as you drive from site to site. As the plants in the presses dry it will be necessary to retighten the presses periodically, at least daily, to keep up the pressure and hold the plants flat.

The label information must include at least the date, the name(s) of the collector(s) and the name and specific location of the lake or water body. Latitude and longitude, or UTM or military grid references are best since they are unique. Names are neither unique nor permanent and some towns and stations are ephemeral. Will the location data you use mean anything to someone from another part of the world 100 years from now? It should also include as much ecological data as possible including other associated plants, location in the lake, specific habitats and rarity. When you put the plant press together have all the mounting card facing the same way, all the tops at the same end, all the newspaper sleeves opening to the same side (preferably the right), and all the specimens from one lake or site together as a group. This greatly facilitates the subsequent job of taking the press apart, logging the data and re-assembling a new press for the next trip.

Specific Specimen Handling Procedures

Group Key

A Key to aquatic plants with similar collection and preservation techniques.

1. The plants are very small and freely floating, on or under the water. They may be stranded on wet mud by declining water levels. Many of them will fit into a 20 mL vial. This group includes the duckweeds and similar plants. **—Group A.**

1. The plants are generally larger and usually rooted in the bottom sediment, have leafy stems and may be submerged, floating or emergent. A few species may be small enough to fit into a 20 mL vial.

    2. The plants are emergent marginals, or if submerged or floating they do not collapse or clump together when removed from the water. These plants are all stiff and hold their shape. **—Group B.**

    2. The plants are submerged and usually have fine or delicate leaves and stems. The leaves tend to collapse into a clump or mat when removed from the water. **—Group C.**

Each of these groups is dealt with separately as they have some different collecting and mounting requirements.

Group A

These are all small, floating plants and many specimens will fit into one 20 mL vial. They may also be found growing on damp muddy banks which are shaded from the direct sun, stranded by declining water levels. Since they are small and freely floating they congregate in sheltered areas and are rare in open water sites. In large lakes they will be found in down-wind and log-jam areas and among dense beds of other vegetation along the shore. They are more generally found in ponds, ditches, sloughs, embayments and other protected waters which are rich in nutrients, but with little, if any, fetch or wind exposure. They will dessicate quickly if left out of water for even a short time; collect them directly into a vial or small bag containing some water.

DESCRIPTIONS AND HANDLING OF THE GROUP 'A' PLANTS

The duckweed *Lemna trisulca* is usually found submerged and lying on the bottom; the other four duckweeds, *L. gibba, L. minor, Wolffia punctata,* and *Spirodela polyrhiza,* float on, or at the surface. While these can be spread out on a herbarium sheet they are often best preserved in a small vial. Except for *Wolffia* these plants are illustrated in the Group 'A' figure. *Wolffia* species are so small and featureless that they are not illustrated. *Wolffia punctata* is very small and almost featureless, even at 10X magnification. The common name is watermeal and it often looks like pollen grains floating on the surface. It is rarely recognized and collected, but is probably more common than recorded, and is usually found growing mixed with other duckweeds.

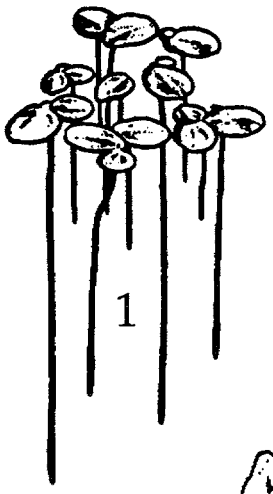
The bladderworts *Utricularia minor* and *U. gibba,* are submerged but are usually found near the surface and often in tangled mats or wrapped around other species of aquatic plants. The *Utricularia* species are represented by *U. intermedia* in the group 'C' figure. These *Utricularia* species may be floated onto a herbarium sheet, but they are also well suited to being preserved in a small vial.

The other Group 'A' plants all floating on the surface and include two aquatic liverworts—*Riccia fluitans* and *Ricciocarpus natans;* one aquatic fern—*Azolla filiculoides* and possibly another aquatic fern—*Salvinia rotundifolia,* an aquarium plant which has not yet been shown to overwinter successfully. These species may be floated onto a herbarium sheet, but they are also well suited to being preserved in a small vial. They are illustrated in the Group 'A' figure.

Legends for the Group A Figure

1 —*Lemna gibba*
2 —*Lemna minor*
3 —*Lemna trisulca*
4 —*Spirodela polyrhiza*
5 —*Azolla filiculoides*
6 —*Salvinia rotundifolia*
7 —*Ricciocarpus natans*
8 —*Riccia fluitans*

Group A



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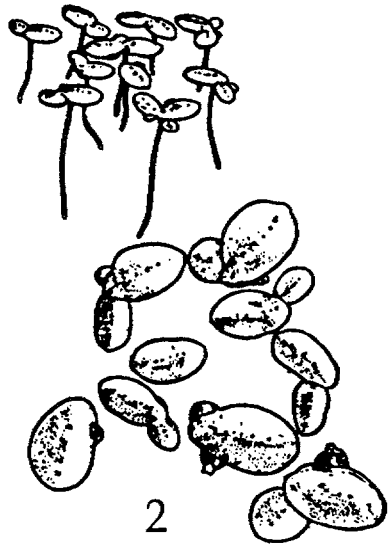

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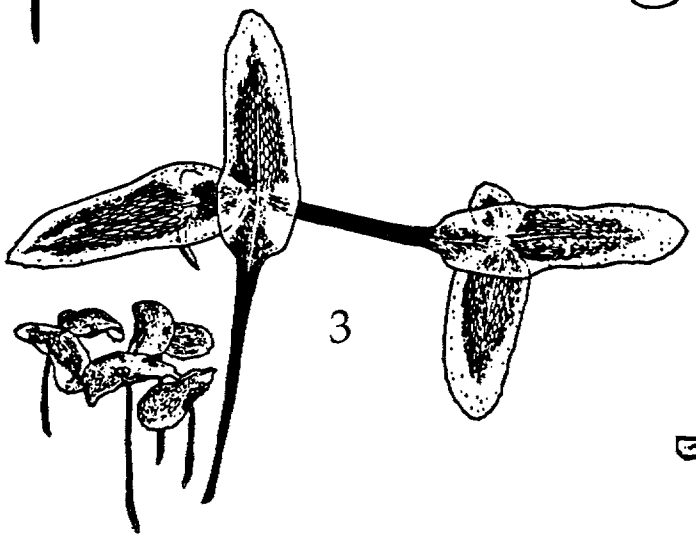

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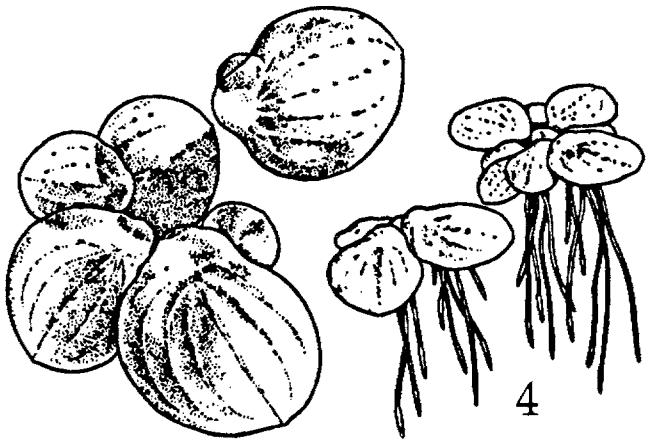

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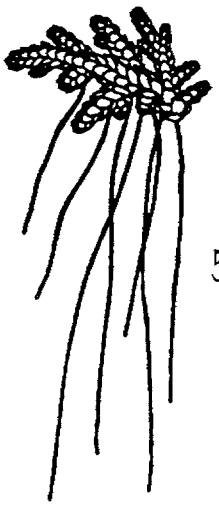

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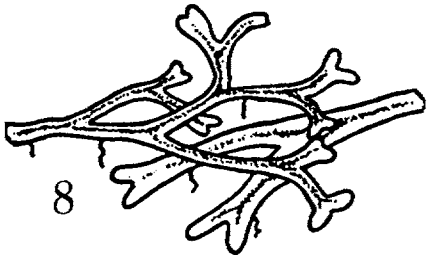

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Group B

These are the stiff or erect species which do not clump together or collapse when removed from the water. A few species may be small enough to fit into a 20 ml vial but most are much larger and all should be mounted on herbarium sheets. A few species are totally submerged, but rigid and self-supporting. Most of these do not have leafy stems but instead their roots and leaves arise directly from a swollen base. These erect and self-supporting submerged species include: *Isoetes , Lobelia dortmanna, Subularia aquatica, Lilaeopsis occidentalis, Tillaea aquatica,* and sometimes *Veronica* .

Most species are marginal and emergent and can support themselves out of water. Almost all of them are rooted in the bottom and have leafy stems which emerge into the air. These self-supporting, marginal and emergent species include: *Sparganium emersum, Sparganium eurycarpum, Ranunculus flammula, Alisma, Sagittaria, Equisetum, Lilaea scilloides, Scheuchzeria palustris, Menyanthes trifoliata, Calla palustris, Acorus calamus, Cicuta, Berula erecta, Oenanthe sarmentosa, Sium sauve, Veronica, Mimulus, Iris pseudacorus, Typha latifolia, Hypericum, Lysimachia, Myrica gale, Potentilla palustris, Myosotis, Triglochin, Gratiola, Montia fontana, Dulichium arundinaceum, Rhynchospora alba, Eleocharis palustris, Scirpus lacustris, Elatine,* and *Marsilea vestita.*

DESCRIPTIONS AND HANDLING OF THE GROUP 'B' PLANTS

The folowing species need no special handling – simply press the whole plant as you find it. Roots should be rinsed free of dirt and adhering wood chips or sand. *Veronica, Tillaea aquatica, Lilaeopsis occidentalis, Subularia aquatica, Lobelia dortmanna, Ranunculus flammula, Alisma, Sagittaria, Equisetum,* 'grasses', *Lilaea scilloides, Scheuchzeria palustris, Myosotis, Triglochin, Gratiola, Montia fontana, Dulichium arundinaceum, Eleocharis acicularis, Elatine, Sium sauve, Mimulus, Hypericum,* and *Lysimachia thyrsiflora.*

Veronica are marginal plants, generally submerged in the spring and emergent in summer. They are small and inconspicuous, and being more common in marginal and wetland habitats, are not often collected in lake surveys. *Tillaea aquatica* is very small and usually overlooked. It generally grows on bare mud flats as water levels recede in the summer, or in wetlands and vernal pools. *Lilaeopsis occidentalis* is a small submerged plant with hollow segmented leaves like small sausages. It grows in marshes, salt flats, and sandy or muddy beaches. It is generally found in coastal or tidally influenced areas (such as Pitt Lake) and may be exposed at low water levels. It is rarely collected.

Subularia aquatica is a small plant generally submerged along the margins of lakes and ponds. It is an inconspicuous plant which is usually overlooked by collectors and is probably more common than collecting records indicate. *Lobelia dortmanna* has thick fleshy leaves in a basal rosette. The plants usually grow in shallow water on hard, sandy bottoms where they can send their inflorescence of showy, white flowers up into the air. Deep water plants do not flower. The large clumps of white roots are also very striking and diagnostic.

Ranunculus flammula is usually found creeping among the rocks or on the wet grassy or muddy margins of lakes. It is conspicuous with its bright yellow "buttercup" flowers. It may also be found in shallow marginal habitats. The leaves may be strictly linear or may have spatulate ends. *Elatine* are small mat-forming plants growing on mud flats, or in the shallow water at the margins of ponds. They are inconspicuous plants and are rarely collected in lake surveys. *Alisma gramineum* has long, narrow, spatulate leaves about as long as the mature inflorescence. *Alisma plantago-aquatica* has short broad leaves and a very tall inflorescence. Both usually grow in shallow water with the leaves, and certainly the inflorescences, emergent. They are marginal plants in lakes, or found in ponds and vernally wet areas. Pressing the mature inflorescence from an *A. plantago-aquatica* plant is a challenge; look for small plants or less mature specimens.

Sagittaria are difficult to distinguish. Leaves are of little diagnostic value; intact inflorescences with flowers and fruits are required. Do not lose the white petals which usually fall off in the collecting bag. These are usually marginal and shallow-water plants but both *Alisma* and *Sagittaria* may grow in deep water. They then have non-surfacing linear leaves totally unlike their typical emergent leaves. *Equisetum* , the horse-tails, are usually marginal in lakes, or found in shallow ponds and wet seepage areas. The stems are segmented and hollow and usually do not have any branches. The fruiting structure, a 'cone', is apical. The 'cones', the presence or absence of branches, and the details of the bracts at the joints are all diagnostic. In addition some species have separate fruiting and vegetative stems which are morphologically distinct.

Lilaea scilloides is an inconspicuous plant of shallow water or seasonally exposed mud banks. It is found from coastal tideflats to interior valleys but is rarely collected. *Scheuchzeria* and *Lilaea* have unique inflorescences and may not be recognized when sterile. The species of *Isoetes* are not practically distinguishable without microscopic examination of the spores which are found in a pouch at the base of the quill-like leaves. These fully submerged plants may grow in quite deep water. *Myosotis* and *Mimulus* are marginal or floating-mat species, usually in ditches, ponds, and other protected waters. They sprawl or creep over the mud or surface of the water in shallow, seasonally-flooded, areas and in ditches. The showy flowers are yellow in *Mimulus* , blue in *Myosotis*.

Triglochin are found in wet, marshy areas, in shallow water, or in seasonally or tidally inundated areas. They tolerate brackish, saline or alkaline waters and grow in coastal bogs, inland meadows, mud flats, and estuaries or coastal strands. A mature inflorescence with fruits is generally required for species identification. *Gratiola* are small, inconspicuous, and rarely collected. They grow in shallow water and on muddy shores or other wet places. *Montia fontana* is also a small inconspicuous plant of shallow, vernal ponds, exposed mud banks, or wet meadows. *Dulichium arundinaceum* is a marginal and shallow-water plant which is in the sedge family but appears 'grassy'. It may also grow in marshes and wet meadows. It is a unique monotypic genus and once recognized should not be confused with anything else.

Sium sauve is a variable plant related to the *Cicuta–Berula–Oenanthe* group. All are marginals in lakes and also found in wet meadows and marshes. An important diagnotic feature within this group of genera is the relationship of leaf-vein endings to leaf-margin teeth. *Sium*, in particular, also grows submerged, where it takes on a very distinct, narrow-leaved form and does not resemble the emergent plants. *Hypericum anagalloides* often grows on logs floating on the water and trails down into the water. It also grows on wet, mossy banks subject to seasonal flooding. The other *Hypericum* species tend to be on gravel bars, stream deltas in lakes, and seasonally inundated gravel shores. All have yellow flowers.

Lysimachia thyrsiflora grows as an emergent or a marginal, in quiet ponds and on sheltered lakeshores, or in ditches. *Eleocharis palustris* is an emergent or marginal plant of the sedge family. The species is variable and widespread in the northern hemisphere. It may be a large plant, up to a meter tall, and grows from an extensive rhizome. *Eleocharis acicularis* is a small mat-forming species, often inhabiting muddy banks left exposed by declining water levels.

Menyanthes trifoliata, Calla palustris and *Potentilla palustris* all have extensive creeping, woody, rootstocks. Do not try to collect a section of the rootstock, usually one cluster of leaves and flowers is sufficient. *Potentilla palustris* is a sprawling shrub along the margins of lakes and ponds, often growing in quite deep water in beaver-dammed pools. The flowers are a deep wine-red colour; the other species in the genus have yellow flowers. *Menyanthes trifoliata* (buckbean) may form extensive beds along the shallow water margins of lakes or extensive stands in shallow delta areas and backwaters. The 3-lobed leaves and striking white flowers make this plant easily recognizable. *Calla palustris* is a northern species growing along the shallow margins of lakes and in wet places. The inflorescence looks like a white skunk cabbage (to which it is related) and has large, spiny, bright red fruits in the fall. The plant is poisonous.

Acorus calamus and *Typha latifolia* are both large 'cat-tails'. *Typha latifolia* usually grows in quite shallow marginal areas or in wet seepage spots and ditches. The species is very common throughout B.C. and produces vast quantities of pollen and seeds. Only the one species is known at present, though others grow in nearby areas. The diagnostic character for *T. latifolia* is the lack of a gap between the male and female flowers on the spike. Similar species growing in surrounding areas have such a gap. The 'cat-tail' may reach 3 m in height. *Acorus calamus* is a smaller plant than the 'cat-tail' but with the same general growth habit. It is however, related to *Calla* and 'skunkcabbage'. It is known from Montana, Washington and Idaho but is very rare in BC. where it grows in shallow marginal habitats as an emergent.

Acorus and *Typha* can be a problem to collect due to their large size. With a sharp knife cut a short section of stem with several leaves and an inflorescence. If you can find a small plant, take the whole thing along with a piece of rhizome. Inflorescences are diagnostic and required to differentiate one species from another. Young inflorescences can be pressed whole but large mature ones are a problem. One solution is to slice them longitudinally into three portions and keep the central portion with the stem; the other two outside pieces will fall apart. Some flowers and seeds should be put into a small envelope or bag and attached to the herbarium sheet as they will tend to fall off the mounting sheet.

Sparganium emersum and *S. eurycarpum* are found in marshes and shallow marginal areas. Both are robust, bright green, conspicuous, emergents. *S. eurycarpum* may reach more than 2 m in height while *S. emersum* is only about half as tall. The large spiny, globular, fruits are very characteristic, with the shape of the seed, as shown in the figures, serving to distinguish them. The seeds of *S. emersum* taper gradually to a point while those of *S. eurycarpum* are abruptly truncate. Also *S. emersum* inflorescences are unbranched while those of *S. eurycarpum* branch several times. *Sparganium emersum* and *S. eurycarpum* plants can be pressed whole, although the latter may sometimes grow rather large. It is the large, hard, globular, spiny fruits which are a problem and longitudinal slicing may be required.

Iris pseudacorus is a large, yellow-flowered, emergent, marginal plant. It is robust, up to 2 m tall, and grows in dense clumps. *Iris pseudacorus* is introduced, but quite widespread, throughout BC. A short piece of stem with leaves and the flowers are sufficient. The fruits are quite large and bulky, up to 10 cm long, and may not press well unless sliced open. This species should not be confused with any others when in fruit or flower, vegetatively they look superficially like *Typha*.

Scirpus lacustris, the bulrush, is a very widespread marginal species in BC, often forming a complete impenetrable fringe around lakes, ponds and marshes. It often grows in shallow water well out into exposed portions of lakes where its extensive rhizome system stabilizes the sandy bottom. Since *Scirpus lacustris* is up to 3 m tall it is a problem to press. All that is really necessary is the upper portion of the stem with the inflorescence, though if a small shoot can be found at the apex of the rhizome it could be collected intact.

Carex and *Juncus* may have extensive rhizomes which are often diagnostic. Collect a short piece of this rhizome with each emergent plant. *Carex* are numerous and widespread throughout BC. Most grow in wet, seepage habitats, though some inhabit dry sand-dunes, and some are marginal aquatics. Mature fruits are required for positive identification in this taxonomically difficult group. *C. sitchensis*, found mostly on the coast and *C. aquatilis* found in the interior represent the many species of *Carex* in the accompanying figures. *Juncus* are mostly marginal though some grow in shallow water and may be seasonally inundated. A mature inflorescence is usually needed to identify rushes. In the figures, *J. nodosus* represents the many *Juncus* species found in BC.

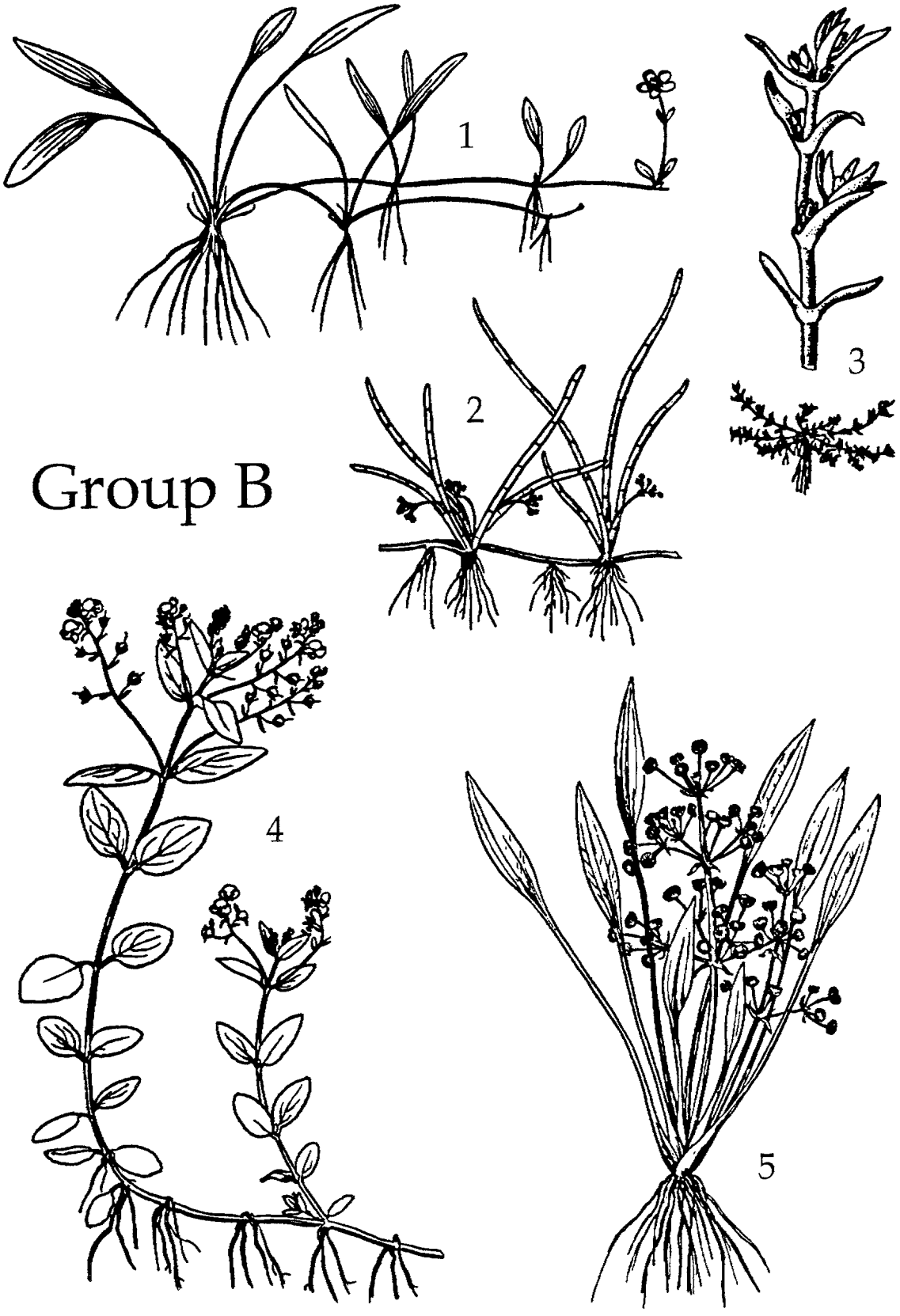
Eleocharis palustris grows in clumps from a rhizome. Break off a small section of rhizome with several emergent stems attached, preferably fruiting stems. *Isoetes* grow from a swollen two-or-three-lobed base which may be hard to press. With large specimens slice this base into two or three sections longitudinally and press all the slices; small specimens may not require slicing and can be pressed whole.

Cicuta, *Berula erecta* and *Oenanthe sarmentosa* are all closely related plants and very similar. The patterns of the veins on the leaves are diagnostic, as is the structure of the swollen base of the plant. Slice the swollen base longitudinally so as to expose the internal cross-septa, and press the pieces cut-side up so the internal structure can be seen. *Cicuta* has several large chambers in the tuberous base. *Cicuta douglasii* is very poisonous; one tuber is sufficient to kill a cow. Be careful.

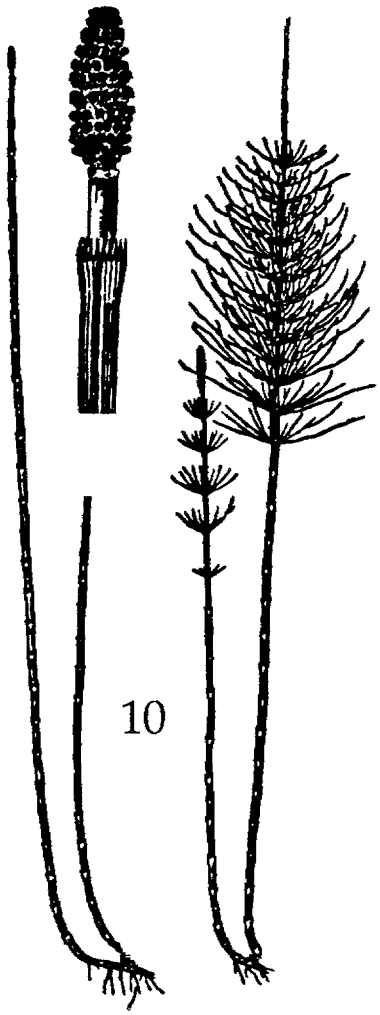
There are a number of genera of grasses which grow in wet marginal habitats in BC. In most cases leaf-sheaths and mature fruits are required for identification. It is usually best to collect some of the roots or rhizomes as well. One genus, *Glyceria*, which tends to grow in deeper water and not be an erect emergent like the rest, is treated under group 'C'. Wild rice, *Zizania aquatica*, is the grass species illustrated.

Legends for the Group B Figures

1 –*Ranunculus flammula*
2 –*Lilaeopsis occidentalis*
3 –*Tillaea aquatica*
4 –*Veronica americana*
5 –*Alisma gramineum*
6 –*Subularia aquatica*
7 –*Lobelia dortmanna*
8 –*Elatine triandra*
9 –*Sagittaria cuneata*
10 –*Equisetum fluviatile*
11 –*Mimulus tilingii*
12 –*Eleocharis acicularis*
13 –*Calla palustris*
14 –*Oenanthe sarmentosa*
15 –*Eleocharis palustris*
16 –*Cicuta douglasii*
17 –*Cicuta bulbifera*
18 –*Acorus calamus*
19 –*Scirpus lacustris*
20 –*Sparganium emersum*
21 –*Sparganium eurycarpum*
22 –*Typha latifolia*
23 –*Juncus nodosus*
24 –*Iris pseudacorus*
25 –*Carex aquatilis*
26 –*Zizania aquatica*
27 –*Lilaea scilloides*
28 –*Myosotis scorpioides*
29 –*Alisma plantago-aquatica*
30 –*Isoetes lacustris*
31 –*Gratiola neglecta*
32 –*Montia fontana*
33 –*Hypericum anagalloides*
34 –*Menyanthes trifoliata*
35 –*Triglochin concinnum*
36 –*Sium sauve*
37 –*Scheuchzeria palustris*
38 –*Berula erecta*
39 –*Dulichium arundinaceum*
40 –*Lysimachia thyrsiflora*
41 –*Potentilla palustris*


1
2
3
Group B
4
5

Group B



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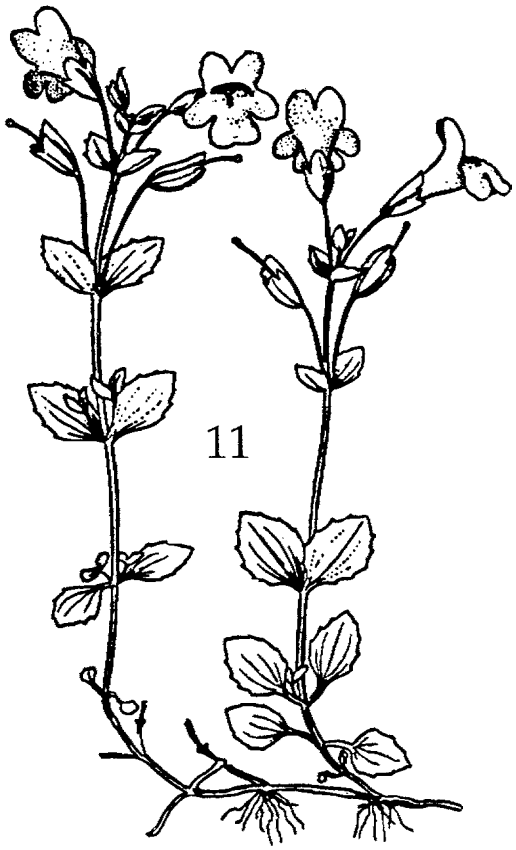

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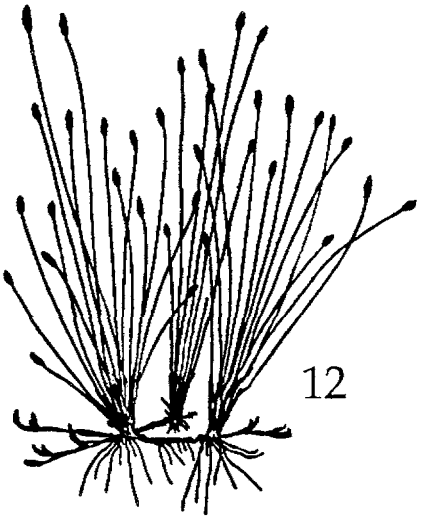

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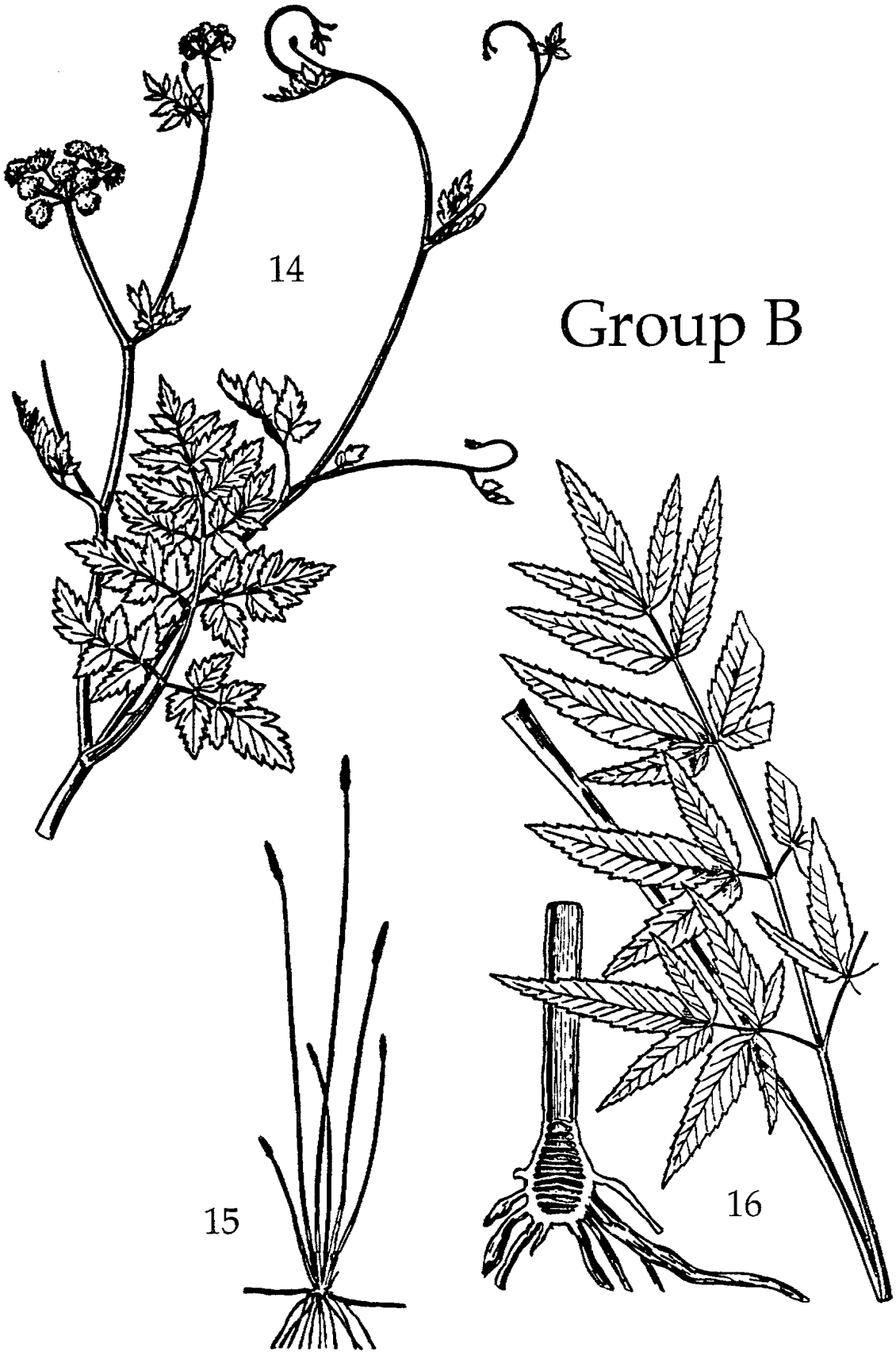

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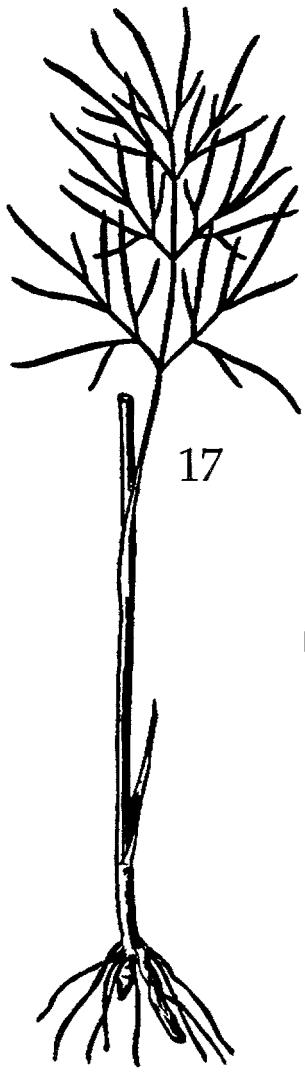

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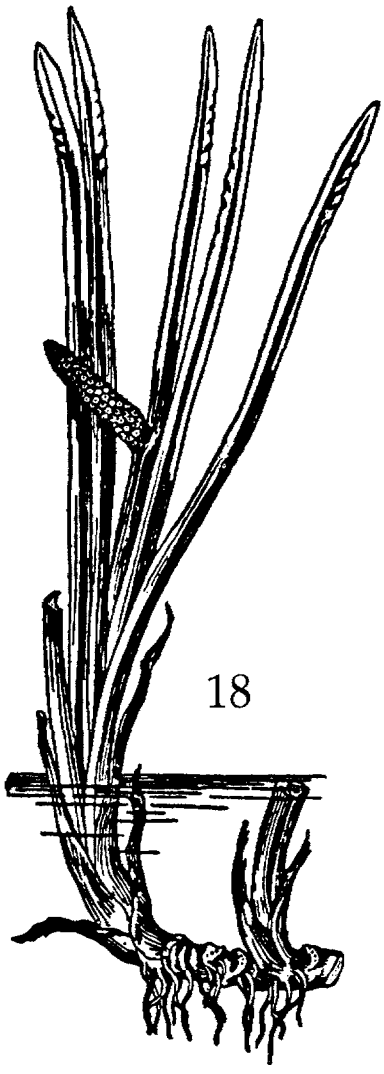

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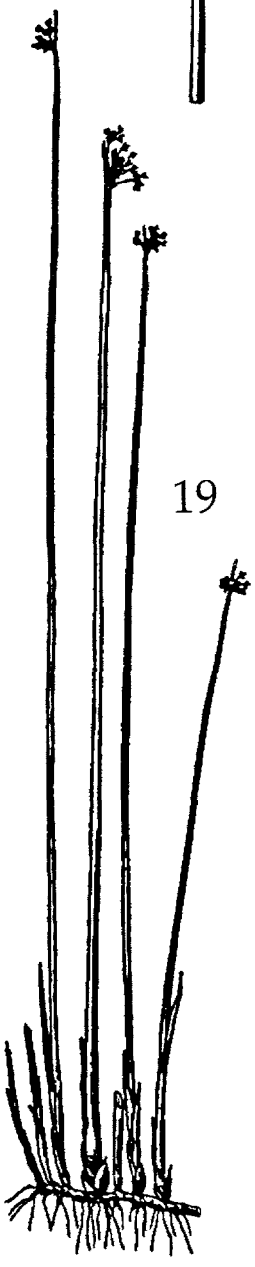

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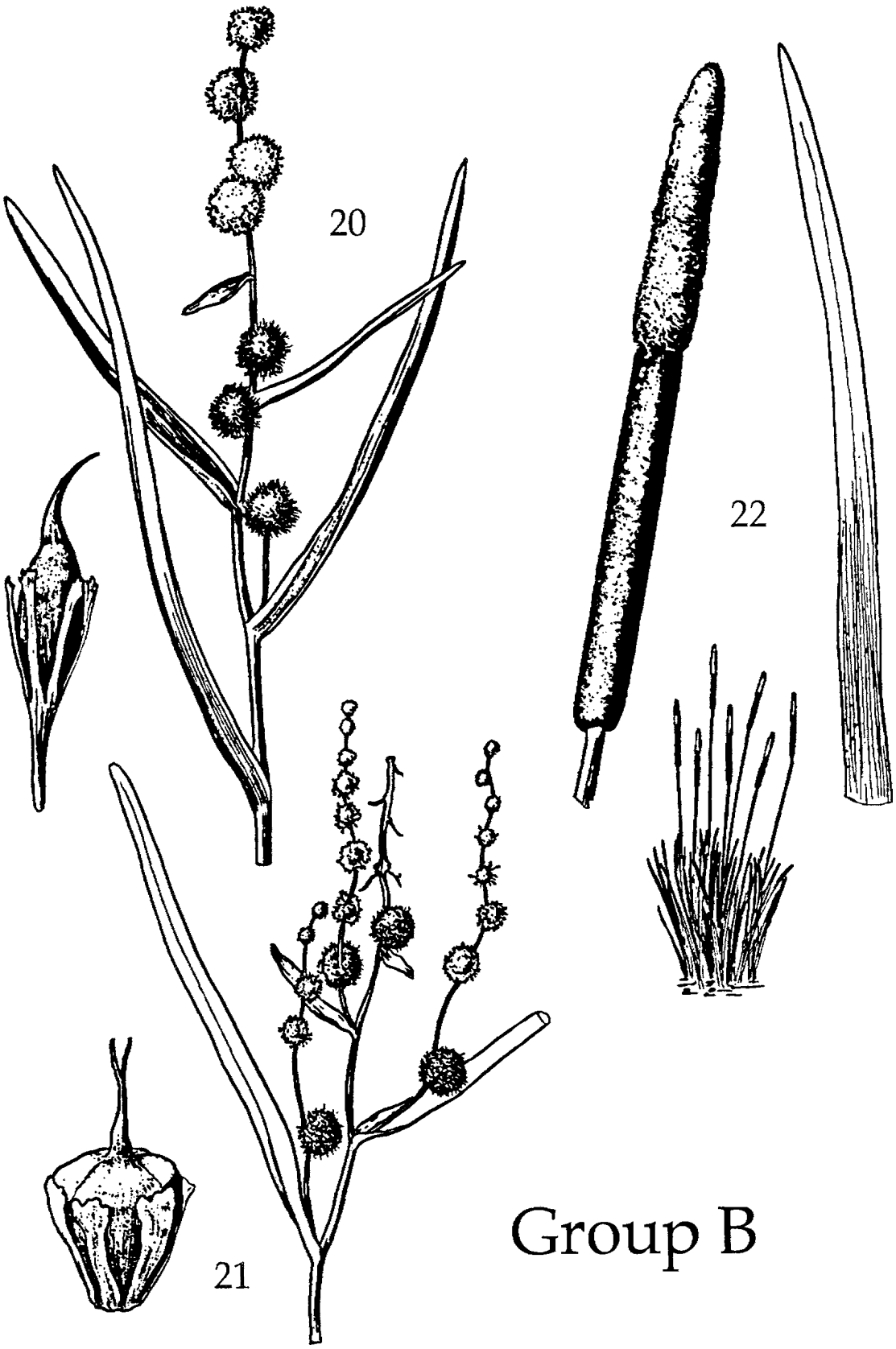

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Group B

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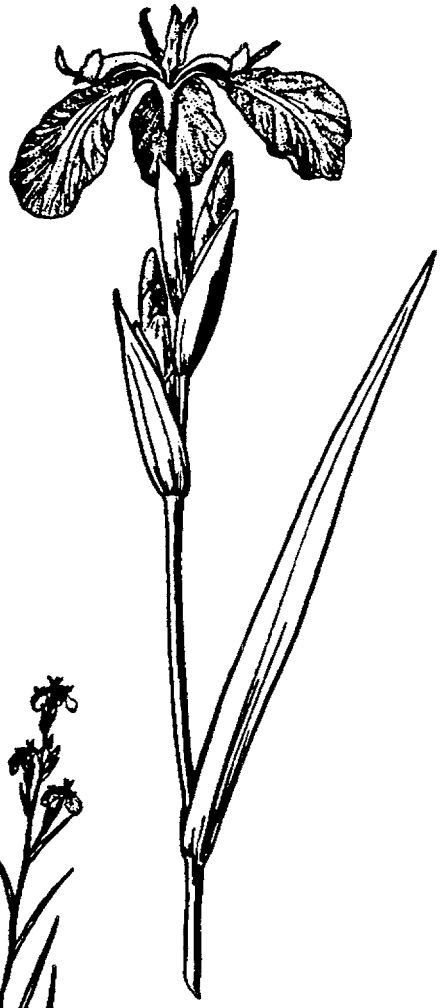

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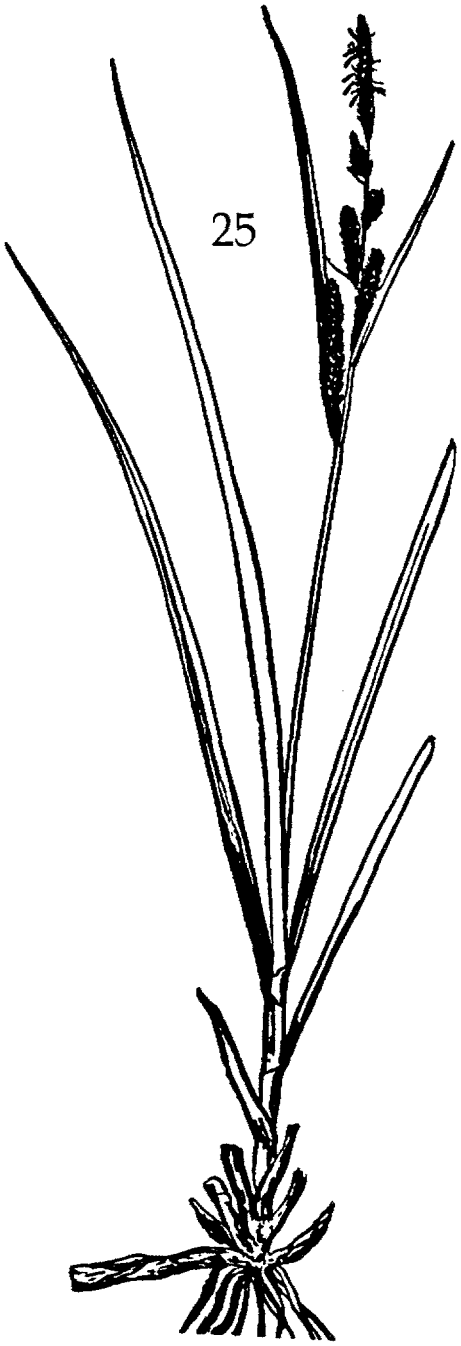

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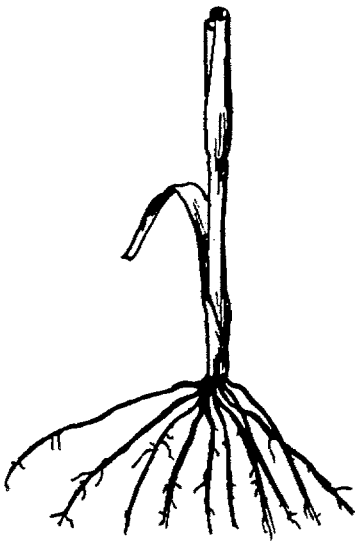

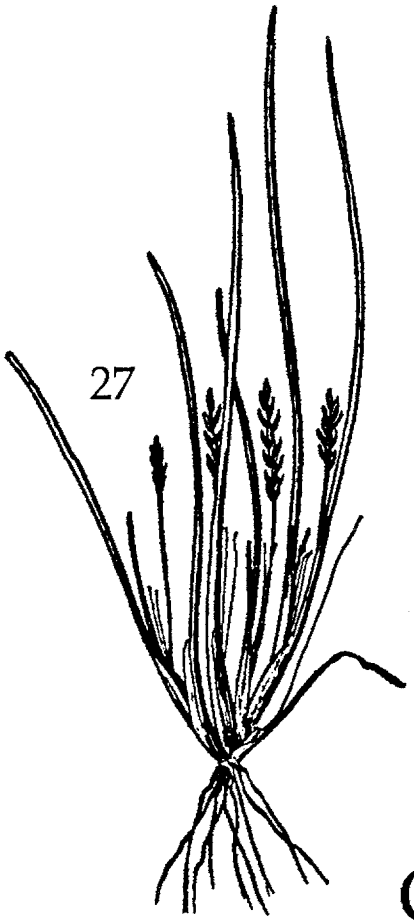

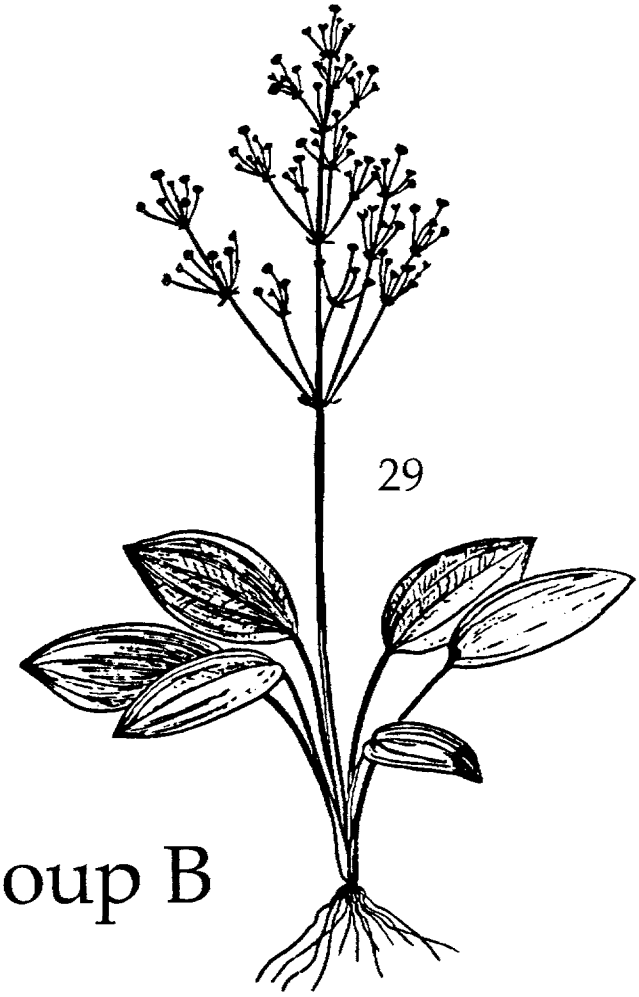

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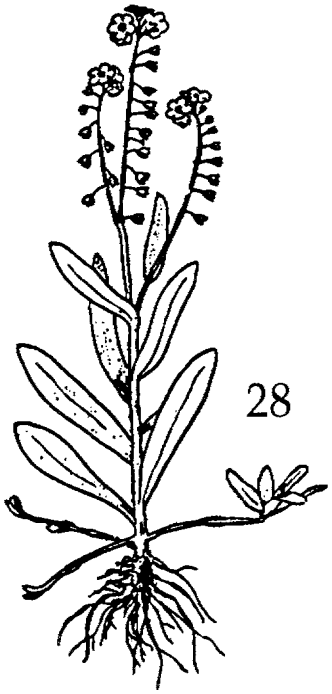

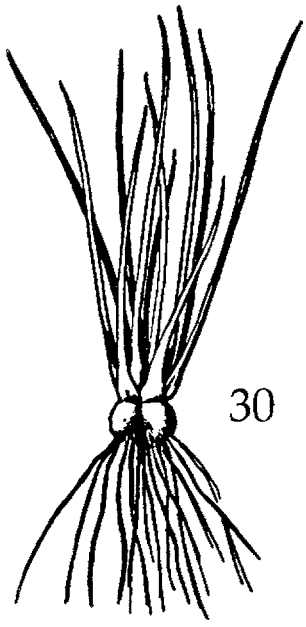

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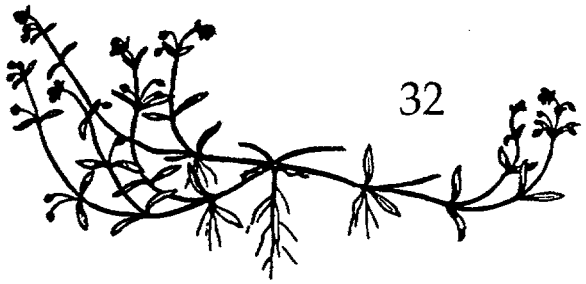

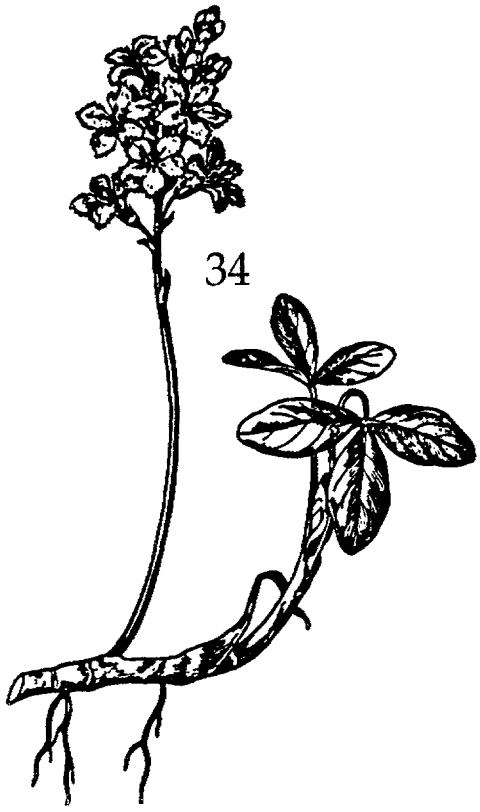

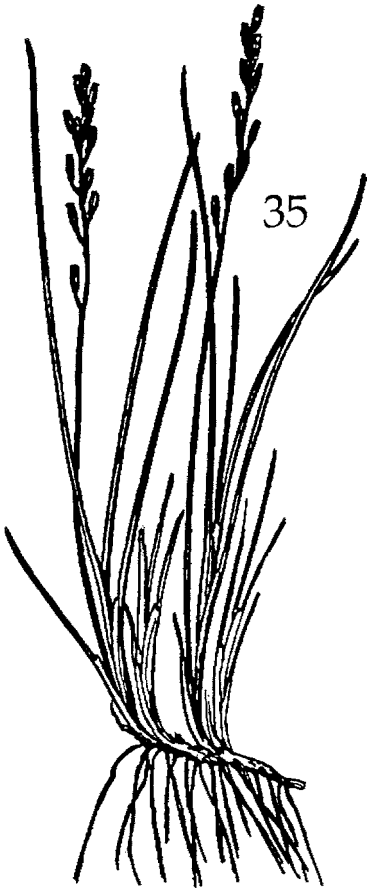

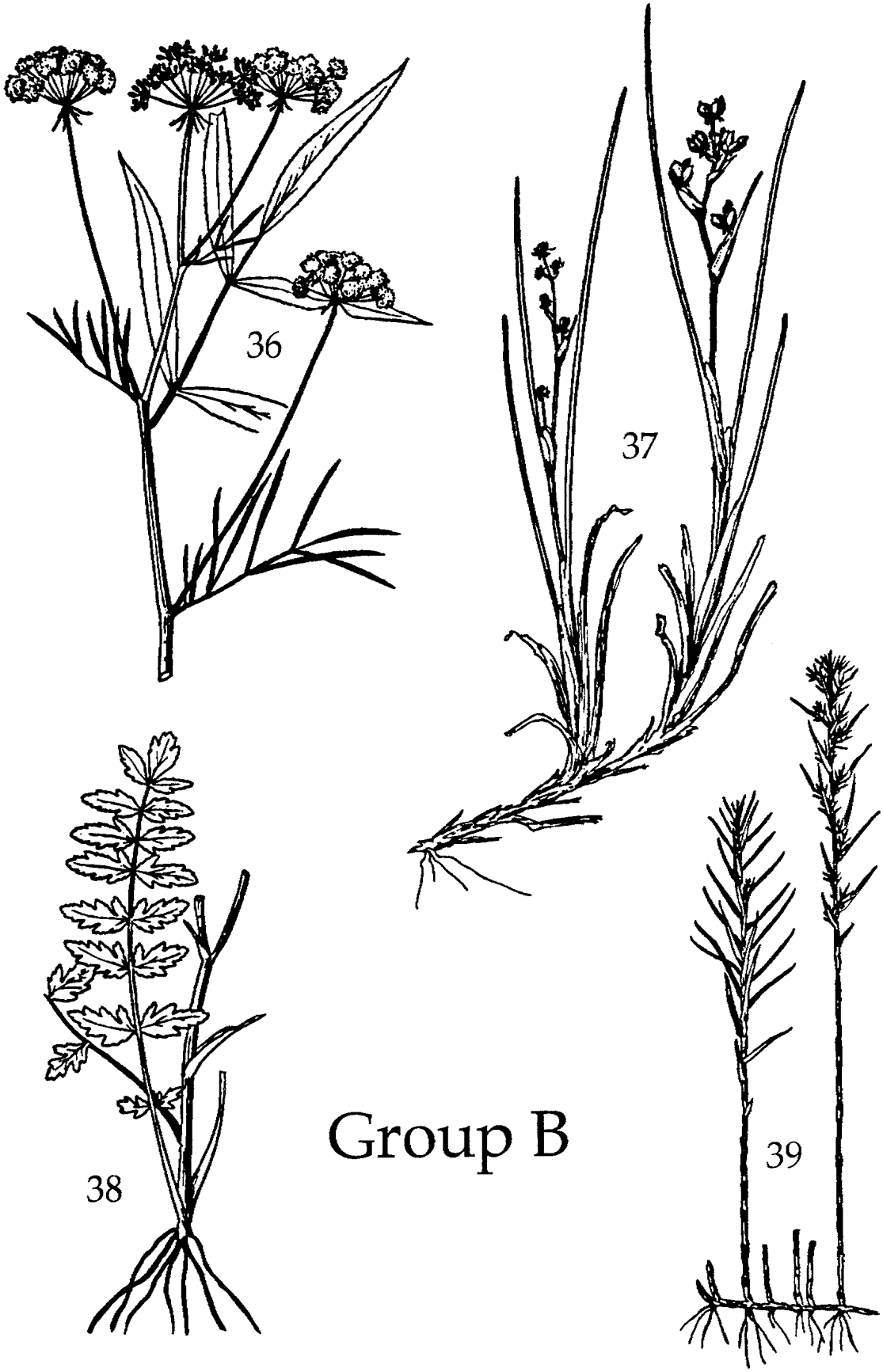

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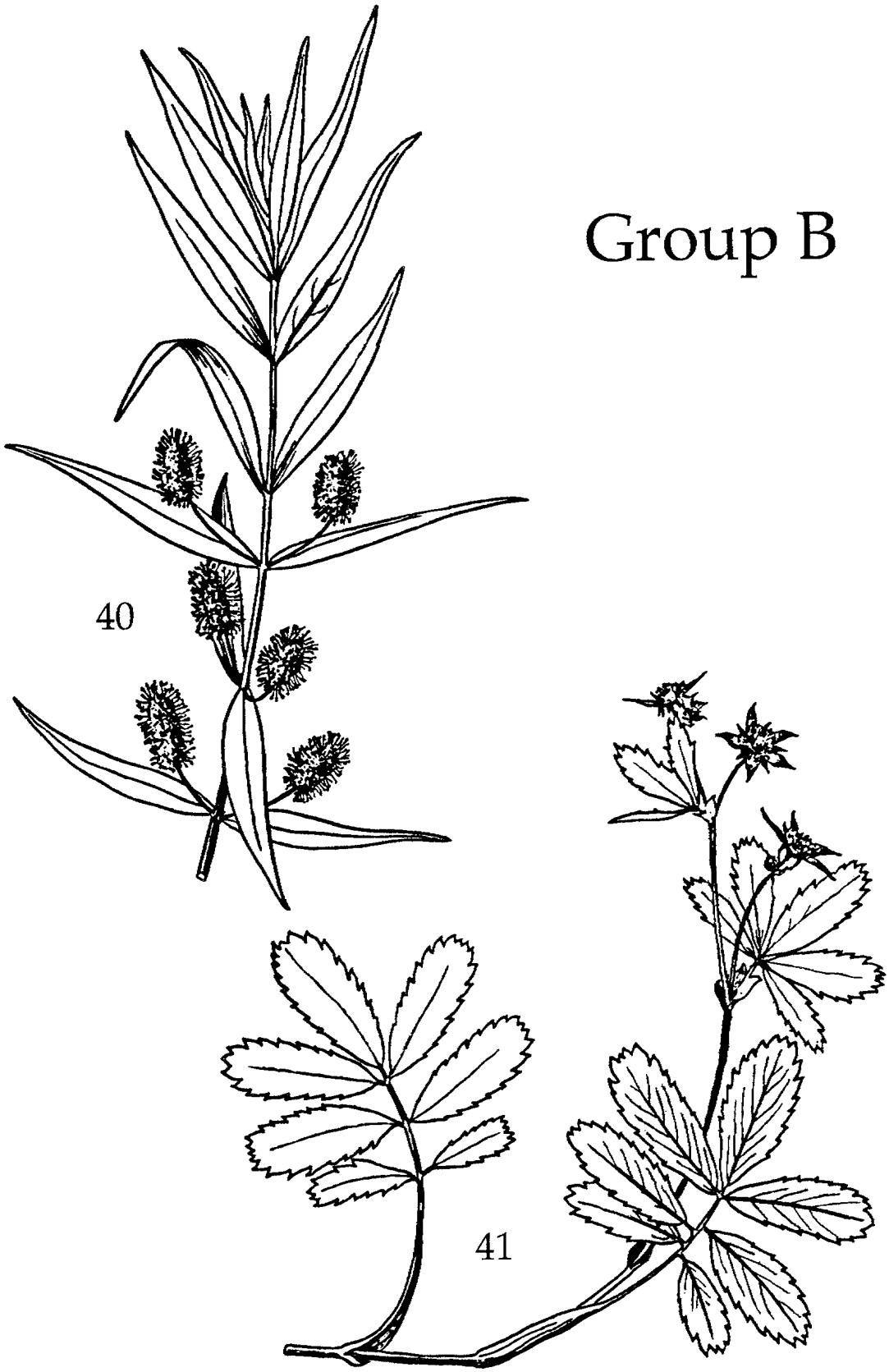


Group C

These plants usually grow either underwater, or floating on the surface with only their flowers emergent. Some species are rooted in the bottom, while others are free-floating. They may be sufficiently stiff to be pressed like group 'B' plants but they generally need to be mounted in a different manner. Submerged specimens of *Sium sauve* and grasses in the genus *Glyceria* are in this group. Occasionally some species in this group may become so encrusted in 'marl', when growing in hard water, that they are rigid enough to be treated like group 'B' plants, except that they should have a blotter added to the press as indicated below. *Ceratophyllum demersum* and *Myriophyllum sibiricum* are examples of plants which may have marl encrustation.

Terrestrial plants of *Hippuris vulgaris, Ranunculus, Myriophyllum, Polygonum* and *Potamogeton* are sometimes found. They are dry and firm enough to press like group 'B' plants. *Elodea* may also grow in a dense, short-internode form which is quite firm and self-supporting. Apart from the above exceptions this group is treated together because they tend to collapse or clump together when removed from the water and thus they need to be floated onto the mounting sheet. As a rule the whole plant should be collected (roots, stems, leaves, flowers and fruits); though as indicated later there are exceptions to this rule. Once mounted and dried many Group 'C' plants adhere to the mounting board and cannot be removed without damage; thus they must be mounted directly onto their permanent mounting board. They may not be dried first between newsprint and then transferred to the board. This latter technique is used with terrestrial plants and may be used on some emergent group 'B' plants.

DESCRIPTIONS AND HANDLING OF THE GROUP 'C' PLANTS

The following species need no special treatment; press the whole plant as collected after rinsing off any mud or debris and floating onto the mounting board: *Sparganium minimum, S. fluctuans, Ranunculus, Utricularia intermedia, Callitriche, Elodea, Najas flexilis, Vallisneria americana, Hippuris vulgaris, Ceratophyllum, Bidens beckii, Rorippa nasturtium-aquaticum, Ludwigia palustris, Ruppia maritima, Marsilea vestita, Limosella, Scirpus subterminalis, Heteranthera dubia, Egeria densa, Zannichellia palustris* and *Myriophyllum.*

Nuphar are the native yellow waterlilies or cow lilies. They grow from subterranean rhizomes which may be many meters long and 20 cm in diameter. Only the petioles grow to the surface and bear a large floating leaf which may often be too large to press in its entirety The leaf is green on the top and the bottom and may be emergent with a rigid petiole when water levels drop. The plants will also grow on wet mud when stranded by declining water levels. Both species have large robust yellow flowers and a sticky muscilaginous coating around the seeds. They grow from marginal situations out to water 2 to 3 meters deep. Cut a thin cross-section of the petiole a short distance below the leaf and press it or note whether it is round or compressed. Cut one leaf in half from apex to notch and press it with one half upside down. Floral details are required for identification. Remove the green sepals and yellow petals from a flower and press them, note how many there are of each in the label; also press a few stamens and note whether they are all yellow or have reddish or purplish markings. As the flower parts, especially the seeds, may be sticky they should be covered with polyethylene or saran wrap to prevent them sticking to the blotter.

Brasenia schreberi is a marginal species usually growing a little deeper than *Nuphar*. *Brasenia* is leaves are peltate (the petiole is attached in the centre of the blade), reddish-green above and red below. The flowers are small, inconspicuous and reddish. *Brasenia* has a rhizome and all that needs to be collected is the apical portion of the stem with several leaves, the bud and preferably the flowers. All the underwater portions of *Brasenia* are covered in a coat of muscilaginous or gelatinous material of variable thickness. When this dries the plants are permanently glued to whatever they are in contact with while being pressed. You must use a sheet of smooth non-porous material such as polyethylene or saran wrap between the plant and the blotter when pressing this species. Turn several of the leaves over to show the undersides as this will not be possible later.

Nymphaea are ornamental water lilies with red, white, pink, yellow or multicoloured flowers. There are a number of "escaped" populations in BC. but most are cultivated by lakeshore owners. Be discrete and tactful when collecting *Nymphaea*. They grow from large subterranean rhizomes and only petioles ascend to the surface as in *Nuphar*. .The floating leaves may be red on the lower surface and are usually smaller and rounder than *Nuphar* leaves. The leaf lobes often overlap obscuring the notch. Collect *Nymphaea* leaves as for *Nuphar* . Floral details are required for identification; collect a few each of the sepals, petals and stamens. Note the colours of these flower parts and the approximate numbers of each; note also whether or not the flower is fragrant, the time of day and whether or not the flower was open. Do not try to collect the rhizomes.

Fontinalis antipyretica is an aquatic moss often found attached to rocks or logs around the margins of lakes and in streams. It may grow quite deep, or in habitats left exposed in summer low-water conditions. In the latter case it becomes dormant for the summer. This plant has not been found in BC. waters with a pH higher than 8.1 since it can not utilize HC03 as an inorganic carbon source for photosynthesis but relies on dissolved C02. *Fontinalis antipyretica,* and other aquatic mosses, hold a great deal of water and should have an extra blotter beneath the mounting board.

All the *Ranunculus* species are shallow water or marginal plants most often found in ponds and ditches, wet meadows or wet muddy areas left by receding water levels. *R. aquatilis* is the most aquatic and may grow as floating mats in deeper water. All are semi-terrestrial and may be found growing on land in modified form. The proper taxonomic status of some of these 'species' is not clear as many are quite similar and all are morphologically plastic in these vegetative characteristics. They have yellow 'buttercup' flowers except for *R. aquatilis* which is white.

Rorippa nasturtiumaquaticum, watercress, is a plant of wet seepage areas, shallow ditches and marginal habitats. It grows in dense mats sprawling over the water and on the banks or shores and prefers nutrient rich water. *Ceratophyllum* do not have roots but may be anchored on the bottom. Usually they float free in large dense mats at the surface. In eutrophic waters *C. demersum* can become a serious nuisance. *C. echinatum* generally grows well submerged and is more difficult to find and collect. They are superficially very similar but may be readily distinguished by the spines on their fruits which are hidden amongst the foliage near the surface. Try to collect some of these fruits in late summer.

Chara, Tolypella and *Nitella* are large algae anchored to the bottom, growing in clumps or mats, and completely submerged in lakes and creeks; some grow in quite deep water. *Chara* has a strong, unpleasant odour when brought out of the water. When fruiting many small orange or red structures may be seen among the branches. The species are difficult to distinguish and generally require a dissecting microscope. They all have a tendency to stick to the blotter and thus before the blotter is put down pieces of polyethylene bag, waxpaper, cellophane or similar material should be placed over the plants. This will peel off readily once the press is thoroughly dry.

Hippuris vulgaris grows on exposed mud banks or in very shallow water where it has short, firm, bright green whorls of leaves or in deep water where the leaves are long, limp and brownish. If it reaches the surface in deep water the leaf form changes abruptly at the waters' surface and both types are found on the same plant. The stem is hollow and appears jointed. The emergent portions and the terrestrial plants do not need to be floated onto the herbarium sheet, but the flaccid submerged plants need this treatment.

Elodea are widespread in a variety of habitats and may become weeds in eutrophic conditions. They may have long internodes with large gaps between leaves or be very compact. Since these are favoured aquarium plants, they may be introduced to a number of lakes. Flowers are very small, white, and on the ends of very long thin stipes so as to reach the surface; they are rarely found or collected. The plants may be found floating freely in a mat at the surface. *Egeria* is very similar to *Elodea* and should be treated the same way. They are rare introduced plants known from only a few lakes.

Polygonum , 'smartweeds', are usually marginal or marsh plants but *P. amphibium* may also grow either in very deep water, with a clump of leaves at the surface and anchored to the bottom by roots and a long stem, or as a low mat on exposed shores. It has clumps of rose coloured flowers. Only *P. amphibium* has broad floating leaves, the other species are emergent with inconspicuous whitish or pinkish flowers. *Polygonum* species, particularly *P. amphibium,* also have a tendency to stick to the blotter and can be dealt with in the same manner as *Chara*. *P. amphibium* growing in deep water may have a very long bare stem with all the leaves at the surface. Collect only the surface portion of the plant with a short section of stem and flowers if available.

Limosella are small rooted plants in shallow water or wet mud. They are inconspicuous and seldom collected. *L. aquatica* is widespread; *L. subulata* maritime. *Najas flexilis* is a fairly common small plant which is inconspicuous when rooted on the bottom and usually collected from floating fragments. It has very distinctive, smooth, lenticular seeds and grows completely submerged in shallow to deep water. *Vallisneria spiralis* is a common aquarium plant and has been introduced to many lakes in BC. When immature and vegetative it is easily mistaken for several other species, but in flower or fruit with its long, coiled, peduncle it is a unique and unmistakable plant. It grows in quiet water, preferably warm, and can be found to moderate depths. It is usually completely submerged and not found as a marginal.

Juncus supiniformis is found both marginally with other *Juncus* , and in deep water as a floating mat, usually anchored to the bottom. The plant is proliferous, producing 'runners' (like a strawberry), which in turn produce more 'runners' as they mature. By the end of the summer a large, floating, tangled, mat of plants can be produced from a single parent plant. All that is necessary to collect is the upper portion of the plant, preferably with flowers, fruits and enough material to show the proliferous nature of the species.

Zannichellia palustris is a very small creeping plant, fully submerged in shallow water. It is usually overlooked since it creeps along the bottom amongst the other vegetation but is instantly identifiable in fruit and likely a lot more common than collecting records indicate. *Heteranthera dubia* is submerged, or floating just at the surface, in quiet water of lakes, streams and ponds. The flowers are pale yellow but rarely seen in BC.; the plant can be difficult to identify without them. Although rarely recognized and collected the species is likely restricted to southeastern BC. *Marsilea vestita* is very rare and known only from several Okanagan locations. It looks like a hairy 4-leaf clover but is actually an aquatic fern with small, hairy, brown, sporocarps at the bases of the leaves. It is usually found on wet mud or gravel, left exposed in the summer by dropping water levels, but also grows in shallow-water marshes.

Callitriche may be found in 1 or 2 meters of water in slow creeks or lakes, but is most often found in marginal habitats, in ditches, or stranded on wet mud. In deeper water, plants are usually rooted in the bottom, have a thin leafy stem in the water column and a rosette of dark green leaves in a cluster at the surface. In ditches they may form very extensive mats covering the entire water surface. Diagnostic characters include the details of leaf-apices, leaf-venation, the junction of the leaves with the stem, and, most importantly, the morphology of the mature fruits. C. *verna*, one of our five species, represents the genus in the illustrations.

Ludwigia palustris is a marginal or marsh plant found only in shallow water.It is often found sprawling over the surface while rooted at, or just below, water level. This species often has reddish leaves and is a favourite aquarium plant. *Bidens beckii* seems to prefer nutrient rich sites. In flower, with its yellow, emergent, head and finely-dissected submerged leaves, it is unmistakable. Sterile specimens must be distinguished from other dissected-leaf genera such as *Ranunculus, Myriophyllum, Ceratophyllum* and *Utricularia*, by the pattern of the leaf dissections. Details of this dissection pattern are shown in the Group 'C' illustrations as an identification guide. *Bidens* is not usually marginal but grows in about 1 to 2 meters in quiet, 'weedy', warm-water areas.

Utricularia are very widespread throughout BC. and very distinctive, both vegetatively, with their bladders which trap planktonic organisms, and in flower, with their yellow 'snap-dragon-like' blossoms. *U. intermedia*, which is illustrated, is often found in acidic sphagnum bogs. One branch with bladders is white and anchored in the substrate, other leafy branches are on top of the substrate. This species usually occurs in shallow marginal habitats. *U. vulgaris* has bladders and leaves together on one large, much-dissected branch. The stem may be 20 cm. in diameter and up to 6 m long. It usually lies on the bottom, but in shallow, warm, 'weedy', ponds may be just below the surface. Small specimens of *Utricularia vulgaris* may be pressed in their entirety, but with large plants take only the apical portion of the plant. Try to find the yellow, emergent, 'snap-dragon-like' flowers later in the season in warm, quiet, ponds and bays.

Scirpus subterminalis grows in shallow marginal habitats in quiet water. The leaves are very thin and lax and float on the surface, although the fertile stems may be emergent. The plants are rhizomatous and rooted in the bottom, and often grow in quite extensive beds. *Glyceria* are grasses often found in wet meadows, marshes and shallow marginal areas. The wavy leaves float on the surface of the water and are quite flaccid. *Ruppia maritima* generally grows in shallow or marshy areas, but may be rooted in water up to 1 meter deep. It is very tolerant of saline or alkaline conditions and may be found in coastal estuarine sites or interior highly alkaline ponds. It is a favorite food of ducks. The plant is scarcely distinguishable from some linear-leaved *Potamogeton*, except when it has a cluster of distinctive fruits on a coiled peduncle.

Sparganium fluctuans and *S. minimum* are both usually found in shallow-water, marginal, or marsh habitats. They have emergent fruiting spikes, but lax floating leaves. Both are much more delicate plants than the two group 'B ' *Sparganium* *S. minimum* has only one male head and two or three female heads in an unbranched inflorescense; *S. fluctuans* has a branched inflorescence with two male heads and two or three female heads on each branch.

Myriophyllum all have finely dissected 'feather-like' leaves in whorls around the stem. They may grow on mud banks exposed by receeding water levels, or as deep as 6 meters. Most have flowers on emergent spikes but some have flowers in the axils of ordinary submerged leaves. The genus occurs in a wide variety of habitats throughout BC, although some species have very restricted distributions and specific habitat preferences. *M. spicatum* is illustrated as a typical species. Specific identification is difficult with vegetative material in most cases. Some plants stick to the blotter and need to be treated like *Chara*.

Potamogeton is the largest genus of aquatic plants in BC. and the species encompass a lot of variability. The 26 species of *Potamogeton* in BC grow in a wide diversity of habitats and growth forms. Potamogetons are found in almost all aquatic habitats from marshes, stranded on wet mud, or in up to 6 meters of water. Diagnostic characters in *Potamogeton* include the fruits, floating leaves, structure of the junction between leaves, stems and petioles, stipules, and nodal morphology. Many are too big to fit on a herbarium sheet since they may surface from as deep as 5 m. Deep plants usually have few submerged leaves, except near the apical portion of the stem.

Some *Potamogeton* species have floating leaves arising near the stem tip and may have lost all, or most, of their submerged leaves by this time. Collect only the upper portion of the stem with flowers, fruits, floating leaves and a few submerged leaves. When pressing these plants make sure that some leaves of each type are upside down and some right side up. Species in this group include *P. diversifolius, P. natans, P. amplifolius, P. nodosus, P. illinoensis, P. gramineus, P. epihydrus, P. alpinus* and *P. oakesianus.*

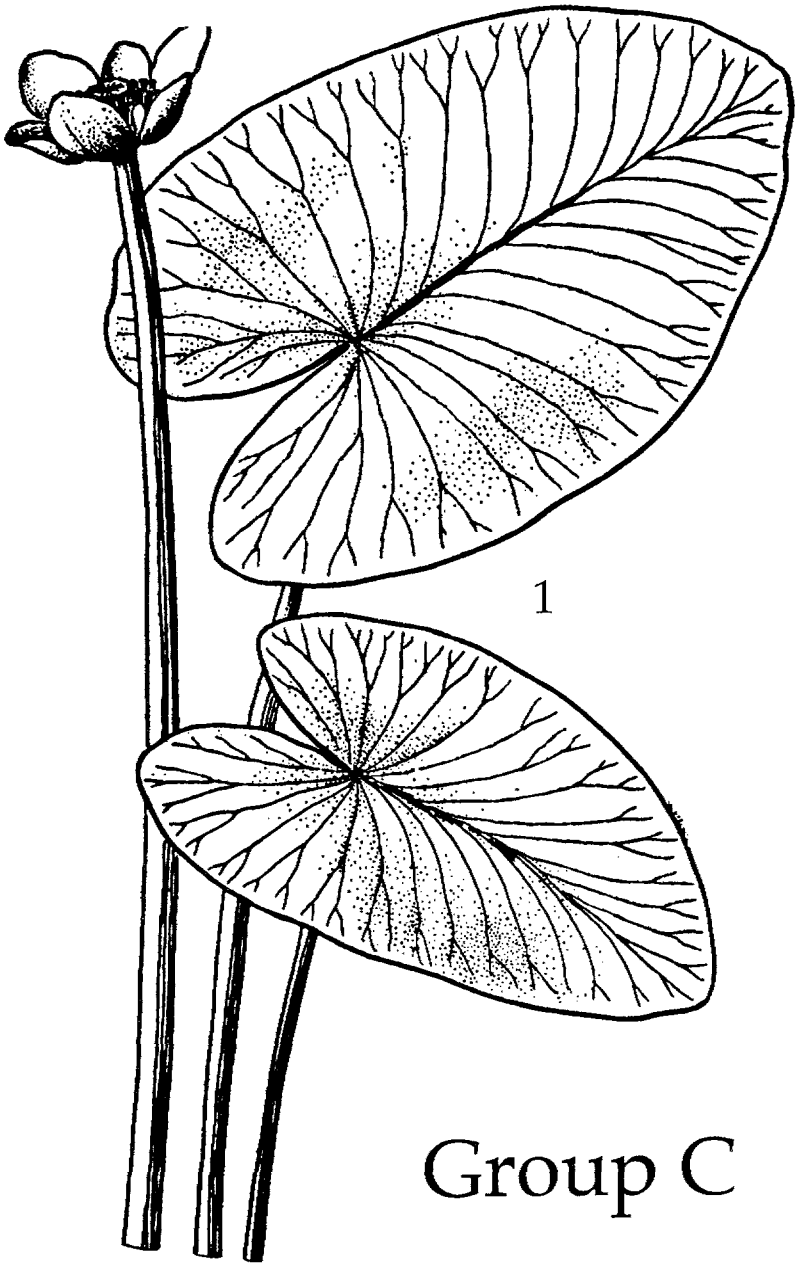
One *Potamogeton* group which can be difficult to distinguish vegetatively, has long, narrow, fully submerged leaves and no floating leaves. *P. pectinatus* is illustrated as an example of this group. *Potamogeton vaginatus, P. filiformis, P. friesii, P. berchtoldii, P. fibrillosus, P. foliosus, P. obtusifolius* and *P. strictifolius* also belong to this group. All of them are usually small enough to collect the whole plant. If bigger specimens are found, take only the upper portions.

Potamogeton alpinus may have some floating leaves but, if so, they are not much different than the submerged leaves. The plant is small enough in any case to collect in its entirety, including some of the rhizome. *Potamogeton crispus, P. zosteriformis, P. praelongus* and *P. perfoliatus* all have broad submerged leaves, but no floating leaves. Except for some *P. crispus* , they are too large to press in their entirety and only the apical portion needs to be collected.

Many of the species of *Potamogeton* are illustrated to show the variety of forms that may be encountered. *P. gramineus,* in particular is very variable in its morphology and its appearance is almost site-specific, depending upon the environmental parameters of the site. *P. gramineus* is commonly found as a dwarf rosette plant on damp mud left by receding water levels. The floating leaves of *P. natans* are usually quite reddish and mature fruiting plants will have lost all their submerged leaves. *P. robbinsii* plants are dark green but usually appear brownish since they form appressed mats on the bottom and are usually covered in periphyton and detritus; but they may be found with an erect, leafy, fruiting stem at times. *P. epihydrus* submerged leaves are very thin and delicate. *P. amplifolius* is a very robust plant with large folded leaves.

Legends for Group C Figures

1 –*Nuphar variegatum*
2 –*Hippuris vulgaris*
3 –*Ranunculus hyperboreus*
4 –*Ranunculus flabellaris*
5 –*Ceratophyllum demersum*
6 –*Polygonum amphibium*
7 –*Elodea canadensis*
8 –*Limosella aquatica*
9 –*Brasenia schreberi*
10 –*Polygonum hydropiper*
11 –*Rorippa nasturtium-aquaticum*
12 –*Zannichellia palustris*
13 –*Juncus supiniformis*
14 –*Najas flexilis*
15 –*Scirpus subterminalis*
16 –*Ludwigia palustris*
17 –*Utricularia intermedia*
18 –*Marsilea vestita*
19 –*Ranunculus gmelinii*
20 –*Sparganium minimum*
21 –*Nymphaea tetragona*
22 –*Ceratophyllum demersum*
23 –*Myriophyllum sibiricum*
24 –*Bidens beckii*
25 –*Ranunculus aquatilis*
26 –*Myriophyllum spicatum*
27 –*Potamogeton illinoensis*
28 –*Callitriche verna*
29 –*Potamogeton perfoliatus*
30 –*Potamogeton amplifolius*
31 –*Potamogeton robbinsii*
32 –*Potamogeton crispus*
33 –*Ranunculus aquatilis*
34 –*Fontinalis antipyretica*
35 –*Utricularia vulgaris*
36 –*Potamogeton epihydrus*
37 –*Chara*
38 –*Potamogeton gramineus*
39 –*Bidens beckii*
40 –*Vallisneria spiralis*
41 –*Potamogeton nodosus*
42 –*Potamogeton pectinatus*
43 –*Ranunculus cymbalaria*
44 –*Ranunculus lobbii*
45 –*Ruppia maritima*
46 –*Ranunculus sceleratus*
47 –*Heteranthera dubia*
48 –*Potamogeton zosteriformis*
49 –*Potamogeton praelongus*
50 –*Potamogeton natans*
51 –*Potamogeton diversifolius*
52 –*Potamogeton alpinus*



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Group C

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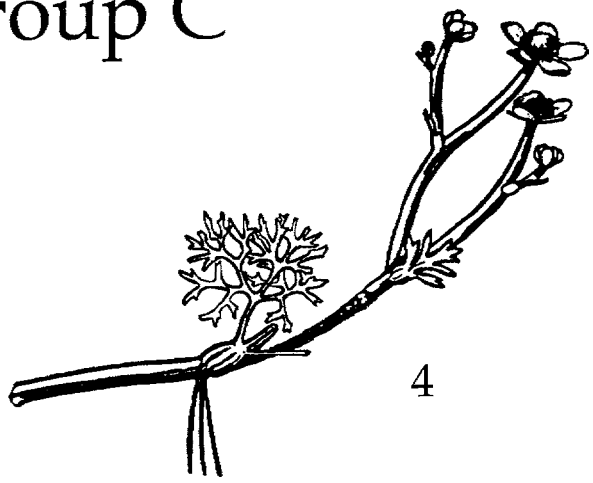

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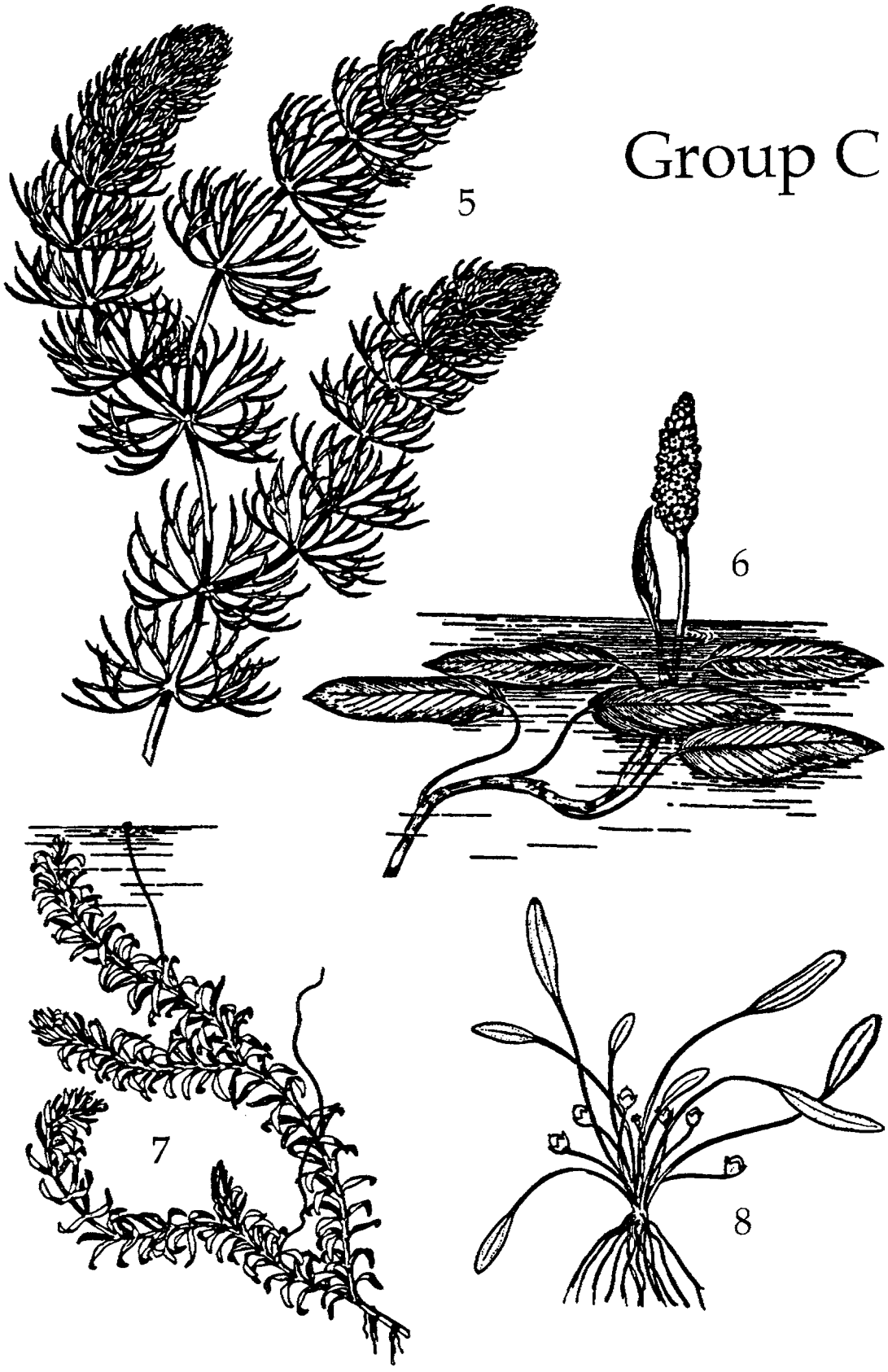
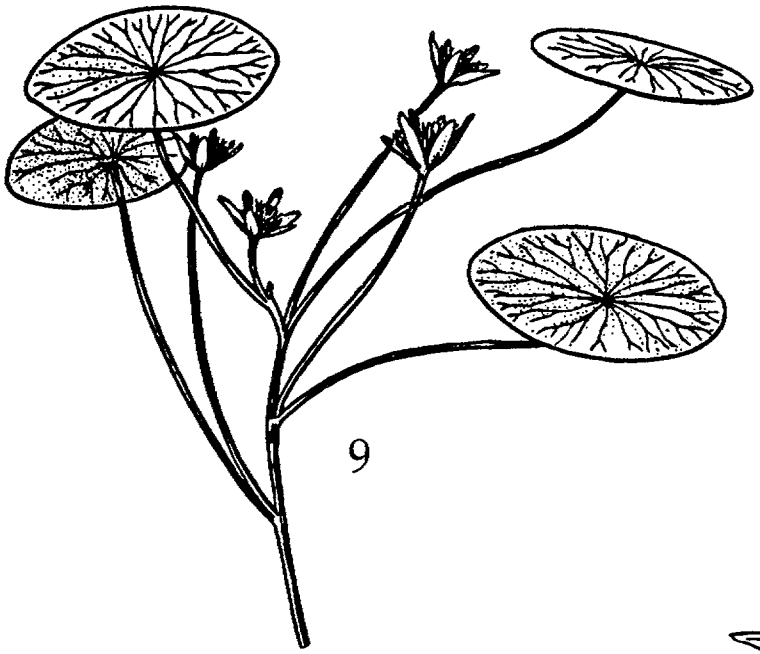
Group C





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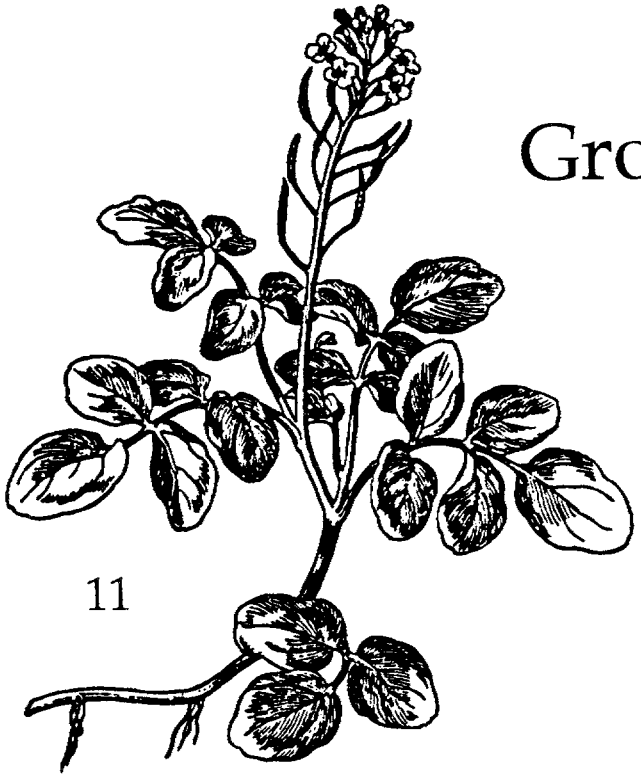

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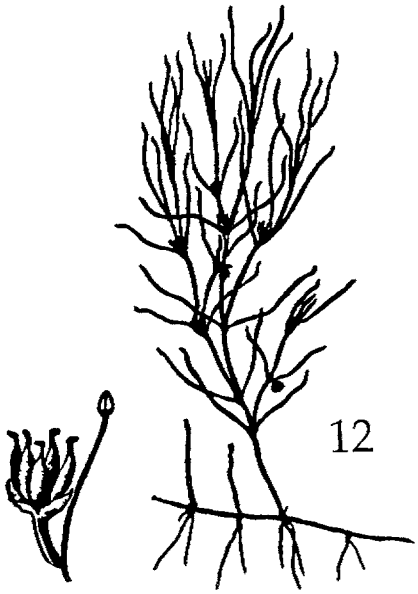

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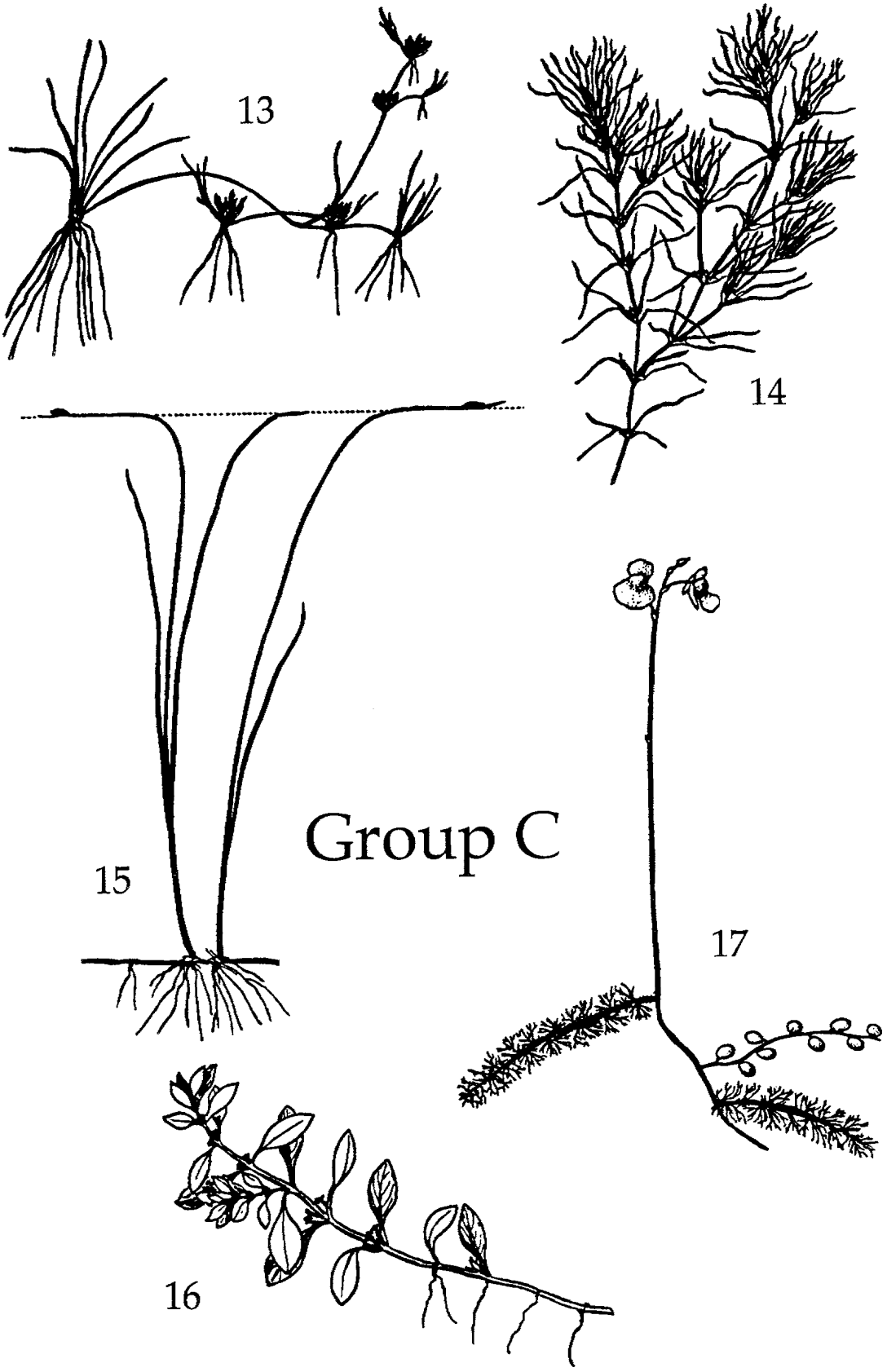
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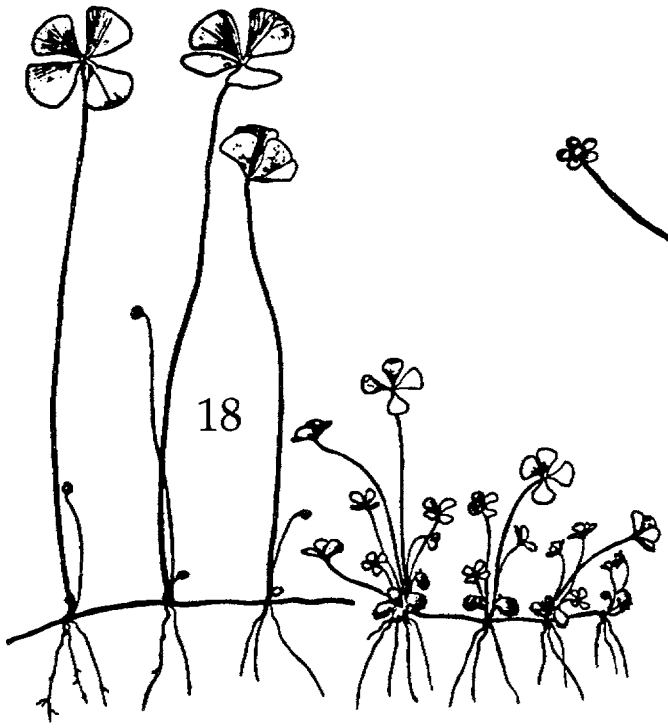

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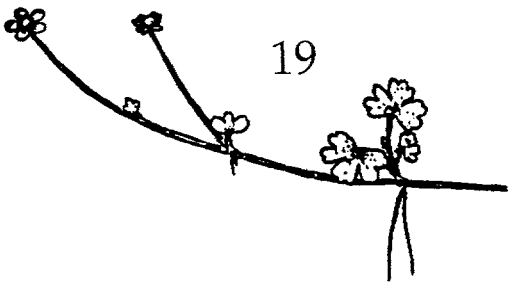

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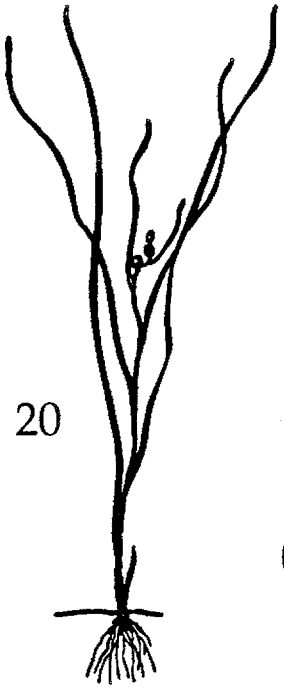

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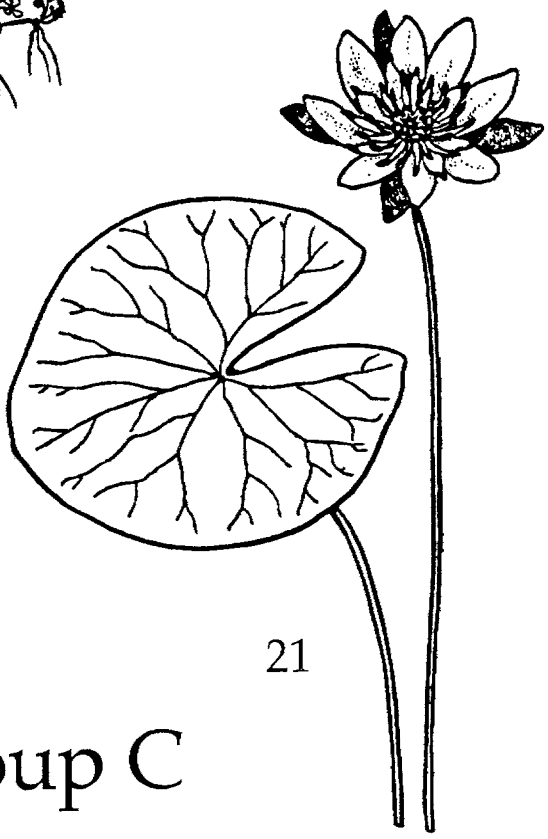

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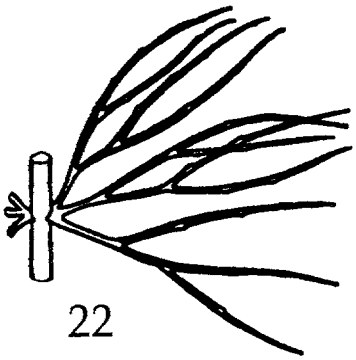

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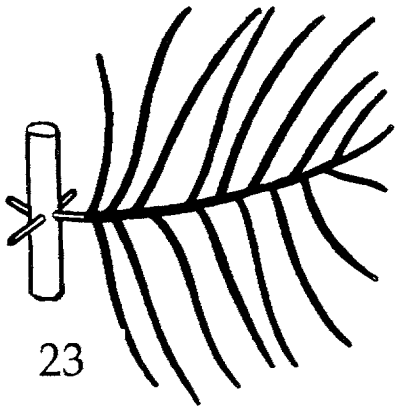

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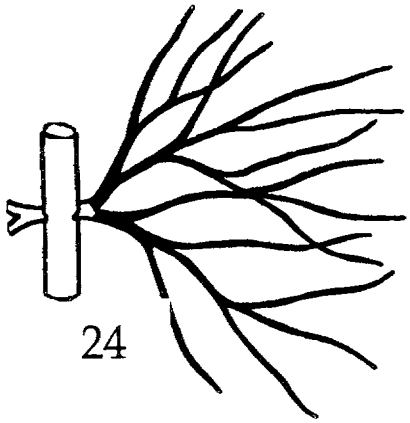

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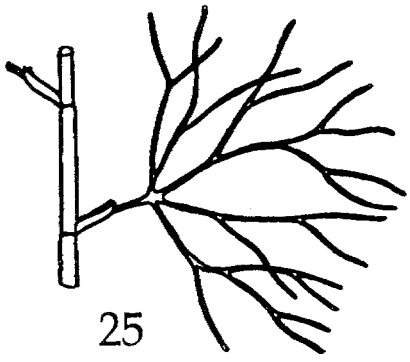

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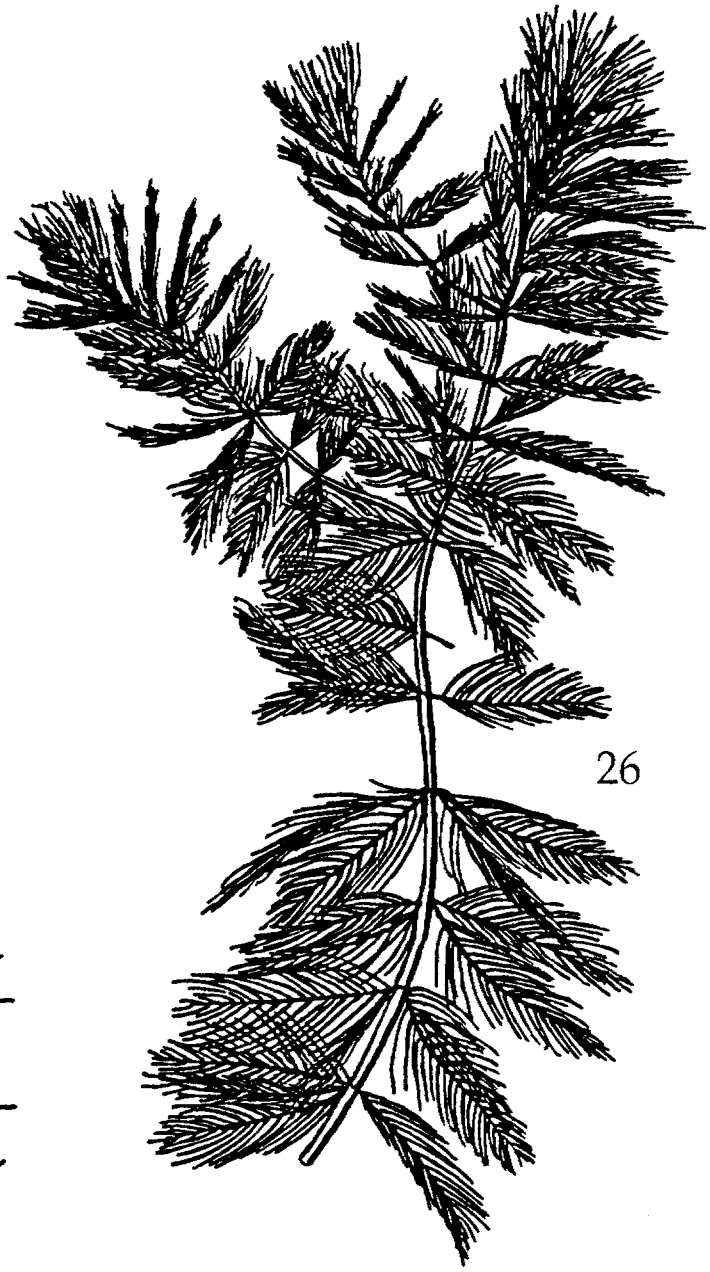

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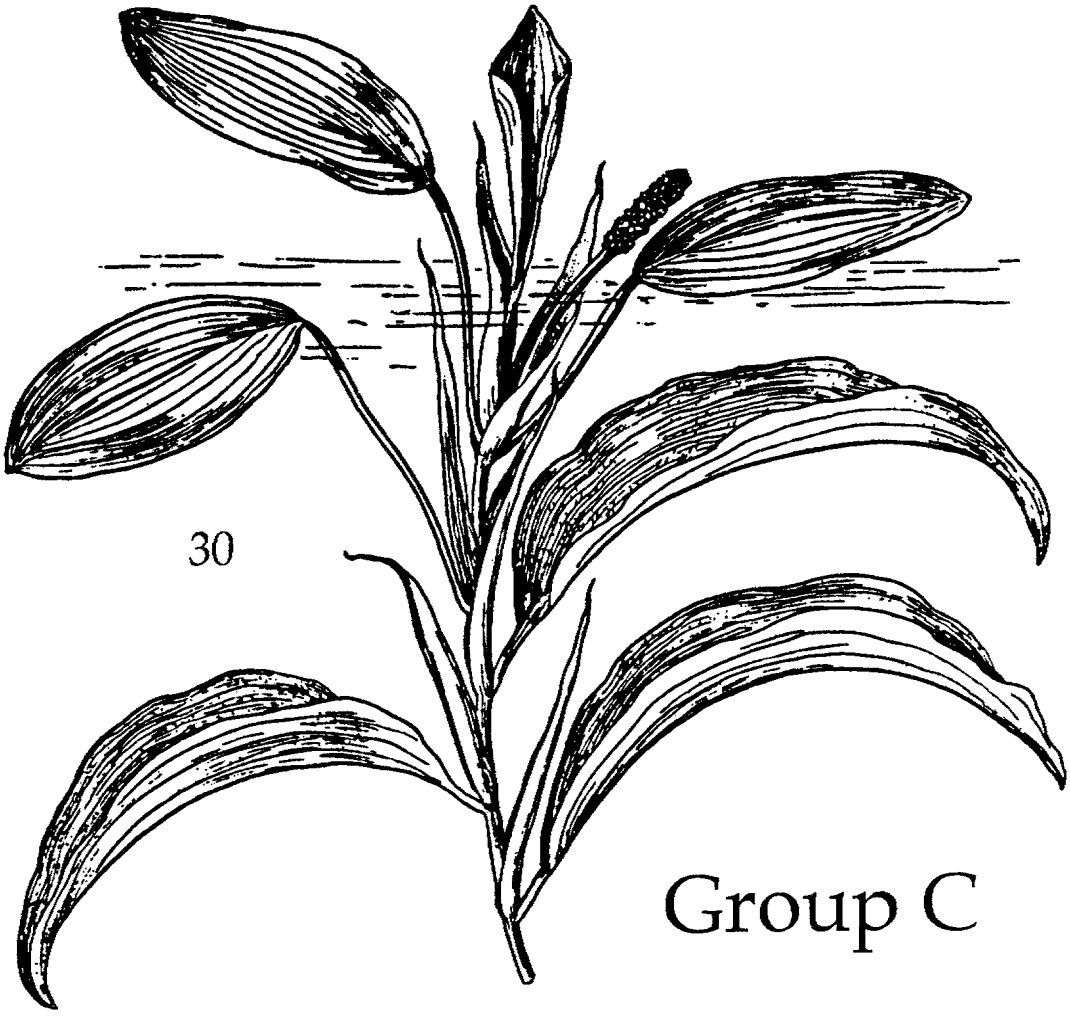

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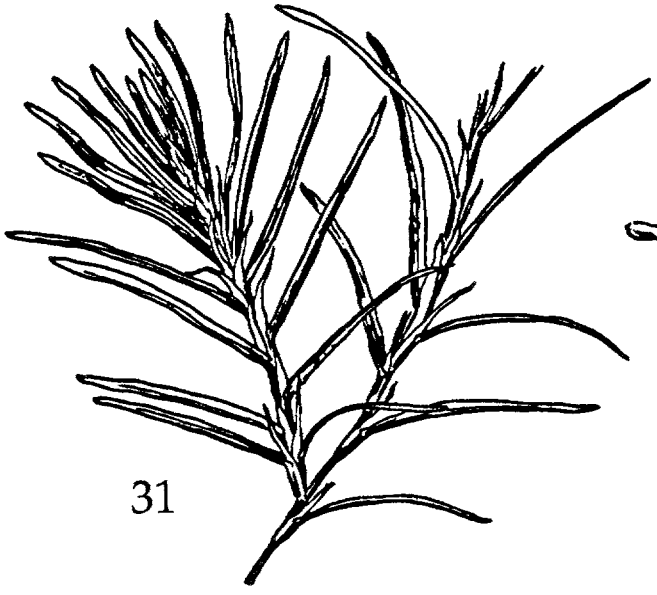

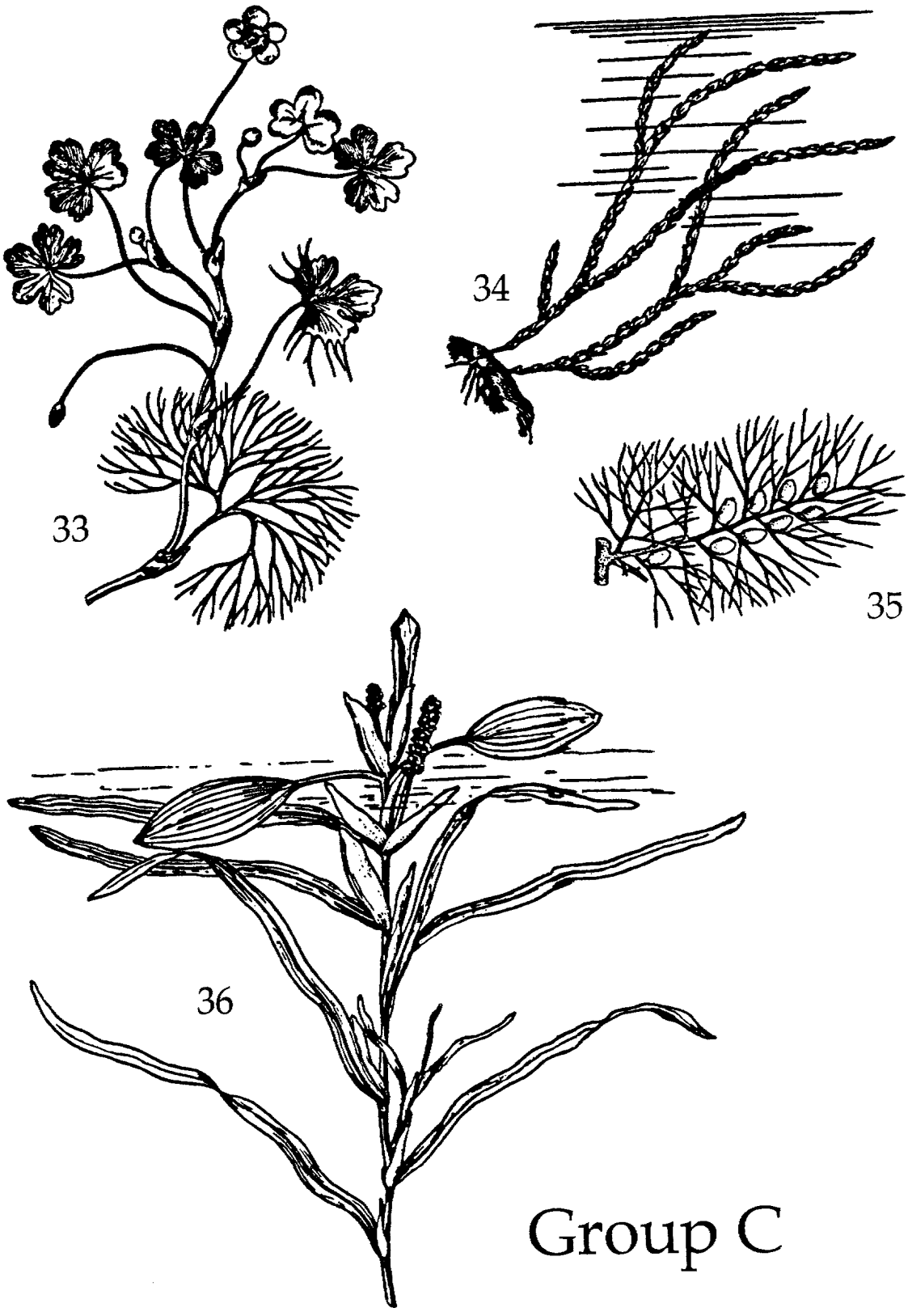

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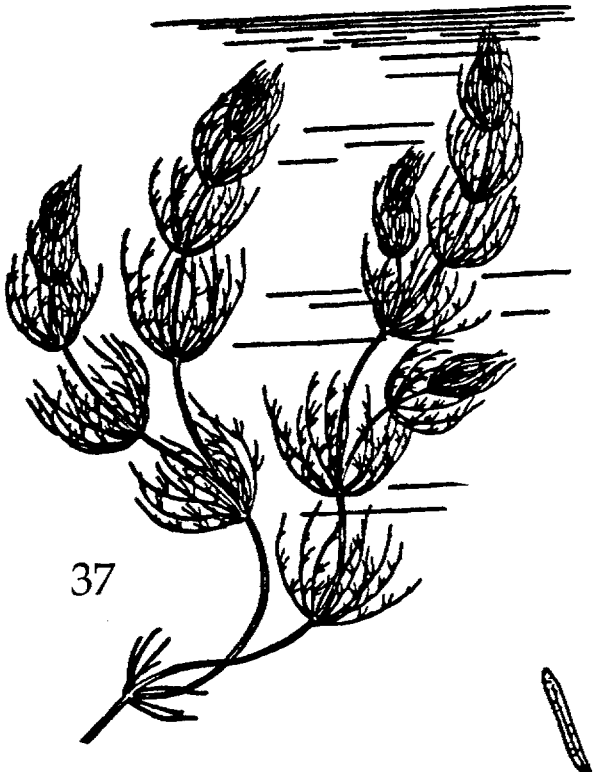

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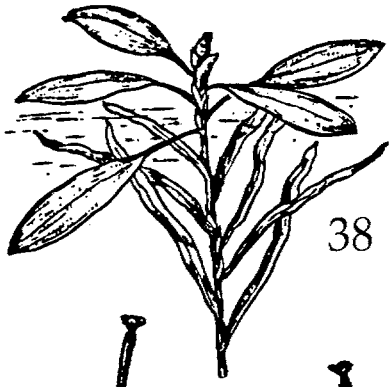

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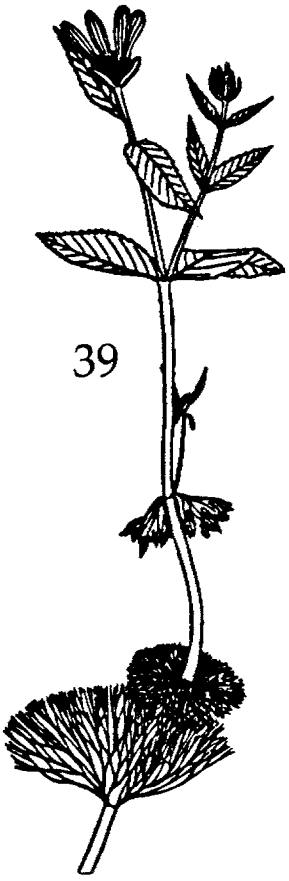

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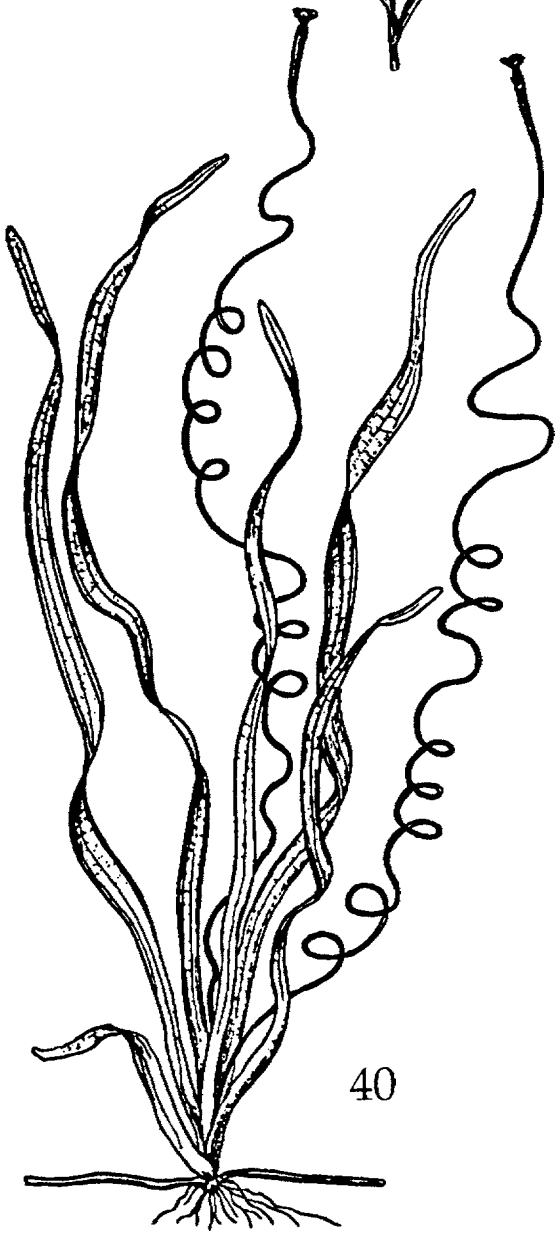

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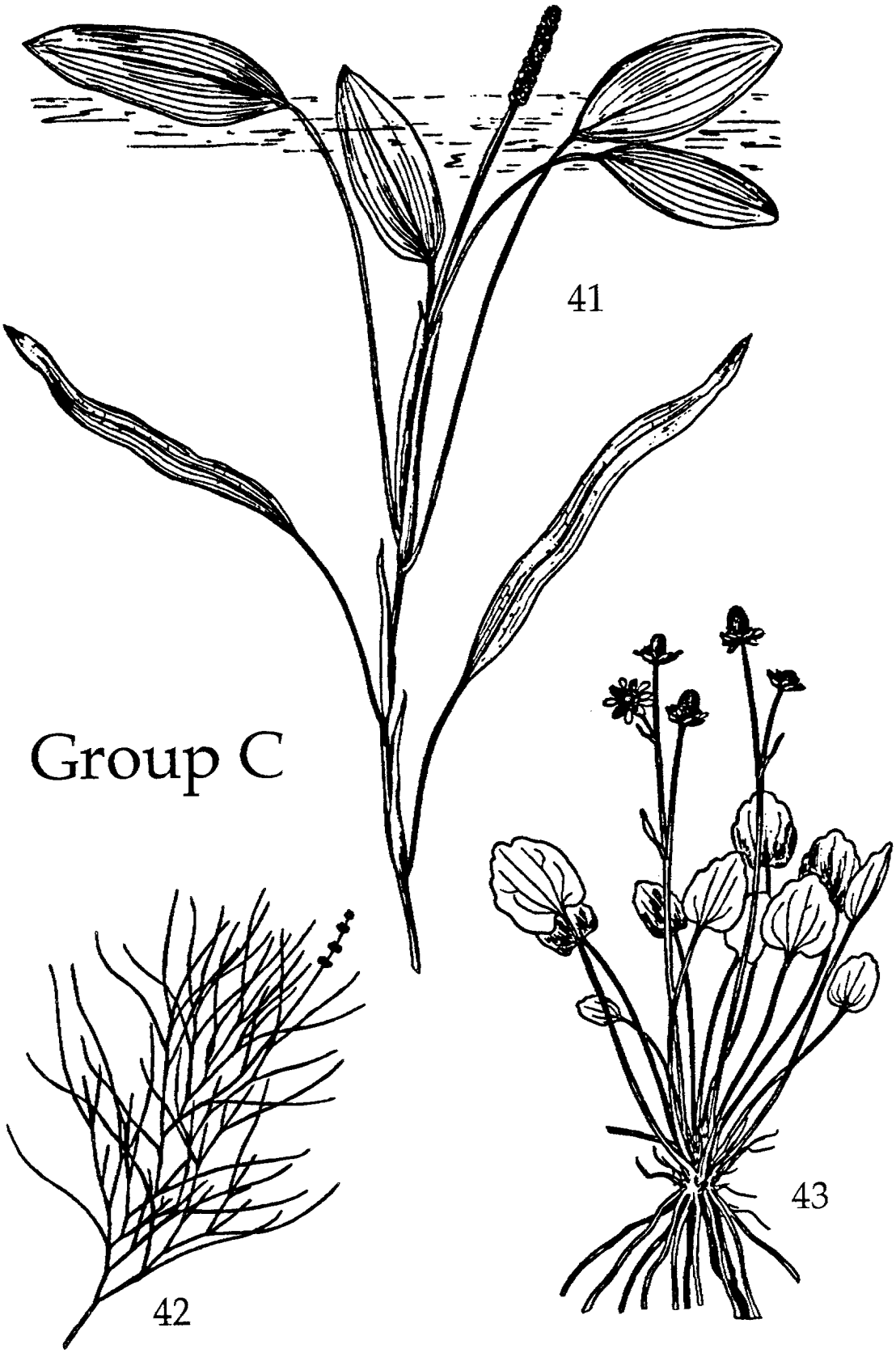
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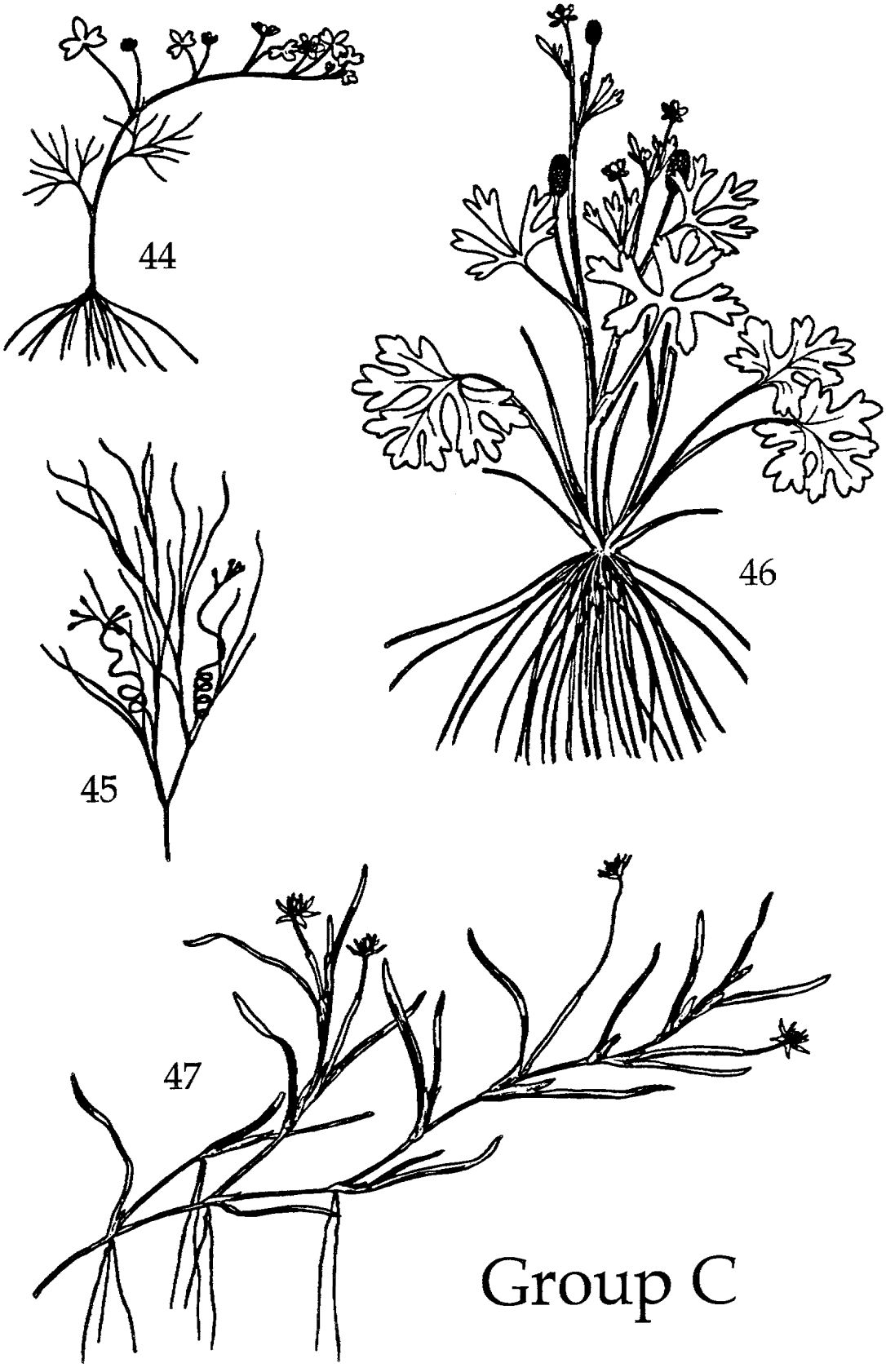

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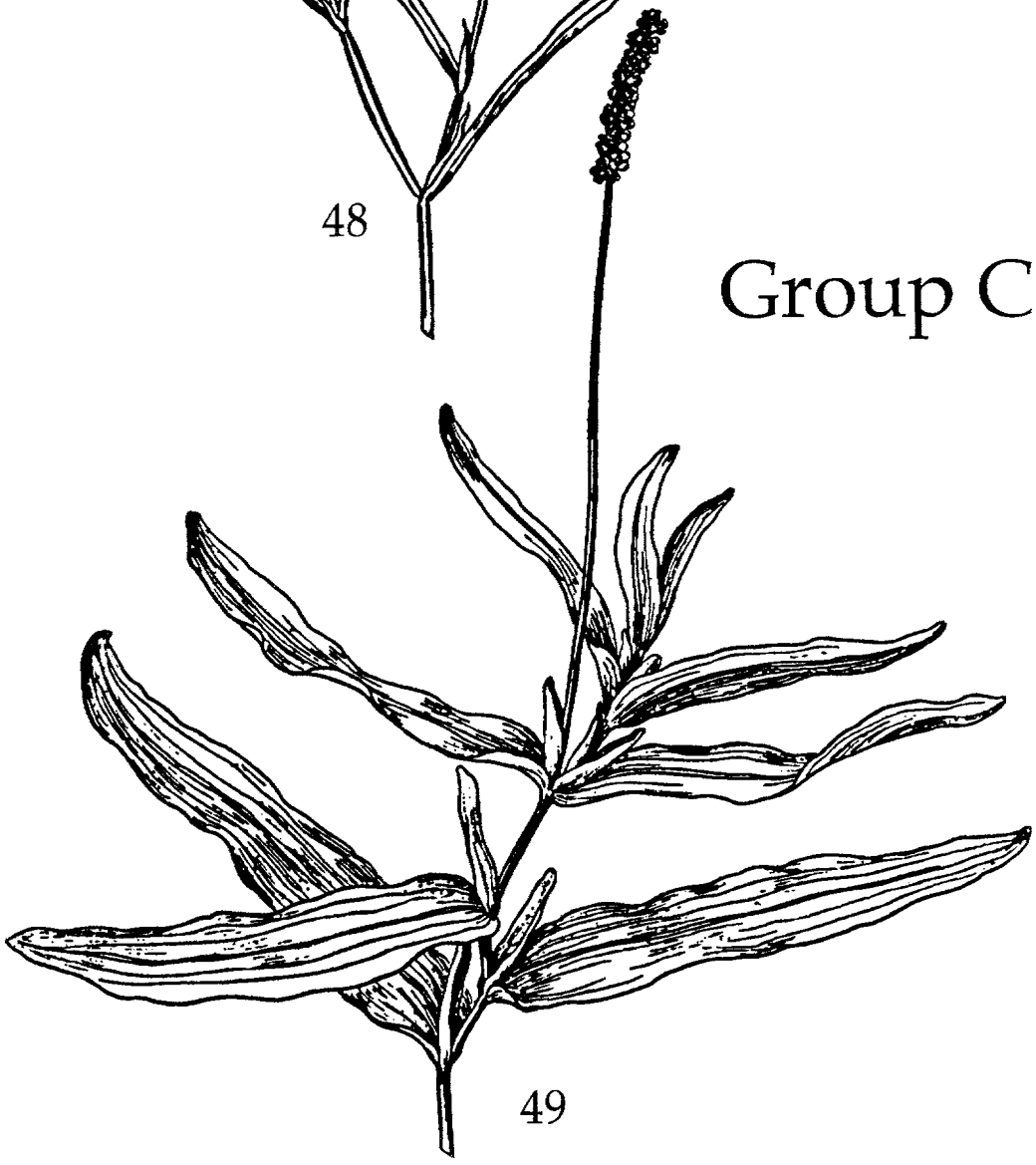

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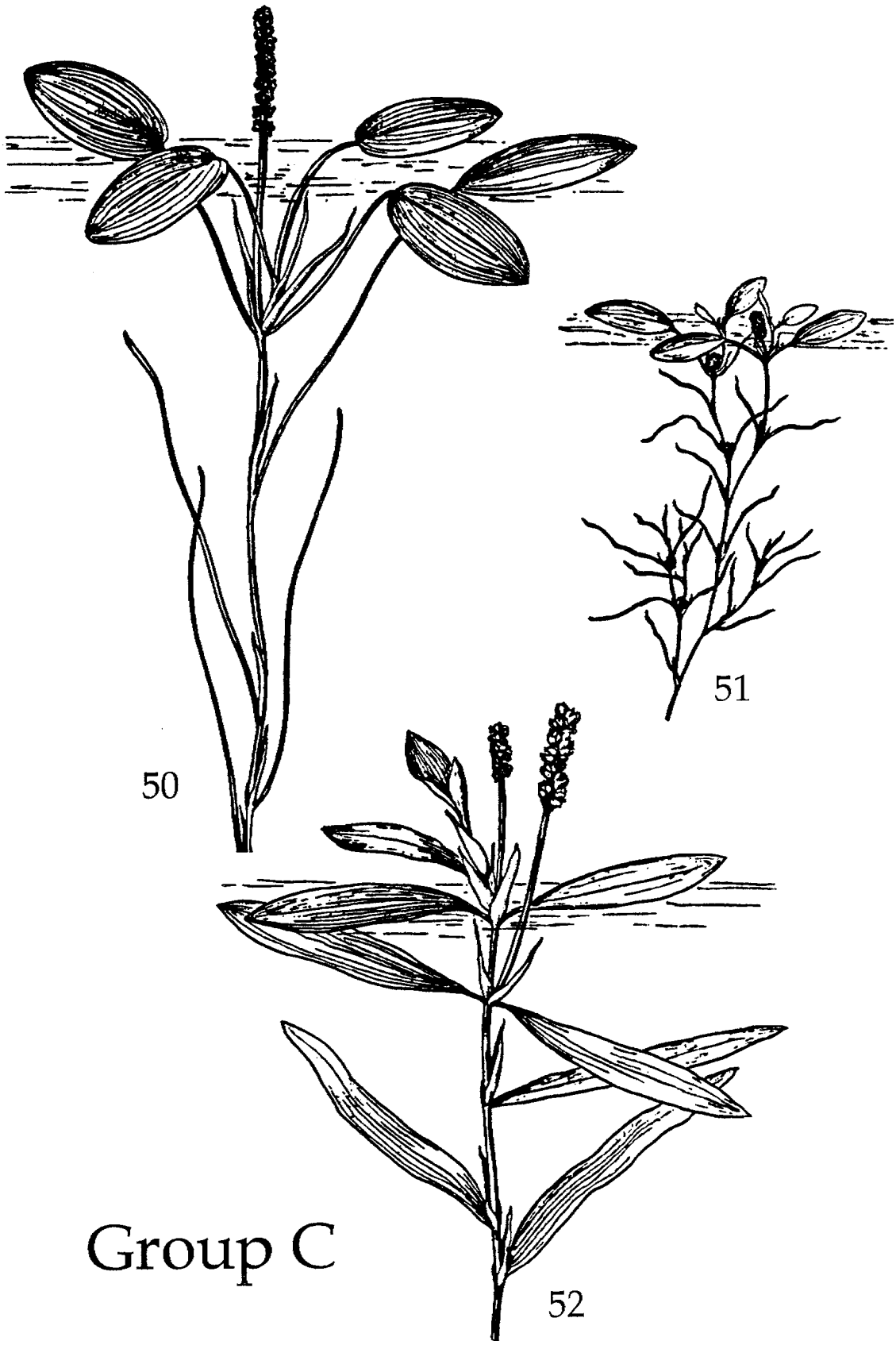

Group C

Biomass Studies

In biomass studies one wants to know how much plant material is present on an area or lake basis. Since plants are not randomly distributed in a lake, the value should be stated for that part of the lake from which the biomass value was produced, or given on an entire lake basis. In all cases an entire, intact, voucher specimen of each species should be collected and put in a herbarium, as a record of what was analysed. The procedures outlined above under the section headed **Identification** should be followed. The studies may produce standing-crop estimates or annual production estimates. The roots, rhizomes and sub-sediment storage organs may be a very significant part of these estimates, well over half for some species.

Plants should not be allowed to dessicate, but should be blotted dry of water adhering to the surface so that an accurate wet-weight can be determined. Rapid drying to a constant weight, in a forced-draft oven with good temperature control, is necessary for accurate results. This can be a challenge when one has hundreds of kilograms of wet plants to process. Some careful planning and pre-timed sampling is necessary, do not come back to the laboratory with hundreds of kilograms of plants all at once.

Isolating a measured area and sampling all the plants within this area, and none from outside, is not a trivial problem for dense weed beds in deep water. In this worst case scene it may be necessary to laboriously clear away the plants surrounding an internal area. This would provide a clear working space in which to measure and outline the desired plot, remove all plants outside the boundaries and then harvest the plot quantitatively. This is not easyto do since most deep weed bed plants do not rise straight up to the surface, but are intertwined and spread out as they ascend.

Standing crop estimates tell one how much plant material is present at the moment of sampling, this value obviously depends upon when the sample is taken. Annual production estimates try to determine how much biomass is produced on the site over a growing season. This takes into account losses during the season and material metabolized by the plants themselves. How to do this without influencing the results, by altering the type and rate of growth by your sampling, is a problem. There are no simple, satisfactory solutions and only rough approximations are possible and these entail considerable experimental work.

Tissue Analyses

Plants tissues may be collected for tissue analyses of metals, pesticides, nutrients, plants products and other parameters, for dry weight/wet weight ratios, or for other laboratory analyses. In all cases an entire, intact, voucher specimen of each species should be collected and put in a herbarium, as a record of what was analysed. The procedures outlined above under the section headed **Identification** should be followed.

For wet-weight/ dry-weight ratios one usually needs the entire plant, but this may not always be the case. One should always specify carefully what was taken. In species with extensive rhizome systems and storage tubers it is not possible to isolate a portion of rhizome or tuber which belongs to a particular stem and its leaves. Representative portions of both parts of the species will have to be analysed separately. Plants should not be allowed to dessicate, but should be blotted dry of water adhering to the surface so that an accurate wet-weight can be determined.

For analyses of chemicals one may well want to analyse distinct portions of the plant separately to determine where the material is localized in the plant. Roots and rhizomes can be significant repositories and sometimes contain the majority of the standing crop of the species, on a wet-weight or dry-weight basis. It must be noted that if a plant has a significant amount of epiphyic periphyton that the analyses may not accurately reflect that of the plant itself. Plants should not be allowed to dessicate, but should be blotted dry of water adhering to the surface so that an accurate wet-weight can be determined. Analyses should probably be done on both a wet-weight and a dry-weight basis. The specific sample handling requierments of the analyses to be carried out, as specified by the laboratory, must be carried out with respect to sample containers, preservatives, shipping times, temperatures and quantities of material.

In some ecological studies a representative sample of known wet-weight is analysed for its chemical constituents and then these values are applied to the whole lake or ecosystem, by estimating the total wet-weight of the plant that is present as determined by biomass studies. Small errors will be magnified greatly as analyses on small samples are scaled up. Do several chemical analyses and several biomass sample estimates in order to get an estimate of the variability of your analyses, and thus the range of values within which your ecosystem or lake total may lie.

Plants growing on different substrates and in different water qualities may provide significantly different chemical analyses. There will also be quite different total chemical levels, and different distributions of these chemicals within the plants, during different seasons of the year. Some plant products which one may want to analyse, sugars, starches, nitrogen compounds, photosynthetic products, respiratory intermediates, and enzymes, will also vary markedly, diurnally and by tissue, depending upon whether they are being made, translocated, stored or converted to other forms. Some of this variation will be weather dependent.

Collection Methods

There are a number of aquatic plant collection methods which have been used. The one to use in a given situation depends upon the specific situation and the reason for the collection.

Picking the whole plant by hand is the best method for getting an entire plant in undamaged condition, particularly for preservation as a herbarium specimen. In shallow water this is readily done by wading if the bottom is firm, or by leaning over the side of a canoe where the bottom is too soft for wading. In deeper water snorkeling is an excellent method and the closer view of the bottom will often allow one to see small plants that were not visible from the surface. In still deeper water SCUBA, or surface-supplied-air diving may be necessary. If there is any wave action, surface ripple or glare, it is difficult to see the bottom from the air; this problem is eliminated when one is underwater.

Rakes or cultivators with long handles can be used to uproot and bring up plants when working from a boat. Cultivators with four long, closely-set prongs are better for uprooting plants but, for small species like *Isoetes*, it may be difficult to bring the plants to the surface. An Ekman dredge will also bring up small species from deep water if the sediment surface is not too hard. In deep water where visibility is poor one can get a random sample of some of the plants which are present by dragging an anchor from a boat. The plants are not in very good shape and the sample is not necessarily representative of all the species present. Usually all that is collected are fragments of plants without roots or rhizomes and small plants like *Isoetes* will be missed. For sample completeness and specimen quality none of these methods are as good as picking by hand.