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NOTES ON MAKING AN HERBARIUM

FROM TIME TO TIME the Arnold Arboretum receives inquiries from people who either want to send plant material for identification or to prepare a reference collection for their own use. While many discussions of the techniques and accompanying problems can be found in the botanical literature, few are readily available in this country for the layman. For this reason these notes have been prepared. For those who desire more detail about specific groups of plants, or about specific problems or specific techniques, an Appendix and Bibliography will be found at the end of the text.

Let it be said at the outset that the best (but far from the most convenient) way to preserve plant material for study is to place the material in jars of preserving fluid. Such a collection, however, is not an herbarium. Liquid preservation has several disadvantages: 1) It is bulky; 2) the liquid tends to evaporate through the best-sealed lid, and in time must be replaced with fresh liquid; 3) to use the specimens for comparison, they must be removed from the jars and spread out in a pan of the liquid; 4) because of the fragility of glass containers it is not easy to transport specimens so preserved or to send them through the mails for identification or study. For special purposes, such as class teaching or preserving material in its natural shape for illustration, liquid preservation can scarcely be improved upon. But for most purposes of reference and identification, drying the plant material under pressure and mounting it on sheets of paper is more convenient and economical.

Herbaria and Their Use

An herbarium specimen is a pressed and dried plant or portion of a plant, accompanied by notes stating at the very least where it grew, when it was collected, and by whom. It is evidence that a particular plant, exhibiting particular charac-

teristics, grew in a particular place at a particular time. Incidentally, when identified, it exemplifies more or less completely the characteristics of the particular taxon [1] of which it is a member.

An herbarium is a collection of pressed and dried plant specimens arranged in some systematic order that facilitates examination of all of the material of a particular taxon. The aim of an herbarium is to accumulate in one place all possible information about the habits, habitats, variations and uses of all the plants with which it may be concerned. An herbarium may be concerned with a particular local area, such as a township, county, or state, or it may attempt to cover a nation, a continent or the world. It may attempt to accumulate all information available about a single taxon, such as a species, or about a few taxa, such as those included in a genus or a family, or it may attempt to contain information about all of the kinds of plants. It may deal with cultivated plants, wild plants, or both. However big or small it may be, it is a repository of information and a research tool of considerable value.

The usefulness of an herbarium or of an isolated herbarium specimen is determined by, and dependent upon, the completeness of the actual specimen(s) and the notes which accompany it(them).

Making an herbarium is the only economical way in which examples of many different kinds of plants, growing naturally in many different places, differing in their environmental requirements, and going through their life cycles at different rates, can be brought together at one time and in one place so that a student can compare simultaneously many different plants at any given stage of their life cycle. Such a situation is essential for identification of plants and for the production of written works that will allow subsequent students to identify other plants without the labor of comparing them with all of the material that was used for the original identification.

Historical Background

Sometime in the 1530's Luca Ghini, who was at that time Professor of Botany in the University of Bologna, Italy, discovered that plants dried under pressure and pasted on sheets of paper could be preserved almost indefinitely — and could be transported easily. It is on record that he had a collection of some 300 sheets so prepared. Unfortunately, it appears that this collection no longer exists. Several of Ghini's students and colleagues recognized the value of this technique and the collections of at least two of them survive. Andrea Cesalpini, the author of *De Plantis Libri XVI*, which is the basis for our consideration of flowers and fruits as the prime structures on which to base identification and classification, formed about 1563 a collection of some 768 specimens of Italian plants. This collection

[1] *Taxon*, pl. *taxa*, is a neutral and/or inclusive term devised to signify a taxonomic group of any rank, i.e. variety, species, genus, etc. In the present example, a second collection might represent a different variety of the species, or a different species in the same genus, or perhaps a different species in a different genus. The term taxon allows for any or all of these possibilities.

PLATE XXIV

An herbarium in use. Note steel cases for mounted specimens and mounted specimens enclosed in heavy manila folders.

is still preserved at the Instituto Botanico of the University of Florence. Ulisse Aldrovandi, who succeeded Ghini as Professor of Botany at Bologna and who taught a number of the most prominent botanists of the next generation, attempted to form an herbarium that was world-wide in scope. About 4,368 specimens of this collection are preserved at the Instituto Orto Botanico in Bologna. The herbarium technique proved so useful that it was quickly adopted by botanists throughout Europe. Arber (10) records that more than 20 collections formed or begun before 1600 are still extant in various European herbaria.

Originally, the individual sheets with plants mounted on them were bound and treated as books. Aldrovandi's herbarium, for example, is preserved as 17 bound volumes. This was the general technique until about 1700. Linnaeus (1707–1778) did not use this technique, preferring to keep the sheets separate and storing them (probably in cases) horizontally. Stearn (182) thinks that Linnaeus' example and teaching led to the spread of this technique — which is the one generally used today.

Binding the single sheets into books had the disadvantage of making any changes or additions to that part of the collection difficult if not practically impossible. This led to the use of portfolios, in which several unattached single sheets could be kept in a book-like fashion, a compromise between bound volumes and single sheets filed in cases. The advantage of portfolios was that they could be stored on shelves like books. The disadvantages were that the specimens were joggled every time the portfolios were moved and could be severely damaged by crushing if shelved too tightly. There was also always the risk of insect infestation, unless the specimens were poisoned — a messy and unpleasant, if not risky, business. However, as late as 1833, Asa Gray was selling bound volumes of mounted grass and sedge specimens entitled *North American Graminae and Cyperaceae.* And even today biological supply houses sell portfolios in which to keep herbarium specimens. Old techniques die slowly.

Preparation of Specimens for the Herbarium

Collecting — What to Collect

The herbaria of the world contain many scrappy specimens. It is not necessary to collect more scrappy specimens. As nearly as possible, an herbarium specimen with its accompanying notes should give a representation of the whole plant. Herbs and small shrubs up to 2 ft.–3 ft. tall should be collected entire (Plate XXV). Lateral branches may be trimmed off, if necessary, as may also some of the remaining leaves, to reduce bulk. The specimen should represent all parts of the root system (the plant should be dug, not pulled), as well as rhizomes, stolons, or tubers, if any (Plate XXVI), basal leaves, cauline (stem) leaves, any leaves or bracts in the inflorescence, and of course flowers and/or fruits.

Large shrubs and trees should be represented by a twig or small branch bearing three or more adjacent leaves, or at least leaf bases, so as to show their arrangement (Plate XXVII). It should, of course, bear flowers and/or fruits. If it is not possible to press the flowers or fruits while attached to the stem, then an explicit

PLATE XXV

Specimen on the folded newspaper in which it was pressed. Note rhizome, and inflorescence bent to fit the folded paper.

statement as to how they are attached should be made in the notes which accompany the specimens. Particular attention should be paid to different forms and sizes of leaves on the same plant. Shade-grown leaves and leaves on sucker shoots of trees or shrubs are frequently different in size or shape or texture from the leaves on twigs bearing flowers and/or fruits. Such variations should be collected and explicitly noted. Material without flowers or fruits should be collected only if it has some unusual value or significance (See Appendix).

Some plants have distinct male and female flowers. In some cases flowers of both sexes may be found in a single inflorescence (poinsettia) or, at least, on the same plant (Indian corn). This is termed monoecism. In other cases, individual plants will produce flowers of only one sex (e.g. willows). This is termed dioecism. In all these cases, it is important to collect both male and female flowers.

Each specimen should be composed of material to fit within the dimensions of a standard herbarium sheet, 11½ x 16½ in. When collecting small herbs, several should be collected, so as to fill a folded sheet of newspaper, and later a standard herbarium sheet. A larger herb or shrub may have its main axis variously bent into a "V", "N", or even an "M" to fit a fold of paper (Plate XXV). The bent stem may be held in place during drying by slipping a small piece of cardboard with a slit in the middle over the bend in the stem (Fig. 1). Alternately, 16 in.

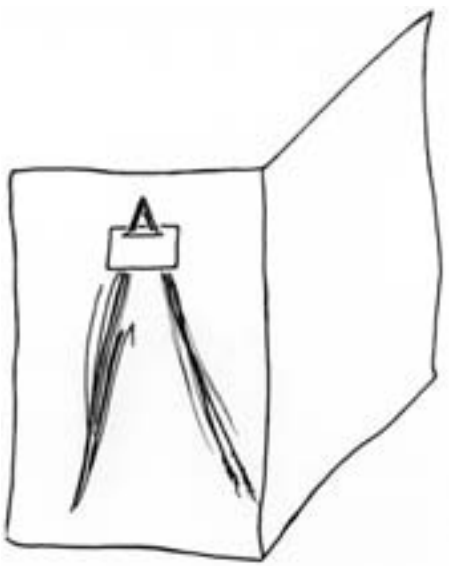


FIGURE 1

sections of axis with leaves or other appendages may be pressed in sequential folds of paper forming a series of specimens which should be numbered serially (185a, 185b, 185c, etc.) (Plate XXVI). If leaves are too large to be pressed flat, they may be folded or split lengthwise just off center so that the portion of leaf

PLATE XXVI

Lilium 'Black Beauty'. This specimen, which includes an entire plant, will be mounted on 3 separate herbarium sheets. The base of the stem and bulb has been split to facilitate drying.

which is pressed includes both the leaf apex and the leaf base, and the entire petiole. If possible the leaf or leaves should be arranged so that both surfaces will show (Plate XXVII).

Flowers that open for only a short time or that shed their petals readily are best put directly into a field press as they are collected, and then kept under pressure until dry.

Flowers composed of very thin tissues may become attached to the pressing paper and be almost impossible to remove when dry without breaking or tearing. Such flowers should be placed between a fold of tissue paper, or a piece of tissue paper and a piece of waxed paper or polyethylene film.

Bulky structures such as large fruits may be placed whole in a cloth bag with a numbered tag and dried entire (Fig. 2a). It is wise, however, to press a thin median cross section (Fig. 2b) and a median longitudinal section (Fig. 2c) to

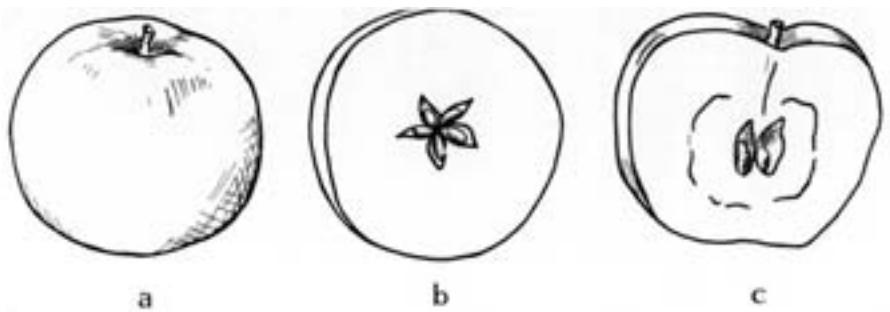


FIGURE 2

demonstrate the size and shape of the structure. It is preferable, if possible, to preserve fleshy structures in liquid. Dry fruits may be stored in cardboard boxes. Special care should be taken that the specimen number always accompanies such material — and that the notes with the rest of the specimen give reference to any separate parts. Additional notes about specific groups of plants will be found in the Appendix.

In general, each collection should consist of at least two specimens — one to be kept by the collector in his own herbarium, and the other(s) to be used for exchange with other collectors or herbaria, or to send to a specialist for identification.

Collecting — How to Collect

Collecting equipment is bulky and awkward to transport. For best results, plant collecting should not be combined with other activities: psychologically, because one can do only one job well at a time; physically, because the results do not warrant the expenditure of energy if collecting is only desultory; factually because specimens snatched in passing do not have the notes on habit, habitat, location, etc. that are necessary to make this kind of specimen most useful. However, there are times when collecting must be a secondary function. When this is the case, the field press method, described below, is the best. If a field press is

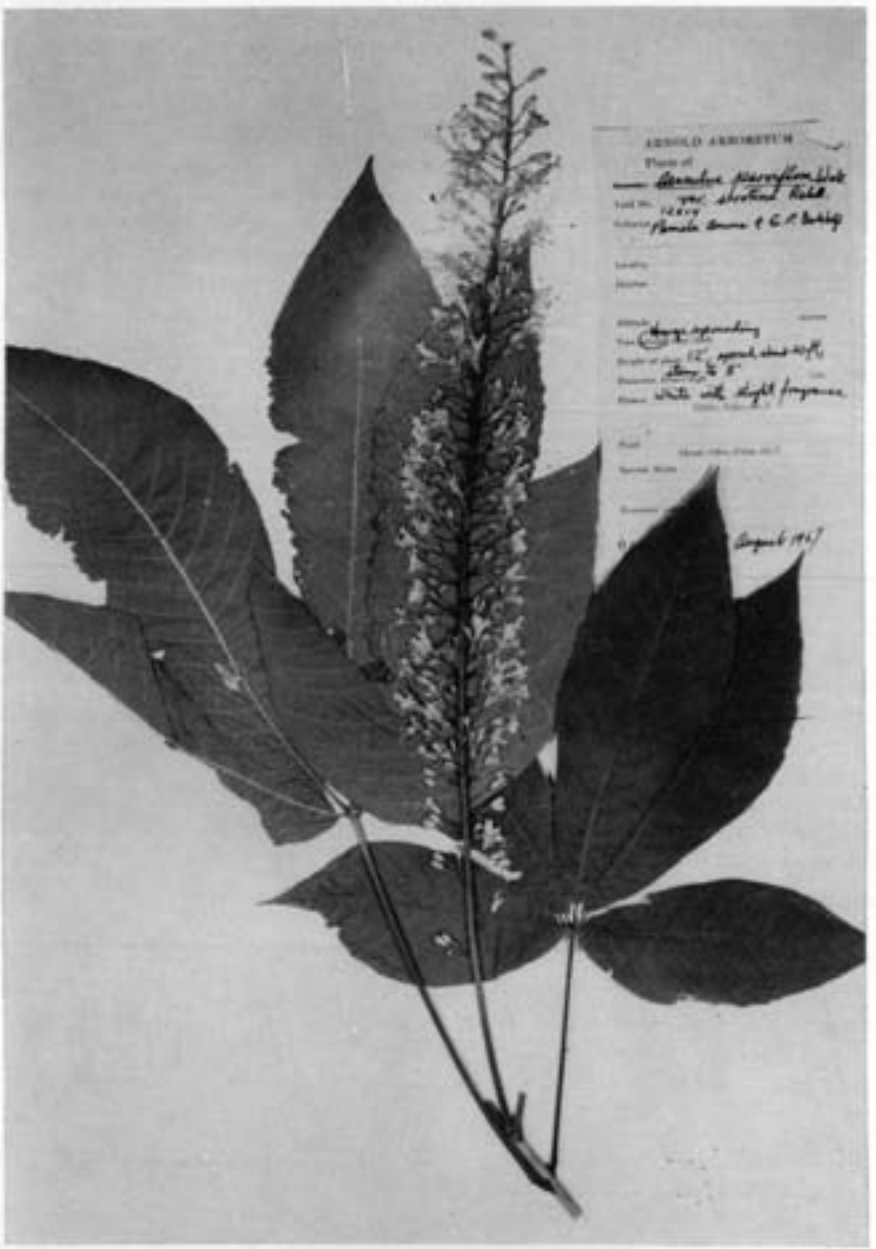


PLATE XXVII

Aesculus parviflora flowering twig, showing arrangement of leaves: one leaf turned to show upper surface, one leaf removed (note petiole base) to reduce bulk.

not available, then a book or magazine, as large as possible, printed on unglazed paper may be used. The specimens should be placed one to a page and copious notes taken, for the value of such snippets and scraps is in direct proportion to the amount of information which accompanies them.

There are, in general, two techniques of collecting — one utilizes a collecting box or vasculum, the other uses the so-called field press. A vasculum is an oblong metal box with a hinged and fastenable door occupying most of one side. It should be provided with a handle and with eyelets so that a carrying strap may be used. A vasculum about 8 x 8 x 24 in. is about the right size. Vascula sold by supply houses are generally smaller — and far too expensive. A metalsmith can easily produce an acceptable article from lightweight sheet steel or aluminum (Fig. 3).

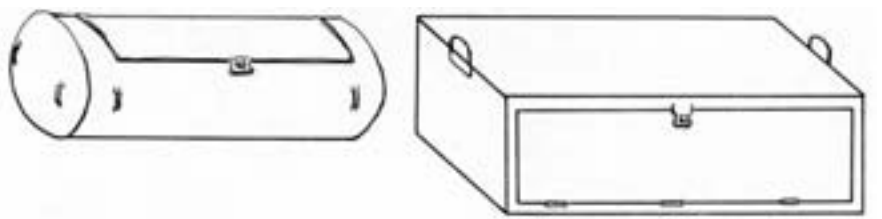


FIGURE 3

It may be circular, elliptical or rectangular in cross section. The vasculum should be painted white, both to reflect the heat of the sun and so keep the interior cool, and to make it more conspicuous when set down on the ground. A large heavy-weight polyethylene bag may be used as a substitute for a vasculum — and some collectors use a large canvas sack. Plant material is collected directly into the vasculum and carried back to the base of operations, where it is sorted and put into the drying press. Care must be taken to insure that the vasculum does not become too hot — or the specimens will be cooked.

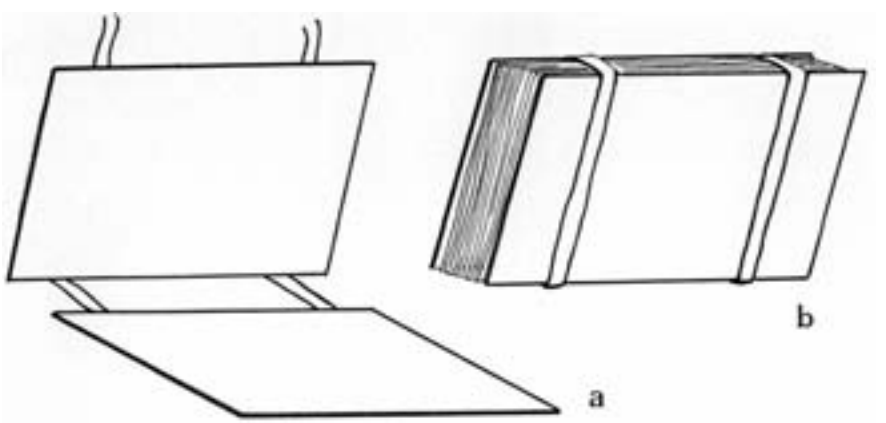


FIGURE 4

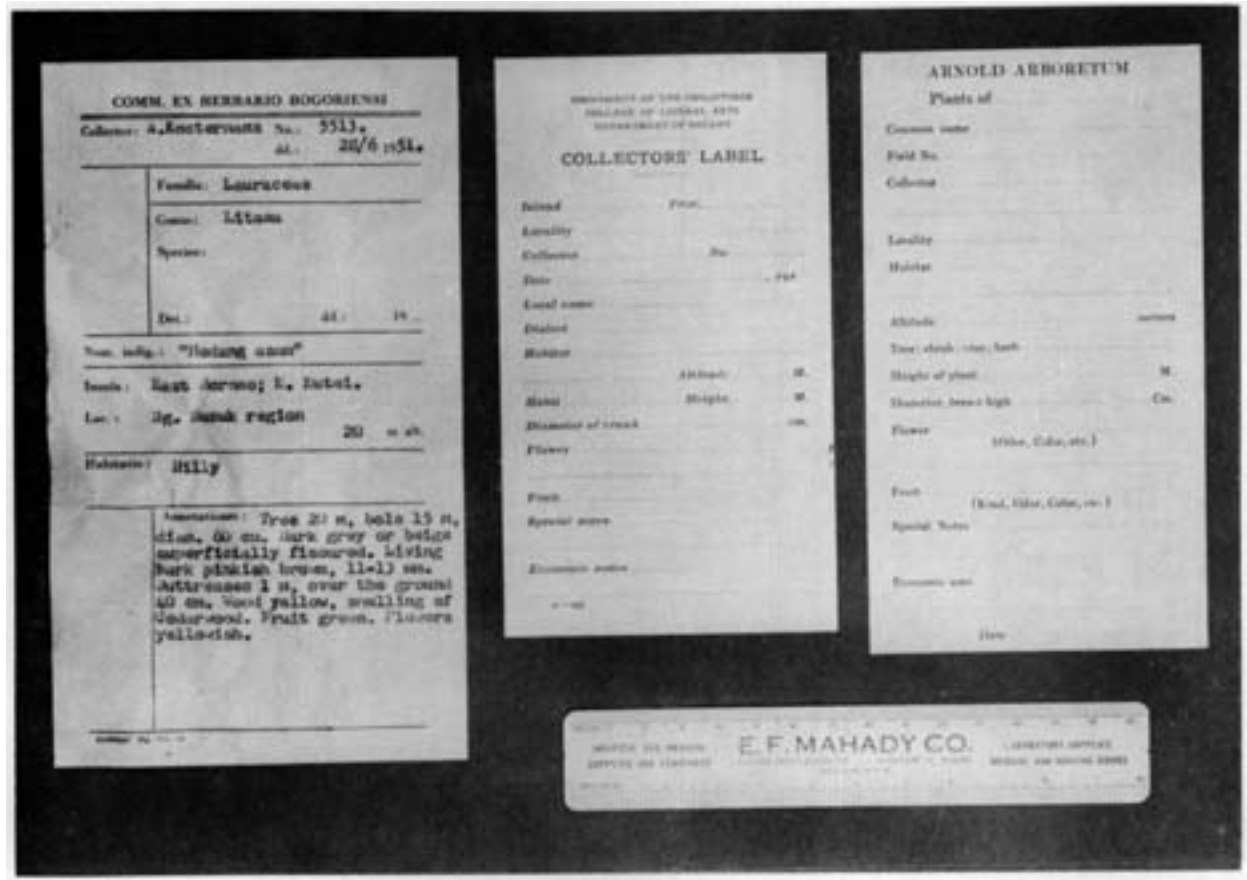


PLATE XXVIII

Field labels. From left to right: the label currently used at the Bogor (Indonesia) Botanic Garden, a label used at the University of the Philippines, the label used at the Arnold Arboretum, Jamaica Plain.

A field press consists of two lightweight press frames, hinged along one side with two short straps and at least one strap around the body of the press to keep it closed and apply some pressure to the contents (Fig. 4a). It may be carried under the arm or it may be fitted with a handle or a carrying strap so that it may be carried in the hand or slung over the shoulder. The frames may be of thin, weatherproof ¼-inch plywood, treated hardboard, or corrugated cardboard or strawboard covered with some waterproof material. The press is filled with folded unglazed paper (Fig. 4b) and the specimens are inserted directly into the folds in the field. On returning to the base, the folded papers with their enclosed plants are put directly into the drying press.

With either technique, a note-book of some sort should be carried into the field and notes taken on the spot when collections are made. It is not safe to trust to memory. Every collector should number all the collections he makes, beginning with number one for the first one. For any given collection the data in the field note-book should include at least the number of the collection, the date, the precise location — sufficiently detailed so that someone else could find the place — and any information about the plant itself that will not show in the pressed specimen. Many people find a pad of printed or mimeographed "field labels" with spaces to be filled in very useful (Plate XXVIII). These are especially advisable for the non-professional taxonomist. Particularly when using the vasculum, it is advisable to correlate notes and specimens by attaching a numbered tag-label to the specimen, the number corresponding to the number assigned in the notes.

Each collection from a particular individual or colony of individuals made at a particular time receives the same number. This number should be written in lead or wax pencil on each folded sheet that holds a specimen from that particular individual or colony. Each collector should maintain a single series of collection numbers throughout his lifetime. Such numbers serve to correlate duplicates of the collections that may be filed in different herbaria. Whatever the identification of the individual collection may be and whatever changes may be made from time to time in that identification, the collector's name and number serve to identify the particular collection for all time.

Drying Specimens

The plant specimen is placed in the fold of a sheet of unglazed paper about 24 x 18 in. which has been folded to give a sheet of 12 x 18 in. This may be newspaper, or it may be unprinted stock specially purchased for the purpose. This folded paper with the included plant specimen is placed between two sheets of blotting paper or other thick absorbent paper — several sheets of newspaper will do (Fig. 5). In American practice, the "sandwich" of collecting paper and blotters is then placed between two 12 x 18 in. sheets of corrugated cardboard or corrugated aluminum (often called ventilators) in which the corrugations run the short direction. All these sheets are placed between two wooden frames and pressed tightly together by two straps. The filled frames are then placed over a gentle source of heat in such a way that the warm, dry air passes through the ventilators (Fig. 6). During drying, the water in the specimen passes by diffusion into the dry paper, then the blotting paper, then to the dry air passing through the

corrugations and is carried off. The specimen decreases in volume as it dries, and it will shrivel unless the press is regularly tightened during drying. If constant pressure is maintained, the decrease in thickness in the specimen will be accompanied by a similar, regular decrease in length and breadth, resulting in a flat, relatively undistorted mummy of the original. Of course, the sandwiches of specimens, papers and corrugated ventilators may be piled together within one set of press frames to any practical size. In general, however, 25–30 individual specimens with blotters and ventilators make a bundle of sufficient size.

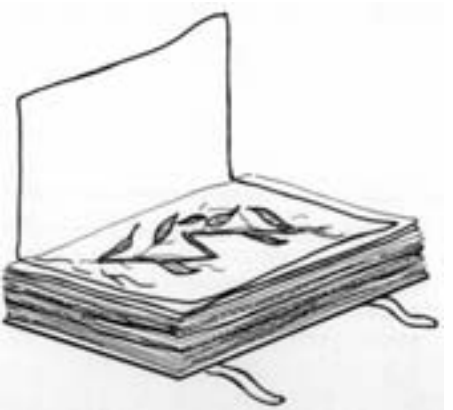


FIGURE 5

In British and older American practice, ventilation is not used but the wet absorbent papers are regularly changed for dry ones until the specimens are dry. This is a laborious and time-consuming technique and does not seem to yield results superior to the previous method.

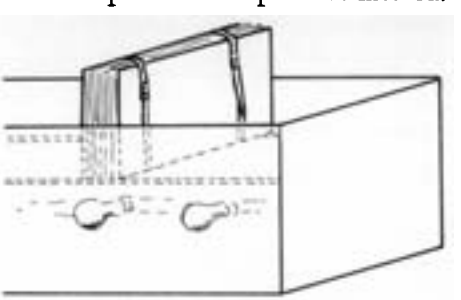


FIGURE 6

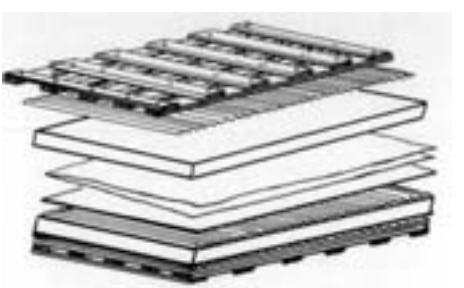


FIGURE 7

For bulky material, a sheet of polyurethane foam (available in thickness between ⅜ in. and 1 in.) may be substituted for one of the blotters. This will fit itself to the specimen and help to prevent shrivelling of parts due to inadequate or unequally distributed pressure (Fig. 7).

The source of heat and the method of holding the press over it vary considerably. In the most elaborate modern installations a closed cupboard or case is fitted

with a heat source at the bottom (an electric heating unit or steam pipes), shelves of expanded metal mesh are arranged about 24 in. apart, and an exhaust fan is fitted at the top. The presses are placed on the shelves, with the corrugations running vertically.

A simple home installation consists of a wooden box without top or bottom and with the two long sides 18 in. apart in outside measurement (Fig. 8). The inside of the box may be painted with aluminum paint. The box is raised from the floor about 1½ in. to allow for ventilation and some heat source such as a series of incandescent lightbulbs or a small electric heater (preferably with a fan), is set in-

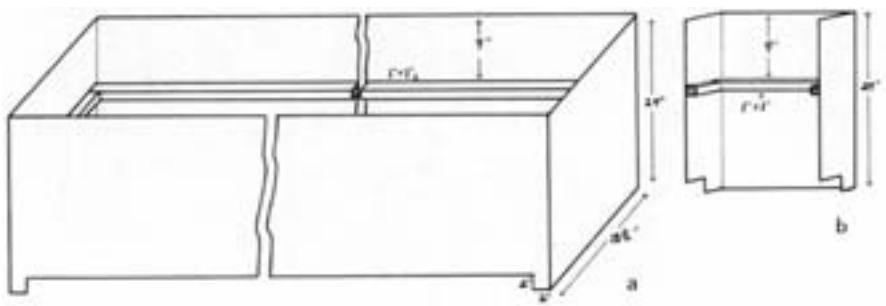


FIGURE 8

side. The presses are set on edge on top of the box with the corrugations running vertically. Such a box and heat source can be constructed so as to be portable. It is not recommended that the heat source be a naked flame.

Mounting Specimens

Two considerations govern the storage of botanical specimens once they are dried. The first is their usefulness as objects of record or study. The second is their preservation for the future. To an extent these two functions are incompatible so the storage methods adopted must involve a compromise between them.

For maximum ease of study, the dried specimen lying loose in the paper in which it was pressed and dried is best. But dried specimens are extremely brittle and when they are kept loose in the folded pressing papers they are easily damaged by handling. Also, the flimsiness and fragility of the individual sheets of paper make the specimens awkward to consult.

The object of "mounting" botanical specimens is to give them a firm physical support that will allow a reasonable amount of handling with a minimum of damage. The kind of paper on which specimens are mounted and the methods used to attach them to the paper are governed by cost, effectiveness, and personal prejudice.

Mounting Paper

Paper used for mounting specimens should be of 100% rag content. So far as a botanist is concerned, an herbarium specimen is a piece of scientific information

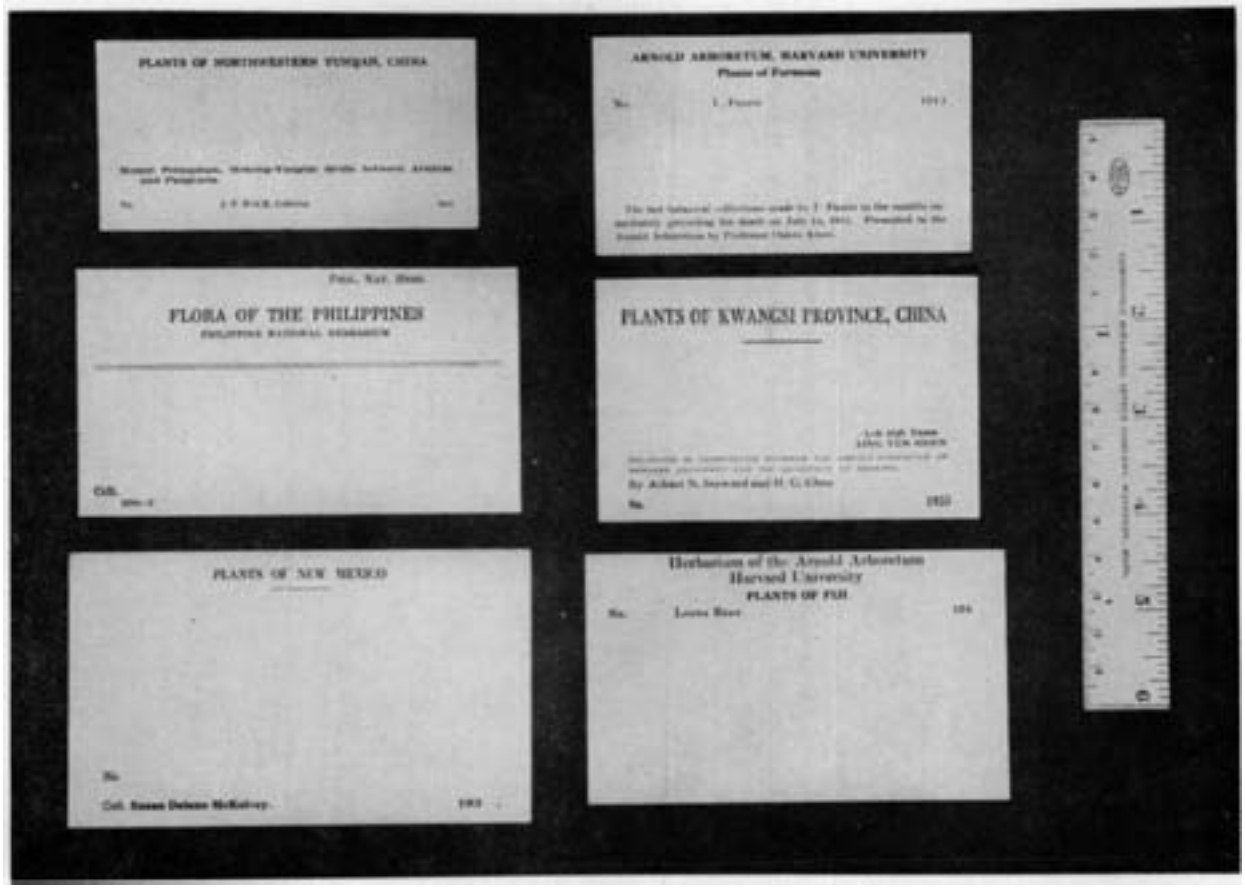


PLATE XXIX

Herbarium labels, of the sizes usually used in the United States at the present time.

to be preserved for all time. Papers made from wood pulp or mixtures of wood pulp and rags tend to deteriorate, yellow, soften, and tear — sometimes within a matter of a few months.

The thickness or weight of the paper to be used depends upon the amount of use the specimens will have, the amount of space available and money available. Where money or space is a prime consideration, the lightest paper that can be used safely is so-called 36 pound stock. Paper of this weight is not very stiff. Consequently the specimens must be glued or fastened over their entire area in order to reinforce the paper. So-called 56 pound stock is a heavier, stiffer paper which should be used wherever the specimens are likely to get much use. Because it is stiffer, the specimens are better protected — and need not be so tightly and completely fastened to the paper.

The size of the paper on which the specimens are mounted varies considerably. In the United States and in most herbaria in the Western Hemisphere, the standard size is 16½ x 11½ in. Linnaeus mounted his specimens on sheets of paper about 12½ x 8 in. The sheets in the herbarium of the British Museum (Natural History) are about 17½ x 11½ in. At the Royal Botanic Gardens, Kew, the sheets are about 16½ x 10½ in. Some continental European herbaria use the size 17 x 11½ in., others use sheets 19½ x 13¾ in. Leningrad uses 15¾ x 11$^{11}/_{16}$ in. (74) and Copenhagen uses 15¾ x 8$^{11}/_{16}$ in. While the size of the sheet is obviously not important *per se* except that the larger sheets allow larger and more complete specimens), all commercially available herbarium paper in the United States is pre-cut to the standard size of 16½ x 11½ in. Also, commercially available cabinets and boxes are made to hold this size paper. Thus, economics dictate the size of the paper on which the specimens are mounted and, indirectly, the size of the specimens collected.

Mounting Labels

Almost every botanist has very strong if not violent opinions about the size, shape and typography of herbarium labels. Actually the form of the label is not important — the thing that is important is that the label should be so designed and of such a size that all the information from the field label can be transcribed onto it.

Traditionally, collectors have supplied little information beyond laconic notes on date and locality with their specimens. This could be readily transcribed on relatively small labels, for many years labels as small as 2 x 4 in. were used. Even today, labels larger than 3½ x 4½ in. are not common (Plate XXIX). Over the past 75 years we have come to realize that we need to know much more about our plants. In most areas it seems to have been the foresters who have led the way in designing field labels that provide space for abundant information. Herbarium botanists have tended to be conservative in this matter, and to reject large labels and field labels as aesthetically or professionally offensive.

Gradually tradition is changing — and petite labels are now being abandoned for practical labels. Perhaps the best solution is the one used at Brussels where a field-type label, 4⅜ x 6¾ in., is printed on good quality paper and used as the herbarium label.

PLATE XXX

Mounting botanical specimens. Attaching the specimen with linen strips.

Laying-Out

Before mounting commences, the dried specimen and its label should be laid on the mounting paper. The label should be placed in the lower right-hand corner where it will be attached (it may be glued to the sheet at this stage). The specimen is moved about until one finds the position where it is best displayed. It is in this position that it should be attached. Specimens should be so arranged that bulky portions do not all come at one general position on the sheets. This allows the sheets to lie more evenly in the cabinet. Detached pieces of the specimen: leaves, flowers, seeds, small fruits, etc., should be placed in small envelopes (such as coin envelopes) or folded paper packets (Fig. 9), which are then pasted to the sheet.

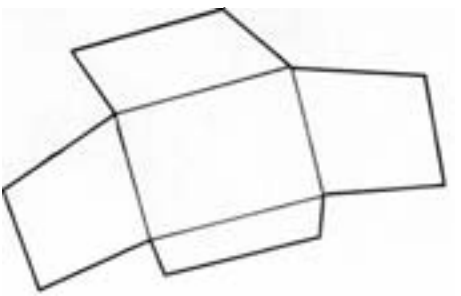


FIGURE 9

It is practical to lay out several specimens at one time so that several mountings may proceed more rapidly. Great care should be taken at this stage (and all others) that specimens and labels are not inadvertently mixed.

Experience, a severe teacher, has taught us that it is not wise to mount more than one collection on a single sheet of paper. Each collection is basically a single piece of information. As such, it stands by itself. Addition of a second collection to the same sheet can lead to confusion. In the first place, the second collection may not represent the same taxon as the first. Even experienced taxonomists have made this kind of mistake! Secondly, with a minimum of two specimens and two labels there is the possibility of confusion as to which label represents which collection.

This is not a theoretical problem but one which arises again and again when dealing with old herbaria in which this practice was followed.

Attaching Specimens to Mounting Paper

1. **Sewing or taping.** Specimens may be attached to the herbarium sheets by passing a heavy cotton or linen thread, about the weight of "carpet thread" around the stems and through the paper. The ends of the thread are tied on the reverse side of the sheet and a sheet of paper or cloth tape is pasted over the knot and loose ends.

   Alternately, or additionally, narrow ⅛–¼ in. wide strips of gummed white cloth tape may be pasted across the surface of the specimen to hold it in

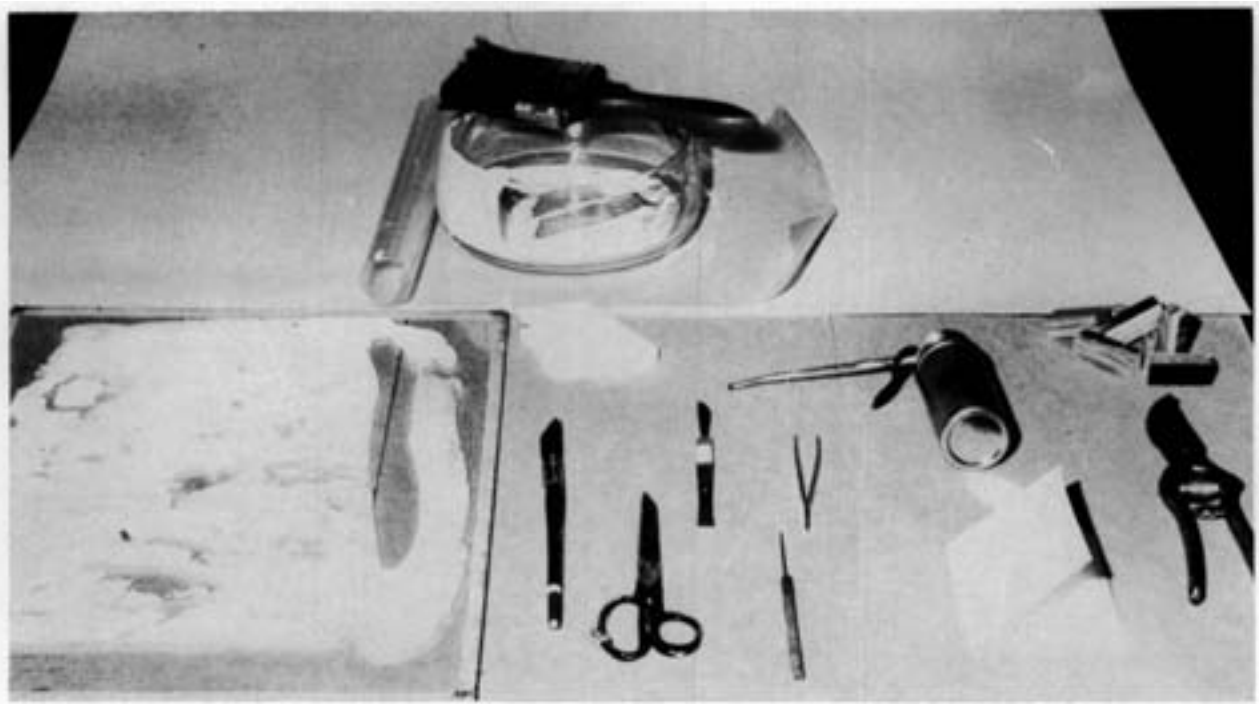


PLATE XXXI

Materials for mounting botanical specimens. (Top) Container for glue with paint-brush for applying it to the glass plate. (Bottom, left to right) Glass plate coated with glue, small paint-brush for "touching up" the glue on the specimens, scissors, scalpel, needle, tweezers, gun-type oil can for dispensing plastic glue, paper packet for loose pieces of specimen, pruning shears for trimming woody specimens, and wooden blocks (See Plate XXXIII).

place (Plate XXX). "Scotch" tape or similar materials should not be used as they deteriorate quickly and are difficult and messy to remove from the specimen when (as inevitably happens with these materials) it must be remounted.

2. **Gluing with a glass plate.** (Plates XXXI, XXXII). In this technique, a glass plate (which may be a sheet of double-strength window glass cut to the size of the herbarium sheet) is covered with a thin layer of glue. The glue should be applied to the plate with a paint brush (Plate XXXI). Linnaeus used "Fish Glue" to fasten his specimens to the paper. This glue (a by-product of the fish-packing industry) is liquid at ordinary temperatures, and was used extensively until the 2nd World War (LePage's Liquid Glue). More recently synthetic, water-soluble, white glue (such as "Elmer's Glue-all") has been used.

   After the surface of the plate has been covered with glue, the specimen is laid on the glued surface, right side up (Plate XXXII, top). It is immediately removed (gently) and laid on the mounting sheet, glued side to the paper. The label is treated in the same way and placed in the lower, right-hand corner of the paper. The specimen is then covered with a piece of waxed paper, over which is placed a blotter, and the whole is placed under a weighted board the size of the herbarium paper (Plate XXXII, bottom). Some institutions use a bag of dry sand as a weight. Several specimens, each with its waxed paper and blotter, may be piled one on top of another. The mounted specimens are left overnight to dry.

3. **Mounting with plastic glue.** This method is either used alone or in conjunction with the glass plate method. In recent years a plastic glue of a special formula has been used increasingly (12, 160). It may be obtained commercially from Carolina Biological Supply Company (See Appendix).

   The plastic glue is dispensed from some sort of a small container — usually a plastic dispenser such as is used for catsup or mustard in restaurants. "Gun" type oil cans may be used — but great care must be taken that the glue does not harden in the spout (Plate XXXIII, top).

   The specimen is laid out on a paper and thin strips of plastic cement are applied over the stems and leaves (Plate XXXIII, top). Metal washers or heavy nails may be used to weight down portions of the specimen that do not lie flat on the paper (Plate XXXIII, bottom). When the glue has hardened one has a plastic strip holding the specimen to the sheet in the same way that a cloth tape would. Both ends of the strip must be in contact with the paper. After plastic glue has been applied, it must be allowed to harden in the air for 3 to 4 hours or overnight. To save space, the mounted specimens can be laid on sheets of cardboard (cardboard ventilators are excellent) and stacked, using small pieces of wood at each corner for spacers (Plate XXXIII, bottom).

   The plastic cement technique has the great advantage that the whole specimen is not attached to the paper over its entire surface. Therefore, flowers or leaves can be detached easily for study. The stiffest, heavyweight

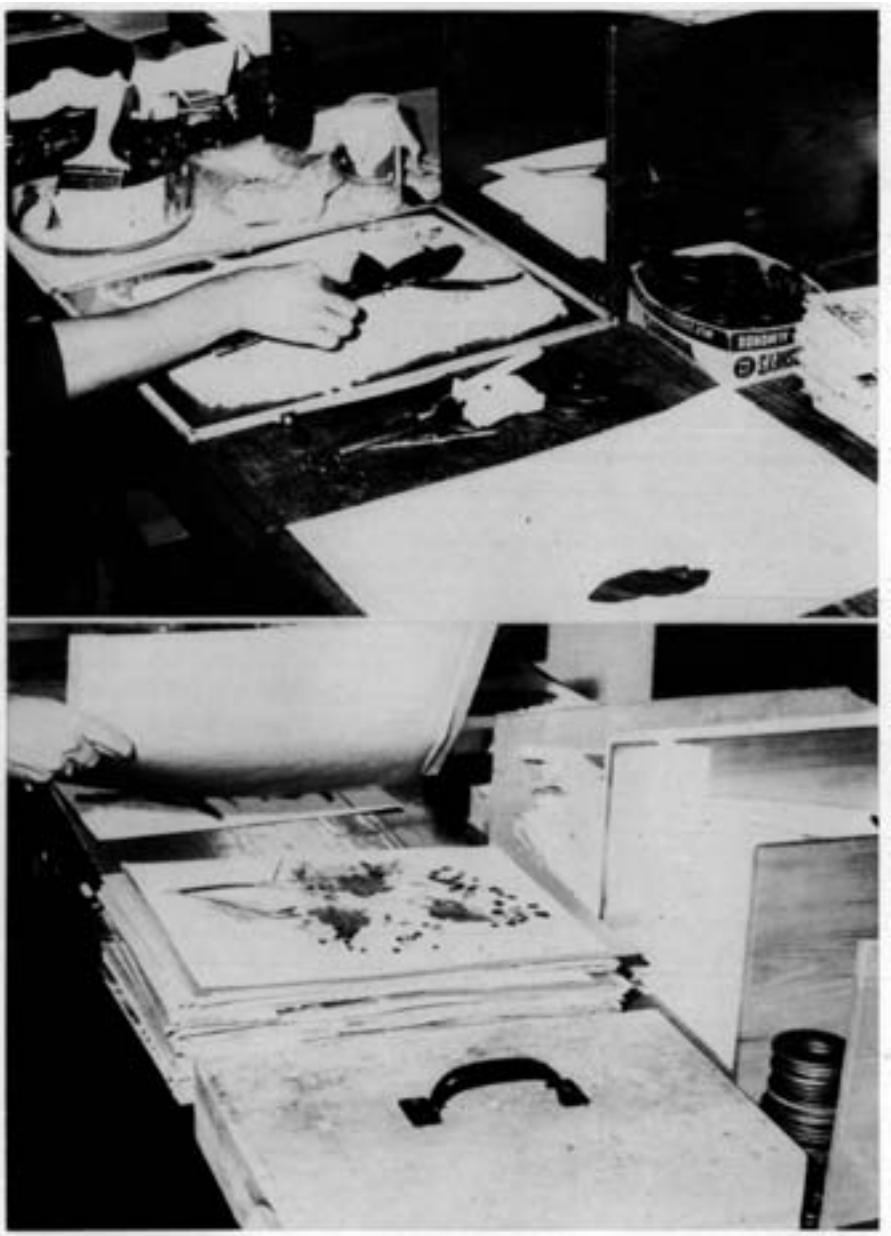


PLATE XXXII

Mounting botanical specimens with a glass plate. (Top) Placing the specimen on the glue-covered plate. (Bottom) The glued specimen on mounting paper, about to be placed under pressure while drying.

paper (56 pounds) should be used for this technique. In addition to making the specimen more readily available for study, this technique allows for very rapid mounting. In many cases, as many specimens can be mounted in an hour as can be done in a day by the other techniques.

Preservation of Specimens

Dried specimens are quite attractive to larvae of various beetles. In many herbaria specimens are kept in airtight steel cases. The specimens are fumigated before they are put in the cases and a little paradichlorobenzene (moth repellent) is kept in each case as a repellent. In the home, the specimens may be kept in a tight cardboard or wooden box, and a stick or ring of paradichlorobenzene, such as is sold to repel moths in closets, placed in the box.

It has been found that when the temperature of the air-hardened plastic glue rises above 90°F., the fumes of paradichlorobenzene will cause the plastic to soften and become viscid. The change is reversible and the glue solidifies again as the temperature of the glue goes below 90°F. This would indicate that mounted specimens ought not to be stored in boxes or closed containers that are exposed to the summer sun — nor stored in an attic or other area subject to excessively high temperatures. Under normal temperature conditions tolerable to human beings this problem should not arise.

Until fairly recently it was standard practice in many herbaria to "poison" all specimens by dipping them before mounting in a 2% solution of mercuric chloride (corrosive sublimate) in 95% ethyl alcohol. *This solution is intensely poisonous and is not recommended.*

If an insect infestation is found in the specimens, the specimens should be placed in an airtight box or large polyethylene bag heavily dusted with paradichlorobenzene crystals, and left for about two weeks.

Arrangement of Herbaria

After the plants have been mounted on herbarium sheets, some arrangement must be devised so that an individual sheet and the information that it provides can be easily located again. The standard practice, which works very well, is to place all of the specimens of one particular kind of plant, species or variety, in a folder of good quality, lightwight paper. The fold is placed on the left-hand side and the name of the species, and variety if applicable, is written in the lower right-hand corner. All species of one genus of plants are placed in a folder of heavy manila paper. The fold is again placed on the left-hand side and the name of the genus is written in the lower left-hand corner. All of the genus folders belonging to one plant family are kept together. For example, the genus *Rhododendron* consists of a large number of species: *Rhododendron maximum*, *Rhododendron catawbiense*, *Rhododendron calendulaceum* (frequently called *Azalea calendulacea*), etc., and a large number of cultivated varieties (cultivars) such as 'Old Port,' 'Cunningham's White', etc. All of these forms can conveniently be filed in one alphabetical sequence within the genus folder. *Rhododendron* is a

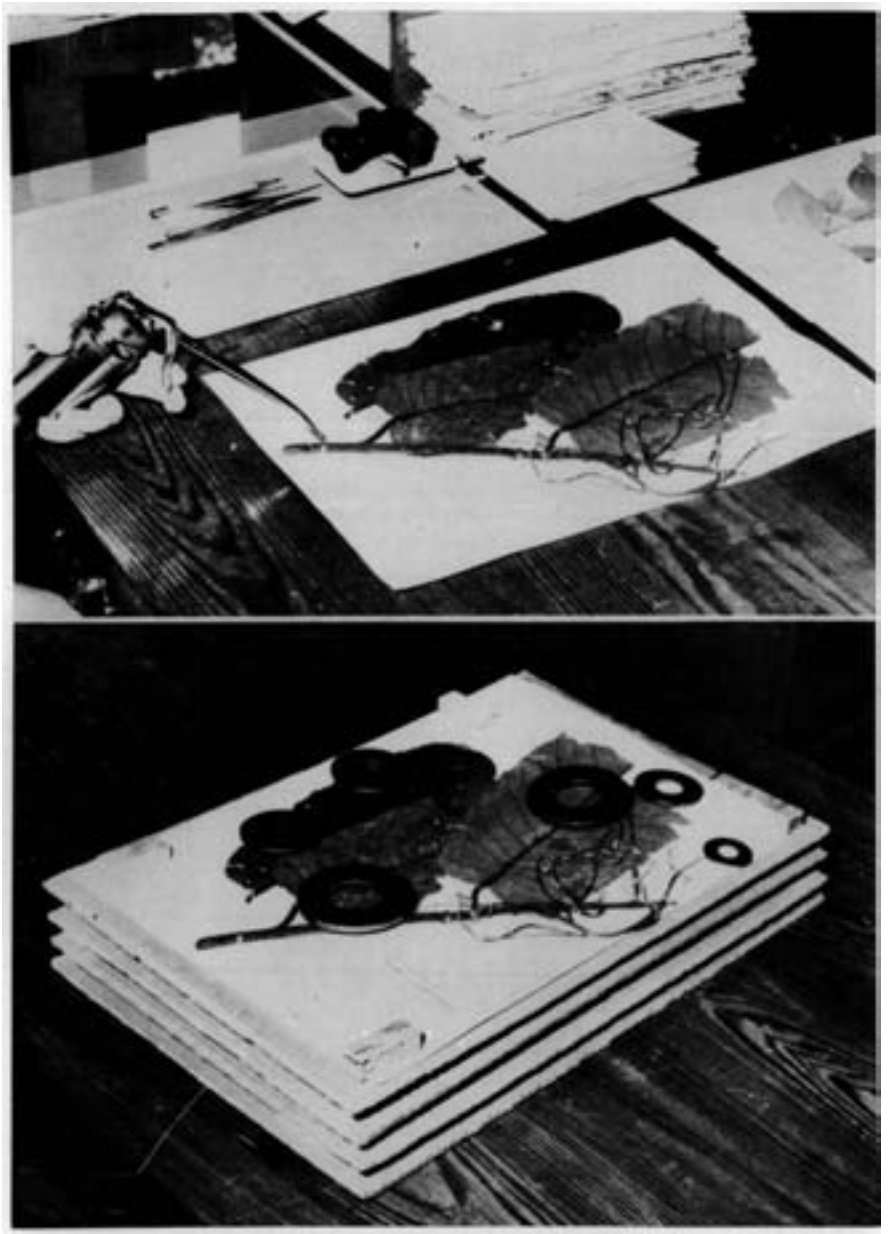


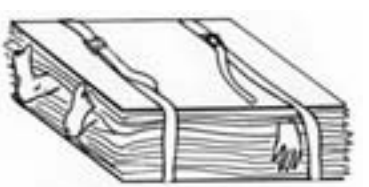
PLATE XXXIII

Mounting botanical specimens with plastic glue. (Top) The glue being applied with a gun-type oil can. (Bottom) The specimen weighted down to the mounting paper while the glue dries. Note the wooden blocks at each corner (see text for explanation).

member of a family of plants, the **Ericaceae,** which includes the blueberries (*Vaccinium*) the heaths (*Erica* and *Calluna*), and many more. The folders containing these genera also can be conveniently filed alphabetically. Finally, the various plant families can be arranged alphabetically. This alphabetical arrangement is not the method used in the great herbaria, in which the plant families are generally arranged according to some system of presumed relationship of the plants, but it is a convenient arrangement.

Storage Containers

A small number of specimens can be stored in portfolios or in cardboard boxes of appropriate size. However, when more than a few hundred specimens are involved, one should consider the purchase of a proper herbarium case. These are made of wood, composition board, or sheet metal. They contain a series of compartments, about 5¾ in. high x 12¼ in. wide x 16¾ in. deep, into which the genus folders are inserted, and the whole case is closed by an airtight door (Plate XXIV). They have the advantages that they are compact and protect the specimens from dust and dirt and insect infestation.



APPENDIX

The following notes on methods for collecting and pressing special groups of plants have been assembled from a number of sources. The list is particularly indebted to lists published by van Steenis (183) and by Fogg (67). Notes included in the manual by Fosberg and Sachet (73) have also been consulted.

Suggestions for Collecting Particular Kinds of Plants

As mentioned earlier, an herbarium specimen should attempt to record, as closely as possible, the exact appearance of the entire plant. On the field label or in the field notes should be noted anything that will not show in the dried specimen, i.e. flower color or fragrance, color of leaves, the presence of a waxy "bloom" on the surface of fruits, etc. In the case of any plant that cannot be preserved entire, a sketch or photograph which will show the branching pattern is very useful.

It is recognized that it is not always possible to obtain a specimen with flowers or fruits particularly when dealing with horticultural material for which identification is needed. In this case, it is very important to supply with the specimen as much additional information as is possible. This should include: 1) the place from which the plant was obtained, 2) the place where the plant is growing, 3) the use to which the plant is being put (hedge, shrubbery, specimen tree, herbaceous border, summer bedding, house plant) 4) what the plant is supposed to do or what the flowers or other ornamental parts are supposed to be like, 5) if possible, a photograph of the plant. Even with all of this it is not always possible to identify the plant but the chances are that some part of the information or the specimen will allow a fairly confident identification to be made.

In general, except for special purposes, as indicated above, a *specimen without flowers or fruit is difficult, if not impossible, to identify.* The following list, compiled from several sources, indicates items to be kept in mind when collecting various kinds of plants. In all cases, it is assumed that the basic specimen will be one that is in flower or fruit.

Acanthaceae — Flowers often detach easily after collecting. Fruits are important.

Agrimonia — Underground parts are useful.

Allium — Underground parts essential, especially the bulb coats. Note if the leaves are flat or rounded.

Amaranthaceae — Ripe fruits are almost essential.

Amaryllidaceae — Do not forget underground parts.

Amelanchier — Flowers and fruits (and leaves) from the same plant. Note habit (erect or stoloniferous).

Annonaceae — Fruiting material alone is of little value. Flowers may open precociously and then grow considerably before and during anthesis.

Araceae — Fruiting material alone of little value. Flowers, inflorescences, and underground parts of great value. Cf. Nicolson, D.N. in Fosberg and Sachet (73).

Araliaceae — Both flowers and fruits should be collected.

Asclepiadaceae — Fruit should be collected to supplement the flowers, but fruit alone is not of much use.

Balanophoraceae — Sometimes dioecious. Tuber surface is important.

Balsaminaceae — Fruit is desirable. Flowers are very fragile and have a tendency to agglutinate on drying under pressure. Preservation of flowers and fruits in liquid is desirable. Notes on flower color and markings very valuable.

Bamboos — Flowers and fruits seldom found but very much desired. Should be accompanied by a complete internode at medium height of culm, including a complete culm sheath (with tip). Cf. McClure, F. A. in Fosberg and Sachet (73).

Begoniaceae — Ripe fruit desirable. Male and female flowers essential.

Betula — Fruiting catkins essential. Bark collection or notes on bark desirable.

Burseraceae — Fruit important.

Cactaceae — Photographs almost essential. Some flowers should be detached, split, and dried separately. Stems may be split, the "flesh" scooped out, and the outer "rind" dried. Cross section of the stem to show arrangement of ribs. Handle with heavy leather gloves and use extreme care. Stems may be dipped into boiling water to kill the tissues and to remove the waxy coating which will allow more rapid drying.

Campanulaceae — Shape of the corolla is essential — corolla may be split and spread out, or a sketch made on the field label, or both.

Capparidaceae — Fruiting material is of limited usefulness. Flowers may open precociously and then grow considerably before and during anthesis.

Caprifoliaceae — Ripe fruit desirable.

Casuarinaceae — Dioecious or monoecious. Male and female flowers and ripe fruit desirable.

Celtis — Color and shape of ripe fruit desirable.

Coccoloba — Leaves from adventitious shoots and leaves from mature twigs; male and female inflorescences and fruits all desirable for accurate identification.

Commelinaceae — Color of petals and anthers should be noted. Flowers may be pressed by placing them between a sheet of waxed paper and a sheet of tissue paper. Alternatively flowers should be preserved in liquid.

Compositae — Flowering heads should be pressed so that some show the upper, others the lower surface of the head. Note the color of the rays and the disk florets. Ripe fruits, basal leaves when produced, median cauline leaves, and underground parts are all highly desirable.

Convolvulaceae — Some flowers should be split open and dried flat. Ripe fruit desirable.

Cornus — Note color of branchlets and mature fruit. Note color of pith of branchlets.

Crataegus — Flowers and fruit from the same tree. Note color of anthers.

Cruciferae — Ripe fruit desirable.

Cucurbitaceae — Dioecious or monoecious. Flowers of both sexes and ripe fruit desirable.

Cyperaceae — Ripe fruit and underground parts desirable. Very young inflorescences alone of little value.

Dahlia — Median leaves, branches from flowering portions, and notes on ray color needed.

Dilleniaceae — Ripe fruits desirable.

Dioscoreaceae — Male and female inflorescences, also axillary bulbils. Underground parts and base of aerial stem. Mature fruits if possible. Notes on direction of twining of stems, i.e. clockwise or counterclockwise.

Dipterocarpaceae — Ripe fruits desirable.

Ebenaceae — Dioecious. Male and female flowers desired — also ripe fruits with calyx attached.

Elaeocarpaceae — Ripe fruits desirable.

Epacridaceae — Ripe fruits desirable.

Ericaceae — Useless without flowers — but ripe fruits desirable in addition. Check for waxy "bloom" on fleshy fruits.

Euphorbiaceae — Dioecious or monoecious — male and female flowers needed. Ripe fruits also desirable. Sap may cause severe dermatitis.

Fagaceae — Male and female flowers — and ripe fruits.

Ferns — see Pteridophyta

Fraxinus — May be dioecious. Both male and female flowers desirable — ripe fruit nearly essential.

Gesneriaceae — Fruits desirable in addition to flowers.

Gnetaceae — Dioecious or monoecious. Male and female flowers and ripe fruit desired.

Gramineae — Underground parts and stolons. Inflorescences should not be too young. Stalks should be pressed to show leaf sheaths and ligules.

Iridaceae — Press flowers between a sheet of waxed paper and a sheet of tissue paper. Fruits are almost essential.

Labiatae — If large enough, some flowers should be split open and pressed flat. Base of aerial stem and underground parts essential. Mature nutlets desirable.

Leguminosae — Flowers and fruits essential.

Liliaceae — Underground parts most desirable. Fruits alone useless.

Loranthaceae — Fruits alone useless. Note host plant.

Malvaceae — Flowers and fruits desirable.

Melastomataceae — Flowers and fruits desired. Petals may drop very quickly.

Menispermaceae — Dioecious. Male and female flowers if possible. Fruiting materials desirable.

Moraceae — Frequently dioecious. Fruits desirable.

Musaceae — Collect axis of inflorescence. Ripe fruits desirable. Photograph of whole plant desirable.

Myristicaceae — Dioecious. Ripe fruits desirable.

Myrtaceae — Fruits very much desired.

Nepenthaceae — Flowers not very important. Pitchers at base of aerial stem not essential — pitchers of full grown cauline leaves essential.

Nymphaeaceae — Ripe fruit desired. Note if leaves are floating on surface of the water or erect.

Orchidaceae — Note color of flowers and markings. Preserve flowers in liquid if possible. Fruits useless by themselves.

Orobanchaceae — Ripe fruits desirable. Note host plant if possible.

Palmae — cf. Bailey, L. H. — The Palm Herbarium . . . Gentes Herbarum 7(2): 151–180, 1946. Tomlinson, P. B. in Fosberg and Sachet (73).

Pandanaceae — Dioecious. Male plants rare. Ripe fruit more desirable than flowers. Stem diameter and leaf tips important. Habit sketch or photograph most desirable.

Piperaceae — Fruit.

Polemoniaceae — Some flowers should be split and pressed flat. Underground parts most desirable.

Polygonaceae — Fruits essential.

Pteridophyta — Spore-bearing fronds should be collected attached to the rootstalk. Sterile fronds may be different from fertile fronds — both should be collected. Scales and hairs on the fronds and on the rhizome or rootstalk are important. Tree ferns — entire petiole should be collected, also a section of the stem showing the leaf scars or leaf bases.

Quercus — Leaves and mature fruits desirable. Flowering material of little value.

Ranunculaceae — Collect underground parts. Fruits very important.

Ribes — Note color of mature fruit.

Rosaceae — Fruits needed.

Rosa — Note habit of plant. Sterile twigs from vigorous new shoots should be collected along with the flowering shoots — the leaves are likely to be different.

Rubiaceae — Fruits very much to be desired.

Rubus — Note habit — canes arching or not, rooting at the tip or not. Collect sections of vegetative shoots as well as flowering shoots, to show differences in leaves.

Salix — Dioecious. Mature male and female catkins and leafy material collected from the same plants essential.

Sapindaceae — Fruits desirable.

Sapotaceae — Fruits desirable.

Schrophulariceae — Some flowers should be split and pressed flat. Note corolla color and markings. Note appendages (if present) on petals. Flowers of some genera drop very quickly. Many forms blacken on drying.

Smilax — If specimen is from a lateral axis, note if main axis is smooth or prickly, particularly at the base. Note fruit color.

Solanaceae — Some flowers should be split and pressed flat. Fruits are desirable.

Styracaceae — Fruits are desirable.

Sympetalae — Collect extra flowers of tubular-flowered forms. Some should be split open and pressed flat to show attachment of stamens and styles, glands, nectaries, etc. (Plate XXXIV).

Symplocaceae — Ripe fruits desired. Note color.

Umbelliferae — Ripe fruits essential. Basal leaves and underground parts very desirable.

Vaccinium — Flowers and fruit essential. Note if fruit is glaucous. Note habit of plant.

Viburnum — Ripe fruit desirable.

Zingiberaceae — Underground parts most desirable. Inflorescences should be in liquid.

Preserving Succulent or Fleshy Plants

Many woody plants growing in dry regions by the sea, or in the tropics, have rather stiff, thick leaves, which dry very slowly in the press. In many cases the slowness in drying is caused by a thick waxy coating on the surfaces of the leaf. Immersing such specimens in boiling water for about 30 seconds or until the leaves become limp will materially increase the speed of drying. Notes should be made on the original appearance of the plant.

Plants with thick, succulent stems, such as cacti and the succulent Euphorbias, may require more drastic treatment. The stems can be cut lengthwise and any soft material scraped out. Here again, immersion in boiling water will likely help.

When handling cacti it is advisable to wear heavy leather gloves. If worse comes to worst, spines can be removed from the fingers by pulling carefully with a pair of tweezers. Care should be taken that the tip is not broken off in the flesh. The tiny, hairlike spines of cacti (glochids) can be removed by running one's fingers through one's hair. This seems rather improbable, but it works!

Care must be taken when handling members of the Euphorbiaceae. The juice of many is extremely caustic. It may cause a severe dermatitis on the skin, or blindness if it gets into the eyes.

Filmy water-plants should be floated out in a pan of water. A sheet of good paper, such as writing paper, can be slid into the water under them and then raised, lifting the plant out on the paper. This should be covered with a sheet of waxed paper and put in the press.

Miscellaneous Notes

Preserving Fluid

The standard botanical preserving fluid is Formol-Acetic-Alcohol (FAA), made by mixing:

Commercial Formalin	5 parts
Glacial (Pure) Acetic Acid	5 parts
50% Alcohol	90 parts

For field work, 70% alcohol alone will do. This may be denatured ethyl alcohol or rubbing alcohol (iso-propyl alcohol) such as can be readily obtained in drug-stores or supermarkets. Great care should be taken to make sure that the covers of all containers holding preserving fluid are tight.

Sources of Supplies

Cambosco Scientific Co., Inc 37 Antwerp Street Brighton Station Boston, Mass. 02135	Plant presses Ventilators (cardboard) Botanical driers (blotters) Mounting supplies
Carolina Biological Supply Co. Elon College, North Carolina and Powell Laboratories Division Gladstone, Oregon	Plant presses Ventilators (cardboard) Botanical driers (blotters) Mounting supplies
General Biological Supply House, Inc. 8200 South Hoyne Avenue Chicago, Ill. 60620	Plant presses Ventilators (aluminum & cardboard) Botanical driers (blotters) Herbarium storage boxes
Ward's Natural Science Estab. Inc. P. O. Box 1712 Rochester, N. Y. 14603 and Ward's of California P. O. Box 1749 Monterey, Cal. 93942	Plant presses Ventilators (cardboard) Botanical driers (blotters) Mounting supplies Herbarium cabinet
Bio Metal Associates P. O. Box 61 Santa Monica California 90406	Plant presses Ventilators (cardboard & plastic) Botanical driers (blotters) Mounting supplies Herbarium cabinet

PLATE XXXIV

Solandra hartwegii, flower slit and spread out to show stamens. Note also the bud, showing aestivation of the corolla, and the detached calyx showing lobing.

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There is no pretense that the list of titles below constitutes anything like a complete bibliography of the published articles that deal with the art of collecting and mounting plants for study. It consists primarily of those articles which have come to the compiler's attention, with emphasis on the American literature. For the European literature, the reader is referred to the bibliographies in van Steenis (183) and Rehder (155). Also, with the exception of a few incidental references, the list deals almost exclusively with the vascular plants.

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