

**A MANUAL FOR
HERBARIUM COLLECTIONS**

R. R. Rao & B. D. Sharma

BOTANICAL SURVEY OF INDIA

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भारतीय वनस्पति सर्वेक्षण
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PREFACE

Botanical collections form the foundation of all plant-based researches. Botanical Survey of India, which maintains the herbaria throughout the country, has attached top priority for plant collections and maintenance of these in various herbaria. In order to boost the survey work and Flora writing programme it has established a Taxonomy training Centre at Coimbatore. It was thought desirable to develop a sort of simple guide to Botanical collections to supplement the teaching programme in this Centre.

The present booklet is mainly adopted from the work of Jain & Rao (1976) and covers only the methodology of plant collections in the field and their preservation in the Herbarium. It is hoped that this manual will be of immense use to all beginners of Herbarium Taxonomy.

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PREAMBLE

Plants have been put to use by man for a variety of purposes, such as food, shelter, clothing and medicine, and lately for many items of luxury.

Though early man collected plants from the wild, later he also cultivated some, and today most of the plants used by us for food, fodder, fibre, timber, etc. are from cultivated sources. But still many fruits, vegetables, medicinal drugs, fodders, minor timbers, vegetable dyes, tanning materials and other minor forest products are gathered from wild growth.

In addition to the plants used by us for our material needs and comforts, a large number of plants are also of scientific interest. For example, some plants have abnormal morphological structures, some have curious means of nutrition and some have curious habit and habitat. Further, some plants are primitive and suggest affinities with plants of ancient times. These are of importance for tracing evolution. Also, the plant kingdom offers such immense variety that the plants put to use today are only a small percentage of the total kinds growing on this earth. Plants are still believed to be a very valuable source for more and more new economic products. This brings us to the question of continuing research into all aspects of plant life such as their origin, evolution, growth, multiplication, distribution and survival.

Botanical collections are the foundation of all such research. Plants have therefore, been collected and grown in gardens for hundreds of years. Later it was found useful and even necessary to collect and preserve them in Herbaria.

HERBARIUM

Herbarium is a store-house of plant specimens collected from far and wide, mounted on appropriate sheets, arranged according to some known system of classification, and kept in pigeon-holes of steel or wooden cupboards, usually specially prepared for the purpose.

Herbaria are generally associated with botanic gardens and educational or research organisations.

According to Fosberg and Sachet (1965) "a modern herbarium is a great filing system for information about plants both primary in the form of actual specimens and secondary in the form of published information, pictures and recorded notes".

Actually, any collection of dried plants can be called herbarium, but now, after long experience, almost standard methods of preparation and arrangement of sheets have been adopted; thus, botanists in different

parts of the world can exchange specimens conveniently and can also work in other herbaria without difficulty.

BOTANICAL COLLECTION

Generally speaking, any process for gathering plants can be called botanical collection. But, the nature of this collection varies with purpose. The various purposes of botanical collections can be summarised as below.

- a. For building up of new herbaria, or for enriching old herbaria.
- b. For collecting plant material for writing a flora.
- c. For collecting material for musea or class work.
- d. For collecting live material for introduction in gardens or for hybridisation work.
- e. For collecting material of particular genus/species for research work or for analysis.
- f. For collecting large quantities of a particular species or part of that plant as crude drug for trade.
- g. For ethnobotanical studies, *i.e.* study of relationship of local inhabitants with plants of the area, noting the uses, avoidances or taboos about plants as stated by local inhabitants.
- h. For collecting specimens for sale/trade to educational institutions, musea, etc.

Materials or equipments

The following list of equipment is rather general, and must vary in different situations. The leader of the party has to consider the weather, duration of trip, size of the party, area of work, mode of conveyance, places of stay, purpose of collection and such other factors and decide what and how much is necessary.

List of equipments

Vasculum	Pencils
Cutter	Rubber
Knife	Ink
Khurpi	Scale
Tree pruner	Pocket lens
Axe	Old newspapers
Ice axe	Drying sheets/Blotting sheets
Polythene bags	Presses
Rain coat	Field presses
Field book	Straps
Field shoes	Ropes

Clothes	Soap
Contingency vouchers	Seal and Rubber stamp
Service stamps	Identity cards
Letter-heads	Torch with batteries
Tents	Binoculars
Camera	Altimeter
Stove	Petromax
Kerosene	Candles
Bags	Shoulder bags
Utensils	Match box
First Aid Box	Medicines
Food stuff	Rations

Some of the important items of field work are discussed below.

a. *Vasculum* : This is a metallic case of tin or aluminium and provided with a tight lid. It should be light in weight so that it is easily carried to field. Generally the size of the vasculum is $50 \times 30 \times 15$ cm. It should have a hinged lid with the hinges fixed on the lower side and the latch on the upper side.

The vasculum is used for keeping the plants immediately after collection. If the weather is too dry and hot, sprinkle some water on the shoots before placing in the vasculum. In the absence of a vasculum, polythene bags can serve the purpose ; these are very light and are easy to carry to field. These bags should be of different sizes.

The vasculum is painted white to deflect heat and also remain conspicuous in greenery of the forest.

b. *Field press* : It is made of two simple hard boards or thin plywood of 30×42 cm, and tied by two leather or cotton straps. Between these planks are placed a number of driers or blotting papers containing plant specimens. The field presses should be as light as possible. Light presses can also be made from wire.

c. *Field books* : These are specially prepared note books for labelling the plants and for recording notes about them in field. The pages of these note books are specially printed, punched and perforated according to an almost uniform pattern. There are slight variations in the items or details to be recorded according to purpose of the botanical collection. One book has hundred leaves, the pages are serially numbered, first book having 1—100, second book 101—200 and so on. The six tags or tickets on each page have same number ; these are detachable on lines of perforation, and can be tied to the specimens with the thread provided in the punched hole of each tag. Thus, each page has same number marked at seven places—one on the page itself and six on the tags or tickets. These

tags are for duplicates of same species. The data for various items for each species should be recorded with care and precision at the time of collection.

d. *Blotting papers/absorbents/drying papers/newspapers* : These are used for pressing and drying the specimens. The quantity depends upon the duration of the camp. Collection number, date or any other data should *NOT* be written on the blotting papers or newspapers. These folders are frequently changed and this can lead to mistakes.

(Heavy and good absorbent papers are manufactured by Hand Made Paper Institute, Pune).

e. *Polythene bags* : These should be of thick quality and preferably in assorted sizes, both for keeping small and large plants and in rainy season also for keeping valuable things like camera, lens, field books, etc.

f. *Specimen tubes* : These should also be in assorted sizes with fixative for bringing pickled material for study. An easier method is to keep numbered flowers or fruits, etc. in thin muslin cloth bags and putting these bags in a big jar or can.

g. *Shoulder bags (Haversack)* : A shoulder bag of thick canvas or waterproof cloth and with a few pockets, is a very useful item for all members of the party. Even the leader of the party will find it useful to have a secateur, a note book, and a small water bottle in his bag, in addition of course, to the valuable kit like camera, binoculars, altimeter, etc., which may not be safe on the shoulders of an untrained mazdoor.

h. *Secateur (Small clippers)* : This is for cutting small twigs from the trees and shrubs for the herbarium. This should be preferably of the anvil or 'snap-cut' type.

i. *Pruning shears* : This is required for cutting twigs from tall trees. There are various types. One arm of the shear is fixed at the end of a cane or stick, the other arm on a rope ; by pulling this rope, the shears close and thus cut the twig. The shears are used for cutting even large shrubs and climbers.

j. *Pick (or Jabbal)* : This is used for uprooting the herbs or bulbous plants. It should be light with a pick point and a chisel edge.

k. *Knife* : Gardener's knife or any other knife can be taken.

l. *Slitted slips of thick paper* : These are used for holding bent parts of plants in position.

m. *Magnifying lens* : This should be of about 10 × magnification. The lens should preferably be tied with a strong thread or string to belt or pocket.

n. *Pencils and ball-pens* : These can be purchased from any good stationery store. Use of copying pencils and easily washable inks should be avoided. Writings of ordinary lead pencils or ballpens stand rain satisfactorily.

o. *Photographic equipment* : If possible two cameras, one with black and white film and other with colour (diapositive) film are useful. Have enough supply of films and a diary for record of exposures (locality, title, etc.).

p. *First-Aid kits* : Complete first-aid kit should be taken to field and medicines for snake-bite, etc. should be provided in it. Some alum or potassium-permanganate crystals to clean water are also essential.

Collection work

Two things should be kept in mind before starting collection work.

- a. Scraps of plants are not wanted.
- b. Good material of a small number of species carefully and intelligently collected, properly annotated, and well pressed is preferable to a large amount of material collected indiscriminately, much of which may have to be eventually discarded. Quality is much more important than quantity, the aim being to enrich the herbarium, and not merely to fill it.

What to collect ?

What plants shall be collected depends on the purpose of study.

If the object of study is the preparation of flora of the region, collection should be exhaustive and samples of all plants of the area should be collected.

Collections should contain at least flowers or fruits or preferably both. Sterile twigs of plants are of little value. In case of grasses, sedges, and other herbs, the whole plant including the underground part should be collected. Collection of a number of plants from a population to show the range of variation in characters is better than collecting a single plant. In recent years, for correct description of species, much emphasis is laid on 'mass collections' or population studies.

It is particularly valuable that, if possible, both flowering and fruiting twigs are taken from the same plant. In precocious flowering species, generally flowers of only one sex are present at a time. Care should be taken to search and collect flowers of both sexes, sometimes from separate plants.

Grasses, sedges and grass-like weeds form a valuable constituent of

ground cover and must be collected. These plants are the easiest to collect, press and dry, but curiously enough, they are often avoided by plant collectors. All groups of plants must be taken to make the collections complete or representative.

a. *Size of the plant specimens*

The size of the card-sheet on which the specimens will finally be mounted is approximately 28×42 cm, and this limits the size of the collected plants or twigs. In case of small herbs, the whole plant with roots or underground parts can be accommodated in one dryer or one mounting sheet. But in case of larger herbs, though it is possible to collect the whole plant, yet it has to be cut into two or three parts. In such cases the field number should be same for all the parts and should be marked A, B, C. etc. For woody plants, such branches, twigs or specimens should be collected as to give a fair representation of the species, and suitable to fill one sheet.

b. *Number of specimens of each species*

Due to various considerations, at least six specimens of each plant are collected ; this is done particularly to facilitate distribution and exchange. Also, unmounted duplicates are useful for certain detailed studies, such as in palynology, anatomy, etc. Duplicates should be deposited in as many herbaria as possible, where they can be maintained safely. If enough duplicates are available, it is advisable to distribute collections to different parts of the country such as Kanjilal Herbarium at Shillong or Central National Herbarium at Calcutta in east, Madras Herbarium at Coimbatore in south and herbarium of Botanical Survey of India or Forest Research Institute at Dehra Dun in north.

c. *Field number*

The numbers given to collections are a very important record. Even the most valuable specimens like type specimens are referred to by collection numbers.

Some collectors give their own individual serial numbers and maintain their sequence even if they change the institutions. On the other hand, some institutions maintain one continuous serial number for collections by their different scientific or technical staff. It is desirable to maintain a continuous serial either of the institute or of an individual for exploration in a particular area till that work is completed.

Each specimen should be numbered before it is put in the vasculum or collection bag. Even if a species was collected previously during the trip, a fresh number should be given for its each fresh collection. Only one series of numbers should be used and sequence maintained.

For each species the number should be entered in the field note-book and a tag bearing that number should be attached to the specimens. As previously stated, as far as possible at least six duplicates of the same species should be collected and the same number given to all duplicates. It will be seen that each page of field note-book provides tags for six specimens.

Field notes

A very important part of the plant collection work is the record of field notes. Detailed notes should be entered in the field note-book at the time of collection in the field itself. Generally, the following details should be recorded in the field note-book.

a. *Date* :

b. *Vernacular names and uses* : The vernacular names should be obtained from the local guide or coolie ; care should be taken to avoid cooked-up names, The names should be very carefully heard and transliterated into Roman. It helps if the name is written also in the local or some Indian script.

c. *Locality* : The name of the place and also the distance and direction with reference to a familiar or known place which can be easily located in a map should be given. A note like '3 km N.E. of Shillong' is much better than simply writing name of the place. It is better to give both.

d. *Habitat* : This denotes the condition under which the plant is growing, such as marsh, grassland, thickets, deciduous forest, rock crevices steep slopes or flat bottom of valley, etc. The purpose is to record the environment in which the plant was found growing. If there is not enough space, it can be written on the back of the page. Notes on associated species are useful. If their names are not known their collection number can be given.

e. *Description* : It should be brief and should include chiefly those characters which cannot be observed in pressed specimens, such as habit—erect or pendant ; inflorescence—spreading or compact, colour of flowers, fruits, leaves, pubescence, presence of aroma and latex. Significant variation in size of plants should be noted. Notes on any other structure of plant which might be of interest can be added, such as shape, size and colour of bulbs and tubers. Note should be made of the relative abundance and frequency of the plants. This information is valuable for commercial collections, and after some field experience, one can make reasonably fair assessment. Sketches of special or curious characters can be

useful in identification. These can be recorded on the back of the page of the field note-book.

f. *Collector's name* : Collector's name should be written in full, and not by mere initials or surname.

After tying the number and recording notes in the field note-book, the specimens are kept in the vasculum or polythene bags or in other containers. They may even be placed in the field press. On days of heavy rainfall, or when there is large amount of collections, pressing in the field is difficult and the work of pressing is done in the camp. Sometimes, for want of time or other exigencies, even numbering of duplicates has to be done in the camp. But this must be avoided as it can involve mixing of collections from different spots, and in case of grasses and sedges, etc. even mixing of species.

Pressing and drying of specimens

Pressing is the process of placing specimens between the absorbents under heavy pressure. Herbaceous specimens should be washed to remove mud from roots. All plant parts such as leaves and flowers etc. are spread out neatly. This needs considerable patience. Some leaves are placed facing up and others facing down to show the characters on both surfaces. This is specially important in case of ferns which have sori on the abaxial side. In case of gamopetalous flowers, if possible, one flower should be split open longitudinally and pressed with corolla spread out to show androecium and gynoecium. If the specimens are longer than the size of mounting sheet, they can be folded like 'V', 'N', 'M' or even 'W'. To hold the point of bend(s) in position, a slit card can be inserted during the process of drying and poisoning. After glueing and stitching, the parts easily stay in position. If there are too many leaves or branches, a few are removed, so that there is as little overlapping as possible and all parts are easily visible. The extra leaves and branches are cut (and not torn away) with a secateur or scissors a little above the base, leaving a small portion, so as to show their position of attachment.

While pressing, the specimens should be placed in such a way that there is almost uniform thickness of the bundle in the middle and on sides. This will provide uniform pressure in the press. Otherwise, there will be a bulge in the middle, which will get more pressure and the sides will not be properly pressed. To avoid this, the specimens are evenly distributed in dryers, *i.e.* some are placed in centre, and some along the sides.

Sometimes corrugated cardboard sheets are also inserted in the bundle alternating with the dryers; this helps in aeration. The care given to a specimen at this stage of pressing is most valuable, because the appearance of the final mounted specimen depends entirely on neat pressing.

The main object of pressing is to flatten and dry the specimens. This is done by keeping the straps tight and by changing the blotters every day for 6-10 days depending on weather. The plants gradually lose their moisture and finally become completely dry. The used and moist blotters are removed and dried and used over and over again.

Sometimes in the tropics, due to very dry weather, it is necessary to press in the field directly in the light field press ; it saves from wilting. The field press (or portfolio) consists of two pieces of light cardboards tied with two straps. One blotter can be used for one or more specimens depending on size of plants. With this method a number of specimens can be conveniently brought to the camp daily in good condition. After reaching the camp, these sheets are transferred to the heavy plant presses.

The process of drying can be hastened by placing the press in sun or in drying chambers. The moist blotters are also dried in sun or by artificial heat. During rainy weather, it is necessary to dry blotters over a stove or near an oven or chimney ; care should be taken not to burn or char the paper or specimens. It should be noted that the thinner the press the quicker the process of drying. When the plants are completely dry, they are removed from the press and placed in ordinary newspapers. For testing this, lift the twig or specimen by one end, if the plant does not bend, it is taken to be dry. These specimens are now ready for poisoning.

Several types of specially made portable dryers or drying chambers have been suggested by McClean and Storey (1930), MacDaniels (1930) and Smith (1946).

Another method of collecting, adopted by many botanists, comprises of packing the bundles at this stage in polythene bags into which formalin is poured. The vapours of formalin kill all pathogens and pests.

Collection of special groups/kinds of plants

The methods described in previous pages relate in general to collection of terrestrial plants of average habit and form. Certain groups like succulents, aquatic plants, aroids, large bamboos and very high trees, etc. require special methods and precautions. These are briefly described below.

a. Collection of succulents

Succulent plants like Cacti, Euphorbias, members of Crassulaceae, etc. present unusual difficulties in making herbarium specimens. Their thick, succulent tissues take very long time to dry and so they require special attention. Unless dried by artificial heating or frequent changing of dryers, they are prone to rot and catch fungal infection. Hence, either the tissues should be killed by dipping in boiling water, or excess of tissues

removed by hollowing out the thick organs. The tissues can also be killed by treating with alcohol or strong formalin. Dipping in boiling water for few seconds is most suitable for killing the tissues. Cacti may be handled by splitting the joints, killing the tissues and then drying them by artificial heat.

While recording the characters of succulents, specially the spiny succulents, details like shape, size and the arrangement of spines and joints should be noted.

b. *Collection of minute plants*

Some plants like *Lemna* and *Wolffia* are microscopic and cannot be processed for the herbarium in the usual way. These plants should be collected in mass with the collection number, notes, etc., sun-dried and put in a packet, and the packet pasted on the mounting board. These can also be preserved in any of the liquid preservatives used for embryological or anatomical studies. The common liquid preservative is :

Ethyl alcohol 95%	....	....	50 cc
Glacial acetic acid	....	....	5 cc
Formaldehyde 40%	....	....	10 cc
Water	....	....	35 cc

The collection number, place, date, etc. should be written on a slip in lead pencil or Indian ink and put inside the jar or pasted on it.

c. *Collection of ferns*

Ferns should be collected with their basal portion, because the shape of rhizome, and hairs and scales on rhizome are important taxonomic characters. If the frond is too big, a portion of frond with basal portion must be collected and the exact size noted in the field note-book, along with other details. Fronds without sori are of little value.

d. *Collection of slender aquatic plants*

After collection, such plants are placed in a tray containing water and are spread out. Then, a wire press or sieve plate with white paper or muslin cloth is inserted below the specimen and taken out ; the paper or cloth is lifted slowly with both hands and placed between the dryers. Some extra dryers are provided below and above. The plants should be changed along with the paper or muslin cloth. For the first one or two days, the changing should be more frequent.

Some aquatic lithophytes like the members of Podostemaceae cannot be detached from the rocky substratum and a portion of the rock needs to be broken apart for collecting them. The rock with the plant has to be either dried or preserved in liquid medium.

e. *Collection of plants having mucilage, gums and resins*

Some plants (like *Hibiscus*, *Dodonaea*, etc.) contain mucilage or resin ; they stick to the dryers and cause difficulty while changing. Such specimens should be placed in a folder of muslin or any other thin cloth and pressed. Only the dryers should be changed and not the muslin cloth, until the plants are fully dry.

f. *Collection of Aroids*

Aroids frequently have a virtually impenetrable epidermis, and unless killed properly, they may continue to grow even in the press. The same is true for some bulbous orchids. The killing is done either by heating at high temperature and under proper ventilation, or by use of alcohol and formalin.

The tubers of the Aroids are often essential for correct identification, but their preservation is tedious. Sometimes whole tubers are collected and kept in museum ; else notes are taken on their shape and size, and their small sections are kept with herbarium specimens.

g. *Collection of very large plants like bamboos, palms and bananas*

Due to their large size, bamboos, palms and bananas and some ferns like *Cyathea* and *Angiopteris* require special methods for collection. There are very elaborate methods and instructions developed by specialists for these groups. The habit of the plant and the approximate size of the culm (or pseudo-stem), leaves and inflorescences must be recorded in the field note-book. Either the whole plant and its main parts should be photographed (with a scale) or their sketches must be made on the spot. Effort should be made to collect leaves (or portion of leaves) noting the actual size. In case of bamboos, few ligules must be collected, noting the serial number of the nodes from base, from which they are taken. In case of bananas it is helpful if spathes with flowers are collected.

h. *Pressing bulky specimens*

Bulky fruits like those of *Capparis*, *Artocarpus*, *Diospyros* and *Balanites* also require special methods for pressing. They can be pressed by slicing the parts sufficiently thin to go into the press. If necessary, the excess tissue is removed after dipping in boiling water. Bulbs normally dry well without splitting. The thick parts make the bundles uneven in pressing, and it is managed by providing pads of paper.

i. *Collection of seeds*

It is advisable to collect seeds along with the collection of specimens. Seeds should be mature. These should be dried and placed in a packet and mounted alongwith herbarium specimens. Collection of seeds is important for following reasons.

- a. Sometimes they aid in identification. Many very useful publications have appeared on external seed morphology of various groups, particularly Fabaceae, Asteraceae, Cyperace, etc.
- b. They are required for growing in experimental gardens.
- c. Exchange of seeds is an important function of all botanic gardens.
- d. With modern technologies herbarium seeds can be used to resurrect species extinct in the wild.

Poisoning and preservation of specimens

The specimens are poisoned either immediately in the camp or after reaching the headquarters. It is advisable to poison the plants immediately after collection ; poisoning kills the plant and thereby the formation of abscission layer is prevented.

Mercuric Chloride

The poisoning is generally done by dipping the whole plant in a saturated solution of mercuric chloride in ethyl alcohol. The plant is again put in dryers and pressed till it gets completely dried.

Mercuric chloride is corrosive for metals, and so enamel trays should be used. The solution is poured in a tray and the specimen is dipped in it with the help of pincers. Dipping fingers in the solution should be avoided and rubber gloves should be used while poisoning. As metal gets corroded, sometimes even pincers made of bamboo sticks or wood are used.

All parts of the plant are dipped in the solution, and left there for 15-20 seconds, depending upon the thickness of the plant. After dipping, the specimens are again placed on a blotter for drying out the excess solution. If it is not possible to spread out the plants nicely immediately after poisoning, it can be done after few hours of drying in the press.

Mercuric chloride solution can be used for poisoning mounted specimens also. This is done with the help of a brush dipped in mercuric chloride solution.

Mercuric chloride is a deadly poisonous chemical and its effect on human beings is cumulative ; hence much care should be taken while poisoning. Poisoning work should be avoided by persons having cuts in their hands.

Lauryl pentachlorophenate

Lauryl pentachlorophenate (LPCP) is used in some herbaria as substitute for mercuric chloride and it is reported to be very effective, and comparatively safer in handling.

Formalin

Recently another method has often been adopted for collecting and poisoning plants during explorations and expeditions involving longer durations. This is also called Formalin method. This method is highly suited for tropical countries, In those places where the day's collections are so numerous that it is not always possible to dry the collections by changing of blotters, this method is adopted. The collections are spread out in ordinary old newspapers and bundled up. Each bundle is then placed in a large polythene bag. 10% formalin is poured over the bundles, so that the bundles just get soaked thoroughly, without however leaving excess of formalin in the bags. The bags are then tied airtight. No further change of folders is necessary till reaching the headquarters.

By this method it is possible to bring the collections made even over 3-4 months. On reaching the headquarters, the bundles are opened out ; the specimens are exposed to the atmosphere to drive-away the excess of formalin fumes. Then the specimens are spread out for pressing and drying as usual.

This method is advantageous in many ways.

- a. It saves the labour and time in daily changing and pressing and drying of blotters during the tour.
- b. As it saves from carrying large amounts of blotters and presses, it reduces the luggage. The old newspapers can be purchased as and when required in any place.
- c. Collections brought by this method need not be poisoned again.
- d. Since the tissues of the plants are killed instantaneously by the formalin fumes, the formation of abscission layers is prevented, thereby preventing detachment of leaves, flowers, fruits and other plant parts.

During the course of pressing and poisoning and changing specimens, many flowers, fruits, seeds and leaves may get detached from the main plant. These should be carefully preserved and put in a paper packet along with the specimens. The same collection number as of the specimen should be written on the packet and while mounting the specimen, the packet should also be pasted on the mounting board.

Fumigation

This is done for killing pests in mounted as well as unmounted duplicate specimens. This process involves any one of the volatile poisonous liquids like methyl bromide, carbon disulphide or carbon tetrachloride. These are placed in small saucers or petri dishes in each herbarium case

and the cases kept closed for about a week. Methyl bromide is used in herbarium of New York Botanical Garden.

Sometimes paradichlorobenzene (PDB) is used. Small cloth bags with paradichlorobenzene are placed in all or many of the pigeon-holes. This chemical can also be sprinkled on sheets or in bundles. PDB should not be used along with naphthalene. Fumigants do not kill eggs or pupae of insects and so fumigation should be done at regular intervals. This chemical is used in Calcutta herbarium.

The liquid fumigants are harmful to human beings. Carbon disulphide is also inflammable. A mixture of (3 parts by volume) ethylene dichloride and (1 part) carbon tetrachloride is recommended as more satisfactory.

Heating

Some herbaria use electric heat instead of fumigation. This requires special insulated herbarium cases with an electric heating element in the bottom. This method is not practised in our country.

Some special methods

The methods described above often lead to discolouration of flowers and leaves. For preserving colour of flowers, absorbent carbon monohydroxide (COH) is soaked in formaldehyde and placed in bottom of a jar. Some gauge is placed on it, and above the gauge are placed the flowers.

The green colour of leaves can be preserved by any of the following solutions.

a. Leaves soaked in the following solution, when dried in usual manner, retain the green colour (Lawrence, 1951).

70 cc	...	...	50 % ethyl alcohol
5 cc	....	...	formaldehyde
2.5 cc	....	....	glycerine
2.5 cc	...	...	glacial acetic acid
20 gm	...	...	cupric chloride (for yellow-green foliage only 10 gm).
2.5 gm	...	....	uranium nitrate

b. Green parts preserved in the following liquid medium retain green colour.

20 gm	...	...	phenol c.p.
20 gm	...	---	lactic acid (sp. gr. 1.21)
40 gm	...	----	glycerine (sp. gr. 1.25)
0.2 gm	...	...	cupric chloride
0.2 gm	...	...	cupric acetate
20 cc	...	...▼	distilled water.

Mounting

After the specimen is pressed, dried and poisoned, it is affixed (along with a label) on a mounting sheet. The mounting sheets are made from heavy long-lasting white card sheet in uniform size of 28 × 42 cm (± 1 cm).

The aim of mounting is that the specimens should be neatly and uniformly spread and fixed on the sheet, and all parts of the plant should be easily visible for study. For achieving this, before the plant is glued on sheet, it should be placed on the sheet in various positions so as to judge which position will give the best display. Some important precautions in this regard are :

- a. Only one specimen is placed on one sheet.
- b. As far as possible, the lower part of the plant, such as root is at the base of the sheet.
- c. There is some space left on the right hand-bottom for label ; if label is already printed on mounting sheet, no part of the plant should cover the label.
- d. The field number tagged with the plant is pasted in a proper straight position, along with the thread.

Mounting is done by various methods ; these can be classified into two main groups.

Glueing the plant on the sheet and stitching

The common technique now in use in our country is pasting specimens to sheet with glue. The common animal glue used for book-binding, joinery work, etc. and available in market as flakes, or pieces is employed.

The glue paste is made by adding flakes of glue to boiling water, gradually and in small quantities, till it makes a thin syrupy paste. As the paste tends to become thick and hard on cooling, the pot is kept on low heat during mounting work. To give this glue some insect repellent property, small quantity of mercuric chloride, thymol crystals or copper sulphate (Blue vitrol) is added.

In some circumstances, when glue is not available or not considered desirable, ordinary white gum paste (available in bottles for office use) can be employed, but this is not satisfactory.

There are two important methods of pasting by glue :

- a. In the first method (glass plate method) the glue or paste is uniformly spread with the help of a brush all over the surface of a glass plate measuring 35 × 50 cm (14 × 20 inches). The plant to be mounted is placed with face upwards on the glass plate and thus all parts of the lower

surface come in contact with glue or paste. Then the specimen along with its field label is lifted up with the aid of forceps and placed on the mounting sheet. The position of the specimen on the mounting sheet must be visualised in advance and after once laying on the sheet, specimen should not be moved. Else, the marks of the glue left by the specimen will disfigure the sheet. The specimen is then firmly pressed by placing a blotting sheet on its top; this blotter removes the excess of glue that might come off on the sides of leaves, etc. After 2 or 3 plants have been mounted, the glass plate may be recoated with glue.

b. In the second method the specimen is laid on an old newspaper, lower side facing up. Then, with the help of a small or large brush, depending on the size of the plant, the glue is applied to all parts of the specimen. The specimen is slowly lifted with the help of forceps or hands and placed on the mounting board. A blotter is placed on the specimen as in the previous method. The newspaper on which the specimen is placed for applying glue is discarded after few applications as the excess of glue on it tends to stick on the upper side of the specimens.

This method is very common in our country, and is more rapid and economical.

While applying glue on the specimens with brush, some parts may get detached from the main twig or plant. In such case care should be taken to place these parts on to the specimens in their natural position. Otherwise, if wrongly placed, opposite leaves might appear to be alternate and vice versa. Small fruits, flowers, seeds, etc. may be placed in small packets and pasted on mounting board.

The mounting sheets with specimens glued on them are kept in press for one day for proper sticking and drying. Next day the bundle is opened and the intermediate blotters or newspapers removed. It is advisable to stitch some of the stiff parts with the help of a strong needle and good thread. Stitches should be small and independent and thread should not be carried from one stitch to another on the lower side of the mounting sheet. On each side of the stem/twig a hole is made and a thread is inserted. A knot is put at the back and thread is cut after each knot. Some mounters paste a piece of paper on the knot at the back of the sheet. It saves the knot from loosening and also from the thread catching on parts of specimens kept underneath. For round fruits many loops of thread are necessary.

Strapping

In this process the specimen is not glued to the sheet, but only loosely strapped to the sheet by means of ordinary thread stitches (as explained in

previous paragraph), or by some other device such as gummed cloth or paper tapes or by liquid plastic method (Archer method).

The gummed cloth (also called Holland Cloth) method is said to be largely employed in some western countries (Porter, 1959). In this method the specimen is affixed to the sheet by small straps/strips of gummed cloth. This method is quicker and easier than glueing, but in tropical climate, often the tapes soon lose their sticking property and come away.

Some years ago, Archer (1950) suggested 'plastic method' for mounting specimens. This method is based on the use of ethyl cellulose and Dow resin dissolved in a mixture of toluene and methanol to obtain a syrupy adhesive liquid which is applied to specimens by means of a special pressure oil gun.

Archer emphasized the importance of using a permanent type of plastic that would not become yellow with age, nor crack. Since the Archer method is very recent, it has not stood the test of time. This method is also not recommended for tropical countries, as the plastic tends to stick to the sheet above it in the folder.

In fact, experience has shown that in our country, the most satisfactory method is by glueing. Gummed tapes, cellophane tapes and plastics tend to lose stickiness with time and often get stuck to sheets above them.

Herbarium labels

Mounting of the specimens is followed by pasting of herbarium labels. The size and design of herbarium labels slightly vary according to need. Size is about 8×12 cm. In general, the labels should contain the following data.

1. Name of the family
2. Name of the genus and species
3. Locality of collection
4. Date of collection
5. Description/remarks/notes
6. Collector's name and number
7. Vernacular name and local uses

Herbarium label is fixed on the bottom right hand corner about 1 cm away from edges of the mounting sheet. It should be fixed with paste or glue. Some herbaria or institutjons get the sheets directly printed with these data in the bottom right hand side of the sheet. Advantages of this method are : economy of paper, saving of time in pasting. Disadvantages of this method are : the card/sheet being very rough, writing is difficult and typing also cannot be done.

After glueing the specimens and pasting the labels, the data on the labels should be entered clearly with some permanent ink, or preferably typed before pasting. Labels are a record expected to last for long, and should not fade out. A specimen without any label, even if it is neatly and properly mounted, is of little value.

Identification or determination of plants

Usually, identification is considered to be the process through which a specimen whose name is not known is recognised by its characters, to be similar to some known plant, and accordingly given a name. But, it is now felt that since no two individual plants are exactly identical, this process should not be called identification, but determination. That is why, the annotation slips are called and marked 'Determinavit' (or abbreviated to Det.) slips. However, the word identification is now so universally employed that it clearly signifies the entire process.

For the purpose of identification, the scientific method is to first study the characters of the plant, check them with the flora of the region (locality of collection), work through the family, genus and species keys and compare with full description and illustration. Thereafter, it is to be carefully compared with earlier identified plants of that species or variety, as the case may be.

For a satisfactory identification, the full process given above is essential. Experienced workers are often able to guess fairly correctly up to the genus and some even up to the species. In such cases, to economise on time, it is not necessary to run through the keys, but it may directly be checked and matched with the already identified sheets of that species.

If the plant does not satisfactorily fit in the key or match in the herbarium, effort is made to compare it with species of adjacent floras in larger herbaria. It is this process which can eventually lead to locating a taxon which does not match with any known taxon, that is discovery of a new taxon.

The next and equally important task in the process of identification is the use of correct nomenclature. Every effort should be made to label the sheets with the latest accepted name for the taxon.

Incorporation (Filing)

Accession

When the specimens are ready (mounted, labelled and identified), they are stamped with a distinctive mark of the herbarium or institution. The stamping is usually done on the top right hand corner. Stamping is done by rubber stamps or printed labels or again by simply printing on the

sheet. Rubber stamps are best because all the mounted sheets are not accessioned. This stamp carries the name of the institution, a serial number called the herbarium accession number, and sometimes the date of accession. The number is given by a numbering machine or written by good ink. The sheets are listed in the accession register, and now the sheets are ready for filing in the herbarium.

Filing of specimens

The mounted, identified and accessioned herbarium sheets are sorted out family, genus and species-wise. All the sheets of the same species are filed in lighter covers called the 'species cover' or folders; and all the species (with species covers or folders) belonging to one genus are placed in one or more folders of heavy paper, called the 'genus cover'. The genus and species covers serve many purposes.

- a. Protection of specimens
- b. Ease in arrangement according to some system
- c. Convenience in handling

In larger herbaria, species from different continents are placed in different genus covers; the name of the continent is noted on the cover.

Arrangement of specimens in the herbarium

The specimens are usually arranged in the herbarium according to some recognised system of classification. In many Indian herbaria, the order and numbering of families and genera is according to Bentham and Hooker's *Genera Plantarum*. This is primarily due to historical reasons as well as for convenience. In case of ferns, arrangement is generally according to Copeland's *Genera Filicum*.

The pigeon-hole, where bundles of a new family start, is marked by a fixed label or by hinged flap-board separator cardboard. The name of the family is printed or written on this in bold letters.

Special arrangements for certain sheets

a. *Segregation of types* : Since type sheets are very valuable and are not supposed to be referred during routine work, they are separated from the other sheets and kept preferably in fire-proof steel almirahs. In this way these irreplaceable type sheets are saved from unnecessary handling and damage. For easy distinction, each type sheet is also wrapped carefully in a folder, marked conspicuously with red label, red margin or band.

b. *Segregation of cultivated plants* : Specimens of common cultivated plants of a region should be separated from others and kept in the general herbarium at the end of each family. It is better if cultivated species are kept in genus covers of a different colour.

c. *Segregation of sheets for students and beginners* : If a herbarium is frequently visited by inexperienced students and other beginners, it is advisable to maintain a set of collections from the local region, separately. This will save main herbarium from mishandling and damage.

d. *Undetermined specimens* : If some plants are not identified, these should not be mixed with others, but should be kept in separate bundles labelled '*Dubia*' ('Indet'), for study by specialists of those groups whenever such persons visit the herbarium.

If the specimens are identified upto the genus, the '*Dubia*' bundles are placed at the end of that genus ; if they are identified only upto family, the sheets are placed in a cover marked 'Genus Indet' at the end of that family.

e. *Bulky herbarium* : Many large specimens, such as bamboos or large rhizomes and fruits cannot be mounted or displayed on mounting sheets, and require special drawers or cupboards. In the U.S. National Herbarium (Smithsonian Institution) in Washington such collections are lodged in large drawers and special shelves ; this section of the herbarium is called 'Bulky Herbarium'.

f. *Handling and sorting of unmounted duplicates* : After mounting 1 or 2 specimens of each collection, the remaining duplicates should be preserved carefully, as these may be needed for various purposes. The bundles of these duplicates should also be fumigated at regular intervals, and stored in closed or open racks. The specimens should be packed in old newspapers and bundles arranged according to serial numbers. The bundles should bear the labels or tags showing the contents (collection number...to...). This will later on help in tracing the duplicate plants.

Summary

In the foregoing pages we have just discussed the importance of plants in our daily lives and the consequent necessity to collect and maintain the data bank on plants. Salient methods of field collection, identification and preservation in the Herbarium are discussed.

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