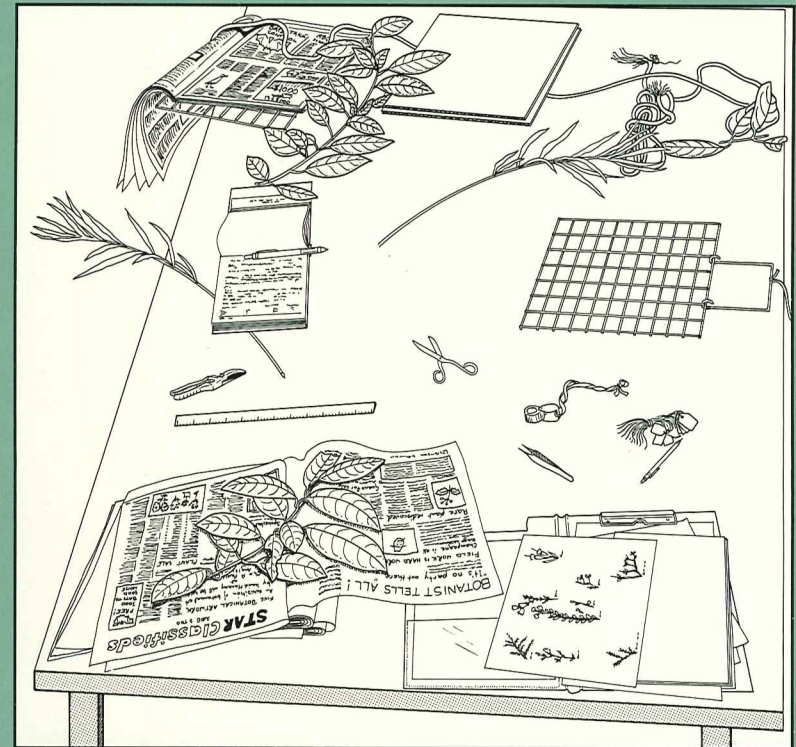


Collection, Preparation & Preservation of Plant Specimens



ROYAL BOTANIC GARDENS SYDNEY

National Herbarium of New South Wales

*Collection, Preparation
& Preservation of Plant
Specimens*



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National Herbarium of New South Wales

Smithell

1992

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Introduction

Specimens of most plants can be preserved indefinitely by careful drying followed by storage in dry, insect-free conditions. Such specimens can be used as permanent reference material. Although lacking the freshness and colour of live material, good, dried specimens with field notes usually provide most of the features required for the identification and systematic study of the plant. ∞

WARNING

Collections must not be made in national or state parks or nature reserves, nor of protected plant species unless a permit has been obtained from the appropriate authority (in NSW it is the Director-General, NSW National Parks and Wildlife Service). Such permits are generally only given for collections made in the course of scientific studies.

Collection

Specimens should be as complete as possible to facilitate identification and to be useful as a plant collection. A typical branch or portion of the stem c. 20–30 cm long, showing the leaves in position and with flowers and/or fruit is required. In the absence of open flowers, buds should be included. If variation in leaf form is apparent, specimens should include different parts of the same plant to represent this variation. Seeds can be useful in the identification of plants and should be included with the specimen if available.

The size of a specimen is usually governed by the size of the herbarium sheet. Samples about 30 cm long make suitable specimens of most species, as herbarium sheets are about 43 cm long x 28 cm wide. Smaller sheets (e.g. foolscap size, c. 32 cm x 23 cm) may be used if necessary, but they are not recommended since they encourage the collection of inadequate specimens.

For plants with large leaves or massive fruits, do not limit the collection in the name of convenience. It is more important to have a complete, useful specimen than to conform to arbitrary rules (but see below about storage of large specimens).

The features most important for identification vary between different plant groups. The major plant groups and some specific requirements are listed below:

Ferns – Specimens should include fertile (spore-bearing) fronds and sterile fronds, as well as part of the rhizome (if present) or base of the stem (stipe). For tree-ferns, a portion of a fertile frond and the base of the frond stalk bearing scales or hairs should be collected.

Herbs – In the case of small herbs the whole plant should be collected. Herbs with underground storage organs should be dug up complete with storage organs. However, if the plant is uncommon, make notes on the characteristics of these basal parts and leave them to shoot again in the following year. This is especially important in the case of orchids and rare species.

Grasses – Grasses and other plants of grass-like habit should be collected whole so as to show the root-stock. Grass clumps may be broken up into small tufts of leaves and flowering stalks, and two or three of these tufts should make a satisfactory specimen. All dirt adhering to the roots should be carefully knocked off or washed away. Grasses are best collected after the flowers have opened, but before fruits are ready to drop. If the grass specimen is longer than the herbarium sheet, it should be bent once, twice or more so as to form a V, N or M (according to its length) and pressed in this position. Attempts to bend it after it is dry will probably cause it to break. In the case of exceptionally tall grasses, the flowering parts and a piece of the basal parts should be collected, and a note made of the height and habit.

Trees – Eucalypt specimens should include flower buds as well as fruits, adult and juvenile leaves (the latter often from suckers near the base of the trunk). Notes should describe the type of bark (rough, smooth, stringy or fibrous) and if rough, how far it extends (e.g. over the base of the trunk only, on the main branches, and/or on fine twigs), sometimes it may be appropriate to collect a wood and bark sample as an ancillary collection.

Plants with large inflorescences or other large parts – When collecting plants such as agaves, palms or *Xanthorrhoea* (grass trees), the lengths of the flowering and non-flowering parts of the inflorescences and trunk heights should be noted. For plants such as large-leaved palms and aroids, the smallest complete leaf is many times larger than the standard sheet. There are two collection and storage methods for such plants. One technique is to cut the leaf into numerous (carefully numbered) portions which are put onto multiple sheets. This has the advantage of not requiring alternative storage areas. Disadvantages include the need for additional documentation, preferably including photographs, and the difficulty of relating the specimen to the

living plant. The alternative technique is to collect the leaf whole and to provide special separate storage for such material. The main disadvantages of this technique are that the material is difficult to handle (press and dry) and greater storage space is required. ☺

Field notes and observations

Locality information and details of the appearance of the plant in the field are important for identification purposes. These are also necessary if the specimens are to be usefully incorporated into a herbarium collection.

Observations should be noted down at the time of collection and should include the locality (the distance and direction from a well-known landmark or town should be given and if possible the longitude and latitude of the site), collector's name, date, the shape and size of the plant, and the colour(s) of the flowers or floral parts when fresh. Notes should also indicate whether the plants were cultivated or grew in natural vegetation, disturbed sites, or pasture areas. Except for cultivated plants, it is desirable to note the altitude, rock or soil type if known, and to describe briefly the habitat (e.g. in eucalypt woodland on dry sandstone ridge; moist grassy site near river bank; rooted in gravel, in water 30 cm deep, in fast-flowing stream). The names or specimen numbers of plants in surrounding vegetation may be noted.

When collecting more than a few specimens it is necessary to assign a number to each collection and record the corresponding field notes in a notebook. A page of a typical field notebook is illustrated on page 5.

Photographs of whole or part of the plant may be used to supplement the information included in the notes. (A note in the field notebook 'photo taken' is then useful.)

If additional material (e.g. photos, seeds, wood, spirit collection) is taken, it should also be numbered with the same collection number as the specimen. The collection number may be written directly onto wood samples with a felt-tipped marking pen. Numbers for material preserved in liquid fixative (e.g. alcohol solution) should be written in pencil and placed in the container as many inks are soluble in alcohol; an additional label on the lid or exterior of the container is advantageous. ∞

Example page from a field notebook

Field name

Scientific name

Family

Collector

Collection number

Date

Location

Latitude

Longitude

Altitude

How common, e.g. dominant, localised, occasional, rare

Habit, e.g. tree, shrub, herb or climber

Height

Flower colour

Fruit colour

Landform, e.g. steep or gentle hillside, ridge top, creek bank, etc.

Rock/soil type

Surrounding vegetation

Other comments

Pressing, drying and preservation

Techniques for pressing and drying specimens have been established for many years. There are minor variations in recommended methods, but they are essentially the same worldwide.

The best specimens are plants that are pressed as soon as possible after collection, before wilting and shrivelling. Most plants may be kept in sealed containers such as plastic bags for up to a day if it is inconvenient to press immediately. However, some plants show such rapid wilting, particularly of the flowers, that such delays are best avoided. Flowers with a lot of nectar may go mouldy very quickly if excess nectar is not shaken off before pressing.

Specimens are pressed flat and dried between sheets of absorbent blotters or semi-absorbent paper such as newspaper. Papers with a glossy surface should be avoided because they are not absorbent enough to aid drying. The plants should be carefully laid out between the drying sheets, as their form at this stage largely determines their ultimate appearance. The flowers should be spread out with the petals carefully arranged, wilted leaves should be straightened and unnecessary shoots of excessively twiggy shrubs may be cut away.

Large flowers (eg *Nymphaea*) or inflorescences (eg *Telopea*) are best cut in half lengthways before pressing. Large and/or succulent fruit is often best preserved by cutting both longitudinal and transectional (from different fruit) sections from them and drying these. Care is necessary to ensure that the maximum amount of useful information is preserved.

Sheets of thick, preferably smooth-sided, centre-corrugated cardboard (such as used in cardboard carton sides), placed between the drying folders will assist air circulation through the press. These are particularly necessary when using a forced circulation of warm air. If such cardboard is not available, additional sheets of newspaper or wooden board (e.g.

plywood) may be used to absorb moisture from succulent specimens.

When plants are uneven in thickness, e.g. where flowers are borne on thick twigs or arise from a thick bulbous base, sheets of spongy plastic foam (polyurethane or similar) about 1 cm thick, placed between the newspaper folders help to distribute pressure evenly across the specimen. If foam sheets are not available, several thicknesses of folded newspaper may be used. Care must be taken to ensure 'damp spots' do not develop in the press. When using foam sheets it is advisable to circulate warm air around the press or change the drying papers more frequently.

Specimens are best pressed with moderate pressure, preferably in an arrangement that will permit as free a circulation of air as possible. This can be achieved by strapping the pile together in a press, i.e. between frames made, for example, from sheets of heavy (non-bending) cardboard, hardboard, plywood, pegboard or, best of all, a lattice of wood or weldmesh (FIG. 1). Supplies of suitable materials can usually be obtained from packaging and cardboard manufacturers, who will cut materials to suitable sizes, or from hardware or building suppliers. The press frames should be the same size as or a little larger than the drying papers. Amateur collectors often press small numbers of specimens by placing books or other weights on the pile of specimens, but this is not recommended as specimens quickly go mouldy without air circulation.

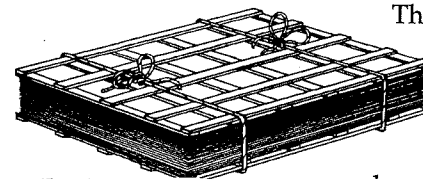


FIG. 1
Plant press

The papers should be checked for dampness and changed when necessary. As the number of changes required will vary with the original succulence/water content of the plants and with the weather conditions, no exact guide can be given. Most plants should dry in less than ten days. For the first few days the paper should be changed daily,

but after that time the frequency of changes needed depends on conditions and relative humidity levels. In tropical and wet conditions daily changes will be necessary throughout the drying period, but in drier conditions the last one or two changes need only be given at intervals of three or four days. Used paper should be discarded, or thoroughly dried again before reuse.

When in the field for an extended time, drying can be aided by placing the pressed plants in a warm, sunny position during the day. In reasonably dry climates, drying is aided by securing the presses to the roof rack of the vehicle whilst driving in dry daytime conditions. If available, a hot-air fan directing air around the press will assist drying. Drying cabinets with a forced circulation of warm air are used in large herbaria to shorten drying time and to lessen the need to change drying papers, but are not necessary for small quantities of specimens.

A few species regularly turn black on drying, but in general, brownish or blackish colours in the completed specimens, or the growth of mould, indicate that drying was too slow, often because the papers were not changed frequently enough in the early stages of drying.

Microwave ovens – Small numbers of specimens can be dried using a microwave oven. The technique recommended in the literature is to place the specimens between unprinted absorbent paper, for example, butcher's paper, not newspaper, which is unsuitable because the chemicals present in the ink may cause a fire. The specimens should be put in a special press which should be of a microwave-safe material (wood, acrylic or polycarbonate sheeting e.g. plexiglass or perspex, NO metal components). If such a press is not available, sheets of cardboard can be placed above and below the specimens and then weighted down. Drying time depends on the power of your oven. In most cases drying is accomplished by irradiating at maximum power for 1–2 minutes per specimen, although it is

often a case of trial and error. It is best to process no more than 10–12 specimens of average thickness per batch. Specimens are usually dried after the moisture that characteristically appears on the glass door has disappeared. If the specimen is damp when taken out of the oven, allow it to stand before re-radiating as moisture continues to evaporate from the specimen for some time. Care must be taken not to irradiate the specimens for too long.

It should be noted that microwave treatment damages seeds and the cellular structure of the plants which may reduce the long-term value of the specimens.

Alternative drying techniques

Silica gel/other desiccants; freeze drying – Alternative methods of drying plant specimens have been used for some time, but are mostly restricted to special purpose collections. The main alternatives are freeze-drying and drying in a desiccant powder such as desiccant silica gel. In general these techniques are used where it is essential to preserve the shape of a delicate plant or organ of the plant such as the flower. Freeze-drying has also been used to preserve the chemical composition of a plant as accurately as possible for later study.

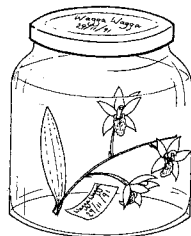
Disadvantages and special conservation problems of specimens dried in these manners are that they are particularly susceptible to damage. The dried parts are fragile, lack support and often catch on packing materials. They must, therefore, be packed especially carefully and stored in small boxes or tubes with some appropriate packing material that does not snag and break small projections. Acid-free tissue paper is often used. Drying in desiccant silica gel crystals or powder can also have the disadvantage that it is difficult to remove all traces of the silica gel after drying.

Special preservation and processing techniques

Wet or spirit collections – Very fleshy or delicate structures, including small algae and orchid flowers, are best preserved in

FIG. 2
Specimens can
be pickled in 70%
ethyl alcohol.

an air-tight glass or plastic jar with a liquid preservative rather than by drying. The type of preservative used should be clearly labelled in the jar. Such material is often referred to as a spirit collection or wet collection. Most material can be satisfactorily preserved in 70% ethyl alcohol (or 70% methylated spirit or denatured alcohol) with 30% water. Your pharmacist can make this up for you and it will keep indefinitely in a tightly stoppered bottle. Colours will fade quickly in spirit, however, so it is a good idea to keep comprehensive notes and photographs.



Small algae – Microscopic algae are often collected in a jar and in the water in which they were found. If the algae are to be stored for more than 2–3 days, a preservative needs to be used. Traditionally this has been the extremely toxic formalin — a small amount can be added to the water to make a 5% final solution, and the container labelled. This must not be sent through the post or by courier. There are some other equally toxic options, for example propylene phenoxytol, but none should be sent through the post. A safer option is to add sufficient concentrated alcohol or methylated spirits to the water containing the algae to make a final solution of 70% alcohol. This treatment dilutes the algae making them difficult to find, so if they can be concentrated somehow first (e.g. by filtering) they can be stored in much less liquid. Another option is to fix the algae in formalin (or something similar) first, and then prepare a microscope glass slide with a permanent water-soluble mounting medium.

Some plants and certain climatic conditions require the use of specialised processing treatments. A brief summary is included here.

Succulent plants – Very succulent plants e.g. cacti, many species of *Ficus* ('figs') and mistletoes drop their leaves entirely upon

drying or remain alive for an excessively long period in the press. This is overcome by killing the plant before pressing, either by freezing the specimen for a few hours, dipping it in boiling water for a few minutes, or by using a microwave oven. The correct time in a microwave oven depends on the type of oven and the specimen itself, but is usually about 2 minutes. Succulent material is 'done' when it has a flaccid, water-soaked appearance.

When the cell tissue has been killed (by freezing, scalding or radiation) the specimen will still require special attention until it has dried completely. The papers must be changed at least daily for the first few days, and complete drying in the case of cacti may take more than a month.

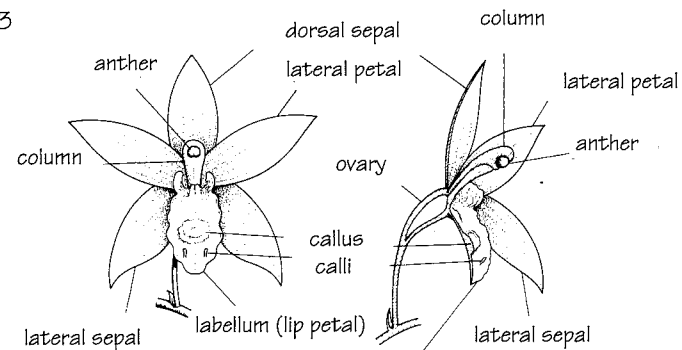
An alternative technique is to collect succulent material in 70% alcohol, as this preserves its original shape.

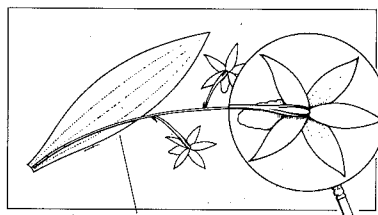
Bulky specimens – Very bulky objects (e.g. *Banksia* spikes, thistle heads) may be cut or sawn lengthwise before pressing.

Orchids – require particular care when pressing due to their delicate flowers (FIG. 3).

The flowers (at least one) should be spread out evenly so that the flower parts face the paper surface without creases or folds (never allow the parts to fold up or stick together) (FIG. 4).

FIG. 3





Flatten leaf so it is not creased or folded.

FIG. 4

Turn flower upside-down against a sheet of paper, spreading out all the organs so they lie flat against the paper before pressing. Drying takes 7-10 days.

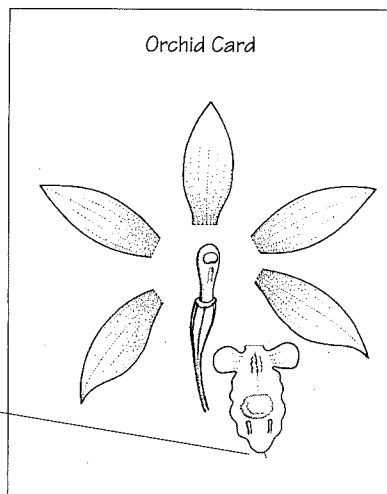


FIG. 5

Spread out lip petal so you can see whole outline and all structures.

Alternatively, cut off each organ of a flower (three sepals, two lateral petals, a lip petal and the column attached to ovary) and spread these parts on the same piece of paper and then press (FIG. 5). A superior method is to preserve the specimen as a spirit collection (FIG. 2).

Water plants – should be carefully laid on a sheet of paper, excess water

removed, then pressed and dried in the normal way. Very soft water plants may require special treatment such as being floated onto a sheet of paper immersed in water and then dried (as is usual for marine algae) or preserving in alcohol or formalin solutions.

Large algae – can be kept damp for a day or so, but it is preferable to dry specimens immediately. If very soft or filamentous, such plants may be best arranged on the mounting sheet while in a dish of shallow water. The mounting sheet is placed first into the dish and the specimens on the sheet then gently slid

from the water. Because such specimens tend to adhere to the drying papers they are best pressed between a mounting sheet (to which the underside of the specimen may remain permanently attached) and a sheet of adhesion-resistant material (e.g. muslin) to prevent the top of the specimen adhering to the drying papers.

Tropical conditions – Under humid, tropical and coastal conditions special methods must be adopted to prevent rapid mould growth before the specimens can be placed in drying cabinets. Placing the entire bundle of drying papers and specimens in a plastic bag and adding a small quantity of ethyl alcohol (enough to saturate with vapour) is a method commonly adopted. This is sometimes called the Schweinfurth method, after an Austrian botanist who collected extensively in tropical areas. Such methods alter specimen colours and should be avoided unless conditions make them essential. ☺

Mounting

Mounting specimens prevents most fragile material from fragmenting and prevents specimens becoming separated from their labels. If the plant collection is a long-term project, specimens should be mounted on sheets of archival (permanent) cardboard or paper with archival-quality fixing media. These include stitching with cotton thread, dental floss, nickel-plated copper wire (for heavier specimens), narrow strips of archival paper, linen tape, or by using an archival adhesive such as methyl cellulose adhesive. A range of archival material is available from S & M Supply Company Pty Ltd.

Dental floss can be used for bulky specimens by puncturing the sheet on either side of the specimen, threading the floss through and tying ends together in a simple reef knot (FIG. 6). Another alternative is a clear, long-lasting 3M tape (Y8440) which is available as a special order from 3M ('Scotch brand') and their distributors. This tape has been in use in some Australian herbaria for approximately 15 years with good success. The use of tape is faster than most adhesives, and is easier to remove (by cutting and peeling from the specimen) if the specimen needs to be examined more thoroughly. Ordinary sticky tapes are unsuitable as the adhesive breaks down, becoming tacky and detached after a few years.

One disadvantage of mounting specimens is that it can make parts of the specimen inaccessible for examination, so it is essential that this be borne in mind during specimen arrangement and mounting. For example, easily reversible mounting media should be used, specimens should be strapped to the sheet, rather than glued all over, and the specimen should be carefully arranged before it is attached so that it shows all features (FIGS. 7-10).

Full-size herbarium mounting sheets are usually about 43 cm long x 28 cm wide. The plant name and accompanying field notes (page 5) should be transcribed on a permanent label stuck to one corner of the herbarium sheet (the bottom right-hand



FIG. 6
Reef knot

corner being the most common) or, sometimes, annotations may be written directly on the sheet or card. Example specimen sheets from the NSW National Herbarium are illustrated in figures 7-10. Cards 20 cm x 13 cm are a suitable size for personal reference sets of identified specimens but are unsuitable for research collections. Note: mounted specimens should not be placed in microwave ovens - adhesives often melt, and tape may ignite.

Small pieces of material which may have become separated from the specimen (e.g. seeds) can be placed in small plastic bags and pinned to the sheet.

FIG. 7
Many larger specimens are best arranged diagonally. This provides both more length and width than positioning longitudinally; it can also prevent parts of the specimens lying behind or over the label.

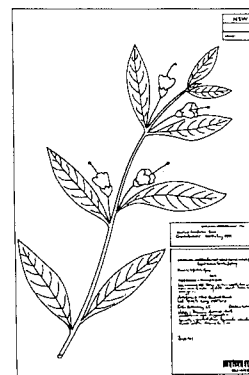


FIG. 8
Over-long specimens can be folded to fit the sheet so that the apex points upward or the base downwards.

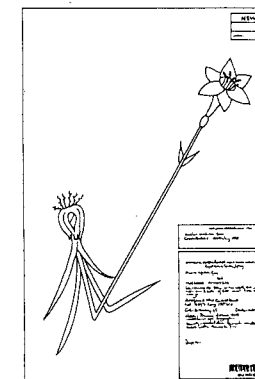


FIG. 9
Display aspects of the flower, fruit and leaves where possible.

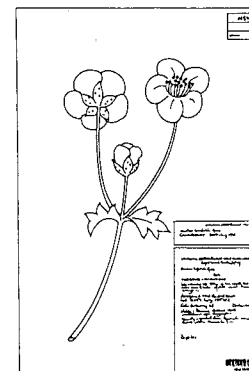
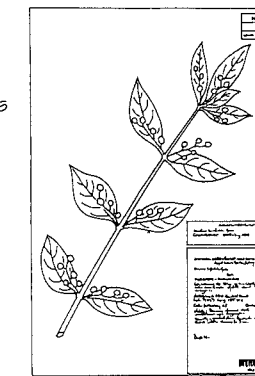


FIG. 10
Choose the best side to display as many features as possible.



Long-term preservation and storage

The long-term preservation of dry plant specimens is largely dependent on protection from insect attack. Specimens collected by Linnaeus in the eighteenth century, and by Banks and Solander on the 'Endeavour' voyage in 1788, are still excellently preserved.

Pests and their control

A range of pests attack dried plant material. The most common pests are insects and fungi, though rodents and other large animals can cause damage in poor storage conditions. Insects eat the material, the paper surrounding the material, and the adhesives and mounting media. Such insect pests range from psocids (book lice), which attack mainly the softer parts such as flowers and soft fruits, to tobacco beetles and carpet beetles, which can bore holes through the toughest of specimens. Many insects are particularly sensitive to relative humidity levels and do not thrive at levels below 50%.

The common and acceptable specimen treatments for insect control are discussed below.

Freezing

Freezing the specimens is the technique least dangerous to human health, and is very simple. The specimens must be frozen to -18°C or colder and kept at that temperature for at least 48 hours. In practice, when specimens are frozen in domestic deep-freezers in bulk and/or in boxes, it is necessary to freeze them for 72 hours (3 days and 3 nights) to ensure that the centres of thick specimens and specimens in the middle of large bundles are reduced to a low enough temperature for long enough time to kill all pests. Bundles of specimens should be sealed in plastic bags to avoid moisture condensing on the sheets as they thaw, or alternatively, dry air should be circulated around the parcel in a desiccating cabinet during re-warming.

Microwave

Specimens may also be treated in a microwave oven to kill any animal life present on them. Microwave treatment is a fast method for small numbers of specimens. The technique is similar to microwave drying of specimens except that a press is not essential for already dry material, and times may be reduced from those required for drying. No absolute guidelines can be given as it is best to use trial and error testing for each set of circumstances and different types of microwave, but times of 1–2 minutes per dried plant specimen should be adequate.

Poisoning

A traditional method of insect control was to poison the specimens with a chemical to make them unpalatable or deadly to pests. However, this is not recommended due to obvious health hazards. Domestic spray-type insecticide is of limited effectiveness and (to avoid staining) should not be sprayed directly on mounted sheets. Sprays may kill surface insects but, for instance, would not penetrate to insects living near the centre of a *Banksia* infructescence or 'cone'. Many spray insecticides are now regarded as possibly detrimental to human health, so health and safety should be carefully considered before these are used. It is essential that specimens that have been poisoned be so identified, both to warn users of the health risks involved and to avoid misleading any later chemical research using the specimens.

Insect deterrents

A number of chemicals have been used or proposed for use as insect deterrents. Of these naphthalene (commonly found as 'moth balls') is probably the most commonly used in herbaria because of its reputation for reasonable effectiveness in insect control, coupled with low toxicity to humans. It should be

noted, however, that naphthalene is poisonous if ingested, naphthalene dust can cause eye health problems for people with contact lenses, and chronic exposure is believed to be implicated in the formation of cataracts. There are also reports of naphtha vapour causing allergies and headaches and of possible carcinogenic effects at very high concentrations. Naphthalene in commercial quantities is most commonly available in flake or chip form. If left loose in containers/boxes it is more readily inhaled or ingested and is more likely to cause problems to people with contact lenses than is naphthalene in block or ball form or naphtha flakes or chips encased in porous bags or boxes. If naphthalene is used as an insect deterrent the levels around specimens must be maintained at a steady, high level to ensure effective insect control. Because of the exposure limits for humans this is best done by storing specimens in boxes or in a sealed cupboard.

Fungal pests

Fungal (mould) attack is mainly a danger to damp specimens, either through incomplete drying during specimen preparation, or to collections that become wet later through flood, other water damage or improper storage conditions. Properly dried plant specimens will not suffer from fungal attack if stored in the correct conditions (see recommendations below) though freeze-dried fungal bodies such as mushrooms have been reported to be very susceptible to mould growth. Specimens with sugary exudations or large quantities of nectar are also particularly attractive to fungi, and need special care during drying to ensure that they dry fast enough to prevent mould growth.

If fungus grows on the specimens these can be brushed with alcohol or methylated spirits (denatured alcohol). However, this may alter the specimen unacceptably for chemical and other investigative research, and only kills the fungus present on the specimen; it does not correct the problems that allowed the

fungus to develop. Specimens treated for fungal attack should be clearly annotated as such, including date and treatment given.

Storage

Dried and pressed plant specimens can be stored in cardboard or plastic boxes, or tied in bundles in light-weight cardboard folders placed in 'pigeon holes'. Alternatively, they can be placed in protective plastic jackets and displayed in ring folders which is recommended if they are to be frequently handled, such as for a reference collection.

Filing

Specimens should be filed in a systematic order if a relatively permanent collection is being made. The major groups, i.e. ferns and fern allies, cycads, conifers, dicotyledons and monocotyledons, are best kept separately. Within these, the families may be arranged alphabetically or according to some classification scheme, such as that given in a flora or handbook. Similarly, the genera within each family and the species within each genus may be filed alphabetically or following some such classification. ∞

Identification

It is important that specimens in a collection are correctly identified. The *Flora of New South Wales*, edited by G. Harden (4 volumes 1990–1993) includes keys and illustrations to enable accurate identification of specimens. If specimens cannot be identified by means such as handbooks, floras or field guides, they may be forwarded to the relevant State herbarium for identification. The National Herbarium of NSW has an identification service for NSW plants as well as a self-help public reference collection. Any specimen submitted should be accompanied by full field and locality information, and each one should be placed on a separate sheet or in a separate dry newspaper folder, the folders being packed as a flat parcel. The specimens should be numbered and a duplicate set of specimens should be retained so that each name can be compared with the appropriate numbered specimen when the list of determinations is returned. No more than 12 specimens will be named in one collection, except under special circumstances.

Specimens should be dried before they are sent, and not packed in cellophane or plastic. Specimens sent in bottles (e.g. algae) should be carefully packed and sealed in plastic to avoid leakage and put in a cooled esky. The bottles should be labelled with the name of any preservative used. Formalin must not be sent through the post.

Specimens forwarded for identification should be addressed to:

Botanical Information Service
Royal Botanic Gardens
Mrs Macquaries Road
Sydney 2000
Telephone (02) 231 8111
Fax (02) 251 7231