A Guide to Collecting and Preserving Fungal Specimens for the Queensland Herbarium

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Overview

What are fungi?
Fungi are not plants or animals. Recent scientific advances, particularly in the field of genetics, have confirmed that fungi are a distinct life form, more closely related to fauna than flora. Consequently, the fungi have been assigned to their own Kingdom. Despite this, the methods of collection and study of fungi are somewhat similar to those used in botany and mycologists normally work alongside botanists in major herbaria, including the Queensland Herbarium at Brisbane Botanic Gardens, Mt Coot-tha, Brisbane.

Fungi are simple, filamentous organisms comprised of masses of thread-like hyphae which constitute the body (mycelium) of the fungus. Fungi are heterotrophic in nature, incapable of directly manufacturing their own organic compounds for energy. Unlike plants, fungi do not contain chlorophyll. Most fungi are microscopic, but some (macrofungi) intermittently produce fruiting bodies (sporocarps) which are highly visible. These sporocarps are probably best compared to the flower and fruit/cone of vascular plants, but combined into one functional unit.

What sort of fungi occur in Australia?
Fungi are quite commonly found in sclerophyllous and rainforest habitats, but can also be located in open paddocks, forestry plantations, garden beds and even in arid zones. Colours vary from extremely vivid and bright to drab, dull tones. Some even produce fluorescent compounds which enable them to emit green light in the dark.

Those fungi which are commonly, referred to as “mushrooms” and “toadstools” belong to a group referred to as the agarics (gilled fungi). Other categories of macrofungi include boletes, cup fungi, club fungi, coraloids, gasteromycetes (puffballs, earthstars, phalloid fungi, bird’s nests), sequestrates (truffles), jellies, corticioids (paint fungi) and polypores.

Australia also possesses a large diversity of another distinct group of macrofungi, the sequestrate fungi, which produce their sporocarps underground. These are not true (gourmet) truffles, but are often referred to as “truffle-like” “Hypogeous” or “sequestrate” are the more technically correct terms.

Australian sequestrate fungi are generally produced within the top 10 cm of the soil, or directly beneath the litter or humus. They can often be detected close to the shallow diggings of foraging mammals, some of which rely on these fungi as an essential food source, or where cracking and/or mounding of the soil surface has occurred.
“Truffle-hunting” by collectors can be undertaken with any three-pronged digging implement, preferably one with curved tines.

**When do fungi produce fruiting bodies?**

Most sporocarps (fruiting bodies) are ephemeral, with the exception of some hard fungi, such as bracket fungi. Consequently, fungi are often ignored as a component of the biota, and are overlooked in the formulation of conservation management policies and reserve selection protocols. However, fungi are constantly present in the environment in the form of mycelium and spores. Fungal hyphae usually occur within or underneath substrate materials, including soil, wood and litter, and therefore remain largely unseen for the majority of their life cycle. The roles they fulfil, however, are crucial in maintaining the health of ecosystems.

Macrofungal fruiting can occur at most times of the year, provided temperatures are amenable and there is sufficient moisture in the ecosystem, but the exact timing is often species specific. Different species require different environmental conditions for fruiting body initiation. Sporocarp survival can last anywhere from a couple of hours to many years, depending on the habitat, physiology, destructive agents and life cycle of the taxon. Characteristically, a ‘peak’ of activity occurs in the fruiting season with maximum diversity and quantity of sporocarp production evident. This fruiting climax is preceded by a couple of days to a few weeks of either steady or rapid build up, and subsequent decline, in fungal productivity.

**What makes fungi so important?**

The macrofungal flora comprises an extremely profuse and heterogeneous component of ecosystem biodiversity and performs vital ecosystem functions. Some macrofungal taxa are parasitic, the mycelium proliferating within the tissues of the living plant host and extracting organic compounds in a one-way nutrient flow. The unhealthy host dies and the fungus continues to degrade the dead organic material. In this way, individual plants with reduced fitness are purged and ecosystem renewal occurs.

Most Australian ecosystems have nutrient-poor soils and nutrient cycling is a key factor moderating their functioning (O’Connell and Grove 1996). Mycorrhizal and saprophytic fungi are variously involved in transporting, storing, releasing and recycling nutrients, as well as interacting with other soil organisms. They improve soil quality and facilitate accessibility to scarce resources for their vascular plant associates (Perry *et al.* 1989; Fitter & Garbaye 1994; Leyval & Reid, 1991; Wardle & Lavelle 1997; Bouger & Lebel 2001). Certain macrofungi provide critical synergisms with both plants and animals, without which ecosystem integrity would be compromised. ‘Ectomycorrhizae’ (ECM) is the term assigned to those macrofungi
which establish a physiological connection within the root systems of approximately 8% of the world’s vascular plant species. Various microfungi, the fruiting bodies of which are generally too small to see with the naked eye, are also involved in mycorrhizal associations. It is estimated that at least 90% of higher plants are reliant on some form of mycorrhizal partnership.

Fungi, along with bacteria and other micro-organisms, and to a lesser extent various invertebrates, are crucial in the decomposition of organic matter and the recycling of nutrients within otherwise mineral-deficient ecosystems. Detritus and litter would accumulate to untenable levels within habitats without the oxidative-enzyme activities of saprophytic fungi constantly operating to degrade lignin and cellulose. In so doing, they play a pivotal role in the cycling of carbon, nitrogen, lead, phosphorous and other trace elements.

The benefit of mycorrhizal fungi to the environment, however, is not restricted to nutrient assimilation. The hyphal component of the ECM fungal organism is often prolific and creates a physical and chemical barrier between the roots and the soil, enhancing the plant’s ability to avoid infection by soil-borne pathogenic micro-organisms. Plant root physiology and the potential for pathogen resistance appear to be regulated, at least to some extent, by altered metabolic functions in the root brought about by ECM fungi-directed modification of root exudates (Leyval & Berthelin, 1993; Rygiewicz & Andersen, 1994; Frey-Klett et al. 2005).

Other protective mechanisms deployed by ECM fungi include production of antibiotic compounds (Sylvia & Sinclair, 1983; Tsantrizos et al., 1991; Olsson et al., 1996) and aggressive competition with pathogenic organisms for the photosynthates assimilated in the plant root cortex (Graham, 2001).

Hyphae ramify between soil particles forming vast networks throughout the litter and adjacent upper soil horizon. Fungal mycelia assist in aggregating soil particles, binding the substrate together, and modifying soil structure (Schreiner & Bethlenfalvay, 1995). Consequently, the enhanced substrate stability reduces the impacts of both hydrologic and aeolian erosive pressures. ECM fungi also indirectly influence soil structure by promoting branching of the associated plant’s fine roots (Linderman, 1988).

**Animal interactions**

Many marsupials, and to a much lesser extent native rodents (according to research to date), incorporate the fruiting bodies of ECM ‘truffle-like’ fungi into their respective diets (Claridge & May, 1994; Vernes et al. 2004). It is believed that aromas produced by underground ‘truffle’ fungi signal to certain mammals that they are mature and ready for consumption (Donaldson & Stoddart, 1994).
These animals then excavate the fruiting bodies and in consuming varying portions smear spore material across their face and paws, and ingest spores which pass through the gut to be deposited in dung at another site. Some marsupials, such as bettongs, are almost totally reliant on ‘truffle-like’ fungi for their survival, the structure of their digestive system having adapted accordingly. Once the propagules have been dispersed, they can infect new or emerging partner plants, thus facilitating their growth and development.

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**Why collect or survey?**

Herbarium collections and associated label data provide

- vouchers for scientific research, including taxonomic, ecological and biochemical analyses
- basic biological material for taxonomists and other researchers to study. A significant proportion of specimens you collect will probably represent new discoveries of Australian fungal taxa
- reference material for accurate identification of fungi
- reliable distribution data for taxa
- the core material upon which application of scientific names is based (Type specimens)
- a permanent record for a species at a particular time and location
- information for production of fungal inventories for your local area
- information for monitoring changes in composition and behaviour over time
- reference material for recognition of those fungi species which are most appropriate for use in localised revegetation programs
- information for monitoring programs which document the introduction and spread of invasive alien species.

In Queensland, many fungi have not yet been collected or scientifically described and there is therefore an added urgency to ensuring that there is a good representation of all the taxa in the state. The importance of lodging voucher specimens of fungi cannot be over-emphasized. These voucher specimens are invaluable for verification of the identity of the studied taxa. Specimens lodged in a recognised, well-curated herbarium will endure in the collection for hundreds of years and thereby their usefulness will continue well into the future. Voucher specimen references included in a publication allow for herbarium material to be readily accessed and verified at any time. The advent of genetic techniques in fungal taxonomy has increased the need for well-annotated and correctly identified specimens to be stored in herbaria, and collected in sufficient quantities to allow limited destructive sampling. These specimens need to be processed and stored so that the DNA is preserved for future study.
Before you start collecting

Permits and access
Collecting specimens in national parks and state forests is illegal unless you have a permit and it specifies the sites at which you intend to collect. If you do not have a permit, apply well before your collecting trip to allow time for the application to be processed. Permits to collect for scientific purposes can be obtained from: www.derm.qld.gov.au/ecoaccess/plants_and_animals

If your foray/survey is planned for a national park or state forest, notify the park or forest rangers of the dates of your intended collecting trip in advance. Before going on to private land you must request permission from the owner to access and traverse their land. Follow the rules of the bush, such as leaving gates as you find them, following paths where possible, taking your litter home and generally minimizing any impact on the environment.

If you are not confident about the fungal collection and preservation procedures outlined in this manual, consider attending forays and workshops organised by the Queensland Mycological Society. Details are obtainable from their website: www.qms.asn.au.

Protective equipment
It is advisable to take personal protective equipment such as sunscreen, a hat, long-sleeved shirt, insect repellent, long trousers, sturdy shoes, a first-aid kit, water and food on any collecting trip. Make sure you have additional suitable equipment as required for the particular job. Gloves, for example, will be needed for seeking out fungi in the litter layer (see list of equipment on page 9).

There is actually little to no risk of being poisoned by handling fungi. Unless trained by a mycologist with considerable experience, however, tasting for descriptive purposes is to be discouraged. Some people may have dermatological or respiratory allergies/reactions. This may be caused by the fungus itself, or by bacteria or other organisms on the fungus, so washing hands after handling fungi is recommended.

Safe travel procedures
Always let someone know where you will be working, and when you expect to return. For prolonged journeys, details of your intended route and destination, call in schedule and expected time of return should be left with someone, preferably the relevant land managers, who can raise help if necessary. Always travel with someone and discuss safety issues and procedures before you
leave. Always make sure that the vehicle is suitable for the job, and functioning properly prior to leaving. All safety equipment such as satellite phones and recovery gear should also be checked prior to leaving.

**Commonly used equipment**

For general collecting you will require a:

- suitable collecting box and/or a wicker basket. For most macrofungi a handyman’s box with multiple compartments is useful and these can be obtained in most hardware stores.

- couple of small collecting boxes for smaller fungi, such as the Ascomycetes. Plastic boxes used for hooks/bait are available from fishing tackle shops and some hardware and department stores, and are very well suited to the purpose.

- roll of aluminium foil (preferred), greaseproof paper or greaseproof bags can be very useful for wrapping larger macrofungi such as boletes. Do not use plastic bags, fungi deteriorate rapidly when wrapped in plastic.

- pocket knife, or trowel, to remove entire specimens from their substrate without damaging tissues.

- GPS for recording accurate latitude, longitude and altitude readings. Alternatively, mark the position on a topographic map and include the map date or datum.

- field notebook. This can be a pocket-sized notebook, or a book of pre-printed specimen labels or the QMS field recording sheet (See Appendix 1). Some collectors use a portable office dictaphone for field notes which are then transcribed on return to base.

- camera for photographing the form, colour and natural habitat of the fungi. Photographs should be linked to each specimen by a unique reference number.

- hand lens, at **least** ×5.

- set of gloves, for protection when collecting in litter.

- box of tie-on tags, often called jeweller’s tags which can be used to provide scale in photographs. If the name and/or number of specimens is marked on the tag it serves as a reliable means of cross-referencing field photographs to collections.

- pencils and felt-tipped pens for marking tags and writing notes, and a ruler for taking measurements.
- field guide to aid in fungi identification. Note that field guides from overseas are only of limited usefulness in the Australian context. While many species may look similar, they quite often are not.
- pronged implement with sturdy handle for truffle hunting.
- soft-bristled artist’s paint brush for cleaning dirt off specimens. When brushing dirt off the specimen, be careful not to remove or disrupt any features, including mycelium, from the base.
- dentist’s mirror. These are angled at the head and have a long handle. They facilitate viewing of the underside of the cap without having to physically handle or dislodge the specimen.

**Specialist equipment**

Collecting some genera may require specialist equipment, for example:

- if you are collecting woody polypores from trees and logs, a mallet and chisel may be useful.
- if you are collecting Boletaceae and Russulaceae, a ferric alum crystal is necessary for checking the iron salts reaction.
- if you are collecting Coprinaceae or collecting in the tropics, a small cool box helps to slow deterioration of specimens.

**Selecting Fungal material**

Select vigorous specimens which adequately represent the taxon. Avoid badly insect-damaged basidiomes. Collect at least two sets of specimens (duplicates), where possible, and number each set separately. Keep one set for your reference, if you so desire, and send the duplicate set to the Herbarium for identification, or as a voucher if required. The Queensland Herbarium does not return specimens.

A good specimen includes all parts of the fungus - cap, hymenium (spore-bearing tissues) and stipe; and ring and volva where present. For some species the colour of the attached mycelium is an important diagnostic character and should be noted. The fungal material should be fertile i.e. it should have mature spores, as these are vital for identification. Some time should be spent looking for a number of individual fruit bodies from the same mycelium. Select individuals that display the range of variation evident within the population.

After taking photographs, immediately wrap specimens in aluminium foil or wax paper, being sure to include the collection tag. Rotting, maggot-infested, water-soaked, mould or algae-covered, or withered specimens should be avoided.
What makes a good collection?

To some extent, the number of fruit bodies which should be collected is determined by their size. A good collection of medium–large fungi normally consists of at least five fruiting bodies in which representatives of each stage of development are present. For medium sized fruiting bodies, at least 10 would be required, for small-medium, at least 20, and for very small about 30 or so. In the case of extremely large fungi, a single sporocarp may suffice. Ensure that sufficient photographs are taken, however, to capture any variations that may occur in the taxon.

The collection should include either a note identifying the host plant/mycorrhizal associate, or some leaves, flowers and/or fruits of the plant if the collector cannot determine its identity. For smaller wood and litter-inhabiting fungi it is worth collecting some of the substrate to which the fungus is attached. Small agarics, such as Marasmius and Mycena, often have a characteristic basal disc. For Ascomycetes, which can be very small, the substrate is often collected to allow examination of the means of attachment of the fungus.

Fruit bodies that are too large for a collecting box, may have to be cut into sections to be transported back to base. Where this occurs, the sections should be vertical, creating halves or quarters so that all parts of the fungus are represented in each half or quarter. Alternatively, a cane basket can be utilised to transport some of the larger specimens.

Collections that are not fully documented are of little value, particularly when date and locality data are absent. Be mindful that your collection may be examined by a taxonomist working in the herbarium 50 or 100 years from now. They will have no way of reconstructing details of what colour the specimen was, or its substrate, habitat, etc, so you must provide this information in your notes and accompanying images.

When to collect

It is advisable to maintain specimens in as fresh a state as possible. It is best if collecting can be done in the morning (until approximately noon), whilst the afternoon is allocated to working on the collections (Halling & Mueller, 2005). Some genera of agarics (e.g. Coprinus) auto-digest (deliquesce) and are consequently very difficult to maintain in good condition unless they are collected very early in the morning or when the sky is overcast.
Step-by-step guide to collecting and drying fungal specimens

1. Choose specimens which are in good condition and representative of the population’s variability. A collection should be comprised of only sporocarps collected at the same time and from the one place. Ideally, the fruiting bodies should be produced by an individual mycelium (some of these can cover an extensive area) and collecting from a small discrete patch is therefore a preferred practice. Note carefully the substrate (what the specimen was growing on/in) and the associated organisms (the species or genera of plants it was growing with).

This photograph illustrates immature and mature specimens of Geastrum saccatum growing in a sandy substrate under Banksia aemula.
2. Use a pocket-knife or a trowel to extract specimens from the substrate, taking care to collect the whole specimen including the base. Don’t collect by cutting the stalk, as the portion of the fungus below the substrate surface often possesses anatomical characters which are taxonomically diagnostic e.g. *Amanita* spp. usually possess a structure called a volva (See Appendix 3). Furthermore, picking by holding on to the stipe may result in the destruction of macro-characters, or result in some features being left behind in the ground.
3. Photographs should include:
   - the specimen growing in its natural habitat
   - a display of the specimen which shows the gills or pores
   - any unusual, distinctive or interesting features
   - the range of variation within the taxon
   - a jeweller's tag to provide scale and as a record of its unique reference number.

If possible, take one photograph containing all these elements. Take several shots from a number of different angles, and with a range of lens apertures and ISO settings, where these features are available. Note that in this photo the number written on the jeweller’s tag is not visible.
4. Specimens should be wrapped in waxed paper or foil (Never use plastic) and placed in a suitable container for transport back to base. Do not mix specimens in the same compartment or bag, you will almost certainly get spore contamination if you mix specimens. It is essential to keep the specimens as fresh as possible for examination back at base.

Many agarics shrivel or fade within a few hours of collection. Avoid overheating or water-logging the specimens during transport back to base. Use of a portable cooler may be required in really hot conditions. Many taxa stain or bruise different colours on their stems, hymenium and caps, and also in their flesh when cut. As far as it is practicable to do so, avoid handling, bruising, breaking or squashing specimens. NEVER press specimens as you do with plant material.

You can initiate the spore depositing process even while still collecting, by placing one of the caps onto a small piece of white paper and wrapping it all in aluminium foil. Place this preparation into the bottom of the basket or box with an attendant note explaining to which collection the preparation belongs.
5. Every specimen should be tagged and a unique collection number written clearly on the tag. If you are on a foray with others, ensure that the field recorder and photographers all agree with the number and details for each collection while still in the field.

6. On returning to base, place any specimens needed for microscopic work or chemical tests in a fridge and examine them within 48 hours. Process such specimens in accordance with the details outlined from Step 9 onwards. Fleshy species, e.g. boletes, are ideally processed immediately, particularly under warmer and more humid conditions, as they are highly susceptible to attack by insects and moulds. It is not unusual to make a nice collection of such seemingly sturdy, fleshy fruiting bodies, only to return to base to find a malodorous brown syrup teeming with maggots in your container instead of fungi.

Keeping records on a foray © Fran Guard

Complete your field notes before going on to the next collection. See the following section of this guide for details of what you need to record.
Do not allow the specimens to frost or freeze. Set the fridge at 5-7°C.
7. Place all remaining specimens on your dryer with labels which include the field notes (see Appendix 1). Your dryer must be set at a temperature between 42-55°C. You may prefer the higher settings where you are experiencing high relative humidity e.g. North Queensland.

![Specimens on a dryer](image)

Specimens on a dryer © Pat Leonard

Note the white plastic sieve at the back used for small specimens which might otherwise be lost or damaged. Packet and field labels are kept with the specimens on the dryer.

Select a mature specimen and put it down for a spore print. Make sure you place a copy of the field number with it. Spore prints are normally made on acid free white paper. For small specimens you can make a spore print on a glass microscope slide. Very occasionally for genera (e.g. *Gymnopus*) that have faint cream or pink spores, a print may be made on black paper which helps distinguish these colours.
A). Fold a square of white paper.

B). Cut a small triangular slot from the centre of the triangle, big enough to pass the stipe of the fungus through it.
C). Place the stipe through the slot in the paper and suspend on the mouth of a plastic beaker/cup. Keep the field number and dryer label with the fungus. While the spore prints are being prepared, you can begin to take notes on your collections.

D). Once a spore print has been obtained, label it and place this on the dryer with the collection and other labels.

Alternatively, remove a cap from its stem and place it with hymenium face-down on a piece of white paper. Place a drop of water on the cap, and cover with a glass to stop it drying out and to protect it from air movements. Leave for several hours to overnight.
8. Carry out any macro-chemical tests that are required, and record the results on a specimen record sheet (see Appendix 2).

Reactions of FeSO$_4$ (pale salmon, above) and Guaiac (positive, green, below) on the stipe of a *Russula* species. © Pat Leonard
9. Complete your record sheet (See below), print photographs, and attach one copy of each to the record sheet.

*Russula* sp. 10

![Image of *Russula* sp. 10]

**Russula** sp. 10 © Pat Leonard

**Cap:** convex with a central depression; to 60 mm diameter; slightly viscid, glabrous; pale peach (7A3); striate to half radius; hardly peeling.

**Stipe:** cylindrical; 60 × 10 mm; glabrous; white

**Gills:** adnate; white, no lamellulae.

**Flesh:** white, unchanging.

**Spores** white, ellipsoid; 6.5-7.6 × 5.5-6.8 µm, average 7.15 (± 0.3) × 6.15 (± 0.45) µm, Q = 1.17 (± 0.01); blunt amyloid warts and short ridges joined to form a partial reticulum.

**Basidia:** clavate; 25-35 × 10-12 µm; four-spored.

**Cheilocystidia:** fusiform; thick-walled; ± 70 × 10 µm; with mucronate apices.

**Pleurocystidia:** fusiform; thick-walled; 60-75 × 9-15 µm; some with a septa, some mucronate, extending 25-30 µm beyond basidia.

**Dermatocystidia:** absent.

**Pileipellis:** an ixotrichoderm of narrow hyaline hyphae 2-3 µm wide.

**Macrochemical reactions:** FeSO₄ on stipe = salmon; guaiac on stipe base = green

**Habitat:** growing singly with *Eucalyptus pilularis* in a mixed rainforest habitat.

**Collection details:** PL 2308, Maroochydore Bushland Botanic Garden, Buderim, 27 Mar 2008.

**Notes:** a delicate pale peach coloured *Russula* which does not appear to be related to any of the species in Cleland or Grgurinovic. More collections needed.
10. If you carry out microscopic inspection of your specimen, record the results on the record sheet. Place any surplus material back on the dryer with the remainder of the collection.

Copies of any micro-photographs taken also make a useful addition to a collection.
11. Assemble the whole collection: dried specimens; spore print; field label from dryer; jeweller’s tag; photographs; and specimen record sheet.
12. Make final check that all the elements have the same unique reference number and that all relevant specimen data are recorded appropriately, then place specimens into a large bag.
Clean all tools and implements that you have used on your foray/survey with 70% methylated spirits (or ethanol, if you have access). This is necessary in order to prevent the possibility of any transferral of contaminants, e.g. pathogens, between sites. Likewise, treat your walking boots by scrubbing them with a bleach solution. If you have used a vehicle to access a remote site, it is advisable to have it thoroughly cleaned, particularly the undercarriage and tyres, before entering another area.

Deliver the bag containing the collections to the Herbarium.
**Data to be recorded in the field**

Fungi collections unaccompanied by field notes are of very little use. Many mycologists use a small notebook or a dictaphone to record information about the specimens they collect, the locality and the associated vegetation. Some information can also be stored on digital cameras and GPS devices. If you use more than one means of recording, cross referencing becomes essential.

When a group is making collections on a foray, one person should be appointed as recorder, and a field sheet used, such as the QMS field sheet at Appendix 1.

**Site information**

1. **Site name**: If the name is not known, then describe how to get to the site from the nearest known locality.
2. **GPS location**: This can be recorded as lat/long or AMG. Remember to also locate the datum you are using. Most GPS devices will also record and store an altitude reading. The preferred datum is GDA94.
3. **Habitat data**: Should include landforms, slope, dominant plant species, vegetation structure, for example ‘open forest’, ‘open woodland’ or ‘grassland’, or the regional ecosystem code, if known. Record any evident management system or any disturbance, for example grazed paddock, recently burnt, or timber extraction.

In most instances this information only needs to be recorded once for each site, but on an extended collecting trip, where more than one ecosystem is traversed, several “site” files may need to be created.

**Specimen information (field)**

The following information about fungal specimens should be recorded in the field:

1. **Reference/voucher number**: to uniquely denote each collection.
2. **Genus and/or species name**: if the name is not known, then a description of the type of fungus, e.g. agaric.
3. **Substrate**: what the fungus was growing on. e.g. leaf, insect, soil, log, twig, sawdust pile.
4. **Associated organism**: which can be either the species name for the vegetative material on which the fungus was growing, or in the case of mycorrhizal fungi, the name of the nearest likely mycorrhizal associate (commonly belonging to the genera: *Acacia, Allocasuarina, Eucalyptus, Corymbia, Leptospermum, Nothofagus, Pinus*; For more details see [http://mycorrhizas.info/ecm.html](http://mycorrhizas.info/ecm.html)).
5. **Field characters**: these differ by genera, but colour, colour changes in the flesh of the fungus, odour, presence and colour of latex, and reaction to ferrous sulphate salts are all best noted in the field as they can fade quickly, and disappear altogether upon drying.

6. **Collector**: the name and initials of the collector.

7. **Determiner**: the name and initials of the person who identified the fungus in the field, or who took responsibility for determining its identity back at base.

8. **Photographer**: the name and initials of the photographer, if different from the collector.

**Data to be recorded at base location**

Macroscopic characters and measurements need to be recorded from fresh material and should be undertaken as soon as practicable on return to base. If a refrigerator is available, and can be set at around 5°-7°C, many specimens may be kept for up to 48 hours. Otherwise the macroscopic features must be recorded on the day of collection. Bear in mind that sporocarp longevity will be influenced by environmental temperature, relative humidity, size and sporocarp texture, moisture and maturity.

It is unrealistic to make more than 10 collections and expect to describe them properly in a single day. Most mycologists would probably not attempt to describe more than 6 collections in a day.

Use a structured record sheet for your notes (See Appendix 2), or refer to a standard description sheet (See Appendix 3). Remember that different fungal genera may need different key characters recorded, e.g. presence and character of latex in agarics is only relevant to *Lactarius* and *Mycena*. A small sketch of a vertical cross section of the fungus is often a useful way to record features.

The list of required descriptive data outlined on page 31 of this document does, at first, appear daunting, but with a visual aid, e.g. hand lens or stereo microscope, and a colour chart, it does not take long to complete, and greatly increases the value of the dried specimens. With experience, you will probably find that you can set up a spore-print and collate notes on a specimen in 15-30 minutes. Allow more time if you are checking microscopic features as well.

**NB**: The quality of light used for interpreting colours is important. Natural daylight is best, but failing that, there are lamps which can be fitted with a full-spectrum bulb that approximates daylight. Fluorescent tubes lack red wave-lengths and will adversely impact your interpretations and the quality of any ‘lab’ photographs taken.
(Halling & Mueller, 2005). An electronic flash is suitable in such circumstances.

If you use a colour chart you should state which one was used, e.g. British Fungus Flora. If you use reference material to assist with descriptions, or you identify the fungus using a monograph or key, it is preferred practice to cite its details in your notes. If you don’t have access to a colour chart use simple terms such as “dark-red”, “intense-orange”, “pale-pink”, “caramel”, “crimson”, etc. Note that these only function as adequate descriptors if their interpretation is applied with consistency.

**Macrosopic characters**

See ‘Structured Recording Sheet’ (Appendix 2) and refer to Appendix 3 for additional descriptive terminology.

1. Cap shape including the presence of features such as an umbo or papillae.
2. Cap colour, use a colour chart.
3. Cap surface texture, e.g. pubescent, fibrillose, glabrous, viscid, scaly.
4. Cap margin, e.g. plicate, rimose, inrolled.
5. Cap diameter in millimetres (range within mature specimens).
6. Cap flesh: cross-section cap and note initial colour, colour changes over time, consistency, latex presence, thickness.
7. Hymenium structure, e.g. gills, pores, teeth, etc.
8. Hymenial attachment, e.g. free, adnexed, etc.
9. Hymenial colour (+ any bruising reactions, or changes with age, presence & colour of latex, flesh colour changes induced by latex)
10. Hymenial margin, e.g. even, serrated, etc.
11. Hymenial margin colour, e.g. concolorous (with sides of gill), darker, paler.
12. Hymenial arrangement, e.g. forked, regular, intervenose.
13. Presence of lamellulae (if agaric).
14. Stipe attachment, e.g. central, lateral, excentric, absent.
15. Stipe colour (use a colour chart), gradations from apex to base, changes with age or handling.
17. Stipe shape, e.g. cylindrical, bulbous, clavate, etc.
18. Stipe surface texture e.g. smooth, viscid, hairy, etc, striate. Does this vary with age, or with position on stipe?
19. Stipe consistency e.g. rubbery, cartilaginous, brittle, etc.
20. Stipe base and attachment, e.g. insititious, caespitose, rhizoids. Note abundance and colour of mycelium.


22. Ring (on stipe): presence, persistence, attachment (is it fixed or does it move?), position, colour, consistency, size and shape.

23. Volva: presence, attachment, consistency, surface ornamentation, colour, colour changes, persistence.


**Microscopic examination**

Whilst it is not necessary to add notes on microscopic characters to dried specimens submitted to the Herbarium, where these have been determined as part of the process of identifying the fungus, they should be added to the record sheet. Using a standard description sheet is useful.

The main microscopic characters generally examined are:

1. Spore shape.
2. Spore size, length and width ranges and averages - measured in microns (µm).
3. Spore reaction to Melzer’s reagent, i.e. amyloid, dextrinoid or inamyloid.
4. Basidia size and shape.
5. Cystidia presence, form and location.
7. Tramal structure.
8. Hyphal dimensions: range of widths
9. Hyphal inclusions or encrustations
10. Clamp connections (on hyphae and/or base of basidia): presence or absence
11. Types of hyphae present e.g. skeletal, generative, etc, and whether there is more than one type or not. Also note that different types can be absent/present in different parts of the sporocarp. Consequently, tissue from the cap, hymenium, stipe and mycelium all need to be examined to effect a truly thorough microscopic description of a specimen.
Other useful data

Macrochemical tests are commonly carried out on some fungal genera. The most common ones involve reactions to a weak solution of potassium hydroxide (5%KOH) and to ferrous salts (FeSO₄). Many only work on fresh material and it is therefore helpful to note the results. Always exercise extreme caution when using any chemicals for such tests, seek advice from an experienced mycologist and familiarise yourself with the health and safety advice relating to the particular chemical you propose to use. Copies of the Material Safety Data Sheets for the two chemicals can be obtained from the Queensland Herbarium.

Drying fungal material

It is important to dry fungal collections quickly as they are often subject to attack by other fungi, bacteria and a range of insects. Any such attacks reduce their value as herbarium specimens.

Fungal specimens reduce in size considerably on a dryer, so it is vitally important to track your specimens with proper labels while they are undergoing the drying process. Colour and shape will also change after drying, and the odour, if present in the fresh specimen, will most likely disappear.

Large specimens will need to be cut to facilitate drying. It is useful if each segment contains all the parts of the fungus, so cutting the specimen vertically into halves or quarters is the preferred method. If sporocarps are very fleshy, this should be done for all fruiting bodies collected, in order to promote drying. Small specimens, such as *Mycena* and many ascomycetes, should be placed on the dryer in small containers. Plastic sieves are useful for this purpose.

In humid conditions, where the specimens are large, drying may take up to 72 hours, whereas for small specimens, ≤12 hours may suffice. Heat should flow upward from its source, via a chimney effect which circulates around the specimens and vents from above. Specimens dried in an oven will bake and be useless. It is critical that specimens are dried slowly. The temperature should not exceed 42-55°C, particularly as DNA extraction is likely to be attempted from the dry material in the future. Leave the specimens on the dryer until they are crisp and brittle (but not baked or burned). Never press mushroom specimens. (Halling & Mueller, 2005)

Drying in the field

Drying specimens in sunlight can be achieved with care (where humidity is low), but will involve close supervision and quite frequent turning of the specimens. Protection of the specimens from
dust, insect and even bird or mammal damage is an important consideration with this method.

Use of wire racks in a field oven can succeed, but the temperature has to be kept relatively low to dispel the moisture without cooking the specimen. Usually the only way of achieving a low enough temperature is to leave the oven door open! In general, much better results are achieved by using electric dryers. If you have dried specimens in the field, always re-dry them on return to base.

**Drying when electricity is accessible**

Various types of dryers are used to prepare fungal specimens for the Herbarium collection. Full temperature controlled desiccating ovens are available, but most collectors will not have access to such equipment.

The most commonly used dryer is that normally used for desiccating fruit such as apple rings and plums. They consist of a heater element, a temperature control and a series of stackable wire mesh or plastic trays on which to place the fungi. The more sophisticated ones have temperature setting, but most only have a numbered dial and you will need to check the operating temperatures by using a thermometer. They achieve excellent results. They tend to be available only in specialist horticultural or kitchenware shops, or via internet order.

Home desiccators which are fan assisted and have stackable plastic trays obtain very good results, but can be tricky to use for large fungi as the trays tend to be very shallow. There can also be a problem with placing labels in these desiccators as the fan can readily move the labels. Ensure the fan is off when you load and unload your desiccator.

In the absence of a specialist dryer, specimens can be dried on a wire mesh suspended over a radiator or a 60 watt light bulb. The majority of specimens placed in a good dryer will dry overnight, whilst large fungi may require 24 hours. In very humid conditions this requirement may increase to as much as 72 hours. Once fully desiccated, specimens must be kept dry or they will re-hydrate and then there is the possibility that they will become mouldy and worthless. Removal of freshly dried specimens directly from the dryer to a herbarium type packet or plastic bag (Zip-lock are best) large enough to accommodate the specimens, spore-print and labels, will help ensure that the specimens remain dry. In extremely humid regions, a small amount of desiccant, such as silica beads, can be added to safeguard against re-hydration and mould growth (Halling & Mueller 2005).
Writing a label to accompany the specimen

The data that accompanies a herbarium specimen is just as important as the specimen itself. Even a very good quality specimen is of no use to the Herbarium unless it has a neatly written, legible label including at least the information detailed below. Bear in mind that the descriptive examples supplied do not represent the only manner in which notes or statements can be written. Work within your capabilities, knowledge and experience, and do not get too caught up in “scientific” terminology if you are a beginning or occasional collector.

Collection number [mandatory]: This is the unique reference or voucher specimen number that has been ascribed from the beginning of the process. It must also appear on any notes or photographs submitted with the specimen.

Specimen name [optional]: Application of a name, whether a scientific binomial or a fabricated “identity”, is an advisable practice to adopt e.g. *Pholiota* sp. No. 3 (probably the more common style), *Pholiota* ‘Mt. Barney’ or *Pholiota* ‘speckled orange’. Any name you elect to utilise should be applied consistently, however, to collections you believe to be of the same “species”.

Collector’s name [mandatory]: the name of the person who collected the specimen.

Date of collection [mandatory].

Determiner’s & Photographer’s names [mandatory, if relevant]: Where the specimens have been scientifically named, the name of the person making the determination should be added.

Key used [optional, where relevant]: Unless the collector has prior knowledge of the taxon and can automatically ascribe a name, it is best if the reference materials used when applying a scientific binomial to the specimen are cited.

Locality [mandatory]: A written description of the locality is necessary, as well as a latitude and longitude reading, map reference, or distance and direction to nearest town or significant geographical feature. The locality description should be sufficient to enable any person to revisit the approximate place of collection. On the other hand, the locality description should not be too verbose and should not include information better included under "Habitat". It should be meaningful to someone not familiar with the local area.
**Inadequate locality descriptions include:**

Mangrove Creek [ambiguous]; Maleny bushland [too vague]; Bunya Mts [too vague]; 5 km S of Rosevale [better, but still vague, and potentially ambiguous where particular area names occur in several localities around the state or country].

**An example of a good locality description:**

2.5 km along Banksia Track, Community Centre, Banksia Beach, Bribie Island, 27° 02’ 52·2” S, 153° 09’ 11” E.

**Geocode** [mandatory]: Transfer the GPS reading obtained in the field to the label, e.g. Lat.: 35° 26’ 43” S, Long.: 135° 17’ 29” E, AGD84; or determine a grid reference from a map.

**Altitude** [optional]: in metres above mean sea level (AMSL).

**Habit** [mandatory]: Description of growth form and substrate e.g. “White omphaloid agaric growing in caespitose clusters on very large, moderately decayed log”.

**Habitat** [mandatory]: Transfer the information from your field notebook. Two possible formats, but by no means the only options, are "eucalypt woodland of *E. populnea*, regional ecosystem 11.3.2" or “Mixed *Acacia*, *Allocasuarina* and *Eucalyptus* forest on brown loamy soil, with sparse shrub layer of predominantly *Leptospermum* and *Pultenaea*, and moderately dense coverage of tussock grasses in ground layer. Fruiting bodies 2m from base of *Acacia* plants”. Note that this information incorporates details of vegetation type, associated flora and soil.

**Field description** [mandatory]: This information is transferred from your field notebook, e.g. "white fungus that exudes mild, white latex from gills when cut, latex turns green on drying”.

**Spore Print Colour**

**Abundance** [optional]: A comment on the frequency of the fungus at the site where you collected it. You may use terms such as "common" or "occasional", or you may give the actual number of fruiting bodies. This field is especially important for documenting the early spread of invasive species.

**Other notes** [optional]: Refer to description on page 24 (*Russula*).
**Freezing specimens**

It is Queensland Herbarium policy to freeze all dried specimens received. This kills any pests which may have escaped the effects of the drying process. If you are on a long collecting trip, or may not visit the Herbarium for some time, you may find it helpful to place the packets containing dried specimens into a large sealable plastic bag (zip-lock is best) or container and place it in a freezer set at minus 18-20°C for 48 hours. This offers additional protection to your specimens and will not harm them or damage their microscopic features. Never freeze fresh specimens.

**Resource links**

**Australia**


Search for collections of fungi held at each Australian Herbarium.


List of all the fungal names, including synonyms, used to describe Australian fungi.


“Queensland Mycological Society” [http://www.qms.asn.au](http://www.qms.asn.au) Bimonthly meetings; regular forays; workshops on collecting and identifying fungi.

**Worldwide**

“Forest Fungi of New Zealand”: [http://www.hiddenforest.co.nz/fungi](http://www.hiddenforest.co.nz/fungi)


“Introduction to Fungi”: [http://www.ucmp.berkeley.edu/fungi/fungi.html](http://www.ucmp.berkeley.edu/fungi/fungi.html)

“Kingdom of Fungi”: [http://www.kingdomoffungi.com](http://www.kingdomoffungi.com)
“Mycokey”:  http://www.mycokey.com  Excellent interactive keys to macro and micro fungi in Europe and over 3000 photographs.

“Mykoweb”:  http://www.mykoweb.com

“New Zealand Fungi”:  http://www.fungi.co.nz


References


organic compounds by pine, beech seedlings inoculated with rhizobacteria, ectomycorrhizal fungi. *Biology, Fertility of Soils*, 15, 259-267


Useful Literature


## Appendix 1: Field Recording Sheet

<table>
<thead>
<tr>
<th>Field No</th>
<th>Species Name</th>
<th>Location</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Columns:***
- **Field No**: identification number for the field record.
- **Species Name**: name of the species observed.
- **Location**: geographical location where the species was found.
- **Notes**: additional information or remarks about the observation.
BEFORE THE FORAY:
Enter the location, date and vegetation type. If this is a site the QMS has not visited before, complete the site data sheet, including GPS reading, the vegetation type and other details. Enter the name and initials of the Leader, Recorder, forayers and photographers.

RECORDING SHEET:
Field No: these are consecutive numbers starting at 1 for each foray. For each record, a jewellers tag with the record number should be handed to the photographers for inclusion in at least one of their photos so that the name can be linked to the images.
Spotted by: enter the initials of the person who found the fungus.
Name: enter the name of the fungus if the name is known. The identification should be independently confirmed by at least one other person. The name may be full name or just the genus.
Field ID: Record the initials of the person who named the fungus.
Confirmed by: enter the initials of the person who confirmed the identification.
Fungus with: if there is uncertainty about the name and someone has volunteered to work on the specimen, or specimens are taken for the Herbarium, then a collection is made. In these cases enter the initials of the person who has collected the fungus. Make sure the collector retrieves the jewellers tag from the photographers and places it with the specimens in the collecting box. Specimens should only be taken by members with a collecting permit.
Un-named fungi: if the fungus cannot be named and no one is willing to take it home to work on a get a name, then mark one of the categories in the boxes above the record sheet. Indicate whether it is an agaric, etc, see pages 14-15 of Fungi Down Under. This allows us to keep track of how many un-named fungi are encountered on a foray.
Substrate: ask the person who spotted the fungus what it was growing on. It is vital to have this information to help identify the fungus. Answers could include soil, litter, wood, large log, living plant, leaf etc.

Associated organism: this is the name of the organism the fungus was living on or with. For example for mycorrhizal fungi where the substrate is soil it will be the host tree: e.g. *Allocasuarina*; for saprophytic or parasitic fungi it will be the name of the tree that the log or leaf came from.

Notes: other useful information can be entered such as the number of specimens or the frequency with which the species was found on the foray.

DEFINITIONS:
Record: “an observation of a fungus at a particular place and time that normally includes the fungus species name, its location, details of the habitat, who collected it and, for fungi that are not in Q-Fungi or Fungimap, who confirmed the identification”. Unnamed fungi are not records and should not be allocated numbers.
Collection: “one or usually several specimens of a fungus from the same mycelium, which relate to a single record and have been collected to be worked upon and deposited in the Herbarium”.

RESPONSIBILITIES:
Foray Leader: makes sure everyone, especially the recorder, gets all the information about each find.
Recorder: makes sure information is completed for all the records and collections and that the photographers have record numbers.
Forayers: make sure that each fungus you spot is recorded and that you tell the recorder the substrate and associated organism. The foray leader will decide if the fungus is to be collected.
Photographers: ensure that each record has at has at least one photo with the numbered jeweller’s tag in it and images of collections show the fungus in situ and illustrate both top and under sides.

AFTER THE FORAY: the recorder should hand the record sheet to the foray leader so that they can prepare the foray report.
# Appendix 2: Structured Recording Sheet

## FUNGUS RECORDING SHEET

<table>
<thead>
<tr>
<th>Locality:</th>
<th>Grid ref:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associate species:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Cap:
- **details:**
  - Diameter: mm.
  - Texture:
  - Surface: Greasy/Matt/Other:
  - Peeling: nil/quarter/half/all
  - Cap margin:

### Flesh:
- **Colour:**
- Smell:
- Taste:

### Gills:
- **Gills/Pores/Teeth**
- Colour:
- Attachment:

### Stipe:
- **Colour:**
- Height: mm Width: mm
- Texture:
- Ring: Present/Absent Volva:

### Spores:
- **Size:** μm × μm
  - Q=
- Colour:

### Cystidia:

### Keyed in:
- Main steps:

### Species determined:

### Illustration:

### Milk:
- **Present/Absent**
- Colour:
- Change:
- +KOH:
- Taste:

### Chemicals:
- FeSO₄:
- Guaiac:
- KOH:

See over for notes, drawings and photographs
Photo 1
Landscape

Photo 2
Portrait

Spore sizes:

Notes:
Appendix 3: Macrofungi Description Aid

Pileus (Cap) Shape
- Applanate (flat)
- Convex (rounded)
- Conical (cone like)
- Campanulate (bell shaped)
- Infundibuliform (centrally depressed)

Pileus apex (top)
- Umbonate (central raised bump)
- Umbilicate (central indent)
- Papillate (pimple in indent)

Pileus surface
- Glabrous (smooth)
- Pubescent (finely hairy)
- Velutinous (like velvet)
- Villose (coarsely hairy)
- Fibrillose (radiating fibres)
- Squamulose (with scales)
- Areolate (breaking into patches)

Pileus margin (cap edge)
- Entire (smooth)
- Striate (lines at edge)
- Tuberculate (furrowed)
- Plicate (pleated)
- Rimose (splitting)
- Inrolled

Lamellae (gills) attachment
- Adnate (right angled)
- Adnexed (acute angle)
- Emarginate (very acute)
- Free (not reaching stem)
- Decurrent (running down stem)
- Sinuate (notched)
- Arcuate (arched)

Lamellae arrangement
- Regular (all gills reach stem)
- Intercalated (with some short gills)
- Furcate (splitting)
- Anastomising (cross gills present)
- Pores (sponge like)
- Hydnoid (with teeth)