MYCOLOGIST'S HANDBOOK

D. L. HAWKSWORTH

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An Introduction to the Principles of Taxonomy and Nomenclature in the Fungi and Lichens

by

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KEW, SURREY, ENGLAND

1974

First published in June 1974 by the Commonwealth Mycological Institute
under the authority of the
Executive Council, Commonwealth Agricultural Bureaux,
Farnham Royal, Bucks., England

ISBN 0 85198 300 6 (cased)

ISBN 0 85198 306 5 (paperback)

Printed in Great Britain by
Western Printing Services Ltd, Bristol

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PREFACE

THIS book owes its inspiration to the late Dr G. R. Bisby's *An Introduction to the Taxonomy and Nomenclature of Fungi*, first published by this Institute in 1945 (with a second edition issued in 1953). By the end of 1969 stocks of the second edition of Bisby's book were almost exhausted and it was clear that a new edition or replacement volume would be required. To both bring the work up to date and provide a useful reference volume for all those concerned with the naming of fungi, the entire text has been completely re-written, many new chapters included, and a few omitted.

Bisby, in common with most of his contemporaries, did not include data relevant to over half of all known Ascomycotina (i.e. the lichen-forming species) and some attempt to rectify this situation has been made.

The portions of the *International Code of Botanical Nomenclature* pertinent to mycologists and illustrated by examples from mycology were originally included by Bisby because the 1935 edition of the Code was not readily available. Although this is no longer the case, the Code has necessarily increased in complexity to such an extent that there is perhaps now a greater need for a Code with mycological examples than there was in 1945.

In a work of this size it is, of course, impossible to treat all the practical and theoretical aspects of the nomenclature and taxonomy of fungi (including the lichens) in the detail they merit and consequently many references to books and papers from which further information can be obtained have been included.

I would like to thank some of my colleagues for their kind assistance in reading and commenting on drafts of various sections: in particular Dr C. Booth, Miss S. Daniels, Mr F. C. Deighton, Mr D. W. Fry, Mr A. Johnston, Dr A. H. S. Onions and Dr B. C. Sutton, all at the CMI; and Mr P. W. James, Mr J. R. Laundon, Dr F. Rose and the mycologists at the Plant Research Institute, Ottawa. I am also grateful to Dr F. A. Stafleu and the International Association for Plant Taxonomy for permission to reproduce portions of the *International Code of Botanical Nomenclature*, and to the following for permission to reproduce line-figures: The Botanical Society of the British Isles and Dr W. T. Stearn (Fig. 17), the British Lichen Society (Figs. 14, 16, 18) and Royal VanGorcum Ltd (Fig. 20).

In conclusion I would like to emphasize that any errors and omissions are my own responsibility.

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15 May 1973

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I. INTRODUCTION

THIS book is intended for all who are concerned with the naming of fungi. It aims to outline the principles and techniques involved in the naming and describing of fungi and lichens, in undertaking taxonomic and floristic studies, and in the formation and maintenance of herbaria and culture collections. The rules controlling the nomenclature of fungi and lichens (The International Code of Botanical Nomenclature), illustrated by examples taken from mycology, together with a glossary of nomenclatural terms, are included. Notes on the application of some recent techniques of value to systematists are also provided as are guides to the tracing of literature sources, the location of some important mycological collections, preparing manuscripts for publication and suggested title abbreviations for mycological books.

Accounts of the different groups of fungi and works to be consulted for the determination of genera and species are outside the scope of this volume. These data are readily obtainable through the latest (sixth) edition of *Ainsworth & Bisby's Dictionary of the Fungi* (Ainsworth, 1971), which includes the lichens, and Ainsworth *et al.* (1973). As general introductions the texts of Bessey (1950), Alexopoulos (1962), Burnett (1968), Webster (1970) and Talbot (1971) are recommended for the fungi; whilst those of Ahmadjian (1967*a*), Hale (1967) and Henssen and Jahns (1974) are for the lichens. A résumé of recent advances in the study of lichens is given by Hawksworth (1973*a*). More detailed accounts of most aspects of fungi and lichens are provided in the comprehensive works of Ainsworth and Sussman (1965, 1966, 1968) and Ahmadjian and Hale (1973*), respectively.

A great deal of revisionary work still needs to be carried out in many groups of fungi and lichens and, although they have been studied for over two centuries, their taxonomy largely remains at a stage of 'cataloguing' with new genera and species continually being described. Revisionary studies are consequently becoming increasingly necessary to draw together the large numbers of species already known.

Systematic mycology is not a subject the study of which can be undertaken lightly. There is a vast literature, and microscopic characters have to be considered for all species, some of which are invisible to the unaided eye. Furthermore the student must have a general systematic biological background for it is essential to determine accurately the hosts and substrates on which fungi occur. It is because of these inherent difficulties and intricacies, however, that systematic mycology can be particularly rewarding for the persevering and careful student.

There are too many fungi and lichens for any individual to study all groups

* This work appeared too late in 1973 to enable data from it to be fully incorporated into the text.

in detail and so the student has to decide in what area he wishes to work. The amateur has complete freedom to study whatever groups may interest him but someone who hopes to make his career in this field has to be more selective. The choice of such a person might be governed by the work of colleagues in his Department or Institute, or by the pathological or industrial importance of particular genera and species. To avoid the duplication of work being carried out elsewhere the potential mycologist should discuss the area in which he proposes to work with as many professional mycologists as possible. Specialists in particular groups are usually aware of studies in progress in other laboratories and herbaria long before they appear in print and are also able to direct others to groups where systematic work is required and where the problems are not likely to prove insurmountable. If such advice cannot be obtained some idea of the studies in progress in particular groups may be obtained from Bulletins, Newsletters and publications appearing on the group (pp. 107–108).

The types of study within the field of systematic mycology which it is possible to carry out may also be limited by the facilities available (e.g. libraries, herbaria, culture collections, good microscopes, chromatography apparatus). Amateurs are able to make important contributions by sending interesting collections to specialists and compiling lists of species present in particular areas, or on specific hosts or substrates. Specialists determining material sent to them are often more inclined to give advice and name specimens if they know that the information they provide is being included in a definite project.

Whatever aspect of systematic mycology is pursued, patience, persistence, care and adequate facilities are prerequisites. The student must not be too eager to revise taxa he really knows little about, nor to describe new genera and species without making certain that they have not been described before. Once a name has been validly published it is irrevocably introduced and requires cataloguing and discussion by other mycologists even if it is found to be the same as a previously described taxon. The publication of a new taxon is consequently a step which should not be undertaken lightly. It is the intention of this book both to help the student to make 'correct' taxonomic decisions and to indicate how best to study and preserve his material and publish his results.

II. COLLECTION AND PRESERVATION

COLLECTION

BEFORE a beginner can take a real interest in systematic mycology and appreciate its problems he needs to acquire a general knowledge of the various groups of fungi to provide a background for further discussion and study. The most satisfactory way to do this is to learn the common species in his own neighbourhood and, to do this, he must collect and study them. He should attempt to develop a keen eye so that smaller and critical species are not overlooked, learn the types of habitats in which particular groups predominate, and recognize the range of variation within individual species in his area. Systematic collecting provides the basis of all taxonomic research. Someone working on a particular group in the laboratory or herbarium also needs to study and collect material of his group in the field. Only through field studies can he become familiar with the inherent variability of species and the effects of environmental factors on them.

The ideal way in which to learn how to collect material is to join field courses, field excursions and forays of national and local natural history societies led by specialists. On such meetings more can often be learnt in an afternoon than an individual working on his own could hope to learn in several weeks. Most collectors at first bring back specimens which are either too small or in too poor a condition for accurate identification. Careful searching of a very limited number of sites is often more fruitful than briefer visits to a large number. Both the quality of the collections obtained and the number of species found tend to be in inverse proportion to the distance travelled whilst collecting.

All collectors should obtain permission to collect in an area from its owner where the property is private. Failure to do this may jeopardize visits by other naturalists (not only mycologists) in the future. As future generations will also wish to study fungi and lichens the collector should be conscious of the need for conservation. Most ephemeral fungi are unlikely to be affected by overcollecting but some groups, particularly the lichens, may all too easily be endangered by overzealous collectors. Lichenologists themselves may have contributed to the decline to extinction of a few rare species in the British Isles. Fortunately, with practice, most lichens can be named in the field with a hand lens ($\times 10$) and where voucher material is needed or a specimen requires microscopic examination only the minimum of material should be taken. Later workers have often been sceptical of unsupported reports of rare lichens they have been unable to refind in the same localities. Collections should reflect what grows in a locality and not what used to grow there before the collector visited it. In collecting species

growing on bark the minimum amount of damage to the tree should be made and where possible the living tissues of the tree not penetrated.

Accurate determinations of hosts and substrates are always necessary. If there is some uncertainty as to the identity of a host plant adequate material for its identification (i.e. flowers, fruits, leaves) should also be collected. Species are sometimes reported from incorrectly named hosts and collectors should ensure that the possibility of this occurring as a result of their slips is remote. Specimens from particular hosts or substrates in the same locality may conveniently be placed in separate carefully labelled bags. White card or paper slips with the locality and host indicated on them in pencil (ink and biro are not satisfactory as they tend to run and become illegible if the material is damp) may then be inserted into each bag. If paper bags or envelopes are employed these data may be written directly on them but polythene bags or tins are more suitable for collecting damp material. Larger fleshy fungi are likely to be damaged if placed in bags and should be wrapped individually in newspaper and carefully placed in flat-bottomed wicker market-baskets.

If material cannot be examined the same day it is collected it should not be left in a damp condition in air tight containers such as polythene bags but thoroughly dried to prevent the growth of unwanted moulds (saprophytic fungi). Notes on any characters likely to be affected by drying (see below) must be made and placed with the specimens as soon as possible.

The beginner is apt to attempt to collect at random anything which catches his eye but this approach tends to lead to very superficial lists from an area. The mycologist should endeavour to pay particular attention to clearly delimited habitats, hosts and groups, on different visits to a site at as many times of the year as possible, if he wants to acquire a reasonably comprehensive knowledge of the fungi in an area. Most mycologists find it extremely difficult to search for all groups in all habitats at the same time.

Some notes on collecting different groups of fungi and techniques for studying some special habitats are given below. It is not possible to discuss all of these in detail here and the references cited should be consulted for further information. A comprehensive account of procedures for collecting and examining fungi of different groups is currently being prepared by the Mycological Society of America. General accounts of collecting and preservation procedures are provided in the British Museum (Natural History)'s *Instructions for Collectors* no. 10 *Plants* (ed. 6, 1957) and by Savile (1962), Fosberg and Sachet (1965) and Smith (1971).

Fleshy fungi

Fleshy fungi (together with larger woody species often now referred to as 'macromycetes'), particularly the larger members of the Agaricales, are the easiest fungi to observe and at the same time one of the most difficult groups to preserve satisfactorily. Whenever possible several healthy specimens of each species at different stages of development should be collected by digging (*not* pulling) them up so as not to damage their bases. On returning from a collecting trip the material should be examined on the same day and, if it is not possible

to name the specimens, the information on characters likely to be affected by drying must be obtained so that they can be determined later. Habit sketches, measurements, colour of different parts, colour on bruising and cutting the flesh, any exudates on cutting, odour, consistency, spore-prints, and any chemical tests (where appropriate; see e.g. Zoberi, 1972) should all be made at this stage. Accurate descriptions of colour are particularly important and some agaricologists paint their sketches using water-colour paints; 35 mm coloured photographic slides are particularly helpful in this connection. Because of the time needed to obtain this information more material than can be properly documented in the available time should not be collected.

When specimens have been documented properly they can be dried rapidly (e.g. over a radiator) and microscopic characters are usually unaffected by this procedure although the colour, shape and size may change dramatically. A useful technique for preparing herbarium specimens of fleshy fungi by slicing them vertically and drying between blotting paper is described by Bohus (1963).

The most satisfactory method of preserving fleshy fungi, however, is by freeze-drying (lyophilization) as specimens preserved in this way show little change in either colour or shape. Freeze-dried specimens are often fragile and require careful handling although this may be overcome to some extent by dipping them in a polyurethane (2):white spirit (1) solution and drying at 50–60°C (see Onions, 1971; Kendrick, 1969). A method of preparing models of fleshy fungi in epoxy resin for display purposes is described by Parmelee (1971).

Rusts and smuts

Rusts and smuts are amongst the easiest fungi to preserve. Rusts should be searched for on both sides of leaves and smuts in the flowers or on herbaceous stems and fruits which are splitting open. Careful determination of hosts is essential in these groups as identification of the fungus may prove difficult if the host is not known or incorrectly named. In collecting rusts search for teliospores as well as the orange-yellow urediniospores ('uredospores'); teliospores form in discrete patches similar to those forming urediniospores but are brown to black. Rusts and smuts are readily preserved by drying the infected leaves between sheets of newspaper under light pressure.

Ascomycotina

Larger fleshy Ascomycotina (e.g. species of *Morchella* Dill. ex Fr. and *Peziza* Dill. ex Fr.) require treatment as described above for fleshy fungi generally (pp. 14–15) but most are readily preserved by drying them slowly. Many species occur on wood and to collect these a strong sheath knife, secateurs and small saw are required. In some pyrenomycetes the perithecial stromata can persist long after the spores have been discharged. To avoid collecting effete material, which is usually unnamable, slice across the edge of a stroma or the top of a few perithecia; if the locules are producing spores they will be seen with the aid of a hand lens (×10) to be filled with whitish mucilage or have a shiny smooth interior but if the fungus is dead the inner walls of the locules appear dull and mucilage is absent.

Many small ascomycetes grow just below the surfaces of stems, leaves and bark with only their minute ostioles protruding. These are easily overlooked without careful searching but species occuring beneath bark can often be discovered by peeling back the surface layers of the bark with a sharp finger-nail or knife. Dung, straw, dead leaves, twigs and stems are also important habitats to search for ascomycetes. Damp rotting stems and decaying wood often have many small fleshy discomycetes.

Lichens

Corticolous, foliicolous and terricolous lichens are collected by similar methods to those employed in other fungi. When foliose lichens are being collected attempts should not be made to peel them from their substrates as this can damage rhizinae which may be needed to identify them; basal parts of some fruticose lichens also have some diagnostic value and so these should not be torn from their substrates but removed carefully paying particular attention to securing their bases. All specimens collected should be representative of the population from which they are taken. Many species of corticolous lichens often occur on single trees (over 30 species frequently occur on some trees in areas of Britain relatively free from air pollution by sulphur dioxide) and a detailed study of a single tree (particularly bark fissures, tree bases and twigs) with a hand lens ($\times 10$) may be needed to detect many of the smaller species. Lichenologists often spend 20–30 minutes studying an individual tree.

Saxicolous lichens (i.e. lichens growing on rocks) are collected with the aid of a geological hammer (1–2 lb) and small cold-steel sharp masonry chisels ($\frac{1}{4}$ and $\frac{1}{2}$ in). Some rocks are difficult to collect from as they tend to flake and disintegrate on chiselling and in some cases it is necessary to scrape material off with a sharp knife. Tombstones and privately owned walls should not be chiselled and in examining these it is most satisfactory to carry out chemical reagent tests and make slide preparations and notes in the field. Rock samples need to be individually wrapped in tissue paper to prevent their being damaged by rubbing against other samples in the collectors' bag. Some species are restricted to particular rock types and so it is important to examine as many rock types as may be present in an area. Before making field excursions it is consequently valuable first to study a geological map of the area to be visited.

In collecting crustose species on soil or in rock crevices the soil immediately below the material should be removed with the specimen, disturbed as little as possible, and carefully wrapped in tissue paper; it can be very tiresome trying to find ascocarps among soil powder in the corner of a paper packet on returning to the laboratory (see also p. 25).

Lichens of all groups are easily preserved by drying (e.g. over a radiator) and show little change (apart from colour in some instances).

For further information on collecting lichens see Duncan (1970).

Deuteromycotina

The collection of Coelomycetes and Hyphomycetes requires careful searching of dead and living stems, bark and leaves. The procedures involved in collecting