SOME BACKGROUNDS FOR AN OHIO MYCOBIOTA[1]

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ABSTRACT

The fungi are eukaryotic, nonchlorophyllous, reducer organisms which occupy specific niches in all environments. They are integral parts of any ecosystem, natural or artificial, which may be delimited. Some groups have retained their necessity for an aquatic habitat. Others became adapted to terrestrial habitats as dead organic matter became available for them. Almost as soon as it was available, certain fungi developed enzyme systems for degrading highly complex products of producer plants, consumer animals, and reducer fungi. A cataglogue of Ohio fungi, which is greatly needed, is being developed from herbarium records, reports in the literature, and personal collections. Best examples of fungus populations are found in large undisturbed natural areas.

The fungi are a heterogenous group of organisms with broad characteristics which cannot be defined by any quick series of epigrammatic statements which can be sorted out, catalogued, and put to some sort of simplified use, or filed away for future reference. Some may have already noted that many species defy anyone to find the proper niche for quick, accurate filing.

The fungi are reducer organisms which cannot manufacture their own food supplies as the green plants do, nor can they ingest their foods as animal and animal-like organisms do. They are nonchlorophyllous, having no chlorophyll or chemosynthetic pigments. They are eukaryotic, having their nuclear material surrounded in a discrete area in the cytoplasm by a nuclear membrane. In the assimilative stage, the more primitive species have no cross walls in the healthy mycelium, resulting in a coenocytic condition with many nuclei scattered through the cytoplasm. In more advanced species, perforate cell walls are formed and each cell may have one, two, or more nuclei.

The reducer habit is associated with the ability of the organism to absorb food ions or molecules. Exoenzymes are secreted into the habitat in the vicinity of digestible nutrient sources. These break down unabsorbable materials into relatively simple ions or molecules which can be absorbed through hyphal walls and cytoplasmic membranes for further dissimilation and rearrangement within the cytoplasm of the cell.

As with all organisms, the ancestors of today's fungi were probably aquatic. They were probably flagellated and motile. Their zoospores could have ingested food, as could have amoeboid stages, but the fungal mycelium needed to absorb its food supplies. Three classes of aquatic fungi with motile cells are recognized today. Fungi in the *Chytridiomycetes* have zoospores and motile gametes which have one posterior whiplash flagellum; the motile cells of the *Hyphochytridiomycetes* have one anterior tinsel flagellum, and motile cells of the *Oomycetes* have one of each of the whiplash and tinsel types of flagella. These fungi continue to retain their need to live in water even though this may be a very thin film on a surface in soil or in other moist habitats.

Eventually, as habitats for reducer-type organisms became available, the fungi came out of the water and into an aerial environment. It is not certain which group came out first, or from what groups the three principal developmental patterns developed. The *Zygomycetes* continue the coenocytic pattern in the mycelium. A large, thick-walled zygospore, and a variety of methods of prodduction of asexual spores in sporangia are characteristic of this class. In the *Ascomycetes*, the ultimate spore-producing cell, the ascus, contains usually eight

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spores, although thus number may vary down to four, two, or one, or up to 16 or more. The cell subtending the ascus is called a crozier, analagous to the clamp connection in the *Basidiomycetes*, which in the latter class may appear either at every septum, or only in the hymenium, or never. The terminal, spore-producing cell in the *Basidiomycetes* is the basidium, on which there are two to eight, but usually four, sterigmata, on the tip of which a basidiospore is produced within a sacklet. In both these classes, there is a great variety of asexual spore states or imperfect states produced. It is not yet possible to determine whether an imperfect state is merely the result of lack of completion of a life cycle, or results from the production of incompatibility factors resulting from heterocaryosis or parasexual phenomena.

In Ohio, land surfaces have been available for colonization for a long time. It may be assumed, therefore, that habitats for all kinds of reducer organisms have been available for at least that length of time. It may be assumed that conditions which existed at any point on the earth's surface could have been present at any other point within the general developmental period of a land-based fungal population, resulting in such widely varying but common species as *Coriolus versicolor* and *Schizophyllum commune*. In the case of the former, many subspecific categories have been recognized, of which a fair percentage occur in Ohio; in the case of the latter, a single morphological entity, with a multiple genetic pattern of variation not readily translatable into subspecific morphological variants, occurs in Ohio. How long the fungi have been in Ohio is not known. However, if the fact that a fungus can produce the enzymes required to break down the complex molecule of naturally occurring lignin is an indication of physiological complexity, if this relationship is a stable characteristic of a number of species, of fungi, and if a relatively long period of time was indeed required for the development of the characteristic, then *Coriolus versicolor* and other white-rot-producing fungi are very old fungi, and have been in Ohio, and other areas where lignin occurs, for a very long time. This characteristic was of course not required in a marine habitat, nor could it have been useful before the lignin molecule or its precursors came into existence. It would not have been useful under swamp conditions, where decomposer organisms could not have attacked ligneus tissues lying under water and soaked by water. Maybe lignin-reducing enzymes did not exist until after the time of the coal measures, and after the oil and the gas pools had been formed. Lentz and McKay, in Davidson, *et al.* (1960), described *Stereum taxodii* from *Taxodium distichum* in southern United States. This fungal species is now placed in the genus *Echinodontium* by Gross (1964). Aoshima *et al.* (1961), showed that this species is also present in Japan and Formosa on *Cryptomeria*, *Torreya*, and *Chamaecyparis*. If it is true that pockets, apparently produced by a pocket rot, in *Araucarioxylon* from the Petrified Forest National Monument, Arizona, were probably produced by this fungus, then it is one of the older fungal species whose progeny continue to produce white pocket rots in coniferous woods.

Today in Ohio, Ellett (1957) has estimated that there are 5000–6000 species of fungi. It is true that only a few of these are able to attack more complex natural organic compounds such as lignin, but with more than 2000 species of producer organisms, and a large number of species of consumer organisms, each producing or reassembling organic compounds throughout its existance, and with man's ability to take these products of producers, consumers, and decomposers and produce additional compounds, many of which are deliberately designed to be nonbiodegradable, the complexity of the problem facing the modern decomposer organisms is formidable.

For a number of years, I have been engaged in the preparation of a list of the fungi of the State of Ohio. It has always seemed to me that it is important to know what organisms are in an area in which work is being carried out. At first this took the form of a collection of Hamilton County and Clermont County specimens during undergraduate days under Dr. Margaret Fulford at the University of Cincinnati. This grew into a more broadly based survey, reaching into Adams, Highland, and Hocking Counties, in a program largely supported by the National Youth Administration. The complete survey of the species of fungi in Ohio is still hardly more than a dream, but a start has been made by compiling the available information, a project in which I am still actively involved.

Fungi have been collected in Ohio since about 1832, or for at least 140 years. Collecting activities have been concentrated in areas near institutions of higher learning, or near centers of high population. The people involved in these collecting activities rarely had complete surveys in mind. While Grover at Oberlin (according to herbarium records) apparently wanted to get as complete a series of the fungi of western Lorain and adjacent Erie Counties as possible, Fullmer at Baldwin-Wallace College reported on the "Myxomycetes of Ohio" (1921), which is fine if one considers "Ohio" as the handful of counties (Erie, Lorain, Hamilton, Licking, Hocking, Summit, Jefferson, Cuyahoga, Columbiana, Lucas, "common" and "everywhere") from which the species were listed. Grover and his colleagues and students collected relatively regularly in a defined area; Fullmer collected in a restricted area, but added published and herbarium records of others in the State. Correspondents of C. G. Lloyd (1898–1925) sent specimens to him for identification as a result of casual collection, for satisfaction of intellectual curiosity, and for a subscription to "The Mycological Writings of C. G. Lloyd" (1898–1925). Grover's open-ended research unfortunately never resulted in publication, but Fullmer's project was published (1921), and forms one building block in a list of 191 species of Myxomycetes of Ohio which is still incomplete for Ohio. Fewer than half the counties of the State have had species of Myxomycetes reported from them.

In one other group of saprobic fungi, an effort was made to list all the species of the state. Overholts' (1911) "The known Polyporaceae of Ohio" was as complete a survey of a group of fungi (the pore fungi) as has been made. In the first edition (1911), a B.S. thesis or report from Miami University, the nomenclature followed that of Murrill (1907–1908). C. G. Lloyd's violent reaction (Cooke, 1954) to this resulted in a treatment which is still used in the taxonomy of these fungi in North America: the volume "Polyporaceae of the United States, Alaska, and Canada" (Overholts, 1953). In contrast, Stover's "Keys to the Agaricaceae of Ohio" (1912) is a summary of the information available from the literature and from his own collections, of the author's undergraduate and early graduate experiences with the fleshy fungi, stated in terms of 1912 understandings of the systematics of these fungi. At the State level, it has never been brought up to date.

Except for summaries of specific groups of plant pathogens published in recent years by Ellett (1959, 1966, 1970), Shelby's (1910) summary of Ohio plant diseases remains a comprehensive although partial list of Ohio's plant pathogens, mostly restricted to those of cultivated plants or native plants under cultivation. Williams and Schmitthenner (1956) have summarized those genera of moulds found in Ohio soils in the vicinity of Wooster. Species names have been used for many of these in work done with moulds in organically enriched soils, waters, and stream banks and sediments by Cooke (1957, 1972) at Cincinnati.

The development of a comprehensive list of the fungi of Ohio is being produced by me from three types of basic data: published reports, herbarium records, and personal collections. The casual perusal of each of these sources leads to the conclusion that in most cases the reporter or monographer worked from material known to him on the basis of armchair research, or of his personal experience with a specific problem in a restricted area extrapolated to a portion of the state or to the whole state. For instance, if a fungus is listed from Hamilton, Hocking, and Geauga Counties, it may have been assumed to have occurred generally throughout the state, regardless of variations in habitat conditions and without further search.

The study of populations of organsims normally results in their being arranged in associations and in various other types of community groupings, something I did in my studies of fungal associations in the northern Rocky Mountains (Cooke, 1955). It is known that separate species, and even individuals, have specific effects on other members of a population, and are affected in characteristic ways by other members of a community. It is relatively easy to determine these characteristics in the cases of many of the individual fungi, but it is less easy to identify the nature of the associations, or communities into which fungi appear to be grouped, in relation to their cooperative, competetive, or antagonistic roles under natural conditions. Presently, on the basis of published records, it is not even possible to determine the identities of most of the members of the fungal associations found in forests, woodlands, oldfields, grasslands, meadows, pastures, or field soils. Neither is it practical to determine the species, or even the genus, to which one should assign most of the less obvious fungi occurring on or in rotting wood.

According to Mason and Langenheim (1957), "the environment of any organism is the class composed of the sum of those phenomena that enter a reaction system of the organism or otherwise directly impinge upon it to affect its mode of life at any time throughout its life cycle as ordered by the demands on the ontogeny of the organism or as ordered by any other condition of the organism that alters its environmental demands." Thus, a protective slime layer, or the inability of a cell wall or membrane to accept a substance for transport, leaves such substances outside the operational environment of the organism possessing such protective devices (Cooke, 1971).

A recent question has suggested a direction toward which such reasoning might go. This may be stated: What mycological reasons are there for preservation of natural areas? A successional sequence in the reducer organisms, with special reference to the saprobic fungi, starts with a living or recently dead piece of organic matter and proceeds through a series of stages to a terminal stage in which there is only a residue of humic acids which are relatively slowly decomposed by certain organisms thought to include certain types of mushroom-producing species of fungi. It is not a simple matter to spell out this succession of fungal organisms. For instance, on a beech log in the forest, the first noticeable fungi are fruit bodies of Hymenomycetes and species of *Hypoxylon*, which were present on the standing trunk and whose assimilative mycelium had contributed to heart-rot, butt-rot, and root-rot conditions. This may include *Armillariella mellea*, *Pleurotus ostreatus*, and species of *Pholiota*, among the agarics; a dozen or more polypores, and several hydnoid, thelephoroid, and other fungi. As the process of decay continues, the organisms responsible for these rotting conditions may fruit—and these include agarics, polypores, and hydnoid, thelephoroid, and tremellaceous fungi. Other members of these groups, as well as a number of types of mould fungi, continue the process until nothing but a pile of humicolous material is left. This material, probably composed mostly of humic acids and lignins, is slowly decomposed by a number of fungi. Fungal species with this overlapping series of stages are known but vaguely; that is, as two examples, at what point *Ischnoderma resinosa* enters the system and then exhausts its nutrient supplies is not definitely determined, nor are these conditions known for *Pluteus cervinus*. Neither are the amounts of the types of nutrients required by each species known.

The removal of such habitats, or of any potentially decomposable habitat, automatically eliminates mycological habitats, and probably species of fungi. In addition, some plant-pathogenic fungi are eliminated on purpose in order to "protect" certain plants in a habitat, which could also have an adverse effect on other members of both the fungal and other kinds of biota.

Preservation is of greatest concern when species are threatened that are rare, or are beneficial. Although specific data have not been developed, it may be said the certain soil fungi, as well as other species of fungi, are indeed rare. Thus these species certainly deserve preservation, as do "beneficial" species of fungi, which are best preserved by the preservation of the areas in which they occur. Most fungi are beneficial. Most facultative plant pathogens are saprobic during parts of their life cycles when they aid in the removal of dead organic matter, making available the elements, ions, and compounds into which this organic matter is decomposed to the succeeding generations of producer organisms. Most human pathogens probably carry out similar processes on keratinophilic materials. The truly saprobic fungus reduces whatever substrate it attacks to mineral elements and to more readily available ions and compounds. The mycorrhizal fungus, in addition, makes available to the roots of its host plant many required nutrients which that plant could not otherwise obtain. In most cases these fungi are associated with rotting vegetable or animal debris. Unfortunately we know little about their physiology or cultural characteristics, outside of laboratory pure-culture experiments with primary wood-decay fungi. If they are seen again in the same area, it is on a different piece of decaying matter which, itself, is being reduced to zero. Thus many fungi are beneficial and, with those species that might be called rare, are deserving of preservation, accomplished by preserving the fungal habitats.

Within a complete ecosystem, however, all kinds of fungi characteristic of the total population are important. Representatives of all the major groups, parasites or pathogens, saprobes, saprophytes, or saprogens, perthophytes or perthogens (fungi living on dead parts of living organisms), and mycorrhiza formers (species which form mycorrhizae or "fungus-roots" with vascular plants, and with gametophytes of Bryophytes and Pteridophytes), are all necessary parts of the system, which could not complete its various cycles without their several activities. At this stage of our knowledge, from man's point of view (not that of the fungus), the best that can be said about the mycological usefulness of a natural area is that it gives us a basis for learning about the kinds of fungi which inhabit particular reserved natural areas in the State, and something about their activities therein. Such information can be used in developing knowledge about adjacent areas, and possibly for reconstructing vegetation patterns in these and other areas. The careful collector, who should obtain specimens as a record of species populations, should also obtain as much habitat information as possible: the type of soil and its parent materials, the kind of wood, the kind of woodland, the trees and other plants of the community, and whatever other information appears pertinent.

Any single rare fungus species can knowingly be preserved, probably, by preserving a large enough area, if size is of importance, so that sufficient potential habitat is available for development of its progeny. Such habitat should be as similar as possible to that in which the fungus was first found, and it should remain in as undistrubed a state as possible. Since fruiting cycles may be irregular rather than annual, fruit bodies may not be observed regularly, and it should not be assumed that the species has died out if it is not seen every time it is looked for.

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