THE FOSSIL RECORD OF THE FUNGI

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ABSTRACT

The assumption that the fungi lack a useful fossil record is dispelled by reports of approximately 500 fossil species. They are summarized here according to one taxonomic treatment and are presented in tabular and graphic form. In addition, a comprehensive bibliography of the fossil fungi is presented. A careful consideration of the preservation and occurrence of fossil fungi reveals that caution must be used in their interpretation. It is also concluded that the fungi were probably more numerous and diverse in the geological past than is generally recognized.

INTRODUCTION

Study of the fossil record, with reference to the evolutionary history and diversity of the fungi, has been minimal. This neglect is due to the unfounded assumption that the fungi lack a fossil record of sufficient scope to be of importance. In fact, approximately 500 species have been described from a broad range of taxonomic categories. The paucity of active investigators in the field, and a general unfamiliarity with the fungi among paleontologists, is largely responsible for this. Various considerations suggest that the number of fossil fungi now known is significantly smaller than the number awaiting discovery, implying that the range and diversity of fungi in geological time is far greater than has been suspected.

The present paper offers a presentation of the known fossil fungi, their preservation, distribution, identification, and classification. Attention is called to a number of external factors that may influence the interpretation of the fossil record. The most impressive general conclusion is that fossil fungi, for the most part, are still awaiting serious investigation.

THE RECORD

Paleomycology has, to some extent, been ignored because of the numerous difficulties surrounding the identification of fossil fungi. The majority of the researchers in the fields of paleozoology and paleobotany are not versed in mycology, and as a result, many promising remains are undoubtedly dismissed as extraneous contamination of the material under investigation. The few workers who are mycologically knowledgeable are likely to notice only fungi discovered in conjunction with some other material more central to the investigation; thus some of the most commendable work (Dilcher, 1965; Dennis, 1970; Scott, 1956) has resulted from studies initially directed at other plant parts which served as the fossil substrate.

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The paleomycological record is consequently compiled not from a systematically assembled body of data, but from an accumulation of chance discoveries. On this basis alone, a paleomycologically oriented research program would do much to increase our knowledge of the fossil fungi.

Interpretational problems are complicated by the varying morphology and composition of the fungi which selectively influence the fossil record. The preservation of smaller hyphae and fruiting structures in wood or on leaves is far more likely than is the preservation of the larger and more ephemeral "mushroom" structures. Predictably, the majority of the reported fossil forms are small fructifications or hyphal strands which frequently are without distinguishing characteristics. Consequently, some are attributed to a given taxon on the basis of a vague resemblance resulting in identifications of a rather tenuous quality.

Of a similar nature are the "wastebasket" or catchall taxa, typified by the genus *Sphaerites* (here dealt with in the order Sphaeriales of the Ascomycetes). The genus comprises a compilation of over a hundred reports of specimens fulfilling Unger's description "Perithecium v. receptaculum innatum rotundatum integrum ostiolo perforatum" (Meschinelli, 1902). Even Meschinelli was driven to note "Omnes species dubiae" with reference to this genus. However, one cannot ignore these reports without first reinvestigating them. A related, though relatively rare, problem is where imagination has apparently been used to identify suggestively shaped fossils as fungal in nature. A classic example is *Dactyloporous* (Herzer, 1893) of the American Carboniferous, which is highly questionable both as to description and illustration.

The greatest portion of the presently known fossil fungi were described prior to 1900, and catalogued by Meschinelli in 1902. In these, as in subsequent reports, one can only trust the judgment of the initial investigator. It is probable that many of the initial reports contain errors, particularly in light of more recent advances in mycology. However, the probability of a described specimen not being of mycological affinities is small, since the majority of 19th century botanists were no less meticulous than those of today.

Perhaps the most pervasive source of error in the literature results from changes in taxonomy since initial publication and because past investigators did not all follow one taxonomic scheme. Examples of subsequent taxonomic changes are many: e.g., various algae reported by Duncan (1876) are now classified as Phycomycetes. Certain specimens initially placed in the Hemisphaeriales (Ascomycetes) are now in the Chytridiales (Phycomycetes) following closer examination of the material (Bradley, 1967). These changes are not limited to the work of the last century; some have affected research as recent as that of Dilcher (1965). It is hoped that these problems will be resolved by summary publications

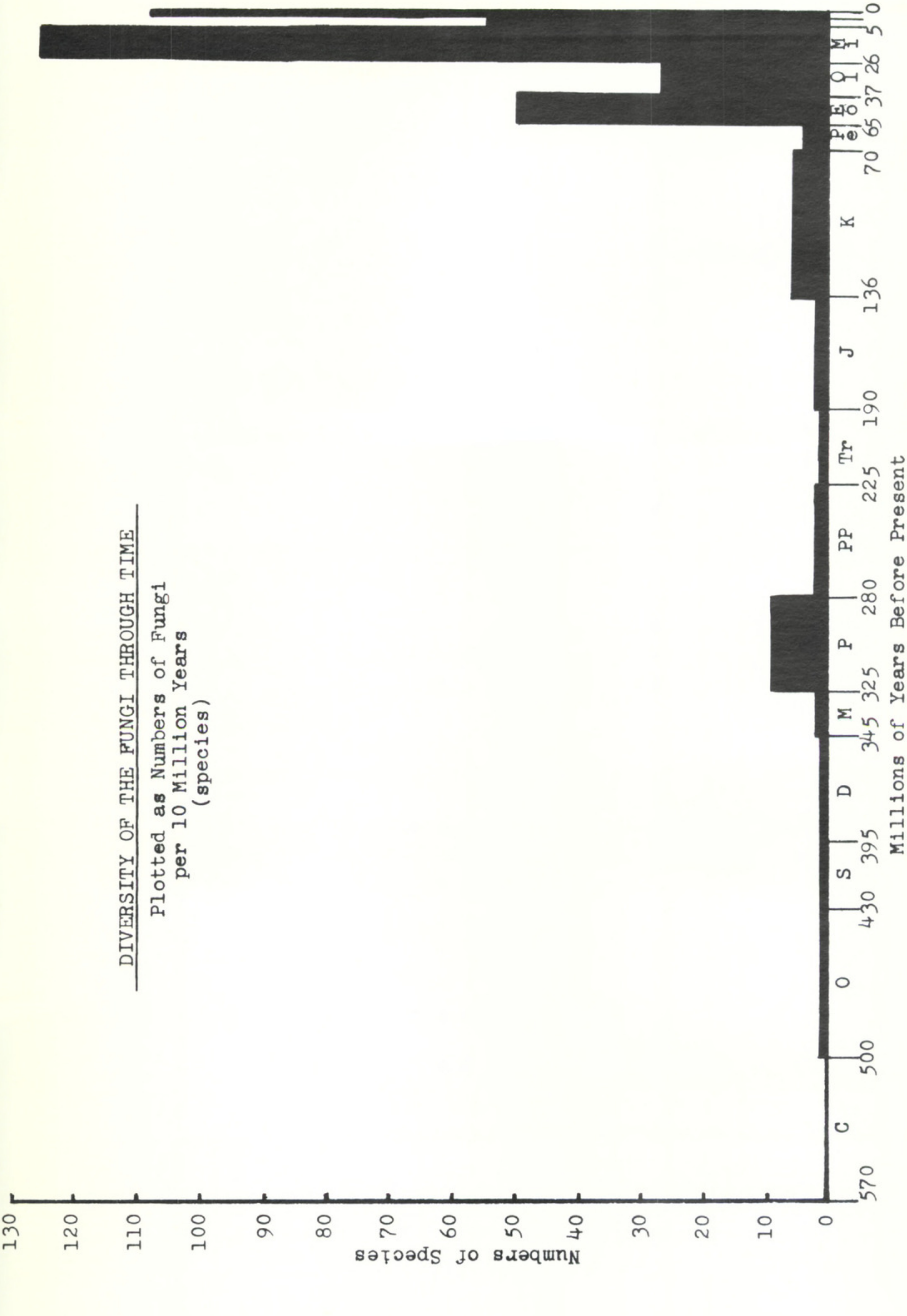

FIG. 1. Diversity of the fungi through time.

updating the taxonomy and uniting the separate treatments of the fossil fungi into one taxonomic framework.

A need exists for a purely taxonomic revision of the fossil fungi. An effort in the reduction of synonomy has been made by Krausel (1961), but only three species of Ascomycetes were involved. Holm (1959) noted that approximately 25 of Meschinelli's generic names are *nomina nuda*, and require taxonomic attention. In terms of pure "housekeeping" much remains to be accomplished.

It is difficult to establish completely acceptable criteria for the identification of fossil fungi because they are only rarely found in the sexual state. Thus the identification of much fossil material is based solely on vegetative morphological characters rather than physiological or sexual ones, and undoubtedly introduces some errors in identification. But it is a problem familiar to paleobotanists and must be accepted.

Workers in coal petrology have cited the existence of coals primarily composed of sclerotia, hence the term "sclerotinite" (Alpern, 1960). Though sclerotinites are claimed by some to occur in Carboniferous coals (Duparque & Delattre, 1953a; Havlena, 1956; Stach & Pickhardt, 1957; Benes & Kraussove, 1964), others feel that only Cretaceous and Tertiary sclerotinites are primarily fungal in origin (Schopf, 1952; Taylor & Cook, 1962). It is not inconceivable that future work might reveal a considerable number of fungi to be present in Paleozoic coals.

In summary, detailed systematic investigation is needed, both to reveal new material and to locate and redefine described species. Mycologically oriented investigations of many fossilizing environments, coal balls for example, will probably reveal new fungal organisms. Careful examination of published fossil floras will likely uncover previously ignored material. Such efforts, coupled with a standardized approach to identification and taxonomy, will improve the fossil record of this neglected group of plants, shedding light on their evolution and on life of the past.

FACTORS INFLUENCING DISTRIBUTION

Perhaps to a greater degree than other branches of paleontology, paleomycology offers but a sketchy picture of the past fungal flora. The survival of a relatively small number of specimens implies a greater likelihood that external factors have influenced the distribution, and hence the interpretation, of the fossil record. It is necessary to identify these factors and their effects to interpret the evolutionary record correctly.

Chief among these factors is the geological distribution of individual fungi as influenced by their specific supporting substrates. Thus the increased numbers and diversity of the fungi in the Eocene and Miocene reflect the increased numbers and diversity of preserved plant remains, and the lack of Triassic and Paleocene fungi results from the paucity of preserved substrates from these periods. This time-distributional control is clearly evident in Fig. 3. Presumed wood-rotting fungi predominate in the Pennsylvanian, endozoic fungi in the Paleozoic and epiphyllous fungi in the Eocene and Miocene, supporting the assumption that the number of known specimens represents only a fraction of the total number of preexisting fungi.

Another factor is the preference of the individual investigator. The concentration of interest in Tertiary leaves serves to inflate the epiphyllous fungal flora of that period. Similarly, the considerable attention given to the microscopic study of Pennsylvanian woods, in comparison to the small amount of microscopic work done on leaves of the same period, serves to tilt the Pennsylvanian fungal record toward wood-rotting fungi. The relatively high incidence of reported endozoic marine fungi in the Paleozoic may reflect a greater emphasis on microscopic study of marine organisms of that era.

A commonly appreciated factor among paleontologists is the differential probability of preservation based on initial size and composition of the organism. Small, well-protected forms, which grow within their substrates, are favored in the fossilizing process, as is borne out by their dominance in the fossil record. Very few macroscopic fungi, woody or fleshy, are known as fossils. The presence of solitary specimens such as the Jurassic polypore (Singer & Archangelsky, 1958) or the Oligocene *Geaster* (Cockerell, 1908a) is sufficient to indicate an advanced state of Basidiomycete evolution during those times. It is quite likely that the smaller, commonly reported forms coexisted with large fleshy forms that were less predisposed to preservation, and hence are not known as fossils.

In summary, it is unlikely that the known distribution of numbers and species of fossil fungi is a correct reflection of the process of evolution. It is equally unlikely that the known geologic distribution of the fungi is totally an artifact of external, non-mycological influences. Undoubtedly both evolution and external factors have combined to yield the known record. It is with an active acceptance of this fact that the paleomycological record should be interpreted.

MYCOLOGICAL EVOLUTION AND THE FOSSIL RECORD

Perspective. The lack of a fossil record has often been cited as the reason for basing evolutionary considerations of the fungi entirely on the extant flora (Bartnicki-Garcia, 1970; Martin, 1968; Savile, 1955, 1968). It is true that the paleomycological record is too scanty to allow the erection of a phylogeny based solely on the fossil evidence. However, the fossil record is not without significance, and any postulated evolutionary scheme must take fossil species and their geological occurrence into account. A brief consideration of the major fungal groups, in which the paleobotanical perspective prevails over the purely mycological, will serve to illuminate this statement.

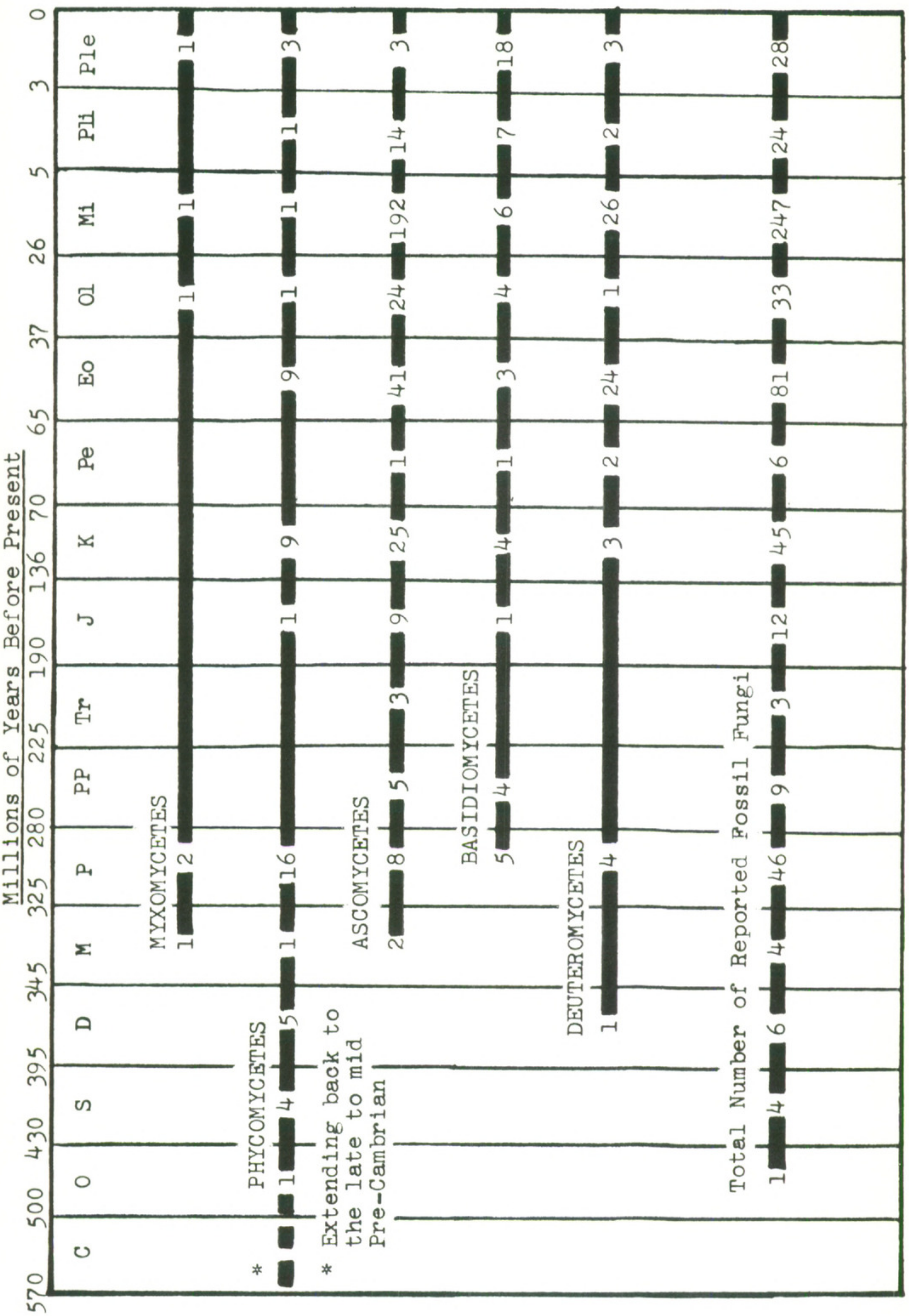

FIG. 2. The classes of fungi in geologic time.

The fact that the first land appearances in geological time of four out of the five major classes of fungi (Fig. 2) are approximately synchronous, precludes any theoretical derivations of one group from another, based solely on fossil evidence. However, the distinct and diverse nature of the five major groups in the Carboniferous suggests considerable previous evolution. Only the Phycomycetes have an extended record, certainly reaching back to the Ordovician (Elias, 1966) and perhaps as far back as the late Pre-Cambrian (Tyler & Barghoorn, 1954; Timofeev, 1970). It seems most probable that future research will reveal more early Paleozoic fungi, and thereby clarify evolutionary relationships. It is also possible that extinct groups will be discovered, the existence of which could fill phylogenetic gaps or suggest new relationships. These would prove highly useful if recognized as entirely new entities, but if forced into preconceived evolutionary positions, their significance would be lost.

Myxomycota. The fossil record contributes little to the understanding of this confusing group of organisms, save to indicate that the class Myxomycetes extends back to at least the Pennsylvanian (Fig. 4). No suggestion as to possible protozoan origins of the group can be derived from the fossil record. Recent promising work has been directed towards correlating Myxomycete spore morphology with taxonomy for the purpose of palynological investigations (Graham, 1971).

Phycomycetes and the origin of the Eumycota. Various organisms have been proposed as the progenitors of the earliest fungi, including the algae and the protozoans (Margulis, 1970; Martin, 1968). The frequent and widespread occurrence of non-septate, hyphal-like filaments of a consistent morphology in the late Pre-Cambrian (Tyler & Barghoorn, 1954; Schopf, 1968, 1970a, 1970b; Schopf & Barghoorn, 1969; Schopf et al., 1973; Timofeev, 1970, among others) suggests an early origin of phycomycetous fungi (Fig. 5). Their presence is not surprising since such simple heterotrophs are a necessity in any functioning ecosystem.

The possible presence of Phycomycetes in the two billion year old Gunflint Chert (Tyler & Barghoorn, 1954) would represent one of the first occurrences of Eukaryotes and might suggest a Prokaryotic ancestor to the group. Recent literature tends to favor a protozoan over an algal origin for the fungi. Such a theory cannot adequately be judged from the fossil record since protozoans, lacking hard parts, are not preserved. If the Gunflint entities are indeed fungi, they would seemingly predate the green algae, and coexist with the bluegreen algae, thus limiting possible algal ancestors to the bluegreens. Even without supporting evidence at present, the possibility of an independent origin of the fungi from a Prokaryotic ancestor should not be overlooked. The existence of two biosynthetic pathway lineages within the fungi has been noted (Bartnicki-Garcia, 1970), and might suggest a possible dual origin for the organisms classed as fungi. The biochemical nature of this distinction precludes any application of it to the fossil record.

The lower Paleozoic diversity of recognized Phycomycetes, two orders reported by Silurian time (Duncan, 1876; Elias, 1966; Taylor, 1971) and a third by the Pennsylvanian (Elias, 1966; Renault, 1896a), suggests a considerable preceding period of evolution. Further indirect evidence may be gleaned from the assumed derivation of the Ascomycetes from the Phycomycetes. The high diversity of Ascomycetes in the Pennsylvanian (six out of a possible eleven orders) suggests a previous extended evolutionary history which in turn suggests an early Paleozoic age for the phycomycete-ascomycete link, and consequently the antiquity of the presumably well-developed phycomycetous ancestor.

Ascomycetes. The proposed ancestors for the Ascomycetes have included both the Phycomycetes and the red algae (Fig. 6, 7, 8). The Phycomycetes are known from the late Pre-Cambrian, and the red algae may be as old as one billion years and are putatively known from the Cambrian (Schopf, 1970). Discounting the ascus-like structure found in the one billion year old Skillogallie Dolomite (Schopf & Barghoorn, 1969), the earliest possible Ascomycete is known from the Mississippian (Smith, 1884) and the first definite specimen from the Pennsylvanian (Batra, 1964). Thus the existing fossil record sheds little real light on this problem.

The theory of Savile (1955, 1968) that the earliest Ascomycetes resulted from the selective pressures for airborne dispersal upon Phycomycetes parasitic within early land plants is a most intriguing one. Assuming such an origin, it is not impossible that the relatively high diversity of Carboniferous Ascomycetes might represent an adaptive radiation from a Devonian origin rather than a long previous evolutionary history. The fossil record does not dispute this theory, but a search for earlier aquatic Ascomycetes should be made. The presence of Devonian Deuteromycetes does suggest pre-Carboniferous Ascomycetes, but does not elucidate the present problem, as these Deuteromycetes do not predate the appearance of land plants.

Within the class, the fossil record supplies a discouragingly small amount of information. The floridean algae and protozoan schools of ascomycete origin favor different orders as being the most primitive within the class. Some of these orders are present in the fossil record but in such small numbers as to limit even the most speculative conclusions. For example, the protozoan school favors the Taphrinales as the ancestral order, but the existence of one probable Mississippian specimen does not constitute strong evidence.

The burst in numbers and diversity of Tertiary fungi has been attributed to the appearance of Angiosperms and a subsequent adaptive radiation of fungi (Graham, 1962; Newell, 1962). This increase can be construed in part as a response of rapid speciation by certain Ascomycetes to the new epiphyllous habitat offered by the Angiosperms. As previously noted, the numbers of reported fungi are influenced by the numbers of leaf deposits and associated researchers that worked on the Tertiary material. In truth, the burst in numbers of fungi is primarily confined to three orders: the Sphaeriales, Phacidales and in part the Hemisphaeriales, all within the Ascomycetes. No similar increase in numbers can be found in any other fungal taxon during the Tertiary. Thus, though the Tertiary does present a greater number of new species of fungi, they are primarily found in one substrate-controlled group. It would seem probable that mycological evolution and speciation may have increased slightly in the Cretaceous and Tertiary in response to the new habitats offered by the evolving Angiosperms. However, this increase in evolutionary rate certainly does not parallel the enormous rise in numbers of reported fungi that characterizes the Tertiary.

Basidiomycetes. The hypothetical basidiomycete ancestor has been ascribed to the Phycomycetes (Bartnicki-Garcia, 1970) and to the Ascomycetes (Bessey, 1950; Savile, 1955, 1958). Again, the fossil record provides scant evidence for either theory. The first fossil Basidiomycetes are from the Pennsylvanian (Renault, 1896a; Dennis, 1970), and the group is poorly represented throughout geologic time (Fig. 9). Savile (1955) has postulated derivation of the Basidiomycetes from the external budding of environmentally stressed Taphrinales (Ascomycetes). Assuming that this enhanced their dispersibility, he suggested that the Basidiomycetes underwent a Cretaceous radiation to the new habitats provided by the Angiosperms, in much the same way as had been postulated for the Ascomycetes in the Devonian. The presence of clamp connections in the Pennsylvanian (Dennis, 1970) would indicate that such a derivation of the Basidiomycetes occurred shortly after the rise of their ancestral Ascomycetes. It thus might be that the Cretaceous radiation of the Basidiomycetes noted by Savile is actually a function of substrate preservation, similar to that discussed with respect to Tertiary Ascomycetes.

Although the Basidiomycetes are poorly represented in geologic time, the actual status of the group is not to be judged by numbers, but by individual specimens. The presence of a Jurassic polypore (Singer & Archangelsky, 1958) and an Oligocene *Geaster* (Cockerell, 1908a) indicate the probable existence of a host of unseen, earlier, advanced basidiomycete forms. It would appear that the Basidiomycetes have suffered disproportionately in the preservational process, and are underrepresented in the record. Thus only a few "windows" reveal the actual advanced levels of evolution that were present.

The contemporaneous existence of the Taphrinales (Ascomycetes) and the Uredinales (Basidiomycetes) might be construed as support for the ascomycetous origin of the Basidiomycetes (Savile, 1965, 1968). However, only one member of each group is present in the Pennsylvanian. Leppik

(1955, 1965, 1967) has proposed a theory of the coevolution of the Uredinales and their hosts through geologic time, according to which the most primitive uredinalian forms are found on ferns, the intermediate forms on gymnosperms and the most highly advanced forms on angiosperms. He has also suggested that uredinalian morphology has evolved in response to climatic change. Both ideas might derive further support from careful examination of fossil material.

The history of one of the most interesting basidiomycete groups, the Gasteromycetes, is equally clouded by lack of data. The presence of *Geaster* in the Oligocene (Cockerell, 1908a) does not disqualify Savile's theory (1968) that the group arose in response to Tertiary climatic fluctuations. But, as this is one of but two reported Gasteromycetes, any theory remains highly speculative. Associations of an apparently mycorrhizal nature have been noted in fossil material extending back to the Pennsylvanian (Weiss, 1904; Halket, 1930; Butler, 1938; Andrews & Lenz, 1943) and the Devonian (Butler, 1938; Boullard & Lemoigne, 1971). The difficulty of differentiating pure parasitism from a mycorrhizal association in fossil material has yielded disagreement on the nature of these fungi (Cridland, 1962).

Deuteromycetes. If Deuteromycetes (Fig. 10) are regarded as species having unidentified sexual cycles (Alexopoulos, 1962) then no evolutionary significance can be attributed to the group as a whole. If they are interpreted as a distinct group which has lost the ability to reproduce sexually, their fossil record assumes greater interest. The use of the modern group as a repository for mycological organisms of uncertain affinities may have influenced the placement there of some equally uncertain fossil organisms.

If identifications are assumed to be correct, two facts are worthy of note. The first is that the group had early origins in the Devonian (Gruss, 1928), perhaps indicating both the early specialization of the loss of sex and the undiscovered existence of earlier Ascomycetes. The second fact is derived from the Tertiary period, where the rise in numbers of Deuteromycetes parallels the rise in numbers of Ascomycetes. If most Deuteromycetes are simply Ascomycetes of which the sexual cycle is unknown, this increase could be the result of greater quantities of leaf substrate, a function previously noted with reference to the Ascomycetes.

SYSTEMATIC ANALYSIS

The following is a compendium of the genera of fossil fungi reported through 1972. The figures give a graphic representation of the geological distribution of the various taxa. The taxonomic system utilized, that of Ainsworth (1961), was selected because of its availability and general acceptance, rather than for any inherent or implied evolutionary relationships.

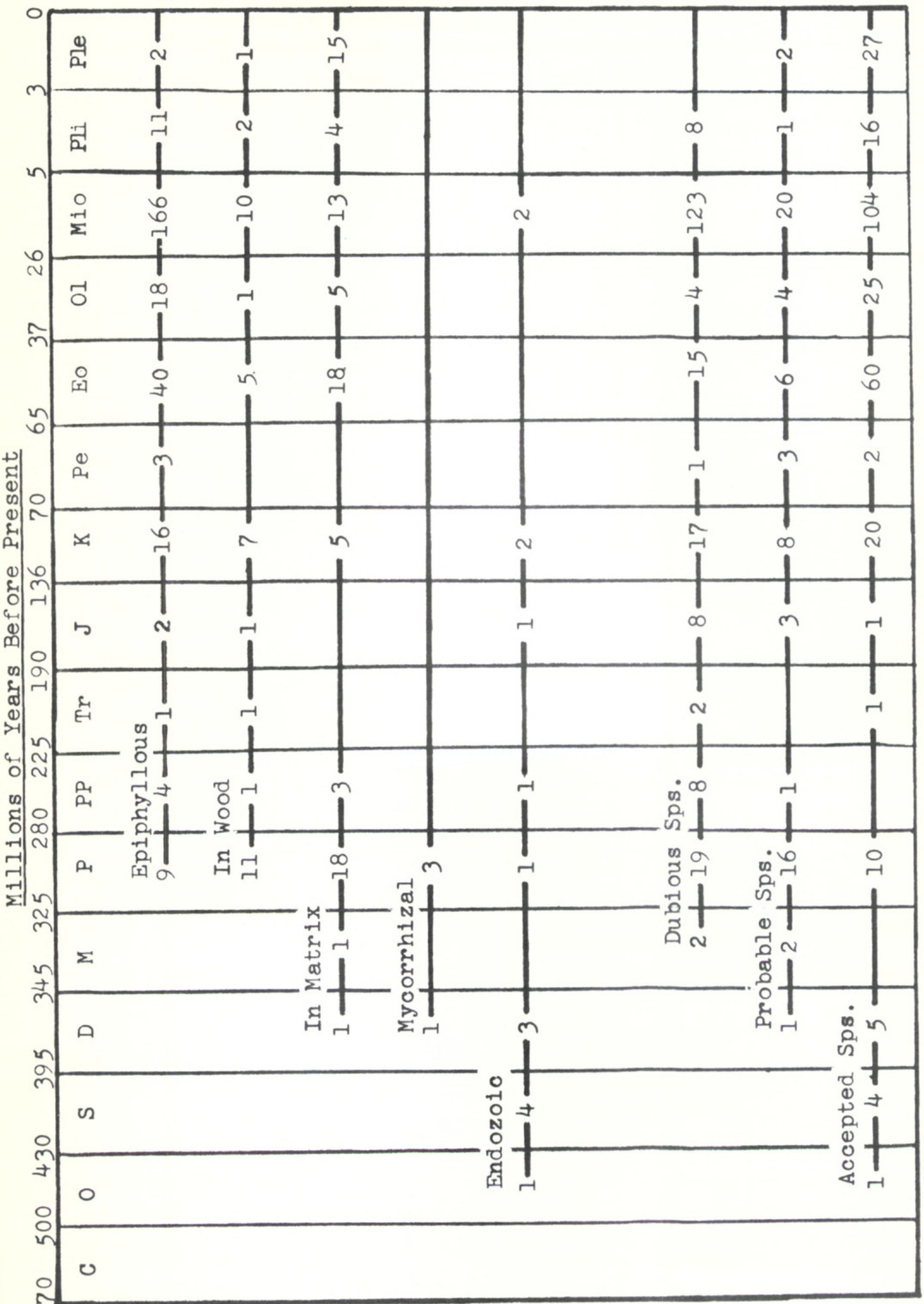

FIG. 3. Upper 5 ranges: distribution of fungal species with reference to substrate in geologic time. Lower 3 ranges: distribution of dubious, probable and accepted fungal species in geologic time.

In the systematic list of fossil fungi each generic name is followed by the number of reported species, their geological ages, substrata, reporting authors and a judgment on the validity of the identifications. The latter is dealt with in three categories:

(1) Accepted–indicating that the taxon has been acceptably identified, as judged from the supporting literature;

(2) Probable–indicating that the supporting material is minimal in some respect, but that the identification is likely correct;

(3) Dubious–indicating that the taxon is suspected of being clearly misidentified.

A graphic presentation of the frequency of each of these categories in geological time is presented in Fig. 3.

The abbreviation E.A. for substratum indicates that the specimen was preserved on fossil angiosperm leaves, and thus was assumed to have had an epiphyllous habitat. A preponderance of the pre-1900 citations were derived from Meschinelli (1902) who compiled the last great survey of the fossil fungi. Further reference to many of these citations can be found in his book, or in his contribution to Saccardo's work (Meschinelli, 1895).

A visual exposition of the five major classes is presented in Fig. 2, and of the orders and their families in Figs. 4-11. In each order and family, the number of reported specimens in each geological period is indicated by a numeral. Where a species is found in more than one period, it is tallied for both. The extension of a taxon's range by dubious species is indicated by a broken line where not masked by coexistent accepted species. The inclusion of reports distinguished only to class or order means that the numbers of reports in higher taxonomic categories will frequently exceed the total number of reports in the included lower taxa.

MYXOMYCOTA

MYXOMYCETES

STEMONITALES

No family

Stemonitis. Tertiary, Baltic amber, Domke 1952. Accepted.

TRICHEALES

No family

Trichea. Pleistocene, in matrix, Graham 1971. Accepted.

NO ORDER

Unnamed. Mississippian, in matrix, Cash & Hick 1879. Dubious.

Bretonia. Pennsylvanian, in matrix, Bertrand & Renault 1892. Accepted.

Mixomycites. Pennsylvanian, in matrix, Bertrand & Renault 1892, Graham 1971. Dubious.

Unnamed. Oligocene, spore, Graham 1971. Accepted.

EUMYCOTA

PHYCOMYCETES

CHYTRIDIALES

Olpidiaceae

Pleotrachelus. Eocene, in matrix, Bradley 1967. Accepted.

Phylyctidiaceae

Entophlyctis. Eocene, in matrix, Bradley 1967. Accepted.

Physodermataceae

Physoderma (Urophlyctites). Pennsylvanian, *Alethopteris,* Magnus 1903. Probable.

No family

Unnamed. Silurian, endozoic in Phyllocarid, Taylor 1971. Accepted.

Unnamed. Devonian, endozoic in Placoderm, Taylor 1971. Accepted.

Unnamed. Devonian, endozoic in *Lingula* shell, Taylor 1971. Accepted.

Grilletia. Pennsylvanian, on seed, Oliver 1903. Probable.

Unnamed. Pennsylvanian, on seed, Oliver 1903. Accepted.

Oochytrium. Pennsylvanian, *Lepidodendron* wood, Renault 1893, 1896a. Accepted.

Chytridineae. Pennsylvanian, *Lepidodendron* cortex, Renault 1896a. Dubious.

Unnamed. Cretaceous, endozoic on brachiopod, Taylor 1971. Accepted.

Caenomyces. 7 species, Eocene, E.A., Berry 1916b, 1924. Accepted. 1 species, Pliocene, E.A., Hollick & Berry 1924. Accepted.

SAPROLEGNIALES

Saprolegniaceae

Palaeachyla. 2 species, Silurian, endozoic in coral and foram, Duncan 1876a. Accepted. 1 species, Devonian, endozoic in coral, Duncan 1876a. Accepted. 1 species, Pennsylvanian, endozoic in coral, Etheridge 1891. Accepted (claims that a spore swarm is present). 1 species, Miocene, endozoic in coral, Duncan 1876a. Accepted.

Achylites. Silurian and Tertiary, endozoic, Duncan 1876a, James 1893a, 1893b. Accepted.

Paleoperone. Pennsylvanian, endozoic in coral, Etheridge 1891. Accepted.

Paleomyces. Pennsylvanian, in matrix, Ellis 1918. Accepted. (Taxonomy confused, saprolegniaceous affinity tentative.)

PERONOSPORALES

Peronosporaceae

Peronosporites. 2 species, Pennsylvanian, in *Lepidodendron,* Smith 1876, 1877. Accepted. In matrix, Ellis 1918. Accepted.

Peronosporoides. Oligocene, epiphyllous, Berry 1916. Accepted.

Pythiaceae

Propythium. Pennsylvanian, endozoic in Bryozoan, Elias 1966. Accepted.

No family

Unnamed. Pennsylvanian, cortex *Astromylon,* Agashe & Tilak 1970. Probable. (May be Chytridialean.)

MUCORALES

Mucoraceae

Paleomyces. Devonian, mycorrhizal, Butler 1938, Wolf 1969b. Accepted. (Taxonomy confused, note citation under Saprolegniaceae.)

Mucorites. Pennsylvanian, in Lepidospore, Renault 1896a. Dubious.

Palambages. Cretaceous, in matrix, Srivastava 1968. Accepted.

Pluricellaessporites. 4 species, Cretaceous, in matrix, Srivastava 1968. Accepted.

Rhizophagites. 2 species, Pleistocene, in matrix, Wilson 1965. Accepted.

Unnamed. Pleistocene, in matrix, Wolf 1969a. Accepted.

NO ORDER

Eomycetopsis. Pre-Cambrian, in matrix, Schopf 1968, 1970b, 1973. Probable.

Unnamed. Pre-Cambrian, in matrix, Tyler & Barghoorn 1954. Probable.

Unnamed. Pre-Cambrian, in matrix, Timofeev 1970. Probable.

Ordovicimyces. Ordovician, endozoic in Bryozoan, Elias 1966. Accepted.

Unnamed. Devonian, in matrix, Fry 1959. Accepted.

Unnamed. Mississippian, trace fossil, Elsik 1966. Probable.

Unnamed. Pennsylvanian, mycorrhizal, Butler 1938. Probable.

Paleomycites. 2 species, Pennsylvanian, cortex *Lepidodendron,* Renault 1896a. Dubious.

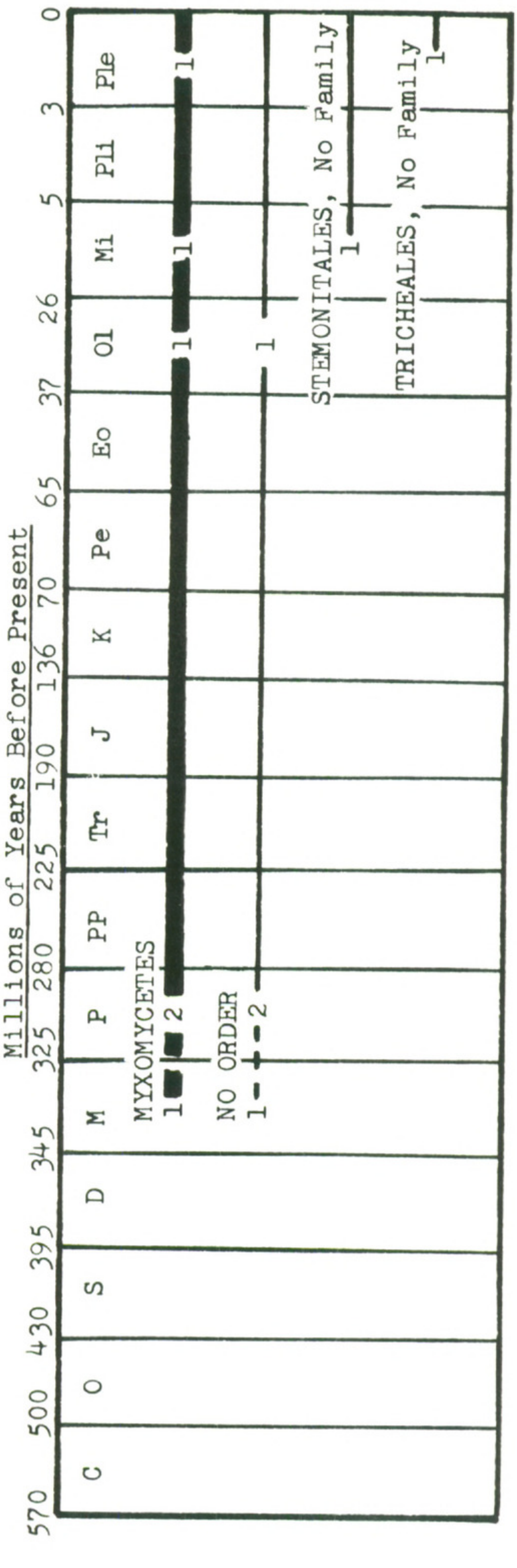

FIG. 4. Ranges of orders within the class Myxomycetes.

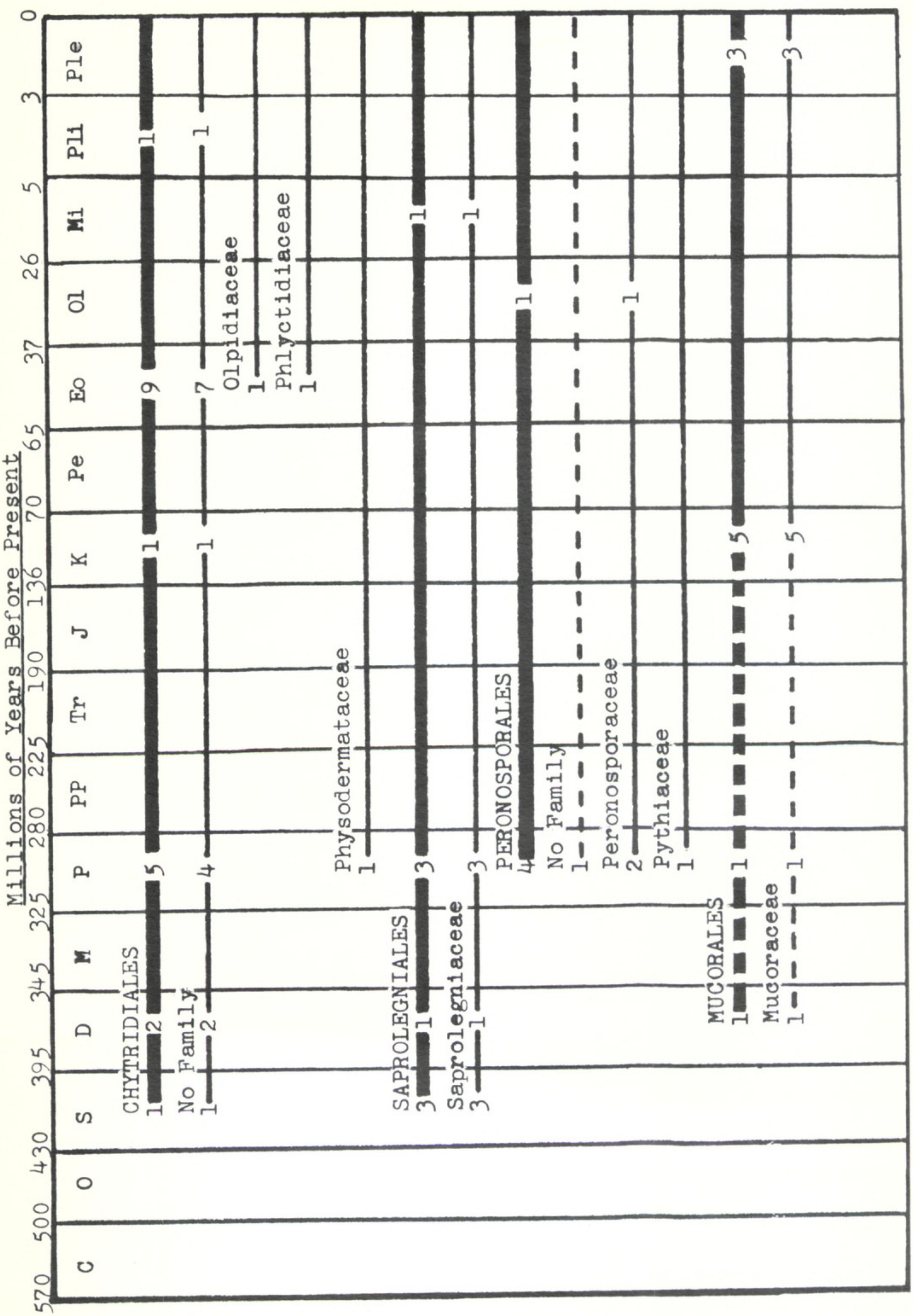

FIG. 5. Ranges of orders and families within the class Phycomycetes.

Phycomycites. Jurassic, endozoic (echinoderm?), Ellis 1915. Probable.
Paleomyces. Cretaceous, in calcite, Ellis 1915. Probable. (Taxonomy confused, note also listed under Mucoraceae and Saprolegniaceae.)
Unnamed. Cretaceous, endozoic in bone, Ellis 1915. Probable.
Unnamed. Cretaceous, trace fossil, Elsik 1966. Probable.
Unnamed. Tertiary, trace fossil, Elsik 1966. Probable.

ASCOMYCETES

TAPHRINALES

Protomycetaceae

Protomycites. Mississippian, *Lepidodendron* root, Smith 1894. Probable.

EUROTIALES

Eurotiaceae

Eurotites. Miocene, unknown, Goeppert 1853. Probable.

ERYSIPHALES

Erysiphaceae

Protoascon. Pennsylvanian, in matrix, Batra 1964. Accepted.
Unnamed. Pennsylvanian, epiphyllous, Barthel 1961. Probable. (Erysiphacean affinity tentative.)
Uncinulites. Miocene, in matrix, Pampaloni 1902, Salmon 1903. Probable. (Erysiphacean affinity tentative.)
Erysiphites. Miocene, E.A., Schmalhausen 1883, Pampaloni 1902, Salmon 1903. Probable. (Erysiphacean affinity tentative.)

Meliolaceae

Meliola. Eocene, E.A., Kock 1939. Accepted.
Perisporites. Eocene, unknown, Pampaloni 1902. Accepted.
Perisporiacites. Eocene, wood, Felix 1894. Accepted.

DOTHIDEALES

Dothideaceae

Dothidites. 1 species, Eocene, E.A., Bureau & Patouillard 1893. Accepted. 6 species, Miocene, E.A., Ettingshausen 1869b, 1888, Goeppert 1885, Heer 1859, 1861b, 1868a, 1874b. Accepted. 1 species, Pliocene, E.A., Bleicher & Fliche 1888. Accepted.

HEMISPHAERIALES

Polystomellaceae

Vizella. 2 species, Miocene, E.A., Selkirk 1972. Accepted.
Entopeltacites. 2 species, Eocene, E.A., Selkirk 1972. Accepted. 3 species, Miocene, E.A., Selkirk 1972. Accepted.

Micropeltaceae

Stomiopeltites. Cretaceous, *Frenelopsis* (conifer), Alvin & Muir 1970. Accepted.
Shortensis. Eocene, E.A., Dilcher 1965. Accepted.
Dictyotopileos. Eocene, E.A., Dilcher 1965. Accepted.
Haplopeltis. Eocene, E.A., Dilcher 1965. Accepted.
Microthyriella. Eocene, E.A., Dilcher 1965. Accepted.
Plochmopeltidella. Eocene, E.A., Dilcher 1965. Accepted.
Stomiopeltis. Eocene, E.A., Dilcher 1965. Accepted.
Plochmopeltinites. Oligocene, E.A., Cookson 1947. Accepted.

Microthyriaceae

Calimothallus. Eocene, E.A., Dilcher 1965. Accepted.
Microthallites. Eocene, E.A., Dilcher 1965. Accepted.
Phragmothyrites. Eocene, E.A., Edwards 1932. Accepted.
Pelicothallus. Eocene, E.A., Dilcher 1965. Accepted.
Brefeldiellites. Eocene, E.A., Dilcher 1965. Accepted.
Trichopeltina. Eocene, E.A., Dilcher 1965. Accepted.
Parasterina. Eocene, E.A., Dilcher 1965. Dubious.
Asterina. Eocene and Pliocene, E.A., Engelhardt & Kinkelin 1908. Accepted.
Asterothyrites. 1 species, Eocene, E.A., Dilcher 1965. Accepted. 4 species, Oligocene, E.A., Cookson 1947. Accepted.

Euthyrites. Oligocene, E. A., Cookson 1947. Accepted.
Microthyriacites. 3 species, Oligocene, E.A., Cookson 1947. Accepted.
Trichopeltinites. Oligocene, E.A., Cookson 1947. Accepted.
Phycopeltis. 2 species, (?) Oligocene, E.A., Cookson 1947. Accepted. Kock 1939. Probable. 1 species, Miocene, unknown, Kock 1939. Probable.
Notothyrites. 2 species, Oligocene, E.A., Cookson 1947. Accepted. 1 species, Miocene, E.A., Cookson 1947. Accepted.
Leptothyriomyces. Miocene, unknown, Krausel 1929. Probable.
Microthyrium. Pleistocene, unknown, Godwin & Andrew 1951. Accepted.

Trichothyriaceae

Trichothyrites. Pleistocene, in matrix, Rosendahl 1943. Accepted.

HYSTERIALES

Hysteriaceae

Hysterites. 1 species, Pennsylvanian, epiphyllous on *Neuropteris,* Grand'Eury 1877. Dubious. 1 species, Permian, epiphyllous on *Cordaites,* Potonié 1893. Dubious. 1 species, Jurassic, epiphyllous on *Podozamites,* Nathorst 1878. Probable. 1 species, Cretaceous, in coniferous wood, Heer 1880. Probable. 9 species, Miocene, E.A., Debey & Ettingshausen 1859, Ettingshausen 1877b, Geyler 1887, Goeppert 1836, 1837, 1841, 1855, Heer 1853, 1855, Massalongo 1859, Unger 1841, 1845, 1850b, Schmalhausen 1883. Accepted, 6; Dubious, 3.

HYPOCREALES

No family

Polystigmites. Miocene, epiphyllous, Massalongo 1857, 1858, Massalongo & Scarabelli 1858–59. Accepted.

SPHAERIALES

Phaeosporae

Rosellinites. 1 species, Permian, in wood, Potonié 1893. Probable. 1 species, Oligocene, in matrix, Beck 1882. Probable. 2 species, Miocene, in wood, Zablocka 1931. Accepted. Unknown, Buzek & Holy 1964. Accepted.
Hypoxylon. Oligocene, in brown coal, Willis & Gill 1965. Accepted.
Palaeosordaria. Oligocene, unknown, Sahni & Rao 1943. Accepted.

Hyalodidymae

Laestadites. Pliocene, epiphyllous, Meschinelli 1892a. Accepted.

Phaeodidymae

Didymosphaerites. Oligocene, epiphyllous on *Typha,* Cockerell 1908b, Pia 1927. Accepted.

Phaeophragmiae

Leptosphaeria. Eocene, in matrix, Bradley 1931. Accepted.
Chaetosphaerites. Eocene, in wood *Rhamnacini,* Felix 1894. Accepted.
Leptosphaerites. Eocene and Miocene, E.A., Felix 1894, Richon 1885. Accepted.
Trematosphaerites. Oligocene, in conifer wood, Heer 1863. Accepted.

Phaeodictyae

Pleosporites. Cretaceous, epiphyllous on *Cryptomeriopsis,* Suzuki 1910. Accepted.

Scolecosporae

Linosporoidea. Miocene, unknown, Keller 1895. Accepted.

No family

Sphaerites. (Entire group of organisms questionable, the species definition is quite loose, and many organisms were placed in the group for lack of better identification.) 1 species, Pennsylvanian, unknown, Feistmantel 1874b, Geinitz 1870. Dubious. 1 species, Jurassic, epiphyllous on *Salicis,* Saporta 1894. Dubious. 14 species, Cretaceous, E.A., Berry 1911, 1919, Heer 1883, Lesquereux 1878. Dubious. 1 species, Paleocene?, E.A., Geyler 1887. Dubious. 9 species, Eocene, E.A., Ball 1937, Berry 1914, 1924, Ettingshausen & Gardner 1879, Gaudin 1858, Gaudin & Strozzi 1864, Geyler 1887, Lesquereux 1878, Massalongo 1859, Saporta 1862, 1873, 1888, Watelet 1866. Dubious. 2 species, Oligocene, E.A., Engelhardt 1881, Ettingshausen 1855. Dubious. 76 species, Miocene, E.A., Baily 1879, Berry 1929, Boulay 1887, Capellini

1874, Engelhardt 1885, Ettingshausen 1867, 1869, 1872, 1877a, 1877b, 1885, 1887, 1888, 1890, Fliche 1886, Fresenius 1856, Gaudin 1855, Goeppert 1837, 1852b, 1855, Heer 1855, 1856, 1859, 1861b, 1868 (a & b?), 1869, 1870, 1874b, Klupfel 1866, Krausel 1961, Ludwig 1855–1858a, 1855–1858b, 1859, 1861a, 1861b, Lugeon 1887, Massalongo 1851, 1852, 1857, 1858, 1858–1859, Menzel 1896, 1898, Meschinelli 1892, Staub 1882, Unger 1840, 1848, Weber 1852, Wentzel 1881, Zablocka 1931. Dubious. 3 species, Pliocene, E.A., Engelhardt 1894, Meschinelli 1898. Dubious.

Pterosphaeria. Cretaceous, in wood, Stopes & Fuji 1909. Accepted.

Chaethomites. Eocene, on seed, Pampaloni 1902, Pia 1927. Probable.

PHACIDALES

Phacidaceae

Xyloma (Rhytisma?). (Group doubtful as a whole, the genus is presently allied with the Mycelia Sterilia. Descriptions frequently poor.) 1 species, Pennsylvanian, unknown, Kusta 1883. Dubious. 4 species, Triassic, epiphyllous on Cycadeoids, Braun 1847, Geinitz 1876, Heer 1876, Nathorst 1879. Dubious. 3 species, Triassic & Jurassic, epiphyllous on Cycadeoids, Braun 1849, Geinitz 1876, Goeppert 1841, 1844. Dubious. 1 species, Jurassic, epiphyllous on Cycadeoid, Goeppert 1844. Dubious. 2 species, Cretaceous, E.A., Ettingshausen 1867, Heer 1882. Dubious. 5 species, Eocene, E.A., Goeppert 1841, Heer 1874a, Watelet 1866. Dubious. 2 species, Oligocene, E.A., Ettingshausen 1855, Unger 1850. Dubious. 39 species, Miocene, E.A., Boulay 1887, Capellini 1874, Englehardt 1876, Ettingshausen 1855, 1857, 1869a, 1869b, 1872, 1877b, 1888, Fliche 1886, Goeppert 1852b, 1855, 1857, Geyler 1876, Heer 1853, 1855, 1880, Ludwig 1859, Massalongo 1851, Unger 1848, 1850a, 1850b. Dubious. 5 species, Pliocene, E.A., Meschinelli 1898, Sordelli 1873. Dubious.

Phacidites. 4 species, Cretaceous, E.A., Englehardt 1881, Ettingshausen 1867, Feistmantel 1874a. Accepted. 1 species, Oligocene, E.A., Geyler 1887. Accepted. 16 species, Miocene, E.A., Beck 1882, Englehardt 1876, 1885, 1896, Ettingshausen 1869, Heer 1855, 1861a, Ludwig 1859, 1861. Accepted. 2 species, Pliocene, E.A., Bleicher & Fliche 1888. Accepted. 1 species, Pleistocene, E.A., Sordelli 1873. Accepted.

Rhytismites. 1 species, Cretaceous, E.A., Heer 1880. Accepted. 2 species, Eocene, E.A., Ettingshausen & Gardner 1880, Geyler 1885. Accepted. 1 species, Oligocene, E.A., Ettingshausen 1853. Accepted. 22 species, Miocene, E.A., Engelhardt 1885, Ettingshausen 1867, 1869b, 1877b, 1885, 1888, Fliche 1886, Geyler 1873–74, Goeppert 1841, Heer 1855, 1859, 1861b, 1868a, 1868b, 1869, 1874b, 1883, Ludwig 1855–58, Sismonda 1859, Unger 1841, 1845. Accepted. 1 species, Pliocene, E.A., Meschinelli 1898. Accepted.

Stegites. 1 species, Eocene, epiphyllous on *Cyperitum*, De la Harpe 1856. Accepted. 1 species, Miocene, epiphyllous on grass, Bram in Sitzenberger 1851, Heer 1855. Accepted.

HELOTIALES

No family

Excipulites (Pyrenopeziza). 3 species, Pennsylvanian, epiphyllous on seed fern and *Cordaites* foliage, Geinitz 1855, Goeppert 1836, 1841, 1848, Kidston 1888, Roehl 1868–69, Schimper 1869, Stur 1883. Dubious. 3 species, Permian, epiphyllous on seed fern and *Cordaites* foliage, Grand'Eury 1877, Gutbier 1849, Potonié 1893. Dubious.

Cenangites. Miocene, E.A., Ludwig 1861?. Accepted.

PEZIZALES

Pezizaceae

Pezizites. 1 species, Miocene, on *Glyptostrobus,* Ludwig 1859, Ettingshausen 1868b. Accepted. 2 species, uncertain, in matrix, Berendt 1845, Goeppert 1852, 1854. Dubious.

NO ORDER

No family

Unnamed. Mississippian, in matrix, Cash & Hick 1879. Dubious.

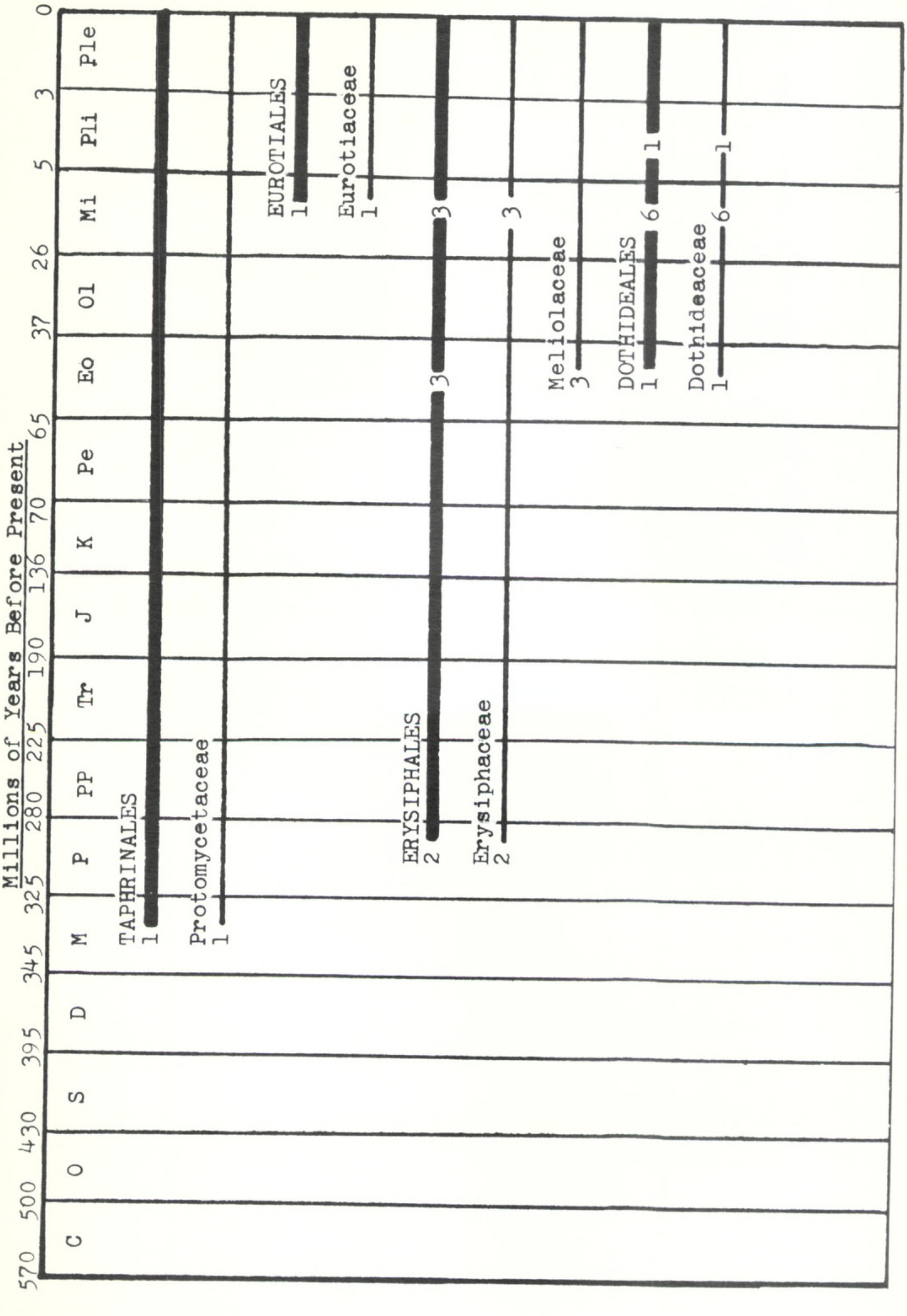

Fig. 6. Ranges of orders and families within the class Ascomycetes: I.

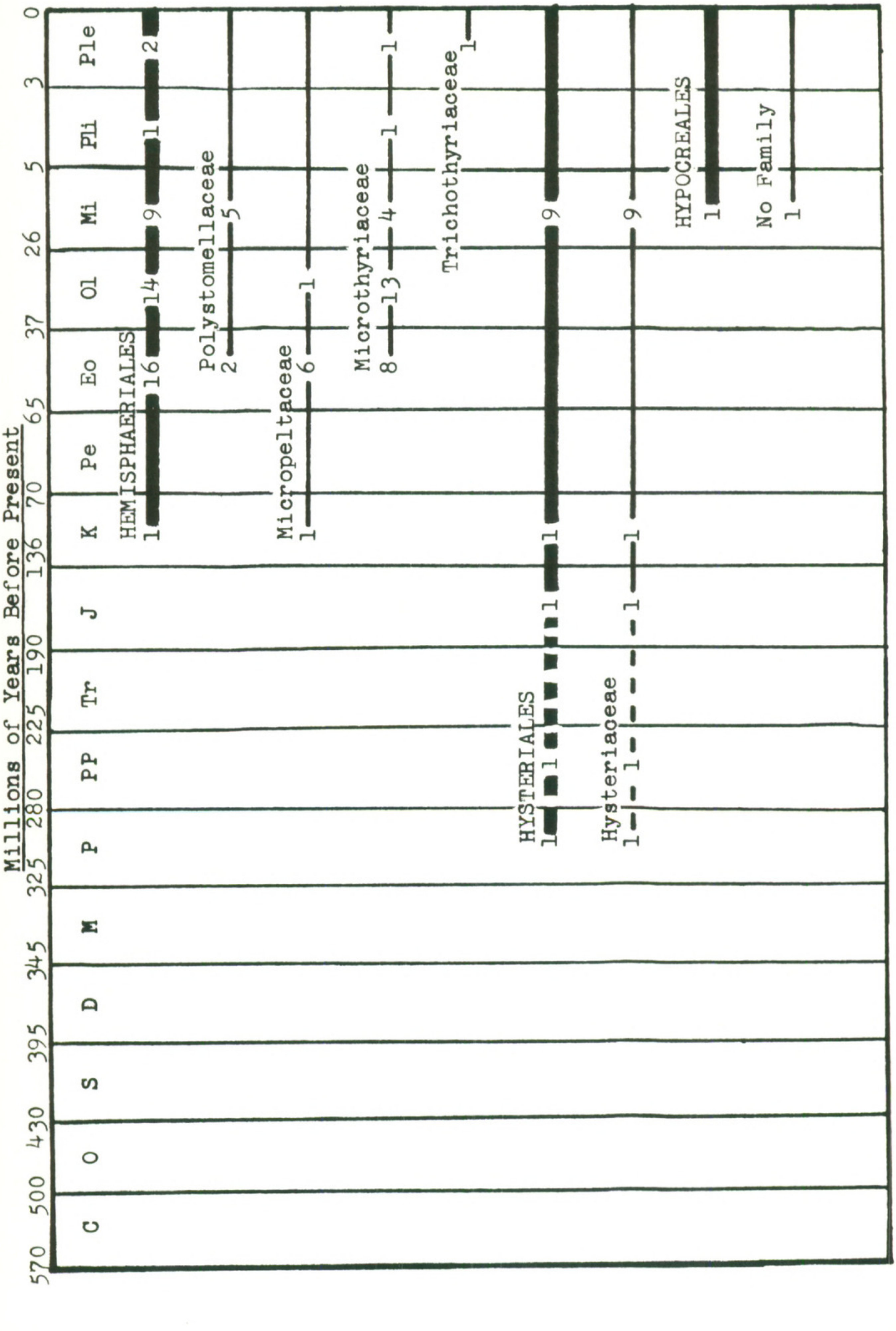

FIG. 7. Ranges of orders and families within the class Ascomycetes: II.

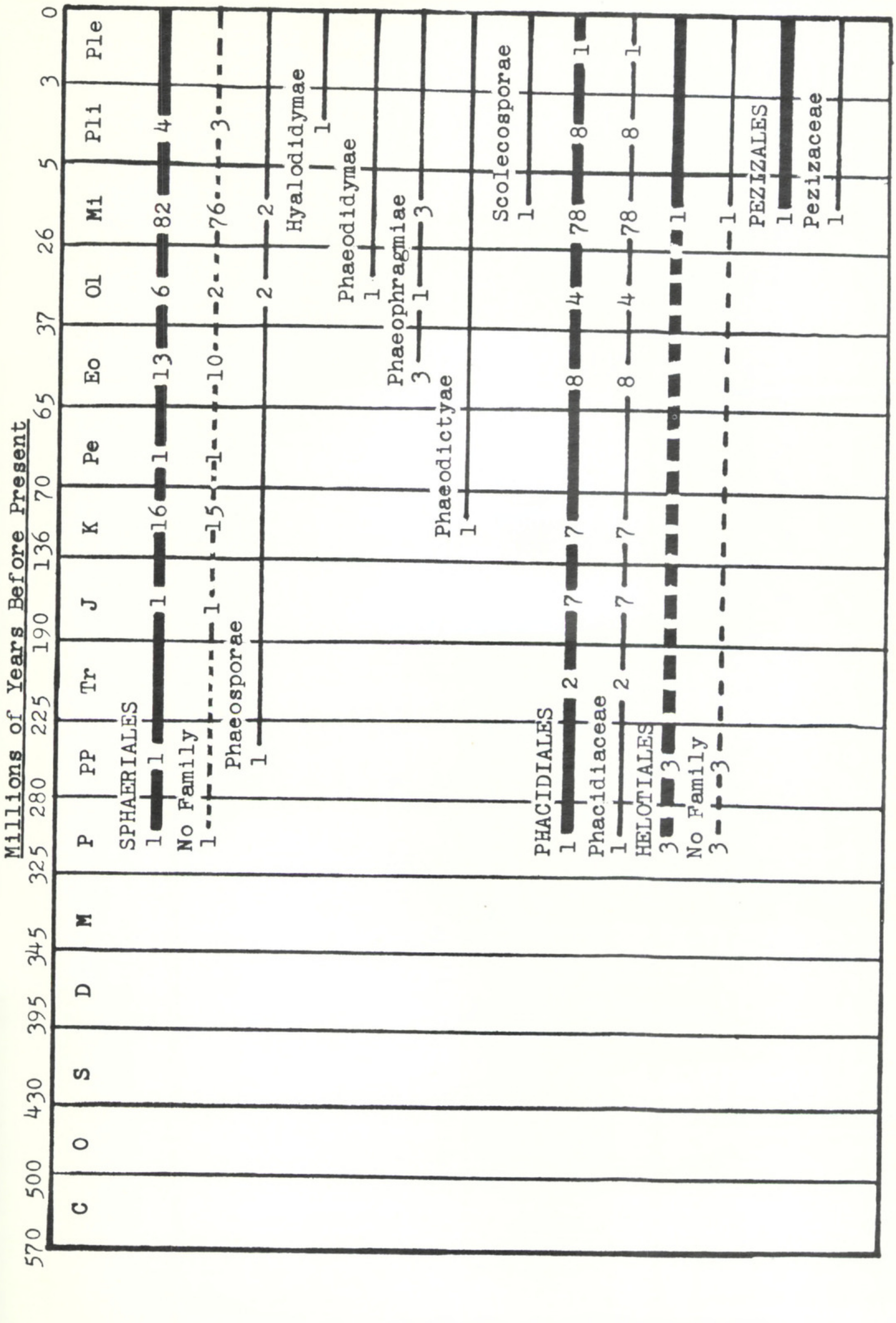

FIG. 8. Ranges of orders and families within the class Ascomycetes: III.

Unnamed. Triassic, epiphyllous on cycadeoid, Schaarschmidt 1966. Accepted. (Suggested to the Dothideales or Myriangiales.)

BASIDIOMYCETES

UREDINALES

Melampsoraceae

Coleosporium. Pleistocene, unknown, Pia 1927. Probable. (Citation incomplete.)

Pucciniaceae

Teleutosporites (Uromyces). Pennsylvanian, *Lepidodendron* wood, Renault 1893, 1896a. Probable.

Puccinites. Cretaceous, epiphyllous on monocot, Dilcher 1965, Ettingshausen 1853. Accepted.

Uromyces. 1 species, Eocene, in matrix, Bradley 1931. Accepted. 1 species, Pleistocene, unknown, Pia 1927. Probable. (Poor description.)

Puccinia. 1 species, Eocene, teliospores in matrix, Wolf 1969b. Accepted. 1 species, Pleistocene, epiphyllous on *Carex*, DeVries 1966. Accepted.

No family

Aecidites. 1 species, Cretaceous, E.A., Debey & Ettingshausen 1859. Accepted. 1 species, Eocene, E.A., Bureau 1881, Bureau & Patrouillard 1893. Accepted. 1 species, Oligocene, E.A., Engelhardt 1881. Accepted. 1 species, Miocene, E.A., Goeppert 1855, 1877. Accepted.

AGARICALES

Thelophoraceae

Hypochinites. Miocene, on conifer wood in amber, Conwentz 1890. Accepted.

Hydnaceae

Hydnites. 2 species, Oligocene, in matrix, Heer 1859, Ludwig 1859. Accepted.

Polyporaceae

Pseudopolyporus. Pennsylvanian, in matrix, Hollick 1910. Dubious.

Polyporus. Pennsylvanian, in matrix, Lesquereux 1877, Lindley & Hutton 1831. Dubious.

Dactyloporus. Pennsylvanian, on (?) *Sigillaria* trunk, Herzer 1893a, 1893b. Dubious.

Phellinites. Jurassic, associated with *Araucaria* trunks, Singer & Archangelsky 1958. Accepted.

Trametites. 1 species, Cretaceous, on *Pinus*, Conwentz 1890. Accepted. 1 species, Pliocene, on coniferous wood, Conwentz 1890. Accepted.

Lenzites. Miocene, unknown, Gastaldi 1858, Sismonda 1859, 1865. Probable.

Polyporites. 1 species, Cretaceous, in matrix, Wieland 1934. Probable. (See Brown, 1938, who thinks it is a lungfish dental plate.) 2 species, Miocene, one in matrix, one on *Sequoia*, Heer 1870, 1875, Ludwig 1857a. Accepted. 3 species, Pliocene, one in matrix, two in Baltic amber, Ludwig 1858a. Accepted. 5 species, Pleistocene, in matrix, Conwentz 1880, 1890, Heer 1866, Massalongo 1858, Meschinelli 1892. Accepted.

Daedalites. 1 species, Pliocene, in matrix, Eichwald 1830, Leveille 1846. Accepted. 1 species, Pleistocene, on *Quercus*, Massalongo & Scarabelli 1858–59. Accepted.

Fomes. 1 species, Pliocene, associated with fir, alder & poplar, Buchwald 1970. Accepted. 5 species, Pleistocene, in matrix, Chaney & Mason 1936, Galbreath 1947, Mason 1934. Accepted.

Ganoderma. Pleistocene, in matrix, Chaney & Mason 1936. Accepted.

Agaricaceae

Archagaricon. 4 species, Permian, unknown, Hancock & Atthey 1869. Dubious.

Agaracites. 1 species, Miocene, unknown, Meschinelli 1891. Accepted. 1 species, Pliocene, unknown, Platen 1907. Accepted. 2 species, Pleistocene, one unknown, the other in wood of *Cupressoxylon*, Conwentz 1890, Felix 1894, Glocker 1857. Accepted.

LYCOPERDALES

Geasteraceae

Geaster. Oligocene, in matrix, Cockerell 1908a. Accepted.

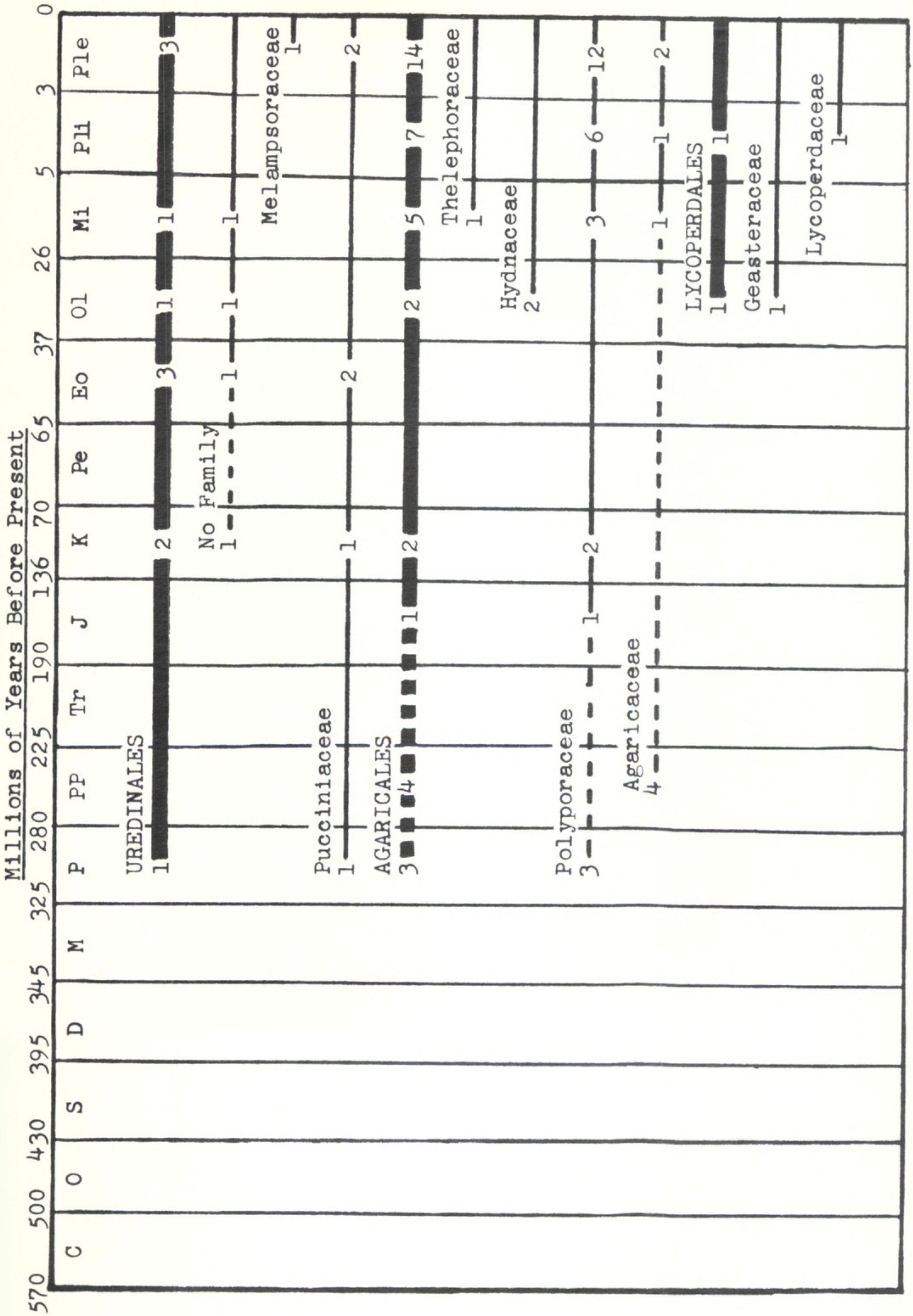

Fig. 9. Ranges of orders and families within the class Basidiomycetes.

Lycoperdaceae

Bovista. Pleistocene, in matrix, Chaney & Mason 1936. Accepted.

NO ORDER

No family

Palaeancistrus. Pennsylvanian, wood *Zygopteris,* Dennis 1970. Accepted. (Clamp connections present.)

Basidiosporites. Paleocene, in matrix, Elsik 1966. Probable.

DEUTEROMYCETES

SPHAEROPSIDALES

Sphaeropsidaceae

Melanosphaerites. Devonian, unknown, Gruss 1928. Probable.

Phomites. Paleocene, E.A., Fritel 1910. Accepted.

Hendersonia. Eocene, in matrix, Bradley 1931. Probable.

Excipulaceae

Unnamed. Pennsylvanian, epiphyllous on *Alethopteris,* Oliver 1903. Probable. (Family placement tentative.)

No family

Depazites. 1 species, Pennsylvanian, epiphyllous on *Hymenophyllites,* Geinitz 1855. Dubious. 1 species, Eocene, E.A., Massalongo 1859, Saporta 1868, 1888. Accepted. 16 species, Miocene, E.A., Engelhardt 1876, 1885, Ettingshausen 1867, 1877b, 1888, Heer 1855, 1883, Ludwig 1859, Massalongo 1857, 1858, Massalongo & Scarabelli 1858–59, Saporta 1868. Accepted. 1 species, Pliocene, E.A., Sacco 1886. Accepted.

MELANCONIALES

Melanconiaceae

Phellomycites (Colletotrichum). Pennsylvanian, wood of *Lepidodendron,* Renault 1896a. Dubious.

Melanconites. Unknown, unknown, Pia 1927. Dubious.

No family

Pestalozzia. 2 species, Eocene, one in matrix, Bradley 1931, the other E.A., Berry 1916b. Both accepted. 1 species, Oligocene, E.A., Berry 1916b. Accepted. 1 species, Miocene, E.A., Berry 1916b. Accepted.

MONILIALES

Moniliaceae

Penicilloides. Pennsylvanian, unknown, Paul 1938. Probable.

Reduviasporonites. Cretaceous, in matrix, Wilson 1962. Accepted.

Ovularites. Cretaceous, unknown, Whitford 1916. Accepted.

Tribolites. Eocene, in matrix, Bradley 1964. Accepted.

Cryptocolax. 2 species, Eocene, wood Magnoliaceae, Scott 1956. Accepted.

Acremonites. Eocene, unknown, Pia 1921. Probable.

Gonatobotrys. Eocene, on flower in amber, Caspary 1907. Accepted.

Ramularia. Eocene, unknown, Caspary 1907. Accepted.

Penicillites. Oligocene, unknown, Berkeley 1848, Goeppert 1852b, 1853, 1857. Accepted.

Monilites. Miocene, unknown, Pampaloni 1902. Accepted.

Sporotrichites. 4 species, Miocene, two on insects in Baltic amber, one on wood, one in matrix, Berendt (Goeppert) 1847, Conwentz 1890, Goeppert 1853, 1857. Two species accepted, two dubious.

Fusidites. Miocene, in wood of conifer, Conwentz 1890. Probable.

Clasterosporium. Pleistocene, in matrix, Cowley 1966. Accepted.

Dematiaceae

Torula. 1 species, Cretaceous, unknown, Caspary 1907. Accepted. 1 species, Eocene, in matrix, Bradley 1931. Accepted.

Brachysporium. 1 species, Paleocene, unknown, Wilson & Webster 1946. Accepted. 1 species, Eocene, in matrix, Bradley 1931. Accepted.

Cladosporites. 2 species, Eocene, E.A., Berry 1916a. Accepted. 1 species, Miocene, in wood, Felix 1894. Accepted. 1 species, Pliocene, in wood, Whitford 1914. Accepted. 1 species, unknown, unknown, Conwentz 1890. Accepted.

Septonema. Eocene, in matrix, Bradley 1931. Accepted.
Cladosporium. Eocene, in matrix, Bradley 1931. Accepted.
Helminthosporium. Eocene, in matrix, Bradley 1931. Accepted.
Bispora. Eocene, in matrix, Bradley 1931. Accepted.
Hyphomycete. Eocene, in matrix, Bradley 1931. Accepted.
Sporidesmium. Eocene, E.A., Dilcher 1965. Accepted.
Haplographites. Eocene, in wood, Felix 1894. Accepted.
Dictyosporites. Eocene, in wood, Felix 1894. Accepted.
Cercosporites. Miocene, in matrix, Salmon 1903. Accepted.
Dematieae. Pleistocene, unknown, Conwentz 1890, 1892. Accepted.

Stilbaceae

Stilbum. Eocene, unknown, Pia 1927. Accepted.

Tuberculariaceae

Patouillardiella. Eocene, E.A., Dilcher 1965. Accepted.
Spegazzinites. Pleistocene, in wood *Pinus,* Felix 1894. Accepted.
Sclerotites (Mycelia sterilia). 4 species, Cretaceous, E.A., Geinitz 1842, Knowlton in Lesquereux 1891, Lesquereux 1878. Accepted. 3 species, Paleocene, unknown, Knowlton 1920. Accepted. 2 species, Eocene, E.A., De la Harpe 1856, Ettingshausen & Gardner 1880. Accepted. 1 species, Oligocene, in wood, Jeffrey & Chrysler 1906. Accepted. 8 species, Miocene, E.A., Capellini 1874, Ettingshausen 1868b, 1877b, 1888, Goeppert 1853, Heer 1855, 1859, 1863, 1868, 1874b, Ludwig 1859, Massalongo 1857, 1858, Peola 1898, Saporta 1868. Accepted.
Phyllerites. (Genus is recognized as leaf outgrowths by Ainsworth & Bisby.) 1 species, Cretaceous, E.A., Stiehler 1855–1858, Debey & Ettingshausen 1859. Dubious. 1 species, Eocene, E.A., Saporta 1888. Dubious. 11 species, Miocene, E.A., Engelhardt 1876, 1885, Ettingshausen 1866, 1867, 1868a, 1877b, 1888, 1890, Goeppert 1855, Heer 1855, Ludwig 1859. Dubious. 1 species, Pliocene, E.A., Engelhardt 1894. Dubious.

GENERA OF NO DISTINCT AFFINITY

Sporocarpon. 2 species and allies: *Dubiocarpon & Mycocarpon;* 3 species, Pennsylvanian, in wood and in matrix, Baxter 1960, Davis & Leisman 1962, Hutchinson 1955. Accepted. (Is fungal in nature.)
Paleosclerotium. Pennsylvanian, in matrix, Rothwell 1972. Accepted. (Is fungal in nature.)
Himantites. Pennsylvanian, unknown, Debey & Ettingshausen 1859. Dubious.
Nyctomyces. 1 species, perhaps Eocene, in wood, Unger 1841–47, 1845, 1850b, Goeppert 1857. Probable. 1 species, Miocene, in wood, Unger 1841–47, 1845, 1850b, Goeppert 1857. Probable. 2 species, unknown, in wood, Menge in Goeppert 1853. Probable.
Incolaria. Pennsylvanian, on *Sigillaria,* Herzer 1893a, James 1893a. Dubious.
Rhizomorphites. 1 species, Pennsylvanian, on wood, James 1885, Lesquereux 1877, 1879–84. Probable. 1 species, Jurassic, in wood, Sterenberg 1920, Trevisian 1845. Probable. 1 species, Cretaceous, in wood, Braun & Goeppert 1841–47. Probable.

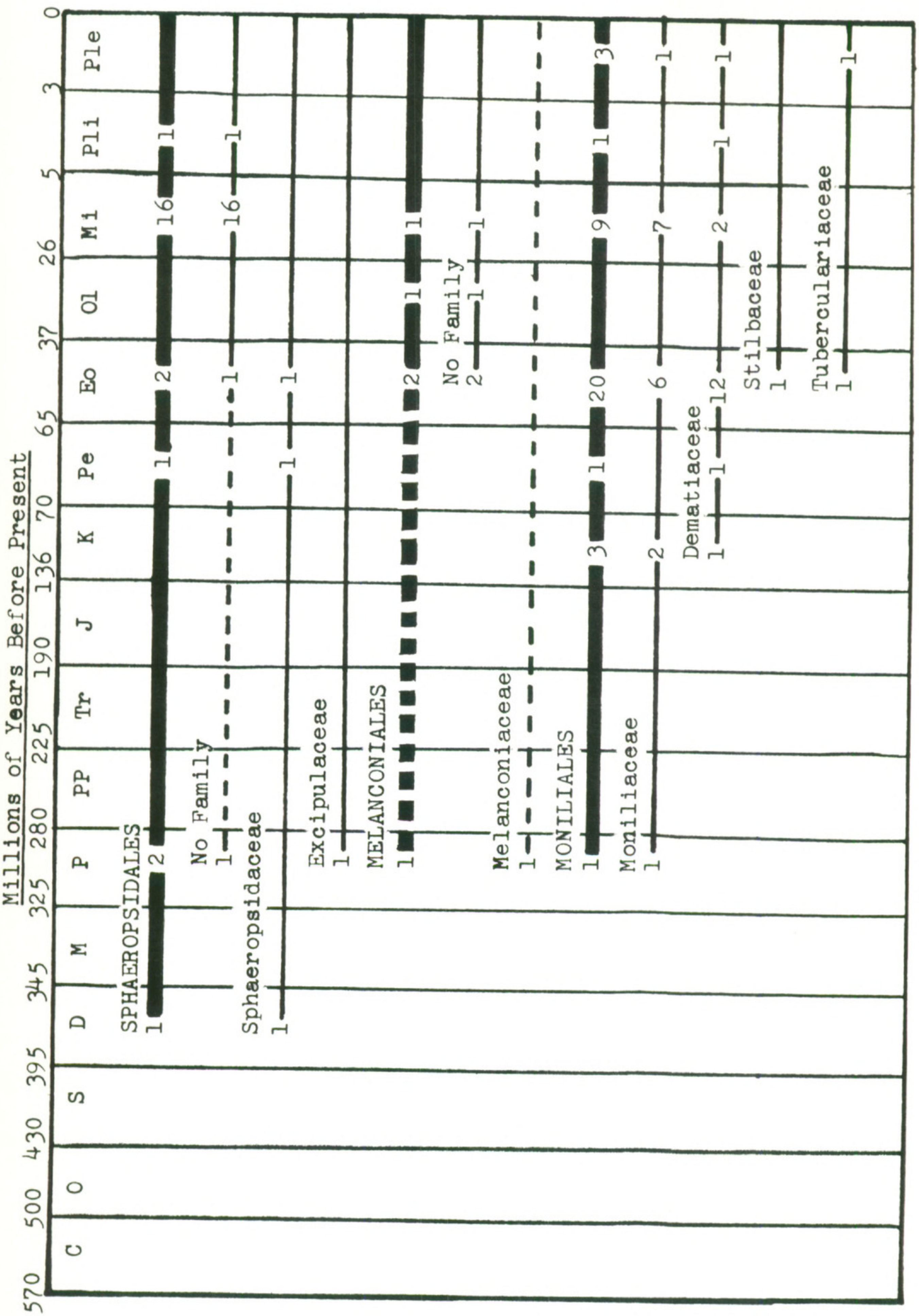

FIG. 10. Ranges of orders and families within the class Deuteromycetes.

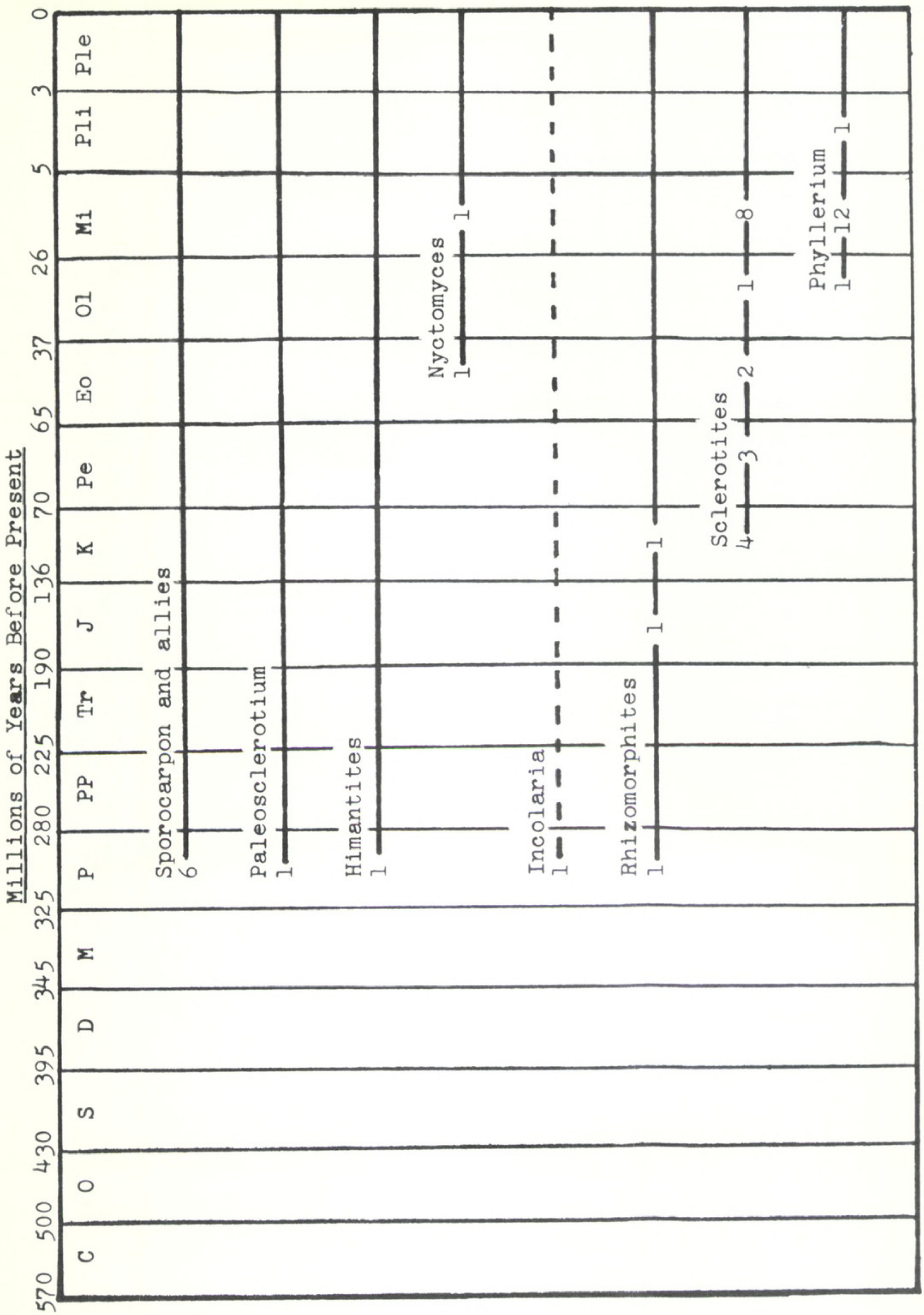

Fig. 11. Ranges of fungi of uncertain or indistinct affinities.

ORDERS AND FAMILIES NOT REPRESENTED IN THE FOSSIL RECORD

MYXOMYCOTA

Acrasiales

Labrinthulales

Hydromyxales

EUMYCOTA

Phycomycetes
- Plasmodiophorales
- Hyphochytriales
- Blastocladiales
- Monoblepharidales
- Leptomitales
- Lagenidiales
- Entomophthorales

Trichomycetes

Ascomycetes
- Endomycetales
- Erysiphales
  - Englerulaceae
- Myriangiales
  - Atichiaceae
  - Myriangiaceae
- Dothideales
  - Capnodiaceae
  - Coryneliaceae

Ascomycetes (cont.)
  - Acrospermaceae
- Sphaeriales
  - Allantosporae
  - Hyalosporae
  - Hyalophragmiae
  - Hyalodictyae
  - Lophiostomataceae
- Laboulbeniales
- Phacidiales
  - Stictidiaceae
- Helotiales
  - Geoglossaceae
- Pezizales
  - Helvellaceae
- Tuberales

Basidiomycetes
- Ustilaginales
- Tremellales
- Agaricales

Agaricales (cont.)
  - Exobasidiaceae
  - "Cryptobasidiaceae"
  - Clavariaceae
  - Boletaceae
- Hymenogasterales
- Phallales
- Sclerodermatales
- Nidulariales

Deuteromycetes
- Sphaeropsidales
  - Nectrioidaceae
  - Leptostromataceae
- Moniliales
  - Cryptococcaceae
  - Sporobolomycetaceae
  - "Dermatophytes"

CONCLUSION

The preceding discussion highlights only a few areas where further work on fossil material would be useful. The basic requirement for a more comprehensive paleomycological record is an increase in the number of paleomycologists. The existing material is often in need of careful reexamination combined with a broad, synoptic perspective. The search for new material requires a systematic examination of the appropriate substrata throughout phanerozoic time, an investigation in which fungi are the object of the search and not just an unexpected by-product. A geological host-parasite index might reveal evolutionary relationships between the two members, and perhaps illuminate their individual evolutionary patterns. Certainly the development of the palynology of fungal spores might lead to the identification of a greater number of fossil fungal groups (Graham 1962, 1971).

The present paper has shown that the fossil record of the fungi is definitely not negligible, has underlined the fact that the record is fragmentary at present, and has outlined some of the reasons for these problems. Since the principal reason that the fungi ar so poorly known is that so little attention is paid to them, it is hoped that the present compilation will stimulate research designed to illuminate the evolutionary history of these interesting organisms.

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