

Chapter - IV

STUDIES IN HYPERPARASITES.

I) INTRODUCTION :

A number of fungi are active parasites of other fungi. Relationship between two species of plants or animals in which one benefits at the expense of the other, usually without killing is known as parasitism. An organism that parasitizes another parasite and such a relationship is known as hyperparasitism. Certain fungi and bacteria are parasitic on plant pathogens. There are also fungi which are actively parasitic on other fungi and such hyperparasitism (mycoparasitism) occurs with several soil fungi as well as with air borne ones. Hyperparasitism is widespread in fungi, particularly in certain orders such as the Hypocreales and Chytridiales. (De Vay, 1956). Fungi enter in to a number of mutualistic relationships with other fungi. Some are facultative (e.g. Rhizoctonia solani) while others are obligate (e.g. Eudarlucella australis) hyperparasites Trichoderma lignorum and some others can be antagonistic or hyperparasitic although different strains are perhaps involved, Hyperparasitic and phytoparasitic fungi show many similarities in host-parasitic interaction; e.g. some are biotrophs (obtaining food from living cells often via haustoria) whilst others are necrotrophs and obtain nutrients from host cells killed before invasion. It is interesting that soil fungi are attacked chiefly by necrotrophic hyperparasites or atleast by those

which quickly kill the invaded host cells, where-as fungi which attack the shoots of plants tend to be parasitized by biotrophic fungi.

II) HISTORICAL REVIEW :

Different degrees of morphological adaptation towards mycoparasitism may be recognized. Several plasmodiophoraceous organisms are intracellular parasites of other fungi. Woronina polycystis was the first to be discovered. A second species, W.phthi is an obligate parasite of pythium. Sorodiscus cokeri is another parasite of pythium species, but causes little or no hypertrophy, while Octomyxa achlyae and O. brevillegniae complete their life cycles in their respective saprolegniaceous hosts in ways similar to W.polycystis. (Karling, 1942-b; Pendergrass, 1950). The parasitic habit of many of the chytrids upon other aquatic or semiaquatic fungi and algae is apparently quite common. A number of these genera are described and illustrated by Fitzpatrick, (1930) and Karling (1924-a). Practically nothing is known regarding their nutritional requirements. Three sorts of mycoparasitic chytrids may be recognized namely ectoparasites, parasites and endoparasites e.g. Solutovaries phythii is an ectoparasitic on pythium. Phlyctochytrium synchytrii is parasitic on the resting sporangia of Synchytrium endobioticum; Chytridium rhizophydii, Septosperma anomalum and S.rhizophydii

are parasites on other chytrids. Some chytrids parasitize filamentous fungi e.g. Chytrionomyces parasiticus on Aphanomyces laevis, Rhizophyidium carophilum on number of water molds. R.fungicola attacks the mycelium of the imperfect fungus Gloeosporium theobronae. Internal mycoparasitic chytrids include species of Rozella and Olpidium. R.cladochytrii parasitizes saprophytic species of the cladochytriaceae. Other species of Rozella attack various aquatic fungi. Three species of Olpidium are known to be mycoparasitic, namely O.uredinis which infects the uredospores of several Puccinia species. O.rhizophlyctidis which inhabits species of Rhizophlyctis and O.allomyces which infects Allomyces species and the chytrid Karlingia rosea. Other internally parasitic chytrids include Pleotrachelus fulgens and P.gouffianus which form their sporangia within the species of Pilobolus, and Pringsheimiella dioica which parasitizes Achlya species. P.dioica forms its resting spores only when two sexually opposite or compatible strains of parasite are present. Catenaria allomyces was discovered growing within Allomyces anomalus in the soil; it can also infect both generations of certain other Allomyces species and also Elastocladia simplex.

Rhizidionomyces anophysatus can attack species of Saprolegnia and Achlya. Rhizidionycopsis japonicus is a parasite of the oogonia of a species of Aplanes. Hypo-

chytrium infestans was discovered inhabiting the ascocarp of a discomycete (Sparrow, 1960). Hyphae of Aphanomyces parasiticus invade the mycelium, young sporangia and young Oogonia of certain other saprolegniaceous fungi and emerge only after they have exhausted the host hyphae. A. exoparasiticus (Couch, 1926), A. cladogamus and Plectospira myriandra (Drechsler, 1943) parasitize pythiaceus hosts. Among the Ectroyellaceae, Pythiella besseyi is an endobiotic holocarpic hyperparasite of Olpidiopsis schenkiana. The allied P. uernalis parasitizes and causes galls of the filaments of certain species of Pythium. A number of endobiotic mycoparasites are classified as Lagenidiales. Indeed two species of the type genus Lagenidium itself are mycoparasites, one L. destruens, being a particularly virulent parasite on a species of Achlya. Further, the genus Olpidiopsis is chiefly composed of parasites of freshwater fungi. The genus Rozellopsis contains Rozella like parasites with biflagellate zoospores (Karling, 1942-a). Rozella inflata (= Pleolpidium inflatum) which parasitizes various Pythiaceus hosts. Although no member of the Perenosporales is known to be characteristically a parasite of other fungi. Mycoparasitism has been observed to occur in dual cultures of certain Pythium species (Drechsler, 1943). Parasitism by P. oligandrum may be taken as an example. Maskins (1963) described a species of Pythium which in laboratory trials parasitized 79 of 98 species of fungi. On 69 hosts it produced

oogonia, an event which depends on the presence of particular exogenous sterols (Huskins et al., 1964).

Parasitism by mucors of other fungi is common. Except for Syncephalis wynneae which parasitizes the discomycete Wynnea macrotis (Thaxter, 1897) all species of Syncephalis are facultative parasites of mucors species of Piptocephalis parasitize only mucorales except for P.xenophila which develops better on ascomycetes (Dobb and English, 1954). Dispira cornuta (= D.americana = D.circinata, fide Agers, 1935) parasitizes only mucorales. D.parvispora likewise parasitizes only mucorales, but D.simplex is known to parasitize only ascomycete, Chaetonium bostrychodes (Benjamin, 1961, 1963). Species of Parasitella and Chaetocladium are morphologically specialized but culturable parasites. Burgeff (1924) concluded that parasitism of Absidia glauca and A.caerulea by Parasitella and Chaetocladium was strictly sex-limited in that single strains of the heterothallic parasites attached only complementary strains of these two heterothallic hosts. However, Satina and Blakeslee (1926) concluded that the parasitic reactions were not truly sex-limited since they found numerous exceptions. A few members of the Kickxellaceae occur in association with other fungi and may prove to be mycoparasitic (Benjamin, 1959).

A number of fungi are reported to be parasitic on members of the Agaricaceae and other higher fungi. Many

ascomycetes are mycoparasitic (Hansford, 1946; Nicot, 1962). Among those which attack basidiomycetous fructifications are species of Hypomyces. H.chryso sperma is common on boletes. The genus Cordyceps contains five species (including the familiar C.ophioglossoides and C.capitata) which live upon the subterranean ascocarp of Elaphoglossum and two which live upon the sclerotia of Claviceps (Kobayasi, 1941). Battarina inclassa is another parasite of hypomyceous ascocarp of Tuber-puberulum. Dardluca caricis (= D.australis) in both perithecial and pycnidial (= Dardluca filum) stage is a cosmopolitan parasite of many macrocyclic and microcyclic rusts. Its perfect stage is generally found on Puccinia species on members of the Gramineae and Cyperaceae (Friksson, 1966). Keener (1934) showed that isolates of this easily cultured parasite differed in their virulence toward different species of rusts. A few discomycetes are mycoparasitic e.g. Micropyxis geoglossi which grows and fruits on the living apothecia of another discomycete, Trichoglossum. The few basidiomycetes which are known to be mycoparasitic are all hymenomycetes e.g. Claudopus subdepluens fruits on the pores and stipe of Polyporus perennis. Boletus parasiticus attack the fruit bodies of scleroderma species, while Asterophora lycoperdoides and A.parasitica (some times classified as species of Nyctalis) live and fruits on a number of agarics; (especially Rossula and Lactarius species). Stropharia epimyces parasitize

Coprinus conatus and C. atramentarius. There are also examples of hymenomyces attacking non-basidiomycetous fungi. Barnett (1963) recently recorded that in laboratory tests some wood rotting polypores and agarics penetrate and damage the endoconidia of Cerutocystis species. He suggests that mycoparasitism would have some survival value for these fungi.

Ampelomyces quisqualis (= Cicinnobolus cesatii) is a parasite which forms pycnidia within the conidiophores, ascocarps, and even vegetative cells of powdery mildews. It is possible that the hyperparasite overwinters as a saprophyte on the leaves bearing the mildews. A. quisqualis grows and sporulates on various nutrient agar media (Emmons, 1930). A number of other hyperparasitic species of Ampelomyces have been described, but it seems doubtful that they are distinct from A. quisqualis (Hansford, 1946). Coniothyrium minitans is a parasite of the sclerotia and sometimes the apothecia, of certain species of Sclerotinia. A number of other pycnidial fungi parasitize leaf-inhabiting ascomycetes (Hansford, 1946) and other higher fungi (Seeler, 1943).

Various hyphomycetes are capable of mycoparasitism, but for many of these it is probably not their predominant habit. This is probably true for certain species of Trichoderma penicilium and cephalosporium. T. lignorum parasitizes a number of diff. soil fungi in artificial culture.

T. viride in artificial culture on acid media parasitizes the hyphae of Armillaria mellea and Polyporus schweinitzii. This sort of parasitism evidently occurs under more natural conditions too, for Boosalis (1956) found that a trichoderma species was able to parasitize the mycelium of Rhizoctonia (Corticium) Solani in unsterilized field soil as also could Penicillium vermiculatum. A species of penicillium is parasitic upon an Aspergillus (Thom & Raper, 1945). Species of Penicillium and Aspergillus have also been observed to invade the sporangiophores of Mucoraceous fungi, just as species of Cephalosporium invade the hyphae conidiophores and conidia of certain species of Helminthosporium (Kenneth and Isaac, 1964). A greater degree of physiological specialization for mycoparasitism is shown by Gonatobotryum fuscum (Shigo, 1960), G. simplex (Whaley and Barnett, 1963) and Calcarisporium parasiticum (Barnett and Lilly, 1958). A rather differently specialized form of mycoparasitism is shown by Dactylella spermatophaga and Trinacrium subtile, which invade the Oospores of root-rotting and other soil-inhabiting oomycetes (Drechsler, 1938). Several hyphomycetes which parasitize the cultivated Mushroom are economically important e.g. Mycogene perniciosa is an important pest which causes enlargement of the stipe, reduction or suppression of the cap and eventually, rapid decomposition of the flesh of the mushroom. Other hyphomycetous parasites of mushrooms include Verticillium malthousei and

Cephalosporium costantinii, both of which can deform the host, though not like Mycogene causing rapid decomposition; and C. lamellaecola which causes fusciation and mildewing of the gills (Smith, 1924; Ware, 1933). Under natural conditions, too, many hyphomycetes are associated with the fruit bodies of higher basidiomycetes (Nicot, 1962). Although harmless saprophytes sometimes grow on perennial or coriaceous fruit bodies, the relationship of many hyphomycetes is undoubtedly a parasitic one. Parasitism of larger ascomycetous fruit-bodies is also known e.g. Fusidium parasiticum attacks the stromata of Xylaria species. Many hyphomycetes which parasitize leaf-inhabiting ascomycetes are listed by Hansford (1946).

Like so many true fungi, myxomycetes too may be attacked by fungal parasites. These are principally hyphomycetes. Stilbum tomentosum is common and forms abundant white conidia on the fructifications of Trichia and other slime molds (Petch, 1945). As well as parasitizing higher plants, Rhizoctonia solani can parasitize other fungi, in spite of its own susceptibility certain mycoparasites (Butler, 1956), on mucorales and the imperfect fungus, Amblyosporium botrytis the only higher fungus R. solani is known to attack. No study of the basic nutritional requirements of these fungi has been attempted.

Many fungi are known to be parasitize phytopathogenic nematodes. In 1954 Rozsypal Schmidt reported a Photomyopsis chytridiale which attack Heterodera schachtii. Drechsler (1937) described 40 sp. of fungi which attack nematodes. The important ones are Dactylaria, Acrostalgamus, Dactylella and Arthrobotrys.

III) ECONOMIC IMPORTANCE :

Hyperparasites can be used to develop control measures. Several attempts have been made to utilise fungi for the control of nematodes - Such as Meloidogenes which attack pineapple in Hawaii for nematodes parasitize on animals in France and for controlling the golden nematode of the potato in England. Some encouraging results were obtained but practical utilization of these fungi in agriculture is still a remote possibility. In Hawaii control of root-knot nematode of pineapple has been secured by the application of the infected soil of pineapple refuge at the rate of 100 to 150 tons/acre. The application of the organic matter favours the growth and development of the nematode trapping fungus, Dactylella bemibicoides which kills the soil nematodes and thus makes the infected land for further cropping. Nematode trapping fungi (Cooke, 1968) fungal parasites of cysts (Bursnall and Tribe, 1974) and endozoic fungi (Giurma and Cooke, 1974) all have been considered for potential to reduce populations of plant pathogenic nematodes but results in the field have been disappointing. Many fungi are parasites or predators on other fungi and

nematodes and through this reaction reduce the number of pathogens. Many genera of fungi such as Arthrobotrys, Dactylella, Dactylaria, Nematoctonus, Harposporium have species that are predacious on free living or plant parasitic nematodes. They do not form any host-parasite relationship with the nematode but entrap them with their special organs and feed on their body contents.

Cinccinobolus seldom reduces the attacks of the powdery mildews in nature because it rarely occurs in large quantities. Several workers have tried to utilize Eudarluca australis (pycniadial stage known as Darluca filum) for controlling rust. The fungus does control the disease under certain natural climatic conditions over which man has little control. As discussed by Chester (1946), extra inoculum of the hyperparasites will not be of much use as the weather, unless very favourable to the development of this hyper parasite, is unlikely to permit any marked control of disease. There are other several fungal species which attack rusts, such as Tubercularia spp., which attack aecia and spermogonia of several rusts and Verticillium hemileiae on Hemileia vastatrix. It is known that in nature fungi causing powdery mildews, rusts and ergot are parasitized by hyper-parasite like species of Darluca and Cerebella. The control of root rot of tea caused by Armillaria melea has been attempted by the use of species of Lasidiplodia in Mysiland.

Remarkable control of *Rhizoctonia* damping-off of sugar beets has been recently obtained through the addition of live cultures of Bacillus subtilis to the infected soil, in the U.S.A. Hyperparasites of rust pustules may prevent sporulation, or cause the pathogen to form teliospores instead of urediospores (Biali et al., 1972).

Hyperparasites of fungi were first described in the 1800's by mycologists with interest in plant diseases. Most reports of hyperparasites suggest that they might be useful for biological control, but hyperparasites are rarely used in pest management programmes. Hyperparasites have provided biological control of plant diseases in experimental plots. An unusual recent example is the control of Claviceps purpurea with Fusarium roseum 'Sambucinum' (Mower et al., 1975) in California. Several other sclerotium forming pathogens are parasitized by fungi. These hyperparasites, have controlled plant diseases in special situations. Trichoderma harzianum isolated from decomposing sclerotia of Sclerotium rolfsii provided control of S.rolfsii in green house and field experiments (Wells et al., 1972). In green house tests, Coniothgrium minitans applied as a pycnidial dust reduced damage by Sclerotium cepivorum on onion plants (Ahmed and Tribe, 1977). The disease potential of Phomopsis sclerotoides, the cause of cucumber black rot in green house soils, was considerably

reduced by adding inoculum of Gliocladium roseum (Moody and Gindrat, 1977).

In Western Australia some soils suppress Phytophthora cinnamoni, and in these soils a highly susceptible host, Eucalyptus marginata, will survive and grow even though the pathogen is present (Broadbent and Baker, 1974-a, b; Malajczuk et al., 1977). On the subject of hyperparasites there has been some good news and some bad news. The good news in phytopathology is that hyperparasites abound in the world. Instance after instance of biological control by one hyperparasite or another is recorded in the literature. Many of these hyperparasites have an impact in some microniches, but their effectiveness is limited. The bad news is that hyperparasites have not been effective over the broad range of their hosts. The following attributes would be useful to increase the probability of hyperparasites providing biological control.

1) A capacity for rapid dissemination : Species of Trichoderma, Gliocladium and Fusarium are ideal because they grow rapidly and sporulate profusely under a variety of environmental conditions. If spores can be used, this type of fungus can be quite effective, (Wells et al., 1972). Several companies have developmental work underway to provide Trichoderma inoculum for biological control, either as spores

or as mycelium on diatomaceous earth granules (Backman and Rodriguez-Kabana, 1975). Unfortunately, many hyperparasites grow very slowly in culture. This makes inoculum production for field applications difficult. Tuberculina darluca and Scytalidium uredinicola, three slow-growing hyperparasites of rust fungi, are difficult to propagate in quantity. Adult insects could facilitate dissemination, since they can locate the target fungus. Because insects, amoebae and nematodes require conditions for propagation very different from the fast growing fungi, cooperative research with entomologists, Zoologists and nematologists would be needed.

2) Infection of parasite throughout its ecological range : Often a hyperparasite that devastates its host in culture or under greenhouse conditions is far less effective under field conditions because its ecological range is more limited than the host's. The bacteria that suppress P.cinnamoni are limited to soils with high levels of organic matter, whereas P.cinnamoni is not limited by the organic content of soils (Broadbent and Baker, 1974-a). Darluca filum prevented telium formation by 99% of the Cronartium strobilinum sori on dwarf live oak in a dense oak ground cover. Under these conditions the hyperparasite infected 93% of the sori. In an adjacent less dense stand, the hyperparasite infected only 32% of the rust Sori, and 26%

of the Sori produced telia (Kuhlman et al., 1978). In the C.purpurea - F.roseum 'Sambucinum' relationship, parasite and hyperparasite apparently have similar ecological requirements in California. Sprinkler irrigation facilitated infection by both the parasite and the hyperparasite (Mower et al., 1975), whether these ecological requirements would be similar over the broad range of the host and parasite has not been explored.

3) Early attack before damage by the parasite :

The ideal hyperparasite attacks the pathogen's infective propagule before it can invade the host. Infection of sclerotia by Trichoderma and Gliocladium eliminates the infective propagule (Wells et al., 1972; Moody and Gindrat, 1977). Bacteria in suppressive soils reduce the P.cinnamoni inoculum by hyphal lysis, breakdown of sporangia and chlamydo-spores, and prevention of Zoospore differentiation (Broadbent and Baker, 1974-a, b; Malajczuk et al., 1977). Similarly D.filum parasitizes uredospores of Puccinia graminis before they are released from the sorus (Carling et al., 1976). However, infection of the oak host by C.fusifforme is not reduced by simultaneous inoculations of the oak with the parasite and hyperparasite D.filum (Kuhlman et al., 1978). An exception to this need for an early attack is the Fusarium on C.purpurea (Mower et al., 1975).

4) A capacity to kill the parasite : Many hyperparasites, however, seem to be associated with the declining stage of the disease cycle. If a hyperparasite is active only during the late stages of the disease cycle, its role may simply be to speed up senescence e.g. Tuberculina maxima. Wicker and Woo (1973) suggested that T.maxima parasitizes the white pine tissue and not the mycelium of C.ribicola. The effect on the parasite would be indirect, since T.maxima would kill the pine cells which in turn would kill the rust. In galls of C.fusiforme pine tissue was similar in T.maxima infected and uninfected tissue (Kuhlman and Miller, 1976) and sporulation by both parasite and hyperparasite occurred for successive seasons in infected tissue (E.G.Kuhlman, unpublished data), whichever is the host of T.maxima, it is generally agreed that aecial sporulation is reduced but that the rust mycelium persists especially at the gall margin (Powell, 1971-b; Van der Kamp, 1970; Wicker and Woo, 1973). Individual plant parasite nematodes may be killed by hyperparasite but entire populations are seldom reduced below the destructive level. Susceptibility, of Lovell peach root stock to root-knot nematode (Meloidogyne sp.) led to its replacement in most areas of California 25 years ago. Recently, low numbers of root-knot nematodes were found in several old orchards established on Lovell rootstock (Stirling et al., 1978).

5) Non-pathogenic to higher plant host : Ampelomyces quisqualis is a hyperparasite of powdery mildew which reduced powdery mildew infection by Sphaerotheca fuliginea and increased fruit production over a nontreated check (Jarvis and Slingsby, 1977). Pathogenicity of T.maxima is less economically damaging to the host and can be **beneficial** if branch galls are prevented from reaching the stem. The failure of T.maxima to advance to the margin of the rust infection suggests this benefit may not be realized. Mower et al., (1975) tested the pathogenicity of F.roseum 'Sambucinum' to wheat and found it to be nonpathogenic. However, F.roseum and F.tricinatum have been shown to be secondary parasites or facultative parasites on snapdragon (Dimock and Baker, 1951).

6) A capacity to persist : Unlike most chemical agents, hyperparasites have the potential for long-term persistence without harmful residues. The hyperparasites has usually persisted in a balanced relationship with the target parasite and the host. In Italy hypovirulence agents persist in E.parasitica in perennial infections that take on a gall like form because the cambium is not killed (Mittempergher, 1979). Since, the virulent forms of E.parasitica have persisted for decades in the United States (Kuhlman, 1979), hypovirulence agents must have a similar

capability. Introduced hyperparasites can have long term advantages. Although a balanced system of hyperparasite, parasite and host has been discussed, long-term persistence of the hyperparasite may be accomplished through the secondary hosts, a saprophytic stage or dormant spore stages. Dactylella oviparasitica utilizes dead roots and the eggs of several free-living and plant parasitic nematodes. Because it is not dependent on Meloidogyne, it can persist when Meloidogyne populations are low, Hyperparasitic bacteria were most abundant in soils rich in organic matter. This finding suggests that the bacteria can be saprophytes or have other hosts that utilize organic matter. A major obstacle for using D.filum to control C.fusiforme is the absence of a mechanism for long term persistence (Kuhlman et al., 1978).

The quest for hyperparasites will continue for several reasons. First, they are an attractive means of disease management. Second, the likelihood of insulting the environment is reduced. And finally, pathologist will remain alert for changes in disease cycles that are caused by hyperparasites. Hyperparasites often reveal their presence through changes in the pathogen population in epidemic area; e.g. Fusarium on Claviceps and T.harzianum on S.rolfsii (Mower et al., 1975; Wells et al., 1972). Hyperparasites of the Cronartium rust

have been studied intensively in this regard and many of the fungi insects and animals that feed on them have been identified (Kuhlman and Miller, 1976; Kuhlman et al., 1976, 1978; Powell 1971-a, c; Wicker and Woo, 1973). Similarly, hyperparasites of dwarf mistletoe (Arceuthobium sp.) have been found through searches for inexpensive means of controlling this insidious parasite (Muir, 1977). Unfortunately, most of the hyperparasites identified in studies of this kind do not provide significant control of the parasite because the hyperparasites are not sufficiently aggressive. Many hyperparasites become effective only after their hosts enter the declining stage of an epidemic or else the signs of the hyperparasite are more obvious than are its effect on the disease.

A recent approach to discovering effective hyperparasites has been through surveys that look for the absence of disease in the presence of host and pathogen and then try to discover the reason for it. The suppressive soils in Australia were discovered in surveys of the incidence and severity of Phytophthora root rot in avocado groves (Broadbent and Baker, 1974-a). The fungal hyperparasites of root-knot nematode was also discovered from a disease survey (Stirling et al., 1978). Hypovirulence in E.parasitica was discovered when trees did not die following infection. If plant pathologists make greater use of disease surveys to find hyperparasites,

we may discover that the fauna is playing an important role too. In areas where C.comandrae is abundant, a multitude of mycetophagous animals feed on rust spores and cankers. Insects damaged 41-62% of the cankers and reduced aeciospores production by 10% (Powell, 1971-c). Giant amoebae can perforate the cell walls and digest the content of conidia of Cochliobolus sativus and Thielaviopsis basicola (Anderson and Patrick, 1978; Old, 1978). The melanized cell wall of C.sativus had been considered especially persistent to degradation. The environment limits many hyperparasites to a small portion of the parasite population. In soils suppressive to P.cinnamomi, hyperparasites are favoured by high level of organic matter. Broadbent and Baker (1974-a) suggested that the avocado grower had created a soil environment similar to naturally suppressive rain forest soils by the addition of fowl manure, dolomite, and synthetic fertilizers and the expensive use of cover crops. The speed with which these changes can be made and the economics of this type of disease management have not been investigated, so the biology of hyperparasitic relationships offers unlimited possibilities for research. To continue to promote finding of this line of research requires further documentation of its occurrence and potential for success.

During the course of taxonomical studies of Indian Meliolaceae, author has come to know that some fungi are

growing as hyperparasites along with Meliola, Asteridiella, Asterina and Capnodium collected from different localities.

Nine hyperparasites are described here. These are

Annellophora solani (Syd.) Hughes on Asterina memecyloniae

Ruan., Cladosporium fulvum Cooke on M.jasminicola P.Henn.

Exosporium ampullaceum (Petch) Ellis on Capnodium eugeniarum

Cooke, Pyriculariopsis parasitica (Sacc.Berl) Ellis on

Meliola ochrocarpi Thite sp. nov., Spiropes davillae (Syd.)

Ellis on Asteridiella terminalae (Hansf. and Diegh) Hansf.,

Spiropes doricarpus (Mont) Ellis on Meliola strychnicola

Gaill, Spiropes guareicola (Stev.) Cif. on M.holigarnae Stev.

Spiropes helleri (Stev.) Ellis on M.canthi Hansf., Vakrabeeje

sigmoidia (cavara) Subram. on M.piperae Thite sp. nov. Out of

eight four are being reported for the first time from India,

four are new records from Maharashtra and one is of new locality

from Maharashtra reported on new additional hosts.

IV) DESCRIPTION OF HYPERPARASITES :

1) Annellophora solani (Syd.) Hughes :

Trans.Brit.Mycol.Soc. 34 : 544, 1951.

≠ Chaetotrichum solani Sydow, 1927 Ann.Mycol. Berl. 25 : 150.

It was first described by Hughes (1951) growing on the leaves of Solanum erythrotrichum Fernald, Costa Rica.

Ellis M.B. Mycol. Pap. 70 : 84, 1958; 82 : 44, 1961; 103 :

36, 1963. Author has also collected it from Amboli growing as hyperparasite on Asterina memecyloniae Ruan. On the leaves of Memecylon umbelatum Burnm. Thus it is the additional host. It also makes a new record to India.

Annellophora solani (Syd.) Hughes (Plate-I) :

Colonies hyphophyllous, dark brown to black, effuse sometimes covering nearly the whole lower surface of the leaf. Mycelium superficial composed of a network of branches and anastomosing, septate, smooth walled, subhyaline to brown hyphae about 2-4 μ thick. Conidiophores arising laterally on the hyphae singly or in a small groups. Often from swollen darker cells. Conidiophores are simple erect straight or bent, mid to dark brown paler towards the apex, septate and about 190 μ long, 5-6 μ wide with upto six successive short, cylindrical or barrel-shaped proliferations. Slightly curved, cylindrical or obclavate conidia formed singly as blown-out ends at the tip of conidiophores. Conidia are pale brown to brown in colour 2-4(6) septate, mostly 3 septate, 17-70 μ long 8-10 μ wide in the broadest part. 6-7.5 μ wide at the truncate base. Conidia some times germinating in situ at the tip to form a short, secondary conidiophore with successive proliferations.

2) Cladosporium fulvum Cooke : Grevillea, 12 :
32, 1883. = Fulvia fulva (Cooke) ciferri, 1954, Atti.

Ist bot. Univ. Pavia, 5, 10 : 246.

Saccarde P.A. 1886, Syll.fung. 4 : 363.

Distribution : Europe, U.S.A. Canada, India, Malaya, Africa, Mauritius, Barbados, W.Indies, S.America, Australia, C.America.

It was first described by Cooke (1883) in England, as a casual organism of tomato leaf mould disease, on Lycopersicon esculentum Mill; N.America. It is an important disease especially of plants grown under glass. Later on it was described on leaves of Lycopersicon esculentum by Butler (1905); Butler and Bisby (1931), from Calcutta, U.B.; Uppal, Patel and Kamat (1935) on leaves and fruits of Lycopersicon esculentum, general distribution; Mitter and Tandon (1937) from Allahabad, U.P., Salam and Rao (1957) from Secundarabad, A.P.; Nema and Agarwal (1960) from Bombay, Adhartal, Jabalpur, U.P., On Tomato fruits by Rao (1966) from Bombay; Shrivastava and Tandon (1966) from Allahabad, U.P.; On seeds of Sorghum by Verma and Khan (1965); On Solanum melangena by Roy (1968) from Korilamukh, Assam; On Dahlia sp. by Roy (1968) from Borbhetta, Assam. Author has also collected it from Amba Ghats (Maharashtra) growing as hyperparasite on Meliola jusminicola P.Henn on the leaves of Jusminum mulabaricum Wt. Thus it is the additional host from Maharashtra.



Cladosporium fulvum Cooke (Plate II) : Colonies effuse, brown, conidiophores, emerging through the stroma on the under surface of leaf; rarely the upper, are erect, septated with knee like joints; mostly simple, rarely branched, divaricate to brown in colour, of various length; but mostly 152 to 170 μ long, 3-7.5 μ wide. Conidia produced terminally or subterminally on the conidiophore singly or in acropetal chains. Mostly one septate, elliptical, slightly constricted at septum. Subhyaline to pale brown in colour, measuring from 11 to 25 μ long and 3-7.5 μ thick.

3) Exosporium ampullaceum (Petch) Ellis :

Mycol. Pap. C.M.I. 82, P.32, 1961 = Helminthosporium ampullaceum Petch.

Distribution : Ceylon, Ghana, Sierra Leone, on dead twigs and branches of Funtumia, Rauwolfia, Theobroma etc. India.

It was first described by Ellis. Later on it was described by Satya (1963) on dead wood of Vallaris heynei Spreng. Bhopal, M.P.; Munjal and Kulshreshtra (1966) on dead twigs Chamba, H.P.; Author has also collected it from Amboli (Ratnagiri) growing as hyperparasite on Capnodium eugeniarum Cooke. On the leaves of Eugenia jambos L. Thus it is the additional host. It also makes new record from Maharashtra.

Exosporium ampullaceum (Petch) Ellis (Plate III) :

Colonies effuse, brown to black, hairy mycelium immersed, Conidiophores are straight or flexuous unbranched, dark brown to olivaceous brown, upto 300 μ long, scars often dark and prominent, Conidia usually solitary, verrucose, obdovate, pseudo septate, generally with a thick dark scar at the base. Conidia shows a colourless band next to the black protruding scar. Conidia measuring 45 to 73 μ long and 15-20 μ wide with 3-6 pseudosepta. Colourless band is more prominent.

- 4) Pyriculariopsis parasiticum (Sacc.Berl) M.B.Ellis :
 = Helminthosporium parasiticum Sacc.Berl., 1889,
Revue.Mycol. 11 : 204.
 = Pyricularia musae Hughes, 1958. Can.Jour.Bot.,
36 : 800.

Distribution : Cameroons, Ghana, Guinea, Jamaica, Sabah, San Thome, Sierra Leone, Taiwan.

It is first described by Ellis (1971) on leaves and stem of Musa. Author has also collected it from Amboli (Dist.Ratnagiri) growing as hyperparasite on Meliola ochrocarpi Thite sp. nov. on the leaves of Ochrocarpus longifolius Bth.and HK.F. Thus it is the new additional host. It also makes a new record to India.

Pyriculariopsis parasitica (Sacc.Berl.) M.B.Ellis

(Plate-IV) :

Conidiophores measuring upto 350 μ long and 8 μ thick. Conidia solitary at ends of denticles, simple, straight, obclavate, smooth, mostly 3 septate. End cells subhyaline intermediate cells rather pale brown, 30-60 μ long and 8.6-11 μ thick at broadest part.

5) Spiropes davillae (Syd.) Ellis :

Mycol. Pap. 114 p. 38, 1968. = Helminthosporium davillae (Syd.)

It was first described by Ellis (1968) on davilla, Brazil. Author has also collected it from Ratnagiri growing as hyperparasite on Asteridiella terminalae (Hansf. and Deigh) Hansf. On the leaves of Terminalia chebula Retz. Thus it is the additional host. It also makes new record to India.

Spiropes davillae (Syd.) Ellis (Plate-V) :

Conidiophores straight or flexuous, mid brown having scars towards the apex. Conidia sigmoid with 2 more more septa, generally 3-8 septa, brownish in colour. Cells at the apex are slightly paler in colour Conidia measuring 36 to 65 μ long and 6-8 μ (6.5 to 7 μ) wide.

6) Spiropes dorycarpus (Mont.) Ellis :

Mycol. Pap. 114, P.11, 1968.

= Helminthosporium dorycarpus (Mont.)

Distribution : Australia, Brazil, Chile, Congo, Cuba, Dominican Republic, Ghana, Guyana, India, Indochina, Malaya, Nigeria, Puerto Rico, S.Africa, Sarawak, Sierra Leone, Taiwan, Tanzania, Uganda, very common on colonies of Meliola, Appendiculella, Irenopsis, Asteridiella, Clypeolella and Schiffnerula on many different kinds of flowering plants.

It was first described by Ellis (1968). Author has also collected it from Londha (Mysore state) growing as hyperparasite on Meliola strychnicola Gall on the leaves of Strychnos nuxhomica L. Thus it is the additional host. It also makes a new record to India.

Spiropes dorycarpus (Mont.) Ellis (Plate VI).

Colonies effuse, olivaceous brown to dark brown hairy or velvety. Conidiophores arising singly or in groups, straight or flexuous, mid-brownish having scars toward apex, 250 μ to 500 μ long and 5 μ wide. Conidia straight or somewhat curved, generally obclavate to fusiform, truncate at the base and somewhat rounded at the apex, generally 3 spetate, paler brown in colour, central cell slightly darker than the end cells, smooth or veruculose, 17 to 37.5 μ long, 5-6.5 μ thick in the broadest part.

7) Spiropes quareicola (Stev.) Cif.

Sydowia, 9 : 303, 1955.

= Helminthosporium quareicola Stev.

Distribution : Assam, Bougainville, Ghana, India, Malaya, Netherlands, New Guinea, Sabah, Philippines, Puerto Rico, Sarawak, Sierra Leone, Solomon Islands, Uganda overgrowing colonies of Asteridiella, Arenopsis and Meliola on many different flowering plants.

It was first described by Ciferri (1955). Later on it was described by Subramanian (1956) on living leaves of unidentified host, castle Rock, Bombay, Maharashtra, Ellis (1968). Author has also collected it from Kandar-doh near Petlond (Dist. Sangli) growing as hyperparasite on Meliola holigarnae Stev. on Holigarna grahamii Hk.F. Thus it is the new additional host from new locality from Maharashtra.

Spiropes quareicola (Stev.) Cif. Plate-VII :

Colonies effuse, dark blackish-brown to black.

Mycelium superficial, composed of network of branches rather pale olivaceous brown, smooth 2-4 μ thick hyphae. On the hyphae conidiophores arising singly or in groups as lateral branches. Lower part of conidiophore is erect, straight or flexuous and sterile, upper part is fertile and shows zigzag regions separated by sterile areas, mid to dark brown, paler near the apex with numerous dark conidial scars, upto 300 μ

long and 6-8 μ thick. Conidia broadly fusiform, pale to dark brown or olivaceous brown, smooth with 3-5 pseudosepta, usually 3 septate, measuring 25 to 65 μ long, 10-16 μ wide in the broadest part, 4-6 μ thick at truncate base and 5-6.5 μ wide at the apex.

8) Spiropes helleri (Stev.) Ellis :

Mycol. Pap. 114 : 14, 1968.

= Helminthosporium helleri Stev.

Distribution : Ghana, Malaya, New Caledonia, Philippines, Puerto Rico, Sabah, Sierra Leone, India. On Asteridiella, Irenopsis and Meliola on various plants.

It was first described by Ellis (1968). Later on it was described by Narendra and Rao (1972) as hyperparasite on Meliola sp. affecting flacourtia sp. Coorg forest, Karnataka. Author has also collected it from Ratnagiri and Amba Ghats growing as hyperparasite on Meliola canthi Hansf. on the leaves of Wendlandia notoniana Wall. Thus it is the new record to Maharashtra on new host.

Spiropes helleri (Stev.) Ellis - Plate VIII.

Conidiophores straight or flexuous, pale olivaceous brown, upto 320 to 450 μ long, smooth, thick walled, conidigenous cells polyblastic, cylindrical 7.5 μ thick with numerous scars. Conidia solitary, obclavate or sometimes

fusiform, rounded at the apex and truncate at the base, brown or dark brown. Central cell slightly darker than end cells; smooth or Verrucose, almost always with 3 transverse septa, measuring 32 to 48 μ long, 6.5 to 8.6 μ thick at the broadest base.

- 9) Vakrabeeja sigmoidea (Cavara) Subram. :
Jour. Indian Bot.Soc., 35 : 466, 1956.
 = M.sigmoidea Hara, 1939. Disease of rice plant, Ed.2 :
 185.
 = Helminthosporium sigmoideum Cav., 1889, Revue.Mycol.
11 : 185.
 = Vakrabeeja sigmoidea (Cav.) Subram. 1956, J.Indian
Bot.Soc., 35 : 465-466.
 = Curvularia sigmoidea (Cav.) Hara. 1889, A monograph
 of rice disease, 42.

Distribution : Ceylon, Egypt, Europe, Fiji, India,
 Japan, Kenya, Malaya, Nigeria, Sabah, U.S.A.

Vakrabeeja sigmoidea (Cavara) Subram. is the imperfect state of Leptosphaeria salvini Catt. which was first described by Cattaneo (1879). Italy on Oryza, causing stem rot - a serious disease. A good account of life history of this fungus is given by Tullis in J.Agric.Res. 47 : 675-687, 1933. Later on it was described by Petrak (1927) and Mundkur (1938) on

lower leaf sheaths and within the cavity of the stem of Oryza sativa, throughout the India; and Subramanian (1956), Singh and Pavgi (1964) on leaf sheaths and stem of Oryza rufipogon Griff; Varanasi U.P. and Oryza sativa L. Varanasi, U.P. Author has also collected it from Amboli (Dist.Ratnagiri) growing as hyperparasite on Meliola piperae. Thite sp. nov., on the leaves of Piper nigrum L. Thus it is the additional host from Maharashtra.

Vakrabeeja sigmoidea (Cavara) Subram (Plate IX) :

Colonies effuse, black, conidiophores macronematous, unbranched brown, upto 200 μ long and 4-6- μ wide. Conidiogenous cells cylindrical with thin walled denticles. Conidia solitary simple, sometimes sigmoid, smooth, usually 3 septate. The end cells are paler or hyaline and intermediate cells are mid-brown in colour. Conidia 45 to 56 μ long and 12 to 15 μ thick in the broadest part and tapering at the ends.

A critical study of literature regarding the occurrence of fungal hyperparasites reveals the facts which are represented in the table No.I. From this table it is clear that there is a natural balance about the number of fungi serving as host to the hyperparasites i.e. about 708 fungi serve as host to about 697 hyperparasites. But the distribution of

Table - I

Host	Class of parasite with numbers				Total
Class of Host	Phycomy-	Ascomy-	Basidio-	Deuteromy-	
: Hosts	: cetes	: cetes	: mycetes	: cetes	:
Phycomycetes	115	100	6	18	124
Ascomycetes	284	7	123	140	362
<u>Meliola</u>	90	374	27	55	195
Basidiomycetes	151	14	47	64	148
Deuteromycetes	68	6	9	48	63
Total	708	127	212	325	697

host as well as parasite amongst the different classes is typical one, which shows the relationship between phylogeny and nutritional habits of different groups of fungi. Because the fungi are considered to have originated from green algae by loss of chlorophyll and development of parasitism. So the saprophytes are considered more primitive than parasites. And parasites are comparatively more primitive than hyperparasites.

From the table it is clear that out of 697 hyperparasites maximum i.e. 325 are from the Class Deuteromycetes. Amongst these 325 hyperparasites 195 are occurring on the ascomycetous hosts. And largest number of hyperparasites is borne by the genus Meliola i.e. 55 with about 212 hyperparasites. Ascomycetes comes next, out of 212 hyperparasites 150 are on Ascomycetous host only. Phycomycetes stand third with 127 hyperparasites where 100 amongst them are on again phycomycetes. Basidiomycetes have 34 hyperparasites out of which 23 are on Basidiomycetous hosts.

Out of 708 members of fungi serving as hosts 375 are from the class ascomycetes bearing about 365 hyperparasites from different classes. Within ascomycetes 90 species of Meliola serve as hosts for hyperparasites from different classes. Class Basidiomycetes is represented by 151 hosts bearing 148 hyperparasites. Phycomycetes follows with 115

hosts bearing 124 hyperparasites. Last is the group Deuteromycetes where the lowest number of hosts, only 68 bearing 63 hyperparasites.

If the percentage of total number of parasites on the hosts of same class is considered, then phycomycetes have 127 parasites. Out of which 100 are on phycomycetous hosts. So about 80% of phycomycetes hyperparasites occur on Phycomycetes hosts. This percentage goes on decreasing when we go to Ascomycetes 66.66%. Basidiomycetes of 60% while in case of Deuteromycetes it is only 15%.

Ascomycetes, Basidiomycetes and Phycomycetes have 375, 151 and 115 members serving as hosts and 212, 127 and 34 hyperparasites. Thus they are showing presence of primitive and higher forms in each group. So the polyphylatic origin of fungi in different lines independent from different groups of genera and red algae is supported by this observation.

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DISTRIBUTION OF HOSTS

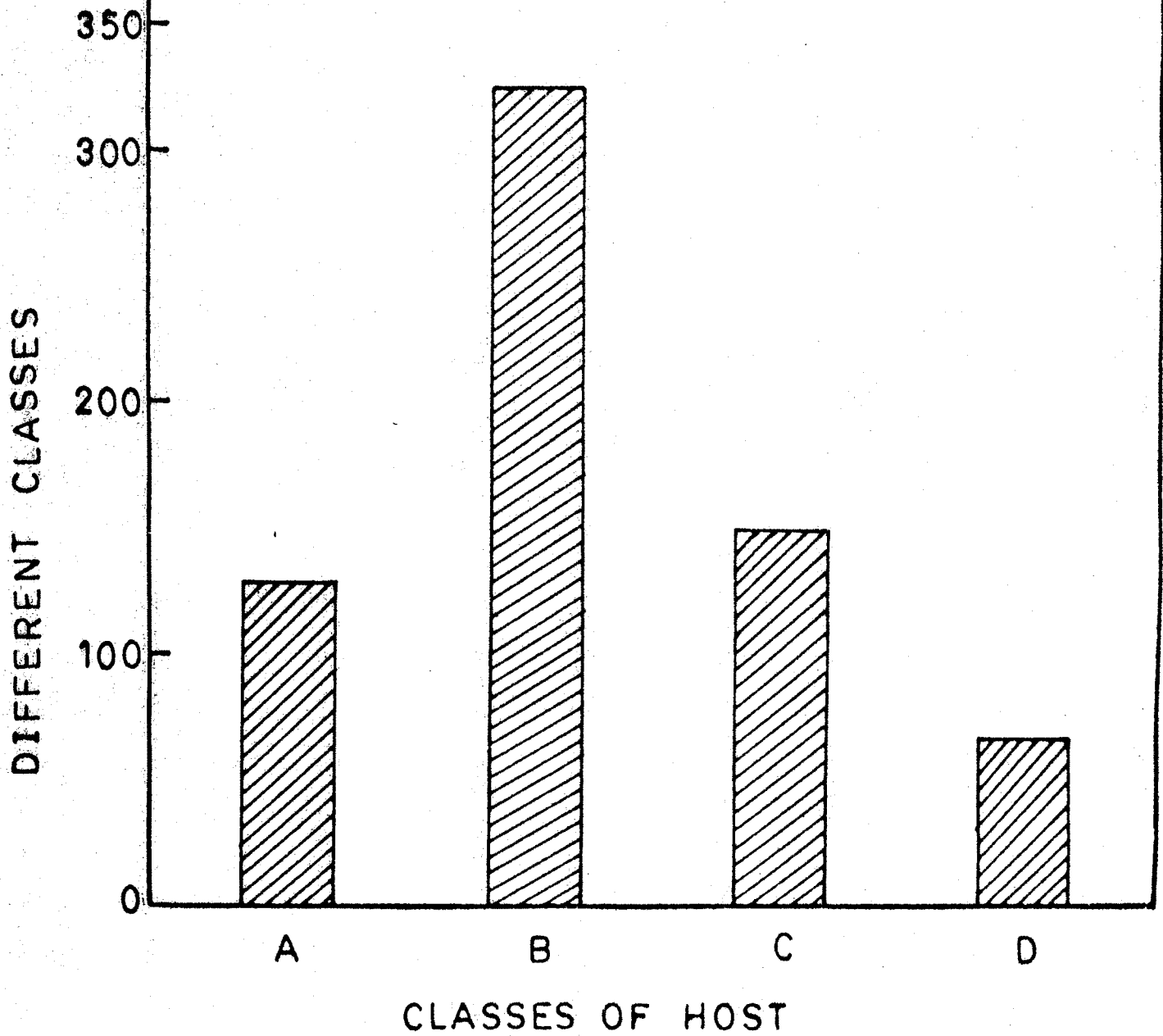


FIG. A—PHYCOMYCETES. C—BASIDIOMYCETES.
B—ASCOMYCETES. D—DEUTEROMYCETES.

DISTRIBUTION OF HYPERPARASITES

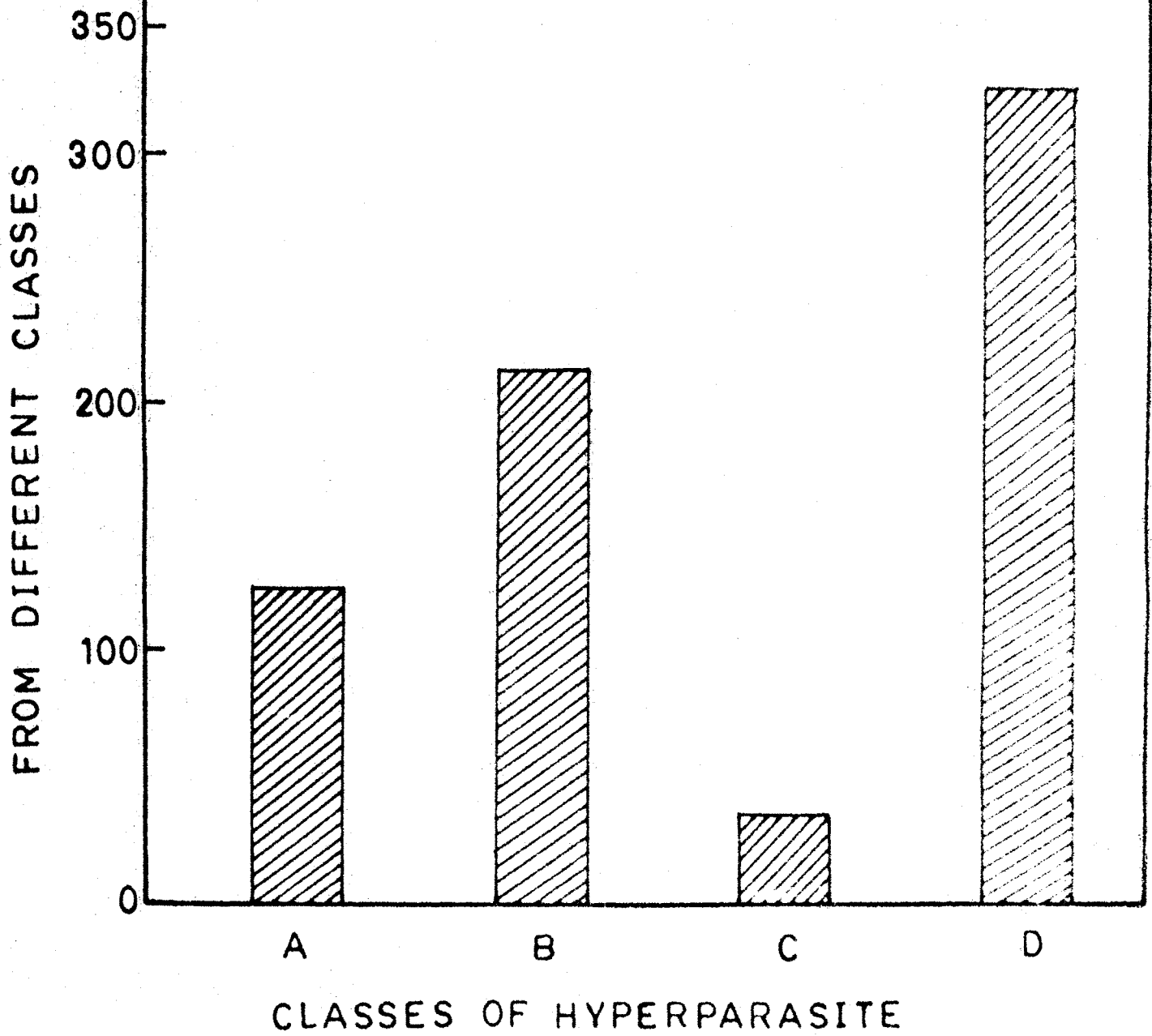


FIG. A—PHYCOMYCETES . C—BASIDIOMYCETES .
B—ASCOMYCETES . D—DEUTEROMYCETES .

Description of Figures

- Plate I : Annellophora solani (Syd.) Hughes.
Plate II : Cladosporium fulvum Cooke.
Plate III : Exosporium ampullaceum (Petch) Ellis.
Plate IV : Pyriculariopsis parasitica (Sacc.Berl.) Ellis.
Plate V : Spiropes davillae (Syd.) Ellis.
Plate VI : Spiropes dorycarpus (Mont.) Ellis.
Plate VII : Spiropes guareicola (Stev.) Cif.
Plate VIII : Spiropes helleri (Stev.) Ellis.
Plate IX : Vakrabeeja sigmoidea (Cavura) Subram.

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PLATE I

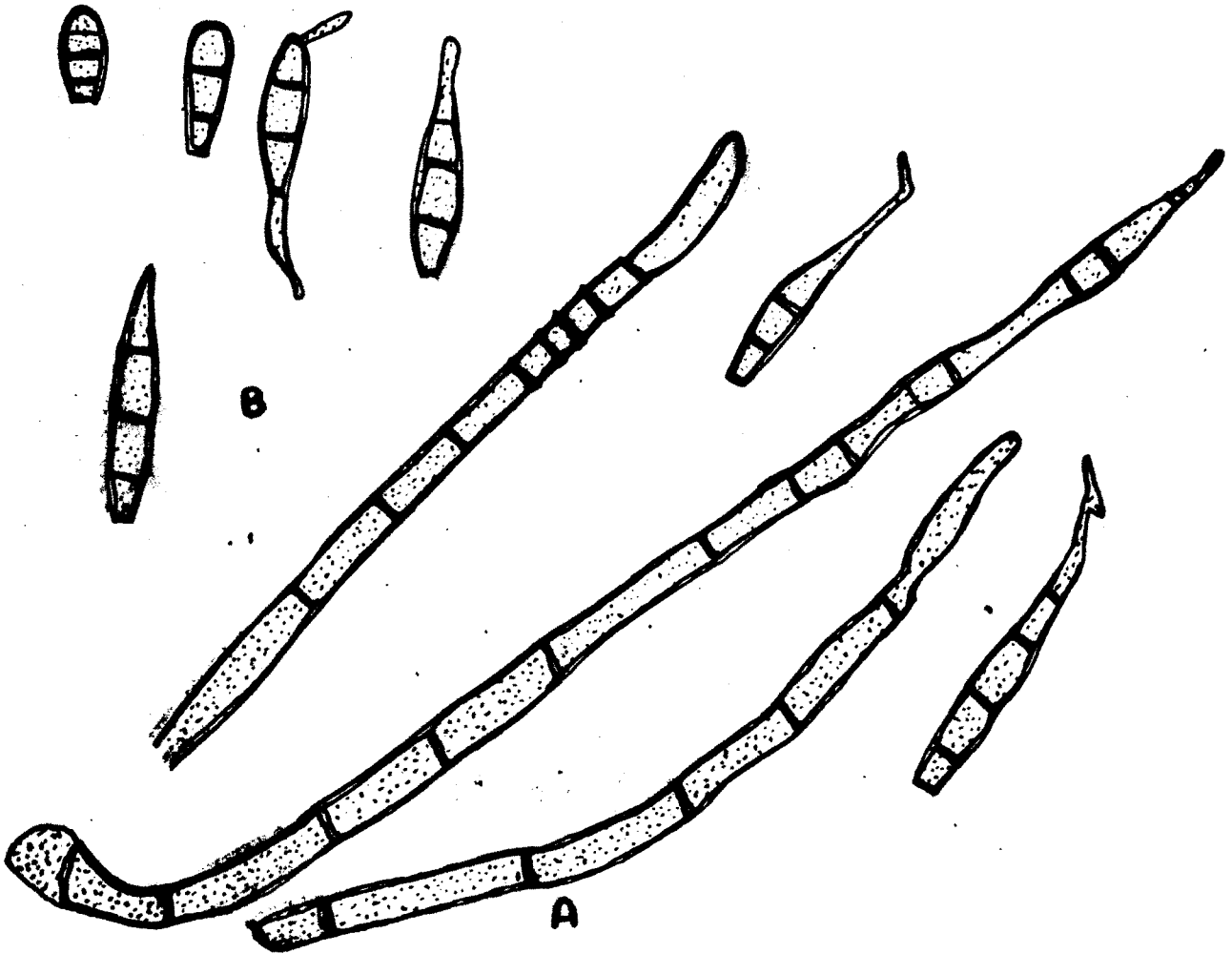


PLATE II

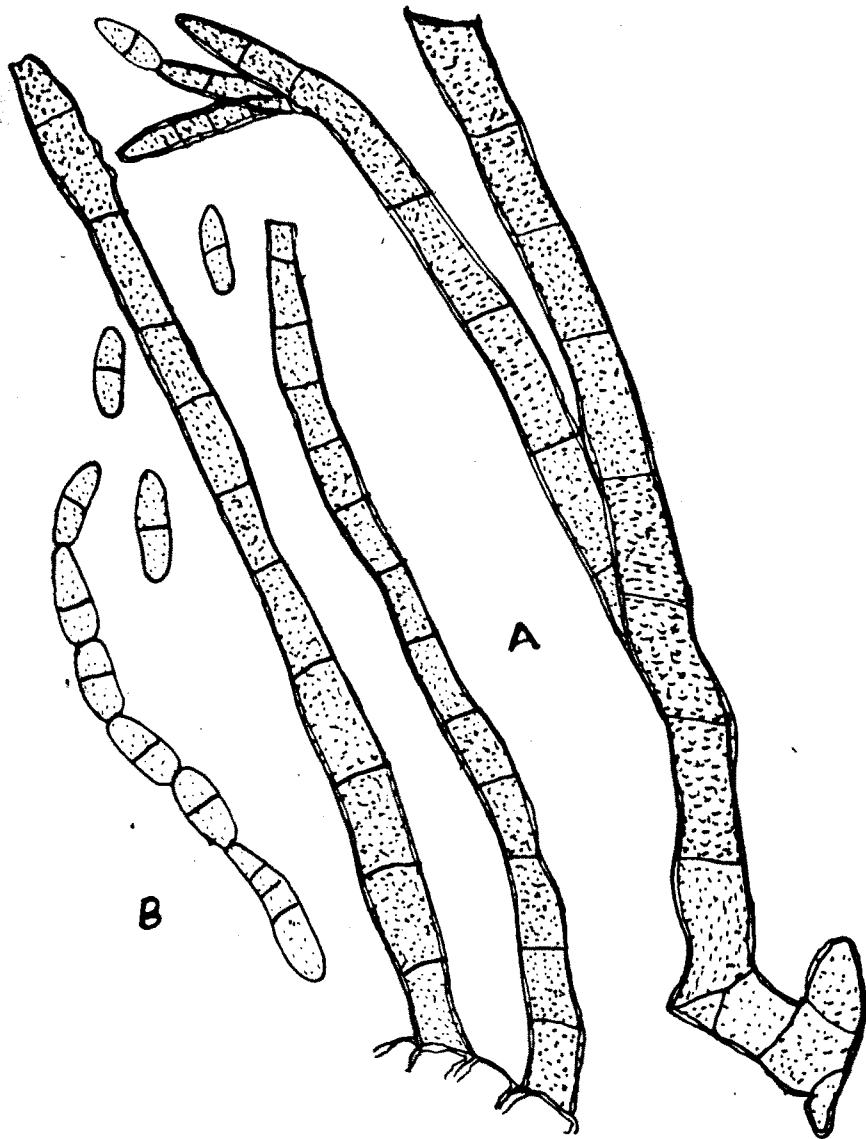


PLATE
III

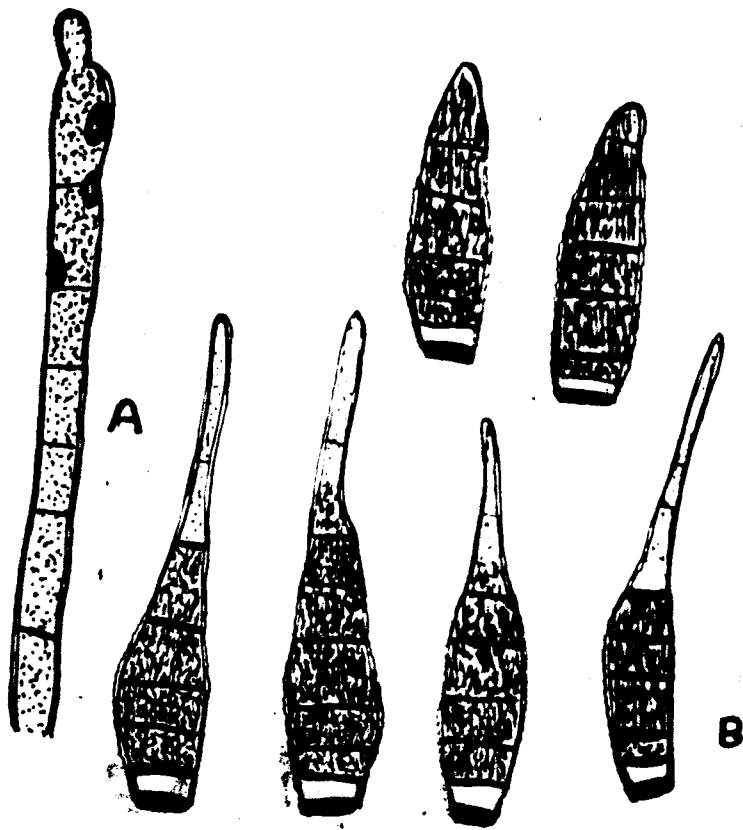


PLATE
IV

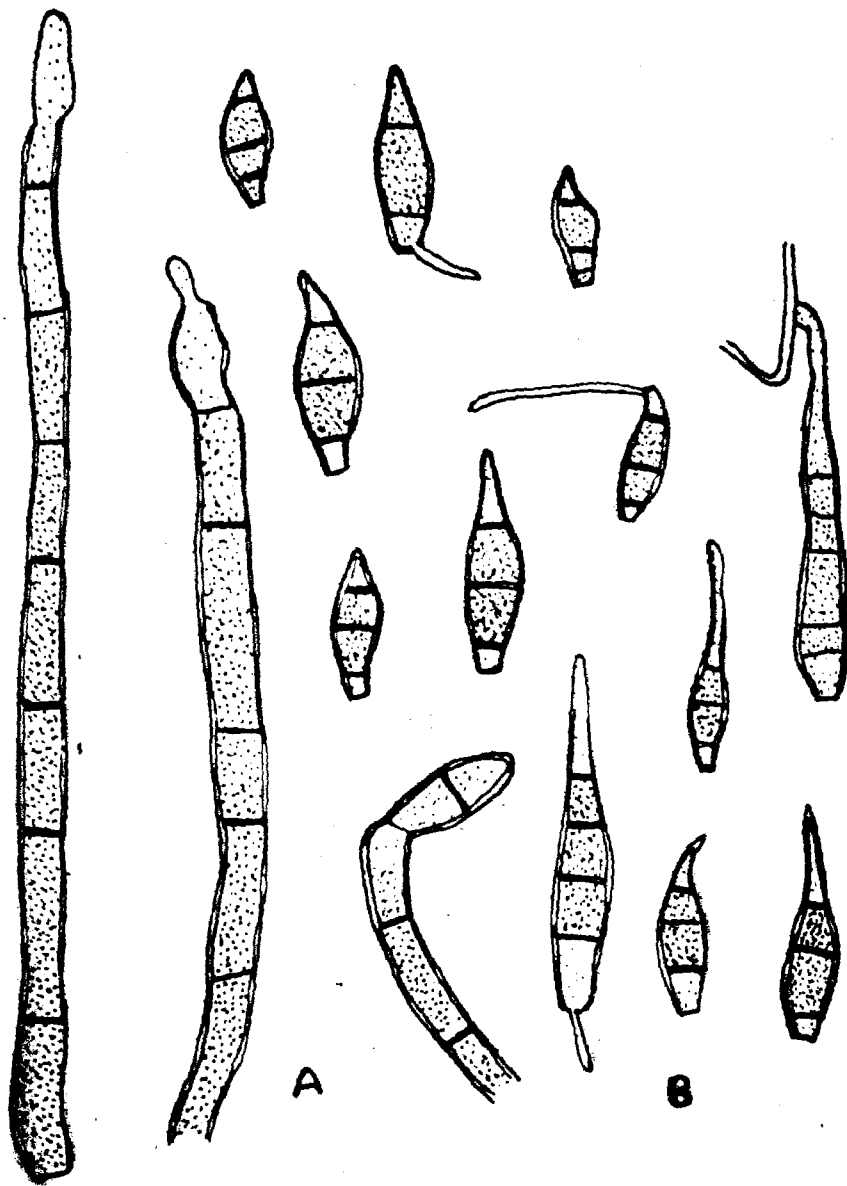


PLATE V

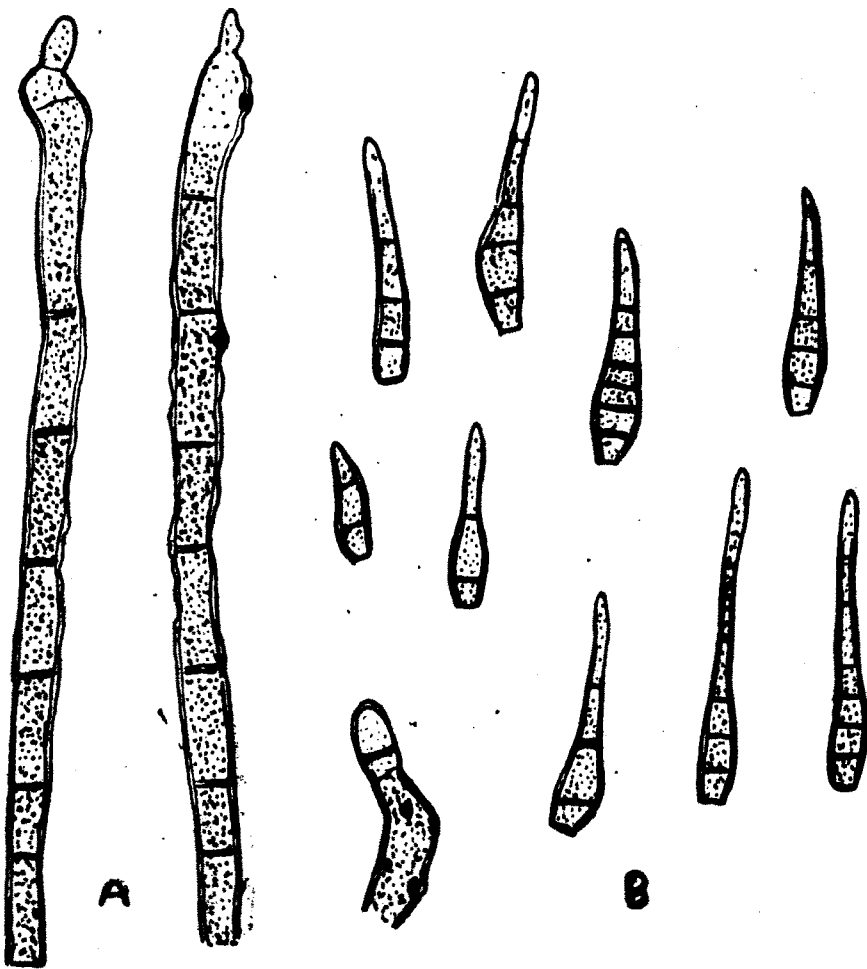


PLATE VI

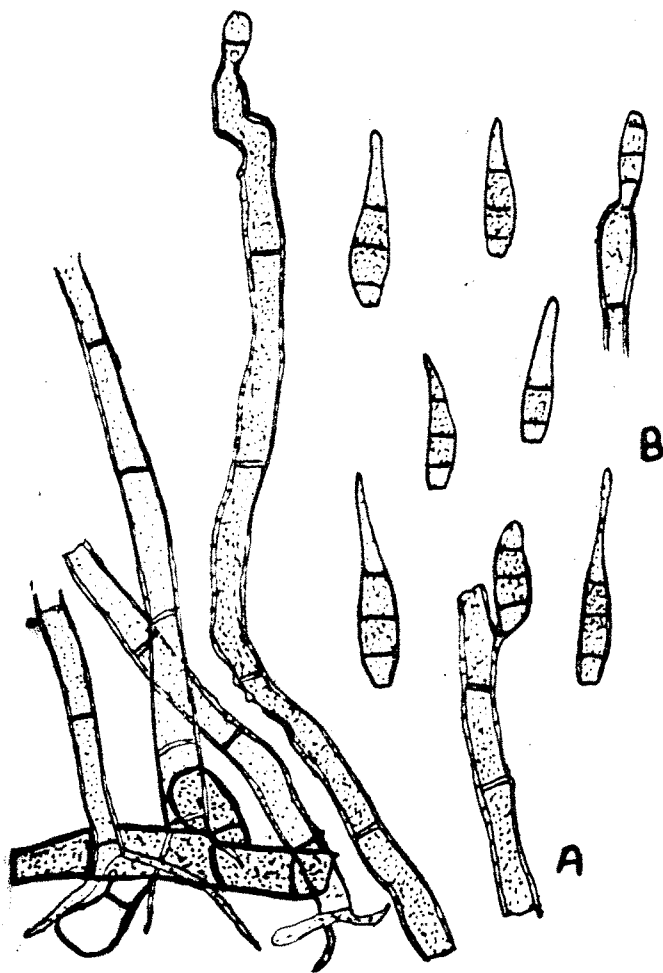


PLATE
VII

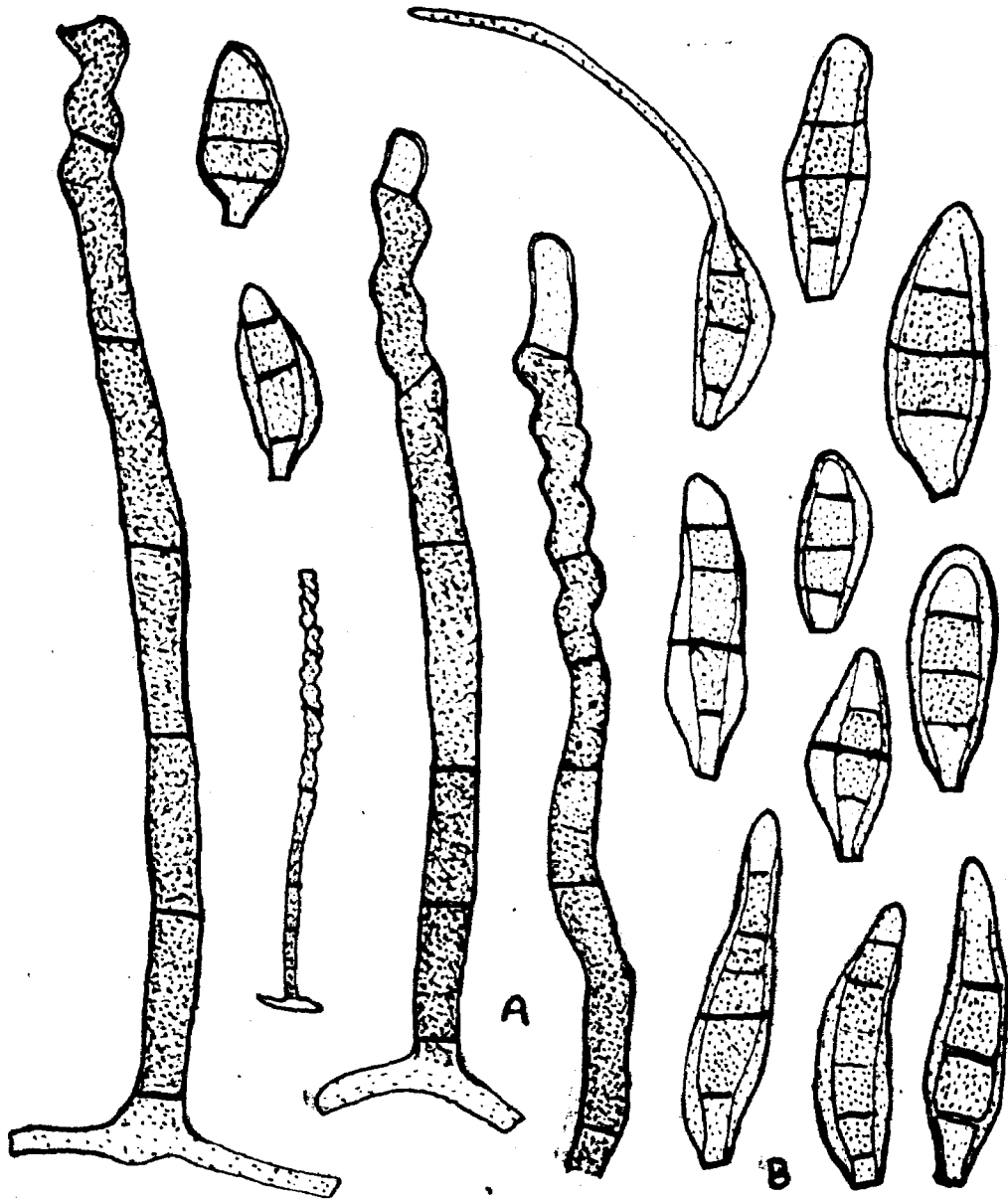


PLATE
VIII

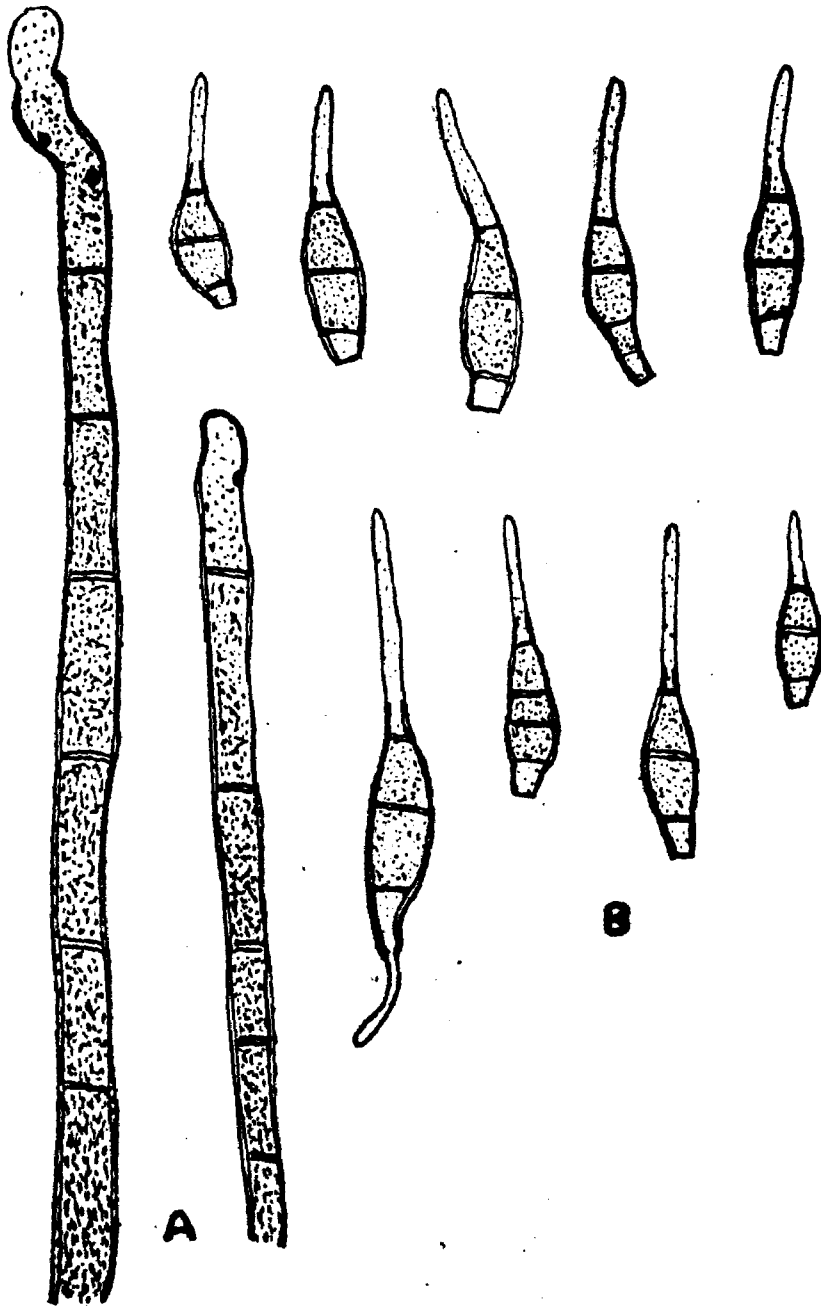


PLATE IX

