SOME ASPECTS OF ECOLOGICAL AND FLORISTIC STUDIES OF RED SEA MANGROVE (*Avicennia marina* Vierh.) AND MARINE FUNGI FROM MITSIUA, ETHIOPIA

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

Ecology and floristics of higher marine fungi of Ethiopian coastal waters (at Mitsiua) of the Red Sea was studied from Sept., 1986 to May, 1987. Wood and pneumatophores of Avicennia marina (mangrove) Swetienia mhagoni (mhagoni) and Fagus sylvatica (fagus) were used as baiting substrates. Mangrove substrate submerged in the sea and driftwoods from Hamlay Desiet were the main materials on which the study was focused. Besides, the study included supportive data from environmental parameters such as temperature, pH, salinity, secchi disc depth, dissolved oxygen, and wood weight and strength losses.

The occurrence of the fungi on the test wood blocks in relation to the environmental parameters and their selective effect on the test wood blocks is discussed. The environmental parameters mentioned above along with ecological factors such as heavy sediments in the water, etc. account for the occurrence of the fungi.

The fungal decay rate on each substrate and 3 sites were studied in terms of weight and strength losses. Among the timber species mhagoni and fagus were found to be the most susceptible and resistant species respectively. Mangrove wood was found to be moderately resistant.

Marine fungi colonizing both test wood blocks in three sites and driftwoods in one site are listed and most of these are described and illustrated. Forty nine species of fungi were isolated and of which Periconia prolifica, Cirrenalia tax. sp. and Culcitalna acrospora on test wood blocks and Periconia prolifica, Lulworthia sp. 1, Gnomonia sp. and Zalerion sp. on driftwoods were dominant species.

In all, 51 species are recorded on wood substrates collected from Mitsiua. Out of these 9 species were found growing only on test wood blocks and 30 species on driftwoods. The remaining 13 species were recorded on both these substrata. Of the total fungal taxa recorded, 22 species belonged to Ascomycotina, 1 to Basidiomycotina and the remaining 28 species to Deuteromycotina.

The following 11 species, viz. (Ascomycotina) *Didymosphaeria* tax. sp., *Halosarpheia* tax. sp., and unidentified unitunicate fungus, (Deuteromycotina) *Cirrenalia* tax. sp., *Diplococcium* tax. sp., *Halosynnema avicenniae* gen. et sp, nov., *Idriella* tax. sp., *Lasiodiploidia* tax. sp., unidentified pycnidial fungus, unidentified hyphomycetous fungus and unidentified mycelia sterilia are new to marine mycocommunity.

Of the total collections, 35 species are obligate marine taxa. 50 species are new records to the Red Sea in particular and 17 species to the Indian Ocean in general. All of them are new to the Ethiopian coast and are additions to our knowledge on the mycoflora of Ethiopia. These findings also raised the number of fungi colonizing *Avicennia marina* from 7 to 27.

The discoveries suggest that the Red Sea in general and the mangrove vegetation in particular support great numbers of fungal species. Also, the fungi along with other microbes and marine borers are organisms that are responsible for the degradation of mangrove and other wood substrates in sea water.

1. INTRODUCTION

Traditionally, mycologists have devoted most of their time to the study of terrestrial fungi. However, in recent years, in view of man's greater concern with environmental problems such as pollution of streams, lakes, rivers, local coastlines, etc. aquatic fungi have received considerable attention. Recent studies also indicate that aquatic fungi play a key role in the productivity of estuaries, streams, and near-shore regions in the sea by way of aiding decomposition of organic matter in situ (Jones, 1976). Lignicolous marine fungi have been paid due attention for their role as wood degraders and decomposers of dead organic substrate (Jones, 1971, 1972, Jones & Irvin 1971; Kohlmeyer & Kohlmeyer, 1979). The lignicolous marine fungi (higher marine fungi sensu Kohlmeyer & Kohlmeyer,1979) include filamentous species of Ascomycotina, Basidiomycotina and Deuteromycotina (Jones, 1976, Kohlmeyer & Kohlmeyer, 1979).

Attempts were also made to understand the geographical distribution of higher marine fungi (Jones, 1968a, 1976; Hughes, 1974, 1975; Hughes & Chamut, 1971; Kohlmeyer & Kohlmeyer, 1979), and this has called for an intensive floristic study of marine fungi from several less-explored regions. According to Kohlmeyer (1984) about one third of all described higher marine fungi at the recent time are from the tropics and sub-tropics. He predicted that when research in tropical marine habitats intensified in the future the ratio is expected to change in favour of tropical fungi. Though 220 species of higher fungi are known from seas and oceans around the world (Kohlmeyer, 1984) and of which 67 species are known particularly from tropical waters of the Indian Ocean, so far only two species are recorded from the Red Sea (Aleem,1978).

In the tropical marine habitats one area where very little work has been done is the mangrove forests (the 'mangal' sensu Kohlmeyer & Kohlmeyer,1979). Mangrove trees produce large amount of litter in the form of leaves and wood but little is known about the higher mycota developing on such substrates

(Kohlmeyer, 1984; Kohlmeyer & Kohlmeyer, 1979; Hewell, 1976; Patil & Borse 1983; Subramanian, 1979). Of over 100 mangrove tree species listed by Chapman (1976) only 8 have been recorded as hosts of marine fungi (Kohlmeyer & Kohlmeyer, 1979).

These all point out that the mangrove habitats and the floristics in general of the tropical waters and in particular of the Red Sea have not been explored in any detail. The objective of the present study is, therefore, to find out what species of higher marine fungi constitute the mycoflora of one of the mangrove forests, in the Red Sea along the Ethiopian coastline, the principal vegetation of which being Avicennia marina Vierh , and the higher marine marine fungi occurring on driftwoods found in the coastal waters at Mitsiua about 120 km from Asmara, in the northern part of the country.

In this project work, the mangrove wood and pneumatophore have been investigated for the possible pattern of fungal colonization during a period of 8 month submersion of the former in sea water. In addition, two of the 'fishing-craft' building wood materials, viz. Fagus sylvatica L. and Swietenia mhogani Jacq. (common Mhogani), also were investigated in place of mangrove wood. The drift woods washed ashore into the mangrove forest were examined for the fungi occurring on them to enumerate the marine mycoflora of the Red Sea along the Ethiopian coastline. The rate of wood degradation caused by the fungi and the possible impact of environmental factors on the occurrence and distribution of the marine mycota have also been investigated.

2. REVIEW OF LITERATURE

2.1. Development of marine mycology

The most significant contribution on marine fungi, one which had a tremendous impact on development of marine mycology, was the pioneering work of Barghoorn and Linder (1944) in which they described several new taxa of indigenous marine mycota and also reviewed the scanty earlier work. These authors obtained fungi from wood that had been submerged continually from 5 months to 1 year below low tide level in the sea throughout, or exposed in the intertidal zone where they were subjected to submersion in water twice a day. That way, they believed that there was little possibility that the fungi obtained were terrestrial forms. Although the existence of true marine saprophytic fungi was questioned (Bauch, 1936), investigations by Borghoorn and Linder proved that fungi do contribute to the decomposition of organic substrates in the oceans.

The first obligate marine fungus, Sphaeria posidoniae (=Halotthia posidoniae), was described by Durieu and Montagne in 1869 on the rhizomes of the sea grass, Posidonia oceanica although earlier Desmaziers in 1849 had discovered the first facultative marine fungus, Phaeosphaeria typharum (Kohlmeyer & Kohlmeyer, 1979). Probably, a series of papers written by Sutherland (1915 a-c, 1916 a,b) were the only publications which dealt exclusively with marine fungi prior to 1944 and three quarters of all currently recognised marine mycota have been described only after the publication of Barghoon and Linder (1944). The first monograph on marine fungi by Johnson and Sparrow appeared in 1961. Most recently, marine mycology has been magnificently reviewed and monographed by Kohlmeyer and Kohlmeyer (1979)

2.2. Definition

2.2.1. Marine habitat and marine fungi.

In a strict sense, a marine habitat is one where salinity exceeds 30‰. Accordingly, a marine fungus was defined as one which occurs regularly, grows and reproduces in a marine habitat (Johnson and Sparrow, 1961). However, such a restrictive definition based strictly on physiological basis cannot generally be applied to a great many ecological situations in which salinity levels and periodicities vary markedly (Hughes, 1975). Moore and Mayers (1959) introduced the term 'Thalassiomycetes' and defined them as (P. 372)'... fungal taxa of any class which are isolated predominantly or exclusively from marine habitats.' Kohlmeyer (1974) used broad ecological bases to define the marine fungi; namely, 'obligate marine fungi' are those that grow and sporulate exclusively in a marine or estuarine (brackish water) habitat and 'facultative marine fungi' are those from fresh water or terrestrial habitats that grow and and probably sporulate also in a marine habitat.

The lignicolous or higher marine fungi comprise filamentous species of Ascomycotina, Basidiomycotina and Deuteromycotina. These groups are briefly described below following Hawksworth et al. (1983).

Ascomycotina (p.27)... the largest group of fungi, for which the ascus (sac-like structure within which typically 8 sexual spores or ascospores are produced) is the diagnostic character... asci may be unitunicate or bitunicate and develop within an ascocarp.

Basidiomycotina (p.46)...., the diagnostic character of this group is the presence of a basidium bearing typically 4 sexual spores or basidiospores which are borne outside the basidium on small sterigmata..... basidiocarps are of varied types.

Deuteromycotina (p.112)... this is an assemblage of Fungi Imperfecti characterised by the absence of a teleomorph (perfect or sexual state). They include conidial fungi that are typically filamentous in which the conidiophores are free or born in sporodochia, synnemata, or pycinidia. Most deuteromycetous fungi are anamorphs of ascomycetes and a few have basidiomycete affinities. They are classified in form-genera and form-species.

Marine or estuarine habitats include the oceans, estuaries, salt ponds, and lagoons connected or not connected to the sea, salt marshes, and swamps including the mangroves, deep or coastal sands and muds in each case, and wood and leaf litter and other detritus that occur in those situations (Kohlmeyer and Kohlmeyer, 1971).

2.2.2. Number of marine fungi

The oceans and seas, compared to the terrestrial habitats, provide a fairly stable environment with small changes in temperature and salinities. Organic substrates such as algae, marsh plants, and plant litter that are accumulated along the shores provide nutrients for fungi. The open ocean is said to be a fungal desert (Kohlmeyer and Kohlmeyer, 1979). As of the number, marine fungi are only 1% of the terrestrial mycota. About 500 species of marine fungi have been described from oceans and estuaries. Of these, 220 species are the higher filamentous lignicolous marine fungi, 177 species are marine yeasts and the remaining less than 100 species are the lower marine fungi (Kohlmeyer and Kohlmeyer, 1979). Perhaps, the relatively stable marine environment and small number of available hosts and substrates did not exert enough selective pressure during the course of evolution to induce the formation of a higher number of different types of fungi.

2.3. FLORISTICS ON MARINE FUNGI.

Intensive collections of marine fungi have so far been restricted to temperate waters of Europe and North America (Cuomo et al., 1985; Farrant, et al., 1985; Hegarty & Carran, 1982; Koch, 1974, 1985; Koch, et al., 1983; Kohlmeyer, 1960; Kohlmeyer & Kohlmeyer, 1977, 1979). Mycological data from the tropical and subtropical marine habitats included descriptions of fungi isolated from washed up organic detritus (algae, grasses, wood, etc.), permanently fixed intertidal and subtidal substrates such as sea grass rhizomes, pilings, ship-wrecks etc., and those arenicolous species isolated from sandy beaches. Marine fungi occurring in the tropical and subtropical Atlantic ocean were reported both from American and

African coasts (Aleem, 1980; Aleem & Malibari, 1981; Cuomo et al., 1985; Kirk & Brandt, 1980; Kohlmeyer, 1977, 1980; Pugh & Jones, 1985; Shearer & Crane, 1980).

2.3.1. Floristic work in tropical regions of Indian Ocean.

The tropical waters in general have been little explored and occurrence of the fungi particularly in the Indian Ocean is said to be poorly reported (Kohlmeyer, 1981, 1984). A few authoratative floristic reports of marine fungi from the tropical parts of Indian Ocean include those of Borse (1984, 1985a, b); Jones (1968a); Koch (1982); Kohlmeyer and Kohlmeyer (1979), Nair (1970); Patil & Borse (1983, 1985); Raghukumar (1973), Subramanian & Raghukumar (1974) and Zanial and Jones (1984; 1985). Very little has been reported from the Arabian Gulf or from the East African coast of the Indian Ocean (Zanial et al., 1984, 1985) and only one paper has dealt with the fungi of the Red Sea (Aleem, 1978). Aleem reported 2 species of higher marine fungi, viz: Corollospora pulchella and Periconia prolifica from the Saudi Arabian coast of the Red Sea and thus so far no marine fungi have been reported from the Ethiopian coastal waters.

Baker and Kohlmeyer (1958) mentioned Halosphaeria quadricornuta (= Antennospora quadricornuta) in connection with a report of soft rot in fishing- crafts caused by marine fungi in India and this was the first fungus documented from the Indian Ocean.

So far about 67 species of lignicolous marine fungi have been described from the tropical parts of Indian Ocean, in the coastal waters of Aden, India, Kuwait, Mauritius, Saudi Arabia and Sri Lanka, and of which 47 species belong to Ascomycotina, 2 species to Basidiomycotina, and 18 species to Deuteromycotina.

2.4. MORPHOLOGICAL AND PHYSIOLOGICAL ADAPTATION OF MARINE FUNGI.

In the marine environment, fungi show remarkable morphological and physiological adaptations. Morphological adaptations that enhance flotation in water and attachment to substrates include devices such as cellular or mucilaginous appendages of fungal spores, spindle-shaped or elongated spores, ridges or striations on the exospore, guttules within the cells, etc. and, in fact, spore appendages were first observed by Barghoorn and Linder (1944). Appendages enlarge the spore surface and thereby minimize the settling rate and assist in keeping the spores suspended in the water and increase their chances of adhering to the floating substrate (Kohlmeyer & Kohlmeyer, 1979).

Kohlmeyer (1972), Jones (1973) and Rees (1980) have studied behavior of spore appendages during flotation, dispersal and attachement. These spore appendages also have taxonomic significance in delimiting genera and species (Johnson, 1980; Jones & Moss, 1978, 1980).

Environmental factors such as salinity, temperature, pH, oxygen, dissolved ions, etc. affect the physiological activity of marine fungi particularly the vegetative growth and reproduction (Jones & Byrne, 1976). Intensive investigations were made primarily on the wood degrading fungi in relation to their salinity tolerances (Jones et al.,1971; Kirk, 1967). The physiological adaptation of marine fungi to salinity and temperature govern their pattern of distribution in marine habitats (Shearer, 1972).

2.5. MARINE FUNGI OF THE MANGROVE HABITAT

2.5.1. Floristic studies

The first set of mangrove fungi were reported by Cribb and Cribb (1955) in Australia and since then more information is available on tropical and sub-tropical mangrove fungi (Aleem & Malibari, 1981; Fell & Master, 1975; Kohlmeyer, 1966, 1969a; 1984; Kohlmeyer and Kohlmeyer, 1964-1969, 1971, 1977, 1979; Lee & Baker, 1973; Maxwell, 1968; Newell, 1976).

The majority of the manglicolous fungi are saprobes and omnivorous (Kohlmeyer & Kohlmeyer, 1979). Wood inhabiting or lignicolous fungi generally invade the wood after the protective bark is removed by the attack of wood-boring animals, storms or human activity (Rehm & Humm, 1973). Wood-inhabiting fungi are found in nature on so-called intertidal wood (Hughes, 1968) and their ecology is studied by wood panels submerged for certain periods of time (Barghoorn & Linder, 1944; Meyers & Reynolds, 1958; Jones et al., 1972).

While comparing his observations with mycota of other mangrove parts, Newell (1976) concluded that seedlings, leaves, and wood of Rhizophora mangle 'all appear to harbor quantitatively and qualitatively unique mycoflora'. Lee and Baker (1973) isolated many fungi from the rhizoplane of R. mangle in Hawaii, but the species isolated were mostly terrestrial. Leaves of R. mangle were studied by Odum (1971) and Odum and Heald (1972) in view of the importance as a source of detritus in the tropical & subtropical environment. Fell and Master (1973, 1975) and Fell et al. (1975) examined the involvement of higher and lower fungi in the degradation of R. mangle.

2.5.2. Vertical and Horizontal Distribution.

The vertical and horizontal distribution of marine fungi has been rarely studied. Investigations on the vertical distribution of marine fungi have been made by Schauman (1968, 1969) on stationary wooden substrates in the Weser estuary. Kohlmeyer (1969a) observed that there is a zonation of marine fungi along the vertical roots, stems, or branches of mangrove trees. Terrestrial fungi developed on roots and branches above the hightide line and an overlaping between marine and terrestrial species occurred at water-air interface in the intertidal zone but no distinct pattern on vertical distribution among the species was evident (Kohlmeyer, 1969a). Mangrove trees like R. mangle and Avicennia marina growing in salinity ranges from full sea water (about 35‰) to pure freshwatrer, and containing obligate mycoflora at salinities near 35‰ are replaced by different mycota in the fresh water area (Kohlmeyer, 1969b)

2.5.3. Ecological studies

Studies on mangrove fungi progressed along two lines of research. One of these has been the approach of Kohlmeyer

(1969a, 1971a), who conducted extensive searches for fungi inhabiting the woody tissues of mangrove vegetation on the coasts of tropical America and Hawaii. He restricted his studies only on those fungi which can directly be observed in their fruiting stages without the use of any cultural techniques.

The second approach involved cultural work with which fungi can be isolated from sediments beneath the mangrove stands and has been studied from different coasts (Lee & Baker, 1972, 1973; Pawar & Thirumalacher, 1966; Rai & Chawdery, 1975; Rai et al., 1969; Swart, 1958). However, those fungi isolated using nutrient agar cultur plates included none of those studied and reported by Kohlmeyer and, consequently the latter had declined to include the species appeared on culture plates as "true" members of mangrove mycocommunity (Newell, 1976). As in other such studies, using these standard isolation techniques, little information could be gathered about the active growth and reproduction of the fungi in the habitat (Subramanian, 1983).

Newell (1976) made a detailed study of fungal succession on the seedlings of red mangrove (Rhizophora mangle L.) in Florida estuaries. According to Newell, mangrove bark appears to be particularly well protected against microbial decay due to high amount of tanning. Wood inhabiting fungi penetrate the wood of submerged mangrove roots and trunks only after the bark has been damaged. From 460 wash-plate, disc plate and damp-chamber samplings and 95 baited-dish sampling, during his 13-month study period Newell recorded 447 fungi (excluding yeasts), representing 84 species of fruiting fungi. These included 42 species of Hyphomycetes, 19 species of Sphaeropsidales, 13 species of Ascomycetes, 3 species of Melanconiales, 3 species of Oomycetes, 2 species ectoplasmic-net fungi, 1 species Zygomycetes and 1 species Basidiomycetes. Of the succession in major fungal groups, Hyphomycetes and Melanconiales were dominant on the still attached viviparous seedlings or the tree (e.g. Alternaria spp. and Cladosporium spp.). After the seedlings were placed in marine and estuarine water, both Hyphomycetes and Melanconiales began decreasing in relative frequency despite the entry of some new Hyphomycetes while the second succession community was observed. Ascomycetes and Sphaeropsidales gained numerical dominance at the third successional stage. As the third mycoseral stage progressed, the Hyphomycetes and Ascomycetes of this community of senescent and dead seedling attackers became the dominant groups, the pycnidial fungi declined in frequency as the remaining viable seedlings approached death. Neither Oomycetes nor Zygomycetes formed a major portion of the fungal occurrences during his study. He also tried to see the effect of fungal attack on the mangrove seedlings by dry weight changes, nitrogen analyses and staining techniques. The succession pattern was in conformity with what had been reported repeatedly for terrestrial litter by Hudson (1962), Kendrick and Burges (1962), and Hering (1965).

Despite the wide distribution and importance of mangrove trees in the tropics, the knowledge of marine manglicolous fungi is limited. However, so far about 46 species of higher marine fungi are recorded on different mangrove substrates. These include 26 species of Ascomycetes, 18 species of Deuteromycetes, and 2 species of Basidiomycetes (Kohlmeyer, 1984; Kohlmeyer & Kohlmeyer, 1979; Patil & Borse, 1983, 1985; Subramanian (1979).

2.6. MARINE FUNGI ON TESTWOOD BLOCKS

Wood, when immersed in the sea, is attacked by micro-organisms (bacteria and fungi) and marine borers (members of molluscan and crustacean genera) (Furtado & Jones, 1980). Marine mycologists used wood blocks, submerged for certain periods of time, to obtain the lignicolous fungi (Barghoorn & Linder, 1944; Meyeres & Reynolds, 1958, Jones, 1968a).

Information of wood colonization by marine fungi has been restricted to a few timber species e.g. *Fagus sylvaticus* and *Pinus sylvestris* (Byren & Jones, 1974, Davidson, 1974), *P. massonia* and *Tectona grandis* (Vrijmold *et al.*, 1982 a,b; 1986).

Jones (1968a) carried out an interesting study of the mycoflora colonizing wood at 18 sites around the world using test blocks of beech and Scots pine. He recorded many fungal species in which the most frequent one was present on 80% of the blocks and the least frequent ones were observed only once.

Weight losses of wood after fungal attack in nature have been analysed by Jones and Irvine (1971), who submerged wooden panels in British coastal waters. After 40 weeks of exposure, beech showed a weight loss of 27.6%, while Scots pine had lost 19.8%. Byrne and Eaton (1972) also exposed panels for 42 weeks in the sea and obtained weight losses of about 20% in both peach and Scots pine.

Recently, on a 14 month investigation, seasonal pattern of appearance of lignicolous marine fungi was worked out in detail in the coastal waters of Hong Kong using pine blocks (Pinus massoniana Lamb.), by Vrijmood et al. (1982a) and 38 species of fungi were isolated by them. Among the fungi isolated, five species (Periconia prolifica, Cirrenalia macrocephala, Ceriosporopsis halima, Trichocladium achrosporium and Halosphaeria quadricornuta) were the most frequent and abundant fungi on the test blocks observed at monthly intervals. Vrijmoed et al., (1982b) continuing work with pine again reported 51 species of fungi, among which only 28 were marine forms. According to these authors, the general distribution pattern and the distribution of more frequently appearing fungi cannot be solely accounted for by differences in salinity but it was suggested that various environmental parameters such as temperature, pH, sediments in the water, competitors, etc. affect the marine fungi in the natural environment.

2.7. THE RED SEA

2.7.1. Hydrography and geographical location

The Red Sea occupies an exceptional position among marine basins. Its peculiar hydrographical conditions are largely generated by partial isolation from the open ocean, its geograhical position in an arid tropical zone, and the prevailing wind system (Halim, 1969). Being located between latitudes 13 and 31^{O} N and longitudes 33.50 and 44^{O}E, the long and narrow basin of the Red Sea is connected with Indian Ocean through the straight of Bab-el-Mendab in the south and with the Mediterranean Sea through the Gulf of Suez in the north (Gorskov, 1985). Outside the shallow reefbound coastal waters the general depth is about 700m, but the bottom is irregular and there are depressions whose depth exceed 2000m. The sill at the south entrance does not exceed 100m and consequently the deep water of the Indian Ocean is largely excluded from the Red Sea. Evaporation is active and largely exceeds precipitation so that salinity and temperature are comparatively high, surface salinity rapidly rises from less than 37‰ at the southern entrance to 40-41‰ in the northern Red Sea and the Gulf of Aquoba, and to more than 41‰ in the Gulf of Suez. The average surface temperature fluctuates between 25°C and 32°C in the south, 21.3°C and 27.9°C in the northern Red Sea. The Gulf of Suez shows a slightly greater amplitude, from 17.9°C to 26.5°C. The lower layers from about 300m downwords, are almost homothermal, near to 21.7°C, except for an adiabatic increase in the deeper waters, and homohaline around 40.5-40.6‰. The Red Sea deeper waters are warmer than any other marine basins at corresponding levels. A layer of minimum oxygen is present at 300-600m, with very low values of 0.4-0.6 ml/l at the minimum. The wind system is related to the monsoon of the Indian Ocean (Halim, 1969).

2.7.2. Mangrove Vegetation

Mangrove trees usually grow only on shores where the vigour of the sun is broken by periodic sea water flooding and where they cannot endure frost (Walter, 1971). They develop in sheltered areas, on mud flats which are exposed, such as estuaries, low tide bays, etc. where wave action is reduced to a minimum (Trait & De Santo, 1972). Among them the numerically important families are the Rhizophoroceae and Avicenniaceae and, the economically important genera of world-wide importance are Avicennia, Burgieria, Conocarpus, Heritiera, Laguncularia and Rhizophora (Arnson, 1985). Many of the species such as Avicennia marina, Sorneratia alba and Rhizophora mangle foliages serve as camel and cattle feed in many arid coastal areas (Chapman, 1976). Avicennia marina Vierch (= A. alba

Blume) (*F*.Verbenaceae) hard wood is used as pillars of houses and fuel, its aromatic bitter juice is used as abortive and bark is employed for tanning (Uphalf, 1968).

In East Africa the mangroves extend from 33° in the south to Gulf of Aqaba (30°N) in the north of Red Sea and about 14 species are reported (Walter, 1971). The small bays which are land-locked by further coralreefs along the Ethiopian coast, where the sea bed lies under very shallow sandy mud supports *A. marina*, the principal vegetation of the area. The mangroves form vegetation belts of Mersa Berissa (17°55'N, 38°35'E) and Mersa Mubarec (16°31;N, 39°08'E) along the Ethiopian coast line (Hemming, 1961).

Many mangrove species have proproots, pneumatophores and viviparous seedlings that are adaptive features for aquatic habitats (Chapman, 1976). Besides, these plants have adjusted their internal fluid concentration in a higher degree than the sea water so as to permit production of turgor pressure which in turn is responsible for the translocation of water in the plants (Scholander, 1968).

3. MATERIALS AND METHODS

The methods followed in the present investigation are largely those of Jones (1971b) and Kohlmeyer and Kohlmeyer (1979). For general mycological techniques, Hawksworth (1974) has been consulted.

3.1. Study area and selection of sites

The study area, Mitsiua, is located on the north east coast of Ethiopia, in the mid-sector of the Red Sea, between latitudes 15^{o} and 38^{o} N and longitudes 28^{o} and 39^{o}E. The port of Mitsiua is a natural harbour enclosed by peninsulas and several small islands (Fig.1). It is an old sea port town established in 1665 by the Turks and developed into an all season port after the invasion by the Italians in 1885.

Under the influence of south-west Monsoon, Mitsiua experiences a cold and wet season from October to March with a maximum temperature of 35.5^{o}c and a minimum of 19^{o}c. This period is also the rainy season of the area and the town receives an average of 3-5 inches of rain every year. The hot dry season begins in April (22.5^{o}c), the temperature raising to 45.5^{o}c in August, and ends in September, the highest relative humidity being 99% during May.

Four sites were chosen at Mitsiua for our investigation of lignicolous marine fungi. The location of these sites is shown in the map of Mitsiua port (Fig.1).

Site 1 - Twalet, is situated along the main coast of Mitsiua the first island of the town. The site is along the Hirgigo Bay extension with a depth of more than 10 m and is a mooring place for fishing crafts. The entire Bay is covered with a thin layer of soft mud and silt at the bottom. A signal float maintained by the Lutheran World Federation Fishers Project Organization about 200 m away from the shore is used to suspend our test wood blocks.

Site 2 - Mitsiua proper, is located in the main commercial harbour - island of Mitsiua. It is on the south-western part of the port facing the mainland. The site is adjacent to those concrete coastal protections built for the mooring of pleasure crafts.

Site 3 and 4 - Hamlay Desiet (Green Island). The island is situated about 1 km, as the crow-flies, from the town of Mitsiua on the south-east direction. It is a small green island, roughly 1 sq. km area, covered by dense mangrove vegetation in which the principal plant species, Avicennia marina, is accompanied by a few shrubs and grass species. The tidal waves are more active here than at the other two sites and, as a result, drift-woods and other thrown-out waste materials get accumulated along the sandy beach of the sheltered mangrove habitat. Site 3 is located about 100 m away from the island on the western edge in the sea much below the low tide zone, and site 4 is in the intertidal zone, inbetween the mangrove trees, on the eastern side.

3.2. The experimental design

The experimental procedures followed in this study are explained below in detail and also shown with a flow diagram (Fig.2).

3.2.1. Preparation of Test wood-blocks:

The higher saprophytic lignicolous marine fungi are the subject of this study. The best method for providing 'baits' for these fungi is to submerge wood blocks in the sea (Jones, 1971b; Kohlmeyer and Kohlmeyer, 1979). Three types of wood materials were used, viz. (i) mangrove wood and pneumatophores (Avicennia marina), (ii) Fagus (Fagus sylvatica), and (iii) Mhagoni (Swietenia mhagoni), the latter two are imported hard wood which are used for constructing fishing-crafts in this country by the Lutheran World Federation Fisheries Project at Mitsiua.

Mature and healthy stems of A. marina measuring 15x4x1.5 cm and pneumatophores of 15 cm length were the mangrove test wood materials and are obtained from the Hamlay Desiet mangrove habitat. Fagus and Mhagoni wood panels were also cut into similar sizes of the mangrove wood. At the center of each test wood block a hole was drilled to insert the suspension rope.

Test wood blocks were air-dried, weighed and steam-sterilized at 121°c for 1 hr. before submersion. Steam sterilization has a disadvantage since it might denature the natural composition of the wood blocks but there was no alternative because we were unable to procure the conventional surface sterilizing agent, propylene oxide, in this country. The test blocks were assembled on a nylon rope so that the adjacent blocks were separated by a knot (Fig.3). Nylon mesh bags (mesh size #1mm) were used to contain the experimental blocks and these were tied to anchors or mangrove roots using thick nylon cords at each site. Each string finally carried 12 test blocks of each wood material (mangrove wood and pneumatophores, fagus and mhagoni) and, at all sites, they were immersed in sea water. Except at site 4, the test blocks in all other sites were made to remain always below the low tide level by tying some weight at the lower end of the suspension cord.

3.2.2. Periodicity of collection of test wood blocks

Test wood blocks at site 4 were lost due to unforeseen human interference and, as a result, only the remaining three sites were studied throughout the 8-month sampling period. Collections were made at 21 days (3-week) intervals from each site.

At each collection, the surface fouling organisms were carefully scapped off and then the test blocks were placed in a sterile polythene bag, labelled, sealed and usually brought to the laboratory on the same day. Where delayed by a day, until arrival in the laboratory, the test blocks were maintained in ice.

3.2.3. Processing of test wood blocks

The wood blocks collected at 3-week intervals were subjected to the following observation procedures, a flow diagram of which is given in Fig.2.

3.2.3.1. Plating of wash-water

Only mangrove wood material was subjected to this treatment. Test wood blocks and pneumatophores from each site were surface-washed in 100 ml sterile sea water (5 s gentle agitation by hand) to enumerate washable and viable propagules of fungi present on them while sampling.

The wash water was serially diluted in sterile sea water to 1: 10,000. The final wash dilution (0.1 ml) was transferred aseptically into petriplates containing Johnson and Sparrow's (1961) marine lignicolous fungi isolation medium (0.1% glucose, 0.01% yeast extract, 1.8% agar and 100 ml aged sea water) embedded with 0.02% streptomycin sulphate. These plates were incubated at room temperature (22°c) and subjected to periodical microscopic examination as the fungal colonies developed.

3.2.3.2. Incubation of test blocks

A damp chamber incubation method was followed to observe the fungi colonized on test blocks in their fruiting stages. Petriplates (5 cm height and 20 cm diam) lined with absorbant cotton and bent glass rod, flooded with sea water and sterilized in the autoclave, were used as the humid chambers. One wood block could be placed horizontally in each damp chamber (Fig.45A). All damp chambers were incubated at room temperature and examined periodically from the 2nd week during their 12-week incubation period.

3.2.4. Collection and observation of driftwoods

Along with the test blocks, driftwood materials were gathered during each collection from the island of Hamlay Desiet. Always the sampling was made at a particular spot near site 4 where the driftwoods were constantly found washed ashore and accumulated inbetween the mangrove pneumatophores (Fig.44B). Also, only those well-decayed driftwoods colonized by fungi were picked up. They were rinsed in natural sea water prior to placing in polythene bags to get rid of any debris found adhering on them.

Soon after bringing to the laboratory each driftwood was scanned for fungal fruit bodies already growing. After enumerating these, drift woods were incubated in humid chambers for more than 12 weeks (maximum 16 weeks) for growth and fructification of those fungal propagules present in mycelial form.

Fresh polythene bags, lined with sterile cotton at the bottom and flooded with sterile sea water, served as the humid incubation chamber for driftwoods. Several driftwoods were placed vertically within each polythene bag and the mouth of the latter was sealed using rubber-bands. These were also incubated at room temperature. Fig. 44C.

3.2.5. Microscopic examination

The test blocks and the driftwoods were examined microscopically for the presence of lignicolous marine fungi. Temporary mounts were prepared in distilled water and microscopic observations such as presence of appendages or septation of spores, etc., cameralucida (Prism-type) illustrations, photomicrography (PM-6 Olympus photographic unit) and measurements were made. Semipermanent preparations were made using lactophenol mountant (phenol, 20g; lactic acid, 20g; glycerol, 40g; water, 20 ml; and a little cotton blue dye). Slides mounted with lactophenol were gently warmed over a spirit lamp to remove any air-bubbles trapped-in, blotted out using an absorbant paper to remove excess mountant and then the edges of the coverslip were sealed using nail lacquer. Lactophenol preparations served only as reference slides since spore appendages, if any, were not recognisable in them during subsequent examination.

Using standard taxonomic keys and literature, in each case, an attempt was made to identify the fungi isolated down to species level. Enumerated fungi were fully described and illustrated. Reference slides and herbarium materials were maintained for all the fungi.

Wherever possible, the fungi were isolated and maintained in pure culture. Johnson and Sparrow's (1961) isolation medium was used. Firstly, fungi growing on wood materials were aseptically transferred to isolation medium in petriplates embedded with 0.02% streptomycin sulphate. As the colonies grew and established, they were examined for their correct identity. Subsequently, the pure culture was transferred to slants and maintained at room temperature.

3.2.6. Measurement of environmental parameters

In a study of the occurrence of marine fungi, it is important that appropriate hydrographic data are recorded during the removal of the test blocks so that interaction between the living organisms and the abiotic environments can be correlated (Jones, 1971b). The following properties of sea water at each site were measured at the time of collection of test blocks

(i) surface water temperature

(ii) pH (using electronic pH meter)

(iii) salinity (using electrical conductivity methods)

(iv) dissolved oxygen (using Winkler method)

(v) light transmission depth (using Secchi disc)

3.2.7. Dry weight change and strength loss determination

Rate of wood decay caused by marine fungi can be determined by measuring weight losses of test blocks (Kohlmeyer and Kohlmeyer, 1979). Weight losses of wood panels after fungal attack in natural habitats have been studied (Jones and Irvin, 1971; Byrne and Eaton, 1972). Dry weight change of test blocks was determined by calculating the difference of weight between submersion and after incubation of the exposed wood blocks.

Normally, as the decay ensues, the strength of the wood decreases due to loosening of wood-fibres and breaking of polymer chains by fungal enzymes and this can be evaluated using a tensiometer (Sharp, 1978). The difference in the wood strength between immersing in sea water and after incubation was determined.

To determine the loss of wood strength caused by fungal decay two methods are followed.

1. Measurement of breaking strength: An instrument has been used Tonindustrie 2508 model by Mitsua cement factory to evaluate the strength of the cement bricks manufactured. When the known area ($5x5x5cm^3$) of a brick is introduced into the machine and pressure is applied to break the former , the force used is indicated on a reading scale (in kg/cm^2). The test wood blocks were introduced in place of the cement bricks and the force required to break the wood indicated the strength remaining after fungal decay.

Test wood blocks were cut into 5x1.5x1cm size and their strength was determined using the above mentioned instrument.

2. Measurement of breaking stress: Wood blocks were cut into 5x1x0.5cm size and fixed to a clamp at one end. The other end of the wood block was fixed on to a tensiometer. As the spring of the tensiometer was pulled by mechanical force, when the wood breaks, the breaking stress is recorded from the scale. The force is measured and converted into power using the following formula

$$b_B = \frac{6l}{bh^2} \quad F_B$$

where, b_B = breaking stress
l = length of the beam
b = breadth of the beam
h = height of the beam
F_B = breaking force.

3.2.8. Computation of data

To depict the pattern of fungal colonization on wood blocks conventional tables and graphs were used, indicating the number of fungal colonies appearing after incubation for a varying period of time, and their percentage occurrence in the test wood blocks has been computed. The data of environmental parameters collected during each sampling period were computed in tables and graphs.

The weight and strength losses caused due to fungal decay on the test wood blocks were computed as percentage weights and strength losses.

4. RESULTS

The present study on the ecology and floristics of marine and mangrove fungi of the Red Sea at Mitsiua was commenced on 17 September 1986. Firstly, lack of any hitherto known mycological information on the Red Sea maritime region prompted me to take up this task although the actual experimental sites were quite far off from Asmara, the place where I conducted my work. Secondly, survey of higher marine fungi occuring on driftwoods from the Red Sea and floristics of Ethiopian microfungi from terrestrial habitats that began a little earlier in the Department of Biology, Asmara University, induced me to work on this area.

The information given in this chapter resulted from work carried out for a period of 8 months. These are presented here in two parts. Part I deals with the ecological studies, and Part II with the floristics, of mangrove and marine fungi. The results are supported by appropriate tables, graphs, illustrations and photomicrographs wherever necessary.

4.1. Ecological Studies

The use of different test wood blocks, viz., Avicennia marina, Swetiena mhogani and Fagus sylvatica, enabled me to isolate and observe those marine fungi colonized during the course of the study period. In addition, this also helped to evaluate the decay of timber due to fungal growth.

4.1.1. FUNGAL OCCURRENCE ON TEST WOOD BLOCKS.

It is significant to note that many marine fungi appeared on the test wood blocks, submerged in the sea, after incubation although a few ubiquitous terrestrial fungi developed along with them. In all, from the three sites, 22 fungal species belonging to 19 genera were recorded (Table 2) on the test wood blocks. Of these, 16 species belonging to 14 genera were recorded only from the mangrove substrata (Table 1). Within the mangrove substrata, of the 16 species, Chaetomium sp., Lulworthia sp. 1, L. sp. 2, Acremonium sp., Cladosporium algarum, Culcitalna acrospora (6 species), grew only on the wood, whereas Halosphaeria sp. and Alternaria sp.

only on pneumatophores and Cirrenalia pseudomacrocephala, C.tax sp., Halosynnema avicenniae, Lasiodiploidia tax. sp., Paecilomyces sp., Penicillium sp., Periconia prolifica, and the unidentified pycnidial fungus (8 species) on both wood and pneumatophores (Table 1).

From the wash-water of mangrove substrata 10 species belonging to 9 genera were isolated (Table 2), of which Drechslera halodes occurred on wood-wash and Periconia prolifica on pneumatophore-wash plates and the remaining species on both.

On the other two test wood blocks also, viz. mhagoni and fagus, a few fungal species were recorded. Lulworthia sp.2, Penicillium sp., and Periconia prolifica were isolated from mhagoni and Acremonium sp., Alternaria sp., Culcitalna acrospora, Lasiodiploidia tax. sp., Paecilomyces sp., and Periconia prolifica from fagus.

Of the 22 species recorded from the test wood blocks, 17 were from site 1, and 16 species each from sites 2 and 3 (Table 3). Based on the overall percentage occurrence of the fungi (Table 4), Periconia prolifica and Cirrenalia tax sp. were the most 'dominant' species. All the other species were below 10% in the overall percentage occurrence. Acremonium sp., Paecilomyces sp., Penicillium sp., Periconia prolifica, and the unidentified pycnidial fungus were present in all the three sites on the test wood blocks. However, except Periconia prolifica, other species were found in one or two samples only. P. prolifica is therefore the most dominant species in all the sites and on the test wood blocks (90%)

Considering the fungal colonization on mangrove wood blocks alone, P. prolifica is again the most dominant fungus, occurring in all the test blocks with 90% occurrence and also having been found in all three sites. It was observed in all the samples of the three sites except the first. The second most dominant fungus on the mangrove was Cirrenalia tax. sp., and it was found in site 1 with an overall percentage occurrence of 16.6% of the test wood blocks and in 60% of the samples made. Culcitalna acrospora was the third dominant fungus of the mangrove in site 1 for it was present in 40% of the samples but with 8.3% occurrence. All the remaining fungi were below 10% overall occurrence and found in only one or two sites with a maximum of 10-20% of the samples.

As seen in Fig 41 the number of fungal species in all the samples was not so high. However the highest frequency of the species was observed in the 3rd week (1^{st} sampling) while the least in the 15th week (5^{th} sampling), 24^{th} week (8^{th} sampling) and 30^{th} week (10^{th} sampling).

4.1.2. Fungal Occurrence in drift woods

It is well known that driftwood is the substrate of highly specialized marine fungi and also these fungi are known to be restrictive to a locality.

To enumerate the marine mycoflora of Ethiopian coastal waters of the Red Sea, driftwoods washed ashore into the intertidal zone at Hamlay Desiet were sampled out during every collecting time. Only those driftwoods which were well-decayed and of varied origin were picked up.

Each driftwood was subjected to microscopic scrutiny for occrrence of fungal fruit bodies. Regardless of this exercise, all the driftwoods were incubated in moist polythene chambers (Rf. materials and methods, No.3.2.4). After incubation, driftwoods were repeatedly examined at least trice in a month and for about 3-4 months.

In all, 43 fungal species were enumerated from the drift woods. They are listed in Table 5. Of these, Halonectría tax. sp., Leptosphaeria sp., Lulworthia spp. Kymadiscus haliotrephus, Halocyphina villosa, Cirrenalia tax. sp., Idriella tax sp., Periconia prolifica and Zalerion sp., were recorded during the cursory observation, prior to incubation, of the driftwoods. All other species developed fruiting stages following incubation.

Table 5 indicates the occurrence of fungi on the driftwoods during different sampling times. Lulworthia sp.1, and Periconia prolifica were recorded throughout the sampling period (100% occurrence); Gnomonia sp., appeared in 80% of the samplings, Zalerion sp. , Halonectria tax. sp., Halosarpheia fibrosa and Kymadiscus haliotrephus in 63%, and Alternaria sp. 1, Aspergillus sp., Cirrenalia tax. sp., and Idriella tax sp., appeared in 45% sampling period. All other species were recorded in less than 45% of the sampling.

4.1.3. Environmental factors of the sampling sites

Table 6 summarizes the average surface water values of environmental parameters measured between the first and the recent sampling for all the three sites. It includes temperature, pH, salinity, light-transmision, and percentage oxygen saturation.

The temperature in all the three sites varied from 27 to 33^{o}c, the lowest being during Jan-Feb., 1987 and highest while commencing the work in early October 1986.

The pH ranged from 7.93 (Oct., '86) to 8.31 (Dec., '86). That is, the sea water was slightly alkaline throughout the sampling period.

The average salinity value, ranged from 37.3 (during Feb., 87) to 40%o (during Dec., 86), that is, the sampling sites had higher concentration of salts throughout the sampling period.

Regarding the light transmission, Secchi disc depth measurement was adopted and the minimum and maximum depth were 6m (Mar., '87) and 9.58m (in Dec., '86) respectively.

The percentage oxygen saturation (dissolved oxygen) showed a range between 80.35 to 99.48%, the lower limit being during Dec., 1986 and the upper limit in Mar., 1987.

These data are appended in Fig 41, to analyse the effect of these factors on the occurrence of fungi.

4.1.4. Decay rate

The rate of decay of mangrove wood, and the other two timber species, due to fungal colonization was computed by calculating dry weight losses and wood strength losses.

The percentage dry weight losses for mangrove wood blocks were found to be from 13.83 to 53.95, from 13.52 to 61.6 and from 14 to 59.6 percent in site 1, 2 and 3 respectively. As indicated in Table 7, the maximum weight loss was in site 2. Mhagoni and fagus test wood blocks showed maximum weight losses of 70.2 and 56.97 for the former and 9.6 and 12.5 percent for the latter in sites 1 and 2 respectively.

Considering the strength losses, the tensiomenter results were found much more reliable than the Tonindustrie 2508 model instrument. Therefore, the results presented in Table 8 show only the strength losses in N/cm^2 following tensiometer method.

Mangrove testwoods show maximum strength losses of 77, 84.7 and 93%, in site 1, 2 and 3 respectively. Whereas mhagoni 97.6, and 97.6%, fagus 63 and 22.6% showed in site 2 and 3 only.

The maximum weight and strength losses of mhagoni were observed in site 2 (Table 7 and 8; Fig. 42 A-B). For the fagus the maximum weight and strength losses were observed in site 2 and 3 respectively (Table 2 & 8; Fig 42 A-B). Therefore, Mangrove wood blocks, stand in between the two timber wood in their percentage weight and strength losses.

4.2. FLORISTIC STUDIES

As mentioned in the previous chapter, along with the test wood blocks, driftwoods were also collected and examined from Mitsiua to enumerate the marine mycoflora of Ethiopian coastal water of Red Sea. Collections were done always from a single spot in the intertidal zone at Hamlay Desiet, very near to the abandoned site 4, once in every 3 weeks, the first and the recent collections being on 17 Sept. 1986 and 16 April 1987 respectively. An earlier exploratory collection of July 86 is also included here. In all, we had 13 lots of collections. In each sampling, as much driftwood as possible was gathered. Prior to incubation, driftwoods were rinsed in natural sea water, in the sea itself, so as to remove any debris found adhering and this greatly minimized the chance occurrence of ubiquitous terrestrial soil fungi.

Driftwoods were examined several times periodically for the growth of fungal fruitbodies, the first scanning being soon after arrival in the laboratory. Once incubated, they were scanned at least thrice in a month for about 3-31/2 months. Beyond this period generally no new fungi were observed on the driftwoods.

More than 50 marine fungi were recorded in the course of our study of which 35 species are described and illustrated in the following pages. Table 5 shows a list of fungi enumerated by us from Ethiopian coastal waters of the Red Sea and their occurrence during the course of our sampling.

Of the 35 species described here, 17 belonged to Ascomycotina, 1 to Basidiomycotina, and 17 to Deuteromycotina. For each species, along with the description, a brief note on its taxonomy and significance is given.

4.2.1. ASCOMYCOTINA

1.1. Antennospora quadricornuta (Cribb & Cribb) Johnson, 1958. J. Elisha Mitchell, Sci. Soc. 74: 46

= Halosphaeria quadricornuta (Cribb & Cribb, 1956. Univ. Queensl. Pap., Dept. Bot. 3: 99 Figs.4, 46-G.

ASCOCARPS solitary or gregarious, subglobose, partly immersed, ostiolate, papillate, dark brown to black, 240-260 um in diam. NECKS 280 x 20-55um. ASCI eight spored, clavate, short pedunuculate, unitunicate, early deliquesing. ASCOSPORES elliptical, two-septate, with a large globule in each cell, 21-33 x 8-11 um, provided wih two sub-terminal stiff appendages at each end, about 25 um long and 1.2 um wide.

Isolated from unidentified intertidal driftwood, (one collection) Hamlay Desiet, Feb. 1987.

Notes: A. quadricornuta is so far known from the tropical waters only (Hughes, 1974) and is reported from the Indian Ocean. Here, this is a new record for the Red Sea and for Ethiopian coastal waters.

1.2. Caryosporella rhizophorae Kohlmeyer, 1985. Indian Acad. Sci. (Pl-Sci), 94: 355-356 Fig.5.

ASCOCARPS gregareous, subglobose, partly immersed, ostiolate, short papillate, periphysate, carbonaceous, black, 420-560 um in diam. NECKS conical, 80-140 x 100 um. PSEUDOPARAPHYSES present, filamentous, septate, branched, hyaline, 2-2.2 um wide. ASCI eight-spored, cylindrical, pedicellate, bitunicate, thick-walled, physoclastic, 180-220 x 13.5-17 um. ASCOCARPS ellipsoidal, 2-celled, with a medium septum, constricted at the septum, slightly curved, dark brown, distinctly verrucose, with distinct, small, light-coloured apices at each end, 17.5-24.5 x 8.5-11 um.

Isolated from unidentified intertidal driftwood (one collection) Hamlay Desiet, Nov. 1986.

Notes: *C. rhizophorae* is so far known only from Central American coastal waters. This is, here, a new record for Indian Ocean and also for the Red Sea along the Ethiopian coast.

1.3. *Chaetomium* sp. Figs.6 a-c

ASCOCARPS solitary to gregarious, pyriform, superficial, papillate, ostiolate, dark-brown to black-coloured, 17-23 x 150-225 um, covered with several non-septate, stiff, darkbrown circinate, hairs. NECKS cylindrical, straight or slightly bent, dark-brown to black, 125-150 x 75 um. ASCI eight-spored, clavate, unitunicate, early deliquescing. ASCOSPORES globose, narrower at both ends, brown to black-coloured, oozing out in the form of a tendril, 100-150 x 62-87 um.

Isolated from *Avicennia marina* test wood blocks (one collection) Hamlay Desiet, Oct. 8, 1986.

Notes: Presence of dark- coloured stiff hairs is characteristic of the genus *Chaetomium* Kunze ex Frice. Over 180 species are known (Ames, 1963). *Chaetomium spp.* are reported from marine habitats. (Newell, 1976, Subramanian & Raghu Kumar, 1974). But Kohlmeyer and Kohlmeyer (1971) doubted their obligate adaptation to the marine environment. Here, it is a new record to the Red Sea Maritime region.

1.4. *Didymosphaeria rhizophorae* J&E. Kohlmeyer, 1967. *Icones, Fungorum Maris* 1:4-5. Figs.7a-c

ASCOCARPS gregarious globose to pyriform, ostiolate, papillate, dark-brown, partly or totally immersed, 312.5 x 187.5 um. NECKS straight or slightly curved, 150 x 87.5 um. ASCI 8-spored, cylindrical, short pedunculate, bitunicate, 167-208 x 16-25 um. ASCOSPORES ellipsoidal, uni-septate, not or slightly constricted at the septum, with thin striations along the longitudinal axis, dark-brown, 13.75-27.5 x7.5-10 um.

Isolated from intertidal driftwoods (two collections), Hamlay Desiet, January 21, 1987 and February 11, 1987.

Notes: D. rhizophorae is so far known from the coastal waters of Atlantic Ocean (Kohlmeyer & Kohlmeyer, 1979). This is, here, a new record to the Indian Ocean and for the Red Sea along the Ethiopian Coast.

1.5. Gnomonia sp. Figs. 8a-c

ASCOCARPS solitary or gregarious, subglobose, ostiolate, papillate, covered with hairs, superficial or immersed, darkbrown to black, 150-187.5x 112-175 um. NECK cylindrical, elongate ellipsoidal, with rounded ends, one to three septate, not or slightly constricted at the septa, hyaline, 13-18 x 6-7 um. ASCOSPORES uni-or biseriate, elongate-ellipsoidal, with rounded ends,one to three septate, not or slightly constricted at the septa, hyaline,13-18 x 6-7 um.

Isolated from drifwood samples (several collections), Hamlay Desiet.

Note: The genus Gnomonia Cesati & Dennotaris is reported from the Atlantic Ocean, Pacific Ocean, and Indian Ocean (Kohlmeyer & Kohlmeyer, 1979). So far three species have been recorded but this fungus does not belong to any of the three. Nevertheless, it is a new record to the Red Sea.

1.6. Halosarpheia fibrosa J & E. Kohlm. 1977. Trans. Br. mycol. Soc. 68: 208. Figs.10, 46I-J.

ASCOCARPS solitary or gregarious, globose or subglobose, superificial or embedded, ostiolate, papillate, light brown, 375-528 um in diam. NECKS curved, cylindrical, light brown, 562-875 x 75 um. ASCI 8-spored subfusiform or clavate, short pedunculate, unitunicate, 79-11.5 x 26.4-33um. ASCOSPORES ellipsoidal, one-septate, very lightly or not constricted at the septum, hyaline, 22.5-28.75 x 15-17.5 um, appendages apical, hook-like.

Isolated from intertidal driftwoods (several), Hamlay Desiet,

Notes: This is the second record of this fungus for the Indian Ocean and a new record for the Red Sea along the

Ethiopian Coast, the first being by Patil & Borse (1982) from the Indian Coast.

1.7. Halosarpheia ratnagiriensis Patil & Borse, 1982. Indian Bot. Reprt., 1:102 Figs.40; 46A-C.

ASCOCARPS solitary to gregarious, fully immersed, pyriform to subglobose, mid to dark brown, immersed portion of ascocarp, paler, ostiolate, papillate, 450-850 x 350-550 um wide. NECK cylindrical, partly hyphoid, subhyaline, periphysate internally, 800-1250 x 100-115 um wide. ASCI clavate, 8-spored, without apical apparatus, thin-walled unitunicate, 150-175 x 33-40. ASCOSPORES indistinctly biseriate, ellipsoidal to fusiform, 2-celled, with a medium septum, slightly constricted at the septum, hyaline, each cell with a centrally located large and several peripheral small globules, 28-36 x 13.5-17.5 um, with apical appendages; appendages centrally attached at each end, elongated, hyaline, narrow at both ends, 13-20 x 4.5-5 um wide, eventually transforming into a delicate, long, unfurling filament.

Isolated from intertidal driftwoods (several collections), Hamlay Desiet.

Notes: H. ratnagiriensis is so far known from tropical parts of the Atlantic Ocean, Indian Ocean (type collection) and Pacific Ocean (Kohlmeyer, 1984). Here, it is a new record to the Ethiopian coastal waters of the Red Sea.

1.8. Halosarpheia sp. Figs. 9a-c; 46E-F.

ASCOCARPS solitary to gregarious, immersed, pyriform to subglobose, ostiolate, papillate, black, immersed lighter than neck, 380-420 x 340-410 um. NECKS cylindrical, 150-200 x 80 um. ASCI 8-spored, clavate, pedunculate, unitunicate, thick-walled, hyaline, 114-145 x 23-36 um. ASCOSPORES broad ellipsoidal, uni-septate not constricted at the septum, hyaline, with appical appendages at both ends, fibrose, 6-87 x 3.7 um.

Isolated from driftwood (one collection), Hamlay Desiet, December 10, 1987.

Notes: The ascus and ascospore sizes do not fit any of the species described by Kohlmeyer (1984) and Patil and Borse (1982). This may be one of the unknown taxa of Halosarpheia.

1.9. Leptosphaeria australiensis (Cribb & Cribb) Hughes, 1969. Syesis 2:132 Fig. 11.

ASCOCARPS solitary or gregarious, subglobose, papillate, carbonaceous, darkbrown in colour, 350 x 250 um. ASCI 8-spored, bitunicate, clavate to fusiform, short pedunculate, 107-112 x 9-15 um. ASCOSPORES fusiform, three-septate, constricted at the septa, smooth, hyaline, without any appendages, 23-27 x 5-7 um.

Isolated from driftwoods of an unknown origin and also Aviccenia marina wood and pneumatophores (several collections), Hamlay Desiet;

Notes: This species is so far known from the tropical and sub-tropical maritime regions (Kohlmeyer, 1984), but here it is a new record for both tropical parts of Indian Ocean and to the Ethiopian coastal waters of the Red Sea.

1.10. Leptosphaeria sp. Fig. 12.

ASCI 8-spored, cylindrical or subclavate, short pedunculate, bitunicate, 89-125 x 8.2-11.5 um. Ascospores biseriate, fusiform, straight or slightly curved, one or two septate, slightly to strongly constricted at the septa, light brown, 25-31.2 x 8.7-13.7 um.

Isolated from driftwood samples (three collections), Hamlay Desiet.

Notes: Several species of Leptosphaeria Cesati & De Notaris are known from marine habitats (Kohlmeyer & Kohlmeyer, 1979). Except the size of the spore, the spore morphology of this species agrees with that of L. obiones (Crouan & Crouan) Sacc. Therefore, here it is not assigned to any species.

1.11. Lindra thalassiae Orpurt, Meyers, Boral & Siman, 1964. Bull. Mari. Gulf. Carrib. 14:406 Figs.13; 46D.

ASCOCARPS solitary to gregarious, half-immersed, globose to subglobose, ostiolate, papillate, dark brown to black, 115-230 um in diam. NECKS cylindrical, 72 x 25-32 um. ASCI 8-

spored filiform, tapering towards both ends, curved (S-,U-, or x-shaped), 14-21 septa, not constricted at the septa, hyaline, tips slightly inflated, 230-360 x 2.5 x 5.2 um.

Isolated from driftwoods (one collection), Hamlay Desiet, January 23, 1987.

Notes: L. thalassiae is so far known only from Atlantic and Pacific Oceans (Kohlmeyer and Kohlmeyer, 1979). This is a new record here for Indian Ocean and the Red Sea along the Ethiopian coast.

1.12. Lulworthia sp.1 Figs.14, 46K-L.

ASCOCARPS solitary or gregarious, immersed to partly superficial, subglobose to pyriform, ostiolate, long papillate on one side mostly, carbonaceous, black, 500-600 x 200-350 um. NECKS cylindrical, curved at the upper top, dark-coloured, emerging above the surface, upto 525 um long. ASCI 8-spored, fusiform or cylindrical, unitunicate, thin-walled, early deliquescing. ASCOSPORES filiform, cylindrical, straight or curved, aseptate, tapering at each end into an apical conical cellular process, 450-560 x 3.3-8.2 um.

Isolated from test wood blocks of A. marina and driftwoods (several collections), Hamlay Desiet.

Notes: Brief notes to L. sp. 1 and L. sp. 2 are given together in the next description.

1.13. Lulworthia sp.2 Fig.15.

ASCOCARPS solitary or gregarious, superficial, globose, ostiolate, without a neck, smooth, subhyaline, 225-262 x 162-187 um. ASCI 8-spored, long-cylindrical, filiform, unitunicate, early deliquescing. ASCOSPORES filamentous, filiform, aseptate, smooth, with rounded apical cellular chambers, hyaline, 92.5-115 x 3.3 um.

Isolated from A. marina and Swietenia mhogani testwood blocks (two collections) Hamlay Desiet and Mitsiua, October, 8 and December 10, 1986.

Notes: Kohlmeyer and Kohlmeyer (1979) described several species of Lulworthia Sutherland but indicated that the genus is in need of a critical revision. As a result they put together many of the species with doubtful identity. I feel that these two species of *Lulworthia* must be put along with the unidentified species for they do not fit into any of the described ones.

1.14. *Kymadiscus haliotrephus* J. & E. Kohlmeyer 1971. *Mycologia* 63:837. Figs.16,47A-B.

ASCOCARPS solitary or gregarious, flat, discoid, fleshy, apothecia-like, sessile, with an obconical foot resting inside the substrate, dark grey to black, 1637 x 300 um. PSEUDOPARAPHYSES clavate, with two septa at the apex, constricted at the septa, apically broadened into a club shaped structure, hyaline to light brown apical cells, 82-92 x 1.7-2 um, at the apex 3.3-6 um wide. ASCI mostly eight, rarely four-spored, bitunicate, clavate, pedicellate 68-90 x 14 x 19 um. ASCOSPORES uniseptate, septum in the lower half, longitudinally finely striated, brown, 16-20 x 7.5-8.75.

Isolated from driftwoods that include both wood and pneumatophores of *A. marina* (several collections), Hamlay Desiet.

Notes: *K. haliotrephus* is a common species of tropical waters and was also reported from *Avicennia* sp. roots in India (Raghu Kumar, 1973).

1.15. *Pleospora* sp. Figs.17, 47C-D.

ASCOCARPS solitary to gregarious, immersed, globose, ostiolate, without distinct papillae, dark-brown, up to 260 um diam. PSEUDOPARAPHYSIS numerous, filiform, septate, persistent, 2 um wide. ASCI eight-spored, cylindrical to clavate, short pedunculate, bitunicate, thick-walled, 171-237 x 20-33 um. Ascospores biseriate, ellipsoidal, muriform, with 6 or 7 transverse septa, with one or two longitudinal septa, constricted at the transverse septa, yellow-brown, surrounded by gelatinous sheath, 25-28 x 8-12 um.

Isolated from driftwoods (one collection), January 23, 1987.

Notes: several species of *Pleospora* Robenhorst ex Cesati & De Notaris are known from marine habitats (Kohlmeyer and

Kohlmeyer, 1979). However this species does not fit to any of the known species of the genus with reference to its size.

1.16. _Torpedospora radiata_ Meyers, 1957. _Mycologia_ _49_:496. Figs. 18,47H.

ASCOCARPS solitary or gregarious immersed subglobose to pyriform, ostiolate, papillate, darkbrown, 300 x 175-200 um. NECK cylindrical, smooth, 140 x 2534 um. ASCI eight-spored, oblong to ellipsoidal, sessile, unitunicate, thin-walled, early deliquescing, 90-130 x 12-155 um. ASCOSPORES elongate cylindrical or clavate, broader at the apex, three septate, not constricted at the septa hyaline, 17.5-37.5 x 3.7-5 um, with two or three radiating appendages at one end, semirigid 13.7-23.7 x 1.2-1.5 um.

Isolated from driftwoods (one collection), Hamlay Desiet, January 21, 1987.

Notes: This species is known mostly from tropical waters (Kohlmeyer & Kohlmeyer 1979). This species here is a new record to the Red Sea along the Ethiopian coast.

1.17. _Unidentified ascomycete_ sp. Figs. 19,46H.

ASCOCARPS gregarious, immersed, pyriform to subglobose, long pedunculate ostiolate, papillate, dark brown to midbrown, 190-230 um in diam. NECK cylindrical, subhyaline, 660 x 120 um. ASCI eight-spored, cylindrical, long pedunculate, bitunicate, thin-walled, straight or curved, 151-230 x 9-13 um. ASCOSPORES uniseriate, cylindrical rounded at both ends, three-septate, slightly constricted at the septa, smooth, hyaline, 16-23 x 5-10 um.

Isolated from driftwoods (two collections) Hamlay Desiet.

Notes: At this moment, this fungus could not be accomodated to any taxa of the marine habitat.

4.2.2. _BASIDIOMYCOTINA_

Halocyphina _villosa_ J. & E. Kohlmeyer, 1965 _Nova Hedwigia_, _9_:100. Figs.20, 47E-G.

BASIDIOCARPS solitary or gregarious, cyphelloid, turbinate or clavate, funnel-shaped, pedunculate, soft, fleshy, white, 490 x 350 um at the mouth region. PERIDIUM composed of closely packed, rarely branched hyphae, 25 um diam, hyaline, forming spherical refractive hairs at the stalk, about 38.5 um wide. HYMENIUM with a network of hyphae lining the inner portion of the funnel shaped basidiocarp. Basidia clavate or cylindrical with a narrow base, nonseptate, 22.5-31 x 3.7-6.2 um, sterigmata 3-4 um long. BASIDIOSPORES subglobose, one-celled, smooth, hyaline, 6-9 x 5-8 um.

Isolated from intertidal driftwood (three collections), Hamlay Desiet, Dec. 29, 1986, Jan 21 and Mar. 4, 1987.

Notes: H. villosa is a monotypic genus and is known from tropical and sub-tropical waters (Kohlmeyer & Kohlmeyer 1979). Here, it is a new record to the Red Sea along the Ethiopian coast. It differs from the type description in having apedunculate (sessile) basidiocarp.

4.2.3. DEUTEROMYCOTINA

3.1.. Acremonium sp. Fig. 21.

COLONIES effuse, light grey. HYPHAE hyaline to pale grey. Conidiophores cylindrical, wider at the base, smooth, hyaline, 25-43.7 x 2.5-5 um. CONIDIA subglobose to pyriform, smooth, 0-septate, pale brown or hyaline 5-11 x 2.5-7.5 um.

Isolated from A. marina and driftwoods of (several collections), Hamlay Desiet.

Notes: Acremonium spp., well known from terrestrial habitat, are also frequently recorded from marine habitats (Newell; 1976 Subramanian & Raghu Kumar, 1974). Here it is a new record for the Red Sea.

3.2. Alternaria sp. Fig. 22.

COLONIES effuse, hairy, dark brown to black. CONIDIOPHORES solitary or in groups, branching, 85-32 x 4.5-6 um. CONIDIA catenate, obpyriform to obclavate, with neck-like apex, muriform (3-5 septa) constricted at the septa, smooth, dark brown to black, 35-41 x 10-12.5 um

Isolated from A. marina test wood blocks, wash water culture plates and driftwoods (several collections), Hamlay Desiet.

Notes: Obligate marine species of Alternaria Nees ex Fries are doubtful according to Kohlmeyer & Kohlmeyer, (1979). However several species are known from marine environments. Here, it is a new record to the Ethiopian coastal waters of the Red Sea.

3.3. Aspergillus sp. Fig. 23.

COLONIES effuse, thick, greyish-green. HYPHAE superficial, branched, subhyaline to hyaline. CONIDIOPHORES straight or curved, unbranched, smooth, subhyaline, terminating into a vesicular head, 120 x 6.5 um wide below and 18.5 wide at the head region. CONIDIOGENOUS CELLS monophialidic, ampuliform, arranged parallely over the head, 8-9.5 x 5 um. CONIDIA catenate, dry, oval to subglobose, verrucose, 0-septate, subhyaline, 7.5-10 x 5-6 um wide, developing in unbranched, basipetally maturing chains.

ASCOCARPS (cleistothecia) growing along with conidial state (holomorphic). CLEISTOTHECIA superficial, gregarious, globose, yellow to golden-yellow, 100-130 um in diam; cleistothecial wall 1-3 layered with elongate cells. ASCI globose to subglobose, eight or four-spored, unitunicate, thin-walled, 13-16.6 um long. ASCOSPORES oval to spherical, 0-septate, subhyaline.

Isolated from wash water plate cultures and driftwoods (several collections), Hamlay Desiet.

Notes: Aspergillus spp. are recorded by Kohlmeyer and Kohlmeyer (1979) from marine habitats. This species is identified at generic level and ascocarp state is accomodated within the genus Emericella.

3.4. Cirrenalia pseudomacrocephala Kohlmeyer, 1968. Mycologia 60:266. Fig. 33.

COLONIES effuse, thin, dark brown to black. HYPHAE superficial or immersed, septate, light brown, 1-1.5 um in diam. CONIDIOPHORES zero to two septate, straight or curved, subhyaline, 20-30 um long, 2.5 um in diam. CONIDIOGENOUS CELLS monoblastic, terminal, 5-6 x 2.5-5 um. CONIDIA mostly coiled three or more septate, slightly or strongly constricted at the septa, subterminal cells darker than the others, cells increasing in diam. from base to apex, 5-10 um in diam.

Isolated from test wood blocks of A. marina and driftwoods (several collections), Mitsiua proper and Hamlay Desiet.

Notes: It is a new record to the Red Sea along the Ethiopian coast.

3.5. Cirrenalia tax. sp. Figs. 24,48C-D.

COLONIES effuse, cottony, sometimes adpressed, brown to greyish brown. Hyphae, distinct, light brown, septate, 5-6.6 um wide. CONIDIOPHORES micronematous, cylindrical, unbranched, with thick dark brown septa, smooth, thick-walled, subhyaline, 1000 x 6.6 um. CONIDIOGENOUS CELLS monoblastic, polyblastic, minute denticulate, with truncate ends, 22-30 x 5.5 um. CONDIA solitary, obclavate, distinctly curved, mostly two septate, rarely one or three to four septate, distinctly constricted at the septa, smooth, brown, 23-33 x 10-16.5 um, basal cells obconical narrowly tapering into a pointed attachment region, 10 um wide, central cells subglobose, 10.5 um diam, terminal cells subglobose to globose, larger and darker than the remaining cells, 13.2-16.5 um diam; stretched conidia 45 x 16.5 um.

Isolated from A. marina testwood blocks and pneumatophores and also driftwoods (several collections), Mitsiua proper and Hamlay Desiet.

Notes: Undoubtedly, this is a new taxon of Cirrenilia Meyers & Moore. It was not possible to keep this isolate in the known species of the genus (Kohlmeyer & Kohlmeyer (1979).

3.6. Cladosporium algarum Cook & Massee in Cook, 1988. Grevillea 16:88. Fig. 25.

COLONIES effuse, cottony, darkbrown to black. HYPHAE distinct, septate, darkbrown, CONIDIOPHORES macronematous, cylindrical, straight or curved, simple, echinulate, dark brown. CONIDIA ellipsoidal, with basal scar, zero to one-septate, slightly or not constricted at the septa, verrucose, solitary, brown, 7.5-16.2 x 7.5 um.

Isolated from A. marina testwood blocks, pneumatophores, wash water plate cultures and driftwoods (several collections), Hamlay Desiet and Mitsiua proper.

Notes: More than one species of Cladosporium have been collected. However, this is the only one fully described here for it was found to agree with Cladosporium algarum Cook & Massee (Kohlmeyer and Kohlmeyer 1979). C. algarum is a new record to the Ethiopian coastal waters of the Red Sea.

3.7. Culcitalna acrospora Meyers & Moore, 1960. Am. J. Bot. 47:349 . Fig.26, 48G.

COLONIES effuse dark brown to black. HYPHAE superficial, immersed light brown to brown, 1.25-2.5 um in diam. CONIDIOPHORES indistinct, integrated, 16.5-24 x 5 um. CONIDIOGENOUS CELLS polyblastic, cylindrical terminal or intercalary 10-16.5 x 4.5-6.5 um. CONIDIA globose to clavate, smooth, 1-3 septate, deeply constricted at the septa, apical cells dark brown, lower cells light brown, apical cells 8.7-17.5 um diam. and lower cells 3-7-6.2 x 5-11.2 um.

Isolated from A. marina testwood blocks and driftwoods (several collections), Mitsiua proper and Hamlay Desiet.

Notes: Following Ellis (1976), this fungus is accomodated in the genus Culcitalna. Kohlmeyer and Kohlmeyer (1979) included the same fungus as a synonym of Trichocladium achrosporum Meyers & Moore following Shearer and Crane (1971). This species is a very common marine fungus and is a new record to the Ethiopian coastal waters of the Red Sea.

3.8. Drechslera halodes (Drechsler) Subramanian & Jain, 1966. Curr. Sci. 35:354. Fig.27.

COLONIES effuse, brown in culture. CONIDIOPHORES single, cylindrical, geniculate at the upper part, straight or curved, septate, polyblastic smooth, brown, 46-65 x 4 um. CONIDIA cylindrical to ellipsoidal, straight or slightly curved, 2-6 pseudosepta, not constricted at the septa, smooth brown, 5-10 x 10.7-18.7 um.

Isolated from wash water plates (one collection), Hamlay Desiet March 25, 1987.

Notes: D. halodes is a true marine fungus and here it is a new record to Ethiopian coastal waters of the Red Sea, the first record being from the Indian Coast.

3.9. Halosynnema Bhat & Mekonnen gen. nov.
Fig.29, 48A-B.

COLONIES sparse, scanty, composed of erect, small synnemata. MYCELIUM partly emmersed, partly superficial, composed of branched, septate, hyphae. SYNNEMATA small, composed of compactly and parallely arranged conidiophores. CONIDIOGENOUS CELLS penicillus, monophialidic, without collarette. CONIDIA catenate, dry, oval, smooth, 0-septate, developing in basipetally maturing chains.

Sp. typ. Halosynnema avicenniae Bhat & Mekonnen.

Kohlmeyer and Kohlmeyer (1979) did not record any synnematous fungus from marine habitats. However, Newell (1976) reported Isaria sp., a synnematous fungus from mangrove habitats in Florida. A human pathogenic synnematous fungus, Allescheria boydii Shearer, was often collected on wood submerged in a North Carolina estuary by Kirk (1967). Both Isaria and Allescheria are characterised by gleoid or slimy conidia and both are said to be ubiquitous terrestrial fungi. Our fungus produces conidia in true chains and therefore cannot be accommodated in the aforesaid two genera. We have no suitable genus so far described (Carmichael et. al., 1980) to place our fungus. This called for establishment of a new species in a new genus.

H. avicenniae gen. et. sp. nov.

SYNNEMA scanty on the substratum, erect, small, narrow at the base, wider above, composed of compactly arranged conidiophores, conidiophores arising from globose cells at the base, synnema 60-100 x 20 um wide at the base, 50-60 um wide above. MYCELIUM partly immersed and partly superficial, composed of branched, septate hyphae. CONIDIOGENOUS CELLS penicillus, monophialidic, without collarette, 12-17.5 x 4.5 um. CONIDIA catenate, dry, oval, smooth, 0-septate, 5-5.8 x 6 um, developing in unbranched biseptal chains, released in columns.

Holotype On testwood blocks and pneumatophores of A. marina (two collections one of them is designated as holotype), Mitsiua proper and Hamlay Desiet, Oct. & Nov. 1986.

3.10. Idriella tax. sp. Fig.28, 48F.

COLONIES effuse, flat, greyish white; below the colony, wood bark becoming dark and carbonaceous. HYPHAE superficial or immersed, septate, lightbrown. CONIDIOPHORES mostly unbranched, rarely branched and long, erect, straight or curved, 40-50(-130) x 5-6.5 um at the base, 2-3 um wide at the tapering tip, septate, smooth, brown, paler towards the apex, terminating in conidiogenous cells. CONIDIOGENOUS CELLS holoblastic, polyblastic, with several unthickened loci. CONIDIA solitary, acropleurogenous, falcate, simple, zero-septate, smooth, hyaline 13.7-23 x 1.2-1.7 um.

Isolated from driftwood (several collections), Hamlay Desiet.

Notes: It is assigned to the genus Idriella Nelson & Wilhem, for the presence of falcate and hyaline conidia and polyblastic conidiogenous cells. So far, we have no representative of this genus from the marine environment. Tentatively, here it is designated as a new taxon.

3.11. Lasiodiplodia tax.sp. Fig. 30.

PYCNIDIA, immersed or errumpent, globose to subglobose, ostiolate, short, papillate or apapillate, solitary or gregarious, dark brown to black, 250-437.5 x 237.5-312.5 um. NECK conical, 62.5-250 x 83 um. CONIDIOGENOUS CELLS lining the inner wall of the pycnidial cavity, 8.75-15 x 1.25-5 um accompanied by nonseptate, hyaline paraphyses. CONIDIA ellipsoidal, 1-septate at maturity, not constricted at the septum, smooth walled, hyaline, later becoming darkbrown, 16.5-22.5 x 10.2-12.5 um.

Isolated from A. marina test wood blocks (three collections), Hamlay Desiet.

<u>Notes</u>: This fungus is assigned to the genus <u>Lasiodiplodia</u> Ell. & Ex. apud Clendein. Here conidia are smooth, whereas in the type species <u>L</u>. <u>theobromae</u> Griff & Maubl. the outer wall of conidia show longitudinal thick striations (Sutton, 1980). Moreover, the type species is a plant pathogen (it is monotypic genus) and our fungus is collected from sterilized test wood material.

3.12. <u>Paecilomyces</u> sp. Fig.31.

COLONIES effuse, cottony, greyish to brown. HYPHAE superficial, branched, septate, thickened at the origin of the conidiophore. CONIDIOPHORES simple, terminal, or lateral on the hyphae, cylindrical, broader at the base but tapering at the apex, straight or curved, septate, bearing phialides, lightbrown. PHIALIDES flask-shaped with cylindrical neck, straight or curved, 7.5 x 2.5-5 um. CONIDIA produced basipetally in chains, oval, nonseptate, lemoniform, light brown, 3.7-5 x 2.5-5 um.

Isolated from <u>A. marina</u> test wood blocks and driftwood samples (several collections), Mitsiua proper and Hamlay Desiet.

<u>Notes</u>: So far, no species of <u>Paecilomyces</u> Bainier has been described from marine habitats (Kohlmeyer & Kohlmeyer, 1979). This is the first record of the fungus from a maritime habitat.

3.13. <u>Papulospora</u> sp. Fig 34

PYCNIDIA solitary or gregarious, globose to subglobose, pyriform, unilocular, immersed or erumpent, ostiolate, papillate, thin-walled, darkbrown to black. 100 x 81 um. CONIDIOPHORES cylindrical, nonseptate, straight or curved, hyaline, 17.5-22.5 x 1.25 um. CONIDIA ellipsoidal, one celled, smooth-walled, mature conidia medium brown to darkbrown, 2.5-10 x 2.5 um.

Isolated from <u>A</u>. <u>marina</u> wash-water plates and driftwoods (several collections), Mitsiua proper and Hamlay Desiet;

<u>Notes</u>: The <u>Papulospora</u> state of conidial fungi is known to be the anamorph of <u>Leptosphaeria</u> and these are reported to

occur in the marine environment (Kohlmeyer & Kohlmeyer, 1979). Here it is a new record both to the Indian Ocean and the Red Sea.

3.14. Periconia prolifica Anastasiou, 1963, Nova Hedwigia 6:260. Figs.32, 48H.

COLONIES effuse, cottony, black. HYPHAE internal in the wood or areal, septate, branched, with numerous conidia, light brown to hyaline. CONIDIOPHORES not differentiated from the hyphae, with lateral or terminal conidiogenous cells, light brown, up to 65 um long. CONIDIOGENOUS CELLS light brown to hyaline, holoblastic, polyblastic, 4.5-8.4 x 2.4-6.6 um. CONIDIA catenulate, globose to subglobose, one-celled, smooth, zero-septate, brown, 8.5-13 um in diam, simple or branching chains, developing basipetally, maturing acropetally, at one or several points on the conidiogenous cell.

Isolated from A. marina testwood blocks and washwater plate and also from driftwoods (several collections), Mitsiua proper and Hamlay Desiet.

Notes: This is the most frequently collected fungus in this study. P. prolifica has earlier been reported from the Saudi Arabian coastal waters of the Red Sea (Aleem, 1978) and is well known from the Indian Ocean. This is here the first record for Ethiopian coastal waters.

3.15. Sympodiomyces parvus Fell & Statzell, 1971. Antonie van Leevenhock 37:362. Fig. 35.

COLONIES effuse, white. MYCELIUM superficial, composed of branched septate hyphae 1.5-2 um wide. CONIDIOPHORES mononematous, unbranched, smooth, hyaline, 40 x 1.5-2 um. CONIDIOGENOUS CELLS holoblastic, polyblastic, sympodial. CONIDIA solitary, globose, zero-septate, smooth, hyaline, thin-walled, 1.5-2 um diam, developing sympodially and acropetally on the conidiophores.

Isolated from driftwoods (several collections), Hamley Desiet.

Notes: This fungus is so far known only from temperate waters and here it is a new record to tropical waters of the Indian Ocean and to the Red Sea.

3.16. Veronaea sp. Fig.36.

COLONIES effuse, cottony, velvety, greyish brown to dark brown. HYPHAE branched, septate, light brown. CONIDIOPHORES, macronematous, mononematous, unbranched rarely branched, smooth, light brown. CONIDIOGENOUS CELLS polyblastic, terminal or intercalary, cylindrical. CONIDIA solitary, simple, fusiform or ellipsoidal, rounded at the apex, smooth, non septate, 2.5--3.7 x 1.2 um.

Isolated from A. marina test wood blocks and wash water plates (several collections), Mitsiua proper and Hamlay Desiet.

Notes: This fungus is so far not recorded from maritime habitats (Kohlmeyer & Kohlmeyer, 1979) and here it is a new record for marine waters.

3.17. Zalerion tax. sp. Fig.37, 48E.

COLONIES effuse, thin, darkbrown to black. HYPEAE superficial or immersed, branched, septate, hyaline. CONDIOPHORES filamentaous, branching, producing conidiogenous cells sympodially, 3-4 um wide. CONIDIOGENOUS CELLS holoblastic, polyblastic, terminal or intercalary. CONIDIA solitary, helicoid or coiled in three plans, forming a ball of cells; cells spherical, smooth, septate, deeply constricted at the septa, dark-brown, basal cell subhyaline, cells 6.25-12.5 um.

Isolated from driftwoods (several collections), Hamlay Desiet.

Notes: I am unable to put this fungus in the known species of Zalerion Moore & Meyers described also by Kohlmeyer & Kohlmeyer (1979)

3.18. Unidentified pycnidial sp. Fig.38.

PYCNIDIA solitary, globose to subglobose, developing within the breathing-pores of pneumatophores, carbonaceous, black, ostiolate, oozing out cream-coloured conidial mass. CONIDIOGENOUS CELLS holoblastic, polyblastic, sympodial, developing from inner layer of pycnidial wall, 10-12.5 x 3-4 um. CONIDIA solitary, slimy, filiform, cylindrical, curved to coiled at the apices, obtuse to rounded at the base, zero-septate, thin-walled, hyaline, smooth, 50-70 x 1.5 um.

Isolated from pneumatophores and testwood blocks of A. marina (one sample), Mitsiua proper and Hamlay Desiet; Oct. 8, 1986.

3.19. Unidentified mycelia sterilia sp. Fig. 39.

HYPHAE septate, branching, anastomosing, light brown, two types of hyphae, - thick, brown, thin, hyaline ones, 1.25-2.6 um, produce a brown pigment in the substratum. Papulospores, globose to subglobose, dark brown to black, superficial, catenulate, 3.75-15 um in diam.

Isolated from driftwoods (one sample) Hamlay Desiet, Oct. 8, 1986.

Note: One species of mycelia sterilia is reported by Kohlmeyer and Kohlmeyer (1979). This is here an unidentified species and is a new record for the Red Sea.

5. DISCUSSION

5.1. ECOLOGY

It is well known that when a piece of untreated wood is submerged for some time in the sea water, it will be colonized by higher marine fungi (Kohlmeyer & Kohlmeyer, 1979). Fungal propagules that become attached under these conditions will start to grow on the ligno-cellulosic substrate and develop into a mycelium. The hyphae of each colonizing species are likely to ramify over the surface as well as the sub-surface region. If no sporulation occurs, the identification of the fungus cannot be established. If sporulation does occur, which may be in the form of conidia or perithecia, the fungus can easily be identified.

However, in the present investigation sporulation occurred in most cases only when the test wood blocks or driftwoods were incubated in moist chambers (in room temperature) in the absence of many ecological factors present in the natural environment. In other words, the fungi recorded on the wood substrates may or may not be true primary colonizers in the natural environment, depending on whether the environmental conditions favour the *in situ* development of fungal propagules. Nevertheless, the sporulated fungi must be the successful colonizers on some suitable substrates in the surrounding waters in order to provide the required inocula to colonize the wood. Thus, although the baiting - incubation method has its limitations, it does provide some basic information regarding the species composition and abundance of the local marine myco-community, the study of which was one of the objectives of this investigation.

5.1.1. Occurrence of fungi

The three dominant species in descending order on the test wood blocks were *Periconia prolifica*, *Cirrenalia* tax. sp. and *Culcitalna acrospora*. Of these, *Pariconia prolifica* was dominant on all testwood blocks and at all the three sites. However, *Cirrenalia* tax. sp., and *Culcitalna acrospora* were observed only on mangroves and also were the dominant species at site one alone.

Occurrence of Periconia prolifica on all substrates and also from all sites indicates that this fungus is not substrate specific and is a most common inhabitant of the mycocommunity of Mitsiua region. Whereas the other two dominant species, Cirrenalia tax. sp. and Culcitalna acrospora, were adapted to the wood and pneumatophores of Avicennia marina. Being enclosed within a Bay and also closer to the mainland, the water in site 1 and 2 is much calmer than in site 3. This would have aided the easy settlement of more fungal propagules and colonization of the wood in the first two sites. This aspect is supported by their higher percentage species similarity (63.6%) in site 1 and 2 than site 1&3 and 2&3 (45%).

From the first collection 13 different species were isolated following incubation of test wood blocks. Subsequent collections yielded 2 to 4 species only. Only one reason can be attributed to the decline in number of species on the testwood blocks. Although P.prolifica and Cirrenalia tax. sp. were the most dominant species on the test wood blocks, neither of them were recorded in the first collection and therefore it is possible that the presence of these two species in the later collections might have exerted some antagonistic effect on other fungi.

In fact, the colonies of P. prolifica were found growing very vigorously covering the entire test wood blocks in 3-4 weeks of incubation. Not only the wood substrates but even some of the calcareous wood borers found adhering on the wood were colonized by P. prolifica. This shows that P. prolifica has no substrate specificity and even adapts to hard substrates such as calcareous shells quite well.

The three sites do not differ much in the environmental factors that are accounted. That is, neither the distribution pattern nor the species composition could be solely accounted for by a single environmental parameter but to the combined effect of all factors. This statement is justified by the presence of Periconia prolifica at all sites and on all substrates, for example, although disssolved oxygen ranged between 80-100% the presence of P. prolica was consistant.

Why was the species composition less in site 3? Two reasons can be given. Firstly, unlike the other two sites, in the Hamlay Desiet wave actions were greater and this churning activity of the water might have continually washed away the fungal propagules settled on the wood surface. Secondly, the bruising effect of the sand grains along with the vigorous wave action would not have allowed the chance settlement of large number of propagules on the substrate.

The other two test wood blocks, fagus and mhagoni, favoured growth of several fungal species. Of these two, fagus harboured more fungal species (5) than mhagoni (2). Again here Periconia prolifica was found growing on both the substrates on all sites.

Having recorded Periconia prolifica, and Lulworthia sp., 1 (100%), Gnomonia sp. (81%) and Zalerian sp. (63%) more frequently on the drift twigs, it can be said that these are the dominant colonizers of wood substrata in Mitsiua region. Similar to the findings on the test wood blocks, Periconia prolifica was found to be a very dominant component of the marine mycocommunity.

The findings presented here supported Jones' (1963, 1968, 1971) and Virjmoed's et al. (1968) observations that the nature and species of wood are important factors affecting colonization of wood by marine fungi.

At this stage of my work the succession pattern of fungal occurrence cannot be analysed because this exercise has been carried out only for a short period of time. Certainly when the present investigation is continued, as it is desired now, the picture of fungal succession patterns can be computed.

5.1.2. Fungal decay

It must be pointed out here that wood when immersed in the sea is colonized not only by fungi but by a variety of organisms such as bacteria and yeasts (microorganisms), marine borers (members of molluscan genera) and several crustacean species. Although marine borer damage is more dramatic, damage by marine fungi can contribute to cause typical wood decay or softrots (Jones & Byrne, 1976). Fungi are also believed to cause a 'preconditioning' of the wood surface prior to settlement of marine larvae (Eltringham, 1971).

Keeping in mind the role of all these organisms in wood decay, in this report only what fungi contribute in this aspect is discussed. From the results obtained it can be stated that fagus is the most resistant, mangrove wood slightly less resistant and mhagoni is most susceptible to fungal decay. It is possible that the fagus wood used by Lutheran for ship-building may be pretreated timber material or the wood composition itself may be resistant to fungal attack. Much work on the biochemistry of wood decomposition by fungal growth in the marine environment should be carried out in the future for further commercial exploitation of this timber wood in this area.

The highly susceptible mhagoni wood certainly is not advantageous for any tropical maritime exercises. However Lutheran uses them as the inner lining of their fishing-crafts.

The medium resistance (certainly not highly susceptible) of mangrove wood can be due its tannin content and wood composition. Although this is a true member of the marine phytocommunity it has not been commercially exploited much. Submersion in the sea water for a prolonged period of time and subsequent analyses of mangrove wood decay and wood strength will have to be carried out on a priority basis since this wood material is available in abundance along the Ethiopian coastal belt and can be used to advantage.

5.2. FLORISTICS

Study on the floristics of Ethiopian microfungi from terrestrial habitats, mostly those fungi growing on dead and decaying plant litter, has been in progress in the Department of Biology, Asmara University for the last few years. Several new and interesting microfungi from Ethiopia have been documented (Bhat, 1983; 1985 a & b; Bhat & Sutton, 1985a & b). Bhat (1986), while reporting on the floristics of Ethiopian microfungi, has also reviewed the historical work on the fungi of Ethiopia. However, so far, there is no record of any kind on the marine fungi from Ethiopian coastal waters of the Red Sea. In fact, the Red Sea in particular and the East African Coast of the Indian Ocean in general has not been explored in any detail for its mycofloristic component.

The results presented in the previous chapter, therefore, now stand as the first survey of the marine fungi of the Ethiopian coast and also for the horn of Africa. The only report on the marine fungi of the Red Sea was that of Aleem (1978) who recorded Corollospora pulchella and Periconia prolifica from the Saudi Arabian coast.

In all, 51 species are recorded on wood substrates collected from Mitsiua (Table 9). Out of these 9 species were found growing only on test wood blocks and 30 species on driftwoods. The remaining 13 species were recorded on both these substrata. Of the total fungal taxa recorded, 22 species belonged to Ascomycotina, 1 to Basidiomycotina and the remaining 28 species to Deuteromycotina.

The following 11 species, viz. (Ascomycotina) Didymosphaeria tax. sp., Halosarpheia tax. sp., and unidentified unitunicate fungus, (Deuteromycotina) Cirrenalia tax. sp., Diplococcium tax. sp., Halosynnema avicenniae gen. et sp., nov., Idriella tax. sp., Lasiodiploidia tax. sp., an unidentified pycnidial fungus , an unidentified hyphomycetous fungus ane unidentified mycelia sterilia are new to the marine mycocommunity.

Of the total collections, 35 species are obligate marine taxa (Table 9). 50 species are new records to the Red Sea in particular and 17 species to the Indian Ocean in general. All of them are new to the Ethiopian coast and are additions to our knowledge on the mycoflora of Ethiopia.

Published records (Kohlmeyer & Kohlmeyer, 1979) related only 6 species of Ascomycotina and 1 species of Deuteromycotina to Avicennia marina substrata. These species were Antennospora quadricornuta, Gnomonia longirostris, G. marina, Leptosphaeria australiansis, Lulworthia spp., Ophiobolus australiansis and Phialophorophoma littoralis.

In this report, 21 species are recorded from the same substrate and of which 5 are new to marine mycocommunity.

Kohlmeyer (1984) indicated that about one third of all described higher marine fungi were from tropics and subtropics. He also predicted that when research in tropical habitats intensified the balance will change in favour of tropical fungi. The present investigation supports his predictions because the number of Indian Ocean fungi has raised from 68 to 84 showing an increase of 20%.

It must be pointed out that the fungi reported in this work are collected from a smaller area at Mitsiua. That is, at this stage, the number and kinds of fungi reported will form only a small portion of the marine mycoflora of Ethiopian coastal waters. When similar explorative work is intensified in future, as it is planned now, scanning many more hosts such as algae, grasses, etc, along the Ethiopian subcontinental coast and also on the coasts of several islands in the Red Sea, discoveries of many more new species and records are expected. This may be true also in the mangroves where several other host plants have never been studied for the occurrence of fungi.

Earlier records of seven species of marine fungi from Avicennia marina were obtained from several tropical and subtropical maritime regions, whereas 26 species are reported here only from Mitsiua. It is possible that this place will yield many more new and interesting marine fungi in the future and A. marina may particularly turn out to be a treasure substrate for these fungi.

Another interesting ecological niche where obligate marine fungi are expected to grow are the sandy shores. These are the arenicolous fungi, growing on sand or calcareous shells. No attempt has been made in this programme to explore this group but these fungi will certainly receive attention in our future exersices. The ecology and nature of nutrition of these fungi are fully untouched.

These all point out that a great deal of mycofloristic explorations will have to be carried out in the future covering a large number of other hosts or substrates and many more areas along the Ethiopian coastline. There is no doubt that it is a rewarding area of mycological research.

6. CONCLUSIONS AND RECOMMENDATIONS

Though the study period was of short duration, the use of different test wood blocks and collection of drift woods at Mitsiua has enabled me to observe the occurrence of a substantially large number of higher filamentous marine fungi, the effect of environmental parameters on their occurrence, selection of specific substrates by the fungi and evaluation of timber decay in the sea. The floristics of marine fungi along the Ethiopian coastal waters of the Red Sea was studied here for the first time in detail.

The occurrences of fungi on the mangrove wood blocks, fagus and mhagoni timber wood and on driftwoods in the sites appear to be similar. Nevertheless the environmental factors along with the ecological components play a key role in determining the species composition. Besides, the type of wood as a bait has a tremendous selective pressure on the fungal colonization qualitatively. Hence indirectly, it is the type of wood that determines rate of decay by the fungi and to remain as a sound and durable or susceptible timber to fungal attack.

It is well known that marine fungi play a key role in the productivity of aquatic ecosystems. However considerable variation in the fungal population occurs in different seasons. Therefore, to evaluate the seasonal pattern and a better picture of the primary colonizers, similar study should be done for a longer time.

If the commercial usage of the mangrove vegetation is desired, the timber has to be studied in detail by exposing it in the sea water for a longer time and then rating it as commercially satisfactory or unsatisfactory timber.

Lastly, the marine mycoflora of the Red Sea along the Ethiopian coastal line has to be explored in several working sites including the islands if documentation and both ecological and geographical studies are to be extended.

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Table 1. Fungal species found colonizing mangrove (*A. marina*).

Species	Sample 1	2	3	4	5	6	7	8	9	10
ASCOMYCOTINA										
Chaetomium sp.	W									
Halosarpheia sp.	P									
Lulworthia sp. 1.	W									
L. sp. 2.	W									
DEUTEROMYCOTINA										
Acremonium sp.					W					
Alternaria sp.	P									
Cirrenalia pseudomacrocephala				W			WP			
*C.*tax. sp.		W	WP			W		WP	W	WP
Cladosporium algarum				W						
Culcitalna acrospora		W					W	W	W	
Halosynnema avicennae	W		P							
Lasiodiploidia tax. sp.	WP									
Paecilomyces	WP					W				
Penicillium sp.	WP									
Periconia prolifica		WP	WP	WP	WP	WP	WP	WP	WP	WP
Unidentified pycnidial fungus	WP									

W = mangrove wood; P = pneumatophores;
WP = wood + pneumatophores

Table 2. Fungi found colonizing the test wood blocks at sites 1, 2 and 3.

Substrate (test wood blocks)	Mangrove DC			WP			Mhagoni		Fagus	
Species \ Site	1	2	3	1	2	3	2	3	2	3
ASCOMYCOTINA										
Chaetomium sp.	+									
Halosarpheia sp.			+							
Lulworthia sp.1		+	+				+			
L. sp.2			+							
DEUTEROMYCOTINA										
Acremonium sp.	+	+	+						+	+
Alternaria sp.	+			+	+	+				+
Aspergillus sp.				+						
Cirrenalia pseudomacrocephala	+	+								
C. tax. sp.	+	+		+	+					
Cladosporium algarum			+	+	+	+				
C. sp.						+				
Culcitalna acrospora	+	+		+	+	+				
Drechslera halodes						+				
Emericella sp.				+	+	+				
Halosynnema avicenniae	+	+								
Lasiodiplodia tax. sp.			+						+	
Paecilomyces	+	+	+							+
Papulospora				+	+	+				
Penicillium sp.	+	+	+	+	+	+	+			
Periconia prolifica	+	+	+			+	+	+	+	+
Veronaea sp.				+	+	+				
Unidentified pycnidial fungus	+	+	+							

DC = damp chamber incubation
WP = wash water plates

Table 3. Occurrence of fungi on the test wood blocks in sites 1, 2, and 3.

Substrate (test wood blocks)	Mangrove			Mhagoni		Fagus	
Species \ Site	1	2	3	2	3	2	3
ASCOMYCOTINA							
Chaetomium sp.	1						
Halosarpheia sp.			1				
Lulworthia sp.1		4	1				
L. sp.2			1	4			
DEUTEROMYCOTINA							
Acremonium sp.	1	1	3			1	4
Alternaria sp	1					5	
Cirrenalia pseudomacrocephala	4,7 1	7					
C. tax. sp.	2,3.6,9,10	2,9					
Cladosporium algarum			1				
Culcitalna acrospora	2,7,8,9	9					
Halosynnema avicenniae	3		1				
Lasiodiplodia tax. sp.			1				7
Paecilomyces	1	1,6	1				3
Penicillium sp.	1	1	1	1			
Periconia prolifica	2-10	2-10	2-10	2-10	2-10	2-10	2-10
Unidentified pycnidial fungus	1	1	1				

Numbers 1,2,3,... indicate the collection number.

Table 4. Total percentage occurrence of the fungi on the test wood blocks.

Species	Occurrence Mangrove DC	Occurrence Mangrove WP	for all test wood blocks
ASCOMYCOTINA			
Chaetomium sp.	1.66		1
Halosarpheia sp.	1.66		1
Lulworthia sp.1	1.66		1
L. sp.2	1.66		2
DEUTEROMYCOTINA			
Acremonium sp.	5.00		5
Alternaria sp.	1.66	6.6	2
Aspergillus sp.		6.6	
Cirrenalia pseudomacrocephala	8.33		5
C. tax. sp.	16.66	5.0	10
Cladosporium algarum	1.66	10.0	3
C. sp.		10.0	
Culcitalna acrospora	8.3		5
Drechslera halodes		1.6	
Halosynnema avicenniae	3.3		2
Lasiodiploidia tax. sp.	3.3		2
Paecilomyces	8.3		6
Penicillium sp.	6.6	10.0	4
Periconia prolifica	90.0	1.6	90
Veronaea sp.		10.0	
Unidentified pycnidial fungus	6.6		4
Unidentified mycelia sterilia		10.0	

DC = damp chamber incubation
WP = wash water plates

Table 5. Percentage occurrence of fungi on driftwoods

Species / Samples	ex	1	2	3	4	5	6	7	8	9	10	% Occ.
ASCOMYCOTINA												
Antennospora quadricornuta								+				9.0
Caryosporella rhizophorae			+		+			+				27.2
Didymosphaeria enalia			+		+				+			27.2
D. rhizophorae								+	+			18.1
D. tax. sp.								+				9.0
Emericella sp.			+		+	+		+	+			45.0
Gnomonia sp.	+		+		+	+	+	+	+	+	+	81.8
Halonectria sp.	+		+		+	+	+	+		+		63.6
Halosarpheia sp.	+	+		+	+				+	+		54.5
H. ratnagiriensis			+	+		+						27.0
Halosphaeria tax. sp.						+						9.0
Leptosphaeria australiensis							+	+				18.1
L. sp.	+		+					+	+			36.3
Lindra thalassiae								+				9.0
Lulworthia sp.1	+	+	+	+	+	+	+	+	+	+	+	100.0
Kymadiscus haliotrephus		+		+	+		+	+		+	+	63.0
Pleospora sp.								+				9.0
Torpedospora radiata								+				9.0
Zopfiella marina	+											9.0
Unidentified unitunicate Ascomycete							+		+			18.0
BASIDIOMYCOTINA												
Halocyphina villosa									+	+	+	27.2
DEUTEROMYCOTINA												
Acremonium sp.								+				9.0
Alternaria sp.1		+										9.0
A. sp. 2		+		+		+		+	+			45.0
Aspergillus sp.				+		+	+	+	+			45.0
Cirrenalia pseudomacrocephala											+	9.0
C. tax. sp.		+				+	+	+	+			45.0
Cladosporium algarum			+		+	+		+				36.3
C. sp.							+					9.0
Diplococcium sp.							+					9.0
Idriella tax. sp.	+		+		+		+	+				45.0
Monodictys sp.	+				+			+				27.2
Paecilomyces sp.		+			+	+	+	+				45.0
Papulospora sp.			+	+		+		+				36.3
Penicillium sp.		+										9.0
Periconia prolifica	+	+	+	+	+	+	+	+	+	+	+	100.0
Sympodiomyces parvus				+		+	+	+			+	45.0
Trichocladium sp.1	+											9.0
T. sp.2	+											9.0
Trichothecium sp.	+											9.0
Zalerion sp.	+	+		+	+		+		+		+	63.6
Unidentified hyphomycete fungus		+	+	+	+							36.4

ex = extra sample, occ. = occurrence, + = presence.

Table 6. Average surface values of some environmental parameters for all the sites.

Sampling number & date		Temperature °C	pH	Salinity ‰	Secchi disc depth m	O_2 sat. %
1	Oct. 8, 86	33	8.21	39.1	-	92.90
2.	Oct.29, 86	30	7.93	38.2	-	98.60
3.	Nov.19, 86	30	8.27	38.2	-	88.50
4.	Dec.10, 86	28	8.31	40.0	9.11	80.35
5.	Dec.31, 86	28	8.01	39.1	9.58	97.56
6.	Jan.21, 86	27	8.29	38.2	6.30	95.35
7.	Feb.11, 87	27	8.08	37.3	6.35	82.15
8.	Mar. 4, 87	27	8.05	38.2	6.00	86.00
9.	Mar.25, 87	28	8.23	37.9	6.69	99.48
10.	Apr.16, 87	29	8.13	37.3	7.20	90.90

Table 7. Percentage weight losses of test wood blocks at sites 1, 2 and 3

Site	Mangrove			Mhagoni		Fagus	
Sample	1	2	3	2	3	2	3
1	13.83	13.52	15.06	4.96	6.41	5.17	3.45
2	17.19	12.16	14.07	8.28	9.86	3.31	3.65
3	18.73	36.60	28.73	6.61	15.36	1.97	5.81
4	33.31	30.43	29.12	25.26	27.08	6.16	7.43
5	32.77	34.82	32.28	26.06	47.33	9.66	12.59
6	47.01	43.39	38.38	30.17	54.93	4.69	10.13
7	49.12	57.12	57.77	42.11	54.96	6.48	6.46
8	45.45	61.60	51.59	42.14	56.93	2.24	6.58
9	51.76	56.95	50.83	45.08	54.92	5.78	8.72
10	53.95	56.46	59.63	70.27	51.65	5.81	6.05

Table 8. Percentage strength losses of test wood blocks at sites 1, 2 and 3.

Site	Mangrove			Mhagoni		Fagus	
Sample	1	2	3	2	3	2	3
1	9.6	20.4	11.4	28.0	22.8	7.6	41.6
2	25.5	46.5	16.7	32.0	33.6	25.8	43.7
3	20.6	-	21.1	54.6	80.2	28.9	38.8
4	77.5	75.5	28.5	85.8	83.8	39.7	48.3
5	54.0	55.2	53.0	80.0	91.8	55.1	47.6
6	52.0	60.8	68.4	83.0	93.4	57.6	46.9
7	58.1	84.7	91.7	87.2	97.4	59.6	40.0
8	58.1	59.6	93.8	94.6	97.6	61.1	59.3
9	50.0	73.4	79.6	73.6	97.6	63.0	62.8
10	35.5	75.1	76.2	97.6	94.0	44.1	60.7

Table 9. List of Fungi (previous and new records) from the Indian Ocean, Red Sea and *Avicennia marina*.

Fungal species	Indian Ocean Prev.	Indian Ocean New	Red Sea Prev.	Red Sea New	*A. marina* Prev.	*A. marina* New
ASCOMYCOTINA						
**Antennospora quadricornuta*	+			+	+	
**Caryosporella rhizophorae*		+		+		
Chaetomium sp.	+			+		+
**Didymosphaeria enalia*	+			+		
**D. rhizophorae*		+		+		
**D.* tax sp.		+		+		
Emericella sp.				+		
**Gnmonia* sp.	+			+	+	
**Halonectria* sp.		+		+		
**Halosarpheia fibrosa*	+			+		
**H. ratnagiriensis*	+			+		
**H.* tax. sp.		+		+		+
**Leptosphaeria australiensis*		+		+	+	
**L.* sp.	+			+		
**Lindra thalassiae*		+		+		
**Lulworthia* sp.1	+			+	+	
**Lulworthia* sp.2	+			+	+	
**Kymadiscus haliotrephus*	+			+		+
**Pleospora* sp.		+		+		
**Torpedospora radiata*	+			+		
**Zopfiella marina*	+			+		
*Unidentified unitunicate Ascomycetes		+		+		
BASIDIOMYCOTINA						
**Halocyphina villosa*	+			+		
DEUTEROMYCOTINA						
Acremonium sp.	+			+		+
Alternaria sp.1	+			+		+
A. sp. 2	+			+		
Aspergillus sp.	+			+		+
**Cirrenalia pseudomacrocephala*		+		+		+
**C.* tax. sp.		+		+		+
**Cladosporium algarum*	+			+		+
C. sp.	+			+		+
**Culcitalna achrospora*		+		+		+
Diplococcium sp.						
**Drechslera holdes*	+			+		+
**Halosynnema avicenniae*		+		+		+
Idriella tax sp.				+		
**Lasiodiplodia* tax. sp.				+		+
**Monodictys* sp.	+			+		
Paecilomyces sp.				+		+
**Papulospora* sp.	+			+		+
Penicillium sp.				+		+
**Periconia prolifica*	+		+			+
Sympodiomyces pavus				+		
Trichocladium sp.1				+		
T. sp. 2				+		
Trichothecium sp.		+		+		
Venonaea sp.		+		+		+
**Zalerion* sp.				+		
*Unidentified pycnidial fungus		+		+		+
Unidentified hyphomycetes fungus		+		+		
*Unidentified mycelia sterilia		+		+		+

* = obligate marine species; prev. = previously recorded;
+ = present.

Figure 41
Number of fungal species or
environme

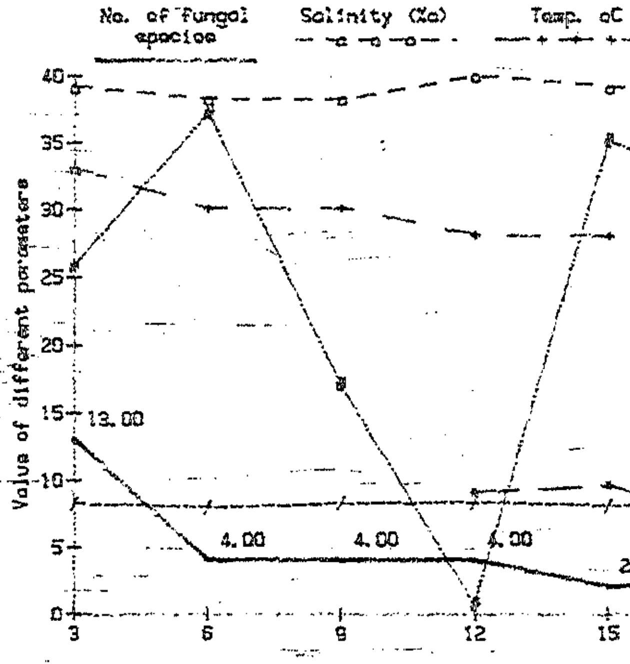


Figure 42A
Percentage weight losses of test wood blocks at sites 1, 2 & 3

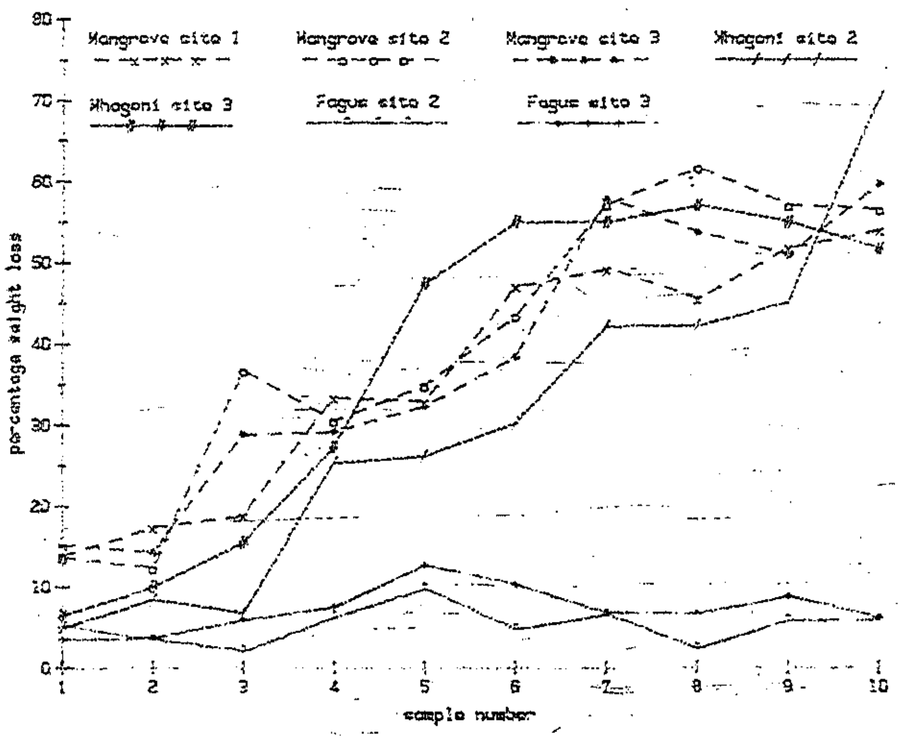


Figure 42B
Percentage strength losses of test wood blocks at sites 1, 2 & 3

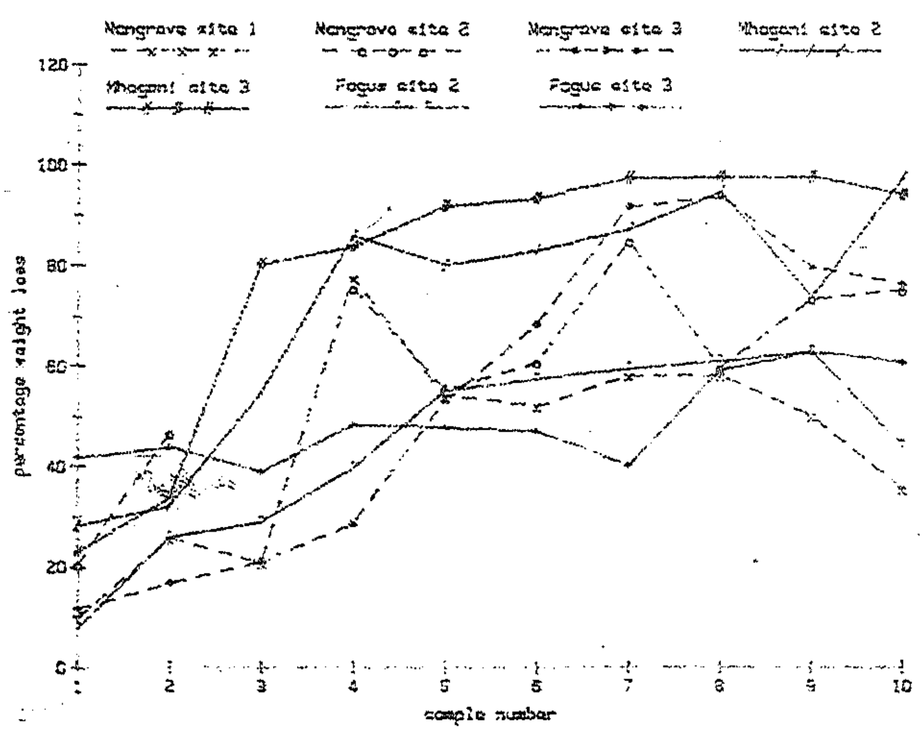


Fig 2. Flow of diagram of experimental procedures

1. Mangrove wood & pneumatophores
2. Mhagoni and fagus testwood blocks
3. Driftwoods

4-6. Wash water plating

7. Damp chamber incubation of test wood blocks in petriplates.
8. Incubation of driftwoods in sterile polythene chambers
9. Microscopic examination

10-11. Wood decay evaluation by weight and strength loss analyses.

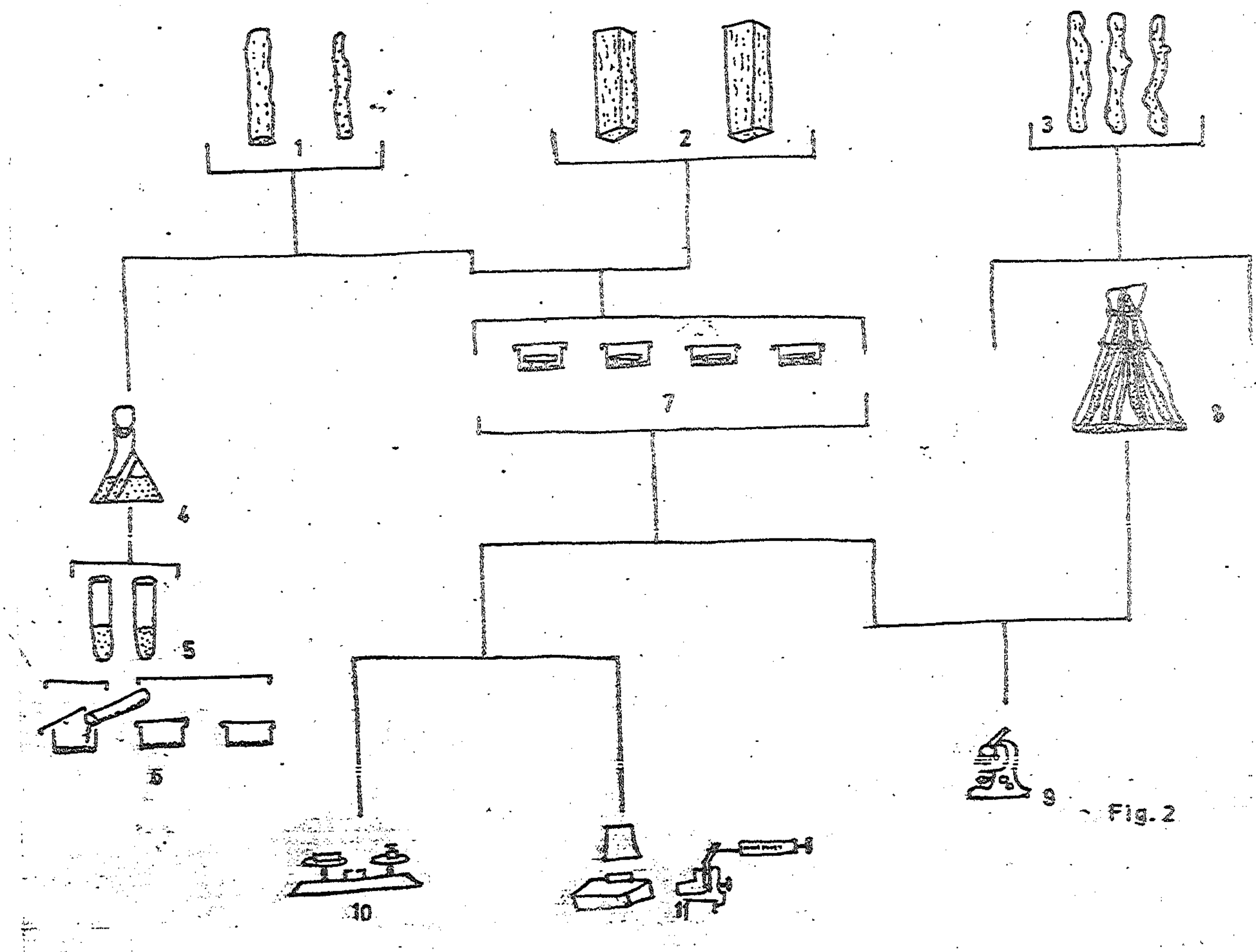


Fig. 2

Fig. 3

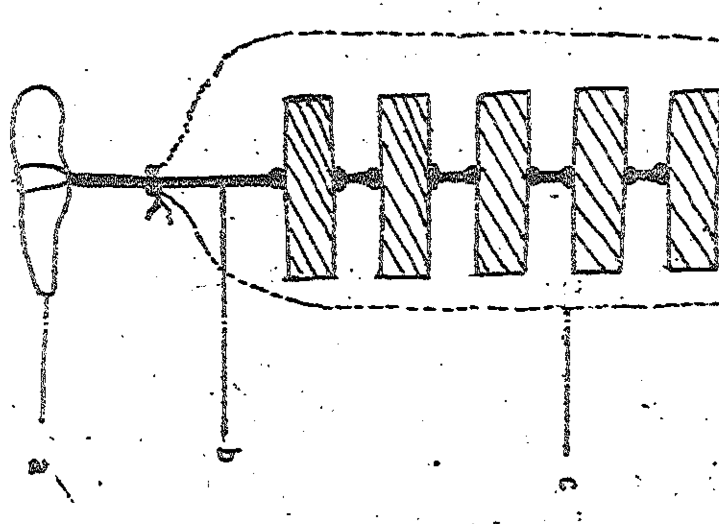


Fig 3. Diagramatic ske
blocks for immersin

a. Anchor weight
b. Suspention rope
c. Nylone mesh
d. Test wood blocks

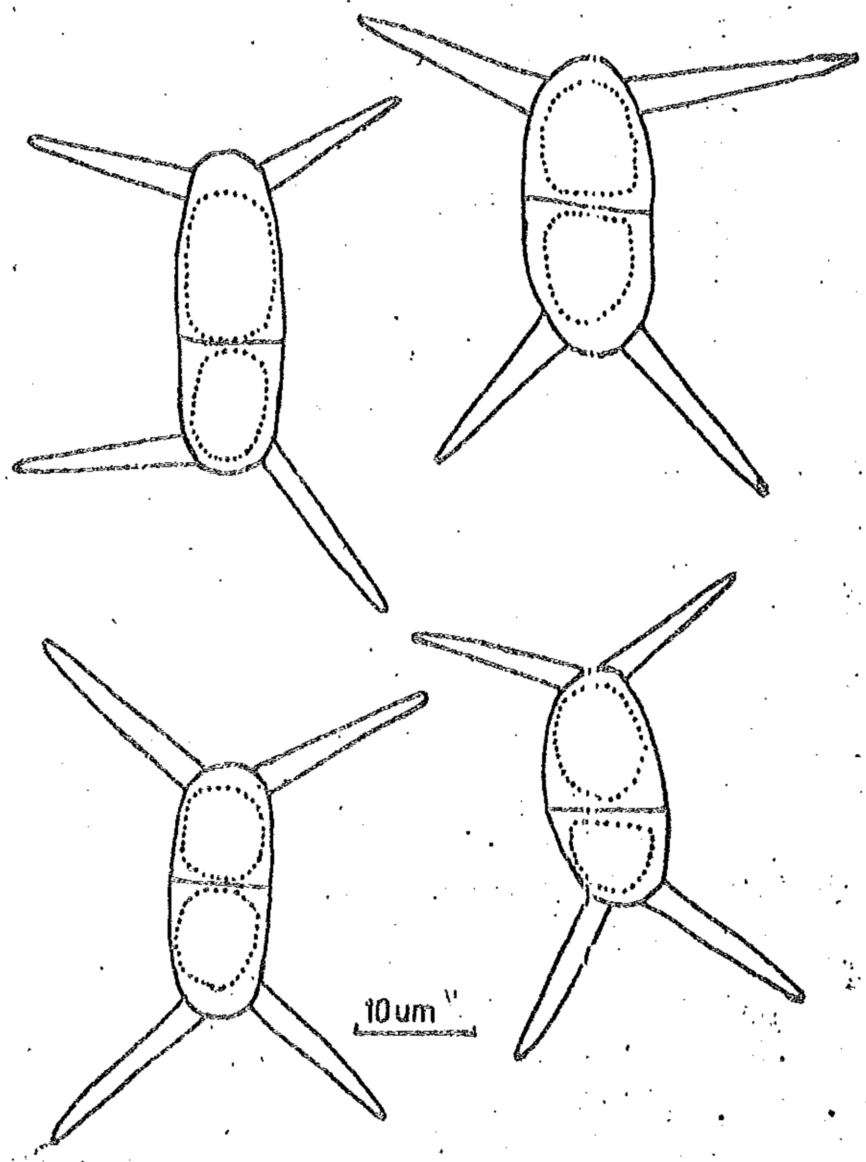


Fig-4. Anntenospora quadricornuta - Ascospores

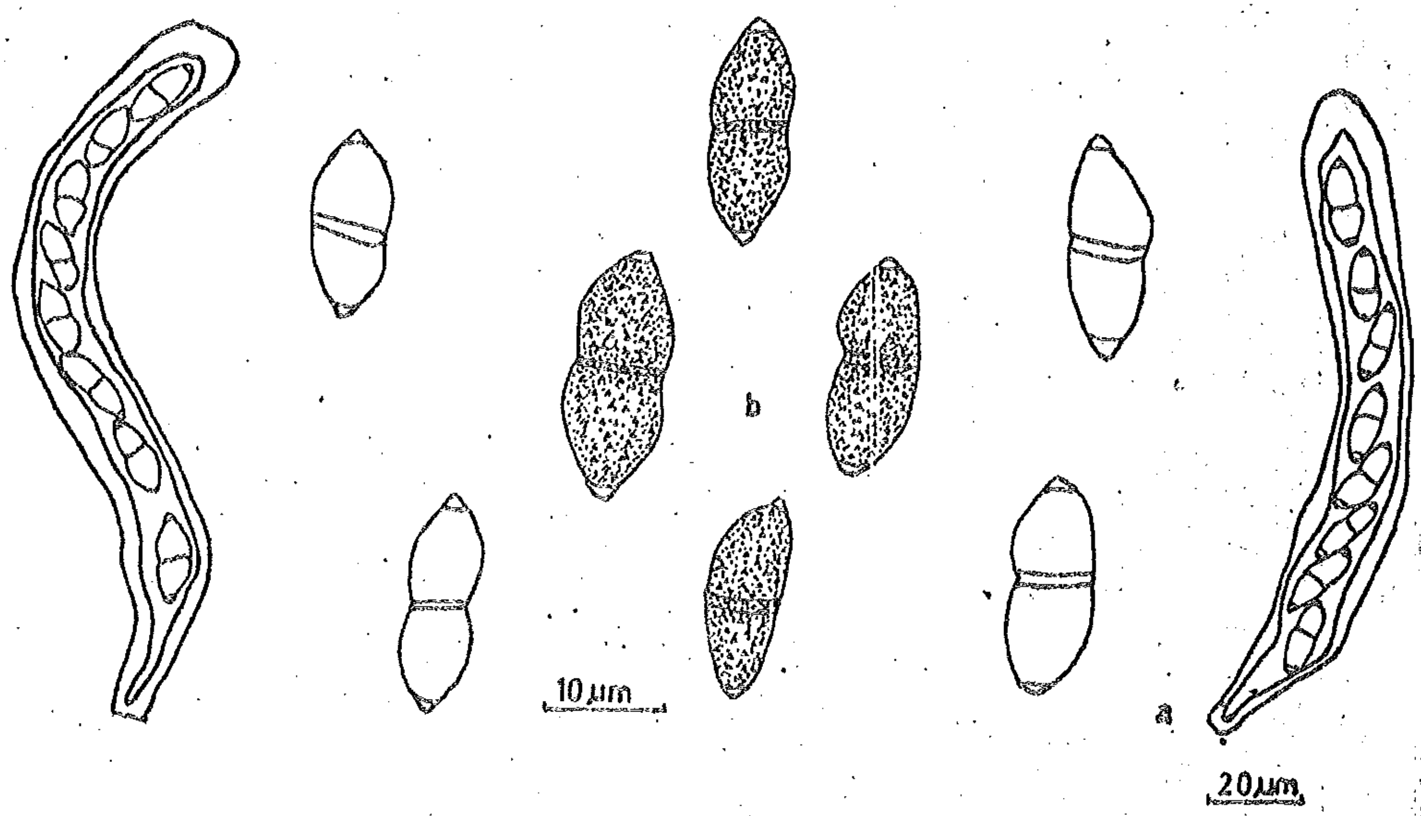


Fig-5. Caryosporella rhizophorae - a, ascus; b, Ascospores

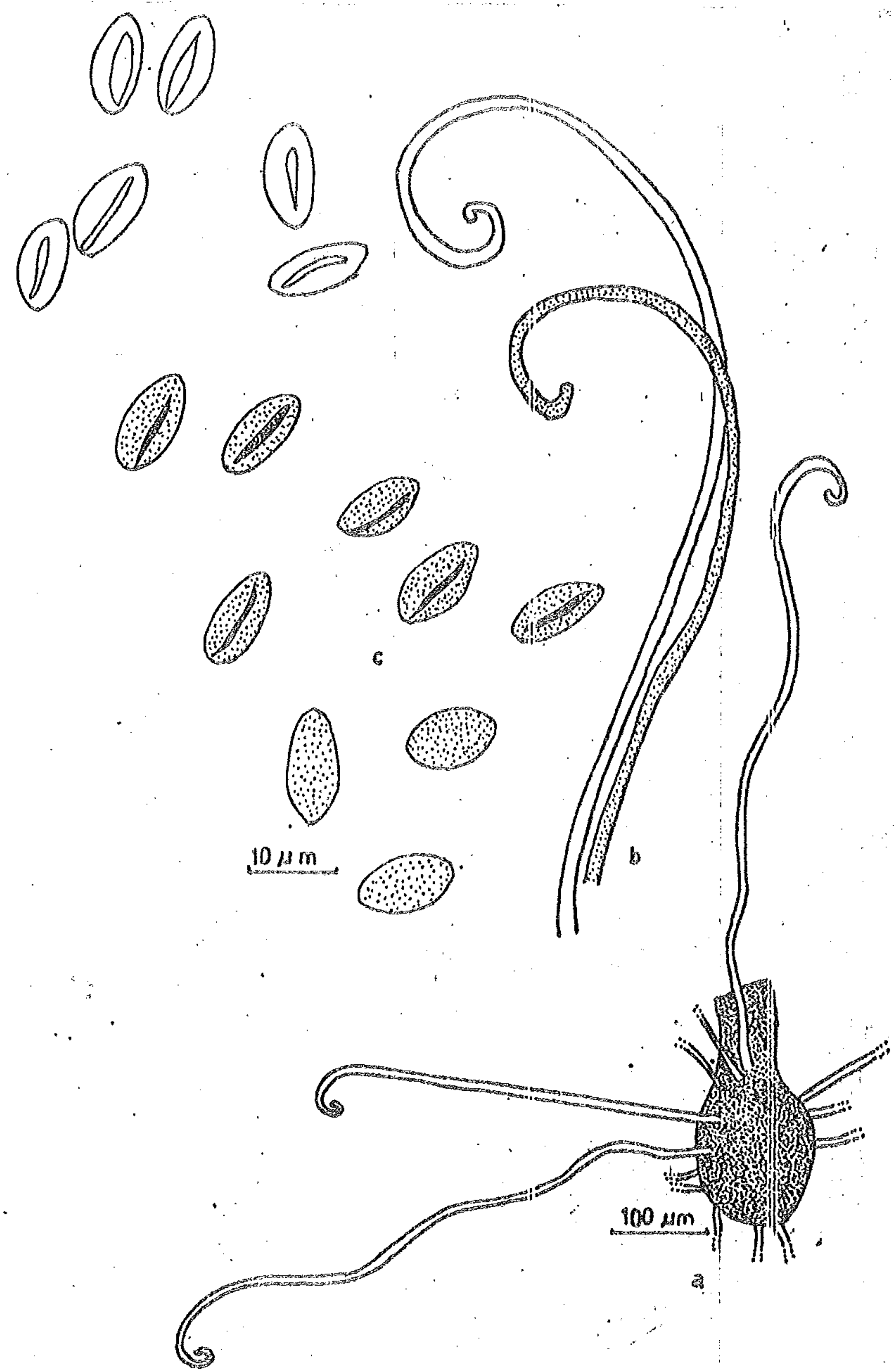


Fig-6. Chaetomium sp.

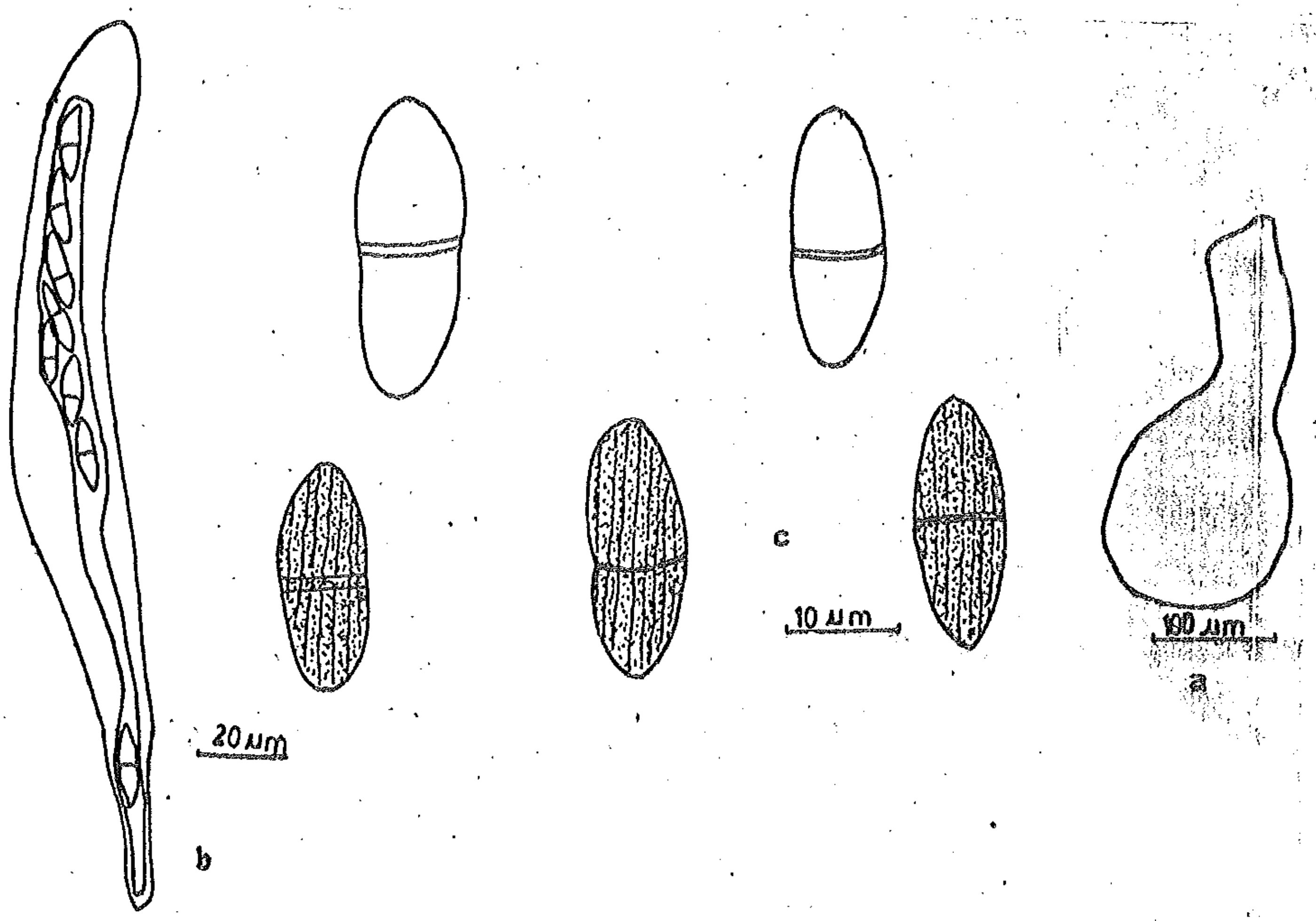


Fig-7. Didymoshaeria rhizophorae
a, Ascuscarp; b. Ascus; c. Ascospores

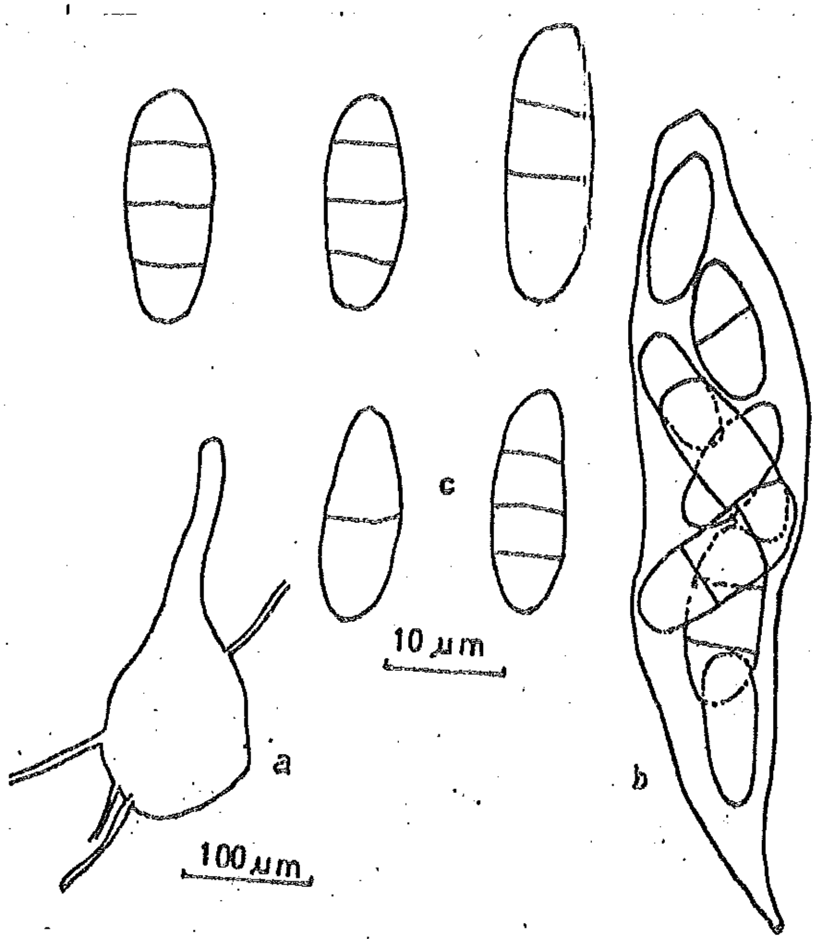


Fig-8. Gnomonia sp.
a, Ascocarp; b. Ascus; c, Ascospores.

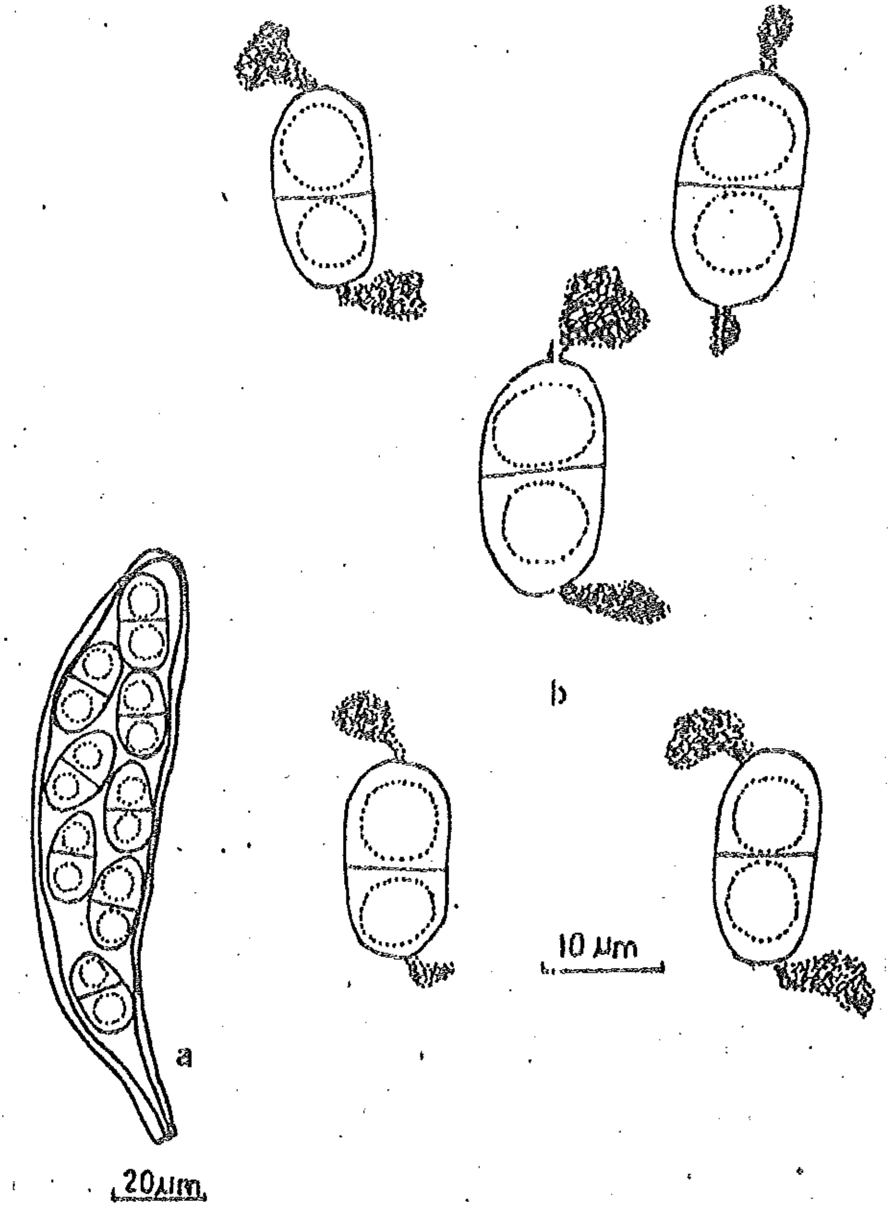


Fig-9. Halosarpheia

a. Ascocarp; b, Ascus; c, Ascospores

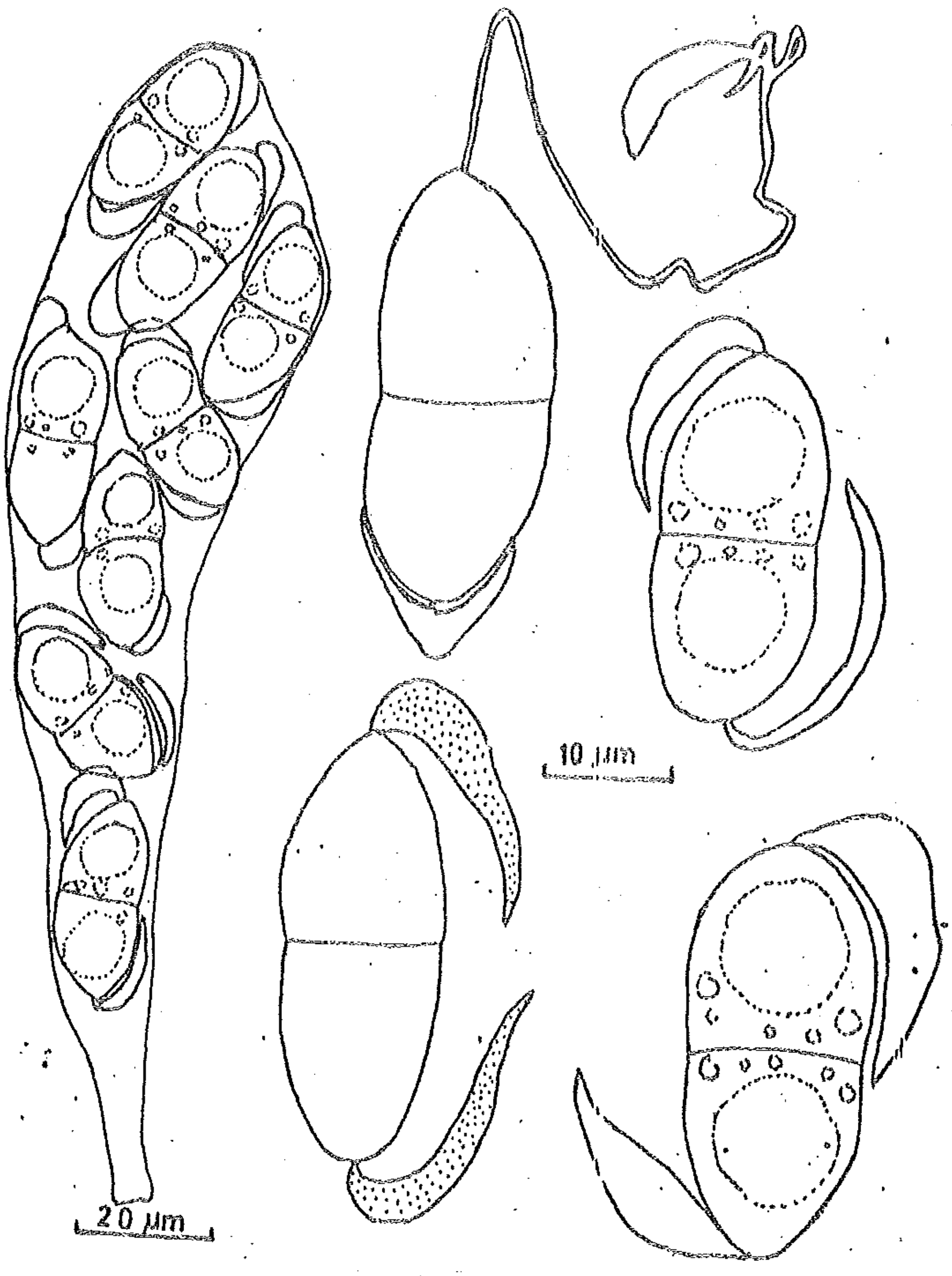


Fig .40 __Halosarpheia ratnagiriensis__

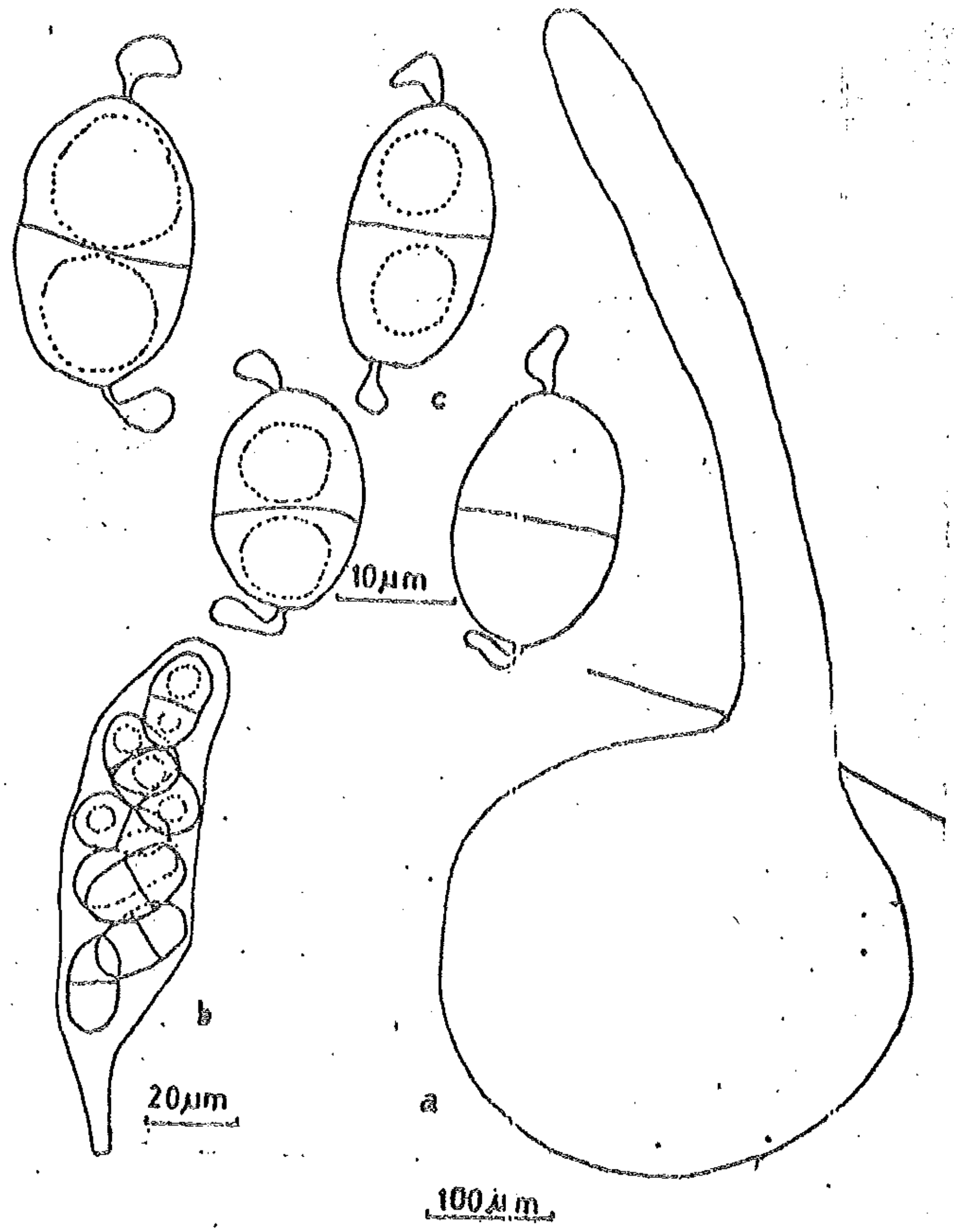


Fig-10. Halosarpheia ratnagriensis
a, Ascus; b, Ascospores

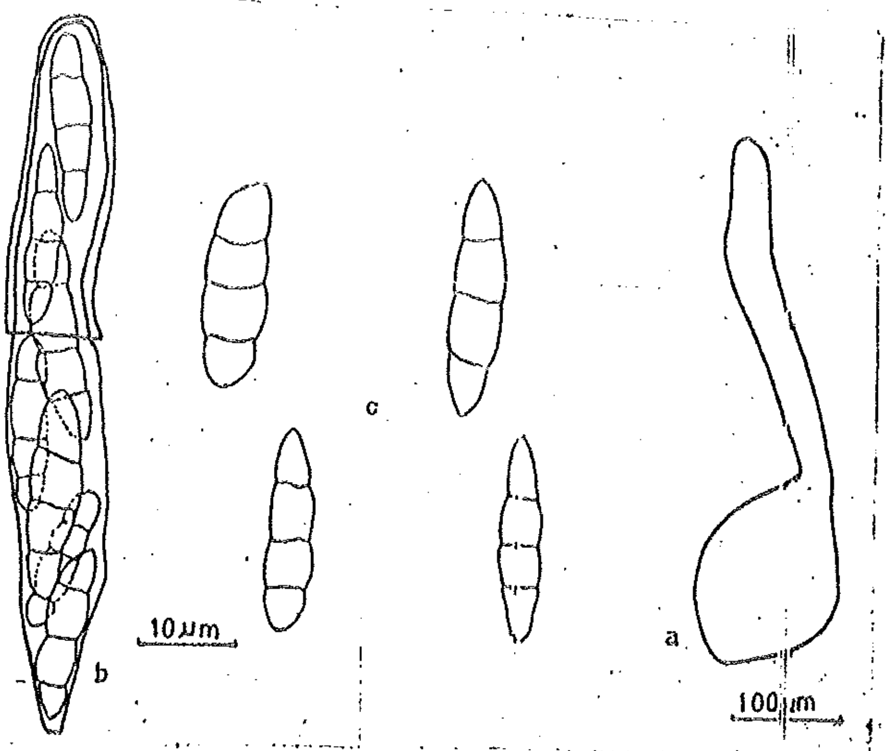


Fig-11. Leptosphaeria australiansis
a. Ascocarp; b. Ascus; c. Ascospores

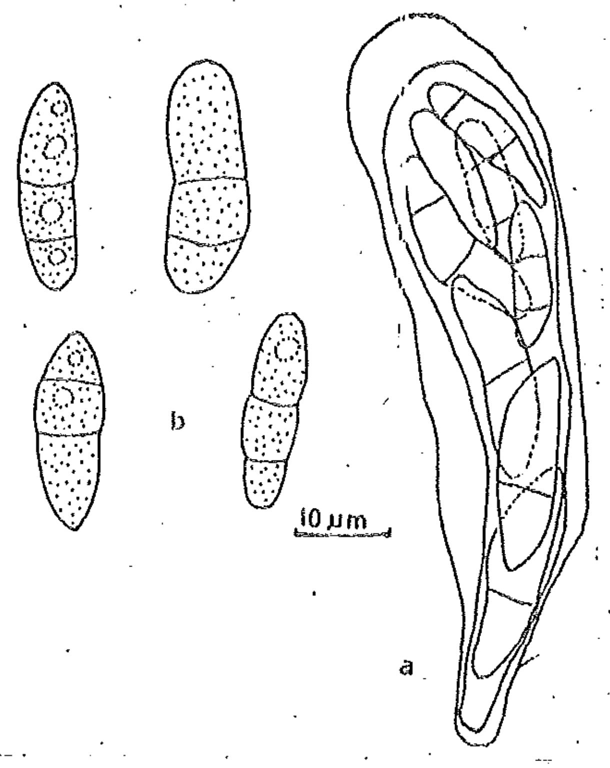


Fig-12. Leptosphaeria sp.
a. Ascus; b. Ascospores

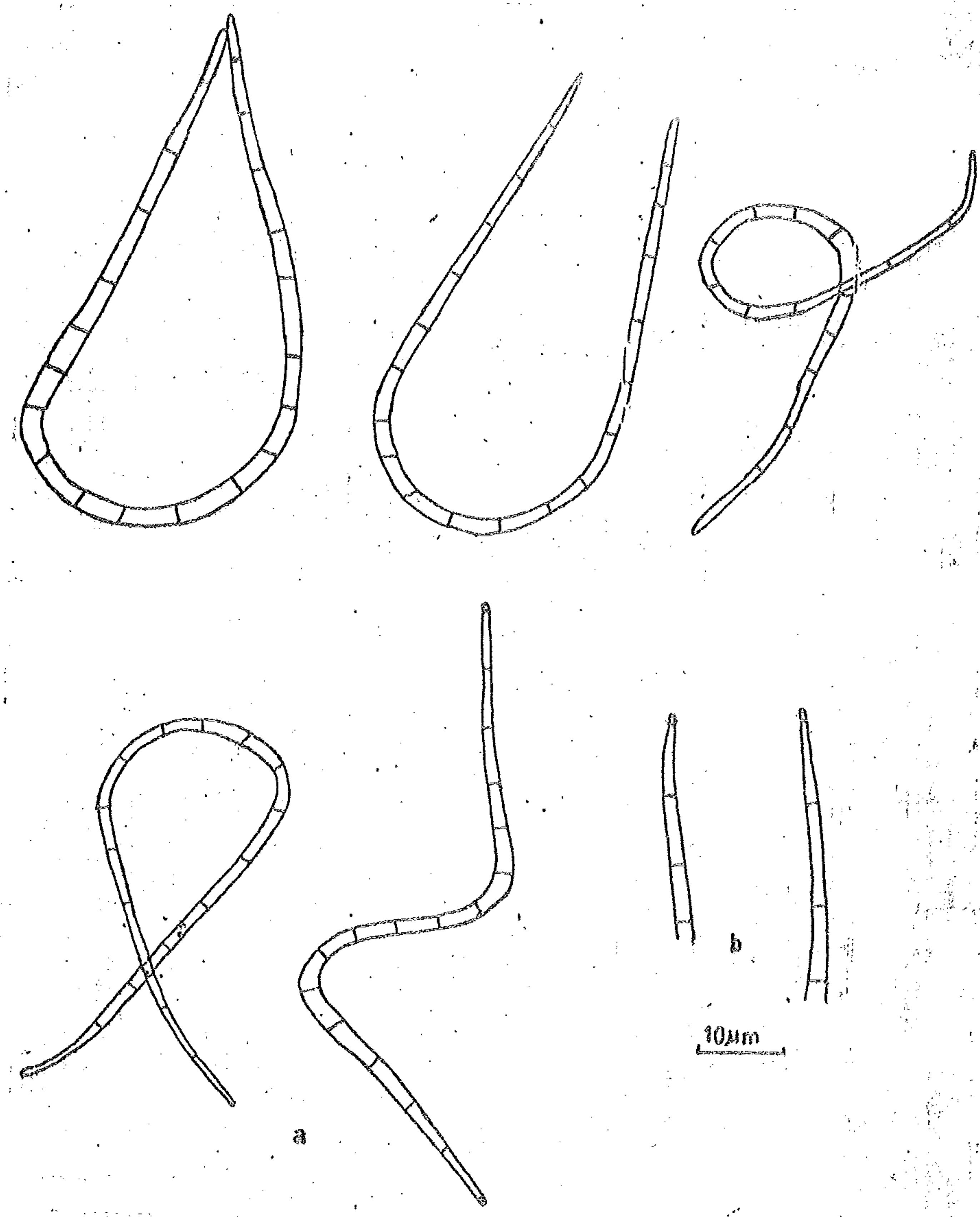


Fig-13. Lindra thallassiae
a. Ascospores; b. Apical cell of ascospore

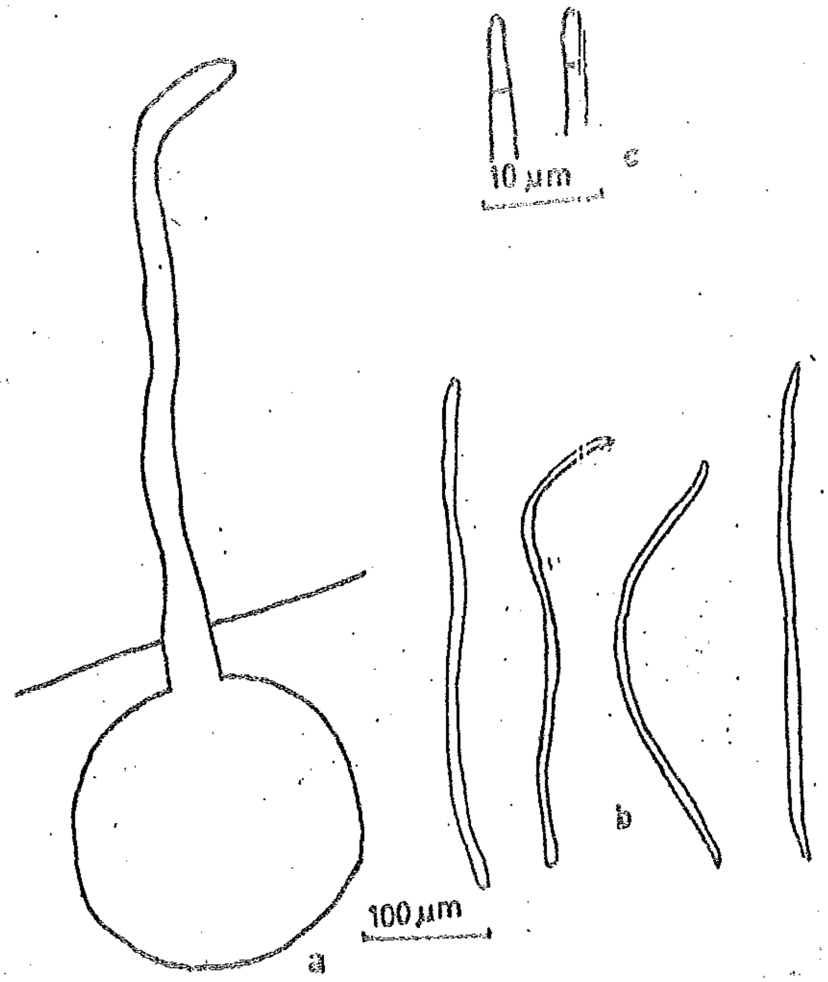


Fig-14. Lulworthia sp. 1
a. Ascocarp; b. Ascospores; c. Apical cell of an ascospore

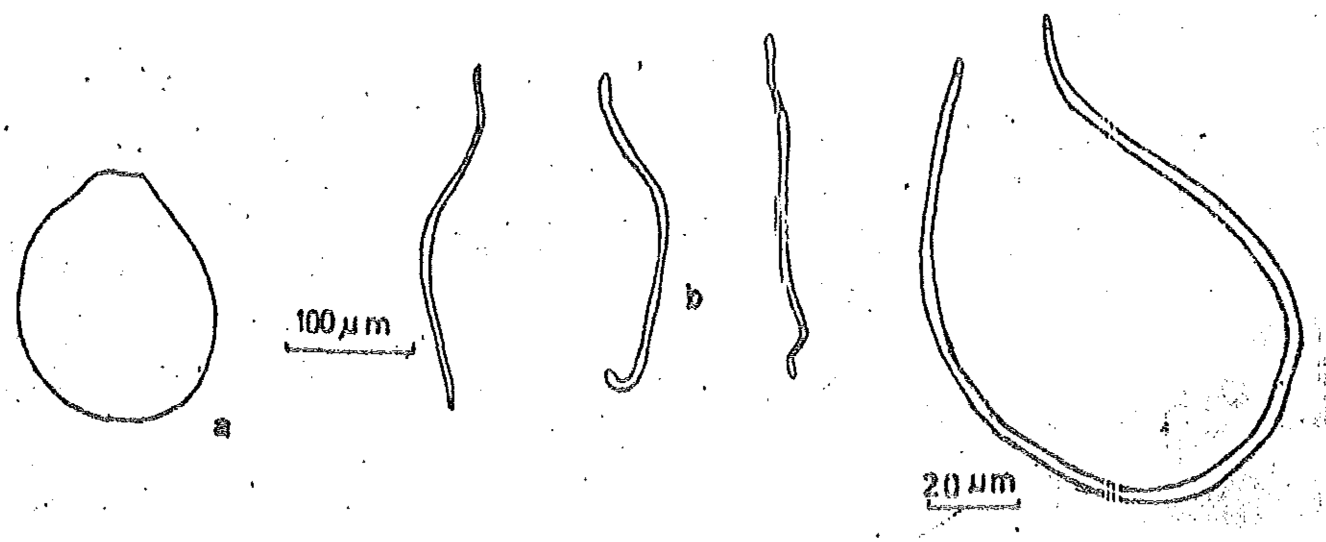


Fig-15. Lulworthia sp. 2
a. Ascocarp; b. Ascospores

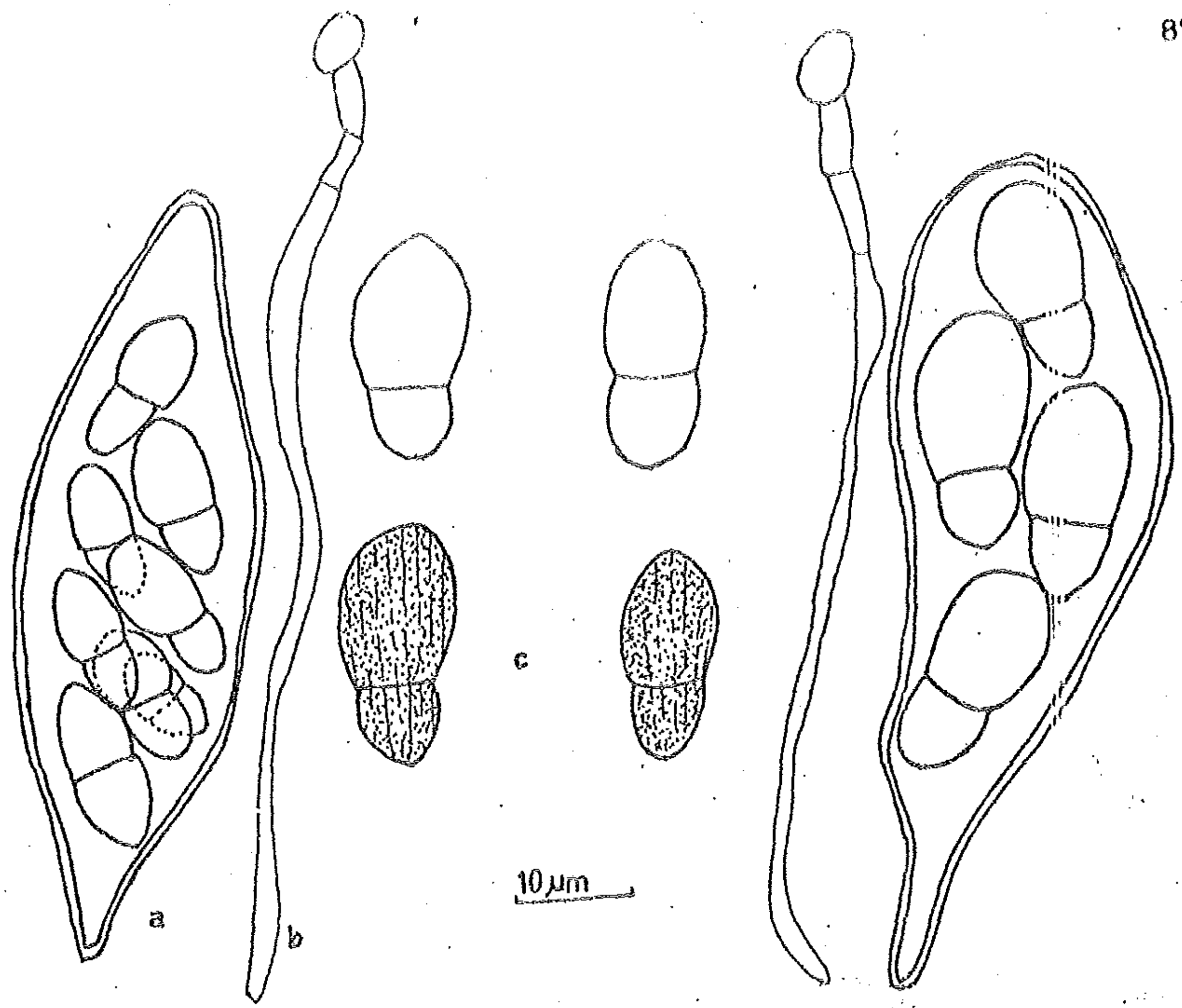


Fig-16. Kymadiscus haliotrephus
a. Ascus; b. Pseudoparophysis;
c. Ascospores

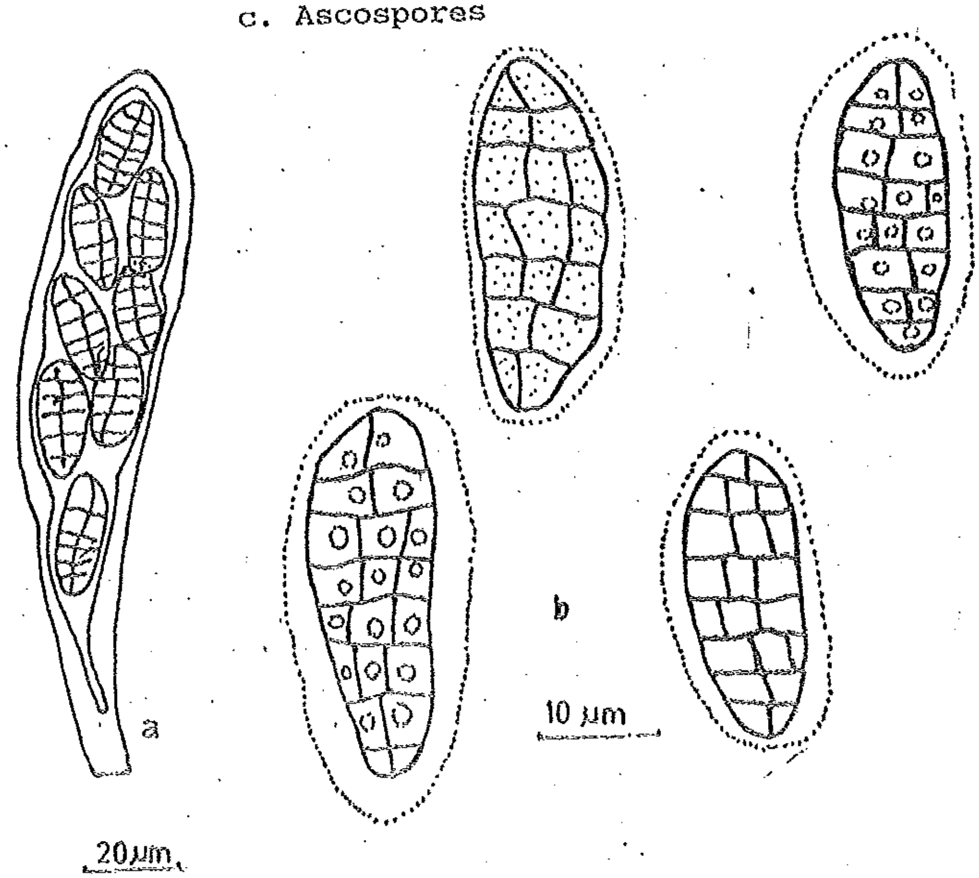


Fig-17. Pleospora sp.

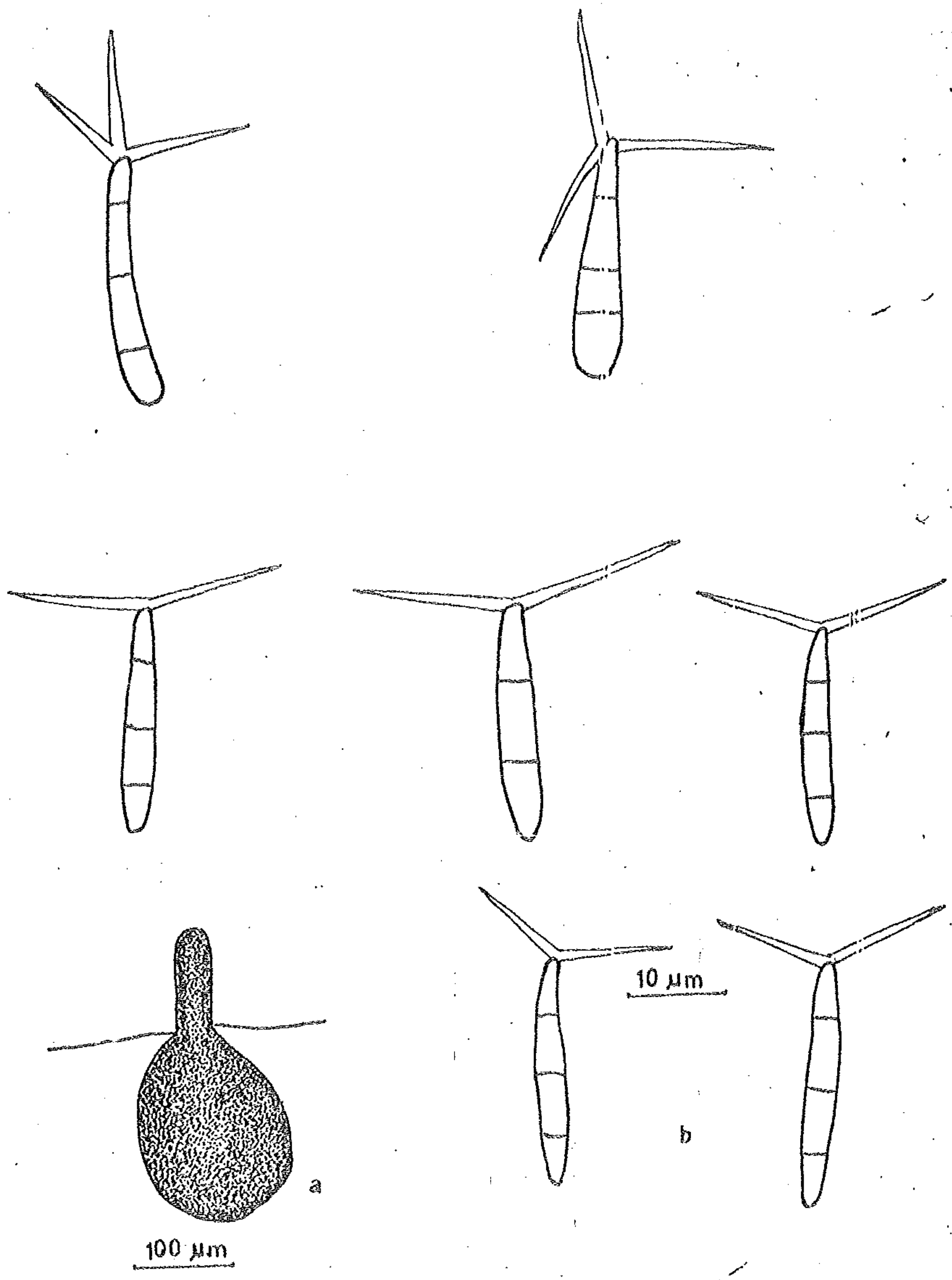


Fig-18. Torpedospora radiata
a. Ascocarp; b. Ascospores

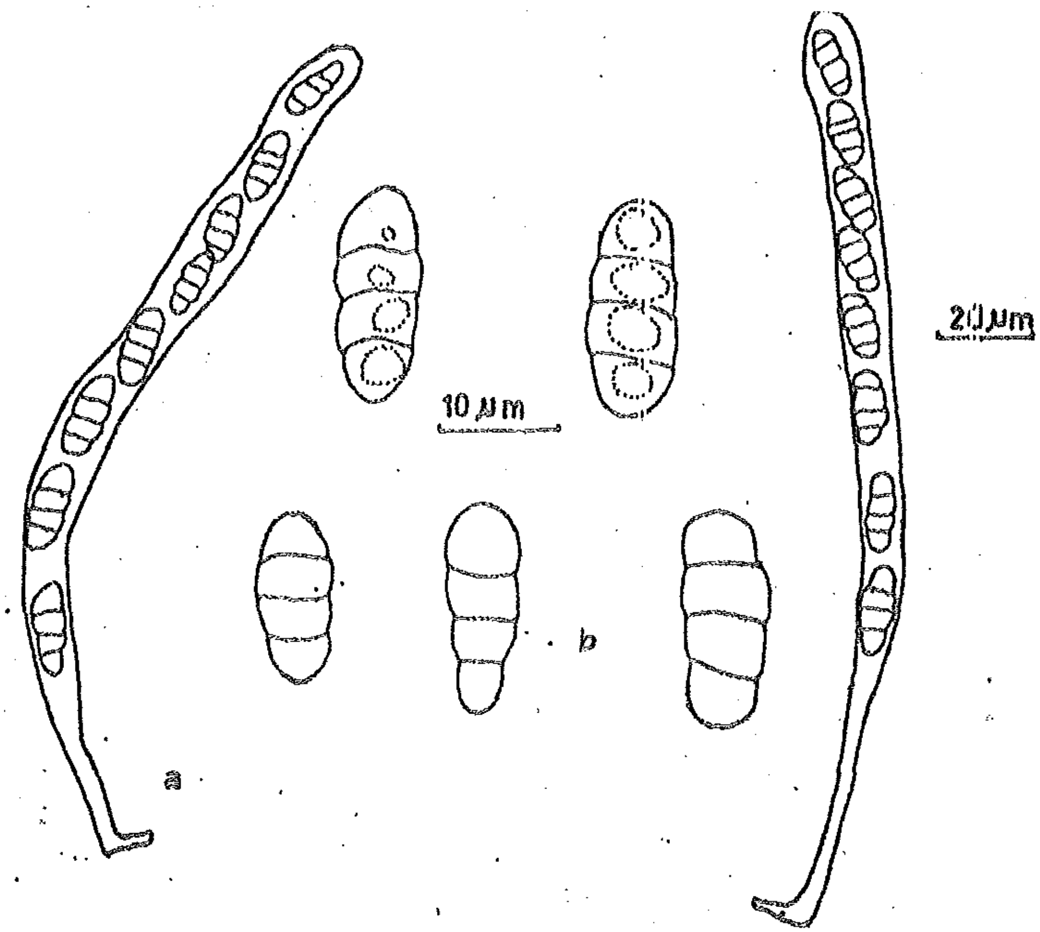


Fig-19. Unidentified unitunicate fungus
a. Ascus; b, Ascospores

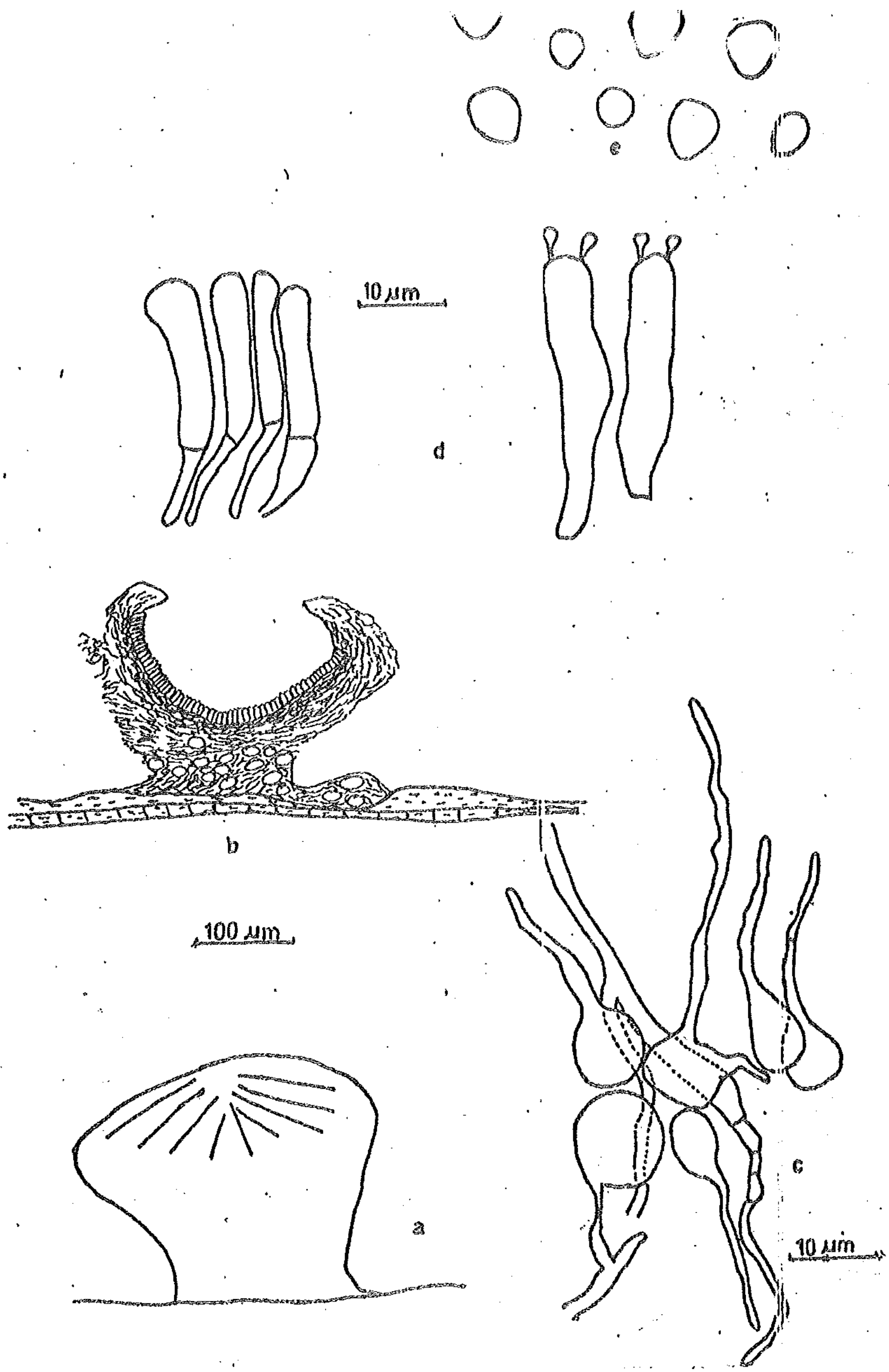


Fig-20. Halocyphina villosa

a. Basidiocarp; b. L.S. of a basidiocarp;

c. Refractive hairs of basidiocarp wall;

d. Basidia with sterigmata; e. Basidiospores

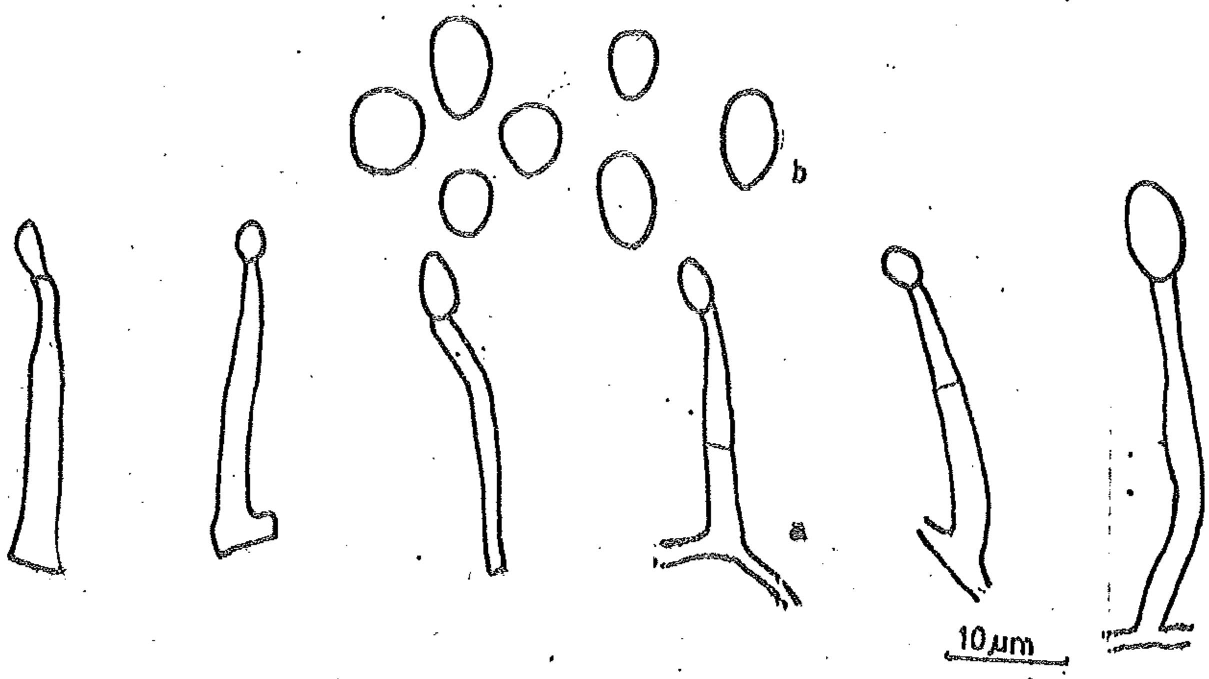
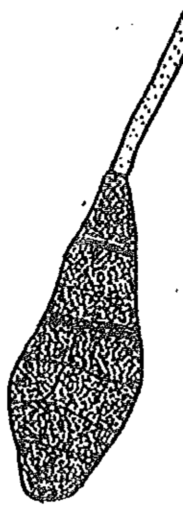


Fig-21. Acremonium sp.
a. Conidiogenous cells bearing conidia
b. Conidia



P

Fig-23. Asperc

a. As

d. Co

e. Co

Fig-33.

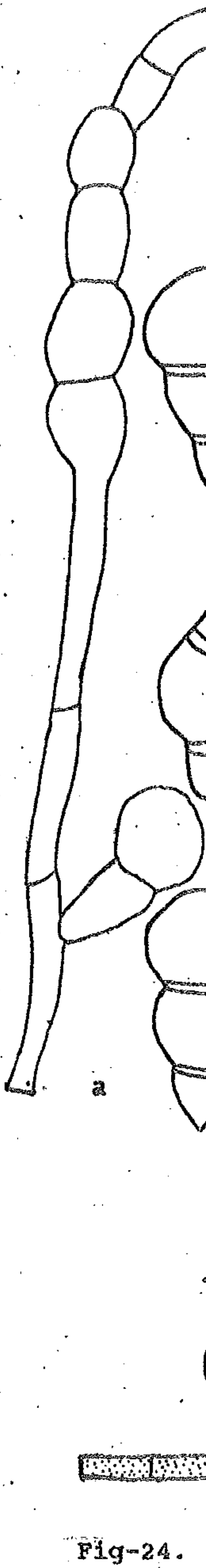
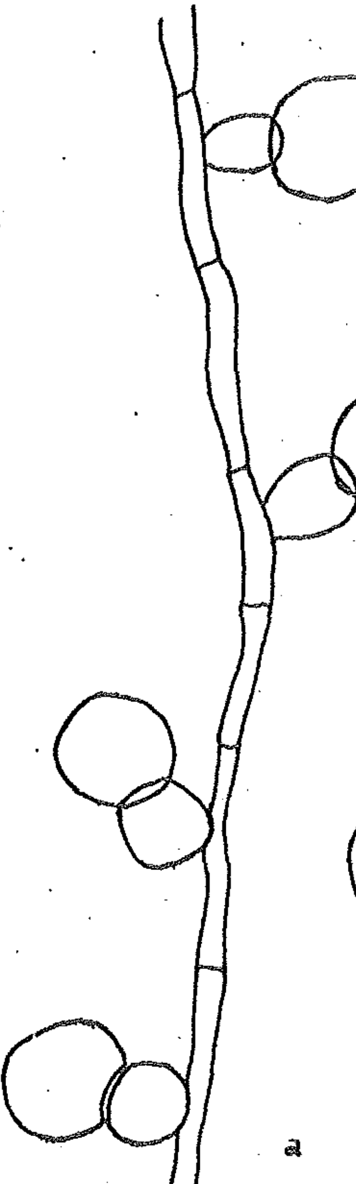


Fig-24.



a

Fig-26.

Fig-27.

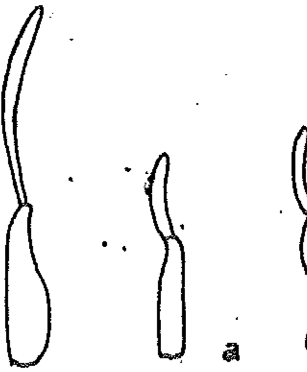


Fig-28. Ic
a.

Fig-29. H
a

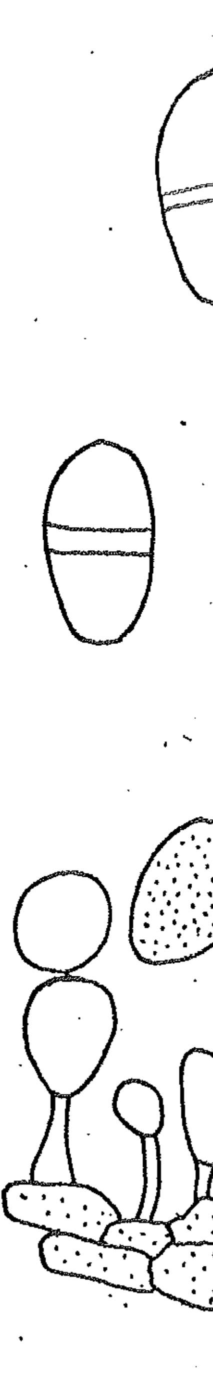
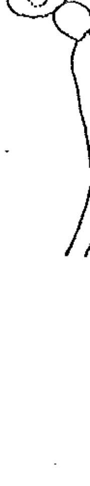


Fig-30. La
a
c

Fig-31



Fig

Fig-34. Pa

a.

b.

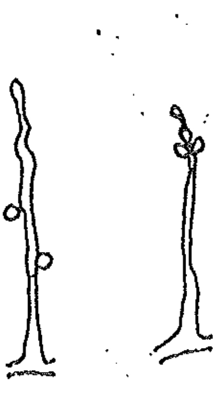
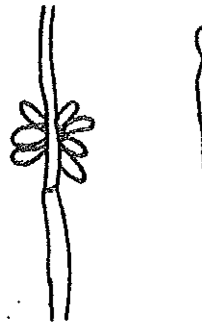


Fig-35.



.Fig-36.

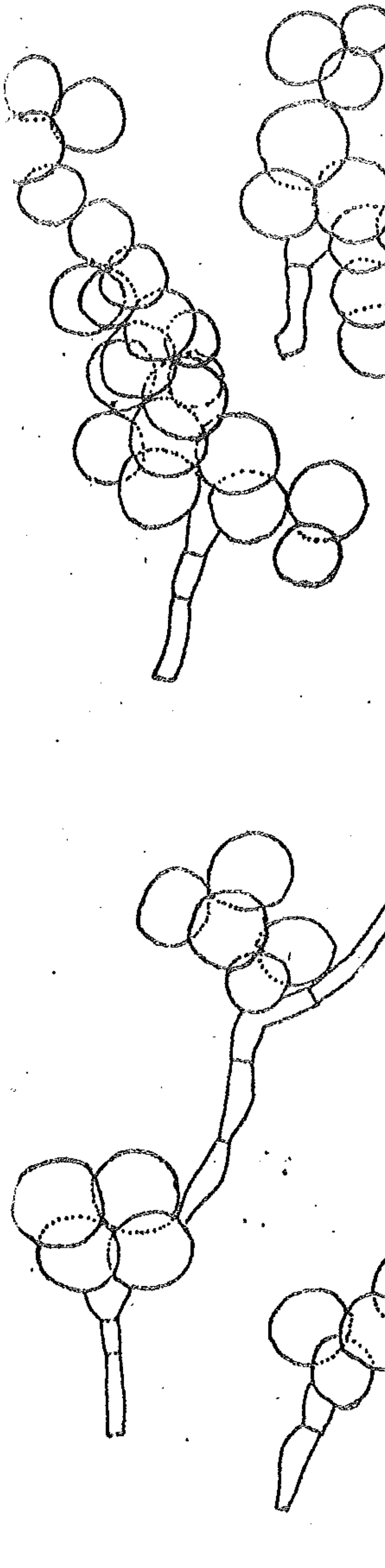


Fig-37.

Fig-

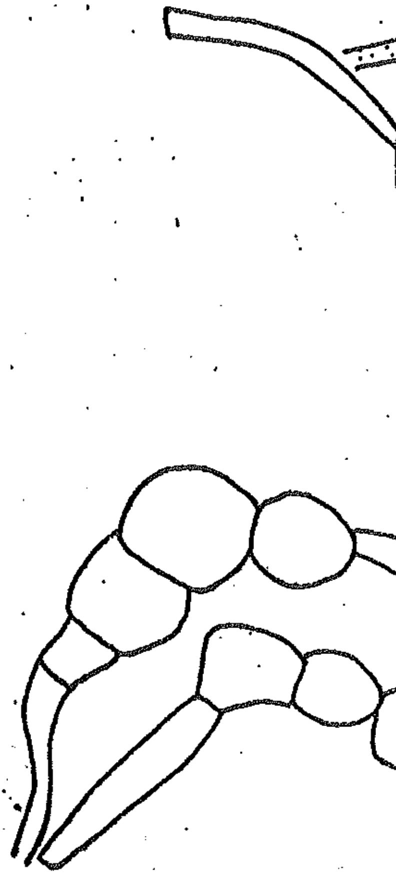


Fig-39

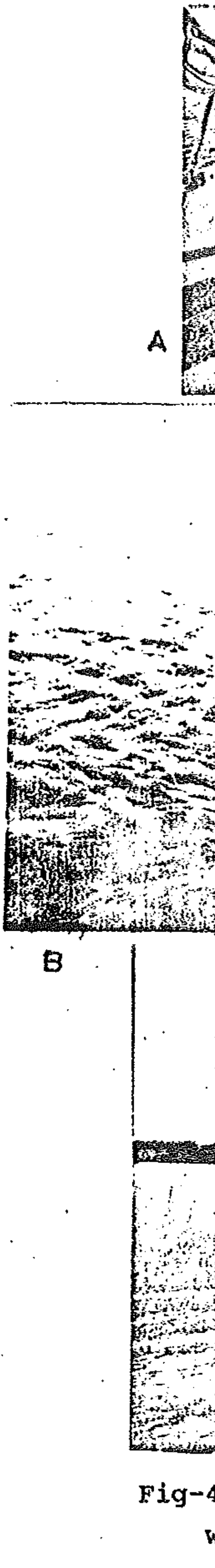


Fig-4

W

k

P

P

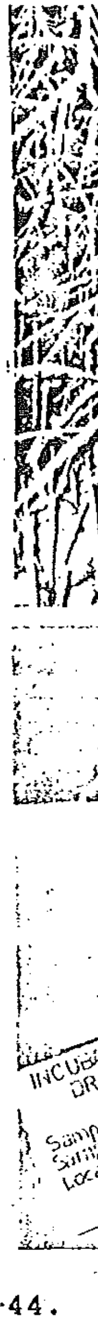


Fig-44.

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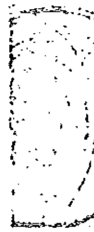

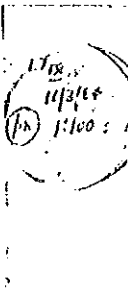

Fig-4

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Fig-46.


B
A
E

Fig-47. A-

C-

E-

A

B

Fig-48.

A

C