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THE AQUATIC PHYCOMYCETOUS FLORA OF
MARINE AND BRACKISH WATERS IN THE VICINITY OF
GLOUCESTER POINT, VIRGINIA

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THE AQUATIC PHYCOMYCETOUS FLORA OF MARINE AND BRACKISH WATERS

IN THE VICINITY OF GLOUCESTER POINT, VIRGINIA 1,2

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INTRODUCTION

As commonly recognized, there are four classes of true fungi (Eumycophyta), Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti. All are represented by species occurring in the marine environment. This investigation has been concerned entirely with representatives of the most primitive group, the Phycomycetes, from brackish and/or marine waters. The study was based on collections made during the months of June, July, and August, 1962.

The principal phycomycetous characteristics include a thallus which may be a single cell with or without an assimilative rhizoidal system, or which may be an extensive coenocytic mycelium; the formation of an indefinite number of spores in a sporangium; and sexual reproduction by conjugation, by various types of planogametic isogamy, or by aplanogametic oogamy. Some ten orders are recognized by Sparrow (1960) as belonging to the so-called "aquatic Phycomycetes." Of these, the Chytridiales, Hyphochytriales, Plasmodiophorales, Saprolegniales, Lagenaiales, and Peronosporales all contain marine species. In addition, species of the aplanetic terrestrial order, Mucorales, occur in marine muds (Johnson and Sparrow, 1961). These orders are distinguished one from the other by the number and nature of the zoospore flagella, the nature of the thallus, and the method of sporogenesi.

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2 Distribution of this report does not constitute publication. The information is subject to correction and/or revision.
MATERIALS AND METHODS

The techniques used during this study for the collection and isolation of marine phycomycetous representatives were essentially the same as those commonly used for collecting fresh-water species. Water samples, bottom sediments, beach sand, algal material, debris and plankton collections were returned to the laboratory immediately upon collection or stored under refrigeration until laboratory facilities were available. Many fungi were observed by the direct and immediate examination of algal, invertebrate, and plankton material. Some species were obtained by allowing algal mats and plankton samples to incubate in water for several days. The great majority of isolates were obtained by the "baiting" of gross cultures with bits of plant and animal substrate (e.g., cellophane, grass, pine pollen, snake skin, shrimp skin, hemp-seed) upon which various Phycomycetes subsequently developed. In numbers of fungi observed this technique proved to be very effective.

York River Collections.-- Collections were made once each month, June-August, at selected sites 10 miles apart from the mouth of the York River to a point 50 miles upstream. At each station plankton samples, water samples, bottom mud, and debris were collected. Plankton collections and plant and animal debris were held and examined directly over a period of several weeks. All other samples were baited and examined periodically as described above. The following sites are designated and salinity ranges recorded:

YR-0 Mouth of the York River; 20.08 °/oo
YR-1 10 miles upstream from mouth of York River; 13.59-16.74 °/oo
YR-2 20 miles upstream from mouth of York River; 8.30-12.77 °/oo
YR-3 30 miles upstream from mouth of York River; 0.07-3.18 °/oo
YR-4 40 miles upstream from mouth of York River; 0.065-0.100 °/oo
YR-5 50 miles upstream from mouth of York River; 0.005-0.037 °/oo

Sarah's Creek Collections.-- A series of water and bottom mud samples were collected in a manner similar to that described above. The following designations have been used and salinities recorded:

SC-1 Red Channel Buoy #2; 17.72 °/oo
SC-2 inside bar to Sarah's Creek; 17.36 °/oo
SC-3 second bar other side of yacht basin; 17.00 °/oo
SC-4 adjacent to Jordan's house; 16.80 °/oo
SC-5 off Midgett's pier; 16.60 °/oo
SC-6 Observer boat-landing; 16.13 °/oo
SC-7...
SC-8) end of Sarah's Creek; 13.69 °/oo
SC-9)
SC-10)
Miscellaneous York River Collections.-- A number of shoreline samples of water, bottom mud, beach sand and plant and animal debris were made from the York River and from brackish streams and tide-water swamps bordering the York. Salinities ranged from 8.50-16.75 °/oo. These collections are designated as follows:

CP-1 at bridge, tidewater stream, north of Yorktown
CP-2 at mouth, tidewater stream, north of Yorktown
CP-3 stream draining brackish pond, 1 mile north of Yorktown, Colonial Pkwy.
CP-4 York River, 1 mile north of Yorktown on Colonial Parkway
CP-6 Indian Field Creek, Colonial Parkway
CP-9 Fellman's Creek at Ringwood Plantation
CP-10 Cub Creek at Cheatham Annex
CP-11 Jones Mill Pond (fresh-water)

VFL-3 sand and water from small drainage stream
VFL-4 crossing beach north of VIMS laboratory
VFL-5

VFL-6
VFL-7 water samples with algal debris, VIMS beach
VFL-8

VFL-9-18 water and beach sand collected near York River bridge

VFL-20
VFL-21 bottom mud and water north of York River bridge
VFL-22

Deep water Collections.-- A series of bottom mud samples were collected from deep water (40-90 ft, in depth) from Chesapeake Bay about 10-15 miles south of Tangier Island. These samples are designated as CB1 - CB5.

Tangier Island Collections.-- A series of soil and water samples were collected from tidal marsh areas of Tangier Island. These collections are designated as T-1 through T-12.

Miscellaneous Collections from Drainage Streams.-- Collections were made from the mouth to the source of a small drainage stream originating in a brackish swamp and flowing approximately 50 yards across clean beach sand into the bay about 1/4 mile north of VIMS laboratory. These samples from mouth to source at 5 yd intervals are designated as ST #1 through ST #8.

Miscellaneous Samples.-- A number of collections of crab-eggs, oyster larvae, infected and dead fish, and similar materials were examined whenever the substrate became available. Such collections were identified and are so designated.
FUNGI COLLECTED

CHYTRIDIALES

Rhizophydiurn Schenk

This is the largest and most complex genus of the chytrids and one in which extensive morphological studies and cross-inoculation work will be necessary before the limits of species can be firmly established (Sparrow, 1960). Members of this genus occur as parasites and saprophytes on a wide variety of plant and animal substrata in both the fresh-water and marine environments. Johnson and Sparrow (1961) recognize four species of Rhizophydiurn from marine habitats. These include R. halophilum Uebelmesser on pine pollen bait from Europe and U.S.; R. cladorhizum Sparrow on Cladophora sp. from Japan; R. codicola Zeller on Codium mucronatum from the U.S.; and R. subglobosum Kobayasi and Ookubo on Bryopsis sp. and Cladophora sp. from Japan. In addition several "fresh-water" species of Rhizophydiurn have been reported from salt water, bottom sediments, marine muds, brackish water. These include: R. couchii Sparrow from Estonia (Aleem, 1952); R. carpophilum (Zopf) Fischer, R. spherotheca Zopf, R. subangulosum Rabenh., and R. sphaeroarpum (Zopf) Fischer from Europe (Harder and Uebelmesser, 1955); R. pollinis-pini (Braun) Zopf, R. gibbosum (Zopf) Fischer, R. ovatum Couch from Europe (Hohnk, 1956); R. patellarium Scholz from Europe (Scholz, 1958); R. utriculare Uebelmesser from Australia and the U.S. (Uebelmesser, 1956); and R. sciadiei (Zopf) Fischer from Europe (Sparrow, 1960).

Like most of the species belonging to the Chytridiales, species of Rhizophydiurn are minute and extremely difficult to identify. As a group the chytrids are morphologically a highly diverse taxon. In addition to being small and oftentimes found only in or on a highly specialized substratum and few in numbers of thalli, for positive identification the number and position of the zoospore flagella must be determined. Zoospore discharge, the extent of the rhizoidal system within the substrate, the development of the zoospore cyst, and the presence of the resting spore are oftentimes essential criteria for identification. The evanescent nature of the zoospores and sporangia, the inconspicuous or hidden endobiotic rhizoidal system, and the rarity of resting spores makes the positive recognition of a specific chytrid a difficult task.


This species is difficult to delimit. Studies of distribution and of host-substrate indicate a wide-spread and omnivorous species or that R. globosum represents a complex of several forms. The Virginia isolate differs from those previously described in the possession of a single apical papilla. In this respect and in habitat it resembles more closely R. couchii. Since resting spores were not observed further comparison was not attempted.


**Rhizophydium sp.** Observed rarely on pine pollen bait from a plankton sample York River (Station YR-4). This extremely large chytrid is unlike any species of Rhizophydium previously described in the formation of secondary zoosporangia by internal proliferation and may represent a new species. A brief description of the Virginia isolate follows: "Zoosporangia sessile, clavate to pyriform, up to 22.4 μ-wide and 78.5 μ in height, renewed by internal proliferation; rhizoidal system delicate, sparsely branched. Zoospores numerous, posteriorly unflagellate, spherical, colorless, with a single eccentric oil globule escaping singly through a wide apical pore. Resting spores not observed."

**Podochytrium** Pfitzer

Among the monocentric, eucarpic chytrids the genus may be recognized by the two-celled sporangium, with basal cell small and sterile. Members of the genus are parasites of fresh-water diatoms, capable of causing infections of epiphytotic proportions (Sparrow, 1951).

**Podochytrium sp.** Parasitic on *Coscinodiscus asteromphalus* and *C. concinnus* from plankton samples collected in the York River (Station YR-1).

This isolate of *Podochytrium* undoubtedly represents a new species. It differs from those fresh-water species previously described in zoosporangial characteristics, in host and habit, and in the formation of a resting spore. The following description applies to the Virginia chytrid: "Sporangia sessile, clavate to pyriform, smooth-walled, 18.0 - 22.4 μ-wide by 32.5 - 38.5 μ-high; basal cell sterile, 8 - 11.5 μ in height. Rhizoidal system very delicate, sparsely branched arising from tip of basal cell or from tip of short (?) penetration tube. Zoospore spherical, 3 - 3.5 μ in diameter, with a single, colorless globule, swarming within the sporangium and emerging singly through 1-3 apical or subapical pores. 5 - 5.5 μ in diameter, swimming directly away. Resting spores spherical, 11.5 - 15.0 μ in diameter, wall dark and thickly incrusted and surrounded by a darkly stained area, germinating by the formation of a sporangium."
Species of *Diplophlyctis* are primarily fresh-water inhabitants of moribund members of the Chlorophyceae. Isolates from plant material collected in waters of high salinity have not been described previously.


The Virginia isolates closely resemble those previously described from fresh-water habitats. Zoosporangiial and resting spore measurements, however, average somewhat smaller. The following description applies to these isolates: "Zoosporangia endobiotic, spherical, variable in size, 12.5 - 20.0 µ in diameter, wall thin and smooth, colorless, discharge tube single, apophysis spherical and 2-8 µ in diameter, rhizoids extensive and richly branched arising from two or three basal axes. Zoospores variable in number, spherical, 2-4 µ in diameter, with a single conspicuous and colorless eccentric globule, posteriorly uniflagellate, emerging in an amoeboid manner, singly, swimming rapidly away. Resting spores endobiotic, spherical, 15-22 µ in diameter, thick-walled and covered by minute spines, yellowish-brown in color, apophysate, rhizoids extensive and much branched, germination not observed." As first noted by Sparrow (1936), small empty zoosporangial-like thalli were sometimes observed in close proximity to mature resting spores. Rhizoidal anastomoses were not observed.

*Rhizophlyctis* A. Fischer

Among the monocentric chytrids with interbiotic eucarpic thalli and a well developed rhizoidal system are species of the genus *Rhizophlyctis* represented in the marine environment by a single member, *R. harderi* Uebelmesser. Eight fresh-water species are known from a variety of substrata (Sparrow, 1960). Among these *R. rosea* (de Bary and Woronin) A. Fischer has been reported from brackish water and bottom sediments (Höhnk, 1956).

*Rhizophlyctis hyalina* (Karling) Sparrow. Aquatic Phycomycetes, p. 445. 1960. Observed on cellophane bait from bottom mud collected in Chesapeake Bay (Station CB-3).

The following description applies to the Virginia isolate: "Sporangium smooth-walled, hyaline, spherical, averaging 44.8 µ in diameter, bearing one to several exit papillae. Rhizoids arising from several points on the sporangium main axes coarse, up to 10 µ in diameter, much branched, extensive, becoming delicate distally. Zoospores numerous, 3-4 µ in diameter, hyaline with a single large globule. Resting spores not observed."
Although the operculate polycentric genus Nowakowskiella has been reported from the marine environment (Harder and Uebelmesser, 1955), species representing its inoperculate counterpart have not been cited previously from waters of high salinity. Fresh-water species of Cladochytrium are primarily inhabitants of dead and decomposing plant tissue. Certain species are parasitic in fresh-water algae. Two species, C. tenue and C. crassum, were represented in the Virginia collections.

Cladochytrium tenue Nowakowski. Cohn, Beitr. Biol. Pflanzen, 2: 92, pl. 6, figs. 6-13. 1876. Isolated on cellophane bait and in decaying Elodea sp., water and bottom samples from York River (Stations YR-3, YR-4, YR-5); and from bottom samples, Sarah's Creek (Stations SC-8, SC-10).

C. tenue may be readily distinguished from other members of the genus by the presence of septate turbinate cells or septate swellings and the formation of smooth-walled sporangia. It differs from the closely related species, C. replicatum and C. tainanum, by the formation of small colorless zoospores (4-6 μ). These isolates differ only in minor details from those previously described.

Cladochytrium crassum Hillegas. Mycologia, 33: 618, figs. 1-40. 1941. Isolated on cellophane bait from water and bottom sediments, drainage stream from brackish swamp (Stations ST-3, ST-6, ST-8).

This species may be distinguished from other members of the genus by the formation of non-septate rhizoidal swellings and intercalary resting spores. In the Virginia isolates the resting spores exhibited a strong tendency toward a roughened and thickened outer wall. They differ from isolates of the closely related species C. hyalinum by the formation of small zoospores (4-6 μ) and a more coarse rhizoidal system.

SAPROLEGNIALES

Achlya C. G. Nees

This genus and related members of the Saprolegniaceae are commonly referred to as "water-molds." According to TeStrake (1959) these fungi do occur in low salinity brackish waters and exhibit a tolerance to high salinity environments under experimental conditions. Stoll (1936) reported Achlya polyandra Hildebrand and A. racemosa from brackish water (Germany). However, Johnson and Sparrow (1961) cite only the genus Leptolegния as having marine representatives.
Achlya racemosa Hildebrand. Jahrb. Wiss. Bot., 6: 249. 1867-1868. Isolated on hemp seed bait from water and bottom mud samples collected from Sarah's Creek (Stations SC-5 and SC-7). These isolates did not differ in any respect from those described previously from fresh-water habitats.

Achlya sp. #1. Three isolates of non-fruiting species of Achlya were obtained from wounded channel cat fish found during a "fish-kill" in the James River. The low frequency of occurrence indicates that this organism was not the causal agent of the fish-kill but was undoubtedly a secondary invader. The morphological features of these isolates are very similar to those of A. bisexualis. They probably represent a female strain of that species (see Scott and O'Bier, 1962).

Achlya sp. #2. Another and distinct non-fruiting isolate of Achlya was obtained on hemp seed bait from a water sample collected from a drainage stream, Gloucester Point (Station ST-3).

Aphanomyces de Bary

Stoll (1936) reported the occurrence of A. laevis de Bary from brackish water (Germany). Members of this genus are widely distributed in the fresh-water environment and are found on a great variety of substrata. Within the genus certain species exhibit a strong parasitic tendency (Scott, 1961).

Aphanomyces laevis de Bary. Jahrb. Wiss. Bot., 2: 179. 1860. Isolated on snake skin bait from a small stream draining a brackish pond, Gloucester Point (Stations ST-2, ST-3, ST-5, ST-6, ST-8); from Sarah's Creek (Station SC-10); on hemp-seed bait in water samples from York River (Stations YR-4, YR-5). This species was by far the most frequently encountered member of the Saprolegniaceae found during the present study. These isolates did not differ among themselves nor were they different in any respect from those previously described.

Aphanomyces sp. Non-fruiting isolates of Aphanomyces were obtained on snake skin bait from bottom mud, York River (Station YR-4), and on hemp-seed from water and bottom mud, Sarah's Creek (Station SC-6). The tendency of certain isolates of Aphanomyces to delay or to fail in the formation of sexual stages under cultural conditions is a well known phenomenon (Scott, 1961).
Leptolegnia de Bary

Two marine species of Leptolegnia are known: *L. baltica* Höhnk and Vallin in Eurytemora hirundoides from Europe and *L. marina* D. Atkins in Pinnotheres pism, Barnea candida, and Cardium echinatum from Great Britain. There is considerable doubt as to whether *L. marina* is correctly placed generically (Johnson and Sparrow, 1961). *Leptolegnia baltica* differs from the fresh-water species, *L. caudata*, also known to occur as a crustacean parasite, only in the possession of stouter hyphae. Comparative studies of both marine and fresh-water species of *Leptolegnia* need to be undertaken before the correct disposition and relationships of species is understood.

*Leptolegnia caudata* de Bary. Bot. Zeitung 46: 610. 1888. Isolated on snake skin bait from samples of water and bottom mud, Sarah's Creek (Station, SC-6).

This isolate does not differ greatly from the marine species, *L. baltica*, nor from those fresh-water isolates previously described (Coker and Matthews, 1937). A description of the Virginia isolate follows: "Hyphae delicate, sparingly branched, 10-15 μ in diameter. Gemmae absent. Zoosporangia filamentous, undifferentiated, up to 500 μ in length, not proliferating. Zoospores formed in a single row, rounded at first becoming elongate at emergence, swimming away immediately (as in *Saprolegnia*) upon discharge, encysting, cysts 10-12 μ in diameter. Oogonia borne on short lateral branches, 25-35 μ in diameter, smooth-walled. Oospore single, almost completely filling the oogonium, 20-30 μ in diameter. Antheridia present, diclinous or androgynous, one or two per oogonium."

Thraustochytrium Sparrow emend. Johnson

Members of this genus and the closely related genus, Japonochytrium are unique in the possession of a typically Chytridium-like thallus with a saprolegniaaceous type zoospore. Three species of Thraustochytrium are known and all are marine. These include *T. pachydermum* Scholz on pine pollen from saline soil (Europe and U.S.), *T. proliferum* Sparrow in marine algae and on agar from sea water (U.S.) and from sea water and brackish water sediments (Germany), and *T. globosum* Kobayasi and Ookuba on green algae from Japan (Johnson and Sparrow, 1961).

This species may be distinguished without difficulty from *T. pachydermun* by the thin-walled sporangium and by the behavior of the zoospores at the time of discharge; and from *T. proliferum* by the lack of internal proliferation and by zoospore behavior, the zoospores being flagellated and actively motile at the time of discharge. In the Virginia material approximately 60% of the living individuals of *Surirella splendida* were parasitized. Species of *Cyclotella*, *Chaetoceros*, *Nitzschia*, *Navicula*, *Coscinodiscus* and *Melosira* in the same collection were not infected. A description of the Virginia isolate follows: "Zoosporangia epibiotic, sessile, globose or ellipsoidal, usually conical at the base, smooth, hyaline, thin-walled, never proliferating; 5.0 µ to 17 µ in height, 5.0 µ to 12.5 µ in diameter; gregarious on the host cell. Rhizoidal system endobiotic, simple or sparingly branched. Zoospores 12-29 in number, laterally biflagellate, reniform; escaping at maturity by the bursting of the distal portion of the sporangial wall, swimming actively for a short period, later encysting; 3.0 µ - 4.0 µ x 2.5 µ. Resting spores not observed."

**PERONOSPORALES**

*Pythium* Pringsheim

Six species of *Pythium* from marine habitats are recognized by Johnson and Sparrow (1961). These include *P. salinum* Höhnk isolated from brackish water, tidal pool sediments and bottom muds from Germany; *P. marinum* Sparrow in *Ceramium rubrum* from Denmark; *P. maritimum* Höhnk in *Ceramium* sp. and from saline soils, Germany; *P. thalassium* D. Atkins in eggs of *Finnotheres pismum* and related crustaceans from Great Britain; *P. imperfectum* Höhnk from brackish water and tidal muds, Germany; and *P. aquatile* Höhnk from brackish water and tidal sediments, Germany. In addition, the following "fresh-water" species of *Pythium* have been observed from brackish and/or salt waters, from tidal muds or bottom sediments: *P. dissotocum* Dreschler, *P. monospermum* Pringsheim, *P. gracile* Schenk, *P. aflatile* Kanouse and Humphrey, *P. catenulatum* Matthews, *P. conidiosporum* Jokl, *P. diacarpum* Butler, *P. elongatum* Matthews, *P. inflatum* Matthews, *P. proliferum* de Bary, *P. pulchrum* Minden, and *P. rostratum* Butler, all reported by Höhnk (1939, 1953, 1956) or by Stoll (1936) from Germany.

Species of *Pythium* are among the most common of the filamentous phycomycetous fungi isolated from the marine environment. They can ordinarily be distinguished by their delicate hyphae and by the formation of an evanescent vesicle at the orifice of the sporangium within which zoospore cleavage takes place. However, zoospore formation in *Lagenidium callinectes* and *L. chthamalophilum* is very similar and, in these species at least, an extensive
mycelial development occurs. Thus it becomes extremely difficult to
distinguish certain species of *Pythium* (e.g., *P. thalassum*) from the myceloid
species of *Lagenidium* on the basis of vegetative characteristics alone.
Virginia isolates include the following:

pollen bait from water samples, York River (Stations YR-3 and YR-4); on
cellophane bait, bottom mud Chesapeake Bay (Station CB-1).

In the absence of sexual stages it is difficult to identify species of
*Pythium*. Any such isolate producing undifferentiated filamentous sporangia
is usually assigned to the taxon *P. afertile*. On this basis alone, however,
*P. afertile* might be any one of several species forming filamentous sporangia
and producing a sexual stage (e.g., *P. monospermum*, *P. marinum*,
*P. gracile*). The failure of an isolate of *Pythium* to form sex organs may be
due to one or more of several environmental factors, substratum or culture
medium, or the absence of a sex-promoting substance. Although the authors
of this binomial contend that *P. afertile* is a distinct species and subsequent
investigators have held to this procedure, the disadvantage of assigning to
asexual isolates a taxonomic binomial can readily be seen. Johnson and
Sparrow (1961) regard *P. afertile* as a fresh-water species occasionally
found in marine habitats. Hohnk (1953) described from tidal mud an imperfect
member of this genus, *P. imperfectum*, which closely resembles *P. afertile*
in many respects. The supposed development of both filamentous and lobulate
sporangia in that isolate must be critically evaluated before *P. imperfectum*
can be accepted as a valid species.

1859. Intramatrical within the moribund filaments of *Nitella* sp., York River
(Station YR-3).

*P. gracile* was originally described as a fresh-water parasite of
*Spirogyra* and *Cladophora*. It has since been reported from a variety of
fresh-water habitats and from sea water and bottom sediments (Hohnk, 1956).
This is the first report of *P. gracile* from brackish waters in the U.S. The
Virginia isolates differ from those previously described in the nature of the
oosporic wall, which is very thin. It differs from the marine species, *P. marinum*
Sparrow, only in the aplerotic nature of the oospore. The fungus is entirely
intramatrical; only the distal portion of the sporangial filaments projects
beyond the cell wall of the host.

*Pythium* sp. Isolated on cellophane bait, Sarah's Creek (Stations SC-7, SC-10)
and from a small drainage stream (Stations ST-3, ST-8).
These isolates were all imperfect species of Pythium possessing complex lobulate sporangia. Sexual stages have not been observed, although in all cases the fungi were maintained on cellophane in water culture for 8-10 weeks. There has been no binomial proposed to include lobulate forms of Pythium which fail to form sex organs, and there is no justification for such a proposal at this time. These isolates might well be asexual stages of *P. torulosum*, *P. inflatum* or any one of several well-defined lobulate species producing sexual stage. The Virginia isolates resemble closely the asexual Pythium described by Höhnk (1953) under the binomial, *P. imperfectum*, except for the complete absence of filamentous sporangia.


Except for the smaller oogonia (16.5 μ - 22.5 μ), this isolate does not differ significantly from the original description. It may well represent the sexual stage of those imperfect isolates described above as *Pythium sp.* and may possibly be the perfect stage of those isolates described by Höhnk as *P. imperfectum*. This species has not been found previously from the U.S.

LAGENIDIALES

Lagenidium Schenk

Members of this genus are commonly found as endobiotic parasites of fresh-water algae, primarily those of the Conjugatae. Species of Lagenidium are also known from mosquito larvae, copepods and other microscopic fresh-water organisms, ova of rotifers and from vascular plant tissue. Two marine species, *L. chthamalophilum* Johnson in the ova of *Chthamalus fragilis* and *Chelonibia patula* and *L. callinectes* in the ova of *Callinectes sapidus* and *Chelonibia patula*, are recognized by Johnson and Sparrow (1961). A third species, as yet undescribed, was observed in the marine alga *Gracilaria* by Johnson (1957). In addition certain "fresh-water" species have been reported as occurring in oceans and estuaries on a variety of substrata. These include *L. entophytum* in *Spirogyra* from brackish water (Aleem, 1952) and *L. pygmaeur* from brackish water and bottom sediments (Höhnk, 1956).


L. callinectes was isolated from approximately 40% of the egg-masses examined. The disease caused by this parasite was the subject of a comprehensive study by Rogers-Talbert (1948). The fungus is a peripheral parasite and does not penetrate deeply into the sponge. Eggs in all states of development are susceptible to infection. In water of high salinity (20-30°/oo) the fungus spreads rapidly over the surface of the egg mass and produces zoospores in great abundance. The following description applies to Virginia isolates collected in June-August, 1962: "Hyphae intra- and extramatrical, contorted and sparingly branched within the ova, extending extramatrically 600-750 μ in length; 14.9 μ - 19.5 μ in diameter. Sporangia filamentous, formed by the direct conversion of extramatrical hyphae, not proliferating. Zoospores laterally biflagellate, 7.5 μ - 12.5 μ, undergoing rapid amoeboid movement and changes in shape within an evanescent vesicle, 90.0 μ - 115.0 μ in diameter; reniform at maturity, swimming rapidly upon dissolution of vesicle, later encysting and germinating by the formation of a slender germ tube. Oogonia and antheridia not observed."

As mentioned previously, it is often times difficult to distinguish certain species of Pythium from the myceloid species of Lagenidium on the basis of asexual morphology alone. These isolates exhibit strong pythiaceous tendencies but are assigned to this species on the basis of the very large, primarily intramatrical hyphae; the non-proliferating, persistent sporangia; and the very large vesicle which is not completely filled by the undifferentiated protoplasmic contents.

DISCUSSION

According to all reports of those investigators who have dealt more extensively with fungi occurring in oceans and estuaries, it is impossible to define rigidly a "marine" or "estuarine" fungus. Although our knowledge of the morphology and occurrence of fungi from salt water habitats is considerable, little is known of the physiological mechanisms which permit their existence in waters of high salinity. Furthermore certain aquatic fungi apparently do not recognize salinity boundaries and are capable of growth and reproduction in both fresh- and salt-water habitats. Thus, the mere occurrence of a particular fungus from such a habitat does not necessarily indicate that it is a marine organism. Morphological modification for existence in salt water is not known among the fungi; nor is any specific nutrient requirement known that might be used to label a particular fungus "marine." Certain fungi do occur exclusively in the salt-water environment. These are usually regarded as marine organisms. Johnson and Sparrow (1961) arbitrarily define
a marine species as one "capable of developing to reproductive maturity
even though exposed at some point in their growth to salinities of 30°/oo or
more, either while continually submersed or intermittently inundated by
tidal waters." The great majority of species observed during this investi-
gation may be regarded a "brackish-water" species, defined by Höhnk (1956)
as those fungi which occur in waters at salinities of 0,11 - 28°/oo.

Most species of Phycomycetes are as yet known from too few localities
to enable the preparation of distribution patterns. Many species are known
only from the original description, others have been reported from two or
three widely separated sites, a few species have well established distribution
patterns. Our scanty knowledge of the occurrence and distribution of these
fungi is the result entirely of our limited search for them.

There are two divergent schools of thought regarding the precise role
of the saprophytic fungi in the marine and estuarine environments. As pro-
fessed by ZoBell (1946) the fungi are of strictly secondary importance to the
bacteria in the reduction and transformation of organic wastes. On the other
hand, many students of the marine fungi believe that the salt-water fungi are
as capable as their fresh-water counterparts in the decay and decomposition
of submerged organic debris. There is as yet little experimental evidence
to support the latter view. The importance of the parasitic fungi on diatoms
and other algae, and on marine invertebrates in the productivity of the oceans
is obvious.

There remains, then, much work to be done to increase our knowledge
of the kinds of fungi present in the salt-water environment, how the so-called
"fresh-water" species are able to adapt themselves to this environment, what
the fungi accomplish physiologically in this vastly complex environment, and
how the various species are distributed in this habitat.
BIBLIOGRAPHY


