THE FUNGI OF THE SALTON SEA, CALIFORNIA--THEIR TAXONOMY, BIOLOGY, AND RELATIONSHIPS

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THE FUNGI OF THE SALTON SEA, CALIFORNIA -- THEIR TAXONOMY, BIOLOGY, AND RELATIONSHIPS

By

Clifford John Anastasiou

A Thesis presented to the General Faculty of
The Claremont Graduate School in partial
fulfillment of the requirements for
the degree of Doctor of Philosophy

We certify that we have read this thesis and approve it as adequate in scope and quality for the degree of Doctor of Philosophy:

Ralph W Ames
Visiting Examiner

Lee W.
Member, Supervisory Committee

Peter H. Raven
Member, Supervisory Committee

Richard K. Benjamin
Chairman, Supervisory Committee

Date 13 July 1962

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ABSTRACT

This study is an investigation of the taxonomy, biology, and affinities of twenty species of lignicolous ascomycetes and imperfect fungi from the Salton Sea, California. Eight species of ascomycetes, all Pyrenomycetes, were studied, of which *Lulworthia medusa* (Ellis & Everhart) Cribb & Cribb, *L. opaca* (Linder) Cribb & Cribb, *Ceriosporopsis halima* Linder, *Halosphaeria mediosetigera* Cribb & Cribb, *Peritrichospora integra* Linder, and *Leptosphaeria orae-maris* Linder are common marine species, and *Pleospora herbarum* (Fries) Rabenhorst is a common terrestrial species. *Amphisphaeria verruculosa* is described as a new species.

The eleven species of imperfect fungi discussed include seven species of terrestrial fungi, *Botryotrichum piluliferum* Saccardo & Marchal emend. Downing, *Stachybotrys atra* Corda, *S. subsimplex* Cooke, *Fusarium solani* (Mart.) Appel & Wollenweber emend. Snyder & Hansen, *Alternaria tenuis* Nees emend. Neergaard, *A. radicina* Meier, Drechsler, & Eddy, and *Acrospeira levis* Wiltshire. *Memnoniella* Höhnel is placed in synonomy with *Stachybotrys* Corda. One species of imperfect fungus, *Clavariopsis bulbosa* Anastasiou, which was described from the Salton Sea, is reported from the Salt Lake, Oahu, Hawaii, and from marine and estuarine habitats. A new genus, *Contortospira*, based on *C. varia* sp. nov., and a new species, *Periconia prolifica*, are described. *Scopulariopsis* sp., growing on bark, could not be assigned to a known species.

A single species belonging to the Mycelia Sterilia is described, *Papulaspora halima* sp. nov.

The aquatic adaptations among Salton Sea fungi and marine fungi in general are usually expressed in spore form and appendages. Vermiform, appendaged, sheathed, tetraradiate, and helicoid spores are aquatic spore forms produced by salt water fungi. The production of spores embedded in wood and released when the surface fibers are washed away, is reported for Acrospeira levis and Contortospira varia.

The affinities of the ascomycetes from the Salton Sea, as a group, appear to be with marine ascomycetes of temperate waters; those of the imperfect fungi, on the other hand, appear to be with marine species of the tropics.

INTRODUCTION

Study of fungi from salt water habitats is a relatively well-established branch of mycology. The recent reviews of Johnson & Sparrow (1961) and Wilson (1960) deal with fungi from marine and estuarine habitats. The present study, on the other hand, is a contribution to the knowledge of the fungi of salt lakes, and there seems to be only one previous paper (Anastasiou, 1961) concerning them. The single species described by Anastasiou, *Clavariopsis bulbosa*, is a relatively common lignicolous fungus in the Salton Sea.

This study is restricted to the Ascomycetes and Fungi Imperfecti, living on wood submerged in the Salton Sea, a salt lake comparable in physical characteristics to the Caspian Sea and well suited for the study of lignicolous fungi. Across the southern end of the lake, thousands of trees and shrubs, killed by flooding, are presently standing in up to fifteen feet of water. This material provides ample substrata for the growth of fungi capable of withstanding the physical conditions of this aquatic environment. I have attempted to collect and study these fungi both on the original substrate and in pure culture.

MATERIALS AND METHODS

In order to study the fungi, small pieces of wood were cut from trees or shrubs submerged in the lake, placed in plastic bags, and taken to the laboratory in an ice chest. Because of the extremely dry heat of the summer months, the latter precaution was necessary to help maintain viability of the fungi during transport to the laboratory. Specimens were transferred to sterile chambers consisting of petri dishes containing 4-5 sheets of filter paper moistened with Salton Sea water. These were examined as soon as possible (within 24 hours) after transfer and then allowed to incubate at room temperature for a period of from four days to a month.

Sandwich panels constructed of various hardwoods also were used in the investigation. The panels were 2 in. x 2 in. x 1/4 in. in size. Each was drilled in the center and seven or eight of them were placed on a galvanized bolt with adjacent panels separated from each other by 1/8 in. wooden spacers. The panels were submerged in the Salton Sea and left for a period of three months. These were then treated as described above.

Cultures normally were maintained on Salton Sea water agar (SSwa) (Anastasiou, 1961) at room temperature. Pure cultures were obtained by picking single spores or small groups of spores from the surface of the substratum or from fruiting structures by means of extremely fine needles mounted in wooden match-sticks. The needle is flamed briefly and cooled in agar immediately before use. Using this technique, I succeeded in isolating and culturing several organisms which previously had resisted culture because of difficulty with bacterial contamination.

To test their ability to grow on fresh water media, organisms were transferred to YpSs, MeYe, PDA (Benjamin, 1959), and agar made by substituting distilled water for Salton Sea water in SSwa (this will be referred to as Fwa). Most organisms also were transferred to sea water agar (Meyers, 1957) to determine their ability to grow in the presence of sea water.

Unless otherwise specified, all collection numbers cited are those of the author.

THE SALTON SEA

History and Characteristics

The Salton Sea is a lake, lacking outlets, located in southern Riverside and northern Imperial counties, California. It comprises about 340 square miles and covers the floor of the Salton Basin which is 273 feet below sea level at its lowest point (Carpelan, 1958). All of my collections are from the southern end of the lake in Imperial County.

The Salton Sea occurs in the bed of an ancient lake, Lake Cahuilla, which occupied over 2,000 square miles and had its upper level 31 feet above sea level (Carpelan, 1961a). Lake Cahuilla was a fresh water lake which received the entire flow of the Colorado River and emptied into the Gulf of California. When the bed of the Colorado River shifted, so that it emptied directly into the Gulf of California, the lake gradually evaporated. During the millions of years since the original lake disappeared, it has been reformed many times when the bed of the Colorado River has shifted. The Salton Sea -- a result of the most recent flooding -- was formed between 1904 and 1907 following the accidental diversion of the Colorado River into irrigation canals built to provide water for the agricultural lands of the Imperial Valley. With the final rediversion of the river into its original bed, the level of the Salton Sea dropped from -195 feet in 1907 to the -250 foot level in 1925 because evaporation exceeded inflow. As more water was brought into the Imperial Valley after 1925, the level began to rise slowly until the present level of -234 feet was reached (Carpelan, 1961a). It has been estimated that the lake will continue to rise to the -220 foot level where stabilization will be reached (Carpelan, 1961a).

Chemical Composition

The chemical composition of the Salton Sea approximates that of normal sea water; it has a lower concentration of Mg^{+}, K^{+}, and Cl^{-}, a higher concentration of $SO_4^{=}$, Ca^{++}, HCO_3^{-}, and $CO_3^{=}$, and approximately the same concentration of sodium ion (see Table I).

Salinity

Salt concentration of the Salton Sea displays an annual cycle. The highest concentration, in the summer, corresponds to the lowest surface elevation -- due to evaporation exceeding inflow -- and the lowest concentration, in the winter, corresponds to the highest surface level -- due to inflow exceeding evaporation (Carpelan, 1961b). The salinity range, as reported by Carpelan (1961b), is from 31.4 to 33 °/oo.[1] Salinity of the Salton Sea is slightly below the salinity of normal sea water, which is 35 °/oo.

Temperature

Temperature is one of the most critical factors in the Salton Sea. As shown in fig. 1, the water temperature range of the Salton Sea exceeds that of the combined variation of marine locations in California and Hawaii. Unlike the oceans, the water temperature of the Salton Sea

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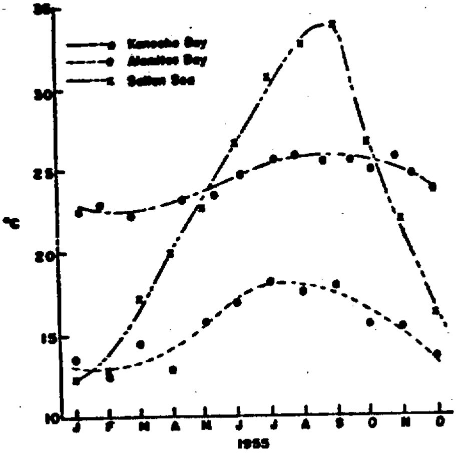
[1] o/oo = parts per thousand.

TABLE I

A Comparison of the Ionic Concentration of Salton Sea Water with that of Normal Sea Water (adapted from Carpelan, 1961b)

	Salton Sea Water o/oo	Salton Sea Water % of total ions	Normal Sea Water o/oo	Normal Sea Water % of total ions
Ca^{++}	0.764	2.27	0.413	1.20
Mg^{++}	0.951	2.82	1.27	3.68
Na^{+}	9.938	29.51	10.55	30.60
K^{+}	0.224	0.67	0.38	1.02
$CO_3^{=}$	0.021	0.06	----	----
HCO_3^{-}	0.159	0.47	0.014	0.04
$SO_4^{=}$	6.806	20.21	2.649	7.68
Cl^{-}	14.422	42.82	19.15	55.53
Analysed	33.290	98.83	34.22	99.75
Total	33.68	100.00	34.48	100.00

Fig. 1. Water temperature variation in the Salton Sea compared with Kaneohe Bay, Oahu, Hawaii, and Alamitos Bay, California, during 1955. (Data from the Salton Sea adapted from Carpelan (1961b); data from Kaneohe Bay adapted from M. Oguri (Pers. Comm.); data from Alamitos Bay adapted from records of State of California, Dept. of Fish and Game (Pers. Comm.).


Kaneohe Bay
Alamitos Bay
Salton Sea
35
30
25
20
15
10
°C
J
F
M
A
M
J
J
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1955

corresponds closely to that of the air above it. Air temperatures are slightly higher than water temperatures in the spring and summer. In the fall and winter, the water temperatures remain slightly higher than the air temperature (Carpelan, 1961b). The effect of water temperature on the distribution of salt water fungi is discussed in the final section of this paper

Future of the Salton Sea

If the Salton Sea is stabilized at -220 feet, the salinity on stabilization in 1970 to 1980 will be approximately 25 °/oo. It would take about twenty years beyond the time of stabilization to reach 40 °/oo, the probable limit of salinity tolerance for marine organisms (Carpelan, 1961b). It appears then, that the Salton Sea will remain within the range of tolerance of marine organisms for at least the next thirty years.

TAXONOMY AND DISTRIBUTION

The Ascomycetes and Fungi Imperfecti found in the Salton Sea represent very diverse groups. In the following treatment, they are arranged alphabetically within the classical spore groupings outlined in Saccardo's *Sylloge Fungorum*.

Ascomycetes

LULWORTHIA Sutherland

Trans. Brit. Mycol. Soc. 5: 259. 1916.

Nonstromatic; perithecia innate, erumpent, or superficial, usually black, gregarious, membranous to carbonaceous; paraphyses absent; asci fusiform, cylindrical or clavate, deliquescent, 4-8-spored, coiled in the venter of the perithecium; ascospores hyaline filiform, functionally one-celled, bearing a hyaline, short, conical, apiculate or rounded appendage-like cell at each end.

The genus *Lulworthia* was proposed by Sutherland (1916) on the basis of *L. fucicola* Sutherland (1916), a species found parasitizing *Fucus vesiculosus*. In 1944, Linder (1944) established the genus *Halophiobolus*, apparently not aware of the existence of *Lulworthia*. Cribb and Cribb (1955) transferred Linder's seven species to *Lulworthia* and described an additional one. Petrak (1952) transferred three species of *Halophiobolus* to *Linocarpon*, but, as is pointed out by Johnson & Sparrow (1961), the transfer is not warranted since *Linocarpon* is comprised of fungi in which the ascocarp has a pseudoclypeus, a structure not found in Lulworthia.

There are three theories concerning the nature of the terminal hyaline structure on Lulworthia spores. Generally, it is regarded as a gelatinous appendage. As evidence for this idea, when the asci of L. opaca break down, the spores often stick together where their appendages touch. Kohlmeyer (1960) considers them to be cell-like end-chambers filled with a cytoplasm-like fluid. Under some conditions the appendages of L. floridana collected in Alamitos Bay, California, will exude a fluid from what is apparently a pore at the apex. Meyers (1957) illustrated a similar phenomenon in this species. A collection of L. medusa from Hawaii included spores which had germinated through the end-cells. The walls of the end-cells were broken at the apices and could be seen to be extensions of the walls of the central cells. Under any circumstance, it appears that Petrak's suggestion (1952) that the appendage is simply a thickening of the epispore wall is not tenable. It is my opinion, that the structure is a cell at the end of the spore which encloses a viscous fluid and gelatinization of the epispore wall of the end cell accounts for its adhesive qualities. This interpretation means, as Johnson & Sparrow (1961) pointed out, that the ascospores of Lulworthia are three-celled with a single elongate cell functioning as the spore proper, and two dead end cells which apparently function in the adhesion of the spores to the substratum and possibly also in flotation.

Key to the species treated.

A. Ascospores mostly longer than 300 µ...L. medusa

AA. Ascospores mostly shorter than 300 µ..L. opaca

LULWORTHIA MEDUSA (Ellis & Everhart) Cribb & Cribb

Papers Univ. Queensland Dept. Botany 3: 80. 1955.

Perithecia embedded, erumpent or superficial; perithecia globose to pyriform or elipsoid, dark brown to black, sometimes with a hyaline base, 157-500 x 275-670 µ innate perithecia often with long necks; superficial perithecia with necks short or absent; asci cylindrical, up to 550 x 12-40 µ; ascospores 320-510 x 1.7-4.0 µ, the appendage-like end-cells, conical, occasionally slightly swollen, 4-9 µ long.

Specimens examined: CALIFORNIA: on wood of *Tamarix aphylla* submerged in the Salton Sea, March 12, 1961, *S27*; June 24, 1961, *S63*; December 20, 1961, *S105*, *S106*.

Lulworthia medusa has been collected on wood from marine stations in Hawaii (on submerged mangrove twigs at Kaaawa, Oahu, August 26, 1961, *H14*) and North Carolina (Gold, 1959). It occurs on the culms of various marine and brackish water angiosperms such as *Spartina cynosuroides* (L.) Roth. (Ellis and Everhart, 1885), *Zostera marina* L. (Mounce and Diehl, 1934), *Andropogon muricatis* Retz (Ellis and Everhart, 1892), *Spartina townsendii* J. & C. Groves (Lloyd, 1958), *Spartina alterniflora* Loisel (Johnson, 1956b), and *Avicennia marina* var. *resinifera* (Forst.) Bakh. (Cribb & Cribb, 1955).

In the Salton Sea the perithecia of *L. medusa* occurred superficially or embedded in the wood of *Tamarix aphylla* and were typically black, occasionally with a hyaline base, and with or without long necks. The necks, when present, ranged from 126-314 x 15.7-31.4 µ ($\bar{x}$ = 205 x 21.6 µ). The perithecia ranged from 157-283 x 275-448 µ. Superficial perithecia developed abundantly on wood incubated at room temperature for a period of 3-5 weeks. Depending on the specimen, superficial perithecia bore elongate necks or short, more or less papillate ostioles.

The asci, bearing a bundle of eight filiform ascospores, are coiled in the perithecium venter prior to deliquescence. After deliquescence the ascospores are released one at a time through the ostiole. Asci are long cylindrical and range from 400 to 550 µ long. Immature ascospores bear numerous vacuoles which disappear with maturation. The conical, hyaline end-cells range from 4.4-7.8 µ long ($\bar{x}$ = 5.7 µ). The spores, inclusive of the end cells, range from 350-510 µ long ($\bar{x}$ = 447 µ).

LULWORTHIA OPACA (Linder) Cribb & Cribb

Papers Univ. Queensland Dept. Botany 3(10): 79. 1955.

Perithecia embedded or superficial, globose to elipsoidal or occasionally elongate; fuscous to black; 180-200 µ diam.; position and length of neck variable; asci clavate to cylindrical, 149-185 x 10.4-16.5 µ; ascospores 141-204 x 1.5-4.8 µ, the appendage-like end-cells, 7-13 µ long.

Specimens examined: CALIFORNIA: on wood of _Tamarix aphylla_ submerged in the Salton Sea, March 12, 1961, _S12_, _S16_, _S23_; July 20, 1961, _S98_.

Lulworthia opaca is a common marine fungus with a world wide distribution and has been reported on wood from Washington (Kohlmeyer, 1960), California (Kohlmeyer, 1960; on oak panel submerged 10 weeks in Alamitos Bay, June 4, 1961, _C78_), the Atlantic coast (Linder, 1944; Johnson, 1956b, 1958a; Gold, 1959), Great Britain (Wilson 1951, 1954, 1956), Germany (Höhnk, 1955, 1956), Sweden (Gustafsson and Fries, 1956).

This species generally occurs on fine twigs of small shrubs submerged in the shallows of the Salton Sea. The perithecia are embedded if developed before removal from the water, and usually superficial if developed in the moist chambers. Perithecia are generally 180-200 µ in diameter, dark brown or black, and embedded with a long neck protruding through the slime layer covering the wood.

The asci, observed in S98, were cylindrical rather than clavate as reported by Johnson & Sparrow (1961), and ranged from 149-185 x 10.4-16.5 µ ($\bar{x}$ 177 x 13.2 µ). Prior to deliquescence of the asci the spores are vacuolate. The end cells are usually not differentiated into hyaline caps until shortly before ascus deliquescence. The spores in S98 ranged from 141-204[1] x 2.2-4.8 µ ($\bar{x}$ = 176 x 3.5 µ) and in S23 they ranged from 149-188 x 1.7-3.4 µ ($\bar{x}$ = 171 x 2.7 µ). The end cells were hyaline, conical, exceedingly adhesive and in S98 ranged from 7-13.1 µ ($\bar{x}$ = 9.0 µ) in length.

CERIOSPOROPSIS Linder

Farlowia 1: 408. 1944.

Stromatic(?); perithecia innate or superficial, light brown or reddish brown to black, usually gregarious, collapsing on drying; paraphyses absent; asci clavate, 8-spored, multiseriate deliquescent; ascospores hyaline, 2-celled, with deliquescent, terminal gelatinous appendages.

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[1] Some of the ascospores were longer than the longest ascus measured. In this case it is probably due to the small sample of asci measured but it may also be due to elongation of the ascospores after deliquescence of the asci.

CERIOSPOROPSIS HALIMA Linder

Farlowia 1: 409. 1944.

Perithecia usually innate, occasionally superficial, reddish brown to black, globose to subglobose or occasionally elongate, membranous, 160-500 µ diam.; neck long, sometimes branched; asci clavate to elipsoidal, bitunicate, 56-90 x 14-26 µ; ascospores 14.5-40.0 x 6.8-14.0 µ; constricted at the median septum, elipsoidal to oval, at least one large guttule in each cell; hyaline appendages of variable length and diameter.

Specimens examined: CALIFORNIA: on Tamarix aphylla wood submerged in the Salton Sea, March 12, 1961, S14, S19, S31, S37.

Ceriosporopsis halima is one of the most common fungi found in marine habitats, and it has been collected in waters of the United States, Canada, Australia, Denmark, Germany, Great Britain, Italy, and Sicily (Johnson & Sparrow 1961). In the Salton Sea, C. halima was collected only during March. Though many wood samples were collected during summer and winter, this organism did not appear. It is possible that high summer temperatures of the Salton Sea have an adverse effect on this organism.

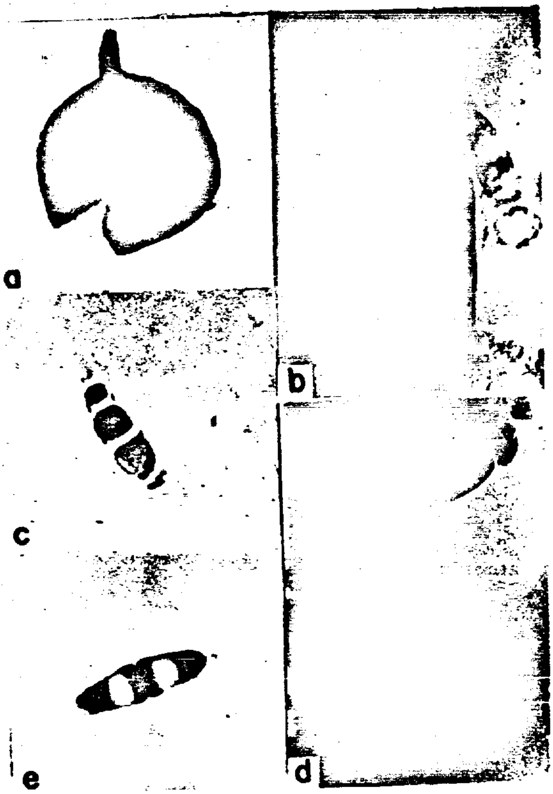
The perithecia (fig. 2a) of the Salton Sea material were reddish brown, gregarious, and in most cases partially innate. They were, without exception, globose, ranging from 172 to 259 µ in diameter. The perithecia were easily recognized under the dissecting microscope because of their color and thin membranous wall. Asci (fig. 2b) were eliptical, clavate or occasionally subcylindrical, 56-89 x 14-22 µ. The ectoascus appeared to have broken down irregularly in several cases, and the spores were contained in the endoascus. After deliquescence of the asci, the spores may be observed passing rapidly out of the ostiole into the surrounding salt water. The spores appear to pass through the ostiole one at a time and tend to move to the surface of the water and float, unless caught by currents.

As reported by Johnson (1958b), ascospores of *C. halima* are surrounded by a sheath of protoplasm (fig. 2c) from the ascus immediately after release from the ascus. This sheath appears to dissolve after a time and is not present in spores found about an older perithecium (fig. 2d,e). In the Salton Sea material, the sheath covers not only the spore but includes about half of the appendage so that the wall of the spore appears to continue beyond the spore and include the appendage.

Two distinct sizes of spores were found in the Salton Sea, small spores (*S14*, *S37*) which measured 14.5-23.5 x 5.2-8.3 µ ($\bar{x}$ = 20.3 x 6.8 µ), and normal-sized spores (*S19*, *S31*), measuring 16.9-33.8 x 7.1-10.7 µ ($\bar{x}$ = 25.8 x 8.7 µ). The smaller spores are considerably smaller than those reported for *C. halima* from marine habitats. The appendages of the small spores are 4.4-14.8 x 1.7-3.5 µ (fig. 2d), those of the larger spores are less distinct but shorter and broader, 4.0-10.4 x 3.5-5.1 µ and taper slightly. All spores bear a distinct oil droplet in each cell.

Linder (1944) reported *Helicoma salinum* Linder as the imperfect stage of *C. halima*. In numerous attempts to obtain the perfect stage from the imperfect stage, or to obtain the imperfect stage from the perfect stage, I, like other investigators (Meyers 1957, Kohlmeyer, 1960), have been unsuccessful. Johnson & Sparrow (1961), who accept the relationship, base their opinion on cultural characteristics other than spore production. Although *C. halima* is fairly common in the Salton Sea during the spring, *H. salinum* has not been collected there, as would have been expected if it were in fact the imperfect stage of *C. halima*.

Fig. 2. Ceriosporopsis halima Linder. a. Mature ruptured perithecium. X 145. b. Ascus just prior to deliquescence. X 1000. c. Appendaged spore ensheathed in slime. X 1000. d. Appendaged ascospores (short-spored form). X 1000. e. Ascospore of long-spored form. X 1000.


a
b
c
d
e

PERITRICHOSPORA Linder

Farlowia 1: 414. 1944.

Nonstromatic; perithecia innate to superficial, shiny black, solitary or, more usually, gregarious, globose, carbonaceous to subcarbonaceous; paraphyses absent; asci broadly fusiform, occasionally fusiform or clavate, 8-spored, deliquescent; ascospores hyaline, 1-5-septate, fusoid-elipsoidal; terminal appendages hyaline, rigid or rarely flexuous, single or in tufts; lateral appendages bristle-like, numerous, attached at or near the median septum.

PERITRICHOSPORA INTEGRA Linder

Farlowia 1:414. 1944.

Perithecia usually superficial or partially innate, black, carbonaceous, rarely sub-carbonaceous, 200-400 µ diam., base flat and flared; neck papilliform, rarely long cylindrical, centric; paraphyses absent; asci broadly fusoid, usually apiculate, deliquescent; ascospores fusoid to elipsoidal, 1-septate, constricted at the septum, 1-several guttules per cell, 21-53 x 6-12 µ (excluding appendages), terminal appendages single, rigid or rarely flexuous, 10-14 x 1-1.5 µ; lateral appendages attached on either side of the median septum.

Specimens examined: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, March 12, 1961, S26, S29.

Peritrichospora integra is one of the most common and widespread of all fungi in the oceans. It is found in both tropical and northern waters. Records include Hawaii (on driftwood inside the reef at Kaaawa, Oahu, August 26, 1961, H26, on driftwood in surf at Moloaa, Kauai, September 1, 1961, H34.), the west coast of the United States (Kohlmeyer, 1960, also on Pseudotsuga menziezii panel submerged in Alamitos Bay, California, February 26, 1961, C57), the Atlantic coast of the United States (Johnson, 1956b), Germany (Höhnk, 1954a,b), Great Britain (Wilson, 1951, 1956; Jones, 1962) and Sicily (Kohlmeyer, 1958a,b).

In the Salton Sea material, perithecia of P. integra develop on Tamarix wood after incubation for a period of two to three weeks. The perithecia develop superficially on shells of barnacles and in the laboratory on walls of the glass moist chambers. Additional fruiting bodies develop on the wood and project through the surface slime. Other investigators have reported it fruiting on various calcareous materials such as teredo burrow linings and Bryozoan exoskeletons as well as sand grains (Höhnk, 1954a; Meyers, 1957; Kohlmeyer, 1960).

Mature perithecia have not been produced in test-tube culture in those isolates I have studied, but when they are transferred to petri dishes prolific fruiting occurs on the glass walls and on the surface of the medium after three to five weeks of incubation.

The perithecia (fig. 3a-b) of the Salton Sea material are globose and carbonaceous, have papilliform necks, and are 157-362 x 141-291 µ (average 277 x 242 µ). The elongate or branched necks reported by Meyers (1957) were not observed. Membranous walls of perithecia also reported by Meyers did not occur in mature fructifications.

Peritrichospora integra tends to fruit on wood in association with other fungi. In collections from California and British Columbia marine stations the perithecia often have been encountered developing among those of Lulworthia floridana or L. opaca. In the Salton Sea the perithecia often develop among the pseudothecia of Leptosphaeria orae-maris Linder. Within the scope of my observations, it is unusual for the perithecia of two species of salt water fungi to develop intermingled.

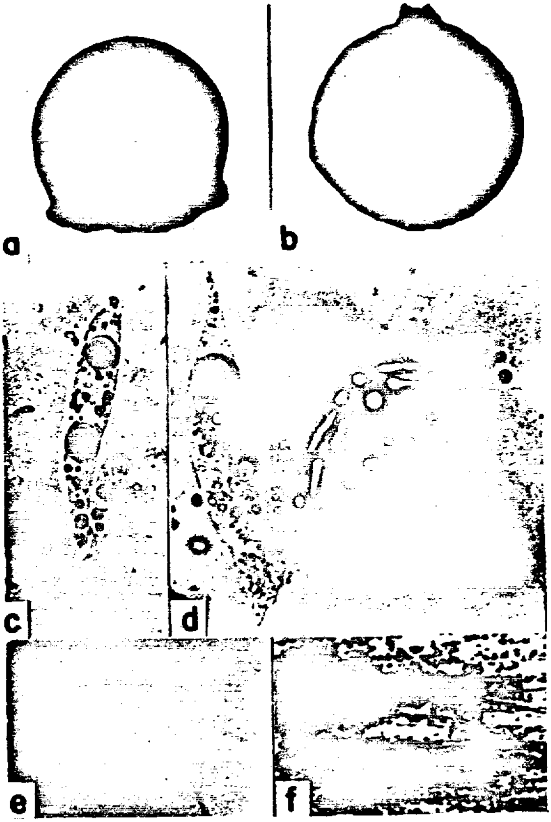
Unlike other marine Pyrenomycetes, the perithecia of P. integra become shiny black long before they reach full size. An apparently mature ascocarp may not have begun to produce ascus initials.

Asci begin development at the base and toward the sides of the young ascocarp. They are, at first, clavate and become fusoid with a distirct apiculus (fig. 3c-d). At maturity they are broadly fusiform and, in the Salton Sea material, the apiculus appears to be present until deliquescence.

Ascospore development is as described by Johnson & Sparrow (1961). The ascospores are usually elipsoidal at ascus deliquescence and appear to elongate and become fusoid. Pseudosepta, as described by Linder (1944) are visible in older spores. The wall of the spore is often slightly constricted at the pseudoseptum. The ascospores (fig. 3e) of the Salton Sea specimens are 21.8-30.4 x 7.0-9.6 µ ($\bar{x}$ = 26.3 x 8.1 µ). The terminal appendages are usually stiff, 8.0-23.1 x 0.9-1.3 µ ($\bar{x}$ = 12.5 x 1.1 µ). Lateral appendages are hair-like, flexuous or rigid, 5.2-15.7 µ.

In culture, the aerial vegetative mycelium of P. integra is light grey in mass. The mycelium developing in the agar varies from dark grey to black depending on the isolate and the medium used. Peritrichospora integra grows well on SSwa, YpSs, MeYe, and PDA. The vegetative mycelium develops in rope-like strands or fans of parallel hyphae (fig. 3f) as well as in an irregular branching manner. The irregular hyphae often become divided into short cells which swell and produce guttulate chlamydospores which become darkened in age. Among the vegetative hyphae numerous perithecial initials are produced. In test-tube culture,

Fig. 3. <u>Peritrichospora</u> <u>integra</u> Linder. a. Perithecium showing flanged base. X 145. b. Perithecium showing papillate ostiolum. X 145. c-d. Asci at various stages of development. X 620. e. Mature spore. X 1000. f. Portion of mycelial mat from culture. X 620.


a
b
c
d
e
f

these do not attain the stage where asci are produced, although a well developed membranous perithecial wall may be formed.

HALOSPHAERIA Linder

Farlowia 1: 412. 1942.

Nonstromatic(?); perithecia innate or superficial, gregarious, black, usually ovoid, membranous, neck variable; paraphyses absent, paraphysoids rare; asci clavate to irregularly fusiform; usually 8-spored, occasionally 2- or 4-spored, deliquescent; ascospores hyaline 2-4-celled, wall constricted, at least at the median septum, elipsoid to fusiform, each cell with at least one large vacuole, apices with a gelatinous cap or appendage, lateral appendages are attached at the median septum.

HALOSPHAERIA MEDIOSETIGERA Cribb & Cribb

Papers Univ. Queensland Dept. Botany 3 (12): 100. 1956.

Perithecia globose to elipsoidal, usually dark brown or black, 240-850 x 140-623 μ; paraphysoids absent; asci clavate to fusiform, unitunicate, deliquescent, 62.3-181 x 20-48 μ; ascospores usually fusiform, 2-4-celled, apices with hyaline caps, 18-45 x 7-21 μ; equatorial appendages lunate, attached laterally, up to 33 x 1 μ, occasionally bristle-like and singly inserted at the septum.

Specimens examined: CALIFORNIA: on Tamarix aphylla wood submerged in the Salton Sea, March 12, 1961, S20, S21, S32, S35; June 24, 1961, S40.

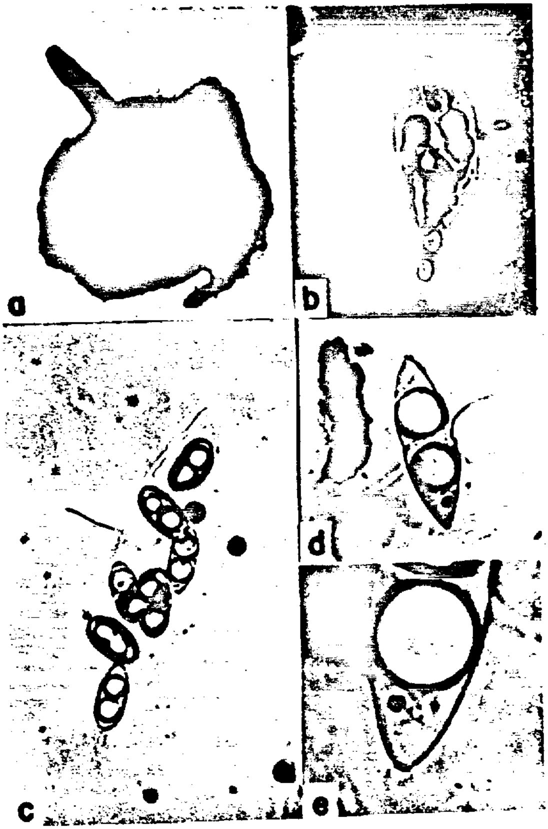
Halosphaeria mediosetigera has been reported from marine locations in Australia, California, North Carolina, Virginia, and the Black Sea (Johnson & Sparrow, 1961). In the Salton Sea it grows on Tamarix wood which is heavily encrusted with barnacles (Balanus amphitrite Darwin). Fructifications are commonly found under the shells and may often be observed after the heavy encrustation is removed. This species apparently does not have high oxygen requirements because of its occurrence under barnacles and in wood which is deeply submerged.

The perithecia observed on removal from the Salton Sea were always embedded in the wood and their large size often prevented removal in intact condition. Perithecia (fig. 4a) are capable of developing superficially in moist chambers and it is probable that they also occur superficially at times in nature. When they develop superficially or in slime the venter is usually globose with a neck about one half the diameter of the venter. The diameter of the venter in superficial perithecia ranges from 228-432 µ.

When perithecia which develop under barnacle shells are allowed to incubate in moist chambers they often are able to break through the base of the shell for release of spores. This phenomenon has also been observed in Antennospora quadricornuta (Cribb & Cribb) Johnson & Sparrow (1961) and Didymosamarospora euryhalima Johnson & Gold (1957) in collections from Hawaii.

The asci of H. mediosetigera deliquesce very soon after the spores are formed, before many of the spores have laid down a median septum. When young, the asci are broadly and irregularly clavate and the ascus wall is closely adherent to the enclosed ascospores. Just prior to deliquescence the asci enlarge and become very thin walled (fig. 4b-c). They appear to be stalked and apiculate. The wall of the apiculus is slightly thicker than the wall bounding the rest of the ascus. At this stage the six to eight spores are loosely arranged in the ascus in a

Fig. 4. Halosphaeria mediosetigera Cribb & Cribb. a Perithecium which was produced superficially in culture. X 82. b-c. Asci just prior to deliquescence. X 620. d. Mature ascospore. X 1000. e. Ascospore with inverted hyaline cap. X 2330.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bi- or multi-serriate fashion. The few asci observed ranged from 62.3-69.6 x 21.8-23.1 μ, which is very much smaller than the measurements reported by Johnson & Sparrow (1961) -- 106-181 x 20-48 μ. Kohlmeyer (1960) reported asci 82-108 x 24-30 μ. At deliquescence the ascus wall breaks down irregularly and releases the spores.

The ascospores (fig. 4d) are non-septate or 1-septate when released from the asci. When they become 1-septate a distinct constriction at the median septum is observed. As the spores continue to elongate, the constriction very often disappears and it is difficult to find a spore with constrictions in an older perithecium. The spore appendages of the Salton Sea organism are always lunate in structure and attached laterally. None of the singly inserted appendages reported by Johnson (1958a) were observed. Apical gelatinous caps (fig. 4e), in many cases inverted, were observed in water mounts and stained preparations, clearly confirming Kohlmeyer's observations (1960).

AMPHISPHAERIA Cesati & de Notaris

Comment. Soc. Cryptogam. Ital. 1(4): 49. 1863.

Nonstromatic; ascocarp superficial or partially innate, black, globose, carbonaceous; neck conical, wart-like, conoidal, or ovoid; paraphyses present; asci cylindrical to clavate, 8-spored persistent or absent; ascospores dark, ovoid, elipsoidal to oblong, ends rounded or acuminate.

Amphisphaeria verruculosa sp. nov.

Fungus pseudotheciis superficialibus vel subinnatis, conoideis, globosis, vel ovoideis, 110-197 x 86-141 μ; collo nullo vel breve et variabile; pseudo-paraphysiis simplicibus vel ramosis, brevi tempore deliquescentibus; ascis cylindricis, bitunicatis, 67.3-115.7 x 6.2-10.7 ($\bar{x}$ = 89.3 x 8.0); ascosporiis stramineis, 2-cellatis, ad septum leviter constrictis, verrunculosis, elipsoidalis vel oblongo-ellipsoidalis, saepe leviter flectis, extremis rotundatis, 7.8-14.4 x 3.7-8.3 μ ($\bar{x}$ = 11.3 x 5.7 μ).

Pseudothecia superficial or partially innate, conical or globose to ovoid, 110-197 x 86-141 μ; neck absent or short and variable, pseudoparaphyses simple or branched, early deliquescent; asci cylindrical, bitunicate, 67.3-115.7 x 6.2-10.7 μ ($\bar{x}$ = 89.3 x 8.0 μ); ascospores yellow-brown, 2-celled, slightly constricted at the septum, verruculose, elipsoidal to oblong-elipsoidal, often slightly curved, ends rounded, 7.8-14.4 x 3.7-8.3 μ ($\bar{x}$ = 11.3 x 5.7 μ).

Holotype: CALIFORNIA: on wood of *Tamarix aphylla* submerged in the Salton Sea, June 24, 1961, *RSA 26*. Transfers of this holotype are deposited at RSA, ATCC, CMI, and CBS.

Amphisphaeria verruculosa and *A. maritima* Linder (1944) both have bitunicate asci and are therefore only tentatively retained in *Amphisphaeria*. Kohlmeyer (1960) transferred *A. maritima* to *Microthelia*, a genus of lichen fungi, on the basis of similarities in ascocarp and asci. Johnson & Sparrow (1961), however, argue that transfer of a non-lichen fungus into a lichen genus is unwarranted until a thorough study of the relationships is undertaken. I agree that, for the present, *A. maritima* and *A. verruculosa* should probably be retained in *Amphisphaeria*.

Amphisphaeria verruculosa has been studied on the natural substrate and in pure culture where it fruits abundantly.

The pseudothecia of A. verruculosa develop superficially or in the softened surface fibres of submerged Tamarix wood. They are mostly without necks, conical, and profusely cover the wood. Amphisphaeria verruculosa also fruits prolifically on SSwa, Swa, YpSs, and PDA, but not on MeYe.

In culture, the pseudothecia formed near the margins are sparse, with globose venters and often a well-formed centric neck (fig. 5f; fig. 6b). In the older regions of the colony they are produced in clusters which eventually fuse and present a solid mass. These pseudothecia usually lack necks (fig. 6a), and when necks are present they are either aborted or eccentric.

Pseudothecia appear to be initiated when the short cells of a filament swell up, divide, and send out numerous branches (fig. 5e). Whether or not this is preceded by hyphal fusions is not known. Hyphal fusions are, however, exceedingly common in the vegetative mycelium. At one end of the complex of cells and branches a small knot of cells begins as a lateral branch and surrounds the main hypha (fig. 5e); this resembles the pseudothecial initial in Sporomia bipartis Cane (Page, 1939). Further development of the pseudoparenchymatous ball of cells eventually envelops the perithecial initials and develops into the mature perithecium.

Pseudoparaphyses are present only in immature ascocarps (fig. 5g; fig. 6c) and soon deliquesce. The immature asci are at first clavate with granular cytoplasm (fig. 5h; fig. 6c) then they become cylindrical and have an extremely thick wall (fig. 5i; fig. 6d) characteristic of young bitunicate asci. As the asci mature, the central cavity becomes enlarged and causes the ascus to become more club-shaped (fig. 5j-l;

Fig. 5. *Amphisphaeria verruculosa* sp. nov. a-d. Stages in production of chlamydospores from vegetative mycelium. e. Pseudothecial initial. f. Mature pseudothecium from culture. g. Pseudoparaphyses. h-l. Stages in maturation of asci. m. Mature ascus in which the ectoascus has ruptured and the endoascus has extended. n. Mature ascospores.

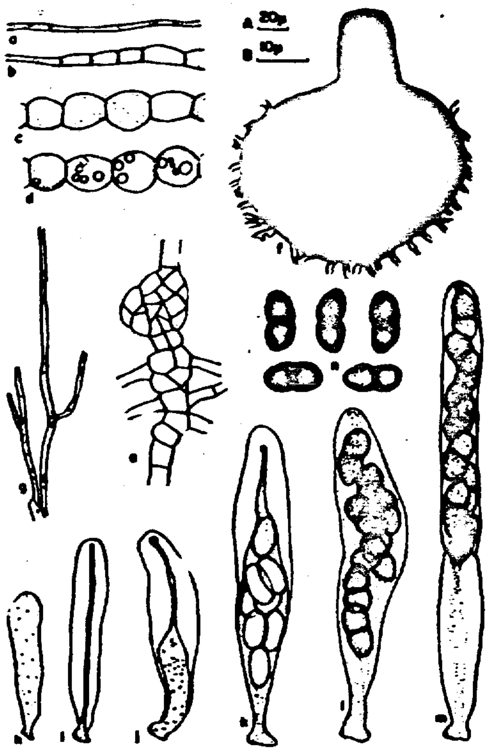
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Fig. 6. *Amphisphaeria verruculosa* sp. nov. a. Immature pseudothecium lacking a neck. X 310. b. Mature perithecium. X 310. c. Pseudoparaphyses and young asci with granular cytoplasm and a thin wall. X 1000. d. Immature ascus which has developed a thick wall. X 1000.

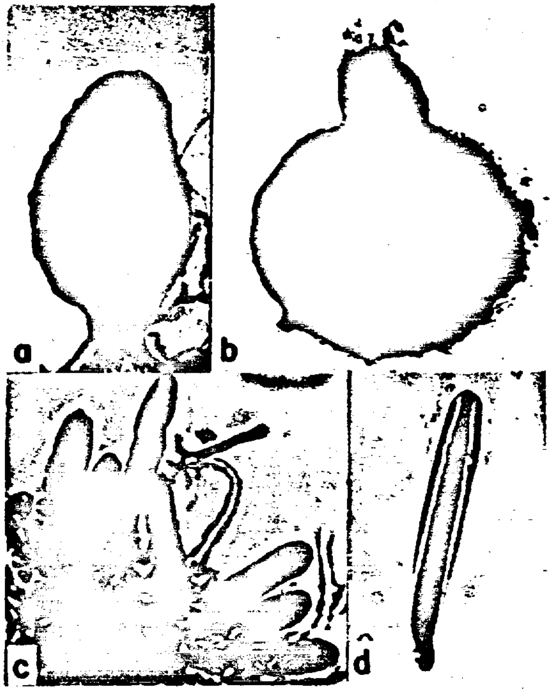
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Fig. 7. Amphisphaeria verruculosa sp. nov. a. Thick-walled immature ascus. X 1000. b. Slightly immature ascus. X 1000. c. Ascus with extended endoascus. X 620. d. Ruptured ectoascus with central thickened cytoplasmic strand. X 2330. e-f. Mature ascospores. X 2330. g. Surface markings of ascospores. X 2330. h. Chlamydospore chain. X 2330.

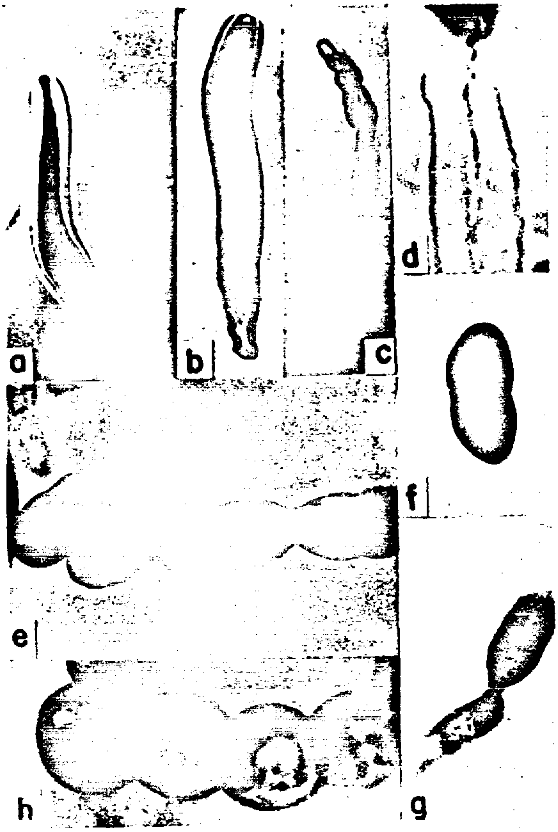
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fig. 7a-b). At maturity the spores are usually biseriate (fig. 5k-m; fig. 7c), occasionally uniseriate (fig. 7b), and are joined to one another and to the base and apex of the ascus by a thick strand of cytoplasm (fig. 5m; fig. 7c-d). The ectoascus splits circumscissilely about two-thirds the distance up the ascus and the endoascus elongates slowly or rapidly depending on whether or not the ascus is completely mature (fig. 5m; fig. 7c-d). The ectoascus of immature asci will rupture when the pseudothecium is broken open in distilled water and the endoascus elongates slowly. The ectoascus cap remains on the tip of the endoascus and begins to deliquesce or may be forced off with the expansion of the endoascus. The basal portion of the ectoascus usually constricts the endoascus which tends to bulge above it. The ectoascus appears to deliquesce after three to four minutes in water. The apex of the endoascus deliquesces and the spores are released through the opening formed.

The yellow-brown ascospores are usually 2-celled (fig. 5n; fig. 7e-f), but occasionally 1-celled. The spores are covered with fine warts, generally visible only under oil immersion (fig. 7g). Aberrant spores with large warts over the surface of the unequally enlarged cells are occasionally produced.

In culture the vegetative mycelium is composed of relatively straight branching hyphae. In age the mycelium is converted into hyaline chains of chlamydospores which eventually become fuscous and guttulate (fig. 5a-d; fig. 7h).

LEPTOSPHAERIA Cesati & de Notaris emend. Saccardo

Sylloge Fugorum 2: 13. 1883.

Stromatic; pseudothecia innate, sometimes superficial, usually sphaerical, coriaceous to carbonaceous or membranous, neck papilliform or lacking; paraphyses present; asci variably cylindrical to saccate; four or eight spored, persistent; ascospores pigmented yellow, olivaceous to brown, 2--several-celled.

LEPTOSPHAERIA ORAE-MARIS Linder

Farlowia 1: 413. 1944.

Pseudothecia innate or sometimes superficial, usually gregarious, broadly ovoid or sub-globose, carbonaceous, 100-395 μ diam.; paraphyses hyaline, simple, occasionally branched, the apex usually clavate, slightly exceeding the height of the asci, 1-2 μ diam.; asci usually clavate, rarely cylindrical, bitunicate, 58-120 x 6.2-12 μ; ascospores brown, 1-septate, distal cell longer than proximal cell, tardily 3-septate, conspicuously constricted at the median septum, wall verruculose, 15.1-32.0 x 3.9-8 μ.

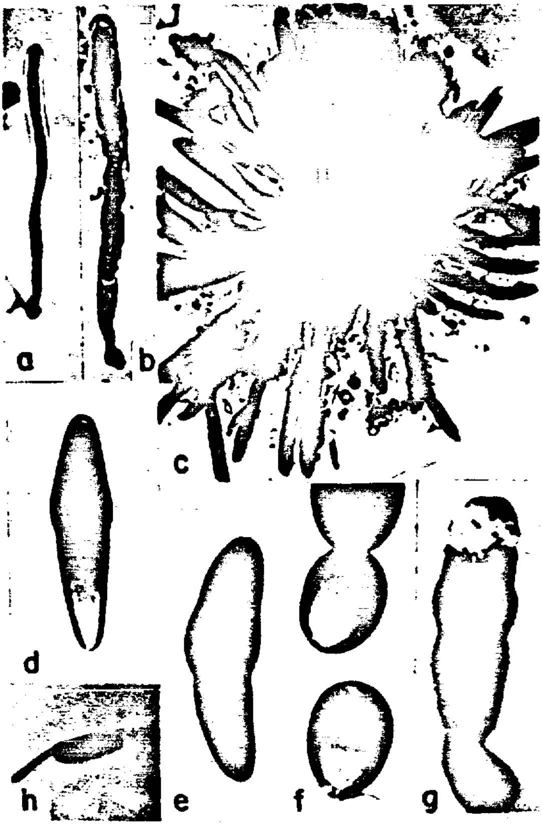
Specimens examined: CALIFORNIA: on *Tamarix aphylla* submerged in the Salton Sea, December 26, 1960, *S1*; March 12, 1961, *S15*, *S17*, *S19*, *S28*, *S29*, *S33*; June 24, 1961, *S45*, *S59*, *S61*, *S72*, July 20, 1961, *S81*. WASHINGTON: on driftwood in False Bay, San Juan Island, December 5, 1959, *Kohlmeyer 176*.

Leptosphaeria orae-maris has been reported from various marine locations in North America and Europe, including Washington, Texas, Florida, North Carolina, Belgium, Sicily (Johnson & Sparrow, 1961), and Great Britain (Jones, 1962). It is the most common pyrenomycete in the Salton Sea and occurs as masses of black pseudothecia covering the exposed wood of flooded trees near the surface of the water. The oxygen requirement of this organism apparently is rather high since it is rarely found on wood submerged more than one foot. In this habitat, its pseudothecia range from 200-350 u ($\bar{x} = 285\ \mu$) in diameter.

This is larger than reported in Linder's original description (Barghoorn and Linder, 1944) but comparable with pseudothecial sizes reported by Jones (1962). Pseudothecia are often superficial on wood, but this may be due to the erosion of the surrounding fibers.

Young asci have an extremely thick wall (fig. 8a) and at maturity (fig. 8b) appear to be bitunicate; however, a distinct double wall was not observed. Mature asci are clavate, bear eight distichous or uniseriate spores, and range from 90-100 x 6.2-8.9 μ. Occasional four-spored asci were observed. Paraphyses are abundant and persistent (fig. 8c). Ascospores are usually two-celled (fig. 8d) and a rich brown. Four-celled ascospores (fig. 8e,h) are rarely observed inside asci, but the condition is often noted in released spores, particularly in cirri produced in moist chambers. Occasional unicellular ascospores (fig. 8f) are produced. These spores are globose to eliptical and appear darker in color than other ascospores. Normal ascospores are 15-22.6 x 3.9-5.2 μ ($\bar{x} = 17.7 \times 4.6\ \mu$). These measurements are considerably less than reported for this organism from marine locations (Jones, 1962). However, comparison of *L. orae-maris* from the Salton Sea with *Kohlmeyer 176*, which has larger spores (Kohlmeyer, 1960), indicates that it is the same organism. The walls of all spores observed were covered with very fine warts (fig. 8g). This condition is especially noticeable in the immature spores and readily serves to separate the two-celled ascospores of this organism from the smooth ones of *Amphisphaeria maritima*. The spores of *L. orae-maris* adhere tenaciously to objects around the fructifications, such as the walls of hyphae (fig. 8h). Observation in

Fig. 8. *Leptosphaeria orae-maris* Linder. a. Young ascus with thick wall. X 620. b. Mature ascus. X 620. c. Ascus centrum with asci and paraphyses. X 320. d. Two-celled ascospore. X 2330. e. Four-celled ascospore. X 2330. f. One-celled ascospores. X 2330. g. Surface markings of ascospores. X 2330. h. Four-celled spore which has adhered to a hyphal strand. X 320.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India ink mounts indicates that the spores are surrounded by a thin gelatinous sheath.

PLEOSPORA Rabenhorst

Herb. Mycol., Ed. 2., p. 547. 1857.

Stromatic; pseudothecium innate or erumpent, globose, elipsoid, or pyriform, membranous, glabrous or tomentose, thin to thick walled; pseudoparaphyses persistent; asci narrowly to broadly clavate or cylindrical bitunicate, persistent; spores yellow-brown to red-brown, muriform.

PLEOSPORA HERBARUM (Fries) Rabenhorst

Herb. Mycol., Ed. 2., p. 547. 1857.

Pseudothecia variable, 100-500 µ in diameter, globose, pyriform or hemispherical, innate, often erumpent, glabrous or slightly tomentose, neck papillate; asci biseriate, 70-250 x 20-50 µ, broadly clavate or cylindrical, the base claw-shaped; ascospores oblong to fusoid, elipsoidal or clavate, 7-septate at maturity, more often symmetrical than asymmetrical, yellow-brown, 16-50 x 10-20 µ, constricted at the central septum, ends broadly rounded.

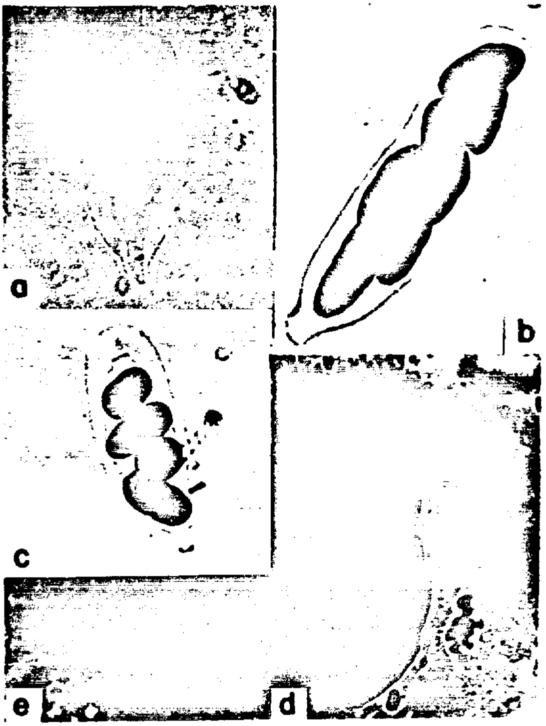
Specimen examined: CALIFORNIA: on wood of Tamarix aphylla submerged in the Salton Sea, March 12, 1961, S18.

Pleospora herbarum is a terrestrial species of world wide distribution which is usually found on leaves and herbaceous or small woody stems. It has not been reported as such from a salt water environment, but Wehmeyer (1961) considers that the descriptions and figures of both

Pleospora laminariana Suth. (1916) and *P. pelvetiae* Suth. (1915) represent forms of *P. herbarum*. The types of both of Sutherland's species apparently have been lost (J. G. Manners, pers. comm.). Johnson (1956a) considered his *Pleospora pelagica* to belong in the *P. herbarum* series, but Wehmeyer (1961), on the basis of Johnson's figures, felt that the species is closer to *P. heleocharidis* Karst.

The specimen obtained from the Salton Sea was examined within twenty-four hours and mature fruiting bodies were found; this discounts the possibility of secondary contamination. Only a few fruiting bodies were examined because the organism failed to develop further in the moist chamber. The pseudothecia were globose or slightly flattened, carbonaceous, superficial (probably by washing away of surrounding fibres) or innate, 393-432 x 400-471 μ. The asci were 71-134 x 20-39 μ ($\bar{x}$ = 96 x 27 μ), oblong when immature (fig. 9a), cylindrical at maturity, and bore four to eight spores in a biseriate fashion (fig. 9b-c). The spores (fig. 9b,e) were 16.0-33.8 x 10.7-15.1 μ ($\bar{x}$ = 26.3 x 12.9 μ), with five to seven transverse septa. In many asci the spores were aborted though the asci appeared normal in all other respects (fig. 9d).

Fig. 9. Pleospora herbarum (Fries) Rabenhorst. a. Immature ascus. X 620. b. Mature ascus with eight spores. X 620. c. Slightly immature ascus with four spores. X 620. d. Ascus with aborted ascospores. X 620. e. Mature ascospore. X 1000.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Fungi Imperfecti

BOTRYOTRICHUM Sacc. & March. emend. Downing
Mycologia 45: 937. 1953.

Vegetative mycelium hyaline, decumbent, usually producing unbranched, septate, upright, gray to brown sterile hairs; aleuriophores hyaline, branched, usually short, producing a cluster of aleuriospores; aleuriospores hyaline, 1-celled, globose. Phialides short, hyaline, producing 1-celled phialospores in chains.

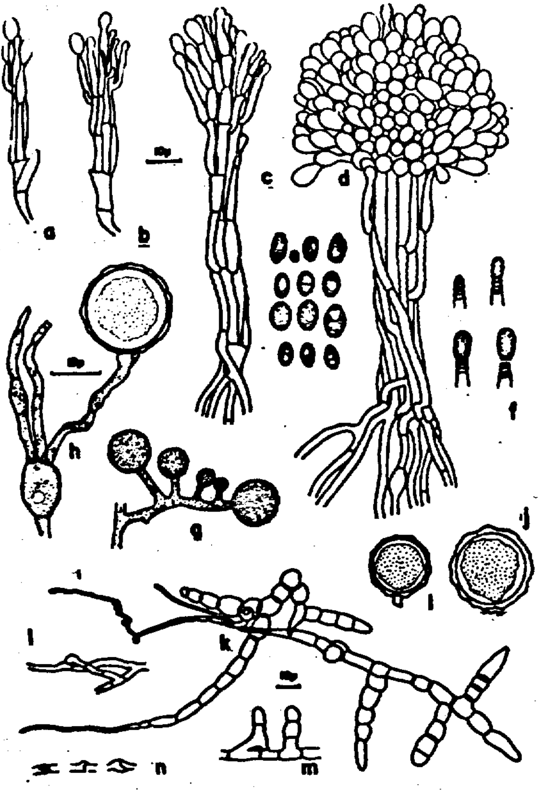
BOTRYOTRICHUM PILULIFERUM Sacc. & March. emend. Downing
Mycologia 45: 937. 1953

Sterile hairs borne on decumbent aerial hyphae, rough, 180-240 x 2.8-3.9 µ; aleuriophores 4-6 x 12-30 µ; aleuriospores 10-21 µ in diam., walls 1-3.5 µ thick, surrounded by a hyaline membrane which ruptures to give the spore a roughened appearance; phialides 20-22 x 2.8-3.3 µ; phialospores 2.8-4.2 x 1.4-2.8 µ, sometimes forming a head due to the production of slime.

Specimen examined: CALIFORNIA: on Tamarix aphylla wood submerged in the Salton Sea, June 24, 1961, S53.

An unusual isotate of Botryotrichum piluliferum, characterized by the absence of sterile hairs and phialospores, was obtained from a branch of Tamarix wood submerged in the Salton Sea. The fertile hyphae are often highly branched, 4-6 µ in diameter (fig. 10g,h), and produce only aleuriospores when the organism is grown on YpSs, MeYe, SSwa, or PDA. Aleuriospores are 5.9-20.2 µ ($\bar{x}$ = 13.9 µ) in diameter (fig. 10i).

Fig. 10. *Scopulariopsis* sp. a-d. Development of synnemata. e. Conidia. f. Development of conidia. *Botryotrichum piluliferum* Saccardo and Marchal emend. Downing. g. Conidiophore with immature aleuriospores. h. Conidiophore with mature aleuriospore. i-j. Mature aleuriospores. *Papulaspora halima* sp. nov. k. Bulbil primordium. l-m. Hyphal fusions. n. Clamp connections.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Thickness of the wall varies according to the medium on which the organism is grown. On SSwa the walls are up to 4 µ thick, but on YpSs they are relatively thin, usually about 1 µ thick. The fungus grew well on all media tested. It is white on all media except YpSs where a tinge of buff is detectable.

According to Downing (1953) the absence of sterile hairs is not unusual in culture, but she states that they are invariably found on the natural substrate. In this case they were not. The absence of phialospores appears to be a more serious deviation, but the fact that they were not observed by Saccardo and Marchal (1885) might suggest that they are not found in all isolates. In spite of the lack of sterile hairs and phialospores in this isolate, comparison of its aleuriospores and aleuriophores with those of a typical isolate of Botryotrichum piluliferum indicates that it simply is an atypical form.

SCOPULARIOPSIS Bainier

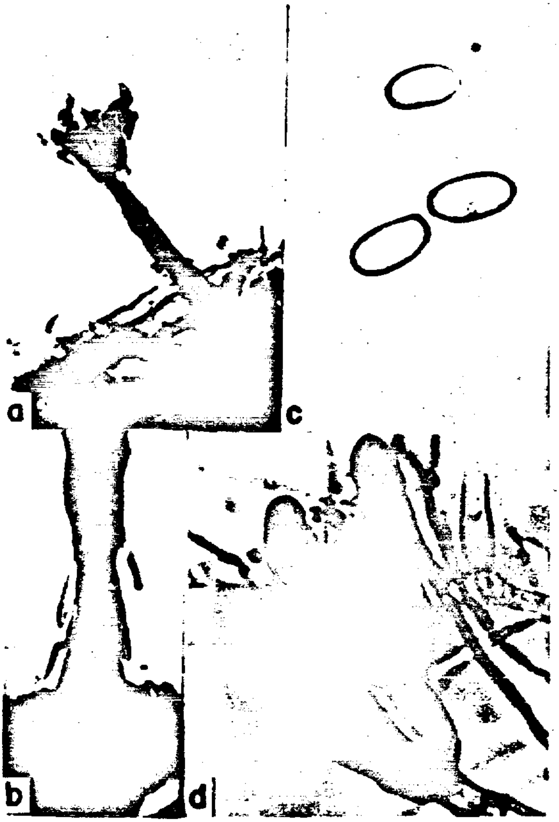
Bull. Soc. Mycol. France 23: 98. 1907.

Vegetative mycelium, hyaline, decumbent; fertile hyphae branched, producing a terminal cluster of annellophores in a penicillate fashion; conidia produced by proliferation through the scar of the previous spore, each conidium leaving a scar in succession; conidia hyaline, one-celled, produced in chains; colonies not green.

Scopulariopsis sp.

An unusual species of Scopulariopsis has been isolated from two samples of Tamarix bark taken from the Salton Sea. The organism produces abundant synnemata in moist chambers and has been isolated on SSwa.

Fig. 11. *Scopulariopsis* sp. a. Young synnema from original bark substrate. X 620. b. Rhizoidal hyphae growing down from synnema. X 1000. c. Mature conidia. X 2330. d. Annellophores with annellations bearing conidia. X 2330.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The complex synnemata developed on the bark are produced from an enlarged intercalary or terminal cell (fig. 10a,b) of a hypha growing on the surface of the substratum. This cell produces a single annellophore which produces spores terminally. Additional annellophores and cells subtending them are produced in a penicillate manner from the enlarged basal cell. Cells produced from the basal cell elongate, become septate and branch secondarily, in a penicillate fashion, until a fairly complex structure is formed (fig. 10c; fig. 11a). Some of these cells produce branches which grow toward the substratum (fig. 11b), penetrate it, and serve to support the developing structure. Additional branches corticate the synnema in a spiral fashion (fig. 10d) and complete the development. The production of conidia is continuous during the development of the synnema.

Conidia of this species, like those of other species of _Scopulariopsis_ (Hughes, 1953), are produced by proliferation through the scar resulting from the release of an antecedent conidium. After the release of each conidium, an irregular ring-like scar, termed an annellation, is left behind (fig. 10f). As annellations are added, the annellophore increases in length and becomes roughened (fig. 11d). Successive spores are produced aerially and form dry chains.

The spores (fig. 10e; fig. 11c) are hyaline, become slightly fuscous in age, and are cylindrical to ovate or oval, 3.9-7.1 x 2.6-4.4 μ ($\bar{x}$ = 6.1 x 3.3 μ). A scar resulting from the release of the spore is apparent at the proximal end and occasionally an additional scar is found at the distal end (fig. 10e; fig. 11c).

Scopulariopsis sp. grows well on SSwa, Swa, MeYe, PDA, and CM, but best growth has been obtained on YpSs. On Czapeks agar about 0.5cm.

of growth was produced after incubation for a week. Sporulation was good on all media tested except Czapeks on which it was extremely sparse.

When the organism was grown in culture, synnemata of the type described were not produced. Instead, annellophores were produced in a penicillate fashion from a stalk consisting of a single hypha. However, the cell producing this stalk was usually an enlarged cell.

Specimens examined: CALIFORNIA: on the bark of *Tamarix aphylla* in the Salton Sea, June 24, 1961, S55, S67.

CLAVARIOPSIS De Wilde. emend. Anastasiou

Mycologia 53: 11. 1961.

Vegetative hyphae hyaline, decumbent; aleuriophores hyaline, erect, branched or unbranched; aleuriospores hyaline, darkening with age, provided with one to four divergent arms with septa at the points of attachment; basal arm 1-septate.

CLAVARIOPSIS BULBOSA Anastasiou

Mycologia 53: 11. 1961.

Submerged aquatic fungus with branched mycelium; aleuriophores septate, branching or unbranched, 10-300 x 3.5 μ; aleuriospores usually with four arms; proximal cell of basal arm bulbous, 10.5-20.0 x 6.2-10.0 μ; distal cell 6.5-10.4 x 6.6-13.2 μ; divergent arms 1-7 septate, 4-70 x 3.8-8.4 μ; catenulate chlamydospores deep olivaceous, black in age, 2—20 spores forming a rarely branched chain; basal spore usually long and thin 9-18 x 4-10 μ; the others slightly longer than broad, 10-18.2 x 7-14 μ.

Specimens examined: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, December 26, 1960, RSA #19 (holotype); July 20, 1961, S84; December 20, 1961, S128. HAWAII: on wood submerged in the Salt Lake, Oahu, August 25, 1961, H6, H9; on waterlogged driftwood in the surf at Kapaa, Kauai, H43. NORTH CAROLINA: on yellow pine panel in Neuse River estuary, July 15, 1959, G. C. Hughes III 37/1178/2/4b.

Clavariopsis bulbosa was first isolated from *Tamarix* wood submerged in the Salton Sea, where it appears to be fairly common. It has also been isolated from Salt Lake, Oahu, Hawaii. The salinity of the surface water in which the specimens were found was 2 °/oo. The isolates (H6 and H9) vary considerably compared with those from the Salton Sea. Although some of the aleuriospores, produced on wood removed from the lake, bore normal divergent arms (fig. 12b), most of them consisted of a single arm arising from the bulbous basal cell (fig. 12a). In some of these spores it is evident that the spore consists of a normal two-celled basal arm with a single "divergent arm" arising from it (fig. 12g). Every aleuriospore examined bore the distinctive bulbous basal cell with the characteristic peg where it was attached to the aleuriophore. The spores also differ from the type in having deeper constrictions at the septa of the divergent arms (fig. 12a-b).

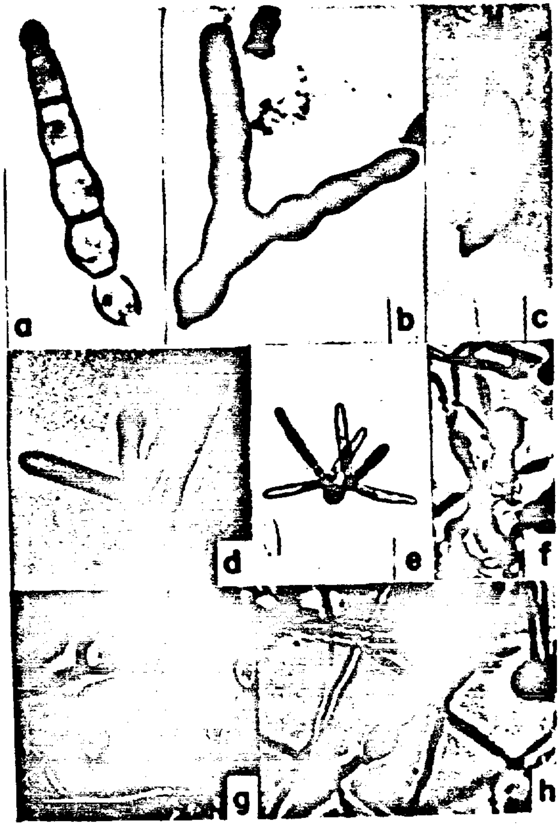
In culture, isolate H6 is characterized by the prolific production of aleuriospores in the older regions of the colonies. The spores consist of a single arm arising out of the basal arm as described above. The spores, however, usually lack constrictions at the septa of the divergent arms (fig. 12c). Many of the spores produce a single divergent arm laterally from the distal cell of the basal arm (fig. 12g). Normal chlamydospores also are produced by this isolate in older regions of the culture. The gross appearance is essentially the same as the type (Anastasiou, 1961).

Isolate H9 produces relatively few aleuriospores in culture, and most of those which have been observed are aborted. Many consist of a bulbous basal cell subtending a second, more swollen, cell (fig. 12f). Chlamydospores are rarely produced in the manner described for the type isolate (Anastasiou, 1961). In H9 they are mainly intercalary in origin and arise from swollen cells of the vegetative mycelium (fig. 13a). The chlamydospore chains are formed as swollen adjacent hyaline cells become thick-walled and dark in color (fig. 13b-c). Occasionally, normal chains are produced laterally from swollen intercalary initials. A strikingly similar production of chlamydospores is reported for *Cordana pauciseptata* Preuss (Hughes, 1955).

An additional isolate of *C. bulbosa*, H43, was obtained from a log immersed in the surf on the island of Kauai, Hawaii. This is believed to be the first record of the species from a marine environment. The aleuriospores, taken from the original specimen, normally had the usual four arms, but a significant number bore additional arms. The additional arms resulted, mainly, from the production of arms or primordia from the bulbous cell of the basal arm (fig. 12d-e). The spore in fig. 12e, is remarkably similar in structure to that of *Orbimyces spectabilis* Linder (1944).

In culture, the aleuriospores of H43 are produced abundantly in the older parts of the colony. They are similar to those produced by H6, except that strong constrictions often occur at the septa of the divergent arm (fig. 12h). However, when the culture is partially immersed in seawater, normal aleuriospores are produced in abundance.

Fig. 12. Clavariopsis bulbosa Anastasiou. a-b. Aleuriospores produced on moist wood. X 1000. c, f-h. Abnormal aleuriospores produced in culture. X 620. d-e. Multi-armed aleuriospores produced on moist wood. d, X 620; e, X 310.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ig. 13. *Clavariopsis bulbosa* Anastasiou. a. Bulbous vegetative yphae. X 620. b-c. Intercalary chlamydospore chains. X 620. . Terminal chlamydospore chain from Neuse River material. X 620. . Aleuriospore from Neuse River material. X 620.


a
b
c
d
e

Catenulate chlamydospores are rare in this isolate, but have been observed. In age, the mycelium becomes dark in color but does not appear to be converted into chlamydospore units described for other isolates listed above.

Clavariopsis bulbosa has also been collected in the tidal estuary of the Neuse River, North Carolina, at a station where the salinity varies from 0 to 15 °/oo (G. C. Hughes III, personal communication). The material available indicates that relatively normal catenulate chlamydospore chains are produced (fig. 13d), along with aleuriospores consisting of 3 to 5 arms (fig. 13e). The aleuriospores examined exhibit the dark pigment often observed in old spores in culture. This dark pigment has not been observed in aleuriospores produced on the natural substrate in other specimens.

The above data indicates that C. bulbosa is variable with respect to the number of divergent arms on the aleuriospores and the production of chlamydospore chains. The characteristic bulbous basal cell attached to the aleuriophore by a peg-like projection appears to be constant in all isolates so far examined.

An unsuccessful attempt has been made to obtain the perfect stage of C. bulbosa by mating isolates which were obtained from Hawaii and the Salton Sea.

FUSARIUM Link

Diss. II. Mag. d. Ges. naturf. Freund 7: 25. 1809.

Vegetative mycelium hyaline or in mass tinged with yellow, pink or purple; conidiophores hyaline, branched, grouped into sporodochia or single; conidia hyaline, variable, often of two types; macroconidia several-celled, cross walls distinct, sickle-shaped; microconidia unicellular, ovoid to subcylindrical or oblong, usually produced singly but occasionally in chains.

FUSARIUM SOLANI (Mart.) App. & Woll. emend. Snyder & Hansen
Am. J. Botany 28: 740. 1941.

Conidia thick-walled, 0-5-septate, truncate or round at the ends, often with a short terminal projection, cream to tan, or yellow to dark green or blue in mass, 8.5-44.5 x 4.2-6.2 µ; chlamydospores terminal or intercalary, hyaline, becoming brown in age, globose to subglobose or pyriform, 8-16 x 6-10 µ.

Specimen examined: CALIFORNIA: on Tamarix aphylla wood submerged in the Salton Sea, March 11, 1961, S31.

Fusarium solani appeared as several bluish-green sporodochia in the bacterial slime covering Tamarix wood twigs in a moist chamber two to three days after they were removed from the Salton Sea.

When cultured on SSwa the organism produces large numbers of conidia over the surface of the mycelium. In age, bluish-green sporodochia are produced in the region of inoculation and on the agar adjacent to the wall of the test tube. The spores are 23.1-43.1 µ x 3.9-5.2 µ ($\bar{x}$ = 36 µ x 4.5 µ) which comes well within the range for the species. The number of septa ranges from one to five with most of the spores 4-septate.

Fusarium solani is a widespread fungus (Gilman, 1957) capable of living in the soil saprophytically or parasitizing plants. It is reported to have parasitized potatoes (Goss, 1940) and is occasionally found on cereal seed (Gordon, 1952). With such wide physiological capabilities it is not surprising to find this organism able to utilize the organic material available in the Salton Sea. Since it thrives on SSwa, there is no question regarding its ability to withstand the high salt concentration.

STACHYBOTRYS Corda

Icones Fungorum husque cognitorum I: 21. 1837.

Memnoniella Höhnel. Centralbl. Bact. II, 60: 16. 1923.

Vegetative hyphae hyaline or darkened in age, decumbent, septate, branched; phialophores hyaline to dark in color, erect, septate, bearing a crown of phialides; phialospores hyaline to brightly colored or dark, one-celled, with or without slime.

Memnoniella and Stachybotrys are separated by a single character, the presence or absence of slime on the spores. Zuck (1946) showed that isolates of Memnoniella echinata were capable of producing some spore heads with slime and some spore heads without slime, even from the same vegetative hypha. As Bisby and Ellis (1949) pointed out, this distinction between Memnoniella and Stachybotrys is doubtful, and I therefore consider them to be synonomous.

Key to the species treated.

A. Phialophores not branching conspicuously....... S. subsimplex

AA. Phialophores branching conspicuously........... S. atra

STACHYBOTRYS SUBSIMPLEX Cooke

Grevillea 12: 33. 1883.

Phialophores simple; phialides light brown to black, 6-12 x 4-6 μ; phialospores globose to eliptical, 3-10 x 3-9 μ, dark brown to black, smooth or verrucose.

Specimen examined: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, March 12, 1961, S17.

This isolate compares favorably with Bisby's description of the species (Bisby, 1943). The measurements of S17 are as follows:

Phialophores: 26.7-62.3 x 2.6-3.5 μ ($\bar{x}$ = 44.8 x 3.1 μ) subhyaline, tapering slightly at the base of the phialides; wall roughened toward the apex; unbranched.

Phialides: 8.7-13.5 x 3.5-5.9 μ. ($\bar{x}$ = 10.9 x 4.5 μ). Ovate, dark toward the apex, in clusters of 4 to 6. Phialides are generally longer and thinner than is usually found in this species.

Phialospores: 6.8-9.3 x 3.9-6.5 μ ($\bar{x}$ = 8.3 x 4.8 μ) eliptical, smooth-walled at first, then rough, dark brown to black.

This organism may be a non-branching form of *S. atra* since the measurements of phialides and spores of this isolate agree remarkably well with those of isolates of *Stachybotrys atra* from the Salton Sea. The main difference between them is the branching habit of the phialophores in isolates other than S17. However, the measurements of various structures in S17 agree more closely with the description of *S. subsimplex* than with *S. atra*.

STACHYBOTRYS ATRA Corda

Icones Fungorum husque cognitorum I: 21. 1837.

Phialophores branched; phialides dark brown, 10-16 x 5-7 µ; phialospores 8-12 x 4-9 µ, dark olivaceous, brown to black, smooth, subcylindrical to oval when produced by fresh growth, rough, oval to subglobose when produced by older growth.

Specimens examined: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, December 26, 1960, S1, March 12, 1961, S15, S18, S23, S31.

The measurements of these isolates compare more closely with those of *S. subsimplex* than with *S. atra* but the highly branching habit of the phialophores places them in *S. atra*. The following measurements are taken from S1.

Phialophores: 59-187 x 2.3-3.6 µ ($\bar{x}$ = 103 x 3.1 µ). Tapering slightly, hyaline below, dark toward the apex. Roughened toward the apex of the older phialophores. Many phialophores branched several times.

Phialides: 9.6-13.0 x 3.3-5.2 µ ($\bar{x}$ = 11.0 x 4.4 µ). Ovate, dark in age, grouped in clusters of 5-8. Phialides are generally shorter and thinner than is usually found in this species.

Phialospores: 6.1-10.4 x 5.2-7.9 µ ($\bar{x}$ = 8.6 x 6.1 µ). Subcylindrical and roughened when young, becoming eliptical and eventually subglobose and highly roughened in age.

Stachybotrys is one of the more common salt water fungi, not only in salt lakes, but in marine locations, especially from warm water areas. It has been encountered regularly in collections from the California coast and Hawaii.

PERICONIA Tode emend. Mason & Ellis

Mycol. Papers 56: 60. 1953.

Vegetative mycelium hyaline or dark, decumbent; conidiophores light or dark, usually differentiated into a broad stipe; conidia dark, one-celled, globose, smooth or warted, lacking an obvious hilum, produced in chains acropetally, maturing basipetally or occasionally produced singly.

Periconia prolifica sp. nov.

Fungus aquaticus submersus, saprophyticus; mycelio in ligno immerso, septato, hyalino; cellulis 8.7-26.1 x 1.3-4.4 µ; conidiophoris 5-200 x 2.5 µ, hyalinis, ramosis vel simplicibus, saepe in pustulas aggregatis; cellulis sporogenis ovatis, hyalinis, levibus, acrogene productis; conidiis 6.1-20.0 diam., atro-brunneis, levibus, catenulatis.

Submerged aquatic fungus, saprophytic, vegetative mycelium in wood, septate, hyaline; cells 8.7-26.1 x 1.3-4.4 µ; conidiophores 5-200 x 2.5 µ; hyaline, branched or unbranched, often in pustules; sporogenous cells ovoid, hyaline, smooth, produced acrogenously; conidia 6.1-20.0 µ diam. ($\bar{x}$ = 11.5 µ), dark brown, smooth, catenulate.

Holotype: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, December 20, 1961, RSA 31. Transfers of this holotype have been deposited at ATCC, CBS, and CMI.

Other specimens examined: HAWAII: on acacia wood submerged in the Salt Lake, Oahu, August 25, 1961, H5, H7, H8; on driftwood submerged in the surf, Anini, Kauai, September 1, 1961, H37; same, Kapaa, Kauai, September 1, 1961, H43.

In addition to the above, many specimens of P. prolifica were collected and studied from the Salton Sea where it was the most common fungus encountered during this study. Examination of slime from the surface of immersed material invariably reveals its spores.

The spores usually are produced in dense clusters which often form mounds on the surface of the substratum. The hyphae at the base of the pustules often soften the wood so that the pustules, in time, are partially buried in the wood. These pustules enlarge and spread over the surface of the wood so that the entire wood specimen may be covered by a mass of brown spores. Chains or clusters of spores may also be produced from short lateral conidiophores on aerial hyphae (fig. 14n).

The spores usually are produced by a hyaline branched conidiophore which arises from the vegetative mycelium (fig. 14f; fig. 15e). Conidophores often are distinctly swollen and in many cases appear to produce the sporogenous cells basipetally (fig. 14 l-m), or only a single spore may be produced (fig. 14g-k). In most cases, however, the sporogenous cells arise acrogenously, and then mature basipetally and form conidia (fig. 14g-e; fig. 15a-d). At maturity the conidia are smooth, deep brown, and each contains a large irregular guttule. As they are disseminated, the chains usually break up into single spores, but occasionally a short chain is observed (fig. 15f). Single spores usually are almost perfect spheres (fig. 14s-v) although varying shapes also occur (fig. 14o-r).

Periconia prolifica is most similar to P. cambrensis Mason & Ellis (1953), a terrestrial fungus which grows on dead wood and bark of various trees, but is distinctly differentiated from it in several characteristics aside from its habitat:

1. The conidiophores of P. prolifica are all hyaline and micronematous; in P. cambrensis the conidiophores are brown and may be micronematous or macronematous.

2. Conidial size in P. prolifica is 6-20 µ in diam. compared to 5-8 µ in P. cambrensis.

3. The conidiophores of P. prolifica often are produced in dense pustules or effusely; those of P. cambrensis are always produced effusely.

Periconia prolifica was isolated from several collections and grew very slowly on SSwa. Slow growth also occurs on YpSs, MeYe, PDA, and Swa. The colonies attained about 1.2cm.diameter after incubation at room temperature for two weeks. Good sporulation occurred on all media tested. A few isolates produced a brown pigment.

The cultures were characterized by a very sparse aerial mycelium on which conidiophores occurred but were not as abundant as on the mycelium embedded in the agar. The mass of conidia produced in the agar causes the culture to be very dark brown and opaque. Also, the sparse aerial mycelium turns light brown in age.

Periconia prolifica has been collected from the Salt Lake on the island of Oahu, Hawaii, and from marine locations on the island of Kauai, Hawaii. The specimens from Kauai were taken from waterlogged driftwood which had become partially embedded in the sand with the exposed wood pounded by the surf about 30 m. from shore. The specimens from the Salt Lake were taken in water of 2 °/oo salinity. The specimens from Hawaii agree in detail with the type.

Fig. 14. *Periconia prolifica* sp. nov. a-c. Acropetal development of sporogenous cells. d-e. Basipetal production of conidia. f. Short, branched conidiophore producing sporogenous cells. g-k. Terminal production of a single conidium. l-m. Basipetal production of sporogenous cells and conidia. n. Aerial branched conidiophore bearing mature spores. o-r. Atypical conidia. s-v. Typical globose spores. a-f, scale A; g-v, scale B.

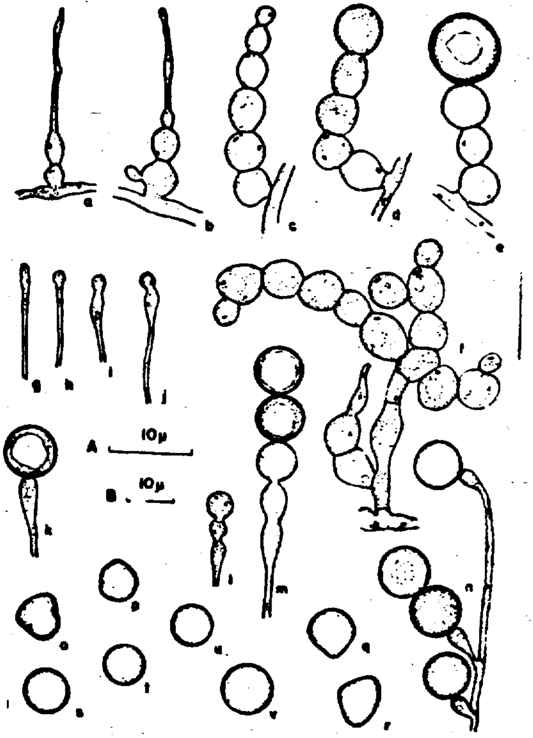
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Fig. 15. *Periconia prolifica* sp. nov. a-b. Acropetal production of sporogenous cells. X 2330. c-d. Basipetal production of conidia. X 2330. e. Micronematous-branched conidiophore with sporogenous cells and conidia at various stages of development. X 640. f. Chain of conidia released from the conidiophore. X 2330.

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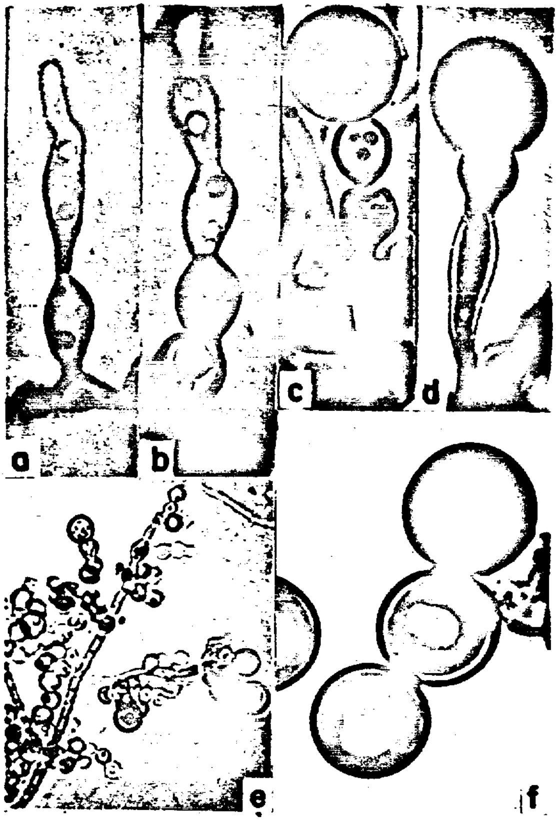

ACROSPEIRA Berk. & Broome

Ann. Mag. Nat. Hist. Ser. III, 6: 449. 1861.

Vegetative mycelium hyaline or darkening with age; aleuriophores hyaline or sometimes dark, unbranched; aleuriospores dark, apical, composed of 1-6 cells, produced from a hooked or coiled initial; phialophores hyaline, producing one-celled hyaline phialospores in chains.

In 1861, Berkeley and Broome described Acrospeira mirabilis as a monotypic genus characterized by a spiral, septate spore primordium in which a single cell enlarges and becomes the functional spore. Wiltshire (1938) described an additional species, A. levis, and transferred Stemphyllium macrosporoidea Berk. and S. asperospora Cooke & Massee into Acrospeira. Although A. macrosporoidea and A. asperospora are similar to A. levis, their spore primordia and mature spores bear little resemblance to those of A. mirabilis. Acrospeira levis and A. mirabilis are similar in the shape of their spore primordia, their method of spore maturation and in their phialospores. Although Wiltshire was hesitant about placing A. macrosporoidea and A. asperospora with A. mirabilis, he did so on the basis of their respective similarity to A. levis. Later, Hughes proposed the genus Monodictys (1958) for a group of dark-spored imperfect fungi having solitary or clustered conidiophores which produce dictyospores singly at the apex. In this assemblage he included A. levis and A. macrosporoidea but, for some unknown reason, did not mention A. asperospora. Almost simultaneously with Hughes' publication of Monodictys, Moore (1958) emended the genus Piricauda on the basis of his studies of the type species, P. paraguayense (Speg.) Moore (P. uleana (Sacc. & Syd.) Bubák), and shortly thereafter (Moore, 1959) placed

Monodictys in synonymy with *Piricauda*. In 1960, however, Hughes showed that the long attenuate structure attached to the conidium of *P. paraguayense* is an appendage rather than the conidiophore, as was believed by Moore (1959) and earlier by Bubák (1914). Viewed in this light, it appears more reasonable to regard *P. paraguayense* as the sole member of a genus differentiated from *Stemphyllium* by its long appendage. *Monodictys*, on the other hand, does not appear to be clearly distinguished from other dictyosporous genera, being constituted on such a broad basis as possibly to include even sporodochial forms. In view of the similarities between *A. levis* and *A. mirabilis*, therefore, I prefer for the present, to accept Wiltshire's original disposition of *A. levis*, retaining it in *Acrospeira*.

ACROSPEIRA LEVIS Wiltshire

Trans. Brit. Mycol. Soc. 21: 236. 1938.

Vegetative mycelium hyaline, 3 µ diam.; aleuriophores short, simple, or branched; aleuriospores usually globose, divided into 2-6 globose, smooth-walled cells, provided with an obconical inferior cell, 12-25 x 10-19 µ, dark at maturity.

Specimens examined: NETHERLANDS: culture obtained from the Centraalbureau voor Schimmelcultures, Baarn, 1938, *S. P. Wiltshire* (CMI, Holotype). Same, 1962, *C. J. Anastasiou* (CBS "meel"). CANADA: on wood of *Thuja occidentalis* in La Fleche Cave, Point Gatineau, *J. K. Shields* (DAOM 64050). CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, December 26, 1960, *S4*; March 12, 1961, *S35*; December 20, 1961, *S126*.

An organism having many of the characteristics of Acrospeira levis has been collected several times from the Salton Sea. As in A. levis, the pores between the cells of the spore are prominent. At least some of the spores have germination pores in the outer walls. This character seems to be variable in other isolates of A. levis. For example, in DAOM 64050 germ pores are found on a very small percentage of the spores compared with the type. In addition to these characters, spore-cell size and spore size are comparable though the Salton Sea fungus tends to form more elongate spores (see Table II).

Spore development in the Salton Sea isolates is very similar to that described for the type. As shown in fig. 16a-d, the primordium may be hook-shaped to begin with and, by septation and enlargement of the distal cells, produce spores quite characteristic of A. levis. On the other hand, the most common type of development is illustrated in fig. 16e-j. Here a more simple type of development occurs in which additional lateral cells are produced by longitudinal division of young spore cells. This gives rise to typical dictyospores (fig. 16 l,h,q; fig. 17e) or more often to three-celled spores (fig. 16m; fig. 17b,c). Three-celled spores resulting from a hooked primordium appear as in fig. 16o.

The conidiophores of both the Salton Sea organisms and A. levis remain attached to the spores after these are released.

The fungus from the Salton Sea differs from the type isolate by producing dictyospores which have the cells very strongly constricted at the septum (fig. 16k-p; fig. 17a-e). The spores of all observed isolates of A. levis are very compact at maturity and are very uniform in appearance. The spores of the Salton Sea organism are extremely

Fig. 16. *Acrospeira levis* Wiltshire. a-d. Development of conidia from a hook-shaped primordium. e-j. Normal conidial development. k-q. Typical conidia.

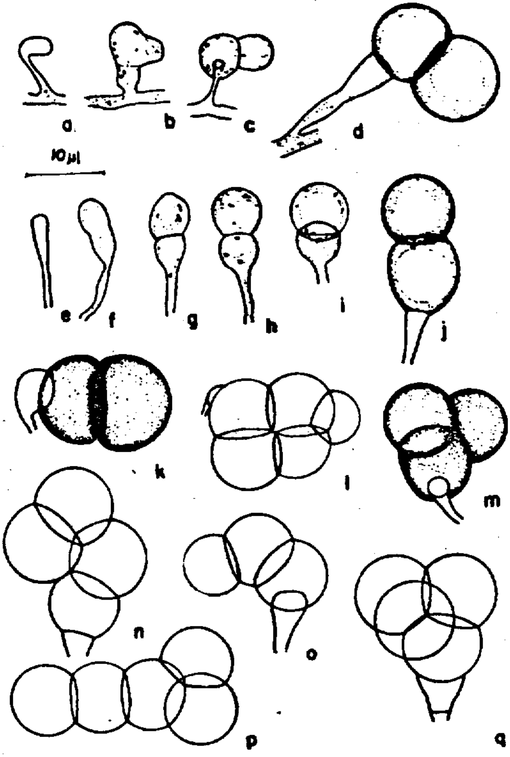
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Fig. 17. *Acrospeira levis* Wiltshire. a. Elongate conidia on conidiophores and subtending hyphae. X 1000. b-d. Conidia produced aerially on wood in a moist chamber. X 2330. e. Conidia produced embedded in submerged wood. X 1000.

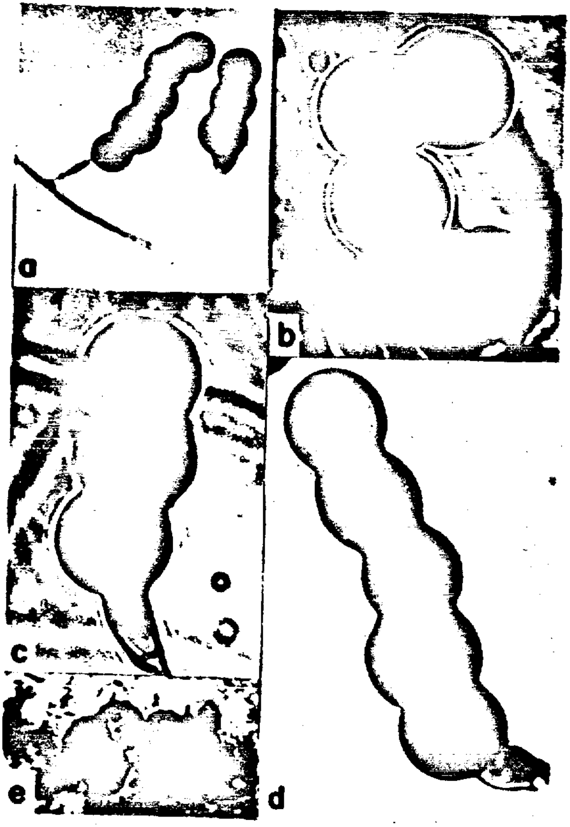
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TABLE II

A Comparison of Spore-cell Size and Spore Size of <u>Acrospeira levis</u> from the Salton Sea and Three Terrestrial Strains

	Spore Size (µ)		Cell Size (µ diam.)	
	Range	Average	Range	Average
Type (CMI)	12.5-20.5	15.1(diam.)	8.9-12.5	10.4
DAOM 64050	12.5-22.3	17.1(diam.)	7.7-16.0	13.9
CBS ("meel")	14.2-24.0	19.4(diam.)	8.9-20.5	13.2
S35	12.2-35.7 x 8.7-17.4	17.8 x 12.0	7.0-11.3	9.1

variable when produced on aerial mycelium, very often forming chains of cells five to six or more cells in length (fig. 17a,d). On the other hand, many of the spores consist of one or two cells (fig. 16d,j). In addition to these differences, S35 did not produce phialospores.

When produced on immersed wood, the spores are embedded (fig. 17e) (as in Contortospira varia) and are disseminated as the softened surface fibres are washed away. Spores produced between the fibres and in the lumens of wood cells are almost always three- or four-celled (fig. 17e) and appear to have been produced from hooked primordia.

ALTERNARIA Nees emend. Wiltshire

Trans. Brit. Mycol. Soc. 18: 135. 1933.

Vegetative mycelium hyaline or dark, decumbent; conidiophores dark, erect, simple or branched, single or in groups, septate, producing conidia terminally and proliferating laterally to the conidial scar; conidia dark, muriform, smooth or warty, typically obclavate; spore body oval or irregularly oval with rounded base and often a beaked apex; at least some of the conidia borne in chains.

Key to the species treated.

A. Conidia 25-73 x 14-36 µ........................... A. radicina

AA. Conidia 10-50 x 5-14 µ........................... A. tenuis

ALTERNARIA RADICINA Meier, Drechsler, & Eddy

Phytopath. 12: 164. 1922.

Vegetative mycelium dark, 2.5-7.0 µ diam.; conidiophores dark brown; conidia produced in long chains, smooth, 25-73 x 14-36 µ, 3-8 transverse septa and a single longitudinal septum dividing some or all of the cells, beak well or poorly developed.

Specimen examined: CALIFORNIA: On *Tamarix aphylla* wood submerged in the Salton Sea, June 24, 1961, S46.

The only large-spored species of *Alternaria* encountered in the Salton Sea was *A. radicina*, a common seed-borne soil fungus. Its spore size, 26.7-71.2 x 14.2-35.6 μ ($\bar{x}$ = 41.4 x 25.6 μ) compares well with measurements reported by Groves and Skolko (1944).

Alternaria radicina grows well on SSwa and Swa. The isolate sporulated weakly on both media and produced a grayish colony with abundant aerial mycelium.

ALTERNARIA TENUIS Nees emend. Neergaard

In Danish Species of *Alternaria* and *Stemphyllium*, p. 114. 1945.

Vegetative mycelium dark; conidiophores brown, short, septate, olivaceous, 3-6 μ diam.; conidia in short or long chains, smooth or warty, 3-5 cross walls, olive brown to dark brown, obclavate, with or without short beaks, 10-50 x 5-14 μ.

Specimens examined: CALIFORNIA: on *Tamarix aphylla* wood submerged in the Salton Sea, December 26, 1960, S1, S2, S12; March 12, 1961, S18, S31, S32.

Alternaria tenuis, commonly developed on wood removed from the Salton Sea, produces the long chains of spores characteristic of the species as circumscribed by Neergaard (1945). It also has been reported from marine and estuarine locations by Siepmann (1959a,b) and Siepmann and Johnson (1960).

Some variation in spore size among the specimens examined was noted:

Isolate	Spore size (µ)
S2	14.2-40.9 x 8.9-19.2 ($\bar{x}$ = 24.9 x 13.1)
S18	10.7-35.6 x 5.3-14.2 ($\bar{x}$ = 21.1 x 11.0)
S31	14.2-32.0 x 7.1-13.9 ($\bar{x}$ = 21.1 x 10.4)

Alternaria tenuis grows well on SSwa and produces a variety of colony types depending on the isolate and sporulation. Weakly or non-sporulating colonies are grayish with lush growth of aerial mycelium. Vigorously sporulating colonies are black with a more or less irregular margin.

Contortospira gen. nov.

Fungus imperfectus, saprophyticus; mycelio hyalino, septato, ramoso; conidiophoris hyalinis, simplicibus, septatis, per occasionem nullis; filamentis conidialis in planis tres vel inaequalite glomeratis, per occasionem ramosis vel conidium alium subtentis.

Imperfect fungus, saprophytic, mycelium hyaline, septate, branched; conidiophores hyaline, simple, septate, occasionally absent; conidial filament coiled in three planes or irregularly and forming a tangled knot or ball of cells; conidial filaments sometimes branched and occasionally subtending an additional conidium.

An imperfect fungus normally producing helicospores was collected several times embedded in wood submerged in the Salton Sea. The organism cannot be placed in any known genus, but is related to both *Helicoon* and *Hobsonia*.

The genus Contortospira is similar to Helicoon but differs from it by producing spores with an irregular spiral in three dimensions. Contortospira, a dematiaceous genus, differs from Hobsonia, a member of the Tuberculariaceae, which also has spores with irregular spirals.

Contortospira varia sp. nov.

Fungus aquaticus submersus; conidiophoris ad 30 x 3-7 μ; conidiis in substrato immersis vel in mycelio effuso positis, fuscis, in massam atris, 15.0-65.2 x 13.5-55.8 μ ($\bar{x}$ = 38.6 x 30.0 μ); cellulis conidialis 5.4-13.1 x 4.7-10.4 μ ($\bar{x}$ = 8.9 x 7.3 μ).

Submerged aquatic fungus; conidiophores up to 30 u x 3-7 u; conidia embedded in the substratum or on an effuse mycelium, brown to dark brown, black in mass, 15-65.2 x 13.5-55.8 μ ($\bar{x}$ = 38.6 x 30 μ); conidial cells 5.4-13.1 x 4.7-10.4 μ ($\bar{x}$ = 8.9 x 7.3 μ).

Holotype: CALIFORNIA: on Tamarix aphylla wood submerged in the Salton Sea, December 20, 1961, RSA 22. Transfers of this holotype have been deposited at RSA, ATCC, CBS, CMI.

Additional specimens examined: Same data as the type, March 11, 1961, S33, S36; December 20, 1961, S116.

Contortospira varia is characterized by extremely variable spores ranging from simple Helicoma-like structures (fig. 18a) to very large, multicellular spores typically found embedded in the softened surface of the wood (fig. 18k). The organism is easily detected with a hand lens or may even be visible to the naked eye. The wood chip characteristically has a black speckled appearance, with the specks slightly below the surface of the wood. When the surface is scraped away, additional spores are visible below the more superficial ones. The embedded spores are normally produced between softened fibres (fig. 19e-f) and occasionally in their lumina. Such embedded spores often reach a very large size and may be composed of several hundred cells. Careful examination of the spore reveals its basic helicoid structure in spite of its often bizarre shape (fig. 18j,k).

The spores of Contortospira varia usually develop on conidiophores, which may be septate (fig. 18f; fig. 19d; fig. 20b) or non-septate (fig. 18d,e). The conidia may, however, be sessile (fig. 18a-c). The conidial initials are coiled, hyaline structures in which the cells swell up and become darkened as the spores mature. Even in some of the simpler spores (fig. 18d-i) their coiled nature often is obscured because of the irregular manner in which the spore filaments twist and occasionally branch (fig. 18d).

When C. varia is allowed to incubate on moist filter paper in a petri dish, abundant aerial spores are produced. These spores (fig. 18f, g; fig. 19a-c) are basically helicoid but the spiral is very loose and the spores often break into short Helicoma-like fragments. Some of the spores fail to coil and are simply long, many celled strands.

Branching of spores often occurs, both when they are produced aerially and when they are embedded in the wood. In a large embedded spore, several branches may be produced which coil about and between one another adding to the complexity of the spore. The filaments of the aerial spores rarely branch more than once.

The production of spores between softened wood fibres (fig. 19e-f) probably represents an adaptation for aquatic dissemination. As the wood is eroded, successive layers of spores are presumably exposed and carried away still attached to wood fibres. This would seem to prolong

Fig. 18. Contortospira varia gen. nov., sp. nov. a-c. Sessile conidia. d-i. Aerial conidia produced in a moist chamber. j-k. Spores produced embedded in submerged wood.

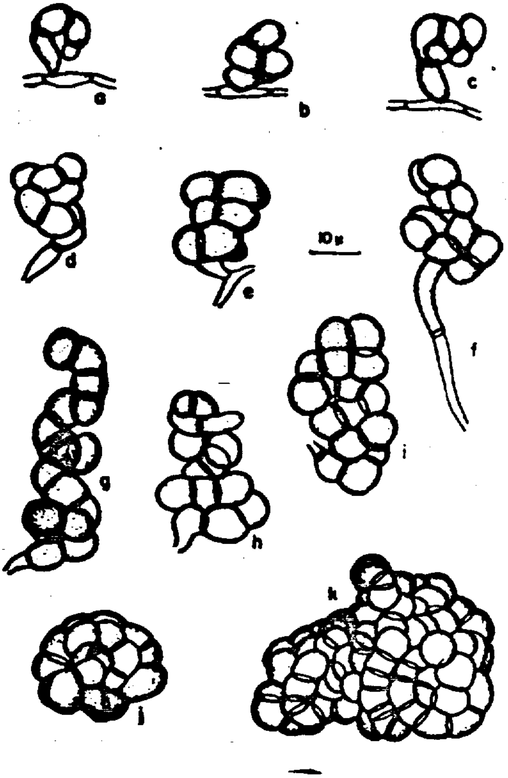
a
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Fig. 19. *Contortospira varia* gen. nov., sp. nov. a-d. Conidia produced aerially on wood in a moist chamber. X 620. e-f. Conidia produced embedded in submerged wood. X 1000.

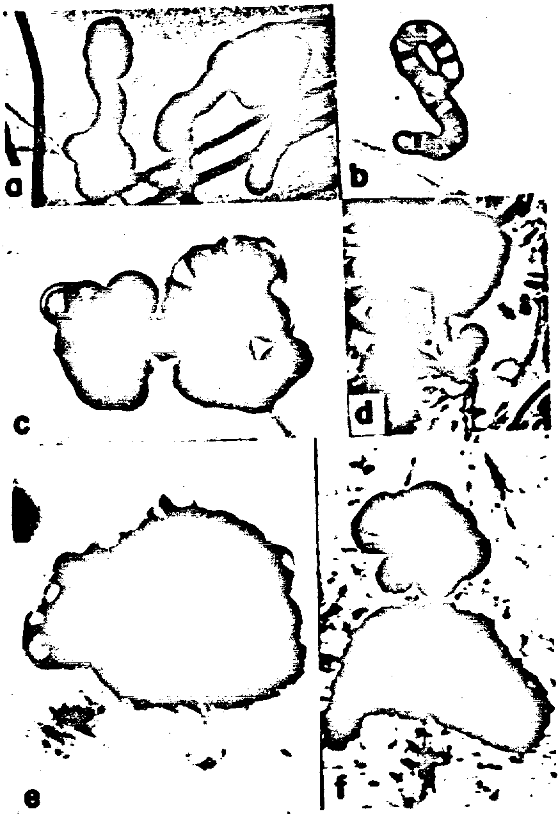
a
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Fig. 20. *Contortospira varia* gen. nov., sp. nov. a. Spore-like structure from culture. X 2330. b. Aerial spore with an elongate cellular conidiophore. X 1000.


a
b

the period of suspension of such large and complex spores. This type of spore production also has been encountered in Acrospeira levis where spores composed of 2-5 cells are produced embedded in the surface layers. Besides dissemination, protection of the developing spores is probably important in both species producing spores in this manner.

Contortospira varia grows very slowly on SSwa, producing a colony only 1 cm. in diameter after incubation for 5 weeks at room temperature. Comparably slow growth also takes place on Swa, YpSs, MeYe, and PDA. On SSwa the mycelium forms very dark, contorted, spore-like structures on the surface of the medium and embedded slightly in the agar (fig. 20a). These structures form a crust over the older part of the colony and when mounted for examination tend to break into segments in a manner similar to that observed for aerial spores from the wood substrate.

Mycelia Sterilia

PAPULASPORA Preuss

In Sturm's Deutschlands Flora, Abt. III, 30: 89. 1851.

Vegetative mycelium hyaline, occasionally dark, producing compact masses of small cells developed from a multicellular primordium; asexual spores lacking.

In the course of examining fungi from the Salton Sea, an organism was encountered which I also have isolated several times from panels submerged in Alamitos Bay, Los Angeles County, California. Because the fruiting structures are complex balls of rounded cells, loosely or densely compacted, and derived from multicelled primordia, they can best be described as bulbils. The organism is therefore placed in the genus Papulaspora.

The genus Papulaspora was established by Preuss (1851) and revised and monographed by Hotson (1912, 1917) to include (Hotson, 1917) all those fungi without known perfect stages or conidia which produce "reproductive bodies of more or less definite form, composed of a compact mass of homogeneous cells which may be few or many in number, but which are usually developed from primordia of more than one cell." The genus circumscribes an extremely heterogenous group of organisms including some basidiomycetes. Hotson (1912) describes three types of primordi. resulting in the production of bulbils. In the simplest type, the bulbil develops from a group of intercalary cells; in a more complex form it develops from a primary spiral; and in the most complex form it develops from one or more perpendicular branches of a hypha. The species of Papulaspora described below is of the third type.

Papulospora halima sp. nov.

Fungus myceliis sterilis; mycelio ramosa, septato, hyalino, pigmentum brunneum faciente; septa ad marginem circulo crasso refractivo-radiosum; bulbilis deinde hyalinis vel atris, 35-500 µ diam., ex cellulis globosis constatis, 7.0-15.7 x 6.1-12.2 µ ($\bar{x}$ = 11.6 x 9.8 µ), ex cellulis primordialis ramosis aut mycelio aetherio aut in agaro submersis oriendi.

Mycelium branched, septate, hyaline, producing a brown pigment; septa with a refractive, thickened, peripheral ring; bulbils hyaline to black in age, 35-500 μ diam., of spherical cells 7.0-15.7 x 6.1-12.2 μ ($\bar{x}$ = 11.6 x 9.8 μ). Bulbils formed from branching primordia in the aerial mycelium and submerged in the agar.

Holotype: CALIFORNIA: on *Tamarix aphylla* wood submerged in the southern marshes of the Salton Sea, July 20, 1961, RSA 23. Transfers of this holotype have been deposited at RSA, ATCC, CBS, CMI.

Other specimens examined: CALIFORNIA: on waterlogged driftwood from the bottom of the Salton Sea, July 20, 1961, S99, S100; on hemlock panel submerged 12 weeks in Alamitos Bay, Los Angeles County, February 26, 1961, C53; same, on spruce panel submerged 10 weeks, June 4, 1961, C109; same, on oak panel submerged 10 weeks, June 4, 1961, C75.

Papulaspora halima is characterized, in culture, by the production of an Argus brown (Ridgway, 1912), water soluble pigment. This pigment was produced in SSwa, Swa, YpSs, and MeYe media, but was not produced when the fungus was grown on PDA. The septa of the vegetative hyphae bear refractive rings which cause the walls to bulge (fig. 21e; fig. 22b-c). The refractive rings are particularly conspicuous in relatively young hyphae. Hyphal fusions are very common in culture (fig. 10 l; fig. 22b-d). The wall is thickened and slightly roughened where hyphae fuse together (fig. 22c-d). In many cases branches from adjacent cells undergo fusion (fig. 10m; fig. 22b). Rarely, structures appearing to be clamp connections have been found on the hyphae; only three (fig. 10n) were discovered during the course of the investigation.

The development of bulbils begins when a single vegetative hypha forms a series of short swollen cells, which give rise to branches that at first are very fine, and often coiled and twisted (fig. 10k). These branches also become septate and form short swollen cells (fig. 10k; fig. 21a), which may in turn branch and form a complex bulbil primordium (fig. 21b). Eventually the cell mass becomes dark stained and at maturity the bulbil is opaque. Most bulbils are relatively small (fig. 21c) but some reach a fairly large size (fig. 21d) and are conspicuous to the naked eye on the wood substrate or in culture. When formed submerged in agar, the bulbils consist of cells that vary greatly in size (fig. 22a).

Papulaspora halima grows well on SSwa, Swa, and YpSs, and may cover the agar surface in a petri dish culture in a period of two to three weeks. On PDA and MeYe only 1 cm. of growth occurred after three weeks of incubation at room temperature. No growth was visible after three weeks of incubation on Fwa at room temperature.

Papulaspora halima appears to resemble most closely *P. aurantiaca* Hotson, from which it is separated by the manner of bulbil production. In *P. aurantiaca* the bulbil primordia are spiral, but in *P. halima* a complex branching primordium occurs (fig. 10k; fig. 21a-b). In *P. halima* fine coils may occur toward the ends of newly formed branches, but these appear to uncoil as the cells enlarge acropetally and they bear little similarity to the sturdy coils of *P. aurantiaca*. Prolific coiling of the aerial mycelium occurs early in the development of *P. halima* on the wood substrate (fig. 22e), but this does not seem to be related to bulbil formation. This phenomenon has not been observed in culture. *Papulaspora halima* also differs from *P. aurantiaca* by the conspicuously swollen septal rings and the consistent production of a brown pigment.

Fig. 21. *Papulaspora halima* sp. nov. a-b. Bulbil primordia produced on moist wood in a moist chamber. X 310. c. Mature bulbil produced on moist wood. X 145. d. Large, sclerotium-like bulbil produced on moist wood. X 145. e. Thickened, refractive septal ring in vegetative hypha. X 2330.

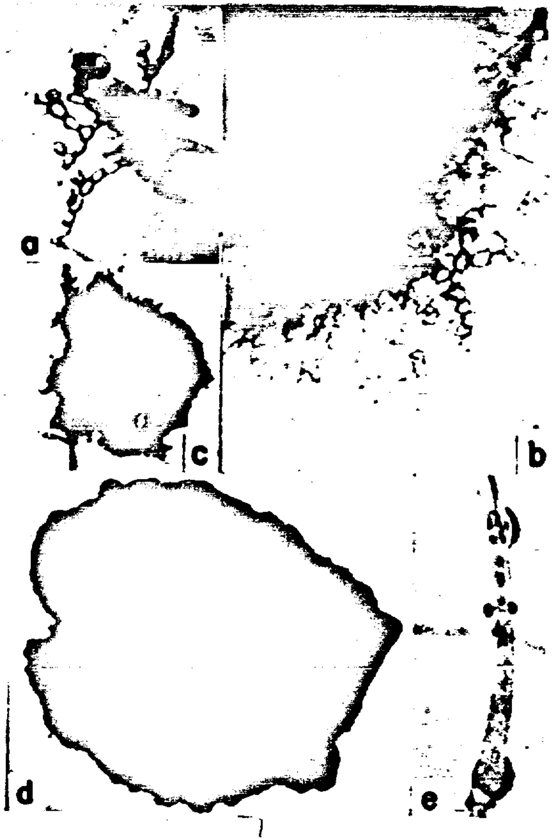
a
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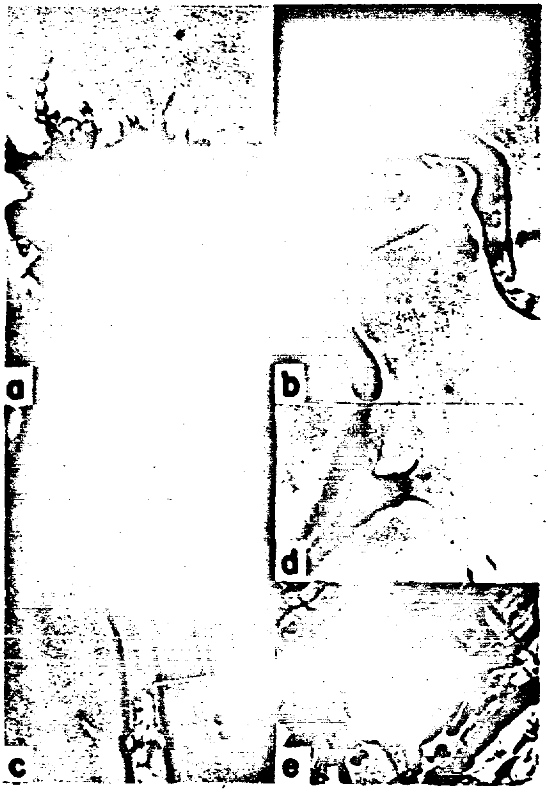
Fig. 22. *Papulaspora halima* sp. nov. a. Bulbil produced submerged in culture. X 310. b-d. Hyphal fusions in vegetative mycelium. X 2330. e. Coiling of aerial mycelium in wood substrate. X 620.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DISCUSSION

Aquatic Adaptations

The fungi of the Salton Sea are mainly of two types, those which are principally adapted for a terrestrial existence but are capable of flourishing under the conditions found in this lake, and those which are specifically adapted for survival under aquatic conditions. Among the latter ascomycetes and imperfect fungi certain adaptations have been selected for under salt water conditions. These adaptations mainly fall into two categories;

1. Those which bring about suspension of the reproductive structure in the water for a longer period of time than would occur in the absence of the adaptation.
2. Those which aid the attachment of the reproductive structure to a favorable substratum.

In reproductive structures where these adaptations occur they usually form the distinctive characteristics and, depending on the form they take, determine the spore type. Because of the fact that evolution toward these adaptations has taken place in several different ways, a number of aquatic spore types may be recognized, each of which bears an expression of one or both of the above types of adaptations.

The Vermiform Spore

The vermiform or filiform spore type is common among aquatic fungi, especially among fresh water hyphomycetes, e.g. *Anguillospora* and *Flagellospora*, and ascomycetes, e.g. *Apostemidium* (Ingold, 1953). The pollen of some aquatic angiosperms also takes this form as in the marine eelgrasses, *Phyllospadix* and *Zostera*.

Among the fungi of the Salton Sea, vermiform spores are produced by *Lulworthia medusa* and *L. opaca*. These two pyrenomycetes produce a long filiform spore with an appendage-like cell at each end. The long filiform spore acts as a parachute as it falls through the water and the appendage-like end cell serves for attachment.

When a perithecium of *Lulworthia opaca* releases spores in Salton Sea water, the spores leave the perithecium through the ostiolum, one after another, with a slow spiral motion. As one spore slowly falls back to the substratum, the succeeding spore often catches it and forces it further up into the water. While the spores remain suspended above the perithecium they are carried away by the slightest current.

The spores of *Lulworthia medusa*, which are twice as long as those of *L. opaca*, tend to coil or bend as they spiral out of the perithecium into the water. Under laboratory conditions, these spores usually become entangled about the perithecium after release. Under field conditions, they probably are carried away quickly.

The appendage-like end cells of *Lulworthia* have a gelatinous epispore wall which is extremely sticky in water, and the spore appendages of *L. opaca* often adhere as the spores pass out of a ruptured perithecium in a water mount. The spores of a single ascus may form an accordion-like chain of eight spores attached to one another by their appendage-like end cells. As reported by Barghoorn and Linder (1944), the appendage-like end cells adhere tenaciously to glass slides or pipettes.

The Appendaged Spore

One of the most common spore types found among salt water ascomycetes is the elipsoid or fusiform two-, or occasionally, many-celled spore bearing gelatinous appendages. It is also occasionally found among fresh water forms such as *Ceriospora caudae-suis* Ingold (1953) which bear a long, coiled appendage at each end of the ascospore. These appendages apparently function both in suspension and attachment. The appendage of *Loramyces fucicola* Weston (1929) does not serve for attachment directly since the spore falls through the water with the appendage trailing and is firmly attached to the substratum by a gelatinous sheath around the head of the spore.

Among marine ascomycetes, hyaline appendages are almost uniformly present on the spores of hyaline-spored species. As far as I know, of the dark-spored species, only *Didymosphaeria spartinae* Grove (1933) bears appendages of this type. Several representatives of the marine pyrenomycetes with appendaged spores are found in the Salton Sea, *Ceriosporopsis halima*, *Halosphaeria mediosetigera*, and *Peritrichospora integra*.

As suggested by Linder (Barghoorn and Linder, 1944), these appendages appear to slow the descent of the spore through the water and to facilitate its attachment to favorable substrata. There are two distinct types of gelatinous appendages: (1) rigid or setose, represented by the lateral appendages of *H. mediosetigera* and the terminal appendages of *P. integra*; and (2) flexuous, represented by the lateral appendages of *P. integra* and the terminal caps of *H. mediosetigera* as well as the appendages of *Ceriosporopsis halima*. Both *P. integra* and *H. mediosetigera* bear both types of appendages.

The flexuous appendages probably are most effective as organs of attachment and the rigid ones most effective in resisting sedimentation. As observed by Linder (Barghoorn and Linder, 1944) and Kohlmeyer (1959) both types of appendages serve to attach the spores to glass slides and other substrata so that they are not easily dislodged. This phenomenon is readily observed when attempts to pipette spores of this type are made.

The Sheathed Spore

Several species of marine fungi produce spores which are sheathed in a layer of gelatinous material, notably *Guignardia ulvae* Reed (1902), *Rosellinia laminariana* Sutherland (1916), and *Massariella maritima* Johnson (1956). An addition to this group is *Leptosphaeria orae-maris* Linder as it occurs in the Salton Sea. When examined in an India ink mount, a spore of *L. orae-maris* has a thin halo about it which probably represents a sheath of slime. As mentioned previously, freshly released spores of *L. orae-maris* become firmly attached to structures about the perithecium, apparently by means of their gelatinous sheaths.

The Tetraradiate Spore

Many aquatic plants produce tetraradiate reproductive structures. They are most common among the fresh water aquatic hyphomycetes where such genera as *Alatospora*, *Articulospora*, *Clavariopsis*, *Heliscus*, *Lemonniera*, *Tetrachaetum*, and *Tetracladium* produce four-armed spores. The tetraradiate condition apparently is of special significance in the aquatic environment since, as Ingold (1953) points out, it has evolved in many different ways among fresh water imperfect fungi and is also found in the propagules of some brown algae, i.e. species of *Sphacelaria*.

In 1959, Webster carried out a study of the sedimentation and impaction of tetraradiate fresh water aquatic hyphomycetes. As a result of his comparison of tetraradiate spores with spores of other shapes, he found that there is no appreciable difference in the sedimentation rates. He did not, however, completely eliminate the problem of convection currents, which would have a drastic effect on sedimentation. As Webster pointed out, the effect of spore structure on sedimentation would be negligible in fast moving streams since the spores would be carried far before settling out regardless of their shape. Ocean currents, however, generally are not as rapid as those of a rushing stream and small differences in spore sedimentation rates may be more critical in this environment.

From his studies on impaction, Webster (1959) found that tetraradiate spores definitely are more effectively retained by traps set up in an experimental stream of water. He attributes this to the fact that such spores always contact the surface of an obstruction by three of their four divergent arms and thus form a stable tripod.

Among salt water fungi, *Nia vibrissa* Moore and Meyers (1959), *Orbimyces spectabilis*, and *Clavariopsis bulbosa* have tetraradiate spores. Among these fungi, however, the number of arms is not constantly four, ranging from one to seven in *C. bulbosa* and even more in *O. spectabilis*. Of these three only *C. bulbosa* has been reported from the Salton Sea.

Experiments with certain strains of *C. bulbosa* have shown that the production of tetraradiate spores may be stimulated by growth in immersed cultures. When grown in agar culture or on damp wood in a moist chamber, most of the spores of these isolates bear only a single arm. However, when placed in water, the spores produced are predominately 4-armed.

Observations of C. bulbosa indicate that the tetraradiate spore is more easily retained by the surface tension membrane than spores without arms. When spores submerged in water are stirred, the tetraradiate ones tend to be caught by the surface tension membrane. Once caught, they tend to float indefinitely. It is because of this that so many spores are found in froth which accumulates in streams. In the oceans, a spore thus caught may be transported a very long distance.

Clavariopsis bulbosa will usually fruit aerially if the colony is growing within a few centimeters of the surface of the water. When the spores are released, they drop onto the water and form a dense layer over the surface which soon develops into a thin mycelial mat. It is not known whether such immediate germination occurs in nature.

The Helicoid Spore

Another aquatic spore type, though not restricted to this habitat, is the helicoid spore. The most common aquatic fungi bearing spores of this type are Helicodendron, Helicoon, Helicoma, and Helicomyces. Glen-Bott (1951) and van Beverwijk (1954) described species which develop on leaves submerged in streams and apparently sporulate when the leaves are exposed after the streams dry up or subside. If the colony is re-submerged, the spores bob to the surface and float, aided by the helical structure which enmeshes a bubble of air which is not readily displaced (Ingold 1953). Where the spore helix consists of only one or two turns it is doubtful that this mechanism is as effective as in more complex spores of this type.

Two genera of helicosporous fungi have been reported from marine habitats, Helicoma, represented by H. maritimum Linder (1944) and H. Salinum Linder (1944), and Cirrenalia, represented by C. macrocephala (Kohlmeyer) Meyers and Moore (1960). The spores of H. maritimum are formed of a filament which is coiled one and one quarter turns, whereas those of H. salinum usually are coiled one and three quarters to four or more turns. The significance of this type of helical spore seems to rest mainly in its ability to resist rapid sedimentation and to be caught easily when it contacts a substratum.

In the Salton Sea the helicoid spore is characteristic of Contortospira varia which will sporulate abundantly when the colony is removed from the water. In the water, the spores normally are produced embedded in and between the wood fibres. It is probable that many of the aerial spores would be effectively disseminated when the colony is re-submerged in water. When an aerially sporulating colony was re-submerged in Salton Sea water under laboratory conditions, many of the spores were left floating on the surface of the water. After the first submersion, air bubbles were trapped in the meshes of the more complicated spores which still remained attached to their conidiophores. After the third submersion most of the bubbles of trapped air had been displaced, and after five submersions no air bubbles could be detected in any of the spores examined. It is doubtful that these spores would bob to the surface when released from their conidiophores. Under conditions at the Salton Sea it is likely that many colonies of this fungus become exposed to the atmosphere and sporulate aerially when the lake subsides in summer. Such colonies will become re-submerged and exposed many times when the water is rough and effective dissemination of the spores may be expected, both on and below the surface.

The Embedded Spore

Two species of fungi from the Salton Sea, Contortospira varia and Acrospeira levis, produce spores embedded in the fibers of submerged wood. This appears to be the only way spores of C. varia are produced when the colonies are continuously submerged. In one specimen of A. levis all the spores observed were embedded in the fibers but in other colonies both surface and embedded spores were produced. Examination of the surface of a fresh collection of Contortospira varia on its natural substratum reveals that when the apores are loosened and exposed by the action of water, they often are attached to fine bits of wood fibers. It is likely that the fine bits of fibers cause the spores to remain suspended a longer period of time because of the increased surface area.

Besides this possible aid to dissemination, protection of the spores during their development may also be important.

The Bulbil

Although bulbil production by Papulaspora halima was not studied under aquatic conditions, the manner in which such structures are formed would seem to favor aquatic dissemination. When the bulbils are first observed developing on wood panels, they appear as networks of hyaline cells easily dislodged from the parent mycelium. These networks, illustrated in fig. 21a-b exhibit structural characteristics which would result not only in a low sedimentation rate, due to parachute action of the open mesh, but also in a tendency to be easily retained by any irregularity of a substratum with which they may come in contact.

Other Aquatic Adaptations

Ascus deliquescence is almost universal among hyaline spored lignicolous marine ascomycetes. The exceptions generally are among bitunicate forms such as Paraliomyces lentiferus Kohlmeyer (1959).

Deliquescence is rare among phaeosporous ascomycetes, especially those with bitunicate asci which apparently function more effectively under aquatic conditions.

As Linder (Barghoorn and Linder, 1944) pointed out, it is to be expected that aquatic ascomycetes would have evolved an alternative method of spore discharge from the forceful discharge of ascospores occurring in terrestrial forms.

At spore maturation or just prior to it, the asci deliquesce and appear to increase the volume of fluid inside the perithecium, thus forcing the spores out through the ostiolum. When this occurs in moist chambers, the spores accumulate at the tip of the ostiolum in a globular mass. When discharged under water, the spores float away.

In spite of the widespread occurrence of ascus deliquescence in marine fungi, asci, especially bitunicate forms, appear to function very well under water. If, in Amphisphaeria verruculosa, a slightly immature perithecium is injured, the asci elongate through the break in the wall and release their spores in a manner similar to that observed in terrestrial ascomycetes. When the ascospores are ejected, they emerge from the ascus with a jerking motion, then float away with the water currents and settle. In a petri dish culture a majority of the spores remains about the ostiolum and at the base of the perithecium.

An additional characteristic of many marine fungi, especially those which bear appendages or gelatinous sheaths, is the presence of large oil droplets within the spores. In such species as Ceriosporopsis halima and Halosphaeria mediosetigera the guttules are so large that the remaining cytoplasm of each cell occupies only an extremely thin peripheral layer. The presence of large quantities of oil in the spore, aside from its food storage function, may serve to lighten it and thus slow its sedimentation rate.

Affinities of the Salton Sea Fungus Flora

The fungi of the Salton Sea are not restricted to this lake, but are found in oceans, estuaries, and other salt lakes. Such species as *Lulworthia opaca*, *L. medusa*, *Peritrichospora integra*, *Ceriosporopsis halima*, and *Halosphaeria mediosetigera* are common marine fungi which have been or will probably be found all over the world, wherever temperature and salinity conditions permit. *Botryotrichum piluliferum*, *Stachybotrys atra*, *S. subsimplex*, *Fusarium solani*, *Alternaria radicina*, and *A. tenuis* are common terrestrial fungi capable of thriving under ocean and salt lake conditions. Species such as *Acrospeira levis*, *Periconia prolifica*, and *Clavariopsis bulbosa* do not appear to be as common in the oceans but all have been found there. *Contortospira varia* and *Amphisphaeria verruculosa* have thus far been reported only from salt lakes.

The two factors which most likely determine the organisms found in the Salton Sea are salinity and temperature fluctuation.

The salinity of the Salton Sea is closely comparable to that of the oceans, the main difference being in the concentrations of the various ions and this is very slight (see Table 1). Salinity is probably not a limiting factor in view of the broad salinity tolerances of such marine fungi as *Piricauda pelagica* Johnson (Gold, 1959) and *Helicoma maritimum* Linder, not known in the Salton Sea but common just a hundred air miles west of it in the Pacific. Indeed, *H. maritimum* grows well on SSwa.

The distribution of many marine fungi seems to be affected by water temperature. For example, such a species as *Cirrenalia macrocephala* (Kohlmeyer) Meyers & Moore (1960) is restricted to relatively temperate waters, whereas such species as Antennospora quadricornuta (Cribb & Cribb) Johnson & Sparrow have clearly tropical distributions. The marine ascomycetes which occur in the Salton Sea are mainly common species of temperate waters: Leptosphaeria orae-maris, Halosphaeria mediosetigera, Lulworthia opaca, Peritrichospora integra, and Ceriosporopsis halima. Of these, P. integra and L. opaca have been shown experimentally to tolerate temperatures as high as 30°C and yet grow well at much lower temperatures (Barghoorn & Linder, 1944).

It must be borne in mind that while some of these fungi undoubtedly have wide tolerances and are capable of surviving under widely varying conditions, the existence of races adapted to specific environments is to be expected.

Among the imperfect fungi, discounting Stachybotrys atra and Alternaria tenuis, which seem to be ubiquitous, Acrospeira levis, Clavariopsis bulbosa, and Periconia prolifica have only been reported from warm water or tropical marine locations. Table III compares fungi known in the Salton Sea with those I have collected in Hawaii and those known from the temperate waters of the Pacific coast of North America. Of the eight ascomycetes, three are known from both areas, two from neither, and the remaining three have been collected in temperate North America but not Hawaii; of the eleven fungi imperfecti, two have been found in both areas, six in neither, and four in Hawaii, not in temperate Pacific North America. These tendencies are all the more impressive since many of the marine species are abundant in their areas of distribution. Of the imperfect fungi, Contortospira varia has been collected only in salt lakes, Salt Lake on Oahu and the Salton Sea. It may, in all liklihood, be collected in the oceans in the future.

TABLE III

A Comparison of Temperate Pacific North American and Hawaiian Collections of Fungi Reported from the Salton Sea

Salton Sea Records	Temperate Pacific N. A. Records	Hawaii Records
Ascomycetes		
Ceriosporopsis halima	x	x
Halosphaeria mediosetigera	x	
Leptosphaeria orae-maris	x	
Peritrichospora integra	x	x
Lulworthia opaca	x	
Lulworthia medusa	x	x
Pleospora herbarum		
Amphisphaeria verruculosa		
Fungi Imperfecti		
Acrospeira levis		x
Clavariopsis bulbosa		x
Periconia prolifica		x
Stachybotrys atra	x	x
Stachybotrys subsimplex		
Alternaria tenuis	x	x
Alternaria radicina		
Botryotrichum piluliferum		
Fusarium solani		
Contortospira varia		
Scopulariopsis sp.		
Mycelia Sterilia		
Papulaspora halima	x	

Spores of the very common temperate marine imperfect fungi, such as Cirrenalia macrocephala, Helicoma maritimum, Piricauda pelagica, and Dictyosporium pelagicum (Linder) Hughes ex Johnson & Sparrow (1961) -- and tropical marine ascomycetes -- such as Antennospora quadricornuta, Torpedospora radiata Meyers (1957), and Metasphaeria australiensis Cribb & Cribb (1955) must regularly be brought into the Salton Sea by the sea birds which fly in from the Gulf of Mexico and the Pacific. Since these organisms are absent or at least rare in the Salton Sea, they are presumably unable to tolerate some aspect of the physical environment in this salt lake.

It is possible that some organisms are seasonally introduced into the Salton Sea, depending on the migration stream, and then die out with re-introduction following during the next favorable season. A possible candidate for this is Ceriosporopsis halima, collected only in March. This species has, however, been collected in the warm waters of Hawaii, though it is rare in this habitat.

The temperature of the Salton Sea ranges from 10-35°C -- an annual fluctuation of 25°, much greater than the extremes at marine stations such as Alamitos Bay, California, and Kaneohe Bay, Oahu, Hawaii (see fig. 1). A comparable fluctuation was reported in the estuary of the Newport River, North Carolina (Gold, 1959). It is possible that warm water ascomycetes cannot tolerate the low winter temperatures of the Salton Sea and that fungi of temperate waters cannot tolerate the extended periods of high temperatures during the summer months. If this were so, however, it would be difficult to explain why the temperate marine ascomycetes can withstand the high summer temperatures and tropical marine imperfect fungi the low winter temperatures. So few organisms are involved, that the distributional relationships discussed above may be largely a matter of coincident individual tolerances. It would be relatively simple, however, to test temperature tolerances for a wide variety of these organisms, thereby probably allowing further deductions to be made about their patterns of distribution.

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