FUNGI ASSOCIATED WITH THE DECOMPOSITION OF THE BLACK RUSH, *JUNCUS ROEMERIANUS*, IN SOUTH FLORIDA

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SUMMARY

A total of 123 fungal taxa was observed on *Juncus roemerianus* leaves. Thirty-four taxa were at a frequency of occurrence of 1% or more; of these, five taxa (*Fusarium* spp., *Cladosporium cladosporioides, Drechslera hawaiiensis, Alternaria alternata* and *Geniculosporium* sp.) were in excess of 25%. The observed community structure was affected by the condition of the leaf (living, senescent or decomposing leaves), position on the leaf (tip, middle or base of the leaf), season of the year (wet vs. dry season) and culture technique. Of less significance was station location within the study site. Comparisons with other studies of *Juncus* and red-mangrove (*Rhizophora mangle*) litter indicated a distinct fungal community structure associated with *Juncus* in subtropical estuarine environments.

Fungi are considered to be one of the primary agents of plant litter decomposition (1, 27). This process is important in freshwater and estuarine environments due to the conversion of protein-poor plant materials to microbial biomass. The microbial biomass becomes available to the primary consumers which initiate food webs leading to commercially important fishes and crustaceans (24). *Juncus roemerianus* Scheele, a rush that inhabits coastal marshlands in Florida, is one of the contributors to this litter system. There have been several reports of fungi isolated from various species of *Juncus* (TABLE I); although the only study of which we are aware of fungi associated with the decomposition process was by Latter and Cragg (19) who examined *J. squarrosus* L. in England. The present study, an examination of the fungi associated with *J. roemerianus* in a subtropical environment, was designed to determine what fungi are associated with (and potentially responsible for) the decomposition process and what effects certain environmental and sampling variables have on the observed fungal community structure. Of particular interest were: time of the year the study was initiated; use of the litter-bag technique; site location; season; condition of the plant, viz. living, senescent and state of decay; and position on the leaf (tip, middle and basal segments).

TABLE I

FUNGI FROM *Juncus* spp. AS REPORTED IN THE LITERATURE

Fungus	*Juncus* sp. (Reference)
Ascomycetes	
Barlaeina amethystina (Quel.) Sacc. & Trav.	*Juncus* sp. (9)
Belonidium juncisedum (Karst.) J. Lind.	*J. biglumis* L., *J. castaneus* Smith (26)
Belonioscypha culmicola (Desm.) Dennis	*Juncus* sp. (9)
Belonopsis iridis (Crouan) Graddon	*Juncus* sp. (9)
Bombardia fasciculata Fr.	*J. effusus* L. (20)
Ciboria juncigera Ell. & Ev.	*Juncus* sp. (26)
C. juncorum Velen.	*Juncus* sp. (9)
Clathrospora spp.	*Juncus* sp. (28)
Claviceps junci Adams	*J. nodosus* L. (26)
C. purpurea (Fr.) Tul.	*J. glaucus* Ehrh. (2)
Cudoniella junciseda (Velen.) Dennis	*J. effusus* (9)
Dasyscyphus apalus (Berk. & Br.) Dennis	*Juncus* sp. (9), *J. effusus* (20)
D. clavisporus Mouton	*Juncus* sp. (9)
D. diminutus (Roberge) Sacc.	*J. squarrosus* L. (19), *Juncus* sp. (9), *J. effusus* (20)
D. fugiens (Bucknall) Massel	*Juncus* sp. (9)
Didymella juncina (Berk. & Rav.) Sacc.	*Juncus* sp. (26)
Didymosamarospora euryhalina Johnson ex Gold	*Juncus* sp. (18), *J. roemerianus* (16)
Didymosphaeria minuta Niessl	*J. effusus* (23)
Dothidea junci Fr.	*J. conglomeratus* L. (8), *J. filiformis* L. (26)
Dothidella junci (Fr). Sacc.	*J. effusus*, *J. tenuis* Willd. (26)
Duplicaria acuminata Ell. & Ev.	*J. drummondii* Mey. (26)
Endodothella junci (Fr.) Theiss. & Syd.	*Juncus* sp. (9), *J. effusus* (20)
Eusordaria tomicoides (Sacc.) von Höhnel	*J. effusus* (20)
Hymenoscyphus repandus (Phillips) Dennis	*Juncus* sp. (9)
Hysteropezizella exigua (Desm.) Nannf.	*J. articulatus* L. (9, 20), *J. subnodulosus* Shrank (9)
Leptosphaeria albopunctata (Westd.) Sacc.	*J. maritimus* L. (26), *Juncus* sp. (18)
L. cladii Cruchett	*J. effusus*, *J. squarrosus* (23)
L. culmifida Karst.	*J. conglomeratus* (15)
L. defodiens Ell.	*J. effusus* (26)
L. obiones (Crouan & Crouan) Sacc.	*J. maritimus* (16), *Juncus* sp. (18)
L. dubiosa (Mont.) Dud.	*Juncus* sp. (16)
L. eustoma (Fuckel) Sacc.	*Juncus* sp. (9)
L. juncicola Rehm apud Winter	*J. trifidus* L. (9, 15)
L. juncina (Awd.) Sacc.	*J. biglumis* (26), *J. conglomeratus* (15), *J. effusus* (23), *Juncus* sp. (9)
L. marina Ell. & Ev.	*J. maritimus*, *J. roemerianus* (16), *Juncus* sp. (18)
L. michotti Westd.	*J. greenei* Oakes & Tuckerm. (5), *J. squarrosus* (15), *Juncus* sp. (26, 9, 5)
L. neomaritima Gessner & Kohlm.	*J. atricapillus* Drejer (23), *J. maritimus* (16), *J. roemerianus* (16), *Juncus* sp. (18)

TABLE I—(*Continued*)

Fungus	*Juncus* sp. (Reference)
L. petkovicensis Bub. & Ran.	*J. conglomeratus*, *J. effusus*, *J. lamprocarpus* Ehrh. (**23**)
L. sepalorum (Vleugel) Lind.	*J. filiformis*, *J. trifidus* (**15**)
Leptosphaeria sp.	*Juncus* sp. (**28**)
Loramyces juncicola Weston	*Juncus* sp. (**9**), *J. effusus* (**20**)
Melanospora zamiae Corda	*J. effusus* (**20**)
Metasphaeria defodiens (Ell.) Sacc.	*J. dichotomus* Ell. (**26**)
Mollisia alpina Rostr.	*J. alpinus* Vill. (**26**)
M. junciseda Karst.	*J. trifidus*, *J. aceticus* Willd. (**26**)
M. palustris (Roberge) Karst.	*J. squarrosus* (**19**), *Juncus* sp. (**9**)
M. stictoides (Cke. & Ell.) Sacc.	*J. tenuis* (**26**)
Monascostroma innumerosa (Desm.) v. Höhn	*J. effusus* (**23**)
Mycosphaerella (*Sphaerella*) *juncellina* Munk	*J. squarrosus* (**23**)
M. perexigua Karst.	*J. conglomeratus* (**23**)
M. wichuriana (Schroet.) Johans.	*J. biglumis* (**26**)
Myriosclerotinia curreyana (Berk. in Curr.) Buckw.	*J. effusus*, *J. inflexus* L. (**25**)
M. juncifida (Nyl.) Palmer	*J. balticus* Willd. × *inflexus*, *J. effusus* (**25**)
Naevia pusilla (Lib.) Rehm.	*J. biglumis* (**26**)
Phomatospora ovalis (Pass.) Sacc.	*J. effusus* (**23**)
Pleospora elynae (Rabh.) Ces. & De Not.	*J. aceticus* (**26**)
P. herbarum (Fr.) Rabh.	*J. triglumis* L. (**26**)
P. infectoria var. *juncigena* (Cke.) Berl.	*Juncus* sp. (**26**)
P. juncicola Ell. & Ev.	*J. balticus* (**26**)
P. rubicunda Niessel	*J. effusus* (**23**)
Pleospora sp.	*Juncus* sp. (**16**)
Phyllachora junci (Fr.) Fekl.	*J. conglomeratus* (**23**), *J. effusus* (**23, 26**), *J. interior* Wiegand (**23, 26**), *J. filiformis*, *J. tenuis* (**26**)
Sclerotinia curreyana (Berk.) Karst.	*J. communis* E. May, *J. filiformis*, *J. glaucus* (**29**), *J. conglomeratus*, *J. effusus* (**9, 20, 29**)
Sclerotinia juncigena (Ell. & Ev.) Whetzel	*J. effusus* var. *pacificus* Fern. & Wieg., *Juncus* sp. (**29**)
Sphaeria junci Fr.	*J. filiformis* (**26**)
Trochila juncicola Rostr.	*J. trifidus*, *J. triglumis* L. (**26**)
Trichometasphaeria sp.	*J. effusus* (**23**)
Hyphomycetes	
Alternaria maritima Suth.	*Juncus* sp. (**18**)
Anguillospora sp.	*J. effusus* (**21**)
Arthrinium (*Tureenia*) *curvatum* var. *minus* M. B. Ellis	*Juncus* sp. (**10**)
A. cuspidatum (Cke. & Harkn.) Tranz.	*Juncus* sp. (**10**), *J. balticus* var. *montanus* Engelm. (**26**)
A. sporophleum Kunze	*Juncus* sp. (**10**)
Aureobasidium sp.	*J. squarrosus* (**19**)
Botrytis sp.	*J. squarrosus* (**19**)
Cercospora juncina Sacc.	*J. canadensis* J. Gay (**26**)
Cladosporium fasciculatum Corda	*J. balticus* (**26**)
Cladosporium sp.	*J. squarrosus* (**19**)

TABLE I—(*Continued*)

Fungus	*Juncus* sp. (Reference)
Doratomyces stemonitis (Pers. ex Fr.) Morton & Smith	*J. effusus* (22)
Epicoccum sp.	*J. squarrosus* (19)
Fusarium curtsii Cke.	*Juncus* sp. (26)
Gloeosporium junci Ell. & Ev.	*Juncus* sp. (26)
Penicillium sp.	*J. squarrosus* (19)
Periconia atra Corda	*Juncus* sp. (10)
P. curta (Berk.) Mason & M. B. Ellis	*Juncus* sp. (10)
P. digitata (Cke.) Sacc.	*Juncus* sp. (10)
P. funera (Ces.) Mason & M. B. Ellis	*Juncus* sp. (10)
Phialophora sp.	*J. squarrosus* (19)
Pleuropedium tricladioides Marvanova & Iqbal	*J. effusus* (21)
Ramularia junci Pk.	*J. marginatus* Rostk. (26)
Selenosporella curvispora MacGarvie	*Juncus* sp. (10)
Tetraploa aristata Berk. & Br.	*Juncus* sp. (10)
Tureenia juncoidea J. G. Hall	*Juncus* sp. (26)
Trichoderma sp.	*J. squarrosus* (19)
Tricladium giganteum Iqbal	*J. effusus* (21)
Varicosporium delicatum Iqbal	*J. effusus* (21)
Verticillium sp.	*J. squarrosus* (19)
Yeasts	*J. squarrosus* (19)
Melanconiales	
Pestalotia zonata Ell. & Ev.	*Juncus effusus* (14)
Sphaeropsidales	
Coniothyrium junci Ell. & Ev.	*J. balticus*, *Juncus* sp. (26)
Dinemasporium graminum Lév.	*J. squarrosus* (19)
Darluca filum (Biv.) Cast.	*J. tenuis*, *Juncus* sp. (26)
Discula junci Smith & Ramsb.	*J. communis* (13)
Eriospora leucostoma Berk. & Br.	*Juncus* sp. (13)
Hendersonia arundinacea Sacc.	*J. biglumis* (26)
H. culmicola Sacc.	*J. lescurii* Boland (26)
H. juncina Ell.	*J. acutus* L., *J. effusus* (13)
H. luzulae Westd.	*J. triglumis* (26)
H. scirpicola Cke. & Hark.	*J. lescurii* (26)
H. trimera Cke.	*J. maritimus* (26)
Leptostroma juncacearum Sacc.	*J. communis*, *J. conglomeratus*, *J. maritimus* (13)
Leptostromella juncina Sacc.	*J. articulatus*, *J. conglomeratus*, *J. effusus*, *J. glaucus* (13)
Leptothyrium juncinum Cke. & Hark.	*J. balticus* var. *vallicola* Rydb., *J. lescurii* (26)
Microdiplodia junci Died.	*J. maritimus* (13)
Neottiospora caricina (Desm.) Höhnel	*Juncus* sp. (8)
Phoma neglecta Desm.	*J. effusus*, *J. maritimus* (13)
Phoma sp.	*Juncus* sp. (16)
Placosphaeria junci Bub.	*J. communis*, *J. conglomeratus*, *J. effusus* (13)
Pycnothyrium junci Grove	*J. communis* (13)
Rhabdospora drabae (Fuckel) Berl. & Vogl.	*J. biglumis* (26)
Septoria junci Desm.	*J. articulatus*, *J. conglomeratus*, *J. effusus*, *J. maritimus* (13), *J. trifidus* (26)
Septoria sp.	*J. squarrosus* (19)
Stagonospora bufonia Bres.	*J. bufonius* L., *J. gerardi* Loisel (13)
S. innumerosa Sacc.	*J. maritimas*, *J. effusus* (13)

TABLE I—(*Continued*)

Fungus	*Juncus* sp. (Reference)
S. junciseda Sacc.	*Juncus* sp., *J. conglomeratus* (**13**)
S. socia Gr.	*J. conglomeratus* (**13**)
S. timera Sacc.	*J. maritimus* (**13**)
Stagonospora sp.	*J. squarrosus* (**19**)
Zygomycetes	
Mortierella sp.	*J. squarrosus* (**19**)
Mucor sp.	*J. squarrosus* (**19**)
Basidiomycetes	
Marasmius androsaceus (L. ex. Fr.) Fr.	*J. squarrosus* (**19**)
Hypholoma elongatum (Pers. ex Fr.) Ricken	*J. squarrosus* (**19**)
Sporobolomyces sp.	*J. squarrosus* (**19**)

METHODS

The study site was in south Dade County, 45 km south of Miami, Florida, in a sawgrass (*Cladium jamaicensis* Crantz), *Junctus* and mangrove (mostly *Rhizophora mangle* L. with some *Avicennia nitida* Jacq. and *Laguncularia racemosa* Gaertn.) marsh adjacent to Little Card Sound (FIG. 1). An approximate 3.5-km transect was established across the vegetation types (**6**, **7**) as part of the study of the role of marshland plant litter in a seawater lagoon environment. The study period was November 1973 to August 1975. For the mycological aspect of the study, two stations (Sta. 8 and 16), about 1 km apart, were selected in the *Juncus* habitat. Environmental conditions, in terms of salinity, water temperature, depth, and duration of water cover were similar at the two stations. Surface water temperatures at the two stations ranged from 15 to 35 C, salinity 6 to 35‰, water levels from 0 to 40 cm. The dry periods were January to April with highest water levels in November.

Fungal populations associated with living plants and with various stages of senescence and decay were determined at both stations. Included were three types of standing leaves: living (green), senescent (green brown) and those in the initial stages of decay (gray). Senescence and decay begin at the tip of the leaf and proceed toward the base; therefore, three portions of each plant leaf were examined: tip, middle, and base. The leaves were sectioned in the field and the sections placed in separate sterile plastic bags for transport to the laboratory. Analyses in the lab were performed on 1.5–2 cm subsamples cut aseptically from each of the sections. Throughout the text and the tables, each subsample is listed as an "observation." The percent frequency

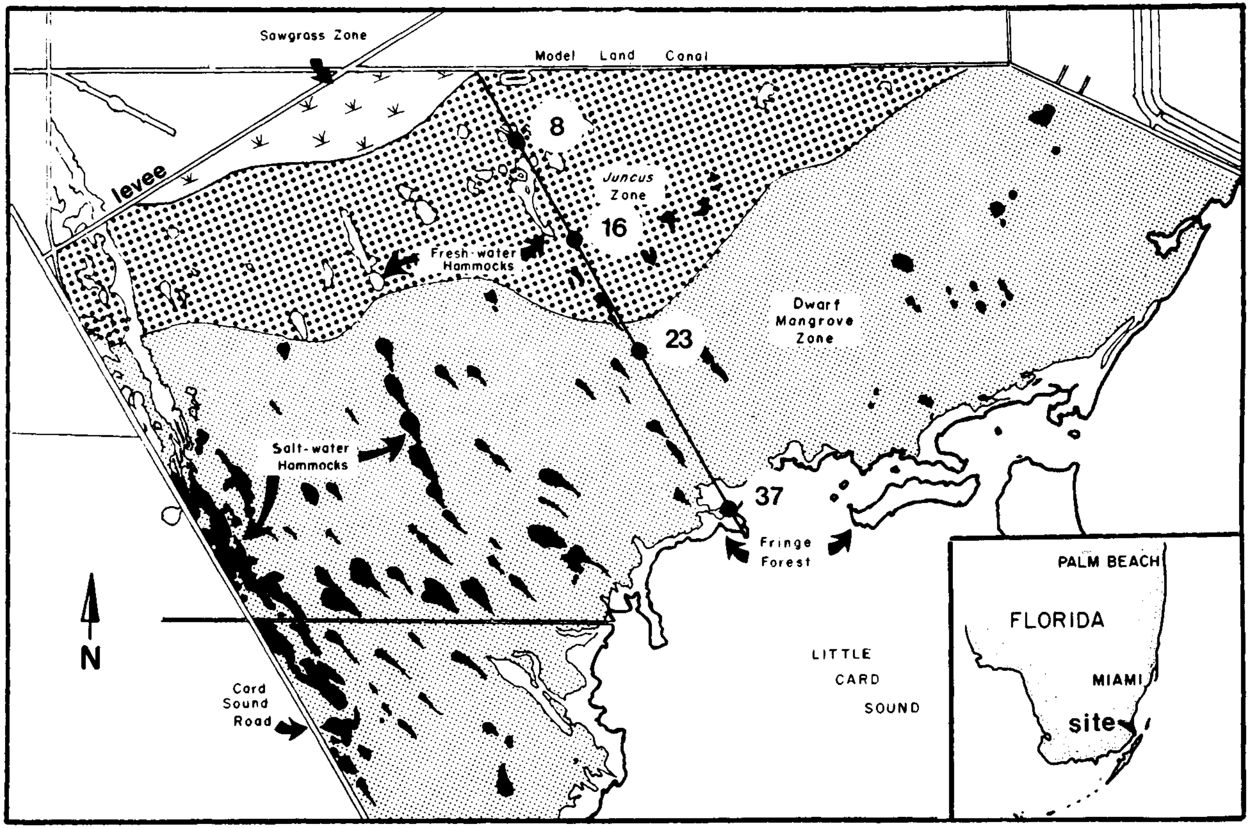

FIG. 1. Station locations at the sampling site.

of occurrence was calculated from the number of positive observations divided by the total number of observations multiplied by 100.

Decaying leaves were examined using a litter-bag technique (**12**). Leaves in the initial stages of decay were cut at the base and placed in nylon bags with a mesh size of 4 mm. There were 25 leaves/bag with three bags/station/yearly sequence. This was a 21-mo study that included four yearly sequences that were initiated November 1973, February 1974, May 1974 and August 1974 at each station. The litter bags were tied to stakes so that they lay at ground level. Samples, which were collected monthly at each station, consisted of the leaves of standing green, green-brown and gray plants; leaves from each of the yearly sequence litter bags; and leaves decaying naturally that were lying on the sediment. Three to five leaves of each of the samples were examined for fungi by direct microscopic observation of the fungi growing and sporulating on the plant, and by incubation of pieces of leaves on a nutrient medium: cornmeal agar prepared with 140 mg/l chloraphenicol and 15‰ seawater. Incubation was at 25 C for 1 wk, with transfer to 20 C with intermittent near-ultraviolet "black light" (3100-4100A, 12 continuous h/da) for 3–5 wk to induce sporulation (**4**). A permanent slide collection of most of the fungal taxa was made.

The occurrence of phycomycetes (particularly species of *Phytophthora* and *Pythium*) was examined by a water-culture technique (**11**). Leaf segments were placed in 100 × 15 mm dishes containing 25 ml of 15‰ autoclaved seawater with 0.5 g/liter streptomycin sulfate and 0.5 g/liter penicillin G and examined for hyphae and sporangia after 2–3 da of incubation.

RESULTS

A total of 123 fungal taxa (TABLE II) was observed on living and decomposing *Juncus* leaves. Thirty-four taxa were found at a frequency of 1% or more (TABLE III; mean frequencies from TABLE X are: *Geniculosporium* sp. 30%, *Stigmatomassaria* sp. 3%, *Stagonospora* sp. 2%), and five taxa (*Fusarium* spp., *Cladosporium cladosporioides, Drechslera hawaiiensis, Alternaria alternata* and *Geniculosporium* sp.) in excess of 25%. These occurrences were affected by factors such as season, station location, sequence of decay, position on the plant leaf and culture technique. During the development of this program there was some concern that containment of *Juncus* leaves in litter bags would alter conditions sufficiently to result in a fungal-community structure that was different from that which normally inhabits decaying material. A comparison of fungal populations on naturally degrading and on litter-bag-contained leaves (TABLE IV) indicated that the numbers and types of taxa were similar. Another factor that was examined was the constancy of the results of community-structure analysis on a yearly basis. Four 1-yr sequences were initiated approximately every 4 mo. The data (TABLE IV) do not indicate consistent differences between these yearly groups. Similarly, differences on a mo-to-mo basis were not indicated (data not shown).

Fungal communities associated with stages of living and decomposing leaves.—As the *Juncus* leaves became senescent and began decomposition they changed from green to green brown and then gray in color. Concomitant changes in the composition of the fungal community were observed. The numbers (TABLE V) of fungal taxa on green (47 taxa) and green-brown (49) leaves were approximately the same and increased significantly (88) when the plants became gray. After the blades fell and underwent the final decomposition phase in water, the number of fungal taxa was reduced ($\bar{\chi} = 55$ for natural decaying leaves and for yr collections 1–4, TABLE V) with a total of 95 taxa (1,726 observations), in contrast to 88 taxa from 511 observations with gray material. Several species were found only on specific stages of living, senescent and decaying plants (TABLE V); however they were not prevalent members of the fungal community (frequency < 1%). Among those fungi that were prevalent, sequences of fungal populations can be discerned (TABLE VI). *Humicola* sp. and *Leptosphaeria juncina* were prevalent on living plants but decreased in abundance when the plants became gray. Several species, although inhabitants of green plants, increased in frequency during senescence; such species include *Geniculosporium* sp., *Cladosporium cladosporioides, Alternaria alternata, Nigrospora sphaerica, Pestalotia* spp. and *Phoma* spp. Other species, *Fusarium* spp., *Drechslera hawaiiensis, Trichoderma viride* and *Myrothecium roridum,* became more prevalent in the litter. In addition there were several species that were not on green plants but became abundant during senescence and decay; included are *Leptosphaeria australiensis, Halosphaeria hamata, Pithomyces chartarum* and *Paecilomyces* spp.

Position on the leaf.—Because senescence and decay initiated at the tops of the leaves and proceeded to the base, fungal colonization during this sequence was examined. In general there were few species with distinct distribution patterns. These included (TABLE VII): *Alternaria alternata, Cladosporium cladosporioides, Coniothyrium* spp. and *Geniculosporium* spp., which were prevalent on tips of the leaves particularly

TABLE II

FUNGI ASSOCIATED WITH *Juncus roemerianus* LEAVES IN SOUTH FLORIDA NOVEMBER 1973–AUGUST 1975

	Green	Green brown	Gray	Litter
Ascomycetes				
Order Dothideales				[a]
Mycosphaerella sp.		+	+	
Order Eurotiales				
?*Arachniotus* sp.			+	
Order Pleosporales				
Guignardia spp.	+		+	
Keissleriella spp.	+		+	
Leptosphaeria australiensis (Cribb & Cribb) G. C. Hughes	+	+	+	+
L. juncina (Auersw.) Sacc.	+	+	+	+
Massarina sp.			+	+
Otthia sp.			+	
Sporormia sp.		+	+	+
Order Sphaeriales				
Achaetomium sp.				+
Ceratosphaeria sp.		+	+	
Chaetomium spp.	+	+	+	+
?*Gnomonia* sp.				+
?*Leptosphaerulina* sp.			+	
?*Lepteutypa* sp.			+	
Melanospora sp.				+
Nectria sp.			+	+
Phomatospora sp.			+	+
Halosphaeria hamata (Höhnk) Kohlm.		+	+	+
Sphaerulina spp.			+	+
Stigmatomassaria sp.	+	+	+	+
Unidentified spp.				
Deuteromycetes				
Order Melanconiales				
Pestalotia sp.	+	+	+	+
Order Moniliales				
Acremonium spp.	+	+	+	+
Alternaria longissima Deighton & MacGarvie	+	+	+	+
Alternaria alternata (Fr.) Keissler	+	+	+	+
Arthrinium sp.	+			
Aspergillus niger Van Tiegh.	+	+	+	+
Aspergillus spp.	+	+	+	+
Aureobasidium sp.	+	+	+	+
Beltrania querna Harkn.				+
Circinotrichum maculiforme C. G. Nees ex Pers.				+
Cirrenalia macrocephala (Kohlm.) Meyers & Moore				+
C. pseudomacrocephala Kohlm.		+		
Cladobotryum sp.				+
Cladosporium cladosporioides (Fresen.) de Vries	+	+	+	+
C. sphaerospermum Penz.	+	+	+	+
Cladosporium sp.		+	+	
?*Costantinella* sp.				+
Cremasteria cymatilis Meyers & Moore		+		
Crinula sp.				
Curvularia protuberata Nelson & Hodges		+	+	
C. tuberculata Jain			+	+
Curvularia spp.	+	+	+	+
Dendryphiella salina Nicot				+
Drechslera halodes (Dreschler) Subram. & Jain	+		+	+
D. hawaiiensis (Bugnicourt) Subram. & Jain ex M. B. Ellis	+	+	+	
Drechslera sp.	+		+	+
Epicoccum purpurascens Ehrenb. ex Schlecht	+	+	+	+
Flagellospora sp.	+			
Fusariella obstipa (Pollack) Hughes				+
Fusarium spp.	+	+	+	+
Geniculosporium sp.	+	+	+	+
Gliocladium sp.			+	
Gliomastix spp.		+		+
?*Hansfordia* sp.			+	
Haplobasidion lelebae Sawada ex M. B. Ellis	+		+	+
Humicola sp.	+	+	+	+
Memnoniella echinata (Riv.) Galloway			+	+
Monilia sp.				+
Monodictys austrina Tubaki			+	
Myrothecium jollymannii Preston			+	+
M. roridum Tode ex Fr.	+	+	+	+
Nigrospora sphaerica (Sacc.) Mason	+	+	+	+
Paecilomyces spp.		+	+	+
Papulospora halima Anastasiou	+			+
?*Penicillifer* sp.			+	
Penicillium spp.	+	+	+	+
Periconia cookei Mason & M. B. Ellis			+	+
P. digitata (Cooke) Sacc.	+	+	+	+
P. echinochloae (Batista) M. B. Ellis			+	+
P. igniaria Mason & M. B. Ellis				+
P. minutissima Corda			+	+
Periconia sp.			+	+
Pithomyces atro-olivaceous (Cke. &				

TABLE II—(*Continued*)

	Green	Green brown	Gray	Litter
Harkn.) M. B. Ellis		+	+	+
P. chartarum (Berk. & Curt.) M. B. Ellis		+	+	
P. maydicus (Sacc.) M. B. Ellis			+	+
Rhinocladiella sp. I			+	+
Rhinocladiella sp. II	+	+	+	+
Rhinotrichum sp.				+
Scolecobasidium humicola Barron & Busch	+	+	+	+
Scopulariopsis sp.	+			
Scopulariopsis spp.	+	+	+	+
Septonema secedens Corda	+		+	+
Spegazzinia tessarthra (Berk. & Curt.) Sacc.	+			
Sporothrix state of *Zygosporium masonii* Hughes			+	
Sporothrix sp.			+	
Stachybotrys atra Corda			+	+
S. cylindrospora Jensen				+
S. kampalensis Hansf.			+	
S. nephrospora Hansf.			+	+
Stachybotrys state of *Melanopsamma pomiformis* (Pers. ex. Fr.) Sacc.				+
Stachybotrys sp.			+	+
Stachylidium bicolor Link ex S. F. Gray			+	
Stemphylium lycopersici (Enjoji) Yamamoto	+			
Stemphylium vesicarium (Wallr.) Simmons	+	+	+	+
Stilbum sp.				+
Tetraploa aristata Berk. &. Br			+	+
?*Thysanophora* sp.			+	
Torula herbarum (Pars.) Link ex S. F. Gray				+
Trichoderma viride Pers.	+		+	+
Veronaea sp.			+	
Virgaria nigra (Link) Nees ex S. F. Gray			+	
Zalerion varium Anastasiou				+
Zygosporium gibbum (Sacc., Rouss. & Bomm.) Hughes				+
Z. masonii Hughes				+
Zygosporium sp.				+
Order Sphaeropsidales				
Botryodiplodia sp.			+	+
Coniothyrium spp.	+	+	+	+
Cytosporina sp.	+	+	+	+
Hendersonia sp.		+		+
Neottiospora sp.	+	+	+	+
Phoma spp.	+	+	+	+
Phomopsis sp.		+		+
Psammina sp.			+	
Pyrenochaeta sp.	+			
Selenophoma sp.			+	+
Septoria sp.	+	+	+	+
Sphaeronaema sp.			+	
Stagonospora sp.	+	+	+	
Zythia spp.	+	+	+	+
Unidentified	+	+	+	+
Zygomycetes				
Order Mucorales				
Blakeslea trispora Thaxter			+	+
Mucor sp.		+		
Syncephalastrum racemosum Cohn ex Schroet.	+	+		

[a] Litter years 1, 2, 3, 4.

on green and green-brown leaves, while the distribution became more evenly divided in the gray and litter stages. *Paecilomyces* spp. and *Pestalotia* spp. were high in frequency in the tip and middle portions of the gray leaves. *Leptosphaeria juncina* was most abundant on the tips and middle segments on green and green-brown leaves. *Leptosphaeria australiensis* and *Halosphaeria hamata* were prevalent on the middle and base of gray and litter leaves; as both species are marine-occurring fungi, their initial infestation in lower portions of the leaf could arise from water-borne transport of propagules. *Fusarium* spp. and *Humicola* spp. were in highest frequency on bottom segments on all types of materials.

TABLE III

FREQUENTLY OBSERVED FUNGI ON *Juncus roemerianus* LEAVES, NUTRIENT-CULTURE TECHNIQUE

Fungus	% frequency
Ascomycetes	
Leptosphaeria australiensis	11
Leptosphaeria juncina	7
Halosphaeria hamata	6
Chaetomium spp.	3
Deuteromycetes	
Moniliales	
Fusarium spp.	52
Cladosporium cladosporioides	46
Drechslera hawaiiensis	44
Alternaria alternata	26
Trichoderma viride	7
Humicola sp.	7
Paecilomyces spp.	6
Myrothecium roridum	6
Nigrospora sphaerica	6
Curvularia spp.	5
Geniculosporium sp.	4
Acremonium spp.	3
Rhinocladiella sp. II	3
Aspergillus niger	3
Periconia spp.	2
Aspergillus spp.	2
Epicoccum pupurascens	2
Pithomyces chartarum	2
Penicillium spp.	1
Cladosporium sphaerospermum	1
Stachybotrys spp.	1
Gliomastix spp.	1
Melanconiales	
Pestalotia sp.	3
Sphaeropsidales	
Neottiospora sp.	3
Coniothyrium spp.	3
Phoma spp.	2
Zythia spp.	1
Total number of observations	3,184

Season.—Season was a particularly important factor. There was a greater number of species in the wet (115 taxa) than the dry (76 taxa) season. Of these, 46 were found only in the wet season, while 10 species were restricted to the dry season. Not only did the number of taxa differ in the two seasons, but the frequency of occurrence of certain fungal taxa varied (TABLE VIII). *Fusarium* spp. were consistently abundant during the wet season in all stages from green to litter. *Cladosporium cladosporioides* was abundant in the wet season on green and green-brown plants, but became prevalent in the dry season on gray and litter material. A few species (*Trichoderma viride, Myrothecium roridum* and *Rhinocladiella* sp. II) were more abundant on the litter in the wet than the dry season. Conversely, there were other species that were prevalent in the dry season rather than the wet, including *Alternaria alternata, Nigrospora sphaerica, Epicoccum purpurascens, Leptosphaeria australiensis* and *L. juncina*. Several species were abundant in the dry season in gray and litter material: *Acremonium* spp., *Periconia* spp., *Phoma* spp., *Pestalotia* spp. and *Cladosporium sphaerospermum*.

Station location.—Approximately the same number of species was found at both stations (Sta. 8: 106 spp., Sta. 16: 101 spp.) on a yearly as well as seasonal basis (wet season Sta. 8: 77 spp., Sta. 16: 75 spp.; dry season Sta. 8: 49 spp., Sta. 16: 49 spp.). There were some differences in frequency of occurrence of certain taxa (TABLE IX); particularly *Drechslera hawaiiensis, Fusarium* spp. and *Myrothecium roridum* that were more abundant at Sta. 8 than Sta. 16.

Culture technique.—The type of observation or culture technique employed will affect the detectable occurrence of fungi. Due to time limita-

TABLE IV

PERCENT FREQUENCY OF OCCURRENCE OF SOME PREVALENT FUNGI ON *Juncus roemerianus* LEAVES, BOTH NATURALLY DECAYING AND IN LITTER BAGS DURING FOUR OVERLAPPING YEARLY SEQUENCES (NOV. 1973–JULY 1975)

Fungus	Natural decaying	Litter year 1	Litter year 2	Litter year 3	Litter year 4
Ascomycetes					
Leptosphaeria australiensis	14	16	15	19	17
Halosphaeria hamata	3	7	10	7	12
Chaetomium spp.	2	7	3	1	1
Hyphomycetes					
Fusarium spp.	73	68	62	81	72
Cladosporium cladosporioides	43	41	54	55	50
Dreschslera hawaiiensis	57	64	57	63	51
Alternaria alternata	23	26	26	29	18
Trichoderma viride	13	8	13	11	19
Humicola sp.	3	3	2	1	3
Paecilomyces spp.	7	8	6	9	10
Myrothecium roridum	12	9	8	10	9
Nigrospora sphaerica	5	3	6	4	1
Curvularia spp.	6	5	7	7	5
Acremonium spp.	6	1	7	2	5
Rhinocladiella sp. II	5	7	4	2	6
Number of observations	430	388	310	334	264

TABLE V

SYNOPSIS OF THE NUMERICAL DISTRIBUTION OF FUNGI ON *Juncus roemerianus* LEAVES

	Green	Green brown	Gray	Total standing	Natural decaying	Litter year 1	Litter year 2	Litter year 3	Litter year 4	Total litter	Number of common species*	Total number of species
Number of fungal species	47	49	88	100	58	63	54	55	43	95	21	124
Number of Ascomycetes	5	9	18	18	6	9	8	6	5	13	1	21
Number of Hyphomycetes	32	29	56	64	45	45	38	42	33	69	17	85
Number of Sphaeropsidales	8	9	11	14	5	8	7	5	5	11	3	14
Number of Zygomycetes	1	1	2	3	0	0	0	0	1	1	0	3
Number of Melanconiales	1	1	1	1	1	1	1	1	0	1	0	1
Number of restricted species**	5	2	17	29	4	2	3	2	3	24		
Number of observations	473	474	511	1,458	430	388	310	334	264	1,726		

* Common species—Those species found in all categories of living and decomposing leaves, and all sampling periods (four overlapping yr periods November 1973–July 1975).

** Restricted species—Those species found only in that particular category.

TABLE VI

PERCENT FREQUENCY FOR ABUNDANT FUNGI ON STANDING LEAVES AND LITTER OF *Juncus roemerianus*

Fungus	Green	Green brown	Gray	Litter
Green and green brown				
Humicola sp.	19	13	5	2
Leptosphaeria juncina	19	21	3	1
Green brown and gray				
Coniothyrium spp.	1	6	5	2
Geniculosporium sp.	3	13	8	1
Green, green brown and gray				
Neottiospora sp.	5	9	6	1
Stigmatomassaria sp.	1	2	3	1
Gray				
Cladosporium cladosporioides	36	38	60	50
Alternaria alternata	18	26	39	25
Nigrospora sphaerica	4	4	14	4
Pestalotia spp.	2	3	11	2
Periconia spp.	<1	<1	7	2
Phoma spp.	<1	1	5	1
Pithomyces chartarum	0	<1	6	1
Epicoccum purpurascens	1	<1	4	1
Cladosporium sphaerospermum	<1	<1	3	1
Gray and litter				
Leptosphaeria australiensis	0	<1	12	16
Curvularia spp.	1	2	10	7
Halosphaeria hamata	0	<1	10	9
Paecilomyces spp.	0	1	7	8
Stachybotrys spp.	0	0	2	2
Acremonium spp.	1	<1	6	3
Litter				
Fusarium spp.	24	28	36	71
Drechslera hawaiiensis	17	24	39	60
Trichoderma viride	1	0	2	12
Myrothecium roridum	<1	1	<1	9
Rhinocladiella sp. II	<1	<1	1	5
Aspergillus niger	1	<1	2	2
Gliomastix spp.	0	0	0	2
Number of observations	473	474	511	1,296

tions we were unable to pursue this to the extent warranted. One of the recommended methods (17) is direct observation of plant material for recognizable fungal-fruiting structures. A cursory examination (TABLE X) of *Juncus* leaves demonstrated an increased frequency of occurrence of at least three fungi (species of *Geniculosporium, Stigmatomassaria, Stagonospora*) with the direct-observation technique as contrasted to results with the nutrient medium. For example, *Geniculosporium* was observed at mean frequency of occurrence of 30% with direct observation, in contrast to 5% with nutrient culture.

TABLE VII

PERCENT FREQUENCY OF OCCURRENCE OF FUNGI ON THE TIP, MIDDLE, AND BASE SECTIONS OF *Juncus roemerianus* LEAVES

	Green			Green brown			Gray			Litter*		
	Tip	Middle	Base	Tip	Middle	Base	Tip	Middle	Base	Tip	Middle	Base
Alternaria alternata	39	9	6	39	25	13	58	40	22	31	22	22
Cladosporium cladosporioides	47	26	34	54	24	29	66	64	50	56	47	45
Coniothyrium spp.	4	0	0	18	1	0	6	6	1	1	2	1
Geniculosporium sp.	10	<1	0	38	0	<1	16	8	0	<1	<1	<1
Paecilomyces spp.	0	0	0	3	<1	0	10	8	1	7	9	9
Pestalotia sp.	4	1	2	7	1	<1	19	12	2	3	1	<1
Leptosphaeria juncina	22	31	4	22	34	8	1	5	2	0	<1	<1
Fusarium spp.	16	26	30	25	15	38	27	34	48	68	71	75
Humicola sp.	11	19	25	<1	10	32	0	<1	14	<1	<1	5
Leptosphaeria australiensis	0	0	0	0	<1	0	<1	12	22	7	27	15
Halosphaeria hamata	0	0	0	0	<1	0	0	15	15	1	12	11
Number of observations	155	160	158	158	156	160	172	169	170	426	434	436

* Litter material for litter years 1, 2, 3 and 4.

TABLE VIII

COMPARISON* OF PERCENT FREQUENCY OF FUNGI ON *Juncus roemerianus* LEAVES DURING WET AND DRY SEASONS ON STANDING MATERIAL**

	Green			Green brown			Gray			Litter		
	Wet season		Dry season	Wet season		Dry season	Wet season		Dry season	Wet season		Dry season
Fusarium spp.	29	>	16	33	>	16	42	<	26	76	>	57
Trichoderma viride	1	=***	1	0	=	0	4	>	<1	15	>	6
Myrothecium roridum	<1	=	0	2	=	<1	2	=	<1	12	>	2
Rhinocladiella sp. II	1	=	0	<1	=	0	2	=	0	6	>	0
Cladosporium cladosporioides	45	>	22	42	>	32	52	<	65	42	<	69
Alternaria alternata	14	<	23	20	<	32	30	<	51	16	<	42
Nigrospora sphaerica	2	<	6	1	<	8	9	<	21	3	<	7
Epicoccum purpurascens	0	<	1	0	<	2	2	<	8	<1	=	1
Leptosphaeria juncina	13	<	32	18	<	29	3	=	2	<1	=	1
Leptosphaeria australiensis	0	=	0	0	<	2	7	<	17	11	<	25
Acremonium spp.	<1	=	2	<1	=	2	4	<	9	3	<	5
Periconia spp.	0	=	0	0	=	1	4	<	10	1	<	3
Phoma spp.	<1	=	2	1	=	2	2	<	6	1	<	3
Pestalotia sp.	2	=	2	2	=	4	6	<	18	1	<	3
Cladosporium sphaerospermum	4	=	0	<1	=	0	<1	<	6	1	<	3
Number of observations	285		188	285		189	320		191	916		379

* 2 × *k* chi square contingency evaluation, $P < 0.05$
** Stations 8 and 16 are pooled.
*** Significant difference not detected ($P > 0.05$).

TABLE IX

COMPARISON OF THE PERCENT FREQUENCY OF OCCURRENCE OF PREVALENT FUNGI ON *Juncus roemerianus* at STATIONS 8 AND 16

Fungus	Station 8		Station 16
Drechslera hawaiiensis	65	>	22
Fusarium spp.	55	>	43
Myrothecium roridum	10	>	1
Alternaria alternata	24	<	28
Leptosphaeria australiensis	9	<	12
Humicola sp.	4	<	10
Nigrospora sphaerica	5	<	7
Curvularia spp.	4	<	6
Cladosporium cladosporioides	46	=**	47
Trichoderma viride	7	=	8
Leptosphaeria juncina	6	=	7
Paecilomyces spp.	6	=	6
Halosphaeria hamata	6	=	5
Number of observations	1,597		1,587

* 2 × *k* chi square contingency evaluation, $P < 0.05$.
** Significant difference not detected ($P > 0.05$).

DISCUSSION

The present study demonstrated several aspects of fungal-community structure associated with living and decomposing *Juncus* leaves. Many of the fungal genera and species from green, senescent and decomposing leaves were previously observed on *Juncus* spp. (TABLE I), while others, such as *Leptosphaeria australiensis, Halosphaeria hamata* and *Drechslera hawaiiensis,* had not been reported. The difference in

TABLE X

FUNGI RECORDED BY DIRECT OBSERVATION* ON *Juncus roemerianus*, PERCENT FREQUENCY OF OCCURRENCE

	Green	Green brown	Gray	Litter**
Geniculosporium sp.	27	33	45	18
Stigmatomassaria sp.	4	8	2	0
Stagonospora sp.	2	0	7	0
Leptosphaeria australiensis	0	0	18	2
Phoma sp.	0	0	5	0
Coniothyrium sp.	0	2	0	0
Leptosphaeria juncina	0	0	2	<1
Unidentified Ascomycetes	2	6	14	5
Unidentified fruiting bodies	25	44	42	55
Negative	46	17	2	22
Number of observations	48	48	55	109

* Includes tip, middle and base, Sta 8 and 16.
** Litter years 1, 2, 3 and 4.

Juncus fungal communities is probably due to types of substrates (species of *Juncus*), environment (much of the previous work was in temperate climates) and culture techniques. The use of the litter-bag technique did not appear to affect the occurrence of fungal species, nor were there any differences attributed to the specific time frame (mo collections or yr sequence) within the study period. Also, there was little difference due to the location within the study site of two stations 1 km apart with similar environmental conditions. The factors that did affect community structure were condition of the leaf (living, senescent or decomposing), position on the leaf (tip, middle or base), season of the year (wet vs. dry), and culture conditions.

In contrasting this study with other reports, the most abundant fungi in the Latter and Cragg (**19**) study of *Juncus squarrosus* in England, were species of *Stagonospora, Septoria, Verticillium* and *Epicoccum.* With the exception of *Stagonospora,* none of these fungi was among the more prevalent organisms in the Florida study. Latter and Cragg found that certain fungi were abundant on tip, middle and basal fractions of *Juncus;* however, none of these species was found in our examination. They also found a progression of species from fresh litter (*Stagonospora, Dinemasporium, Dasyscypha* and *Mollisia*) to a replacement on older litter by species of other fungi (*Trichoderma, Penicillium* and *Mortierella*). Of these, in the south-Florida study, *Stagonospora* sp. was found on green and gray materials and *Trichoderma* sp. was abundant on litter.

Another comparable study is the report of mangrove-leaf decomposition in south Florida (**11**, **12**). There is a basic difference in the decomposition proccesses of *Juncus* and mangrove-leaf litter. Following senescence in mangrove leaves, the leaves fall into the water, the soluble organics leach rapidly from the leaves and the decomposition process is often complete in 3 mo or less. In contrast, *Juncus* leaves begin senescence and decomposition while attached to the plant; a considerable proportion of the organics are removed from the blade prior to the weakening of the base of the leaf and the leaf's falling into the water, where a slow (1–2 yr) decomposition takes place (Newell, Fell and Tallman, unpublished data).

Differences in substrate quality and decomposition rate of *Juncus* and mangrove leaves were reflected in fungal-community structures. Of particular significance was the prevalence of *Phytophthora* spp. on mangroves in contrast to the absence of members of that genus on *Juncus.* Extensive repeated sampling of *Juncus* in all stages from green blades to litter did not reveal the presence of this fungus. Presumably, on mangrove leaves *Phytophthora* utilized readily assimilable carbon compounds that were present in early stages of decomposition, although some species of *Phytophthora* have been shown to utilize cellulose (3).

Four of the most abundant fungi (species of *Alternaria, Fusarium, Cladosporium* and *Drechslera*) on *Juncus* were also prevalent on mangrove leaves as were species of other genera such as *Pestalotia, Nigrospora* and *Trichoderma*. The differences in community structures were particularly noticeable in the ascomycetes: *Leptosphaeria juncina* and *L. australiensis* did not appear on mangroves while *Lulworthia* sp. did not inhabit *Juncus*. Fungi such as species of *Humicola, Coniothyrium, Geniculosporium, Periconia, Halospheria hamata* and *Paecilomyces* were more prevalent on *Juncus* than mangroves, in contrast to the abundance of species of *Cylindrocarpon, Phyllosticta, Aspergillus* and *Penicillium* on mangroves.

ACKNOWLEDGMENTS

This research was funded by Florida Power and Light Corporation, Miami, Florida and the Department of Energy Contract EY 76S053081. We particularly want to acknowledge the cooperation of the F.P. & L. representatives: Dr. Nancy Walls, Mr. Charles Henderson and Mr. Joe Riggs. Dr. S. Y. Newell and Mr. I. M. Master, RSMAS, assisted throughout the program, particularly with the fungal identifications; Ms. R. Cefalu and Ms. A. Statzell-Tallman assisted in the field program. This is a contribution from the Rosenstiel School of Marine and Atmospheric Science.

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Accepted for publication September 11, 1978