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SHORT COMMUNICATION

FIRST RECORDS OF THE SEAGRASS PARASITE *PLASMODIOPHORA DIPLANTHERAE* FROM THE NORTHCENTRAL GULF OF MEXICO

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Introduction

The parasite *Plasmodiophora diplantherae* is a causal agent of enlarged shoot galls in seagrasses. Ferdinandsen and Winge (1914) described the genus *Ostenfeldia* for a plasmodiophoraceous organism in shoot galls of *Halodule wrightii* (as *Diplanthera wrightii*) collected from St. Croix, West Indies (now U.S. Virgin Islands). After re-examination of this material by Cook (1933), the parasite was renamed *Plasmodiophora diplantherae* (Ferd. & Winge) Ivimey Cook. Den Hartog (1965) re-examined additional herbaria specimens collected throughout the world and concluded *P. diplantherae* was specific to the host genus *Halodule*.

Traditionally studied with the fungi, members of the genus *Plasmodiophora* are flagellate protists (Patterson 1999) in the Phytomyxea (Eukaryotes, phylum Cercozoa) (Cavalier-Smith 1998). Informally called plasmodiophorids (Braselton 1995), these organisms are obligate endobionts in a diverse group of terrestrial, marine and freshwater hosts including higher plants, algae and oomycetes. Eleven genera are currently recognized, containing 36 species (Maier et al. 2000). Plasmodiophorids are characterized by a multinucleate vegetative structure called a plasmodium, which divides at maturity to form either (1) sporangia that produce biflagellate, motile zoospores, or (2) resting spores which are released when the host cell breaks (Karling 1968). Many plasmodiophorids induce cell hypertrophy in their hosts via cell enlargement (den Hartog 1989). In vascular plant hosts, however, the parasite is restricted to the inner cortex and thus plant growth can continue (den Hartog 1965). *Plasmodiophora diplantherae* causes enlarged internodes (galls) in host shoots which contain rust brown, smooth-walled resting spores 4-4.5 µm in diameter (Karling 1968).

Plasmodiophora diplantherae is known to occur throughout the pantropical distribution of its host, the seagrass genus *Halodule*. However, records in the subtropical region are limited to Tampa Bay, FL where it was detected once during an examination of herbarium specimens of *H. beaudettei* collected in December 1951 (den Hartog 1965) and to Fort Pierce, FL where it was collected once infecting *H. wrightii* (Braselton and Short 1985). This communication represents the first report of this parasite from Mississippi and Louisiana in the northcentral Gulf of Mexico (GOM).

Materials and Methods

During an investigation of seagrass roots in the northcentral GOM, seagrass plants were collected from three seagrass bed sites (Figure 1): Pointe aux Pines, AL (22 August 2006, site 1); Grand Bay National Estuarine Research Reserve (NERR), MS (9 September 2006, site 2); and Chandeleur Islands, LA (27 September 2006, site 3). Additional *H. wrightii* specimens were also collected from Horn Island, MS (13 October 2006, site 4) and from Chandeleur Islands, LA (19 June 2008, site 3).

Core samples (15 cm x 30 cm) containing seagrass roots and surrounding marine sediment were taken at three randomly selected points along two 25 m transects 100 m apart at sites 1, 2 and 3. Salinity (ppt), pH, dissolved oxygen con-

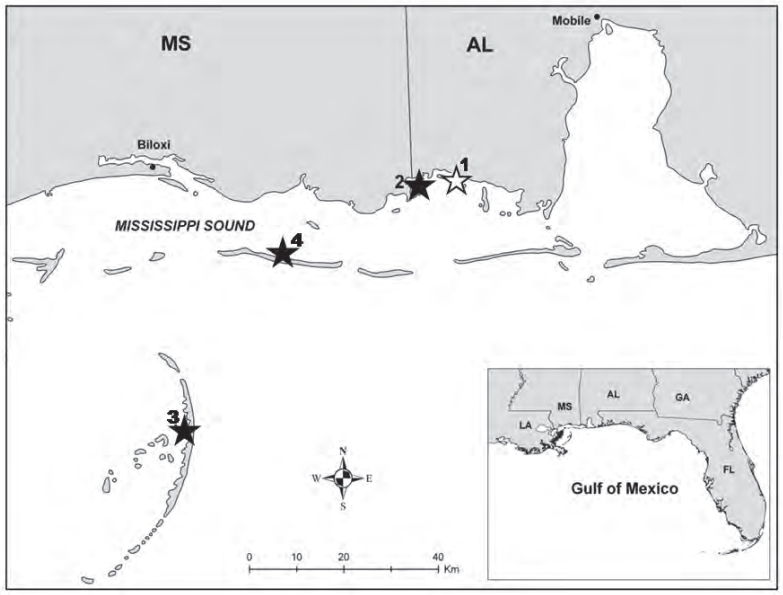

Figure 1. *Location of seagrass collecting sites within the northcentral Gulf of Mexico. Site 1 = Pointe aux Pines, AL; Site 2 = Grand Bay National Estuarine Research Reserve, MS; Site 3 = Chandeleur Islands, LA; Site 4 = Horn Island, MS. Black stars indicate sites at which* Halodule wrightii *parasite* Plasmodiophora diplantherae *was present.*

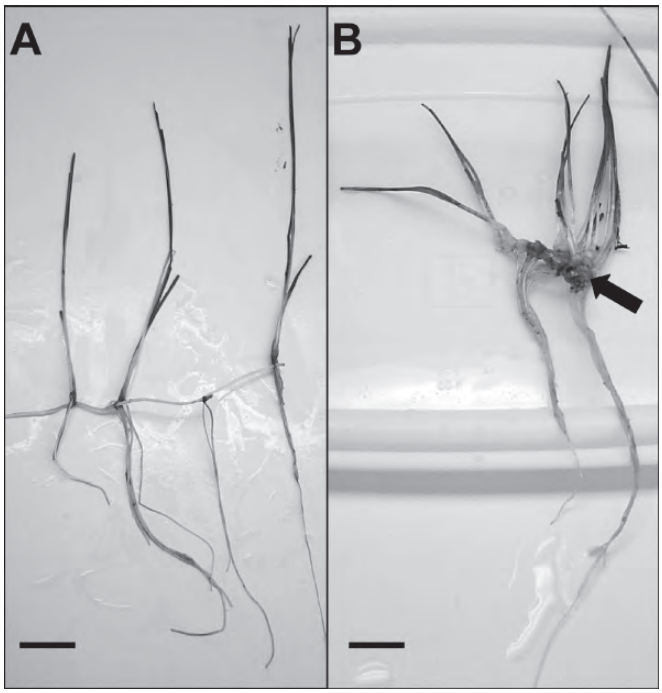

Figure 2. *A. Healthy* Halodule wrightii *plant. B.* Halodule wrightii *infected with* Plasmodiophora diplantherae*, causing galls at internodes (arrow). Scale bar = 2 cm.*

tent (%), and water temperature (°C) were recorded for each transect and water depth (m) was recorded for each core. Cores were placed in sterile plastic bags, transported back to the lab on ice and stored at 4 °C.

Seagrass plants were removed from surrounding sediment using an 850 µm (size 20) stainless steel sieve and separated by species within 24 h of collection. Fresh shoot galls were mounted in distilled water, crushed, and examined using a Nikon Eclipse 80 microscope equipped with Nomarski interference contrast optics. Digital photographs of microscopic structures were taken using a SPOT Insight camera and measurements were made using SPOT 4.1 software. Infected and healthy specimens were preserved in 50% alcohol. A dried voucher specimen and a microscope slide voucher were deposited in the herbarium of the University of Southern Mississippi's Gulf Coast Research Laboratory (HGCRL) (Ocean Springs, MS).

Results and Discussion

No infected *H. wrightii* plants were collected at Pointe aux Pines, AL (site 1). One core out of 6 collected at Grand Bay NERR, MS (site 2) and one core out of 6 collected at Chandeleur Islands, LA (site 3) contained *H. wrightii* infected with *P. diplantherae*. In the infected cores, 53% of 103 *H. wrightii* shoots collected at the Grand Bay NERR exhibited infection, and 100% of 3 shoots collected at the Chandeleur Islands were infected. Additional *H. wrightii* specimens exhibiting *P. diplantherae* infection were collected from Horn Island, MS (site 4) in October 2006 and from Chandeleur Islands, LA in June 2008 (64% of 22 shoots infected).

Infected specimens of *H. wrightii* closely resembled the descriptions and illustrations of Ferdinandsen and Winge (1914) and illustrations redrawn by Karling (1968). Host shoot tissue was transformed into white galls at the internodes in infected specimens, and host plant rhizomes and shoots were stunted and disfigured when compared with uninfected specimens (Figure 2). Gall diameter ranged from 1-3 mm. In actively growing shoots, galls were white to light cream near the shoot apex as in Braselton and Short (1985). However, the current study observed reddish brown galls further away from the apex (Figure 3), whereas Braselton and Short (1985) noted these galls were brown. Host gall tissue was brittle, breaking easily to release abundant smooth-walled, red-brown globose spores measuring 4-4.6 µm in diameter (Figure 4). Biflagellate zoospores were not observed. Not all shoots on a given rhizome were infected with *P. diplantherae*. One plant exhibited 4 healthy shoots next to 4 infected shoots on one rhizome.

Similar water temperatures, pH readings and supersaturated dissolved oxygen concentrations were recorded at sites 1-3. Water depth was shallower at site 1 (0.60 m) than at site 2 (0.90 m) and site 3 (1.05 m). *Plasmodiophora diplantherae* was not observed at site 1, which suggests that the parasite may require deeper water.

Den Hartog (1989) noted that species of the seagrass genus *Zostera* similarly infected with the related parasite *P. bicaudata* have noticeably stunted roots, allowing the plants to become uprooted easily. During collecting trips for the

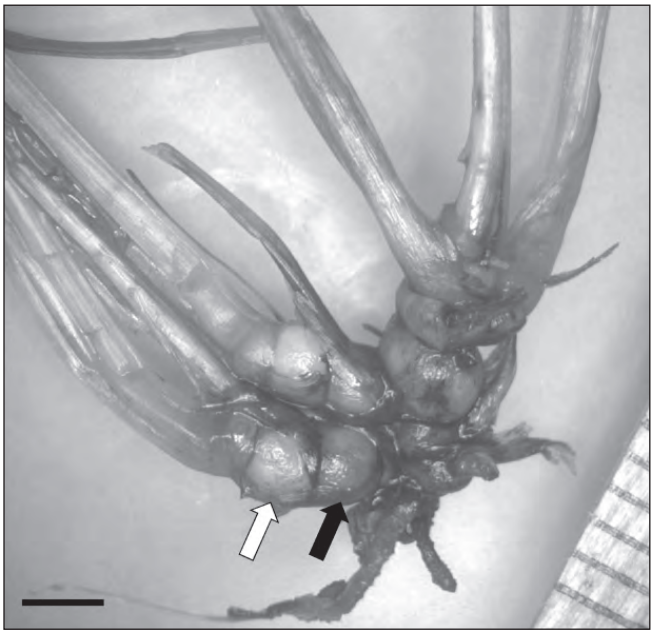

Figure 3. *Swollen internodes (galls) of* Halodule wrightii *infected with* Plasmodiophora diplantherae*. Galls closer to shoot apices were white-cream (white arrow), while galls closer to rhizome were reddish-brown (black arrow). Scale bar = 2 mm.*

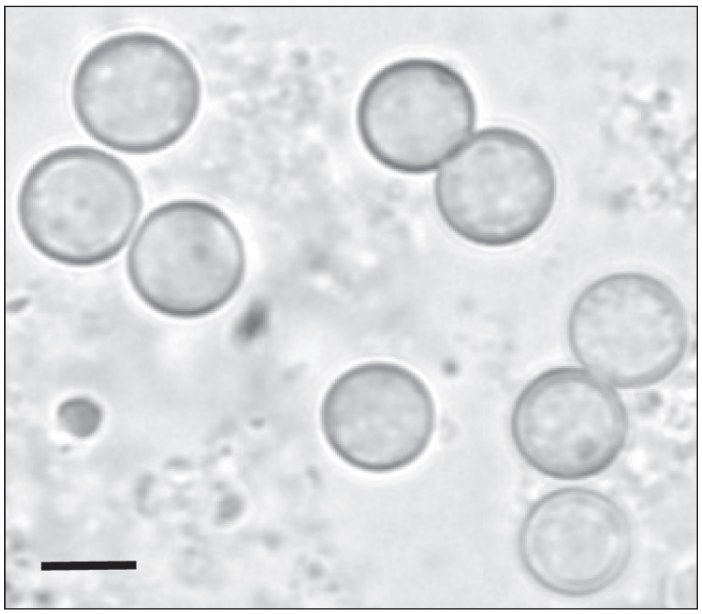

Figure 4. *Resting spores of* Plasmodiophora diplantherae. *Scale bar = 4 µm.*

current study, numerous floating *H. wrightii* plants were observed at all sites where this parasite was collected. Seagrass uprooting could be a serious problem facing these declining habitats, and uprooting may also aid in the dispersal of *P. diplantherae*. Additionally, seagrass uprooting may be partially to blame for the low establishment rate (<50%; Fonseca et al. 1998) of current seagrass restoration projects. Seagrass restoration scientists in the northcentral GOM should be aware of the presence of this parasite. Factors determining the pattern of occurrence of *P. diplantherae* are currently unknown.

This study detected *P. diplantherae* in both fall and spring in the northcentral GOM over the course of three years. *Plasmodiophora bicaudata* is thought to overwinter in the rhizomes of *Zostera* plants (den Hartog 1989) and whether *P. diplantherae* shares this ability is unknown. However, plasmodiophorids can persist in the environment as resting spores, which were detected in this study within *H. wrightii* galls. Chlorine has demonstrated success in inactivating plasmodiophorid resting spores (Datnoff et al. 1987), and may hold promise for treating infected *H. wrightii* raised for future restoration activities.

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