CHECKLIST OF FISH IN RICE AND SUGARCANE FIELDS OF THE EVERGLADES AGRICULTURAL AREA

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Abstract: *We conducted three years of fish surveys in rice and sugarcane fields of the Everglades Agricultural Area. Canals and ditches, as well as rice fields, were included in the survey. We observed 22 species of fish, of which eight were non-native species. Eastern mosquitofish* (Gambusia holbrooki) *dominated the catch numerically (77%). Other small fishes made up most of the remainder, and included flagfish* (Jordanella floridae) (5%)*, bluefin killifish* (Lucania goodei) (2%)*, least killifish* (Heterandria formosa)(4%), *and sailfin molly* (Poecilia latipinna) (10%)*. Species composition of fish communities were similar to those found in other studies in south Florida in rice fields and in ditches and canals. While there were a number of non-native species caught they did not dominate the communities in numbers or species richness.*

Key Words: Fish checklist, fish, Everglades Agricultural Area, agriculture, Florida

The Everglades Agricultural Area (EAA) is a 280,000 ha area of farmlands in south Florida at the southern end of Lake Okeechobee. South Florida has been the site of many environmental studies in natural habitats of the Everglades system due to a major restoration effort currently underway. While fish occurrence and habitat use have not been studied in the EAA, studies of fish in natural freshwater habitat have increased since the 1970s thanks to Everglades restoration activities (Loftus and Kushlan, 1987; Kobza et al., 2004; Gaff et al., 2000; Loftus et al., 2004; Trexler et al., 2000).

Fishes in marshes of south Florida have adapted to a hydrological regime of seasonally varying water depths and even absence of water over large portions of their habitat for periods of time (Loftus and Eklund, 1994). Shallow marshes provide habitat for small fishes and are probably used less by larger fishes due to density of plants and shallowness of water (Loftus and Eklund, 1994). Therefore, short-hydroperiod areas of the Everglades probably support populations of small fishes and juvenile life stages of larger fishes. Important to the health of Everglades fish populations has been the presence of deep water refugia, traditionally provided by alligator holes (Loftus and Eklund, 1994) but also provided by canals in the managed system (Trexler et al., 2000). We hypothesize that rice field habitat is an analogous habitat to short-hydroperiod marshes, and that canals and ditches associated with agricultural fields provide habitat for many of south Florida's fish species.

STUDY AREA—Our study was conducted in rice fields of the Everglades Agriculture Area (EAA) near Belle Glade, Florida, between October 2002 and September 2004. Historically, south Florida was dominated by the greater Everglades ecosystem. From Lake Okeechobee southward, water flowed across a wide landscape of marshes, sloughs, tree islands, and mangrove swamps into Florida Bay (Porter and Porter, 2002). Vast expanses of sawgrass (*Cladium jamaicense*) marsh, over thousands of years, worked to produce a layer of rich peat soil more than 3.7 meters deep (Snyder and Davidson, 1994). Before the turn of the 20th century, drainage of the northern part of the Everglades commenced with production of a system of canals and dikes in the vicinity of and around Lake Okeechobee. The Everglades Agricultural Area came into being in the early 1950s (Light and Dineen, 1994). The EAA is an area south of Lake Okeechobee that is surrounded by drainage canals and water control structures.

Approximately 200,000 ha of the EAA are cultivated. Sugarcane is the dominant crop grown in the EAA and covers about 180,000 ha; the rest is planted in vegetables, rice, and sod (Izuno et al., 1991; Schueneman, 2002). Water management on farms is accomplished by using open canals to raise or lower the water table (Izuno et al., 1991). Canals are permanent structures and are dug into the limestone bedrock. They connect to fields via a system of temporary and permanent ditches. Permanent pumping stations are used to discharge water from farms and are augmented by smaller moveable pumps for individual field/crop water management. Agricultural areas are connected through ditches and canals to natural areas of the Everglades to the south and Lake Okeechobee in the north. This has allowed colonization of the EAA of both native and non-native fish.

Sugarcane is grown on irrigated fields in which water level is controlled through a series of ditches and canals (Izuno et al., 1991). Sugarcane provides upland habitat but supports very few wildlife species by itself (pers. obs.). Habitats associated with edges and ditches in sugarcane are often brushy and provide habitat for some wildlife species. Large ditches and canals tend to be permanently flooded and also provide habitat for aquatic species (Trexler et al., 2000).

Rice has been grown in the EAA since the 1950s, but only since 1977 has it been grown in any appreciable amount (Lodge and Clark 1996). It is grown through the spring and summer in rotation with sugarcane, and is flooded throughout the growing season. This aquatic habitat provides an opportunity for invertebrates and fishes to colonize from field ditches (perhaps through pumps as well) and reproduce in the flooded fields. Once a rice field is flooded with approximately 30 cm of water, pumping ceases and fields remain flooded until harvest approximately 80 days later. At harvest, a final drawdown serves

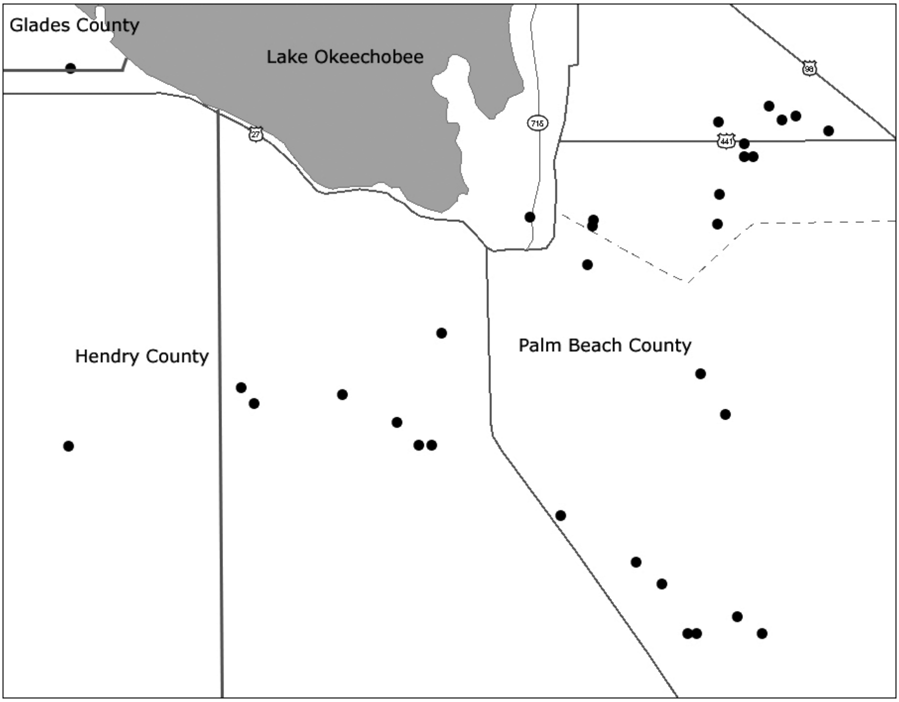

FIG. 1. Sampling locations for fish in agricultural fields of the Everglades Agricultural Area.

to concentrate aquatic animals and is analogous to periodic drydowns in natural Everglades habitat.

METHODS—We chose to sample rice and sugarcane fields with differences in management and construction, such as edge vegetation, dike or berm construction, and canal and ditch layout. Road accessibility also affected the study areas chosen. Each field consisted of 8 to 10 smaller sub-fields separated by ditches. Ditches and internal subfields were chosen randomly within each larger field. If a ditch or canal was inaccessible for setting minnow traps, a second choice was randomly selected. We surveyed a total of 26 fields with 11 traditional and two organic rice fields and 13 sugarcane fields (Fig. 1). Each field was visited multiple times throughout the year.

We used two different fish traps, double-funnel wire minnow traps with 3 mm mesh (Gee traps) and Breder traps (Breder, 1960; rice fields only). Breder traps are box traps constructed of clear plexiglass with a funnel at the mouth. Visual surveys were also conducted for larger fishes in deeper canals as well as for general fish activity. We also used a cast net to assess presence of larger fishes in the canals. We did both overnight and 20-minute sampling; un-baited traps were placed at dusk for overnight sampling and/or early morning for 20 minutes while we conducted other surveys. We set traps in canals and ditches for all surveys, and edge and mid-field within rice fields. Traps were placed near the waters' edge and submerged half way to allow air-breathing species access to air if caught in the traps during the survey. In sugarcane fields we used only minnow traps and placed them in canals and in ditches within sugarcane where possible. Sometimes vegetation choked off ditches and canals making it impossible to use traps. In rice fields traps were set in canals and ditches a week before flooding and throughout the growing season. Both minnow and Breder traps were used in and adjacent to rice fields and were placed side by side where possible.

TABLE 1. List of fish caught in our study, relative abundance in the EAA and relative abundance in other studies (Loftus and Eklund 1994; Loftus, 2000, Kobza et al., 2004; and Ceilley, unpublished data). a = abundant, c = common, u = uncommon and r = rare, lc = locally common, * = non-native species. In our study a = > 50%, c = 2–49%, u = 0.1–1.9% and r = < 0.1%.

EAA Study	Abundance EAA	Other Studies	Locations Caught
Florida gar *Lepisosteus platyrhincus*	u	r - c	canal, field
Bullhead sp. *Ameiurus sp.*	r	r - u	all locations
Walking catfish* *Clarias batrachus*	r	u - lc	field
Armored catfish* *Pterygoplichthys multiradiatus*	u	not found	all locations
Brown hoplo* *Hoplosternum littorale*	r	not found	canal
American flagfish *Jordanella floridae*	c	lc - a	all locations
Golden topminnow *Fundulus chrysotus*	u	u - a	all locations
Bluefin killifish *Lucania goodei*	c	c	all locations
Eastern mosquitofish *Gambusia holbrooki*	a	c - a	all locations
Least killifish *Heterandria formosa*	c	u - c	all locations
Sailfin molly *Poecilia latipinna*	c	u - c	all locations
Brook silverside *Labidesthes sicculus*	r	r - lc	ditch, field
Bluespotted sunfish *Enneacanthus gloriosus*	u	u - c	all locations
Bluegill sunfish *Lepomis macrochirus*	u	u - c	all locations
Redear sunfish *Lepomis microlophus*	r	u - c	ditch, field
Dollar sunfish *Lepomis marginatus*	r	u - c	canal, field
Largemouth bass *Micropterus salmoides*	r	u - lc	canal
Black acara* *Cichlasoma bimaculatum*	r	u - lc	all
Mayan cichlid* *Cichlasoma urophthalmus*	u	u - c	all
Oscar* *Astronotus ocellatus*	r	u - c	all
Blue tilapia* *Oreochromis aureus*	r	lc - c	canal
Spotted tilapia* *Tilapia mariae*	r	u	all

We did not use Breder traps in canals due to water depth and potentially fast currents, nor did we use them in overnight sets due to an inability to guarantee animals' access to air.

All fishes and invertebrates caught from each trap were identified to species and counted. We made note of any deformities or abnormalities in each animal. Individuals were released as soon as possible after we retrieved the trap. We also recorded presence of larger individuals by species in the canals and ditches during visual surveys.

RESULTS—We trapped a total of 18,993 fish of 22 different species in rice and sugarcane fields. These included eight non-native species, either trapped or observed, all at frequencies of less than 1% (Table 1). Eastern mosquitofish (*Gambusia holbrooki*) dominated fish communities by number in the EAA, comprising about 77%. Four other species were present at from 2% to 10% of the catch, the remainder were present in lower percentages. These four species included flagfish (*Jordanella floridae*) (5%), bluefin killifish (*Lucania goodei*) (2%), least killifish (*Heterandria formosa*)(4%), and sailfin molly (*Poecilia latipinna*) (10%).

We observed the most species in canals (20); the fewest in ditches (17). One species, walking catfish (*Clarias batrachus*), was collected once in a rice field. The most common species were caught in multiple locations. Several that were caught or observed only in canals and ditches included blue tilapia (*Oreochromis aureus*), brown hoplo (*Hoplosternum littorale*), brook silverside (*Labidesthes sicculus*), bullhead sp. (*Ameiurus sp.*), and largemouth bass (*Micropterus salmoides*).

We also trapped a variety of invertebrates including Everglades crayfish (*Procambarus alleni*), riverine grass shrimp (*Palaemonctes paludosus*), and insects such as predaceous diving beetles (Family: Coleoptera), and odonate naiads (Family: Odonata).

DISCUSSION—The fish communities we observed were similar to those found in other south Florida studies (Kobza, et al., 2004 and Loftus, 2000 (Table 1). Two non-native species that we observed have recently entered the region and were not reported in other studies – brown hoplo (*Hoplosternum littorale*) and armored catfish (*Pterygoplichthys multiradiatus*).

Most south Florida fish are generalists and resilient in the face of disturbance (Trexler et al., 2000). Those characteristics enable some species to utilize such temporary habitats as rice fields. Over the period of cultivation, about 80 days, the fields are able to sustain large fish populations and provide abundant food for predatory vertebrates including other fishes and birds. Duration of flooding in rice fields is similar to that of short-hydroperiod marshes in which small fish dominate the system (Loftus and Kushlan, 1987). Short periods of flooding, shallow water, and dense vegetation, such as occurs in rice fields, limits colonization by larger fish (Loftus and Eklund, 1994), but probably serves as nursery areas for many species. However, those fishes are present in adjacent canals and field ditches where we caught juveniles of larger species in or adjacent to rice fields.

A study of short-hydroperiod karst wetlands (Loftus et al., 2001) studied re-flooding of the wetlands and the timing in which different species re-colonized newly flooded habitat. All species in our study were within a group that might be referred to as 'pioneering' fish or those that re-colonized early in the flooding stage. These fish colonized natural marshes within 4 to 5 weeks of inundation. Neither pike killifish (*Belonesox belizanus*) nor marsh killifish (*Fundulus confluentus*) were caught in our study area. Pike killifish do not occur in inland habitat (more than 10–12 km from the coast) and marsh killifish tend to inhabit brackish water (Loftus, 2000). Freshwater fish found in other south Florida studies include native species tarpon (*Megalops atlanticus*), golden shiner (*Notemigonus crysoleucas*), coastal shiner (*Notropis petersoni*), lake chubsucker (*Erimyzon sucetta*), and spotted sunfish (*Lepomis punctatus*) and were not collected in this study.

Fishes have been present in rice fields nearly as long as people have been growing rice. In some cultures, these fish may provide a secondary food crop (Fernando, 2002; Halwart et al., 1996) or be used to control mosquito populations (Washino and Hokama, 1967). Fish may be purposefully introduced or may colonize through pumps (Poizat et al., 1999) or through contact with adjoining water bodies (Ali 1990). Rice fields are artificial wetlands that have been shown to provide habitat for wetland birds such as herons and egrets that prey on small fish and invertebrates (Kushlan and Hafner, 2000). Drawdowns for cultivation are similar to drying of natural wetlands but occur more rapidly, over a period of a few days to a week and are generally during the wet season. Very high concentrations of fish have been observed in ditches subsequent to drawdowns, and, during the wet season, fish may occur in higher numbers than natural environments (D. Gawlik, 2006). These fish are available as forage for wading birds that disperse from Lake Okeechobee or other natural areas in south Florida during the summer. The flooding cycle of rice occurs on a regular yearly basis on thousands of acres throughout the EAA. This annual cycle begins from April or May through late summer or fall depending on the number of ratoon crops which means that flooding in rice occurs before the natural wet season.

Aquatic habitat in the EAA supports a variety of native and non-native fish that is similar to other short hydroperiod marshes in south Florida. Rice fields seem to provide nursery habitat for smaller fish that are able to utilize the shallow water and dense vegetation. While we found two exotic species not reported in the literature for natural areas in south Florida, we did not find unnaturally high numbers of non-native species. This may be because our sampling techniques did not adequately sample larger canals or other habitats.

ACKNOWLEDGMENTS—We thank Dr. W.F. Loftus for assistance with the project and with the manuscript. Michelle Casler provided valuable assistance with graphics. We also thank the Everglades Agricultural Area Environmental Protection District for funding this project. The growers and managers of the Everglades Agricultural Area provided invaluable assistance with access and locating fields. Research was conducted under IACUC permit number A747 from the University of Florida. Additional support for this research was received from the Florida Agricultural Experiment Station.

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Florida Scient. 70(2): 113–119. 2007
Accepted: August 22, 2006