Freshwater Fish Assemblages in Isolated South Florida Wetlands

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Abstract - We sampled fish communities in 19 isolated cypress pond and herbaceous marsh wetlands at locations in southwest, south-central, and southeast Florida. Breder fish traps were more effective at sampling fish communities at these sites than either seine or dip nets. We collected 23 total species, but species richness varied from 1–16 among sites. The availability of deepwater refugia and the extent to which periodic flooding connected these wetland habitats to other aquatic environments appeared to be principal factors influencing composition of fish assemblages. Models of fish distribution in response to hydrological changes in the Everglades have proposed size-structured, fish functional groups of ≤ or > 7 cm, but our data suggested size and ecology of fish functional groups in isolated wetlands may be better described as small, omnivorous species (≤ 15 cm) and larger predatory species (> 15 cm). We suggest incorporating fish functional groups in programs to monitor ecological health of isolated wetlands in south Florida may be more productive than attempts to identify specific indicator species or relying solely upon measurements of physical, chemical, or plant-community parameters.

Introduction

Rapidly increasing coastal populations and large-scale agricultural operations in south Florida have challenged water resource managers responsible for maintaining healthy aquatic systems. Attempts to evaluate the effects of public demand for water on aquatic systems through physical and chemical attributes without also including biological measures cannot adequately reflect impacts on ecosystem health (Harris 1995). Most biological measures used to assess functional change in wetland systems focus on plant-community structure (e.g., Zampella and Laidig 2003), but ecological health of wetlands should also be evaluated in terms of the functional attributes of faunal communities. Fish may be a key criterion to include when judging ecosystem health, because fish serve as excellent indicators of environmental conditions and form vital trophic links with higher level consumers (Harris 1995).

Isolated and semi-isolated wetlands (collectively referred to as isolated) in south Florida are particularly vulnerable to anthropogenic impacts such as lowered water tables due to pumping of groundwater for urban and agricultural uses. Because many wetland habitats in south Florida are only periodically connected to other wetland systems during high-water events, negative impacts to fish communities within these environments can have potentially long-lasting implications for higher-level consumers such as wading birds.

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Unfortunately, little published information is available regarding fish communities of isolated wetlands in south Florida or techniques that work well to sample them.

Information on fish communities of freshwater wetlands in south Florida comes primarily from inventories of the Florida Everglades (Loftus 2000) and Big Cypress Swamp (Ellis et al. 2003). These inventories reveal that the native fish fauna of south Florida's major freshwater wetland ecosystems is dominated by small species, especially the Poeciliidae, Cyprinodontidae, and Fundulidae. Based on this information, Gaff et al. (2000) defined small (≤ 7 cm) and large (> 7 cm) fish functional groups in a model for assessing spatial patterns of fish densities in freshwater marshes of the greater Everglades ecosystem. It is not known, however, whether these functional fish groups are appropriate for use in more isolated wetlands. We report results of surveys of fish communities in isolated herbaceous marsh and *Taxodium ascendens* Brongn. (pond cypress) and *T. distichum* (L.) Rich. (bald cypress) wetlands in southwest, south-central, and southeast Florida conducted with rapid, non-lethal sampling techniques. In addition to providing information on fish assemblages, we comment on sampling techniques and discuss the use of size-delimited fish functional groups as indices for monitoring environmental conditions in isolated wetlands.

Methods

We surveyed fish communities at 19 isolated freshwater wetlands in south Florida during 21–26 November and 11–13 December, 1996. By isolated wetlands, we refer to small marsh- and cypress-dominated wetland habitats entirely surrounded by upland or dry landscapes at least seasonally and potentially for multiple years, depending on regional flooding patterns. Wetlands sampled in southwest Florida included five cypress ponds located within the Flint Pen strand, a 6100-ha cypress swamp located in Lee County within the Corkscrew Regional Ecosystem Watershed. Sampling sites in south-central Florida included 3 herbaceous marshes and two cypress ponds within the Disney Wilderness Preserve located in Osceola and Polk counties. We also sampled seven sites in southeast Florida that included two cypress ponds and four marsh habitats in Jonathon Dickinson State Park (Martin County) and three marsh sites in Savannas Preserve State Park (St. Lucie County). We recorded water temperature, dissolved oxygen, and conductivity at each site with a YSI Model 58 portable dissolved oxygen meter and probe, and used multiple regression to model the effects of these water-quality parameters on species richness and relative abundance.

We sampled each site with passive and active techniques to evaluate the utility and selective nature of each technique under a range of habitats and environmental conditions. The same sampling procedures were followed at all sites. Passive sampling was conducted with rectangular, clear plastic fish traps (10 x 10 x 45 cm) constructed after the design of Breder (1960). We deployed 6 Breder fish traps (two floating, four weighted) in shallow areas throughout each site. Traps were placed to maximize sampling coverage of microhabitats (e.g, emergent vegetation, woody debris) and left in place for two hours. Concurrent active sampling was conducted by three persons with standard D-frame, 1-mm mesh dip nets for 30 min. Dip nets were worked through all microhabitats, including vegetation, open water, and around trees and woody debris, and any fish captured were evaluated to species level. We also pulled a small-mesh fish seine through each site, the length of which was continually adjusted as necessary to avoid trees and other obstructions. Dip nets and seines were used to determine whether these methods would collect additional species that avoided Breder traps. Fish captured with the seine and dip nets were recorded to species and included in analyses of species richness, but not relative abundance.

Fish were identified to species in the field or labeled for later identification and, with the exception of voucher specimens, released. Species were identified with taxonomic keys and verified by Dr. Carter Gilbert (Curator of Fishes, Florida Museum of Natural History, University of Florida, Gainesville, FL) as needed. Taxonomic names and authorities follows the Integrated Taxonomic Information System (ITIS); (http://www.itis.gov). Voucher specimens were preserved in a 10–20% formalin solution and submitted to the South Florida Water Management District for archiving.

We calculated percent frequency of occurrence for each species among sites by region. Restrictions on the number of individuals that could be sacrificed necessitated a rapid assessment approach for quantifying species in fish traps. We made quick counts of individuals and assigned abundance scores for each species as one (n = 1), six (n = 2–9), 17 (n = 10–24), or 25 (n > 25) and summed these values across all sites to calculate rank relative abundance among species. We compared species richness and relative species abundance among habitats and regions with two-way ANOVA, and used Fisher's least significant difference (LSD) multiple range tests to evaluate differences. Data were square-root transformed, and plots of residuals were used to ascertain whether assumptions of equal variance and normality were met (Sokal and Rohlf 1981). We used size and life-history traits to assign each species to one of two functional groups: (1) small (≤ 15 cm) omnivorous species, or (2) large (> 15 cm) predatory species.

Results

We collected 23 species of fish representing 10 families from nine isolated cypress pond and 10 isolated herbaceous marsh sites in south Florida (Table 1). Species richness varied among sites from 1–16 (mean = 6.2, SD = 3.8), and at a 90% level of confidence, differed among regions ($F_{2,15} = 3.13$, $P = 0.07$), but not among habitats ($F_{1,15} = 1.93$, $P = 0.18$). Multiple-range tests revealed wetlands in southwest Florida had significantly greater species richness (mean = 10.6, SD = 3.6) than those in south-central Florida (mean = 3.6, SD = 1.3), and that those in southeast Florida were intermediate and did not differ from either of the other two regions (mean = 5.2, SD = 2.6).

Relative species abundance also differed among regions ($F_{2,15} = 2.98$, $P = 0.08$), but not among habitats ($F_{1,15} = 0.48$, $P = 0.50$). As with species

Table 1. Families, scientific names, common names (in parentheses), and functional group designations (1 = small, omnivorous species ≤ 15 cm; 2 = predatory species > 15 cm) for fish collected from isolated herbaceous marsh and cypress pond wetlands in southwest (SW), south-central (SC) and southeast (SE) Florida. Percent frequency of occurrence and species richness is provided by region and habitat, and numbers of sampling sites for each are provided in parentheses. Mean percent frequency of occurrence, cumulative abundance score, and abundance rank (where 1 = most abundant) calculated across all sites combined are provided for each species. * = non-native species.

			SW	SC		SE				
Family	Species	Funct. group	Cyp. (n = 5)	Marsh (n = 3)	Cyp. (n = 2)	Marsh (n = 7)	Cyp. (n = 2)	Mean % freq.	Abund. score	Abund. rank
Atherinopsidae	*Labidesthes sicculus* Cope (brook silverside)	1	20	0	0	0	0	5	1	16
Centrarchidae	*Enneacanthus glorious* Holbrook (blue spotted sunfish)	1	80	0	0	57	100	53	65	6
	Lepomis marginatus Holbrook (dollar sunfish)	1	20	0	0	0	0	5	6	15
	Lepomis microlophus Günther (redear sunfish)	2	20	0	0	0	0	5	6	15
	Lepomis punctatus Valenciennes (spotted sunfish)	2	20	0	0	0	0	5	7	14
	Lepomis gulosus Cuvier (warmouth)	2	100	0	0	0	0	26	36	11
Cichlidae	**Cichlasoma bimaculatum* Linnaeus (black acara)	1	80	0	0	14	0	26	41	10
Cyprinodontidae	*Lucania goodei* Jordan (bluefin killifish)	1	80	0	0	0	50	26	15	13
	Jordanella floridae Goode (flagfish)	1	100	0	0	0	0	26	60	7
Elassomatidae	*Elassoma evergladei* Jordan (Everglades pygmy sunfish)	1	80	100	100	86	50	84	211	2
Esocidae	*Esox americanus* Gmelin (redfin pickerel)	2	0	0	50	0	0	5	6	15
Fundulidae	*Fundulus chrysotus* Günther (golden topminnow)	1	60	0	50	14	100	37	91	5
	Fundulus lineolatus Agassiz (lined topminnow)	1	0	0	0	14	50	11	7	14
	Fundulus confluentus Goode (marsh killifish)	1	60	0	0	0	0	16	18	12
	Leptolucania ommata Jordan (pygmy killifish)	1	0	0	0	57	100	32	47	9
	Fundulus cingulatus Valenciennes (redfaced topminnow)	1	0	100	100	71	100	63	208	3
Ictaluridae	*Ameiurus nebulosus* Lesuer (brown bullhead)	2	20	0	0	0	0	5	1	16
	Ameiurus natali Lesueur (yellow bullhead)	2	0	0	50	0	0	5	6	15
	Noturus gyrinus Mitchill (tadpole madtom)	1	0	0	0	14	0	5	1	16
Lepisosteidae	*Lepisosteus platyrhincus* DeKay (Florida gar)	2	20	0	0	0	0	5	1	16
Poeciliidae	*Gambusia affinis* Baird and Girard (eastern mosquitofish)	1	100	100	100	100	100	100	370	1
	Heterandria formosa Girard (least killifish)	1	100	0	0	57	50	53	145	4
	Poecilia latipinna Lesueur (sailfin molly)	1	100	0	0	0	0	26	52	8
Species richness:	total (mean, SD)		16 (11, 3.6)	3 (3, 0)	6 (5, 2.1)	10 (5, 2.8)	9 (7, 1.4)	23 (6, 3.8)		

richness, relative fish abundance was consistently greatest at wetlands in southwest Florida (mean = 115.9, SD = 51.3). However, in terms of abundance, wetlands in southeast Florida had lowest fish abundance (mean = 44.3, SD = 24.5), and those in south-central Florida were intermediate (mean = 74.1, SD = 8.2).

Small, omnivorous fish represented 70% of species collected and included the 10 most abundant species (Table 1). Based on abundance scores summed across all sites, smaller omnivorous fishes outnumbered larger predatory fishes approximately 24:1. *Gambusia affinis* (eastern mosquitofish) was the most abundant species and the only species collected at all 19 sampling sites. The 2nd- and 3rd-most abundant species were *Elassoma evergladei* (Everglades pygmy sunfish) and *Fundulus rubrifrons* (redfaced topminnow), respectively (Table 1). The best-represented family was Centrarchidae (sunfishes) with five species, and included three of the seven large, predatory species recorded. Fundulidae was represented by four species, Poeciliidae and Ictaluridae were each represented by three species, Cyprinodontidae by two, and a single species was collected from each of the Atherinopsidae, Cichlidae, Elassomatidae, Esocidae, and Lepisosteidae. One non-native species, *Cichlasoma bimaculatum* (black acara), was collected at 4 of 5 (80%) locations in southwest Florida and at 1 of 9 (11%) locations in southeast Florida.

All but three of the species (87%) were captured by Breder fish traps. *Lepisosteus platyrhincus* (Florida gar), *Ameiurus nebulosus* (brown bullhead), and *Labidesthes sicculus* (brook silverside) were captured exclusively by seine at a single location, but seining generally proved impractical and was abandoned at most locations due to constant entanglement. Dip nets captured approximately 50% of the species collected by fish traps. Dissolved oxygen (0.5–9.5 mg/L), water temperature (18.5–25.0 °C), and conductivity (20–461 μS/cm) varied widely among sampling locations, but none of these parameters exerted a significant predictive effect on either species richness ($F_{3,18}$ = 0.72, P = 0.56, R^2 = 0.13) or relative abundance ($F_{3,18}$ = 0.17, P = 0.92, R^2 = 0.03).

Discussion

The fish communities we sampled were dominated by small, omnivorous forage fishes both in number of species (70%) and abundance, with small forage fishes outnumbering larger predatory species by about 24:1 (Table 1). Fish found in Florida wetlands typically survive a broad range of water chemistry parameters (Hoyer and Canfield 1994), and we detected no discernible effect on fish communities within the range of parameters measured.

Species richness varied from 1–16 among sites and was statistically different among regions (Table 1). Regionally, both mean species richness and relative abundance were greatest in fish communities sampled from southwest Florida. Wetlands sampled in southwest Florida were exclusively cypress pond habitats; however, when compared across regions, we detected no statistical difference in species richness or relative abundance between cypress ponds and marsh sites. The greater mean species richness observed at southwest Florida locations was likely associated with seasonal flooding that increased connectivity with other wetlands during the summer rainy season, which has been reported to influence species richness and the presence of larger species (Kushlan 1980, 1990). The sites sampled in southwest Florida were located within or immediately adjacent to the Flint Pen strand, a seasonally flooded cypress swamp that serves as an important conduit of seasonal sheet flow (surface flooding) within the 24,281-ha Corkscrew Regional Ecosytem Watershed (South Florida Water Management District 2006). Cypress ponds in south-central and southeast Florida occurred in more isolated cypress domes and were not direct components of larger wetland systems, although they may be connected with other wetlands during periodic flood events.

Structural cover associated with woody debris and cypress and deepwater refugia may also be important for some larger predatory species, particularly among the Centrarchidae and Ictaluridae. Although we did not quantify water depths, several of the cypress ponds in southwest and south-central Florida had deep holes (ca. 1.5–2 m) that likely served as fish refugia during dry periods and provided conditions suitable for supporting larger predatory species. All seven predatory species were collected exclusively from cypress ponds in these areas, and deepwater refugia at these locations were probably critical for sustaining large, predatory fishes such as *Esox americanus* (redfin pickerel) and *Ameiurus natalis* (yellow bullhead) through multiple dry seasons, particularly in more isolated wetland habitats (Table 1). Deep areas were not observed in the herbaceous marsh sites we sampled, which would limit the ability of these areas to support larger species, especially late in the dry season when isolated wetlands may become mostly or completely dry. The extent to which herbaceous marsh sites were seasonally or periodically connected with other wetlands was not known, and the lack of deepwater refugia was probably the major factor influencing absence of larger predatory species at these locations.

Breder fish traps (Breder 1960) captured all but three of the species collected and were more effective than either dip nets or seine. Breder fish traps were also easier both to use and to standardize sampling effort than the other methods. In addition, they are portable, reasonably easy to make (we built ours), and can be deployed rapidly. Although two species of large, predatory fish (Florida gar and brown bullhead) and one species typically associated with open water environments (brook silverside) were captured solely by seine, seining was generally impractical in these type of wetlands due to constant entanglement and had to be abandoned at most sites. Dip nets were easy to use and provided opportunities to actively sample different areas and microhabitats, but were not as efficient and collected only about half as many species as Breder fish traps, probably due to disturbance caused when wading in areas sampled. Dip nets also have the disadvantage of being difficult to standardize in terms of sampling effort and efficiency among individuals and locations. Consequently, Breder fish traps were the most efficient means evaluated for sampling isolated wetlands and, although these traps are not a good method for capturing adults of larger predatory species, they did capture juveniles. Although Breder fish traps are not as effective for sampling fish populations where seines can be used effectively (Layman and Smith 2001), other researchers have reported positive results using Breder traps in freshwater wetlands. Ceilley and Cox (1995) reported as many as eight species of fish collected by Breder trap during a single sampling event. Sargent and Carlson (1987) evaluated advantages and disadvantages of various wetland fish-sampling techniques and concluded Breder traps supplied excellent spatial and temporal resolution at reasonable cost when used in marsh habitats where relative densities or catch-per-unit-effort data will suffice and the principal marsh resident fish species can be used as indicator species.

Fish assemblages in large wetland ecosystems of south Florida are influenced by multiple factors including protective cover and depth, connectivity to other bodies of water, and hydrology (Carlson and Duever 1977, Ellis et al. 2003, Kushlan 1976, Loftus and Kushlan 1987). The presence of deepwater refugia and connectivity with other aquatic environments also appeared to be key factors influencing species richness and the presence of larger predatory fish in the isolated wetlands we sampled. We suggest these fundamental effects on fish community structure provide a means for evaluating changing hydrological conditions on the ecological health of isolated wetlands, and that monitoring fish assemblages in terms of functional fish groups may provide a more meaningful index of ecological health than attempting to identify select indicator species (Landres et al. 1988) or relying solely on measurements of physical, chemical, or plant-community parameters. Models developed as part of Everglades restoration efforts are utilizing this approach and size-structured, functional fish groups of ≤ 7 and > 7 cm to simulate fish distribution in response to changes in hydrology (Gaff et al. 2000). Whereas these size classes may be appropriate for the Everglades, many of the small, ubiquitous species collected from isolated wetlands exceed lengths of 7 cm (e.g., *Fundulus* spp.), but typically do not exceed lengths of 15 cm. Consequently, defining functional fish groups as small, omnivorous species (≤ 15 cm) and larger predatory species (> 15 cm) may better reflect the ecology of isolated wetlands, and we encourage additional work be done to evaluate the utility of this approach.

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