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Early life stages of fishes in plant communities in a cove at Aliceville Lake, Alabama-Mississippi, USA

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Abstract

Aquatic plants in backwater areas play, in many instances, important roles in structuring freshwater fish assemblages. This study examined the overall importance for fishes of vegetated backwater habitats in a cove at Aliceville Lake, an impoundment of the Tennessee-Tombigbee Waterway. An inventory of adult fishes compiled from earlier reports was made and compared it with early life stages of fishes collected with light traps. The overall efficiency of light traps for collecting early life stages of fishes was also tested. It was expected that abundance and species richness of young fishes collected reflected the overall abundance and species richness reported in the literature. A total of 1,778 fishes (1,388 early life stages, 78%, and 390 juveniles, 22%) representing 12 genera and 10 families was collected. These 10 families represented 62.5% of the families previously reported having adults in Aliceville Lake. Experimental tests confirmed that the light trap is efficient in attracting fishes as long as they are present in its area of influence. Even though the cove studied contained diverse macrophyte beds that lead to highly variable habitat use by young fishes, the obtained results confirmed that it was not as strongly used as spawning ground as it would be predict based on previous reports. Factors influencing this variability in macrophyte beds still remain unknown. Fishes at Aliceville Lake may respond to habitat complexity at scales other than those considered in this study and along habitat structure other than macrophytes. Although this study documents important use of vegetated backwaters at Aliceville Lake, further investigation is necessary to better understand the complex relation between early life stages of fishes and aquatic plants. Identification of these factors and knowledge of their mechanisms would facilitate better management of these ecologically important ecosystems.

Key words: backwaters, vegetated areas, early life stages of fishes, light trap, Aliceville Lake, Teneessee-Tombigbee Waterway.

Poblaciones de peces en comunidades de plantas en un remanso en Aliceville Lake, Alabama-Mississippi, USA

Resumen

Las plantas acuáticas en áreas de remanso desempeñan, en muchas instancias, papeles importantes en la estructuración de los ensamblajes de peces de aguas continentales. En este

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estudio se examinó la importancia general para los peces de hábitats de remanso con vegetación en una bahía en el Lago Aliceville, un embalse del Tennessee-Tombigbee waterway. Se efectuó un inventario de peces adultos compilado de reportes anteriores y se comparó con estadios de vida tempranos colectados con trampas de luz. Se comprobó la eficiencia general de las trampas de luz para recolectar peces en los primeros estadios de vida. Se esperaba que la abundancia y la riqueza de los peces recolectados en los primeros estadios de vida reflejaran la abundancia y riqueza de especies generales reportadas en la literatura. Se recolectaron 1.778 peces (1.388 en los primeros estadios de vida, 78% y 390 juveniles, 22%) representando 12 géneros y 10 familias. Estas 10 familias representaron el 62,5% de las familias cuyos adultos habían sido reportadas previamente en el Lago Aliceville. Pruebas experimentales confirmaron que la trampa de luz es eficiente atrayendo peces siempre y cuando estén presentes en su área de influencia. Aunque el remanso estudiado contenía lechos de macrofitas diversos que permitieron un uso altamente variable del hábitat por parte de los peces en los primeros estadios de vida, los resultados confirmaron que este no fue tan fuertemente usado como área de desove como se esperaría basado en reportes previos. Los factores que influencian la variabilidad en el uso del hábitat de los lechos de macrófitas permanecen aun desconocidos. Los peces en el Lago Aliceville pudieran responder a la complejidad del hábitat a escalas diferentes a las consideradas en nuestro estudio y a estructuras del hábitat diferentes a las macrofitas. Aunque este estudio documenta un uso importante de los remansos con vegetación en el Lago Aliceville, se requieren más investigaciones para lograr entender mejor la compleja relación entre los peces en sus primeros estadios de vida y las plantas acuáticas. La identificación de estos factores y el conocimiento de sus mecanismos facilitarían un mejor manejo de estos ecosistemas ecológicamente importantes.

Palabras clave: remansos, áreas con vegetación, primeros estadios de vida de peces, trampas de luz, Lago Aliceville, Teneessee-Tombigbee Waterway.

Introduction

There has been a long scientific controversy about the role plant coverage plays for freshwater fishes. A question asked many times is: is plant coverage an important habitat attribute for fishes? There has not been an unequivocal answer to this question, and the search continues. But what is it all about plant coverage and fishes? Aquatic plants have been recognized as important ecological components of aquatic systems, and are often primary regulators of ecosystem function. Introduction or removal of aquatic plants affects fish community composition, production, and limnological characteristics (1-3).

Dense, submerged plant communities support greater number, biomass, and diversity of fishes than do most other freshwater habitats (3-5). Juvenile fishes become more abundant as plant density and complexity increase (6-7). Nevertheless, macrophytes could negatively affect the physicochemical characteristics of the water they inhabit. For example, plant respiration reduces and/or depletes dissolved oxygen during the night reducing habitat availability for fishes (2, 8).

In addition to aquatic plants, riverine backwater habitats are important to fishes. They are usually nonflowing and depths are shallower than in channels, which allow water to warm earlier in the year and attain higher temperatures. Turbidity is low, and total dissolved solids and potential productivity are high compared to channels. Dissolved oxygen is more variable than in the channel, but high concentrations may occur at the surface, and woody cover and aquatic plants are more common than in the channel (9).

Consequently, backwaters provide velocity refugia and thermal cues for spawning adults, submersed substrates for egg attachment, and clear water for fishes that feed visually (10). Backwaters invaded by stream fishes during floods become important spawning grounds and nurseries, which influence population and community structure of fishes (11). Approximately 90% of fish species in the lower Mississippi Basin exploit backwaters, and characteristic fish assemblages have been observed (12).

The goal of this study was to help to elucidate the controversy by determining the overall importance for fishes of vegetated backwater habitats in a cove at Aliceville Lake, an impoundment of the Tennessee-Tombigbee Waterway. To accomplish this objective, it was made an inventory of adult fishes compiled from earlier reports and compared it with early life stages of fishes collected in this study. It was expected that abundance and species richness of early life stages of fishes collected reflected the overall abundance and species richness reported in the literature.

Materials and methods

Study site

This study was conducted in a cove of Aliceville Lake, a reservoir impounded in 1979 on the Tennessee-Tombigbee Waterway, located on the Alabama-Mississippi border. The reservoir is primarily riverine in appearance with minimal water level fluctuations that, in conjunction with the rapid sedimentation of backwater areas has encouraged development of aquatic plant stands. The reservoir has a surface area of 3,362 ha, a maximum depth of 11 m, and annual water level fluctuations that average 0.2 m (during flood periods fluctuations may exceed 1.0 m) (1).

The cove studied was selected because it represented different levels of macrophyte densities and plant species. Its surface area was approximately 7.6 ha and it had a mean depth of 0.6 m (1). The average percentage of area of the cove occupied by aquatic plants in peak summer has varied slightly in the last five years (85-95%; 1). The predominant emergent plant species in the cove were waterprimrose (*Ludwigia hexapetala* and *L. peploides*), smartweed (*Polygonum* spp.), and alligatorweed (*Alternanthera philoxeroides*). Submergent plant species included Eurasian watermilfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*), curlyleaf pondweed (*Potamogeton crispus*), and hydrilla (*Hydrilla verticillata*), and the primary floating plant species was water hyacinth (*Eichornia crassipes*).

Fish community

This study was dependent on previous records of fish species richness and spawning phylogeny. Knowledge of spawning time provided orientation for protocol and scheduling. Previous studies indicated that sunfishes (*Lepomis* spp.) and largemouth bass (*Micropterus salmoides*) dominated vegetated sites at Aliceville Lake, and that 80% of the centrarchids were collected in submergent vegetation (1). Adults of 56 species have been documented from Aliceville Lake (1, 13). Spawning season and temperature associated with spawning of most of these fishes are well known (14-16), although they had not been summarized previously. Available data indicate that over 90% of these fish species spawn between March and August (figure 1).

Sampling method

Backwater vegetated areas are structurally complex habitats that are challenging to sample. Sampling methods such as pop nets, tow nets and seines are not effective in shallow habitats obstructed by macrophytes. Subsequently, it was used a light trap originally designed by Floyd et al. (17)

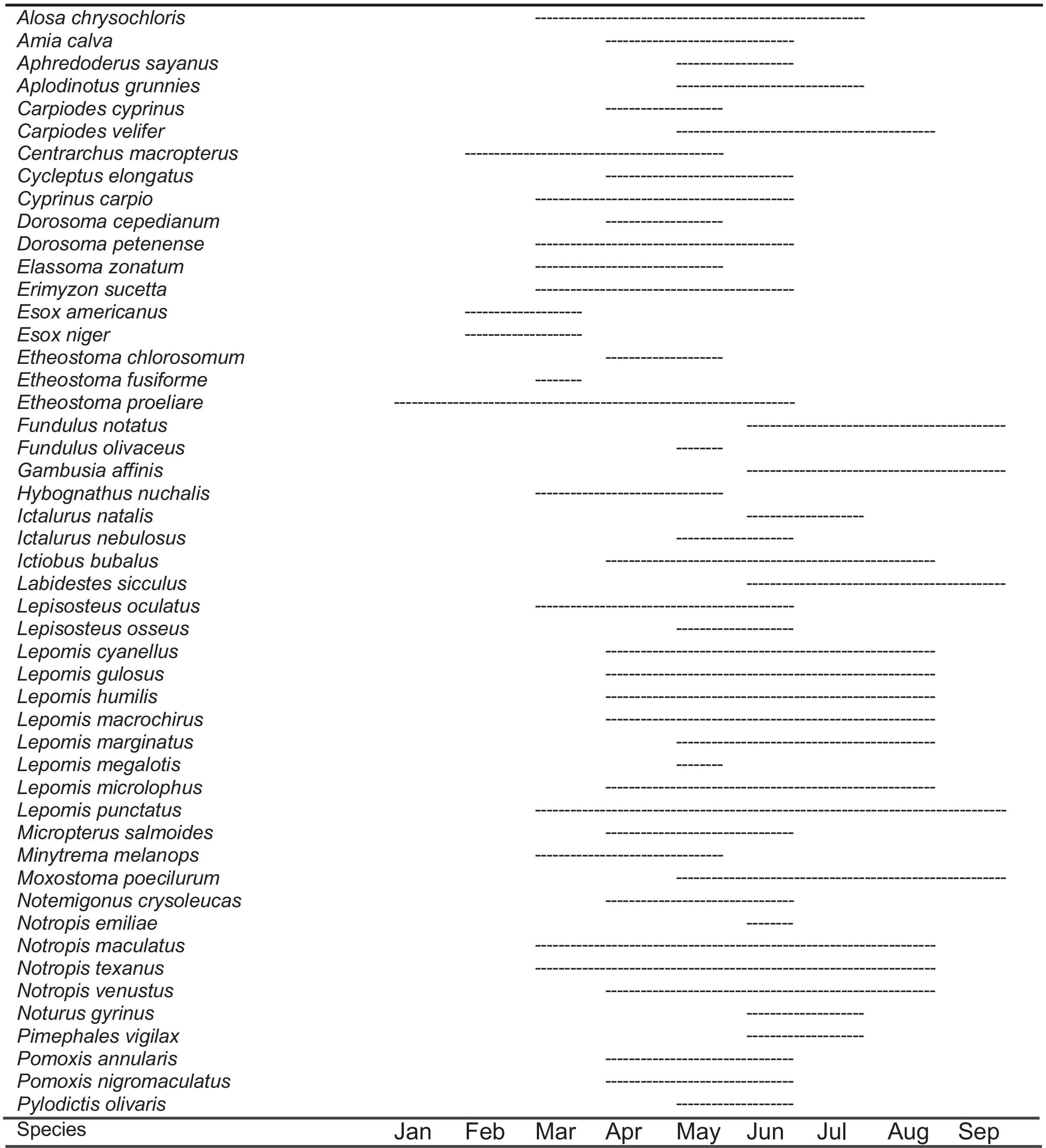

Figure 1. Spawning period for fish species in Aliceville Lake as reported in the literature.

and modified after Killgore and Morgan (18). The trap was a slotted trapping system where four, 150-mm long 5-mm wide entrance slots allowed early life stages of fishes to enter the trap's inner chamber.

The cove was mapped with a 76-grid location, and during each sampling period 12 light traps were set at positions chosen randomly from this grid. Light traps were fished twice during May, July, and August, and once during March, April, and June 1998 for a total of 9 sample dates and 108 light traps. Traps were lighted with 12-h Cyalume chemical sticks. During each sampling period each trap was set for one night from approximately 3 h before sunset to 3 h after sunrise for an approximated soak time of 16 h. Early life stages of fishes were removed from the traps and preserved in vials containing 5% buffered formalin. In the laboratory, fishes were counted and identified to the lowest possible taxon.

Primary references for identification of early life stages of fishes included Holland-Bartels et al. (16), Hogue et al. (19) and Auer (20). Fishes were measured for total length to the nearest 0.1 mm. Criteria used for separating early life stages of fishes from juveniles were total lengths for early life stages as reported in the literature, and the prevalence of a yolk sac. When no specific references on early life stages were found in the literature (i.e., banded pygmy sunfish, *Elassoma zonatum* and mosquitofish, *Gambusia affinis*), only specimens with evidence of yolk sac were reported. All common and scientific names follow Robins et al. (21). Voucher specimens for all groups were confirmed with the assistance of Dr. Robert Wallus (Tennessee Valley Authority, Water Resources, Knoxville, TN). Water temperature was determined at near-surface depths with a YSI Model 55 DO meter.

Efficiency of the light trap

Although previous studies have demonstrated that this sampling gear collects fishes from many families (18, 22), no references exist regarding use of light traps in Aliceville Lake. To test the efficiency of this sampling gear, an experiment with a neuston-type net was performed in the field. The neuston net was deployed four times at selected sites in the cove. Early life stages of fishes were collected by pulling the neuston net through stands of aquatic vegetation for three minutes, and then a light trap lighted with a Cyalume chemical stick was introduced into the neuston net and left overnight.

Because vegetated habitats in the cove made it difficult to gather a sample large enough to use in the experiment, a supplementary test was conducted in a pond. However, testing the gear in a pond limited the number of fish species that could be evaluated. In the pond, the neuston net was deployed four times at selected sites. In this test, early life stages of fishes were collected by towing and pulling a plankton net through stands of aquatic vegetation in selected locations along the pond banks. Eight tows were made at each location. After a tow was completed, the plankton net was rinsed and fishes introduced into a bucket with water to identify fishes considered in good conditions. Then, 5-78 fishes, along with a light trap were placed inside the neuston net and left overnight for a mean soak time of 15 h. The trap then was removed from the neuston net and the number of fishes collected was compared to remaining fishes in the net. Light trap efficiency was expressed as percentage of catch (% = number captured / actual population x 100). In addition to the field experiment, eight light traps were set in the pond at the same time as the experimental method to test efficiency of the light trap in field conditions and to corroborate presence of early life stages of fishes in the pond.

Results

Light trap efficiency

Results from this experiment indicated efficiency of light traps for catching fishes was high for centrarchids and mosquitofish. The experiments succeeded three out of seven times in collecting early life stages of fishes. However, only individuals of the genus *Lepomis* (most likely bluegill *L. macrochirus*) were collected in amounts to render reliable results. Percent of catch for *Lepomis* ranged from 64 to 84% (mean 72%, N= 3). Another species collected were largemouth bass (3 individuals) and mosquitofish (2 individuals).

The alternative light traps set in the pond at the same time as the experimental method collected a significant amount of both largemouth bass and bluegill. For example, eight light traps collected a total of 1,286 largemouth bass and 47 bluegills.

Number of fishes collected

A total of 1,778 fishes (1,388 larvae, 78%, and 390 juveniles, 22%) representing 12 genera and 10 families was collected. These 10 families represented 62.5% of the families previously reported having adults in Aliceville Lake. Fishes in the family Centrarchidae were the most abundant and contributed 59% to the total number of early life stages of fishes collected. Larvae and juvenile stages of three genera of this family were sampled during the study: *Lepomis* spp., *Micropterus* spp., and *Pomoxis* spp. The family Poecilidae made up 24% of the sample and was represented by mosquitofish (*G. affinis)*. Both larvae and juveniles of this species were collected. Fishes from the families Atherinidae and Elassomatidae were abundant in the samples and were represented by brook silverside (*Labidesthes sicculus)* and banded pygmy sunfish (*E. zonatum)*, accounting for each 7% of the early life stages of fishes collected. These two families, along with Centrarchidae and Poecilidae, accounted for 96% of the fishes in the sample.

Juveniles of the families Atherinidae and Elassomatidae also were collected. Cyprinodontidae contributed <2% of the sample, and was represented by blackspotted topminnow (*Fundulus olivaceus)* and/or blackstripe topminnow (*F. notatus)*. Juveniles of this family were collected throughout the sampling periods. The families Percidae, Cyprinidae, Belonidae, Catostomidae, and Clupeidae contributed each <1% of the total sample and no juvenile fishes from these families were collected.

Temporal occurrence of early life stages of fishes

Several of the fish taxa collected during this study appeared to have extended spawning seasons at Aliceville Lake, although chronologies of peak of early life stages of fish abundances associated with temperature were evident. Early life stages of *Lepomis* spp., brook silverside, and mosquitofish were collected throughout the sampling periods and peaked in May-June, when water was warmer. Both fundulids and percids appeared to have an extended spawning period from March to July. Abundance of fundulids peaked in May and percid abundance was highest in June. Both largemouth bass and banded pygmy sunfish presented a most restricted occurrence period. Banded pygmy sunfish occurred from March to June and largemouth bass from April to June. Both of these species peaked in May. Individuals in the families Catostomidae, Cyprinidae, Clupeidae, Belonidae, and the genus *Pomoxis* in the family Centrarchidae occurred during a very restricted period. Individuals of the Catostomidae family were only collected early in spring at lower temperatures, and cyprinids were collected in April and early May, peaking at April at lower temperatures. Fishes from the family Belonidae and the genus *Pomoxis* were collected only in May, and clupeids were only collected in August. Figure 2 shows early life stages of fish abundance as a function of date and temperature for *Lepomis* spp., mosquitofish, and *Micropterus* spp.

Discussion

Aquatic plants play an important role in structuring fish assemblages (23-25). They provide higher carrying capacity for food resources due to the availability of substrates for prey and higher productivity (25). However, high densities of these plants can lead to physical and chemical restrictions for fishes, especially hypoxia at night during the hot season (2). It is expected that these

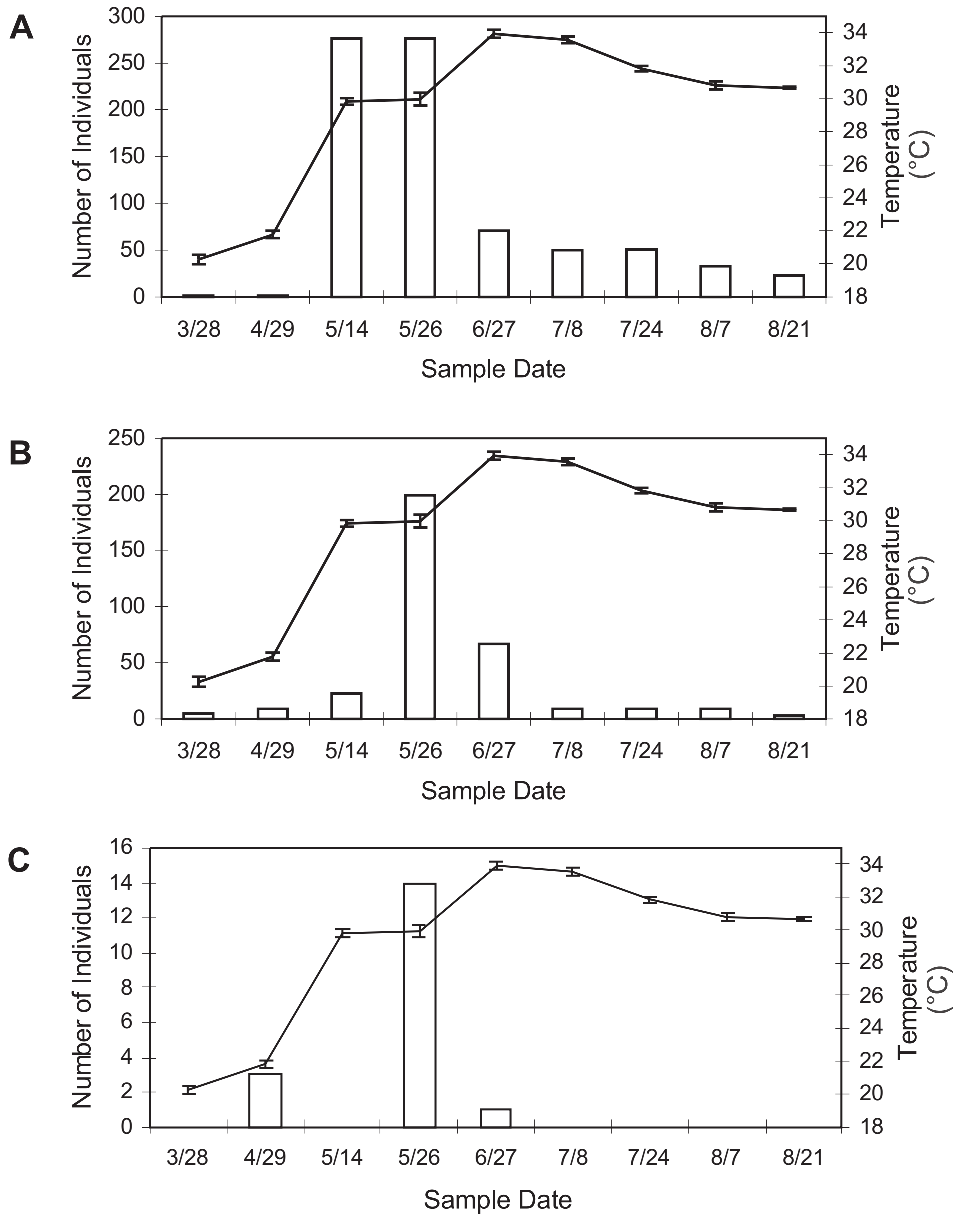

Figure 2. Early life stage of fish abundances as a function of date and temperature (°C) for *Lepomis* spp. (A), mosquitofish (*Gambusia affinis*) (B) and *Micropterus* spp. (C) collected from Aliceville Lake.

positive and negative effects on fishes can explain their horizontal distribution and diel movements in lentic habitats near stands of macrophytes. The degree of response to these conditions is variable depending on fish assemblage composition, dominant life strategies and ontogenetic stage (25).

Backwaters, on the other hand, have been found to be important nursery areas for fishes characteristically found there and for main-channel species as well (e.g. 26). Overall, numbers of early life stages of fishes and species richness found in the cove under study were lower than expected given the number of adult fish species reported previously. Approximately 56 adult fish species grouped in 16 families have been documented to occur in Aliceville Lake, 90% of which spawn from March to August at temperatures between 4 and 29 C (figure 1).

Light trap has been demonstrated to catch a wide range of families and species. For example, Dewey and Jennings (27) collected 5,530 fish from 7 families in Lawrence Lake, a backwater lake of the upper Mississippi River. Killgore and Morgan (18) collected 34 species of early life stages of fishes representing 12 families in the floodplain of Cache River, Arkansas and littoral zone in Lake Marion, South Carolina. Dibble et al. (28) collected 2,962 early life stages of fishes of 37 different taxa grouped in 13 families in two wetlands of Lake Erie. Hoover et al. (22) collected over 17,000 fishes (over 32 species) grouped in 11 families in a riverine wetland of the lower Mississippi Basin. In all the works cited above, darters, minnows, shiners, and particularly centrarchids were well represented. Although during the study individuals of 10 families were collected (62.5% of the families previously reported having adults at Aliceville Lake), only individuals grouped in 12 genera were reported.

The experimental tests confirmed that the light trap is efficient in attracting fish as long as they are present in its area of influence. Thus, results confirm the study cove is not as strongly used as spawning ground as it would be predicted based on previous reports. The cove had a surface area around 7.6 ha and a mean depth of just 0.6 m. Two years previous to this study, plant coverage in the cove was 88% and was reported to be greater than other coves in the lake (1). Although additional information is required to confirm these findings, small area and depth seem to make this cove an exceptional habitat for macrophytes. Both living and senescent aquatic plants remain in the cove all year providing spatially overcrowded habitats, which in turn provide resistance to both early life stage and adult fishes.

The results corroborate previous research suggesting that centrarchids dominate the fish community at Aliceville Lake. Previous studies reported age-0 largemouth bass and early life stages of sunfishes (*Lepomis spp.*) dominated vegetated sites at Aliceville Lake (1, 6). In this study, *Lepomis* spp., the most abundant and frequently captured taxon, peaked in May constituting approximately 71% of the sample. Mosquitofish, the second most abundant and frequently captured species, also peaked in May. Sixty seven percent of this species was captured in May. Typically, mostly lepomids species have been reported to spawn between April and August. However, mosquitofish have been reported to spawn between June and September. Robison and Buchanan (15) reported that mosquitofish breeds throughout the summer in Arkansas. The mosquitofish has been recognized as having broad ecological tolerances. Ahuja (29) reported that mosquitofish were able to survive temperatures ranging from 6 to 42°C for brief periods and DO content as low as 0.18 mg/L. In this study, mosquitofish were collected during the entire sampling period and at broad levels of temperature and DO. Brook silverside was the other species collected throughout the sampling period. In Arkansas this species has been reported to spawn in late spring and summer when water temperatures reach 20-22.8°C (15).

Knowledge of temporal and spatial occurrences of early life stage and juvenile fishes is essential for effective fisheries management (30). The timing and duration of early life stages of fishes appearance in lakes is poorly known and may be influenced by water temperature, photoperiod, food density, and predator abundances (31). Represented in the group of early life stages of fishes collected at Aliceville Lake are taxa with a wide variety of life history strategies, including spring and summer spawning, littoral and pelagic spawning, broadcast spawning, and nest building. Species with pelagic phase in the early life history included Lepomis spp. and Pomoxis spp. The seasonal chronology of species appearance and dominance is probably due to differences in temperature requirements for spawning, incubation, and growth, which vary among species (32). Overall, the results obtained in this study suggest that the taxa collected present a much wider spawning period at Aliceville Lake.

Conclusion

It is concluded that the shallow, vegetated backwaters in the study cove at Aliceville Lake contain diverse macrophyte beds that lead to highly variable habitat use by fish species. Factors influencing this variability in habitat use in these habitats still remain unknown. Fishes at Aliceville Lake may respond to habitat complexity at scales other than those considered in this study and along habitat structure other than macrophytes. Although this study documents important use of vegetated backwaters at Aliceville Lake, further investigation is necessary to better understand the complex relation between early life stages of fishes and aquatic plants. Identification of these factors and knowledge of their mechanisms would facilitate better management of these ecologically important ecosystems.

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