Spawning Sequence of Largemouth Bass, Bluegill, and Gizzard Shad[1]

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Abstract: The effect of body size on the temporal spawning sequence of female largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and gizzard shad (*Dorosoma cepedianum*) was examined in 2 Mississippi reservoirs by monitoring gonadal development through portions of the spawning seasons. Largemouth bass began spawning in late March when water temperature was near 15° C, gizzard shad in about mid–April at temperatures nearing 17° C, and bluegill in late April when temperatures reached 21° C; however, spawning seasons of the 3 species overlapped. Ovarian activity of largemouth bass and gizzard shad suggest strongly that the larger females spawned earlier than smaller ones, but the evidence in bluegill was weaker. Considering that the spawning season of the bass and 2 prey species overlapped, the bass that were spawned earliest and parented by the largest females in the population were larger and more likely to begin eating shad and bluegill earlier in life.

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The largemouth bass (*Micropterus salmoides*) is usually the most abundant fish predator in southern reservoirs (Jenkins 1975, Miranda 1984), and the bluegill (*Lepomis macrochirus*) and shads (*Dorosoma* spp.) are its most frequent fish prey (Timmons and Pawaputanon 1980, Miranda 1986, Storck 1986). Production of largemouth bass hinges on availability of fish prey of suitable size (Davies et al. 1982). Often, the availability of such prey depends on heavy predation pressure to maintain a dynamic prey community with a high reproductive ratio (Popova 1978). Gizzard shad (*D. cepedianum*) and bluegill frequently overpopulate in reservoirs, developing large biomasses of fish of below-average condition and reduced reproductive capacity that are too large to be eaten by average-size predators (Noble 1981). Efforts to increase production of largemouth bass in reservoirs should be directed

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[1] A portion of the data included here was previously published by Miranda and Muncy (1987) in an analysis of the effects of time of spawning on recruitment of young largemouth bass.

toward improving energy flow by enhancing production and utilization of the forage species.

Largemouth bass generally start eating fish during the first year of life. The size of the young-of-the-year (YOY) bass and of the fish prey dictate the pattern of use (Shelton et al. 1979, Miller and Storck 1984, Keast and Eadie 1985). Maximum use generally occurs when bass hatch early in spring and grow rapidly so that they exceed the size of forage fish larvae when these become available. Therefore, the time of spawning can determine the effectiveness of YOY bass as predators. Time of spawning is generally affected by such factors as temperature and photoperiod (Lam 1983), but there are indications that it may also be influenced by the size of the spawner. An understanding of the spawning sequence of the major predator and prey species in reservoirs could lead to an understanding of the reasons for prey overpopulation in some reservoirs and serve as a basis for the development of management strategies directed at increasing prey-predator interactions during early life. In the present study, we examined 1) the seasonal spawning distribution of largemouth bass, bluegill, and gizzard shad, and 2) the time of spawning of fish of each species as related to body size of the reproducing female.

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Methods

The study was conducted in 2,670-ha Bay Springs Reservoir and the 1,170-ha Yellow Creek Arm of Pickwick Reservoir. These man-made impoundments, located at the origin of the Tennessee-Tombigbee Waterway in northeast Mississippi, are connected by a 35-km navigation canal. We collected largemouth bass, bluegill, and gizzard shad by electrofishing for 30 minutes in each of 6 randomly selected shoreline areas of both reservoirs using a boat-mounted, 240-V, AC generator. Sampling was conducted 2 consecutive days at 2-week intervals from 1 March through 10 May 1985. Surface water temperature was recorded at the beginning of each sampling period.

Spawning times of the 3 species were determined by monitoring changes in percentage of body weight contributed by the ovaries over the sampling period. Fish were measured as total length to the nearest millimeter and weighed to the nearest gram. Ovaries were dissected and weighed to the nearest 0.1 g. A maturity index (MI) was computed for each female as 100 × ovary weight / total body weight. MI values generally increase as vitellogenesis progresses prior to spawning, and decrease as eggs are released during spawning. Thus, the time when ovaries reached maximum MI values was interpreted as the beginning of spawning.

Results and Discussion

A paired *t*-test indicated that surface temperatures in the 2 reservoirs were not significantly different ($P > 0.05$) during the sampling season. The MI values of each species, separated into length classes, were compared between reservoirs using a multiway analysis of variance model that isolated the variation due to length class, time, and reservoir. Results of the analysis indicated that MI values were not significantly different between reservoirs for any of the 3 species. This was not surprising considering MI values within length classes were fairly variable, temperature regimes were not different, and the reservoirs are only 35 km apart and connected. In subsequent analyses, data from the 2 reservoirs were combined according to species.

Maturity indexes of 300 female largemouth bass ≥250 mm long ranged from 0.1 to 9.5. Fish <250 mm showed little or no change in MI and were not included in this analysis. Although MI values varied greatly among bass of similar length, they were generally greater in larger than in smaller fish. The MI values for largemouth bass were similar to those recorded in West Point Reservoir, Alabama and Georgia, by Timmons et al. (1980*a*). MI values in the study reservoirs started peaking in late March when temperature was near 15° C (Fig. 1), within the spawning temperature range reported by Carlander (1977). MI values of larger females peaked earlier, suggesting they began spawning earlier than smaller females.

Estimated MI's of 269 gizzard shad ≥150 mm long ranged between 0.2 and 19.9, with mean values (Fig. 1) similar to those recorded by Baglin and Kilambi (1968) in Beaver Reservoir, Arkansas. Spawning apparently started near mid–April at water temperatures nearing 17° C. A literature survey conducted by Miller (1960) concluded that there is great variation in the temperature at which gizzard shad spawn, but most populations start spawning between 15° and 25° C. The MI values of larger shad also peaked earlier, suggesting earlier spawning by larger shad. Older and larger gizzard shad in Beaver Reservoir also spawned first (Baglin and Kilambi 1968). Unlike largemouth bass, the MI's of all sizes of shad, except the smallest, which were still increasing when sampling stopped, peaked at similar average values (Fig. 1). Maturity indexes of 581 female bluegill ranged from 0.2 to 12.0 and averaged lower than those of gizzard shad (Fig. 1). Females <100 mm long showed almost no ovarian development and thus were omitted in our analysis. Spawning seemed to have started in late April when water temperature reached about 21° C. Water temperatures approaching 21° C were also required to initiate spawning in other areas (Mraz and Cooper 1957, Snow et al. 1962, Beard 1982). The relation between body length and time of spawning was not clear. The MI values of most bluegills peaked at the same time except for those of the smallest length group in which values were still increasing by 10 May when sampling was completed. In Wisconsin, large female bluegills spawned before the smaller ones when both were present in the same area (Beard 1982).

Largemouth bass started spawning about 2 weeks before gizzard shad and 4

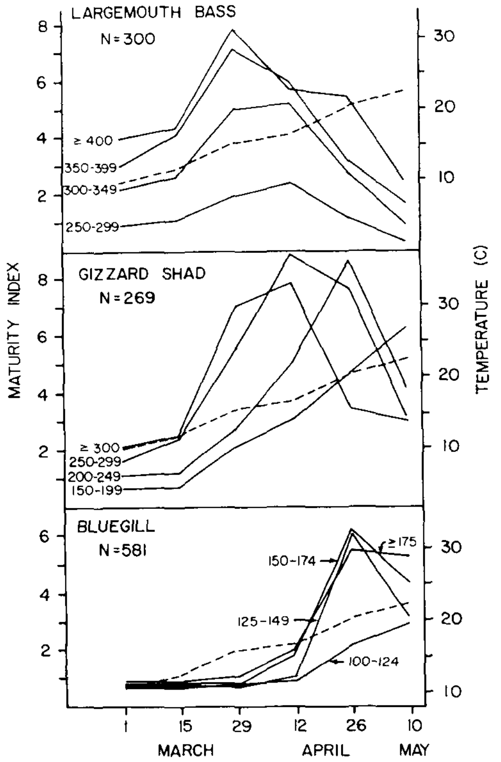

Figure 1. Mean maturity indexes for female largemouth bass, gizzard shad, and bluegill of various length classes in Bay Springs Reservoir and the Yellow Creek Arm of Pickwick Reservoir, Mississippi, 1985. The solid lines indicate the average maturity index for fish of the given length groups and species; dashed lines indicate average water temperature.

weeks before bluegill, though the spawning seasons of the 3 species overlapped. Because fish were sampled at 2-week intervals and spawning started precipitously, MI peaks could have occurred during the interim period between samples at values higher than those recorded. Weekly sampling might have shown more accurately the time when spawning began. Nevertheless, the MI values determined in this study demonstrate that largemouth bass started spawning before gizzard shad, shad before bluegill, and that large bass and shad, and possibly bluegill, spawned earlier than their smaller counterparts.

Cove rotenone samples taken in July and August indicated length of YOY largemouth bass ranged from 40 to 145 mm, bluegill from 15 to 60 mm, and gizzard shad from 30 to 100 mm (Fig. 2). The length spreads observed within species were presumably a result of differences in time of spawning and genotypes as well as other variables. Although other variables can in time obscure length advantages

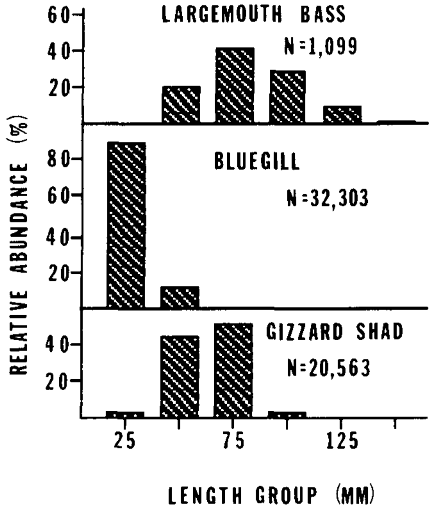

Figure 2. Length-frequency distributions of Age 0 largemouth bass, bluegill, and gizzard shad collected in rotenone samples in Bay Springs Reservoir and the Yellow Creek Arm of Pickwick Reservoir, July–August 1985.

obtained as a result of early hatching, a recent study concluded that in Age 0 largemouth bass a strong positive correlation existed between age and length (Isely and Noble 1987).

In southern reservoirs shads and sunfishes (*Lepomis* spp.) are usually the most abundant forage fish in the diet of largemouth bass. However, large portions of bass year classes are often unable to eat these forage fish during their first year of life (Shelton et al. 1979, Timmons et al. 1980*b*, Miranda et al. 1984). YOY bass can become piscivorous early in life if they are large enough when prey fish begins to hatch (Shelton et al. 1979, Keast and Eadie 1985). In Bull Shoals Reservoir, Arkansas, gizzard shad was the dominant food in the stomach of bass ≥40 mm long (Applegate and Mullan 1967). In West Point Reservoir, 50-mm bass started to eat forage fish more regularly, and sunfishes were their most common prey fish (Timmons et al. 1981). Inasmuch as the spawning season of largemouth bass overlapped that of gizzard shad and bluegill, a portion of the bass year class may never be large enough during the first year of life to feed on the newly hatched prey. Spawning of bluegill may continue throughout the summer in well-fertilized farm ponds but is often insignificant in reservoirs after peak spawning in late spring (Davies et al. 1982). Thus, largemouth bass that hatch early are more likely to become piscivorous during their first year of life than those that hatch later.

In the study reservoirs, only a portion of the new year class of largemouth bass was large enough to swallow YOY gizzard shad or bluegill. Generally, largemouth bass will not eat shad longer than about one-half its total length or sunfish longer than one-third its length (Shelton et al. 1979). To estimate the relative availability of prey of suitable size for bass, we plotted the lengths of gizzard shad and bluegill against the transformed (× ½ or × ⅓) lengths of the bass. Plots indicated that

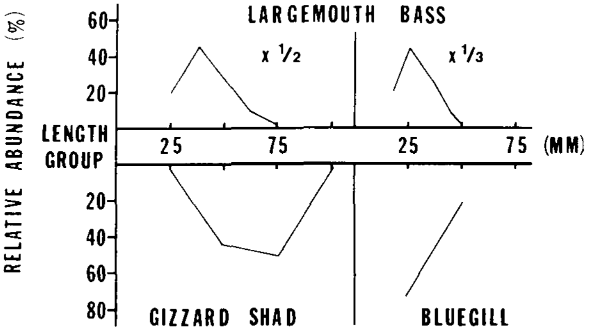

Figure 3. Transformed length frequencies of largemouth bass (× ½ and × ⅓) plotted opposite to lengths of gizzard shad and bluegill to illustrate relative availability during July–August, 1985, in Bay Springs Reservoir and the Yellow Creek Arm of Pickwick Reservoir.

there was a shortage of gizzard shad for the smallest ⅔ of the bass year class, and that roughly ¾ of the year class was large enough to eat bluegill prey (Fig. 3).

Temporal spawning in relation to size may be important in fishery management for at least 2 reasons. First, if large bass spawn earliest, their progeny have the greatest chances of becoming piscivorous early in life. Piscivory in the YOY bass is desirable because it leads to faster growth, reduced exposure to predation, and possibly higher recruitment to the fishery (Aggus and Elliot 1975, Adams et al. 1982, Miller and Storck 1984, Keast and Eadie 1985). Inasmuch as largemouth bass fisheries are selective for the largest individuals (Miranda et al. 1987), high harvest rates may result in marked reductions in the average length of the adult stock and the percent of the young that hatch early enough to prey on larval fish. This concept has been developed by modelling the spawning of largemouth bass populations having adults of different average lengths to simulate length frequencies of the hatches by late spring (Miranda and Muncy 1987). Second, temporal spawning in relation to size results in spawning activities extending over a longer season as the length range of the broodstock increases. Consequently, a broad range in the length distribution of the spawners would decrease the likelihood of failure of a year-class in bodies of water afflicted by short-term environmental fluctuations during spawning. In any event, management to maintain broad-ranging length distributions and increase recruitment in exploited largemouth bass fisheries may require protection of the larger spawners. Techniques to protect adult fish, such as length and creel limit regulations, have been discussed elsewhere.

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