FOOD HABITS OF THE WHITE AMUR STOCKED IN PONDS ALONE AND IN COMBINATION WITH OTHER SPECIES

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IT IS BECOMING INCREASINGLY IMPORTANT that biological methods be used for controlling undesirable aquatic plants in both artificial impoundments and natural waters, since many of our existing chemical control methods are potentially hazardous to the ecological balance of a pond, lake, or river, as well as to man himself. A number of organisms exist which will effectively control or eliminate certain aquatic plants. Several fish species have shown promise as weed control agents, one of these being the white amur (*Ctenopharyngodon idellus* Valenciennes) also known as grass carp (Avault, Smitherman, and Shell, 1968). This fish has been in the United States for a decade, but is an exotic species indigenous to large rivers in China. One of the major reasons that white amur are not being widely used in this country is the fear that they may become established in our natural waters, as did the common carp, and compete with native fish for food organisms. Hora and Pillay (1962) reported that white amur do not spawn in ponds—they spawn in large rivers. If this is so, and it seems to be, it is possible that they can be used in ponds which are not connected to natural waters.

Hora and Pillay (1962) classified white amur as an omnivore, and stated that it has a distinct preference for vegetable food, such as grass, leaves, weeds, and all kinds of aquatic plants. Young fry are said to feed on zooplankton. Stevenson (1965) found that when small white amur (80 to 120 millimeters) were kept in aquariums, they preferred *Daphnia*, chopped earthworms, and chironomid larvae to canned spinach, *Spirogyra*, or *Eleocharis*. When the fish were transferred to earthen ponds, they were frequently seen taking cut blades of Bermuda grass floating on the pond surface. He also reported that in 60 days, 24 white amur per acre reduced, but did not completely eliminate, *Chara*, *Najas*, *Eleocharis*, and *Polygonum*; while 30 white amur per acre eliminated *Chara* and *Najas*, but not *Anacharis*, within 90 days. However, commercial fish feed was given to the fish in both cases.

Avault (1965) reported that *Chara*, *Eleocharis*, and *Potamogeton* were eliminated from 0.1-acre earthen ponds within 90 days by 40 white amur per acre, size 12 to 16 inches. Cross (1969) compiled a list of aquatic plants eaten by white amur, in order of preference. He found that 9-inch white amur in aquariums ate *Daphnia*, tubifex worms, and *Asellus*, an isopod crustacean, as well as vegetation.

Avault et al. (1968) found that white amur (250 to 400 millimeters) stocked at rates of 20 to 40 per acre controlled a wide variety of aquatic weeds, and recommended that the lowest stocking rate at which weeds are controlled should be used. Cross (1969) reported that under certain conditions, white amur will eat more than its own weight of plant material in a day, while Stott and Orr (1970) estimated

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that the conversion rate of aquatic weeds (wet weight) to fish flesh by white amur is about 224:1.

In the present study, white amur were tested in two types of stocking, alone in fertilized ponds with aquatic plants added, and stocked in combination with other fish species in a fertilized pond with little natural macrophyte vegetation. Observations were made on their effectiveness in controlling aquatic weeds and their food habits compared to other fishes in the population.

MATERIALS AND METHODS

White amur alone.—Ten 0.1-acre earthen ponds at the Fisheries Research Unit, Auburn University Agricultural Experiment Station, Auburn, Ala., were used for this experiment. Aquatic plants were obtained from Lake Seminole in Georgia, on June 11, 1969, and were stocked into the ponds the following day. Eurasian milfoil (*Myriophyllum spicatum*) was collected from a relatively pure stand of plants, and was stocked into each pond at the rate of 900 pounds per acre. Two other species, alligatorweed (*Alternanthera philoxeroides*) and waterhyacinth (*Eichhornia crassipes*), were entangled with each other so that they could not be separated. A combined weight of 800 pounds per acre was stocked into each pond. Two other plant species, *Potamogeton diversifolius* and *Chara* spp., were added to the ponds on June 30, at the rates of 400 and 100 pounds per acre, respectively. The plants were obtained from other ponds on the station.

Ponds were fertilized on June 17, June 30, and July 24, with NH_4NO_3 at the rate of 75 pounds (8-0-0) per acre.

White amur, age I+, size 7-inch were stocked on July 16, about 1 month after the first plants were stocked. Although some ponds had poor plant growth, most ponds had an adequate amount of plants for testing the white amur. Stocking rates, average lengths and weights, and standing crops, by treatment are listed in table 1.

Records were kept on the amount of plants in each pond to determine the efficacy of the different stocking rates of white amur. An estimate was made of the areal percent composition covered by each species.

On August 18, one white amur was removed from each pond in order to analyze the stomach contents. Each fish was replaced by another white amur somewhat smaller in size (average, 97 grams). When ponds were drained, stomachs of one-half the number of white amur in each pond were removed and preserved for analysis. Since it was difficult to distinguish different parts of the intestine, the entire gut was considered as being the stomach.

White amur in combination with other species.—A 5.2-acre earthen pond (S-15) was stocked with a combination of 500 channel catfish, *Ictalurus punctatus*, (5 inches); 50 largemouth bass, *Micropterus salmoides*, (1 inch); 25 redeye bass, *M. coosae*, (3 to 6 inches); 25 spotted bass, *M. punctulatus* (3 to 6 inches); 50 Israeli carp, a variety of the mirror strain of common carp, *Cyprinus carpio*, (6 to 11 inches); 1,000 fathead minnows, *Pimephales promelas*, (1 to 3 inches); and 50 white amur, (5 to 7 inches) per acre, during February to May, 1968. This experiment was designed to evaluate competition and growth of these species when stocked together.

The pond received superphosphate fertilization during 1968 and 1969. In addition, experiments with cage culture of channel catfish and also of *Tilapia aurea* were conducted in the pond in 1969. Wastes from the feed and feces supplied organic fertilization. Fish in the pond were fed 1.25 pounds of a commercial trout feed daily from June 1 to June 25, 1969.

Table 1.—*Stocking rates, average lengths and weights, and standing crops of white amur (by treatment), July 16, 1969*

Treatment	Number of fish per acre	Average TL (mm)	Average weight (g)	Average standing crop (pounds per acre)
1[1]	0	—	—	0
2	20	175	64	3
3	40	176	64	6
4	80	184	76	13
5	160	186	78	27

[1] Control ponds, no fish.

Table 2.—*Average lengths, weights, percent survival, and standing crops of white amur; also includes standing crops of waterhyacinth and alligatorweed, and presence or absence of other plant species (by treatment), October 31, 1969*

Treatment	Number of fish per acre	Average TL (mm)	Average weight (g)	Percent survival	Average standing crop (pounds per acre)			Other plants [1]		
					White amur	Water-hyacinth	Alligator-weed	Milfoil	Chara	Potamo-geton
1	0	—	—	—	0	7,320	100	P	P	P
2	20	356	552	100	24	4,090	50	P	P	P
3	40	281	283	100	25	440	50	A	A	A
4	80	290	297	88	46	1,080	50	A	A	A
5	160	238	154	100	54	3,440	80	A	A	A

[1] P=plants were present at draining, A=plants were absent at draining.

Table 3.—Fish recovered, percent survival, standing crops, and ranges of lengths and weights in pond S-15, including fish taken by angling and at draining

Species	Percent survival	Standing crop (pounds per acre)	Range in length (inches)	Range in weight (pounds)
Channel catfish	79	[1] 311	[1] 6–20	[1] 0.05–2.8
Largemouth bass	38	[1] 21	[1] 5–14	[1] 0.06–1.5
Redeye bass	61	[1] 3	[1] 4–9	[1] 0.03–0.3
Spotted bass	52	6	11–13	0.55–0.8
Israeli carp	89	224	19–23	4.4–10.0
Fathead minnow	—	0.3	—	—
White amur	81	96	16–22	1.3–5.1
Total		661.3		

[1] Includes reproduction.

All species were collected either by angling or seining from May through September, 1969. Stomachs were immediately removed and preserved for analysis of contents. Food habits of fathead minnows were not studied.

RESULTS

White amur alone.—All ponds were drained on October 23, 1969, 133 days after the first plants were stocked and 99 days after the fish were stocked. An analysis of variance of the average lengths and average weights of the white amur at the time of stocking showed that the sizes of the smallest and largest fish were not significantly different (5 percent level). There were significant differences in sizes of fish recovered at draining, whose average lengths, weights, survival, and standing crops are listed by treatment in table 2, which also includes standing crops of waterhyacinth and alligatorweed, and presence or absence of other plant species.

Waterhyacinth and alligatorweed were weighed the day after draining the ponds, after allowing them to dry out from the same amount of time as prior to stocking (24 hours). Other plant species could not be easily removed, and the effect of white amur on these plants could only be evaluated by the presence or absence of these species.

Figure 1 illustrates the stomach contents of fish taken on August 18 and October 23. No attempt was made to identify insects found in the stomachs, since only pieces of mature insects were found. No insect larvae were found in any of the stomachs.

White amur in combination with other species.—Pond S-15 was drained on December 10, 1969. The fish recovered, percent survival, standing crops (pounds per acre), and ranges in length (inches) and weight (pounds) are listed in table 3. Figure 2 illustrates the stomach contents of the adult fish in the pond for the period May through September, 1969.

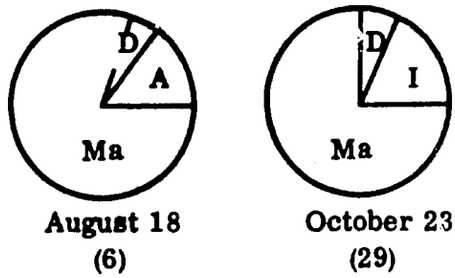

Figure 1.—Stomach contents of white amur stocked alone in ponds (insects were all mature forms). Code to food categories is as follows: (A) algae, (D) debris, (I) insects, (Ma) macrophytes. Numbers of fish in parentheses.

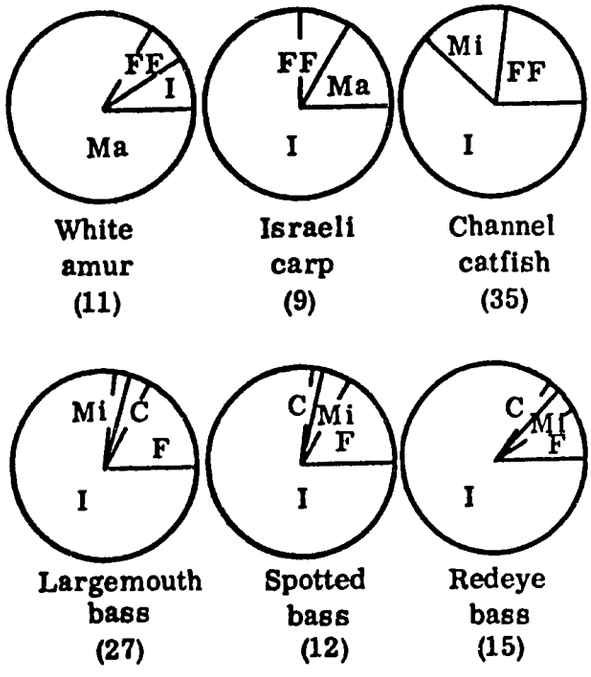

Figure 2.—Stomach contents of fish taken by angling from a 5.2-acre pond during May through September, 1969. Code to food categories is as follows: (C) crustacea, (F) fish, (FF) fish feed, (I) insects, (Ma) macrophytes, (Mi) miscellaneous. Numbers of fish in parentheses.

DISCUSSION

White amur alone.—The average weight (at draining) of white amur stocked at the rate of 20 per acre was significantly higher (5 percent level) than those stocked at rates of 40, 80, and 160 per acre. They grew from 64 grams at stocking to 552 grams at draining (99 days).

According to stomach analyses, white amur will resort to eating insects when plants are no longer available. This was more evident when bottom vegetation was eliminated, and floating plants were unavailable due to their being in shallow water. Highest standing crops of waterhyacinths were produced in control ponds. Lowest standing crops of hyacinths were present in ponds containing 40 white amur per acre, but higher standing crops were present in ponds with 80 and 160 per acre. This was due to the plants' being rooted in shallow water around the pond edges, thus being unavailable to the fish.

Alligatorweed standing crops were similar in all ponds, regardless of stocking rates of white amur. Eurasian milfoil, *Chara*, and *Potamogeton* were eliminated, in 99 days or less, in ponds stocked with 40 or more white amur per acre. Rates of stocking of white amur which will effectively control floating weeds could not be determined due to shallow water around the pond edges.

White amur in combination with other species.—White amur in pond S-15 grew from an average of 60 grams (0.13 pound) to 1,470 grams (3.24 pounds) in 617 days (20.5 months). Although they made up 7 percent of the total number of fish stocked (excluding fathead minnows), they comprised 14.5 percent (by weight) of the total standing crop. Their food (fig. 2) consisted mainly of macrophytes (84 percent by volume) with only a relatively small amount of insects (9 percent), mainly chironomid larvae, and rarely, *Chaoborus* larvae and chironomid adults. The plant material in white amur stomachs appeared as shredded blades of grass. It is very likely that this material was centipedegrass (*Eremochloa ophiuroides*), a lawn grass whose roots and stolons occasionally trail into the water at the pond edge. On several occasions white amur were observed with their heads out of the water, nibbling at overhanging grasses. No aquatic macrophytes were available to the fish at any time during the experiment. The pond bottom was completely clear of vegetation at draining, but many chironomid larvae were seen.

Israeli carp (fig. 2) preferred insects (75 percent)—mainly *Chaoborus* larvae, and chironomid larvae and adults—to macrophytes (16 percent). In general, a more insectivorous habit was indicated by Israeli carp.

The largemouth and spotted bass (fig. 2) had similar stomach contents (77 percent insects and 17 percent fish), while redeye bass (fig. 2) ate fewer fish (9 percent) and more insects (85 percent). The stomach contents of channel catfish (fig. 2) consisted mainly of insects (62 percent), but supplemental feed made up a significant amount (23 percent).

In general, it seems that food habits of white amur are not at all similar to the other fish species in this experiment. Although white amur did eat aquatic insects, this food item composed only a very small amount, by volume, of the stomach contents (9 percent). Just as in the case where they were stocked alone, white amur resorted to eating insects only when absolutely necessary. This was evident in this experiment, where there was virtually no plant material available.

CONCLUSIONS

White amur, when stocked alone at rates of 40 (or more) per acre, effectively eliminated *Chara* spp., *Potamogeton diversifolius*, and Eurasian milfoil in less than 99 days, and caused a decrease in the amount of waterhyacinths in 0.1-acre earthen ponds. Under these conditions, their diet consisted mainly of macrophytes and algae (75 to 95 percent by volume) and only a small amount of mature insects (0 to 18 percent).

When stocked in combination with channel catfish, Israeli carp, and three basses (largemouth, redeye, and spotted) their diet consisted of 84 percent macrophytes and only 9 percent insects (larvae). In this case, with virtually no aquatic plants in the pond, white amur resorted to nibbling grass roots and stolons at the pond edge.

These findings point out the benefits of using white amur in situations where biological methods of weed control are preferable to chemical methods. They also indicate that white amur do not pose a threat as a competitor for food organisms eaten by game fish. They also provide an excellent food source and game fish since they can be taken by angling using worms as bait.

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