Potential of the White Amur (*Ctenopharyngodon idella* Val.) as a Biological Control for Aquatic Weeds in Indiana[1]

R. G. Willey, M. J. Doskocil and C. A. Lembi
Department of Botany and Plant Pathology
Purdue University, West Lafayette, Indiana 47907

Abstract

Six-inch white amurs (*Ctenopharyngodon idella* Val.) were maintained in greenhouse aquaria and barrels to study their potential as biological control agents for aquatic weeds. The fish were subjected to a variety of plant and animal diets, exposed to varying concentrations of rotenone, and the water in which they were growing was tested for nutrients released by fish defecation. Results show that the fish will eat many common Indiana weeds, including several *Potamogeton* species, *Ceratophyllum Lemna*, filamentous algae, and others. The fish also consumed all animal material presented. The monitored nutrients increased over a 25-day period with largest increases occurring in ammonia and nitrate levels. The fish were very sensitive to concentrations of rotenone as low as 6×10^{-3} parts per million.

Introduction

Many Indiana ponds and lakes have become infested with aquatic vegetation to the extent that they are no longer useful as recreational areas unless vegetation control practices are utilized. Indiana farm pond owners and lake association groups now rely primarily on either mechanical harvesters or the application of a herbicide at least once each season to insure reasonably weed-free waters. These methods have their limitations, however. Mechanical harvesters are expensive for the individual pond owner, and chemical treatment, although often effective, can be expensive since retreatment is frequently required. Fish kills caused by plant decay and the concomitant oxygen depletion of the water sometimes accompany chemical treatment.

In 1963, researchers at the U.S.D.A. Fish Farm Experimental Station in Stuttgart, Arkansas, began investigating the potential of *Ctenopharyngodon idella* (variously known as the white amur, Chinese carp or grass carp) as a biological control for aquatic weeds. In these studies the fish proved not only to dispose of aquatic plants and to lack the undesirable attributes of the common carp, but it also possessed many desirable qualities: "An informal taste panel . . . rated the white amur second only to red snapper, and better than catfish, bass, and trout. With weights exceeding 100 pounds, this fish has tremendous possibilities with the American fisherman. It has been caught on popping bugs, pellets, grass, worms, and other similar baits, and when hooked, it exhibits terrific fighting capabilities. It is able to withstand a wide range of water temperatures from 0° to 35°C, can tolerate salinities as high as 10,000 ppm and can withstand oxygen concentration as low as 0.5 ppm" (4).

Although the amur has been released in certain Arkansas lakes for weed control, most states including Indiana have banned the importation

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of the fish until both short-term and long-term studies can be conducted on its effects on the aquatic ecosystem of each geographic area. In the fall of 1972, we obtained a special permit from the Indiana Department of Natural Resources to import 20 amurs for study in indoor aquaria. The general purpose of the indoor study was to investigate the amur's potential for controlling Indiana aquatic weeds. The study also was designed to pinpoint some of the problems the amur might cause in an aquatic environment before it is actually introduced to an outdoor site. The specific objectives of the study were to determine: 1) the food preferences of the amur among aquatic weeds common to Indiana; 2) the ability of the fish to eat living animal material as well as plant material; 3) the potential of the amur to release plant nutrients into the water; and 4) its sensitivity to the fish toxicant rotenone.

Methods

Twenty six-inch (15 cm) white amurs were obtained from the Arkansas Fish and Game Commission, Little Rock, Arkansas, and were housed in either 15 gal glass aquaria or in 17 gal plastic-lined barrels. The containers, located in the greenhouse, were equipped with sub-sand filters and an oxygen supply.

Aquatic plant and animal materials to be used in the food trials were collected from farm ponds in the Lafayette and Crawfordsville areas. In the plant preference trials, the fish were given weighed amounts of three aquatic weed species, and the order of disappearance of the species from the barrel was noted to determine the weed preferences of the fish and whether any weed was rejected completely. Various combinations of weed species were provided for each fish. In the animal feed trials, the fish were placed in aquaria with both a highly preferred plant species (*Potamogeton crispus*) and test animals to provide the amurs with a choice of food types. Animals tested included American toad tadpoles (*Bufo americanus*), red worms (*Bimastus* sp.), ½-inch and 1½-inch minnows (*Notropis* sp.), and mayfly (*Ephemera*) and dragonfly (*Anax*) nymphs.

Nutrient release studies were conducted on water samples collected every 5 days from barrels. Each barrel contained one amur and a mixture of three plant species: *Lemna minor*, *Elodea canadensis*, and *Potamogeton foliosus*. Nitrate was measured using the cadmium reduction method (7), ammonia was tested with a Hach Model NI-8 Ammonium Nitrogen Test Kit, phosphate phosphorus by the ascorbic acid method (7), and potassium with a National Instrument Laboratories Sodium-Potassium flame photometer. Temperature and pH were also monitored.

The rotenone studies were conducted using white amurs, black bullheads (*Ictalurus melas*) and green sunfish (*Lepomis cyanellus*) in glass aquaria. Rotenone (90% powder, Sigma) concentrations used were 4×10^{-3}, 6×10^{-3}, 8×10^{-3}, and 10^{-2} ppm. The fish were exposed for a period of 24 hours.

Results

The white amurs (Fig. 1) ate all plants placed in the barrels including both higher aquatic species and filamentous algae. They did, however, show a decided preference for those plants with tender leafy shoots rather than either plants with coarser, thinner leaves or filamentous algae. In addition, the fish ate the leaves of the plants first, leaving the stems and apical meristems intact. Only if the fish were not provided with more fresh plant food did they begin to eat the stems of the plants. Of all of the plants, the filamentous blue-green alga *Lyngbya*, which forms a thick black mat on the surface of the water, was least preferred by the fish although it, too, was eventually eaten when no other food was provided. The plants in order of preference (* indicates filamentous algae) were *Elodea canadensis*, *Chara* sp., *Potamogeton crispus*, *Lemna minor*, *Potamogton foliosus*, *Najas flexilis*, *Pithophora*,* *Ceratophyllum demersum*, *Sirogonium*,* and *Lyngbya*.* Other common Indiana weeds which were readily eaten but not included in the preference test were *Potamogeton pusillus*, *Myriophyllum* sp., *Wolffia columbiana*, and *Azolla* sp.

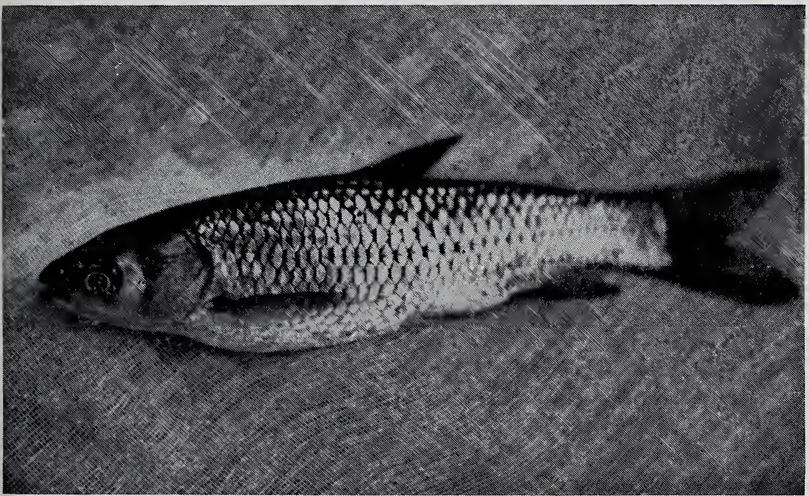

FIGURE 1. *The white amur* (Ctenopharyngodon idella *Val.*) *2/3 actual size.*

Even though the amurs ate continually as long as plant food was provided, the fish did not show the weight and length gains which might be expected. In fact, over a period of 3 months of active feeding, the fish gained only an average of 5 g in weight and 1 cm in length. The small weight and length gains were undoubtedly due to the small size of the barrels and aquaria in which the fish were housed. Most of the plant food consumed was passed as fecal material which caused the water to become very turbid after only a week of active feeding. Microscopic examination of the fecal material showed it to consist mainly of chunks of unbroken cells and plant tissue.

The food tests indicated that the amur will readily eat animal material. In almost all cases, when the animal material was added to the tanks containing amurs and one of their favorite plant foods, curly leaf pondweed (*Potamogeton crispus*), the fish immediately turned to the animals and ate them. The fish did not consume the larger 1½-inch *Notropis* minnows but did eat the smaller ones. The amurs did not eat the tadpoles immediately. The curly leaf pondweed was eaten first over a period of 10 days and then the fish consumed the tadpoles once the curly leaf was gone. To check the possibility that the amurs were attracted to the animals because of their movement in the water, dead red worms were added to the aquaria. However, the amurs also ate these moribund organisms.

The nutrient release studies indicate that all of the nutrients except phosphate increased in the water (Fig. 2). Over a period of 25 days, the ammonia increased by more than 1600%, nitrate by 1100% and potassium by 970%. Although the overall phosphate levels generally decreased by 32% over the initial measurements, the levels began to increase gradually at 20 days. The decrease shown by phosphate may have been due to the extreme hardness of the water, so that phosphate was gradually precipitated as calcium phosphate, or by the removal of the phosphate by microscopic algae present in the water.

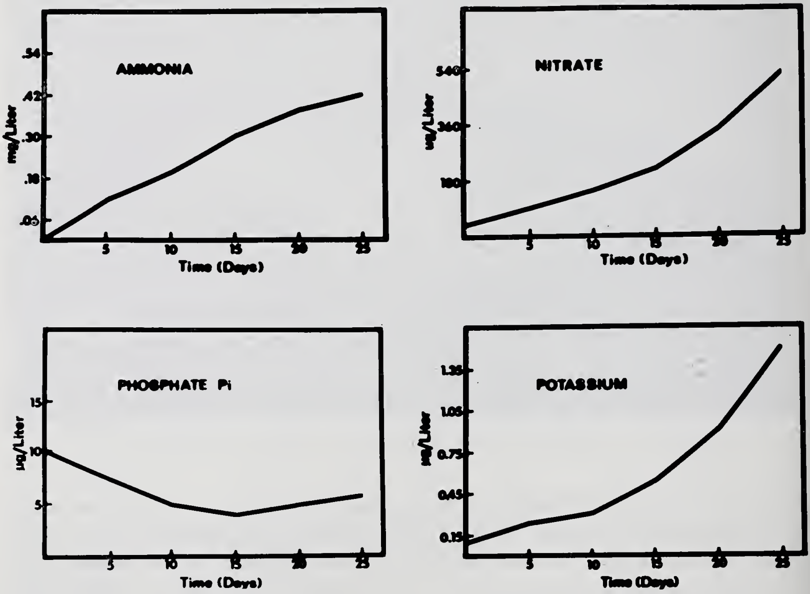

FIGURE 2. *Measurements of nutrient release into the water by the white amur.*

The amurs appeared to be very sensitive to rotenone and began to show stress at the lowest concentration of rotenone used, 6 x 10^{-3} ppm, after 3 hours exposure. However, by 24 hours the fish had recovered and were swimming normally. At 8 x 10^{-3} and 10^{-2} ppm, the fish actually came to the surface of the water and were floating on their sides after 4-5 hours. After 24 hours, the fish had recovered and were swimming normally. The catfish and bluegills were not affected by any of the concentrations of rotenone used.

Discussion

The results of this study agree with those of other researchers (2, 3) who have found that the white amur will eat almost any aquatic plant material. The amurs in our study consumed all plant material either free-floating or rooted except for microscopic algae in the water and short filamentous algal growths on the sides of the barrels. The amur masticates its food by pharyngeal teeth which grind the food against a hard pad in the throat. The fish is not equipped to consume microscopic or bloom-forming algae (3). Consequently, the amur could not be used to control blue-green algal blooms which are common to many Indiana lakes.

The lack of incorporation of the plant material into fish flesh was also noted by other researchers (5, 8). Although in our study, the fish were stunted by the small containers and passed most of the food consumed as feces, Hickling (5) noted that digestion is incomplete even in those fish maintained in the field and growing rapidly. About half of the food material is passed out as feces; the fish digest only the contents of those cells which have been broken by mastication. The large amounts of undigested and partially digested plant material re-entering the water could thus provide a ready source of nutrients for plant growth. Although the amur would be expected to control the higher plant and filamentous algal growths, it could not control blue-green blooms which might be stimulated by the additional nutrient inputs. The nutrient studies indicate that nitrate, ammonia, and potassium, all forms readily utilized by blue-green algae, are released into the water by the amur. Although our tests were conducted in a small, closed system which is not at all indicative of a large, open, field situation, the fact that the fish does defecate such large quantities of plant material and nutrients into the water indicates that the fish is limited both in its ability to convert plant material into animal material and in removing excess nutrients from the water.

Several investigators maintain that the amur is exclusively a vegetarian at lengths greater than 6 inches (3, 6). In fact, Bailey (3) states that even after most of the vegetation has been cleared from a pond, the fish still do not turn to animal matter. However, studies conducted in Missouri (1) indicate that the amur prefers freshwater shrimp to plants and eats plants only if they are the only choice. These tests, like ours, were conducted in aquaria rather than in the field and may be prejudiced by the fact that the fish could not help but notice the animal material in the aquarium. In addition, the Missouri tests were conducted on 3-inch fish which might be expected to be omnivorous. Aquarium studies have not, to our knowledge, been conducted on amurs larger than 6 inches although our studies on 6-

inch amurs indicate that the fish have a preference for animal food over plant material.

Bailey (3) observed that amurs appeared to be very sensitive to rotenone, a generally used fish toxicant. He noted 100% kill of 4-inch amurs in aquaria with 6.4×10^{-3} ppm rotenone. This concentration is considerably lower than the dosage recommended by the U.S. Bureau of Sport Fisheries for complete kill of native game species (0.05 ppm). Our tests confirmed Bailey's results and showed that 6-inch fish are sensitive (although not killed) by 6.0×10^{-3} ppm rotenone. This observation may have practical consequences for controlling amurs in a body of water. If the fish can be stunned with low concentrations of rotenone once they have removed the vegetation from a pond, it may be possible to remove the fish from the water, revive them in fresh water, and use them again in another pond or lake. Stunning the fish is desirable for their removal from a pond particularly since the fish are very excitable, and when seined have been known to thrash and jump about violently and injure net handlers.

Unfortunately, indoor aquaria studies can only indicate some of the problems and potentials of the white amur for controlling aquatic weeds and point out some of the areas which require further study. Determination of how the fish will affect the aquatic ecosystem awaits outdoor testing in a closely monitored natural environment. Hopefully, this kind of study will be conducted in conjunction with the Indiana Department of Natural Resources within the next few years.

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