FOOD HABITS, GROWTH, AND CATCHABILITY OF GRASS CARP IN THE ABSENCE OF AQUATIC VEGETATION

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ABSTRACT

Grass carp *(Ctenopharyngodon idella)* were stocked into a 3.6-ha Georgia pond devoid of vegetation to simulate conditions that might occurr in a pond where grass carp have eliminated the macrophytes. The fish were readily captured by hook-and-line fishing. The stomachs of 417 grass carp contained primarily terrestrial macrophytes; no fish or fish eggs were found. Many of the grass carp examined weighed less than when they were stocked.

INTRODUCTION

The grass carp *(Ctenopharyngodon idella)* is an effective macrophyte control agent that could be useful in the United States (Avault et al. 1968). According to Kilgen and Smitherman (1971), the possibility that grass carp might compete with native fish for food is one of the major reasons the fish is not being widely used in this country for weed control. Although it is generally recognized that young grass carp are omnivorous (Inaba and Nomura 1956), the findings of several authors indicate that grass carp may not be entirely herbivorous as adults and this has led to speculation that the fish could compete directly with native fish for food. For example, Hickling (1966) considers the gut length of the grass carp to be more like that of an omnivore than a herbivore. Cross (1969) found that grass carp 22.5 cm in length that were kept in aquaria would eat *Daphnia,* tubifex worms (family *Tubificidae),* and *Asellus.* Stevenson (1965) stated that pond culture in Asia may have masked a preference by grass carp for food other than plants and suggested further research into their food habits. Greenfield (1973) also believed that more research into grass carp food habits was needed.

Grass carp reach a maximum weight of 50 kg in Russia (Nikol' skii 1956) and this large potential size has led to speculation about their possible use as a sport fish. Sneed (1971) reported that grass carp have been caught on a variety of baits, including live minnows, at the Fish Farming Experiment Station, Stuttgart, Arkansas. Kilgen and Smitherman (1971) stated that grass carp could be caught on worms and considered them to be a game fish. Zawisza and Backiel (1972) reported that grass carp appeared to be very vulnerable to angling. In contrast, Courtenay and Robins (1973) reported that "the potential of the species as a sport fish seems nil." Apparently no quantitative evaluation of the susceptibility of grass carp to angling has been published, so it is not surprising that disagreement exists concerning its potential as a sport fish.

The ability of the grass carp to completely eliminate equatic vegetation is documented (Avault 1965; Sills 1970; Alikunhi and Sukumaran 1964). Thus, if the fish is widely stocked for weed control, situations will almost certainly arise where the fish will eliminate all vegetation. In such a situation, the probability of the grass carp becoming benthophagous or piscivorous would certainly be higher than if vegetation were present. Vulnerability to angling should also be higher in the absence of aquatic vegetation. Grass carp were stocked in a pond devoid of aquatic vegetation to simulate a condition that would occur in waters where grass carp have eliminated vegetation. Food habits, growth, and catchability were studied to determine if the fish would change from a herbivorous diet or be susceptible to angling.

MATERIALS AND METHODS

Fettig pond, located on Fort Gordon Military Installation near Augusta, Georgia, has a surface of 3.6 ha and a maximum depth of 4.5 m. The pond has a generally sandy bottom except in the deepest areas where it is primarily muck, and has a history of being weed free. No submersed or floating aquatic plants were found in the pond before the introduction of grass carp. A few cattails *(Typha)* were present along about 20 m of shoreline.

Prior to grass carp introduction, the outlet pipe of the pond was covered with a heavy screen to prevent the fish from escaping. In a qualitative survey of the fish population, made at night by electrofishing, eight species of fish were captured. Bluegills *(Lepomis macrochirus)* and brown bullheads *(Ictalurus nebulosus)* appeared to be the most abundant.

Grass carp 175 to 680 mm in total length and at least 1 year old were stocked on 1 June, 27 July, and 4 August 1972. Individual lengths and weights were recorded, and all except 22 of the smallest fish were tagged with numbered Floy F. D. 67 tags. A total of 912 grass carp were stocked, of which 61 were recovered dead within 4 days of stocking.

Grass carp were removed from the pond in three phases. In Phase 1, during which an attempt was made to capture fish weekly from 5 July 1972 to 1 July 1973, 176 grass carp were captured by angling during the daytime, 2 by gill nets set over night, and 1 by electrofishing at night. Captured fish were sacrificed and immediately placed on ice. Within 1 hour each fish was weighed and measured, its tag number was recorded, and stomach (considered to be the entire gut) was placed in 10% formalin.

In Phase 2, public fishing was permitted during the day for four consecutive weekends starting 30 June 1973. Each party of anglers was given a census card, on which time of arrival was entered by the creel clerk. All anglers returned the card when they left. No creel limit was set on grass carp. At the check station, all grass carp were sacrificed, weighed and measured, and the stomaches from 239 of the 246 grass carp caught were preserved in 10% formalin. Coolers full of ice were maintained at the check station to encourage anglers to bring in grass carp immediately after capture. Stomachs of fish obtained immediately after capture were preserved individually and those of fish that anglers had kept for an unknown period were pooled in a single container. Fish other than grass carp caught by anglers were counted and weighed.

In Phase 3 the pond was treated on 9 August 1973 with enough antimycin to give a concentration of approximately 2 ug/ 1. A concentration of ug/ 1 of antimycin is commonly used in ponds at Fort Gordon to eradicate centrarchids from catfish ponds. Because the largest grass carp stocked (680 mm total length) was recovered after antimycin treatment and no grass carp were observed in the pond after treatment, it was assumed that the kill (156 dead grass carp recovered) was complete. Stomachs were not collected from grass carp killed with antimycin. Freshly killed grass carp were measured and weighed; decomposed fish were measured or merely counted. Other species of fish killed by antimycin were collected, sorted into size groups and counted.

Six or nine bethos samples were taken approximately monthly from August 1972 to July 1973 with a 15 cm x 15 cm Ekman dredge. These samples were preserved in the field in a 10% formalin solution. Benthic organisms were separated from debris in the laboratory with a saturated calcium chloride solution.

Grass carp stomach contents were sorted in the laboratory with the aid of sieves (U.S. Standard Numbers 20, 30, and 140). The contents were first placed in a white enamel sorting pan, water was added, and the food mass was broken up. Often there was enough mud in the contents to make it impossible to see the bottom of the sorting pan. The stomach contents and water in the sorting pan were slowly poured onto the series of screens. Sand remaining in the pan was then removed. Water that passed through the number 140 screen was placed in a pilsner glass for at least 8 hours to allow the mud to settle. Stomach contents trapped on the Number 140 screen consisted primarily of fine sand, plant fragments, partially digested material, and detritus. This material was collected and labeled as "unseparated material." Stomach contents retained by the Number 20 and Number 30 screens were returned to the sorting pan and examined for insects and other animal remains. Pieces of catfood and liver found in a few of the stomachs were discarded because they had obviously been used as bait.

The dry weights of all categories of food were obtained by drying for 24 hours at 105 C. Volume of insects was estimated by spin drying for 1 minute (Howmiller 1972) and weighing; a specific gravity of 1 was assumed. Volume of sand, mud, unseparated material, and plant fragments was determined by multiplying the dry weights by a conversion factor calculated for each category of food item. The contents of the pooled stomachs collected during the creel census were combined, but the contents of the other stomachs were analyzed individually. Frequency of occurrence of various food items and the percent of stomachs containing food were not investigated for the pooled stomachs.

RESULTS

Terrestrial macrophyte fragments were the most abundant food item in the 131 stomachs that were pooled (Fig. 1). Animal remains, which accounted for only 0.05% of the dry weight and volume of the pooled stomach contents, consisted of 99% (by volume) fragments of earthworms (Oligochaeta), and 1% Dipteran pupae cases, ants (Formicidae) and unidentified fragments. These earthworms had probably been used as bait. No fish or fish eggs were found in the pooled stomach contents.

Contents of 286 stomachs analyzed individually were similar to that of the pooled stomachs. Fragments of terrestrial macrophytes and sand composed at least 60% by dry weight of the stomach contents in all months except February (Fig. 2), while fragments of terrestrial macrophytes were generally the most abundant category of food by volume (Fig. 3). Plant fragments were present in all of the stomachs that contained food items. The only animal remains found in the individually analyzed stomachs were insects and insect fragments, which amounted to only 0.01% of the dry weight and volume of the contents. These insect remains were composed of 81% (by volume) ants, 10% Dipteran pupae cases, 6% terrestrial insects other than ants, 1% Dipteran larvae, and 2% unidentified fragments. Insects were present in 23 of the 280 stomachs that contained food. The maximum percentage of insect remains observed in any of these 23 stomachs was 3% dry weight.

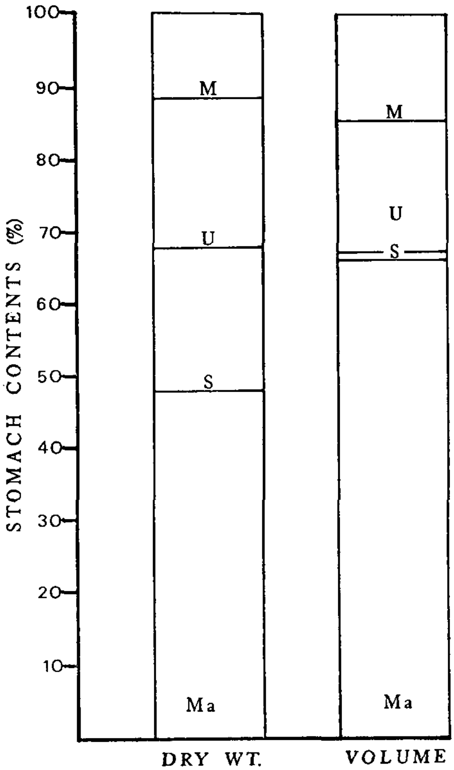

Figure 1. Pooled stomach contents of 131 grass carp (300 - 565 mm total length) collected from fishermen. Categories of food items are as follows: M = mud; U = unseparated material; S = sand; Ma = terrestrial macrophytes. Animal remains, which made up only 0.05% of the total contents, are not included in the graph.

The mean number of organisms in the Ekman dredge samples was highest in December, when no grass carp were captured for stomach analysis. Number of organisms per Ekman dredge sample was lowest during the summer months (Fig. 4), the time when most of the grass carp stomachs were collected, but at least some Dipteran larvae were available as potential food.

Grass carp stocked on 1 June 1972 gained up to 46% of their body weight in 4 months. By the end of the study when the fish had grazed terrestrial plants to a point above the water level the average weight of the grass carp recovered was less than when stocked (Fig. 5).

The 246 grass carp harvested by anglers made up 28% of the weight of all fish caught during the weekends of public fishing. Number of grass carp caught per angler hour was highest on the first day of fishing when 0.16 grass carp per angler hour were caught (Fig. 6). Only 156 grass carp were recovered when the pond was treated with antimycin 13 days after the last day of public fishing. Assuming that fish counted at the creel census station represented 100% of the grass carp mortality occurring from the day the pond was open to fishing until the day the pond was treated with antimycin, and assuming 100% recovery of grass carp after the antimycin treatment, fishermen harvested 61% of the grass carp population in 8 days of fishing.

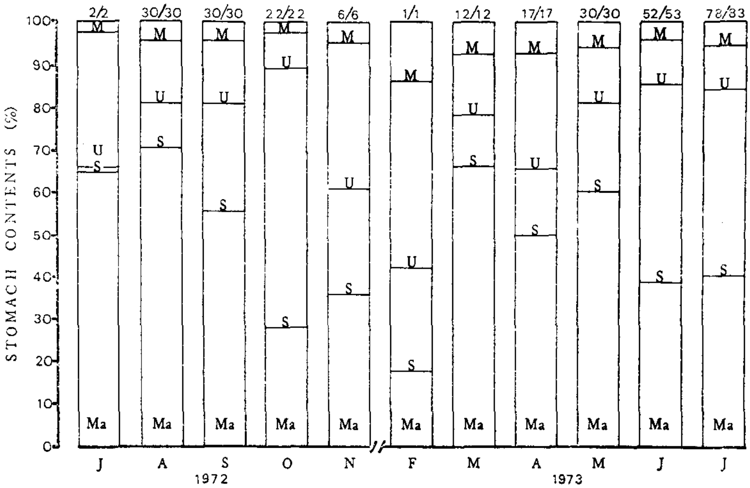

Figure 2. Stomach contents of 286 grass carp (286 - 588 mm total length) that were captured by individual effort or obtained from fishermen immediately after capture. Percentage composition is based on dry weight. Numbers above bars indicate number of stomachs with food/total number of stomachs examined. Code to food items same as Fig. 1. Animal remains, which made up no more than 0.2% of the total contents in any month are not included in the graph.

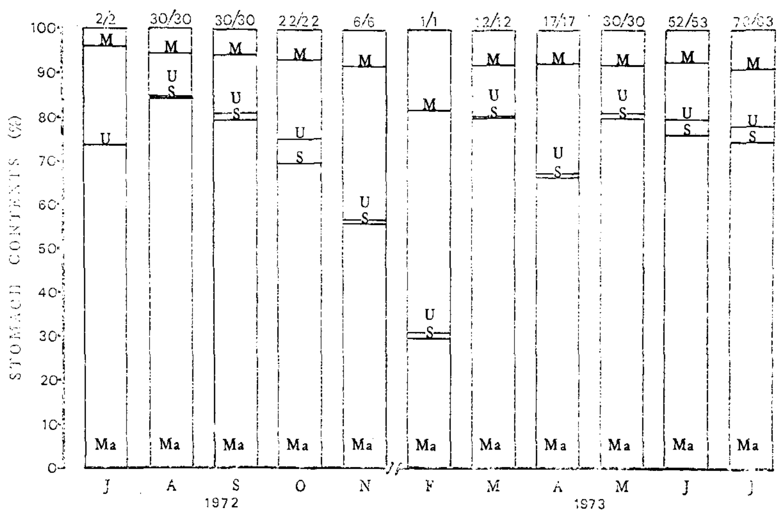

Figure 3. Stomach contents of the same grass carp represented in Fig. 2, with contents expressed as percentage of total volume. Numbering and code to food items are as in Fig. 2.

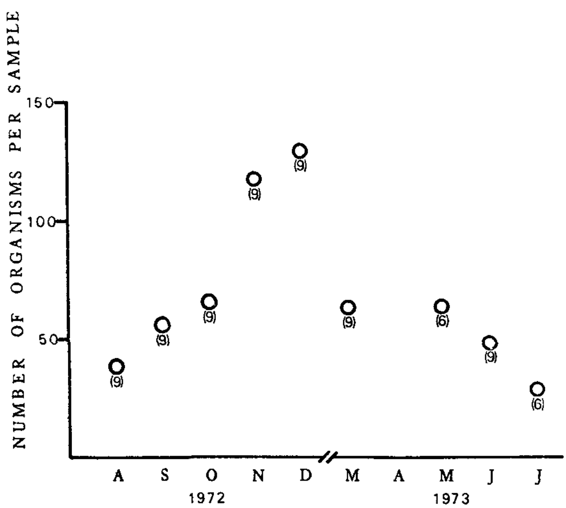

Figure 4. Mean number of organisms per 15 cm x 15 cm Ekman dredge sample from Fettig pond. Numbers in parentheses indicate number of samples taken each month. Dredge contents were washed in a #30 sieve before preservation. Organisms were 92% (by number) Dipteran larvae.

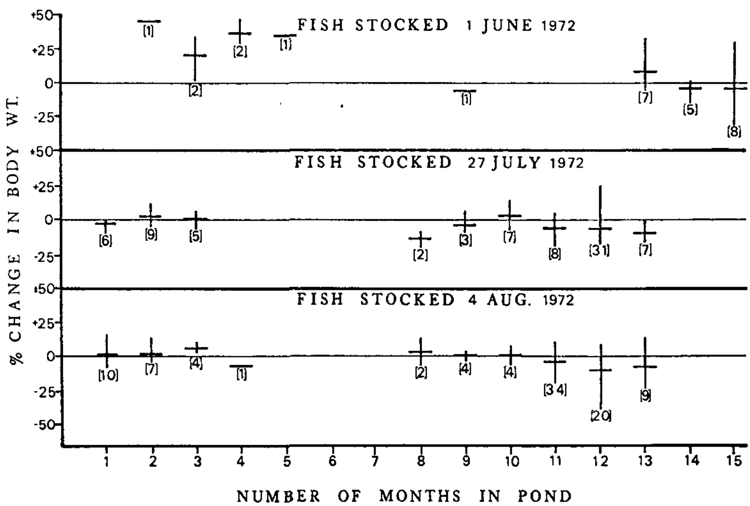

Figure 5. Percentage of change in body weight of tagged grass carp recovered from Fettig pond. Short horizontal lines represent mean change in body weight since stocking; vertical lines represent range of percent change in body weight observed. Numbers in brackets indicate number of fish weighed.

DISCUSSION

The amount of sand and mud in the grass carp stomachs indicated that the fish were ingesting the pond bottom. The almost total absence of benthic organisms in the stomachs demonstrates that the fish were not selectively feeding on Dipteran larvae that the Ekman dredge samples indicated were present. Partially decayed organic material present on the pond bottom may have been of some nutritive value to the fish. Grass carp were often observed with their heads out of the water feeding on overhanging terrestrial vegetation, similar behavior was reported by Kilgen and Smitherman (1971).

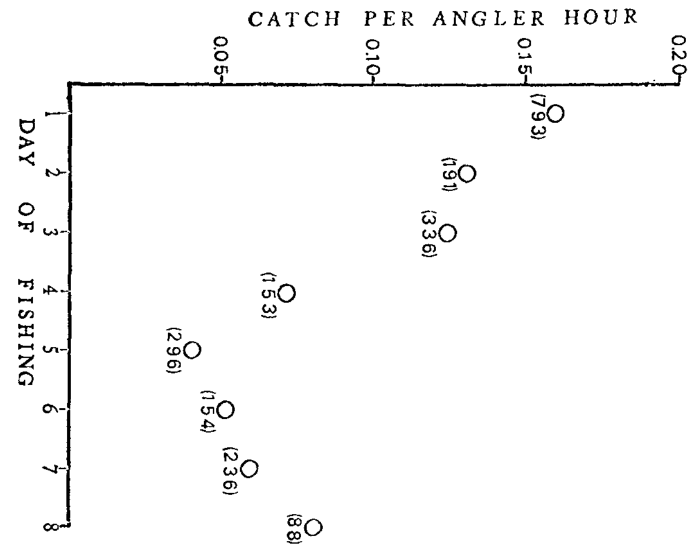

Figure 6. Number of grass carp caught per angler hour for each of 8 days of public fishing. Numbers in parentheses indicate number of angler hours of fishing effort expended each day.

Kilgen (in press) reported little use of insects by grass carp in a pond infested with macrophytes in which the fish were fed. Kilgen and Smitherman (1971) found 9% by volume of insects (primarily chironomid larvae) in the stomachs of 11 grass carp collected from a 5.2-acre (2.1 ha) pond artifically fed and devoid of vegetation, and 0 to 18% by volume of mature insects in two groups of grass carp collected from 0.1 acre (0.04 ha) ponds that contained no other species of fish. No single pond used in the above two studies was characterized by containing the 3 environmental conditions typical of Fittig pond, i.e. no artificial feed, no aquatic macrophytes, and an established fish population. Thus, the food habits of grass carp in Fettig pond may be more representative of what the fish would eat in a large lake or reservoir where grass carp have eliminated vegetation than any of the ponds used by Kilgen and Smitherman (1971) and Kilgen (in press).

No fish or fish eggs were found in the 417 grass carp stomachs examined. Nests of largemouth bass *(Micropterus salmoides)* and bluegills were observed in the pond and ripe golden shiners *(Notemigonus crysoleucas)* were caught by angling while grass carp were being captured for stomach analysis; consequently some eggs should have been available for possible predation. Over 5,000 fish, mostly bluegill and redear sunfish *(Lepomis microlophus),* less than 4.9 cm in total length were collected when the study pond was treated with antimycin. The number of fish shorter than 4.9 cm collected represented only a small percentage of fish of that size range actually present because large numbers of brown bullheads rapidly devoured weak and dying fish. Thus, a considerable number of small fish were available to the grass carp for food. The grass carp lost weight, however, suggesting that fish of the size range (286 to 588 mm) studied did not become piscivorous even when they were losing weight and probably starving.

The creel census data from this study indicate that fishermen should be able to catch grass carp if the fish eliminate aquatic macrophytes from a body of water. Courtenay and Robins (1973) reported that fishermen will readily transport fish from one body of water to another. Without some form of strict control to prevent illicit removal of grass carp from a body of water, unauthorized introductions by fishermen could result. Where strict control of angler access is possible, the stocking of a few grass carp could provide some trophy size fish, especially after the grass carp eventually eliminate the vegetation.

The fact that grass carp were caught on bait such as earthworms is evidence that the fish will consume animal material However, the scarcity of animal remains in the stomachs of starving fish indicated that they are almost entirely herbivorous. A possible explanation of this seemingly contradictory evidence can be found in Edwards (1973). He reported that young grass carp in aquaria readily ate invertebrates that were exposed in the water, but did not overturn small pebbles to search for invertebrates hidden on the aquaria bottom. If older grass carp in the wild behaved similarly, their readiness to consume bait presented by fishermen while ignoring insects hidden in the pond bottom is explained.

This investigation demonstrates that grass carp (total length 286 - 588 mm) did not become piscivorous when no aquatic vegetation was present, even though they were losing weight. Neither did grass carp utilize the benthic organisms shown to be available in Ekman dredge samples. Grass carp in a weed free pond were readily caught utilizing conventional hook and line fishing techniques.

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LIFE HISTORY OF WARMOUTH IN THE SUWANNEE RIVER AND OKEFENOKEE SWAMP, GEORGIA

by

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ABSTRACT

Life history data were collected from Suwannee River and Okefenokee Swamp warmouth (*Lepomis gulosus*) from 19 July 1968 through 28 June 1973. Suwannee River warmouth became sexually mature in the third year of life, while warmouth from the Okefenokee Swamp became sexually mature in the second year of life. Collection of fecund warmouth suggested that the nesting season extended from April to late July or early August and that peak spawning generally occurred in early May. Fecundity estimates varied from 3,029 to 22,850 ova per female and generally increased with fish length. The average total lengths of Suwannee River warmouth at ages I through VIII were 52, 73, 105, 132, 158, 177, 189, and 214 mm, respectively. Okefenokee Swamp warmouth were 54, 90, 127, 154, 179, 179, and 190 mm at ages I through VII, respectively. The length-weight relationship of Suwannee River warmouth was $\log W = -5.4996 + 3.3726 \text{ Log } L$. The equation, $\log W = -5.2395 + 3.2736 \log L$, described the length-weight relationship of Okefenokee Swamp warmouth. Warmouth of all lengths from both locations were carnivorous and fed on insects, fish, and crustaceans.