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NOTES

Evaluation of Methods for Capturing Grass Carp in Agricultural Canals[1]

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INTRODUCTION

During 1980-1981 grass carp (*Ctenopharyngodon idella* Val.) were stocked into irrigation and drainage canals in a south Florida citrus grove to control aquatic plants, especially hydrilla (*Hydrilla verticillata* L. F. Royle). The grass carp effectively controlled hydrilla in these agricultural canals when stocked at a density of 110 grass carp (average weight = 0.6 kg) per hectare of water. Success of hydrilla control was affected by survival and emigration of the fish. Poor survival of the grass carp was related to low water levels encountered in the shallow canals during normal irrigation and drainage operations, anaerobic conditions in areas of dense aquatic vegetation, and application of herbicides and insecticides. Movement of the grass carp increased during rising water events. The fish tended to swim "upstream" (i.e., into the inflowing water), resulting in emigration from the treatment areas. Emigration was partially controlled by barriers; however, barrier use was limited by water flow requirements for drainage and irrigation.

Based on these experiences, the effectiveness of weed control by grass carp in agricultural waterways would be improved with the development of methods for capturing and controlling the distribution of grass carp. The purpose of this paper is to report successful and unsuccessful methods for capturing and moving grass carp in agricultural waterways.

METHODS

This study was conducted in the irrigation and drainage canals at the Congen Properties, Inc. citrus grove, LaBelle, Florida (Hendry Co.). The canals were 3-4 m wide (bottom width) and had steeply sloping banks. Water depth, affected by the irrigation program, fluctuated between 1-2 m. Steel pipe barriers were installed at several locations to prevent the escape of grass carp from the study sites and, in conjunction with water control structures, to separate 3 canals into 6 experimental units ranging from 483 m long (0.145 ha) to 1207 m long (0.362 ha) . Grass carp averaging 0.61 kg (range 0.50-1.60 kg, standard deviation 0.04 kg) were stocked into these canals at densities of 97-559 fish ha^{-1} during 28 June-7 July 1982. Evaluations of techniques for herding, attracting, and trapping grass carp were conducted during August-September 1982 (Table 1).

RESULTS AND DISCUSSION

Fyke nets (1.0-1.2-m opening, 2.5-cm bar mesh) with wings attached to the canal banks were fished for 5 net-nights in standing water. Although numerous Florida gar (*Lepisosteus platyrhincus* DeKay), brown bullhead (*Ictalurus nebulosus* (Lesueur)), bluegill (*Lepomis macrochirus* Raf.), and redear sunfish (*Lepomis microlophus* (Gunther)) were caught in the 5 net-nights effort, only 1 grass carp was caught. Due to poor success capturing grass carp and the capture of 3 alligators (*Alligator mississippiensis* (Daudin)) during the 5 fyke net sets, we abandoned further use of fyke nets set overnight in standing water.

Fyke nets were evaluated in flowing water in 4 trials. In two trials the fyke nets were placed at the upstream end of a canal and the water control structure was opened to produce a high volume flow of water. After approximately 1 hour flow, vegetation fragments impinged on the net

TABLE 1. TECHNIQUES FOR HERDING, TRAPPING, AND ATTRACTING GRASS CARP EVALUATED IN CANALS AT CONGEN PROPERTIES, LABELLE, FLORIDA, 1982.

Technique	Mean stocking rate	Number of trials	Success rating[1]
Fyke net	436	5	0
Flowing water	526	4	0
Seine	559	1	+
Moving barrier	488	3	+
Surface disturbance	538	5	0
Electroshock	538	16	+
Flowing water and electroshock	537	2	0
Rotenone/potassium permanganate	328	2	0
Baited cage	516	5	++
Baited trap	452	3	++
Baited area	452	3	++

[1]"0", unsuccessful; "+", limited success; "++", successful.

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and impeded water flow. No grass carp were caught. In two trials the fyke nets were placed at the upstream end of a canal unit and a water current was produced by pumping 1400 liters min^{-1} through the fyke net for 1 hour. No grass carp were caught. Perceptible current (by observation) only extended approximately 50 m downstream of the net. Considering the strong upstream movement response of grass carp to flowing water, failure to attract the grass carp to the fyke nets may have been related to methodological problems. Long duration, high volume flows may be more successful.

A seine (10-m x 2-m x 6-mm bar mesh) was tested to herd grass carp into a fyke net. The seine was pulled approximately 200 m. Three grass carp were herded into the fyke net, but 17 grass carp swam around or jumped over the seine as we pulled it down the canal. Because obstructions in the canal made seining difficult and reduced efficiency, further attempts at herding grass carp with a seine were abandoned.

To circumvent the obstructions in the canals a moving barrier was constructed. The barrier was a wire mesh (1.2-cm square) panel attached vertically to the front of a 3.7-m long flat bottom boat. The wire mesh panel was approximately the width of the canal. Flexible chains spaced at 2-cm intervals hanging from the bottom of the wire mesh panel allowed the barrier to conform to the irregular canal bottom. The boat was pushed slowly down the center of the canal. In one trial, 15 grass carp were herded to a barrier, but in two subsequent trials the grass carp escaped around or under the moving barrier.

The limited success with the seine and moving barrier was related to physical characteristics of the canals. These techniques would probably be more effective in canals with uniform depth and width and without obstructions.

Five trials were conducted to evaluate surface disturbance for herding grass carp. The surface disturbance was created by slapping the water with a PVC pipe while walking down the center of the canal toward a barrier. Based on the results of these 5 trials, grass carp swam away from the surface disturbance when initially applied, but could only be herded short distances before passing through the source of disturbance.

A total of 18 trials were conducted to evaluate electroshock to herd grass carp to barriers or into fyke nets. Electroshock was provided by a pulsed direct current, battery powered backpack electroshocker (Coffelt Electronics Model BP4, Englewood, Colorado) operated at 125 pulses per second and 100-150 volts. The operator slowly walked down the center of the canal holding the electrodes 1.0-1.7 m apart. Grass carp were successfully herded to a barrier in two of 11 trials. In five trials to herd grass carp into fyke nets a total of 16 grass carp were captured. Electroshock also was employed in conjunction with flowing water to herd grass carp into a fyke net. A 1400 liter min^{-1} water current was pumped 1 through a fyke net while the electroshocker was moved upstream toward the net. No grass carp were caught in two trials. Results from all electroshock trials indicated the grass carp avoided the electrical stimulus and, in general, were more effectively herded toward a barrier or a fyke net than by surface disturbance; however, we were not able to consistently herd grass carp to a barrier or into a fyke net without the fish escaping around or through the electric field.

Two trials were conducted to evaluate attraction of grass carp to potassium permanganate when the fish were stressed with rotenone. In a static water trial rotenone (Noxfish, 5% active ingredient, Pennick, Inc., Lyndhurst, New Jersey) was uniformly applied to the entire canal at 0.05 mg $liter^{-1}$ and potassium permanganate was applied at 0.05 mg $liter^{-1}$ to a 10-m length of the canal where a fyke net was placed. No grass carp entered the fyke net or were observed in the area of the potassium permanganate. Of six grass carp observed in the treated section of the canal, three died. A second trial was conducted in slowly flowing (appoximately 10 cm sec^{-1}) water. Rotenone was uniformly applied to the canal at 0.05 mg/liter and a perforated can containing potassium permanganate was placed in a fyke net at the upstream end of the canal. In this trial one grass carp was collected in the trap net, and 15 grass carp were observed swimming at the water surface toward the fyke net. These fish began swimming normally, apparently having recovered from the rotenone stress, before reaching the fyke net. Although unsuccessful, the desired behavioral response was obtained in the flowing water trial. Further use of this technique must consider the need to fine-tune the application of rotenone and potassium permanganate to different water flows and solve the problem of toxicant discharge into adjacent waters.

We tested the attraction of grass carp to a plastic mesh (2.0-cm square) cage baited with hydrilla and duckweed (*Lemna* sp.). The cage was 1.5-m X 1.0-m X 1.0-m high with a 0.3-m diameter hole in each end. In two trials conducted in different canal units, grass carp entered the cages and consumed the vegetation in four and seven days after the cages were initially installed and baited. The cages were left in place and more vegetation was added. Grass carp entered the cages in 3 hours to 2 days (3 trials). These results indicate grass carp will enter a cage to consume vegetation, but there is an initial avoidance of the cage.

A second identical cage was modified into a trap by installing plastic mesh funnels (0.3-m long, tapering inward to a 0.2-m diameter opening) to the two ports in the cage and a removable wire mesh top. The trap was installed and baited with hydrilla and duckweed. No grass carp entered the trap for 15 days, but 7 grass carp were caught on day 16. The trap was left in place, fish were removed and more vegetation added. In two successive trials 1 and 2 grass carp entered the trap after 11 and 7 days, respectively. As found for baited cages, there was an initial period of avoidance. The period of avoidance decreased in subsequent trials in the same canal. The baited cage and baited trap were tested simultaneously in the same canal unit. Although the trap and cage were similar structures, except the trap had plastic mesh throats in each end and a wire mesh top, the avoidance period for traps was longer than for cages.

Attracting grass carp to traps baited with aquatic vegetation appears to be a useful technique for capturing small numbers of grass carp over a long period of time when the area contains no vegetation consumable by the grass carp. Improved trap design may improve the efficiency of this technique.

The attraction of grass carp to aquatic vegetation was also evaluated in an unobstructed section of a canal unit. A sheet of plastic extending 20 cm above and 40 cm below the water surface was installed 60 m from the end of the canal and duckweed was added as bait. In four successive trials the grass carp entered the baited area within 24 hours. The grass carp were more readily attracted with aquatic vegetation to the unobstructed area than to cages or traps. Baiting to an unobstructed area would simplify live capture of grass carp if, after the grass carp were attracted, the fish were contained by placement of a barrier and collected with rotenone as described by Colle *et al.* (1978).

The response of grass carp to barriers and traps affected our ability to herd and capture grass carp. Grass carp were herded with aversive stimuli until a confining structure blocked their escape path. Grass carp were attracted to baited cages and traps, but they were more quickly attracted to an unobstructed area with aquatic vegetation. Apparently, confining structures were stronger aversive stimuli than the herding stimuli. There were no noticeable differences in avoidance of various types of traps or barriers. Rather, it appears that any structure that blocks free movement of the grass carp is a strong aversive stimulus. Any attempts to control the distribution of grass carp by herding or attraction techniques should consider elimination of confining structures.

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