Removal of Triploid Grass Carp Using Fish Management Bait (FMB)

by

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Introduction

Triploid grass carp *(Ctenopharyngodon idella)* have been used in Florida for aquatic plant management since 1984 (Trent et al. 1992). Although this sterile herbivore is an effective, economical biological plant management tool, it has not been routinely stocked in large public waters because it sometimes removes desirable aquatic vegetation after nuisance target plants are eliminated (Sutton and Vandiver 1986; Leslie et al. 1987; Wiley, Tazik, and Sobaski 1987; Langeland 1990). Once eradication occurs, grass carp may prevent growth of aquatic macrophytes for many years (Van Dyke, Leslie, and Nall 1984; Leslie et al. 1987; Bain et al. 1990; Trent et al. 1992).

Low stocking rates of grass carp may be successful in controlling target vegetation without damaging the native plant community in the short term (Leslie et al. 1987; Phillippy et al. 1989). However, aquatic vegetation growth and the amount of plant control required change over time as a result of many variables, including water levels, weather patterns, nutrient loading, and age-specific feeding preferences of the fish (Osborne and Sassic 1981; Sutton and Vandiver 1986; Wiley, Tazik, and Sobaski 1987). Consequently, long-term selective aquatic plant management using triploid grass carp requires the ability to manipulate the amount of vegetation control (i.e., the number of fish). Supplemental stockings can be used to increase the amount of plant control (Sutton and Vandiver 1986; Trent et al. 1992), but an efficient and practical method of triploid grass carp removal to decrease the amount of plant control has not been developed (Hestand, Thompson, and Phippen 1987; Trent et al. 1992; Bonar et al. 1993). The risks of damaging nontarget vegetation in triploid grass carp aquatic plant management programs will be greatly reduced when a feasible triploid grass carp removal technique is developed.

Fajt and Grizzle (1993) indicated that ingested rotenone is lethal to common carp *(Cyprinus carpio)*. The objective of this study was to determine if triploid grass carp can be removed with a rotenone bait and if so, to develop a methodology to selectively remove significant numbers of triploid grass carp (50 percent or more) for population control.

Materials and Methods

Fish Management Bait (FMB) is a floating fish food containing rotenone that was developed for selective removal of undesirable fish (Prentiss, Inc., Floral Park, NY). Various FMB formulations were produced in attempts to develop an FMB that would be highly preferred by triploid grass carp and were prepared by adding flavor ingredients to the original feed mix prior to extrusion. Flavor ingredients included alfalfa, fish meal, chicken meal, yeast, and a combination of fish meal, chicken meal, and yeast. Trainer pellets for each flavor were produced and contained the same formulation as FMB minus the active ingredient rotenone.

FMB was tested at the Florida Game and Fresh Water Fish Commission's Richloam Fish Hatchery (Sumter County) and seven central Florida lakes. FMB trial procedures included dispensing 250 to 400 g of trainer pellets (small nugget size) once or twice daily from an automatic fish feeder to attract and train

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triploid grass carp. After a feeding response was initiated and stabilized (generally 10 to 25 days), 125 to 400 g of FMB were given to the fish. Uneaten FMB was removed after triploid grass carp had finished feeding. Test sites were inspected for 2 days following FMB application to count and remove dead fish. At Richloam Fish Hatchery, ponds were drained after FMB trials to verify the number of surviving triploid grass carp.

In lakes, the number of triploid grass carp at the feeders was visually estimated by counting fish during feeding. During FMB trials, dying or dead triploid grass carp were marked and returned to the lakes on the first day when possible. On the second day, all dead fish were counted and removed. The number of triploid grass carp killed with FMB was estimated using the Peterson method (Ricker 1975) as follows:

$$N = M * C/R$$

where

- N = estimated number of triploid grass carp killed during the FMB trial
- M = number of triploid grass carp marked the first day
- C = total number of triploid grass carp collected the second day
- R = number of marked triploid grass carp collected the second day

Results and Discussion

Richloam Fish Hatchery

Nine FMB trials at Richloam Fish Hatchery were conducted at water temperatures below 23 °C. Many triploid grass carp consumed FMB and became ill (observed porpoising) but subsequently revived. None of the 327 triploid grass carp were removed. In 25 trials at or above 23 °C, 147 of 382 (38 percent) triploid grass carp were removed. During nine initial FMB trials (first test on those fish), 131 of 336 (39 percent) fish were removed (Table 1). As triploid grass carp population density and the number of feeding fish increased, a greater percentage was removed with FMB (Figure 1). This was attributed to more aggressive feeding because of less food per fish. In 16 retrials (tests on survivors of previous tests), 16 of 191 (8 percent) triploid grass carp were removed (Table 2). Previously tested fish avoided FMB, and retrials were much less effective than initial trials. While all flavors of FMB removed at least 20 percent of the triploid grass carp in two trials, the most effective were fish meal and alfalfa.

Lake Monterey

Lake Monterey (0.5 ha, Orange County) was tested with FMB in an attempt to remove the 48 triploid grass carp present in the lake. The most effective trial was the first in which 30 of 48 (63 percent) triploid grass carp were removed with alfalfa FMB (Table 3). Three retrials removed 3 of 18 (17 percent) remaining fish. Overall, 33 of 48 (69 percent) triploid grass carp were removed in the 6-month period from April to October 1993. Nontarget fish found dead included 30 threadfin shad *(Dorosoma petenense)* and seven bluegill *(Lepomis macrochirus)*.

Table 1
Fish Management Bait (FMB) Initial Trials at Richloam Hatchery, 1992-1993

Date	Site	FMB	Number TGC per ha	N / P (%)
8/31/92	Pond 8	Original	1,285	41 / 52 (79)
5/03/93	Pond 1	Fish meal	815	21 / 33 (64)
6/29/93	Pond 1	Alfalfa	692	16 / 28 (57)
6/29/93	Pond 2	Combination	667	14 / 27 (52)
8/10/93	Pond 9	Alfalfa	593	1 / 24 (4)
5/17/93	Pond 1	Yeast	494	2 / 20 (10)
5/17/93	Pond 2	Chicken meal	470	6 / 19 (32)
8/10/93	Pond 15	Alfalfa	259	25 / 68 (37)
9/30/92	Pond 15	Original	247	5 / 65 (8)
1992-93 Total 9 Trials				131 / 336 (39)

Note: Water temperatures were 23-31 °C. Number TGC per ha = number of triploid grass carp per hectare. N = number of triploid grass carp removed, and P = number of triploid grass carp present.

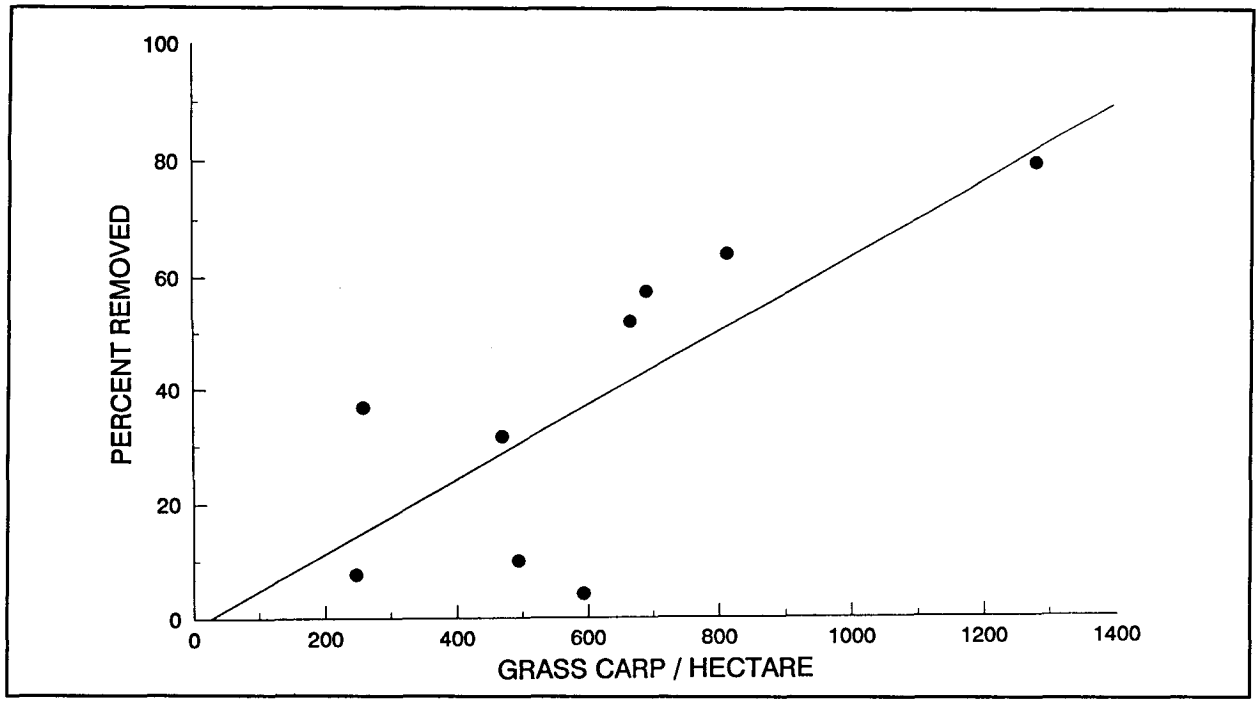

Figure 1. Percentage removal of triploid grass carp with Fish Management Bait was positively correlated with population density (r-square = 0.57)

Table 2
Fish Management Bait (FMB) Retrials at Richloam Hatchery, 1992-1993

Date	Site	FMB	Number TGC per ha	N / P (%)
9/27/93	Pond 9	Alfalfa	568	0 / 23 (0)
7/07/93	Pond A	Alfalfa	536	5 / 52 (10)
9/27/93	Pond A	Alfalfa	484	0 / 47 (0)
10/08/92	Pond A	Original	474	2 / 46 (4)
10/15/92	Pond A	Original	452	1 / 44 (2)
6/07/93	Pond 1	Yeast	445	2 / 18 (11)
5/03/93	Pond A	Fish meal	442	2 / 43 (5)
5/10/93	Pond A	Fish meal	423	1 / 41 (2)
6/08/93	Pond 1	Alfalfa	395	0 / 16 (0)
6/08/93	Pond 2	Alfalfa	321	1 / 13 (8)
6/07/93	Pond 2	Chicken meal	321	0 / 13 (0)
8/10/93	Pond 2	Combination	321	0 / 13 (0)
8/10/93	Pond 1	Alfalfa	297	1 / 12 (8)
5/10/93	Pond 1	Fish meal	297	0 / 12 (0)
9/16/92	Pond 8	Original	272	0 / 11 (0)
9/27/93	Pond 15	Alfalfa	163	1 / 43 (2)
1992-93 Total 16 Trials				16 / 191 (8)

Note: Water temperatures were 23-31 °C. Number TGC per ha = number of triploid grass carp per hectare. N = number of triploid grass carp removed, and P = number of triploid grass carp present. Some fish were tested multiple times, so the total number present is less than the sum of column P.

Table 3
Fish Management Bait (FMB) Trials at Lake Monterey (0.5 ha, Orange County), 1993

Date	FMB	Number TGC per ha	N / P (%)
5/5	Alfalfa	96	30 / 48 (63)
5/20	Alfalfa	36	0 / 18 (0)
7/20	Alfalfa	36	2 / 18 (11)
10/5	Fish meal	32	1 / 16 (6)
1993 Total 4 Trials		96	33 / 48 (69)

Note: Water temperatures were 24-31 °C. Number TGC per ha = number of triploid grass carp per hectare. N = number of triploid grass carp removed, and P = number of triploid grass carp present.

After FMB trials were completed, Lake Monterey was renovated with liquid rotenone (one part per million) to determine the number of triploid grass carp remaining and the species and numbers of other fish present. A total of 2,032 fish weighing 156 kg was collected (Table 4). Fish species present that were not visibly affected by FMB included largemouth bass *(Micropterus salmoides)*, black crappie *(Pomoxis nigromaculatus)*, redear sunfish *(Lepomis microlophus)*, warmouth *(Lepomis gulosus)*, channel catfish *(Ictalurus punctatus)*, brown bullhead *(I. nebulosus)*, blue tilapia *(Sarotherodon milotica)*, lake chubsucker *(Erimyzon sucetta)*, goldfish *(Carassius auratus)*, golden shiner *(Notemigonus chrysoleucas)*, tadpole madtom *(Noturus gyrinus)*, mosquitofish *(Gambusia affinis)*, and swamp darter *(Etheostoma fusiforme)*. Wildlife observed during Lake Monterey trials included black vulture *(Coragyps atratus)*, herring gull *(Larus argentatus)*, anhinga *(Anhinga anhinga)*, mallard duck *(Anas platyrhynchos)*, common egret *(Casmerodius albus)*, common grackle *(Quiscalus quiscula)*, and Florida softshell turtle *(Trionyx ferox)*. No effects of FMB on wildlife were observed.

Table 4
Number and Weight of Fish Removed During Lake Monterey Renovation, November 9, 1993

Fish	Number	Weight, kg	Harvestable[1]	
			Number	Weight, kg
Sport Fish				
Largemouth bass	113	18.3	16	10.2
Black crappie	3	0.6	3	0.6
Redear sunfish	488	36.8	266	33.6
Bluegill	772	23.6	147	14.1
Warmouth	207	2.3	7	0.9
Total Sport Fish	1,583	81.6	439	59.4
Rough Fish				
Brown bullhead	24	9.6	21	9.5
Channel catfish	4	3.8	4	3.8
Grass carp	15	45.2		
Tilapia	3	4.5		
Lake chubsucker	4	2.4		
Goldfish	1	3.2		
Total Rough Fish	51	68.6	25	13.3
Forage Fish				
Golden shiner	6	<0.1		
Madtom	1	<0.1		
Mosquitofish	2	<0.1		
Swamp darter	2	<0.1		
Threadfin shad	387	5.4		
Total Forage Fish	398	5.4		
Grand Total	2,032	155.7	464	72.7

[1] Harvestable lengths are defined here as largemouth bass–300 mm; black crappie–180 mm; redear sunfish, bluegill, and warmouth–160 mm; and channel catfish and brown bullhead–200 mm.

Study lakes

FMB was tested at six lakes ranging from 38 to 152 ha. In 14 initial trials (first application of FMB at that feeder location), 112 triploid grass carp were removed, including 93 of 133 (70 percent) triploid grass carp observed at the feeders (Table 5). In 11 initial trials, 35 triploid grass carp were marked. While 17 (49 percent) were recovered on the following days, recovery rates of marked fish ranged from 25 to 72 percent. The remaining fish were not found because of predation (primarily alligators *(Alligator mississippiensis)*) and large size of the study areas. Based on the Peterson estimates, 145 triploid grass carp (84 percent of the fish observed at the feeders) were killed in 14 initial trials.

During seven retrials (second or third test at that feeder location), FMB removed 7 of 70 (10 percent) fish observed at the feeders (Table 5). Fish fed readily on trainer bait but avoided FMB, indicating that previously tested triploid grass carp detected rotenone in FMB even after waiting 50 days between trials. Futhermore, survivors of initial trials remained at the feeder (as opposed to a new group of fish moving in after some initial fish are removed) and apparently stayed in a home range. Fewer fish were observed at the feeders during retrials than initial trials.

At Live Oak Lake (152 ha, Osceola County), feeders were moved to new locations for the final set of trials in an attempt to attract new groups of triploid grass carp. Since feeding activity was greater at dusk than 9:30-11:00 a.m. (regular testing time), FMB was tested at dusk (7:00 p.m.). This strategy was successful, as FMB removed 27 of 30 (90 percent) fish observed at three feeders. This was more effective than the previous set of trials where FMB removed 14 of 20 (70 percent) fish observed at two feeders (Table 5). Six percent of the estimated number of triploid grass carp in Live Oak Lake was removed with FMB in 6 weeks (five trials). At this rate, one quarter of the population could be removed during the effective annual removal period of 6 months (May to October when water temperatures typically exceed 23 °C in central Florida)

Table 5
Study Lakes Tested with Alfalfa Fish Management Bait (FMB), 1992-93

Lake	Size, ha County	Number TGC per ha	Number Feeder Trials	Number TGC at Feeders	Number TGC Removed (%)	Number TGC Killed (%)
Initial Trials						
Joy[a]	38-Marion	2.6	1	5	5 (100)	5 (100)
Whippoorwill	132-Orange	12.3	3	60	42 (70)	56 (93)
Miona	70-Sumter	2.5	1	0	0	0
Live Oak	152-Osceola	4.9	1	3	0 (0)	0 (0)
Padgett	80-Pasco	15.7	2	-	19 (-)	33 (-)
Mill Dam	60-Marion	5.3	1	15	5 (33)	8 (53)
Live Oak	152-Osceola	4.9	2	20	14 (70)	16 (80)
Live Oak	152-Osceola	4.8	3	30	27 (90)	27 (90)
Subtotal – 6 lakes			14	133[b]	112 (70)[b]	145 (84)[b]
Retrials						
Joy[a]	38-Marion	2.5	1	10	0 (0)	0 (0)
Whippoorwill	132-Orange	11.9	3	30	4 (13)	4 (13)
Whippoorwill	132-Orange	11.9	3	30	3 (10)	3 (10)
Subtotal – 2 lakes			7	70	7 (10)	7 (10)
Total – 6 lakes			21	203[b]	119 (49)[b]	152 (59)b

Note: Water temperatures were 26-31 °C. Number TGC per ha = estimated number of triploid grass carp (TGC) per hectare, number TGC at feeders = number of TGC observed at the feeder(s), Number TGC killed = estimated number of TGC killed (when different from number TGC removed; this is based on second day recovery rates of marked fish - see text), and percent = percent of number TGC at feeders.
[a] Lake Joy was tested with the original FMB formulation (rather than alfalfa FMB).
[b] Lake Padgett trial is omitted from total because number TGC at feeders was not estimated.

if moving feeders consistently attracts new groups of fish.

Nontarget fish found dead during FMB trials at study lakes included 25 golden shiners, 25 Seminole killifish *(Fundulus seminolis)*, and one threadfin shad at Lake Miona (70 ha, Sumter County), five taillight shiners *(Notropis maculatus)* and one warmouth at Lake Whippoorwill (132 ha, Orange County), five taillight shiners at Lake Padgett (80 ha, Pasco County), three bluegill at Lake Joy (38 ha, Marion County), and one largemouth bass at Live Oak Lake. The unusually high bi-kill at Lake Miona was attributed to the absence of triploid grass carp. In this situation, smaller fish had the opportunity to feed much more extensively than when the larger triploid grass carp were present. In the other 20 lake trials, triploid grass carp were present and 15 nontarget fish (less than one per trial) were removed. No effects of FMB on wildlife were observed; species present included otter *(Lutra canadensis)*, alligator, bald eagle *(Haliaeetus leucocephalus)*, osprey *(Pandion haliaetus)*, anhinga, black vulture, turkey vulture *(Cathartes aura)*, great blue heron *(Ardea herodias)*, common egret, snowy egret *(Leucophoyx thula)*, wood stork *(Mycteria americana)*, white ibis *(Eudocimus albus)*, common grackle, common gallinule *(Gallinula chloropus)*, and turtles.

Conclusions

This study showed that triploid grass carp can be removed with a rotenone bait. FMB was effective during most initial trials and removed up to 79 percent of the triploid grass carp present. Alfalfa FMB was the most extensively tested flavor and removed an average 70 percent of the triploid grass carp that were observed at feeders during initial lake trials (mean eight fish per trial). Retrials were ineffective, and each trial removed less than 15 percent of the triploid grass carp present (mean one fish per trial).

In lakes, triploid grass carp remained in home ranges; retrials at each feeder location will likely be ineffective unless success increases after waiting several months between applications. Moving feeders to new locations attracted new groups of fish (equivalent to an initial trial) and may be essential to attract the highest number of vulnerable fish. Using FMB for triploid grass carp population control (removal of at least 50 percent of the population) may be feasible in lakes if moving feeders consistently attracts naive fish and if the majority of the triploid grass carp population can be attracted to feeders. More information about triploid grass carp home ranges is needed to determine the effective area of a single feeder, the distance required to move a feeder out of the home range of tested fish, and the number of trials required to completely treat various size lakes. Future research should also determine optimum feeder location characteristics (depth, cover, distance from shore, etc.) and application times (dawn or dusk), if any.

FMB was selective to triploid grass carp and resulted in minimal bi-kill when triploid grass carp were present. Removal of 51 forage fish (golden shiners, Seminole killifish, and threadfin shad) occurred in one trial where smaller fish had the opportunity to feed thoroughly (triploid grass carp were absent). Uneaten FMB should be removed after triploid grass carp have finished feeding to minimize bi-kill. No effects of FMB on wildlife were observed.

At water temperatures below 23 °C, triploid grass carp were able to recover from FMB. Applications should be made when the water temperature exceeds 23 °C. The efficiency of FMB (percentage removal of triploid grass carp) improved as fish feeding activity increased. Feeding activity was most aggressive when food supply was limited; thus, the amount of trainer pellets and FMB should be minimal (250 to 400 g per feeding time). Two cups (250 g) of FMB was enough to remove up to 30 triploid grass carp at a single feeder.

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