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Hauling and Post-stocking Mortality of Triploid Grass Carp

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INTRODUCTION

Grass carp (*Ctenopharyngodon idella* Val.) are generally stocked at low rates (< 12 fish / lake hectare) to control problem aquatic vegetation (primarily hydrilla *Hydrilla verticillata* L. F. Royle) in Florida lakes. Plant control has been variable, even among similar lakes stocked with grass carp at identical rates. Because grass carp mortality can significantly influence the degree of plant control achieved (especially at low stocking rates), knowledge of fish longevity and mortality rates should help in successfully predicting grass carp stocking rates necessary to achieve plant management goals.

Grass carp mortality rates have been estimated for diploid (Colle et al. 1978, Hill 1986, Shireman et al. 1986) and hybrid (Harberg and Modde 1985) fish, from individual plant control studies (Colle et al. 1978) and hatchery grow-out programs (Thomas and Carter 1977, Harberg and Modde 1985). There is a great deal of variation among published estimates (3-95%), and little work has been done to describe mortality of triploid grass carp once they have been stocked. This study was undertaken to examine mortality of triploid grass carp stocked for aquatic plant control in Florida. The specific objectives of the study were to determine initial mortality rates of triploid grass carp hauled from production facilities at different distances from Florida, and to estimate annual mortality of triploid grass carp in ponds previously stocked for aquatic plant control. Knowledge of triploid grass carp mortality rates and factors affecting these rates will assist managers in using this important aquatic plant management tool more effectively.

MATERIALS AND METHODS

Controlled pond studies were conducted to investigate mortality immediately (within 30 d) following stocking of triploid grass carp. Winter (December - January) and late spring (May - June) evaluations were conducted in 1989-90 at the Florida Game and Fresh Water Fish Commission's Richloam Fish Hatchery near Webster, Florida. Fish from three different sources were evaluated during each time period, with fish from Richloam used in each case as a group representing minimum hauling distance (Table 1). Fish were brought to the hatchery on transport trucks from two other sources, in conjunction with previously-scheduled plant control activities in other parts of Florida.

For the winter test, fish from the three sources (N=197-250 fish from each source) were given identifying clips and stocked into a 0.14 hectare hatchery pond immediately following hauling (Table 1; total pond density=1,429 fish/hectare). Pond temperatures during this test ranged from 13-19 C, and fish experienced tempering gradients of 0 C (Richloam), 6 C (Arkansas), and 7 C (Alabama), respectively, at stocking. For spring tests, fish (N=25-81 fish from each source) were marked and stocked into four, 0.04 hectare ponds, two of which were covered with bird netting (Table 1; pond densities=1,250 fish/hectare). Pond temperatures during spring tests ranged from 24-30 C, and fish experienced tempering gradients of 0 C (Richloam), 2 C (Florida), and 9 C (Arkansas), respectively, at stocking. All fish used in these tests were of a size typically used when stocking lakes in Florida for control of aquatic plants.

Mortality was determined by draining ponds and counting the number of fish remaining at the end of each test period. Tests for differences in hauling mortality, related to fish source and treatment (netted versus open), were made using a chi-square test for differences in probabilities (Conover 1971). All differences were considered significant at the $P = 0.05$ level. Five of six possible comparisons between spring treatment replicates were not significant, so replicates for each source were combined.

Post-stocking evaluations were conducted in May 1987, 1988, and 1989 by making rotenone (Noxfish Toxicant, 5% active ingredient) reclamations of six urban ponds (0.4 - 2.0 hectares) in central Florida (Table 1). These ponds had been previously stocked with triploid grass carp for aquatic plant control. Source and fish size were the same as those used in evaluations of hauling mortality; fish were

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TABLE 1. EVALUATIONS OF HAULING AND POST-STOCKING MORTALITY OF TRIPLOID GRASS CARP. IN HAULING TESTS, PERCENT MORTALITY IS THAT IN A SINGLE POND FOR WINTER TESTS AND AN AVERAGE FOR TWO PONDS IN SPRING TESTS; 95% CONFIDENCE LIMITS ARE SHOWN IN PARENTHESES. FOR POST-STOCKING EVALUATIONS, ANNUAL MORTALITY (RICKER 1975) IS REPORTED. LENGTH OF TEST IS DAYS FOR HAULING EVALUATIONS AND MONTHS FOR POST-STOCKING EVALUATIONS.

Trial	Fish source	Time hauled (h)	Fish size (mean TL, mm)	Length of test	Percent mortality
		Hauling Evaluations			
Winter	Richloam[a]	1	296	35 days	27 (--)
	Alabama[b]	10	371	30	6 (--)
	Arkansas[c]	24	288	34	27 (--)
Spring (Net)	Richloam	1	376	28	39 (6)
	Florida[d]	4	297	28	20 (9)
	Arkansas	24	349	25	42 (15)
Spring (Open)	Richloam	1	426	27	15 (10)
	Florida	4	297	28	28 (0)
	Arkansas	24	344	25	52 (8)
		Post-stocking Evaluations			
Lake Lucerne	Richloam	3	289	20 mo.	60
Lake Kelly	Richloam	3	405	32	42
Lake Greenwood	Arkansas	24	325	30	15
Michigan Street	Arkansas	24	275	15	20
I-4 East	Arkansas	24	275	15	6
I-4 West	Arkansas	24	275	15	62

[a]Richloam Fish Hatchery, Webster, Florida. Hauling densities=120-240 kg/m³; fish hauled with O_2 and NaCl.
[b]Easterling Fish Hatchery, Clio, Alabama. Hauling densities=120-240 kg/m³; fish hauled with O_2.
[c]Arkansas Aquatics-Keofish Farm, Keo, Arkansas. Hauling densities=360-480 kg/m³; fish hauled with O_2.
[d]Florida Fish Farms, Center Hill, Florida. Hauling densities=240-360 kg/m³; fish hauled with O_2.

originally stocked between September and January. To estimate mortality, marked grass carp were placed in ponds prior to application of rotenone, and fish were recovered for 3 days following treatment. The ratio of marked grass carp recovered to marked fish stocked was used to estimate the remaining population (Colle et al. 1978). Annual mortality was calculated as described by Ricker (1975).

RESULTS AND DISCUSSION

Hauling mortality in winter ranged from 6% to 27% (Table 1). In spring tests, fish in ponds with bird netting experienced hauling mortality from 20% to 42%, while fish in open ponds experienced mortality from 15% to 52% (Table 1). These values are comparable to those reported by Kirk (1992) for triploid grass carp in ponds, and are within the range of values previously reported for diploid grass carp (Colle et al. 1978, Hill 1986, Shireman et al. 1986). Distance hauled, water temperature at stocking, and fish size all had some influence on hauling mortality.

Initial mortality of fish following stocking can be attributed to hauling and stocking stress, which can in turn be related to hauling distance (Carmichael et al. 1984) and hauling density (Carmichael 1984). In the present study, mortality among groups of triploid grass carp hauled from 1-24 h was significantly different in spring tests but not in winter tests. Fish hauled for 24 hours had in all cases the highest initial mortality. In spring tests, Florida fish (hauled for 4 h) experienced significantly lower mortality than Arkansas fish (hauled for 24 h) in netted and open ponds, while Richloam fish (hauled for 1 h) had significantly lower mortality than Arkansas fish in open ponds but not netted ponds. Fish hauled for the longest time were also hauled at the highest densities, and we were not able to determine the influence of these individual factors (distance versus density) on initial mortality. However, Carmichael et al. (1984) found severe changes in blood chemistry, directly related to duration of hauling, that affected survival of largemouth bass (*Micropterus salmoides* L.). These changes occurred after fish had been hauled for 24-30 h. Carmichael (1984) indicated long periods (more than 64 h) appear necessary for recovery from hauling stress.

Water temperature at stocking (Shireman et al. 1978, Carmichael 1984, Wiley et al. 1987) was another factor influencing triploid grass carp mortality. Mortality of fish from Arkansas in winter was approximately half that of fish hauled from Arkansas in late spring. Mortality of Richloam fish in winter was 31% less than that of Richloam fish in netted ponds in spring, but 80% greater than that of fish in open ponds. High mortality of Arkansas fish hauled in late spring probably resulted from difficulties in tempering fish over a large temperature gradient (+9 C). High hauling densities influence the ability to adequately temper fish, due to the limited amount of water available for exchange.

While all fish used in hatchery tests were typical stocking-size fish, slight differences in fish size could also have influenced mortality in our tests (Shireman et al. 1978, Swanson and Bergersen 1988). In winter tests, survival of the larger (mean TL=371 mm) Alabama fish was more than four times better than that of smaller (mean TL=296 mm and 298 mm, respectively) Richloam and Arkansas fish. In spring tests, Richloam fish averaging 426 mm in length had one half the mortality of Richloam fish averaging 372 mm, even though the larger fish were in open ponds. Better survival of larger grass carp, due to decreased vulnerability to predation, has been indicated previously (Shireman et al. 1978, Hill 1986, Swanson and Bergersen 1988). Since piscivorous predators were not present in the hatchery ponds during these tests, increased survival of larger fish may have been due to their increased resistance to handling stress or to their ability to avoid avian predators. Alexander (1977) found that birds, primarily great blue herons (*Ardea herodias*) and American mergansers (*Mergus merganser*), were capable of ingesting brown trout (*Salmo trutta*) up to 380 mm in length, and could injure larger fish without ingesting them, but he indicated that bird predation probably drops off sharply on fish greater than 350 mm long. In the current study, bird netting did not provide significant benefits in terms of reduced mortality, indicating either that bird netting is not an effective deterrent, or that hauling stress was the primary determinant of mortality. There were no significant differences between mortality of Florida and Arkansas fish in netted versus open ponds. There were significant differences between Richloam fish in netted versus open ponds; however, these differences were the opposite of what might be expected (higher mortality in the netted ponds), and were, again, most likely due to increased resistance of larger fish to handling stress.

Annual mortality in post-stocking evaluations ranged from 6% to 62%, 15 to 32 months following stocking (Table 1). The relationship between total mortality and time following stocking was not significant ($r=0.37$, $P=0.47$), providing additional evidence that the major period of mortality for triploid grass carp probably occurs soon after stocking (Harberg and Modde 1985). While mortality in post-stocking evaluations did not appear related to distance hauled, fish size, or water temperature at stocking, factors influencing mortality in post-stocking evaluation ponds probably interacted in a manner similar to that seen in our hatchery tests. Additional influences on triploid grass carp mortality could have included morphology or location of the water body (Alexander 1977), vegetation abundance or grass carp stocking density (Wiley et al. 1984, Hill 1986), and angling mortality (Hill 1986, Wiley et al. 1987).

Triploid grass carp mortality, both hauling and post-stocking mortality, has the potential to significantly impact aquatic plant control plans that include use of this fish. In the present study we observed initial mortality as high as 52% and annual post-stocking mortality up to 62%. While both initial mortality and post-stocking mortality were quite variable, the potential for high mortality should be considered by aquatic plant managers when developing management strategies. To minimize mortality, triploid grass carp should be stocked at times of the year when low mortality would be expected (between November and April in Florida), large fish (300 mm TL or greater) should be used, and adequate tempering should be conducted at the time of stocking.

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