Hydrilla Consumption by Triploid Hybrid Grass Carp in Aquaria[1]

Robert J. Wattendorf, *Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, 801 NW 40th Street, Boca Raton, FL 33431*

Paul L. Shafland, *Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, 801 NW 40th Street, Boca Raton, FL 33431*

Abstract: Triploid hybrid grass carp (*Ctenopharyngodon idella* x *Hypophthalmichthys nobilis*) were provided known weights of hydrilla (*Hydrilla verticillata*) in 300 liter aquaria, to determine consumption rates for age I hybrids from 6 size groups, 21 to 37 cm total length (TL). Mean consumption rates for these groups at 26° C ranged from 25% to 52% of their body weight/day (% BW/D) or 1.7 to 8.6 g dry weight of hydrilla/day (g DW/D). Smaller hybrids generally ate less hydrilla than larger fish, but expressed as a percentage of their body weight, small hybrids consumed more than large hybrids. The exception was the intermediate size hybrids (31 cm TL group), which consumed significantly ($P < 0.05$, Tukey's range test) more both in dry weight of hydrilla and in percent body weight than other groups. Regression of dry weight consumed/day on total hybrid length produced the following equation: g DW/D = –6.1 + 0.039(TL); with a correlation coefficient of 0.82. Since hybrids grew very little (0.1 g/day) during the 40 to 59 day trials, consumption rates were considered to be near maintenance levels.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 37:447–458

In Florida and other southern states, exotic aquatic weeds have dispersed rapidly and developed such dense stands as to be detrimental to the interests of man (Haller 1979). Such exotic plants as hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhornia crassipes*), alligator-weed (*Alternanthera philoxeroides*), Brazilian elodea (*Egeria densa*) and torpedograss (*Pani-*

[1] Contribution No. 35, Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, 801 NW 40th Street, Boca Raton, FL 33431.

cum repens) have been documented as noxious in Florida (Tarver et al. 1979). Hydrilla was first observed in Florida in 1960 and spread throughout the state becoming common in 250,000 ha of water by 1977. In that year alone, 15,000 ha of hydrilla were chemically treated at a cost of $9.1 million (Haller 1979).

Swingle (1957) recommended grass carp (*Ctenopharyngodon idella*) as a potential biological weed-control agent, and in 1963, grass carp were imported from China into Alabama and Arkansas. A controversy soon developed over the advisability of stocking grass carp in open waters (Cross 1969, Sneed 1971, Greenfield 1973, Sutton 1977). By 1977, 35 states had banned or regulated use of grass carp (Sport Fishing Institute 1977), while at least 2 states allowed their stocking (Sport Fishing Institute 1976). Since then, natural spawning of grass carp has occurred in the Mississippi River (Conner et al. 1980), resulting in deregulation in Missouri, because elimination was not considered feasible (Sport Fishing Institute 1980).

Grass carp can control most noxious aquatic weeds (Gasaway and Drda 1978, Miley et al. 1979, Von Zon 1979). However, there was concern about reducing beneficial aquatic plant biomass to below desirable levels and about occasional failures to achieve control (Beach et al. 1976, Miley et al. 1979). Moreover, concern was expressed about possible detrimental effects on water quality, macroinvertebrate habitats, fish nursery areas, and waterfowl food sources, especially where the possibility of natural spawnings exist (Greenfield 1973, Courtenay and Robins 1975, Ware and Gasaway 1976, Gasaway and Drda 1977, 1978).

In light of these potential problems with use of grass carp, news of a triploid hybrid grass carp (grass carp x bighead carp (*Hypophthalmichthys nobilis*)) being produced in Hungary in 1978 was expectantly received in the United States (Buck 1979), since hatchery produced triploids were probably sterile. Malone and Son Enterprises (Lonoke, Ark.) produced the first hybrid grass carp in the United States in 1979. All hybrids initially tested from the 1979 spawns were triploid (Lynch 1979, Beck et al. 1980). In 1980, handling techniques at Malone and Son Enterprises' hatchery were refined, increasing the egg to fingerling survival rate, but concomitantly, the percent of triploids declined to about 50% and there was a higher proportion of deformities. In 1981, Malone and Son Enterprises applied a thermal-shock to the eggs, which presumably caused retention of the second polar body and resulted in greater than 95% triploid progeny, with less than 5% deformities (Wattendorf 1981, Magee and Philipp 1982, Callahan and Osborne 1983).

Differences in quality between hybrid year classes have made comparing research results difficult. Effective use of hybrid grass carp requires development of hatchery techniques which consistently produce high quality hybrids (i.e., triploid, few deformities and good growth). The objective of this study was to determine consumption rates by high quality hybrid grass carp of various sizes when fed only hydrilla.

Methods

Hydrilla consumption trials were performed in 6 300-liter glass aquaria filled with aerated city water. Aquaria were equipped with substrate filters and 300 watt submersible heaters (set at 26° C). Black plastic sheets around the aquaria reduced visual disturbances and weighted lids prevented escape. Fluorescent illumination was provided from 0800 to 1700 hours 5 days a week, and natural light reduced the abruptness of the transition to darkness. Aquaria were briefly checked each morning to determine if feeding was necessary and water quality samples were taken weekly.

A total of 6 experiments were conducted, each utilizing a different size class of hybrid, with 3 replicates of each. Experiments were conducted at 3 separate times with 2 size groups each time. Differences among trials are delineated in Table 1.

All hybrids were spawned by Malone and Son Enterprises in 1981 and grown at the Florida Game and Fresh Water Fish Commission's Richloam Hatchery. These age I hybrids had average or better growth rates and were judged to be triploids based on scale counts (10 to 11 above the lateral line) and erythrocyte nuclear dimensions (long axis range: 5.7 to 7.5 μ, short axis/long axis (circularity) range: 0.3 to 0.7, per Wattendorf 1982).

Hydrilla was collected from areas where no herbicides had been used (to our knowledge) for at least 1 month prior to collection. Individual leafy, green strands of hydrilla were cleaned of excess periphyton, insects and molluscs. Clumps were then allowed to drip-dry for 8 minutes, after which they were squeezed to remove additional water and their weights were adjusted to 160 g. A lead-weight was attached and 2 to 7 clumps were placed in each aquarium depending on the hybrids recent feeding history.

Feeding periods were terminated when 1 aquarium had less than a 1 to 2 day food supply remaining (assuming constant feeding rates). At that time, remaining hydrilla was removed, weighed, and replaced with fresh clumps. After each feeding period, 25% of the water was siphoned out along with accumulated feces and replaced by fresh water. Each experiment continued until consumption rates became semi-constant. Upon termination of each experiment, fish weights and morphometric measurements were taken and blood smears were made.

Relative consumption rate was expressed as percent body weight consumed in hydrilla per fish per day (% BW/D) and actual, unadjusted consumption rate was reported as grams dry weight of hydrilla eaten per fish per day (g DW/D). The following equations were used:

$$\%\ \mathrm{BW/D} = (\mathrm{HYD_{in}} - \mathrm{HYD_{out}})\ /\ (\overline{\mathrm{HYB}}\ /\ N.\ \mathrm{Fish}\ /\ \mathrm{Days}),$$

$$\mathrm{g\ DW/D} = (\mathrm{HYD_{in}} - \mathrm{HYD_{out}}) \times (0.06\ /\ N.\ \mathrm{Fish}\ /\ \mathrm{Days})$$

where $\mathrm{HYD_{in}}$ = wet weight of hydrilla put in, $\mathrm{HYD_{out}}$ = wet weight of hydrilla

Table 1. Differences between experimental trials with 6 different size classes of triploid hybrid grass carp. The yes/no under "control section" refers to whether or not a quarter of the tank was used as an exclosure to test hydrilla response in the absence of feeding; yes or no under "quinaldine" refers to whether or not the fish were anesthetized with 15 mg/liter quinaldine and 200 mg/liter ethanol prior to handling. Temperature is in degrees celsius, and ammonia is in mg/liter.

Size group (cm TL)	Dates (1982)	*N* fish aquarium	Control section	Quinaldine	Temperature	pH	NH_3
21	17 May–12 Jul	2	Yes	No	26.3–26.3	7.0–7.1	0.03–0.07
23	24 Sep –22 Nov	1	No	Yes	25.8–26.3	7.9–7.9	0.04–0.06
25	27 Aug–23 Sep	1	No	Yes	26.0–26.1[a]	7.8–8.2	0.06–0.10
31	1 Jun –15 Jul	2	Yes	No[b]	26.1–26.2	7.0–7.0	0.05–0.09
34	24 Sep –22 Nov	1	No	Yes	25.6–25.9	7.8–7.9	0.04–0.09
37	27 Aug–23 Sep	1	No	Yes	26.0–26.1[a]	8.0–8.2	0.06–0.08

[a] These fish were used in a consumption trial at 30° C run from 2 Aug–23 Aug just prior to this trial.

[b] A previous batch of 31 cm TL hybrids had contracted *Columnaris;* therefore, when these fish were placed in the aquaria, to reduce handling stress, they were not weighed and measured.

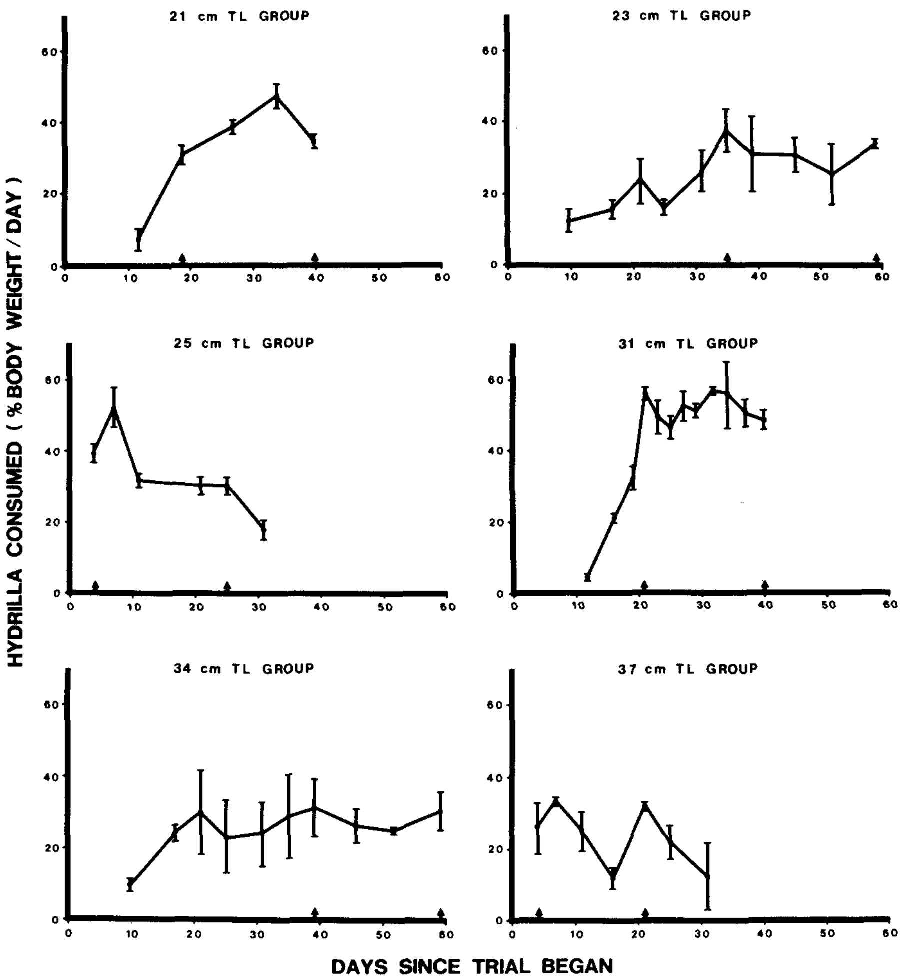

Figure 1. Mean amount of hydrilla consumed in % BW/D ± 1 standard error for each feeding period for 6 size groups of triploid hybrid grass carp. Samples between the arrows were used for statistical analyses to eliminate acclimation periods and the decline in feeding at the end of the 25 and 37 cm TL group experiments.

removed, $\overline{HYB}$ = the average weight of hybrids put in and removed, *N.* Fish = number of fish per aquarium, Days = number of days hydrilla was available to hybrids.

Further analyses using SAS software (Ray 1982) were performed on data from at least 4 consecutive feeding periods (17 to 23 days) during which feeding rates for each group were semi-constant (Fig. 1). Acute effects of handling and familiarization with the feeding routine were thereby obviated. Analyses of variance were performed to evaluate differences between size groups; regression equations also were calculated.

To test the precision of the hydrilla weighing method, 4 160-g clumps were prepared, then soaked and reweighed 4 times each. Mean weight of the 4 clumps for all 4 reweighings was 157 ± 5 g. These clumps were then dried at 70° C for 92 hours, during which period they were weighed several times until a consistent dry weight was obtained (9.5 ± 0.6 g). With this technique, mean dry weight was 6.0 ± 0.3% wet weight.

During the first trial, 25% of each aquarium was used as an exclosure to test hydrilla response in the absence of feeding. An average weight change of 1.0 ± 3.3 g/day/clump was found for hydrilla which was not fed on. In subsequent trials, the exclosure sections were not used, and in order to keep estimated consumption rates conservative, amount of hydrilla consumed was not adjusted to reflect plant growth.

Results

Mean consumption rates for the 6 size groups of hybrids ranged from 25% to 52% BW/D and 1.7 to 8.6 g DW/D, with the maximum in both categories associated with the 31 cm TL group (Table 2). Maximum consumption rate for a single feeding period was 76% BW/D for the 31 cm TL hybrids (Table 2).

Analyses of variance indicated highly significant differences ($P < 0.0001$) between size groups for either relative (% BW/D) or actual (g DW/D) consumption rates. With relative consumption as the dependent variable,

Table 2. Mean total length ($\overline{TL}$) in millimeters and mean weight ($\overline{WT}$) in grams, with the standard error (SE), for the 6 size groups of triploid hybrid grass carp used in the hydrilla consumption experiments; 3 replicates were run for each size group. Consumption rates are presented as the mean and standard error of the percent body weight consumed/day (% BW/D) and grams dry weight consumed/day (g DW/D). Means are taken from the combined values from 4 or 5 consecutive feeding periods, which best represent each of the 3 replicates. Maximum % BW/D is the greatest value observed for 1 period.

Size group	$\overline{TL}$	± SE	$\overline{WT}$	± SE	$\overline{\% BW/D}$	± SE	$\overline{g DW/D}$	± SE	Maximum % BW/D
21	207	2	77	3	38	2	1.7	0.1	55
23	233	5	118	9	32	3	2.2	0.2	46
25	246	1	124	6	37[a]	3	2.8	0.2	59
31	311	9	275	17	52	1	8.6	0.3	76
34	340	1	356	17	28	2	6.0	0.5	44
37	371	2	470	12	25[b]	3	7.2	0.7	34

[a] In a preceding trial at 30° C these fish consumed an average of 50% BW/D.
[b] In a preceding trial at 30° C these fish consumed an average of 30% BW/D.

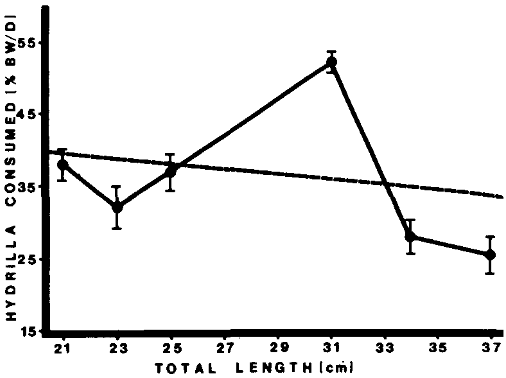

Figure 2. Mean percent body weight consumed/day (dots) ± 1 standard error (vertical bars) for 6 size groups of triploid hybrid grass carp, with the predicted regression line (dashed line). The regression equation was: % BW/D = 45.6 − 0.03(TL); $r = -0.17$; $P < 0.030$.

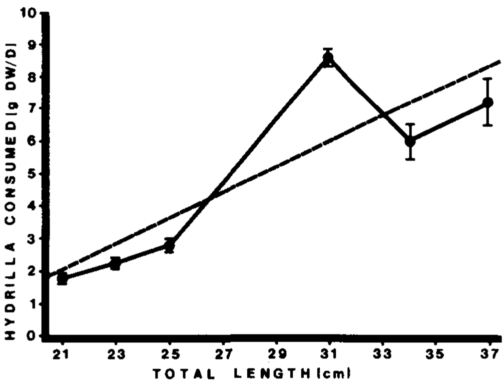

Figure 3. Mean amount of hydrilla consumed/day in grams dry weight (dots) ± 1 standard error (vertical bars) for 6 size groups of triploid hybrid grass carp, with the predicted regression line (dashed line). The regression equation was: g DW/D = −6.1 + 0.039(TL); $r = 0.82$; $P < 0.0001$.

56% of the variability was accounted for by size group. Tukey's multiple comparison test indicated that 31 cm TL hybrids ate significantly ($P < 0.05$) more relative to their body weight than any other size group. The other size groups were arranged showing that large hybrids consumed less hydrilla, when expressed as a percentage of their body weight, than did small hybrids. Regression of relative consumption rate on actual hybrid length, however, was not highly correlated ($r = -0.17$, $P < 0.03$, Fig 2).

When dry weight of hydrilla consumed/day was used as the dependent variable, with size group as the independent class variable, the model accounted for 77% of the variability. Tukey's multiple comparison test in this case grouped the 31 and 37 cm TL hybrids together, and other groups were arranged according to their means with large hybrids consuming more hydrilla than small hybrids. Regression of actual consumption on hybrid length produced the equation: g DW/D = −6.1 + 0.039(TL), which was highly significant ($r = 0.82$, $P < 0.0001$, Fig. 3).

Discussion

Analyses of variance and Tukey's multiple range test indicated that hybrids of intermediate size (31 mm TL) ate more hydrilla per day on the average than did any other size group, both in actual and relative consumption rates. Several (plausible) explanations exist for this unexpected result. First, having 2 fish/aquarium in experiments with 21 and 31 cm TL hybrids may have stimulated feeding, since hybrid grass carp are gregarious fish. Second, 31 cm TL group fish were not weighed and measured prior to stocking, thus reduced handling may have had an effect. Third, 21 and 31 cm TL hybrids were tested in early summer (Table 1), and seasonal differences may have been a factor (Prowse 1971). Fourth, aquaria dimensions ($51 \times 107 \times 46$ cm) may have been too confining for fish larger than 31 cm TL. Finally, there may be a peak in hybrid consumption rates at 31 cm TL.

Except for the 31 cm TL hybrids, small hybrids consistently tended to consume less hydrilla than large hybrids, whereas in percent body weight consumed/day, small hybrids tended to eat more than large hybrids. Regression of relative consumption rates on hybrid length, within the size range tested, however, indicated a mean of 38% BW/D and that the slight downward trend for larger fish was not highly significant ($P > 0.03$, Fig. 2). As would be expected, regression of actual consumption rate on hybrid length (Fig. 3) indicated there was positive correlation between actual consumption and hybrid size within the size range tested.

The 25 and 37 cm TL groups were tested at 30° C before lowering the temperature to 26° C (Table 1). At the higher temperature, both groups consumed more hydrilla (Table 2). This suggests temperature may also be an important factor when comparing feeding rates reported by various researchers.

Other researchers who have studied hybrid grass carp feeding under laboratory conditions have reported slightly lower to comparable feeding rates. Cassani and Caton (1983) used 5 1980 hybrids ($\bar{x}_{TL} = 32$ cm) to compare consumption rates on 5 plant species which were fed individually. Results indicated that less hydrilla was consumed than musk-grass (*Chara* sp.), duckweed (*Lemna minor*) or southern naiad (*Najas guadalupensis*), but more than coontail (*Ceratophyllum demersum*). At 26° to 31° C, these hybrids consumed about 28% BW/D of hydrilla for 7 days. This rate compares to consumption rates early in the experiment; however, as the 31 cm TL hybrids became acclimated after nearly 3 weeks, consumption rate leveled off at approximately 52% BW/D.

Shireman et al. (1982) found that hybrid grass carp ($\bar{x}_{TL} = 15$ cm) spawned at the University of Florida in 1981 grew at rates comparable to grass carp ($\bar{x}_{TL} = 16$ cm) when fed only trout chow, but did not perform well on strictly vegetative diets. When fed only hydrilla at ambient temperatures (13° to 24° C), hybrids consumed 19% to 44% BW/D versus 30% to 68%

BW/D for pure grass carp. Hybrids lost 4 g each while grass carp gained 34 g each in 16 weeks.

Sutton (1982) tested large ($\bar{x}_{WT} = 2800$ g) 1979 hybrids and small ($\bar{x}_{WT} = 500$ g) 1979 and/or 1980 hybrids in a pool study of hydrilla consumption. At least 7 of 15 small hybrids were diploid whereas all 3 large ones were triploid. Large triploid hybrids consumed 2.5 to 9.2 g DW/D and small hybrids ate 0.0 to 0.9 g DW/D. Comparably sized hybrids ($x_{WT} = 470$ g) in this study consumed 7.2 g DW/D, thus consuming about 8 times more hydrilla than the lower quality (47% diploid) hybrids used by Sutton.

By way of comparison, many investigators have also studied the grass carp. In plastic pools with flow-through water, 99 g grass carp ate 165% BW/D; 153 g grass carp ate 114% BW/D, and both 753 and 1,020 g grass carp ate 73% BW/D (Sutton 1974). Assuming that 100 to 500 g grass carp (comparable to the size hybrids used) would consume about 120% BW/D, then the hybrids in this study averaged about one-third (38% BW/D) of the relative consumption rate of Sutton's grass carp. However, these hybrids were tested in filtered aquaria and grass carp were in larger flow-through pools. Besides differences in feeding environments and social effects, the hybrids only gained 0.1 g/day versus 6.2 g/day gained by Sutton's grass carp.

Since Sutton (1981) indicated a maximum growth rate of 5.3 g/day for 1,026 g hybrids and 0.7 g/day for 108 g hybrids when fed only hydrilla, it appears that the hybrids in this experiment were feeding at maintenance levels rather than at levels for active growth. The confined aquarium space, privacy sheet, lack of predators, and readily available food presumably reduced energy expenditures and lessened the need for caloric intake. In addition, the filtered aquaria represented closed systems which frequently produce lower feeding rates than flow through systems (Prowse 1971).

Hydrilla may not adequately fulfill the hybrid grass carp's nutritional requirements. When hybrid grass carp were fed brine shrimp (45% protein), catfish pellets (32% protein), water-meal (*Wolffia* sp.) or duckweed (30 to 35% protein) either singularly or in combination, it was found that diets high in animal protein produced greater growth than purely vegetative diets (Cassani et al. 1982). Moreover, they have found hybrids in ponds will gorge on water fleas (*Cladocera* sp.) and that hybrid fingerlings readily feed on mosquito larvae (*Culex quinquefasciatus*) and leeches (Hirudinea). Hybrid grass carp may have a greater nutritional requirement for essential amino acids, which are best supplied in animal protein, than do grass carp. Scherbina and Sorvachev (1967) reported that most plant material is deficient in 2 essential amino acids, lysine and methionine. Small supplements of animal protein (or synthetic lysine and methionine) may allow hybrids to more effectively utilize plant material and stimulate their feeding. For instance, increased consumption of hydrilla has been noted in hybrid grass carp ponds when pelleted feed was used as a dietary supplement (Frederick Aldridge, pers. commun.). Such an increased need for animal protein may be explained by the genetic contributions of the paternal species, since bighead carp are carnivorous (viz. zooplanktivorous).

In conclusion, triploid hybrid grass carp between 21 and 37 cm TL consumed about 38% BW/D, when fed only hydrilla, in aquaria at 26° C. Mean consumption for the 6 size groups used ranged from 25% to 52% BW/D, or 1.7 to 8.6 g DW/D of hydrilla (29 to 143 g fresh weight). The greatest amount consumed was by 31 cm TL hybrids, which during 1 period consumed 76% BW/D (209 g fresh weight, 12.5 g DW/D). Under these conditions, hybrid grass carp do not approach their normal growth rate, and presumably use less energy than they would in nature. Therefore, their caloric needs in nature would be higher.

Literature Cited

Beach, M. L., W. W. Miley, II, J. M. Van Dyke, and D. M. Riley. 1976. The effect of the Chinese grass carp (*Ctenopharyngodon idella* (Val.)) on the ecology of four Florida lakes, and its use for aquatic weed control. Fla. Dep. Nat. Resour. Final Rep., Tallahassee. 247pp.

Beck, M. L., C. J. Biggers, and H. K. Dupree. 1980. Karyological analysis of *Ctenopharyngodon idella, Aristichthys nobilis* and their F_1 hybrid. Trans. Am. Fish. Soc. 109:433–438.

Buck, H. 1979. Optimism swells with the possibility of a sterile hybrid grass carp. Fisheries 4(5):31.

Callahan, J. L. and J. A. Osborne. 1983. Comparison of the grass carp and hybrid grass carp. Aquatics 12–15.

Cassani, J. R. and W. E. Caton. 1983. Feeding behavior of yearling and older hybrid grass carp. J. Fish Biol. 22:35–41.

———, ———, and T. H. Hansen, Jr. 1982. Culture and diet of hybrid grass carp fingerlings. J. Aquat. Plant Manage. 20:113.

Conner, J. V., R. P. Gallagher and M. F. Chatry. 1980. Larval evidence for natural reproduction of the grass carp (*Ctenopharyngodon idella*) in the lower Mississippi River. Fourth Larval Fish Conf. Univ. of Miss. USFWS, Biol. Serv. Prog., Natl. Power Plant Team, FWS/OBS-80-43. Ann Arbor, Mich. 179pp.

Courtenay, W. R., Jr. and C. R. Robins. 1975. Exotic organisms: an unsolved, complex problem. BioScience 25(5):306–314.

Cross, D. G. 1969. Aquatic weed control using grass carp. J. Fish Biol. 1:27–30.

Gasaway, R. D. and T. F. Drda. 1977. Effects of grass carp introductions on waterfowl habitat. Trans. 42nd North Am. Wildl. Nat. Resour. Conf. 73–85.

——— and ———. 1978. Effects of grass carp introductions on macrophytic vegetation and chlorophyll content of phytoplankton in four Florida lakes. Fla. Sci. 41(2):101–109.

Greenfield, D. W. 1973. An evaluation of the advisability of the release of the grass carp, *Ctenopharyngodon idella,* into the natural waters of the United States. Trans. Ill. State Acad. Sci. 66(1–2):47–53.

Haller, W. T. 1979. Aquatic weeds in Florida. Pages 1–15 *in* Shireman, J. V. (ed.). Proc. of the Grass Carp Conf. Gainesville, Fla. Univ. of Fla., Inst. of Food and Agric. Sci.

Lynch, T. 1979. White amur experience leads to development of grass carp hybrid. Aquaculture 6(1):33–36.

Magee, S. M. and D. P. Philipp. 1982. Biochemical genetic analyses of the grass carp ♀ x bighead carp ♂ F_1 hybrid and the parental species. Trans. Am. Fish. Soc. 111:593–602.

Miley, W. W., II, A. J. Leslie Jr., and J. J. Van Dyke. 1979. The effects of grass carp (*Ctenopharyngodon idella* Val.) on vegetation and water quality in three central Florida Lakes. Fla. Dep. Nat. Resour., Final Rep., Tallahassee. 119pp.

Prowse, G. A. 1971. Experimental criteria for studying grass carp feeding in relation to weed control. Prog. Fish-Cult. 33(3):128–131.

Ray, A. A. (ed.). 1982. The SAS User's Guide: Statistics. SAS Institute Inc., Cary, N.C. 585pp.

Shcherbina, M.A. and K. F. Sorvachev. 1967. Resorption of amino acids of artificial feeds in the process of feed advancement along the intestine in carps. Pages 500–511 *in* Karzinkin, G. (ed.). Metabolism and Biochemistry of Fishes. Izadtelstvo "nauka," Moskva. Translated from the Russian.

Shireman, J. V., R. W. Rottmann, and F. J. Aldridge. 1982. Consumption and growth of hybrid grass carp fed four vegetation diets and trout chow in circular tanks. Ctr. for Aquat. Weeds, Univ. of Fla., Gainesville. 17pp.

Sneed, K. E. 1971. A controversial biological control. Am. Fish Farmer 2:6–9.

Sport Fishing Institute. 1976. Grass carp outlawed. SFI Bull. 278:7.

———. 1977. Grass carp banned in 33 states. SFI Bull. 281:5.

———. 1980. Missouri ends grass carp ban. SFI Bull. 314:3.

Sutton, D. L. 1974. Utilization of hydrilla by the white amur. Hyacinth Control J. 12:66–70.

———. 1977. Grass carp (*Ctenopharyngodon idella* Val.) in North America. Aquat. Botany 3:157–164.

———. 1981. Aquatic plant preferences and feed conversion efficiencies of the hybrid grass carp (*Hypophthalmichthys nobilis* Rich. X *Ctenopharyngodon idella* Val.). Fla. Dep. Nat. Resour., Annu. Rep., Tallahassee. 38pp.

———. 1982. Aquatic plant preferences and feed conversion efficiencies of the hybrid grass carp (*Hypophthalmichthys nobilis* Rich. X *Ctenopharyngodon idella* Val.). Fla. Dep. Nat. Resour. Quarterly Rep. (III), Tallahassee. 10pp.

Swingle, H. S. 1957. Control of pond weeds by the use of herbivorous fishes. Proc. South. Weed Control Conf. 10:11–17.

Tarver, D. P., J. A. Rodgers, J. J. Mahler, and R. L. Lazor. 1979. Aquatic and wetland plants of Florida. Fla. Dep. Nat. Resour., Tallahassee. 127pp.

Von Zon, J. C. J. 1979. The use of grass carp in comparison with other aquatic weed control methods. Pages 15–24 *in* Shireman, J. V., ed. Proc. of the Grass Carp Conf. Gainesville, Fla., Univ. of Fla., Inst. of Food and Agric. Sci.

Ware, F. J. and R. D. Gasaway. 1976. Effects of grass carp on native fish populations in two Florida lakes. Proc. Southeast. Assoc. Game and Fish Comm. 30:324–335.

Wattendorf, R. J. 1981. Hybrid grass carp report. Pages VII(1):23–VII(1):46 *in* Shafland, P. L., R. J. Wattendorf, R. S. Anderson, and R. J. Metzger. Annu. Rep. for Non-Native Fish Res. to Fla. Game and Fresh Water Fish Comm., Tallahassee.

———. 1982. Hybrid grass carp research: Genetic monitoring. Pages XIII(1):1–XIII(1):17 *in* Shafland, P. L., R. J. Wattendorf, R. S. Anderson, and R. J. Metzger. Annu. Rep. for Non-Native Fish Res. to Fla. Game and Fresh Water Fish Comm., Tallahassee.