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Using Grass Carp in Aquaculture and Private Impoundments

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Grass carp (*Ctenopharyngodon idella*) are native to large river systems of eastern Asia, from the Amur River on the Russian-Chinese border southward. Because of their association with the Amur River, they are sometimes called "White Amur."

Grass carp have been introduced into more than 50 countries for foodfish culture and aquatic vegetation management. The U.S. Fish and Wildlife Service, in cooperation with Auburn University, first introduced grass carp into the U.S. in 1963 to investigate their usefulness in controlling aquatic vegetation. **No native North American species of fish is as strictly herbivorous as the grass carp.** Therefore, there are no native species available for aquatic vegetation management. Grass carp have proven to be effective in controlling many species of algae and submerged aquatic vegetation.

Since their introduction, grass carp have been stocked into most states, either legally or illegally. Diploid (i.e., normal or non-sterile) grass carp have escaped into U.S. river systems and appear to have established reproducing populations in the Mississippi, Missouri and Trinity river drainages. Fear that grass carp might devastate beneficial native aquatic vegetation in public waters prompted many states to ban their further stocking. Although naturalized grass carp do not appear to have established large, destructive populations, they are a controversial topic among some natural resource managers.

Table 1 gives the status of grass carp permitting in the Southern Region at the time this publication was written. **Before stocking grass carp, check with state game and fish/natural resource agencies or Extension fisheries or aquaculture specialists for the legal requirements.**

Description

Grass carp are a member of the Order Cypriniformes and Family Cyprinidae. Cyprinidae is the largest family of freshwater fish species and includes all the minnows and carps. Grass carp have an oblong or elongated body with

Table 1. Status of permits for grass carp (*Ctenopharyngodon idella*) stocking in the southern United States.

State	Status	Genetic requirements
Alabama	legal - no permits required	diploids or triploids
Arkansas	legal - no permits required	diploids or triploids
Florida	legal - permit required	triploids only
Georgia	legal - permit required[1]	triploids only
Kentucky	legal - permit required	triploids only
Louisiana	legal - permit required	triploids only
Mississippi	legal - permit required	diploids or triploids
North Carolina	legal - permit required[2]	triploids only
Oklahoma	legal - no permit required	diploids or triploids
Puerto Rico	legal - dealers permitted[1]	diploids or triploids
South Carolina	legal - permit required	triploids only
Tennessee	legal - dealers permitted[1]	triploids only
Texas	legal - permit required	triploids only
Virginia	legal - permit required	triploids only
Virgin Islands	legal	diploids or triploids

[1]Dealers must be permitted, but individuals do not need permits to purchase grass carp from permitted dealers.

[2]Permits are required only for ponds larger than 10 acres or with more than 150 fish.

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relatively large scales; the head is broad and the belly rounded (Fig.1). The dorsal and anal fins are short with no spines and the caudal fin is deeply forked. Their jaws have simple lips with no teeth and they have no barbels (i.e., whiskers). Like other Cyprinidae, grass carp have pharyngeal teeth (i.e., in the throat). These pharyngeal teeth are in two rows and enable the grass carp to cut/shred the vegetation it consumes. Their flesh is white, firm and not oily, but the muscle mass contains "Y" bones. Grass carp flesh is considered a delicacy by many seafood enthusiasts.

Figure 1. A grass carp.

Diploid versus triploid

Normal grass carp have 48 chromosomes. This is known as the diploid or 2N chromosome number. Sterile grass carp are produced in hatcheries by physically shocking the eggs immediately after fertilization either with temperature (hot or cold) or pressure. The resulting fish are triploids (3N) because each cell has an extra set of chromosomes. Triploids are infertile.

There appears to be no difference in vegetation preference between diploid and triploid grass carp. However, triploids consume only 90 percent of the amount diploids consume. Triploid grass carp also do not live as long as the diploids (10 to12 years versus 20+ years, respectively). All grass carp sold in the U.S. are from private hatcheries and have been artificially spawned using hormone injections, manual stripping of eggs and sperm, and incubation of the eggs. Triploid grass carp are further manipulated by shocking the eggs to produce the triploid sterility. After fish reach 4 to 12 inches, blood cells from each fish are tested using a Coulter Counter™ to verify the triploid chromosome number. This increased handling and testing is the reason triploid fish usually cost two or three times as much as diploids.

Life history and plants controlled

Grass carp spawn naturally only in rivers with high water flows and appropriate temperature. The water/current velocity must be sufficient to keep the semi-buoyant eggs suspended as they are carried downstream. If the eggs fall to the bottom, they will succumb to siltation and low dissolved oxygen. It is estimated that the eggs must remain suspended for 20 to 40 hours, which means that they may travel 30 to 110 miles (50 to 180 km), depending on water velocity, before hatching. **Therefore, grass carp cannot spawn in ponds.**

Fry and early juvenile grass carp are stocked into fertilized ponds where they initially feed on plankton and benthic invertebrates. At 1 inch in length, grass carp start feeding on macrophytes (non-microscopic plants) but can and do consume some animal foods throughout their lives.

Fingerling grass carp will consume insect larvae, other invertebrates, and even small numbers of fish fry, but only when desirable vegetation is unavailable. Several researchers suggest that the small amount of animal matter they consume probably is the result of ingesting epiphytic organisms associated with plants.

Research has shown that the size and type of vegetation are the factors that influence consumption rates the most. (Most of this research has been conducted on fingerlings and juveniles and not on adult fish.) Generally, grass carp prefer the soft, tender tips of young, growing plants and submerged vegetation. It is known that grass carp consume literally hundreds of aquatic plant species. It is probably safe to say that if they are hungry and deprived of preferred vegetation, they will consume any plant material they can find, including terrestrial plants overhanging the water.

Young grass carp (less than 3 pounds) prefer soft vegetation and consume species such as duckweeds, filamentous algae and chara. **Any preference for filamentous algae appears to decrease with age.** The most preferred plants are succulent and low-fiber. As carp grow, more plant species and less succulent ones are added to the diet. Table 2 illustrates preference rates based on research carried out in tank studies of mostly juvenile grass carp. **It should be emphasized that even though grass carp will eat a particular plant they may not control that plant unless fish are stocked in sufficient numbers and preferable plants are not available.** It is not desirable for grass carp to completely remove all rooted vegetation because this may increase the turbidity associated with intense algal blooms.

Grass carp are fed commercial pelleted diets as juveniles in hatcheries, and they never seem to forget this. They will continue to consume pelleted diets throughout their lives. Pond owners often complain that grass carp consume fish food rather than the plants they were intended to control.

Grass carp grow rapidly under favorable conditions. Food consumption rates are influenced by temperature, age and size of fish, dissolved oxygen and plant species. Grass carp consume vegetation intermittently at temperatures as low as 37 ^{o}F (3 ^{o}C). They eat steadily at 50 to 60 ^{o}F (10 to 16 ^{o}C), with optimal consumption at temperatures between 70 and 86 ^{o}F (21 and 30 ^{o}C).

Consumption rates at optimal temperatures vary with fish size. The reason grass carp are so good at controlling aquatic vegetation is that they have a very short gut compared to other herbivores. This short gut decreases retention time (less than 8 hours) in the gut and reduces digestive efficiency to only 60 or 70 percent. Because of this reduced efficiency, they eat more vegetation.

Research has shown that juveniles (2.4 to 6 inches, 6 to 15 cm) consume 6 to10 percent of their body weight in vegetation each day (wet weight basis). As fish grow, the consumption rate increases. Fish weighing 2 to 2.5 pounds (1 to 1.2 kg) can consume more than their body weight each day (in some cases 300 percent). Larger fish can consume up to their body weight per day under ideal conditions. Reportedly, fish larger than 10 pounds eat only 20 to 30 percent of their body weight. Obviously, at these consumption rates grass carp can quickly reduce vegetation if stocked in proper numbers, in good quality water, and at optimum temperature.

Table 2. Common aquatic plants consumed by grass carp.

Plant common name	Order of preference[1]
hydrilla	1
chara (muskgrass)	2
pondweeds (*Potamogetan*)	3
bushy pondweed (Southern naiad)	4
elodea	5
watermeal	6
duckweeds	7
water-fern (*Azolla*)	7
coontail	8
hygrophila	9
cattail[2]	10
torpedograss	10
salvinia	10
water-aloe (*Stratiotes*)	11
watercress	12
torpedograss	13
Eurasian watermilfoil	14
eel grass (*Vallisneria*)	15
maidencane[2] (*Panicum*)	16
parrot feather	16
know grass (*Paspalum*)	17
water hyacinth	17
giant bulrush[2]	18
water lettuce	18
soft-stem bulrush[2]	19
water lilies	19

[1]Adapted from “Grass Carp - A Fish for Biological Management of Hydrilla and Other Aquatic Weeds in Florida” by David L. Sutton and Vernon V. Vandiver, Jr., University of Florida IFAS, Bulletin 867; and from “Managing Aquatic Vegetation With Grass Carp - A Guide For Water Resource Managers” edited by John R. Cassani, American Fisheries Society, Bethesda, Maryland. Some plants have the same number, which means grass carp like them equally.

[2]Young, succulent, underwater shoots are preferred.

The water quality needs of grass carp are similar to those of most other warmwater fish. Consumption is best at dissolved oxygen concentrations higher than 4 mg/L (ppm); consumption appears to stop at dissolved oxygen concentrations below 3 mg/L. Grass carp can tolerate moderate salinity but eat less as salinity increases from 1.3 to 9 parts per thousand (ppt). They stop eating if salinity reaches 12 ppt. Prolonged exposure to 9 to 10 ppt salinity is lethal, but they can survive for short periods at even higher salinity.

Stocking rates

Stocking rates should be based on grass carp vegetation preferences and the biomass of plants in a pond. Many submerged plants can have a very high biomass, partly because they are 90 to 95 percent water. Species such as hydrilla, southern naiad, chara, elodea and coontail can have a total wet biomass of more than 10 tons per acre.

Filamentous algae are often a problem in fry and fingerling ponds, making it difficult or impossible to harvest the fish. This is particularly true in the spring of the year. Larger numbers of small grass carp are needed to control filamentous algae than many other plant species because filamentous algae is not a favored food and it develops in the late winter when water temperatures are cool and grass carp consumption is correspondingly low. Some species of algae, such as *Pithophora*, are particularly unpalatable. In one 5-acre catfish fingerling pond choked with *Pithophora*, 200 3- to 5-inch grass carp per acre (1,000 total) were required to control the problem. In 2 weeks the producer was able to seine and remove the catfish and recover the grass carp, which had grown to 8 inches. Obviously this was an extreme case, but it illustrates how water temperature and vegetation preference must be taken into consideration.

Table 3 gives stocking rate recommendations. It is best to stock grass carp during cool weather, as they do not handle well at temperatures above 75 ºF (24 ºC).

Often managers stock too few fish to control the problem. If grass carp are over-stocked they simply have little to eat and do not grow. They will then consume pelleted feed if it is available. It is usually better to overstock than to understock.

While grass carp live many years, their effectiveness for vegetation control decreases significantly after 5 to 7 years. At this age their growth rate and food consumption slow. **Ponds usually need to be restocked with grass carp every 5 to 7 years; or, each year 20 percent of the original number can be restocked to offset mortality** (especially with triploids).

In new or renovated ponds, three to five grass carp per surface acre can be stocked to prevent submerged aquatic vegetation from becoming established. This usually prevents submerged aquatic weeds for 5 to 7 years.

Preventing escape

Because grass carp are natural inhabitants of rivers, they readily escape ponds that overflow. A flow of only a couple of inches will allow even large grass carp to escape. Therefore, many states recommend, or even mandate, that barriers be placed across emergency spillways (i.e. canals, culverts, etc.) before grass carp can be stocked into ponds.

Table 3. Suggested stocking rates (per acre) for grass carp in private ponds.[1]				
	Percent of pond infested by noxious vegetation			
	0 - 10	10 - 30	30 - 50	> 50
Stocking density[2]	5	10 - 12	12 - 15	20 or more

[1]Grass carp must be large enough to avoid predation by other species of fish. If there are predatory species (e.g., largemouth bass) in the pond, grass carp should be larger than 8 inches.

[2]If the vegetation to be controlled is low on the grass carp's preference list, increase stocking by 30 to 50 percent. Some states specify stocking numbers on their permits.

Many different materials and designs can be used for escapement barriers. Probably the best design uses horizontal bars spaced 2 inches (5 cm) apart (Fig. 2). Leaves and small branches can pass through the barrier without clogging it. Net or mesh type barriers trap leaves and branches and can then collapse under the increased water pressure. Escapement barriers should be at least a foot above the highest expected water level to keep grass carp from jumping over them. Grass carp are very adept at jumping.

Removal methods

It is very difficult to seine grass carp because they can jump so well. They are easiest to remove when ponds are drained. Other methods of removing them include angling, bow-fishing and using rotenone baits. Grass carp can occasionally be caught using heavy-duty fishing tackle and a dough-type bait (like that used for common carp). Grass carp have a habit of staying near the surface and this makes it relatively simple to use a bow. Grass carp are susceptible to rotenone (a restricted-use pesticide that requires an applicators license). Prentiss, Inc. has developed a pelleted bait infused with rotenone called Prentox, Prenfish™. See the label for information about the training required to use this product.

Conclusion

Grass carp can effectively control aquatic vegetation, particularly submerged vegetation. The key to using grass carp is to stock the proper number based on their vegetation preferences, the water temperature, and the biomass and pond coverage of the plants. Grass carp are especially advantageous in aquaculture because they: 1) eliminate chemical treatments that could involve water use restrictions; 2) are relatively inexpensive; and 3) usually do not have to be handled.

Selected references:

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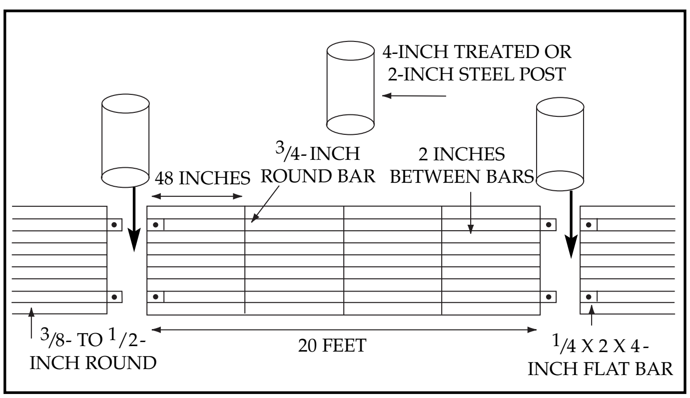

Figure 2. Example of a spillway barrier.

SRAC fact sheets are reviewed annually by the Publications, Videos and Computer Software Steering Committee. Fact sheets are revised as new knowledge becomes available. Fact sheets that have not been revised are considered to reflect the current state of knowledge.

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