The concentrations of water quality parameters measured were not considered detrimental to the fish (Table 2). Additionally, no problems were experienced with bacterial diseases or parasites infestation.

Table 2. Means and Extreme Variations of Water Quality Parameters Measured in a Pond During Cage Culture of Albino and Normal Channel Catfish, Tifton, Georgia, 1971.

	Mean	Range	
Dissolved Oxygen (PPM)	6.5	4.6	8.5
Free Carbon Dioxide (PPM)	4	0	10
Total Hardness (PPM)	55	45	60
pH	7.1	6.1	9.0
Temperature (°F)	77	56	88

LITERATURE CITED

Collins, R. A. 1970. Cage culture of catfish in reservoir lakes. Proc. Twenty-fourth Ann. Conf. S. E. Assn. Game and Fish Comm. 24:489-496.

Harvey, W. R. 1960. Least-squares analysis of data with unequal subclass numbers. USDA ARS 20-8. 157p.

Hatcher, R. M. 1971. Cage culture of channel catfish. Conference Proceedings: Producing and Marketing Catfish in the Tennessee Valley. Tennessee Valley Authority. Bulletin Y-38. 96p.

Heaton, E. K., T. S. Boggess, Jr., R. E. Worthington, and T. K. Hill. 1973. Quality comparisons of albino and regular (gray) channel catfish. J. Food Sci. 38:1194-1196.

Prather, E. E. 1961. A comparison of production of albino and normal channel catfish. Proc. Fifteenth Ann. Conf. S. E. Assn. Game and Fish Comm. 15:302-303.

Schmittou, H. R. 1969. Developments in the culture of channel catfish, *Ictalurus punctatus* (Rafinesque), in cages suspended in ponds. Proc. Twenty-third Ann. Conf. S. E. Assn. Game and Fish Comm. 23:226-244.

MACROPHYTE CONTROL BY GRASS CARP IN CATFISH PONDS

by

James W. Terrell

and

Alfred C. Fox

U. S. Fish and Wildlife Service

Georgia Cooperative Fishery Unit

School of Forest Resources, University of Georgia

Athens, Georgia

ABSTRACT

Macrophyte standing crop (primarily *Eleocharis* and *Utricularia*) was reduced nearly 90% in two catfish ponds after introduction of grass carp *(Ctenopharyngodon idella)*. Abundant vegetation remained in 1-m^2 exclosures placed in the ponds as controls. The stocking ratio of grass carp (live weight) to macrophyte standing crop (dry weight) that resulted in vegetation control within 1 year was 0.15 in the pond is which the fish were fed pelleted food and 0.06 in the pond in which the fish were not fed. Scattering of feed over the entire pond rather than confining it to a few locations may have discouraged grass carp from feeding on pellets and contributed to the success of vegetation control.

INTRODUCTION

The grass carp *(Ctenopharyngodon idella)* is an effective aquatic weed control agent (Avault 1965; Avault et al. 1968; Sneed 1971; Stevenson 1965; Sills 1970). Avault et al. (1968) recommended that the number of grass carp stocked should be the lowest that will control weeds. Choice of a proper stocking rate should take into consideration at least four factors: weed biomass to be removed; relative palatability of the weed species present; size of fish available for stocking; and length of time within which control is desired. To achieve weed control consistently, the stocking rate of grass carp should be related to the total standing crop of weeds. However, relatively little information is available concerning the relationship between weed standing crop and the number of grass carp that could be stocked for weed control in U.S. waters.

The grass carp generally does not control vegetation in ponds in which the fish are fed artificial feed. Krupaur (1971) stated that grass carp stocked to reduce weed growth should not be artifically fed, and Crowder and Snow (1969) reported that grass carp preferred pelleted food to vegetation in catfish and bluegill ponds. Prowse (1971) believed, however, that if pelleted feed were spread over the entire pond rather than placed at one or a few locations, grass carp might successfully control vegetation.

This study was designed to evaluate the effectiveness of grass carp in controlling nuisance macrophytes in two catfish ponds located in Fort Gordon Military Reservation near Augusta, Georgia. The fish in one pond (here termed a "fed pond") received artificial feed while the fish in the other pond (here termed "non-fed pond") were not fed. Estimates of standing crop of macrophytes were made so that the stocking rates could be related to ponds with various degrees of weed infestation.

MATERIALS AND METHODS

Whittimore, a 3.6-ha pond with a maximum depth of 4.8 m, was stocked with 2,500 fingerling channel catfish *(Ictalurus punctatus)* per ha 1 year before this study was begun. Mosquitofish *(Gambusia affinis)* and brown bullhead *(Ictalurus nebulosus)* were also present in Whittimore. Clay Pit III, a 1.2-ha pond with a maximum depth of 5.7 m, was constructed and stocked exclusively with 2,500 fingerling blue catfish *(Ictalurus furcatus)* per ha 3 years before this experiment. The fish in Whittimore were never fed whereas those in Clay Pit III were fed supplemental artificial feed after stocking. Clay Pit III was not fed on Saturdays, Sundays, holidays or on days when the water temperature was below about 18 C. On days when fish in Clay Pit III were fed, 45 kg of pelleted floating catfish feed was dispersed on the surface by boat.

Before grass carp were stocked, 20 hardware cloth or nylon net exclosures, 1 m^2 in surface area, were placed in the weed beds of each pond to serve as controls. After grass carp had been stocked, paired vegetation samples were taken to compare the density of ungrazed vegetation inside the exclosures and vegetation outside the exclosures. The sample taken inside the exclosure was taken at random and the sample outside the exclosure was taken 1 m from the exclosure sample, on an axis parallel to the shoreline and on the side of the exclosure nearest the inside sample. Each sample location was recorded to avoid sampling the same location twice.

Vegetation samples were collected with a sampler made of 2 light sections of tubular steel pipe having a cross sectional area of 0.1 m^2. Each section was about 1 meter long and the sections could be fitted together for use in water nearly 2 meters deep. Teeth were cut into one end of one section, and this toothed end was dropped onto the vegetation from above the surface of the water. All vegetation in the tube was then removed through the top of the tube with a modified four pronged garden hoe. Vegetation samples were stored at 2 C until they could be cleaned of mud and debris, and then dried at 105 C for 24 hours and weighed. There were few emergent plants in either pond; the samples contained only submersed or floating macrophytes *(Eleocharis* and *Utricularia). Eleocharis* was the predominate plant in both ponds.

Grass carp, age 15 months, were weighed, measured, tagged with a Floy F.D. 67 tag, and stocked in both ponds on 3 August 1972. Observed mortality within 3 days after stocking was recorded. The initial stocking rates of grass carp (minus the 3-day mortality) and the weed biomass estimate made the day after stocking were used to compute the ratio of stocked fish weight (live) to macrophyte weight (dry). The standing crop of vegetation in both ponds appeared to have reached its annual peak at the time the grass carp were introduced.

The paired sampling program utilizing the exclosures was begun 1 month after grass carp introduction. Paired samples were taken at 10 of the exclosure sites in each pond on 7 September 1972 and 9 July 1973. The other 10 exclosures in each pond were sampled on 12 June and 5 August 1973. The area occupied by vegetation in each pond was measured concurrently with the 1973 paired vegetation samples, so that the 1973 standing crops of vegetation could be compared with the 1972 standing crops.

Grass carp were killed 1 year after introduction. Antimycin was used in both ponds. Floating feed was added to the fed catfish pond at the usual feeding time (1030 hours) and antimycin was added 3 hours later after the feed had been eaten. The stomach was removed from 25 grass carp collected within 7 hours after feeding for food analysis. The entire gut was considered to be the stomach. Hickling (1966) reported that food passes through the digestive tract of the grass carp in about 7 hours. Stomachs were immediately placed on ice, then frozen until they could be examined.

In the laboratory, stomach contents were placed in a white enamel pan, water was added and the food mass was broken up. Fragments of fish feed were removed and the stomach contents were examined for insect remains. The stomach contents were then slowly poured from the pan onto a U.S. Standard Number 140 sieve. Sand that remained in the enamel pan was removed. Water that passed through the sieve was allowed to stand for at least 8 hours to allow the mud to settle. Macrophyte fragments were retained by the sieve. No insect remains were found in any of the stomachs. Weights of the separated mud, sand, macrophytes, and fish feed were obtained after the materials had been dried at 105 C for 24 hours.

Table 1. Standing crops of vegetation and stocking rates of grass carp in a fed and a non-fed catfish pond, Fort Gordon, Georgia.

Pond	Surface Area (ha)	Macrophyte (dry wt.) standing crop (kg) + standard error	Grass carp stocked[a]			Ratio of stocked fish (live wt.) to standing crop of macrophytes (dry wt.)
			Number	total wt (kg)	ave. wt. (kg)	
Whittimore (no artificial feeding)	3.6	1,627 = 181	179	98.55	0.55	0.06
Clay Pit III (fish feed added)	1.2	465 = 48	133	70.72	0.53	0.15

[a]Less 72 hour mortality of 1 fish in Whittimore and 9 fish in Clay Pit III.

RESULTS

The ratio of stocked grass carp (live weight) to macrophyte standing crop (dry weight) was highest in the fed pond (Table 1). There was a significant difference (P 0.05; t = 3.52; d.f. = 9) between the density of exclosure vegetation and vegetation outside the exclosures in the non-fed pond when paired vegetation samples were taken on 7 September 1972 approximately 1 month after grass carp were stocked (Fig. 1). This difference was not noticeable at the time of sampling. When paired vegetation samples were taken in 1973, however, the difference between the amount of vegetation inside and outside the exclosures was very obvious in both ponds. Standing crops of vegetation in both ponds were much lower in 1973 than in 1972 (Fig. 2 and 3). On 4 August 1973 after 1 year of grass carp grazing the estimated reduction in standing crop was 88% in the fed pond and 89% in the non-fed pond.

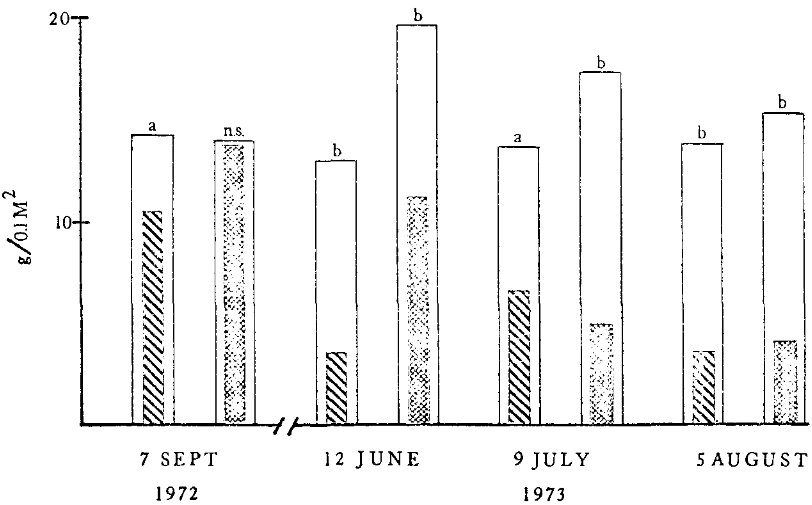

Figure 1. Comparison of average density (g dry wt/0.1 m²) of control vegetation inside exclosures (unshaded bar) with the density of vegetation outside exclosures, subject to grass carp grazing (shaded bar inside unshaded bar). Letters above bars indicate significance level of difference in density between control and outside of exclosure vegetation. n.s., P 0.05; a, P 0.05; b, P 0.01. Hatched bar shows density of vegetation outside exclosure in Whittimore (in which fish were not fed); heavily shaded bar shows density of vegetation outside exclosure in Clay Pit III (in which fish were fed).

The stomach contents of 25 grass carp from the Clay Pit III was 93% vegetation, 1% catfish feed and 6% sand and mud. Grass carp from this pond in which the fish were fed had gained an average of 1.6 kg while those from Whittimore pond had gained 1.1 kg. The percentage survival of grass carp was 76% in the fed pond and 91% in the non-fed pond.

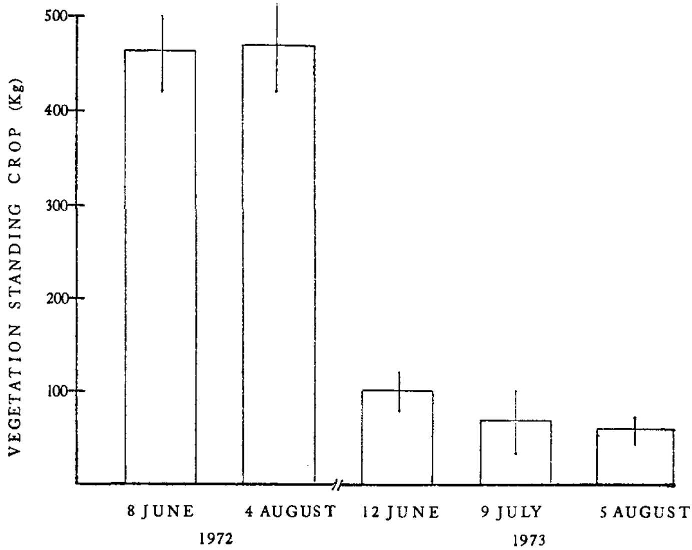

Figure 2. Total standing crop of vegetation (dry weight) in Clay Pit III (in which fish were fed) before and after introduction of grass carp on 3 August 1972. Vertical lines at the top of the bars represent + 1 standard error.

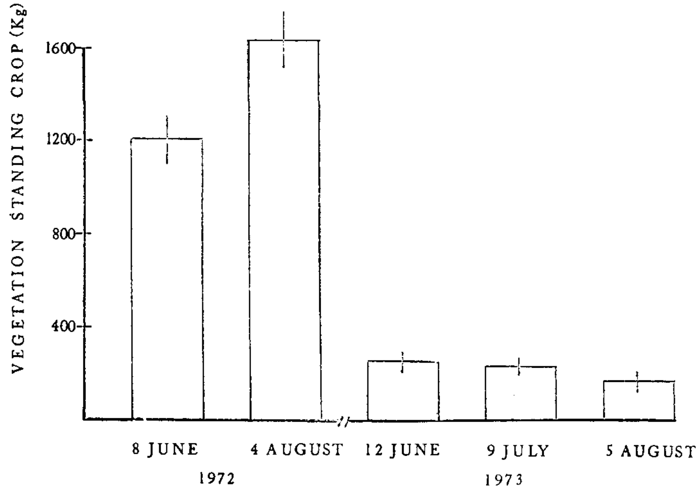

Figure 3. Total standing crop of vegetation (dry weight) in Whittimore (in which fish were not fed) before and after introduction of grass carp on 3 August 1972. Vertical lines at the top of the bars represent + 1 standard error.

DISCUSSION

The marked decreases in vegetation in the ponds indicate that grass carp controlled vegetation, whether or not supplemental feed was available. Spreading the feed over the pond surface as suggested by Prowse (1971) may have discouraged grass carp from feeding on pellets and contributed to the success of vegetation control. The stomach contents of grass carp collected from the fed pond indicated only light feeding on pellets. Kilgen (in press) reported that grass carp controlled *Eleocharis* in a sunfish (Centrarchidae) pond, and ate little of the supplemental pelleted food available to them. Since all of the grass carp stomachs from our study pond were collected on one day, possible seasonal variation in pellet utilization was not determined. The fact that a higher density of grass carp produced no greater degree of weed control in the fed pond than that achieved in the non-fed pond suggests that feeding on artificial feed reduced the effectiveness of grass carp to control aquatic vegetation in this study.

The stocking rates used in this study may give different results if used with plants other than *Eleocharis* and *Utricularia* or if used in different geographical areas. For example, assuming that the dry weight of aquatic macrophytes is equal to 10% of the wet weight (Boyd 1967), Singh et al (1969) found that grass carp eliminated *Hydrilla, Najas,* and *Ceratophyllum* in 41-49 days in four ponds that were stocked with an average ratio of grass carp (live weight) to macrophyte standing crop (dry weight) of 0.07. This stocking ratio is not significantly different (P 0.05) from the ratio (0.06) used in Whittimore to achieve control over a 1 year period.

On the basis of the average weight of all fish stocked (0.54 kg) and the average density of all control vegetation (152 g dry wt/1 m^2) the ratios of grass carp (live weight) to standing crop of macrophytes (dry weight) of 0.15 in Clay Pit III and 0.06 in Whittimore are equivalent to 422 and 169 fish/ha of vegetation, respectively. Many of the suggested grass carp stocking rates that have appeared in the literature for ponds in which fish are not fed supplemental rations, such as the 100 to 125 fish/ha of water surface area proposed by Sneed (1971), are in reasonable agreement with the rate of 169 fish/ha vegetation if the water is not complelety covered with weeds.

The high survival rates and rapid growth of the grass carp in the present study imply that the vegetation may have been eliminated if the fish had been left in the ponds for longer than a year. The stocking rates used may be too high if the goal is vegetation control for a period of time greater than one year rather than vegetation elimination.

ACKNOWLEDGEMENTS

Terry Terrell aided in the collection of all weed samples. The Georgia Cooperative Fishery Unit is jointly supported by the Georgia Department of Natural Resources, U.S. Fish and Wildlife Service, and the University of Georgia.

LITERATURE CITED

Avault, J. W. 1965. Preliminary studies with grass carp for aquatic weed control. Prog. Fish-Cult. 27(4): 207-209.

Avault, J. W., R. O. Smitherman, and E. W. Shell. 1968. Evaluation of eight species of fish for aquatic weed control. FAO Fisheries Report 44. VII E-3: 109-122.

Boyd, C. E. 1967. Some aspects of aquatic plant ecology. *IN* Charles E. Lane, Chairman, Res. Fish. Resources Symposium, Athens, Ga. p. 114-129.

Crowder, J. P. and J. R. Snow. 1969. Use of grass carp for weed control in ponds. FAO Fish Culture Bull. 2, (1), 6.

Hickling, C. F. 1966. On the feeding process of the white amur *Ctenopharyngodon idellus*. Proc. Zool. Soc. Lond. 148:408-419.

Kilgen, R. H. In Press. Food habits of white amur, largemouth bass, bluegill, and redear sunfish receiving supplemental feed. Proc. 27 Annu. Conf. Southeast. Assoc. Game Fish. Comm.

Krupaur, V. 1971. The use of herbivorous fish for ameliorative purposes in central and eastern Europe. Proc. Eur. Weed Res. Coun. 3rd Int. Symp. Aquatic Weeds. p. 95-103.
Prowse, G. A. 1971. Experimental criteria for the study of grass carp feeding in relation to weed control. Proc. Fish-Cult. 33(3):128-133.
Sills, J. B. 1970. A review of herbivorous fish for weed control. Prog. Fish-Cult. 32(3):158-161.
Singh, S. B., K. K. Sukumaran, K. K. Pillai, and P. C. Chakrabarti. 1969. Observations on efficiency of grass carp *(Ctenopharynogodon idella Val.)* in controlling and utilizing aquatic weeds in ponds in India. Proc. Indo-Pacif. Fish. Coun. 12(II):220-235.
Sneed, K. E. 1971. The white amur, a controversial biological control agent. Am. Fish Farmer & World Agric. News. May, 1971. p. 6-9.
Stevenson, J. H. 1965. Observations on grass carp in Arkansas. Prog. Fish-Cult. 27(4):203-206.

USE OF HUMAN CHORIONIC GONADOTROPIN (HCG) TO PROMOTE GAMETIC PRODUCTION IN MALE AND FEMALE LARGEMOUTH BASS[1]

by
Robert L. Wilbur[2] and Freddy Langford
Eustis Fisheries Research Laboratory
Eustis, Florida 32726

ABSTRACT

Fifty male and 106 female largemouth bass were injected with human chorionic gonadotropin (HCG) during the 1972 and 1973 spawning seasons. Milt production was increased or maintained in 80% of the males tested, and 63% of the females ovulated. Females with spent or immature gonads did not noticeably respond to HCG injections. Females tested during the latter half of both spawning seasons demonstrated lower percentages of successful ovulations and reduced numbers of eggs per ovulation. Ninety percent of the ovulated females required only one injection, whereas nearly half of the females that resorbed their eggs required two injections before resorption could be determined. Results indicate that some females can be ovulated twice or three times with multiple injections, but that the success rate is too low to enable practical application. Most females ovulated within 48 hours of injection. Ovulated eggs, if not stripped and fertilized, became inviable within 12 to 16 hours of ovulation.

INTRODUCTION

A sharp increase among anglers pursuing trophy largemouth (*Micropterus salmoides*) in the southeast has stimulated interest in hybridization and selective breeding as a means of enhancing both maximum potential growth and rate of growth. A prerequisite to selective breeding is that single females can be bred to many test males or conversely that one male can be bred to many test females. In that this would be practically impossible to carry out in pond culture, laboratory production of progenies is necessary. Ovulation of female largemouth must be induced and synchronized with spermatogenesis of her male partners. This is complicated by apparent blockage of reproductive pathways in largemouth bass removed from their natural habitats into laboratory containment.

Refining such a technique by over-riding this blockage was the first hurdle overcome in a selective breeding study presently being investigated by the Florida Game and Fresh Water Fish Commission. Although photoperiod and temperature controls have been successfully used to control gonadal recrudescence in a variety of fishes (Wiebe, 1968; Carlson, 1973; Henderson, 1963; McInerney and Evans, 1970), hormonal injection was considered to have superior potential in that there was no need for expensive temperature control equipment and fish holding time would be less.

[1]Contribution from Federal Aid Restoration Funds under Dingell-Johnson F-24, State of Florida. Paper Number 16 of the Eustis Fisheries Research Laboratory, Florida Game and Fresh Water Fish Commission.
[2]Present Address: Arizona Game and Fish Department, Research Division. 2222 West Greenway Road, Phoenix, AZ 85023.