USE OF THE GRASS CARP FOR CONTROL OF HYDRILLA IN SMALL PONDS[1]

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INTRODUCTION

Studies on biological control of aquatic weeds have increased in recent years. While other control methods provide only temporary relief, biological control offers the potential of exerting a constant pressure on the target species. Many different organisms have been and are being studied for their potential to control aquatic weeds. The grass carp (*Ctenopharyngodon idella* Val.) appears to be a promising means for control of submersed weeds (Cross 1969; Hickling 1965; Sutton 1977; and Swingle 1957).

Hydrilla (*Hydrilla verticillata* Royle) was introduced into Florida in the late 1950's and has spread rapidly and has become the major submersed weed problem in Florida. The grass carp is one of the most promising organisms being investigated for its potential to control hydrilla.

CONTROL OF HYDRILLA IN ORANGE COUNTY PONDS

Following the stocking of grass carp in small ponds in central Florida for hydrilla control, it was found that high stocking rates of grass carp would be necessary to control dense infestations of hydrilla (Sutton 1974). In this study, one-quarter of each of four ponds 0.08 ha in size were planted with hydrilla, vallisneria (*Vallisneria americana* Michx.), chara (*Chara* sp.), and southern naiad (*Najas guadalupensis* Spreng. Magnus).

Within two years, hydrilla became the dominant plant in the control pond without fish, while the ponds stocked with 137 to 360 grass carp per ha contained no hydrilla at the end of the test period. Vallisneria remained in the ponds in the presence of up to 900 kg of grass carp per ha. Even though grass carp will eat vallisneria, this plant is not a preferred food. This study suggested that through careful management of the grass carp it

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might be possible to encourage growth of certain aquatic plants while using the grass carp to stress growth of the hydrilla.

SMALL POND STUDIES

1. FPL Pond. A 0.4-ha pond which had a history of excessive hydrilla growth was stocked on 30 September 1975 with 40 grass carp averaging 0.5 kg in weight (100 fish per ha) (Table 1). At the time of grass carp stocking, hydrilla was estimated to cover approximately 80% of the surface area.

On 25 March 1976, 39 grass carp averaging 1.67 kg were removed from the FPL pond using rotenone. Hydrilla growth was no longer visible at the surface of the pond. Grass carp had grown at a rate of 0.19 kg per month or 6.6 g per day.

The FPL pond was restocked on 18 May 1976 with five fish of an average weight of 1.89 kg which is equivalent to 12 fish per ha or 24 kg per ha. By the end of the 1976 growing season, hydrilla had not regrown to the surface. This stocking rate kept the hydrilla growth in check.

A survey of the FPL pond was begun on 15 December 1976 to monitor the presence and relative abundance of vegetation. The survey consisted of stretching two lines across the pond and sampling with a long-handled probe every 1.5 m along each line. The average of the two lines recorded as the percent frequency of occurrence of vegetation along the transect lines are presented in Table 2.

Hydrilla accounted for 13% of the vegetation occurring along the transect line in December 1976, but only 2% for the same month a year later. The most abundant plants in the pond were chara, southern naiad, the common bladderwort (Ultricularia macrorhiza B.). These plants remained relatively stable although bladderwort did increase 10% from December 1976 to December 1977.

A vegetation survey was not conducted prior to grass carp stocking in this pond; therefore, the frequency of occurrence of vegetation cannot be compared precisely to that present in the pond before the grass carp were stocked. Based on the previous history of the pond where hydrilla was seen at the surface of the pond for several years, the stocking of grass carp had reduced the growth of hydrilla to a low level. Hydrilla did not grow to the surface during the 1976 or 1977 growing season. The stocking of 12 grass carp (24 kg of fish) per ha was sufficient to prevent reestablishment of hydrilla for two growing seasons.

2. BCC Pond. A 0.6-ha pond on the Broward Community College campus had a history of hydrilla problems. This pond was treated with herbicides in the spring of 1975, but by June of that year the pond was heavily infested with hydrilla around the edges. On 27 June 1975 the pond was stocked with 10 grass carp averaging 0.5 kg, on 10 September 1975 with 10 fish averaging 0.5 kg, and on 30 October 1975 with 10 fish averaging 0.8 kg each for a total of 30 grass carp. One-third of the pond was again treated with herbicides on 17 December 1975 to help control the hydrilla.

Hydrilla was not present at the surface of the pond in the spring of 1976. The pond was rotenoned on 27 May and 27 grass carp averaging 4.1 kg were removed. The pond was restocked in June 1976 with five grass carp averaging 2.0 kg each. Hydrilla did not grow to the surface for the remainder of the year, and a vegetation survey revealed that the hydrilla growth had been checked by the restocking of grass carp (Table 3). Hydrilla was a minor portion of the vegetation in the pond during 1976 and 1977.

3. Vo-Ag Pond. In order to follow closely the removal of hydrilla from a small pond by the grass carp and their subsequent effect on the vegetative propagules of this submersed plant, 19 grass carp averaging 1.08 kg were placed in this 0.25 ha pond on 15 October 1976. The pond contained slightly over 80% hydrilla as based on the transect lines (Figure 1) with hydrilla growing to the surface. The abundance of hydrilla was relatively stable through the January sampling date. By March 1977, the hydrilla was starting to disappear with a rather dramatic decrease from May to July.

All 19 grass carp were removed on 7 December 1977 using rotenone. At that time the fish weighed an average of 4.27 kg. The weight of the fish on a per ha equivalent was 82 kg when stocked and 329 kg when removed. During this 418-day period the fish grew at a rate of 0.23 kg per month or 7.6 g per day.

The number of vegetative propagules in this pond was estimated by collecting 25 core samples every 2 months (Figure 2). The core samples were obtained with a device which removed a portion of the hydrosoil composed of a surface area of 86 cm^2 by about 20 cm in depth. Cores were washed on a small mesh screen which allowed the propagules to be separated from the hydrosoil.

The number of turions and tubers was estimated at 29.8 and 12.6 million per ha, respectively, at the time the grass carp were stocked (Figure 2). After 1 year the number of turions and tubers was estimated at slightly under 400 thousand and 3.1 million per ha, respectively.

A comparison of the sizes of tubers for the November 1976 and 1977 sampling dates shows a reduction in number for all sizes for this time period (Figure 3). Core samples from the November 1976 sampling time contained tubers as small as 4 mm, not shown in the graph, while none smaller than 7 mm were found a year later. Also, no tubers 14 mm in size were found in the November 1977 core samples.

These data suggest that one of the initial effects of the grass carp is a reduction in the number of turions. Additional studies will be required to evaluate the long term effect on the tubers as well as on the turions.

4. Hillcrest Pond. The approved herbicides, diquat and copper sulfate, were applied to this 0.31-ha pond during January 1976 and again in February 1977 to control hydrilla infestation. These applications of herbicides controlled the hydrilla. On 7 April 1977 five grass carp averaging 3.0 kg were stocked in the pond. Hydrilla did not reappear after this stocking.

Core samples (15) collected 3 February 1977 were used to estimate the number of hydrilla vegetative propagules prior to stocking of grass carp for regrowth control. The number of tubers and turions was estimated at 1.9 million and 150 thousand per ha, respectively. On 21 December 1977, another set of core samples (25) was collected which indicated the number of tubers was 2.1 million and the number of turions was 92 thousand per ha. These results are similar to that for the Vo-Ag Pond in that one of the short-term effects of the grass carp for regrowth control is more pronounced on reducing the number of turions than the number of tubers.

5. Hamlet Pond. In order to evaluate growth of grass carp on the basis of sex, 10 female and 10 male 3-year-old fish were placed in this 0.49 ha pond. These fish had been selected from a group of 3-year-old fish so that the initial weight of both sexes were the same at the time of stocking. The 20 fish averaged 1.6 kg when they were placed in Hamlet Pond on 29 April 1976. Hydrilla was abundant during most of the growth period, but the pond did not contain any of these plants growing up to the surface of the water when the fish were removed on 18 February 1977.

The female grass carp had increased to an average weight of 4.2 kg during this 295-day period, while the males averaged 2.3 kg. The average daily growth rate was 14.9 g and 7.8 g, respectively for female and male fish.

DISCUSSION

The previous history of the ponds served as the bench mark for evaluating the impact of grass carp feeding. Since dense infestations of hydrilla had been present and repeated applications of herbicides were necessary to keep the hydrilla under control, it is assumed that excessive growth of hydrilla would have occurred if the ponds had not been stocked with grass carp. One the hydrilla infestation was controlled with herbicides a stocking rate of 8 to 12 grass carp per ha was effective in keeping hydrilla from rapidly establishing itself, at least for two growing seasons.

Small grass carp are very likely to be preyed upon (Gasaway 1977); therefore, for long-term stocking, large fish 0.5 kg or larger in weight may be required. The growth rate of female grass carp was almost twice that of males. This is in agreement with other studies (Hickling 1967). However, we did not determine whether females consumed twice the amount of vegetation as males. Information of this type will be useful in determining optimal numbers for stocking uniform populations of fish.

Most of the food preference studies (Avault 1965; Gidumal 1958; and Pentlow and Stott 1965), have been conducted with small fish or in small containers. In the small ponds we used, the large grass carp were either seeking out the regrowth of hydrilla or at least consuming it sufficiently so that other plants were competitive with hydrilla.

Stocking with low numbers of grass carp allowed desirable native vegetation to grow. In the FPL and BCC Ponds, the plants that grew were ones that became established naturally. For example, some vallisneria, a desirable aquatic plant, was present in the BCC Pond prior to application of the herbicide and stocking with grass carp. Once the dense growth of hydrilla was under control, vallisneria could grow. Additional studies are needed to evaluate the possibility of using the grass carp to keep regrowth of hydrilla at a low level while encouraging growth of desirable plants which either develop naturally or are transplanted to the body of water. In this way it may be possible to replace problem weeds with desirable aquatic plants.

Short-term effects of stocking low numbers of grass carp are: (1) preventing regrowth of hydrilla, and (2) reducing the number of turions. Since the tubers grow below the surface of the hydrosoil, as opposed to the turions which fall off the plant and lay on top of the hydrosoil, the tubers may remain viable for a long period and serve as a source reservoir of propagules to reinfest the body of water. The long-term effect of low stocking rates of grass carp for regrowth control will require additional study.

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Table 1. Schedule for grass carp stocked and removed from the FPL Pond for hydrilla control and for controlling the regrowth of hydrilla and other species.

Date	Fish per ha	Weight (kg) per ha
A. Hydrilla control		
30 September 1975	100	51
25 March 1976	98	163
B. Regrowth control		
18 May 1976	12	24

Table 2. Frequency of occurrence (%) of aquatic vegetation in the FPL Pond.

Aquatic vegetation	15-Dec-76	22-Apr-77	15-Jun-77	21-Sep-77	15-Dec-77
Hydrilla verticillata Royle	13.0	2.2	5.4	1.2	2.0
Chara sp.	31.5	42.2	32.4	35.2	36.1
Najas quadalupensis (Spreng.) Magnus	30.1	26.7	35.7	35.2	27.8
Utricularia macrorhiza B.	16.4	13.3	22.2	26.1	26.4
Eleocharis sp.	2.7	2.2	1.1	1.1	2.1
Bacopa sp.	—	2.2	—	—	2.1
Nitella sp.	—	—	1.1	—	—
Panicum repens L.	—	2.2	1.1	—	1.4
Polygonum sp.	—	—	0.5	0.6	—
Stenotaphrum secundatum (Walt.) Kuntze[a]	—	—	0.5	—	1.4
Ludwigia peruviana L.	—	—	—	—	0.7
Scintello sp.	—	—	—	0.6	—
Bare hydrosoil	6.3	9.0	—	—	—

[a] Not an aquatic plant but grows at the edge of a pond and tolerates flooding.

Table 3. Frequency of occurrence (%) of aquatic vegetation in the BCC Pond.

Aquatic vegetation	15-Dec-76	22-Apr-77	15-Jun-77	21-Sep-77	15-Dec-77[a/]
Hydrilla verticillata Royle	12.1	8.3	0.8	4.8	4.4
Chara sp.	—	—	—	—	0.9
Eleocharis sp.	0.9	—	—	—	—
Bacopa sp.	—	—	—	—	3.5
Cyprus sp.	0.9	—	—	—	—
Lippia sp.	—	—	—	—	2.6
Stenotaphrum secundatum (Walt.) Kuntze[b/]	—	—	2.3	—	14.8
Ludwigia peruviana L.	0.9	—	4.5	—	—
Vallisneria americana Michx.	14.7	19.3	17.6	34.6	13.9
Panicum repens L.	11.2	11.0	9.2	7.7	12.2
Hydrocotyle umbettata	7.8	3.7	11.5	3.9	9.6
Bare hydrosoil	51.5	57.5	49.5	49.0	38.1

a/ Rise in water level flooding plants around the edge of the pond.

b/ Not an aquatic plant but grows at the edge of the pond and tolerates flooding.

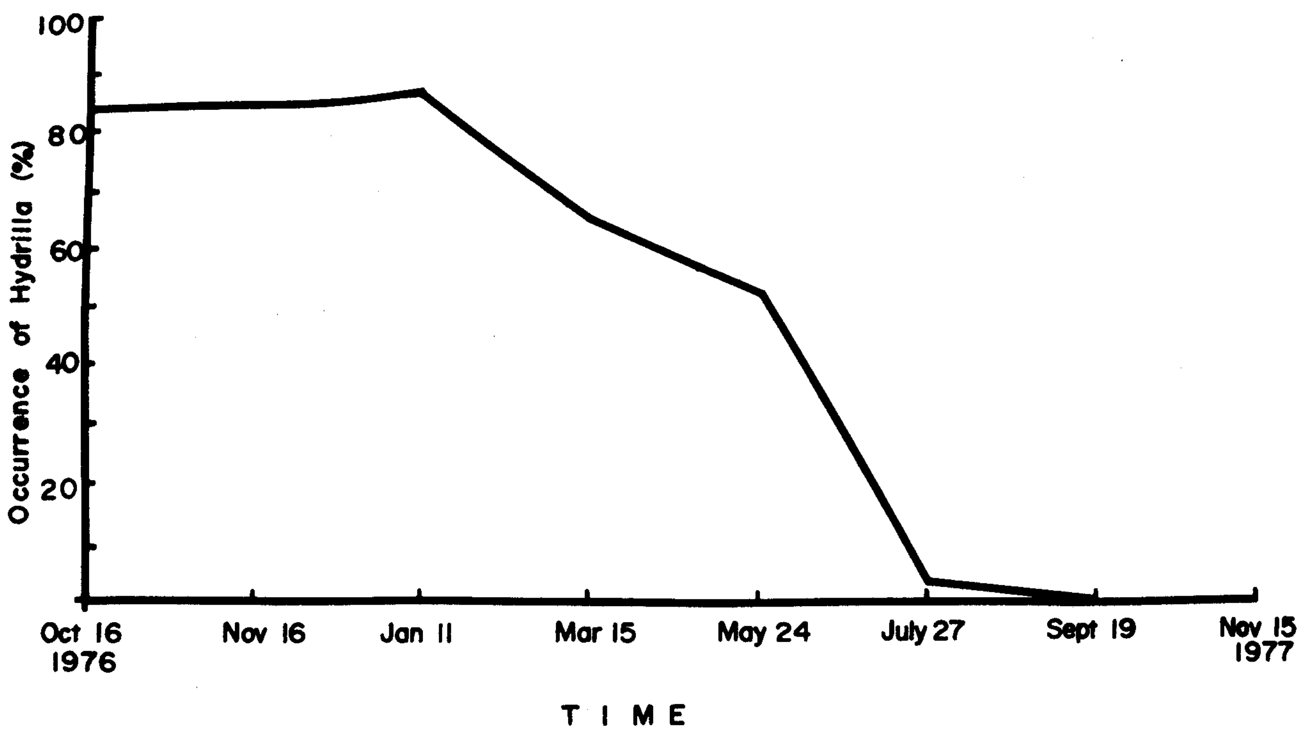

Figure 1. Percent occurance of hydrilla in Vo-Ag Pond as determined by line transect.

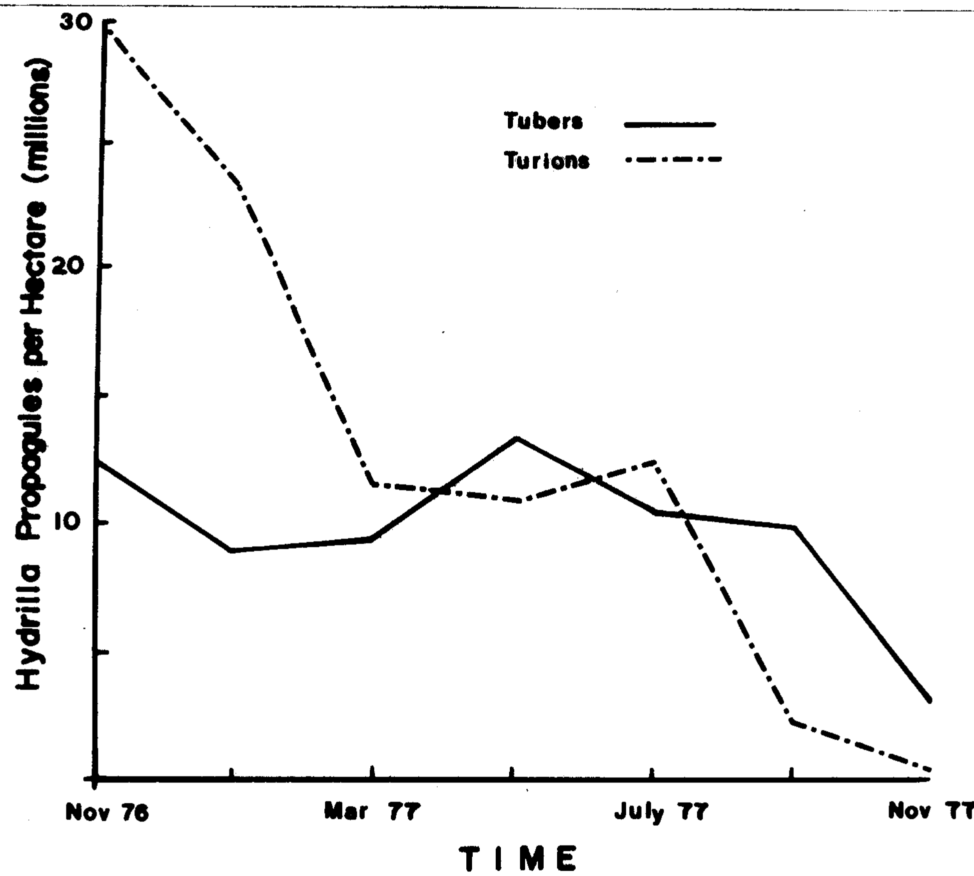

Figure 2. Number of vegetative propagules collected from Vo-Ag Pond.

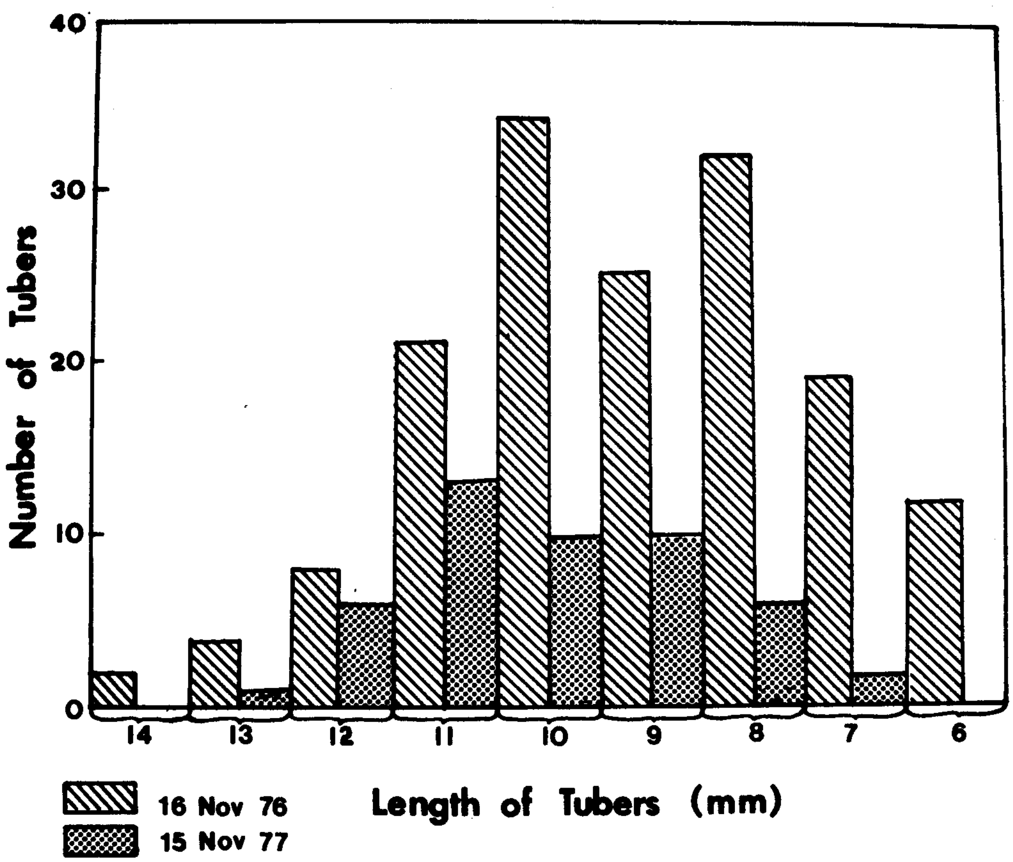

Figure 3. Number and length of tubers collected from Vo-Ag Pond.