

Biological Control of Aquatic Weeds in Egypt Using the Grass Carp (*Ctenopharyngodon idella*)

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Abstract

Biological control of aquatic weeds is increasing all over the world with many different organisms being used. The advantages of biological control in comparison to other methods are that it combines relatively low cost with a minimum of detrimental side effects. One biological agent, grass carp, *Ctenopharyngodon idella*, has attracted the attention of both weed scientists and engineers. This paper presents a brief summary of results obtained during the last eight years, including weed control, optimal stocking size and density of fish, predators, fence construction, fish production, impact on Bilharzia and economics. The paper presents also up-to-date information of a large experiment, in which a canal was stocked by 1/3 million grass carp, 15 to 20 g each, in early 1986. The results have proved that this method can be used safely for controlling submerged weeds and algae, the hydraulic efficiency of the stocked canal was much improved, and the value of fish production exceeded the cost of the program.

Introduction

During the last 15 yrs, grass carp (*Ctenopharyngodon idella* Valenciennes; Cyprinidae) has received increasing interest in many countries, and results have been reported on its use for controlling aquatic weeds. The importance of these weeds is correlated with the growing importance of irrigation. In Egypt, aquatic plants cause serious problems by reducing hydraulic efficiency, and thereby increasing silting of canals (Khattab and El-Gharably 1984, 1986a, and 1987). Not only do they prevent water from reaching the end of canals, but also a considerable amount of water is lost. Aquatic weeds also interfere with navigation, and prevent fishing and other recreational activities. Moreover, aquatic weeds provide a suitable habitat for the intermediate host of Bilharzia parasites.

At present, three major types of aquatic weed control are carried out in Egypt: manual, mechanical, and chemical. Manual control is expensive, slow, inefficient and includes a number of risks for labourers. Mechanical control consumes a lot of fuel and requires skilled manpower and good organization, which makes it expensive. Furthermore, the effect of both manual and mechanical control do not last long. Chemical control has often been considered as an alternative. In some countries, however, the use of aquatic herbicides is prohibited, mostly because of undesirable side-effects on agriculture, human health, fish production and the environment. Moreover, the use of chemicals shifts the composition of aquatic weeds towards non-susceptible species.

Since mass transport of fish by air became possible, the herbivorous Chinese grass carp has been imported all over the world to help solve aquatic weed problems, and to help overcome the protein shortage. The Institute of Weed Control and Channel Maintenance (IWCCM) started a research programme on the use of grass carp with the cooperation of Dutch consultant Ilaco/Euroconsult. The first experiment was conducted in 1977 (El-Gharably *et al.* 1978), and directly afterwards, some larger experiments were carried out. Results were quick and encouraging, such that the Ministry of Irrigation (MOI) decided to include the use of grass carp in the overall maintenance programme of the irrigation system. In 1981, a large-scale hatchery was established by the IWCCM, with ultimate capacity of half a million grass carp of stocking size. This production was used for intensive field experiments during the last six years.

Problems of Aquatic Weeds in Egypt

The total length of canals and drains in Egypt exceeds 47 000 km. For many reasons, floating, submerged, ditchbank, and emergent aquatic weeds flourished and spread all over Egyptian water courses during the last decade.

Since 1978, the IWCCM has carried out field studies to identify the size of the aquatic weed problem. Results showed that the total infested length with all types of weeds in canals during 1986 was 26,100 km (83.7% of total length); in drains it reached 12,950 km (79.8%). The distribution of infested lengths according to type of weeds in canals and drains in 1985-6 is given in Table 1.

Table 1. Common weeds in canals and drains in Egypt in 1985-6.

Common weeds	1985		1986	
	km	%	km	%
Floating weeds:	3,100	6.54	2,800	5.91
<i>Eichhornia crassipes</i> (Mart.) Solms-Laubach (Pontederiaceae)				
<i>Lemna</i> spp. (Lemnaceae),				
<i>Nymphaea caerulea</i> Savign. (Nymphaeaceae)				
Submerged weeds:	18,400	38.81	18,950	39.98
<i>Potamogeton</i> spp. (Potamogetonaceae)				
<i>Ceratophyllum demersum</i> L. (Ceratophyllaceae)				
<i>Najas armata</i> (Najadaceae)				
Emergent and ditchbank weeds:	7,800	16.45	8,500	17.93
<i>Typha domingensis</i> Pers. (Typhaceae)				
<i>Phragmites australis</i> (Cav.) Trin.				
<i>Cyperus alopecuroides</i> Rottb. (Cyperaceae)				
<i>Polygonum salicifolium</i> Brouss. (Polygonaceae)				
<i>Paspalum paspaloides</i> Scribn. (Poaceae)				
<i>Echinochloa stagnima</i> (Retz.) Beauv. (Poaceae)				
Mixture of more than one weed type:	9,800	20.67	8,800	18.56
Total	39,100	82.47	39,050	82.38

Table 1 showed little improvement in infested lengths by floating weeds during 1986 compared to 1985. This was followed by an increase in lengths infested by submerged weeds. Ditchbank weeds increased in 1986, mainly in drains. In general, the total length infested by all types of weeds in canals and drains remained almost the same in 1985-6. Moreover, the main problem is focussed in the high infestation by submerged weeds (Table 1). These submerged weeds have seriously affected the hydraulic efficiency of the irrigation system. Many successful efforts have been made by MOI to control such weeds by mechanical, chemical and manual methods, but the problem still existed. Therefore, it was hoped that biological control using the grass carp could control submersed weeds in Egypt in canals having permanent water all year. This paper presents results obtained from one of the major experiments conducted during 1986-7 on Basussiya Canal, which show that successful control of aquatic weeds with grass carp can occur.

Methods and Materials

The study site is located on Basussiya Canal, which starts at a gate from the River Nile 20 km north of Cairo. This earthen canal has a design capacity of $18.5 \text{ m}^3 / \text{sec}$ and is trapezoidal in cross-section. The canal bed is 22 m wide, and the ratio of bed width to water depth is 7.4. It conveys water north-eastward for 28 km and has a slope of 7 cm/km. The canal provides irrigation water to 33,000 ha of farmlands, mostly of citrus trees.

Since 1978, the first 15 km of the canal has been severely infested by submerged weeds, mainly *Potamogeton pectinatus* L. (Potamogetonaceae), *Ceratophyllum demersum* L. (Ceratophyllaceae) and algae. The percent cover of the water surface in summer by these weeds sometimes reaches 50%. Fig. 1 shows the infestation in 1984 and 1985, which affected seriously the hydraulic efficiency of the canal, and hampered water from reaching lands on the canal tail during the high-demand months of June and July.

Although the Irrigation District has included the canal in the chemical control programme using acrolein since 1980, the canal still suffers from many weed problems. This has encouraged the IWCCM to stock the head reach of the canal with grass carp. The total length of the reach is 20 km, and is separated by two barriers to prevent the emigration of fish: a weir drop of 60 cm upstream, and control regulator downstream. The total area of water surface is estimated to be 70 ha.

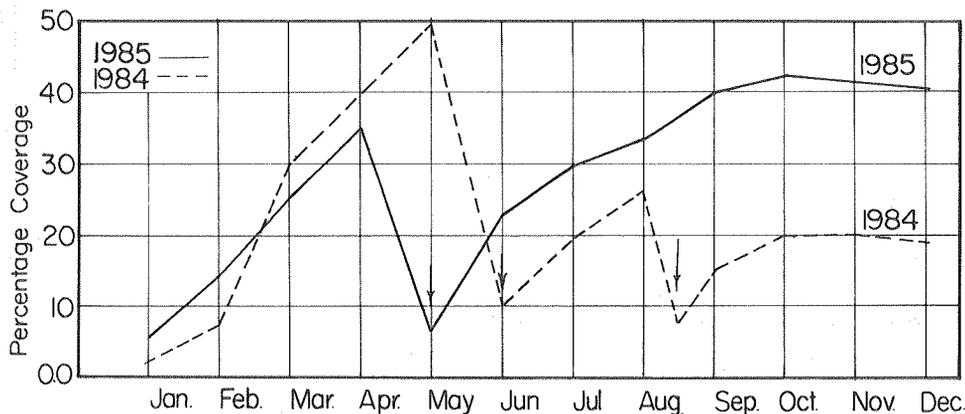


Figure 1. Basussiya Canal Experimental Reach, percent cover by submerged Weeds -
↓ showing acrolein injection, 1984-5.

In March 1986 the experimental area was stocked by grass carp weighing 15 to 20 g each (average stocking density 90 kg/ha). Weeds and grass carp samples were monitored frequently in the study area from February to December. Maximum weed coverage reached 15% in March - April, and fish weight ranged from 250 to 750 g each in December (a few fish weighed > 1 kg). In March 1987, the same reach was restocked with about 367,000 fingerling grass carp weighing 15 to 25 g each (average stocking density 105 kg/ha). The canal was monitored till October (just before submitting this paper). Results showed that percent coverage by submerged weeds never exceeded 10%, and individual fish weight was 200 to 550 g each.

In two experiments, grass carp were stocked in five equal sections, to obtain good starting distribution along the reach. The average daily water temperature recorded ranged from 19°C in winter to 27°C in summer.

Results and Discussion

Basussiya Canal experiments proved that biological weed control using the grass carp is promising in Egypt and can be used without any side effects for controlling submerged weeds (*P. pectinatus*, *C. demersum*, and algae).

Percent of weed coverage decreased from 50% in 1984-5 to < 10% in 1986-7, after stocking grass carp (Figs. 1 & 2). The hydraulic efficiency was improved, and water has reached the end of the canal without any additional maintenance work except for removing some waterhyacinth, *Eichhornia crassipes* (Mart.) Solms-Laubach (Pontederiaceae) manually in July 1986. Emigration of fish from the experimental plot was estimated at 10 to 15% of the stocked quantity. Fishing was restricted during the spring and summer only. The two experiments proved also that the small starting weight of individual fish gave adequate results in controlling submerged weeds and algae if predation is not significant, as is the case in Egypt. Monitoring the fish showed fair production in grass carp as well as in native fish.

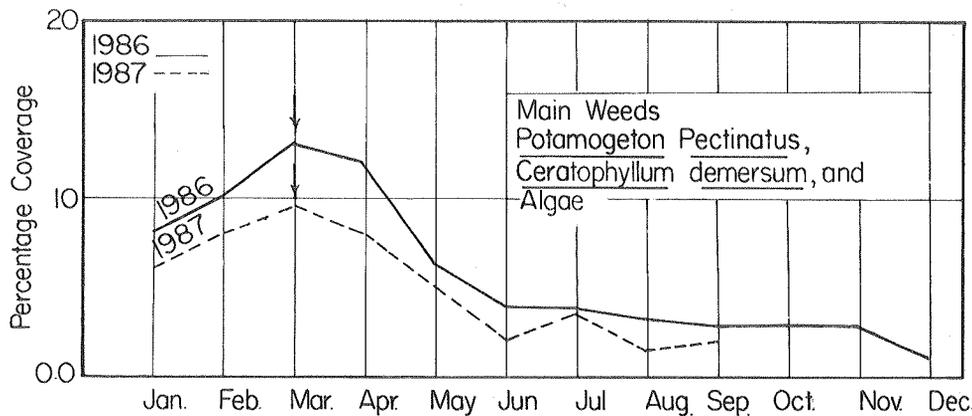


Figure 2. Basussiya Canal Experimental Reach, percent cover by submerged weeds -
↓ stocking of fish 1986-7.

A summary of results of the project, and recommendations for the future work follow:

- (a) Aquatic weed control using the grass carp gave excellent results in Egypt if fish were stocked at the right time.
- (b) Grass carp rarely reproduce outside their natural habitat (Stanley *et al.* 1978). However, artificial reproduction (Woynarvich and Horvath 1980) was successful under the Egyptian conditions.
- (c) Small grass carp can control effectively most submerged weeds in the Egyptian channels, because predation was low.
- (d) The waterways should be cleaned thoroughly just before stocking with grass carp, so that they have only to cope with new, small growing plants. If this is not done, additional mechanical work might be needed during summer, and this will increase the costs. Therefore, grass carp should be stocked at the beginning of spring, shortly after the maintenance period of the irrigation system.
- (e) Measures should be taken to prevent fishing from canals stocked by grass carp during spring and summer to avoid having to re-stock additional fish or use mechanical control.

- (f) Net production of the grass carp is estimated at 500 kg/ha/yr in 1986, compared to 400 kg/ha/yr in the previous work (Khatab and El-Gharably 1986a).
- (g) In Egypt, costs of weed control using grass carp were just less than half of those by conventional methods, largely due to the rapid increase in herbicide prices and wages of labourers for chemical and manual control, respectively (Khatab *et al.* 1981, 1984). This is in accordance with data from other countries (Jahnichen 1974, Stott and Buckley 1978, van Zon 1978). However, if the additional yield of fisheries is taken into consideration, weed control with grass carp will result in net profit.
- (h) Biological control of aquatic weeds using grass carp resulted in the lowest vegetation coverage and consequently, the lowest number of the intermediate host of Bilharzia parasites (Ilaco 1983-1985, Khatab and El-Gharably 1986b).
- (i) Although grass carp showed a great deal of promise as an effective tool to control aquatic weeds in the Egyptian irrigation systems, additional barrier research work is required to confine the fish to the areas where they are needed.

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