EVALUATION APPLYING BIOLOGICAL METHODS TO MANAGE AQUATIC WEEDS

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ABSTRACT

Increasing aquatic weeds infestation in channels causes many problems such as obstruction of water flow, prevent water to reach the canal end …etc. Different types of aquatic weeds have increasingly infested Egyptian canals since the spring of 1975. Before that year the aquatic weed problems was in balanced growth. Manual, Mechanical and biological methods are used to keep weeds to an acceptable low level with minimum cost. The main objective of this study is to evaluate the application of biological control method with grass carp on management of aquatic weeds.

Analysis of available data of 22 selected Egyptian canals showed that the grass carp (*Ctenopharyngodon idella*) have to be stocked with a right number depending on water surface area of canals with density not less than 100 kg/ha. Also, it was deduced that the integrated control methods, mechanical and biological, must be used in the season of weeds infestation to control aquatic weeds. The recommended rules to apply biological control method must be applied to increase the efficiency of using grass carp to control aquatic weeds

Keywords: Aquatic weeds Management, Biological Methods, Grass carp.

INTRODUCTION

The total length of Egyptian networks (canals and drains) exceeds 47000 km, 31000 km canals and 16000 km drains (Khattab and El-Gharably, [10] and Mashaly *et al*. [16]). The degree of weeds infestation channels is affected by environmental factors, including water transparency, depth of water, physicochemical water quality, water currents and air temperature. El-Gharably *et al*. [4] attributed the increasing spread of aquatic weeds in the irrigation and drainage channels of the Nile Delta to some other ecological factors, e.g. increasing pollution from agricultural practices, industrial pollution and human activities along canals and drains.

Aquatic weeds have been classified into three general groups, which are floating, submerged, and ditch bank and emergent plants. In the period from 1980 to 1994 the

submerged weeds had infested the Egyptian canals and drains with 50% of the total infested length (Khattab, [14]).

Control of aquatic weeds in Egypt

Aquatic weeds are controlled in Egypt by four methods, which are manual, mechanical, biological, and chemical. The chemical control method is potentially hazardous to the eco-system and even to the man himself. So application of chemical method had been stopped in Egypt since 1990. Therefore, the biological methods have been used on large scale to control submerged weeds.

Biological control methods are applied by using fish such as grass carp, ducks, geese, swans ….etc. (Salah El-Deen, [18]). The grass carp (*Ctenopharyngodon idella*) is used in Egypt and gives a good result to control aquatic weeds especially submerged weeds which are difficult to control by conventional techniques. Also, no manifest damage to the environment has been caused from grass carp. Control of submerged aquatic weeds has become a global problem due to high reproduction rate and perennial growth.

1. Manual control

This method was practiced in Egyptian canals and drains of bed width and water depth less than 4 m and 1.5 m respectively (Khattab and El-Gharably, [10]). Since 1985, the use of this method is decreasing and being replaced gradually by mechanical control (Khattab and El-Gharably, [12]). In 1995, a new project was started to clean and maintain small Egyptian canals (bed width less than 2m) by using developed manual tools. The results of applying this project in Upper Egypt and Delta were suitable to be applied in a large scale. One of the main advantages of this method is to clean the canal without any damage on the cross section.

2. Mechanical control

Aquatic weeds controlled in Egyptian channels mechanically by dredging or cutting them, depending upon the efficiency of machine. Most machines are operated from the banks such as hydraulic excavators. Mowing boats are developed to control submerged and emergent weeds in channels more than 8 m wide and the water depth is deep enough for operation (Khattab and El-Gharably, [9]). Mowing buckets fixed on four wheel drive tractor were used to control weeds for wide channels less than 5 m (Khattab and El-Gharably, [10]). Harvesters were also used to control aquatic weeds. Chaining method is effectively applied in Upper Egypt to control the emergent and submersed weeds. In addition, Barriers are used to restrain the drift of free floating weeds and allow water to pass through them.

3. Biological control

Biological method using the grass carp have been applied in Egyptian channels since 1981 on limited scale for research only and result was encouraging to apply on large

scale (Khattab and El-Gharably, [13]). In the spring of 1985, the grass carp was stocked in Sinnuris canal and a good result had been obtained. This result was related to absence of fishing and the fact that the grass carp stayed in stocked sections (Ilaco, [6]). The preliminary experiments in drain near Cairo showed that in the absence of submerged weeds the grass carp prevented the spread of emergent species (El-Gharably *et al*. [3], Ilaco, [5]). In order to use the grass carp with high efficiency in Egyptian channels, the grass carp need to be stocked with a certain density as shown in Table (1) (Ilaco, [6]).

Table (1): Average Grass Carp Weight and Stocking Density (Ilaco, [6])

Stocking Density		Average Grass Carp Weight
N	(kg/ha)	(gm)
5000	50-60	10-15
4000	60-90	20
3000	60-120	30
1500	120-150	100
1000	180-250	200
500-850	200-300	300

(gm: gram, kg: kilogram, ha: hectare, and N: number of grass carp)

Smaller grass carp is more selected and recommended in submerged species than bigger individuals because small fish grow quickly and need more food per kilogram body weight than larger fish (Van Zon, [20] and [22]). Therefore small fish control weeds more efficiently than large fish. The preferable situation will be that various sizes are present, as these will in principle consume a wide range of plant species. Kishan *et al*. [15] deduced that the floating weeds are not favored by the grass carp as a food. Costs of weeds control from Egyptian channels using grass carp with additional mechanical methods were less than half of those of conventional methods (Khattab *et al*., [8]). This result agreed with many other researches such as Jahnichen [7], Scott and Buckley [19], and Van Zon. [21] and [22].

There are three main problems affecting the efficiency of applying biological control in Egypt. The first one is the Bayluscide, which is injected by Ministry of Public Health, for Bilharzia control. These chemicals not only kill the snails that transmit Bilharzia, but also the grass carp as well as other fish species. The second problem is the escape of grass carp to other water bodies, and it lowers the stocking density. Existing natural barriers (weirs, pumping stations, .etc) used to prevent the grass carp escaping from the stocked section. However, often these structures are not available and different methods then need to be employed to prevent grass carp from escaping (Ilaco, [6]). The third problem is the legal and illegal fishing. Early fishing of the grass carp and using electrical or chemical methods in fishing have to be prevented to apply the biological control method. Also, Ilaco [6] reported that grass carp should not be stocked in canal and drains sections which pass through village because it is easy to

fish and poor water quality were showed in this area.

Results of intensive experimental investigations, which were carried out by Khattab and El-Gharably [11], in Egypt to control submerged weeds by grass carp, proved the following:

- During weeds growth (summer season) additional mechanical control with grass carp gave excellent results.
- The most economical size to stock grass carp in channels is between 10 to 20 gram, with stocking density ranging between 90 to 120 Kg/ha.
- In 1981 Khattab *et al*., [8] recommended that a restock of 25% of grass carp every year will be necessary due to over fishing. However, restocking about 50% and 100% of grass carp is necessary to compensate for over stocking for drains and canals respectively (Khattab and El-Gharably, [11]).

Finally, it is difficult, however, to evaluate the exact amount of fish which could be necessary and research is needed to determine stocking rates (Dubbers *et al.*, [2] and National Academy of Science, [17]).

Application procedure of using Grass Carp

The application procedure to apply biological control method by using grass carp in Egyptian channels was summarized by Ilaco [6] and CMRI [1] (Channel Maintenance Research Institute) as follows:

- Monitoring of selected channel is needed to estimate the state of weeds infestation. The type of weeds infestation is also determined.
- Suitable time to stock the grass carp have to be chosen to obtain excellent results. Experimental studies showed that the suitable stocking time in Egyptian channels ranged from February to March.
- The selected channels should be cleaned thoroughly from aquatic weeds before stocking with grass carp.
- Caution should be taken to prevent fishing of the grass carp from the selected channels.
- By computing the water surface area of selected channels, the density and weight of grass carp can be estimated from Table (1).

To obtain excellent results for using the grass carp, water depth and water surface width must not be less than 1.5 m and 12 m respectively (CMRI, [1]). Also, the selected channels are operated without dry period. The water quality of channel should be taken into consideration to keep grass carp in good health.

The aim of the present study is to evaluate the applied biological control method (using grass carp) on Egyptian channels. The non-acceptance procedure to use grass carp, which was applied in some Irrigation Districts, was also discussed in this study.

MATERIAL AND METHODS

Twenty two Egyptian canals distributed on six Irrigation Districts were selected to evaluate the effect of applied biological control method (using grass carp) to control aquatic weeds. These districts are distributed along upper (Asyout and Qena), middle (Fayoum), and Delta (Ismailya, Monoufya, and Dakahlya) of Egypt. The data were collected from twenty two canals to determine the total water surface area of canal, surface area of canal infested by weeds, number of grass carp stocking in the canal, and the average weight of grass carp. The grass carp density was also deduced depending on total water surface area of canal .The collected data covered the period from year 1997 to 2005 for the selected Irrigation Districts.

RESULTS AND DISCUSSIONS

There are various parameters to evaluate the effectiveness of biological weed control method. Generally, only short term effects are evaluated and rated either "good" (few plants) or "poor" (high density of weeds still present). The selected Irrigation Districts were classified to three groups. The first group included Qena, Asyout, and Fayoum Irrigation Districts. The second and third groups were Monoufya and West Dakahlya Irrigation Districts, and Ismailya Irrigation District respectively.

1. Qena, Asyout, and Fayoum Irrigation Districts

From the analysis of the available data for the three Irrigation Districts, it can be shown that the estimation number of grass carp, which was stoked into the canals, was suitable to control weeds. From Figure (1), it can be shown that the stoking density of grass carp in Kalabiya and Asfoun canals (Qean Irrigation District) increased generally with years (from 1998 to 2005) especially in the last year. Different size of grass carp was used to consume all types of submerged weed. This result means that the increasing grass carp density is essential to obtain an agreement result in control weeds.

Stocking density of grass carp (average weight 25 gm) in the Naga Hammady El Gharaby and El Gergaoueya canals (Asyout District) was also increased with years (except year 1998). These densities are suitable to control aquatic weeds but it was observed regrowth of weeds during July and September. The results of biological control method in the two canals were accepted because the stocking rate appeared to be sufficiently to keep the canals clean during the autumn and winter season.

In addition, the biological control method was applied in El Walidya canal and acceptable result was obtained although, the stocking density of grass carp reduced in the last three years as shown in Figure (2).

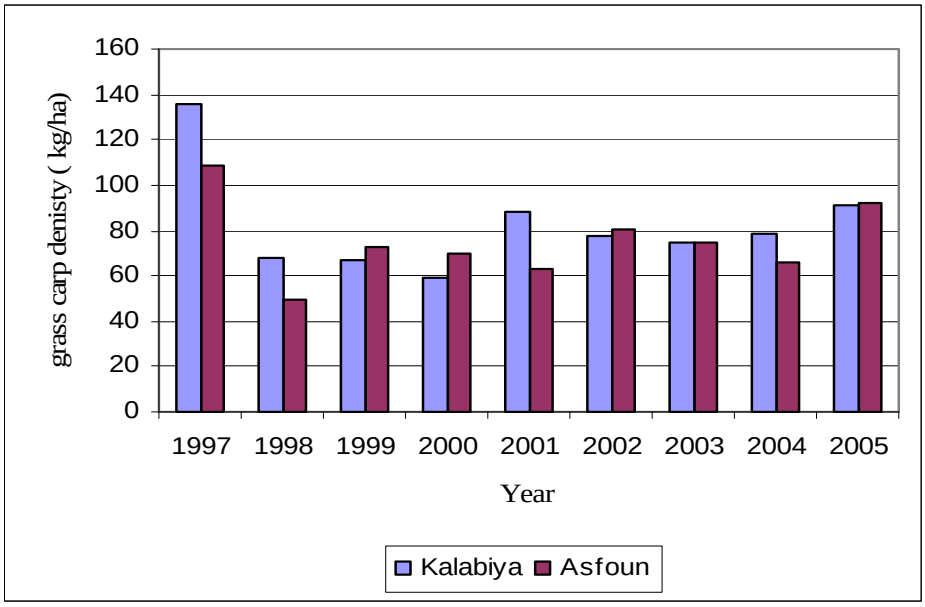

Figure (1): Grass carp density with year for Qena District

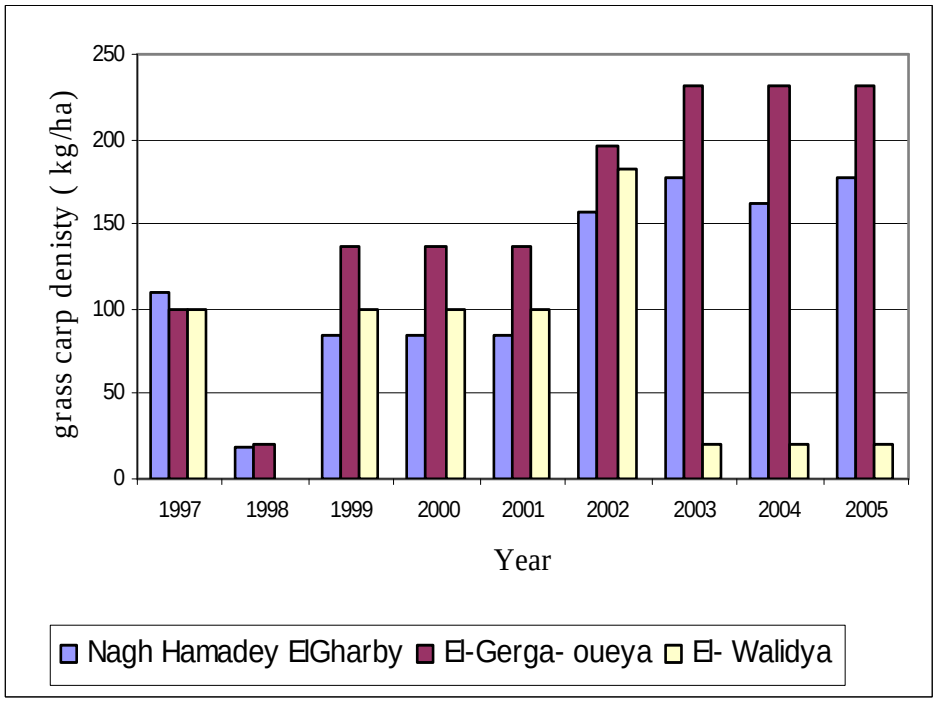

Figure (2): Grass carp density with year for Assyout District

From the stocking density of grass carp, which was recommended equal to 60-90 Kg/ha by Ilaco [6] and equal to 90-120 Kg/ha by Kattab and Garably [11], it can be deduced that Kattab and Garably suggested a higher stocking density to be more effective in controlling submerged weed. It was observed that the stocking rate of Naga Hammady El Gharaby and El Gergaoueya agreed with the recommended stocking rate.

While in Fayoum Irrigation District, it can be shown from Figures (3) and (4) that the range of stocking density of grass carp ranged between 50 to 84 kg/ha with average weight 12.5 gm. The stocking density agreed with the recommended stocking density by Ilaco, [6]. It was observed weeds problem in these canals occur mainly in spring and summer. Practically, the stocking rate appeared to be not sufficient to keep the canals clean, it should be increased with different size to control all the type of aquatic weed.

2. Monoufya and West Dakahlya Irrigation Districts

The data of the second group for eight canals were collected and summarized in Figures (5) and (6) for Monoufya and West Dakahlya Irrigation Districts respectively. In West Dakahlya, the canals suffered from weeds problem although the stocking density of grass carp was higher than the recommended density by Ilaco [6] and CMRI [1] in most years. It was shown that there was not systematic in the stocking rate of grass carp, one year stocking over the recommended density, other years reduce this stocking density, and in some years applying biological control method was stopped as shown in Figure (6). Therefore, the Irrigation District suffered from weeds problem. These canals gave alarm that there was something not right, such as a big number of escaping fish from canals or killing due to chemical. While in canals of Monoufya Irrigation District, the weeds problems have decreased since 2001.

From the results of the applying grass carp in Monoufya and West Dakahlya Irrigation Districts, it may be concluded that, the biological control has clear advantages over the conventional programs. While the actual results in West Dakahlya may vary considerably, depending on the mechanical equipment more than biological control. In addition, restocking and applying the regulation of stocking the grass carp have to be applied to obtain an acceptable result for using grass carp.

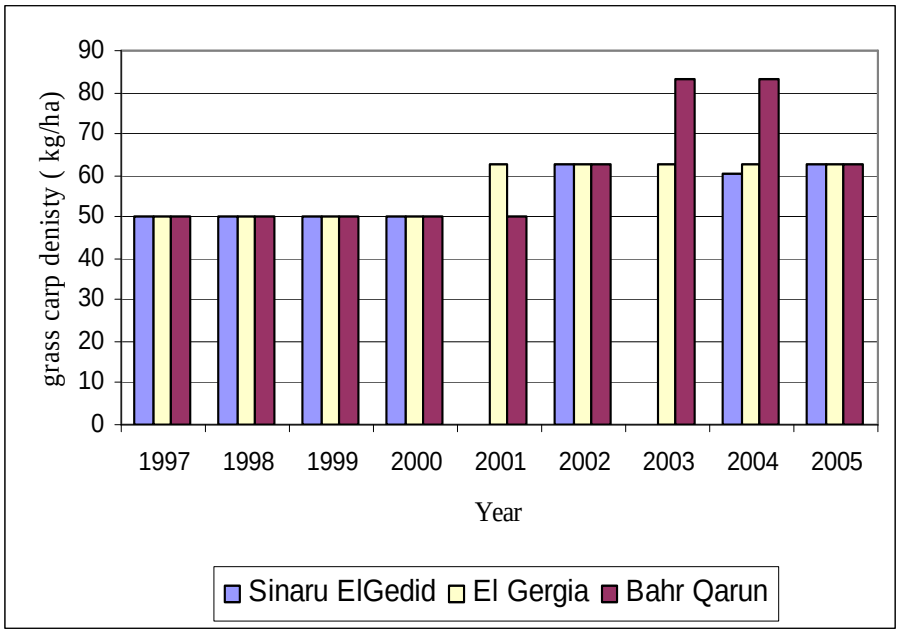

Figure (3): Grass carp density with year for Fayoum District

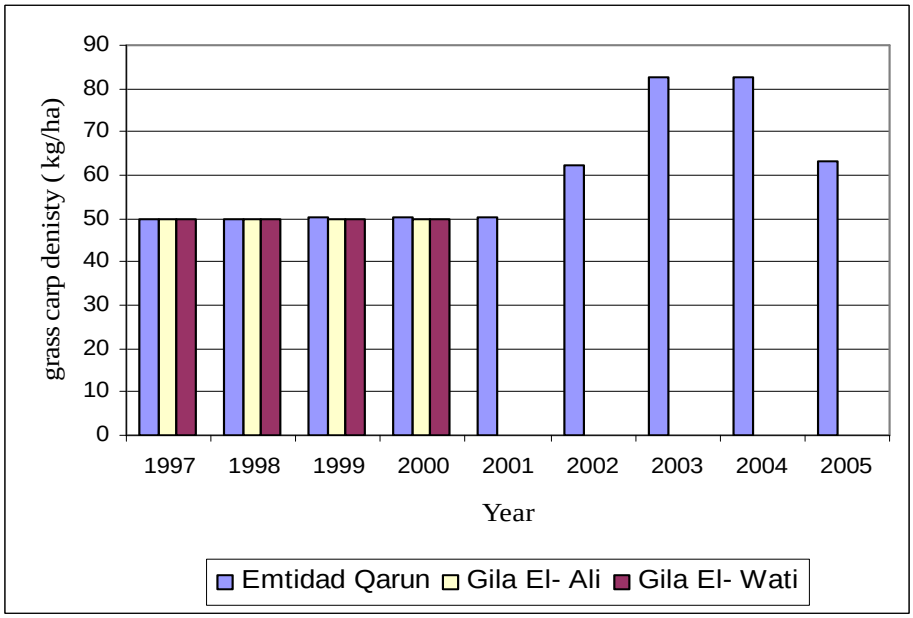

Figure (4): Grass carp density with year for Fayoum District

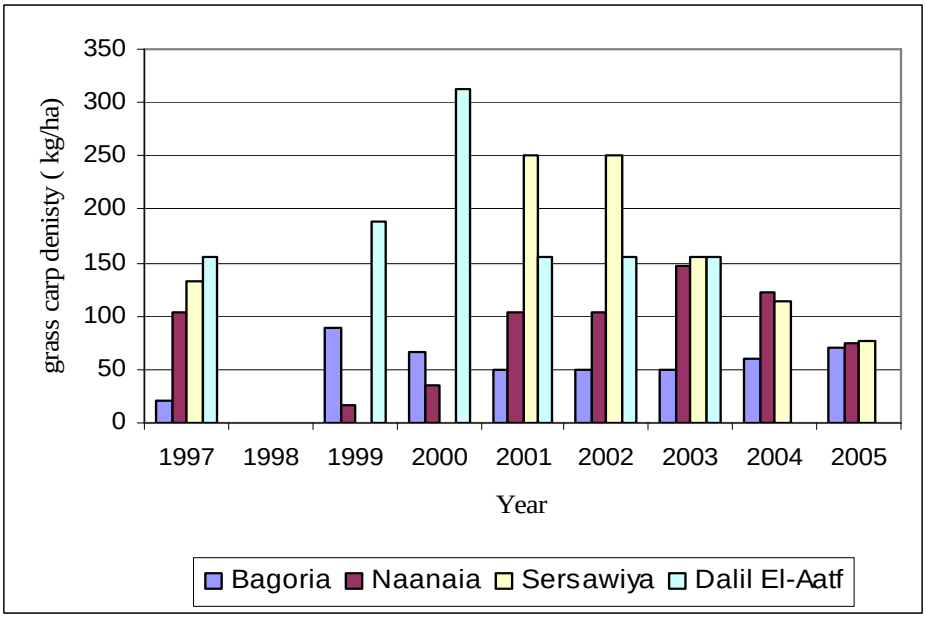

Figure (5): Grass carp density with year for Monoufya District

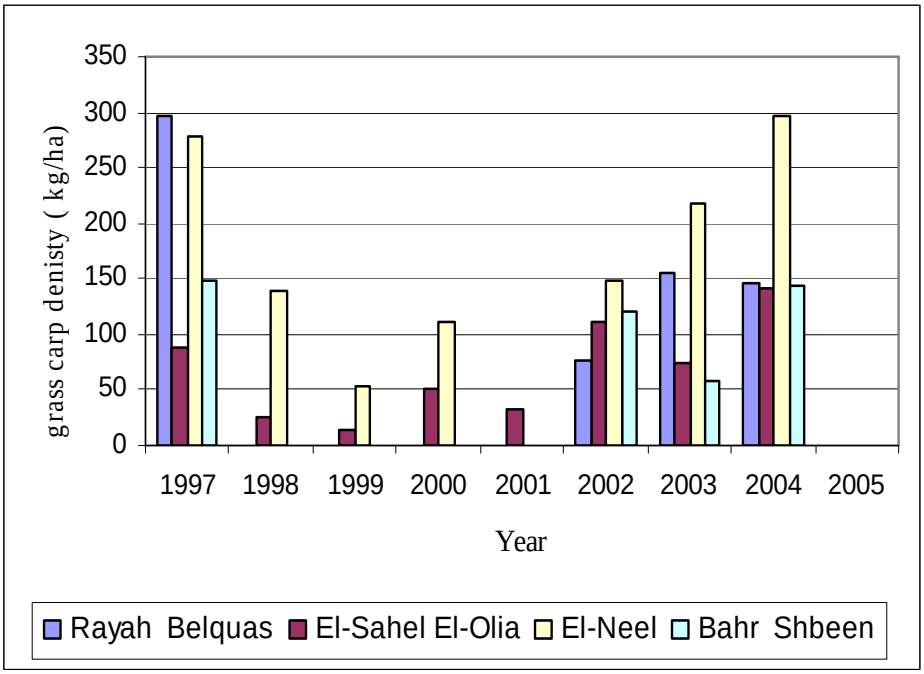

Figure (6): Grass carp density with year for West Dakahlya District

3. Ismailya Irrigation District

Ismailya is the first Irrigation District that has applied the biological control method and a good result was obtained which contribute to apply it on large scale. In this study, Ismailya District was represented in Suez, Port Said, and Manauef canals. It can be shown that the stocking rate appeared to be not sufficient to keep the Suez and Port Said canals clean during the autumn and winter season as shown in Figure (7). However, in Manauef canal, the stocking rate appeared to be sufficiently to keep the canal relatively clean specially the last years.

Excessive nutrients were found in Suez Canal such as phosphorus and nitrogen which are critical for plant growth. Nutrient are cycled in the canal through the process of plant production, decomposition of plant and animal matter through fungi and bacteria, and the ensuring release of nutrients. Some nutrients become part of the bottom sediments, some become available for algae and plant growth, and some stay dissolved in the water column.

A systematic combination of biological and mechanical methods should be the most efficient solution for the Suez and Port Said Canals. Also, it is necessary to increase the amount of fish in the canals in the next years.

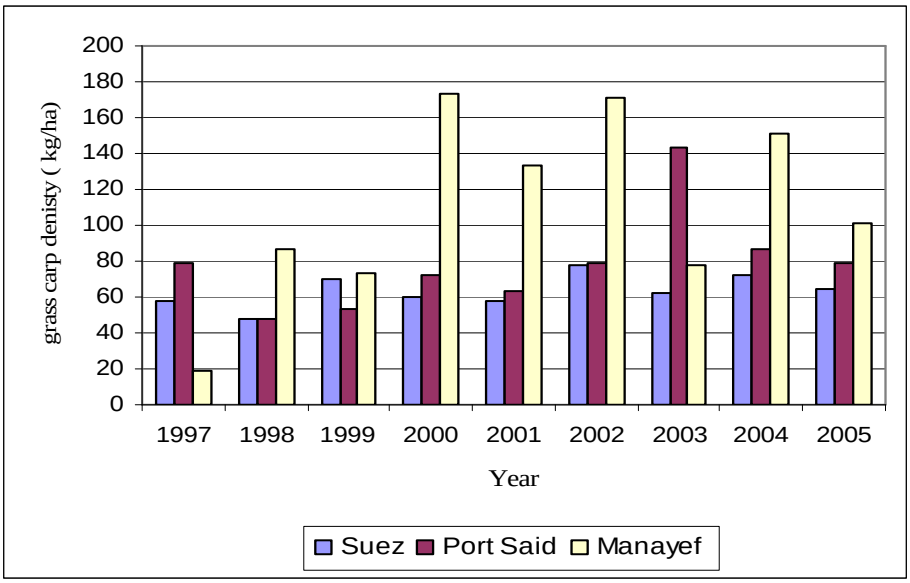

Figure (7): Grass carp density with year for Ismailya District

4. Studied District Summary

From the analysis of the available data, it can be shown that the Qena and Assyout Districts applied the procedure of applying stoking density of Grass carp by estimating the total water surface area of canal. Therefore an acceptable result was obtained to

control weeds. While in Fayoum District, it depends on estimating of the infested water surface area of canals. However in the Monoufya and Dakahlya District in some years reduced the number of grass carp by estimating the infested area, so a problem of aquatic weeds was observed. Ismailya District had weeds problem when the stocking density depend on the estimated of infested area and when the infested area equal to total surface area, acceptable result was obtained. It was concluded that the low stocking rates of grass carp reduced the efficiency of weeds control.

The suggested stocking density of grass carp was depended on experimental study and reduce this density was not recommended. Finally, the infested surface area is not needed to estimate the stocking density of grass carp. However, it may be important to estimate the cost for mechanical control, which is used to clean the selected canals before using grass carp. These may make confusion in estimating the number of grass carp.

Also, biological weed control encourages three problems: escape of fish from the stocked sections, Bayluscide injections by the Ministry of Public Health for bilharzias control, illegal fishing. The recommended rules to apply biological control method by Grass carp must be applied to increase the efficiency of using grass carp to control aquatic weeds.

SUMMARY AND CONCLUSIONS

Evaluation of the application procedure of biological weed control using grass carp was studied on twenty two canals distributed on six Egyptian Irrigation Districts for period from 1997 to 2005. The incorrect application was observed in some canals where the stoking density of grass carp was estimated based on the infested surface area by weeds. However, the stocking density must be estimated based on the total water surface area of the canal. Therefore, decreasing the number of grass carp gave a non-acceptable result to control weeds.

It can be concluded that the grass carp have to be stocked with density not less than 100 kg/ha for average grass weight ranged from 10 to 20 gm to obtain the acceptable result. Decreasing the stocking density may be needed in some special canals, but these canals must be observed to estimate the suitable decreasing amount without any effect on the biological control efficiency. It was also concluded that biological weed control method by grass carp is an effective method, although it does not control the ditch bank weeds and water hyacinths. It was suggested to involve farmers to guard the stoking Grass carp in canals through organizations representing them. Also, the Irrigation District engineers are responsible for guarding the fish in the channels through coordination with health directorates, Fish Resources Authority, police and other concerned parties.

This study showed that the grass carp in combination with mechanical or manual control methods must be used in the season of weeds infestation. Also the canal must

be stoked by the right amount of grass carp. Finally, weed control with grass carp is an effective alternative to control aquatic weeds, when the recommendation procedures were used. Further studies are recommended to evaluate the biological control method using grass carp in many other Egyptian Irrigation Districts.

REFERENCES

1. CMRI (Channel Maintenance Research Institute) (1999), "The Principle of Applying Biological Control in Channels", Technical Report, National Water Research Center, Channel Maintenance Research Institute, Cairo, Egypt.
2. Dubbers, F., Ghoneim, S., Siemeling, M.E., El-gharably, Z., Pieterse, A.H., and Blom, J. E. (1980), " Aquatic Weed Control in Irrigation and Drainage Canal in Egypt by Means of Grass Carp (*Ctenopharyngodon idella*)", Proc. V Int. Symp. Biol. Confr. Weeds, Brisbane, Australia.
3. El-Gharably, Z., Tolba A., Pieterse, A.H., and Druyff, A.H. (1978), "Preliminary Experiments with Grass Carp for the Control of Aquatic Weeds in Egypt", Proc. Eur. Weed Res. Soc., 5th Symp. Aquatic Weeds, Amsterdam, the Netherlands, pp. 369-374.
4. El-Gharably, Z., Khattab, A.F. and F.A.A. Dubbers, 1982. Experience with grass carps for the control of aquatic weeds in irrigation canals in Egypt. Proc. 2nd Int. Symp. on Herbivorous Fish. EWRS Wageningen, the Netherlands, pp. 17-26.
5. Ilaco (International land Development Consultants) (1978), "Aquatic Weeds Control Project", Final Report, 123 p.
6. Ilaco (International Land Development Consultants) (1985), "Final Report, Grass Carp Project in Egypt" Ilaco, Arnhem, the Netherlands.
7. Jahnichen, H. (1974), "Senkung der kosten beider wasserpflanzenbekampfung durch den Amurkarfen (*Ctenopharyngodon idella*)", Z. Binnenfisch. DOR, 21: 85-89.
8. Khattab, A.F., El-Gharably, Z., and Dubbers, F. (1981), "The Grass Carp, A Future Alternative for Control of Aquatic Weeds in the Arab Republic of Egypt", Proc. 4th Afro-Asian Reg. Conf., ICID, Lagos, Nigeria, pp. 215-226.
9. Khattab, A.F. and El-Gharably, Z. (1982), "Some Activities of the Research Institute of Weeds Control and Channel Maintenance", Journal of Egyptian Engrs. Soc., No. 4, Vol. 21, pp. 14-26.
10. Khattab, A.F. and El-Gharably, Z. (1984), "The Problem of Aquatic Weeds in Egypt and Methods of Management", Proc. EWRS 3rd Symp. on weed problems in the Mediterranean Area, Lisbon, Portugal, pp. 335-344.
11. Khattab, A.F. and El-Gharably, Z. (1985), "The Problem of Aquatic Weeds in Egypt and Methods of Management", Cairo, Egypt.
12. Khattab, A.F. and El-Gharably, Z. (1986), "Management of Aquatic Weeds in Irrigation System with Special Reference to the Problem in Egypt", 7th Int. Symp. on Aquatic Weeds, Louborough, U.K., pp. 199-206.
13. Khattab, A.F. and El-Gharably, Z. (1987), "Problems of Aquatic Weeds in Irrigation Systems and Methods of Management", 6th Afro-Asian Regional Conference, ICID, Cairo, Egypt.

14. Khattab, A.F. (1993), "Problem of Aquatic Weeds in Egypt after Construction of High Dam", ICOLD, 61st Executive Meeting, Cairo, Egypt.
15. Kishan, R., Kumor, M., Chandi, J., and Kumor, R. (1997) “Control of Aquatic Vegetation in Reservoirs and Canals by *Ctenopharyngdon Idella* (Grass Carp)”, 2nd International R and D Conference, 1997, Vadodara, India.
16. Mashaly, I.A., El-Halawany, E.F. and Omar, G. (2001), Vegetation analysis along irrigation and drain canals in Damietta province, Egypt. Journal of Biological Science 1(12): 1183-1189.
17. National Academy of Sciences (1976), “Making Aquatic Weeds Useful: Some Perspectives for Developing Countries”, Washington, 175 pp.
18. Salah El-Deen, M.A. (1995), “Biocontrol Agents of Aquatic Weeds”, Water Science Journal, 18th Issue, National Water Research Center, Egypt, pp. 18-23.
19. Scott, B. and Bukley, B.R. (1978), “Costs for Controlling Aquatic Weeds with Grass Carp”, Proc. EWRS 5th Symp. Aquatic Weeds, Amsterdam, Netherlands, pp. 253-260.
20. Van Zon, J.C.J. Van (1978), “Status of Biotic Agents, Other than Insects or Pathogens, as Biocontrols”, Proc. IV Int. Symp. Bio-Contr. Weeds, Gainesville, Floridn, pp. 245-250.
21. Van Zon, J.C.J. Van (1979), “The use of grass carp in comparison with other aquatic weed control methods”, Proc. Grass Carp Conference, Gainesville, pp. 15-24.
22. Van Zon, J.C.J. Van (1981), “Status of the Use of Grass Carp (*Ctenopharyngodon idella* Val.)”. Proc. V. Int. Symp. Biol. Contr. Weeds, Brisbane, Australia.