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Derleme / *Review*

The status of grass carp (*Ctenopharyngodon idella*, Valenciennes 1844) in Turkey

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Summary: The grass carp (*Ctenopharyngodon idella*, Val. 1844) among other Chinese carps has been receiving worldwide attention as a biological control agent for aquatic vegetation and as a source of food. The benefits of using grass carp for plant control include its long term effects, constant feeding activity on invasive macrophytes, low long term costs and the potential for conversion of weed biomass to fish protein. The grass carp was first introduced outside its native area for aquaculture and aquatic management purposes after 1945 and in Turkey after 1972. In this paper, it is my aim to provide some information on different studies relating to grass carp introduction in Turkey and explain in their introduction the factors that inhibit and encourage its development and give some suggestions supported by related literature.

Key words: Biological control, feeding, grass carp, reproduction, Turkey

Ot sazanının (*Ctenopharyngodon idella*, Valenciennes 1844) Türkiye'deki durumu

Özet: Ot sazanı diğer Çin sazanları içinde su bitkilerinin mücadelesinde biyolojik kontrol ajanı ve besin kaynağı olarak dikkat çekmektedir. Ot sazanını su bitkileri mücadelesinde kullanımının faydaları, sabit beslenme aktivitesi ile su bitkileri üzerindeki etkilerinin uzun süreli olması, uzun dönemde maliyetin düşük olması ve bitki biyomasını hayvansal proteine çevirme potansiyelidir. Ot sazanı yerel alanı dışına 1945 yılından sonra akvakültür ve su yönetimi amaçlarıyla tanıtılmış, ülkemize ise 1972 yılından sonra getirilmiştir. Bu çalışmada, ot sazanının ülkemizdeki tanıtımına ilişkin değişik çalışmaların ve tanıtımlarındaki sınırlayıcı ve teşvik edici faktörlerin ortaya konması ve ilgili literatürlere dayanarak bazı önerilerin verilmesi amaçlanmıştır.

Anahtar sözcükler: Besleme, biyolojik kontrol, ot sazanı, Türkiye, üreme.

Introduction

Grass carp are native to the large river systems of eastern Asia, from the Amur River on the Russian-Chinese border southward and has been diffused mainly for culture and aquatic vegetation control to other regions such as Asia and North America and virtually all of Europe since 1945 (19, 22, 24).

Grass carp was introduced in Turkey from Romania by the General Directorate of State Hydraulic Works in 1972. Initially, the necessary investigations were not done on a continual basis. After the determination of the side effects of chemical aquatic plant control in the 1980s, public attention was oriented towards grass carp as a biological control agent of aquatic plants rather than using it as food. This paper, various studies were reported related to grass carp done since 1972 in Turkey, aims to provide some information relating to the introduction of grass carp, explain in their introduction the factors that inhibit and encourage its development and give some suggestions supported by related literature.

Adaptation studies

Sixteen investigations were carried out by the General Directorate of State Hydraulic Works between 1972 and 1994 to measure the ability of grass carp to serve as a biological agent: five in fish ponds, nine in irrigation and drainage channels and two in natural lakes. According to (1), good results were obtained in fish ponds within seven months. In irrigation and drainage channels, the fish couldn't be maintained, while in natural lakes, the grass carp stocked were not of suitable size for biological control and the experiments weren't successful (1).

Reproduction studies

Artificial reproduction of grass carp has been carried out successfully since 1972 in hatcheries of the General Directorate of State Hydraulic Works located in different regions of the country in order to stock grass carp to the reservoirs built by this foundation in Turkey. An investigation was conducted a reproduction study to prepare a data base for further studies on the reproduction of grass carp under artificial conditions (10). In the study, the amount of stripped eggs, the volume of stripped sperm, the fertilization rate, and the hatching rate were determined. These were similiar to the results of reproduction studies of grass carp in other countries (9, 24, 28, 29).

Feeding experiments

There was a certain amount of information available in the literature on the feeding of grass carp (2, 7, 10, 25, 30).

In our feeding experiment, in order to raise the carp to a size that could be utilized for biological control, larvae were fed with starter feed including 51% raw protein for the first 9 days and then with feed including 43% raw protein for the following 14 days in the first experimental group while zooplankton as a natural food was given to the second experimental group. The growth of larvae was superior with the starter feed including 51% raw protein to the diet of natural food in the first nine days of the experiment tank condition (13). When these results were compared with studies in earthen ponds, it was observed that the growth parameters were better in these ponds (9) because of the limitless feeding ability of larvae and the higher abundance of natural food in ponds than in the tanks.

In the fry feeding experiment, the raw protein contents of the feeds were 20%, 37% and 43% in the experimental groups, respectively. The best growth was observed among the experimental groups that were fed with the feed highest in raw protein (13). Although grass carp consume macrophytes comprised of about 20% raw protein in ponds, reservoirs etc, in tank conditions they consumed feeds with 43% raw protein and showed better growth parameters when compared to feed with lower protein content. Grass carp fry culturing is important to bring them to a size at which they can avoid predation so that they can be used at in biological control studies in shortest possible period rather than utilized as a food resource; thus different feeding regime investigations should be encouraged for grass carp fry.

Food preference

There is some disagreement as to the length of time over which grass carp fry consume zooplankton and benthic organisms. It has been reported that the transition from animal to plant food occured at age 36-40 days and at about 50 mm in length (24, 30). It was indicated that grass carp reached a length of 4.83±0.09 cm in the seventh week, similiar duration to that in the literature and filamentous algae were replaced by macrophyte fragments. Besides the macrophytes, animal material such as the rotifers *Monostyla* and *Lecane* and the cladoceran *Bosmina* were found, and the proportion of animal material in the gut varied between 11 and 28% from week two to the end of the investigation (17). This shows that while feeding on macrophytes, grass carp ingest all the living organisms in the pond, associated with plants, including rotifers (18), oligochaetes, chironomid larvae and other aquatic organisms.In the same pond, the decrease of phytoplankton biomass from the first week of the experiment was attributed to the feeding activity and food preference of two week old grass carp. When the food preference of grass carp changed to macrophyte, phytoplankton biomass increased in the pond (8).

Utilization of grass carp in biological control

The potential of grass carp as a weed control agent is more substantial than its suitability as an aquaculture species. Grass carp were used successfully in waterways of Netherlands to remove vegetation at 250 kg/ha stocking rates. Complete vegetation removal was undesirable in those channels not to cause drift of bottom materials and bank erosion when the fishes graze (31). Grass carp introductions at Red Haw Lake in Iowa resulted in a decrease of aquatic macrophytes from 2,438 g/m^2 in 1973 to 211 g/ m^2 in 1976, with species of Potamogeton, Elodea, Ceratophyllum and Najas all control effectively by grass carp (23). It was dedicated for Florida Lakes that rates of 50 to 638 grass carp per hectare have been found to provide effective control of problematic *Hydrilla* (33).

By consuming plants, phosphorus as a nutrient withdrawn from systems by grass carp. Grass carp retain 50- 90% of this phosphorus in their flesh (5,21). It was reported that phosphorus retention by grass carp was estimated 74.4% and the results of this experiment supported the idea that the utilization of grass carp might be an effective method removing phosphorus from aquatic systems (14).

The grass carp’s feeding activity is mainly dependent upon water temperature. Therefore, water temperature must be considered. For a successful biological control with grass carp, water temperature should exceed 20^{o}C. It was reported in the study on grass carp that when the water temperature in a pond reached 24 ^{o}C, there was a sharp decrease in vegetation and *Myriophyllum verticulatum, M. spicatum, Chara fragilis, Carex curvula, Potamogeton natans, P. nodosus, Ceratophyllum demersum, C.submersum, Nasturtium aquaticum* were completely eliminated. At the end of the experiment only plants with hard tissue that couldn’t be consumed by grass carp remained in the pond (3).

Grass carp can consume plants at higher temperatures that they can’t consume at lower temperatures. (19) stocked grass carp at different ratios in earthen ponds. In the ponds, the lowest water temperature was about 20^{o}C and the highest was measured at 25.5^{o}C. *Cladophora* and *Zygnema* species of aquatic plants were consumed by grass carp in the first month of the experiment; however, *Chara* was eliminated completely when the water temperature reached its highest value, 25.5°C. At the end of the stocking period, *Phragmites* was the only plant not consumed by the grass carp. In an other study conducted by the same researchers (20) in a spring originated pond that had the same water quality features as in the previous study, the water temperature reached a maximum of 23°C. While *Potamogeton pectinatus*, *Ceratophyllum submersum* and *Lemna trisulca* were preferred primarily by grass carp and disappeared in the pond, filamentous algae, *Cladophora* sp., *Zygnema* sp. and *Spirogyra* sp. decreased but did not disappear. This shows grass carp palatability changes as temperature increases. At higher temperatures they will consume plants that were not consumed at lower temperatures (24).

The effects of grass carp on the aquatic environment

In the countries where the introduction of grass carp has carried out in large water systems such as lakes and channels, some notifications related to their indirect impacts on fish populations because of vegetation removal were declareted. It was reported that reduction of vegetative hiding places maked small fish such as *Gambusia* spp. and fry vulnerable to piscivorous and a decline occured in some fish populations because the removal of vegetation on which these species deposited eggs (34). Besides these, polyculture with grass carp has been reported to enhance production of cyprinids (35). In Turkey, grass carp were introduced to small water bodies such as ponds and irrigation pools, the effects on the other fish hasn't been studied yet.

Some studies have been designed to obtain more field information on the effects of grass carp on aquatic environments by comparing some water quality parameters, phytoplankton, zooplankton and benthos in various ponds with and without grass carp in Turkey (15, 18, 19, 20).

The size of the body of water stocked, hydrology, natural nutrient relationships, the amount of vegetation removed and the climate created some difficulties for evaluating the effects of grass carp on water quality (24). Water quality changes may occur because of nutrient release from broken stems, the decay of uneaten plants and decaying feces. It was reported that the lowest values of nitrite-nitrogen, nitrate-nitrogen, and total phosphate were measured in the pond without grass carp (19). However, grass carp stocking didn't change oxygen values, after macrophyte removal, oxygen levels were maintained by increases in phytoplankton (15, 19, 20, 24).

Nutrient release can cause an increase in phytoplankton. Although it was reported that phytoplankton increase doesn't occur in all cases (5,15,19) were observed that phytoplankton abundance was encouraged by grass carp after consuming macrophytes. However, the lowest values of phytoplankton abundance and chlorophyll *a* concentration were found in the pond with highest stocking rate of grass carp. This could be explained by the high abundance of zooplankton and benthic fauna in this pond On the contrary, phytoplankton abundance and chlorophyll *a* concentration were found at higher rates inside the cage without grass carp than in the pond, whereas zooplankton and benthic fauna were found at higher rates in the pond than in the cage (20).

In the ponds with grass carp zooplankton abundance was affected by an increase in nutrients and phytoplankton after the elimination of vegetation. Zooplankton composition was dominated by rotifers and also partially composed of small cladocerans (15, 19, 20). It was also reported that vegetated habitats support diverse zooplankton populations, represented by species inhabiting the littoral zone. When the vegetation is removed, the zooplankton community shifts to more pelagic forms (32). Benthic fauna was also affected by vegetation removal. It was reported that benthic fauna abundance increased by 2 to 3 times in ponds with grass carp in comparison to the control pond without fish. Thus elimination of vegetation by grass carp caused an increase in benthic fauna growth (19).

The possible effects of grass carp on the ecosystem are complex and depend upon the stocking rate, the size of fish stocked, macrophyte abundance, the size of the system and the complexity of the ecosystem (24).

Stress response and diseases

In an experimental study, the tolerance of grass carp to salinity was also investigated by assessing the levels of hematocrit, leucocrit, plasma, glucose, sodium, potassium and calcium (36). It was determined that grass carp have the ability to survive at a salinity of 10‰. This may mean that the fish could migrate from one river system to another by passing through an estuary and grass carp can, naturally, control the vegetation in estuaries. Broader and more long-term studies related to salinity are necessary.

When grass carp is introduced to a new location, it may not be immune to indigenous parasites and infectious diseases. Therefore, it can easily be infected by local pathogens and may suffer heavy losses (9,27). However, worldwide introduction of grass carp also enhanced the possibility of the spread of fish diseases and parasites. Most of the diseases and parasites of grass carp have been reported from culture conditions because of high stocking densities, enriched waters and stress stimulate pathogens (12, 31).

Viruses (*Rhabdovirus* sp.), fungi (*Saprolegnia* spp.) and bacterium (*Aeromonas salmonicida, Myxococcus piscicola*) cause considerable debilitations and mortality in grass carp culture. Over forty species of parasitic protozoa are reported from grass carp and over twenty trematodes, about five cestods and a few nematods have been found in grass carp. The cestode, *Bothriocephalus* *gowkongensis* represents the major parasitic introduction from far east to have serious effects on other fish and has caused extensive losses in European common carp culture. (4, 12, 24, 31). The parasites which will find conditions suitable for developing or where intermediate hosts occur, are able to survive. Although no precautionary measures were taken after grass carp introduction in Florida, no exotic parasites were identified (27)

In the culture conditions of grass carp in Turkey, some disease problems occured causing a high level of mortality (16). With two month old fry fed with alfa-alfa in out-door conditions, bacterial disease and some ectoparasites such as *Trichodina* sp., *Dactylogyrous* sp. and *Chilodonella* sp. occured. The mortality rate reached 70%. After this outbreak the remaining healthy population was transferred to in-door conditions for better control. Following this transfer, an ectoparasite identified as *Ichthyophthirius multifiliis* caused a high mortality rate of 80%. Additionally, one-year-old grass carp fed with supplemental commercial feed in earthen ponds were examined for endoparasites. The cestods, *Ligula intestinalis* and dominantly *Bothriocephalus gowkongensis* existed in the abdominal cavity. In one-year-old grass carp the mortality rate was low, although growth was impaired. Therefore, the introduction of grass carp is best accomplished with fry reared artificially and without contact with the spawners. With this method, the danger of importing undesirable pathogenic agents is almost excluded. Good sanitation can give the fish health-protection, so optimal water temperature can be a quarantine for grass carp (4, 12, 24).

Conclusions

The current position with regard to grass carp in Turkey can be summarized as follows;

1. The utilization of grass carp is under the control by the State of Water Resources Foundation and grass carp has been introduced to the water bodies such as reservoirs and irrigation ponds. Also grass carp is delivered by this foundation to the relevant departments of universities for experimental studies. Since 1972, no records have been kept regarding its natural spawning in Turkish water bodies.

2. Grass carp seems to be potentially useful for successful aquatic plants control. However, studies should be continued in the long term (more than one year) and also the effects of grass carp on native and other fish, such as vegetation spawners in the water bodies should be investigated. Besides this, the use of grass carp in biological control can be investigated with the combination of other aquatic plant control methods (chemical and mechanical).

3. One problem of grass carp is its removal from water bodies by local residents without any control. This problem causes failure in the sustainability of biological control in some water bodies. Some precautions should be taken to limit fishing.

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