The Feeding Preferences of Grass Carp (Ctenopharyngodon idella Val.) For Ten Aquatic Plants

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Abstract

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Introduction
Emergent, submerged, free-floating and floating-leaved macrophytic plants are common and integral component of many ponds and lakes. Excessive growth of aquatic weeds causes numerous problems in Iranian freshwater systems (Filizadeh, 1996). These weeds interfere with agricultural irrigation, restrict recreation, reduce fish harvest and have detrimental effects on fish populations, interferes with recreational activities, and causes water quality to deteriorate (Allen and Wattendorf, 1987). The problems are particularly acute in the shallow, warm environments of farm ponds during the summer months (Miller and Decell, 1984). The macrophyte cover of Iranian freshwater system is generally dominated by ten species, Lemna minor, Chara sp, Najas guadalupensis, Hydrilla verticillata, Potamogeton pectinatus, P. perfoliatus, P. crispus, Azolla filiculoides, Ceratophyllum demersum, and Myriophyllum spicatum. These plants and filamentous algae were indicated as the most troublesome weeds in a recent national inquiry to water managers.

Mechanical removal of plants such as hand harvesting, weed cutters, chaining and raking, the only weed control method extensively used in Iran, is often labor expensive and costly. Mechanical method is generally ineffective because fragments of all major weeds form new shoots and roots, and reinfestation rapidly occur (Mitchell, 1980; Opuszynski, 1972). Chemical treatments are also expensive and can directly or indirectly harm other aquatic life and water quality; despite a good experimental results were obtained against Azolla filiculoides and Typha latifolia (Catarino, et al. 1997). However submerged weeds such as Potamogeton pectinatus, P. crispus, Ceratophyllum demersum, and Myriophyllum spicatum the species presenting the largest weed problems, showed weak response to several herbicides such as diquat, paraquat and glyphosate (Zweerde, 1990). Some experimental results of aquatic weeds control by grass carp in irrigation canals, ditches, drinage channel and fish ponds are available (Fowler and Robson, 1978; Opuszynski, 1972; Pine and
Anderson, 1991). Although it has been reported that grass carp prefers filamentous algae and duckweed to macrophytes, there are little published data on the feeding preferences of the species for macrophytes (Swanson and Bergersen, 1988).

Iranian freshwater systems have favourable water temperature (12-32 ºC) for grass carp suitable for the maintenance of feeding throughout most of the year. Also grass carp are highly tolerant to adverse limnetic conditions such as low oxygen, high salinity and chemical hazards (Catarino, et al. 1997).

The composition and relative abundance of the existing plant assemblages are important in determining the control efficacy, the most favourable stocking rates and potential changes in local vegetation. The objective of this study was to determine the feeding preferences of grass carp for *Lemna minor*, *Chara* sp, *Najas guadalupensis*, *Hydrilla verticillata*, *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum*, and *Myriophyllum spicatum*. The results were used in conjunction with data from a field study to determine the effectiveness of *Ctenopharyngodon idella* as a biological vegetation control agent.

### Materials and Methods

The feeding preferences of grass carp for *Lemna minor*, *Chara* sp, *Najas guadalupensis*, *Hydrilla verticillata*, *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum*, and *Myriophyllum spicatum* were tested in two replicated experiments.

#### Fiberglass tank experiment:

Twelve 2500 l fiberglass tanks (200 cm long, 110 cm wide, 115 cm water depth), placed outdoor at Guilan Research and Training Fishery, Bandar-Anzali, Iran, in 2000 and 2001. The water in the tanks were aerated by air pump, warmed to 25 ± 0.5 ºC, and had an open circuit water exchange system that completely replaced the water volume every 24 hours. Preference trials were conducted in June 2000 and July 2001 using grass carp with an average weight of 55 grams (SD, 10.5 g). Each individual fish was used in only one feeding trial. New fishes were used in each replication. Four tanks were used as replicates. Mature plants for fiberglass experiment were collected daily from Anzali lagoon. In each trial at duration of 168 hours, the experimental plants, previously weighted, were placed in the fish tanks. By the end of first day, if any plants were nearly or totally consumed, additional plants were added. At the end of test period, all uneaten plants and plant fragments were removed and weighted to determine the amount ingested.

There was plant growth in the test fiberglass tanks during the 196 hours of experiment. No grass carp mortality occurred during the experiment. Temperature (ºC), water pH, conductivity and dissolved oxygen were measured daily in experimental tanks.

#### Pond experiment:

To assess the potential of grass carp to consume the aquatic weeds an additional experiment was conducted in the Shahid Ansari Research Station, Rasht, Iran during June 2000 and July 2001. This experiment took place in 90 days. Experimental ponds were covered by natural vegetation such as *Chara* sp, *Najas guadalupensis*, *Hydrilla verticillata*, *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *P. natans*, *Azolla filiculoides*, *Ceratophyllum demersum*, and *Myriophyllum spicatum*. Grass carp with an average weight of 60 grams were transferred to two small fish ponds (18m length, 10m width, 2.5m water depth). Each pond was divided in two parts by a plastic net, providing four replicates, and preventing the passage of grass carp. Stock rate in each part was 18 grass carp. A third pond, without grass carp acted as control, with two replicates. At the end of experiment, total and individual plant
cover in each half pond were measured and compared with controls. Also, grass carp were weighted at the end of experiment.
In both experiments data were analyzed for treatment effects by standard ANOVA procedures with subsequent use of Tukey's Least Significant Difference test (Little and Hills, 1978) to separate means.

**Results and Discussions**
The mean of water quality parameters in the tank and pond were water temperature 25 °C, pH 7.7, dissolved oxygen 8.9 mg l⁻¹ and conductivity 435 µS cm⁻¹.
During the two years of the experiments in the fiberglass tanks, grass carp showed generally small growth rate, although an increase occurred after carp release within pond with values above 0.65% per day. Grass carp growth rate are strongly dependent on several factors such as the quantity and nutritional value of plant food, the salinity, age and density of carp population, size location, temperature and the dissolved oxygen in the water. The high carp densities used in pond experiment and the typed of food were likely responsible for the reduce growth rates.
In tank experiment, a mean consumption of *Lemna minor* (504 g), *Chara sp* (485 g), *Najas guadalupensis* (480 g) and *Hydrilla verticillata* (473 g) at 168 hours were not significantly different and have eaten significantly greater quantities than any other plant (Table 1). Preference declined significantly (P<0.05) for consumption of *Potamogeton pectinatus* (155 g), *P. perfoliatus* (146 g) *P. crispus* (135 g), *Azolla filiculoides* (128 g), *Ceratophyllum demersum* (109 g) and *Myriophyllum spicatum* (85 g) respectively. At the end of experiment in tank conditions, grass carp fed on nearly all parts of *Lemna minor*, *Chara sp*, *Najas guadalupensis* and *Hydrilla verticillata*. However the soft and tender plant tissue such as young leaves of *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum* and *Myriophyllum spicatum* were preferred.

**Table 1. Mean consumption of ten macrophytic plants by grass carp (Ctenopharyngodon idella) in tank conditions at duration of 196 hours.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Mean consumption (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lemna minor</em></td>
<td>504-a</td>
</tr>
<tr>
<td><em>Chara sp</em></td>
<td>485-a</td>
</tr>
<tr>
<td><em>Najas guadalupensis</em></td>
<td>480-a</td>
</tr>
<tr>
<td><em>Hydrilla verticillata</em></td>
<td>473-a</td>
</tr>
<tr>
<td><em>Potamogeton pectinatus</em></td>
<td>155-b</td>
</tr>
<tr>
<td><em>P. perfoliatus</em></td>
<td>146-b</td>
</tr>
<tr>
<td><em>P. crispus</em></td>
<td>135-b</td>
</tr>
<tr>
<td><em>Azolla filiculoides</em></td>
<td>128-bc</td>
</tr>
<tr>
<td><em>Ceratophyllum demersum</em></td>
<td>109-c</td>
</tr>
<tr>
<td><em>Myriophyllum spicatum</em></td>
<td>85-c</td>
</tr>
</tbody>
</table>

*Means with a common superscript were not significantly different at P<0.05 as determined by Tukey’s Least Significant Difference test to separate means.

The variation of plant biomass and cover in the ponds are presented in Table 2. At the end of experiment, the total vegetation cover was significantly higher in the control pond (P<0.05). *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum*, and *Myriophyllum spicatum* cover and weight in the trail ponds were no different from the control. These results suggested that grass carp with the average weight of 60 grams did not eat properly these species. The final biomass and cover of *Lemna minor*, *Chara sp*, *Najas guadalupensis* and *Hydrilla verticillata* showed a great difference between test and control ponds (P<0.05).
Table 2. Mean biomass (kg m$^{-2}$) and cover (%) of experimental macrophytes at the beginning and the end of pond experiments with grass carp (*Ctenopharyngodon idella*).

<table>
<thead>
<tr>
<th>Species</th>
<th>Beginning (Control)</th>
<th>Final (Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biomass (kg m$^{-2}$)</td>
<td>Cover (%)</td>
</tr>
<tr>
<td><em>Lemna minor</em></td>
<td>0.12</td>
<td>6</td>
</tr>
<tr>
<td><em>Chara sp.</em></td>
<td>0.105</td>
<td>8</td>
</tr>
<tr>
<td><em>Najas guadalupensis</em></td>
<td>0.346</td>
<td>11</td>
</tr>
<tr>
<td><em>Hydrilla verticillata</em></td>
<td>0.146</td>
<td>9</td>
</tr>
<tr>
<td><em>Potamogeton pectinatus</em></td>
<td>0.189</td>
<td>8</td>
</tr>
<tr>
<td><em>P. perfoliatus</em></td>
<td>0.445</td>
<td>11</td>
</tr>
<tr>
<td><em>P. crispus</em></td>
<td>0.505</td>
<td>13</td>
</tr>
<tr>
<td><em>Azolla filiculoides</em></td>
<td>0.235</td>
<td>7</td>
</tr>
<tr>
<td><em>Ceratophyllum demersum</em></td>
<td>0.40</td>
<td>11</td>
</tr>
<tr>
<td><em>Myriophyllum spicatum</em></td>
<td>0.245</td>
<td>8</td>
</tr>
</tbody>
</table>

Several researches had showed the types of macrophytes preferred by grass carp (Cross, 1969; George, 1983; Pine and Anderson, 1988). However, large variations of food preference can occur, when pond or field conditions are used (Fowler and Robson, 1978; Mitchell 1980; Zweerde, 1990).

Results showed that smaller fish had selected softer plant tissue and youngest plants, while bigger fish eat a wide variety of tough and fibrous plants. *Lemna minor*, *Chara* sp, *Najas guadalupensis* and *Hydrilla verticillata* had shown as preferred whilst *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum* and *Myriophyllum spicatum* are generally avoided.

Despite variety results which showed a large variation, from 100 percent body weight and more to as low as 1%, daily consumption rates of grass carp for the *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum* and *Myriophyllum spicatum* were relatively low (Bonar et al. 1990; Cai and Curtis, 1989). Some studies showed that the rate of grass carp consumption and its growth, are related to the nutritive value of the plants, such as the gross energy content of the diet (Cassani and Caton, 1983, 1986; Bonar et al. 1990; Cai and Curtis, 1989). The rate of calcium and cellulose in macrophyte tissue were the best predictors of consumption rates and palatability.

Data on macrophyte consumption in the tank experiment was in close agreement with the results of a pond study in which grass carp was tested as a biological agent for vegetation control. Agreement with Duthu and Kilgen (1975), results showed that *Lemna minor*, *Chara* sp, *Najas guadalupensis* and *Hydrilla verticillata* were controlled successfully, while *Potamogeton pectinatus*, *P. perfoliatus*, *P. crispus*, *Azolla filiculoides*, *Ceratophyllum demersum* and *Myriophyllum spicatum* persisted in the test ponds throughout the study.

Results obtained indicate that grass carp can effectively control the aquatic weeds of Iranian fresh water systems. Although, grass carp will preferably consume some beneficial native plants (Dekozlowski, 1994; Kirk and et al. 1996). Water managers and farmers must be practiced caution to choose this type of weed control to avoid the escape of carp in non-target areas to feed on native plants, which may favor the spread of undesirable species. In many Iranian fresh water systems, wetlands and natural rivers, the native plant community *Lemna minor*, *Chara* sp, *Najas guadalupensis*, *Hydrilla verticillata* and *P. natans* already being substituted by exotic plants such as *Azolla filiculoides*, *Potamogeton pectinatus*, *P. crispus*, *Ceratophyllum demersum* and *Myriophyllum spicatum* (Filizadeh, 1996). The feeding of
grass carp if enhance for the indigenous plants, decreasing the plant diversity of these ecosystems will occurs (Santha and et al. 1991; Schramm and Jirka, 1986).

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