Utilization of Grass Carp (Ctenopharyngodon idella) for Inhibition of Hyacinth (Eichhornia crassipes) Population Blooming

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Abstract: The rapid growth of water hyacinth in Cirata Reservoir becomes an issue that must be addressed, because of disrupting the function of the reservoir as a power plant. Research on reduction of water hyacinth population using grass carp was performed on floating net in Cirata Reservoir, West Java, Indonesia. The number of fish stocked was 30 fishes per nets, fish average weight of 100 g/fish, 150 g/fish and 200 g/fish as treatment. Each treatment was triplicates. Hyacinth (root length of 10-15 cm and 10-15 cm height) was placed in the transect (1 x 1 m) made from PVC pipe. As much as 8000 g hyacinth was introduced in each transect. This introduction was repeated every week. Experiment lasted 4 weeks. The highest percentage of hyacinth biomass reduction (86.8 – 88.4 %) occurred on treatment of 30 fishes (size 200 g/fish). However, 100 g/fish was recommended for controlling the blooming of water hyacinth. The choice of 100 g/fish is based on the highest feeding rate (31.5-35.2%). However, since there is no regulation yet for the introduction of grass carp to the open water in Indonesia, the usage of this fish for biocontrol of aquatic weed has not yet been legally allowed.

Key words: Grass Carp • Cirata • Eichhornia crassipes • Floating Cage Culture

INTRODUCTION

Cirata is one of reservoirs in West Java that utilizes water flow of Citarum River as hydroelectric plants. People living around Cirata rely on reservoir water as a source of livelihood, one of which is fish culture in floating net cages.

Household waste (Domestic), industrial wastes and agricultural activities and fishery waste flowing into Citarum River, West Java, Indonesia, can degrade water quality leading to reservoir ecosystem balance disturbance. Disruption of the balance of the reservoirs ecosystem brings about decreased productivity and reduces the usability of the reservoir (i.e. fish culture) characterized by the incidence of fish mass death. In addition, it can also cause eutrophication (Excessive nutrient enrichment), which triggers the rapid growth of algae or aquatic weeds (i.e.water hyacinth).

Water hyacinth population explosion becomes a problem that has to be solved in Cirata. The existence of excessive water hyacinth populations creates problems and losses in reservoirs such as silting, blockage of irrigation canals, water transport disruption, decreasing the yield of fisheries, interfering with the operation of power plants and lower reservoir aesthetic value.

The research aimed to control the population explosion of water hyacinth (Eichhornia crassipes) in Cirata by using grass carp (Ctenopharyngodon idella) in a floating cage culture.

Grass carp have been an effective management tool for removing aquatic vegetation in many countries around the world [1]. Most grass carp introductions are aimed at reducing, not eliminating weeds. Some plant lives are essential to permit maintenance of a balanced aquatic ecosystem. Over grazing by grass carp can encourage the predominance of inedible plant species including filamentous algae [2].

Fish have been important in aquatic weed control. Triploid sterile grass carp has become the fish of choice for several weeds. Naiad, fanwort, hydrilla, coontail,
various pondweeds, bladderwort, elodea and chara are plant species usually controlled with the triploid sterile grass carp. Plants that are not preferred by the grass carp and, therefore, are not controlled very well include emergent tough or woody stem species such as cattail, water lily and rush. Filamentous algae, water milfoil, Nitella and water shield are not controlled very well [3].

**Eichhornia Crassipes:** The water hyacinth (*Eichhornia crassipes* [Mart. Solm.] originated from Brazil and has spread out to many subtropical and tropical countries. Water hyacinth first entered Indonesia in 1894 in Bogor Botanical Garden as an ornamental plant.

This plant has short-trunked plant, diameter of 1-2.5 cm, 1-30 cm long and 5-25 cm wide. Water hyacinth does not branch and hairless, root length 0.3-0.5 m. Water hyacinth growing in water rich in nutrients will have long petiole (Stem) up to >100 cm short roots (<20 cm). Meanwhile, water hyacinth growing on nutrient-poor water, petiole length <20 cm, but the root >60 cm [4].

This aquatic plant reproduce generative and vegetative ways. New plants can be produced from seeds or they represent clones derived from stolon elongation due to division of auxiliary meristems of mother plant [5]. Under normal conditions water hyacinth can cover the water surface of 10 kg/m² wet weight, reach maximum density of 50 kg/m² wet weight [6]. Moreover, if the roots have stuck to the substrate, the hyacinth will grow permanently, so that the process silting will go faster. The water hyacinth plants require nutrients and sunlight in its growth, which can cause food competition with phytoplankton and will result in reduced phytoplankton populations, so that water productivity decline.

**Grass Carp (Ctenopharyngodon idella):** Grass carp (*Ctenopharyngodon idella*) is a Chinese carp spread across many countries, both in cold climates or in the tropics. It is almost completely herbivorous [7]. Grass carp was introduced to Indonesia (Sumatra) in 1915 and in 1949 brought to Java for the purpose of cultivation. Grass carp can grow bigger and faster, but can not spawn naturally in Indonesian waters [8].

**MATERIAL AND METHODS**

The research was performed in Cirata Reservoir, West Java, Indonesia, using floating cage, constructed from HDPE (High density polyethylene). Adaptation of grass carp lasted for 7 days before use. The number of fish stocked was 30 fishes per treatment, fish average weight of 100 g/fish, 150 g/fish and 200 g/fish as treatment with three replications. As much as 8000 g hyacinth (Root length of 10-15 cm and 10-15 cm leaf height) was introduced in each treatment. Those hyacinth were placed in a transect (1 x 1 m) made from PVC pipe. They covered the whole area of transect. This hyacinth introduction in each treatment was repeated every week in order to bring back the transect with 100% hyacinth coverage. Experiment was conducted for 4 weeks. Biomass weight was calculated by the following equation.

\[ \sum F = B_t - B_{t+1} \]

Where:
- \( \sum F \) = Biomass of hyacinth consumed by grass carp (g)
- \( B_t \) = Biomass of hyacinth within transect at week t (g)
- \( B_{t+1} \) = Biomass of hyacinth within transect at week t+1 (g)

Biomass percentage change of hyacinth at transect was calculated by the following equation.

\[ \% Br = \frac{B_t - B_{t+1}}{B_t} \times 100\% \]

Where:
- \( \% Br \) = % Biomass reduction of hyacinth at transect
- \( B_t \) = Biomass of hyacinth within transect at week t (g)
- \( B_{t+1} \) = Biomass of hyacinth within transect at week t+1 (g)

Total biomass of grass carp was counted with the following formula.

\[ B_t = N_t \times W_t \]

Where:
- \( B_t \) = Total Biomass of grass carp at week t (g)
- \( N_t \) = Number of grass carp at week t
- \( W_t \) = Average Biomass of grass carp at week t (g/fish)

Feeding rate was calculated by the following equation.

\[ FR (\%) = \left( \sum F / BT \right) \times 100\% \]

Where:
- \( FR \) = Feeding rate
- \( \sum F \) = Biomass of hyacinth consumed by grass carp at week t (g)
- \( BT \) = Total Biomass of grass carp at week t (g)
Correlation between grass carp biomass and amount food (hyacinth) consumed at each treatment (100, 150, 200 gr of grass carp) was calculated, in order to determine the closeness between the two variables.

RESULTS

Weight of hyacinth eaten by fish was presented at Table 1. The level of hyacinth consumption (Daily feed) by fish size of 100 g/fish ranged 983.3 – 1137.8 g, size 150 g/fish ranged 1040.0 – 1126.7 g and size 200 g/fish ranged 6080.0 – 6306.7 g hyacinth per day. Percentage of hyacinth biomass reduction was 73.8 – 85.3% for 100 g fish, 78.0 – 84.5% for 150 g fish and 86.7-88.4% for 200 g fish.

Hyacinth biomass reduction on transect of 100 g/fish ranging 73.8 - 85.3% illustrates that within 1 week, 30 grass carp (size 100 g) was able to reduce the 73.8 - 85.3% weight of hyacinth (Figure 1).

The highest range of feeding rate percentage (31.5 - 35.2%) occurred on 100 g fish weight treatment, followed by 150 g fish weight treatment (23.3 – 24.0%) and 200 g fish weight treatment (18.3 - 19.2%).

Correlation between fish biomass (g) and food (E. crassipes) consumed (g) for each treatment was y=69.33x + 3050 (R^2=0.9639) for grass carp size of 100 g, y=76.69x + 4496.6 (R^2=0.9383) for grass carp size of 150 g and y=72.01x + 5980 (R^2=0.838) for grass carp size of 200 g. The closeness of the correlation between the weight of fish and the amount of feed consumed is shown by the value of R^2. The higher the R^2, the higher the closeness. 100 gr sized fishes have the highest closeness value of fish biomass and food consumed per week correlation.

DISCUSSIONS

Different treatment of fish weight showed similar results namely all fishes well consumed hyacinth till the end of experiment. No mortality among 30 experimented fishes in each treatment occurred during four weeks of experiment. There was also no sign of sickness due to food scarcity. The similar phenomenon was also reported by Pipalova et al. [9]. No mortality was recorded. The ability of grass carp eating water plants depends on the size of water plants and fish size [10]. Grass carp tolerates a wide range of environmental conditions;

### Table 1: Grass carp grazing on hyacinth.

<table>
<thead>
<tr>
<th>Week</th>
<th>100 g/fish treatment</th>
<th>150 g/fish treatment</th>
<th>200 g/fish treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily Feed (g)</td>
<td>Fish Biomass (g)</td>
<td>% Feeding Rate</td>
</tr>
<tr>
<td>1</td>
<td>983.3</td>
<td>3120.0</td>
<td>31.5</td>
</tr>
<tr>
<td>2</td>
<td>1064.4</td>
<td>3200.0</td>
<td>33.3</td>
</tr>
<tr>
<td>3</td>
<td>1137.8</td>
<td>3233.3</td>
<td>35.2</td>
</tr>
<tr>
<td>4</td>
<td>1096.7</td>
<td>3340.0</td>
<td>32.8</td>
</tr>
</tbody>
</table>

![Day 1 to Day 7](image1.png)

Fig. 1: Hyacinth coverage at the beginning of experiment (Day 1) and after 1 week of experiment (Day 7).
they can survive at water temperatures of 32 to 105 °F and are nearly as tolerant as catfish to low dissolved oxygen concentrations. The fish grows rapidly, as much as 5 to 10 pounds a year. It must consume large quantities of plant material to grow and may consume 2 to 3 times its weight in plant material per day [11]. Our finding confirmed this literature that the highest % feeding rate was 35.2%.

The first part hyacinth eaten by grass carp is the root. Then, the balance of the weed will disappear and cause the leaves to touch the surface of the water and then the leaves will be eaten by the fish. Died hyacinth is marked with yellow and red.

Grass carp weights suitable to be applied to eradicate blooming hyacinth population in Cirata size of 100 g/fish. Selection of average weight of 100 g/fish is considered based on the highest feeding rate percentage (31.5 - 35.2%). It means that fish size of 100 g/fish consumes much more hyacinth than that of 150 gr and 200 gr fish size. It has been reported that small grass carp (10 - 13 cm length) are generally more effective at controlling nuisance aquatic vegetation than larger grass carp since they have higher energy demands per unit body mass and feeding rates [12,13,14]. On the contrary, in New Zealand, apparently only grass carp weighing about ~500 g can be expected to consume substantial amounts of the weeds Myriophyllum propinquum, Lagarosiphon major and Ceratophyllum demersum [15].

Grass carp feed almost exclusively on aquatic plants. Since grass carp can not reproduce in ponds and lakes they make an excellent biological control agent. Their introduction to an impoundment has little lasting impact as they cannot reproduce there. However, it must be scrutinized further no particularly adverse effects on indigenous or other introduced species of fish, or invertebrate and confirmed that good weed control could be achieved.

Grass carp can provide economical and effective control of plants in cool northern waters, although stocking rates will have to be higher than those used in warm waters of the southern United States [16]. Grass carp stocked at 4.5 kg per tonne of vegetation eradicated almost all aquatic plants in 94.5 ha Lake Dgal Wielki, Poland [17].

Change in the density of hornwort (Ceratophyllum demersum L) was first noted three weeks after grass carp release. By five weeks after grass carp release there was a trend in the reduction of surface weed within the enclosures [18]. Hydrilla and pondweeds (Potamogeton spp) were the most common items reported to be eaten by grass carp and species most commonly avoided were in the genera Nymphaea, Potamogeton, Myriophyllum, Nuphar and Typha [19].

The stocking rate for grass carp depends on the severity of the weed problem. When used to prevent the establishment of submersed weeds, 5-10 small (3-6 inch) carp per acre should be stocked. The same stocking rate is also adequate if the pond is lightly infested with weeds. For more severe weed problems, 10-15 fishes per acre should be stocked. For heavily weed infested ponds, stocking rates can be increased to 15-25 per acre or greater. Grass carp must be stocked at a size large enough to prevent them from being eaten by predator fish such as bass and large catfish [11].

The controversy over the distribution and use of grass carp is based on the potential effect of this fish on native fish and wildlife. Considerable discretion should be used when planning to stock these fish into ponds and every effort should be made to prevent their escape into natural waters. To further diminish the likelihood that grass carp will reproduce and thrive in natural waters, it is recommended that only sterile, triploid carp can be used [11]. Biological control via triploid grass carp is legal in Illinois ponds. This carp is sterile and cannot reproduce [20].

Biological control is an option for certain aquatic weeds. The major advantages are ease of application and no concern over damage to plants irrigated with treated water. Triploid grass carp can control many submerged vascular aquatic weeds. Grass carp are usually used to control all vegetation in a pond, rather than selectively controlling certain vegetation. Replacement stocking of grass carp is necessary when fish are lost. A permit is required to stock grass carp and only triploid fish can be legally used in SC [21].

**CONCLUSION**

The ability of grass carp grazing hyacinth was affected by the freshness of the hyacinth. Grass carp disliked withered and died hyacinth. Percentage of hyacinth biomass reduction in transects of 30 fishes (Size 200 g) reduced up to 86.8 – 88.4%. According to the highest feeding rate percentage (31.5 – 35.2%), 100 g/fish was recommended for controlling the blooming of water hyacinth. However, since there is no regulation yet for permission of the introduction of grass carp to open water in Indonesia, the use of this fish for biocontrol of aquatic weed has not yet been legally allowed.
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REFERENCES