GIANT SALVINIA *(Salvinia molesta)* AS A PARTIAL FEED FOR NILE TILAPIA *(Oreochromis niloticus)*

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Abstract

In August 1999, giant salvinia (*Salvinia molesta* Mitchell) was found along the lower Colorado River in irrigation drainages. To investigate the possible use of this invasive weed as a feed for the herbivorous fish, tilapia (*Oreochromis niloticus* Linneus), plants were collected from the river and fed to tilapia. The study was conducted in a 4,000-L recirculating system. One of three treatments was assigned to each of fifteen 200-L tanks after they were stocked with tilapia at a density of five fish per tank (five replicates per treatment). The first treatment group, the feed control, contained fish only and was fed a commercially available tilapia diet; group two, the giant salvinia and fish only, did not receive prepared feed; and group three, the giant salvinia and fish plus feed treatment, contained fish and salvinia, and was fed a commercial diet. Average fish growth over 23 days was slightly higher (7.3 g per fish), but just short of significantly different, in the giant salvinia plus feed treatment than the feed control treatment. These findings suggest that Salvinia could be used as a feed supplement or ingredient in tilapia diets.

Introduction

Giant salvinia (*Salvinia molesta*) is native to southern Brazil, but has been widely distributed to many parts of the world (Mitchell 1979). Under favorable conditions, this floating water fern can become a devastating aquatic nuisance, disrupting native species as well as human activities by rapidly covering large areas. Capable of explosive growth, giant salvinia can block waterways, hindering both fishing and other recreational activities (Mitchell et al. 1980). The first record of giant salvinia being transported out of its native range was in 1939, when it was introduced by the botany department at the University of Columbo in Sri Lanka (Williams 1956). It has since been moved to Australia, Papua New Guinea, southern India, Namibia, Botswana and South Africa (Room 1986, 1990). Experimentation and research into classical biological control of this rapidly growing weed with host specific arthropods has brought its population under control in each of these countries (Julien and Griffiths 1998). Mechanical removal was underway from the Hawksberry River near Sydney Harbor, Australia in July of 2004.

In 1999, giant salvinia was discovered along the banks of irrigation drainage canals in the Palo Verde Irrigation District new Blythe, California. These drains lead directly to the

Colorado River, and within weeks, salvinia had spread into the main channel of the Colorado River. Eventually, the infestation spread downriver to Mexico, impacting natural river systems as well as irrigation systems in Arizona, California and Mexico. Since 1999, resource agencies and irrigation managers have used a variety of weed control methods, including chemical and mechanical treatments. Triploid grass carp (*Ctenopharyngodon idella* Valenciennes) and tilapia had previously been introduced for biological weed control in some of the canals along the lower Colorado River (Costa-Pierce and Doyle 1997) and maybe contribute to the biological control of this invasive weed. The current study was designed as part of an effort to explore the use of herbivorous fish for biological control of giant salvinia and for potential uses of salvinia. This particular aspect was designed specifically to determine if tilapia benefit nutritionally from consuming giant salvinia as measured by weight gain.

Materials and methods

An experiment was conducted over 23 days at the University of Arizona's Environmental Research Laboratory to evaluate the role of giant salvinia in a tilapia diet. Nile tilapia (*Oreochromis niloticus*) were housed in a greenhouse with a closed recirculating system. Fish were fed a commercial tilapia feed from Integral Fish Feeds in Grand Junction, CO two times each day at 08:00 and 14:30 at an average of 2% body weight per day. This ration is well below a level to encourage rapid growth and was meant more as a maintenance feed well below satiation. Water was constantly recirculated through a series of mechanical and biological filters and returned to the system.

The experimental culture system consisted of 15 tanks, each with a water volume of 200 L each plus a 1,000-L sump. This system was situated under a 70% light transmission shade-cloth. A recirculating system was chosen to minimize temperature and water quality differences among experimental groups during the study period. The 15 tanks were initially filled with a combination of municipal water and water from a much larger tilapia holding system. No water was discharged from the experimental system while the feeding trial was in process, in order to ensure containment of giant salvinia under quarantine. Municipal water was added to compensate for evaporation. Water quality parameters including dissolved oxygen, pH and temperature were monitored weekly to ensure suitable conditions for viable growth of fish and plants.

Three-month-old fish were randomly selected from a general population of tilapia. Fish were tagged just below their dorsal fins using five tag colors, enabling easy identification of individual fish for monitoring growth. Tagged tilapia with an average weight of 88 ± 3.5 g were stocked at a density of five fish per 200 L tank. Fish were acclimated in the test system for 2 weeks prior to the giant salvinia feeding trial, during which time all tanks were supplied with a commercial tilapia diet two times per day at 2% of the initial body weight per day.

Each of the 15 tanks was then randomly assigned to one of three treatment groups. Tanks in the first treatment group, the fish feed control, contained fish only. Tanks assigned to the second group, the giant salvinia and fish minus feed treatment, and third group, the giant salvinia and fish plus feed treatment contained both giant salvinia and fish. Fish in the feed control and giant salvinia and fish plus feed groups were fed the commercial tilapia diet.

Giant salvinia was added to tanks in the salvinia and fish minus feed treatment and the salvinia and fish plus feed treatment at a rate of 380 grams wet weight per tank, enough to cover approximately 75% of the water surface. Giant salvinia was monitored daily by visual inspection in these tanks to assess standing biomass. Tanks in which all plant matter was consumed, were given additional giant salvinia.

On day 14, all fish and the standing giant salvinia biomass were weighed and returned to their respective tanks. On day 23, as on day 14, all fish and any remaining giant salvinia were weighed. For both day 14 and day 23, fish were weighed individually and weights were recorded by tank number and tag color to monitor growth of individual fish.

Following completion of the experiment, data were analyzed using the statistical software package JMP IN 4 (SAS Institute Inc., USA). In both cases, a one-way ANOVA followed by a Linear Contrast was used to separate the means. The significance level was set at $\alpha = 0.05$.

Results and discussion

Survival of tilapia was 100% during the trial. Environmental conditions in the experimental system over the 23 days of this study were well within the acceptable limits for both tilapia and giant salvinia. Temperature ranged from 23.4 to 25.4ºC. Dissolved oxygen ranged from 7.43 mg/L to 7.76 mg/L.

Quantification of the impact of tilapia on the standing crop of giant salvinia

On average, 491 g of giant salvinia was consumed per tank in the giant salvinia and fish minus feed treatment ($p < 0.0001$, $t = 9.8901$, df = 12). Similarly, standing biomass of giant salvinia was reduced by 301 g per tank in the giant salvinia and fish plus feed treatment, 274 g more per tank than tanks in the giant salvinia control treatment ($p < 0.0001$, $t = 5.8365$, df = 12). Tanks in the giant salvinia and fish minus feed treatment group consumed 190 g more giant salvinia, on average, than tanks in the giant salvinia and fish plus feed treatment ($p = 0.0016$, $t = 4.054$, df = 12). Salvinia growing in adjoining tanks grew considerably, so all plant loss could be attributed to fish consumption (which was easily observed).

Tilapia growth as a result of eating giant salvinia

Fish growth in tanks assigned to the giant salvinia and fish minus feed treatment group was lowest (Table 1), with a mean weight loss of 11.9 g per fish, whereas fish in the feed control treatment increased their weight by an average of 6.4 g per fish, a difference of 18.3 g per fish ($p < 0.001$, $t = 4.7574$, df = 67). Fish in the giant salvinia and fish plus feed treatment grew 13.7 g per fish, 7.3 g more than the fish in the feed control treatment ($p = 0.0753$, $t = 1.8068$, df = 67). The difference in growth between fish in the giant salvinia and fish minus feed treatment and the giant salvinia and fish plus feed treatment was 25.6 g ($p < 0.001$, $t = 6.4169$, df = 67).

Table 1. Changes in mean fish weight over 23 days when offered a commercial fish feed alone, giant salvinia alone or the two in combination.

	Fish Weight (g) (mean ± standard error)		
Treatment	**Day 0**	**Day 23**	**Change**
Fish with Commercial Feed (Control)	91.1 ± 5.9	96.6 ± 6.2 ^{b}	6.4 ± 8.9
Giant Salvinia and Fish Minus Feed	89.2 ± 7.3	77.3 ± 6.3 ^{a}	-11.9 ± 6.7
Giant Salvinia and Commercial Feed	84.8 ± 7.6	104.8 ± 10.7 ^{b}	13.7 ± 21.4

Means followed by a subscript are statistically different at $\alpha = 0.05$.

Implications

Tilapia consumed considerable amounts of fresh salvinia in the experiments but achieved only marginal nutritional benefits. Tilapia fed only salvinia consumed almost 100g per fish during the 23 days, but still lost weight. Fresh salvinia contains high amounts of moisture and some fiber that appears to contribute little to fish nutrition.

However, in conjunction with other feed, there may have been a benefit. An extended period of feeding may have increased the growth differences to a significant level. Drying the salvinia and incorporating it into the feed as an ingredient may also have demonstrated a more pronounced effect. Considering the wide availability of salvinia and a desire to find a constructive use for the plant, additional feeding trials may be useful to determine a more appropriate feeding method and level. Despite the low level of nutritional benefit that giant salvinia provides to tilapia, tilapia do impact the standing biomass of giant salvinia, even when offered a nutritional alternative, as evidenced by the reduction of giant salvinia in the giant salvinia and fish plus feed treatment tanks. This is an important characteristic in regards to the use of tilapia as a biocontrol for giant salvinia in the environment.

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References

Costa-Pierce, B. A. and R. W. Doyle. 1997. Genetic identification and status of tilapia regional strains in southern California. *In*: B. A. Costa-Pierce and J. E. Rakocy (eds.). Tilapia Aquaculture in the Americas. The World Aquaculture Society, Baton Rouge, Louisiana. pp. 1-17.

Julien, M. H. and M. W. Griffiths. 1998. Biological control of weeds, Fourth edition: A world catalogue of agents and their target weeds. CAB International, New York, New York. 223pp.

Mitchell, D. S. 1979. Aquatic weeds in Papua New Guinea. Sci. New Guinea 6: 154-160.

Room, P. M. 1986. Biological control is solving the world's *Salvinia molesta* problems. *In:* Proceedings EWRS/AAB 7th Symposium on Aquatic Weeds 1. European Weed Research Society, Loughborough, England. pp. 271-276.

Room, P. M. 1990. Ecology of a simple plant-herbivore system: Biological Control of *Salvinia*. Trends Ecol. and Evol. 5(3): 74-79.

Williams, R. H. 1956. *Salvinia auriculata* Aubl.: the chemical eradication of a serious aquatic weed in Ceylon. Trop. Agr. 33: 145-157.