# Feeding Habits Of The White Amur On Waterhyacinth[1]

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## ABSTRACT

White amur (*Ctenopharyngodon idella* Val.) approximately 1.0 kg in weight were more effective in controlling growth of waterhyacinth (*Eichhornia crassipes* [Mart.] weight. The large fish fed on the leaves and bulbous petioles of the plant, while the small fish fed principally on the roots. Control of plant growth was limited primarily to the fish reducing the number of daughter plants produced. This study suggests that high stocking rates with the white amur will be required to control growth of waterhyacinth.

## INTRODUCTION

Waterhyacinth was introduced into the United States in 1884 at a horticultural exhibit in New Orleans. Because of its beautiful flower, the public spread the plant across the southeastern United States in many localities. The plant spread rapidly and quickly became a noxious weed (8). Mechanical and chemical methods to control growth and spreading of this floating plant have provided only temporary control at best. To date, the most economical and effective method of control is by spraying (2,4-dichlorophenoxy)acetic acid (2,4-D) on this plant (4, 5, 7).

Biological agents appear to have great promise for control of some aquatic plants. The most promising for control of many species of aquatic plants is an exotic, herbivorous fish, the white amur (3). This fish will consume a number of submersed aquatic plants, but little information is available to indicate its effectiveness on some of the floating plants. Therefore, a study was designed to evaluate feeding habits of the white amur on waterhyacinth plants. Introduction of any exotic species always involves the risk that it may become a problem rather than solving the one for which it was introduced. Experiments were conducted in large containers covered by nets to prevent the escape of fish.

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## METHODS AND MATERIALS

*Selection and Handling of Plants.* Waterhyacinth plants were taken from ponds and canals in the Fort Lauderdale area. Except where indicated, the plants were counted and placed in test containers and samples set aside for dry weight determination. After the plants were established for 1 week, fish were introduced into the containers to feed upon the waterhyacinths for a period of time. At the conclusion of each trial, the plants were again counted and dry weight determined.

*Care and Handling of Fish.* Prior to and after each trial, the white amur were kept in holding tanks and fed hydrilla (*Hydrilla verticillata* Royle). At the beginning of each trial, the fish were weighed. Upon completion of each feeding trial, the fish were removed from the test containers and again weighed and placed back into the holding tanks. In order to minimize injury while being handled, the fish were tranquilized using a solution of $C_6H_4N{:}C(CH_3)CH{:}CH$ (Quinaldine)[3] at the rate of 10 to 15 ppm in water. During the weighing process, the fish were generally out of water for less than 1 minute. They were revived by being placed into water without the tranquilizer.

*Experiment I.* In this experiment three small concrete tanks with inside dimensions of 218 cm long, 76 cm wide, and 58 cm deep were filled with 960 liters of unfiltered pond water. A drain pipe allowed excess water from rainfall to flow out of the container. Two white amur, ranging in weight from 88 to 163 g, were placed in each tank after the waterhyacinth plants had grown to cover the surface of the water. The fish were removed after 3 weeks, weighed, and then placed in similar tanks covered with waterhyacinth plants for an additional 3 weeks. This experiment was conducted during June and July of 1970.

*Experiment II.* Plastic-lined pools 3.6 m in diameter and 0.9 m high containing 5,170 liters of pond water under natural environmental conditions were used in this and the following experiments. After placing the waterhyacinth plants in the pools, approximately 100 g of a commercial fertilizer (20-10-15) were added to the pools to provide nutrients for plant growth. No effort was made to maintain a uniform initial plant size as the sizes varied according to season, locality, and general environmental conditions.

White amur, averaging 1,086 g, were allowed to feed on the plants for 2-week periods in September, November, and December of 1970. A total of six pools were used in each month, with three pools containing two fish each, and three without fish serving as controls.

*Experiment III.* Beginning in January 1971 and continuing through April, fish averaging 136 g were allowed to feed on waterhyacinth plants for four 2- and 4-week periods. For each time period six pools were used, three pools containing two fish each and three pools serving as controls. From May 1971 through August, the above procedure was repeated except that fish averaging 1,047 g were used. Measurements for determining the influence of the white amur on growth of waterhyacinth included number and weight of plants, surface area of the pool covered by the plants, and fish weight.

*Experiment IV.* In October 1971 waterhyacinth was placed in the plastic-lined pools and again allowed to establish for 1 week prior to introduction of fish. This procedure was continued for nine 4-week feeding periods. For each feeding period 12 pools were used. Two fish averaging 151 g were placed in each of three pools and two fish weighing an average of 1,046 g were placed in each of three others with the remaining six pools as controls. At the end of 4 weeks the white amur were removed from the pools and placed in other pools where they were fed hydrilla for 1 week after which they were returned to the pools containing waterhyacinth. The same fish were used throughout this experiment. Growth of the waterhyacinth was determined by plant number.

## RESULTS

*Experiment I.* White amur grew an average of 14.5 g while contained for a 3-week period in concrete tanks with a surface cover of waterhyacinth. During an additional 3-week period the fish grew an average of 27.4 g to give an average of 42.0 g for the 6-week feeding period. These fish ate only the roots of the waterhyacinth plants.

*Experiment II.* Waterhyacinth in the control pools increased in number by 646, 195, and 311 during September, November, and December, respectively, while the plants in the pools with fish increased by 591, 42, 110, for these same periods (Table 1). Dry weight of plants from pools containing the white amur was lower than plants from the controls. Fish in this experiment ate the leaves as well as the roots.

*Experiment III.* Small white amur were not effective in reducing waterhyacinth growth during 2-week feeding periods in January through April 1971; furthermore, only during February was growth of plants reduced as compared to the control during the 4-week feeding periods (Table 2). In general, fish lost weight during the 2- and 4-week feeding periods.

During May through August 1971, growth of waterhyacinth was reduced more during 4-week feeding periods by the large white amur than during the 2-week feding periods (Table 3). Plant weight was generally lower in the pools with fish than in the control pools. More significant differences were observed between pools with and without fish for surface area covered by waterhyacinths, than for plant numbers or weight. Growth of the fish occurred only during the 2-week feeding period in May. For the remaining feeding periods, these fish lost weight while in the pools with the waterhyacinth.

*Experiment IV.* White amur approximately 10 fold the weight of smaller fish were more effective in reducing number of waterhyacinth as compared to the control during nine 4-week periods beginning in October 1971 (Figure 1). In this experiment fish growth was observed for all of the feeding periods except for the large fish in June 1972. Growth rates were approximately the same for these two

[3]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the University of Florida or by the U.S. Dep. of Agr., and does not imply its approval to the exclusion of other products that may also be suitable.

TABLE 1. EFFECT OF WHITE AMUR FEEDING ON WATERHYACINTH IN PLASTIC POOLS DURING 2-WEEK FEEDING PERIODS IN 1970 (EXPERIMENT II).

| Determination | September[a] | | November[a] | | December[a] | |
|---|---|---|---|---|---|---|
| | Mean | Standard deviation (±) | Mean | Standard deviation (±) | Mean | Standard deviation (±) |
| 1. Number of plants[b] | | | | | | |
| A. Control pools | | | | | | |
| 1. Initial | 150 | — | 50 | — | 100 | — |
| 2. Final | 796 | 63 | 245 | 37.5 | 411 | 85.3 |
| B. Pools with two fish each | | | | | | |
| 1. Initial | 150 | — | 50 | — | 100 | — |
| 2. Final | 741 | 58 | 92 | 2.6 | 210 | 42.3 |
| 2. Dry weight of plants (g) | | | | | | |
| A. Control pools | | | | | | |
| 1. Initial | 6.9 | 1.4 | 30.1 | 10.9 | 63.4 | 9.3 |
| 2. Final | 10.2 | 1.5 | 17.4 | 5.7 | 75.9 | 3.4 |
| B. Pools with two fish each | | | | | | |
| 1. Initial | 6.9 | 1.4 | 30.1 | 10.9 | 63.4 | 9.3 |
| 2. Final | 7.7 | 2.3 | 14.5 | 5.1 | 23.7 | 51.0 |
| 3. Weight of white amur (g)[c] | | | | | | |
| A. Initial | 1048 | 105 | 1057 | 120.8 | 1155 | 12.2 |
| B. Final | 1156 | 85 | 1101 | 135.8 | 1183 | 134.4 |
| C. Growth per day | 6.3 | 2.3 | 3.2 | 1.4 | 2.0 | 1.6 |

[a]Each value is the results from three pools.
[b]Plants allowed to establish for 1 week prior to introduction of the fish.
[c]Each value is the mean of six fish.

sizes of fish except during the feeding periods in October 1971 and June 1972 when the small fish grew at a faster rate than the larger fish.

## DISCUSSION

White amur weighing approximately 1.0 kg were more effective in limiting growth of waterhyacinth than were fish approximately 10 fold less in weight. Small fish fed primarily on the roots while the large fish ate the leaves and bulbous portions of the leaves as well as the roots. Control of plant growth in this study appeared to be limited primarily to the fish reducing the number of daughter plants produced. However, in some cases, at the end of the feeding periods, a number of decayed and decomposing parent plants were noted in the pools.

Stocking with two fish per pool represents 1,903 fish per ha or 770 fish per acre. This is considerably higher than a recommended rate of 100 to 400 fish per ha for control of submersed plants (3). The large fish used in the pools represent an average of 1,903 kg of fish weight per ha or 1,698 lb per acre. Lupachera (6) found that 450 to 500 kg of 2-year-old white amur were sufficient for control of some submersed plants. Our studies suggest that high stocking rates with the white amur will be required to control growth of waterhyacinth.

TABLE 2. EFFECT OF SMALL WHITE AMUR ON GROWTH OF WATERHYACINTH PLANTS IN PLASTIC POOLS (EXPERIMENT III).

| Measurement and time of year (1971) | Feeding period[a]: 2-week | | Feeding period[a]: 4-week | |
|---|---|---|---|---|
| | Control | With fish | Control | With fish |
| 1. Plant growth (number/day) | | | | |
| January | 2.83 d-q | 2.43 b-p | 3.73 k-w | 3.19 l-s |
| February | 1.24 a-k | 0.58 a-h | 6.91 y | 3.59 k-v |
| March | 0.16 a-c | −0.19 a-b | 0.56 a-f | 1.44 a-l |
| April | 3.36 j-t | 2.17 b-n | 2.31 b-o | 0.70 a-i |
| 2. Surface area[b] (sq. m.) | | | | |
| January | −0.05 d-p | −0.23 c-k | −0.18 c-l | −0.29 b-j |
| February | 0.03 f-r | −0.17 c-m | 0.12 h-t | −0.32 b-h |
| March | −0.17 c-m | −0.30 b-i | 0.02 f-q | 0.12 h-t |
| April | 0.10 h-s | 0.16 h-u | 1.16 y | −0.12 d-n |
| 3. Growth of white amur (g/day) | | | | |
| January | — | −0.64 a | — | −0.10 a |
| February | — | −1.80 a | — | 0.80 a |
| March | — | −4.70 a | — | 0.80 a |
| April | — | −0.89 a | — | −0.26 a |

[a]Each value is the average of three replicates. In cases of negative values, these were obtained due to the final value being less than the initial. Values for each measurement followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.
[b]Values represent the difference between the initial and final surface area of the pool covered by the plants.

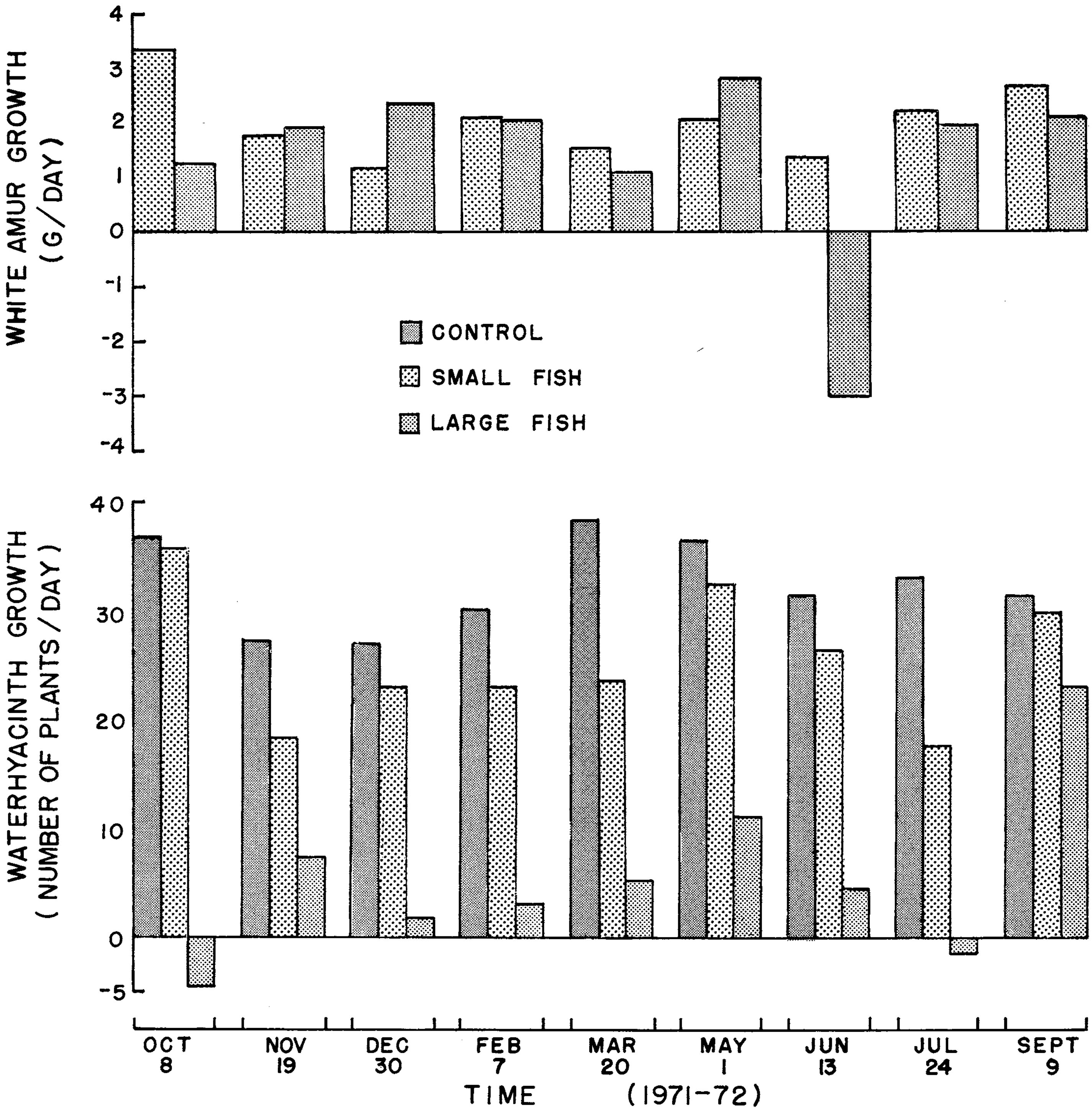


Figure 1. Effect of white amur on growth of waterhyacinth in plastic-lined pools for nine 4-week periods. Negative values were obtained due to the final value being less than the initial.

A growth rate of 6.3 g per day was the largest fish weight gain in this study, and in some cases, the fish lost weight while feeding on waterhyacinth. Hickling (2) reported growth rates for the white amur as high as 11.7 g per day, with the female fish growing faster than the males. Growth rates as high as 13.5 g per day have been observed for fish feeding on hydrilla and Southern naiad (*Najas guadalupensis* [Spreng.] Magnus) in plastic-lined pools (1). The white amur appeared to be unable to utilize waterhyacinth plants as effectively as some other aquatic plants.

TABLE 3. EFFECT OF LARGE WHITE AMUR ON GROWTH OF WATERHYACINTH IN PLASTIC POOLS (EXPERIMENT III).

| Measurement and time of year (1971) | Feeding periods[a] | | | |
|---|---|---|---|---|
| | 2-week | | 4-week | |
| | Control | With fish | Control | With fish |
| 1. Plant growth (number/day) | | | | |
| May | 4.62 n-y | 1.93 a-m | 6.07 v-y | 0.51 a-e |
| June | 5.62 s-y | 4.83 o-y | 0.57 a-g | 0.41 a-d |
| July | 6.41 x-y | 4.00 m-x | 5.11 q-y | −0.25 a |
| August | 5.03 q-y | 2.95 d-r | 3.51 k-u | 0.92 a-j |
| Dry wt (total in g) | | | | |
| May | 74.50 l-n | 19.30 c-k | 8.40 b-j | −32.30 a-c |
| June | 3.40 b-i | −0.30 b-g | 87.60 n | −17.80 b-e |
| July | 34.50 e-l | −77.40 a | 1.50 b-h | −39.40 a-b |
| August | 38.00 f-m | −23.70 b-d | 86.20 m-n | −3.00 b-f |
| 2. Surface area[b] (sq. m.) | | | | |
| May | 0.34 n-x | −0.42 b-g | 1.07 y | −0.52 b-e |
| June | 1.07 y | −0.06 d-o | −0.05 d-p | −0.63 b-c |
| July | 0.22 k-v | −0.72 k-v | 0.23 k-w | −1.43 a |
| August | 0.51 z-x | −0.45 b-f | 1.06 y | −0.54 b-d |
| 3. Growth of white amur (g/day) | | | | |
| May | — | 0.38 a | — | −1.41 a |
| June | — | −2.41 a | — | −0.32 a |
| July | — | −2.41 a | — | −2.17 a |
| August | — | −1.19 a | — | −1.27 a |

[a]Each value is the average of three replicates. In the case of negativ e values, these were obtained due to the final value being less than the initial. Values for each measurement followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

[b]Values represent the difference between the initial and final surface area of the pool covered by the plants.


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