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Plant Preferences of Triploid Grass Carp

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ABSTRACT

Aquatic plants commonly found in irrigation ditches and farm ponds in northern California were presented to two year old triploid grass carp (*Ctenopharyngodon idella* Val.) to determine feeding preference. The experiment was conducted over a 5-month period beginning in June. Three species of plants were presented during each trial and plant species were overlapped. It was assumed that the rankings established in pairwise comparisons could be extrapolated to the entire group. Order of grass carp preference for aquatic plants was the following: American pondweed (*Potamogeton nodosus* Poir.)>dioecious hydrilla (*Hydrilla verticillata* (L. f.) Royle >elodea (*Elodea nuttallii* Planch.>egeria (*Egeria densa* Planch.)>curlyleaf pondweed (*P. crispus* L.)>waterprimrose (*Ludwigia peploides* (HBK) Raven)>sago pondweed (*P. pectinatus* L.)>chara (*Chara flexilis* L.)>spikerush (*Eleocharis acicularis* L.)>parrotfeather (*Myriophyllum aquaticum* (Vellozo) Verdcourt) >Eurasian watermilfoil (*M. spicatum* L.)>waterhyacinth (*Eichhornia crassipes* Mart.). Coontail (*Ceratophyllum demersum* L.) was uprooted, floated to the surface, and was not eaten. Kjeldahl protein and gross energy of the plants were determined and not found to be correlated with preference.

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INTRODUCTION

Grass carp have been shown to have an order of preferences for certain aquatic plants (Cross 1969, Fischer 1968, Leslie et al. 1987, Michewicz 1972, Edwards 1974, Fowler and Robson 1978). Preferences are thought to be determined by water temperature (Stroganov 1963, Verigin et al. 1963), softness of plants (Fischer 1968), static versus flowing conditions (Pine et al. 1989), size of fish (Pine et al. 1990), and nutritional properties of the plants (Van Dyke and Sutton 1977, Venkatesh et al. 1978, Wiley 1984, Pine et al. 1989, 1990). Studies using pelletted diets have also indicated that rate of consumption in some fish is directly correlated with gross enerrgy content of a diet and dietary protein levels (Jobling 1981, 1987). The objectives of this study therefore, were to determine the plant preferences of triploid grass carp in Northern California and examine the relation between gross energy content and protein levels in these plants and the triploid grass carp plant preferences.

MATERIALS AND METHODS

Triploid grass carp were held in a 10,000-L doughboy pool supplied with aerated water prior to experimentation.

Fish were fed *ad libitum* with an equal (by weight) mix of the three aquatic plants under study plus lettuce (*Lactuca sativa* L.) for at least a month before the start of each trial.

Six outdoor 10,000-L fiberglass pools covered with 50% shadecloth were used in this study. Each pool was divided in half to provide two replicates and supplied with aerated well water at a flow rate to provide a 24-h turnover. Total number of replicates per trial were 9 with 3 controls.

Aquatic plants were transferred to plastic containers as mature plants from either canals or reservoirs where they occurred naturally. Four containers of each plant species tested per trial were randomly placed in each pool section and allowed to acclimatize for one month.

Numbers of plants that could be studied concurrently were limited to three species because of space limitations in the pools. Plant species presented to the fish were overlapped in trials and it was assumed that the rankings established in pairwise comparisons could be extrapolated to the entire group. Biomass of each species was equalized among sections through use of a non-destructive estimation technique (Pine et al. 1989). Plant shoot lengths were measured for all plants in each container prior to introduction of fish. This information was later used to correct treatment fresh weight values for plant growth during the experimental interval. Plants were tested in the following months: June, July-American pondweed, sago pondweed, spikerush, and dioecious hydrilla; March, May-Eurasian watermilfoil, curlyleaf pondweed, chara, and dioecious hydrilla; August-parrotfeather, waterhyacinth, waterprimrose; August, September-egeria, sago pondweed, coontail, elodea.

The following water quality variables were measured in pool #6, a representative replicate, prior to and during each trial as in Pine et al. (1989): total alkalinity, total hardness, conductivity, pH, dissolved oxygen, and turbidity. A 0 to 35 C maximum-minimum thermometer was placed in this pool.

A total of 135 triploid grass carp were used in the five trials. At the start of each trial, 27 fish were anesthesized with quinaldine sulfate at 10 mg/L for 15 to 30 minutes and their wet weight was determined.

Three fish were placed in each of the 9 experimental sections. Three sections had no fish and so acted as controls. When visual observation indicated complete removal of the one, most preferred plant species, the trial was ended. The pools were partially drained, fish anesthesized for removal and measured for wet weight. Plants were cut off at the soil surface and their fresh weight was recorded. Plants were then dried for 24 h at 100 C. Kjeldahl nitrogen was determined using the AOAC method (1984) and gross plant energy was determined with a Gallenkampf bomb calorimeter.

Statistical analysis of plant fresh weight comparisons was done with arcsine transformed data using Duncan's multiple range test. Statistical comparisons between Kjeldahl nitrogen or gross energy values was done using Duncan's multiple range test. Statistical comparisons between percent control fresh weight and Kjeldahl nitrogen and percent control fresh weight and gross energy were done using linear regression. All statistical tests were done at the $P \leq 0.05$ significance level.

RESULTS AND DISCUSSION

Total hardness, oxygen, and turbidity demonstrated the most fluctuation of the water quality parameters tested, but were not significant to the overall conduct of the study. Average temperatures in test pools were low from February to May (15 to 18 C) and highest from June to August (23 C). The temperature of the well water entering the pools was approximately 18 C and tended to buffer temperature fluctuations.

Triploid grass carp had a mean weight of 257.2 ± 69.9 g at the beginning of the study (N = 135 ± SD) and had an average weight gain of 5.93 ± 4.20 g for the 5 trials. Weight gain seemed to be positively correlated with temperature with the greatest gains occurring during July/August.

Trials lasted either 4 or 10 days depending on the rate of plant consumption. Trials with dioecious hydrilla, egeria, or American pondweed lasted 4 days, trials with waterprimrose, waterhyacinth, and parrotfeather lasted 10 days, and trials with dioecious hydrilla and Eurasian watermilfoil having both high and low preference, respectively, lasted 4 days. Greatest reductions in fresh weight were with American pondweed, dioecious hydrilla, elodea, and egeria (Figure 1). Coontail was presented as a rooted plant and was subsequently broken off but not noticeably consumed by fish. Least preferred plants were waterhyacinth, Eurasian watermilfoil, parrotfeather, spikerush, and chara. Roots of floating plants were consumed quickly. Above water plant material, however, was consumed much more slowly. Chara has a strong odor associated with it and this may help to explain the relatively low preference.

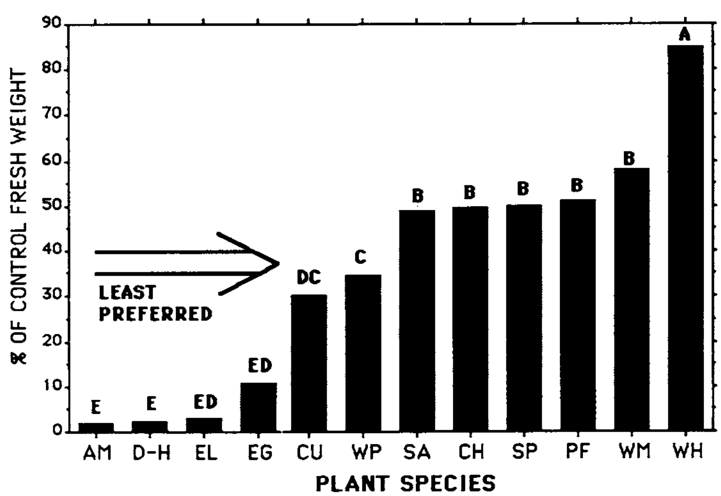


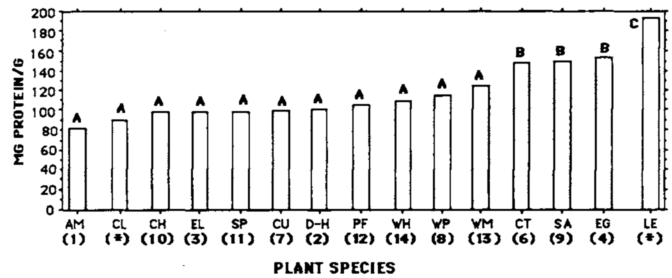
Figure 1. Comparison of triploid grass carp preference of thirteen plant species using plant fresh weight percent of control as the variable of comparison. Fresh weight percent of control was calculated by dividing the mean of control fresh weight plants into treatment fresh weight for each plant species and multiplying by 100. Each bar represents the mean of 4 values. Letters above bars = within experiment comparisons based on Duncan's Multiple Range Test done on arcsine transformed data ($P \leq 0.05$). Bars with similar letters are not significantly different. AM = American pondweed; D-H = dieocious hydrilla; EL = elodea; EG = egeria; CU = curlyleaf pondweed; WP = waterprimrose; SA = sago pondweed; CH = chara; SP = spikerush; PF = parrotfeather; WM = Eurasian watermilfoil; WH = waterhyacinth. Coontail was uprooted but not consumed and was not included in preference comparisons.

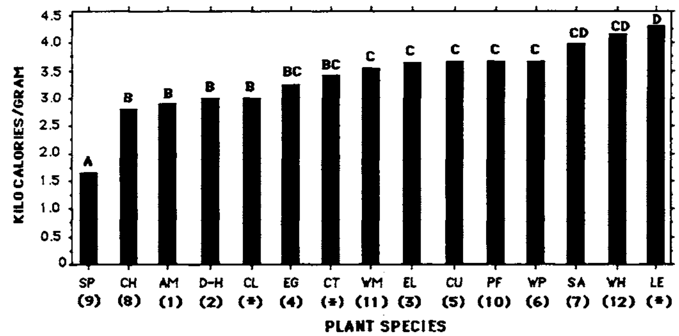
Sago pondweed may not be highly preferred because it formed a floating mat on the surface. Flowing systems where plants are pulled beneath the water surface have been shown to increase preference for sago pondweed (Pine et al. 1989) and accessibility of plants to triploid grass carp was shown to be the most important variable in determining both preference and consumption rate in static and flowing systems (Pine et al. 1989).

Plant preferences in the 1989 study are similar to those found in other studies. Differences may be caused by use of diploid fish and a different feeding regime. In a study that demonstrates these differences (Edwards 1974), diploid fish were used and plants presented using tied bunches. Plant preference was: elodea>curlyleaf pondweed>coontail>egeria. In another study using diploid fish (Stroganov 1963), plants were presented in feeding frames and plant preference was: elodea>coontail>chara>watermilfoil>sago pondweed. A study conducted in a lake environment (Leslie et al. 1988) showed similar preferences with an interesting observation made that selective browsing resulted in the expansion of non-preferred aquatic plant species as preferred plants were removed.

Low correlations ($P \geq 0.05$) between plant Kejldahl protein or gross energy and percent of control fresh weight indicate that preference was not determined by these nutritional variables. American pondweed had the lowest Kjeldahl protein at 82 mg protein/g dry wt and was the most preferred plant. Egeria had the highest amount of 150 mg protein/g dry wt (Figure 2). Since algae (*Cladophora* spp.) was present in experimental pools during this study, Kjeldahl protein and gross energy was determined for it although there were no indications that this affected the study. Lettuce was also analysed and used as a comparison with literature values for these determinations. Lettuce had the highest Kjeldahl protein and gross energy content of all plants determined at 192 mg protein/g dry wt and 4300 calories/g, respectively (Figure 2). Spikerush had the lowest gross energy at 1700 calories/g and waterhyacinth had the highest at 4175 calories/g dry weight (Figure 2). Other measurements of protein and energy, such as net protein value and digestible energy, respectively, may correlate with grass carp plant preference and should be studied.

The results of this study may be used in predicting the sequence of plant elimination when triploid grass carp are stocked in static systems such as reservoirs and farm ponds. If a static system has only less preferred plants, higher stocking rates or larger fish may need to be used, otherwise, control of vegetation may not be achieved, or may take two or three seasons.





* Plants not included in preference test

Figure 2. Kjeldahl nitrogen (top) and gross energy (bottom) (gram dry wt^{-1}) of fourteen aquatic plants and lettuce. Each bar represents the mean of two values. Letters above bars = within experiment comparisons based on Duncan's Multiple Range Test ($P \leq 0.05$). Bars with similar letters are not significantly different. Numbers in parenthesis below each plant species correspond to fresh weight preferences, thus (1) = most preferred. See Figure 1 legend for plant abbreviations.

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