Prey preference in two species of North American bladderworts (*Utricularia*) suitable for water gardens

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Introduction

Carnivorous plants almost always attract significant attention (D'Amato 1998), and since many of them are attractive because of bright red and green foliage plus a range of flower colors, water gardeners may wish to use these plants in their ponds or along their pond margins.

One concern that might arise from the use of carnivorous plants in the water garden is the possibility of their affecting other parts of the garden. While most carnivorous plants are not weedy, and few of them would be capable of puncturing a pond liner, some of the aquatic carnivorous plants might capture young fish or other small creatures in water gardens, disturbing the ponds' ecology. If a water gardener breeds valuable fish, trapping of their fry by the plants would be especially problematic. Since such carnivorous plants, which include both the waterwheel plant (*Aldrovanda vesiculosa*; Droseraceae) and aquatic bladderworts (*Utricularia* spp.; Lentibulariaceae), are some of the easiest to cultivate in water gardens, it is important to determine what effects they might actually have on young fish and other small animals.

Prey preference is the selection of particular species of prey. While one author's (DWD) laboratory has previously dealt with prey preference in *A. vesiculosa* (Chadwick & Darnowski 2002), this paper describes experiments designed to test the prey preferences of two aquatic bladderworts, *U. gibba* (the mud bladderwort) and *U. foliosa* (foliose bladderwort).

Utricularia gibba, composed of thin filaments of cells bearing rounded suction traps and yellow flowers, is the most widely ranging bladderwort in the world; native to six continents, it grows readily in a wide range of environments from the oligotrophic waters favored by most aquatic carnivorous plants to truly eutrophic waters as are found in most lily ponds. *Utricularia foliosa* (Figure 1) grows very well under this wide range of conditions as well, but it is much more robust and bears 10-100 times as many traps per unit length of the main stem (Darnowski, pers. obs.). It also has yellow flowers and is native to the southeastern US (Schnell 2002).

Materials and Methods

Plants of *U. gibba* from an existing laboratory culture were grown in aquaria which received both light from a south-facing window and constant supplemental fluorescent lighting. Plants of *U. foliosa* were obtained from Lee's Botanical Gardens (Florida, USA; www.lbg-cp.com) and cultured as for *U. gibba* until use.

Experimental protists and crustaceans, both unicellular (*e.g. Blepharisma* sp.) and multicellular (*e.g. Volvox* sp.), were obtained from Carolina Biological Supply (Burlington, North Carolina, USA) and either used immediately or cultured until used. Small fish (*Poecilia reticulata*, syn. *Lebistes reticulata*) were obtained from local pet stores and kept in tanks as per *U. gibba* and *U. foliosa*, but not with those plants. These guppies bred, and the immature fish, approximately 0.5 cm long and 1-2 mm in diameter, were used for experiments. All culture containers were 4.1 cm × 4.1 cm × 7.3 cm tall clear plastic boxes. Each container was filled with 20 ml of pond water to provide a medium amenable for the plants and other organisms. The water was filtered through Whatman #1 filter paper to remove any protists or small animals which might confound the results of the experiments below.

Three experiments were performed to determine the effects of these aquatic carnivorous plants on protists and small animals which might be found in cultivated ponds. In the first experiment, prey were offered to either five pieces of *U. gibba* each approximately 15 cm long or to one apical piece of *U foliosa* approximately 8 cm long. These prey represented three size categories: 1)small (rotifers, microscopic animals; water bears, a different type of microscopic animals; *Volvox*, a microscopic multicellular green alga; *Stentor,* a large unicellular protist; and *Arcella*, a type of amoeba*)*, 2)medium (copepods, ostracods, amphipods, and *Daphnia*, all small crustaceans easily visible to the naked eye; and *Hydra*, a multicelluar animal approximately 1 mm tall), and 3)large, i.e. white cloud mountain minnow fry (*Tanichthys albonubes*), ghost shrimp (*Thalassinidea callianassidae*), and fairy shrimp (*Artemia* sp.). Prey were tested within their size group—*i.e.* all of the small prey listed above were offered in one container, all of the medium sized ones in another, etc. After one week, traps were examined using a dissecting microscope.

Based on this first set of experiments, prey which were trapped never or almost never (all large prey above, *Daphnia*, *Stentor*, *Arcella*) were eliminated from further work on prey preference. In the second experiment, the remaining eight types of prey were provided to bladderworts again, but mixed together. The relative numbers of prey types in the prey mixture are shown in column two of Table 1. Enough of this mix was added in each repetition so that approximately ten of the rarest prey type (i.e. amphipods, copepods, ostracods) were offered in each repetition. The results of trapping were tabulated after one week.

In the third experiment, because of the particular relevance of young fish being trapped for water gardening enthusiasts, young fish were exposed to bladderworts, with the bladderworts being provided in greater density than previously, i.e. ten pieces of *U. gibba* or five of *U. foliosa*. Young guppies were used instead of white cloud mountain minnows because of their easier availability. After one week, each container was examined to determine whether the fish was alive, and if not, how it had died.

Results

In the second experiments in which bladderworts were offered a mixture of possible prey (Table 1), the most commonly caught organisms were rotifers and the single-celled green alga *Chlamydomonas*, which were trapped in far greater numbers than other equally abundant prey organisms. Most other prey offered were rarely if ever trapped.

In the third experiment in which young fish were offered to bladderworts, the fish were very frequently killed during the week. Four of the six young guppies offered to *U. gibba* were captured, while only one of the six young guppies offered to *U. foliosa* were captured. Examination

Prey type	Relative Abundance	Percentage Trapped	
		U. foliosa	*U. gibba*
Rotifers	100	2%	2%
Water Bears	10	0%	60%
Chlamydomonas sp.	1000	2%	0.5%
Blepharisma sp.	100	100%	0.3%
Volvox sp.	100	2%	2%
Amphipods	1	0%	0%
Copepods	1	0%	0%
Ostracods	1	0%	0%

Table 1: Trapping of prey by *Utricularia*

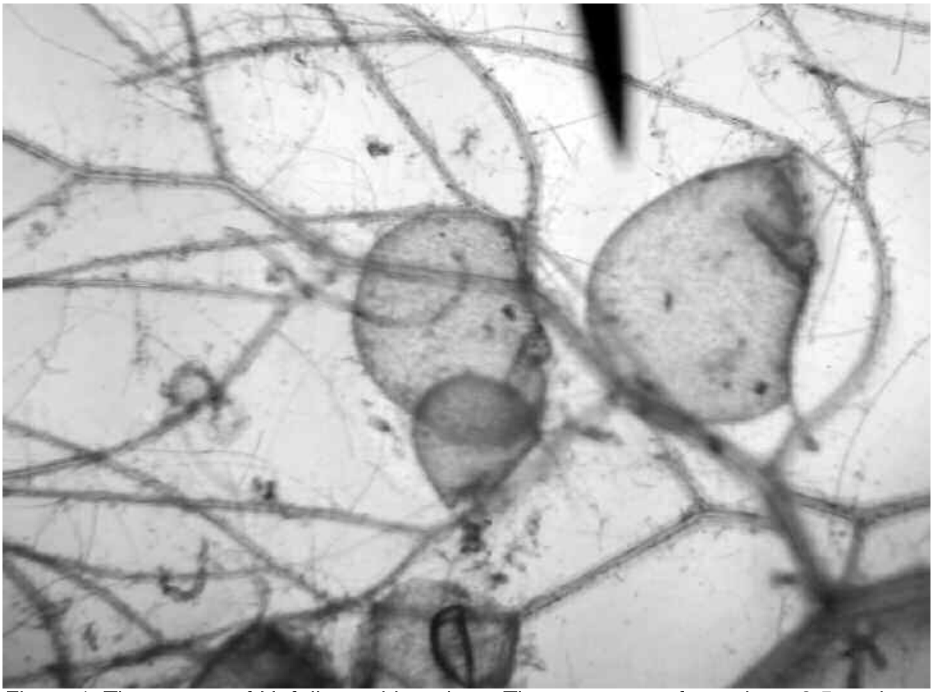

Figure 1: Three traps of *U. foliosa* with stolons. The traps range from about 0.5 to about 2 mm long. The black pointer points to a bladder. Photograph by Andrew Koerber.

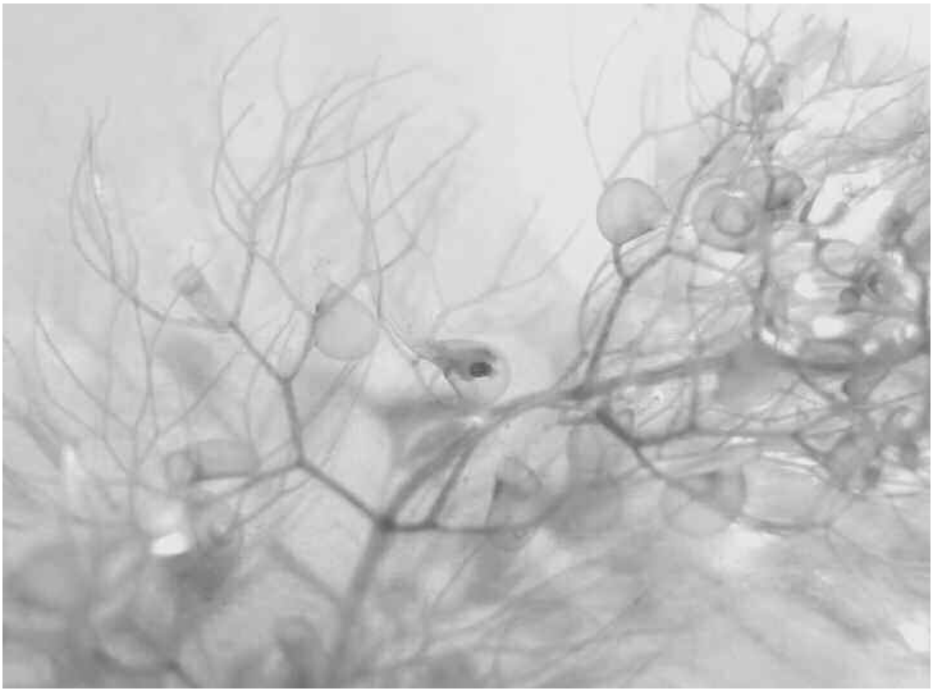

Figure 2: Baby killifish, of very similar size and behavior to a baby guppy, trapped by *U. radiata*, with traps of very similar size and arrangement to *U. foliosa*. This type of trapping, by the head, was less common than trapping of a fin. Photograph by Douglas Darnowski.

of the cultures usually showed the dead fish with its tail trapped in a bladderwort trap which was either still attached to the plant or which had fallen from the plant (Figure 2).

Discussion

These experiments were undertaken to examine the role that bladderworts might play in a pond—given a range of prey, which ones are preferentially trapped by these carnivorous plants? This study complements earlier investigations on the abiotic preferences (light, [CO_2], presence of various metal ions) of aquatic *Utricularia* (McDermott & Darnowski 2002; Saha & Darnowski 2005).

The most striking result is that whether prey was provided individually or in mixes, there are clear preferences for certain prey types. This agrees with previous findings in the genus *Utricularia* and in *Aldrovanda vesiculosa* (Harms & Johansson 2000; Chadwick & Darnowski 2002). Both of those studies found that the behavior of prey resulted in prey selection by aquatic carnivorous plants. For example, in *A. vesiculosa*, prey which frequently moved about among plants and which also rested on the plants were often caught, probably due to their greater time near the traps and therefore the greater probability that they would encounter the traps' trigger hairs.

In our experiments, trapping frequency varied between species for a given type of prey. For example, water bears were caught by *U. gibba* but not by *U. foliosa*, perhaps due to the differences in their behavior. Rotifers were moved more actively in this experiment than waterbears, so perhaps they were caught by both species due to collisions with traps' trigger hairs. In contrast, the more lethargic waterbears may have some behaviors which lead to their trapping by *U. gibba* but not by *U. foliosa*—this needs further testing, perhaps using time lapse video microscopy to track waterbear behavior. Perhaps waterbears prefer to rest on the less densely packed stems of *U. gibba* compared to those of *U. foliosa* and are thus much more likely to be near the traps of *U. gibba*, leading to their being trapped.

Other results may be similarly explained by the behavior of prey species. For example, *Chlamydomonas* sp., probably too small to trigger the traps by themselves, may be caught accidentally along with other, larger prey. The low frequency of trapping for crustaceans may be due to the relatively large size of the individuals offered to plants in this work. In future, offering of juvenile individuals might lead to different results.

There were differences between the two types of bladderwort tested, most surprisingly that the species with far more traps per unit length, *U. foliosa*, trapped fewer prey. It has been suggested that the traps of *U. purpurea* may function as aquaria in which mutualistic organisms grow, rather than as carnivorous organs (Richards 2001). *Utricularia purpurea* is in a different taxonomic section of *Utricularia* from *U. foliosa*, but *U. foliosa* does have smaller trigger hairs than many other bladderworts, somewhat like *U. purpurea* (Taylor 1989). If the hypothesis regarding *U. purpurea* is true, perhaps *U. foliosa* shares this trait to a more limited extent.

From this work, one recommendation for water gardeners is that aquatic carnivorous plants are probably a safe addition to the ecology of their ponds, so long as the bladderworts do not dominate other forms of vegetation. Given that this generally does not occur in natural sites where bladderworts and waterlilies occur (Darnowski, pers. obs. in USA and Australia), these plants should make an interesting addition to home ponds.

One caveat is that for those seeking to breed fish, it may be necessary to provide either an entirely separate habitat for breeding or at least separate enclosures within the larger pond. This recommendation comes from the finding that small fish in areas in which bladderworts grew densely were frequently trapped. One author (DWD) has noted in his own pond that the areas of most dense growth provide a suitable substrate on which fish lay their eggs, so preventing contact between the plants and breeding fish, their eggs, and/or their fry may be important if aquatic carnivorous plants are to be kept in waterlily ponds in which fish are bred.

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