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A COMPARATIVE ANALYSIS OF THE DIATOM FLORA ON THE SNAIL *AMPULLARIA CUPRINA* FROM THE GOSHEN PONDS, UTAH

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Abstract.— Seventeen genera and 60 species of diatoms were identified from four different substrates in a warm spring-fed pond near Goshen, Utah. The diatom forms sampled included both plankton and periphyton. A minimum of 400 individuals were counted from each sample. Diversity and similarity indices were calculated, and substrate relationships were identified on their basis.

Diatoms have long been known to grow on a wide variety of substrates and in a highly diversified range of habitats. Just such a range of distribution has been observed to occur in the Intermountain West, where diatom research during the last seven years has revealed over 700 species of diatoms in many different aquatic and terrestrial ecosystems.

During the period between April 1973 and April 1975, the diatom flora of the Goshen ponds and wet meadows, Utah County, Utah (a series of warm, spring-fed ponds), was under investigation (St. Clair and Rushforth 1977). Periodically during this study, several large specimens of *Ampullaria cuprina* (mystery snail) were collected from the site designated "Lower Pond." A dense growth of algae colonized the shells of these organisms. In May 1974, several large specimens of this snail were collected and taken to the laboratory in order to identify and characterize the attached algal flora. The present paper treats the diatom species identified from the shell of the snail and compares diatom communities on the snail to planktonic, epiphytic, and epilithic communities in the lower pond.

Materials and Methods

In early May 1974, four substrates in the Lower Goshen Pond were sampled. The plankton was sampled by filtering pond water through a 67-μm mesh plankton net and concentrating it in a 30-ml vial attached to the net. Periphyton on the vegetable material in the pond was sampled by collecting various reeds, grasses, and filamentous algae from the pond. Several rocks from the bottom of the pond were scraped in order to obtain epilithic diatoms. Finally, two specimens of *Ampullaria cuprina* (mystery snail) were collected. All samples were taken to the laboratory, and the diatoms were cleaned using acid oxidation methods (St. Clair and Rushforth 1976). Cleaned frustules were dried on cover slips and subsequently mounted in Naphrax mountant.

Diatoms were identified and counted using a Zeiss RA microscope with Nomarski interference phase-contrast accessories and a 100x oil immersion objective. A minimum of 400 individual diatoms were counted per sample to obtain relative density information for each species.

Diversity and similarity indices were calculated using an IBM 360 model 5 computer in order to obtain community structure information for each substrate. The diversity index was calculated using a program based on the formula

$$\bar{d} = -\sum_{i}^{s} (Ni/N) \; Log_2 \, (Ni/N)$$

in which S = the number of species, Ni = the number of individuals in species i, and

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N = the total number of individuals in S species (Cairns and Dickson 1971, Wilhm and Dorris 1968).

This formula is independent of sample size and gives an index which is high when many species are evenly represented in the community and low when most of the individuals occur in only a few species.

The similarity index was calculated from Ruzicka's (1958) formula:

$$SI = \frac{\sum_i \min(x_i, y_i)}{\sum_i x_i + \sum_i y_i - \sum_i \min(x_i, y_i)}$$

in which xi and yi = relative density for the ith species in the two samples being compared. This index gives a quantitative measure of the similarity between two stands of data.

Results

The diatom flora from the four sites included 17 genera and 60 species (Table 1). Of these, 12 genera and 40 species were found on the snail, 11 of the species being unique to the snail's shell. The 5 most common species (Table 2) comprised 61.7 percent of the diatom flora from the snail's shell. The remaining species had relative densities below 4.2 percent, and 20 species were below 1 percent.

A comparison of the diatom communities from the four habitats suggested some general relationships. The rock and vegetable substrates had fewer total species and lower diversity (Table 3) than occurred in the plankton or on the snail shells. The lowest diversity occurred on the vegetable substrate, which appeared to be the most specialized habitat of the four. It also had the least similarity to the other habitats (Fig. 1). *Achnanthes minutissima* was the diatom best adapted to the vegetative habitat, comprising 59 percent of the flora. The higher diversity and total number of species in the plankton and snail samples were due to instability in these habitats.

Instability in the plankton environment was caused by surface turbulence and the upswelling of subterranean water. As a result, many benthic diatoms were present in the plankton. The similarity of the rock and plankton habitats (Fig. 1) indicates that the influx of epilithic diatoms into the plankton was considerable.

Instability in the diatom community on the snail shell was probably a result of the

TABLE 1. Phylogenetic listing of diatom species identified in this study (The species identified with an asterisk were collected from the snail's shell).

ORDER RHIZOSOLENIALES
- *Terpsinoe musica*

ORDER FRAGILARIALES
- *Fragilaria brevistriata* var. *inflata* *
- *Fragilaria capucina* var. *mesolepta* *
- *Fragilaria construens* *
- *Fragilaria construens* var. *venter* *
- *Fragilaria crotonensis* *
- *Synedra delicatissima* *
- *Synedra incisa* *
- *Synedra pulchella* var. *lacerata* *
- *Synedra tabulata* *
- *Synedra ulna* *
- *Synedra ulna* var. *contracta* *

ORDER EUNOTIALES
- *Eunotia curvata* *

ORDER ACHNANTHALES
- *Cocconeis pediculus*
- *Cocconeis placentula* var. *lineata* *
- *Achnanthes bottnica* *
- *Achnanthes exigua* var. *heterovalva* *
- *Achnanthes exigua*
- *Achnanthes lanceolata* var. *dubia*
- *Achnanthes lanceolata* *
- *Achnanthes linearis* *
- *Achnanthes minutissima* *
- *Rhoicosphenia curvata*

ORDER NAVICULALES
- *Anomoeoneis vitrea*
- *Diploneis elliptica*
- *Navicula cryptocephala* var. *veneta*
- *Navicula dicephala* *
- *Navicula mutica* *
- *Navicula pelliculosa* *
- *Navicula perpusilla* *
- *Navicula pupula*
- *Navicula pupula* var. *rectangularis*
- *Navicula radiosa*
- *Navicula tripunctata* *
- *Navicula* sp. 1*
- *Navicula* sp. 2
- *Navicula* sp. 3
- *Pinnularia viridis* *
- *Entomoeoneis alata*
- *Amphora coffeaeformis*
- *Amphora ovalis* *
- *Amphora ovalis* var. *pediculus* *

Amphora veneta°
Cymbella affinis°
Cymbella cistula°
Cymbella delicatula°
Cymbella laevis
Cymbella ventricosa°
Cymbella sp.°
Gomphonema angustatum
Gomphonema constrictum°
Gomphonema gracile°
Gomphonema intricatum°
Gomphonema parvulum°

Order Epithemiales
Denticula elegans°

Order Nitzschiales
Nitzschia denticula
Nitzschia dissipata
Nitzschia frustulum°
Nitzschia frustulum var. *perminuta*°
Nitzschia palea

snail's motility. The shell is conducive to diatom attachment and growth, and, as the snail moves among the aquatic vegetation and stony substrate, it becomes seeded with diatoms which occur in these habitats. The continuous movement creates instability by causing frequent removal and addition of diatom frustules, thus preventing the dominance of any one species and providing for colonization of a wider variety of species than commonly occurs on a single stationary substrate. For this reason the diatom flora on the snail's shell had higher diversity and lower similarity to the rock sample than might be expected.

A more complete and replicated sampling program is planned to further investigate

Table 2. Diatom species with relative density above 5 percent in at least one habitat.

	Vegetative	Snail	Rock	Plankton
Achnanthes exigua var. *heterovalva*	1.4	11.0	7.7	8.3
Achnanthes minutissima	59.0	20.0	36.6	24.5
Cymbella delicatula	.4	1.1	11.7	1.5
Fragilaria brevistriata var. *inflata*	2.1	7.5	7.9	3.9
Fragilaria construens	.7	8.2	7.0	5.1
Fragilaria construens var. *venter*	.2	15.0	3.9	3.9
Fragilaria crotonensis	16.2	.9	3.6	11.2
Synedra ulna	5.2	2.2	2.7	2.9

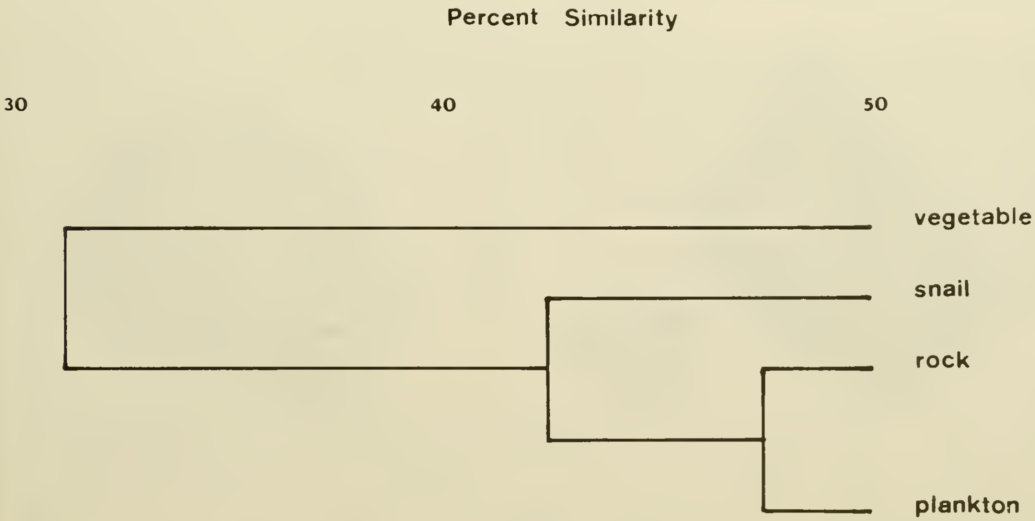

Fig. 1. Cluster dendrogram showing similarity of diatom communities from plankton, vegetable, snail, and rock substrates. Similarity indices were computed on the basis of relative density for diatom species.

the differences and relationships which exist in the plankton, rock, snail, and vegetable habitats of Lower Goshen Pond.

Table 3. Shannon Weaver diversity index for diatom communities from four habitats in Lower Goshen Pond.

Sample	Diversity Index	Total Species
Vegetative	2.42	31
Snail	4.07	40
Rock	3.34	29
Plankton	3.82	36

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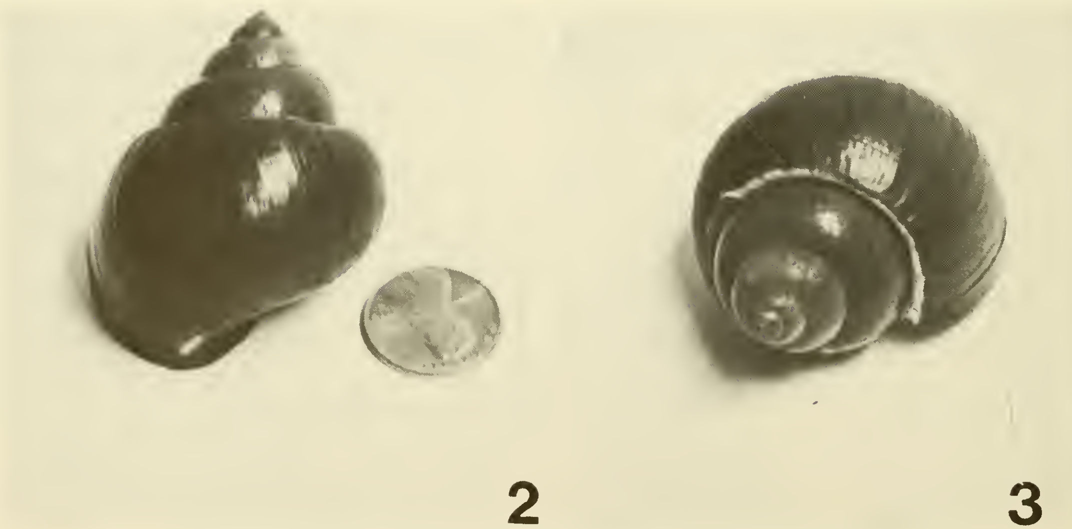

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Figs. 2-3. Representative specimens of *Ampullaria cuprina* (Mystery snail).