

GLCA

ALGAL FLORA OF SELECTED HANGING GARDENS

by

Richard L. Clark

In the fall of 1972, algae from five selected hanging gardens in the Lake Powell-Glen Canyon area were collected and identified.

The hanging gardens of the area are the result of the appearance of water on an exposed sandstone surface. This water seeps down through the Navajo Sandstone until it comes in contact with an impervious layer. The presence of the impervious layer produces an accumulation of water which is released wherever the sandstone outcrops. On this "drip line" or "drip wall", as it will be called in this paper, various species of blue green algae, green algae, and diatoms grow in an interesting ecological relationship on the Navajo substrate. The purpose of this study was to establish the algal floristics of the drip wall, the plunge basins, the runoff streams, and adjoining features of the Glen Canyon hanging gardens.

Studies of this type are unique to Utah. Interestingly enough no record of investigation of hanging garden algal flora exists in the state's volumes of scientific literature. Most of the algal studies in the state have been investigations of lentic water systems (lakes and ponds). Norrington (1925) studied the algae in certain mountain lakes, as well as some streams, of the Wasatch and Uinta Ranges. In 1931, Snow reported the algae she had found in Utah Lake. Ruth Patrick of the Academy of Natural Sciences of Philadelphia in 1936 reported her observations of the diatom flora of the Great Salt Lake. Piranian (1937) has made a preliminary study of the plankton

present at the Bear River Bird Refuge. Chatwin in 1956 investigated the vertical distribution of plankters in Deer Creek Reservoir. Clark (1956) in an analysis of plankton counting procedures made some observations of the algal flora of Bear Lake. Harding (1970-71) added to our knowledge of the algae of Utah Lake.

A couple of good stream studies have been completed in the state. Clark in 1968 compiled a reliable periphytic flora of the Logan River. He called the algae he observed "phytoplankton", but most of what he observed was dislodged bottom organisms. Squires (1972) in his comprehensive ecological study of the algae of Hunington Canyon, Utah prepared a species list of the algae of that river system.

Coombs (1964) looked at a number of aquatic environments in the western Uinta Mountains and reported algal species he observed there.

Flowers looked at the vegetation of Glen Canyon in a 1959 paper. His study was preliminary to the filling of Lake Powell behind Glen Canyon Dam. Though some algae species are reported, no mention is made of the algae present in the hanging gardens of the area.

Dr. Flowers has prepared two student manuals for the identification of algae, "Common Algae of Utah" and "The Blue Green Algae of Utah". Neither volume indicates distribution, nor are sites of collection referred to. Obviously, the algae keyed in these works must have been seen someplace in the state.

The above description of algal studies in the state is not exhaustive. Other studies have been carried on, but these investigations mentioned have at least a few species in common with those found in the hanging gardens of Glen Canyon. So many studies list

algal taxa without species epithets. Though technically this is permissible, the practice does not adequately communicate the specimen type that existed at the collection site.

Methods

Algae were collected from the drip walls, plunge basins, runoff streams and their confluences with Lake Powell, and adjoining areas of the gardens including (1) Step Garden (33a), (2) Pool Garden (33c), (3) Three Garden (33d), (4) Ribbon Garden (33b), and (5) Death Camas Garden. Primary collections were secured on November 2, 1972. Additional collections were taken two days later on November 4, 1972 and a month earlier, October 5, 1972, Three Garden was sampled.

All samples were preserved in formalin and returned to the laboratory at Brigham Young University at Provo, Utah.

Temporary microscopic slides were prepared of the preserved material. Blue green algae and green algae were identified to species. A crude estimate of abundance was noted. If a species was likely to be present in any given microscopic field, it was recorded as being "abundant" symbolized in the study as (A). If it could be found easily, though not always present in a given field, the species was designated "common" and symbolized (C). On the other hand, if the species had to be extensively searched for, it was designated as "rare" (R) in abundance.

Diatoms were cleaned by boiling collected material in sulfuric acid briefly. Potassium dichromate was then added to the diatom-acid solution was washed from the cleaned diatoms with water. Diatoms were separated from the acid solution by centrifugation. Cleaned diatoms

...were allowed to dry on microscopic cover glasses and then were mounted in hyrax mounting media. These permanent slides were observed, the diatom species identified, and their relative abundance recorded in the same manner as indicated above for the blue green and green algae.

Once a species list had been produced for the hanging gardens, the literature was searched for other reports of the same species found in the gardens. In this way a rough sketch of distribution in the state of Utah was established for each species encountered in the gardens. Distribution maps for each taxon found in the Glen Canyon gardens were prepared for both state of Utah and for the Lake Powell area.

and a month earlier, October 3, 1964.

All samples were preserved in 10% formalin.

Results

The following list of species was identified from among the algal flora of the hanging gardens:

I. Division Chlorophyta

A. Class Chlorophyceae

1. Order Tetrasporales

a. Family Palmellaceae

Palmella miniata Leiblein

2. Order Chaetophorales

a. Family Trentepohliaceae

Trentepohlia? aurea (L.) Martius

3. Order Zygnematales

a. Family Zygnematales

Spirogyra fluviatilis? Hilse

b. Family Desmidiaceae

Cosmarium botrytis Menegh.

Cosmarium cucumis Corda.

Cosmarium meneghinii var. concinnum Rob.

Staurostrum trihedrale Wolle

II. Division Chrystophyta

A. Class Bacillariophyceae

1. Order Pennales

- a. Family Fragilariaceae
 - Diatoma vulgare var. linearis V.H.
 - Synedra acus Kütz.
 - Synedra amphicephala Kütz.
 - Synedra rumpens var. fragilaroides Grun.
 - Synedra ulna (Nitz.) Ehr.
- b. Family Achnanthaceae
 - Achnanthes flexella (Kütz.) Brun
 - Achnanthes microcephala (Kütz.) Grun.
 - Achnanthes minutissima Kütz.
 - Cocconeis placentula var. euglypta (Ehr.) Cl.
- c. Family Naviculaceae
 - Anomoeoneis exilis form lanceolata (Kütz.) Cl.
 - Anomoeoneis vitrea (Grun.) Ross comb nov.
 - Caloneis bacillaris var. thermalis (Grun.) Cl.
 - Mastogloia smithii var. lacustris Grun.
 - Navicula cryptocephala Kütz.
 - Navicula mutica var. cohnii (Hilse) Grun.
 - Navicula pupula var. capitata Skv. & Meyer
 - Navicula radiosa Kütz. var. radiosa
 - Navicula radiosa var. tenella (Breb.) Grun.
 - Navicula tripunctata var. schizonemoides (V.H.) Patr.
 - Pinnularia sp.?
 - Pinnularia sp.?
 - Pinnularia sp.?
- d. Family Gomphonemataceae
 - Gomphonema sp.
 - Gomphonema intricatum Kütz.
 - Gomphonema lanceolatum Ehr.
 - Gomphonema olivaceum (Lyng.) Kütz.
 - Gomphonema parvulum (Kütz.) Grun.
- e. Family Cymbellaceae
 - Cymbella cistula (Hemp.) Grun.
 - Cymbella hebridica (Greg.) Grun.
 - Cymbella microcephala Grun.
 - Cymbella norvegica Grunow
 - Cymbella naviculiformis Auer.
 - Cymbella sp. 1
 - Cymbella sp. 2
 - Cymbella incerta Grunow
- f. Family Epithemiaceae
 - Denticula elegans Kütz.
 - Rhopalodia gibba (Ehr.) O. Müll.
- g. Family Nitzschiaceae
 - Hantzschia amphioxys (Ehr.) Grun.
 - Nitzschia amphibia Grun.
 - Nitzschia palea (Kütz.) Smith
 - Nitzschia sp.?

III. Division Cyanophyta

A. Class Myxophyceae

1. Order Chroococcales

- a. Family Chroococcaceae
 - Chroococcus turgidus (Kütz.) Naegeli
 - Gloeocapsa nigrescens Naegeli
 - Glosocapsa rupestris Kütz.
 - Gloeotheca rupestris (Lyngb.) Bornet
- 2. Order Oscillatoraceae
 - a. Family Oscillatoraceae
 - Lyngbya contorta? Lemmermann
 - Oscillatoria agardii Gomont
- 3. Order Nostocales
 - a. Nostocaceae
 - Anabaena? oscillarioides Bory
 - Nostoc muscorum Agarh.
 - Nostoc paludosum Kütz.
 - b. Family Scytonemataceae
 - Scytonema alatum (Carm.) Borzi
 - Scytonema myochrous (Dillw.) Agardh.

A Key to the Classes of Algae Found
in the Glen Canyon Hanging Gardens

- 1. Cells with the photosynthetic pigments dispersed through the protoplasm, chloroplasts lacking, often blue-green, but may be yellow to brown -----CYANOPHYCEAE (blue green algae)
- 1. Cells with the photosynthetic pigments collected in chloroplasts, green, yellow, or orange but seldom blue-green in color -----(2)
- 2. Plants reacting positively to iodine-starch test, chloroplast often grass green in color (exception: Palmella miniata's chloroplast is brick orange.) -----
-----CHLOROPHYCEAE (green algae)
- 2. Plants reacting negatively to iodine-starch test, most often chloroplast is orange to gold in color -----
-----BACILLARIOPHYCEAE (diatoms)

Chlorophyceae - The Green Algae

The chlorophyte algae have chloroplasts that have both chlorophyll a and chlorophyll b present. Starch is the common food reserve material.

A Key to the Genera of Chlorophyceae (Green Algae)
in the Glen Canyon Hanging Gardens

- 1. Cells in filaments------(2)
- 1. Cells not in filaments------(3)
- 2. Chloroplast with 2 or more spiral bands---Spirogyra
(one species present, Spirogyra fluviatilis Hilse)

SPECIES	THREE GARDEN	STEP GARDEN	POOL GARDEN	RIBBON GARDEN	D. CAMAS GARDEN
<u>Palmella miniata</u>	C	A		C	
<u>Trentephlia aurea</u>	R	A			
<u>Spirogyra fluviatilis</u>		C			C
<u>Cosmarium botrytis</u>			R		
<u>Cosmarium cucumis</u>					C
<u>Cosmarium meneghinii</u>	R	R	R		R
<u>Staurostrum trihedrale</u>		R			
<u>Diatoma vulgare</u>		R			
<u>Synedra acus</u>	A*				
<u>Synedra amphicephala</u>					C
<u>Synedra rumpens</u>					R
<u>Synedra ulna</u>	R*				C
<u>Achnanthes flexella</u>		C	C	A	C
<u>Achnanthes microcephala</u>			R		C
<u>Achnanthes minutissima</u>	R A* A**	R	R		R
<u>Cocconeis placentula</u>		R	R		
<u>Anomoeoneis exilis</u>			R		
<u>Anomoeoneis vitrea</u>		C	C	A	C
<u>Caloneis bacillaris</u>		R*			
<u>Mastogloia smithii</u>	C			C	
<u>Navicula cryptocephala</u>	C*	R	C		C
<u>Navicula mutica</u>	R*	R			
<u>Navicula pupula</u>	R*				R
<u>Navicula radiosa</u>	R*				
<u>Navicula radisoa tenella</u>	C*				
<u>Navicula tripunctata</u>	R*		R		
<u>Pinnularia</u>	R*				
<u>Pinnularia</u>	R*				
<u>Pinnularia</u>	R*				
<u>Gomphonema sp.</u>				R	C
<u>Gomphonema intricatum</u>	C*				R

Fig. 24. Distribution and relative abundance of algae in hanging gardens, (A, abundant; C, common; R, rare).

SPECIES	THREE GARDEN	STEP GARDEN	POOL GARDEN	RIBBON GARDEN	D. CAMAS GARDEN
<i>Gomphonema lanceolatum</i>	R*				
<i>Gomphonema olivaccum</i>	C*				
<i>Cymbella cistula</i>	A**				
<i>Cymbella hebridica</i>			C		
<i>Cymbella microcephala</i>	A A* C**	A	A	A	C
<i>Cymbella</i> sp.		C		A	
<i>Cymbella naviculiformis</i>	R*				
<i>Cymbella</i> sp.	C R*	C	A	A	R
<i>Cymbella</i> ?				C	
<i>Cymbella</i> ?	C	A	A	A	A
<i>Denticula elegans</i>	C R**	A	C	C	C
<i>Rhopalodia gibba</i>	C*				
<i>Hantzschia amphioxys</i>	R*				R
<i>Nitzschia palea</i>	R*				R
<i>Nitzschia amphibia</i>	R*				
<i>Nitzschia</i> sp.	R*				
<i>Chroococcus turgidus</i>	C	A	C	C	C
<i>Gloeocapsa nigrescens</i>	C	C			C
<i>Gloeocapsa rupestris</i>	A		R	C	C
<i>Gloeotheca rupestris</i>		A	C		C
<i>Lyngbya contorta</i>	C	A	C	C	C
<i>Oscillatoria agardii</i>			R		
<i>Anabaena oscillariodes</i>	R	R	R	R	R
<i>Nostoc muscorum</i>			A	A	
<i>Nostoc paludosum</i>	R	C		C	
<i>Scytonema alatum</i>	A	C	C	C	C
<i>Scytonema myochrous</i>	A	A	A	A	A

* collected in the runoff stream at Three Garden

** collected at the confluence of Three Garden stream with Lake Powell

Pinnularia

For Fig. 24. Continued.

Gomphonema inornatum

SPECIES NAME
2. Chloroplast, a parietal plate-----Trentepohlia

3. Protoplast embedded in extracellular gelatinous sheath, often merged into a common matrix-----Palmella
(one species present, Palmella miniata Leiblein)

3. Protoplast not embedded in extracellular gelatinous sheath----(4)

4. Semicells triangular in outline-----Staurostrum
(one species present, Staurostrum trihedrale Wolle)

4. Semicells hemispherical, often apically truncate, in outline-----Cosmarium.

Spirogyra fluviatilis ? Hilse

Description--Vegetative cells with plane end walls, width 32-36 μ , length 160-180 μ (ratio 1 : 5-6); chloroplasts three, making 3 to 4 turns in each cell; conjugation sclariform, tubes formed by both gametangia; fertile cells shortened and inflated to 70 μ ; zygote ovoid, 47-85 μ x 68-110 μ with median spore wall brown, corrugate, or finely wrinkled (description of sexual structure after Tiffany, 1952, p. 154). This identity was found in standing water attached to the sandstone substrate of a plunge basin at Step Garden. It was also present in running water on the complex wall at Death Camas Garden.

Discussion--Fruiting material was not collected. For this reason positive identification of the species is difficult. Vegetative characteristics do coincide with those provided by most descriptions.

Trentepohlia? aurea (L.) Martius

* collected in the runoff stream at Tower Garden

Description--Plant mass yellow-green; filaments sparingly branched; cells somewhat inflated, with smooth walls, 10-13 μ in diameter, 30-50 μ in length; gametangia globular, lateral on the branches, or terminal, 20-38 μ in diameter; sporangia usually terminal on curved cells, about the same size as the gametangia. (Description of sexual structure

after Prescott 1962. p. 134). The drip wall at Step Garden produced light green patches of this algae. It was also noted in small amounts in the Three Garden drip wall collection.

Discussion--Sexual structures were not definitely identified on our specimen. Prescott (1962, p. 134) says this plant often appears rusty-red to orange from the presence of cellular haematochrome.

Palmella miniata which was in association with Trentepohlia aurea demonstrated this exact property. Our specimens of this taxon were not brick red as were the chloroplasts of Palmella, rather they appeared light green under the microscope and yellow-green on the drip wall.

Palmella miniata Leiblein

Description--Cells ellipsoidal, embedded in copious mucilage thus forming amorphous colonies, with an individual cell sheath; chloroplast cup-shaped, with a single basal pyrenoid, brick red from presence of haematochrome. This species was relatively abundant in all gardens on the drip wall except Pool Garden and Death Camas Garden. No specimen were found at either of these two sites.

Discussion--Our collections showed plants that were much more ellipsoidal than those illustrated by Tiffany (1952, p. 23). The chloroplasts in our cells were quite irregular, and yet their cup-like properties were evident. This taxon when colonial was in association with Lyngbya

contorta.

Staurastrum trihedrale Wolle

Description--Cells small, punctate-granulate, length 35-49 μ , diameter 25-30 μ ; semicells in front view and in end view triangular, angles rounded, sides slightly concave; sinus narrow, linear. Step Garden's

drip wall was the only place this species was observed.

Discussion--Wolle's original description indicates the sides of the semicells of this desmid are concave. Our specimen do not appear distinctly concave. In fact, some individuals might be described as having convex sides. Because of the size and basic morphology similarities in other respects, we feel justified in assigning our specimen to this taxon.

The Genus Cosmarium

Key to Species

1. Cells less than 15 μ in diameter-----
-----Cosmarium meneghinii var. concinnum
1. Cells more than 20 μ in diameter ----- (2)
 2. Cells with rounded ends-----Cosmarium cucumis
 2. Cells with truncate ends-----Cosmarium botrytis

Cosmarium meneghinii var. concinnum Rob.

Description--Cells $1-1\frac{1}{2}$ times as long as wide, 9-12 μ in diameter, 14-16 μ long, with angles truncate; constriction forms a narrow sinus; semicells subquadrate; sides diagonally rounded; chloroplasts one in each semicell. This desmid was an occasional find on the drip wall in all gardens except Ribbon Garden.

Discussion--Wolle (1892, p. 70-71) mentions that this desmid has a wide variation in morphology and appears to have a wide distribution. Our specimen are more rhombic than those illustrated by Wolle. His semicells are almost rectangular. He does point out, however, that variations do occur from rounded to diagonally truncate. We noted little variation within our collection.

Cosmarium botrytis Menegh. This species was observed

Description--Cells 1-2 times as long as broad, 45-55 μ in diameter, 60-70 μ long, constriction forms a narrow sinus; semicells with nearly straight base, crenulate; sides converging from the inferior rounded end to the subtruncate end, slightly convex. This species was restricted to the drip wall at Pool Garden.

Discussion--Our specimen differ from Wolle's description in that the ends are subtruncate; Wolle calls for truncate ends. In other respects there is agreement.

Cosmarium cucumis Corda.

Description--Cells ovate, nearly twice as long as wide, length 55-56 μ , width 25-35 μ ; ends broadly rounded; constriction linear, isthmus about one-third the diameter of the cell, chlorophyll covering the inside of the walls of the cell. This desmid was collected at Death Camas Garden. It was not particularly abundant, but could not be considered rare.

Discussion--Our specimen were somewhat smaller than Wolle's description allows. However in a footnote Wolle points out "forms are found of much smaller dimensions.....down to a diameter of 15 μ are not rare".

A Key to the Genera of Bacillariophyceae (Diatoms)
in the Glen Canyon Hanging Gardens

Discussion--Wolle (1981) p. 74-75 mentions that this genus has a wide variation in morphology and appears to have a wide distribution. For

1. Frustules with pseudoraphe on both upper and lower valves----- (2)
1. Frustules with raphe on at least the lower valve, often present on both valves----- (3)

cells are 2. Valve with both transverse striae and costae--Diatoma
(one species present, Diatoma vulgare var. linearis)

2. Valve with transverse striae but no costae--Synedra

3. Raphe present on lower valve only------(4)
3. Raphe present on both upper and lower valves------(5)
 4. Valve bent or curved on the transapical (longitudinal) axis usually lanceolate in shape-----Achnanthes
 4. Valve bent or curved on the transverse axis, usually ovoid in shape-----Cocconeis
(one species present, Cocconeis placentula var. euglypta)
5. Raphe located in or near an excentric keel next to one lateral margin of the valve------(6)
5. Raphe located near the transapical midline of the valve, no keel present------(7)
 6. Upper and lower valve keel on the same side of the keel--
-----Hantzschia
(one species present, Hantzschia amphioxys)
 6. Upper valve keel on opposite side of frustule from lower valve keel-----Nitzschia
7. Valve asymmetrical at the transapical axis-----Cymbella
7. Valve symmetrical at the transapical axis------(8)
 8. Valve asymmetrical at the transverse axis-----
-----Gomphonema
 8. Valve symmetrical at the transverse axis------(9)
9. Frustules internally septate-----Mastogloia
9. Frustules not internally septate------(10)
 10. Blank spaces in striae forming longitudinal zigzag pattern on the frustule-----Anomoeoneis
 10. Striae with no such blank spaces on the frustule------(11)
11. Valve with smooth transverse costae-----Pinnularia
11. Valve with transverse striae or rows of puncta----Navicula

Bacillariophyceae - The Diatoms

These chrysophyte algae have chloroplasts that have both chlorophyll a and chlorophyll c present. Oils are the common food reserve material. A silicified cell wall is typical of the group.

Note the following two diatoms have not been included in the key:--

1. Denticula elegans Kütz.

2. Rhopalodia gibba (Ehr.) O. Müll.

Note for a Navicula-like diatom with broad rounded ends see Caloneis bacillaris var. thermalis (Grun.) A.El.

Diatoma vulgare var. linearis V.H.

Description--Valve linear, with rounded apices; length 44.75 μ ; width 7-10 μ ; striae about 16 in 10 μ ; costa irregularly placed, 5-8 in 10 μ ; pseudoraphe narrow, indistinct. This diatom was collected from the drip wall at Step Garden. It's occurrence was low.

Discussion--Our specimen agrees completely with Patrick's description (1966, p. 111) of the taxon. Two interesting questions raised here are: (1) Why is it found only in Step Garden? (2) Why is it present in the wall at all? Patrick says this diatom "prefers cool, flowing water". The drip wall of Step Garden does not support particularly "cool" water, and certainly the water is not running.

The Genus Synedra

Key to Species

1. Valve narrow, linear, capitate at the poles--Synedra amphicephala

1. Valve linear-lanceolate to lanceolate, not capitate at the poles------(2)

2. Striae opposite------(3)

2. Striae alternate---Synedra rumpens var. fragilaroides

3. Valve lanceolate, central area longer than wide--Synedra acus

3. Valve linear-lanceolate, gently attenuated, central area missing or near square-----Synedra ulna

Synedra amphicephala Kütz.

Description--Valve linear to linear-lanceolate, with capitate apices, length 20-75 μ , width 3-4 μ ; striae 11-16 in 10 μ ; pseudoraphe narrow, central area lacking. This diatom was found quite commonly in Death Camas Garden, but only there.

Discussion--This diatom is rectangular in girdle view. Though it was not extremely easy to find a representative in the Death Camas Garden collection, still it appeared fairly often. Patrick points that this taxon has a wide distribution and seems to be able to tolerate a number of different ecological situations.

Synedra rumpens var. fragilaroides Grun.

Description--Valve linear to linear-lanceolate, somewhat swollen at midvalve, attenuate, with rostrate apices, length 40-75 μ , width 3-5 μ ; striae 10-12 in 10 μ , alternate with each other; pseudoraphe distinct, becoming slightly wider toward the central area; central area longer than broad (it may be swollen). One specimen of this taxon was observed in Death Camas Garden.

Discussion--Our specimen was particularly short, and the central area was located in the center of the valve. This would make one believe that it was perhaps misformed in some way. Patrick says that the taxon is often found in waterfalls, brooks, and springs. The water runs off Death Camas Garden in a bit of a waterfall. Still the low incidence of the diatom would indicate that it is not completely suited to the hanging gardens.

Synedra

Synedra acus Kütz.

Description

Description--Valve lanceolate, tapering to rounded to slightly capitate

ends

ends, length 90-180 μ , width 4-6 μ ; striae parallel, 11-14 in 10 μ ;

pseudoraphe

pseudoraphe narrow, becoming a little wider toward the central area;

central area

central area distinct, a little longer than broad. Synedra acus was

the prominent

the prominent alga in the runoff stream at Three Garden.

Discussion

Discussion--Patrick points out that again this species has an apparent

wide distribution

wide distribution. It seems to do best in water of medium hardness.

One wonders

One wonders why the diatom does so well in the stream but was not found

at all on the Three Garden wall or at the confluence of the stream

with Lake Powell.

Description

Synedra ulna (Nitz.) Ehr.

Description

Description--Valve linear, very gradually attenuated to the rostrate

rounded poles

rounded poles, length 60-100 μ , width 5-8 μ ; striae parallel, 9-11 in

10 μ

10 μ ; pseudoraphe narrow, widening toward the center; central area

not much longer

not much longer than broad, often almost square, missing in many of

our specimen. Like S. amphicephala and S. rumpens var. fragilaroides

this taxon

this taxon was found in Death Camas Garden. Its incidence was higher

there than

there than its two relatives. It was rare in the Three Garden Stream.

Discussion

Discussion--Synedra ulna is probably one of the most widespread diatoms.

It is reported

It is reported often from a number of habitats from lentic to lotic

water systems

water systems. It is easily identified and probably as often mis-

identified

identified. It has countless forms and varieties. We are convinced

we have

we have the nominate variety here.

Achnanthes flexella (Kütz.) Brun. var. flexella

Description--Valve arched and somewhat twisted, elliptical, with ends

quite arcuate, but rounded, length 45-55 μ , width 20-25 μ ; raphe valve with narrow diagonally sigmoid raphe, proximal ends of the raphe small bulbous yet well within the central area, distal ends of the raphe terminating on opposite sides of the valve; striae radiate throughout, slightly wider and less numerous in the middle portion, punctate; pseudoraphe valve with large rectangular central area. A. flexella was either common or abundant in the drip wall of all gardens except Three Garden. It was not observed in material collected there.

Discussion--This diatom was one of the largest and most conspicuous in the study. The interesting thing about that is that most Achnanthes collected in the streams of the Mountain West are extremely small. Our description agrees with that of Patrick with the possible exception that our specimen were more elliptical than her drawing would indicate.

Achnanthes microcephala (Kütz.) Grun.

Description--Valve linear-lanceolate with capitate ends, length 10-20 μ , width 2-3 μ ; Raphe valve with narrow linear axial area, and variable central area; raphe filiform; striae slightly radiate, becoming more numerous toward the poles; pseudoraphe with narrow, linear pseudoraphe, central area lacking; striae 28 in 10 μ at the center becoming more numerous at the poles. This taxon was commonly found in collections from Death Camas Garden. It was rare in Pool Garden.

Discussion--It is easy to confuse this diatom with A. minutissima. Both are small and they are found in the same collections. This taxon is longer and has more capitate ends. Our description of the diatom agrees with Patrick's.

Achnanthes minutissima Kütz.

Description--Valve linear-elliptical with rounded subrostrate poles, length 10-20 μ , width 3-4 μ ; raphe valve with narrow, linear axial area and irregular central area, striae slightly radiate; pseudoraphe valve with narrow, linear axial area slightly broadened in the center; striae on both valves 30-32 in 10 μ . This species was very prevalent in and at the confluence of Three Garden stream. It was also rarely seen in the drip wall of Three Garden, Pool Garden, and Death Camas Garden.

Discussion--This is probably the smallest species in our collection.

In the collection at the confluence of Three Garden stream with Lake

Powell, it along with Cymbella cistula almost made a bitypic community.

Our specimen seem more attenuate than others collected in river systems and when compared with Patrick's description and drawings. The central area on the raphe valve would seem to more stauros than we have seen in A. minutissima before.

Cocconeis placentula var. euglypta (Ehr.) cl.

Description--Valve elliptical, length 10-20 μ , width 8-12 μ ; raphe

valve with narrow axial area, and small ovate central area; raphe

filiform; striae on raphe valve curved radiate; pseudoraphe valve with

narrow linear pseudoraphe; striae on pseudoraphe valve broken into a

series of two to four conspicuous dashes forming longitudinal hyaline

lines, curved radiate. C. placentula var. euglypta was rarely observed

at both Pool Garden and Step Garden.

Discussion--Our description of this diatom agrees completely with

that of Patrick. In general the specimen observed here were toward

diatom agrees with Patrick.

the lower limits in size suggested by Patrick, but still fit easily within those limitations. The diatom was interestingly found in the wall material. Cocconeis has a gelatinous pad that allows it to assume an epiphytic habit. A question arises as to its niche in the hanging garden community.

Hantzschia amphioxys (Ehr.) Grun.

Description--Valve linear, with capitate ends, arcuate, concave on the keel margin; keel puncta short, 8-10 in 10 μ ; striae 16-18 in 10 μ ; frustule length 20-100 μ , width 5-10 μ . This diatom was found rarely in Three Garden stream.

Discussion--Our specimen was toward the short end of Hustedt's size limitations.

The Genus Nitzschia

Key to Species

1. Striae fewer than 20 per 10 μ -----Nitzschia amphibia
2. Striae more than 20 per 10 μ -----Nitzschia palea

NOTE: A few other Nitzschia species were seen, but not well enough to be identified. See page

Nitzschia amphibia Grun.

Description--Valves linear-linear lanceolate, attenuated at the poles, length 12-50 μ , width 3-5 μ ; keel puncta 7-9 in 10 μ ; striae 16 in 10 μ . This diatom was rarely found in the Three Garden stream and on Death Camas Garden drip wall.

Discussion--Our specimen fits well the description of Hustedt.

Nitzschia palea (Kütz.) Smith

Description--Valves linear-lanceolate, with rostrate ends, length

18-65 μ , width 2-4 μ ; keel puncta 10-12 in 10 μ ; striae 33-36 in 10 μ .

This diatom was rarely found in the Three Garden stream and on Death Camas Garden drip wall.

Discussion--Our specimen fits well the description of Hustedt.

Nitzschia sp.

A number of other Nitzschia species were seen in the collection from Three Garden stream in rare numbers.

Discussion--These species were not well enough represented for

identification. This diatom was found rarely in Three Garden stream.

The Genus Cymbella

Discussion--Our specimen was toward the lower end of Hustedt's size limitations.

Key to Species

1. Valve with isolated punctae in the central area, raphe strongly arcuate-----Cymbella cistula
1. Valve without isolated punctae in the central area, raphe usually straight or nearly so----- (2)
 2. Axial area one quarter or more the width of valve----- (3)
 2. Axial area narrow less than one quarter the width of valve----- (4)
3. Raphe obviously complex, poles acutely rounded, striae lineate--
-----Cymbella incerta
3. Raphe apparently filiform, poles subrostrate, striae punctate---
-----Cymbella sp. 1 - page
4. Length of valve less than 25 μ --Cymbella microcephala
length 11-15 μ , width 1-1.5 μ ; keel puncta 10-12 in 10 μ . This diatom was rarely found in the Three Garden stream and on Death Camas Garden drip wall.
4. Length of valve more than 25 μ ----- (5)
5. Raphe dorsally bent from poles to central area, frustule rhombic
-----Cymbella sp. 2
5. Raphe straight, frustule not rhombic----- (6)
 6. Apex of valve subrostrate, central area widened, rhombic
-----Cymbella naviculiformis

Description--Valves linear-lanceolate, with rostrate ends. Length

6. Apex of valve not subrostrate, central area inconspicuous
to rounded------(7)

7. Raphe eccentric, ventral stria straight--Cymbella hebridica

7. Raphe nearly centra., ventral stria bent--Cymbella norvegica

Cymbella microcephala Grun.

Description--Valve linear, nearly symmetrical, with rostrate to capitate ends, length 15-23 μ , width 3-5 μ ; striae parallel to slightly radiate, 24-30 in 10 μ , axial area narrow, indistinct from the central area; central area lacking. This diatom was the most abundant and widely distributed in the hanging garden algal flora. It was found literally, at all collecting stations in the gardens, and in numbers that would allow it to be designated as being common.

Discussion--Our specimen agree with the description of Hustedt's.

There is some variation in size in a given population and in the shape of the poles. Hustedt allows for these differences in his treatment of the taxon.

Cymbella cistula (Hemp.) Grun.

Description--Valve arcuate, with convex dorsal margin and straight to concave ventral margin, often gibbous mid valve, with poles subrostrate and rounded, length 30-50 μ , width 8-15 μ ; striae parallel to slightly radiate throughout, 8-10 in 10 μ , punctate; axial area linear, central area longitudinally ovate, with 0-4 (5) isolated puncta located ventrally. The confluence of Three Garden stream with Lake Powell somehow provided excellent habitat for the growth of this diatom.

Discussion--There was great variation in size and basic morphology in members of the population sampled in the hanging gardens. All the

variations did fit Hustedt's limitations for the taxon. The species seems to be naturally quite variable. Our collection would certainly testify to that.

Cymbella naviculiformis Auer

Description--Valve linear-elliptical, with abruptly produced ends, with ventral margin straight and dorsal margin convex, length 25-35 μ , width 8-12 μ ; striae radiate throughout, about 14 in 10 μ ; axial area lanceolate; raphe slightly arcuate, filiform, central area rhombic. This diatom was found rarely in Three Garden stream.

Discussion--As is true of so many of the diatoms in the hanging garden flora, this diatom fits the size limitations on the lower side of the scale as proposed by Hustedt. Its morphology however differs little from Hustedt's description nor from his illustration.

Cymbella hebridica? (Greg.) Grun.

Description--Valve strongly asymmetrical, with dorsal margin convex, and ventral margin slightly convex, with ends rounded, length 40-45 μ , width 8-12 μ ; striae radiate at mid valve, parallel near the poles, 10-12 in 10 μ ; axial area narrow, widening toward the central area; raphe straight, with central fissures bent dorsally, central area longitudinally ovate, indistinct from the axial area. This identity was quite common in the drip wall flora at Pool Garden. It was not observed at other locations.

Discussion--There is considerable question in our minds as to the correct identification of this taxon. It was found in association with C. norvegica on the Pool Garden drip wall. C. norvegica was highly abundant at this site. There was some morphological variation in this

abundant species. C. hebridica is different from C. norvegica in its more orbicular central area, its dorsally originating raphe, and its more lanceolate shape. Our specimens were much bigger than allowed by Hustedt. His upper limit is 40 μ long. In other characters, the taxon is in agreement.

Cymbella sp. 1

Description--Valves lanceolate, nearly symmetrical, with ends subrostrate, length (36) 45-55 (81) μ , width 13-19 μ ; striae distinctly punctate, somewhat irregular in length, radiate throughout, 10-12 in 10 μ , 10-12 puncta in 10 μ ; axial area broad, widening towards central area, up to 1/3 the width of the valve, raphe distinct, with central pores unilaterally hooked towards the ventral side; central area elliptic, indistinct from the axial area.

Cymbella sp. 1 resembles C. lata Grun, except the axial area is broader, the striae are radiate throughout, and the puncta are coarser. This new taxon was restricted to the drip wall at Step Garden and was found in abundance at Ribbon Garden.

Clark 666 November 2, 1972, Ribbon Garden, Ribbon Canyon, Lake Powell, San Juan County, Utah, BRY; Clark 665 Step Garden, Driftwood Canyon, Lake Powell, Kane County, Utah, BRY, PH US.

Discussion--This species is a unique and beautiful diatom. In the Ribbon Garden diatom flora, it is much larger than any other diatom that is present there with the possible exception of Achnanthes flexella.

Cymbella incerta var. naviculacea Grunow

Description--Valves linear lanceolate, nearly symmetrical, with poles acute, rounded, 30-60 μ long, 6-10 μ wide, with dorsal margin convex

and central margin less convex, slightly swollen near midvalve; striae radiate throughout, more radiate near poles, 14-16 in 10 μ , lineate; axial area lanceolate, broad, widening towards central area; raphe ribbon-like, convex dorsally, slightly displaced ventrally near central area; central area, indistinct, slightly wider than axial area, with ventral striae shortened.

Clark 670 November 2, 1972, Ribbon Garden, Ribbon Canyon, Lake Powell, San Juan County, Utah, BRY; Clark 671 Step Garden, Driftwood Canyon, Lake Powell, Kane County, Utah, and Clark 672 Death Camas Garden, Glen Canyon, Lake Powell, San Juan County, Utah, BRY PH US.

Discussion--This diatom showed much variation in size, but its basic morphology remained constant. This was true within a collection and between collections as well. It was prominent in all drip wall collections suggesting that it might be a dominant member of the drip wall algal community.

Cymbella sp. 2

Description--Valves bent, rhombic, with rounded poles, 19-25 μ long, 6-8 μ wide; dorsal margin convex, ventral margin slightly convex, swollen strongly at midvalve; striae radiate throughout valve length, 18-20 in 10 μ at midvalve, 24-26 in 10 μ at poles, punctate; axial area narrow, lanceolate, widening toward center; raphe arcuate, convex dorsally; central area indistinct, only slightly wider than axial area.

Cymbella sp. 2 resembles C. brehmi Hust. except the valves are longer and wider, the striae are finer, and the axial area is wider. This diatom was restricted to the drip wall at Ribbon Garden. It was in moderate abundance there.

Clark 669 November 2, 1972, Ribbon Garden, Ribbon Canyon, Lake Powell, San Juan, Utah, BRY.

Discussion--This interesting diatom really has no equals. We have compared it with Cymbella brehmii, but it really had few similarities with it. Valve size and striation were the only common characters observed. Of particular interest in this diatom is the biarcuate nature of the raphe. We have not seen this before in a diatom. The unusual shape of the diatom is also of interest; not only does it have a peculiar valve view, which is rhombic, but the valve surfaces appear to be humped or rounded. This was evident in girdle view.

Cymbella norvegica Grunow

Description--Valves semielliptical to semilanceolate, with rounded poles, 38-50 μ long, 8-10 μ wide; dorsal margin convex; ventral margin slightly convex to straight; striae radiate throughout most of valve, convergent near poles, 11-12 in 10 μ at midvalve, 13-15 in 10 μ near poles, punctate; axial area narrow, linear, slightly excentric; raphe straight, with terminal pores bent dorsally at central area and poles; central area indistinct, only slightly wider than axial area.

Cymbella norvegica resembles C. hebridica (Greg.) Grun. except the valves are 38-50 μ long, the poles are more truncate, and the raphe is located more centrally. This diatom was especially abundant on the drip wall at Pool Garden. It was also found on drip walls of all other gardens collected. A few specimen were observed at Three Garden stream.

Clark 668 November 2, 1972, Ribbon Garden, Ribbon Canyon, Lake Powell, San Juan County, Utah, BRY; Clark 667 Pool Garden, Cottonwood Canyon, Lake Powell, San Juan County, Utah BRY, PH, US.

Discussion--There is some variation in shape and size in this taxon.

This variation was especially prevalent from the material that was

collected from the drip wall at Pool Garden. The principle morphological alteration was shortness and a more tringular outline.

The Genus Gomphonema

Key to Species

1. Central area with isolated punctum------(2)
1. Central area without isolated punctum------(4)
2. Valve length less than 30 μ ---Gomphonema parvulum
2. Valve length more than 30 μ ------(3)
3. Striae less than 10 in 10 μ -----Gomphonema intricatum
3. Striae more than 10 in 10 μ -----Gomphonema lanceolatum
4. Central area, unilateral-----Gomphonema sp.
4. Central area, equilateral----Gomphonema olivaceum

Gomphonema parvulum (Kütz.) Grun.

Description--Valve clavate to cuneate-lanceolate, with attenuate, rounded apices, length 20-30 μ , width 8-12 μ ; striae nearly parallel, 12-14 in 10 μ ; axial area broad, indistinct from central area, central area with an isolated punctum, striae often shortened. Three Garden stream was the only habitat this diatom was found in. It was rarely round.

Discussion--This diatom is not the G. parvulum that we most often see in stream studies. The striae are more parallel and the central

area less distinct. Still it fits Hustedt's description well; our

assignment here is justified.

Gomphonema olivaceum (Lyng.) Kütz.

Description--Valve clavate with broad apex and narrower base, both

ends rounded, length 25-35 μ , width 6-10 μ ; striae strongly radiate, 9-15 in 10 μ ; axial area linear, narrow; raphe filiform; central area rectangular, near stauros. This taxon was quite common in Three Garden Stream.

Discussion--This diatom is one of the most common Gomphonemas in water systems that we have looked at. Its incidence was low here in comparison to other habitats we have seen it in. Characteristically in girdle view, both margins have a distinctive bend concavely. This was not noticeable in our hanging garden specimen.

Gomphonema intricatum Kütz.

Description--Valve narrow, sublinear to sublanceolate, with mid portion inflated, both poles attenuated and rounded, length 45-55 μ , width 6-10 μ ; striae radiate at mid valve, convergent at the poles, lineate; axial area distinct, moderately wide; raphe filiform; central area eccentric with an isolated punctum. This taxon was commonly found in Three Garden stream and rarely found on the drip wall at Death Camas Garden.

Discussion--In general the Gomphonemas are a difficult group to differentiate. Their characters tend to overlap. We have assigned our taxa to this species based primarily on striation and valve size. The apical pole of our specimen is not as broad as that illustrated by Hustedt. The central inflation in our specimen tends to be more inflated and obvious than that shown by Hustedt.

Gomphonema lanceolatum Ehr.

Description--Valve clavate-lanceolate, with mid area inflated, both poles attenuated and obtuse; length 35-45 μ ; width 6-10 μ ; striae

slightly radiate throughout, 11-13 in 10 μ , lineate; axial area narrow linear; raphe filiform; central area unilateral, with an isolated punctum. This species was a rare collection at Three Garden stream.

Discussion--As was the case with G. intricatum this specimen does not quite fit Hustedt's description and illustration of the taxon. Our specimen are more attenuated at the apical pole hence tend to appear more inflated at the mid-valve. The striae are finer than those of G. intricatum (the latter has about 10 in 10 μ) and the species can be further distinguished by its comparative broadness.

Gomphonema sp.

Description--Valves linear-lanceolate, symmetrical to cymbiform along longitudinal axis, 45-52 μ long, 9-10 μ wide; poles rounded, nearly equal in size, often with small septae; occasionally basal pole somewhat more swollen; striae punctate, slightly radiate throughout, occasionally parallel near poles, 10-12 in 10 μ near midvalve, 16-18 in 10 μ near poles; raphe straight, complex; axial area narrow, sometimes inflated between central area and poles, widened toward midvalve; central area and poles, widened toward midvalve; central area rectangular, unilateral, extended or nearly extended to margin, without isolated punctum. Gomphonema sp. resembles G. lanceolatum Ehr. except the poles are inflated, there is no isolated punctum, and the central area extends to one margin. This species was found in rare abundance in Ribbon Garden. It was common in Death Camas Garden.

Clark 674 November 2, 1972, Ribbon Garden, Ribbon Canyon, Lake Powell, San Juan County, Utah, BRY; Clark 673 Death Camas Garden, Glen Canyon, Lake Powell, San Juan County, Utah, BRY, PH, US.

Discussion--No cymbiform types were found in the collection taken from Ribbon Garden. However numbers of asymmetrical forms were noted in the samples taken from Death Camas Garden. There were also regular forms in the Death Camas collection. The species varies little in size but does have this odd morphological variation.

Mastogloia smithii var. lacustris Grun.

Description--valve linear-lanceolate to elliptical-lanceolate, with subrostrate ends, length 50-55 μ , width 12-14 μ ; striae slightly radiate throughout most of valve, parallel at ends, 18 in 10 μ , punctate; puncta 14 in 10 μ ; loculi of intercalary band about equal in size, inner margin slightly convex, 5 in 10 μ ; axial area narrow, linear, with raphe filiform, appearing to be relocated laterally four-fifths of way from apex to central area; central area rectangular, extending to inner margin of locules. Collected off the drip wall in Ribbon Garden where it was common. Occasionally observed in drip wall material collected at Three Garden.

Discussion--Patrick (1966, p. 300) gives size limitations of this taxon as: length 20-45 μ , width 8-11 μ . She reports that the larger specimen observed by Hustedt (1959, p. 503) of up to 65 μ in length and 16 μ in width have not been seen in the United States. Our specimen fits Hustedt's description very well with the exception that the locules of our specimen are larger, 5 in 10 μ as characteristic of the taxon. Patrick's description of the raphe mentions lateral displacement midway between apex and central area. Our specimen show this displacement of the raphe, however it occurs much closer to the central area.

The Genus Anomoeoneis

Key to Species

1. Valve lanceolate with obtuse rounded poles-----
-----Anomoeoneis exilis
1. Valve elliptical-lanceolate with subrostrate to capitate ends---
-----Anomoeoneis vitrea

Anomoeoneis exilis form lanceolata (Kutzing) Cleve

Description--Valve narrowly lanceolate with obtuse rounded ends, length 25-45 μ , width 4-6 μ , striae very fine 30 in 10 μ , radiate throughout. Axial area narrow; raphe straight, filiform central area small, orbicular. This diatom was found in Pool Garden.

Discussion--only one specimen of the taxon was found in our collection. The diatom measured 37 μ in length and 6 μ wide and fit Dr. Hustedt's description (1959, p. 752) in other characters as well.

Anomoeoneis vitrea (Grun.) Ross var. vitrea

Description--Valve lanceolate to elliptical-lanceolate, with ends subrostrate to capitate, length 20-38 μ in 10 μ , width 5-8 μ in 10 μ ; striae 30-35 in 10 μ , radiate, finely punctate; axial area narrow and linear; raphe straight, filiform; central area ovoid. This diatom was observed in all gardens except Three Garden.

Discussion--Our specimen fit well the description of Patrick (1966 p. 380). Most of the specimen observed were of the larger capitate form. However, Pool Garden produced in addition, the smaller subrostrate type mentioned by Patrick in her discussion of the taxon.

The Genus Pinnularia

The Genus Pinnularia

Three species of Pinnularia were seen. All came from Three Garden stream. Only one of them was seen more than one time. None of the three can be identified with the available literature. Pinnularias as a group are poorly described. We will hope to find additional specimens in order to adequately describe these taxa.

The Genus Caloneis

Only one species was determined. It is: Caloneis bacillaris var. thermalis (Grun.) A.El.

Caloneis bacillaris var. thermalis (Grun.) A.El.

Description--Valve linear with broadly rounded ends, length 34-55 μ , width 8-10 μ ; striae parallel to very slightly radiate throughout, 18-20 in 10 μ , lineate; axial area, lanceolate, widening toward the middle of the valve; raphe slightly bowed laterally; central area indistinct from the axial area, rounded. Specimen of this taxon were collected from Three Garden stream.

Discussion--Our collections of this taxon were not unlike Patrick's description (1966 p. 586) with the exception that some individual cells fell below the lower length limitations prescribed by Patrick, also the distinct rounded central area was not common on our specimen.

380). Most of the specimen observed were of the

However, Pool Garden produced in addition, the

type mentioned by Patrick in her discussion of

The Genus Navicula

Key to Species

1. Valve elliptical-----Navicula mutica
1. Valve lanceolate or linear----- (2)
 2. Valve longer than 40 μ ----- (3)
 2. Valve shorter than 40 μ ----- (4)
3. Central area rectangular, length-width ration 7:1-----
-----Navicula radiosa var. radiosa
3. Central area orbicular, length-width ratio 5-6:1-----
-----Navicula tripunctata var. schizonemoides
4. Valve linear with broad capitate poles-----
-----Navicula pupula var. capitata
4. Valve lanceolate, attenuated----- (5)
5. Apex rostrate to capitate-----Navicula cryptocephala
5. Apex rounded-----Navicula radiosa var. tenella

Navicula mutica var. cohnii (Hilse) Grun.

Description--Valve elliptical, length 12-19 μ , width 6-8 μ ; striae radiate, distinctly punctate, irregularly shortened in the central area, 14-20 in 10 μ ; axial area linear, narrow, central area large, transverse. Representatives of this taxon were found in collections from Step Garden and from Three Garden stream.

Discussion--This diatom differs from the nominate variety by its elliptical shape and its more coarse punctation. Our specimen seemed to vary little from either the description of Patrick (1966, p. 454) or Hustedt (1930, p. 275).

Navicula radiosa Kütz. var. radiosa

Description--Valve linear-lanceolate with rounded acute ends, length 70-76 μ , width 8-11 μ ; striae radiate throughout most of valve, convergent at ends, 10-12 in 10 μ ; axial area narrow, widening slightly toward central area; raphe straight, hooked at the terminal node; central area rectangular in shape, not extending to margins of valve.

This taxon was collected only in the stream at Three Gardens. Its occurrence there was rare.

Discussion--Our description of the diatom is in agreement with Patrick (1966, p. 509). She gives size limitations of 40-120 μ in length and 10-19 μ in width, which the few specimens we observed easily fit within. Our specimens do differ, however, with Patrick's drawing of the taxon on p. 561 in that the Three Gardens diatom has much more transversely widened central area. Patrick explains in her description that this variation in the central area is often the case.

Navicula tripunctata var. schizonemoides (V.H.) Patr.

Description--Valve lanceolate to linear lanceolate, with ends obtusely rounded, length 50-60 μ , width 9-11 μ ; striae, radiate becoming convergent at the apices, lineate, 10-12 in 10 μ ; axial area narrow, widening slightly toward the apices, raphe straight, filiform; central area orbicular. This taxon was present in the stream at Three Garden and in the drip wall at Pool Garden.

Discussion--The taxon fits well Patrick's description (1966, p. 514). Our specimens are a littler wider than the limitations proposed by Patrick.

Navicula pupula var. capitata Skv. Meyer

Description--Valve linear-lanceolate, with broadly capitate ends, length 16-25 in 10 μ , width 6-8 μ ; striae, radiate throughout valve, short, irregular about the central area, lineate; axial area narrow; central area transversely widened nearly to margins of valve. This taxon was seen one time in collections from Ribbon Garden and several specimens were observed from the Three Garden stream.

Discussion--Navicula pupula var. capitata exhibited great size variation in collections taken from the hanging gardens though its incidence was low. Particularly a number of those observed were smaller than allowed by Patrick (1966, p. 496). Hustedt (1930, p. 281) also gives a lower limit in length of 20 μ and in width, 7 μ . In other respects our specimens seem to agree with the descriptions of the taxon by both Patrick and Hustedt.

Navicula cryptocephala Kütz. var. cryptocephala

Description--Valve rostrate with rostrate rounded poles, length 30-40 μ in 10 μ , width 5-8 in 10 μ ; striae radiate throughout most of the valve, parallel at the poles, lineate, 14-16 in 10 μ ; axial area, narrow, slightly wider as it merges with the central area; raphe straight, filiform; central area transversely widened, elliptical. This taxon was collected only at Three Garden stream. Few specimens were observed.

Discussion--The diatom fits Patrick's description (1966, p. 503) well. The striation may be a little coarser than apparent from her description otherwise its characters fit within her outlined limitations.

Navicula radiosa var. tenella

Description--Valves lanceolate with acute, rounded poles, length 22-40

μ , width 5-8 μ ; striae radiate at center, parallel at ends, 13-16 in 10 μ , lineate; axial area narrow, slightly widened toward the center of the valve; central area very small with median striae often unusually long. Three Garden stream was the only place this diatom was found. It was perhaps the most common Navicula in the system.

Discussion--Our specimen often fell below the lower limits in size established by Patrick (1966, p. 510), especially in length. Her lower limit of 25 μ was extended to 22 in material from our collection.

Patrick describes the taxon as having a striae count of 15-18 in 10 μ .

We have found the striae to be coarser in the valve center, near 12-14 in 10 μ . However those striae toward the poles seem to be similar to those described by Patrick.

Denticula elegans Kütz.

Description--Valve linear, with sides convex to straight and ends rounded, 15-40 μ long, 5-7 μ wide; raphe near valve margin; transapical ribs strong, 3-6 in 10 μ ; striae 15-17 in 10 μ ; septum strongly developed. This taxon was widespread in the study area. It was found on all drip walls and rarely in the Three Garden stream.

Discussion--Only Cymbella udiparia shared as wide a distribution in the hanging gardens as Denticula elegans. Like Rhopalodia gibba this diatom is a member of the Epithemiaceae. Hustedt divides the family into two subfamilies based primarily on the position of the raphe in relation to the valve margin and the Keel. D. elegans then is placed in one of the subfamilies and R. gibba in the other.

Rhopalodia gibba (Ehr.) O. Müll.

Description--Valve linear, arcuate on the dorsal, straight on the

ventral side, reflexed at the ends; costae 6-7 in 10 μ ; striae 12-14 in 10 μ ; length of valve 80-140 μ . This diatom was very commonly found in Three Garden stream along with Synedra acus.

Discussion--This diatom is difficult to describe, yet when it is seen it is very distinctive. The raphe is usually difficult to see. It is found in a keel along the convex edge of the valve. The species has been found by many to develop in large numbers primarily during the fall of the year.

A Key to the Genera of Cyanophyceae (Blue-green Algae)

in the Glen Canyon Hanging Gardens

1. Thallus a branched or unbranched filament (trichome)----- (2)
1. Thallus a spherical or globular colony in which the individual cells are not united end to end----- (6)
 2. Heterocysts and/or gonidia present in the filament----- (3)
 2. Neither heterocysts nor gonidia present in the filament----- (5)
3. False branches present----- Scytonema
3. False branches absent----- (4)
 4. Trichomes solitary or intertwined in an amorphous mass-----
----- Anabaena
(one species present, Anabaena? oscillarioides)
 4. Trichomes twisted into a firm, definite gelatinous matrix-----
----- Nostoc
5. Trichome with gelatinous sheath present----- Lyngbya
(one species present, Lyngbya contorta)
5. Trichome without gelatinous sheath present--- Oscillatoria
(one species present, Oscillatoria agardii)
 6. Protoplasts rod-shaped, cylindrical---- Gloeotheca
 6. Protoplasts spherical, except after division----- (7)

7. Colored gelatinous sheath present in older colonies-----
-----Gloeocapsa
7. Colorless or hyaline gelatinous sheath present in older colonies
-----Chroococcus
(one species present, Chroococcus turgidus)

Discussion--This order The Genus Scytonema

It is very distinctive.

found in a few places. Key to Species

1. Sheaths very wide, forming lateral "wing-like" expansions-----
-----Scytonema alatum
1. Sheaths not forming wing-like expansions-----
-----Scytonema myochrous

Scytonema alatum (Carm.) Borzi

Description--Filaments 24-66 μ in diameter, hyaline to ochraceous; branches in pairs between heterocysts, relatively short; cells cylindric to barrel-shaped, 8-15 μ in diameter, 8-15 μ long; heterocysts subglobose; sheaths broad, highly lamellated, diverging forming lateral "wings". This blue-green algae was common to abundant on the drip wall of all five gardens sampled.

Discussion--S. alatum forms a brown wooly mat near the surface of the gelatinous matrix of the drip wall algal complex. It is found usually in association with S. myochrous. The taxon is distinctive with its laterally extending gelatinous wings. S. myochrous has diverging lamellated sheaths but the divergence is much more gradual forming more cylindric filaments.

3. Trichome without gel.
(one species present)
Scytonema myochrous (Dillw.) Agardh.

Description--Filaments 18-36 μ wide hyaline to highly ochraceous, long and flexuous branches often single or in pairs; cells, discshaped in younger portion; to cylindric heterocysts quadrate, near 10 μ in

diameter sheaths thick lamellated, with layers gently diverging. This species was endemic to the drop wall of all five hanging gardens sampled.

Discussion--Our original consideration was that, in fact, we had two species here instead of one. One had barrel-shaped cells and a wide sheath with gently diverging lamellations. The other had cylindric cells, a narrow sheath and parallel lamellations. And the second species was smaller than the first. Prescott (1962 p. 535) points out in his description of the taxon that wide variation can exist in this primarily aerial species. Closer inspection revealed that the specimen originally thought to have parallel lamellations did diverge, but in great lengths. All the variation noted from the gardens does fit within Prescott's limitations.

Anabaena? oscillarioides Bory

Description--Filaments, straight to flexuous, entangled in a thin gelatinous layer or solitary cell barrel-shaped to truncate-globose, (4-6 μ in diameter); heterocysts round or ovate, 6-8 μ in diameter; gonidia cylindrical, developing on both sides of heterocyst, rarely on one side, 8-10 μ in diameter, 20-40 μ in length (description of heterocysts and gonidia taken from Prescott (1962 p. 517)). Samples taken from drip walls in all gardens produced fragments of filaments of this identity in small amounts.

Discussion--We are assigning this identity to this taxon on a tentative basis. We are doing so on the basis of cell size, habitat, and associations. Our specimen had spherical cells that measured near 4 μ in diameter. Prescott (1962 p. 517) points out that collections he has seen of the taxon have been found "subaerial in swampy places", among other types of habitats. He also points out that this taxon has been

found as an isolated solitary filament among other algae. Positive identification is not possible because filaments produced no observable heterocysts nor gonidia. This means that we have the distinct possibility of not having an anabaena at all, but rather another member of the Hormogonales, likely an oscillatoria because of the lack of an observable sheath.

The Genus Nostoc

Key to Species

1. Colony microscopic with only one or two filaments-----
-----Nostoc paludosum
1. Colony macroscopic usually with many filaments-----
-----Nostoc muscorum

Nostoc paludosum Kuetzing

Description--Thallus, small oblong to subspherical microscopic colony, up to 1 mm in diameter; trichome loosely coiled in older colonies, tightly coiled in younger colonies; embedded in copious gelatin; cells barrel-shaped, 3-4 μ in diameter, olivegreen; heterocysts ovate, 4-5 μ in diameter, 6 μ in length; gonidia ovate, 4-5 μ in diameter, 6-8 μ long, smooth. This blue-green algae was a common observation in material collected from Step Garden and Ribbon Garden. It was found rarely at Three Garden.

Discussion--Our collection and description agrees completely with Prescotts analysis (1962 p. 524) of the taxon. This interesting tiny Nostoc species seldom has more than one or two filaments present in the gelatinous envelope. Our specimens were usually spherical to football-shaped.

Nostoc muscorum Agarh.

Description--Colony spherical, greenish to bluegreen, firm, trichomes crowded, entangled, individuals sheaths not evident, more densely aggregated toward the surface of the mass; cells 3-4 μ x 306 μ , spherical but compressed, heterocysts 6-7 μ in diameter, spherical oblong, often in series (gonidia description after Flowers n.d. (b) p. 50). Nostoc muscorum Agarh. was abundant on the wall at Pool Garden.

It was present but less abundant in the drip wall at Ribbon Garden.

Discussion--Prescott (1962 p. 524) describes the colony of this species as "a brown, lumpy, or tuberculose membrane, firm and leathery when growing on small, densely aggregated spherical colonies; with age becoming larger and confluent, soft and gelatinous, often depressed spreading out into flat membranaceous sheets." Our observations of the colony agree totally with neither Flowers nor Prescott. We have found the colony to be quite spherical even up to the size of 15 mm. Dr. Flowers description could however pertain to our specimen in its developmental sequence. We just have noticed no spreading membranous forms. Our description of the trichome and cells are in complete agreement with both Prescott and Flowers.

We found no gonidia in association with the filaments. Heterocysts were always present. Flowers (n.d. (b) p. 50) points out that "fruiting is rare in this taxon.

Lyngbya contorta? Lemmermann

Description--Trichomes 2.5-4 μ in diameter, irregularly coiled or twisted, not uncommonly straight, not tapering at the apex, not constricted at the cross walls; cells 1-2 μ wide, 4-9 μ long, cylindric;

cross wall not distinctly evident, cell contents pale olivaceous; sheaths thin but firm. Lyngbya contorta was very common to all drip wall collecting sites. It was abundant in samples taken from the moister areas of the wall at Step Garden.

Discussion--There may be some question as to the identification of this species. Flowers (n.d. (b) p. 40) described it as a "loose and wooly, yellowish-green, floating mass." He says further that a single collection had been made in a pond near lake Point, Utah which he described as a crusty mass. Prescott (1962 p. 500) describes the species as being either solitary or planktonic. In our collections the identity was found in association with Palmella miniata. Lerbleim embedded in copius mucilage. Because of the orange plastids of Palmella the algal complex assumed a distinctive rust color especially on the wall at Step Garden. The morphology of individual trichomes fit both the description of Flowers (n.d. (b) p. 40) and Prescott (p. 500)

Oscillatoria agardii Gomont

Description--Trichomes straight throughout entire length, briefly tapering at anterior end; ends capitate or smooth; cells 3-6 μ in diameter, not constricted at the cross wall, length $\frac{1}{2}$ to 1 times width; cross walls granular. This species was collected at Pool Garden drip wall only.

Discussion--Prescott, who is primarily a lake phycologist, points out that O. agardii is often found in blue-green masses with interwoven straight filaments. Our specimen was found in association with other drip wall algae. Though the growth habit differs here, the morphology of our specimen is consistent with Prescott's description. This same

taxon was observed by the author at Teet Tsu Springs and Cottonwood Springs which are in the Lake Powell area.

Gloeotheca rupestris (Lyngb) Bornet

Description--Cells ovate to cylindric ovate, irregularly scattered throughout a copious colorless gelatinous matrix, solitary, in 2's, or 4's in small families surrounded by definite sheaths. Gloeotheca rupestris was observed in the drip walls of Step Garden, Pool Garden, and Death Camas Garden.

Discussion--In 1942 Drouet and Daily proposed merger of the genus Gloeotheca with Aphanotheca and then reassigned them to the genus Anacystis. The original differentiation was based on the presence of definite individual cell sheaths present in Gloeotheca but supposedly missing in Aphanotheca. Such sheaths often appear among members of Aphanotheca thus clouding the distinction between the two genera.

Hence this taxon often appears in the literature as Anacystis rupestris Drouet and Daily. We have elected here to follow the older classification and to use the genus designation Gloeotheca to point out the presence of definite lamellations present in our specimen.

The Genus Gloeocapsa

Key to Species

1. Gelatinous sheath blue or black-----Gloeocapsa nigrescens

1. Gelatinous sheath orange or gold-----Gloeocapsa rupestris

Gloeocapsa nigrescens Nag.

Description--Colony 1 - approximately 16 cells, spherical; up to 10 μ in diameter, individual cells spherical to ovate, up to 5 μ in diameter,

blue-green in color; gelatinous matrix colorless at first becoming blue, violet, to blue-black. Gloeocapsa nigrescens was particularly plentiful in samples taken from the drip wall in lower Three Garden. It was also collected on the drip wall of step Garden and Death Camas Garden.

Discussion--Daily (1942) points out that this species is not often collected on substrates of limestone or sandstone. Our collections showed great variation in colony size. Also the amount of gelatinous matrix surrounding the sheathed protoplasts varied greatly as well.

Gloeocapsa nigrescens was found in smaller numbers but in association with Gloeocapsa rupestris. Especially was this true in samples taken from lower Three Garden.

Gloeocapsa rupestris Kütz.

Description--Colony 1 to many celled, spherical to ovate, 15-85 μ in diameter; protoplasts spherical, hemispherical, to ovate, up to 10 μ in diameter, blue-green in color; gelatinous matrix colorless at first becoming yellow, orange to brown with age. This species was richly abundant in the drip wall material of lower Three Garden. No identifiable material was found in Step Garden and the taxon was rare in Pool Garden. Discussion--This species exhibits even more morphological variation than its fellow species Gloeocapsa nigrescens. The individual cell sheaths are often scalloped but the usual homogeneous sheath is more common. The colonial sheath can also be scalloped. Daily (1942) points out this species in the Indiana area is most often collected from dark stratum on rock. Specimen that he has seen come from limestone and sandstone cliffs in Indiana.

Chroococcus turgidus (Kütz.) Naegeli

Description--Thallus few to many celled (usually 2-4 celled), enclosed in a wide hyaline lamellate colonial sheath, 15-50 μ in diameter; individual cells blue-green to brown, 8-23 μ in diameter. This taxon was present in the drip walls of all five gardens collected.

Discussion--Some colonies in our collection fall below the lower limits in size prescribed by both Daily (1942 p. 643) and Prescott (1962 p. 450). In other respects these abnormally small colonies fit the description of the taxon. There is the possibility that these small forms are in fact immature forms of other chroococcalin species.

Conclusions

The hanging garden drip wall in the Glen Canyon area is primarily a blue-green algae community. Probably the most prominent member of that community is Scytonema myochrous. Scytonema alatum is also very abundant in the wall material. Its association with S. myochrous is not clear yet. There are places one can collect almost pure samples of S. alatum. This was particularly true of Three Garden. The outer surface of the thick gelatinous wall was brown with S. alatum. Most of the time, however the two species will be mixed, or S. myochrous will be the only member present.

Members of the Chroococcaceae were also part of that blue-green community. Gloeocapsa, Chroococcus, and Gloeotheca were always found associated with the filamentous Scytonemas. There is every reason to believe these smaller plants are the source of the heavy gelatin that makes up the drip wall. Just what the details are of their association in the wall community is yet to be found out.

101
All of the drip walls studied supported a flora of diatoms. Those diatoms present in the walls, are few in number of species, but each is unique. None like them have been reported in the state of Utah, and further study might reveal that none like them have been reported ever before.

The green algae were present primarily in locations that water from the wall took on stream characters. Palmella miniata did add extensive gelatinous material to the wall, but it was found in areas where there was abundant moisture.

The wall must be a unique environment. None of the species dribbled over into the runoff stream at Three Garden for instance. The stream had its own flora with very little overlap with the taxa that were to be found in the wall. The flora of the stream reminded one of stream flora in other parts of the state with species of Synedra, Navicula, Rhopalodia, Pinnularia, and Nitzschia showing up there.

At the point of the water from Three Garden joining the water of Lake Powell, only two diatom species were found; no other types were present, either blue-green algae or green algae. Cymbella cistula was found here and only here in the study.

Literature Cited

- Chatwin, S. L. 1956. The vertical distribution of phytoplankton of Deer Creek Reservoir, Wasatch Co., Utah. M.A. Thesis, Univ. of Utah, Salt Lake City, Utah.
- Clark, William J. 1956. An evaluation of methods of concentrating and counting the phytoplankton of Bear Lake, Utah-Idaho. M.S. Thesis, Utah State Univ., Logan, Utah.
- _____. 1958. The phytoplankton of the Logan River, Utah, a mountain stream. Ph.D. Thesis, Utah State Univ., Logan, Utah.
- Coombs, Robert. 1964. A floristic and ecological survey of the algal flora of the western Uinta Mountains and adjacent areas. M.S. Thesis, Univ. of Utah, Salt Lake City, Utah.
- Flowers, Seville. 1959. Vegetation of Glen Canyon. In ecological studies of the flora and fauna in Glen Canyon. Univ. of Utah Anthropological Papers, 40: 21-61.
- _____. n.d. (a). Common algae of Utah. Univ. of Utah. 70 pp. mimeo.
- _____. n.d. (b). The blue green algae of Utah. Univ. of Utah. 69 pp. mineo.
- Foster, Harris N. 1960. An ecological study of a warm sulfur spring in Salt Lake Valley, Utah. M.S. Thesis, Univ. of Utah, Salt Lake City, Utah.
- Harrison, J. William. 1926. A preliminary study of the fresh water algae of Washington County, Utah. M.S. Thesis, Brigham Young University, Provo, Utah.
- Hustedt, F. 1930. Baccillariophyta (Diatomeae). In Pascher, A. Die Süßwasser-Flora Mitteleuropas. Heft 10:466 pp.
- _____. 1959. Die Kieselalgen, Deutschlands, Österreichs and der Schweiz. In Rabenhorst's Kryptogamen-Flora, Band VII, Parts 1-3. 2122 pp.
- Norrington, Annie. 1925. Phycological study of the Wasatch and Uinta Ranges in Utah. Ph.D. Thesis, Univ. of Chicago, Chicago, Illinois.
- Patrick, Ruth. 1936. Some diatoms of Great Salt Lake. Bull. Torrey Bot. Club. 63 (3): 157-166.
- Patrick, Ruth and Reimer, Charles W. 1966. The diatoms of the United States Vol. I. Monographs of the Academy of Natural Sciences of Philadelphia. No 13. 688 pp.

Piranian, George. 1937. The plankton of the Bear River Migratory Water Fowl Refuge, Utah. M.S. Thesis, Brigham Young University, Provo, Utah.

Prescott, Gerald W. 1962. Algae of the western Great Lakes area. Wm C. Brown Co. Dubuque, Iowa. 977 pp.

Ralfs, John. 1848. The British Desmidiaceae. Reeve, Benham, and Reeve. London, England. 225 pp.

Randhawa, M.S. 1959. Zygnemaceae. Indian Council of Agricultural Research. New Delhi, India. 478 pp.

Snow, Edna. 1931. A preliminary study of the algae of Utah Lake. M.S. Thesis, Brigham Young University, Provo, Utah.

Squires, Lorin E. 1972. A quantitative and ecological survey of the algae of Huntington Canyon, Utah. M.S. Thesis, Brigham Young University, Provo, Utah.

Tiffany, Lewis H. and Britton, Max E. 1952. The algae of Illinois. Univ. of Chicago Press, Chicago, Illinois. 407 pp.

Wolle, Francis. 1887a. Fresh-water algae of the United States. Vol. I (text). The Comenius Press, Bethlehem, Pa. 364 pp.

_____. 1887b. Fresh-water algae of the United States. Vol. II (plates). The Comenius Press, Bethlehem, PA. 2300 ill.

_____. 1892. Desmids of the United States.

_____. 1911. Desmids of the United States. Lake City, Utah.

_____. 1912. Desmids of the United States. Lake City, Utah.

_____. 1913. Desmids of the United States. Lake City, Utah.

Norrington, Annie. 1925. Phycologia. Ranges in Utah. Ph.D. Thesis, Illinois.

Patrick, Ruth. 1936. Some diatoms. Bot. Club. 41 (3): 157-160.

Patrick, Ruth and Bulman, Charles. 1937. Some diatoms. Bot. Club. 42 (3): 157-160.