Observations on the Algal Flora of Seneca Cavern, Seneca County, Ohio[1]

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ABSTRACT. **A total of 25 algal taxa were found in subaerial samples from Seneca Cavern, an earth crack cave in Seneca County, OH. Most algae were typical aerophilic species, with *Chlorella miniata, Pleurochloris commutata, Navicula tantula,* and *Navicula contenta* f. *biceps* being the most abundant species. The flora was species poor in comparison to other caves, likely because of dimness of lighting and absence of standing and running water. This paper represents the first report of cave algae in Ohio.**

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INTRODUCTION

Algal floras have been studied for a number of different subaerial habitat types by various researchers throughout the world. These habitats have drawn attention because of their marked differences from aquatic habitats typically studied by phycologists. Places studied include desert seep walls (Johansen et al. 1983a,b; Rushforth et al. 1976), wet walls associated with waterfalls or springs (Camburn 1982, Lowe and Collins 1973), moss epiphytes (Ando 1977, 1978, 1979, 1981, 1982, 1985; Dodd and Stoermer 1962; Stoermer 1962), volcanic steam vents (McMillan and Rushforth 1985), and caves (Carter 1971; Claus 1955, 1962a,b, 1964; Palik 1960). Of these habitats, caves are perhaps the most unusual because they have very reduced seasonality and generally have light only at the mouth or when artifical lights are installed.

Only two studies have considered subaerial algal floras in Ohio. These studies reported algae on the sandstone cliffs in southeastern Ohio, primarily in the Hocking Hills region (Koch 1976, Lowe and Collins 1973). In the neighboring state of Kentucky, the algal floras of eight cliffs in the Appalachian Plateaus Province were studied by Camburn (1982), and the diatom flora of Mammoth Cave was reported by Van Landingham (1964, 1966, 1967). Apart from the study of Mammoth Cave, all other cavern studies in the United States have been restricted to the western states and Hawaii (Bahls 1981, Rushforth et al. 1984, St. Clair and Rushforth 1976, St. Clair et al. 1981).

Because of the paucity of information on cave algae in this part of the country, the decision was made to study the algae of Seneca Cavern in Seneca County, OH. Seneca Cavern is unusual in that it is an earth crack cave of dolomite and limestone, rather than a limestone cave formed by water flow. Thus it does not have the stalactite and stalagmite formations nor the dampness of caves previously studied. It is closed during winter, and thus experiences a loss of light for several months. When illuminated, light is provided by incandescent bulbs, many of which are colored red or green. Lighting is generally dimmer than that previously observed in other caves open to the general public. Mosses are present on many substrates around white lights, and moisture from groundwater seeps into the cave year-round. The cavern has seven recognized levels. A small inaccessible stream runs through the lowermost level of the cavern. This paper reports the results of a study of the subaerial surfaces within the cave.

MATERIALS AND METHODS

The geology of Seneca Cavern is reported in Ruedisili et al. (1990). They report the existence of seven levels in the cavern and give a map to the surveyed levels of the cavern. The lower levels (5–7) lie in the Lucas dolomite formation, level 4 lies in the brown dolomitic limestone of the Bellepoint member of the Columbus formation. The upper three levels lie in light gray limestone. Ten samples were collected in the cavern on 8 October 1989 from noticeably damp sites which received at least some light from white incandescent bulbs. The site descriptions are as follows: 1) fairly dry, near-vertical site on level 7; 2) mossy, near-horizontal area on level 6; 3) drier site 4 ft up from site 2 on level 6; 4) path between levels 5 and 6; 5) nearly horizontal, wet area, dolomitic limestone on path between levels 4 and 5; 6) wet area on level 4; 7) calcium carbonate deposit on level 4; 8) dripping area of roof on level 4; 9) drier site, moss with soil accumulation on level 2; 10) drier site, moss and moss protonema on level 1. Samples were made by collecting scrapings of mosses and algae from the rock substrates.

Non-diatom algae were isolated and identified from samples plated on solid Bold's Basal Medium (Bischoff and Bold 1963) and allowed to grow for 4 weeks under continuous light. It was necessary to cultivate the algae since direct examination showed the bulk of the cells present to be small coccoid green algae unidentifiable without the use of unialgal cultures. Permanent diatom mounts were prepared using standard acid oxidation procedures and mounting cleaned material in Naphrax resin. All algae were identified with an Olympus BH2 photomicroscope with Nomarski differential interference optics.

Relative densities of diatom species were determined by making counts of 200–400 cells. Low numbers of diatoms were counted because of the paucity of frustules on the slides and were deemed adequate because of the unusually low diversity in the samples.

RESULTS AND DISCUSSION

A total of 12 algal taxa were isolated from the plates of solidified media. These included four cyanobacteria, five chlorophytes, and three chrysophytes (Table 1). A specific epithet for one *Nostoc* species was not determined because

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TABLE 1

Algae from Seneca Cavern as observed in culture material.

SPECIES	SITE NUMBER 1	2	3	4	5	6	7	8	9	10
Cyanophyta										
Nostoc muscorum Ag.					X	X		X		
Nostoc punctiforme (Kutz.) Hariot						X	X			
Nostoc species				X						
Oscillatoria foreaui Fremy					X	X	X			
Chlorophyta										
Chlorella miniata (Naeg.) Oltm.	X	X		X	X	X		X		X
Chlorella species 1	X									
Chlorella species 2								X		
Klebsormidium flaccidum (Kutz.) S., M. et. Bl.								X		
Stigeoclonium polymorphum (Franke) Heering					X	X				
Chrysophyta										
Navicula tantula Hustedt		X		X	X			X		
Pleurochloris commutata Pascher				X		X	X	X		
Pleurochloris pseudopolychloris Pascher	X					X		X		

X indicates presence of the alga at the sampling site.

of the absence of heterocysts and akinetes. Two *Chlorella* species were likewise unidentifiable. The most widespread species was *Chlorella miniata* (Naeg.) Oltm., which occurred in seven of ten samples. *Navicula tantula* Hust. and *Pleurochloris commutata* Pascher were also fairly common. Samples 5, 6, and 8 had the greatest diversity of species.

A total of 14 diatom taxa were found in the permanent diatom preparations (Table 2, Fig. 1). *Navicula tantula* was the most abundant species in most samples. *Navicula contenta* f. *biceps* (Arnott) Grunow and *N. contenta* f. *parallela* Peters. were also very abundant and widespread. In samples 7, 9, and 10, where diatoms were very scarce, *Navicula contenta* f. *biceps* was most common, though the number of specimens observed to make a count was low in all three samples. Sample 5 had the greatest diversity, possessing every species encountered in the cavern. Sample 6 also showed a fair amount of diversity compared to other samples. Sites 5 and 6 were the wettest sites in the cavern, whereas sites 9 and 10 were possibly the driest sample areas. Thus, algal abundance and diversity within the cave seems to be largely determined by moisture levels.

In comparison to other studies of cave algae, the Seneca Cavern samples had very low algal diversity. For example, Claus (1955, 1962a,b) generally found over 80 species of algae in Hungarian caves, most of which were cyanophytes. The largest group of algae in the present study was the diatoms, with 14 species. The number of diatoms was also depauperate when compared to the species lists from other caves. For example, Bahls (1981) found 43 diatom taxa in Lewis and Clark Caverns, MT; Carter (1971) found 94 diatom taxa in Devil's Hole Cave, Scotland; and Rushforth et al. (1984) found 49 diatom taxa in Thurston Lava Tube, HI. St. Clair and Rushforth (1976) and St. Clair et al. (1981) likewise observed high numbers of diatom taxa in the caves which they studied. Mammoth Cave is the only cavern studied so far having similar species richness to Seneca Cavern, with 16 diatom taxa reported (Van Landingham 1964).

The species observed in Seneca Cavern are all aerophiles typically found in mesic subaerial habitats. *Navicula contenta* f. *biceps* has been noted both as an aerophile and as a species commonly associated with mosses (Ando 1979). *Navicula tantula,* the other abundant species, has commonly been observed in other subaerial habitats as well (Johansen et al. 1983a, Rushforth et al. 1984). The other less abundant taxa have likewise been reported in various studies of subaerial algae. Floristically then, Seneca Cavern has typical subaerial algae (particularly diatoms), but shows a marked reduction in number of species.

There are several possible explanations for low diversity in the cavern. First, we did not sample any standing water in the cave, but rather sampled only subaerial sites. This is not so in other studies. For example, small pools occur in many caves, including those studied in Montana, Utah, Oregon, and Kentucky (Bahls 1981, St. Clair and Rushforth 1976, St. Clair et al. 1981, Van Landingham 1964). Second, light was very low in Seneca Cavern, and colored lights with wavelengths less suitable for photosynthesis were commonly utilized. The cavern is closed during cold months, and thus is in total darkness from October to April. The combination of low intensity lights and infrequency of illumination combine to make light the most probable limiting factor in algal growth. Third, the cavern is an earth crack cave, and has noticeably drier surfaces than most limestone stalactite/stalagmite caverns, particularly in late summer when sampling was done.

The diatom assemblage observed in Seneca Cavern was very different from that observed in other caves. For example, of the 16 species reported from Mammoth Cave

TABLE 2

Relative densities of diatom species in Seneca Cavern.

SPECIES	SITE NUMBERS									
	1	2	3	4	5	6	7	8	9	10
Achnanthes linearis (W. Sm.) Grun.	2.5				6.2	3.8				
Achnanthes marginulata Grun.					.5					
Anomoeoneis vitrea (Grun.) Ross					P	1.0				
Eunotia exigua (Breb.) Rabh.					2.3	.5		1.5		
Fragilaria leptostauron (Ehr.) Hust.					.5					
Fragilaria vaucheriae (Kutz.) Peters.					P					
Frustulia vulgaris (Thwaites) De T.					P					
Navicula contenta f. *biceps* (Ar.) Grun.	22.5	35.5	51.0	40.0	30.0	11.1	100.0	50.0	100.0	100.0
Navicula contenta f. *parallela* Peters.	20.0	3.0		2.5	.5	10.6	17.0			
Navicula cryptocephala v. *veneta* (K.) Rabh.					1.5	.5				
Navicula tantula Hust.	55.0	61.5	49.0	57.5	58.5	72.0		31.5		P
Nitzschia hantzschiana Rabh.					P					
Pinnularia subcapitata Greg.					P					
Synedra rumpens Kutz.					P	.5				

P indicates the taxon was present, but did not occur in the species count.

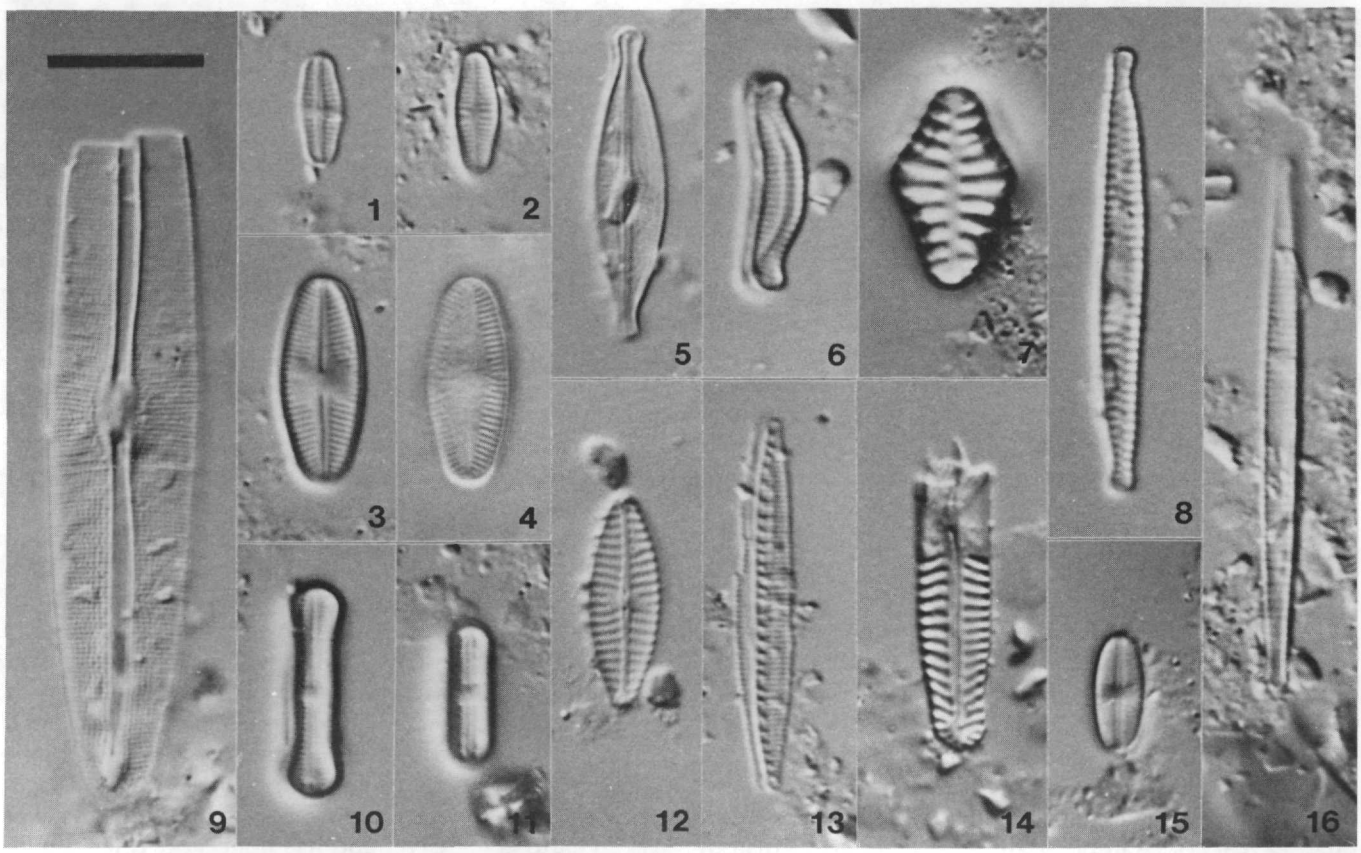

FIGURE 1. Diatoms found in Seneca Cavern.
Plate 1. *Achnanthes linearis,* raphe valve. Plate 2. *Achnanthes linearis,* araphid valve. Plate 3. *Achnanthes marginulata,* raphe valve. Plate 4. *Achnanthes marginulata,* araphid valve. Plate 5. *Anomoeoneis vitrea.* Plate 6. *Eunotia exigua.* Plate 7. *Fragilaria leptostauron.* Plate 8. *Fragilaria vaucheriae.* Plate 9. *Frustulia vulgaris.* Plate 10. *Navicula contenta* f. *biceps.* Plate 11. *Navicula contenta* f. *parallela.* Plate 12. *Navicula cryptocephala* var. *veneta.* Plate 13. *Nitzschia hantzschiana.* Plate 14. *Pinnularia subcapitata.* Plate 15. *Navicula tantula.* Plate 16. *Synedra rumpens.*
Scale = 10 um, all figures same scale.

in Kentucky, only *Synedra rumpens* was present at Seneca. Of the 43 taxa in Lewis and Clark Caverns, only *Navicula contenta* f. *parallela* was found in our samples. The most similar subaerial habitat reported in the literature is that of Thurston Lava Tube in Hawaii, which shared 7 taxa with Seneca Cavern, including *Achnanthes linearis, Fragilaria vaucheriae, Frustulia vulgaris, Navicula contenta* f. *biceps, Navicula contenta* f. *parallela, Navicula tantula,* and *Synedra rumpens*. The dissimilarity of the algal flora of Seneca Cavern from other cave floras studied within the continental United States indicates that studies of algal floras in other caves in this region are warranted. We hope to pursue such studies in the future.

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