Algae of Ozarkian Springs and Spring Streams: Winter Aspect Near Head of Crane Creek, Stone County, Missouri

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The Ozark Mountains have been formed through erosion by water of an ancient uplift of approximately 3000 feet. They are bounded on the northeast by the Missouri River and the Mississippi, on the southwest by the Neosho River and Grand Lake in Oklahoma, and on the south by the Arkansas River. The remnants of the porphyry dome cover a relatively small area in eastern Missouri where they impart acid characteristics to the waters and soils of the St. Francis basin.

Differential resistance to weathering, order of superposition of rocks, their structure and outcrop pattern and their permeability have brought about a topography with steep slopes, many sinks, springs, bluffs and water-soaked cliffs. These features furnish a great variety of habitats. Further variations are produced by chemical factors in relation to physiological requirements of organisms.

Previous records of fresh-water algae of the Ozark region of Missouri are those of Drouet (1932), who listed 7 genera and 6 species, those of Leake (1954), whose investigations added 43 genera and 51 species to the list. The present investigation adds 24 genera and 84 species to these lists.

No previous study of the ecology of algae has been made in the White River Hills region. Some information concerning the relation of the algal flora of the southern portion of the Ozark uplift to seasonal and geological conditions was given by Couch (1942). Cozzens (1939) in his paper analyzing and mapping geological factors of the Ozarks, included a short discussion of the ecological relationships of these factors to the forest cover. The ecology, geology, and physiography of the higher vegetation of the whole Ozark region has been studied by Steyermark (1951 a, b) and by Schery and Nevins (1951). Phytogeographers find that a similarity exists between the vascular plants of the Ozarks and those of the Applachian Mountains, which indicates a continuous distribution of the two floras in earlier geologic times. One could expect that the algal distribution might follow the same pattern in the two areas. Much more evidence, however, is needed before making any definite statement concerning this matter.

The investigations which provide ecological and taxonomic data for the present study were made during a period from December 1959 to April 1960 in the border area between the Springfield Plateau and the White River Hills region. Here the local relief is mostly between 500 and 600 feet, characteristic of the Burlington-Boone formation limestones. The hilltops are covered with a mantle-rock of weathered chert which comes from the nodules, lenses, and beds of the original limestone rock. Drainage is rapid and the water table is low. Outcrops of impervious rock layers on the hillside make possible the horizontal seepage and more moist soils beneath them.

There are many springs in the area. Being outlets for underground streams their year-round temperature is fairly constant. Runs from them near the source are also remarkably stable thermally, neither warming in summer nor freezing in winter. Eddies and backwaters have temperatures which fluctuate more, and fringes of ice may form along the margins.

COLLECTIONS AND METHODS

Collections for this study were made near the head of Crane Creek, a [redacted] of James River, which in turn flows into White River.

The head-water spring of Crane Creek rises at the foot of a railroad embankment which separates it from the limestone bluff where it had its original source. For a quarter of a mile along the stream many other springs contribute to the flow. The portion of the stream studied is approximately one-half mile in length and its many twists and turns are within thirty-one acres of bottom land. Much of the water of the stream comes from small springs arising under limestone ledges close to the margin. In addition to these and the head-water spring, which flows 6 million gallons per day, there are four springs which flow an average distance of 40 feet before emptying into the main stream. The largest of the four flows 4 million gallons per day.

The average width of the main creek is 25 feet and its average depth is 1 foot. There are a number of deeper pools along the course of the creek. The maximum depth of these is 6 feet. The stream flow is 25 million gallons per day and the rate of flow is 150 feet per minute. Two sections of the stream flow south, one flows north, and the others are easterly in direction.

Stream-bed deposits are mostly coarse gravel, but there are also mud, sand and rock bottoms, and various combinations of these. One-hundred and forty-three collections were made and examined in their fresh state. Epiphytic forms were examined both in situ and from scrapings and squeezings of higher plants and algae. Since the water was practically free of true plankton, no collections of this kind were made except from a slough which had a bloom of almost pure *Chlamydomonas*.

BIOTIC FACTORS

The dominant seed plant of Crane Creek is water-cress *(Nasturtium officinale* R. Br.) which borders the stream and covers the shallower runs except for the swiftest central channels. Clumps of water-milfoil *(Myriophyllum heterophyllum* Michx.), water starwort *(Callitriche heterophylla* Pursh), arrow lilly *(Sagittaria latifolia* Willd.), bur reed *(Sparganium americanum* Nutt.), the pond weeds *(Potamogeton illinoiensis* Morong, *P. foliosus* Raf. var. *foliosus* and water purslane, *Ludwigia palustris* (L.) Ell. var. *americana* (DC.) Fernald and Griscom, are rooted in the quiet marginal waters, usually in mud or gravelly mud. *Callitriche* may also be found in the more rapid portions of the stream. The moss, *Fontinalis,* is very abundant and is found in all habitats. It is a dominant of the swift-water community, but may also form mats over the whole stream bed. The liverwort, *Riccia fluitans* L., is a dominant of the quiet marginal water community. Colonies of *Riccia* may be either free-floating or submerged and, like *Callitriche,* may be found in rapids, where they are firmly attached to stones.

All these seed plants and mosses harbor attached or free-floating algae, besides many protozoans, crustaceans, and other invertebrates, so that any stream segment could be considered as a microcosm. In the rapid waters *Vaucheria* is the associated alga present in greatest quantity. *Nitella* and *Tolypella* are the associates in the quiet marginal water. A typical situation is the *Nitella* which borders *Nasturtium* in muddy bottoms at a depth of 15 inches. It also forms great cushiony masses in deep water marginal to *Nasturtium,* varying in submergence from just below the surface to 3 feet.

PHYSICO-CHEMICAL FACTORS

Data for January, February, March and April 1960, on dissolved oxygen, normal carbonate and methyl orange alkalinity are shown in Table I, and the water temperature and hydrogen-ion concentration in Table II. These data are tabulated according to habitat for the purpose of comparing the averages and ranges of each with the others.

TABLE I. DISSOLVED OXYGEN, NORMAL CARBONATE, AND METHYL ORANGE ALKALINITY

	Dissolved O_2-Av.	Normal Carbonate	M.O. Alkalinity - Av.
1. Springs	9.49 ppm.	O ppm.	13 ppm.
2. Rapids	9.97 ppm.	O ppm.	19 ppm.
3. Stream margins	10.8 ppm.	O ppm.	15 ppm.
4. Sloughs & backwaters	10.5 ppm.	O ppm.	14 ppm.

TABLE II. WATER TEMPERATURE AND HYDROGEN-ION CONCENTRATION

	Average Temp.	Temp. Range	Average pH
1. Springs	53°F.	52°-54°F.	7
2. Rapids	54°F.	47°-57°F.	7.2
3. Streams margins	55°F.	48°-56°F.	7.2
4. Sloughs & backwaters	48°F.	36°-58°F.	7.6

TABLE III. DATA — U.S. WEATHER BUREAU — 1960

Month	Air Temperature (°F)				Precipitation (In.)		Sunshine (Hrs.)	Sky Cover		
	Max Av.	Min Av.	High	Low	H_2O	Snow or Sleet	Total	% of Possible	Total 10ths	Av.
Jan.	43.2	26.1	69	6	.95	2.2	116:49	38	225	.73
Feb.	39.9	22.8	71	7	2.26	15.1	164:57	52	209	.72
March	41.6	23.3	49	—1	1.37	12.3	205:04	55	220	.71
April	68.9	46.1	84	33	2.42	Tr.	229:35	58	193	.64

No measurements of light penetration were made, but the clearness and shallowness of the water and the absence of plankton and other shading influences made it probable that the winter insolation is one of the most important factors in the growth of algae in the lotic water (Table III).

DISCUSSION

Four communities (algae-bryophyte) are recognized in the headwaters of Crane Creek during the winter months. These are: 1. the *Meridion-Diatoma-Vaucheria-Fontinalis* community of springs; 2. the *Synedra-Vaucheria-Batrachosperum-Fontinalis* community of most rapid portions of the run; 3. the *Synedra*-Characeae-*Rhizoclonium-Riccia* community of slower marginal currents; 4. the *Synedra*-Ulotrichales-Zygnematales com-

munity of sloughs and backwaters. Observation shows that the communities of springs and rapids are least likely to show seasonal changes. Whitford (1956) refers to the opinion held by Butcher and others that lack of seasonal variation in dominance and the great abundance of attached algae in lotic waters emphasize the probability that these effects are due to renewal of substances conducive to growth, carried in constant supply by the water bathing them. Conversely, the organisms in quiet water may have growth substances exhausted quickly from the film of liquid around them. Incidentally this is perhaps why the organisms in samples from rapidly running water are so short-lived when transferred to aquaria, even when the temperature is the same as in the original habitat.

In all communities diatoms are dominant. *Synedra* of several species prevailed in all except the spring community where *Meridion* was epiphytic on *Vaucheria* and *Diatoma* on *Fontinalis*. In swift water diatoms may be filamentous with basal attachments, as well as epiphytic. Since most of the listed genera were present in all but one community, Table IV seems to indicate that associations between some diatoms and other genera of algae or higher plants was specific.

TABLE IV. EPIPHYTIC ASSOCIATION OF DIATOMS

Hosts / Diatoms	Synedra	Gomphonema	Meridion	Melosira	Cymbella	Navicula	Cocconeis	Surirella	Diatoma
Fontinalis	*		*	*		*	*		*
Vaucheria	*	*	*		*		*		
Nasturtium	*	*	*				*		
Sparganium	*	*	*		*		*		
Callitriche	*	*			*	*	*	*	
Batrachospermum	*		*		*	*			
Nitella	*		*				*		*
Ricc'a	*						*		
Rhizoclonium	*	*	*	*	*				

The taxonomic list of diatoms represents only species of distinctive appearance. Many more, not listed, await identification.

Associated with the dominants of Community 1 were species of *Tribonema, Tetraspora, Pediastrum, Closterium, Cosmarium,* and *Staurastrum*. The compact mats and clumps of mixtures of *Vaucheria* and *Fontinalis* of Community 2 included filaments of *Rhizoclonium, Tribonema,* and species of the Zygnemataceae. Many colonies and unicells of desmids and Chlorococcales were present also. *Batrachospermum* was seldom mixed with the other dominants, but its streaming masses attached to stones were definitely an important part of the Community 2. Contrary to the findings of some other investigators, who state that freshwater red algae are red only when growing in deep water, *Batrachospermum* shows red color invariably even in the shallowest water in Crane Creek. The Characeae[1] of Community 3 were *Nitella flexilis* Agardh and *Tolypella intricata* Leonhardi. These tend to form clumps separate from the other dominants. *Riccia fluitans* L. also floated in spherical masses of almost pure culture. Next in abundance to these and their associated diatoms and other algae was *Tetraspora*. The quiet waters of Community 4 were

[1]Identification of the Characeae by Fay K. Dailey.

much richer in numbers of species than any of the other habitats. Many other unicells, colonies, and filaments of other orders than the dominant Ulotrichales and Zygnematales were present.

Blue-green algae, although not abundant, were found in all communities, either mingled with the filamentous, attached and floating vegetation or in films on rock surfaces. In numbers of species and in quantity they do not form an important part of the population.

TAXONOMIC LIST

In this list the small letters after the species names indicate the habitat(s) in which each was found: ep — epiphytic; p — pool; r — rapids; sb — sloughs and backwaters; sm — stream margins; sp — springs; u — ubiquitous.

The numbers indicate the dominant species and the degree of their dominance on a scale of 1 to 5. The numbered species will therefore account for the greater bulk of the algal population.

The asterisk indicates species added by the present study to the two earlier ones, (Drouet, 1932; Leake, 1954).

	Dom.	Hab.	
CHLOROPHYTA			
Volvocales (4 genera, 5 species)			
**Chlamydomonas globosa* Snow			sb
**Eudorina elegans* Ehrenberg		sm	sb
Gonium pectorale Mueller		sm	sb
Gonium sociale (Duj.) Warming		sm	sb
Pandorina morum (Muell.) Bory		sm	sb
Tetrasporales (4 genera, 5 species)			
Gleocystis major Gerneck *ex* Lemmerman		sm	sb
**Palmodictyon viride* Kuetzing		sm	sb
Sphaerocystis Schroeteri Gerneck *ex* Lemm.		sm	
Tetraspora cylindrica (Wahl.) C. A. Agardh	3	sm	
Tetraspora gelatinosa (Vauch.) Desvaux		sm	
Ulotrichales (9 genera, 11 species)			
Aphanochaete repens A. Braun		sm	sb
**Chaetophora pisiformis* (Roth) Agardh		sm	sb
Draparnaldia acuta (Ag.) Kuetzing	2	r	
**Geminella ordinata* (West and West) Heering		sm	sb
Hormidium klebsii G. M. Smith		sm	sb
**Microspora amoena* (Kuetz.) Lagerheim		sm	
Stigeoclonium subsecundum Kuetzing	2	sm	
**Ulothrix sublissima* Rabenhorst		sm	
**Ulothrix tenerrima* Kuetzing		sm	
**Ulothrix zonata* (Weber & Moore) Kuetzing		sm	sb
Ulvella sp.		sb	
Oedogoniales (1 genus, 2 species)			
Oedogonium abbreviatum (Hirn) Tiffany	3	sm	r
Oedogonium varians Wittrock & Lundell	3	sm	r
Cladophorales (1 genus, 1 species)			
Rhizoclonium hieroglyphicum (Ag.) Kuetzing		sm	

Chlorococcales (12 genera, 17 species)				
**Actinastrum gracilimum* G. M. Smith		sm	sb	r
Characium angustatum A. Braun		sm	r	
Characium obtusatum A. Braun		sm	r	
Coelastrum speciosum (Wolle) Brunthaler		sm		
Excentrosphaera viridis Moore		sm		
**Oocystis elliptica* W. West		sb		
Ophiocytium capitatum Wolle		sm		
Ophiocytium desertum Printz		sm		
**Pediastrum simplex* (Meyen) Lemmerman		sp	r	
**Planktosphaeria gelatinosa* G. M. Smith		sm	sb	
**Protococcus viridis* C. A. Agardh		sm		
**Scenedesmus abundans* var. *brevicauda* G. M. Smith		sm	r	
**Scenedesmus arcuatus* Lemmerman		sm		
Scenedesmus bijuga (Turp.) Kuetzing		sm	r	
**Scenedesmus linearis* Hansgirg		sm	r	
**Seenedesmus obliquus* (Turp.) Kuetzing		sm	r	
**Treubaria triappendiculata* Bernard		sm		
**Treubaria crassispina* G.M. Smith		sm		
Westella linearis G. M. Smith		sm		
Zygnematales (5 genera, 21 species)				
**Closterium acerosum* (Shrank.) Ehrenberg		sm	sp	
Closterium acerosum var. *elongatum* Breb.		sm		
**Closterium Ehrenbergii* Meneghini		sp		
**Closterium lanceolatum* Kuetzing		sm		
**Closterium Leibleinii* Kuetzing		sp		
Closterium moniliferum (Bory) Ehrenberg		sp	sm	
**Closterium rostratum* Ehrenberg		sb	sm	
**Cosmarium cyclicum* Lundell		sp		
**Cosmarium granatum* Brebisson		sp	sm	
Cosmarium obtusatum Schmidle		sm		
**Cosmarium punctulatum* Brebisson		sm		
**Cosmarium subspeciosum* Nordstedt		sm		
**Cosmarium vexatum* West		sp	sm	r
Mougeotia robusta (De Bary) Wittrock		sm		
**Spirogyra affinis* (Hass.) Petit		sm		
Spirogyra Collinsii (Lewis) Printz		sm	sb	
**Spirogyra denticulata* Transeau		sb		
Spirogyra reticulata Nordstedt		sb		
**Spirogyra rugosa* (Trans.) Czurda		sb		
**Spirogyra tenuissima* (Hass.) Kuetzing		sm		
**Spirogyra varians* (Hass.) Kuetzing		sm		
**Staurastrum alternans* Brebisson		r		
**Staurastrum punctulatum* var. *Kjelmani* Wille		r	sm	
Charales (2 genera, 2 species)				
**Nitella flexilis* Agardh	3	sm		
**Tolypella intricata* Leonhardi	5	sm		

EUGLENOPHYTA

Euglenales (3 genera, 15 species)			
Euglena acus var. *rigida* Heubner	sm	sb	
Euglena alata Thompson	sm	sb	
**Euglena fusca* (Klebs) Lemmermann	sm	sb	
Euglena gracilis Klebs	sm	sb	
Euglena intermedia (Klebs) Schmitz	sm	sb	
Euglena proxima Dangeard	sm	sb	
Euglena rubra Hardy	sb		

Euglena spirogyra Ehrenberg		sm	sb	
**Euglena spiroides* Lemmermann		sb		
**Euglena tripteris* (Duj.) Klebs		sm	sb	
Euglena viridis Ehrenberg		sb		
Phacus triqueter (Ehrenb.) Dujardin		sm	sb	
**Trachelomonas Dybowskii* Drezepolski		sm		
Trachelomonas hispida var. *coronata* Lemm.		sm		
Trachelomonas robusta Swirenko		sm		
CHRYSOPHYTA				
Xanthophyceae (3 genera, 3 species)				
**Botrydium granulatum* (L.) Grenville		sm		
**Tribonema bombycinum* (Ag.) Derbes & Solier		r	sm	
Vaucheria geminata (Vauch.) De Candolle	1	r	sm	
Chrysophyceae (1 genus, 1 species)				
Synura ulvella Ehrenberg		sm	sb	
Bacillariophyceae (16 genera, 41 species)				
**Achnanthes linearis* (W. Smith) Cleve		sm		
**Amphora ovalis* Kuetzing		sm		
**Cocconeis placentula* var. *lineata* (Ehrenb.) Cleve	1	ep	r	sm
**Caloneis trinoidis* (Lewis) Boyer		sm		
**Cymatopleura elliptica* (Breb.) W. Smith		sm		
**Cymatopleura elliptica* forma *spiralis* (Chase) Boyer		sm		
**Cymbella cymbiformis* (Ehrenb.) Van Heurck		r	sm	sp
**Cymbella excisa* Kuetzing		"	"	"
**Cymbella lanceolata* (Ehrenb.) Brun	4	"	"	"
**Cymbella parva* (W. Smith) Cleve		"	"	"
**Cymbella turgida* (Greg.) Cleve		"	"	"
**Cymbella ventricosum* Kuetzing		"	"	"
**Diatoma elongatum* (Lyngb.) Agardh	4	sp	sm	sb
**Fragillaria Harrisonii* (W. Smith) Greenow		sm		
**Gomphonema acuminatum* var. *coronatum* (Ehrenb.) Rabenhorst	1	u		
**Gomphonema aequale* (Greg.) Van Heurck	1	u		
**Gomphonema constrictum* Ehrenberg	1	u		
**Gomphonema montanum* (Schumann) Van Heurck	1	u		
**Melosira distans* (Ehrenb.) Kuetzing		sm	sp	
Melosira varians Agardh	2	"	"	
**Meridion circulare* (Grev) Agardh	2	ep	r	sm
**Meridion constrictum* Ralfs		"	"	"
**Meridion intermedium* H. L. Smith	2	"	"	"
**Navicula elginensis* Ralfs	2	u		
**Navicula radiosa* Kuetzing	2	u		
**Navicula virdis* (Nitzsch.) Kuetzing	5	u		
**Nitzschia acicularis* (Kuetz.) W. Smith		sm	sb	
**Nitzschia vermicularis* (Kuetz.) Hantzsch		r	sm	
**Stauroneis anceps* var. *hyalina* Perag. & Brun		sb		
**Surirella delicatissima* Lewis		sm		
**Surirella elegans* Ehrenberg		sm		
**Surirella elegans* Terry abnormal form		sm		
**Surirella solea* (Breb.) W. Smith		sm		
**Surirella Terryi* Ward		sm		
**Synedra aequalis* Kuetzing	3	u		
**Synedra Danica* Kuetzing	4	u		
**Synedra delicatissima* var. *angustissima* (Green.) Van Heurck	2	u		
**Synedra familiaris* Kuetzing	1	u		
**Synedra longissima* W. Smith	1	u		
**Synedra spathulifera* Grunow	4	u		
**Synedra vitraea* Kuetzing	5	u		

CYANOPHYTA

Chroococcales (2 genera, 2 species)				
Dactylococcopsis fascicularis Lemmermann		sm	sb	
Merismopedia convoluta Brebisson		sm	sb	
Oscillatoriales (3 genera, 3 species)				
Anabaena sp.		sm	sb	
Oscillatoria sp.	1	r	sm	sb
Spirulina sp.		sm	sb	

RHODOPHYTA

Nemalionales (1 genus, 2 species)			
Batrachospermum moniliforme Roth	2	r	
Batrachospermum vagum (Roth) Agardh	2	r	

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