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BLUEGREEN ALGAE OF A COASTAL SALT PANNE AND SURROUNDING ANGIOSPERM ZONES IN A LOUISIANA SALT MARSH

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ABSTRACT: A one year study found nineteen species of bluegreen algae associated with a coastal salt panne and four surrounding angiosperm zones in a southwestern Louisiana salt marsh. A thin, unstratified, nearly homogenous algal mat composed primarily of *Schizothrix calcicola, S. arenaria,* and *Nostoc spumigena* was widely distributed over the marsh. The standing crop of bluegreens appeared to increase with angiosperm diversity, canopy density and height, and with declining salinity and light intensity.

Bluegreen algal communities are widely distributed in coastal areas around the Gulf of Mexico and along the Atlantic coast of the United States as far north as New Jersey (Birke, 1974). In North America, investigations on the ecology and taxonomic composition of these communities have focused on the Atlantic Coast. The more important studies have been those of Webber (1967) and Blum (1968) in Massachusetts, Ralph (1977) in Delaware, Sage and Sullivan (1978) in Mississippi, Sanders (1979) in North Carolina and Dailey *et al.* (1982) in Georgia.

Maples and Watson (1979) previously described the algal flora of six salt pannes along the southwestern Louisiana coast. The purpose of this study was to characterize the edaphic bluegreen algal community of a salt panne and its associated angiosperms in a Louisiana Gulf coast marsh.

MATERIALS AND METHODS

A salt panne in a coastal marsh near Holly Beach, Cameron Parish, Louisiana (29°45.2'N, 93°25.4'W) was selected for this study. Five sampling zones based on the predominant vegetation were established in the study area (Table 1). Five soil samples to a depth of 2 cm were collected in each zone during November 1979, and January, May and August 1980. Soil surface temperatures were recorded on each sampling day. Light readings were taken with a GE Model 214 meter at the soil surface and immediately above the vegetation canopy at the same time on each sampling date. The light readings were recorded in foot candles and reported as percent of incident light reaching the soil surface (Table 2).

In the laboratory the soil cores were air dried, composited, and passed through a No. 10 soil sieve and all debris removed. One gm of soil was placed in 9 ml of modified Allen's media (Starr, 1978) and shaken on a Vortex Genie for one minute. A serial dilution of each sample was prepared following the procedure described by Throndsen (1978). The resulting dilutions were 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4}. These were incubated for 2-3 weeks on a 16/8 hour light/dark regime at 35° C in a Freas 818 incubator. At the end of the incubation period each tube was examined for bluegreen algae and the presence or absence of a species recorded. This counting method allowed for temporal and spatial abundance to be deter-

Table 1. Distribution of angiosperm species surrounding a salt panne in southwestern Louisiana.

Vegetation Zone*	Major species	Common name
B	Bluegreen algae (no angiosperm present)	
SB	*Salicornia bigelovii* Torr.	Glasswort
SL/DS	*Distichlis spicata* (L). Greene	Saltgrass
	S. bigelovii	
	Suaeda linearis (E11.) Moq.	Sea blite
SL	*Baccharis halimifolia* L.	Groundsel bush
	S. linearis	
SP	*B. halimifolia*	
	Eleocharis sp.	Spikerush
	Iva fructescens L.	Marsh elder
	Scirpus olneyi Gray	Three cornered sedge
	Spartina patens (Ait.) Muhl.	Wire grass
	S. spartinae (Trin.) Hitch.	Gulf cordgrass

*Symbols based on dominant species in each zone.

mined for each species. Identifications were made following Drouet (1968, 1973), Drouet and Daily (1956), and Humm and Wicks (1980). After each sample had been analyzed taxonomically, a community diversity statistic was calculated. This was the Information index (Shannon and Weaver, 1949):

$$H' = -\sum_{i=1}^{S} \frac{n_1}{N} \log_2 \frac{n_1}{N},$$

where H' (species diversity) is expressed as bits/individual, n_1 is the number of occurrences of each species, N is the total occurrences for all species, and S is the total number of taxa in the sample. Selected pair of bluegreen algal communities were compared using the similarity index proposed by Stander (1970):

$$SIMI = \frac{\sum_{i=1}^{S} P_{ij} P_{in}}{\sqrt{\sum_{i=1}^{S} P_{ij}^2} \sqrt{\sum_{i=1}^{S} P_{in}^2}},$$

where P_{ij} and P_{in} are the proportions of the i-th taxon in the j-th and n-th samples, and S is the total number of taxa. The proportions were based on the data presented in Table 3.

RESULTS

The soils of salt pannes in southwestern Louisiana are generally alkaline. The pH of samples from the study area ranged from 8.06 to 8.73 with little seasonal variation (Table 2). Salinities varied from 8.5 to 48.0‰ with the highest values recorded always in the bare (B) zone and the lowest in the *Spartina patens* (SP) zone. The soil surface temperatures varied with vegetation zone and season. Seasonal temperatures ranged from a low of 12.0 in winter to 41.6°C in summer (Table 2). The lowest average monthly value for precipitation was 1.81 in. in February while the highest was 11.92 in. in May (NOAA Climatological Station, Hackberry, Louisiana). The reference station is located ca. 9.4 km north of the study site. The percent of incident light reaching the soil surface in each vegetation zone is inversely related to the canopy height and shows the increased shading effect of the taller grasses (Table 2).

In the laboratory, nineteen species of bluegreen algae were isolated and identified. Of these, nine were found to be common to all vegetation zones (Table 3).

Table 2. Physical characteristics of a salt panne and surrounding angiosperm zones in southwestern Louisiana.*

Vegtation zone	B	SB	SL/DS	SL	SP
Soil surface temp (°C)	28.5	27.4	27.2	26.5	26.4
Salinity (‰)	38.0	24.0	11.0	9.0	9.0
pH	8.5	8.7	8.3	8.1	8.1
Canopy height (cm)	0.0	23.5	35.0	40.0	60.0
% incident light reaching soil surface	100.0	80.0	67.0	53.0	20.0

*All values are annual means (n 4) except for canopy height which is the maximum height recorded during the growing season.

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Table 3. Relative abundance of bluegreen algae based on presence or absence in serial dilution cultures for four seasonal collections in a southwestern Louisiana salt marsh.*

Species		Vegetation zone					Total
		B	SB	SL/DS	SL	SP	
Anabaina	*oscillarioides* Bory	9	6	18	33	29	95
Anacystis	*aeruginosa* (Zanard.) Dr. & Daily		3	10	25	30	68
	dimidiata (Kutz.) Dr. & Daily		3	3	6	10	22
	marina Dr. & Daily	7	18	21	32	23	101
	montana (Lightfoot) Dr. & Daily	6	11	38	47	61	163
Calothrix	*crustacea* Shoush. & Thur.		5	13	16	22	56
Coccochloris	*aeruginosa* (Nag.) Dr. & Daily		1		1		2
	elabens Dr. & Daily	2	1		3	2	8
	stagnina Dr. & Daily	8	3	10	25	23	69
Entophysalis	*deusta* Dr. & Daily				1	1	2
Microcoleus	*lyngbyaceus* (Kutz) Crouan	5	7	8	32	24	76
Nostoc	*spumigena* (Mert.) Dr.	15	11	23	45	57	141
Oscillatoria	*lutea* Ag.	1			1	1	3
	submembranacea Ard. & Straff	5	4	6	2	6	23
Porphyrosipon	*notarisii* (Menegh.) Kutz.			1			1
Schizothrix	*arenaria* (Berk.) Gom.	17	24	22	33	42	138
	calcicola (Ag.) Gom.	39	51	68	69	71	298
	mexicana Gom.			1	3		4
Spirulina	*subsalsa* Oerst.			1			1
Total No. Occurrences		114	148	243	374	402	1271
Total No. Species		11	14	15	17	15	19

*The maximum number of occurrences for each species and vegetation zone is 80, for each species and all zones is 400, and for each zone and all species is 1520.

Zone SL supported the largest number of species and zone B the smallest number. There appeared to be a relationship between the standing crop of bluegreen algae and the presence of angiosperms. The bluegreen mat in the field was usually no thicker than 1 mm and not visible except in zones SL/DS, SL and SP. The mat usually consisted of four common species, *Schizothrix calcicola, S. arenaria, Anacystis montana* and *Nostoc spumigena,* with many minor species present.

Species diversity values (H') for the different zones were rather low indicating dominance by a few species (Table 4). In all seasons, diversity was lowest in the zone devoid of an angiosperm canopy. Finally, diversity tended to be highest in spring and lowest in fall for each zone.

A matrix of similarity values (SIMI) for all community pairs is presented in Table 5. All values were very high, and ranged from 0.851 to 0.988.

DISCUSSION

Salt pannes along the coast of southwestern Louisiana are generally broad, shallow areas devoid of angiosperms. The panne used for this study was a bowl-shaped barren area with a distinct zonation of angiosperms surrounding it. Beneath the vegetation is found a bluegreen algal mat composed primarily of three filamentous species: *Schizothrix calcicola, S. arenaria,* and *Nostoc spumigena.* Two species, *Anacystis marina* and *A. montana,* form an important secondary association. Unlike the luxurious, stratified mats described by Sorenson and Conover (1962) at South Padre Island, the mats associated with salt pannes in this Gulf coast region are thin and not stratified. The algal mat was visible under the vegetative canopy, particularly in the SL

Table 4. Species diversity characterizing the bluegreen algal community associated with a Louisiana salt panne (November 1979 — August 1980).

Season	Vegetation zone				
	B	SB	SL/DS	SL	SP
Summer	1.914 (8)*	2.175 (8)	2.597 (10)	3.456 (14)	2.457 (10)
Fall	1.443 (4)	1.560 (5)	2.485 (9)	2.232 (8)	2.175 (8)
Winter	1.477 (5)	2.832 (10)	2.474 (10)	3.435 (14)	2.693 (11)
Spring	2.717 (9)	3.338 (12)	3.107 (11)	3.171 (12)	3.395 (13)

*Number of species.

and SP zones, and except for the bare (B) zone showed little variation in species number (Table 3).

Forty-seven percent of all species were found in all zones of the study area and 63% were found beneath the angiosperm canopy. The latter figure compares favorably to that of 67% reported for a British salt marsh by Steward and Pugh (1963). Similarity indices calculated for all community pairs clearly indicate that the salt panne and the associated four angiosperm zones support a nearly homogeneous community of bluegreen algae.

Birke (1974) reported that salinity stress reduced the number of species associated with coastal bluegreen algal mats. Sanders (1979) stated that salinity stress played a major role in determining the algal composition in mats of coastal North Carolina and that moisture was important for the relative growth and activity of the mats. Nienhuis (1978) reported that variations in sediment composition, salinity and percent cover of angiosperms had no limiting effect on either the species composition or number of species of bluegreen algae in a Dutch salt marsh. Ralph (1977) and Sage and Sullivan (1978) suggested that light was the most important factor determining bluegreen algal distribution in coastal salt marshes. Darley *et al.* (1981) suggested that light was not the primary factor limiting algal production in a Georgia salt marsh. They suggested that the algal assemblage in a short-*Spartina* marsh was shade adapted and algal productivity was nitrogen limited. In my study there was an obvious increase in the standing crop of algae in zones SL and SP and the % of incident light reaching the soil surface in the SP zone was 20% (Table 2) which is similar to the value (26%) reported by Darley *et al.* (1981) for a *Spartina* marsh in Georgia.

This study together with the work of Sage and Sullivan (1978) strongly support the inclusion of Gulf coast marshes in Ralph's (1977) hypothesis that a single, ubiquitous bluegreen algal association is common to all temperate North Atlantic salt marshes. There are only two notable differences between this study and the Mississippi studies of Sage and Sullivan (1978). The first is that *Schizothrix arenaria* and *Microcoleus lyngbyaceus* are abundant beneath the angiosperm canopy only in the Louisiana study and the second is the large number of occurrences of potential N-fixers in the standing crop of bluegreens for this study. This may be ecologically significant for salt marshes along the Louisiana coast.

Table 5. Matrix of similarity values (SIMI) for comparisons of edaphic bluegreen algae samples from a coastal marsh in southwestern Louisiana.

	Zone*			
	SB	SL/DS	SL	SP
B	.924	.924	.876	.851
SB		.934	.871	.843
SL/DS			.943	.943
SL				.988

*Symbols based on dominant species in each zone. (Table 1)

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