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Elemental Composition of Five Submersed Aquatic Plants Collected from Lake Okeechobee, Florida

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ABSTRACT

Chemical composition of the macrophytic alga chara (*Chara* sp.), and four angiosperms-hydrilla (*Hydrilla verticillata* (L.f.) Royle), Illinois pondweed (*Potamogeton illinoensis* Morong), southern naiad (*Najas guadalupensis* (Spreng.) Magnus), and vallisneria (*Vallisneria americana* Michx.) was determined on samples collected during August 1990 from 146 sites in Lake Okeechobee, Florida. Eleven macro- and micro-nutrients were analyzed: C, N, Ca, Mg, Mn, K, P, Zn, Na, Fe, and Cu. MANOVA was able to separate plant species on the basis of their chemical composition; micronutrients were most important in separation of species by discriminant analysis. Hydrilla and southern naiad had the highest concentration of nitrogen and phosphorus in the species tested.

Key words: chara, eelgrass, hydrilla, musk grass, southern naiad, Illinois pondweed, vallisneria.

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INTRODUCTION

Submersed aquatic plants are a conspicuous feature of many aquatic systems. Submersed plants play a key role in aquatic food webs by providing substrate for epiphytes (Cattaneo and Kalff 1980) and invertebrate colonization (Soszka 1975) as well as providing a forage source and refugia for fish (Lubbers *et al.* 1990). Shardendu and Ambasht (1991) analyzed nutrient composition of four submersed macrophytes and concluded that variation in nutrient content was a function of the age of the species tested.

Little research has been conducted on tropical freshwater systems (Table 1) and most systems studied were mesotrophic to oligotrophic deepwater systems. Scheffer *et al.* (1992) for example reported that the distribution of two *Potamogeton* species was differentially affected by changes in lake stage over a 20-yr period in six interconnected shallow-water lakes in the Netherlands.

Submersed plant samples were collected along 60 transects in the northern, western, and southern littoral area of Lake Okeechobee. Individual plant taxa were separated to test whether these plant species have a unique chemical composition.

TABLE 1. CHEMICAL COMPOSITION OF FIVE SUBMERSED PLANTS FROM LAKE OKEECHOBEE AND OTHER LOCATIONS.

Species	C	N	Ca	Mg	K	P	Zn	Na	Fe	Cu	Mn	n	Locality	Reference[1]
Chara	N.D.[2]	17.10	195.00	7.90	13.90	2.90	68	400	N.D.	25	1,620	N.L.[3]	New Jersey	1
	N.D.	14.30	260.40	N.D.	8.01	9.40	139	26,630	12,200	N.D.	N.D.	28	Poland	2
	206.92	15.03	110.06	7.20	4.68	0.77	112	12,983	13,221	90	1,155	12	Florida	3
	(69.89)	(7.26)	(53.38)	(4.90)	(7.12)	(0.49)	(66)	(11,493)	(9,765)	(61)	(936)			
Hydrilla	N.D.	20.78	269.20	4.00	38.51	2.05	N.D.	N.D.	3,300	N.D.	N.D.	74	Florida	4
	N.D.	17.80	41.60	23.40	23.42	0.53	N.D.	36,600	970	5.7	150	6	Florida	5
	N.D.	25.10	N.D.	N.D.	52.14	0.83	N.D.	N.D.	N.D.	5.8	N.D.	10	Florida	6
	N.D.	14.55	32.5	2.61	58.24	0.77	87	1,560	1,060	N.D.	60	2	Florida	7
	N.D	22.50	N.D.	N.D.	N.D.	2.20	278	N.D.	N.D.	98	N.D.	37	Australia	8
	316.58	33.24	48.13	6.52	25.78	1.87	134	26,043	12,518	84	2,904	32	Florida	3
	(66.56)	(6.15)	(36.66)	(3.74)	(12.11)	(1.05)	(58)	(15,182)	(9,801)	(179)	(2,089)			
Naiad	N.D.	N.D.	9.80	4.70	34.90	1.50	48	6,100	710	48	34,900	N.L.	South Carolina	9
	313.77	23.66	67.24	6.52	20.27	1.07	133	43,968	9,285	60		22	Florida	3
	(35.70)	(11.26)	(44.79)	(4.77)	(10.89)	(0.54)	(88)	(20,045)	(7,023)	(36)				
Illinois	N.D.	4.79	208.00	0.60	7.74	0.42	N.D.	N.D.	0.6	N.D.	N.D.	N.L.	South Carolina	4
pondweed	319.75	16.52	63.83	5.76	16.41	1.22	130	3,419	46.8	65	1,186	36	Florida	3
	(45.37)	(6.86)	(52.92)	(5.21)	(9.20)	(0.90)	(99)	(1,215)	(33.3)	(47)	(1,256)			
Vallisneria	N.D.	42.00	8.2	N.D.	N.D.	4.30	N.D.	N.D.	N.D.	N.D.	20	20	New York	10
	324.82	20.64	27.77	5.36	33.91	1.64	241	7026	1.01	77	295	59	Florida	3
	(57.47)	(11.06)	(30.16)	(1.97)	(19.32)	(1.31)	(176)	(2,924)	(1.30)	(83)	(338)			

NOTE: Macronutrients (Carbon = C, Nitrogen = N, Calcium = Ca, Magnesium = Mg, Potassium = K, Phosphorus = P) are expressed as mg/g dry weight, micronutrients (Zinc = Zn, Sodium = Na, Iron = Fe, Copper = Cu, Manganese = Mn) are expressed as µg/g dry weight. sample number indicated by n. Lake Okeechobee values are mean and (in parentheses) standard deviations.

[1]References: 1 Hutchinson 1975, 2 Bernatowicz 1969, 3 this research, 4 Langeland 1982, 5 Sutton 1985, 6 Sutton & Portier 1983, 7 Sutton & Portier 1991, 8 Finlayson *et al.* 1980, 9 Boyd 1978, 10 Grise *et al.* 1986.

[2]N.D. = Not determined.

[3]N.L. = Not listed.

MATERIAL AND METHODS

Lake Okeechobee(26°56.00'N, 80°55.00'W), located in south central Florida, is a managed reservoir with multiple uses including flood control, irrigation, and recreation, and serves as a regional source of potable water. Lake Okeechobee is the second largest freshwater lake wholly within North America and is subtropical to tropical. The lake is classified as eutrophic and has a mean water column depth of <3.0 m (Canfield and Hoyer 1988). Over 21% of the lake area consists of littoral habitat.

Submersed plant biomass samples were collected during 18 to 31 August 1990 from 60 transects located along the northern, western, and southern littoral zone. Samples were collected along these transects when species dominance changed (Canfield *et al.* 1983). Biomass samples consisted of all above-sediment vegetation in 0.25-m^2 quadrats. Samples were cleaned of sediment and debris, washed free of obvious epiphytes, separated into component species, dried at 60C, and then ground to homogeneity using a Wiley Mill equipped with a #60 (250 µm) mesh. Carbon and nitrogen analyses were made with a Carlo Erba Model NA1500 elemental analyzer using atropine as the external calibration standard. For all other elemental analyses (Ca, Mg, Mn, K, P, Zn, Na, Fe, and Cu), 1.0 g of each sample was ashed at 550C for 4 hr, then acidified (HCl) and analyzed by the IFAS Soil Testing Laboratory using an ICAP spectrophotometer (Hanlon and Devore 1989). Data were normalized (to sample weight digested) prior to statistical analyses (Statistical Analysis System 1985).

RESULTS AND DISCUSSION

A total of 146 samples were analyzed for chemical composition (Table 1). Vallisneria was the most abundant species analyzed (59 samples), whereas chara had the fewest replicate samples (12).

Generally hydrilla, southern naiad, Illinois pondweed, and vallisneria had similar chemical composition relative to that of chara. Only calcium content of chara was higher than in the other four species. High calcium content would be expected in charophytes because of the calcium carbonate cell wall (Bold and Wynne 1985). It is surprising that the calcium value for chara is low compared to other studies as Lake Okeechobee water column calcium concentrations exceed 50 mg/l throughout the lake (Zimba pers. obs.). Perhaps previous researchers included a significantly larger proportion of the external carbonate-epiphyte outer layer, or the combustion temperature used during our ashing procedure exceeded the optimal for this single element (Hanlon, pers. comm.).

MANOVA was able to separate the five species based upon their unique chemical composition. All eleven variables were statistically different ($F = 6.57$, $p \leq 0.001$, d.f = 5,1,93). Discriminant analysis identified what elements allowed for separation of the five species (Figure 1). A plot of the group centroids (means) on canonical axes 1 + 2 suggests greatest separation of chara from the other taxa. Micronutrient concentrations, particularly iron, copper, and magnesium, were most significant in separating chara from the other four species.

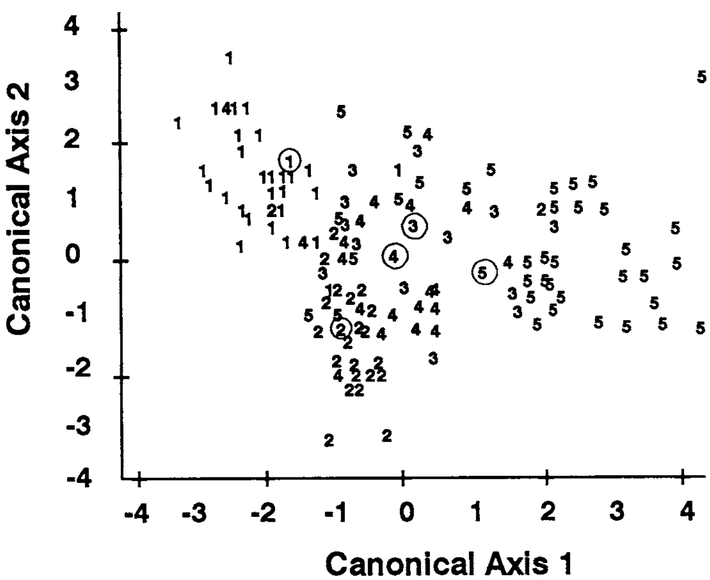

Figure 1. Plot of discriminant analysis results on canonical axes 1 and 2. Circled values are group centroids for each species (1 = chara, 2 = hydrilla, 3 = naiad, 4 = Illinois pondweed, 5 = vallisneria).

Ratios of carbon:nitrogen (C:N) or nitrogen:phosphorus (N:P) have been used to assess physiological state of aquatic vegetation (Goldman *et al.* 1979, Wheeler and Bjornsater 1992). C:N ratios for the five macrophytes averaged 14.40 (range 9.46 to 19.44), a value much higher than the Redfield ratio of 6-7 which suggests plants are nitrogen limited. N:P ratios for the macrophytes averaged 16.33 (range 12.58 to 23.55), suggesting phosphorus limitation. However, both nitrogen and phosphorus concentrations in the macrophytes are in excess of critical levels determined for five species of green and red macroalgae (Wheeler and Bjornsater 1992) or six species of submersed aquatic plants (Gerloff and Krombholz 1966). These data suggest that caution should be exercised when using elemental ratios as the sole means of judging physiological health.

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