Catabolic Diversity of Periphyton and Detritus Microbial Communities in WCA-2a of the Everglades

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INTRODUCTION

Nutrient runoff from agricultural soils in addition to hydrologic conditions have altered the Everglades ecosystem through enhancement of soil nutrient levels, particularly P, which promoted vegetation intrusions by cattail (*Typha domingensis*) into areas previously dominated by sawgrass (*Cladium jamaicense*). Because of prolonged response of vegetation to eutrophication, microbial processes and patterns may be used as sensitive early indicators of changes in environmental conditions.

The characterization of the metabolic activities of the heterotrophic microbial communities has been successfully utilized in understanding C flow in ecosystems. The objectives of this study were to determine patterns in the response of heterotrophic microbial communities to addition of C-substrates in soils along a nutrient enrichment gradient in the Everglades.

MATERIALS AND METHODS

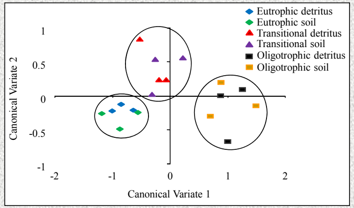
Detritus and soil (0-10 cm) were sampled at three sites along a nutrient enrichment gradient, 2.3 (eutrophic), 5.1 (transitional), and 10.2 (oligotrophic) km south of the S10-C water inflow structure of WCA-2a, and analyzed for biogeochemical properties. The short-term response (2-d incubation) of the heterotrophic microbial community to C-substrates (alcohols, amino acids, carboxylic acids, and polysaccharides) was measured as CO_2 production.

RESULTS

Detritus consisted of recently-deposited plant material, mainly *Typha* residue at the eutrophic site and *Cladium* residue plus periphyton at the oligotrophic site. Detritus at the transitional site was a mixture of residues of the two adjacent sites. Soil at all sites represented a more decomposed, consolidated organic material having approximately 87% organic matter. Total P ranged from 1890 mg kg^{-1} (eutrophic) to 693 mg kg^{-1} (oligotrophic).

Total P and $NaHCO_3$-P*i* concentrations were approximately twice as high for detritus than underlying 0-10 cm soil. Corresponding to the gradient in total P and $NaHCO_3$-P*i*, detritus microbial biomass was highest at the eutrophic site near inflow and decreased toward the oligotrophic interior of the wetland. Total and extractable organic C tended to be higher at eutrophic than transitional and oligotrophic sites. While P levels and microbial biomass were higher for detritus than soil, total and extractable C did not vary between strata.

Basal CO_2 production was highest at the eutrophic site and lowest at the oligotrophic site for detritus but not soil. Basal respiration was 137% higher in detritus than soil at the eutrophic site. Detritus CO_2 production was higher than soil basal and SIR at the eutrophic site for most amino acids and alcohols, carboxylic acids, and polysaccharides. Carboxylic acids and polysaccharides provoked the greatest increase in detrital CO_2 production of all C-substrates.



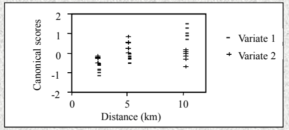


Table 1. Basal and substrate-induced CO_2 production (μg CO_2-C g^{-1} hr^{-1}) in detritus and 0-10 cm soil amended with amino acids and alcohols for eutrophic, transitional, and oligotrophic sites in Water Conservation Area-2a. ANOVA results were obtained for a model with the terms site (DF=2), nested depth within site (DF=3) with residual DF=12. The LSD was determined at $\alpha = 0.05$.

Treatment	Strata	Eutrophic	Transitional	Oligotrophic	LSD
Basal	Detritus	19	11	11	4
	Soil	8	12	9	
Amino acids					
alanine	Detritus	39	14	19	11
	Soil	26	32	33	
cysteine	Detritus	40	19	20	11
	Soil	25	26	22	
aspartate	Detritus	36	16	18	9
	Soil	15	16	12	
glutamine	Detritus	34	17	13	8
	Soil	25	26	26	
methionine	Detritus	24	13	14	7
	Soil	23	16	15	
histidine	Detritus	37	15	23	10
	Soil	21	21	25	
lysine	Detritus	31	12	14	7
	Soil	21	23	19	
proline	Detritus	28	13	14	7
	Soil	21	19	22	
tyrosine	Detritus	27	13	14	6
	Soil	15	19	19	
Alcohols					
glycerol	Detritus	29	15	16	9
	Soil	21	18	18	
mannitol	Detritus	37	13	17	13
	Soil	23	34	25	

Table 2. Basal and substrate-induced CO_2 production (μg CO_2-C g^{-1} hr^{-1}) in detritus and 0-10 cm soil amended with carboxylic acids and polysaccharides for eutrophic, transitional, and oligotrophic sites in Water Conservation Area-2a. The ANOVA results were obtained for a model containing the term site (DF=2), nested depth within site (DF = 3) with residual (DF = 12). The LSD was determined at $\alpha = 0.05$.

	Strata	Eutrophic	Transitional	Oligotrophic	LSD
Carboxylic acids					
acetate	Detritus	40	23	29	12
	Soil	26	22	25	
formate	Detritus	26	19	18	6
	Soil	20	24	22	
oxalate	Detritus	35	28	38	12
	Soil	29	30	30	
butyrate	Detritus	35	19	19	10
	Soil	19	21	19	
malate	Detritus	36	22	29	11
	Soil	23	23	18	
propionate	Detritus	23	12	12	6
	Soil	19	18	17	
valerate	Detritus	31	17	16	7
	Soil	15	14	17	
Polysaccharides					
glucose	Detritus	39	27	33	15
	Soil	18	23	19	
maltose	Detritus	43	20	20	10
	Soil	15	21	25	

Overall, the HMA responses were moderately successful at distinguishing sites. The HMA profiles for the eutrophic site generated a distinct and tight cluster of points in the lower left hand corner of the graph, and were characterized by negative scores in both canonical variates, suggesting that microbial communities were exhibiting an affinity for N-containing substrates at the eutrophic site and a preference for fermentation products at the oligotrophic site. However, utilization of the canonical variates as comprehensive descriptors of the C processes in this wetland may require a finer sampling of soils along the nutrient enrichment gradient.

CONCLUSIONS

Heterotrophic microbial activity along a nutrient gradient was influenced by a variety of C-substrates, but impacts varied with strata. Detritus and soil from eutrophic, transitional, and oligotrophic sites possessed the ability for utilization of a wide variety of C-substrates.

The patterns of substrate utilization were different at each of the three sites depending on nutrient availability, which influenced microbial biomass levels. Heterotrophic microbial activity was enhanced by addition of C-substrates, suggesting that labile organic C was a limiting factor along the gradient, even at the oligotrophic site.

External nutrient loading altered metabolic pathways of organic matter decomposition. The patterns of HMA were different in wetland soils with divergent nutrient contents, and patterns in relation to nutrient enrichment provided insight into the microbial response to changes in environmental conditions.

Stimulation of HMA by C-substrates has important implications for management of the Everglades ecosystem. External nutrient loading and internal nutrient cycling may result in stimulation of HMA and ultimately increase organic matter decomposition and nutrient regeneration to floodwater, further contributing to the eutrophication of WCA-2a.