Amino acids in salt marsh detritus[1]

Abstract—Amino acids declined by more than 50% on death of marsh plants, but increased again almost to the level of the living plant during in situ decomposition. A decline in the ratio of total amino acid to crude protein in spite of increases in both AA and CP implies nitrogen sources in the marsh other than the amino acids and ammonia in the plants.

Organic production by salt marsh plants is extremely high (Keefe 1972; de la Cruz 1973) and tidal flushing of the marsh results in a net flux of organic biomass, usually in the form of decomposing detrital particles, into the marine waters (de la Cruz 1965; Heald 1969). Salt marsh detritus is a source of food for estuarine and nearshore marine consumers (e.g. Darnell 1967). The high nutritional quality of plant detritus has been attributed to certain biochemical changes during its decomposition to particulate detritus. For example, microbial colonization of the detritus changes the chemical complexion of the decaying particles. Nutrient absorption, adsorption, and other processes by which heterotrophic transformations of suspended detritus are carried out in estuarine waters are still not clearly understood.

Hall et al. (1970) found that the total amino acid content of detrital material in estuarine water is an order of magnitude lower than that of the marsh plant that produced it. However crude protein increases during decomposition of marsh plant material to particulate detritus (Odum and de la Cruz 1967; de la Cruz and Gabriel 1974). Our observations on estuarine seston suggest that its relatively high inorganic content (77–81%) makes nutrient levels appear low when interpreted on a dry weight basis. Observations that nutrient levels in plants change during death and decomposition prompted us to examine the amino acid constituent of four species of marsh plants and their detritus.

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Total amino acid content was determined in samples of live, dead, partially decayed, and particulate detritus of four species of plants abundant in Mississippi marshes, the needlerush *Juncus roemerianus*, the giant cordgrass *Spartina cynosuroides*, the bulrush *Scirpus americanus*, and the salt grass *Distichlis spicata*. Live plants were collected from St. Louis Bay estuary, Mississippi, during summer and dead plants in fall. The partially decayed materials were recovered from dead plants enclosed in nylon litter bags (2.5-mm mesh) and allowed to decompose in situ for 6 months (de la Cruz and Gabriel 1974); detritus particles ($\leqslant$ 2.5 mm) were retrieved by passage through the mesh of bags that had remained in the field for 12 months.

The samples were dried at 103°C. One-half gram of each was hydrolyzed in 6 N HCl for 24 hr (Smith et al. 1965). Analyses were performed by the use of the automated ion-exchange method of Spackman et al. (1958), in a Beckman model 120C amino acid analyzer. All samples were analyzed by the standard 4-hr protein hydrolyzate procedure. Norleucine and ϵ-amino-n-caproic acid were used as the internal standards for the acid-neutral and basic columns. These standards were added to the samples just before hydrolysis.

Crude protein was calculated from total Kjeldahl nitrogen (Assoc. Off. Agr. Chem. 1965) with a 6.25 conversion factor.

The percentage of amino acids in our four species of marsh plants is generally lower than the values of Hall et al. (1970) for *Spartina alterniflora*. We found, however, higher concentrations of histidine (in all four species), proline (in *Juncus*), glycine and lysine (in *Juncus* and *Scirpus*), and arginine (in *Juncus*, *Scirpus*, and *Distichlis*) than previously reported. Total amino acid declined by at least 50% in the dead plants (Table 1) but increased in the

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Table 1. Amino acid analysis (mg g^{-1}) of live, dead, and decayed marsh plants and detritus decomposed in situ. Values in parentheses are based on ash-free dry weight.

	Juncus roemerianus				Spartina cynosuroides				Scirpus americanus				Distichlis spicata			
Amino acid	Live	Dead	Decayed	Detritus	Live	Dead	Decayed	Detritus	Live	Dead	Decayed	Detritus	Live	Dead	Decayed	Detritus
Lysine	4.3	1.7	2.6	3.0	1.9	0.8	1.5	1.6	4.0	1.5	1.6	1.9	2.9	1.1	1.6	1.8
Histidine	1.8	0.7	0.6	1.1	0.7	0.4	0.5	0.5	2.1	0.5	0.5	0.7	1.0	0.4	0.5	0.7
Arginine	4.0	1.6	2.8	3.3	1.7	0.7	1.5	1.7	3.2	1.1	1.5	2.0	2.8	1.0	1.5	2.0
Aspartic acid	6.6	3.9	4.8	7.5	8.6	1.3	3.5	3.9	16.9	2.6	2.3	5.2	6.0	2.2	3.3	5.7
Threonine	3.7	2.3	2.3	4.4	1.7	0.7	2.1	2.3	4.0	1.5	2.0	2.5	2.6	1.3	2.0	3.1
Serine	3.5	2.3	2.8	4.1	2.0	0.8	1.8	1.9	4.2	1.6	2.0	2.3	2.7	1.4	1.8	2.6
Glutamic acid	8.7	4.2	5.0	8.2	3.9	1.3	3.7	4.0	16.3	2.6	3.5	5.0	6.1	2.3	3.5	5.5
Proline	11.9	2.1	2.3	3.7	3.4	0.7	1.9	1.9	4.7	1.6	1.8	2.4	3.9	1.5	1.9	2.9
Glycine	3.9	2.4	2.8	4.8	1.7	0.8	2.2	2.5	3.3	1.6	2.0	3.4	2.9	1.4	2.1	3.8
Alanine	4.5	2.4	2.9	4.9	2.3	0.9	2.4	2.5	4.3	1.6	2.1	3.3	3.5	1.6	2.3	3.7
Half cystine	trace	trace	0.3	0.5	trace	0.0	trace	trace	0.9	trace	trace	trace	trace	trace	trace	trace
Valine	5.2	2.3	2.5	4.2	2.0	0.8	2.1	2.2	4.9	1.5	1.8	2.8	3.0	1.3	1.9	3.2
Methionine	1.0	0.8	0.8	1.5	0.5	0.3	0.8	0.7	1.3	0.5	0.7	0.8	0.9	0.5	0.8	1.1
Isoleucine	3.4	1.7	2.1	3.1	1.3	0.5	1.3	1.5	3.6	1.1	1.7	2.0	2.1	0.9	1.3	2.2
Leucine	5.8	3.0	3.8	5.5	2.5	1.0	2.5	2.5	5.4	2.0	2.5	3.5	4.2	1.7	2.4	3.7
Tyrosine	2.3	1.1	1.0	2.1	1.0	0.4	0.9	1.0	1.9	0.7	0.9	1.3	1.5	0.6	1.0	1.4
Phenylalanine	3.7	1.8	2.1	3.2	1.7	0.6	1.5	1.6	4.0	1.1	1.4	2.2	2.4	1.0	1.4	2.3
Total amino acid (AA)	74.3 (78.6)	34.3 (36.4)	41.5 (45.4)	65.1 (92.3)	36.9 (39.3)	12.0 (13.0)	30.2 (34.6)	32.3 (47.6)	85.0 (96.0)	23.1 (26.3)	29.3 (31.7)	41.3 (59.5)	48.5 (51.9)	20.2 (22.0)	29.3 (32.6)	45.7 (72.3)
Crude protein (CP)	79.0 (83.6)	49.5 (52.6)	57.6 (63.0)	87.1 (123.5)	46.9 (50.0)	19.0 (20.6)	44.4 (50.9)	49.5 (68.8)	100.3 (113.3)	30.7 (34.9)	37.4 (40.5)	64.4 (92.8)	69.2 (74.0)	29.8 (32.5)	48.2 (53.6)	72.3 (114.4)
% AA in CP	94.05	69.29	72.05	74.74	78.68	63.16	68.02	69.25	84.75	75.24	78.34	64.13	70.09	67.79	60.79	63.21

Table 2. Amino acid ratios (units per 100 AA and ammonia units) in living marsh plants (upper values) and in plant detritus (lower values).

Amino acid	Juncus	Spartina	Scirpus	Distichlis
Acidic				
Aspartic	8.61 / 11.09	22.05 / 11.29	18.88 / 11.57	11.90 / 11.55
Glutamic	11.36 / 12.11	10.00 / 11.59	18.21 / 11.13	12.09 / 11.16
Basic				
Lysine	5.61 / 4.43	4.87 / 4.64	4.47 / 4.23	5.75 / 3.65
Histidine	2.35 / 1.62	1.81 / 1.45	2.35 / 1.56	1.98 / 1.42
Arginine	5.22 / 4.87	4.36 / 4.91	3.58 / 4.45	5.56 / 4.06
Neutral				
Threonine	4.83 / 6.50	4.36 / 6.67	4.47 / 5.57	5.17 / 6.29
Serine	4.57 / 6.06	5.13 / 5.51	4.69 / 5.12	5.37 / 5.27
Proline	15.54 / 5.47	8.72 / 5.51	5.25 / 5.35	7.74 / 5.88
Glycine	5.09 / 7.09	4.36 / 7.25	3.69 / 7.57	5.75 / 7.71
Alanine	5.87 / 7.23	5.90 / 7.25	4.81 / 7.35	6.94 / 7.51
Valine	6.79 / 6.20	5.13 / 6.38	5.47 / 6.24	5.94 / 6.49
Isoleucine	4.44 / 4.58	3.33 / 4.35	4.02 / 4.45	4.17 / 4.46
Leucine	7.57 / 8.12	6.40 / 7.25	6.03 / 7.80	8.34 / 7.51
Sulfur				
H. Cystine	trace / 0.74	trace / trace	1.01 / trace	trace / 0.20
Methionine	1.31 / 2.22	1.27 / 2.03	1.45 / 1.78	1.79 / 2.23
Aromatic				
Tyrosine	3.00 / 3.10	2.55 / 2.89	2.12 / 2.90	2.98 / 2.84
Phenylalanine	4.82 / 4.73	4.36 / 4.64	4.47 / 4.90	4.76 / 4.67
Ammonia	3.00 / 3.84	5.38 / 6.38	5.03 / 8.02	3.76 / 7.10

tissue decomposed for 6 months and was back almost to the level present in the living plant (except in *Scirpus*) in the detritus. Percent crude protein in live plants, which is comparable to the values of Burkholder (1956), Odum and de la Cruz (1967), and Hall et al. (1970) in *S. alterniflora* and by de la Cruz and Gabriel (1974) in *J. roemerianus*, also declined significantly in the dead plants, but it increased in the detritus stage to above the level in live plants. In terms of ash-free dry weight, amino acid contents increase by 15, 17, and 28% in *J. roemerianus*, *S. cynosuroides*, and *D. spicata*, and protein by 32, 27, and 35%. *Scirpus americanus* shows the highest percentages of amino acids and crude protein in the live tissue, which decline by 38 and 18% in the detritus stage but remain at levels comparable to those of the three other marsh plants. We found that *Scirpus* contains 25% less crude fiber and decomposes more rapidly than other species in this marsh (de la Cruz 1973); the *Scirpus* detritus used here is thus relatively in a much more advanced stage of decay and consequently of biochemical breakdown. The decline in the ratio of amino acid to crude protein (AA:CP), in spite of increases in both components, suggests the presence of sources of nitrogen in the marsh other than the amino acids and ammonia within the plants. These sources could include breakdown products of chemical compounds (e.g. alkaloids) in the plants, nitrogen-containing substances from the marsh attached to the detrital material, and microbial protoplasm on the detrital particles.

In terms of amino acid ratios (i.e. units per 100 amino acid units), the four plants contain comparable concentrations except for proline, glutamic acid, and aspartic acid, which are about twice as high in living *Juncus*, *Scirpus*, and *Spartina* respectively (Table 2); these levels dropped back on death of the plants. Amino acid ratios in the detritus derived from all four species are similar, indicating that the same amino acids are built up during decomposition.

Seven (in *Distichlis*) and 12 (in the other three species) of the 17 amino acids analyzed increase from living plants to detritus, although this is balanced by decreases particularly in the acidic and basic amino acids. The sulfur group shows the lowest concentration. Ammonia also increases from living plant to detritus.

Certain biochemical changes during decomposition of dead plant materials clearly lead to an increase in amino acid content which, expressed on an ash-free basis, may reach a level exceeding that in the living plant. The increment in protein content seems to be environmentally influenced, as can be seen by comparing the amino acid to crude protein ratios (Table 1). AA:CP ratios declined by 19, 9, 21, and 7% during the in situ decomposition of *Juncus*, *Spartina*, *Scirpus*, and *Distichlis*.

This study shows a reconstitution of nutritional quality in marsh plant detritus despite a drastic decline in amino acids on death of the plants. Suspension feeders may be exposed to food particles of even higher nutrient level than are the grazers on the marsh plants. Our analyses support the general observation that estuarine detritus may be a food source of high nutritional value.

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