found that the vast majority of species, in Great Barrier Reef spawn in the summer months when the rainfall was maximum. Panikkar and Aiyar[10] also concluded that the lowering of salinity, consequent to the onset of north-east monsoon, influences the breeding of animals along the Madras coast.

Changes in salinity seem to influence the breeding of marine invertebrates in 2 ways. In some animals the lowering of salinity stimulates spawning while in others it may trigger off reproductive activities[22]. In the south-west coast of India, *Uca annulipes*, *Portunus pelagicus*, *Metapenaeus affinis*[22] and *Balanus amphitrite communis*[23] are found not to breed in the monsoon months. Pillay and Nair[21,22] have contended that these animals had a prolonged stress due to very low salinity.

Vellar estuary receives copious rain during the north-east monsoon period (October to December). During this season the area records more than half of the total rainfall for the year. At this time the river is flooded and the salinity touches an all time low (0 to 4‰) for the year. Even though there is no rain in January, the heavy fresh water run off from the land keeps the salinity very low throughout this month and it is in February that the normal conditions return. *C. longitarsus* does not appear to breed during the monsoon season. With the stabilization in environmental parameters in February it starts its reproductive activities and continues it up to October till the onset of monsoon. Tolerance experiments conducted in the laboratory showed that this crab can tolerate a wide range of salinity (from 1 to 35‰). However, they did not survive in fresh water (0‰). Even during heavy rains the salinity at the bottom of the estuary was around 5‰ due to a salinity wedge. Possibly this crab migrates from the intertidal region to the deeper areas of the estuary during monsoon.

Giese[18] pointed out that the larvae are produced at a time when favourable environmental conditions exist, i.e. the breeding is so timed as to provide maximum larval survival. Boolootian *et al.*[12] correlated breeding with availability of food for the larvae. Pillay and Nair[22] also suggested that the timing of breeding is based on the fact that the planktotrophic larvae will have a better chance of finding an adequate food supply if liberated at a period when suitable types of planktonic food are available in the medium. Presently, laboratory experiments show that the zoeae of *C. longitarsus* are unable to tolerate low salinity (below 20‰) and the development was quicker and the survival rate of larvae better in the salinity range of 20-35‰, when there is lush plankton production. Breeding of *C. longitarsus* during monsoon months is quiescent when larval mortality also may be high due to heavy freshwater inflow from the Vellar river.

Thanks are due to UGC, New Delhi, for financial help.

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Biochemical Changes in Mangrove Foliage During Growth & Decomposition

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Received 13 *September* 1976; *revised received* 11 *April* 1977

Biochemical changes during 5 developmental stages of mangrove foliage and subsequent decomposition resulting into detritus have been studied, taking into consideration the nutritional value of foliage. Carbohydrate and lipid decrease during growth and decomposition of the two species (*Rhizophora mucronata* and *Avicennia officinalis*. Protein values, on the other hand show a gradual increase probably as a result of microbial colonization and thus enhancing the nutritional value of detritus. C : N ratio in general shows a downward trend in different stages of mangrove foliage.

MANGROVE foliage plays an important role in the formation of detritus which is utilized by several estuarine and marine detritovorous organisms[1] Various aspects such as formation, distribution and utilization of detritus in different ecosystems like seagrasses, estuaries and mangroves have been studied earlier[2-5]. An attempt has been made to construct a mangrove foodweb model taking into consideration the various aspects[1]. Process of detritus formation and the changes into the major metabolites of salt marsh plants during growth and decay have been reported earlier[6]. Total caloric values of seven species of mangroves from Goa have been determined[7]. The present communication gives the biochemical changes during different stages of foliage growth and decomposition.

Mangrove leaves at different stages of development and after their fall in the swamp water were collected at Mashem, 100 km south of Panjim, Goa. The entire investigation was divided into 5 different stages on the basis of leaf development and decomposition as follows: Stage I, vegetative leaf buds; stage II, actively photosynthesizing leaves; stage III, mature or yellow leaves from trees; stage IV, freshly fallen mature leaves from swamp; and stage V, old decayed leaves from swamp.

Leaves of *Rhizophora mucronata* Lamk. and *Avicennia officinalis*, L., the 2 dominant species in mangrove swamps of Goa, were selected and leaf samples from each were collected and transported to the laboratory in ice box without adding any preservative. Samples were ground to a fine paste and stored in a deep freeze. These were analysed as soon as possible. Protein, carbohydrate, lipid, organic matter and carbon were estimated following the procedures described by Bhosle *et al.*[7].

Major metabolites at different stages of growth and decomposition in *R. mucronata* and *A. officinalis* showed interesting trends (Table 1), and organic matter decreases with the increase in ash content from stage I to V (Table 2).

Per cent organic carbon in both the plants decreased from stage I to stage V. However, the per cent nitrogen in *R. mucronata* and *A. officinalis* showed a gradual increase during the above stages (Table 3). C:N ratio in *R. mucronata* which was maximum (15·80) at stage I, gradually decreased to 2.29. Similarly in *A. officinalis* the ratio declined from 26·97 at stage I to 2·91 at stage V.

Caloric values calculated from major metabolites such as protein, carbohydrate and lipid are shown in Fig. 1. Caloric values determined from protein fraction, increased both in *A. officinalis* (292·67 to 1560 cal/g) and *R. mucronata* (350 to 810 cal/g), whereas the values calculated from carbohydrate and lipid fraction decreased from stages I to V.

Nutritional values of detritus from marshy plants have been reported[3,5,6,8,9]. The work on detritus has largely been on *Spartina alternifolia*, *Zostera marina* and other salt marsh plants. The importance of mangrove detritus as food for estuarine and marine organisms has been investigated[1,2,10].

In both the species carbohydrate values decreased (Table 1) during growth and decomposition which confirms the earlier views[2,6]. Percentage of lipid although small in early stages (stage I), increased in larger leaves and then decreased. Protein values (N×6·25) on the other hand, increased as the foliage became older and it was maximum when the leaves were decaying; the increase was more in *A. officinalis* than in *R. mucronata*. While investigating[2] the changes in the biochemical composition during growth and decomposition in *Rhizophora mangle*, it was indicated that protein which is greater in active leaves (stage II in the present investigation), declines in ripe or yellow leaves (stage III) and again increases in decaying leaves (stage V). In the present investigation, protein values in both the species showed a constant increase. Increase of 96-300% in protein after decaying process of the salt marsh plants was reported[6].

It was suggested[2,11] that the increase in protein in decaying leaves may be due to the growth of microbial organisms on detritus particles. Fell *et al.*[11] studied in detail the microbial flora, meiofauna and other organisms responsible for the degradation. They opined that decrease in carbon is because of leaching while increase in nitrogen is because of microorganisms. High nutritional quality of detritus was attributed to some biochemical, changes occurring during its decomposition[12]. The amino acid content was observed to decrease on the death of salt marsh plants, followed by an increase during decomposition of plants[12]. Further it was concluded that the increase in protein content is influenced by the environmental changes. Conversion of low protein plant tissue to high protein animal protoplasm and the absorption or adsorption of dissolved nutrients by the decomposing detrital matter enhanced the organic concentration[6]. This

TABLE 2 — PER CENT ORGANIC MATTER AND ASH IN MANGROVE LEAVES

Stage	*R. mucronata*		*A. officinalis*	
	Ash	Organic matter	Ash	Organic matter
I	10·19	89·91	1·87	98·12
II	12·96	87·07	11·1	88·89
III	12·74	87·29	8·32	91·67
IV	24·34	75·73	12·31	87·68
V	35·06	64·98	40·7	59·29

TABLE 1 — CHANGES IN SOME METABOLITES OF MANGROVE LEAVES DURING THEIR GROWTH AND DECOMPOSITION

[All values (%) are expressed on wet weight basis]

Stage	*R. mucronata*			*A. officinalis*		
	Carbohydrate	Lipid	Protein (N×6·25)	Carbohydrate	Lipid	Protein (N×6·25)
I	14·4	0·93	6·11	24	2	5·18
II	13	7·13	7·21	23	6·26	5·43
III	13	4·46	7·86	12	6·46	7·73
IV	7	3·93	10·93	12	5·53	12·62
V	3	3·29	14·37	3	4·06	27·75

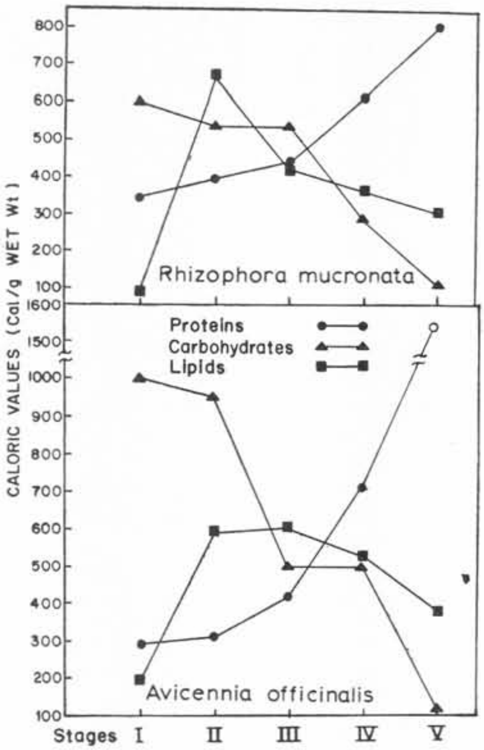

Fig. 1 — Changes in caloric values of proteins, carbohydrate and lipid in *R. mucronata* and *A. officinalis*

TABLE 3 — PER CENT CARBON, NITROGEN AND C:N RATIO OF MANGROVE LEAVES DURING DIFFERENT STAGES

[All values (%) expressed on wet weight basis]

Stage	*R. mucronata*			*A. officinalis*		
	Organic carbon	Nitrogen	C:N ratio	Organic carbon	Nitrogen	C:N ratio
I	18·17	1·15	15·80	27·24	1·01	26·97
II	13·11	1·43	9·16	23·63	1·15	20·5
III	11·63	1·57	7·4	20·79	1·5	13·83
IV	7·82	2·13	3·67	16·1	2·44	6·57
V	6·21	2·71	2·29	14·03	4·82	2·91

further increased protein content in the decomposed matter.

Decrease in the particle size of the detritus plays an important role in the increase of its nitrogenous content. As a result of fragmentation or disintegration of the foliage, particle size decreases resulting in an increase in the surface area, on which colonies of microbial organisms develop[13]. Nitrogenous contents increase with the decrease in the particle size in *Spartina alternifolia*[4]. The observations on the metabolic changes in the species of salt marsh plants[6] confirm the present findings that carbohydrate and lipid percentages decrease while protein content increases during the growth and decomposition.

Organic matter and ash content (Table 2) in *R. mucronata* and *A. officinalis* showed a definite trend. Increase in ash was probably associated with accumulation of minerals, which might have been absorbed by the plants from the adjoining soil and also because of microbial mineralization. In *R. mangle* an initial ash of 6·7% has been recorded[2].

C:N ratio and the protein percentage in both the species (Table 3) showed an interesting correlation. During growth of leaves and their final decomposition C:N ratio declined because of increase in protein nitrogen. Fell *et al.*[11] have also noted similar decreasing trend in C:N ratio in mangrove plants. Several processes like leaching and mineralization through microbial decay lead to a fluctuation in the nitrogenous and non-nitrogenous matter of decomposing foliage[13].

Caloric values determined from protein of *R. mucronata* and *A. officinalis* gradually increased during growth and decomposition of foliage (Fig. 1). Increase in protein caloric values was also reported[6,14]. From the comparison of the caloric values of *R. brevistyla* with tropical forest trees, it was concluded that the mangrove trees had a higher energy content than the other trees[15]. These findings agree with those reported in the present communication. Decrease in the caloric values calculated from carbohydrates and lipids (Fig. 1) might be because of their utilization within the leaves after the stage II.

High nutritive values of mangrove foliage during its decomposition suggest that if the decomposition process could be accelerated artificially by introducing desired microbial flora, the mangrove swamp could possibly support a fairly large population of detritovorus species during aquaculture.

The authors thank Dr S. Z. Qasim for stimulating discussion and going through the manuscript critically.

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