

The distribution of algae epiphytic on pneumatophores of the mangrove, *Avicennia marina*, at different salinities in the Kosi System

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Samples of algae epiphytic on the pneumatophores of *Avicennia marina* (Forssk.) Vierh. were collected at different seasons of the year. The distribution of this mangrove, which extends from the mouth of the estuary to Wankute island, approximately 6.5km upstream, covers a salinity range from 35‰ to 7‰ at its upper limits, and includes the Ukhwalwe inlet in which the surface water of the upper reaches is 0‰. Thirty-six species of epiphytic algae were collected across this distribution range, of which there were 11 rhodophycean, 17 cyanophycean (cyanobacteria), 7 chlorophycean and 1 phaeophycean. Most of the red algae were restricted to the high (>25‰)

salinity areas, while the blue-green algae generally appeared to have a wider salinity and exposure tolerance. Six algal species were found to have a distribution covering the entire salinity range, 10 species were recorded in waters ranging from 35‰ to 7‰, 16 and 2 species were limited to high (>25‰) and lower (5–18‰) salinity areas, respectively, while one species occurred only in freshwater. The ecological implications of these results are discussed. The need for additional collections from localities to the north is stressed to establish the affinities of this community with those in more tropical areas.

Introduction

The mangrove vegetation of the Kosi System has been well documented (Tinley 1958, Breen and Hill 1969, Steinke and Ward 1973, Ward *et al.* 1986). Not only does this System have the third largest area under mangroves in South Africa (Ward and Steinke 1982), but also six arboreal species are represented, viz. *Avicennia marina* (Forssk.) Vierh., *Bruguiera gymnorrhiza* (L.) Lam., *Rhizophora mucronata* Lam., *Ceriops tagal* (Perr.) C.B. Robinson, *Lumnitzera racemosa* Willd. and *Xylocarpus granatum* Koen., the last three of which do not occur naturally further southwards (Ward *et al.* 1986). *A. marina*, which has a wide distribution in the tidal basin, decreases with distance from the mouth and finally reaches its limits on Wankute island between lakes Mpungwini and Makhawulane (Ward *et al.* 1986).

Less well known, however, are the mangrove-associated algae which are usually most abundant on the pneumatophores (aerial roots) of *A. marina* (Lambert *et al.* 1987, 1989). The epiphytic algae are often present as a conspicuous algal felt which is termed the bostrychietum (Post 1936). In the St Lucia Estuary algae epiphytic on this mangrove have been shown to make a significant contribution to the litter of that system (Steinke and Naidoo 1990), while at Beachwood (Mgeni Estuary) blue-green algae (cyanobacteria) on the pneumatophores and on surface sediments have

been estimated to provide through nitrogen fixation a significant percentage of the annual nitrogen requirements of the mangrove trees (Mann and Steinke 1993). Because of their ecological importance, a study of algae epiphytic on *A. marina* in the Kosi System was initiated. This study was related to water salinities which show a general decrease from the mouth towards the upper part of the System.

Study Area

The Kosi System comprises a series of lakes linked via channels to a shallow tidal basin which is connected to the sea by a narrow mouth. The outline of the System and the distribution of *A. marina* are shown in Figure 1.

Salinities showed a decrease from the mouth towards lake Nhlange which is mostly oligohaline (Table 1). These salinity ranges are based on periodic measurements usually with a hand-held refractometer. The value in Ukhwalwe, a tidal backwater, was registered in the sheltered uppermost section which coincided with the limit of distribution of *A. marina*.

Ward *et al.* (1986) have given a brief description of the hydrology of the tidal basin. Except where the mangroves are adjacent to a channel, the ebbing tide leaves the pneumatophores exposed for several hours each day. While no

comparable figures are available, personal observations (TDS) suggest that the period of emersion is longer than occurs in most intertidal mangrove communities in this country.

Materials and Methods

Sampling sites and sampling times

Sampling sites A–G are shown in Figure 1. At sites A and D the pneumatophores extended from an area emersed at low tide to standing water in a channel. At sites F and G, which

are not usually tidal, pneumatophores extended from an exposed shore into permanent water. The majority of pneumatophores at these two sites was not permanently immersed. At sites B, C and E pneumatophores were emersed at low tides and immersed at most high tides.

For logistical reasons the sampling period was protracted. Over a period of five years sampling was carried out once only in each of the following months, viz. January, April, June, August and October. In this way a seasonal coverage was obtained. Collection at site C was made only at the first sampling. As it was so close to site B, this site was considered superfluous and was not re-sampled. No results have been reported for this site.

Sampling methods

Two procedures were followed to sample pneumatophores for algal distribution determinations. At the first four sampling times, i.e. January to August, a modified proportionate stratified random technique was employed to overcome the decrease in size and number of pneumatophores, and also in algae, which occur from the lower to the upper tidal limits. Initially samples were collected from a transect along the water’s edge, and each sample was obtained by cutting a pneumatophore at substratum level. Submerged pneumatophores were also sampled from the area adjacent to the transect. Subsequent parallel transects were then sampled in the same way up to the inland margin of the pneumatophores. Distance between transects was normally 1m, but where pneumatophores were sparse, a wider spacing was employed. Following systematic sampling, the area was searched at random to reduce the chance that any material had been missed. Random collection was the only procedure adopted in Ukhalwe where pneumatophores with algae were so few that transect sampling was not undertaken.

In the October sampling the second procedure was adopted to obtain frequency data and to enable computer analysis of the data. From sites B, E and F at least 50 pneumatophores were collected at random from transects as described above. Sites A and D were each divided into two areas: one, in which pneumatophores were exposed at low tides, and the other, in which the aerial roots were in permanent water. From each area the pneumatophores were collected at random from transects as described above. Because of the paucity of aerial roots, Ukhalwe was not included in this survey.

Identification of algae

All samples were preserved in a mixture of 5% formaldehyde in estuarine water at the sample site and transferred to the laboratory for processing. There the algae were careful-

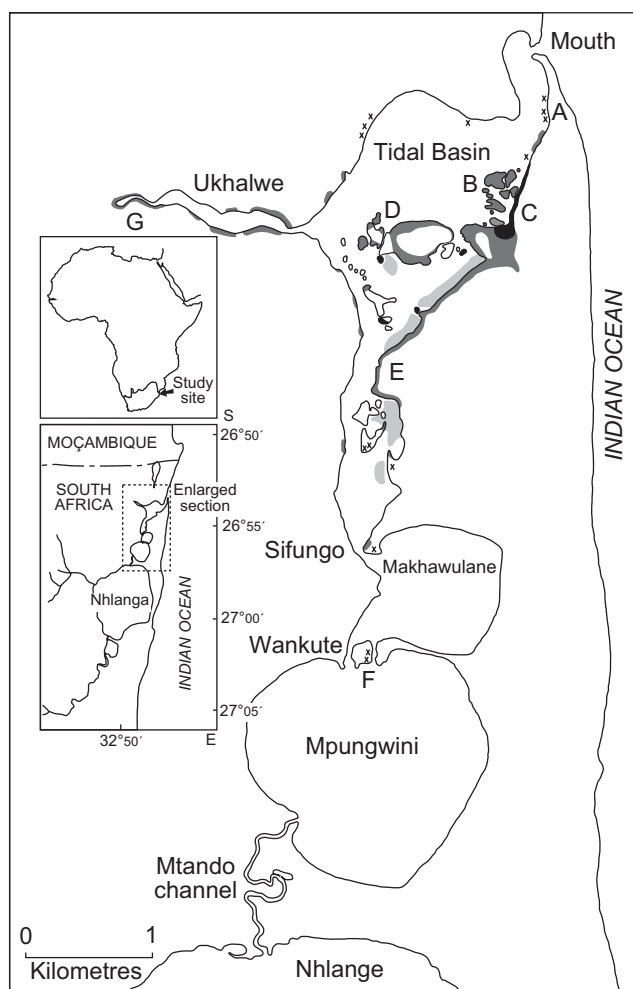


Figure 1: Locality map showing the distribution of *Avicennia marina* and sampling sites (A–G) in the Kosi System. x = isolated individuals or small groups; intensity of hatching reflects density of individuals (after Ward *et al.* 1986)

Table 1: Salinities in the Kosi System

Sampling site	Mouth	Tidal basin			Wankute island	Ukhalwe (upper)
	A	B	D	E	F	G
Salinity ranges (‰)	33–35	30–35	24–30	15–18	7–8	0

ly removed from the pneumatophores with a sharp blade and separated into species according to the keys of Lambert *et al.* (1987, 1989). Diatoms (Bacillariophyceae) were not included in this survey. Microscopic slides were prepared according to the method of Lambert *et al.* (1987) and slide voucher specimens have been housed in the Department of Botany, University of Durban-Westville.

Data analysis

Algal community composition data were compiled from assays of pneumatophores collected from all samplings at each site. In addition, from the last set of data it was possible to calculate species frequencies for each site, using the same formula as in Beanland and Woelkerling (1982), i.e.

$$F = \frac{\sum N}{N} \times 100$$

where F = the percentage frequency; $\sum N$ = the number of pneumatophores on which a particular alga occurred; and N

= the total number of pneumatophores surveyed. For comparison with data from Australia the relative profusion of taxa has been determined from the percentage frequency data (Davey and Woelkerling 1980). Species have been assigned to one of five categories: Rare (F < 5%); Sporadic (F = 5–24%); Occasional (F = 25–49%); Common (F = 50–75%); Abundant (F > 75%) (King and Wheeler 1985).

These data were also subjected to Detrended Correspondence Analysis (DCA) (Hill 1979) and classification by an agglomerative complete linkage programme, using Euclidean distance as the measure of similarity (PISCES 2001).

Results and Discussion

The epiphytic algal vegetation on the pneumatophores of *A. marina* was found to be fairly rich in species: there were 36 taxa, which included 11 rhodophycean (red algae), 17

Table 2: Epiphytic algae collected at the six sampling sites

Taxon	Sampling Sites					
	A	B	D	E	F	G
Rhodophyceae						
<i>Bostrychia moritziana</i>	+	+	+			
<i>B. tenella</i>		+				
<i>Caloglossa leprieurii</i>	+		+		+	+
<i>Ceramium</i> sp.	+	+				
<i>Gelidium</i> sp. 1	+					
<i>Gelidium</i> sp. 2	+	+				
<i>Murrayella pericladus</i>	+	+	+			
<i>Plocamium</i> sp.	+					
<i>Polysiphonia subtilissima</i>	+			+	+	+
cf. <i>Lophosiphonia</i> sp.						+
Unident. freshwater red	+					
Cyanophyceae						
<i>Aphanocapsa elachista</i> var. <i>conferta</i>	+	+	+	+		
<i>A. montana</i>	+	+	+	+		
<i>Calothrix contarenii</i>			+			
<i>C. scopulorum</i>	+	+	+	+	+	
<i>Chroococcus hansgirgii</i>	+			+		
<i>C. turgidus</i>	+	+	+	+	+	
<i>Dermocarpa olivacea</i>	+	+				
<i>Hydrococcus rivularis</i>	+	+	+			
<i>Microcoleus chthonoplastes</i>	+	+	+	+	+	+
<i>Oscillatoria chlorina</i>	+	+	+			
<i>O. limosa</i>	+	+	+	+	+	+
<i>Phormidium ambiguum</i>	+	+	+	+	+	+
<i>Rivularia bullata</i>	+	+	+	+	+	+
<i>Scytonema hofmannii</i>	+	+	+	+	+	
<i>Spirulina subsalsa</i>	+	+				
<i>Xenococcus acervatus</i>	+	+	+	+	+	
<i>X. kernerii</i>	+	+	+			
Chlorophyceae						
<i>Cladophora</i> sp. 1	+	+	+		+	
<i>Cladophora</i> sp. 2					+	
<i>Enteromorpha clathrata</i>					+	+
<i>E. flexuosa</i>	+	+			+	
<i>Monostroma</i> sp.				+		
<i>Rhizoclonium</i> cf. <i>implexum</i>		+	+			
<i>R.</i> cf. <i>riparium</i>	+	+	+	+	+	
Phaeophyceae						
<i>Giffordia</i> cf. <i>duchassiagniana</i>	+					

cyanophycean/cyanobacteria (blue-green algae), 7 chlorophycean (green algae) and 1 phaeophycean (brown algae) (Table 2). Fifteen species (7 red, 6 blue-green, 1 green and 1 brown algae) were restricted to the higher salinities, while two species of green algae and one unidentified red alga were found only in water of 5–18‰ and zero salinities, respectively. However, seven cyanophycean and three chlorophycean occurred over a range of salinities (excluding zero salinity in Ukhalwe), while two rhodophycean and four cyanophycean were present at all sampling sites (representing the entire range of salinities) in the System (Table 3).

Although the total number of taxa compares favourably with that obtained from a similar study in Kenya (Coppejans and Gallin 1989), the species composition provides an interesting basis for comparison. While many of the species were common to both sites, in our study there were fewer red and green algae, but more blue-green algae, recorded. The greater number of red and green algae in Kenya may be due to the fact that many of these were found exclusively on *Sonneratia alba* (Gallin *et al.* 1989) which does not occur in the Kosi System. Also, some of their records included species present on debris. The reason for the difference in blue-green algae at the two sites is not clear, although the authors of the Kenyan article admitted that they had limited data especially from the upper shore.

Other recent studies involving epiphytic algae on mangroves in the Indo-Pacific region were conducted in Mozambique (Silva 1991), Natal (Mgeni Estuary) (Phillips *et al.* 1994, 1996) and Australia (Davey and Woelkerling 1980, Beanland and Woelkerling 1982, King and Wheeler 1985). Silva (1991) identified 16 taxa of cyanophycean, of which 75% were found growing exclusively on *A. marina*. Of these, five were represented in the Kosi System. The checklists of algae on pneumatophores in Natal were not comprehensive, but the findings have relevance to this study and will be discussed later. The Cyanophyceae were not included in the Australian studies, but the results showed that there were 53 Rhodophyceae, 22 Chlorophyceae and 13 Phaeophyceae. These numbers are far in excess of those identified for the Kosi System and even for South Africa as a whole (Lambert *et al.* 1987, 1989). The answer may lie partly in the fact that mangroves in Australia occur over a wider latitudinal and therefore climatic range than mangroves in South Africa.

In this study it is interesting to note that, of the Rhodophyceae, only three species can be classified as occasional, according to the categories defined by King and Wheeler (1985), and then only at high salinity (Table 4). Of the Cyanophyceae, only two species could be regarded as common and one species as occasional, with the remainder as sporadic. Only one member of the Chlorophyceae, viz. *Rhizoclonium cf. riparium*, occurred throughout the System, but was found in greatest numbers (common to abundant) in the lower salinities. These values generally are very much lower than those obtained for New South Wales and indeed lower than those in many other estuaries in South Africa (Steinke, pers. obs.).

There are some puzzling gaps in the check-list. Pocock (1969) recorded two species of *Catenella*, viz. *C. opuntia* (= *C. caespitosa*) and *C. subumbellata*, from the pneumatophores of *A. marina*, at Inhaca Island, approximately

Table 3: Species grouped according to salinity regimes

Salinity regimes	Taxa
Stenohaline (>25‰)	<i>Bostrychia moritziana</i> <i>B. tenella</i> <i>Ceramium</i> sp. <i>Gelidium</i> spp. (2 spp.) <i>Murrayella pericladus</i> <i>Plocamium</i> sp. cf. <i>Lophosiphonia</i> sp. <i>Rhizoclonium cf. implexum</i> <i>Giffordia cf. duchassiagniana</i> <i>Calothrix contarenii</i> <i>Dermocarpa olivacea</i> <i>Hydrococcus rivularis</i> <i>Oscillatoria chlorina</i> <i>Spirulina subsalsa</i> <i>Xenococcus kernerii</i>
Euryhaline (5–18‰)	<i>Cladophora</i> sp. 2 <i>Monostroma</i> sp.
Oligohaline (<5‰)	unident. freshwater red
Entire range (excluding 0‰)	<i>Cladophora</i> sp. 1 <i>Enteromorpha flexuosa</i> <i>Rhizoclonium cf. riparium</i> <i>Chroococcus hansgirgii</i> <i>Calothrix scopulorum</i> <i>Aphanocapsa montana</i> <i>A. elachista</i> var. <i>conferta</i> <i>Scytonema hofmannii</i> <i>Xenococcus acervatus</i>
Entire range (including 0‰)	<i>Caloglossa lepreurii</i> <i>Polysiphonia subtilissima</i> <i>Microcoleus chthonoplastes</i> <i>Oscillatoria limosa</i> <i>Phormidium ambiguuum</i> <i>Rivularia bullata</i>
Euryhaline/oligohaline	<i>Enteromorpha clathrata</i>

100km north of Kosi. However, following examination of that material, Lambert *et al.* (1987) suggested that there may well be only one southern African species of *Catenella*, namely *C. nipae*. This species was not collected at Kosi, although, in addition to Inhaca, there are records of *Catenella* spp. from Tanzania (Jaasund 1976) and Kenya to the north and Transkei to the south (Lambert *et al.* 1987). Although the waters in this System carry a low silt load, which is considered to favour this species, the long periods of emergence of the pneumatophores at low tide probably do not favour its presence (Lambert *et al.* 1987).

Although only *Bostrychia moritziana* was collected regularly during this survey, Pocock (1969) recorded four other species from Inhaca. Although most of those from Inhaca were also collected along the KwaZulu-Natal and Transkei coasts (Lambert *et al.* 1987) and are widespread in mangrove communities elsewhere (King and Puttock 1989), their absence from this System is contrary to expectation. Most surprising is the absence of *B. radicans* which at St Lucia

Table 4: Epiphytic algae collected for frequency analysis (Figures in body of table represent pneumatophores with algae; those in brackets indicate percentage frequencies)

Sampling sites	A		B	D		E	F	Mean % frequency
	imm.	em.*		imm.	em.*			
No. pneumatophores sampled	60	61	100	50	50	50	50	
Entities								
Rhodophyceae								
<i>Bostrychia moritziana</i>	22 (36.7)	13 (21.3)	8 (8.0)	11 (22.0)	3 (6.0)	0 (0.0)	0 (0.0)	13.54
<i>B. tenella</i>	0 (0.0)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.24
<i>Caloglossa lepreurii</i>	4 (6.7)	2 (3.3)	0 (0.0)	5 (10.0)	1 (10.0)	0 (0.0)	0 (0.0)	2.85
<i>Gelidium</i> sp. 2	2 (3.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.48
<i>Murrayella pericladus</i>	17 (28.3)	22 (36.1)	0 (0.0)	3 (6.0)	1 (2.0)	0 (0.0)	0 (0.0)	10.21
<i>Polysiphonia subtilissima</i>	20 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4.75
Cyanophyceae								
<i>Calothrix scopulorum</i>	2 (3.3)	7 (11.5)	6 (6.0)	5 (10.0)	0 (0.0)	1 (2.0)	0 (0.0)	4.99
<i>Chroococcus turgidus</i>	5 (8.3)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.43
<i>Microcoleus chthonoplastes</i>	4 (6.7)	6 (9.8)	20 (20.0)	32 (64.0)	11 (22.0)	6 (12.0)	0 (0.0)	18.76
<i>Oscillatoria limosa</i>	45 (75.0)	3 (4.9)	1 (1.0)	1 (2.0)	2 (4.0)	3 (6.0)	0 (0.0)	13.06
<i>Phormidium ambiguum</i>	9 (15.0)	2 (3.3)	16 (16.0)	19 (38.0)	19 (38.0)	14 (28.0)	0 (0.0)	18.76
<i>Rivularia bullata</i>	10 (16.7)	0 (0.0)	10 (10.0)	6 (12.0)	0 (0.0)	0 (0.0)	0 (0.0)	6.18
Chlorophyceae								
<i>Cladophora</i> sp. 1	4 (6.7)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.19
<i>Cladophora</i> sp. 2	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	9 (18.0)	2.14
<i>Enteromorpha flexuosa</i>	4 (6.7)	2 (3.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.43
<i>Rhizoclonium</i> cf. <i>riparium</i>	22 (36.7)	13 (21.3)	31 (31.0)	34 (68.0)	29 (58.0)	40 (80.0)	3 (6.0)	40.86
Bare Pneumatophores	0	26	49	0	10	5	40	30.88

* imm. = immersed, em. = emersed

(Steinke and Naidoo 1990) was found to occur in emergent sites and seemed better able to withstand drying conditions than *B. moritziana* (Mann and Steinke 1988).

While clearly there are affinities in the algae of this estuary, with those of more tropical areas to the north, there is a need for additional collections from these localities to provide more reliable information on these relationships. For this reason the recent contribution of Silva (1991) is important, and it is to be hoped that in the future there will be more studies embracing other algal groups.

The fact that some algal species were not collected regularly suggests that these species were relatively infrequent, were seasonal, or that there were sampling inadequacies. Because most of the more common species were collected at all sampling periods, it is perhaps more likely that the occasional records did reflect a relatively infrequent occurrence. This was also the experience of Coppejans and Gallin (1989) who considered a large number of algae to be rare.

Of the Rhodophyceae, most were restricted to the areas of higher salinity near the mouth. However, *Caloglossa lepreurii* and *Polysiphonia subtilissima* did also extend into the lower salinity areas of the System, although both species were more abundant in the higher salinities. An unidentified taxon was found only in zero salinity in Ukhalwe (Tables 2, 3, 4). The results have revealed a high number of Cyanophyceae in this System. The abundance of these algae relative to other algal groups is greater in the sites where pneumatophores are emersed for long periods. Most of these sites are in the tidal basin where, as mentioned earlier, the period of emersion is longer than in most estuaries.

In the Wankute area, while still tidal, at least during springs, there is a high proportion of pneumatophores above mean water level. It would appear that the high proportion of Cyanophyceae is a response to the relatively dry conditions which prevail in this estuary as a result of the long periods of emersion. The ability of blue-green algae to withstand environmental stresses has been recognised (Sage and Sullivan 1978, Thursby and Davis 1984). The most common and widely-distributed blue-green algal species, particularly in the drier habitats, were *Phormidium ambiguum*, *Rivularia bullata*, *Microcoleus chthonoplastes* and *Scytonema hofmannii*. All these species are characterised by a sheath which encloses the algal cells (Lambert *et al.* 1989). Dor (1975), working in the Sinai mangrove swamps, suggested that the sheaths of blue-green algae formed a capillary system which possibly aided in the retention of water for prolonged periods. In addition, Stewart (1977) found that some species, e.g. *M. chthonoplastes*, have a gel-like protoplasm and are found inside protective mucilaginous matrices which absorb water easily during wet periods and aid in water retention during emersion. The work of Phillips *et al.* (1994, 1996) has relevance here. These workers confirmed that, in the Mgeni Estuary, horizontal and vertical zonation of algae epiphytic on pneumatophores of *A. marina* was governed largely by tidal phenomena such as tidal inundation and wetting frequency, desiccation and salinity.

Salinity was found to have a marked influence on algal distribution in this study as well (Figures 2A, 2B and Tables 3, 4). The ordination of the sites and the species on the first two axes of the DCA analysis (Figures 2A, 2B) showed a marked distribution on the basis of salinity. The sites were

Table 5: Two-way table of algal communities and their diagnostic species in the Kosi System, as identified on *A. marina* pneumatophores. Only presence of species is indicated

Sites	Community 1		Community 2		Community 3		Community 4	Salinity Regimes
	A	B	D	E	F	G		
Diagnostic species of Community 1								Stenohaline >25‰
5. <i>Gelidium</i> sp. 1	+							
8. <i>Plocamium</i> sp.	+							
10. cf. <i>Lophosiphonia</i> sp.	+							
16. <i>Chroococcus hansgirgii</i>	+			+				
36. <i>Giffordia</i> cf. <i>duchassiagniana</i>	+							
Diagnostic species of Community 2								
2. <i>Bostrychia tenella</i>		+						
14. <i>Calothrix contarenii</i>			+					
34. <i>Rhizoclonium</i> cf. <i>implexum</i>		+	+					
Species common to Communities 1 & 2								
1. <i>Bostrychia moritziana</i>	+	+	+					
4. <i>Ceramium</i> sp.	+	+						
6. <i>Gelidium</i> sp. 2	+	+						
7. <i>Murrayella pericladus</i>	+	+	+					
18. <i>Dermocarpa olivacea</i>	+	+						
19. <i>Hydrococcus rivularis</i>	+	+	+					
21. <i>Oscillatoria chlorina</i>	+	+	+					
26. <i>Spirulina subsalsa</i>	+	+						
28. <i>Xenococcus kernerii</i>	+	+	+					
Diagnostic species of Community 3								Euryhaline 5–18‰
33. <i>Monostroma</i> sp.				+				
30. <i>Cladophora</i> sp. 2					+			
Species common to Communities 1, 2 & 3								Entire range, excl.0‰
12. <i>Aphanocapsa elachista</i>	+	+	+	+				
13. <i>Aphanocapsa montana</i>	+	+	+	+				
15. <i>Calothrix scopulorum</i>	+	+	+	+	+			
17. <i>Chroococcus turgidus</i>	+	+	+	+	+			
25. <i>Scytonema hofmannii</i>	+	+	+	+	+			
27. <i>Xenococcus acervatus</i>	+	+	+	+	+			
35. <i>Rhizoclonium</i> cf. <i>riparium</i>	+	+	+	+	+			
29. <i>Cladophora</i> sp. 1	+	+	+		+			
32. <i>Enteromorpha flexuosa</i>	+	+						
Diagnostic species of Community 4								Oligohaline <5‰
11. Unident. freshwater red						+		
Species common to Communities 3 & 4								
31. <i>Enteromorpha clathrata</i>					+	+		
9. <i>Polysiphonia subtilissima</i>	+			+	+	+		
Species common to all Communities								Entire range, incl.0‰
20. <i>Microcoleus chthonoplastes</i>	+	+	+	+	+	+		
22. <i>Oscillatoria limosa</i>	+	+	+	+	+	+		
23. <i>Phormidium ambiguum</i>	+	+	+	+	+	+		
24. <i>Rivularia bullata</i>	+	+	+	+	+	+		
3. <i>Caloglossa leprieurii</i>	+	+	+	+	+	+		

classified into five algal communities (Figure 2 and Table 5) on the basis of the presence of species diagnostic of the various communities. However, there were often a number of species common to many of the communities and only a few diagnostic species for each community (Table 5). The number of species correlated significantly with salinity ($r = 0.98$, $P < 0.01$), with the number of species declining with salinity from the mouth to the upper lakes. This is also evident in Table 5 where there are fewer species common to communities of the less saline waters. The reason for the decreased species diversity of the lower salinities is probably related largely to the greater salinity variations which occur in the upper tidal reaches than at the mouth. At the

mouth the salinity is fairly constant, but with increased distance from the mouth the interplay between tidal action and the freshwater of the upper lakes can, from field measurements, introduce greater variations in salinity than that experienced at the mouth. Such variations have been shown to present many challenges to the physiological processes of estuarine inhabitants and enhance the rate of decrease of species (McLusky 1981).

Although this study has shown epiphytic algae to be widespread, we believe that they do not make a very important contribution to the Kosi System under present conditions. Even though sampling of aerial roots for biomass determination was not carried out, it was apparent that, even in

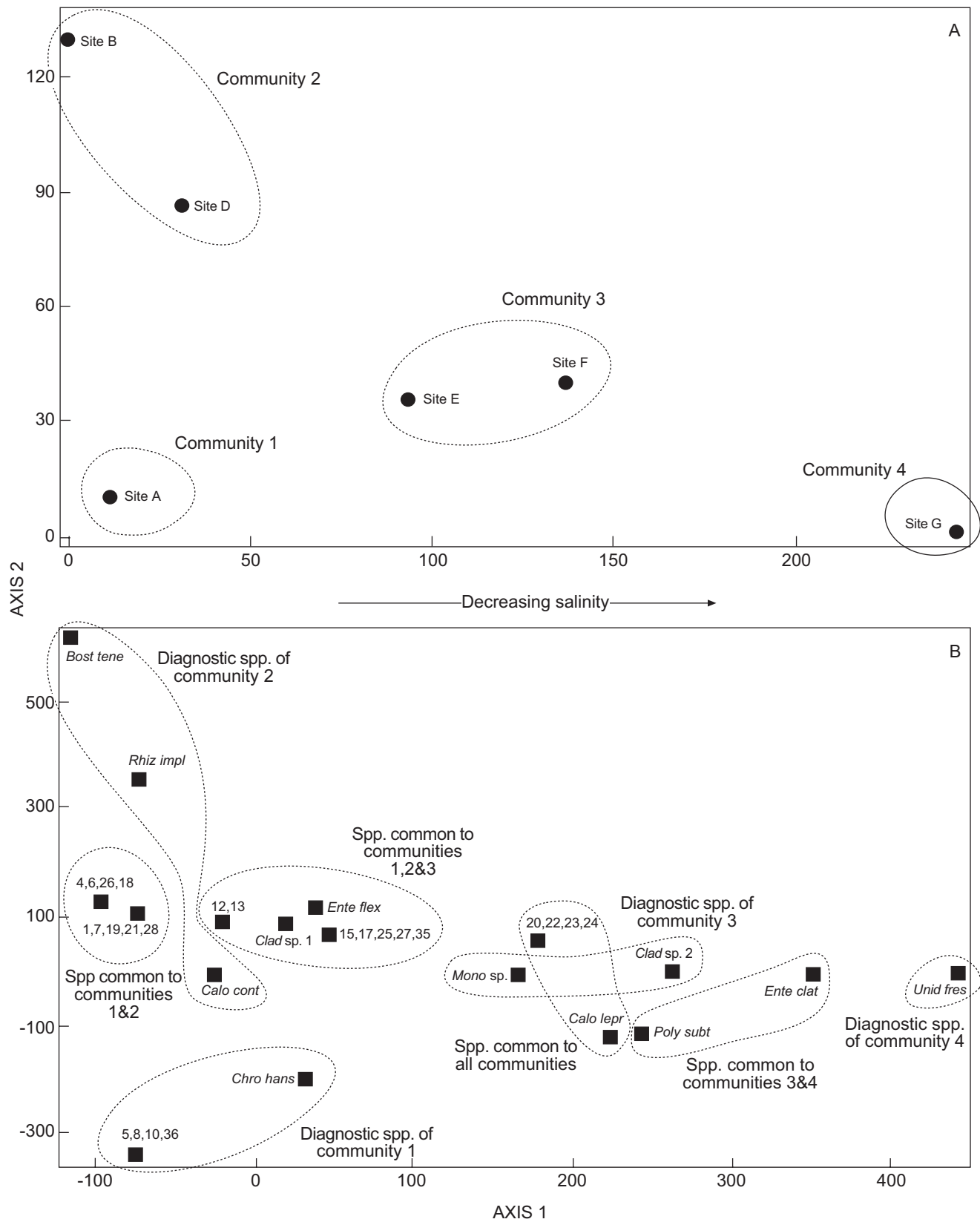


Figure 2(A): Detrended Correspondence Analysis (DCA) ordination of the four algal communities on the first two axes. See Figure 1 for location of the sites. **(B):** DCA ordination of the algal species distributed on the first two axes, to show the relationship between algal species and communities identified in Figure 2(A). See Table 5 for the identification of the species codes or numbers

areas where these pneumatophores were submerged for long periods, the biomass values were low by comparison with those in St Lucia (Steinke and Naidoo 1990). The low silt load and the sandy, relatively infertile sediments in the Kosi System are considered to be significant in limiting growth of the mangroves and also the epiphytic algae (Ward *et al.* 1986). Crabs have been shown to be important in the degradation of mangrove litter and in the recycling of nutrients (Robertson 1986, Steinke *et al.* 1993). The regular, systematic removal of these animals in large numbers by the local inhabitants must therefore curtail that aspect of the nutrient supply and aggravate the poor growing conditions in this System.

Conclusions

1. The 36 algal taxa recorded in this System included 11 rhodophytes, 17 cyanophytes/cyanobacteria, 7 chlorophytes and 1 phaeophyte.
2. There were some puzzling gaps in the check-list. Certain algae found to the north and south were not recorded in the Kosi System.
3. The rhodophytes were collected most commonly in areas of higher salinity near the mouth, although an unidentified species was also found in zero salinity in Ukhalwe.
4. The canophytes/cyanobacteria were the most numerous group of algae. The abundance of these relative to other algal groups was greater in sites where pneumatophores were emersed for long periods.
5. Salinity was found to have a marked influence on distribution. The number of algal species declined as the salinity decreased from the mouth to the upper reaches of the System.
6. While there are affinities in the algae of this System with estuaries to the south and with those of more tropical areas to the north, there is a need for additional information particularly from more northern localities.
7. Epiphytic algae do not appear to make a significant contribution towards the productivity of the System under present conditions.
8. Quantitative studies of the results support the findings of distinct algal communities with a decrease of diagnostic species in less saline waters, but these data could be supported by more intensive sampling more extensively throughout the Kosi System.

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