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Seasonal occurrence of marine ascomycetes and anamorphic marine fungi in mangroves of Godavari and Krishna deltas, East coast of India

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ABSTRACT

Seasonal occurrence of marine ascomycetes and anamorphic marine fungi in mangroves of Godavari and Krishna deltas, East coast of India was studied. The results showed more percentage occurrence of ascomycetes during dry period and more anamorphic fungi during wet period and converse was true in dry and wet periods for respective groups where the percentage occurrence was less than the usual. Among the various environmental factors studied such as maximum and minimum air temperatures, relative humidity, salinity, surface water temperature and average monthly rainfall only average monthly rainfall showed an effect on the species richness and abundance of ascomycetes and anamorphs. No or low rain fall favored higher percentage of ascomycetes and a good rainfall has favored an increase in the anamorphic fungi and a decrease in ascomycetes.

Key words: Seasonality, *Ascomycetes,* anamorphic marine fungi, *Rhizophora* spp., *Avicennia* spp.

INTRODUCTION

Mangroves are tropical and subtropical swampy forests comprising trees of many unrelated genera that share the common ability to grow in estuarine and coastal environments. Mangroves, commonly known as mangals, are plants that develop in estuaries, bogs and lagoons, the areas that are protected from wave action (Kohlmeyer and Kohlmeyer, 1979). In terms of energy and matter mangroves are considered as open systems having an "interface" between an upland terrestrial and coastal estuarine ecosystems (Lugo and Snedakar, 1974). India has a vast coastline of about 5,700 km divided into east and west coasts. Mangroves as one of the coastal wetland ecosystems offer an ideal environment for fish farming. Several species of flora and fauna, native to mangrove environment, depend on the stability of this environment (Untawale, 1987). The biomass produced in mangroves is enormous and various organisms including woodborers, fungi and bacteria recycle it. This recycling of nutrients helps in the sustenance and maintenance of this environment. However, in recent times vast areas of mangroves have been destroyed for commercial exploitation and other human disturbances (Jones and Alias, 1997; Ong, 1995). Although such concerns have been expressed at various fora and remedial measures such as revegetation of mangroves are under the process, they also need immediate attention in the form of knowledge on the detritus organisms. Among other organisms involved in nutrient recycling, fungi rather than bacteria play an important role in maintaining the ratio of carbon and nitrogen (Fell and Master, 1980).

Terrestrial fungi and lichens occupy the aerial parts of mangrove plants while marine fungi occur at lower parts where their trunks and roots are permanently or intermittently submerged in water (Kohlmeyer and Kohlmeyer, 1979). At the high tide mark there will be an interface and overlapping of marine and terrestrial fungi. Hence mangrove trees are considered to be fascinating study objects for the mycological investigations (Kohlmeyer and Kohlmeyer, 1979).

Though survey type studies and a few ecological investigations have been carried out from east (Chinnaraj, 1993; Raghukumar, 1973; Ravikumar and Vittal, 1996; Sarma and Hyde, 2001; Sarma and Vittal, 1999, 2000, 2001, 2002, 2004; Sarma *et al*., 2001) and west (Borse, 1988; Ananda and Sridhar, 2004; Maria and Sridhar, 2003) coasts, however, observations on seasonal distribution of major taxonomic groups, viz. ascomycetes and anamorphic fungi, are lacking.

In the present study substrata belonging to mangrove plant genera *Rhizophora* and *Avicennia* spp. were collected at bimonthly intervals from Godavari and Krishna deltas, Andhra Pradesh state, East Coast of India during January 1994 to November 1995. They were examined microscopically for identification of marine ascomycetes and marine anamorphic fungi after incubating for one week or up to 2 months for fungal fruition or immediately after they were brought from the field. The data depicting the seasonal occurrence of the two major fungal groups was recorded. The ascomycetous and anamorphic fungi recorded are presented in different tables and graphs and the results have been compared and discussed in the present paper.

MATERIALS AND METHODS

Sample examination: The samples after bringing back to the laboratory were examined either directly or after incubation in plastic bags containing a piece of moistened sterile tissue for one week or up to two months. The fungi were examined directly under a binocular microscope, identified based on the keys (Kohlmeyer and Volkmann-Kohlmeyer, 1991). The general microbiological techniques followed were according to Booth (1971); Kohlmeyer and Kohlmeyer (1979); Jones and Hyde (1988).

Microscopy: Direct examination method was followed wherein the dead and decomposing samples were examined directly under a stereo microscope and ascomata, basidiomata, conidiomata were cut and their spores/conidia were picked up with a sharp needle for those fruit bodies which are superficial, whereas the host surface had to be cut with the help of a razor for the immersed ascomata or

conidiomata to expose the fruit bodies and pick the spores. They were then transferred to a microslide (in the case of hyphomycetes the conidia were directly picked up with a needle and transferred onto a microslide), mounted on an appropriate medium, a cover slip was placed on top of the sample material, exposed to flames of a spirit lamp for a few seconds to remove the air bubbles and excess moisture and finally sealed with the DPX mountant.

Sampling Area: The mangrove plants along Godavari delta mangroves at **Coringa**, near Kakinada and **Balusutippa** near Yanam of East Godavari district, Andhra Pradesh, East coast of India (falling within latitudinal range of 16° 31',16° 45'N and longitude 82° 14', 82° 20'E) and along Krishna delta at Nakshatranagar, near **Kothapalem**, Repalle, Guntur district, Andhra Pradesh, East coast of India (falling within latitudinal range of 15° 50', 15° 55' N and longitude 80° 45', 80° 50' E), were examined for manglicolous fungi during January 1994 to November 1995 at bimonthly intervals. The Godavari and Krishna deltaic mangroves owing to their geographical proximity show similarity in certain climatic factors. The region enjoys tropical humid climate with a mean annual temperature of 27.7°C and with a dry season extending from 5 to 6 months from December and May. The air temperature fluctuates throughout the year with a mean minimum of 18.9-26.9°C at night and a mean maximum of 28.8-38.7°C during the day. The Indian coast is influenced by two monsoon cycles, namely, south west and north east monsoons. Along the east coast major precipitation is experienced from September to December. The area receives monsoon rains during July-September and cyclonic rains in October-November. However, the rains may come unusually in other months also. Cyclones are frequent in the Bay of Bengal and often hit the east coast. Normally the number of rainy days varies from 53 to 64 days. The high waters correspond to south west monsoon when it rains in the Western Ghats where the Godavari and Krishna rivers take their origin. During the rainy period of at least 5 months the fresh water covers the halophytic formations. Consequently, the salinity of the water is low. On the other hand, the salinity increases considerably in the hot dry season from March-June because of excessive evaporation. The salinity varies from 35‰ between March-June to 5‰ between October and December. The magnitude of the freshwater input controls the salinity regime. The rainfall together with the freshwater discharge seems to affect the sequence of zones in the tidal region. The discharge of freshwater is more at Godavari delta than at Krishna delta. The mangrove forests of Godavari and Krishna rivers have similar climatic factors, vegetation and soil types (Sidhu, 1963, Subba Reddi, 1982, Lakshminarayana, 1986, Umamaheswara Rao, and Narasimha Rao, 1988). Metereological data recorded in the study sites during the bimonthly samplings from January 1994 to December 1995 has been presented in **Table 1**.

The number of different ascomycetous species or different anamorphic fungal species occurring in each bimonthly sampling is expressed as species richness. Percentages calculation was made based on the occurrence of number of ascomycetous species recorded divided by the total number of fungal species recorded in each bimonthly sampling x 100.

Table 1. Hydrographic data recorded at Godavari and Krishna deltas during the study period (Sarma and Vittal, 1998-99)

	Parameters	1994						1995					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
Godavari delta	Max. temp. (°C)	29.1	34.6	37.6	31.5	32.9	29.2	27	34.2	34.4	31.8	32.6	31.1
	Min. temp. (°C)	20.2	24.1	28.3	25.3	25.2	22.7	20.3	24.5	26.9	25.8	26.2	22.6
	Surface water temp. (°C)	25	31	33	30.5	31.5	25.5	26	31.5	32.5	30	29	26
	Average monthly RH (%)	74.5	79.4	72.9	85	80.1	75.7	78	73.4	82.6	84.5	82.9	74.2
	Salinity (‰)	14.2	20	33.1	9.6	4.4	3.5	5.8	25	28.2	6.2	5.3	5.1
	Average monthly rainfall (mm)*	-	8.4	1.1	191	47.6	286	49.5	-	291	203	136	14.2
Krishna delta	Max. temp. (°C)	29.5	32.9	37.9	34.2	34.3	28.6	27.9	32.4	34.3	33.2	33	31.5
	Min. temp. (°C)	17.5	21.5	28.2	25.5	24.6	20.9	18.1	21.3	25	25.2	24.7	21.7
	Surface water temp. (°C)	26	31.5	33	30.5	31	26	26	31.5	33	31	29	26
	Average monthly RH (%)	94.3	84.5	67.6	73.9	73.5	88.7	87.2	83	95	82.4	81	85.7
	Salinity (‰)	22	24.5	37.1	11.5	8.0	3.9	7.8	27.2	32	19	8.1	7
	Average monthly rainfall (mm)*	0.5	-	0.6	51.3	78	430	138	0.2	192	121	90	11.3

* The data is provided only for the sampling months and not the months in between

Similarly, the number of anamorphic fungal species recorded in each bimonthly sampling was divided by total number of fungal species recorded x 100. In the case of abundance, the total number of ascomycetes recorded in each bimonthly sampling was divided by the total fungal occurrences in each bimonthly sampling and then multiplied by 100. Similarly, for calculating the abundance of anamorphic fungi the total number of anamorphic fungal occurrences was divided by total fungal occurrences x 100.

RESULTS

The seasonal occurrence of ascomycetes and anamorphic fungi recorded in each bimonthly sampling was recorded and a comparison is made in terms of species richness and abundance. Accordingly, the results are explained, separately, for (i) number of species of ascomycetes or anamophic fungi recorded expressed as species richness and (ii) number of fungal occurrences of ascomycetes and anamorphic fungi expressed as abundance, on each host and at each site. Literature on the occurrence of marine fungi in mangroves shows that around 80% belong to ascomycetes and around 20% belong to anamorphic fungi. In the present study the ascomycetes mostly ranged between 60% to 100% and anamorphic fungi between 0 to 40%. Hence in this paper if a mention is made on the increase or decrease in the percentage of ascomycetes or anamorphic fungi then it reflects on the differences in the range mentioned above.

1. Number of species (species richness) of ascomycetes *vs.* anamorphic fungi during different months of samplings

1.a. Godavari delta : During the dry months of January, March, May 1994 anamorphic fungi contributed 22, 18 and 10% of the total fungi on *Rhizophora apiculata*, at Godavari delta (**Table 2**). They contributed 35, 35 and 28% during the wet South west and North east monsoon months of July, September and November 1994 that bring rains. The ascomycetous species percentage varied from 58.8 to 66.7% during these months. In January and May 1995 there were unusual rains recorded however, rains were less in comparison during November 1995, which is also unusual. The following months of sampling in 1995 namely January, March, May, July and September were recorded with 30% or more of anamorphic fungi (**Table 2**), whereas ascomycetous fungi were around 65%. However, November 95 was unusual because usual cyclonic rains did not occur instead very low rainfall was recorded. The percentage of anamorphic fungi became below 20% and that of ascomycetes was around 80%.

Table 2. Number of anamorphic fungi and ascomycetes against total number of species recorded during the study period at Godavari delta (Species richness)

Host	Group	1994						1995					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
RA	*Total no. of species in each sampling	11	10	9	17	12	24	24	27	21	25	20	28
	Species of anamorphic fungi	2	1	2	6	3	7	8	9	7	10	7	5
	%	18	10	22.2	35.3	25	29.2	33.3	33.3	33.3	40	35	17.9
	Species of ascomycetes	9	8	7	10	8	16	15	17	13	15	12	22
	%	81.8	80	77.8	58.8	66.7	66.7	62.5	63	61.9	60	60	78.6
AV	*Total no. of species in each sampling	17	11	6	16	11	30	22	16	9	16	16	28
	Species of anamorphic fungi	4	3	2	4	1	8	6	3	2	4	5	6
	%	23.5	27.3	33.3	25	9.1	26.7	27.3	18.8	22.2	25	31.3	21.4
	Species of ascomycetes	12	7	4	11	9	21	15	12	7	11	10	21
	%	70.6	63.6	66.7	68.8	81.8	70	68.2	75	77.8	68.8	62.5	75

* RA = *Rhizophora apiculata; AV = Avicennia* spp. Lone basidiomycete *Halocyphina villosa* was also recorded in this study but it has not been shown

On this host, at Godavari delta, it seems that, the rains promote more number of anamorphic fungi, while lesser number of ascomycetous fungi was recorded indicating that dryness might promote more number of ascomycetes. It also partially complements that the low salinity promoted anamorphic fungi and more saline conditions promoted ascomycetes.

No definite trend was discernible in the case of *Avicennia* spp., at Godavari delta with any of the environmental parameters. None of the climatic factors seem to have a consistent effect on the seasonal occurrence of ascomycetes and anamorphic fungi on this host at Godavari delta during the study period (**Table 2**).

1b. Krishna delta: At Krishna delta, on *Rhizophora apiculata,* the percentage of anamorphic fungal species was more or less the same throughout the sampling period except during May 1994 (**Table 3**). In the case of ascomycetes, they were around 65% throughout except during May 1994 where all recorded fungi were ascomycetes. On *Avicennia* spp., at Krishna delta, the anamorphic fungi were not recorded during dry periods of 1994 (January, March, May) and less number of anamorphic fungi were recorded during wet months i.e. July, September and November 1994. However, during May, July, September 1995, a higher percentage of 38.5%, 27.3%, 26.7%, respectively of anamorphic fungi were recorded. In November 1995 where rainfall was minimal, less anamorphic fungi were recorded. On this host, at this site, there is an indication that during dry months' ascomycetes completely dominated but when rainfall was available bringing in freshwater and moisture more anamorphic fungi were recorded i.e. more than 25% (**Table 3**).

Table 3. Number of anamorphic fungi and ascomycetes against total number of species recorded during the study period at Krishna delta (Species richness)*

Host	Group	1994						1995					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
RA	*Total no. of species in each sampling	10	11	11	13	16	17	30	25	20	29	27	28
	Species of anamorphic fungi	3	3	-	2	4	6	10	8	5	10	8	9
	%	30	27.3	-	15.4	25	35.3	33.3	32	25	34.5	29.6	32.1
	Species of ascomycetes	7	8	11	11	11	11	19	16	14	18	18	18
	%	70	72.7	100	84.6	68.8	64.7	63.3	64	70	62.1	66.7	64.3
AV.	Total no. of species	3	4	7	9	9	11	13	10	13	22	19	9
	Species of anamorphic fungi	-	-	-	1	1	1	1	-	5	6	5	1
	%	-	-	-	11.1	11.1	9.1	7.7	-	38.5	27.3	26.3	11.1
	Species of ascomycetes	3	4	7	7	7	9	9	9	8	15	13	8
	%	100	100	100	77.8	77.8	81.8	69.2	90	61.5	68.2	68.4	88.9

* RA = *Rhizophora apiculata; AV = Avicennia* spp. *Lone basidiomycete *Halocyphina villosa* is not shown

2. Comparison on number of fungal occurrences (abundance) belonging to ascomycetes and anamorphic fungi

2a. Godavari delta: During dry months, ascomycetes were more abundant than their usual percentage when compared to anamorphic fungal occurrences on *R. apiculata* at Godavari delta in the year 1994 (**Table 4**). However, during wet season, the anamorphic fungi occupied around 40% during July, 1994 and 1995 but also during March and May, 1995 of which in May 1995, unusually, maximum rainfall and moderate temperatures prevailed. In general, an increase in the percentage of abundance of anamorphic fungi was observed when a higher monthly rainfall occurred. The other parameters such as maximum and minimum air temperatures, salinity, relative humidity, average monthly rainfall did not show a regular pattern for a correlation with an increase or decrease in the percentage abundance of ascomycetes and anamorphic fungi.

In the case of *Avicennia* spp., irrespective of the rainfall, salinity or temperature the abundance of ascomycetes was above 80% throughout the sampling period, while the number of fungal occurrences of anamorphic fungi has been low throughout (**Table 4**). This is in contrast to data on number of species recorded which was above 20% in the case of anamorphic fungi, but when it came to the total fungal occurrences, the anamorphic fungi seem to be below 20% when compared to ascomycetes. No definite pattern could be observed on this host at this site for any of the parameters studied to have a consistent effect on the percentage abundance variation in ascomycetes or anamorphic fungi.

2b. Krishna delta: At Krishna delta, on *Rhizophora apiculata,* percentage of fungal occurrences of anamorphic fungi (abundance) was less during dry period but more during wet months during September and November 1994 and January 1995 months of sampling. Even though rains were

Table 4. Number of occurrences (abundance) of anamorphic fungi and ascomycetes as against total number of samples supporting sporulating fungi recorded in each sampling during the study period at Godavari delta*

Host	Group	1994						1995					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
RA	*total samples supporting sporulating fungi	40	69	41	121	59	176	250	192	177	153	214	214
	Samples supporting anamorphic fungi	3	2	3	54	11	42	55	72	68	66	55	52
	% contribution	7.5	2.9	7.3	44.6	18.6	23.9	22	37.5	38.4	43.1	25.7	24.3
	Samples supporting ascomycetes	37	63	38	63	47	131	192	116	84	87	141	160
	% contribution	92.5	91.3	92.7	52.1	79.7	74.4	76.8	60.4	47.5	56.9	65.9	74.8
AV	*total samples supporting sporulating fungi	49	36	56	134	77	178	161	100	66	117	145	175
	Samples supporting anamorphic fungi	7	4	6	13	1	21	9	3	6	11	18	18
	% contribution	14.3	11.1	10.7	9.7	1.3	11.8	5.6	3	9.1	9.4	12.4	10.3
	Samples supporting Ascomycetes	40	31	50	117	75	157	144	96	60	104	118	155
	% contribution	81.6	86.1	89.3	87.3	97	88.2	89.4	96	90.9	88.9	81.4	88.6

* RA = *Rhizophora apiculata;* AV = *Avicennia* spp. * the % occurrence of *Halocyphina villosa,* a basidiomycete, is not shown

abundant in May and July 1995 their percentage occurrence was low. Naturally their space was occupied by ascomycetes as per the per cent calculations (**Table 5**). On *Avicennia* spp. at Krishna delta, however, the abundance of ascomycetes was more during dry period and less during rains (**Table 5**).

Table 5. Number of occurrences (abundance) of anamorphic fungi and ascomycetes as against total number of samples supporting sporulating fungi recorded in each sampling during the study period at Krishna delta*

Host	Group	1994						1995					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
RA	*Samples supporting sporulating fungi	29	37	40	59	63	88	212	153	73	253	160	116
	Samples supporting anamorphic fungi	8	3	-	2	16	35	64	41	8	39	38	34
	Percentage contribution	27.6	8.1	-	3.4	25.4	39.8	30.2	26.8	10.9	15.4	23.7	29.3
	Samples supporting ascomycetes	21	34	40	57	46	53	145	108	64	213	115	72
	Percentage contribution	72.4	91.9	100	96.6	73	60.2	68.4	70.6	87.7	84.2	71.9	62.1
AV	*Samples supporting sporulating fungi	5	16	23	32	24	60	109	52	40	176	137	36
	Samples supporting anamorphic fungi	-	-	-	1	1	1	6	-	7	27	21	1
	Percentage contribution	-	-	-	3.1	4.2	1.7	5.5	-	17.5	15.3	15.3	2.8
	Samples supporting Ascomycetes	5	16	23	29	22	47	100	41	33	124	106	35
	Percentage contribution	100	100	100	90.6	91.7	78.3	91.7	78.8	82.5	70	77.4	97.2

* RA = *Rhizophora apiculata;* AV = *Avicennia* spp. * the % occurrence of *Halocyphina villosa,* a basidiomycete, is not shown

DISCUSSION

Fungi are known to grow rapidly in the vegetative form by expanding their hyphal network and form extensive mycelial formation under favorable conditions. In general, they turn into reproductive phase under unfavorable conditions (Alexopoulos *et al.,*1996; Webster and Weber, 2007). The reproductive phase could be a sexual state that produces ascospores within asci and enclosed in a fruit body known as ascomata or basidiospores outside a basidium enclosed in a fruit body known as basidiomata or asexual state wherein different types of conidia are formed which are diploid in nature. Variation requires sexual union whereas a simple multiplication is possible with conidial formation. The asexual states also often have genetic variation through a process known as parasexual life cycle (Alexopoulos *et al.,* 1996; Webster and Weber, 2007). Hence it is of interest to investigate how the changing environmental factors in a year affect the life cycles of marine fungi on natural substrata.

The seasonal occurrence of marine fungi from Godavari and Krishna deltas was discussed in Sarma and Vittal (1998-99). However, the seasonal occurrence of sexual (ascomycetes) and asexual (anamorphic) states of marine fungi separately was not discussed earlier and hence is presented in this paper. There is only one publication that is available on the seasonal occurrence of ascomycetes and anamorphic fungi as major groups (Shearer, 1972). But, even this study also, it was not from mangroves but drift wood from open sea coast (Shearer, 1972). Such a meager data has been a drawback for comparisons with other studies. Hence most of the discussion revolves around the present study and conclusions are based on the results obtained in the present study.

The changes in the percentages of species richness or abundance fell in the range of 60% to 100% in the case of ascomycetes and 0-40% in the case of anamorphic fungi. The seasonal effects examined in the present study though show differences in the percentages the overall dominance of ascomycetes in the marine environment (60-100%) did not change. Hence any increase or decrease discussed in the present paper is with reference to difference within the ranges of the two respective groups mentioned above.

In the present study the percentage of number of different fungal species (also referred to as species richness) (**tables 2** & **3**) and number of fungal occurrences (abundance) (**tables 4** & **5**) belonging to ascomycetes and anamorphic fungi was tabulated separately and results presented. The data was maintained separately in the expectation that an increase in species richness need not also show an increase in the abundance of ascomycetes or anamorphic fungi. However, on examination of the data it was found that there is not much of a difference in the trends available on the variations in the species richness or abundance (**Tables 2-5**).

No or less amount of rainfall seem to increase the percentage occurrence of ascomycetes both in terms of species richness (**Figs. 1** & **5**) and abundance (**Figs. 4** & **8**) during dry season i.e. bimonthly samplings of January, March and May and a decrease during wet season i.e. bimonthly samplings of July, September and November. Contrary was found to be true in the case of anamorphic fungi. This pattern has been observed in the case of *R. apiculata* at Godavari delta and *Avicennia* spp. at Krishna delta in the year 1994. In the year 1995, however, there were unusual rains in the otherwise considered dry season i.e. January and May months of sampling in 1995. Such unusual rains also reflected on the species richness and abundance where low percentage of ascomycetes was recorded in January and May 1995. In the year 1995 the November month was relatively dry and hence the percentage of species richness and abundance of ascomycetes had increased. The opposite was true in the case of anamorphic fungi on these sites at the respective sites. However, on *R. apiculata* at Krishna delta (**Figs. 3** & **7**) and on *Avicennia* spp. at Godavari delta (**Figs. 2** & **6**) such a strong correlation to average monthly rainfall could not be established although broadly it agrees with the general effect that rainfall has on these two major groups i.e. ascomycetes and anamorphic fungi (**Tables 2-5**; **Figs. 1-8**).

The rains seem to promote germination and better colonization of anamorphic fungi and hence a relative percentage increase in the species richness and abundance was found. Another argument that may be put forward is that the rains may bring more number of propagules of anamorphic fungi than ascomycetes and that could be one of the reasons why more number of anamorphic fungi were recorded during the rainy months of sampling. Whereas, dry periods associated with hot sunny days increase salinity and encourage colonization and fruiting of more percentage of ascomycetes. While rainfall seem to be a major factor in the small percentage changes observed in the present study the salinity seems to broadly complement such changes with a secondary role.

The effect of other environmental factors such as surface water temperature (**Figs. 9-16**) and salinity (**Figs. 17-24**) were plotted for the percentage differences in the distribution of ascomycetes and anamorphic fungi in terms of species richness (**Figs. 9-12; 17-20**) and abundance (**Figs. 13-16; 21-24**). No definite pattern could be discerned with these two parameters.

Fig.1. Effect of Average monthly rainfall on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Godavari delta

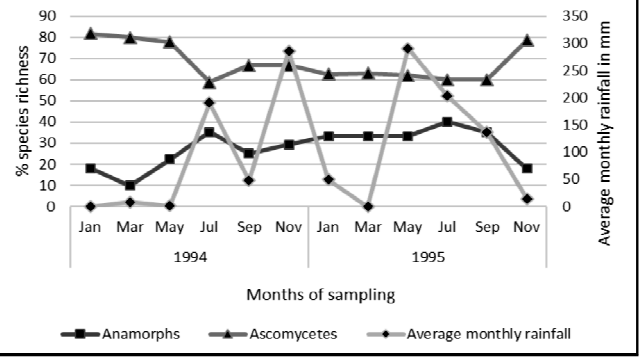


Fig.2. Effect of Average monthly rainfall on species richness of ascomycetes and anamorphic fungi on *Avicennia* spp. at Godavari delta

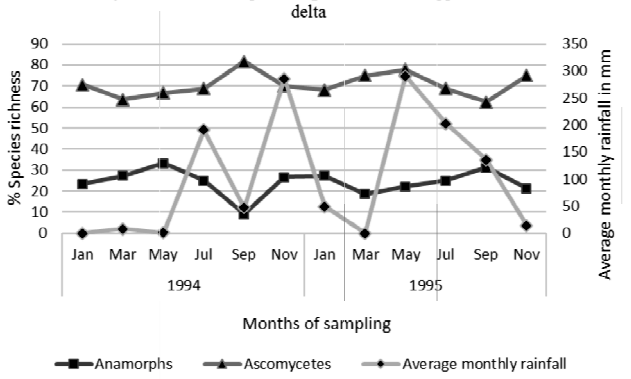


Fig.3. Effect of Annual monthly rainfall on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

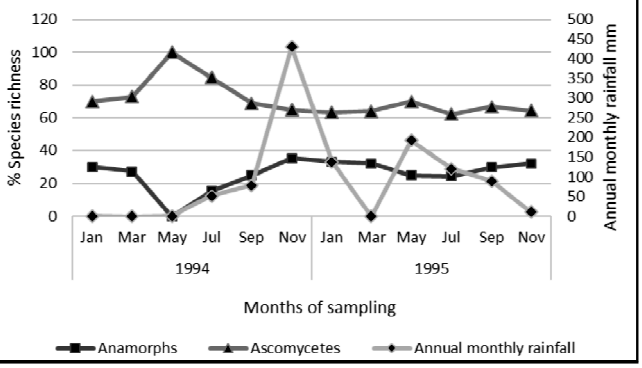


Fig.4. Effect of Average monthly rainfall on species richness of ascomycetes and anamorphic fungi on *Avicennia* spp. at Krishna delta

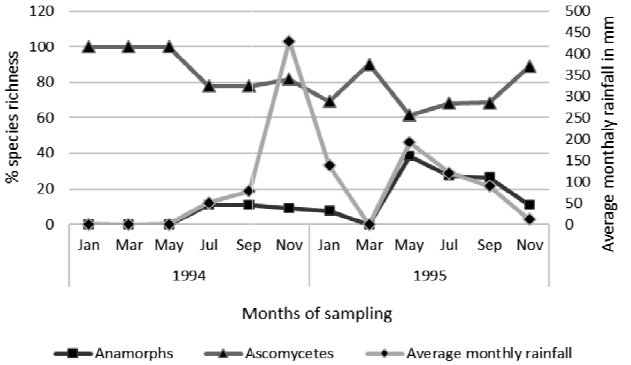


Fig.5. Effect of Average monthly rainfall on the abudance of anamorphs and ascomycetes on *R. apiculata* at Godavari Delta

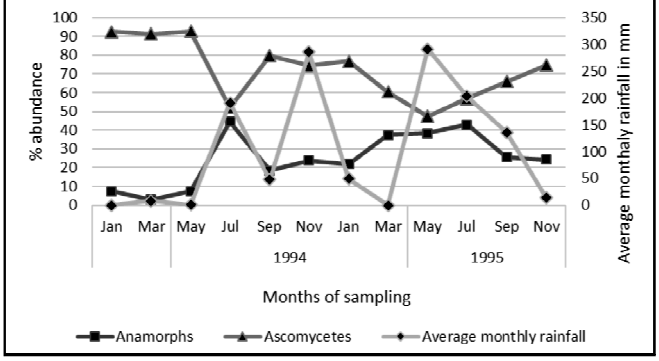


Fig.6. Effect of Average monthly rainfall on abundance of ascomycetes and anamorphic fungi on *Avicennia* spp. at Godavari delta

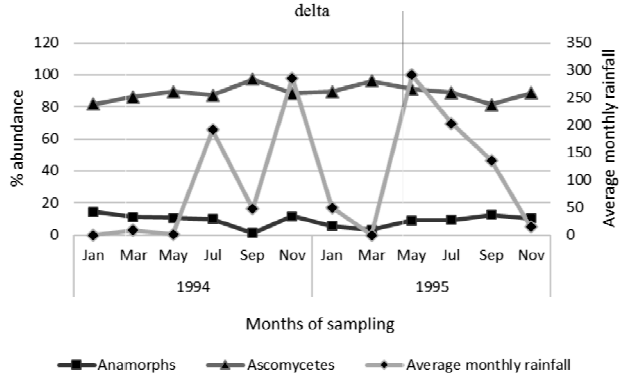


Fig.7. Effect of Average monthly rainfall on abundacne of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

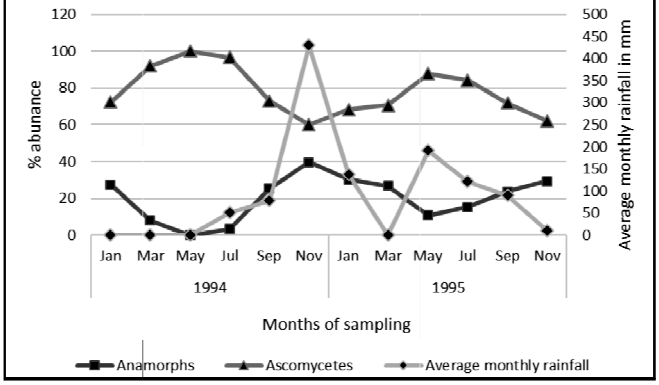


Fig.8. Effect of Average monthly rainfall on abundance of ascomycetes and anamorphic fungi on *Avicennia* spp. at Krishna delta

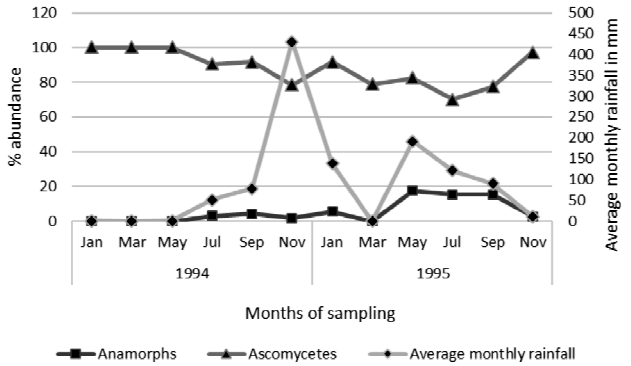


Fig.9. Effect of Surface water temperature on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Godavari delta

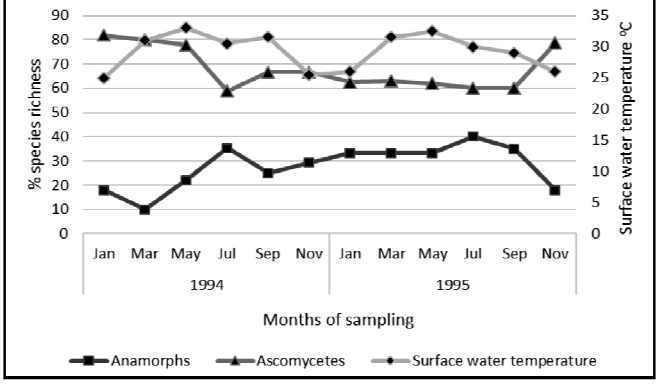


Fig.10. Effect of surface water temperature on species richness of ascomycetes and anamorphic fungi on *Avicennia* spp. at Godavari delta

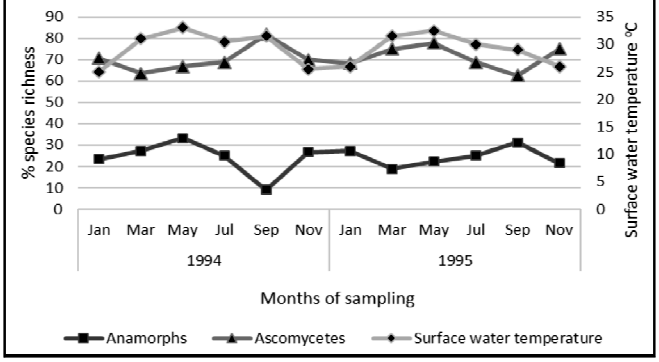


Fig.11. Effect of Surface water temperature on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

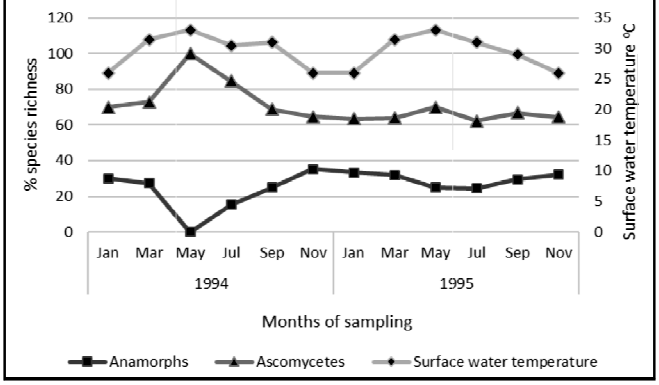


Fig.12. Effect of Surface water temperature on species richness of ascomycetes and anamorphic fungi on *Avicennia* spp. at Krishna delta

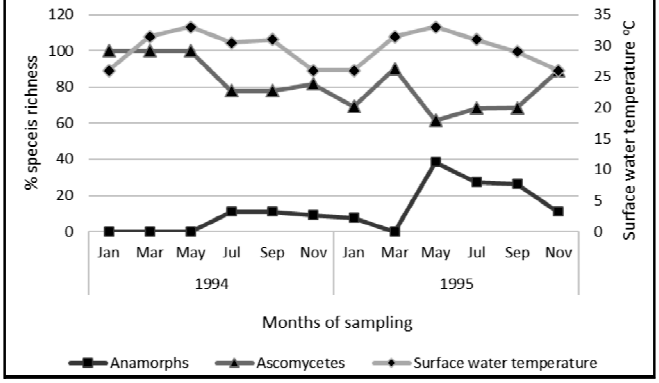


Fig.13. Effect of Surface water temperature on the abudance of anamorphs and ascomycetes on R. apiculata at Godavari Delta

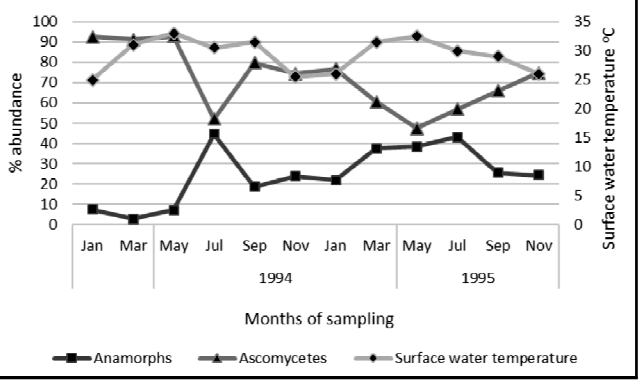


Fig.14. Effect of surface water temperature on abundance of ascomycetes and anamorphic fungi on *Avicennia* spp. at Godavari delta

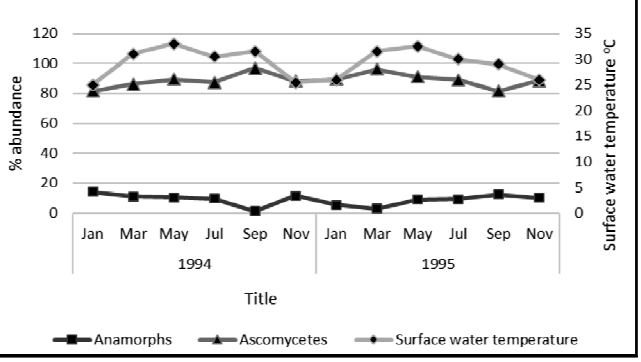


Fig.15. Effect of Surface water temperature on abundacne of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

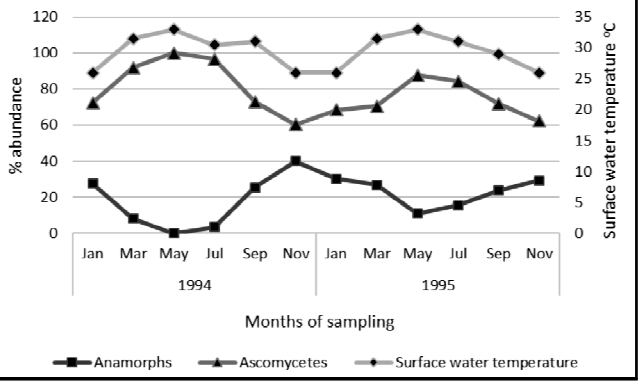


Fig.16. Effect of Surface water temperature on abundacne of ascomycetes and anamorphic fungi on *Avicennia* spp. at Krishna delta

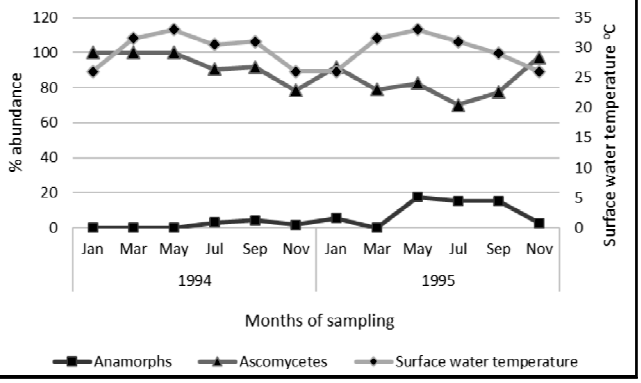


Fig.17. Effect of Salinity on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Godavari delta

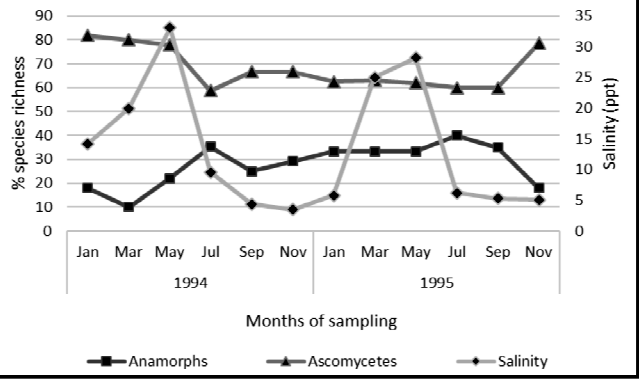


Fig.18. Effect of salinity on species richness of ascomycetes and anamorphic fungi on *Aicennia* spp. at Godavari delta

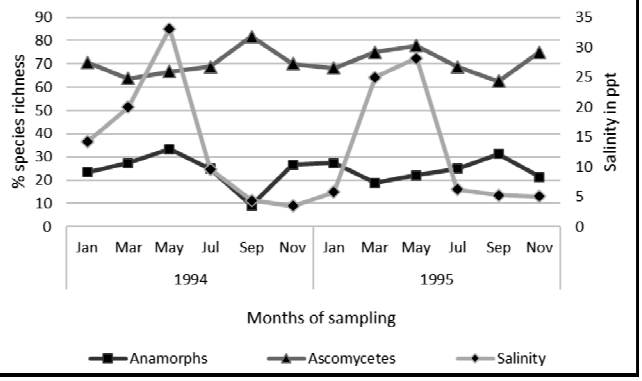


Fig.19. Effect of Salinity on species richness of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

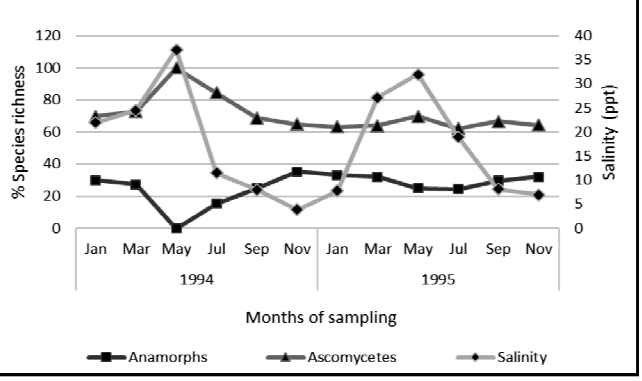


Fig.20. Effect of Salinity on species richness of ascomycetes and anamorphic fungi on Avicennia spp. at Krishna delta

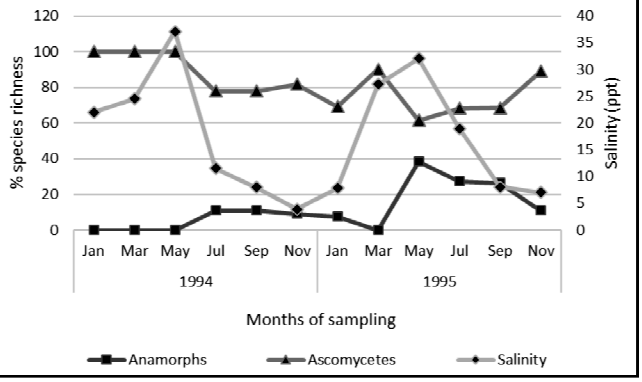


Fig.21. Effect of Salinity on the abudance of anamorphs and ascomycetes on *R. apiculata* at Godavari Delta

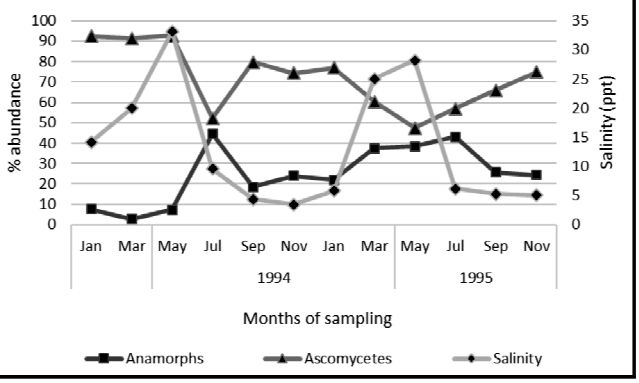


Fig.22. Effect of salinity on abundance of ascomycetes and anamorphic fungi on *Avicennia* spp. at Godavari delta

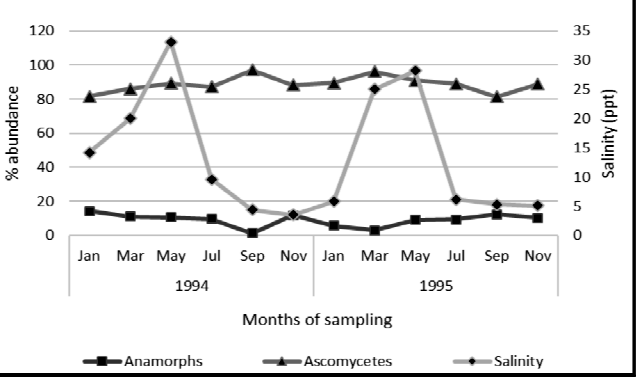


Fig.23. Effect of Salinity on abundacne of ascomycetes and anamorphic fungi on *R. apiculata* at Krishna delta

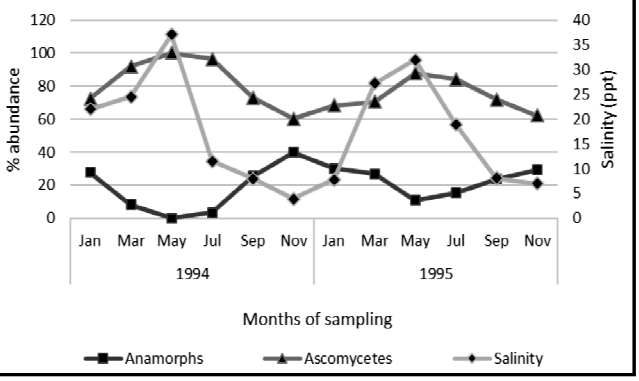
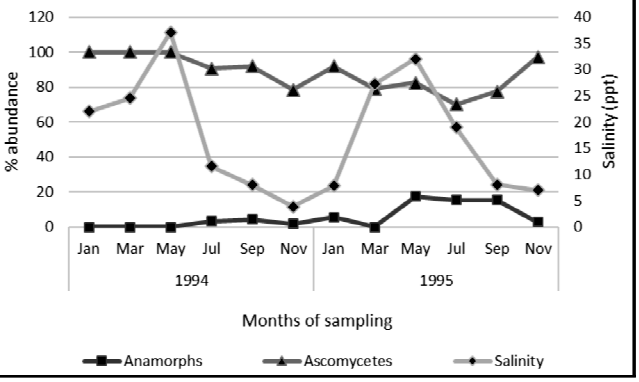


Fig.24. Effect of Salinity on abundance of ascomycetes and anamorphic fungi on *Avicennia* spp. at Krishna delta



Information on seasonal occurrence of mangrove fungi is meagre. Aleem (1980) observed that mangrove fungi display a seasonal periodicity with more numbers and growth intensity in wet season (May-November). During the wet season, not only the number of species increased but also their frequency and growth intensity. The following fungi: *Haligena viscidula, Leptosphaeria australiensis, L. avicenniae, Halorosellinia oceanica* and *Torpedospora radiate* were found to be more frequent on mangroves towards the end of rainy season (September October).

Another study available for comparison is that of Shearer (1972) from Chesapeake Bay, USA. The difference between these two studies is that while the Godavari and Krishna deltas are mangrove sites where salinity changes occur due to freshwater in surge, in the case of Chesapeake Bay it is a sandy beach and sea water is predominant and the samples observed were drift wood and hence the host samples are different. At Chesapeake Bay Shearer (1972) recorded less number of anamorphic fungi during wet season and more during the dry season. Converse was true in the case of ascomycetes. This is in contrast to the results obtained in the present study wherein it was observed that the dry season has affected the percentage differences by way of an increase in ascomycetes and decrease in anamorphic fungi and wet season favored an increase in percentage of anamorphic fungi than ascomycetes. This is a significant difference between the two studies

Most of the anamorphic fungi can remain in the asexual state perennially for several generations without resorting to the sexual stage. In fact, this fact has made a separate code for such fungi to have a different nomenclature for asexual states. However, in the recent times, with the advent of molecular techniques, the connection between sexual and asexual states is being established based on homologies of highly conserved gene sequences, for example, the nuclear ITS region of DNA which is considered as a universal bar code for fungi (Schoch *et al.,* 2012). Sequences of most of the marine fungi would have been deposited but gene banks may not have data on all sexual and asexual states of marine fungi. Hence no attempt has been made here as of now for such links between sexual and asexual states in this study. Moreover, even if such links are established it is still interesting to know during which season the fungus may choose to prop up as a sexual state or asexual state. Future studies should be directed towards this with molecular inputs.

CONCLUSION

To conclude it may be stated that in the present study excepting rainfall no other parameter seems to have a definitive effect on the distribution of ascomycetes and anamorphic fungi during different months of sampling. It may also be further stated that the seasonal effect on sexual and asexual state of fungal diversity requires long term studies involving multiple year examinations to get any definitive conclusions on the effect of different environmental parameters.

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