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# Manglicolous fungi from Chorao mangroves, Goa, West coast of India: Observations on fungal species consortia

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**ABSTRACT**

Manglicolous fungi constitute an ecologically distinct group of fungi that colonize fallen, lignocellulosic mangrove substrates. Studies on their species consortia have been few. This study relates to manglicolous fungal consortia of the Chorao mangroves, Goa, India. The most frequent fungi were *Aigialus grandis*, *Dactylospora haliotrepha, Marinosphaera mangrovei*, *Morosphaeria ramunculicola, Rhizophila marina, Verruculina enalia, Halocyphina villosa* and *Trichocladium achrasporum*. Three distinct fungal assemblages were seen. In one, typified by *Aigialus grandis*, the fungi occurred both in association with others, as well as singly, suggesting a comensalistic occurrence. In the second, characterized by *Trichocladium achrasporum* and *Verruculina enalia*, the fungus occurred almost only in association with others, suggesting a mutualistic behaviour, or as the anamorphic stage of an undetermined teleomorph. The fungus *Rimora mangrovei* always occurred singly, suggesting a possible antagonsitic life style. Further observations in other geographical areas and laboratory experiments will shed more light on the exact ecological behaviour of manglicolous fungi.

**Key words:** mangrove fungi, marine fungi, fungal diversity, species consortia

## INTRODUCTION

There has been tremendous interest in fungal community structures because such studies help in understanding ecosystem dynamics, such as mutualism, commensalism and antagonism (Cooke and Rayner, 1984). For example, a study based on 454 sequencing reads of the small subunit ribosomal RNA (SSU rRNA) gene of Glomeromycota helped to postulate that that partner specificity in Arbuscular Mycorrhizae symbiosis in forest tree species may occur at the level of ecological groups, rather than at the species level, of both plant and fungal partners (Öpik et al., 2009). A study on fungal consortia of spring sap flows of trees attempted to explain competition within and between sap-flow yeast species to be the result of nutritional effects or the action of killer toxins (mycocins) (Weber, 2006). Similar studies will help in explaining interaction between fungal species occurring on fallen, mangrove plant material, namely the manglicolous fungi, which are an exclusive ecological group. Numerous studies have been carried the world over on fungal composition of fallen, mangrove lignocellulosic materials (Sarma and Hyde, 2001). Most papers have been of a taxonomic nature while others (Sarma and Hyde, 2001; Sridhar and Maria, 2006) have studied fungal ecology and species communities. This study addresses fungal species consortia of manglicolous fungi from Chorao mangroves of Goa , the diversity of which has been described earlier (Sarma and Raghukumar, 2013).

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## MATERIALS AND METHODS

Samples of fallen, decomposing mangrove substrata (mostly prop roots and a few seedlings of *Rhizophoroa mucronata* were collected on 9.11.1998 and 5.2.1999 from Chorao, Goa, west coast of India (latitude 15º 30'N and longitude 73º 55E). The materials and methods followed are as described in Sarma and Raghukumar (2013). The samples were observed under a stereo-zoom microscope to locate fruit bodies or conidia were picked and transferred onto a micro-slide. The micro-slide preparations were observed under a binocular microscope for identification of the fungi. Standard manuals (Kohlmeyer & Kohlmeyer 1979, Kohlmeyer & Volkmann-Kohlmeyer 1991) and other publications on new genera and species of mangrove fungi were studied to identify the fungi. The samples (149) were examined directly after

they were brought back to the laboratory or after incubating in moist chambers for short durations i.e. up to 2 months. The sample size ranged between 3 cm to 30 cm but mostly fall between 15 cm to 25cm.

## RESULTS

A total of 37 species were recorded on *Rhizophora mucronata* samples. These included 25 ascomycetes, 2 basidiomycetes and 10 mitosporic fungi (Table 1). The fungus with highest percentage occurrence on *R. mucronata* in the present study was *Aigialus grandis* (19%) followed by *Morosphaeria ramunculicola* (7.9%), *Rimora mangrovei* (7.5%), *Trichocladium achrasporum* (7%), *Dactylospora haliotrepha* 6.5%), *Rhizophila marina* (6%) and *Halocyphina villosa* (5.5%). Ten fungi were recorded only once. Altogether 202 fungal occurrences were recorded from 149 samples. These percentage calculations followed by conversions into frequency groupings help us to verify whether a very frequent fungus had high frequency of association with other fungi or not (Table 1).

Out of 149 samples 135 samples supported sporulating fungi and the remaining were without any fruition (Table 2). Ninety five samples were recorded with only one fungal species on each sample, 21 samples harbored 2 species each, 13 samples had any 3 species; 4 samples had any 4 species and only 2 samples were recorded with up to 5 species on a particular sample (Tables 1 and 3). The sample size ranged between 3 cm to 30 cm but mostly fall between 15 cm to 25cm.

A few examples of fungal species consortia observed in this study were as follolws: (i) *Aigialus grandis* + *Phoma* sp., + *Morosphaeria velatospora* + *Dactylospora haliotrepha* + *Halocyphina villosa* = totally 5 species on the same sample; (ii) *A. grandis* + *Sagaromyces ratnagirieinsis* + *Saccardoella rhizophorae* + *Trichocladium achrasporum* ( 4 species), (iii) *Savoryella paucispora* + *Marinosphaeria mangrovei* + *Cirrenalia basiminua* (3 species).

Of the 37 species recorded in the present study 25 occurred along with one or more other fungi, while the remaining fungi occurred singly. Among the former *Aigialus grandis* occurred along with 18 other fungal species, followed by *T. achrasporum* (12), *Dactylospora haliotrepha* (10) and *Halocyphina villosa* (8). *Aigialus grandis* is the only fungus which has been found occurring in combination with a large number (18) of other fungal species (Table 1). Among these, more number of combinations *A. grandis* had was with *C. pygmea* (5 samples), *D. haliotrepha* (on 5 samples), *H. villosa* (on 4 samples), *C. basiminuta* (on 4 samples), *Verruculina enalia*, *Rhizophila marina* and *Trichocladium achrasporum* (on 3 samples each) and *Saagaromyces ratnagiriensis* (on 2 samples). It can be inferred from the above that *A. grandis* prefers to be associated with other fungal species than occurring alone. *Rimora mangrovei* occurred singly in all of the 13 samples in which it was found.

## DISCUSSION

Co-occurrence could indicate either a commensalistic or a mutualistic association. The former signifies a tolerance to other species, but not necessarily one where the species interacts in any ecological manner with others (Pouska et al., 2013; Sridhar and Maria, 2006; Strongman et al., 1987; Weber, 2006). Alternatively, a mutualistic association might indicate that such species depended on each other in a mutualistic or a parasitic association. Lignocellulose is a complex substrate, comprising lignin, cellulose and hemicelluloses, as well as rapidly leaching out labile organics (Kausar et al., 2010; Raghukumar et al., 1994; Reddy, 1995). Species which occur in consortia might rely on each other to act as a community in breaking down specific parts of the substrate which is then used according to the requirement of each individual species (Kausar et al., 2010; Pouska et al., 2013; Weber, 2006).

*A. grandis* was the most frequently isolated fungus. This species was often associated with other fungi but also occurred individualy with almost equal frequency. Similar was the case with *Morosphaeria ramuniculicola* and *Halocyphina villosa*. It is likely that such species are commensals, their association with other species not necessarily owing to their dependence on them (Kausar et al., 2010; Pouska et al., 2013; Shearer and Zare-Maivan, 1988; Weber, 2006). On the contrary, *Verruculina enalia* occurred only in association with other species. *Trichocladium achrasporum*, was found associated with other species in 12 out of 13 samples. Such species may be dependent upon other fungi for their colonization. One possible explanation is that their enzymatic arsenal is inadequate and they might rely on others to prepare the substrate before they can colonize ((Bucher et al., 2004; Strongman et al., 1987). Thus, several fungi may be involved in degrading a given substrate, complete degradation depending on the species consortium. Interestingly, *Rimora mangrovei* and *Trimmatostroma* sp were found singly on all samples in which they were found. It will be interesting to study such species for their competition and antagonistic properties that excludes other fungi from colonization. There are a few examples of studies on fungi having antagonistic properties (Fryar et al., 2001, 2005; Shearer, 1995; Shearer & Zare-Maivan, 1988; Yuen et al., 1999a,b).

Although preliminary conclusions as above can be drawn from this study, it is important to confirm these in future studies and the following limitations of this study have to be borne in mind. (1) Conclusions based on species consortia can be arrived at only with a large number of samples and verification from many geographical sites.

**Table 1 : Percentage occurrence and pattern of co-occurrence**

| No | Name of the species | No. of samples in which a fungus had co-occurrence | No.of samples in which a fungus had no co-occurrence | Total fungal occurrences | % occu-rence | Number of other fungal species with which a particular fungus had co-occurrence |
|---|---|---|---|---|---|---|
| 1 | *Aigialus grandis* Kohlm. & S. Schatz | 23 | 16 | 39 | 19.0 | 18 |
| 2 | *Aniptodera chesapeakensis* Shearer & M.A. Mill. | - | 1 | 1 | 0.5 | - |
| 3 | *Dactylospora haliotrepha* (Kohlm . & E. Kohlm.) Hafellner | 10 | 3 | 13 | 6.5 | 10 |
| 4 | *Halosarpheia minuta* W.F. Leong | 1 | - | 1 | 0.5 | 1 |
| 5 | *Halorosellinia oceanica* Whalley, E.B.G. Jones, K.D. Hyde & Laessøe | 2 | 2 | 4 | 2.5 | 2 |
| 6 | *Hypoxylon* sp. | 1 | - | 1 | 0.5 | - |
| 7 | *Hysterium sp.* 1 | 3 | - | 3 | 1.5 | 3 |
| 8 | *Hysterium* sp.2 | 1 | - | 1 | 0.5 | - |
| 9 | *Leptosphaeria australiensis* (Cribb & J.W. Cribb) G.C. Hughes | 2 | 1 | 3 | 1.5 | 3 |
| 10 | *Lulworthia sp.* | 1 | 2 | 3 | 2.0 | 1 |
| 11 | *Marinosphaera mangrovei* K.D. Hyde | 7 | - | 7 | 2.0 | 7 |
| 12 | Morosphaeria ramunculicola(K.D. Hyde) Suetrong, Sakayaroj, E.B.G. Jones & C.L. Schoch ≡ *Massarina ramunculicola* K.D. Hyde | 6 | 10 | 16 | 9.0 | 6 |
| 13 | M. velatospora (K.D. Hyde & Borse) Suetrong, Sakayaroj, E.B.G. Jones & C.L. Schoch ≡ M. velataspora *K.D. Hyde & Borse* | 4 | 1 | 5 | 2.5 | 7 |
| 14 | *Payosphaeria minuta* W.F. Leong | 1 | 1 | 2 | 1.0 | 3 |
| 15 | *Pedumispora rhizophorae K.D. Hyde & E.B.G. Jones* | 1 | - | 1 | 0.5 | - |
| 16 | *Phaeosphaeria oraemaris*(R.V. Gessner & Kohlm.) Shoemaker & C.E. Babc | 2 | - | 2 | 1.0 | 2 |
| 17 | *Rhizophila marina* K.D. Hyde & E.B.G. Jones | 7 | 5 | 12 | 6.0 | 6 |
| 18 | *Rimora mangrovei* (Kohlm. & Vittal) Kohlm.,Volkm-Kohlm., Suetrong, Sakayaroj & E.B.G. Jones ≡ *Lophiostoma mangrovei* Kohlm. & Vittal | - | 13 | 13 | 7.5 | 1 |
| 19 | *Saagaromyces ratnagiriensis* (Kohlm.) K.L. Pang & E.B.G. Jones | 4 | 1 | 5 | 2.5 | 5 |
| 20 | *Saccardoella marinospora* K.D. Hyde | - | 1 | 1 | 0.5 | - |
| 21 | *S. rhizophorae* K.D. Hyde | 2 | - | 2 | 1.0 | 3 |
| 22 | *Savoryella lignicola* E.B.G. Jones & R.A. Eaton | 2 | 0 | 2 | 1.0 | 3 |
| 23 | *S. paucispora* (Cribb & J.W. Cribb) Jorg. Koch | 1 | - | 1 | 0.5 | - |
| 24 | *Tirispora mandoviana* V.V. Sarma & K.D. Hyde | - | 1 | 1 | 0.5 | - |
| 25 | *Verruculina enalia* (Kohlm.) Kohlm. & Volkm.-Kohlm. | 6 | - | 6 | 3.0 | 5 |
| 26 | *Calathella mangrovei E.B.G. Jones & Agerer* | - | 2 | 2 | 1.0 | - |
| 27 | *Halocyphina villosa* Kohlm. | 6 | 5 | 11 | 5.5 | 8 |
| 28 | *Cirrenalia basiminuta* Raghuk. & Zainal | 5 | 1 | 6 | 3.0 | 6 |
| 29 | *Helenospora varia* (Anastasiou) E.B.G. Jones ≡ *Zalerion varium* Anastasiou | - | 1 | 1 | 0.5 | 2 |
| 30 | *Hydea pygmea* (Kohlm) K.L. Pang & E.B.G. Jones . ≡*Cirrenalia pygmea* Kohlm. | 5 | 3 | 8 | 4.0 | 5 |
| 31 | *Periconia prolifica* Anastasiou | 1 | - | 1 | 1.0 | 2 |
| 32 | *Phoma* sp. | 5 | 3 | 8 | 3.5 | 7 |
| 33 | *Phomopsis mangrovei* K.D. Hyde | - | 1 | 1 | 0.5 | - |
| 34 | *Phomopsis* sp. | - | 1 | 1 | 0.5 | - |
| 35 | *Stagonospora* sp. | - | 1 | 1 | 0.5 | - |
| 36 | *Trichocladium achrasporum* (Meyers & R.T. Moore) Dixon | 12 | 1 | 13 | 7.0 | 12 |
| 37 | *Trimmatostroma* sp. | - | 4 | 4 | 2.0 | - |
| | Total | 121 | 81 | 202 | | |

**Table 2 : Distribution of fungi on samples of *R. mucronata* at Chorao**

| Distribution | Samples examined |
|---|---|
| Samples without any fungal fruition | 14 |
| Samples with only one species | 95 |
| Samples with 2 species | 21 |
| Samples with 3 species | 13 |
| Samples with 4 species | 4 |
| Samples with 5 species | 2 |
| Total | 149 |

**Table 3: Comparison of percentage of co-occurrence or occurring singly**

| Name of species | % co-occurrence with other fungi | % occurrence singly |
|---|---|---|
| *Aigialus grandis* | 59 | 41 |
| *Morosphaeria ramunculicola* | 45 | 55 |
| *Rimora mangrovei* | - | 100 |
| *Trichocladium achrasporum* | 85 | 14 |
| *Dactylospora haliotrepha* | 76 | 23 |
| *Rhizophila marina* | 58 | 42 |
| *Halocyphina villosa* | 54 | 45 |
| *Hydea pygmea* | 63 | 37 |
| *Phoma* sp. | 71 | 28 |
| *Verruculina enalia* | 100 | - |
| *Cirrenalia basiminuta* | 83 | 16 |
| *Saagaromyces ratnagiriensis* | 80 | 20 |

(2) The present study is based on recording species based on occurrence of fruiting bodies by direct examination method and not the ones in vegeatative (mycelial) stage. There could have been more species colonizing the substrate than observed herein. (3) Only 'higher' or true fungi can be examined and not the stramenopilan or oomycetous fungi and thraustochytrids. (4) Samples in this study were incubated for a period of up to 2 months. However, a longer incubation could have yielded more species (Prasannarai and Sridhar, 2003). None the less, the present study points to various interesting ecological behaviours of manglicolous fungi, which need to be pursed.

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