

# Follicolous fungi of mangrove plants of Indian Sundarbans—A treasure house of Ethnobotanical medicine

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## Follicolous fungi of mangrove plants of Indian Sundarbans—A treasure house of ethnobotanical medicine

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Folk medicines have good impact in rural sectors of Sundarbans. The traditional knowledge holders of this region, well-versed in the local traditional knowledge, use the mangrove plants for healing the local rural communities. These mangrove plants harbour a wide array of novel natural products which are potential sources of future drugs against ancient and emergent diseases. Rural poor and marginalized people of mangrove forest area depend on mangrove plants for primary health problems. The contiguous mangrove vegetation of the Ganges- Brahmaputra delta are now the targets of various fungal attack which may create conservation problem in future. During a survey of Follicolous fungi of ethno-botanically important plants of Indian Sundarbans, a number of fungi were isolated. These fungi represented four classes viz., Pyrenomycetes, Teliomycetes, Coelomycetes and Hyphomycetes. Pathogenicities of isolated fungi were tested on detached leaves of their respective hosts. This study revealed the spectrum of fungal diversity, host specificity, local distribution and pathogenicities of fungi causing foliar diseases of medicinally important mangrove plants of Indian Sundarbans.

**Key words:** Ethnobotany, Follicolous Fungi, Folk Medicine, Mangrove, Sundarbans

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### INTRODUCTION

Mangroves are coastal forests found in sheltered estuaries and along river banks and lagoons in the tropics and subtropics (Maity and Choudhury, 2013). They cover an approximate 18.1 million hectares on the globe (Pal and Chaudhuri, 2012). More than 40% of the world's mangroves are present in South and South-East Asia. Mangroves act as an effective carbon sink (Komiya et al. 2008) and sequester higher amount of CO<sub>2</sub> (than any other non-mangrove forest type) which approximately amounts to 100 tons of CO<sub>2</sub> per hectare (Ha) and also stabilize the soil particles to control erosion. The Sundarbans are the largest mangrove forest in the world, covering about one million hectares of the Ganges-Brahmaputra delta in India and Bangladesh (Gopal and Chauhan, 2006). David Prain, the author of *Flora of Sundarbans*, described

the floristic composition and recorded 334 species belonging to 245 genera and 75 families. This flora includes a total of 69 mangrove species distributed in 49 genera and 35 families (Mandal and Naskar, 2008). Unlike most mangroves in other parts of the world, the Sundarban flora is dominated by the families Sterculiaceae and Euphorbiaceae. The vegetation is characterized by the *Sundari* (*Heritiera fomes*) trees from which the name of the forest is derived. It is associated with other trees such as *Gewa* (*Excoecaria agallocha*), *Goran* (*Ceriops decandra*) and *Keora* (*Sonneratia apetala*). The Bangladeshi side is dominated by *Sundari* and *Gewa* (Iftekhar, 2008), whereas the Indian side is dominated by *Gewa* and *Goran* (Chowdhury et al. 2014). Some of the threatened plant species include *Hental* (*Phoenix paludosa*) and *Golpata* (*Nypa fruticans*). All most all the plants reported so far from this region are economically

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and commercially important. Various parts of the plant have been traditionally used in indigenous medicine by the local communities of the mangroves across tropical Asia and Oceania (Table 1). The medicinal properties of mangrove trees provide a wide domain for medicinal uses; most to be explored (Prabhakaran and Kavitha, 2012). These mangroves are the last stronghold of the Bengal Tiger (*Panthera tigris tigris*), the top predator in these forests. The estuarine crocodile (*Crocodylus porosus*) is the top predator in the creeks and channels. The Sundarbans play a significant role in the regional economy of the Lower Gangetic Delta, and the national economy of Bangladesh (Getzner and Islam, 2013).

Mangroves constitute a dynamic ecosystem with a wonderful consortium of different life forms including plants, animals and microbes of both terrestrial and aquatic habitats. Several mycologists have shown interest in the exploration of fungi in tropical mangroves. Although a number of fungal species have been reported by a number of workers from Indian mangroves (Vittal and Sarma, 2006; Raveendran and Manimohan, 2007; Raghukumar, 2008; Borse *et al.* 2009; Nambiar and Raveendran, 2009; Kumaran and Hur, 2009; Ravikumar *et al.* 2009; Sridhar, 2009; Alias *et al.* 2010; Bhimba *et al.* 2011; Khan and Manimohan, 2011; Li *et al.* 2011; Pal, 2012; Sarma, 2012; Borse *et al.* 2013; Suciati and Rahmansyah, 2013; Pal, 2014) very little is known about fungal diversity and their parasitic relationship with mangrove plants of Sundarbans which is the largest mangrove forest in the world covering 1.48-1.73 million acres of land. Sundarbans has a humid, tropical maritime climate with an annual rain-fall about about 1650 to 1800 mm in Central and Northern areas and about 2790 mm in outer coasts. The average maximum and minimum temp. 29°C (June-July) and 20°C (Dec.-Jan.) respectively and the humidity varies between 70-80%. Leaf-infecting fungi of Sundarbans play a significant role in litter decomposition apart from their involvement in various diseases of mangrove plants. Despite the fact, a large majority of them remains yet to be identified. This communication is intended to focus the extent of diversity in foliar fungi of medicinal mangrove plants of Sundarbans, their host specificity, local distribution and pathogenicity.

## MATERIALS AND METHODS

Both healthy and infected leaves were collected at

random from living trees, shrubs and herbs of Sundarbans forests in different seasons placed in polythene bags and brought to the laboratory for examination. The organisms were isolated from infected leaves following the standard method (0.1% HgCl<sub>2</sub> and sterile distilled water), identified and maintained in Potato-dextrose-agar medium (except *Skierka* and *Graphiola*) at 25± 1°C. Dried infected plants were finally mounted on herbarium sheets. All the herbarium specimens are deposited in the Plant Pathology Herbarium, Department of Botany, Calcutta University.

For pathogenicity tests, 10 healthy detached leaves of each host species were thoroughly washed with sterile distilled water, allowed to dry, placed on sterilized moist filter papers in disinfected plastic trays and inoculated with drops (0.02 ml/drop) of spore suspension of test fungus. They trays were covered with glass plates and sealed with petroleum jelly to prevent evaporation of water during incubation. Control set was maintained in each case with drops of sterile distilled water instead of spore suspension. Inoculated leaves were incubated for 72 hr. at room temp. 30-32°C and in diffused light. The percentage of lesion production was calculated on the basis of total number of inoculum drops placed on leaves of test species. The organisms were reisolated from leaves and compared with the stock cultures.

## RESULTS AND DISCUSSION

Ethnomedicine is an emerging thrust area in scientific research. Ethnically Indian Sundarbans is dominated by scheduled tribes (Chowdhury and Maity, 2014). Folk medicine is an important part of the traditional knowledge (TK) of most indigenous communities. The Sundarbans are located on the largest and also the most densely populated delta on the globe. Health care is one of the major problems of this region. Its largely rural, marginalized population, living in the vicinity of the largest single block of mangrove forest in the world, predominantly depend on the rich mangrove flora for their primary health care. The kobiraj or baidya (herbalist), bawalli (diagnostician) and ojha (healer) are the traditional knowledge holders (TKHs) of the Sundarbans. Most of these TKHs practice TK-based medicine which is dependent on the local mangrove forests. The locals rely upon the witch-doctors or shamans who customarily diagnose diseases by trance communication with the spirit world.

**Table 1.** Some important medicinal mangrove plants of Indian Sundarbans

| Plant                                     | Vernacular Name | Family         | Plant part(s)          | Biological activity                                                                       |
|-------------------------------------------|-----------------|----------------|------------------------|-------------------------------------------------------------------------------------------|
| <i>Acanthus ilicifolius</i> L.            | Hargoza         | Acanthaceae    | Leaf                   | Anticancer, antimicrobial, antioxidant & hepatoprotective                                 |
| <i>Acrostichum aureum</i> L.              | Hado            | Pteridaceae    | Leaf                   | Anticancer                                                                                |
| <i>Aegiceras corniculatum</i> (L.) Blanco | Khalsi          | Myrsinaceae    | Stem                   | Anti-inflammatory                                                                         |
| <i>Avicennia officinalis</i> L.           | Jat-Bain        | Avicenniaceae  | Seed, Stem-Bark, Leaf  | Astringent & aphrodisiac agent                                                            |
| <i>Bruguiera gymnorrhiza</i> (L.) Lamk.   | Kankra          | Rhizophoraceae | Leaf                   | Anticancer                                                                                |
| <i>Bruguiera parviflora</i> W. & A.       | Bakul-Kankra    | Rhizophoraceae | Leaf                   | Anticancer                                                                                |
| <i>Ceriops decandra</i> (Griff.) Ding Hou | Jhamti-Goran    | Rhizophoraceae | Leaf and pneumatophore | Antinociceptive                                                                           |
| <i>Ceriops tagal</i> (Perr.) Robinson     | Mat-Goran       | Rhizophoraceae | Leaf                   | Stimulate glucose uptake by cultured L6 rat muscle cells, antihemorrhagic & antirheumatic |
| <i>Cynometra ramiflora</i> L.             | Singara         | Leguminosae    | Leaf                   | Anticancer                                                                                |
| <i>Derris scandens</i> Benth.             | Noa-Lata        | Leguminosae    | Stem                   | Anti-inflammatory & antiarthritic                                                         |
| <i>Derris trifoliata</i> Lour.            | Pan-Lata        | Leguminosae    | Root bark              | Antimicrobial                                                                             |
| <i>Excoecaria agallocha</i> L.            | Gewa            | Euphorbiaceae  | Leaf                   | Antioxidant, purgative & antiulcer                                                        |
| <i>Heritiera fomes</i> Buch.-Ham.         | Sundari         | Sterculiaceae  | Stem bark              | Antioxidant, antihemorrhagic & antimicrobial                                              |
| <i>Ipomoea pes-caprae</i> (L.) Sweet.     | Chagarkuri      | Convolvulaceae | Leaf                   | Antiarthritic & astringent                                                                |
| <i>Nypa fruticans</i> (Thunb.) Wurumb.    | Golpata         | Arecaceae      | Inflorescence          | Cooling & antiphlogistic                                                                  |
| <i>Phoenix paludosa</i> Roxb.             | Hental          | Arecaceae      | Root                   | Diuretic, analgesic, cooling & antiphlogistic                                             |
| <i>Rhizophora apiculata</i> Bl.           | Bhora-Garjan    | Rhizophoraceae | Leaf & stem bark       | Antioxidant, anti HIV, antihyperglycemia                                                  |
| <i>Rhizophora mucronata</i> Lamk.         | Garjan          | Rhizophoraceae | Leaf & stem bark       | Antioxidant, anti HIV, antihyperglycemia                                                  |
| <i>Sarcolobus globosus</i> Wall.          | Baoli-Lata      | Asclepiadaceae | Fruit & Leaf           | Antiarthritic & analgesic                                                                 |
| <i>Sesuvium portulacastrum</i> (L.) L.    | Gada-Bani       | Aizoaceae      | Leaf                   | Antiviral & antimicrobial                                                                 |
| <i>Sonneratia caseolaris</i> (L.) Engl.   | Chak-Keora      | Sonneratiaceae | Fruit                  | Antihemorrhagic                                                                           |
| <i>Suaeda maritima</i> Dumort.            | Gire-Sak        | Chenopodiaceae | Leaf                   | Antimicrobial                                                                             |
| <i>Xylocarpus granatum</i> Koen.          | Dhundul         | Meliaceae      | Stem bark & fruit      | Antiulcer & antidiarrhoeal                                                                |
| <i>Xylocarpus moluccensis</i> Pierre      | Pasur           | Meliaceae      | Leaf                   | Anticancer & antioxidant                                                                  |

However, the TKHs are also gifted in the use of the local mangrove plants for healing the rural population. Some of the ethnobotanically important true mangrove species of the Sundarbans are summarized in Table 1.

Mangroves have long been a source of wonder for the layman and of curiosity to the scientists.

Traditionally, local people use these mangroves for their benefit, but their increasing populations have led to an alarming non-sustainable abuse of this natural resource. Mangroves harbour a wide array of novel natural products (Banerjee *et al.* 2008; Tamarkar *et al.* 2008; Uddin *et al.*, 2009; Wangenstein *et al.* 2009; Singh, *et al.* 2009; Adib *et al.* 2010; Khajure and Rathod, 2011;

**Table 2:** A variety of fungi isolated from infected leaves of mangrove plants of Sundarbans

| Fungus                                                                                     | Fungal Class | Plant species (Host)                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Acremonium strictum</i> W. Gams                                                         |              | <i>Rhizophora apiculata</i> Bl.                                                                                                                                                                                                                                                                                                                                 |
| <i>Alternaria alternata</i> (Fr.) Keissler. agg.                                           | Hyphomycetes | <i>Aegiceras corniculatum</i> (L.) Blanco,<br><i>Heritiera fomes</i> Buch.-Ham., <i>Xylocarpus granatum</i> Koen.                                                                                                                                                                                                                                               |
| <i>A. infectoria</i> E.G. Simmons                                                          |              | <i>Rhizophora mucronata</i> Lamk., <i>X. granatum</i> Koen.                                                                                                                                                                                                                                                                                                     |
| <i>A. tenuissima</i> (Kunze ex Pers.) Wiltshire                                            |              | <i>Avicennia officinalis</i> L.                                                                                                                                                                                                                                                                                                                                 |
| <i>Ascochyta</i> sp.                                                                       | Coelomycetes | <i>A. officinalis</i> L.                                                                                                                                                                                                                                                                                                                                        |
| <i>Aspergillus versicolor</i> (Vuill.) Tirab.                                              |              | <i>A. corniculatum</i> (L.) Blanco                                                                                                                                                                                                                                                                                                                              |
| <i>Bipolaris colocasiae</i> (M.P. Tandon & Bharg.) Alcorn                                  |              | <i>A. officinalis</i> L.                                                                                                                                                                                                                                                                                                                                        |
| <i>Cercospora mucronata</i> Purkayastha & Pal                                              | Hyphomycetes | <i>R. mucronata</i> Lamk.                                                                                                                                                                                                                                                                                                                                       |
| <i>Cercospora rhizophorae</i> Creager                                                      |              | <i>R. mucronata</i> Lamk.                                                                                                                                                                                                                                                                                                                                       |
| <i>Cladosporium oxysporum</i> Berk & M.A. Curtis                                           |              | <i>R. mucronata</i> Lamk.                                                                                                                                                                                                                                                                                                                                       |
| <i>Cladosporium</i> sp.                                                                    |              | <i>Ceriops decandra</i> (Griff.) Ding Hou                                                                                                                                                                                                                                                                                                                       |
| <i>Coelomycete</i> sp.                                                                     |              | <i>Bruguiera gymnorrhiza</i> (L.) Lamk.                                                                                                                                                                                                                                                                                                                         |
| <i>Colletotrichum gloeosporioides</i> (Penzig) Penzig & Sacc.                              | Coelomycetes | <i>Acanthus ilicifolius</i> L., <i>A. officinalis</i> L.,<br><i>Ceriops tagal</i> (Perr.) Robinson, <i>Derris scandens</i> Benth., <i>D. trifoliata</i> Lour., <i>E. agallocha</i> L., <i>Nypa fruticans</i> (Thunb.) Wurumb., <i>P. paludosa</i> Roxb.,<br><i>Rhizophora apiculata</i> Bl., <i>R. mucronata</i> Lamk., <i>Sonneratia caseolaris</i> (L.) Engl. |
| <i>Coniella musaiaensis</i> var. <i>hibisci</i> B. Sutton                                  |              | <i>E. agallocha</i> L.                                                                                                                                                                                                                                                                                                                                          |
| <i>Corynespora cassiicola</i> (Berk. & M.A. Curtis) C.T. Wei                               | Hyphomycetes | <i>B. gymnorrhiza</i> (L.) Lamk.                                                                                                                                                                                                                                                                                                                                |
| <i>Curvularia clavata</i> B.L. Jain                                                        |              | <i>Bruguiera parviflora</i> W. & A.                                                                                                                                                                                                                                                                                                                             |
| <i>C. lunata</i> (Wakker) Boed.                                                            |              | <i>A. ilicifolius</i> L., <i>D. scandens</i> Benth., <i>Ipomoea pescarpae</i> (L.) Sweet, <i>Xylocarpus moluccensis</i> (L.) Roem.                                                                                                                                                                                                                              |
| <i>C. lunata</i> (Wakker) Boed. var. <i>aeria</i> (Batista, de Lima & Vasconc.) M.B. Ellis | Hyphomycetes | <i>D. trifoliata</i> Lour.                                                                                                                                                                                                                                                                                                                                      |
| <i>C. pallescens</i> Boed.                                                                 |              | <i>X. moluccensis</i> (L.) Roem.                                                                                                                                                                                                                                                                                                                                |
| <i>Cytospora</i> sp.                                                                       | Coelomycetes | <i>E. agallocha</i> L.                                                                                                                                                                                                                                                                                                                                          |
| <i>Drechslera hawaiiensis</i> (Bugnicourt) Subram. & Jain ex M.B. Ellis                    |              | <i>D. trifoliata</i> Lour.                                                                                                                                                                                                                                                                                                                                      |
| <i>Drechslera</i> sp.                                                                      |              | <i>E. agallocha</i> L.                                                                                                                                                                                                                                                                                                                                          |
| <i>Exserohilum psidii</i> A. Sivanesan                                                     | Hyphomycetes | <i>X. granatum</i> Koen.                                                                                                                                                                                                                                                                                                                                        |
| <i>Exserohilum</i> sp.                                                                     |              | <i>R. apiculata</i> Bl.                                                                                                                                                                                                                                                                                                                                         |

Contd.

| Fungus                                                           | Fungal Class  | Plant species (Host)                                                                                                     |
|------------------------------------------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------|
| <i>Fusarium equiseti</i> (Corda) Sacc.                           |               | <i>A. ilicifolius</i> L., <i>Sarcobolus globosus</i> Wall.                                                               |
| <i>F. pallidoroseum</i> (Cooke) Sacc.                            |               | <i>A. ilicifolius</i> L., <i>Acrostichum aureum</i> L., <i>C. decandra</i> (Griff.) Ding Hou, <i>H. fomes</i> Buch.-Ham. |
| <i>Glomerella cingulata</i> (Stoneman) Spauld. & H. Schrenk      | Pyrenomycetes | <i>E. agallocha</i> L.                                                                                                   |
| <i>Graphiola phoenicis</i> Poit.                                 | Teliomycetes  | <i>P. paludosa</i> Roxb.                                                                                                 |
| <i>Myrothecium cinctum</i> (Corda) Sacc.                         |               | <i>D. scandens</i> Benth.                                                                                                |
| <i>M. roridum</i> Tode ex Fr.                                    |               | <i>E. agallocha</i> L.                                                                                                   |
| <i>Nigrospora sphaerica</i> (Sacc.) Mason                        |               | <i>C. decandra</i> (Griff.) Ding Hou                                                                                     |
| <i>Nigrospora</i> State of <i>Khuskia oryzae</i> Hudson          | Hyphomycetes  | <i>N. fruticans</i> (Thunb.) Wurumb.                                                                                     |
| <i>Paecilomyces lilacinus</i> (Thom.) R.A. Samson                |               | <i>H. fomes</i> Buch.-Ham.                                                                                               |
| <i>Penicillium pinophilum</i> Hedgc.                             |               | <i>B. parviflora</i> W. & A.                                                                                             |
| <i>Pestalotiopsis agallochae</i> Pal & Purkayastha               | Coelomycetes  | <i>E. agallocha</i> L.                                                                                                   |
| <i>P. bruguierae</i> Purkayastha & Pal                           |               | <i>B. gymnorhiza</i> (L.) Lamk.                                                                                          |
| <i>P. caseolaris</i> Purkayastha & Pal                           |               | <i>S. caseolaris</i> (L.) Engl.                                                                                          |
| <i>P. guepini</i> (Desmazieres) Stey.                            |               | <i>X. granatum</i> Koen.                                                                                                 |
| <i>P. heritierae</i> Purkayastha & Pal                           |               | <i>H. fomes</i> Buch.-Ham.                                                                                               |
| <i>P. mangiferae</i> (P. Henn.) Stey.                            |               | <i>D. scandens</i> Benth.                                                                                                |
| <i>P. moluccensis</i> Purkayastha & Pal                          |               | <i>X. moluccensis</i> (L.) Roem.                                                                                         |
| <i>P. palmarum</i> (Cooke) Stey.                                 |               | <i>N. fruticans</i> (Thunb.) Wurumb.                                                                                     |
| <i>P. versicolor</i> (Speg.) Stey.                               |               | <i>P. paludosa</i> Roxb.                                                                                                 |
| <i>Phoma minutispora</i> P.N. Mathur & Thirum                    |               | <i>C. decandra</i> (Griff.) Ding Hou                                                                                     |
| <i>Phoma</i> sp.                                                 |               | <i>Suaeda maritima</i> Dumort.                                                                                           |
| <i>Phomopsis mangrovei</i> Hyde                                  |               | <i>C. decandra</i> (Griff.) Ding Hou                                                                                     |
| <i>P. rhizophorae</i> Batista & Maia                             | Coelomycetes  | <i>R. apiculata</i> Bl.                                                                                                  |
| <i>P. sonneratae</i> Purkayastha & Pal                           |               | <i>R. apiculata</i> Bl., <i>R. mucronata</i> Lamk.                                                                       |
| <i>P. xylocarpae</i> Purkayastha & Pal                           |               | <i>S. caseolaris</i> (L.) Engl.                                                                                          |
| <i>Phomopsis</i> sp. cf. <i>commelinae</i> E. Punithalingam      |               | <i>X. moluccensis</i> (L.) Roem.                                                                                         |
| <i>Phomopsis</i> sp.                                             |               | <i>B. gymnorhiza</i> (L.) Lamk.                                                                                          |
| <i>Phyllosticta mangrovei</i> Purkayastha & Pal                  |               | <i>A. ilicifolius</i> L., <i>Cynometra ramiflora</i> L., <i>E. agallocha</i> L.                                          |
| <i>Phyllosticta</i> sp.                                          |               | <i>C. ramiflora</i> L.                                                                                                   |
| <i>Pithomyces</i> sp.                                            | Hyphomycetes  | <i>A. corniculatum</i> (L.) Blanco                                                                                       |
| <i>Skierka agallocha</i> Raciborski                              | Teliomycetes  | <i>E. agallocha</i> L.                                                                                                   |
| <i>Sporothrix</i> sp.                                            |               | <i>R. mucronata</i> Lamk.                                                                                                |
| <i>Stemphylium</i> sp. cf. <i>vesicarium</i> (Wallr.) E. Simmons | Hyphomycetes  | <i>A. corniculatum</i> (L.) Blanco                                                                                       |
| <i>Trichothecium roseum</i> (Pers.) Link                         |               | <i>P. paludosa</i> Roxb.                                                                                                 |

**Table 3:** Distribution of fungal species in different localities of Sundarbans isolated from medicinally important mangrove plants

| Locality        | Serial No. of fungi shown in Table 2                                                         |
|-----------------|----------------------------------------------------------------------------------------------|
| Bak-Khali       | 2, 7, 13, 17, 24, 25, 27, 28, 30, 31, 32, 33, 35, 38, 40, 41, 43, 44, 46, 47, 50, 51, 52, 56 |
| Bhagbatpur      | 2, 13, 17, 17a, 20, 25, 27, 34, 51, 57                                                       |
| Chandanpiri     | 27, 42                                                                                       |
| Jammu Island    | 7, 13, 27                                                                                    |
| Lothian Island  | 5, 13, 17, 25, 30, 39                                                                        |
| Patibania       | 5, 13, 27                                                                                    |
| Prentice Island | 13, 15, 19, 47                                                                               |
| Saptamukhi      | 7, 13                                                                                        |
| Ajmalhari       | 2, 13, 19, 27, 39                                                                            |
| Chulkati        | 2, 3, 13, 25, 27, 48                                                                         |
| Dhonchi         | 10, 13, 23, 34, 35, 36, 37, 40, 54                                                           |
| Dulibhasani     | 3, 12, 13, 27                                                                                |
| Haliday Island  | 8, 25, 27                                                                                    |
| Herobhanga      | 3, 13, 27, 50                                                                                |
| Kalas Island    | 7, 13, 18, 27, 29, 41, 55                                                                    |
| Kultali         | 27                                                                                           |
| Raidighi        | 35                                                                                           |
| Harinbhanga     | 27, 52, 53                                                                                   |
| Khatuajhuri     | 13, 25, 27, 50                                                                               |
| Panchamukhani   | 6, 27                                                                                        |
| Pirkhali        | 2, 4, 13, 27, 38                                                                             |
| Saznakhali      | 2, 9, 11, 13, 14, 16, 21, 24, 25, 26, 27, 41, 45, 46, 50, 53                                 |
| Chamta          | 27                                                                                           |
| Chandkhali      | 13, 25, 27, 50                                                                               |
| Matla           | 3, 7, 49                                                                                     |
| Netidhopani     | 13, 22                                                                                       |
| Baghmara        | 24, 27, 29                                                                                   |
| Chhotahard      | 25, 27                                                                                       |
| Goashaba        | 2, 27, 52                                                                                    |
| Gona            | 7, 27                                                                                        |
| Mayadwip        | 1, 5, 13, 27, 29, 41                                                                         |

Mishra, 2012; Sathe *et al.* 2014). More studies need to establish the physical, chemical and biological properties of their phytochemicals as likely sources of forthcoming therapeutic drugs. Therefore, sound management strategies are urgently needed to conserve these mangroves for their immense medicinal value.

In course of this study 57 species of follicolous fungi belonging to 32 genera were isolated from infected leaves of 83 hosts distributed among 24 mangrove plant species of Sundarbans (Table 2). The fungi listed in Table 2 represent four classes, viz. Pyrenomycetes (1 species), Teliomycetes (2 species), Coelomycetes (24 species) and Hyphomycetes (30 species). The most prevalent genera are *Pestalotiopsis* (9 species), *Phomopsis* (6 species), *Curvularia* (4 species), *Alternaria* (3 species). A few fungal species, namely, *Colletotrichum gloeosporioides* (isolated from 11 host species), *Fusarium pallidoroseum* (4), *Alternaria alternata* (3) and *Curvularia lunata* (5) are also very common on mangrove plants of Sundarbans. Among the fungi, *Skierka agallocha*, a rust on *Excoecaria agallocha* deserves special attention because of its unique characters such as ellipsoid to subclavate urediniospores, bilaminar walls with echinulate structures or wing-like projections on the outer walls of the spores. Chavan reported pycnial, aecial and uredinial stages of this rust from Maharashtra, India. Subsequently uredinial stage was also found in Sundarbans, West Bengal (Pal and Chaudhuri, 2012). A biotrophic fungus detected on leaves of a palm (*Phoenix paludosa*) was identified as *Graphiola phoenicis*.

The spectrum of fungal diversity in Sundarbans appears to be very wide and hence frequent exploration is needed. It is not unreasonable to assume that diversity in parasitic fungi is related to parasitism since increase in diversity leads to enhance parasitism. It is of common occurrence in the field that a fungal parasite having different strains may attack a wide range of host species. Genetic diversity in all types of organisms is increasing with time due to natural and/or unnatural causes. Besides, evolutionary changes also take place in both hosts and parasites which is probably necessary for balancing the changes in resistance of the host and virulence of the pathogen.

The distribution of leaf infecting fungi in different localities of Sundarbans is shown in Table 3. Although materials were collected from 31 localities of Sundarbans, maximum number of fungi was obtained from Bak-Khali (24) followed by Saznakhali (16), Bhagbatpur (10) and Donchi (9 species) for est.

The fungal diversity in mangrove forests of

**Table 4:** Pathogenicity tests of different fungi on detached leaves of living medicinal mangrove plants

| Host                   | Pathogen                                     | *% production of lesions |       |
|------------------------|----------------------------------------------|--------------------------|-------|
|                        |                                              | 48 h.                    | 72 h. |
| <i>E. agallocha</i>    | <i>C. gloeosporioides</i> *                  | 95.00                    | 95.00 |
| <i>D. scandens</i>     | <i>P. mangiferae</i>                         | 40.00                    | 40.00 |
| <i>P. paludosa</i>     | <i>P. palmarum</i>                           | 00.00                    | 22.50 |
| <i>E. agallocha</i>    | <i>P. agallochae</i> *                       | 55.00                    | 55.00 |
| <i>C. decandra</i>     | <i>P. versicolor</i>                         | 20.00                    | 20.00 |
| <i>X. granatum</i>     | <i>P. guepini</i>                            | 05.00                    | 25.00 |
| <i>B. gymnorhiza</i>   | <i>P. bruguierae</i>                         | 60.00                    | 70.00 |
| <i>S. caseolaris</i>   | <i>P. caseolaris</i>                         | 25.00                    | 27.50 |
| <i>H. fomes</i>        | <i>P. heritierae</i>                         | 20.00                    | 20.00 |
| <i>B. parviflora</i>   | <i>C. clavata</i>                            | 32.00                    | 32.50 |
| <i>D. scandens</i>     | <i>M. cinctum</i>                            | 32.50                    | 35.00 |
| <i>E. agallocha</i>    | <i>M. roridum</i> *                          | 95.00                    | 97.50 |
| <i>A. corniculatum</i> | <i>A. alternata</i>                          | 80.00                    | 85.00 |
| <i>A. officinalis</i>  | <i>A. tenuissima</i>                         | 25.00                    | 70.00 |
| <i>R. mucronata</i>    | <i>P. rhizophorae</i>                        | 17.50                    | 20.00 |
| <i>E. agallocha</i>    | <i>C. musaiaensis</i> var. <i>hibisci</i>    | 50.00                    | 55.00 |
| <i>R. apiculata</i>    | <i>Pithomyces</i> sp.                        | 37.50                    | 60.00 |
| <i>E. agallocha</i>    | <i>Drechslera</i> sp.                        | 25.00                    | 30.00 |
| <i>A. corniculatum</i> | <i>Stemphylium</i> sp. cf. <i>vesicarium</i> | 15.00                    | 25.00 |
| <i>R. mucronata</i>    | <i>C. mucronata</i> *                        | 20.00                    | 20.00 |
| <i>R. mucronata</i>    | <i>C. rhizophorae</i>                        | 30.00                    | 32.50 |
| <i>C. decandra</i>     | <i>N. sphaerica</i>                          | 27.50                    | 37.30 |
| <i>C. ramiflora</i>    | <i>P. mangrovei</i>                          | 20.00                    | 22.50 |

\*% based on the total number of spore suspension drops placed on leaves of each host species (4 drops/leaf; 10 leaves/host species) temp. 30-32°C.

Sundarbans and their parasitic relationship with mangrove plants are important issues of marine biology. It appears from Table 2 that a large number of fungi have been isolated from living leaves and pathogenicities of 23 fungi were tested on healthy detached leaves of their respective host plants following the method as described. In all cases fungi produced lesions on upper surfaces of leaves within 48 hr. of inoculation except *Pestalotiopsis palmarum* which took 72 h. to produce 22% lesions. Eight fungi were able to produce lesions within 24 h. Results in Table 4 reveal that a large number of fungal species are potential parasites of mangrove plants of Sundarbans.

*Skierka agallocha* and *Graphiola phoenicis* are known parasites of *E. agallocha* and *P. paludosa* respectively. It is a matter of great concern that several medicinal plants of Sundarbans are now targets of fungal attacks in different seasons which may cause conservation problems in future.

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