A REVIEW OF BIODIVERSITY STUDIES OF SOIL DWELLING ORGANISMS IN INDIAN MANGROVES

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Abstract

The dynamic mangrove ecosystem is complemented by the activities of its soil organisms. Much study has been conducted in the various mangroves in India and the literature is scettered. This review provides an analysis of previous studies on various diversified soil organisms of mangroves and a listing of the references available until date providing a comprehensive bibliography.

Introduction

Mangrove ecosystem has long been a natural resource of importance to mankind by virtue of its utility and aesthetic value. This ecosystem is one of the most productive ecosystems of tropical and subtropical regions of the world and serves as nursery, feeding and spawning grounds for commercial fin fishes and shell fishes. Mangroves have attained great importance both in terms of economic and ecological aspects, therefore, various conservation programmes have been taken to protect this fragile ecosystem all over the world. In India, mangroves are found in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharastra, Gujarat, and Andaman and Nicobar Islands.

The dynamic mangrove ecosystem supports numerous diversified soil micro, meio, and macro organisms. All these soil organisms, especially microbial flora, play a very active role in the degradation of mangrove foliage, which is continuously shed and decomposed in the mangrove substratum. These benthic organisms form an important component of the detritus food chain of coastal area. The objective of this review dealing with biodiversity of the mangrove forest ecosystem of India is to assess and list out the previous studies on various diversified soil organisms of mangroves.

In the present review an attempt has been made to analyse the various studies on soil organisms of Indian mangroves in the order of micro, meio and macro organisms (Table 1).

Studies on micro organisms

Studies on the micro organisms of Indian mangrove ecosystem revealed the fact that several of these forms were found in the mangrove sediments.

Nitrogen fixing bacteria have been isolated from mangrove sediments of Pichavaram (Lakshmanaperumalsamy, 1987; Ravikumar, 1995) and Sunderbans (Sengupta & Chaudhuri, 1990, 1991). Similarly nitrogen fixing cyanobacteria were isolated from Pichavaram mangroves (Ramachandran & Venugopalan, 1987; Ramachandra Rao, 1992).

The sulphate reducing bacteria have been isolated from the mangrove swamps of Goa (Saxena *et al*., 1988; Lokabharathi *et al*., 1991). Purple photosynthetic bacteria were studied from the sediments of Pichavaram mangrove (Vethanayagam, 1991). The iron oxidising and iron reducing bacteria have been studied from Goa and Konkan mangroves (Panchanadikar, 1993). Methanogenic bacteria have been studied from the mangrove sediments of Pichavaram (Ramamurthy *et al*., 1990) and Kodiakkarai (Mohanraju & Natarajan, 1992). Phototrophic thionic bacteria in the anaerobic and micro aerophilic strata of mangrove sediments were found in Cochin (Chandrika *et al*., 1990). Fungus-like bacteria, *Actinomycetes* were also isolated from mangrove sediments of Cochin (Kala & Chandrika, 1993). Bacteria have been isolated from the mangroves of Andamans (Shome *et al*., 1995).

Krishnamurthy *et al*., (1986) reported the structure and organization of tintinnid protozoa from mangroves of Parangipettai. Seasonal distribution of the protozoa, *Acanthamoeba rhysodes* was studied from mangrove sediments of sunderbans (Bhattacharya *et al*., 1987).

Sediment dwelling fungi from the mangrove swamps, have been studied by Matondkar *et al*., (1980 a, b) in Goa, Misra (1986) in Andaman and Nicobar Islands, Venkatesan and Natarajan (1987) in Pichavaram, Nair *et al*., (1991) and Prabhakaran *et al*. (1987) in Maharashtra, and, Prabhakaran and Gupta (1990) in Cochin. These investigations include the systematic study, seasonal distribution and the influence of hydrographical parameters on fungi. Twenty microfungal species belonging to 12 genera were isolated from mangrove muds of Andamans (Misra, 1986). At Cochin, 31 fungal isolates were recorded from mangrove sedi-

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Table 1. Biodiversity studies of soil organisms in Indian mangroves

Authors / Group of Organism	Year of publication	Mangrove area	Type of organism	Type of work
Micro Organisms				
Bhattacharya *et al*.	1987	Sunderbans	Protozoa	Seasonal distribution
Chandrika *et al*.	1990	Cochin	Bacteria	Occurrence
Kala & Chandrika	1993	Cochin	Bacteria	Occurrence
Krishnamurty *et al*.	1986	Parangipettai	Protozoa	Seasonal distribution
Lakshmanaperumalasamy	1987	Pichavaram	Bacteria	Occurrence
Loka Bharathi *et al*.	1991	Goa	Bacteria	Ecology
Matondkar *et al*.	1980a	Goa	Fungi	Distribution
	1980b	Goa	Bacteria & Fungi	Seasonal distribution
Misra	1986	Andamans	Fungi	Occurrence
Mohanraju & Natarajan	1992	Kodiakkarai	Bacteria	Occurrence
Nair *et al*.	1991	Maharastra	Fungi	Occurrence
Panchanadikar	1993	Goa & Konkan	Bacteria	Occurrence
Prabhakaran & Gupta	1990	Cochin	Fungi	Occurrence
Prabhakaran *et al*.	1987	Cochin	Fungi	Seasonal distribution
Ramachandran Rao	1992	Pichavaram	Cynobacteria	Distribution
Ramachandran & Venugopalan	1987	Pichavaram	Cynobacteria	Occurrence
Ramamurthy *et al*.	1990	Pichavaram	Bacteria	Distribution
Ravikumar	1995	Pichavaram	Bacteria	Occurrence
Saxena *et al*.	1988	Goa	Bacteria	Occurrence
Sengupta & Choudhury	1990	Sunderbans	Bacteria	Occurrence
	1991	Sunderbans	Bacteria	Ecology
Shome *et al*.	1995	Andamans	Bacteria	Occurrence
Venkatesan & Natarajan	1987	Pichavaram	Fungi	Seasonal distribution
Vethanayagam	1991	Pichavaram	Bacteria	Occurrence
Meio Organisms				
Ali *et al*.	1983	Pichavaram	Nematod	Energy flow
Ansari *et al*.	1993	Goa	Nematod Turbellarian Copepod	Vertical distribution
Goldin *et al*.	1996	Maharastra	Nematod Polychaete Oligochaete	Seasonal distribution
Rao	1986	Andamans	Nematod Copepod	Distribution
Sarma & Wilsanad	1994	Bhitarkanika	11 major taxa	Distribution
Sinha & Choudhury	1988	Sunderbans	Nematod	Occurrence
Sinha et al.	1987	Sunderbans	Nematod	New description
Macro Organisms				
Anthalye & Gokhale	1998	Maharastra	Polychaete Mollusc Sea anemone	Description
Bhunia & Choudhury	1981	Sunderbans	Major groups	Occurrence
Chakraborty & Choudhury	1985	Sunderbans	Crab	Occurrence
	1992a	Sunderbans	Crab	Distribution
	1992b	Sunderbans	Crab	Ecology
Chandrasekaran & Natarajan	1994	Pichavaram	Crab	Seasonal distribution
Choudhury *et al*.	1984a	Sunderbans	Major groups	Distribution
	1984b	Sunderbans	Major groups	Distribution
Deb	1989	Andamans	Crab	New description
Ghosh *et al*.				
Ingole *et al*.	1994	Goa	Mollusc	New record
Jahan *et al*.	1990	Sunderbans	Mollusc	Occurrence

Kasinathan & Shanmugam	1985	Pichavaram	Mollusc	Occurrence
Mishra *et al*.	1994	Maharastra	Sea anemone	Occurrence
Misra & Choudhury	1985	Sunderbans	Polychaete	Seasonal distribution
Nandi & Choudhury	1983	Sunderbans	Major groups	Seasonal distribution
Padmakumar	1984	Bombay	Major groups	Distribution
Patra *et al*.	1988	Sunderbans	Major groups	Distribution
	1990	Sunderbans	Major groups	Distribution
Pillai & Appukutan	1980	Manauli	Mollusc	Occurrence
Poovachiranon	1992	Andamans	Crab	Biology
Radhakrishna & Janakiram	1975	Godavari & Krishna	Mollusc	Occurrence
Rajagopalan *et al*.	1986	Cochin	Mollusc Crab	Occurrence
Rambabu *et al*.	1987	Nizampatnam	Mollusc	Behaviour
Ray & Choudhury	1985	Sunderbans	Insect	Seasonal distribution
Sethuramalingam & Khan	1991	Pichavaram	Crab	Occurrence
Shanmugam & Kasinathan	1987	Pichavaram	Mollusc	Biology
Sing & Choudhury	1984	Sunderbans	Hemichordate	Occurrence
	1985	Sunderbans	Hemichordate	Biology
	1992	Sunderbans	Holothuria	New record
	1995a	Sunderbans	Hemichordate	Distribution
	1995b	Sunderbans	Mollusc	Distribution
Sunil Kumar	1995a	Cochin	Major groups	Distribution
	1995b	Cochin	Major groups	Seasonal distribution
	1995c	Cochin	Polychaete	Distribution
	1997	Cochin	Major groups	Vertical distribution
	1998a	Cochin	Major groups	Distribution
	1998b	Cochin	Polychaete	New record
	1999a	Cochin	Mollusc	New record
	1999b	Cochin	Isopod	Occurrence
Sunil Kumar & Antony	1993	Cochin	Polychaete	Occurrence
	1994a	Cochin	Polychaete	Seasonal distribution
	1994b	Cochin	Polychaete	Seasonal distribution
	1994c	Cochin	Polychaete	Distribution
Untawale & Parulekar	1976	Goa	Major Groups	Occurrence

Major groups include the polychaetes, crustaceans and molluscs followed by nemerteans, sipunculids, actinarians etc.

Table 2. Research papers published for Indian mangroves from the soil habitat

Group of Organism	Number of publication	% of papers published
Micro Organisms	24	31.58
Meio Organisms	7	9.21
Macro Organisms	45	59.21
Total	76	

ments (Prabhakaran *et al*., 1987). A total of 25 species of fungi, belonging to 15 genera have been isolated from mangrove soil of Alibag in Maharastra (Nair *et al*., 1991).

Studies on meio organisms

Ali *et al*. (1983) made studies on the composition of nematodes in connection with energy flow of mangrove ecosystem in Pichavaram. Sinha *et al*. (1987) described a new species of nematode from mangrove swamps of Sunderbans. Seventeen stylet bearing nematodes were found in Sunderbans mangrove (Sinha & Choudhary, 1988). Nematodes are the dominant taxon followed by copepodes in South Andaman mangrove sediments; bulk of fauna occur in superficial layers of the sediment (Rao, 1986). The meiofauna comprising nematodes, turbellaria and harpacticoids are being reduced with increasing sedimentation in mangrove of Goa (Ansari *et al*., 1993). Meiofauna of the Bhitarkanika mangrove sediments include 11 major faunal taxa, of which nematodes are the dominant group (Sarma & Wilsanand, 1994). Meiofauna of the mangrove sediments of Thane creek in Maharastra is dominated by nematodes (Goldin *et al*., 1996).

Studies on Macro Organisms

Apart from the investigations on micro and meio organisms, various macrobenthic studies have been made in Indian mangrove environment. These studies include the description, occurrence, distribution and abundance of macro organisms. The most common macro forms of the intertidal mangrove sediments are polychaetes, crustaceans and molluscs. In addition to this, sipunculids, nemerteans, actiniarians, gobiids, hemichordates, holothuriodeans etc. are also found.

Singh and Choudhury (1984) reported the occurrence of hemichordate worm, *Saccoglossus* sp. and after that Singh and Choudhury (1985) studied the breeding and feeding behaviour of this worm from Sunderbans mangrove. Seasonal distribution of *Saccoglossus* sp. has been studied from the mangrove swamps of Sunderbans (Singh & Choudhury, 1995a). Singh and Choudhury (1992) described a new record of holothuroid, *Protankyra similis* from mangrove swamps of Sunderbans.

Molluscan fauna was studied from mangroves of Godavari and Krishna estuarine systems (Radhakrisha & Janakiram, 1975). Nine species belonging to eight genera were found. Pillai and Appukuttan (1980) reported the occurrence of molluscs in the mangroves of Manauli Island, southeastern coast of India.

Molluscan fauna was enlisted from Pichavaram mangroves by Kasinathan and Shanmugam (1985). Ten species belonging to nine genera were recorded. Snail studies conducted include the larval development of salt marsh snail *Melampus ceylonicus* from Pichavaram mangroves by Shanmugam and Kasinathan (1987) and the response of a mangrove mud snail, *Terebralia Palustris*, to the mangrove substratum from Nizampatnam in the Krishna estuarine region by Rambabu *et al.* (1987). *Geloina erosa*, a mangrove clam, has been reported as a new record from west coast of India (Ingole *et al*., 1994). A total of 26 intertidal molluscs have been recorded from mangroves of Sunderbans (Jahan *et al*., 1990). Studies on the distribution of five species of gastropods belonging to five genera were made in a mangrove area of Sunderbans (Singh & Choudhury, 1995b). Occurrence of an infaunal gastropod, *Hydrobia* sp., has been reported from Cochin mangrove sediments and it is a new record from Indo-pacific mangrove areas (Sunil Kumar, 1999a).

The ecology of Tabanid larva and pupae (Diptera) was studied by Ray and Choudhury (1985) from Sunderbans mangrove.

Studies on crab include occurrence and population studies on fiddler crabs (*Uca* spp.) from the mangroves of Sunderbans (Chakraborty & Choudhury, 1985; Charkraborty & Choudhury 1992a); *Myopilumnus andamanicus*, a new genus and a new species of xanthid crab described from mangroves of Andamans (Deb, 1989); Brachyuran crabs of the Pichavaram mangroves by Sethuramalingam & Khan (1991); biological studies on the mud crab *Scylla serata* from the mangrove ecosystem of Andamans by Poovachiranon (1992); and, zonation of brachyuran crabs from Sunderbans mangrove by Chakraborty and Choudhury (1992b). Totally 18 species of crabs belonging to 11 genera were reported. Chandrasekaran and Natarajan (1994) have made studies on the seasonal abundance and distribution of seeds of the mud crab, *Scylla serrata* from Pichavaram mangroves. The occurrence of the wood borer *Sphaeroma* sp. within the mangrove subsoil of Cochin is the first ever report from such a habitat of Indian mangroves (Sunil Kumar, 1999b).

Bhunia and Choudhury (1981), Nandi and Choudhury (1983), Choudhury *et al.* (1984a,b) and Patra *et al.* (1988; 1990) have made studies on the distribution and abundance of major macrobenthic organisms such as polychaetes, crustaceans, molluscs, sipunculids, nemerteans, actinarians etc. from the mangrove ecosystem of Sunderbans. Misra and Choudhury (1985) enlisted the occurrence of 30 species of polychaetes belonging to 24 genera and 13 families from Sunderbans mangroves. Faunal association of intertidal mangrove habitats in Hooghly-Matlah estuary has been studied (Ghosh *et al*., 1990). Untawale and Parulekar (1976) observed the macro faunal production in the mangroves of Goa.

The sea anemone, *Acontiactis gokhaleae*, has been reported as a biofouler in the mangrove mudflats along Thane creek in Maharastra (Mishra *et al*., 1994). Species description of polychaetes, molluscs and sea anemones of the mangrove habitat in Thane creek have been made by Anthalye and Gokhala (1998). Macrobenthic organisms of the mangrove swamps of Bombay were studied by Padmakumar (1984).

Rajagopal *et al.* (1986) reported the occurrence of epifaunal crabs and molluscs from the intertidal area of Cochin mangroves. Studies have been made on the ecological aspects of polychaete fauna from Cochin Mangroves (Sunil Kumar & Antony, 1993; 1994a,b). Thirty-three species belonging to 20 genera under 10 families have been recorded. Sunil Kumar and Antony (1994c) reported the occurrence and distribution of a polychaete worm, *Paraheteromastus tenuis* from Cochin mangroves and considered it as an indicator organism of pollution in the Cochin backwaters. Ecological studies have been made on the macrobenthic organisms like polychaetes, infaunal crustaceans and molluscs and other groups in the Cochin mangrove ecosystem (Sunil Kumar, 1995a,b). Polychaete-sediment interactions were evaluated from the mangrove sediments of Cochin (Sunil Kumar, 1995c). Depth-wise distribution of macro-invertebrates in the intertidal mangrove sediments of Cochin showed that at all three tidal zones macro organisms tended to be concentrated at the top 0-5 cm substratum and they decreased towards deeper levels (Sunil Kumar, 1997). Occurrence and distribution of macrobenthos in a traditional prawn field 'Chemmen Kettu' and adjacent mangroves in Cochin backwaters have been investigated (Sunil Kumar, 1998a). Five polychaetous annelids from Cochin mangroves have been reported as a new record to

Indo-Pacific mangrove region (Sunil Kumar, 1998b).

Inspite of the occurrence, description, distribution and documentation on various groups of soil dwelling organisms from Indian mangroves, principally from Sunderbans of West Bengal, Pichavaram of Tamil Nadu and Cochin of Kerala, and also from Goa, Maharastra and Andaman and Nicobar Islands, information is scanty of biodiversity studies from the mangrove habitats of Gujarat, Karnataka, Andhra Pradesh and Orissa. Mangrove of Andaman and Nicobar Islands are the second largest mangrove ecosystem of India next to Sunderbans, and more studies are required there as well as other least explored mangrove habitat of both west and east coasts of India with reference to biodiversity conservation programmes.

From this review of biodiversity studies, it can be inferred that mangrove soil habitat is biologically rich and provides an unique ecological niche to a variety of soil dwelling organisms. Most of the previous biodiversity studies on soil organisms within mangrove ecosystem are related to macro faunal components as evident from research publications of 59.21 per cent out of total 76 research papers (Table 2). Soil meiofaunal and microbiological aspect contributed 9.21per cent and 31.58 per cent respectively of total research publications. More information is needed primarily on the species composition and diversity of meio and micro organisms of the mangrove ecosystem of Indian subcontinent.

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