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## RESEARCH ARTICLE

### BIODIVERSITY AND CONSERVATION OF MANGROVES OF DEVI RIVER ESTUARY (ODISHA), INDIA

\*<sup>1</sup>Panda, S. P., <sup>2</sup>Mardaraj, P., <sup>3</sup>Subudhi, H. N. and <sup>4</sup>Sahu, A. K.

<sup>1,2</sup>O/o DFO, Mangrove Forest Division (WL), Rajnagar, Kendrapara, Odisha

<sup>3</sup>Crop Improvement Division, CRR1, Cuttack, Odisha

<sup>4</sup>SPMU, ICZMP Odisha, 108 Surya Nagar, Bhubaneswar, Odisha

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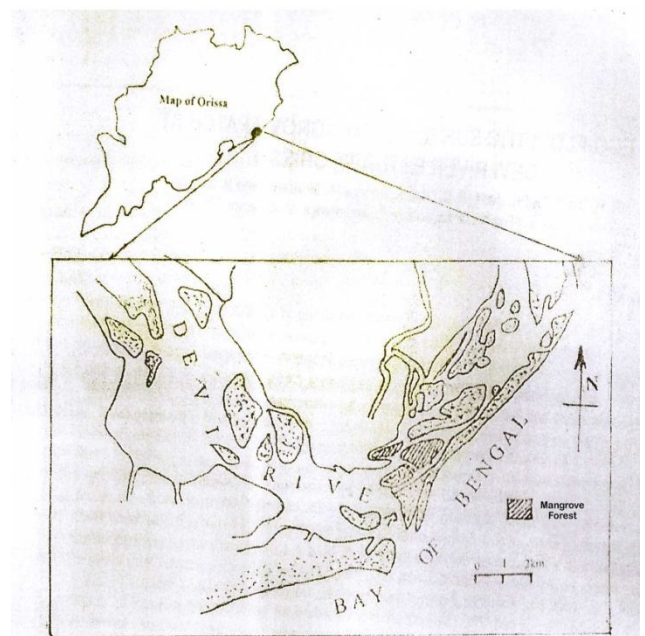
#### ABSTRACT

Devi estuary lying between 86° 04' - 86° 20' E longitude and 19° 45' - 19° 57' N latitude harbours a moderately rich and diverse flora of mangroves. But in the past the species diversity was remarkably high as indicated by Ravishankar *et al.* (2004). 15 exclusive mangrove species (true mangroves) have been reported from this mangrove chunk of Odisha prior to the recent survey. In course of time there is tangible shrinkage of habitat as well as population of mangroves. Some species have already been wiped out, a few are on the verge of extinction and many species have shown very restricted distribution putting them in threatened/ vulnerable/ rare category (Nayar and Sastry, 1987). The depletion of the species is mainly due to severe biotic pressure coupled with other coastal dynamic changes and ecological changes. Mangrove forests are composed of several species having great economic potentialities, which inspire the people to exploit the mangrove forests in an unplanned manner to meet their needs. This causes depletion of species. So, immediate conservation of the mangrove forests are need of the hour. Realising this, the Government of India now emphasizes over the conservation of mangrove vegetation in all the states, where it is present. This aims at the interventions, such as restoration, rehabilitation and conservation of the unique and priceless estuarine ecosystems of the coastal regions. Due to the incessant efforts of the Forest Departments of Odisha in general and Mangrove Forest Division (WL), Rajnagar, Kendrapara in particular under the Integrated Coastal Zone Management Project the rate of depletion has significantly decreased in the Mahanadi delta and Bhitarkanika National Park through large scale mangrove plantations. If these measures will be implemented in the Devi estuary then the depletion of the mangroves can be checked to a large extent. Taking these facts and the un-exploredness of the mangrove flora into account, this communication emphasizes on the floristic composition and conservation of the mangroves.

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#### INTRODUCTION

India harbours about 5% (4461 sq.km) of the world's mangroves (status: Anonymous, 1987) which is 0.14 % of the total land mass of India (Pattnaik *et al.* 2010). About 80 percent, is along the east coast with major concentrations in Odisha, West Bengal and Andaman & Nicobar Islands. About 2,670 sq kms of mangrove formations are located in deltaic regions. In Odisha, the mangroves occur in discontinuous patches along the coast of Balasore, Bhadrak, Jagatsinghpur, Kendrapara, Puri and Ganjam (in part). According to the satellite survey mapping, the mangroves cover from Balasore coast to Puri coast is about an area of 211 sq kms. Samal and Patnaik (1989) reported that in Odisha, the mangroves spread over an area of 214.58 sq km. Out of the total mangrove area of the state, Mahanadi delta covers an area of 120 sq kms alone. But the mangroves of the estuaries of the rivers like Brahmani, Baitarani, Budhabalanga and Devi were not taken into consideration though these regions had rich mangrove forests in the past. Devi estuary in the district of Jagatsinghpur of Odisha lies in between 86° 04' - 86° 20' E longitude and 19° 45' - 19° 57' N latitude constitute a significant mangal formation of the Mahanadi delta (Map.1). In this region a congenial ecosystem of the mangroves and their associates are present. The concentration of the species is more in the Bandar Forest Block towards the mouth of the river Devi. Unlike the other mangrove productive regions of the state, this region also has undergone habitat destruction due to the operation of biotic factors of various categories.



Map.1 Odisha Map Showing Devi River Mouth

So the mangrove forests in the estuary of river Devi are mostly in the denuded state due to reclamation of forest lands for human settlement, paddy cultivation, aquaculture practices and over-exploitation of

\*Corresponding author: Panda, S. P.

O/o DFO, Mangrove Forest Division (WL), Rajnagar, Kendrapara, Odisha

woody elements for various requirements. So it is high time to conserve and restore these rare as well as important life forms from the verge of extinction. Realizing the broad spectrum of utilitarian value of the mangroves a survey programme has been undertaken to study the floristic composition, sociability, distribution pattern and utility of this rare plant community. During this survey 165 angiospermic species, including the mangroves and their associates along with a pteridophytic species have been collected, identified and housed in the herbarium of the Post Graduate Department of Botany, Utkal University, Bhubaneswar.

## METHODOLOGY

Regular field trips were made to different mangrove areas of this region in different seasons in order to study the floristic composition, identification and data collection. The methodology followed is in accordance with Jain and Rao (1977). Special attention was given to distribution, abundance and flowering and fruiting time. The identification and nomenclature of the species have been made upto date with consultation of the modern floras and monographs available.

## RESULT

### (I) PAST BOTANICAL WORK

Haines (1921-1925) the pioneer plant explorer for the state of Bihar and Odisha has given a list of 45 mangroves from Mahanadi delta, fringes of Chilika Lake and Chandipur. Mooney (1950) the subsequent worker made short trips to Mahanadi delta, Jambu, Hukitola, False point and added 12 more taxa to the previous compendium. There after this region remained untouched quite for a long time. However, Rao and Banerjee (1967, 1982), Rao *et al.* (1970), Banerjee and Das (1972), Rao and Shastry (1974) and Banerjee (1986) have carried out ecological studies in the coastal tract of Odisha; especially on the coastal vegetation and made number of new distributional records. Choudhury *et al.* (1991) and Choudhury (1994, 1998, 2001) have highlighted in detail on the diversity and conservational aspects of the mangroves of the Bhitarkanika, Paradeep and Mahanadi delta. Subudhi *et al.* (2002a) have provided an exhaustive list of wetland plants from the coastal tracts of Odisha. The collections were mainly from Paradeep and Mahanadi delta region. Recently Nayak *et al.* (2002), Nayak and Choudhury (2001), Panda *et al.* (2004, 2005b, 2007), Subudhi and Choudhury (1998) and Subudhi *et al.* (2002b, 2006) have studied the mangroves of Mahanadi delta and Odisha coast and their conservation as well as utilization. Panda *et al.* (2005a) have high-lightened the socio-economic importance of some of the mangroves of the Devi estuary. Mandal *et al.* (2008) carried out some eco-floristic studies on only 14 mangrove species of Devi estuary. From these, it is quite clear and understandable that due attention was not given to scientific study and management of mangrove forests of Odisha in general and Devi estuary in particular. So, the work done so far emphasizes on the need for a detailed floristic and vegetation survey of the mangroves of the Devi estuary.

### (II) TOPOGRAPHY

The altitude of the mangrove swamps of Devi estuary (delta) is equal to the MSL. The mangrove harbouring delta of Devi appears as a basin due to the ridges in the periphery and gradual sloping of the core region. Soil erosion is quite a regular phenomenon; deposition of new silts occurs in the opposite side of the eroded land. The maximum tidal height reaches up to 5 mts above the MSL.

### (a) GEOLOGY

The geology of the Devi estuary is of coastal alluvium type. These are the recent sediments belonging to Holocene age, produced by depositions from riverine, marine and aeolian forces. Winds play a pivotal role in delta building in the sub-aerial and sub-marine

environments in the Odisha coast. Due to this river bed and river bank dunes, beach dunes are developed. The coastal waves, tides and littoral drift act together with the sediment influx and build a beach. During the tides, suspended fine sediments are carried from the coast into the inland areas and deposited in different type of sub-environments giving rise to tidal flats and tidal swamps etc. This fine soft sediment and salt water swamps often give rise to the unique vegetation of mangroves. In brief, the wave deposited sediments produce beaches and beach dunes, where as tidal sediment depositions produce tidal flats and tidal swamps as well.

### (b) SOILS

The deltaic alluvium is of finely clay texture. The deltaic soils are formed from transported materials brought from catchments by rivers. In the coastal zone, the wave energy depositions give rise to coarser and permeable soil where as in tidal conditions very fine grained saline soils are found. The deltaic periphery is characterized by lateritic residual soils formed by the weathering of the country rocks. In the beaches, river channels and in Aeolian dunes coarse sandy soils are met-with. Coarse loamy soils are the characteristics of the upper flood plains and levees. Fine loamy soils are found in lower flood plains, where as clayey soils and organic soils are found in the axial parts of tidal flats and tidal swamps. However, the surface soil consists of silt loam or clay loam. Presence of other organic-compounds and humus varies from estuaries to fringes of water bodies. The soil types in the vicinity of sea shore are mostly sandy in nature often mixed with clay. Hard lateritic and red loam soils are associated with hill slopes or rocky zones. Alluvial soils mixed with sands are found along the river beds.

### (c) CLIMATE

The climate is tropical monsoonal in nature.

#### (i) Temperature

This region mostly enjoys 3 distinct seasons in the year such as Summer, Rainy and Winter. The hot season commences from March when the temperature begins to rise and May is the hottest month when temperature varies from 35-42°C. With the onset of monsoon i.e. in the late June, temperature decreases appreciably. During the South-west monsoon, the days are cooler and the temperature ranges from 25-30° C. After withdrawal of monsoon by the 1<sup>st</sup> week of October, the temperature of both days and nights decreases steadily. December is the coldest month when temperature ranges from 15-20° C.

#### (ii) Rainfall

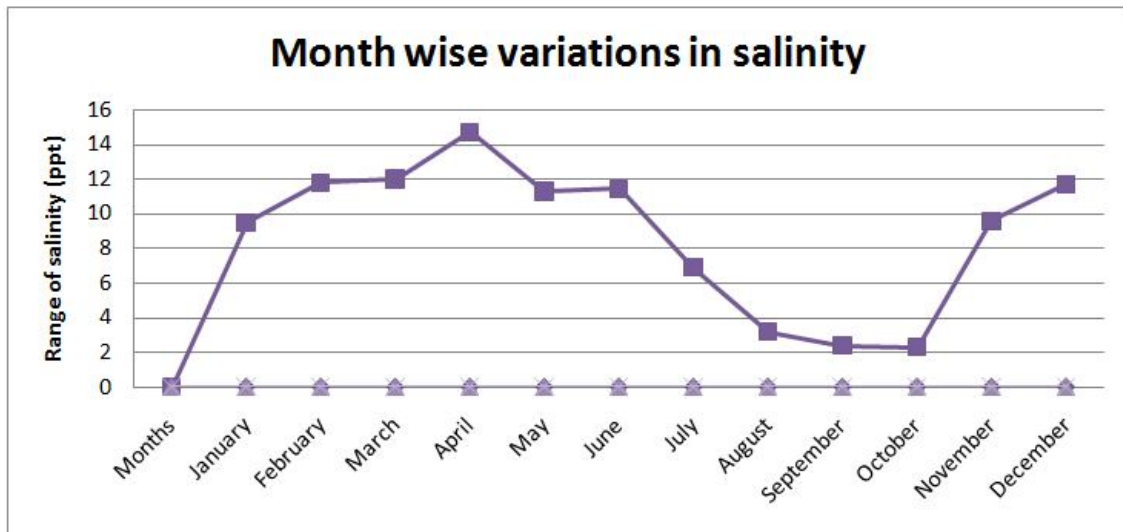
This zone receives an average annual rainfall of 137.75 cm. per year. Maximum rainfall occurs in the month of July-October. Sometimes pre-monsoonal rain prevails during April – June. Some amount of rainfall is received during winter by North-East monsoon.

#### (iii) Humidity

Humidity is maximum in the month of November to January. Then it drops off gradually towards the month of June.

### (III) FLORISTIC COMPOSITION

The mangrove forests of Devi estuary exhibit high magnitude of degradation resulting in only shrubby elements and at places a few trees (Fig.6). Sporadic occurrence of *Avicennia officinalis*, *Sonneratia apetala* indicate the antiquity of mangrove forests extent in this region. The species of the top canopy are *Rhizophora apiculata*, *Rhizophora mucronata*, *Ceriops decandra*, *Avicennia marina*, *Bruguiera cylindrica*, *Kandelia candel* and *Sonneratia apetala* etc. These species are found commonly towards the fringes of creeks and



channels where salinity is higher. *Excoecaria agallocha* and *Dalbergia spinosa* occur in less abundance in this region. Besides these, *Pongamia pinnata*, an element of deciduous forest is quite common in these mangrove forests.



Plate 1. *Acanthus ilicifolius*

The bushy shrubs growing in drier areas near the creek and channels are *Acanthus ilicifolius* (Fig.1), *Aegiceras corniculatum*, *Aegialitis rotundifolia*, *Clerodendrum inerme* and *Phoenix paludosa* etc. *Hibiscus tiliaceus* and *Phoenix paludosa* (Fig.3) are also occur in the drier regions, where the soil is mostly clayey. In the elevated dry



Plate 2. *Acrostichum aureum*



Plate 3. *Phoenix paludosa*

areas *Eugenia bracteata* is quite common. *Cyperus malaccensis* and *Myriostachya wightiana* are generally gregarious in the mudflats enjoying the full tidal inundation. *Porteresia coarctata* is also found in similar habitats. The ground flora is composed of species like *Synostemon bacciformis*, *Suaeda maritima*, *Suaeda nudiflora* (Fig.4),



Plate 4. *Suaeda nudiflora*

*Fimbristylis ferruginea*, *Sphaeranthus africanus* and *Desmodium triflorum* etc. Pure formations of *Paspalum vaginatum* along with *Fimbristylis ferruginea* are observed which are used as fodder and act as good soil binder/soil stabilizer. Among the climbers / twiners of

this region *Derris trifoliata*, *Derris scandens*, *Finlaysonia obovata*, *Ipomoea macrantha* are worth mentioning. In the drier and sandy regions *Atylosia scaraboides*, *Caesalpinia bonduc*, *Caesalpinia crista*, *Toddalia asiatica* are commonly met with in association with the mangroves. The sand dune vegetation comprises of the species like *Bulbostylis barbata*, *Cyperus arenarius*, *Hydrophylax maritima*, *Indigofera nummularifolia*, *Ipomoea pes-caprae*, *Launaea sermentosa*, *Phyllanthus rotundifolia*, *Pedaliium murex*, *Portulaca pilosa* subsp. *pilosa*, *Sesuvium portulacastrum*, *Solanum trilobatum* (Fig. 5),



Plate 5. *Solanum trilobatum*

*Spinifex littoreus* etc. Above these *Tamarix troupii* and the single pteridophytic species i.e. *Acrostichum aureum* (Fig.2) are also found abundantly. A single representative of the species *Erythrina fusca* a member of Fabaceae is observed on the bank away from the river mouth where there is no tidal inundation and salinity is very low.



Fig.6. Denuded mangrove forests of Devi estuary

### Distribution of Mangroves

The mangrove ecosystems of the river Devi is located in the southern most part of Mahanadi delta. These mangrove area comes under Kujang Range of Rajnagar Mangrove Forest Division (WL), Kendrapara. The mangroves are distributed in the three protected forest areas. The mangrove forests luxuriant in the protected forests along the creeks of Boruan nadi of Batikolia estuary.

Name of the protected forest Area in ha.

Bandar Forest Block 700.00 ha.

Boruan Forest Block 274.08 ha.

Salio Forest Block 41.60 ha.

### (a) Salio Forest Block

The mangroves of this forest area are mainly confined to the river bank of Batikolia and in the islet of Kajolpota. The notable species of this area are *Phoenix paludosa*, *Myriostachya wightiana*, *Acanthus ilicifolius*, *Aegiceras corniculatum*, *Ceriops decandra*, *Derris trifoliata*, *Dalbergia spinosa*, *Avicennia alba*, *Excoecaria agallocha*, *Caesalpinia nuga*, *Suaeda maritima*, *S. nudiflora*, *Sesuvium portulacastrum* and *Fimbristylis ferruginea*. In the river bank *Phoenix paludosa* is dominant where as *Acanthus ilicifolius* is dominant as well as found in homogenous patches in the islet.

### (b) Boruan Forest Block

This is a forest area of degraded mangroves comprising of the species like *Phoenix paludosa*, *Avicennia officinalis*, *Excoecaria agallocha*, *Ceriops decandra*, *Aegialitis rotundifolia*, *Aegiceras corniculatum*, *Acanthus ilicifolius*, *Kandelia candel*. The mangroves are mainly concentrated in the Nendhera region.

### (c) Bandar Forest Block

Out of the 3, forest blocks this block is endowed with rich and diverse mangrove flora. The forests are mainly confined to the regions of Dhanuharbelari, Sahebdia, Khakrapadia, Nadiakhia, Adipal and Subhiadia. The mangrove ecosystem of this region is comprised of the species like *Cyperus malaccensis*, *Fimbristylis ferruginea*, *Ipomoea pescaprae*, *Carissa spinarum*, *Opuntia stricta*, *Pandanus tectorius*, *Eugenia bracteata*, *Porteresia coarctata*, *Sonneratia apetala*, *Phoenix paludosa*, *Avicennia alba*, *A. marina*, *Excoecaria agallocha*, *Ceriops decandra*, *Bruguiera cylindrica*, *Aegiceras corniculatum*, *Acanthus ilicifolius* etc. *Rhizophora apiculata* is mostly found in Sukhiadia only. The pteridophytic representative *Acrostichum aureum* is also found abundantly in this forest areas, the leaves of which are preferred by the salt water crocodiles to lay their eggs by making nests.

### Phenology of Flowering

During the survey attentions were paid to observe the flowering and fruiting time of the mangrove taxa extant in this river estuary. The phenological information of the mangrove species were enlisted in the below given table along with their habit and classification (Ghosh *et al.* 2003).

### Vegetational Analysis

The mangrove forests of Devi estuary are moderately rich and diverse. A total of 55 mangrove species including associates and sand dune species belonging to 47 genera and 30 families have been observed in luxuriance. Out of these, 13 are true mangroves 13 associates and 13 are fall under the back mangrove and 16 sand dune/beach flora categories respectively. The vegetation of Devi river delta is broadly of estuarine type.

### Estuarine Vegetation

This is a unique and typical type of vegetation especially found in river deltas, where there is admixture of river water and sea water. In the coastal region of Orissa, estuarine vegetation is commonly met-with in the river deltas of Budhabalanga, Brahmani, Baitarani, Subarnarekha, Mahanadi and Devi. The vegetation in the river estuary of Brahmani and Baitarani is very rich and gregarious due to the enforcement of wildlife protection act, since of its declaration as sanctuary in 1974. But the vegetation in the Mahanadi delta are in denuded state due to construction of Paradeep Port (1965) and Paradeep Phosphate factory, construction of residential complexes. Generally this type of vegetation can be classified into 4 sub-categories.

- (i) Eumangal
- (ii) Semi-mangal
- (iii) Transition mangal
- (iv) Salt bush formation

Table 1. Flowering calendar of mangroves along with their classification

Name of the species	Family	Flowering-Fruiting Period	Habit	Classification (TM/MA/BM/BF)
<i>Acanthus ilicifolius</i> L.	Acanthaceae	March-June	Shrub	MA
<i>Acrostichum aureum</i> L.	Polypodiaceae	-----	Herb	MA
<i>Aegialitis rotundifolia</i> Roxb.	Plumbaginaceae	November-May	Tree	TM
<i>Aegiceras corniculatum</i> (L.) Blanco.	Myrsinaceae	November-July	Tree	TM
<i>Alternanthera paronychioides</i> St. Hill.	Amaranthaceae	February-April	Herb	BM
<i>Atylosia scaraboides</i> (L.) Benth.	Fabaceae	August-December	Herb	BM
<i>Avicennia marina</i> (Forssk.) Vierh.	Avicenniaceae	February-June	Tree	TM
<i>Avicennia officinalis</i> L.	Avicenniaceae	March-July	Tree	TM
<i>Bruguiera cylindrica</i> (L.) Bl.	Rhizophoraceae	January-May	Tree	TM
<i>Bulbostylis barbata</i>	Cyperaceae	July-December	Herb	BF
<i>Caesalpinia bonduc</i> (L.) Roxb.	Caesalpinaceae	August-February	Climber	BM
<i>Caesalpinia crista</i> L.	Caesalpinaceae	January-May	Climber	BM
<i>Carisa spinarum</i> A. DC.	Apocynaceae	March-December	Shrubs	BF
<i>Ceriops decandra</i> (Griff.) Ding.-Hou.	Rhizophoraceae	January-June	Tree	TM
<i>Clerodendrum inerme</i> Gaertn.	Verbenaceae	April-December	Climber	MA
<i>Cyperus arenarius</i> Retz.	Cyperaceae	January-May	Herb	BF
<i>Cyperus malaccensis</i> Lamk.	Cyperaceae	January-May	Herb	BF
<i>Dalbergia spinosa</i> Roxb.	Fabaceae	April-October	Shrub	MA
<i>Derris scandens</i> (Roxb.) Benth.	Fabaceae	July-December	Climber	MA
<i>Derris trifoliata</i> Lour.	Fabaceae	February-June	Climber	MA
<i>Desmodium triflorum</i> (L.) DC.	Fabaceae	September-January	Herb	BF
<i>Erythrina fusca</i> Lour.	Fabaceae	March-May	Tree	BM
<i>Eugenia bracteata</i> (Willd.) Roxb. ex DC.	Myrtaceae	November-February	Shrubs	BF
<i>Excoecaria agallocha</i> L.	Euphorbiaceae	March-June	Tree	TM
<i>Fimbristylis ferruginea</i> (L.) Vahl	Cyperaceae	April-September	Herb	BF
<i>Finlaysonia obovata</i> Wall.	Asclepiadaceae	November-April	Shrub	BM
<i>Hibiscus tiliaceus</i> L.	Malvaceae	January-June	Tree	BM
<i>Hydrophylax maritima</i> L.f.	Rubiaceae	June-December	Herb	BF
<i>Indigofera nummulariifolia</i> (L.) Livera ex Alston	Fabaceae	October-January	Herb	BF
<i>Ipomoea macrantha</i> Roem. & Schult.	Convolvulaceae	January-March	Climber	BF
<i>Ipomoea pes-caprae</i> (L.) R. Br.	Convolvulaceae	Throughout the year	Climber	BF
<i>Kandelia candel</i> (L.) Druce	Rhizophoraceae	All around the year	Tree	TM
<i>Launaea sarmentosa</i> (Willd.) Schultz-Bip. ex Kuntze	Asteraceae	April-August	Herb	BF
<i>Myriostachya wightiana</i> (Nees ex Steud.) Hook.f.	Poaceae	June-December	Herb	MA
<i>Pandanus foetidus</i> Roxb.	Pandanaceae	November-June	Shrub	BM
<i>Paspalum vaginatum</i> Sw.	Poaceae	January-April	Herb	BF
<i>Pedaliium murex</i>	Pedaliaceae	August-January	Herb	BF
<i>Phoenix paludosa</i> Roxb.	Arecaceae	March-July	Shrub	TM
<i>Phyllanthus rotundifolia</i>	Euphorbiaceae	September-March	Herb	BF
<i>Pongamia pinnata</i> (L.) Pierre	Fabaceae	July-February	Tree	BM
<i>Porteresia coarctata</i> (Roxb.) Tateoka	Poaceae	August-January	Herb	MA
<i>Portulaca pilosa</i> L. subsp. <i>pilosa</i> Geesink	Portulacaceae	July-October	Herb	BF
<i>Rhizophora apiculata</i> Bl.	Rhizophoraceae	April-June	Tree	TM
<i>Rhizophora mucronata</i> Poir.	Rhizophoraceae	April-June	Tree	TM
<i>Saccharum spontaneum</i> L.	Poaceae	August-November	Herb	BF
<i>Sesuvium portulacastrum</i> (L.) L.	Aizoaceae	January-May	Herb	MA
<i>Solanum trilobatum</i> L.	Solanaceae	May-March	Shrub	BM
<i>Sonneratia apetala</i> Buch.-Ham.	Sonneratiaceae	February-May	Tree	TM
<i>Sphaeranthus africanus</i> L.	Asteraceae	November-February	Herb	BF
<i>Spinifex littoreus</i> (Burm.f.) Merr.	Poaceae	August-December	Herb	BF
<i>Suaeda maritima</i> (L.) Dumort.	Chenopodiaceae	February-May	Herb	MA
<i>Suaeda nudiflora</i> Roxb.	Chenopodiaceae	April-August	Herb	MA
<i>Synostemon bacciformis</i> (L.) Webst.	Euphorbiaceae	July-January	Herb	BM
<i>Tamarix troupii</i> Hole	Tamaricaceae	August-November	Tree	BM
<i>Toddalia asiatica</i> (L.) Lamk.	Rutaceae	July-November	Herb	BM

(Note: TM- True Mangroves; MA- Mangrove Associates; BM- Back Mangroves; BF- Beach Flora)

### (i) Eumangal

The species of this category are considered as true mangroves having pneumatophores, vivipary, buttresses. The species can also withstand water logging and high salinity. These taxa are having stilt root, pneumatophores and buttresses. The species viz. *Rhizophora apiculata*, *Rhizophora mucronata*, *Avicennia marina*, *Avicennia officinalis*, *Aegiceras corniculatum*, *Ceriops decandra*, *Kandelia candel*, *Sonneratia apetala* etc. are under this category. *Avicennia officinalis* is found as a dominant element in the bank of other creeks and channels. *Rhizophora* community gives a distinctive appearance due to their profuse knee roots, which remain partially inside water during tide. *Porteresia coarctata* and *Myriostachya wightiana* grow luxuriantly in the Eumangal zone near the creeks and channels having very high salinity and check soil erosion.

### (ii) Semi-mangal

The elements of this group show different type of adaptations. In many cases the species lack pneumatophores and vivipary. These species can grow in less salinity. Notable elements of this category are *Bruguiera cylindrica*, *Excoecaria agallocha*, *Tamarix troupii* etc. The ground flora is very poor in respect of species composition. The species viz. *Myriostachya wightiana*, *Cyperus malaccensis*, *Suaeda maritima*, *Suaeda nudiflora*, *Sesuvium portulacastrum* are found in homogenous patches in the mudflats. *Fimbristylis ferruginea* is observed in the drier parts. Significant climbers of this region are *Derris trifoliata*, *Dalbergia spinosa*, *Finlaysonia obovata* etc. *Excoecaria agallocha* is found less abundantly in the fringes of creeks and channels. On the contrary, this taxa are found almost in pure formation in the drier and elevated areas.

**(iii) Transition mangal**

The species of this category exhibit some features of halophytes but they are well adapted to terrestrial habitats. Some of these are evergreen while others are deciduous. These species colonise in the areas, where there is no tidal flow. The species are *Hibiscus tiliaceus*, *Excoecaria agallocha*, *Phoenix paludosa*, *Dalbergia spinosa*, *Aegialitis rotundifolia* etc. Notable twiner of this region is *Derris scandens*. In the drier regions *Toddalia asiatica* is observed. *Hibiscus tiliaceus* is found in the vicinity of the water bodies in association with other taxa. In similar habitat *Clerodendrum inerme*, *Phoenix paludosa*, *Tamarix troupis* are found. Saline water occasionally floods these areas. Along the fringes of the defuncted creeks usually thickets of *Acanthus ilicifolius* in association with *Caesalpinia crista*, *Acrostichum aureum* (Mangrove fern), *Phoenix paludosa* form ideal niche. *Pandanus foetidus* is also occasionally met-with in similar habitats forming thick patches. Besides these, *Pongamia pinnata*, a deciduous element is also found in abundance away from the water bodies.

**(iv) Salt-bush Formation**

Along the littoral tracts, the scattered sand dunes as well as sand bars mostly sustain xeric herbs, of which extensive patches of *Ipomoea pes-caprae* deserves special mention. Other common xeric elements are *Bulbostylis barbata*, *Cyperus arenarius*, *Sesuvium portulacastrum*, *Pedaliium murex*. These elements act as sand binders as well as sand stabilizers. Soil erosion is considerably checked by the extensive spread of these species. *Ipomoea pes-caprae*, *Hydrophylax maritima* mostly cover the ground. The herbaceous flora mainly consists of the species like *Bulbostylis barbata*, *Launaea sarmentosa*, *Spinifex littoreus*, *Cyperus arenarius*, *Pedaliium murex* etc.

**Statistical Analysis**

During the present survey programme a total of 54 Angiospermic mangrove species (including associates) and a single pteridophytic mangrove associate species (fern) under 48 genera belonging to 30 families have been collected. Out of 54 species, 45 species of dicot species are distributed under 39 genera belonging to 27 families, while 09 monocot species spread over 08 genera under 02 families. A single species of mangrove associate fern was observed under the Polypodiaceae family. It is interesting to note that all the species of monocots are sedges and grasses. The approximate ratio of monocot and dicot species is 1:5. So it indicates that dicots are represented by five times more than the monocots, which is represented in the Table-2. Out of total 29 families, 20 families are represented by single species. Fabaceae is the first dominant family followed by Poaceae, Rhizophoraceae and Cyperaceae. Among the mangrove families Rhizophoraceae is the dominant family comprising of 5 true mangrove species under 4 genera.

**Table 2. Percentage of families, genera and species of dicots and monocots**

Groups	Families		Genera		Species	
	No.	%	No.	%	No.	%
Dicotyledones	27	93.1	39	82.87	45	83.33
Monocotyledones	02	06.89	08	17.02	09	16.66

Note: Excluding the fern species under the pteridophytic family Polypodiaceae

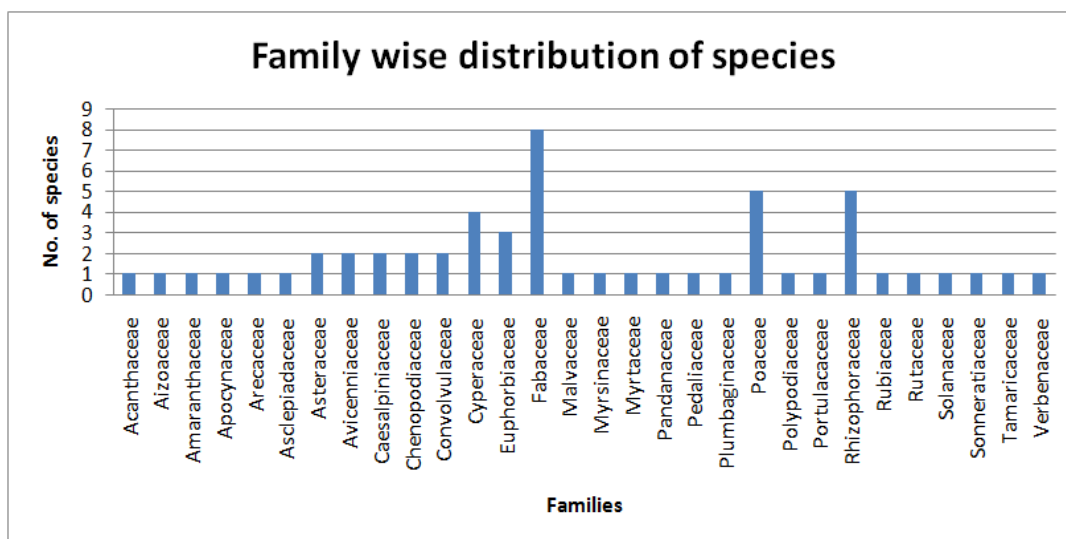
**Observations:** The rare species such as *Cerbera manghas*, *Heritiera fomes*, *Xylocarpus granatum*, *Bruguiera parviflora*, *Ipomoea campanulata*, *Intsia bijuga* and *Mucuna gigantea* which are present in Bhitarkanika National Park are totally absent in this region. Over and above mangrove species like *Heritiera littoralis*, *Bruguiera parviflora* are also not found in this region. Ravishankar *et al.* (2004) of M.S. Swaminathan Research Foundation reported 15 exclusive mangrove species from the Devi mouth wetlands. But during the current explorations the earlier recorded mangrove species like *Heritiera fomes*, *Lumnitzera racemosa*, *Avicennia alba* and *Bruguiera gymnorhiza* by the team of M.S. Swaminathan could not be relocated. A single plant of *Erythrina fusca* was observed away from the river mouth. This is an associate species of mangroves. In Odisha this species is a cultivated one (Saxena and Brahmam, 1994-96). The disappearance of the species may be due to severe anthropogenic pressure leading to large scale habitat destruction of the mangroves. Large areas under mangrove vegetation has been reclaimed by the immigrants for paddy cultivation and their settlement as well. In these areas only *Acanthus ilicifolius* is found as a remnant of the past vegetation. Most of the species exhibit stunted growth due to microclimatic changes and anthropogenic interferences.

**Table 3. List of rare/ threatened/ vulnerable species**

Name of the species	Family	Habit	Status
<i>Aegialitis rotundifolia</i> Roxb.	Plumbaginaceae	Tree	Vulnerable
<i>Avicennia marina</i> (Forssk.) Vierh.	Avicenniaceae	Tree	Threatened
<i>Erythrina fusca</i> Lour.	Fabaceae	Tree	Rare
<i>Ipomoea macrantha</i> Roem. & Schult.	Convolvulaceae	Climber	Rare

**CONSERVATION**

Though the mangrove forests play a crucial role in the day to day life of the local inhabitants and also provide security to them from different environmental hazards like resistance against oceanic cyclones, check soil erosion, rapid encroachment of sea and provide breeding ground for various types of fish and water fowls has undergone extinction. These forests have a great significance in the socio-economic upliftment of the state. Realizing this Government of India as well as the State Government now emphasizes on its conservation. In the first phase large scale mangrove plantations were under taken by jointly by the Mangrove Forest Division (WL),



Rajnagar, NGOs (Non Governmental Organisations) and EDC (Eco Development Clubs) in the Mahanadi delta region and Bhitarkanika National Park under the World Bank funded Integrated Coastal Zone Management Project (ICZMP). In this connection sites for conservation and plantation have been selected and mangrove species are also screened on priority basis to impart immediate conservation due to their lean populations. A bright example of this programme is the MPCA (Medicinal Plant Conservation Area) which has been established in the Kansaridia Forest Block of Mahanadi delta in order to conserve as well as to increase the population density of *Xylocarpus granatum* along with some other valuable species of mangroves as well by considering their rapid depletion. For mangrove plantations under ICZMP, seedlings of mangroves including their associates were raised in several nurseries of the Mangrove Forest Division (WL), Rajnagar, Odisha. Now efforts were made to identify sites having mangrove forest coverage of a minimum size of at least 10 ha. to be declared as field gene banks on the basis of mangrove species richness and diversity. This is a significant effort for the conservation and restoration of this rare productive ecosystem of the mangroves. Similar steps should be under taken on priority basis in the Devi estuary region to check the genetic erosion as well as for restoration of degraded mangrove areas. But all these are not adequate to prevent or conserve these rare plant communities from the verge of extinction. So, for immediate as well as effective conservation of this forest ecosystem involvement of the local inhabitants is very vital. Side by side the local people should be well aware of the serviceable value of the mangrove species and their scientific as well as judicious exploitation. So far as management strategies are concerned, the mangrove forests should be prohibited from human interferences by declaring "sanctuaries". Pisciculture activities should be discouraged. Large scale afforestations should be under taken in denuded mangrove areas. Adequate protection should be given to mangrove juveniles, which will result in restoration of mangrove vegetation. *In-situ vis-à-vis ex-situ* way of conservation strategies should be undertaken to conserve the mangrove forests in general and rare / endangered species in particular.

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