# Seshaiyana

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**Indian estuaries, mangroves, coral reefs and lagoons**

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**Instructions to authors**

We welcome research and popular articles, notes, news, snippets and cartoons or any scientific information on our core subjects—estuaries, mangroves, coral reefs and lagoons in and around Indian waters.

The articles should not exceed five typed pages in double space.

Figures should be clear for good reproduction.

References should be limited and cited in the text by name and year. *Council of Science Editors Style* may be referred to for listing references at the end.

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We invite comments, suggestions and constructive criticism on *Seshaiyana* from the authors and readers.

## *Dear readers,*

*We are meeting you little differently this time by presenting five articles.*

*First two articles bear information on Manakkudy estuary which is situated almost at the southern most tip of the peninsular India and has connection with the Arabian Sea. From these articles, it appears that this estuary has many interesting and unexplored ecological and biological facts, which, we hope, will draw the attention of ecologists.*

*Third article presents the available basic information on the mangroves of Sundarbans, north-east coast of our country, in the form of tables.*

*Fourth article provides an idea about a few features of the three mangrove species of the genus* Sonneratia *from Maharashtra coast.*

*Fifth article, in Q&A format, would certainly attract aquarists and aquaculturists with its many scientific facts on clownfishes, their ornamental value and the possibility of breeding them under captive conditions—with attractive colour photos. By simply contacting the corresponding author of this article, anybody would be able to buy these clownfishes easily for their aquaria or, if they are interested, they can learn the technology of breeding them under captive conditions, sell the young ones to the aquarists and earn money.*

*Please help us to help you and others by sending us your valuable comments and suggestions about our newsletter.*

***Prof. T. Balasubramanian***
***Prof. S. Ajmal Khan***

## Hi there everybody!

Do you know who am I, carrying the page numbers for this issue of *Seshaiyana*?

I am a subadult male, and my name is *Amphiprion percula*. I am about eight months old and my length is *ca* 5 cm. I may become a female depending on the size and behaviour of my partner(s). I may become sexually mature (either stay as a male or become a female—protandrous hermaphrodite) within a month or two.

People say that I am very attractive to look at and mesmerize you all, with my pleasant orange coloured body and the white bands bordered by black lines to add more beauty to me. My rounded fins, snout and my colours make me look doll-like and a damsel.

I may cost about Rs. 800 at this size. But if you buy me with one of my partners, you only have to pay Rs. 1500, for both of us together.

Now, I am going to surprise you by saying that you can look at my beautiful parents too in this issue. They are at the inside back cover of this issue.

I and my parents are in the hatchery of CAS in Marine Biology, Annamalai University, at Parangipettai, but in different tanks.

Hope, you will enjoy knowing more about us by reading this issue, also by looking at our photos.

While most of the creatures on the earth, like me, make you, the human beings, very happy, I don't see you all caring to know and realize the importance of our existence. Why? Will you be able to satisfy me with your answer?

Thanks for listening to me patiently!

I cordially wish you all 'Happy New Year' (2010)!

**Your friend**
***Amphiprion percula***

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## Disclaimer

# Diversity of fauna associated with four different species of seaweeds of Manakkudy estuary

## Introduction

The innumerable species of animals associated with algae and other intertidal plants form a major group known as phytal fauna (Thomson, 1878). The seaweeds of tropical estuaries support diversified biota. They provide shelter and protection to phytal fauna from severe wave action, predation and desiccation, thereby functioning as an ideal habitat with abundant supply of food of animal origin (Mohan Joseph, 1978a). Further, the seaweeds serve as a breeding and feeding ground for phytal fauna, especially for the juveniles of the commercially important fishes. The importance of phytal fauna in the food chain of marine ecosystem especially in littoral region is well understood (Yogamoorthy, 1982). In this backdrop, the present study was undertaken to find out the species composition of phytal fauna of Manakkudy estuary.

## Materials and methods

The present study was carried out on the diversity of phytal fauna of the mangrove afforested area situated in the gradient zone of Manakkudy estuary. A quadrate (25 $cm^2$) was used for sampling; the seaweeds and other organisms present within the quadrate were collected. Four species of seaweeds have been identified using the key of Umamaheswara Rao (1987): *Chaetomorpha aerea*, *Enteromorpha compressa*, *Gracilaria verrucosa* and *Hypnea musciformis*. The collection of fauna associated with the seaweeds was carried out following the procedure advocated by Sarma and Ganapati (1972), and they were identified using the manual of Kathiresan (2000). The quantitative data on phytal fauna are expressed in terms of average number of animals per 100 g of alga.

## Results and discussion

Among the nine groups of phytal fauna observed, harpacticoids ranked first in abundance followed by amphipods, molluscs, foraminiferans, tanaidaceans, decapods, polychaetes, nematodes and isopods. The range, mean and number of months of occurrence of each species of fauna are provided in Table 1.

The mean values (number of animals/100 g of alga) of the phytal fauna associated with the four species of seaweeds of the Manakkudy estuary increased in the following order:

*E. compressa* → *C. aerea* → *H. musciformis* → *G. verrucosa*

(227.25 no./100 g) (300.75 no./100 g) (451.51 no./100 g) (452.50 no./100 g)

Among the four seaweeds *G. verrucosa* was observed to support the highest mean density of phytal fauna. Yogamoorthi (1982) observed the amphipods, harpacticoides, nematodes and ostracods to dominate in the phytal faunal composition in *G. verrucosa* occurring in Vellar estuary. In the present study, harpacticoides, amphipods, molluscs and tanaidaceans were found to be more abundant.

An important observation made in the present study was that harpacticoid copepods contributed the highest percentage of phytal fauna in all the four seaweeds occurring in the Manakkudy estuary. Most of the harpacticoides living in seaweeds are herbivores and feed on unicellular algae which grow on seaweeds (Mohan Joseph, 1978b). Gopalan and Sree Kumaran Nair (1975) reported that harpacticoides associated with the weed mat were numerically the most abundant group in Cochin backwaters—but that is on a different species of seaweed, *Salvinia auriculata*.

Amphipods ranked next to harpacticoides. Among the four species of seaweeds, the highest abundance of amphipods per 100 g alga was recorded in *C. aerea* (73) followed by *G. verrucosa* (70.08).

The highest number of molluscs was recorded in *G. verrucosa* (48) followed by *C. aerea* (36.08), *H. musciformis* (30.75) and *E. compressa* (18.67). Among molluscs, the gastropod *Stenothyra blanfordiana* was observed to be dominant over other species in all the four seaweed species investigated. Gastropods found associated with the seaweeds were scavengers or detritus feeders and few were algivores (Mohan Joseph, 1978b). The foraminiferans such as *Elphidium* sp. and *Globigerina* sp. were found to be more abundant in *C. aerea* (42).

In the case of nematodes, the highest mean value was recorded in *H. musciformis* (13.5) followed by *C. aerea*, *G. verrucosa* and *E. compressa*. The highest number of nematodes recorded in *H. musciformis* could be attributed to the structure of the thallus which retains more sediment and in turn harbours nematodes (Sarma and Ganapati, 1972).

The highest mean value of decapods was recorded in *G. verrucosa* (18) and *Penaeus indicus* was observed to be dominant over the seven other species of shrimps recorded in Manakkudy estuary.

The highest annual mean population of polychaetes was recorded in *G. verrucosa* (13.75), and *Perinereis cultrifera* was dominant in *C. aerea* and *E. compressa* whereas *Dendronereis aestuarina* occurred in plenty in *G. verrucosa* and *H. musciformis*. Sarma and Ganapati (1975) found *P. cultifera* to be associated with *E. compressa* and *Ulva fasciata* in Visakhapatnam harbour buoys.

The isopod was represented by the genus *Sphaeroma* and it was found to be associated with all the four seaweed species. The mean abundance of this species was found to be the highest in *C. aerea* (12.67).

The group Tanaidacea was represented by a single species, i.e., *Apseudes gymnophobia* and the mean abundance of this species was found to be the highest in *G. verrucosa*.

## Conclusions

- Due to the fact that the copepods (harpacticoides) are the ideal food organisms for many commercially important fishes, their abundance in Manakkudy estuary may mean higher productivity in the estuary. The seaweeds appear to be responsible for the abundance of copepods; they provide the habitat for unicellular algae on which the copepods feed.

**Table 1. Phytal fauna (number of animals/100 g alga) associated with four different seaweed species of Manakkudy estuary**

| S. No. | Species | *C. aerea* | | | *E. compres* | | | *G. verrucosa* | | | *H. musciformis* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Range | Mean | No.[a] | Range | Mean | No.[a] | Range | Mean | No.[a] | Range | Mean | No.[a] |
| | **Amphipods** | **30–182** | **73.0** | **11** | **27–172** | **55.75** | **11** | **28–150** | **70.08** | **11** | **24–120** | **51.75** | **11** |
| 1 | *Gradidierella bonnieroides* | 0–36 | 11.58 | 9 | 0–20 | 6.08 | 6 | 0–30 | 7.84 | 5 | 0–25 | 5.52 | 4 |
| 2 | *G. macronyx* | 0–15 | 5.33 | 6 | 0–6 | 0.92 | 2 | 0–8 | 2.0 | 3 | 0–16 | 1.83 | 2 |
| 3 | *G. megnae* | 0–20 | 4.67 | 4 | 0–10 | 2.17 | 3 | 0–20 | 6.92 | 6 | 0–11 | 3.17 | 4 |
| 4 | *G. gravipes* | 0–20 | 11.08 | 9 | 0–20 | 5.08 | 5 | 0–18 | 7.08 | 7 | 0–15 | 5.33 | 6 |
| 5 | *Gammaropsis esturinus* | 0–25 | 3.92 | 3 | 0–13 | 4.92 | 6 | 0–11 | 1.75 | 2 | 0–13 | 1.58 | 2 |
| 6 | *Ampithoe ramondi* | – | – | – | – | – | – | 0–12 | 3.0 | 4 | – | – | – |
| 7 | *Parahyale hawaiensis* | 0–50 | 10.83 | 4 | 0–100 | 15.75 | 5 | 0–40 | 3.33 | 1 | 0–36 | 3.0 | 1 |
| 8 | *Eriopisa abilashi* | 0–16 | 4.0 | 5 | – | – | – | 0–16 | 6.5 | 8 | 0–14 | 5.33 | 6 |
| 9 | *E. chilkensis* | 0–10 | 0.83 | 1 | – | – | – | 0–14 | 4.42 | 6 | 0–10 | 2.33 | 3 |
| 10 | *Eriopisa* sp. | 0–12 | 1.0 | 1 | – | – | – | 0–10 | 1.5 | 2 | 0–10 | 3.33 | 6 |
| 11 | *Eriopisella* sp. | – | – | – | – | – | – | – | – | – | 0–8 | 1.33 | 2 |
| 12 | *Parorchestia notabilis* | 0–18 | 3.17 | 3 | 0–18 | 3.42 | 4 | 0–20 | 9.25 | 9 | 0–20 | 7.0 | 7 |
| 13 | *P. morini* | 6–21 | 12.33 | 11 | 0–18 | 9.5 | 9 | 8–35 | 15.92 | 11 | 0–20 | 11.42 | 10 |
| 14 | *Orchestia platensis* | 0–10 | 2.83 | 4 | 0–14 | 4.42 | 5 | – | – | – | – | – | – |
| 15 | *Photis digitata* | 0–10 | 1.25 | 2 | 0–12 | 3.50 | 4 | 0–7 | 0.58 | 1 | 0–7 | 0.58 | 1 |
| | **Molluscs** | **21–62** | **36.08** | **11** | **10–36** | **18.67** | **11** | **30–72** | **48.0** | **11** | **24–120** | **30.75** | **11** |
| 1 | *Clithon oulaniensis* | – | – | – | – | – | – | – | – | – | – | – | – |
| 2 | *Natica lineate* | 0–3 | 0.25 | 1 | – | – | – | – | – | – | – | – | – |
| 3 | *Melania tubereulata* | 3–8 | 3.16 | 7 | – | – | – | 0–8 | 4.67 | 9 | 0–4 | 0.67 | 2 |
| 4 | *M. scabra* | 2–8 | 2.92 | 7 | – | – | – | 0–8 | 3.83 | 9 | 0–8 | 2.92 | 7 |
| 5 | *Cerithidea* sp. | – | – | – | – | – | – | 0–4 | 0.33 | 1 | – | – | – |
| 6 | *Stenothyra blanfordiana* | 12–50 | 24.92 | 11 | 0–38 | 16.5 | 10 | 12–60 | 29.0 | 11 | 8–52 | 22.33 | 11 |
| 7 | *Modiolus metcalfei* | 2–6 | 1.33 | 47 | 0–38 | 16.5 | 10 | 5–16 | 8.67 | 11 | 0–12 | 4.83 | 9 |
| 8 | *Gari radiate* | 3–8 | 3.5 | 8 | 0–10 | 1.25 | 2 | 0–10 | 1.50 | 3 | – | – | – |
| | **Decapods** | **6–20** | **10.34** | **9** | **0–9** | **3.89** | **9** | **13–25** | **18.0** | **11** | **0–19** | **8.67** | **11** |
| 1 | *Penaeus indicus* | 0–8 | 1.92 | 4 | 0–5 | 0.75 | 2 | 0–9 | 2.08 | 4 | 0–6 | 0.92 | 2 |
| 2 | *P. monodon* | 0–9 | 2.33 | 6 | 0–4 | 0.75 | 3 | 0–10 | 2.5 | 6 | 0–3 | 0.5 | 2 |
| 3 | *P. merguiensis* | – | – | – | – | – | – | 0–3 | 0.25 | 1 | – | – | – |
| 4 | *P. semisulcatus* | – | – | – | – | – | – | 0–4 | 0.33 | 1 | – | – | – |
| 5 | *Metapenaeus dobsoni* | 0–7 | 0.58 | 1 | – | – | – | 0–9 | 0.75 | 1 | 0–6 | 0.50 | 1 |
| 6 | *M. monoceros* | 0–6 | 1.25 | 3 | – | – | – | 0–6 | 2.17 | 5 | 0–3 | 0.50 | 2 |
| 7 | *M. affinis* | 0–7 | 2.17 | 6 | 0–4 | 0.33 | – | 0–10 | 2.42 | 5 | 0–3 | 0.75 | 3 |
| 8 | *Macrobrachium* sp. | 0–8 | 4.25 | 9 | 0–5 | 2.0 | 8 | 0–15 | 7.5 | 10 | 0–18 | 5.5 | 10 |
| 9 | *Scylla serrata* | 0–2 | 0.17 | 1 | – | – | – | – | – | – | – | – | – |
| | **Polychaetes** | **5–22** | **10.25** | **9** | **0–16** | **6.33** | **9** | **7–28** | **13.75** | **11** | **2–19** | **7.83** | **11** |
| 1 | *Perinereis cultrifera* | 0–8 | 3.75 | 9 | 0–6 | 1.75 | 5 | 0–9 | 3.33 | 8 | 0–4 | 1.0 | 4 |
| 2 | *Dendronereis aestuarina* | 0–10 | 3.5 | 8 | 0–8 | 2.83 | 6 | 4–10 | 6.83 | 11 | 2–8 | 4.17 | 11 |
| 3 | *Ceratonereis costae* | 0–4 | 0.92 | 4 | 0–3 | 0.50 | 2 | 0–4 | 1.17 | 5 | 0–4 | 0.92 | 3 |
| 4 | *Amphinome* sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| 5 | *Melacoceros indicus* | – | – | – | – | – | – | – | – | – | – | – | – |
| 6 | *Prinospio polybranchiate* | 0–2 | 0.5 | 3 | 0–3 | 0.50 | 2 | 0–6 | 1.42 | 4 | 0–4 | 0.83 | 4 |
| 7 | *P. cirrifera* | 0–5 | 1.42 | 5 | 0–4 | 0.75 | 3 | 0–6 | 0.83 | 2 | 0–7 | 0.92 | 3 |
| 8 | *Nereis* sp. | 0–2 | 0.17 | 1 | – | – | – | 0–2 | 0.17 | 1 | – | – | – |
| | **Nematodes** | **4–22** | **9.83** | **10** | **0–10** | **3.67** | **7** | **2–21** | **8.0** | **11** | **6–30** | **13.5** | **11** |
| 1 | *Desmodora* sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| 2 | *Eurystomina* sp. | 0–10 | 4.17 | 10 | 0–8 | 1.92 | 4 | 0–7 | 2.83 | 7 | 0–9 | 5.33 | 10 |
| 3 | *Chromadorina* sp. | 0–7 | 2.17 | 5 | 0–1 | 0.08 | 1 | 0–5 | 1.83 | 7 | 0–8 | 2.33 | 6 |
| 4 | *Oncholaimus* sp. | 0–9 | 3.5 | 6 | 0–6 | 1.67 | 4 | 0–10 | 3.33 | 6 | 0–15 | 5.84 | 9 |
| | **Tanaidaceans** | | | | | | | | | | | | |
| 1 | *Apseudes gymnophobia* | 0–38 | 16.5 | 10 | 0–25 | 3.33 | 2 | 0–88 | 36.33 | 10 | 10–76 | 30.83 | 11 |
| | **Isopods** | | | | | | | | | | | | |
| 1 | *Sphaeroma* sp. | 0–35 | 12.67 | 10 | 5–16 | 7.75 | 11 | 0–12 | 3.67 | 7 | 0–10 | 4.58 | 6 |
| | **Harpacticoides** | **66–220** | **90.08** | **11** | **20–160** | **101.92** | **11** | **128–504** | **234.42** | **11** | **92–418** | **180.42** | **11** |
| 1 | *Enteropine* sp. | 12–70 | 30.67 | 11 | 0–26 | 8.17 | 5 | 40–130 | 72.58 | 11 | 0–118 | 56.58 | 10 |
| 2 | *Microsetella* sp. | 40–150 | 59.41 | 11 | 20–242 | 93.75 | 11 | 88–384 | 161.84 | 11 | 90–300 | 123.84 | 11 |
| | **Foraminiferans** | **30–80** | **42.00** | **11** | **0–58** | **26** | **10** | **0–50** | **20.25** | **10** | **0–60** | **23.83** | **10** |
| 1 | *Elphidium* sp. | 18–44 | 26.75 | 11 | 0–46 | 21.5 | 10 | 0–18 | 2.33 | 2 | 0–26 | 4.0 | 3 |
| 2 | *Globigerina* sp. | 10–36 | 15.25 | 11 | 0–18 | 4.5 | 4 | 0–32 | 17.92 | 10 | 0–34 | 19.83 | 10 |

[a] Number of months of occurrence.

- It may be worth emphasizing that more number of *P. indicus* has been found to occur with *G. verrucosa* along with the polychaetes. It may be possible that *G. verrucosa* is harbouring more polychaetes which in turn are being fed by *P. indicus*. But further studies on this line are necessary to confirm this observation.
- The thin filamentous fronds of *Enteromorpha compressa* with poor sediment retention capacity may explain comparatively lower faunal association than that of other algae (Selva Ranjitham *et al.*, 2008).

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## Hi *dear fishes,* you keep surprise us for ever!

A group of scientists recently revealed a secret that the marine fishes produce $CaCO_3$ in their intestine and excrete it.

$CaCO_3$ is essential to maintain the pH balance in the seawater—"vital for the health of coral reefs and other marine life".

A conservative estimate through computer modelling revealed that fishes have the potential to produce about 45%, or more, of the essential $CaCO_3$ to the ocean life; also the $CaCO_3$ production may increase with the increase in temperature and $CO_2$. That way due to the impact of climate change, fishes are likely to have bigger influence on the chemistry of oceans in future.

[*Source*: *Mar. Pollut. Bull.*, 58(2): 171.]

## Relative enrichment of nitrogen and phosphorus in the sediments of Manakkudy estuary

In most of the coastal ecosystems, nitrogen (N) present in the water is known to limit photosynthesis. The limiting activity of N has been established in most of the estuaries (Richards, 1965; Ramadhas and Sundararajan, 1984). Hence the availability of N and phosphorus (P) in the sediments of Manakkudy estuary was checked to assess their importance in deciding the fertility during the year 2000.

Manakkudy estuary is located on the southwest coast of India (latitude 8° 05′ north; longitude 77° 32′ east), *ca* 8 km northwest of Kanyakumari (Fig. 1). Four sampling stations were fixed up in the Manakkudy estuary for the present study. Station 1 was fixed in the marine zone and stations 2–4 were fixed in the gradient zone, between gradient and tidal zones and tidal zone, respectively. Sediment samples were collected using a shallow water corer and the N and P contents of the sediments were assessed following the standard procedures of Ramadhas and Santhanam (1996).

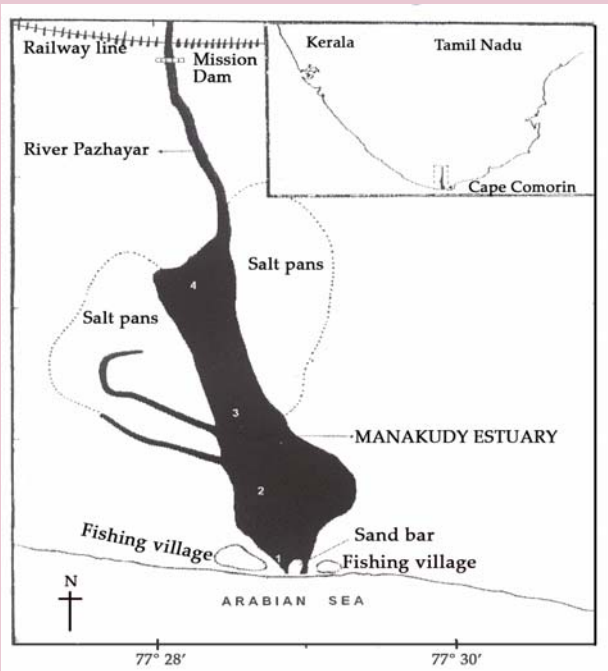


**Fig. 1. Map of Manakkudy estuary.**

The values of organic N and P are given in Tables 1 and 2.

ΔN:P ratio calculated for the four stations are given in Table 3. The highest values of ΔN:P ratio were recorded during the beginning of the northeast monsoon season (October). The values remained very low during the post-monsoon season (January–March).

Among the two nutritive elements, N ranked first followed by P and the mean ΔN:P ratio increased in the following order in the four stations:

Station 1 (8.75:1) → Station 2 (15.88:1) → Station 3 (16.34:1) → Station 4 (17.27:1)

The mean ΔN:P ratio was found to increase from the mouth to the upper reaches of the estuary. The relative domination of N was responsible for the higher values of this ratio (>15:1) registered in stations 2–4. Thus, in these sediments the regeneration of nutrients would suppress the N limiting condition of the overlying water column.

In the present study ΔN:P ratio remained high during the northeast monsoon season (October–December); the values were relatively higher also during the southwest monsoon season (June–September). Thus, it was possible to conclude that both northeast and southwest monsoonal rains relatively helped the enrichment of N in the sediment. From the data collected through the present study, it became obvious that sediment functions as a ready source of N to the overlying water column. Since N is known to act as the limiting nutrient in most of the estuaries, N enrichment in the sediments would play a vital role in deciding the biological fertility of the system. The values of the sedimentary N and P reported in the present study are comparable to the values recorded for Tuticorin coastal waters by Veerabahu (2000). Further studies are required to affirm the chemical forms in which N and P contents of the sediment of Manakkudy estuary are influenced by monsoonal discharge of freshwater and consequent accumulation of sedimentary N and P.

**Table 1. Temporal and spatial variations (mean ± SD, *n* = 3) of sedimentary organic nitrogen (µg/g) in Manakuddy estuary**

| Month | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| January, 2000 | 0.090 ± 0.002 | 0.100 ± 0.007 | 0.121 ± 0.04 | 0.137 ± 0.08 |
| February | 0.124 ± 0.005 | 0.158 ± 0.016 | 0.146 ± 0.022 | 0.134 ± 0.006 |
| March | 0.075 ± 0.001 | 0.174 ± 0.008 | 0.167 ± 0.007 | 0.127 ± 0.008 |
| April | 0.071 ± 0.000 | 0.152 ± 0.04 | 0.175 ± 0.021 | 0.093 ± 0.003 |
| May | 0.054 ± 0.005 | 0.109 ± 0.13 | 0.124 ± 0.011 | 0.093 ± 0.003 |
| June | 0.040 ± 0.001 | 0.131 ± 0.007 | 0.088 ± 0.003 | 0.074 ± 0.005 |
| July | 0.040 ± 0.001 | 0.120 ± 2.02 | 0.123 ± 0.004 | 0.102 ± 0.001 |
| August | 0.157 ± 0.001 | 0.125 ± 0.09 | 0.155 ± 0.011 | 0.098 ± 0.001 |
| September | 0.161 ± 0.002 | 0.091 ± 0.06 | 0.111 ± 0.001 | 0.124 ± 0.010 |
| October | 0.044 ± 0.002 | 0.132 ± 0.05 | 0.135 ± 0.033 | 0.113 ± 0.009 |
| November | 0.090 ± 0.004 | 0.109 ± 0.007 | 0.105 ± 0.002 | 0.105 ± 0.002 |
| December | 0.094 ± 0.019 | 0.148 ± 0.12 | 0.172 ± 0.050 | 0.175 ± 0.001 |

**Table 2. Temporal and spatial variations (mean ± SD, *n* = 3) of total sedimentary phosphorus (µg/g) in Manakuddy estuary**

| Month | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| January, 2000 | 0.179 ± 0.052 | 0.050 ± 0.001 | 0.048 ± 0.001 | 0.051 ± 0.005 |
| February | 0.102 ± 0.008 | 0.090 ± 0.001 | 0.088 ± 0.002 | 0.060 ± 0.001 |
| March | 0.055 ± 0.005 | 0.045 ± 0.001 | 0.040 ± 0.001 | 0.073 ± 0.003 |
| April | 0.096 ± 0.008 | 0.033 ± 0.000 | 0.059 ± 0.001 | 0.040 ± 0.001 |
| May | 0.044 ± 0.004 | 0.066 ± 0.001 | 0.046 ± 0.001 | 0.034 ± 0.001 |
| June | 0.044 ± 0.006 | 0.078 ± 0.000 | 0.036 ± 0.001 | 0.022 ± 0.001 |
| July | 0.022 ± 0.003 | 0.021 ± 0.001 | 0.025 ± 0.001 | 0.014 ± 0.000 |
| August | 0.028 ± 0.001 | 0.012 ± 0.000 | 0.016 ± 0.001 | 0.016 ± 0.001 |
| September | 0.014 ± 0.001 | 0.015 ± 0.001 | 0.015 ± 0.001 | 0.011 ± 0.000 |
| October | 0.003 ± 0.001 | 0.006 ± 0.000 | 0.007 ± 0.001 | 0.006 ± 0.000 |
| November | 0.014 ± 0.000 | 0.014 ± 0.000 | 0.009 ± 0.001 | 0.006 ± 0.000 |
| December | 0.012 ± 0.000 | 0.008 ± 0.001 | 0.009 ± 0.000 | 0.010 ± 0.000 |

**Table 3. ΔN:P ratio of sediments in four stations of Manakuddy estuary**

| Month | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| January, 2000 | 1.11:1 | 4.43:1 | 5.58:1 | 5.95:1 |
| February | 2.69:1 | 3.89:1 | 3.67:1 | 4.95:1 |
| March | 3.02:1 | 8.56:1 | 9.25:1 | 3.85:1 |
| April | 1.64:1 | 10.20:1 | 6.57:1 | 5.15:1 |
| May | 2.72:1 | 3.66:1 | 5.97:1 | 6.06:1 |
| June | 2.01:1 | 3.72:1 | 5.41:1 | 7.45:1 |
| July | 4.03:1 | 12.65:1 | 10.89:1 | 16.13:1 |
| August | 12.42:1 | 23.07:1 | 21.45:1 | 13.56:1 |
| September | 11.50:1 | 13.43:1 | 16.39:1 | 24.96:1 |
| October | 32.48:1 | 48.71:1 | 42.70:1 | 41.70:1 |
| November | 13.98:1 | 17.24:1 | 25.83:1 | 38.75:1 |
| December | 17.35:1 | 40.96:1 | 42.32:1 | 38.75:1 |

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# Mangrove diversity in the Sundarban Biosphere Reserve, West Bengal, India

Sundarbans is one of the most productive ecosystems of the world providing habitats to a large number of commercially important marine and estuarine organisms, such as shrimps, crabs, molluscs (Chaudhuri and Choudhury, 1994; Naskar and Mandal, 1999), fishes, etc., besides others. This delta is influenced by a tidal range of about 3.5–5 m in the estuaries (Choudhuri and Chaudhury, 1994). It is characterised by a complex network of estuaries, creeks and islands—a classic example of a tide-dominated coastal depocenter (Stanley and Hait, 2000). This unique but fragile and dynamic ecosystem is now under stress due to several natural (eastward tilting of the delta and eventual subsidence besides sea-level rise) and anthropogenic factors (pollution, deforestation for settlement and aquaculture), which are responsible for the loss of habitat followed by consequent loss of biodiversity and productivity in the area (Stanley and Hait, 2000).

## Table 1. Details of true mangrove species (30) of Sundarbans

| S. No. | Botanical name | Local name | Family | Size/nature | Habitats | Halophytic adaptive features | Flowering period | Fruiting period | Medicinal value/economic importance | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | *Avicenna officinalis* L. | Jat-bain | Avicenniaceae | Tall tree | True estuarine zone, intertidal river flats/slopes | Germination cryptoviviparous, pneumatophores present | Jan.–Jun. | May–Aug. | Stem bark, astringent; green unripe seeds, purgatives; roots, aphrodisiac | Pioneer, most dominate |
| 2. | *A. alba* Blume | Kal-bain | Avicenniaceae | Tall tree | True estuarine zone, intertidal river flats/slopes | Germination cryptoviviparous, pneumatophores present | Dec.–May | Apr.–Aug. | Fodder and fuel | Pioneer, most dominate |
| 3. | *A. marina* (Forsk.) Vierh. | Peyara-bain | Avicenniaceae | Medium tree | True estuarine zone, intertidal river flats/slopes | Germination cryptoviviparous, pneumatophores present | Oct.–Mar. | Oct.–Mar. | Stem barks, tannin; wood, minor carpentry work and fuel | Soil binder, most dominate |
| 4. | *Acanthus ilicifolius* L. | Horkoch | Acanthaceae | Shrub | Gregarious on the river bank | Small stilt roots, incipient viviparous | Jul.–Dec. | Dec.–Jan. | Leaves, tiger bite and snake bite | Most dominate |
| 5. | *A. volubilis* Wall. | Lata Horkoch | Acanthaceae | Climber | On the river bank | Stilt roots, incipient viviparous | Jan.–Nov. | Jul.–Jan. | Crashed fruit, blood purifier | Rare |
| 6. | *Aegialitis rotundifolia* Roxburgh | Tora | Plumnbaginaceae | Shrub | Intertidal river flats/slopes | Germination cryptoviviparous | Feb.–May | Jul.–Aug. | – | Common |
| 7. | *Aegiceras corniculatum* (L.) Blanco | Khalsi | Mysinaceae | Tall shrub | Intertidal river banks/flats | Germination cryptoviviparous | Dec.–Mar. | May–Aug. | Flower nector, main source of honey | Produces best quality honey |
| 8. | *Bruguiera gymnorrhiza* (L.) Lamk. | Kankra | Rhizophoraceae | Medium tree | Middle estuarine zone, intertidal river bank | Viviparous hypocotyls, broom-like stilt roots, knee roots | Dec.–Mar. | Jan.–Jun. | Bark, for diarrhoea and anti-diabetic | Tidal environment indicator, common |
| 9. | *B. cylindrica* (L.) Blume | Bakul | Rhizophoraceae | Medium tree | True estuarine zone, intertidal ridge forest | Viviparous hypocotyle | Nov.–May | Dec.–Jun. | Stem bark, contain higher percentage of tannin; wood, construction and fuel | Over-exploited, occasional |
| 10. | *B. Parviflora* Wight and Arnold ex Griffith | Bakul-kamkra | Rhizophoraceae | Small tree | Intertidal, true estuarine zone | Viviparous hypocotyle | Jul.–Oct. | Nov.–Feb. | Timber, fuel | Over-exploited, occasional |
| 11. | *B. sexangula* (Lour.) Poir. | Kankra | Rhizophoraceae | Medium tree | Intertidal ridge forest | Viviparous hypocotyle | Dec.–Mar. | Nov.–Jun. | Timber, house building | Over-exploited, occasional |
| 12. | *Ceriops decandra* (Griff.) Ding Hou | Jamtti-goram | Rhizophoraceae | Tall shrub | Middle estuarine zone | Viviparous hypocotyle, broom-like stilt roots | Nov.–Jun. | Dec.–Jul. | Bark extract, anti-haemorrhagic | Tidal environment indicators, common |
| 13. | *C. tagal* (Perr.) C.B. Robinson | Mat-goram | Rhizophoraceae | Medium tree | Middle estuarine zone, intertidal ridge forest | Viviparous hypocotyles, stilt roots | Nov.–Jun. | Nov.–Jun. | Bark, rich in tannin, used for dyeing fishing nets, good fuel charcoal | Occasional |
| 14. | *Excoecaria agallocha* L. | Gneoa | Euphorbiaceac | Tall to medium tree | Inner estuarine riverine zone | Gall on trunk bases | Mar.–Jul. | Jul.–Aug. | Latex, against carbuncle, leprosy | Most dominate |
| 15. | *Excoecaria bicolor* (Hassk.) | – | Euphorbiaceae | Tall to medium tree | River beds with *Porteresia coarctata* | Gall on trunk, non-viviparous | May–Nov. | Jun.–Dec. | Heart wood and pneumatophores, scent – but not commercially used | Most dominate |
| 16. | *Heritiera fomes* Buch.-Ham. | Sundari | Streculiaceae | Tall tree | Intertidal river bank/ridge | Conical woody pneumatophore, waxy cuticle with tomentum stellate scale | Jan.–Jul. | Jun.–Sept. | Fruits as vegetable, timber value | Endangered species |
| 17. | *H. littoralis* Dryand. in Aiton | Sundari | Streculiaceae | Tall tree | Outside tidal zone | Leaves coriaceous elliptic oblong | Feb.–Aug. | Feb.–Aug. | Yields timber | Occasional |
| 18. | *Kandelia candel* (L.) Druce | Goria | Rhizophoraceae | Midium tree | Intertidal river flats/banks, middle estuarine zone | Viviparous hypocotyls, conical trunk bare | Nov.–May | Jan.–Jul. | Anti-diabetic green fruits or kernels edible, used as poultice to boils | Tidal environment indicator, common |
| 19. | *Nypa fruticans* (Thunb.) Wurmb. | Golpata | Arecaceae | Palm | Inner estuarine riverine zone | Rhizomatous, palm stenless, with cryptoviviparous | Mar.–May | May–Nov. | Fruits, used in skin disorder | Endangered, occasional |
| 20. | *Phoenix paludosa* Roxb. | Hental/Bokhra | Arecaceae | Tall bushy palm | River banks and ridge forest | Palm with trunk and pneumatophores | Mar.–May | May–Nov. | Stem, very much durable wood | Perfect hide for 'jungle king' |
| 21. | *Rhizophora apiculata* Blume | Garjan | Rhizophoraceae | Medium tree | Intertidal river banks, slopes | Viviparous hypocotyls, stilt roots | Nov.–May | Dec.–Jul. | Bark is astringent, anti-diabetic | It is at the verge of extinction. |
| 22. | *R. mucronata* Lamk. | Garjan | Rhizophoraceae | Medium tree | Intertidal river banks, slopes | Viviparous hypocotyls, stilt roots | Dec.–Mar. | Feb.–Jun. | Bark powder, astringent; young fruit, edible | Tidal environment indicator, common |
| 23. | *Sonneratia apetala* Buch.-Ham. | Keora | Sonneratiaceae | Tall tree | Intertidal river flats/slopes | Pneumatophores without vivipary | Nov.–Jul. | Apr.–Aug. | Wood, house building, excellent fuel | Core mangrove, common |
| 24. | *S. caseolaris* (L.) Engler | Chak-keora | Sonneratiaceae | Midium tree | Intertidal, inner estuarine riverine zone | Pneumatophores without vivipary | Nov.–Jun. | Aug.–Dec. | Stem bark, higher percentage of tannin; wood, carpentry works | Core mangrove, rare |
| 25. | *S. griffithii* Kurz. | Ora | Sonneratiaceae | Medium tree | True estuarine zone, intertidal river flats/slopes | Pneumatophores without vivipary | Nov.–Jun. | Apr.–Aug. | Stem bark, tannin; wood, carpentry works, fuel | Occasional |
| 26. | *Scyphiphora hydrophyllacea* Gaertn. f. | Tagri bani | Rubiaceae | Tall shrub | Occasional on the mature soil in the river banks | Aerial roots present | Mar.–Aug. | May–Dec. | Fuel wood, warn shoot .0extract, stomach-ache | Severely exploited |
| 27. | *Tamarix dioica* Roxb. ex Roth. | Lal jhau | Tamaricaceae | Shrub to small tree | River bank, back mangal | Presence of dense vessels may help to uplift adequate water to leaf | Jul.–Oct. | Jul.–Oct. | Use to treat dysentery and skin disease | Common |
| 28. | *Tamarix gallica* L. | Nona jhau | Tamaricaceae | Small tree | On the land-ward fringes | Non-viviparous | Jun.–Dec. | Dec.–Mar. | Galls and twigs, astringent for skin diseases | Occasional |
| 29. | *Xylocarpus granatum* Koenig | Dhundul | Meliaceae | Tall tree | Middle estuarine zone, intertidal river banks/slopes | Buttress roots and pneumatophores | Dec.–May | Throughout the year | Barks, asrtringent; fruit and seeds, prevent bleeding and digestive problems | Threatened |
| 30. | *X. mekongensis* Pierre | Passur | Meliaceae | Tall tree | Middle estuarine zone, intertidal river banks/slopes | Buttress roots and pneumatophores | Dec.–May | Throughout the year | Barks, astringent against diarrhoea and dysentery and other abdominal troubles | Threatened |

## Table 2. Details of mangrove associated species (29) of Sundarbans

| S. No. | Botanical name | Local name | Family | Size/nature | Habitats | Halophytic adaptive features | Flowering period | Fruiting period | Medicinal value/economic importance | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | *Acrostichum aureum* L. | Hudo | Pteridaceae | Erect fern | Gregarious in the above reaches | Rhizomatous, without pneumatophore and vivipary | Nov.–Feb. | – | Leaves, vegetable; the paste of rhizomes, treatment of boils | Only 1 mangrove fern in Sundarbans |
| 2. | *Aeluropus lagopoides* (L.) Trin. | Nona durba | Poaceae | Aquatic grass | River flat | No aerial roots, non-viviparous | Aug.–Jan. | Aug.–Jan. | Fodder and forage | Occasional |
| 3. | *Aerva lanata* | Chhaya | Amaranthaceae | Herb | River slopes | No aerial roots, non-viviparous | Jun.–Mar. | Jun.–Mar. | Acts as soil binder | Rare |
| 4. | *Ammannia baccifera* L. | Dadmari | Lithraceae | Herb | River flat | Fruits globose, irregularly dehiscing | Feb.–May | Feb.–May | Eaten as vegetables | Common, soil binder |
| 5. | *Atalantia correa* M. Roem | Ban lebu | Rutaceae | Under shrub | Intertidal ridge forests | Conical trunk bases | Oct.–Mar. | Oct.–Mar. | Fatty oil from fruit against rheumatism | Rare |
| 6. | *Brownlowia lanceolata* (L.) Kosterm | Lata Sundari | Tiliaceae | Small tree/tall shrub | Intertidal river slopes | Aerial air roots, non-viviparous | Jun.–Sept. | Jun.–Sept. | – | Common |
| 7. | *Cerbera odollam* Gaertn. | Dabur | Apocynaceae | Small tree | Mangrove swamp forest | Whorled branches, milky latex | Jun.–Aug. | Jun.–Aug. | In hydrophobia | Rare |
| 8. | *Crinum defixum* Ker-Gawler | Sukha-darsan | Amaryllidaceae | Erect herb | Inner estuary river flats/slop | Rhizome bulbous, non-viviparous | Oct.–Nov. | Oct.–Jan. | Diaphoretic and emollient | Occasional |
| 9. | *Cuscuta reflexa* Roxb. | Swarnalata | Cuscutaceae | Parasitic herb | On low trees | No aerial roots, non-viviparous | Jan.–Nov. | Feb.–Dec. | Medicinal and ornamental purpose | Common |
| 10. | *Dolichandrone spathacea* (Linn. f.) K. Schumann | Gorsinga | Bignoniaceae | Medium tree | Mangrove reclaimed river bank | No aerial roots, non-viviparous | Nov.–Mar. | Nov.–Mar. | Seed powder, antiseptic | Rare |
| 11. | *Finlaysonia obovata* Wall. | Dudhilata | Asclepiadaceae | Climber | Tidal zone | No aerial roots, non-viviparous | Apr.–Nov. | Apr.–Nov. | Leaves, salad | Common |
| 12. | *Heliotropium curassavicum* L. | Nona Hatisur | Boraginaceae | Prostrate herb | Spreading in the salt crust | Succulent, accumulation of salt in leaf | May–Aug. | Jan.–Dec. | Root powder, sores and wounds | Occasional |
| 13. | *Hibiscus tiliaceus* L. | Ban-kapas | Malvaceae | Medium tree | Mangrove reclaimed zones | Stellate hairs on lower epidermis | Jan.–Oct. | Oct.–Dec. | Treatment of obstinate cases of urine | Non-littoral species |
| 14. | *Hoya parasitica* (Roxb.) Wall. ex Wight | Pargachha | Asclepiadaceae | Parasitic shrub/herb | On the old *Xylocarpus* sp. | No aerial roots, non-viviparous | – | – | Ornamental | Rare |
| 15. | *Hydrophylax maritima* L. | – | Rubiaceae | Spreading herb | Coastal sand dune soil | Germination hypogeal, tap and adventitious roots present | Jul.–Sept. | Jul.–Sep. | Warm shoot extract, said to be useful in stomachache | Soil binder |
| 16. | *Ipomoea pes-caprae* (L.) Sweet. | Chhagal kunri | Convolvulaceae | Prostrate herb | On the sandy sea beach | Tap roots and several adventitious roots | Oct.–Nov. | Nov.–Dec. | Leaves, rheumatism and as astringent | Acts as sand binder |
| 17. | *Lannea coromandelica* (Houtt.) | Jiyal | Anacardiaceae | Medium tree | Wetland | Ovate lanceolate leaf-let | Dec.–Jun. | Dec.–Jun. | Enhance milk secretion of mother, yields firewood, gum | Common |
| 18. | *Lumnitzera racemosa* Willd. | Kripal | Combretaceae | Small tree | True estuarine zone and intertidal river flats | Infrequent aerial roots, without pueumatophore | Mar.–Aug. | Jul.–Dec. | Leaf decoction relieves thirst in infants; stem decoction against itches | Occasional |
| 19. | *Myriostachya wightiana* (Nees ex Steud. Hook. f.) | Nalai | Poaceae | Erect shrub | In river bed with *Proteratia* | Culm tufted, erect, stout root smooth | Jun.–Dec. | Jun.–Dec. | For paper pulp | Occasional |
| 20. | *Phragmites karka* (Retz.) Trin. ex. Steud. | Nalor durba | Poaceae | Aquatic grass | In marshy places | No aerial roots, non-viviparous | Dec.–Mar. | Dec.–Mar. | As paper pulp, culm for making chair, basket, mat, fodder | Occasional |
| 21. | *Porteresia coarctata* (Roxb.) Tateoka | Dhani ghash | Poaceae | Common grass | Newly silted up river flats | Stout creeping rhizome or root stock, branched polished, node swollen | Jul.–Dec. | Jul.–Dec. | Ripe seeds are cooked like rice | Pioneer vegetation |
| 22. | *Ruppia maritima* L. | Nonajhangi | Ruppiaceae | Submerged, sea grass | Stagnant brackishwater pools | No aerial roots, non-viviparous | Aug.–Jan. | Aug.–Jan. | Nutritious food for brackishwater fish and prawn species | Occasional |
| 23. | *Salicornia brachiata* Roxb. | Nona sak | Chenopodiaceae | Erect/ prostrate herb | Mangrove reclaimed river bank | No aerial roots, non-viviparous | Nov.–May | Mar.–May | Sometimes used as vegetables | Occasional |
| 24. | *Sarcolobus carinatus* Wall. | Kali lata | Asclepiadaceae | Twining shrub | Mangrove thickets | Without aerial roots | Mar.–Dec. | Aug.–Dec. | Fruits occasionally cooked as vegetables | Occasional |
| 25. | *S. globosus* Wall. | Baole lata | Asclepiadaceae | Twining shrub | Mangrove thicket river flats | With aerial roots | Mar.–Nov. | Aug.–Dec. | Fruits occasionally cooked as vegetables | Occasional |
| 26. | *Suaeda nudiflora* (Willd.) Moq. | Giria sag | Chenopodiaceae | Erect herb | Silted up river flats and slopes | Tap-root well developed, deep shrunken | Nov.–Mar. | Feb.–May | Young foliages as vegetables | Common |
| 27. | *S. maritima* (L.) Dumort. | Giria sag | Chenopodiaceae | Erect herb | Silted up river flats and slopes | Fleshy leaves and dense cymes | Nov.–May | Feb.–May | Soil binder | Saline environment indicator, soil binder |
| 28. | *Thespesia populnea* (L.) Sol. ex. Corr | Paras | Malvaceae | Tall tree | Mangrove reclaimed zones | Infrequent aerial roots | Jul.–Dec. | Nov.–Jan. | Leaves for relieving headache | Umbrella tree |
| 29. | *Viscum orientale* Willd. | Manda | Loranthaceae | Epiphytic shrub | Epiphytic on the mangrove tree | Normal roots, no halophytic adaptation | Jun.–Oct. | Oct.–Jan. | Drug in heart and blood circulation therapy | Occasional |

## Table 3. Details of back mangrove species (25) of Sundarbans

| S. No. | Botanical name | Local name | Family | Size/nature | Habitats | Halophytic adaptive features | Flowering period | Fruiting period | Medicinal value/economic importance | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | *Aglaia cucullata* (Roxb.) Pellegrin | Amur | Meliaceae | Medium tree | Swamp forest | Aerial pneumatophore | Oct.–Jan. | Oct.–Jan. | Yields timber and fuel | Occasional |
| 2. | *Caesalpinia nuga* (L.) Ait. f. | Shringrilata | Caesalpinaceae | Climbing herb | Littoral forests and thickets | Stilt roots, non-viviparous | Jan.–Mar. | Jan.–Mar. | Root, diuretic, use to treat stones in bladder | Common |
| 3. | *C. crista* L. | Shingrilata | Caesalpinaceae | Twining shrub | Back mangal habitat | Stilt roots, non-viviparous | Mar.–Jul. | May–Dec. | Leave powder as uterine tonic | Occasional |
| 4. | *C. bonduc* (L.) Roxb. | Nata karanja | Caesalpinaceae | Twining shrub | Back mangal habitat | Stilt roots, non-viviparous | Mar.–Jul. | May–Dec | Seed oil, cosmetic; stem bark, febrifuge | Occasional |
| 5. | *Capparis zeylanica* Linn. | – | Capparidaceae | Climber | Back mangal habitat | No aerial roots, non-viviparous | Jul.–Mar. | Mar.–Apr. | Fruits used in pickles | Occasional |
| 6. | *Casuarina equisetifolia* L. | Bilati jhau | Casuarinaceae | Tall conical tree | Coastal, sandy and silty area | Drooping branches | Jan.–Aug. | Jan.–Aug. | Decorative purpose, produce tannin | Check soil erosion, wind breaker |
| 7. | *Clerodendrum inerme* (L.) Gaertn. | Ban jui | Verbenaceae | Shrub | Beyond high-tidal reaches | Stilt roots, non-viviparous | Jul.–Mar. | Mar.–Apr. | Used as febrifuge | Common |
| 8. | *Cryptocoryne ciliata* (Roxb.) | Kerali | Araceae | Erect shrub | Silted up river flat | No aerial roots, non-viviparous | Jun.–Aug. | Jul.–Dec. | Medicinal value | Occasional |
| 9. | *Cynometra ramiflora* L. | Shingar | Caesalpinaceae | Small tree | Back mangal habitat | Stilt roots, non-viviparous | Oct.–Mar. | Oct.–Mar. | Timber value | Rare |
| 10. | *Derris scandens* Benth. | Nona lata | Leguminosae | Climbing shrub | Back mangal habitat | Stilt roots, non-viviparous | Mar.–Jul. | Jun.–Aug. | Stem and root, chemical to kill fish | Occasional |
| 11. | *Derris indica* Bennett | Karanja | Leguminosae | Medium tree | Back mangal habitat | Stilt roots, non-viviparous | Feb.–Jul. | Jun.–Sep. | Stem powder, bronchitis and cough | Occasional |
| 12. | *D. trifoliata* Lour. | Kali lata | Leguminosae | Twining shrub | Back mangal habitat | Stilt roots, non-viviparous | Feb.–Jul. | Jun.–Aug. | Stimulant and counter irritant | Occasional |
| 13. | *Dalbergia spinosa (*Roxb.) | Chulia kanta | Fabaceae | Small tree | Back mangal habitat | Stilt roots, non-viviparous | Feb.–Jul. | Jun.–Sep. | Seed oil, cosmetic; leaves and bark, febrifuge | Rare |
| 14. | *Dendrophthoe falcata* (L.f.) Etting. | Mandar | Loranthaceae | Epiphytic shrub | Epiphytic on the mangrove tree | No aerial roots, non-viviparous | Jan.–Oct. | Oct.–Mar. | In scent industry | Occasional |
| 15. | *Dodonaea viscosa* (L.) Jacq. | Belati mehendi | Sapindaceae | Shrub | Common in hedges | No aerial roots, non-viviparous | Mar.–Apr. | Mar.–Apr. | Leaves for wounds swellings, burns | Common |
| 16. | *Hibiscus tortuosus* Roxb. | Ban-kapas | Malvaceae | Medium tree | Mangrove reclaimed zones | No aerial roots, non-viviparous | Nov.–Mar. | Nov.–Mar. | Medicinal | Occasional |
| 17. | *Holarrhena antidysenterica (*Heyne ex Roth.) Wall. | Kurchi | Apocynaceae | Small tree | Village surrounding | Leaves sub-sessile | May.–Feb. | May–Feb. | To treat dysentery, malarial fever | Common |
| 18. | *Manilkara hexandra* (Roxb.) Dub. | Bilati bakul | Sapotaceae | Large tree | Core tidal forest area | No aerial roots, non-viviparous | Apr.–Nov. | Apr.–Nov. | Bark, febrifuge; seed, edible oil | Rare |
| 19. | *Pandanus fascicularis* Lamk. | Keya kanta | Pandanaceae | Palm-like small tree | Back mangal habitat | Aerial root present | Mar–Nov. | Mar.–Nov. | Used to remedy small pox, leprosy | Rare |
| 20. | *Pentatropis capensis* | Chhagal lata | Asclepiadaceae | Twining shrub | Back mangrove thickets | Ovate leaves | Nov.–Jan. | Nov.–Jan. | Medicinally as alternative, refrigerant | Occasional |
| 21. | *Sesuvium portulacastrum* L. | Nona sabuni | Aizoaceae | Prostrate herb | Silted up open forest bed | Decumbent or ascending, much branched | Oct.–Apr. | Oct.–Apr. | Fruits occasionally edible | Occasional |
| 22. | *Solanum trilobatum* L. | Nona begun | Solanaceae | Twining under shrub | Back mangal thickets | Diffuse porous vessel in stem | Oct.–Mar. | Oct.–Mar. | Leaves and fruits occasional as vegetables | Common |
| 23. | *Thevetia peruviana* (Pers.) Sch. | Kalkephul | Apocynaceae | Shrub | Flat land | Flower fragrant, fruit poisonous | – | – | Purgative in flatulence, liver complaints | Occasional |
| 24. | *Tylophora tenuis* (Roxb.) | Antomul | Asclepiadaceae | Twining herb | Banks of creeks | No aerial roots, non-viviparous | Nov.–Mar. | Nov.–Mar. | Use in excessive perception, small-pox | Common |
| 25. | *Vitex negundo* L. | Nisinda | Verbenaceae | Evergreen shrub | Common in hedges | 4-angled branches clothed with white tomentose, lanceolate leaves | Jul.–Mar. | Mar.–Apr. | Serve as a valuable insecticide | Common |

A thorough knowledge about the species, their habitat conditions and prevailing environmental parameters is essential to chalk out a comprehensive conservation strategy for the protection of this unique mangrove ecosystem. Bearing this in mind, a list of 84 plant species of Sundarban mangroves (30 true mangrove species, 29 mangrove-associated species, 25 back mangrove species) with their ecobiological properties is presented in Tables 1–3.

Several mangrove species, such as *Heritiera fomes*, *Nypa fruticans*, *Proterasia coarctata*, *Kandelia candel*, *Aegiceras corniculatum*, *Sonneratia apetala*, *S. caseolaries*, *S acida* and *Rhizophora* spp., are now considered as endangered species. Immediate conservation measures are needed to ensure the long-term sustainability of the species.

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# Morphometric and other variations in three species of *Sonneratia*

A survey along the coast of Maharashtra, during the months of August, December and April respectively during the monsoon, winter and summer seasons of 2004–2006, attracted our attention towards interesting variations among the three species of *Sonneratia*, namely, *S. alba*, *S. apetala* and *S. caseolaris*. The variations in the number of fruits, seeds, seedlings and pneumatophores of the above-mentioned species are reported here.

The variations noticed among the three mangrove species are listed below:

- Plenty of fruits were noticed with only very few seedlings—low seedling density.
- The fruits of *S. alba* collected from Rajapur estuary had reddish-pink pulp, compared to the white coloured pulp generally seen.
- The fruits of *S. caseolaris* were larger in size but the seeds were very small.
- The pneumatophores of *S. caseolaris* were comparatively larger and were 5–6 ft in height at Kolawal estuary.

**Table 1. Morphometric and other variations in three species of *Sonneratia* along Maharashtra coast**

| Species | Number of fruits/ Plants | Fruit diameter (cm) | Fruit weight (g) | Number of seeds/ fruit | Seedling density (number/ $m^2$) | Pneumato-phore density (number/$m^2$) |
|---|---|---|---|---|---|---|
| *S. alba* | 442 | 4.66 | 34.149 | 112 | 29 | 26 |
| *S. apetala* | 758 | 2.09 | 6.983 | 64 | 2 | 28 |
| *S. ceseolaris* | 858 | 5.08 | 67.167 | 543 | 10 | 17 |

The low seedling density observed presently may be attributed to the sensitivity of plants growing under various saline conditions at the time of germination than the other stages, as observed earlier by Ayers and Hayward (1948). Seedling establishment may be a crucial stage, for mangroves (Tomlinson, 1986). Bhosale (1990) has also observed occasional occurrence of seedlings of *Sonneratia*. The number of pneumatophores observed was found to be low (*ca* 28/plant) in *S. apetala* of Maharashtra compared to 200–300 pneumatophores per plant observed by Naskar and Mandal (1999) in Sunderbans.

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## Rise in $CO_2$ level will lead to the death of corals

Present level of $CO_2$ in the atmosphere: **387 ppm**
Scientists' target: **320 ppm**; breaking point: **380 ppm**
Expected rise in 2050: **450 ppm**

**We still couldn't stop using the fossil fuels !**

[*Source*: Reefs could perish by end of century. *Times of India*, Chennai Edition, 8 July, 2009, p. 13.]

(continued from the back cover)

**Is it possible for anybody to rear and breed the clownfishes?**

Yes, anybody can learn the technology; in other words, we can train anybody who has the interest, aptitude and meticulousness. We can help people to earn money too.

**How to earn money by rearing and breeding these fishes?**

For example, a single pair can produce 400–2000 eggs (depending on the conditions in the hatchery and feed) twice a month. At least 50–55% survival can be expected from these eggs, i.e., 50–55 young ones can be obtained from 100 eggs.

Each pair of just three months reared young ones can be sold for at least Rs. 300. The price may vary depending on the species. That way you calculate, how much profit we can get out of a single parent-pair.

**What about the expenditure for this captive-breeding?**

We have developed different packages to suit varied interests. Please contact us, and we will explain how it can be accomplished.

**Have you trained anybody so far?**

Yes, we have trained 300 people by conducting four training programmes: two in our Centre and two in Ramnad District.

**Has anyone benefitted by your training?**

The people we trained are from the coastal districts of Tamil Nadu, and most of the entrepreneurs from Parangipettai (near to our Centre and Vellar estuary) are ready to establish hatchery and are waiting for the sanction of loan and release of subsidies.

**What is significant in the technologies you have developed?**

We have succeeded in rearing and breeding these clownfishes in estuarine water. In the natural environment, these fishes breed under high saline waters.

**How can anybody be benefitted by your 'achievement'?**

Our aim is to help the lower-middle class people who live near estuarine banks, mangrove and backwater regions to set up the backyard hatcheries and earn more money.

**What is 'backyard hatchery'?**

It is like setting up small hatchery units in the backyard or anywhere in the house-premises.

**What are all the drawbacks in clownfish breeding?**

Clownfish breeders may face challenges while culturing live feed (initial feed for the newly hatched larvae), disease outbreaks during rearing periods and mortality due to salinity fluctuations during monsoon. However, aquarists need not worry about these challenges; they can easily maintain their fish tanks with the available modern aquarium gadgets.

**What kind of service you extend towards clownfish breeding?**

At present, we sell them to the aquarists and train people in captive-breeding of clownfishes.

**What are your aims for the future?**

- Improve the survival rate of the captive-bred clownfishes at lower salinity
- Enhance the colour and size of the hatchery-bred clownfishes
- Help coastal people to earn more money
- Develop the technology to rear all the 28 species of clownfishes
- Train the clownfish culturists

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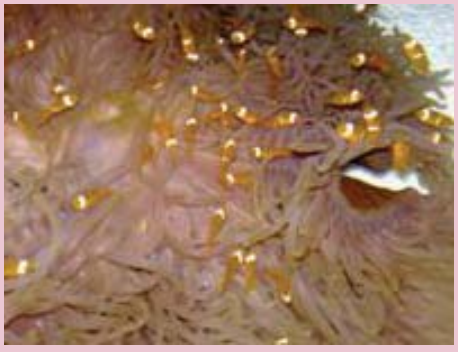

Two-month old juveniles of *Amphiprion percula*: length *ca* 2 cm. They will reach the marketable size (*ca* 3 cm) in about three months. At that time each fish costs Rs. 150. In this photo, they are living with the sea anemone *Heteractics magnifica*.

Spawning pair of percula anemone fish, *Amphiprion percula*—only clownfish having white bands bordered by black lines, are more in demand, with the sea anemone *Stichodactyla* sp. The female (*ca* 8.5 cm in length) is swimming away from the sea anemone; the male (*ca* 6 cm in length) is with the sea anemone (their F1-offspring is carrying the page number of this issue).

Juveniles of *Amphiprion sebae*: size, age and marketable size are similar to those of the juveniles of *A. percula*. But the price is Rs. 30. In the above photo, they are living with the sea anemone *Stichodactlyla* sp.

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