*Journal of Coastal Development* ISSN: 1410-5217
Volume 8, Number 2: February 2005: 107-121 Accredited: 23A/Dikti/Kep/2003

Original paper

# A PRELIMINARY STUDY ON BENTHIC AND ARBOREAL FAUNA ASSOCIATED WITH MANGROVE *Rhizophora Mucronata* ON THE EAST COAST OF MAURITIUS (INDIAN OCEAN) WITH SPECIAL REFERENCE TO THE MOLLUSCA

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*Received: November, 15, 2004 ; Accepted: January, 20, 2005*

## ABSTRACT

*Mangrove ecosystems are important as they harbour a diversity of life forms. This study aimed at studying the benthic and arboreal macrofaunal diversity and abundance associated with three naturally occurring mangrove forests of Mauritius, Western Indian Ocean. The mangrove areas included Roches Noires, Mahebourg and Pointe Maurice, on the east coast of the island. The field study was carried out at low tide during summer season from October 2003 to February 2004. At each of the three sites, the arboreal and benthic macrofauna were sampled separately, using quadrats of 1 m x 1 m and 25 cm x 25 cm, respectively. Sixty-four benthic and 42 arboreal quadrats were collected from Roche Noires, 40 benthic and 41 arboreal quadrats at Mahebourg and 40 benthic and 30 arboreal quadrats at Pointe Maurice. The results showed that benthic habitat is more diverse with regards to molluscan families (24 families) than the arboreal habitat (5 families). Pointe Maurice has a more diverse benthic fauna. Relative percentage abundance and mean density of molluscan families are reported. Highest mean densities and relative abundance were recorded for the Family Littorinidae among arboreal macrofauna. In benthic macrofauna, the highest mean densities and relative abundance were noted in Family Cerithiidae at Roches Noires and Mahebourg.*

**Keywords**: Diversity, benthic, arboreal, macrofauna, molluscs, mangrove, Mauritius

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## INTRODUCTION

Mangrove trees are halophytic woody plants that grow at the interface between land and sea in tropical and subtropical region, and are vital for healthy coastal ecosystems. They enrich coastal waters, yield commercial forest products, protect coastlines and support coastal fisheries (Kathiresan and Bingham, 2001). They are among the world's most productive ecosystems, since they produce large amount of litter in the form of falling leaves, branches and other debris (Kathiresan and Bingham, 2001). Breakdown and decomposition of mangrove litter is accelerated by the feeding activities of invertebrates (Camilleri, 1992). The mangrove eco-system also serves as nursery areas for juvenile fish and shrimps (Robertson and Duke, 1996).

Berry (1963) described the mangrove habitat as a three dimensional community, a horizontal zone from land towards sea and a vertical zone from ground to treetop. Frith (1977) points out the distinct microhabitats recognised within these two zones. Mangrove communities are unique, due to the vertical extent of the trees, true terrestrial organisms can occupy the upper levels (Nybakken, 1988)

while simultaneously true marine animals occupy the bases and the extensive surface area provided by the prop roots and pneumatophores (Hogarth, 1999). A heterogeneous community of organisms live in, on or around mangrove trees and seek attachment, shelter or nutrients (Hogarth, 1999). The community is also characterised by sediment–dwelling macrofauna, which include epifauna fauna (organisms on the sediment surface) and the infauna (organisms buried in the sediment).

The main macroinvertebrate fauna associated with mangroves include insects (Hogarth, 1999; Balasubramanian *et al.,* 2003), crustaceans (Vergara-Filho *et al.,* 1997; Ajmal Khan, 2003) and molluscs (Hogarth, 1999). The crustacean fauna are dominated by brachyuran crabs (Hogarth, 1999). A high diversity and abundance of prawns and shrimps are also harboured by mangroves (Kannupandi *et al*., 2003). Moreover, another group of crustaceans, barnacles are also found abundantly on mangrove roots and pneumatophores (Kathiresan and Bingham, 2001). Gastropod snails are the most common mollusc inhabitants of mangroves and they can be deposit feeders, herbivores or feed on algae growing on the tree bark. Bivalve molluscs such as encrusting oysters and mussels are found attached to roots (Hogarth, 1999). Mangrove sediment surface also have gastropods and crustaceans as the major groups (Berry, 1975). In the sediment, the macrobenthos is characterised by annelids such as polychaetes (Guerreiro *et al.,* 1996). Most organisms occur in the upper 20 cm of the substratum, although some polychaetes and decapods can occur at greater depths (Wada *et al*., 1987). A more extensive review on mangrove-associated fauna and their occurrence in the mangrove ecosystem is given by Kathiresan and Bingham (2001).

Very few studies exist on mangroves in Mauritius (Appadoo, 2003) and among these studies on mangrove-associated fauna or flora are very rare. One of the earlier studies where fauna of mangroves of Mauritius is mentioned is that of Baissac *et al.* (1962). In the latter study the occurrence of *Littorina* species at higher levels on mangrove trees, and mussels such as *Brachyodontes variabilis* in partly submerged plants are reported. Recently a study has been carried out on mangrove-associated fungi (Poonyth *et al.,* 1999). The purpose of this study is to investigate the macroinvertebrate fauna associated with the mangrove *Rhizophora mucronata* in three naturally occurring mangrove areas along the east coast of Mauritius. *Rhizophora mucronata* was selected for the study as it is the more dominant of the two mangrove species known from the island and it occurs in pure stands in most swamps (Fagoonee, 1990; Poonyth, 1998). The focus was on diversity and abundance of the benthic and tree-dwelling (arboreal) macroinver-tebrates with special reference to the molluscs.

## MATERIALS AND METHODS

### *Study sites*

Three sites of naturally occurring mangrove areas were chosen: Roche Noires in the north-east (20º07′S, 57º44′E), Pointe Maurice in the east (20º16′S, 57º47′E) and Mahebourg in the south-east (20º24′S, 57º42′E). The sites are located in shores, which are protected from heavy wave-action. The Roches Noires study site covers an area of 70 m long and 12 to 15 m wide. It consists of stands of *Rhizophora mucronata* of heights ranging from 2 to 5 m. The river Francois flows into the study area. The site at Pointe Maurice is a strip of mangrove forest growing close to a sandy beach. The area is 45 m long and has a width of 5 to 6 m, consisting of two to three *R. mucronata* trees (an older forest). No direct source of freshwater is available there. The study site at Mahebourg is next to the river La Chaux and the sediment is muddy with abundant basaltic rocks. The mangrove area is 60 m long and relatively wide with three to five trees of heights 2 to 5 m making up the forest belt (10 to 12 m wide).

### *Sampling methods*

The areas were studied during the summer months from October 2003 to February 2004 at low tides. The sampling was designed to collect macrofauna associated with the sediment (benthic fauna) and macrofauna associated with the mangrove plants (arboreal fauna). A random table obtained from Fowler

(1998) was used to set quadrats on the sites. For the benthic sampling, a metal quadrat of 25 cm x 25 cm was used. Sediment was scraped within the quadrat to a depth of about 8 to 10 cm with the help of a hand shovel. A total of 144 samples of benthic sediment were collected, with 64 quadrats at Roche Noires and 40 quadrats at each of the two other sites. To sample the arboreal fauna, four metal poles marked at a height of 1 m, were connected by ropes of 1 m length to construct a 1 m x 1 m quadrat. Since the arboreal fauna occupies a vertical zone, the organisms were collected up to 1 m from the ground. Macrofauna found on the prop roots, pneumatophores, tree trunk, branches and leaves were collected using hands or forceps. A total of 113 quadrats, 42 from Roches Noires, 41 from Mahebourg and 30 from Pointe Maurice were set up for arboreal sampling.

### *Laboratory analysis*

Wolff (1987) defined macrofauna as all invertebrate animals retained by a sieve of mesh size 0.5 or 1.0 mm. The benthic samples were sieved through a sieve of mesh size of 1.0 mm. The fauna was sorted out from the sample of sediment retained in the sieve after backwashing. The samples were spread on a white tray, covered with water and fauna were collected (Hartley *et al*., 1987). The organisms collected were placed in small labelled plastic bags and preserved with 10% formalin for later identification. The arboreal fauna was washed and also preserved with 10% formalin.

### *Identification of fauna*

The identification was done under a stereomicroscope with external light source, especially for small specimen. The first step in the process involved identification at class level. The Class Bivalvia was characterised by specimen with paired dorsally hinged valves and Class Gastropoda was characterised by snail-like appearance with spiral or dome shaped shell (Richmond and Rabesandratana, 1997). The second step involved identification at family level, which was done by using characters highlighted by Michel (1985) and Richmond and Rabesandratana (1997). Coloured plated showing patterns on shells as provided by both Drivas and Jay (2001) and Richmond and Rabesandratana (1997) were useful for identification process. Marginal terrestrial families were identified by consulting local authority on terrestrial molluscs (V. Florens). Species identification was done only for the family Littorinidae for arboreal fauna collection using the same literature.

### *Data treatment and diversity indices*

A list of families together with their densities (number per quadrat), percentage occurrence was compiled for the arboreal and benthic fauna at each site. The Shannon diversity and evenness indices were calculated (Magurran, 1988) using the ecological statistical analysis software (Brower *et al.,* 1997).

Rarefaction technique was used to calculate the expected number of families. This method enables comparisons of samples with variable sampling effort (Magurran, 1988). The rarefaction calculator of Brzutowsky (2003) was used.

## RESULTS AND DISCUSSION

### Results

The fauna arboreal or benthic collected by the above methods consisted mostly of molluscan species. The other phyla recorded were 1 species of Annelida (polychaeta) and 2 species of Crustacea including the portunid crab *Scylla serrata* (Forskal). No further identification was carried on these phyla.

### *Faunal Density and relative abundance*

*Benthic fauna*

A list of the benthic molluscan families collected with their mean densities at the three sites given in Table 1.

**Table 1.** Density of molluscan families recorded in benthic habitat at Roches Noires, Pointe Maurice and Mahebourg

| | Roches Noires (mean ± SD) | Range | Pointe Maurice (mean ± SD) | Range | Mahebourg (mean ± SD) | Range |
|---|---|---|---|---|---|---|
| **Class Gastropoda Families** | | | | | | |
| Cerithiidae | **87.22±86.38** | 10 - 377 | 1.1±1.41 | 0 - 6 | **32.38±21.97** | 4 - 104 |
| Conidae | 0 | 0 | 0.03±0.16 | 0 -1 | 0 | 0 |
| Coralliophilidae | 6.72±16.84 | 0 - 95 | 0.08±0.35 | 0 - 2 | 1.90±3.2 | 0 –13 |
| Cymatidae | 0.36±0.96 | 0 - 5 | 0.28±0.60 | 0 - 2 | 0 | 0 |
| Epitoniidae/ Eulimidae | **23.67±19.02** | 0 - 98 | **8.70±8.19** | 0 -31 | 2.50±4.43 | 0 - 19 |
| Haminoeidae | 0.41±1.3 | 0 - 5 | 0 | 0 | 0 | 0 |
| Littorinidae | 0.05±0.38 | 0 – 3 | 0 | 0 | 0 | 0 |
| Mitridae | 2.27±3.16 | 0 - 14 | 1.73±2.45 | 0 - 10 | 0.05±0.32 | 0 - 2 |
| Nassariidae | 4.09±5.82 | 0 - 25 | 0.13±0.33 | 0 - 1 | 1.20±2.14 | 0 - 11 |
| Naticidae | 1.16±3.17 | 0 - 24 | **2.75±4.87** | 0 - 24 | 0.05±0.22 | 0 –1 |
| Neritopsidae | 0 | 0 | 0 | 0 | 0.05±0.22 | 0 - 1 |
| Patellidae | 2.65±2.33 | 0 - 9 | 0.28±0.75 | 0 - 4 | 2.00±3.27 | 0 -12 |
| Phenacolepadidae | 0.02±0.13 | 0 - 1 | 0.38±0.70 | 0 - 3 | 0.10±0.49 | 0 – 3 |
| Pyranidellidae | 1.03±2.63 | 0 - 12 | 0.10±0.44 | 0 - 2 | 0.68±1.07 | 0 - 3 |
| Terebridae | 0.22±0.52 | 0 - 2 | 0.85±1.53 | 0 - 8 | 0 | 0 |
| Truncatellidae | 3.67±8.37 | 0 - 41 | 1.73±2.14 | 0 - 9 | **3.50±4.18** | 0 – 18 |
| Turridae | 0.42±1.82 | 0 - 11 | 0.05±0.22 | 0 - 1 | 0.03±0.16 | 0 –1 |
| Vanikoridae | 1.86±2.14 | 0 - 9 | 1.58±2.39 | 0 - 9 | 0 | 0 |
| **Class Bivalvia Families** | | | | | | |
| Donacidae | 0.44±0.83 | 0 - 3 | 1.28±1.77 | 0 - 6 | 0.05±0.32 | 0 – 2 |
| Mytilidae | 0.03±0.18 | 0 - 1 | 0 | 0 | 0.15±0.43 | 0 – 2 |
| Psammobiidae | 0 | 0 | 0 | 0 | 0.15±0.43 | 0 – 2 |
| Pinnidae | 0.09±0.34 | 0 - 2 | 0.50±0.96 | 0 - 3 | 0.30±0.61 | 0 – 3 |
| Limidae | 0.11±0.44 | 0 - 3 | 0.23±0.54 | 0 - 2 | 0.03±0.16 | 0 – 1 |
| Lucinidae | 0.30±0.83 | 0 - 4 | 0.28±0.72 | 0 - 3 | 0.03±0.16 | 0 - 1 |

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The benthic habitat fauna is characterised by the presence 18 gastropod families and 6 families of bivalves. High densities are noted in Families Cerithiidae, Eulimidae, Nassaridae and Truncatellidae. Twenty-one families were collected at Roches Noires and the highest mean numbers per 625 $cm^2$ were noted for the Family Cerithiidae. At Mahebourg, 18 families were collected with highest numbers per 625 $cm^2$ in Family Cerithiidae. At Pointe Maurice, 19 families were collected with highest mean densities in the Family Eulimidae. The family Cerithiidae had the highest percentage of occurrence (more than 60%) at Roches Noires and Mahebourg and Eulimidae (39.5%) at Pointe Maurice (**Figure 1**).

### *Arboreal fauna*

A list of arboreal molluscan families collected with their mean densities at the three sites is given in Table 2. Species from 3 families were collected at Roches Noires and Pointe Maurice and five families were collected from Mahebourg. Highest mean numbers per 1 $m^2$ were observed for the Family Littorinidae at all three sites. The relative percentage abundance of the different families is shown in Figure 2, and Littorinidae had the highest percentage occurrence (>90%) at the three sites.

**Table 2.** Density of molluscan families recorded in arboreal habitat at Roches Noires, Pointe Maurice and Mahebourg

| | **Roches Noires (mean ± SD)** | **Range** | **Pointe Maurice (mean ± SD)** | **Range** | **Mahebourg (mean ± SD)** | **Range** |
|---|---|---|---|---|---|---|
| **Class Gastropoda Families** | | | | | | |
| Cerithiidae | 0 | 0 | 0 | 0 | 0.51 ± 1.81 | 0 - 9 |
| Ellobidae | 0 | 0 | 0.03±0.18 | 0 - 1 | 0.02 ± 0.16 | 0 - 1 |
| **Littorinidae** | **28.07± 12.81** | **4 - 54** | **13.53±19.07** | **0 - 75** | **15.19 ± 15.55** | **9 - 71** |
| Neritidae | 0.09 ± 0.37 | 0 - 2 | 0.60±2.11 | 0 - 10 | 0.15 ± 0.42 | 0 -2 |
| Planaxidae | 2.52 ± 6.95 | 0 - 40 | 0 | 0 | 3.21± 13.09 | 0 - 82 |

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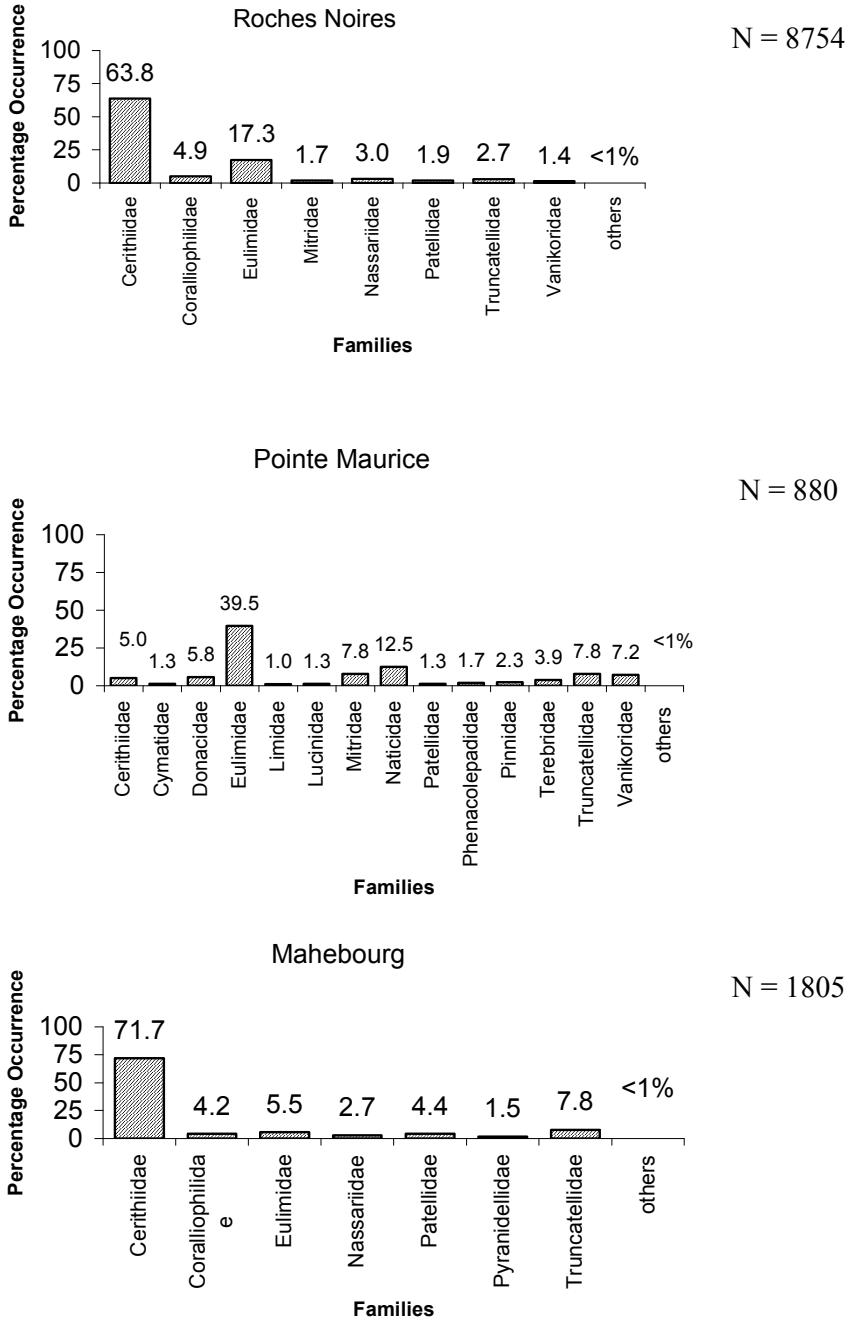


**Fig. 1.** Percentage occurrence of molluscan families occurring in benthic habitat (N indicates number of individuals examined)

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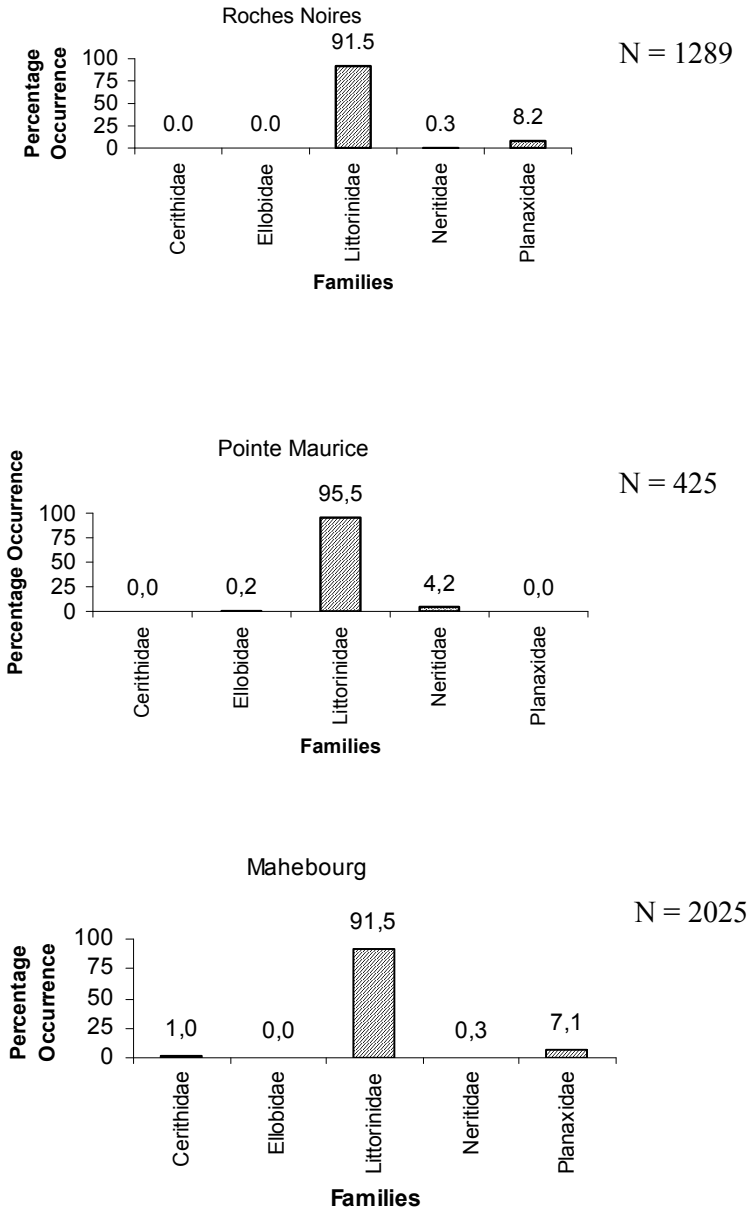


**Fig. 2**. Percentage occurrence of molluscan families occurring in arboreal habitat (N indicates number of individuals examined)

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The arboreal Littorinidae consisted of three species, *Littoraria scabra* (Wood), *L. undulata* (Gray), and *L. pintado* (Wood). All these species were previously placed in the genus *Littorina* (see Richmnond and Rabesandratana, 1997). Among these three species *Littoraria scabra* had the highest percentage abundance (>55%) followed by *L. undulata* (Figure 3).

***Faunal Diversity***

For arboreal fauna, Shannon diversity index was noted to be high at Mahebourg, but families had higher evenness index at Roches Noires. For benthic fauna highest Shannon index and evenness was noted at Pointe Maurice (Table 3).

**Table 3.** Diversity indices for arboreal and benthic molluscan families at three sites

| Site | | Number of Quadrats | Number of Families | Shannon Index | Evenness Index |
|---|---|---|---|---|---|
| Roches Noires | Arboreal fauna | 42 | 3 | 0.31 | **0.27** |
| Pointe Maurice | | 30 | 3 | 0.19 | 0.17 |
| Mahebourg | | 41 | 5 | **0.34** | 0.21 |
| Roches Noires | Benthic fauna | 64 | 21 | 1.33 | 0.44 |
| Pointe Maurice | | 40 | 19 | **2.12** | **0.84** |
| Mahebourg | | 40 | 18 | 1.15 | 0.40 |

Rarefaction curves (Fig. 4) plotted for the expected number of families, showed that Mahebourg has higher expected number of families compared to the other two sites for arboreal fauna. With regards to benthic fauna (Fig. 5), Pointe Maurice had the highest expected number of species.

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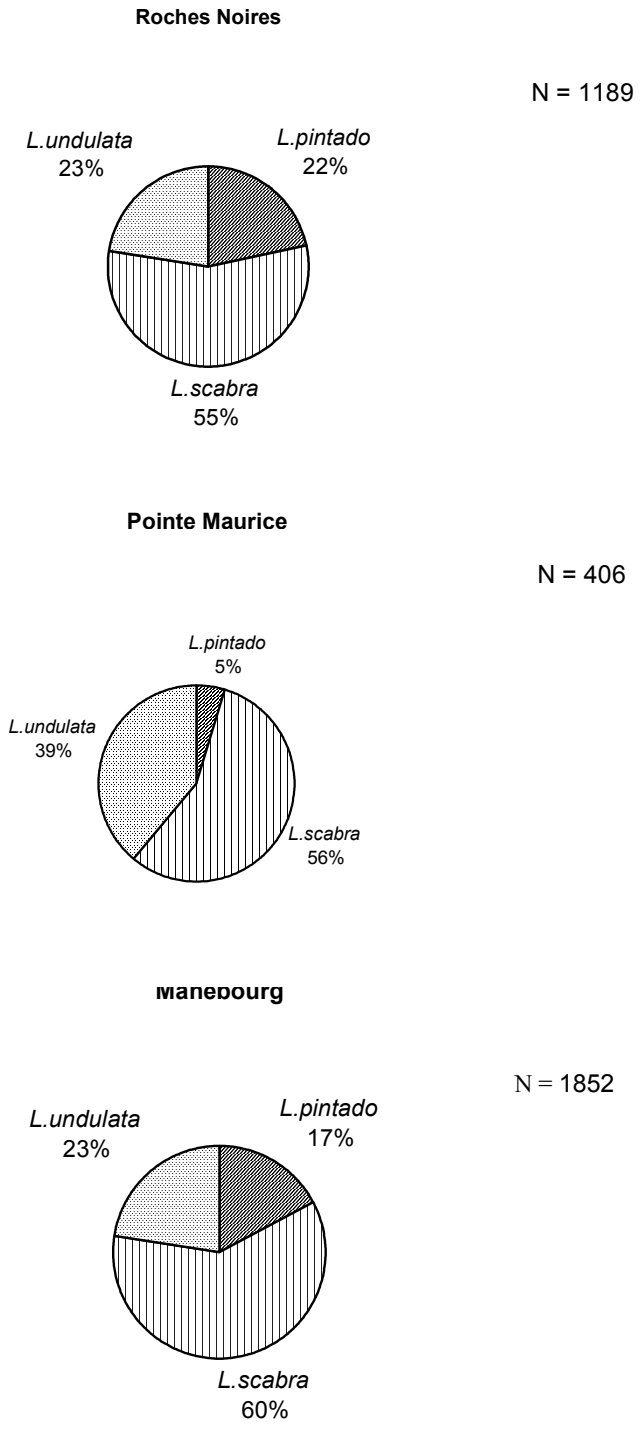


**Fig. 3.** Percentage occurrence of *Littoraria* species among Littorinidae collected from arboreal habitat (N indicates total number of littorinids examined).

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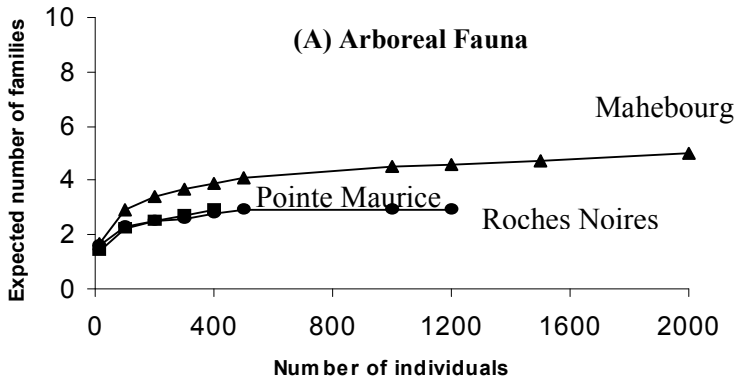


**Fig. 4** Rarefaction curves showing expected number of families in arboreal habitat

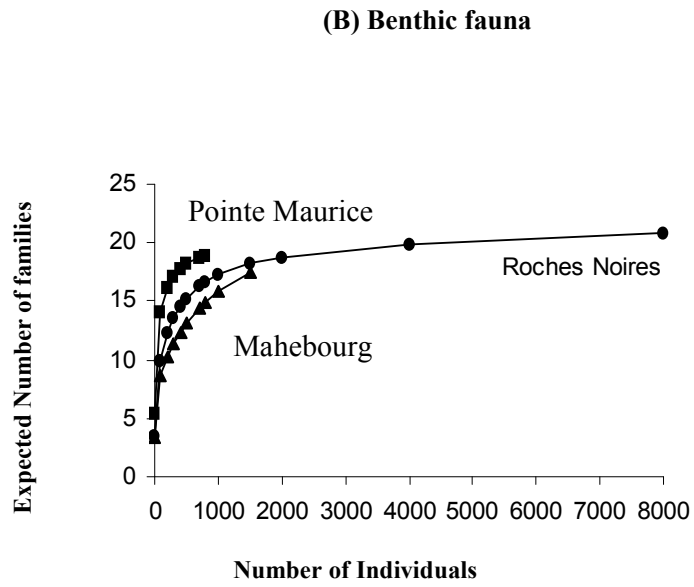


**Fig. 5** Rarefaction curves showing expected number of families in benthic habitat at three sites

# DISCUSSION

### *Mollusc of Mangrove Biotope*

The study is the first to provide information on mollusc's families that are present in the *Rhizophora mucronata* habitats and their relative abundances in three naturally occurring mangrove regions in Mauritius. The arboreal fauna is dominated by the presence of *Littoraria* species. Baissac *et al.* (1962) noted that *Littoraria* species occur on mangrove plants that are not reached by high tides in Mauritius. They also noted that some species such as *Littoraria scabra* are located in sheltered regions of the island. This is in line with the observations made in this study where the three areas of mangroves studied are located in areas, which are not exposed to heavy wave action. Some littorinids are known to be herbivorous and resistant to desiccation (Michel, 1985) and it is possible that occupying mangrove habitats such as tree trunks give them better survival value.

The findings also support previous observations on the species of *Littoraria*, namely of *L. scabra, L. glabrata* which are typical of mangrove trunks and stilt roots occurring in the supralittoral fringe in the Indian Ocean region (Richmond and Rabesandratana, 1997). Frith *et al.* (1976) in a study in Phuket Island noted the high occurrence of gastropod mollusc such as *L. scabra* among the mangrove biotopes, and with the latter species occurring as high as 5.5 m on the tree trunks. Frith *et al.* (1976) and Macintosh *et al.* (2002) point out that mangrove dwelling gastropods of localities within the Indo-pacific consists predominantly of the families Littorinidae, Neritidae and Ellobidae as observed in the current study. Ellobidae occur on arboreal habitat of mangrove habitat of Mauritius (for example *Cassidula labrella* Deshayes), and are characteristic marginal terrestrial species (V. Florens, pers. comm.). The other family observed in this habitat from Mauritius are the Planaxidae, a family typical of marine protected areas with estuarine conditions in Mauritius (Baissac *et al.,* 1962).

The benthic fauna is characterised by a more diverse representation of gastropod families and it includes bivalve families. High densities were recorded for the gastropod family Cerithiidae. This family is known to be abundant in eulittoral zone and shallow-water. They are mostly microalgae and detritus feeders (Richmond and Rabesandratana, 1997). Frith *et al.* (1976) noted that Cerithiids among the most abundant gastropods molluscs in the seaward part and seaward edge of mangrove forests in a study in Phuket Island. The other family fairly well represented in the benthic habitat in this study are the Nassaridae, which are known as mud snails and are carnivorous detritivores (Richmond and Rabesan-dratana, 1997). Family Truncatellidae is considered as marginal terrestrial family (V. Florens, pers. comm.) and is observed to be abundant at Pointe Maurice.

### *Faunal Diversity*

Although quadrat size is not the same for arboreal fauna and benthic fauna, the benthic fauna supports a higher diversity of molluscs than the arboreal. One of the possible reasons is the arboreal habitat will allow only survival of species that are protected against desiccation to survive. Moreover, few organisms feed directly on mangroves as reported by Wells (1983) and the benthic habitat is richer because it includes organisms that feed on mangrove detritus.

The three sites under study shared some similar trends with regards to the families, for example Littorinidae and Neritidae, formed part almost exclusively of arboreal fauna. The benthic fauna showed more variation among sites, with highest diversity noted at Pointe-Maurice. From personal observations on tree diameter, Pointe Maurice appears to be an older forest. Sasekumar and Chong (1998) in a study on faunal diversity in Malaysian mangroves, observed higher taxa diversity in older forests compared to younger ones. In Mauritius, no previous study on diversity of benthic or arboreal fauna in mangroves exists for comparison with the results of this study. The current diversity survey of the sites therefore provides baseline information, which can be used in designing further studies and investigating possible reasons for the observed trends.

ISSN: 1410-5217
Accredited: 23A/Dikti/Kep/2003

## CONCLUSION

This study gave an indication of *Rhizophora mucronata* associated mollusc families, but it is no way exhaustive. Future work will consider investigating other invertebrate groups associated with mangroves in Mauritius and will be designed to take measurements of mangrove plants, and investigate the influence of local environmental parameters at different mangrove sites and their relationships on the distribution, abundance and diversity of associated organisms. Comparison with open areas are needed to confirm whether the organism collected are typical of mangrove biotopes or they are present only because of environmental characteristics of the habitat.

## ACKNOWLEDGEMENTS

We are grateful to the University of Mauritius for by providing transport facilities as well as technical staffs for the fieldwork. We thank Mr. V. Florens for his valuable help in identification of some of the molluscs.

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ISSN: 1410-5217
Accredited: 23A/Dikti/Kep/2003

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