An Analysis of Zooplankton Fauna Associated with Mangrove and Non-Mangrove Ecosystems in Mauritius

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Paper accepted on 18 February 2015

Abstract

Zooplankton are important components of marine food webs, yet very few studies exist on the mangrove plankton of Mauritius. The aim of this study was to analyze the zooplankton fauna and to assess differences between mangrove and non-mangrove ecosystems. Two mangrove ecosystems (Pointe D'Esny and Ferney) and one non-mangrove ecosystem (Bois des Amourettes) were studied for zooplankton abundance, diversity and community structure along the south-east coast of Mauritius. The study was conducted from October to December 2012 and plankton samples were collected using standard plankton nets. Zooplankton fauna of the three ecosystems were representative of the Phyla Arthropoda, Sarcomastigophora, Mollusca, Nematoda, Annelida, Chaetognatha and Ctenophora. Copepods formed the bulk of the zooplankton community (66.44% in Pointe D'Esny mangrove ecosystem and 36.43% in the non-mangrove ecosystem). Cyclopoid Oithona was the most abundant zooplankton in the two mangrove ecosystems with densities of 964 Organisms m-3 and 7760 Organisms m-3 while Foraminiferan Globigerina (329 Organisms m-3) was the most abundant organism in the non-mangrove one. Mangrove sites were found to be more diverse (Margaleff's Diversity Index: 1.71 and 1.41) in zooplankton than non-mangrove site (Margaleff's Diversity Index: 1.27). This study supports the view that mangrove ecosystems are a rich habitat and nursery ground.

Keywords: *Zooplankton, Abundance, Diversity, Mangrove, Copepods, Cyclopoid Oithona*

Running Title: zooplankton in mangroves

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1. INTRODUCTION

Mangrove forests are highly productive tropical ecosystems (Bouillon et al. 2002). The mangrove habitat has been regarded as a zooplankton-rich area (Robertson & Blaber, 1992). Zooplankton are free-swimming animals or drifters, typically microscopic, that have limited power of locomotion and are found in the open water column (Harris et al. 2002). Coastal mangroves provide habitat, shelter, food and breeding grounds for zooplankton. Zooplankton are an important link in the aquatic food chain affecting organisms at the different trophic levels either directly or indirectly. They play a significant role in the microbial loop and nutrient cycling (Harris et al. 2002). Ecological observations on zooplankton communities are important in assessing the health of coastal ecosystems since pollution can reduce species diversity and abundance and may allow for increases in population of pollution-tolerant species (Ramaiah, 1997).

There is a scarcity of published data on zooplankton in coastal mangrove ecosystems in Mauritius. Most studies have been on a large scale basis around the South Western Indian Ocean, aboard vessels with sophisticated equipment. For example, Conway et al. 2003 conducted research that focused on zooplankton diversity in the Mascarene Plateau. Among the few studies done in the coastal areas are the works of Modoosoodun et al. (2010) on the phytoplankton and zooplankton abundance in coastal areas of Mauritius.

Coastal mangroves form part of the environmentally sensitive area (ESA) in Mauritius under protection due to indirect-direct use value provided by these ecosystems. Mangrove health is significant to small state developing islands like Mauritius where seafood is of commercial importance and a source of income to fishermen. Around 70% of commercial fish species depend on mangroves particularly in their juvenile stages (CBD, 2006). Erosion, mostly due to anthropogenic effect, is one of the major coastal degradation issues in Mauritius (Baird 2003, MOE 2005). The aim of this study is investigate zooplankton abundance and diversity in two mangrove and one non-mangrove ecosystem along the south-east coast of Mauritius. Data obtained from this study will help in the assessment of the quality of individual mangrove ecosystems in Mauritius and highlight the importance of mangroves propagation along coastline which is important to protect against coastal erosion and also for development of the mangrove ecosystems.

2. MATERIALS AND METHODS

Study sites

Three sites were selected along the South-east coast of Mauritius at Pointe d’Esny, Ferney and Bois Des Amourettes (Figure 1). The south-east coast of Mauritius has a wet and humid environment as the rainfall is influenced by the South-East trade winds. Site 1 (20025’52” S; 57043’44” E) at Pointe D’Esny and site 2 (20024’40” S; 57041’51” E) at Ferney are two mangrove ecosystems comprising Bruguiera gymnorrhiza and Rhizophora mucronata mangrove species. Site 3 (20022’40” S; 57043’81” E) at Bois Des Amourettes is a non-mangrove ecosystem.

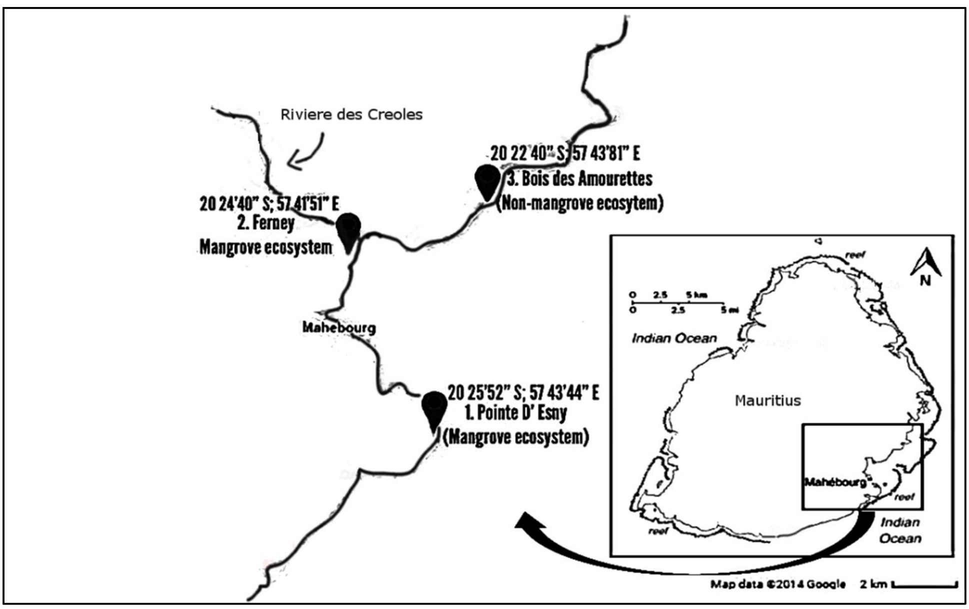

Figure 1. Sampling sites along South-East coast of Mauritius; Site 1- Mangrove Ecosystems at Pointe D’Esny, Site 2- Mangrove Ecosystem at Ferney and Site 3- Non-Mangrove Ecosystems at Bois Des Amourettes (Oct-Dec 2012).

Site 1 at Pointe D'Esny comprises a coastal mangrove ecosystem located near the Blue Bay rich coral ecosystem. Soowamber (2011) reported that the mangrove density was lowest in the high tide inundation zone at Pointe D'Esny with a mean of 171600 mangroves per meter square. It is characterized by a sandy substrata and has *Rhizophora* species, mostly found along the mangrove belt while the *Bruguiera* species is found inward and deeper in the mangrove forest. The mangroves are not close together and gaps in between mangroves can be observed in the mangrove forest. Mean water temperature range from 28.53 to 33.27 ^{o}C and salinity ranges from 30.71 to 38.09 PSU (Oct-Dec 2012).

Site 2 at Ferney comprises a coastal estuarine mangrove ecosystem. Freshwater influx comes from the river 'Rivière des Creoles'. The substratum is muddy and rich in mangrove detritus. The brackish water is very turbid. The prop roots of *R.mucronata* form a dense network of linked roots with the other mangroves. The knee roots of *B.gymnorrhiza* can also be observed at the site. The mean water temperature ranges from 27.07 to 30.53 ^{o}C and water salinity ranges from 15 to 27.68 PSU (Oct-Dec 2012).

Site 3 at Bois des Amourettes comprises the coastal non-mangrove ecosystem. It does not have any mangroves but macrophytic plants are present along its shore. It is characterised by muddy substratum. Mean water temperature ranges from 27.03 to 28.97 ^{o}C and water salinity ranges from 31.25 to 39.35 PSU (Oct-Dec 2012).

Sampling and data analysis

Zooplankton samples from the three sites were collected during low tide from October 2012 to December 2012 on a monthly basis. A standard zooplankton net of pore size 153 micrometers and mouth diameter of 30 cm was used to filter 100 L of water using a 10 L calibrated bucket. The water was sampled in the littoral zones just below the water surface (30-40 cm depth) and poured into the net using the bucket. The filtered samples were collected in 250 ml plastic bottles containing 10 ml of 5% buffered Formalin for fixation and storage. Water temperature, pH and salinity were recorded using Oaklon pH 300 series meter and ERMA handheld refractometer respectively.

In the laboratory, a 1 ml subsample from each sample was transferred to a Sedgwick-Rafter counting chamber under an inverted light microscope to determine species composition and zooplankton density. Samples were sorted out into different taxonomic groups, identified to the genus level using Conway *et al*. 2003 as reference. All zooplankton individuals in the 1000 quadrants of the SR chamber were counted and sorted. The densities of individual species were then computed according to the following equation (Kamaladasa & Jayatunga, 2007):

Zooplankton density per sample for each identified taxa:

$$= \frac{\text{(average number of individuals in 1 ml water from 3 subsamples) X Sample volume (ml)}}{\text{Volume of water filtered (100000 ml)}}$$

Mean zooplankton density per site (Organisms L^{-1}) for each identified taxa:

= (average number of individuals from 27 samples)/100000 ml

Subsequent conversion of the mean zooplankton density from Organisms L^{-1} into Organisms m^{-3} was done for easy interpretation of results. A one way analysis of variance test (ANOVA) was performed to determine whether there is statistically significant differences in mean zooplankton density between the 3 sites. A post hoc analysis was then done to determine between which sites the mean zooplankton density are significant. Games-Howell test was chosen for the ANOVA post-hoc analysis since both sample size and variances were unequal. Margalef's Diveristy index ($D_{mg} = (S-1)/ \ln N$) was used to estimate diversity of the sites instead of other indices like Shannon-Wiener since it is less dependent upon sample size and more sensitive to species represented by few individuals (Magurran, 1998). Pielou's Evenness index ($J^l = H^l \div \ln S$) was used to assess the evenness in distribution of zooplankton at each site. Statistical tests were performed using IBM SPSS 20.

3. RESULTS

Zooplankton community structure

Zooplankton fauna at Pointe D'Esny coastal mangrove ecosystem (site 1) was represented by 5 phyla: Arthropoda, Mollusca, Sarcomastigophora, Nematoda and Annelida. Copepods (66.44%), polyplacophora larvae (17.88%), copepod nauplius (8.37%), and foraminiferans (5.16%) formed the bulk of zooplankton at this site (fig.2.). Total zooplankton abundance at this site was 16610 Organisms m^{-3}.

The zooplankton fauna at Ferney coastal mangrove ecosystem (site 2) was represented by 6 phyla: Phylum Arthropoda, Sarcomastigophora, Mollusca, Nematoda, Chaetognatha and Ctenophora. Copepods (27.11%), foraminiferans (21.69%), copepod Nauplius (21.48%), nematodes (8.69%), polyplacophora larvae (4.88%), bivalve larvae (4.83%), decapod larvae (3.43%), chelicerates (2.35%), gastropod larvae (2.05%) and gastropod (1.50%) constituted the bulk of zooplankton at this site (fig.3.). Total zooplankton abundance at this site was 6006 Organisms m^{-3}.

Zooplankton fauna at Bois Des Amourettes coastal non-mangrove ecosystem (site 3) was represented by 4 phyla; Arthropoda, Mollusca, Sarcomastigophora and Annelida. Copepods (36.43%), foraminiferans (32.83%), gastropods (8.80%), polyplacophora larvae (7.69%), copepod Nauplius (6.7%), gastropod larvae (2.89%), and bivalve larvae (1.87%) constituted the bulk of zooplankton at this non-mangrove site (fig.4.). Total abundance of zooplankton at this site was 1310 Organisms m^{-3}.

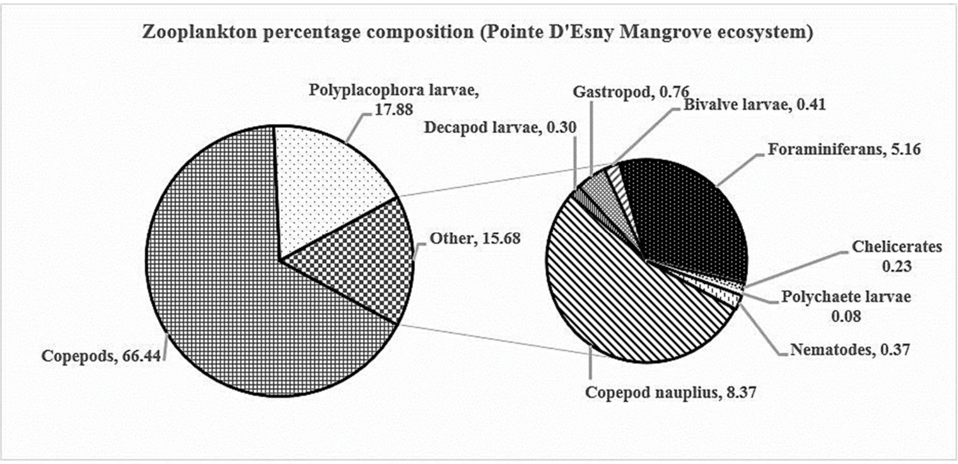

Figure 2. Percentage composition of zooplankton Pointe D'Esny Mangrove ecosystem (Site 1).

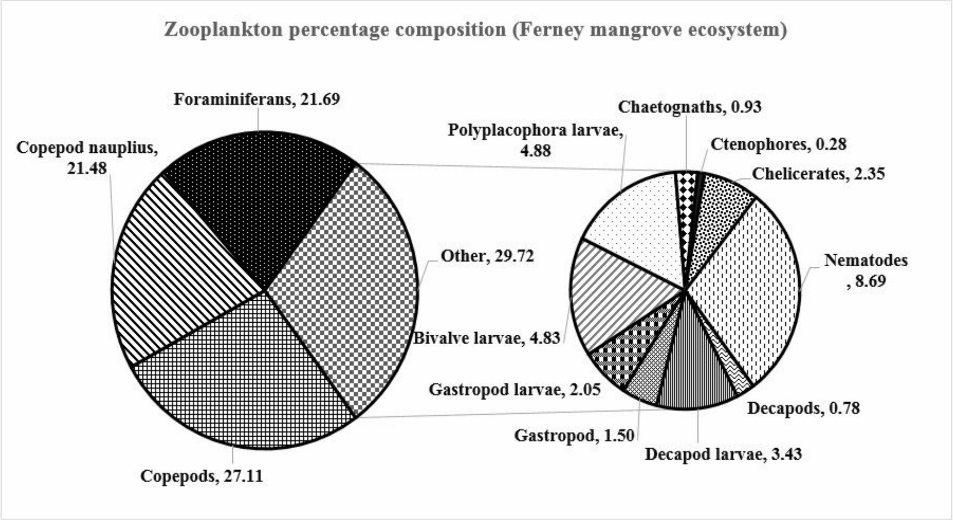

Figure 3. Percentage composition of zooplankton at Ferney Mangrove ecosystem (Site 2).

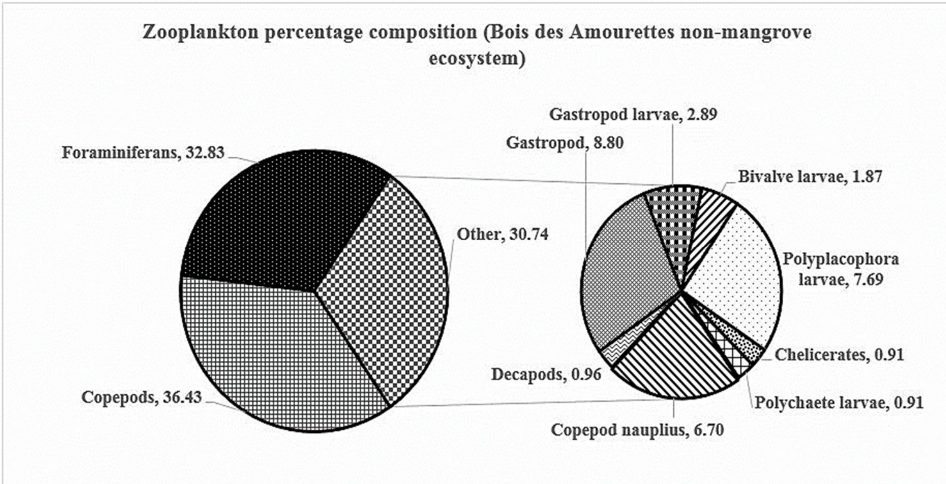

Figure 4. Percentage composition of zooplankton Bois Des Amourettes Non-mangrove ecosystem (Site 3).

Zooplankton density

Highest total mean zooplankton density, 12118.2 organisms m^{-3}, was recorded at Pointe D'Esny mangrove ecosystem followed by 3803.7 organisms m^{-3} at Ferney mangrove ecosystem. Bois des Amourettes non-mangrove ecosystem had the lowest total mean zooplankton density of 972.3 Organisms m^{-3}.

Both Pointe D'Esny and Ferney mangrove ecosystems had the highest density of the cyclopoid *Oithona*, 7760 Organisms m^{-3} and 964 Organisms m^{-3} respectively belonging to class Copepoda of phylum Arthropoda (Table 1). Bois Des Amourettes non-mangrove ecosystem had the highest density of the Foraminifera *Globigerina* belonging to phylum Sarcomastigophora, 329 Organisms m^{-3} followed by Cyclopoid *Oithona*, 252 Organisms m^{-3}.

Copepods were dominant at all three sites as indicated by the high density of cyclopoids, calanoids, harpacticoids and poecilostomatoids (Table 1). Mollusc *Atlanta* was present at both mangrove sites while mollusc *Jhantina*, (107 Organisms m^{-3}) was only present at the non-mangrove site.

One way ANOVA test yielded no statistically significant difference in mean zooplankton density between the 3 sites ($F(2, 98) = 2.861$, $p = 0.062$). Post hoc analysis using the Games-Howell test yielded statistically significant difference in mean zooplankton density between Ferney mangrove ecosystem and Bois des Amourettes non-mangrove ecosystem ($p = 0.048$). No statistically significant difference in mean zooplankton density was found between: Pointe D’Esny mangrove ecosystem and Ferney mangrove ecosystem ($p=0.495$), Pointe D’Esny mangrove ecosystem and Bois des Amourettes non-mangrove ecosystem ($p=0.116$).

Table 1: Mean density of zooplankton in Mangrove and Non-mangrove ecosystem.

	Mean density (Organisms/m^3) (± Standard deviation)		
	Mangrove Ecosystem	**Mangrove Ecosystem**	**Non-mangrove Ecosystem**
Genera	**Pointe D'Esny (Site 1)**	**Ferney (Site 2)**	**Bois Des Amourettes (Site 3)**
Oithona	7760 (± 940)	960 (± 288)	252 (± 222)
Calanus	82.7 (± 143)		11.1 (± 19.2)
Paracalanus	1220 (± 735)	242 (± 165)	
Pareucalanus	713 (± 1240)	83 (± 144)	
Clausocalanus	663 (± 413)	60.6 (± 55.1)	
Miracia	280 (± 134)	107 (± 106)	36.5 (± 63.2)
Distioculus	183 (± 231)	61.3 (± 21.3)	107 (± 95.5)

Oculostella	29.6 (± 51.3)		24.8 (± 42.9)
Euterpina	34.5 (± 34.2)	86.4 (± 49.3)	11.7 (± 20.3)
Harpacticoid	59.1 (± 74.1)		
Sapphirina		11.7 (± 20.3)	
Carycaeus	11.7 (± 20.3)	12.3 (± 81.3)	
Ostracoda		46.9 (± 81.3)	
Cladocera			11.7 (± 20.3)
Pycnogonida	37.9 (± 39.4)	141 (± 205)	11.1 (± 19.2)
Atlanta	126 (± 19.6)	90.1 (± 104)	
Jhantina			107 (± 95.2)
Sagitta		55.6 (± 96.2)	
Globigerina	286 (± 140)	860 (± 1320)	329 (± 570)
Globorotalia	180 (± 190)	375 (± 331)	11.7 (± 20.3)
Spirillina	36.4 (± 37.1)	52.9 (± 91.6)	11.7 (± 20.3)
Quinqueloculina	354 (± 69.5)	14.8 (± 25.7)	47 (± 40.7)
Nematoda	61.3 (± 55.9)	522 (± 309)	
Ctenophora		17.1 (± 29.6)	

Zooplankton Diversity

Margaleff diversity index has no limit value and is dependent upon variation in species number between sites (Magurran, 1998). The higher the diversity index, the more diverse is the site. Margaleff's diversity index showed highest diversity in zooplankton for Ferney mangrove ecosystem (D_{mg}=1.71) followed by Pointe D' Esny mangrove ecosystem (Table 2). Bois Des Amourettes non-mangrove ecosystem was the least diverse in zooplankton fauna (D_{mg}=1.27). Pielou's index of evenness has a range of zero to one as it is based on the Shannon-Wiener index, zero signifying no evenness and one signifying complete evenness. The non-mangrove ecosystems (E= 0.81) is more even in zooplankton species distribution while the mangrove ecosystems have a slightly less even distribution (Table 2).

Table 2: Evenness and Diversity Indices of zooplankton for each site

(Oct-Dec 2012)	Pointe D'Esny Mangrove ecosystem	Ferney Mangrove ecosystem	Bois Des Amourettes non-mangrove ecosystem
Pielou's Evenness (E)	0.63	0.73	0.81
Total number of zooplankton species (S)	24	27	19
Margaleff (D_{mg})	1.41	1.71	1.27

Physical Parameters

Coastal water pH at the three sites were close to neutral. The lowest salinity recorded at Ferney mangrove ecosystem (PSU= 21.3) and highest saline water at Bois Des Amourettes non-mangrove ecosystem (PSU=35.3). The mean water temperatures for the 3 sites varied between 28 to 30 ^{o}C for the three month period (Table 3).

Table 3: Physical parameters recorded for the three month period for each site

(Oct-Dec 2012)	Mean pH	Mean Temperature (^{o}C)	Mean Salinity (PSU)
Site 1	7.68±0.74	30.9±2.37	34.4±3.69
Site 2	7.51±0.69	28.8±1.73	21.3±6.34
Site 3	7.75±0.64	28.0±0.97	35.3±4.05

4. DISCUSSION

Community structure

Copepods and foraminiferans formed the bulk of the zooplankton community structure for both mangrove and non-mangrove ecosystems. However, percentage composition and mean densities of copepods were higher in the mangrove ecosystems. This was also observed from the high abundance of copepod nauplii recorded at the three sites. This result was consistent with other studies reporting that copepods are the dominant zooplankton in coastal mangroves. Mangrove plankton assemblages of Matang Mangrove Forest Reserve (MMFR) in Malaysia were comprised of more than 47% copepods (Chew & Chong, 2011). Copepods' ability to exploit pelagic food webs through complex prey-predator interactions, energy cycling and its role in the microbial loop (Magalhães *et al.* 2009) may justify their high abundance in the zooplankton community.

Cyclopoid *Oithona* is the copepod with the highest mean density at each site making it the dominant zooplankton in the mangrove and non-mangrove ecosystem. In a study by Modoosoodun *et al.* (2010), zooplankton of Family Oithonidae were also found in high abundance in Mauritian coastal water at Balaclava Marine Park. Due to its high abundance, ubiquitous presence in coastal and oceanic waters and global distribution from polar to tropical latitudes, *Oithona* has recently become a subject of interest (Uye & Sano 1998, Gallienne & Robins 2001, Nielsen & Sabatini 1996, McKinnon & Klumpp 1998, cited in Terol & Saiz., 2013). One reason for this organism's widespread distribution might be its ability to control its rate of metabolism e.g. by balancing egg production rate with food scarcity (Terol & Saiz, 2013).

Foraminiferans belonging to the meroplankton were present at all three sites. Their abundance may be explained by their broad dietary range. In a study by Oakes *et al*. (2010), rapid uptake of mangrove detritus by foraminiferans was reported suggesting even more versatility in their nutrition. Hence, their presence in high abundance in both mangrove and non-mangrove ecosystems is not unexpected.

Other abundant zooplankton fauna include gastropods and nematodes in the mangrove ecosystems. Site 2 had a higher density of nematodes which may be explained by its river-sea dynamics. Chen *et al.* (2012) reported higher densities of nematodes where influx of freshwater from Sarawak River together with decomposed mangrove leaves enriched the area while the hydrodynamic force oxygenated the substratum. Gastropod *Atlanta* was in higher density at site 1. This may be due to this site having slightly higher water temperature and higher salinity compared to site 2 as noted by physical parameters for the 3 month period. Khade & Mane (2012) reported that low salinity and temperature were detrimental to some molluscs species since this affected their osmoregulation. These are mostly sensitive molluscs species which cannot regulate their body fluids to fluctuating osmotic balance affecting their distribution and density in the water (Khade & Mane, 2012). Hence, fresh water influx such as river inflow or amount of rainfall the site receives might be affecting the density of this zooplankton differently. This needs to be further investigated. Salinity difference of the coastal water might also be a reason of the presence of gastropod *Jhantina* only at the non-mangrove site.

Among the zooplankton larvae, megalopa and zoea of decapods were only recorded at site 2. Many tropical decapod species undergo extensive migration in

different habitats as adults to spawn and habitat shifts by their larvae form part of their metamorphosis to juvenile stages (Haywood & Kenyon, 2009). Migration of decapods might be one of the reason for their recorded absence. The mangrove habitat structure and hydrography difference between the two mangrove sites might also justify this occurrence since at site 2, the mangroves are denser, closer together with the river bringing sediments which make the water muddier. This makes predation risks to the larger larvae lower as compared to site 1 where the clearer water provides less camouflage from its main predators which are mostly juvenile fishes.

Zooplankton diversity

Site 2 was the most diverse mangrove ecosystem. One reason can be a diversity of habitats and freshwater input from the river into this coastal mangrove ecosystem. Boundary regions between fresh and sea water are true ecosystems with their own characteristic fauna and specific communities due to the river-sea-coast contact (Binet *et al.* 1995). Binet *et al.* (1995) also reported that diversity increases as ecosystems with good inland and marine water input increases. This may explain lower diversity at site 1 which does not have the dynamic element of a river in its coastal mangrove ecosystem and lowest diversity in the non-mangrove ecosystem which provides only a euhaline environment with no mangrove. The non-mangrove site was also more even in zooplankton species distribution as indicated by the Pielou's evenness index. This is not unexpected since this site is less diverse in zooplankton species.

Zooplankton density

Both coastal mangrove ecosystems had higher total mean zooplankton density but the means were not statistically different between these 2 ecosystems. Robertson *et al.* (1988) reported higher annual zooplankton density range of 11300 to 19700 organisms m^{-3} and higher density of zooplankton-feeding juvenile fishes in tropical Australian mangrove waters than in other habitats like seagrass flats and offshore environments. They noted marked seasonal densities of zooplankton taxa in mangrove habitats which were not influenced by physical

parameters of the coastal water. This also indicates that presence of high density of zooplankton may be one of the reasons that make mangroves ecosystems important nursery sites for fish.

Mean zooplankton density was significantly different between site 2 and site 3. Freshwater influx from the river and mangrove presence might be the reason for this difference in mean zooplankton density. In another study done in Mauritius at the Balaclava marine park, Modoosoodun *et al*. (2010) reported highest mean zooplankton density of 18533 organisms m^{-3} in freshwater environment as compared to sandy beach, estuarine and rocky coastal environment. Mangroves were not reported at their study site, thus presence of mangroves might impact the mean zooplankton density in the freshwater environment differently as assessed in this study.

Modoosoodun *et al*. (2010) also noted positive correlation of phytoplankton and zooplankton density with pH and salinity. A study by Saifulla *et al*. (2010) reported estuarine water of Sarawak mangrove estuaries to be ideal for growth and sustenance of phytoplankton. High phytoplankton density in mangrove ecosystems means a higher density of its predators which are mostly zooplanktons. Mangrove sites thus provide a highly beneficial environment for zooplankton in terms of food.

Mean zooplankton density in site 1 were not statistically different from site 3. These two sites were almost similar in pH, salinity and temperature except for the presence of mangroves at site 1. On the other hand, site 2 and site 3 ecosystems were statistically different in mean zooplankton density. Site 2 had mangroves but there was a marked difference in their coastal water salinity due mostly to freshwater influx at site 2. Further investigation need to be carried out in order to assess the correlation between these physical parameters and zooplankton density at each site.

5. CONCLUSION

This study highlights the importance of mangroves along tropical coasts as they harbor significantly higher mean zooplankton density and diversity. The zooplankton diversity is further enhanced in coastal ecosystem with freshwater influx dynamics. It also shows that copepods are the dominant zooplankton in the pelagic environment; cyclopoid *Oithona* being the most abundant zooplankton in the mangrove ecosystems. The abundance of Foraminiferans in coastal ecosystems with particularly higher densities in non-mangrove ecosystem was also brought to light.

Zooplankton studies provide great scope for small island developing state like Mauritius where the sea is exploited for food. Abundance, diversity and community structure of zooplankton in mangrove ecosystems in this study may provide baseline data for assessing water quality of these ecosystems in the future. Such data is useful for potential fishery related activities in the mangrove ecosystems or in its nearshore waters.

ACKNOWLEDGEMENTS

I am thankful to the University of Mauritius for logistic facilities. Part of this work has been presented as an abstract at the eighth WIOMSA Symposium in Maputo 2013.

6. REFERENCES

BINET, D., RESTE, L., & DIOUF, P.S., (1995). The influence of runoff and fluvial outflow on the ecosystems and living resources of West African Coastal Waters. FAO Corporate Document Repository, *FAO Fisheries Technical Paper Series* 1-133

BAIRD, W.F., & Associates (2003). Study on Coastal Erosion in Mauritius, in association with Reef Watch Consultancy LTD, Mauritius and Dr Michael Risk. *Report prepared for the Ministry of Environment*, Republic of Mauritius 5-103.

BOUILLON, S., P.C. MOHAN, N. SREENIVAS, & DEHAIRS, F. (2000). Sources of suspended organic matter and selective feeding by zooplankton in an estuarine mangrove ecosystem as traced by stable isotopes. *Marine Ecology-Progress Series* **208**, 79-92.

CHEN, C. A., LONG, S. M., & ROSLI, N. M (2012). An Ecological Study of Free-living Marine Nematodes in Teluk Awar, Sarawak, Malaysia. *Borneo Journal Resource of Science and Technology* **2**, 1-10.

CHEW, L.C. & CHONG V.C., (2011). Copepod community structure and abundance in a tropical mangrove estuary, with comparisons to coastal waters. *Hydrobiologia* **666,** 127-143.

CONVENTION ON BIODIVERSITY (CBD) REPORT. (2006). *National report for the republic of Mauritius*, Ministry of Environment and National development in collaboration with UNEP/GEF **3**, 25-188.

CONWAY, D.V.P., WHITE, R.G., HUGUES-DIT-CILES, J., GALLIENNE, C.P. & ROBINS, D.B (2003). Guide to the coastal surface zooplankton of the Southwestern Indian Ocean. Defra Darwin Initiative Zooplankton Programme, Version 1. *Marine Biological Association of the United Kingdom Occasional Publication* No 15.

HARRIS, R., WIEBE, P., LENZ, J., SKJOLDAL, H.R., & HUNTLEY, M (2002). *ICES zooplankton methodology manual*. London NWI 7BY, UK. Academic Press.

HAYWOOD, M. D., & KENYON, R. A (2009) Habitat Shifts by Decapods—an Example of Connectivity Across Tropical Coastal Ecosystems. *Ecological Connectivity among Tropical Coastal Ecosystems*, Springer, London, New York, 229.

KAMALADASA, A. I., & JAYATUNGA, Y. N. A. (2007). Composition, density and distribution of zooplankton in South West and East Lakes of Beira Lake soon after the restoration of South West Lake. *Ceylon Journal of Science (Biological Science*s) **36**, 1-7.

KHADE, S.N & MANE, U.H (2012). Diversity of Bivalve and Gastropod Molluscs in Mangrove ecosystem from selected sites of Raigad district, Maharashtra, West coast of India. *Recent Research in Science and Technology* **4**, 16-20.

MAGALHÃES, A., LEITE, N. D. R., SILVA, J. G., PEREIRA, L. C., & COSTA, R. M. D. (2009). Seasonal variation in the copepod community structure from a tropical Amazon estuary, Northern Brazil. *Anais da Academia Brasileira de Ciências* **81**, 187-197.

MAGURRAN, A.E., (1998). *Ecological diversity and its measurement*. New Jersey, Princeton University Press.

MODOOSOODUN, K., APPADOO, C., & OOCHEETSING, S., (2010). An investigation on the phytoplankton and zooplankton abundance and diversity at the Balaclava marine protected area in the north-west coast of Mauritius. *Journal of Environmental Research and Development* **5**, 366-374.

MOE (2005). Mauritius Staking Out the Future. *Partnership for Sustainable Development*, Ministry of Environment and National Development Unit, Republic of Mauritius 3-98.

OAKES, J., CONNOLLY, R.M., & REVILL, A.T (2010). Isotope enrichment in mangrove forests separates microphytobenthos and detritus as carbon sources for animals. *Limnology and Oceanography* **55**, 393.

RAMAIAH, N. (1997). Distribution and abundance of copepods in the pollution gradient zones of Bombay Harbour-Thana creek-Bassein creek, west coast of India. *Indian Journal of Marine Sciences* **26**, 20-25.

ROBERTSON, A. I., DIXON, P., & DANIEL, P. A. (1988). Zooplankton dynamics in mangrove and other nearshore habitats in tropical Australia. *Marine ecology progress series. Oldendorf* **43**, 139-150.

ROBERTSON, A.I. & S. J. M. BLABER (1992). Plankton, epibenthos and fish communities. In: "Tropical Mangrove Ecosystem" (A.I. Robertson and D.M. Alongi, eds.), *American Geophysical Union*, Washington DC, USA 173-224.

SAIFULLAH, A. S. M., HENA, M. A., IDRIS, M. H., HALIMAH, A. R., & JOHAN, I. (2014). Diversity of Phytoplankton from Mangrove Estuaries of Sarawak, Malaysia. *World Applied Sciences Journal* **5**, 915-924.

SOOWAMBER, T., (2011). Sediment Characteristics and meiofauna of mangrove ecosystem in East coast of Mauritius, *B.Sc project*, University of Mauritius 40.

TEROL, S.Z. & SAIZ, E (2013). Effects of food concentration on egg production and feeding rates of the cyclopoid copepod *Oithona davisae*. *Limnology & Oceanography* **58**, 376–387.