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MACRO-FAUNA COMMUNITIES IN A TROPICAL MANGROVE FOREST OF ZANZIBAR ISLAND, TANZANIA

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ABSTRACT
The diversity, distribution and abundance of the macro-fauna community were studied in the Nyeke Mangrove forest during 2010 and 2012. Biodiversity results of macro-fauna for the first time have shown that there are 159 species from the study area. Shannon Weiner index of diversity (H) accounted for a high value of 2.4, 1.5 and 1 indicating more diverse community within various habitats for fish, gastropods and crab species respectively. A total of 34 species of fish belonging to 15 families were recorded in all stations. Serranidae were relatively more abundant accounted for 11 and 44% in stations 1 and 2 respectively composed of 5 species belonging to genus Epinephelus. 16 species of crabs were observed belonging to 5 families (Grapsidae, Ocypodidae, Pilumnidae, Eriphiidae and Portunide). The species found were relatively more abundant in the middle (Z2) and lower zone (Z3) *Perisesarma ortmanni* (45 and 37% respectively) and *Perisesarma guttatum* (35.1 and 32.7% respectively). The mangrove gastropods mainly composed of three families (Potamididae, Littorinidae and Neritidae) with 6 species *Cerithidea decollate, Cerithidea micoptera, Littoraria scabra, Littoraria glabrata, Littoraria pallescens* and *Nerita lineate*. The most abundant gastropod species are *L. scabra* accounted for 34.7% at station 3. The mangrove associated insects were registered for the first time, with 103 species belonging to 49 families. The most abundant order was Hymenoptera composed of 27 insect species. Based on mangrove zonation, there is significant high number of insects in order of upper > middle > lower mangrove zone. This study intends to contribute for a better and ecological sound management of the mangrove biodiversity resources of Uzi Island.

KEY WORDS: Biodiversity; Fauna; Mangrove ecosystem; Species

INTRODUCTION

Mangrove forest play a vital role in maintaining environmental complexity and influencing the diversity and distribution of animals related to the ecological system (Lee, 1998; Gao *et al*., 2005). Mangroves of Zanzibar makes up a second largest natural forest with very diverse in aquatic fauna composition including mammals (red colobus and Sykes monkey, Ader's duiker, and suni antelope and blue duiker), molluscs (bivalves, oysters), gastropods crustaceans, fish, insects; and terrestrial fauna also with mammalian, reptile and birds (Akil & Jiddawi, 2001; Nowak & Jone, 2009; Mchenga & Rashid, 2010). However, mangroves and their associated macrofauna are under threats Worldwide through human population pressure (Masden & Maclaren, 2010), including the mangrove resources of Zanzibar Island (UNEP, 1989; McLanahan & Young, 1996). Overexploitation of mangrove resources for construction purposes, fuel, boat building, and fishing gear have been impacted mangroves ecosystem dramatically (Semesi, 1998).

Mangrove forests have strong linkages with coastal environment and are considered important areas for sustenance of the coastal communities (ICZM, 2009). In Zanzibar, mangrove ecosystem is located on a strategically economic zone for tourism industry which contributes 22% of GDP and about 80% of government revenues (OCGS, 2007). This industry extracts numerous benefits from mangroves ecosystem and could be potential economically beneficial to coastal dweller nearby mangrove areas. Healthy ecological system with high biological diversity could provide great opportunity for development of eco-tourism industry that helps in conserving and sustainable utilization of the forest resources (Mchenga & Rashid, 2010). Despite of great opportunity and growing efforts of conservation in the Zanzibar Island, it has not been enough and biodiversity losses continue (Mease, 2009). Meanwhile, macro-fauna play an important part in mangrove ecological system both as consumer and transporter in the energy flow and material circulation of the system. Macro-fauna community structure is the potential biological and ecological index to recognize environmental change and quality of mangrove ecosystem (Tang *et al*., 2007).

Only few studies on mangrove fauna have been conducted in Zanzibar (Ngoile & Shunula, 1992; Akil & Jiddawi, 2001). This paper examines the diversity, distribution and abundance of the macro-fauna in a Nyeke mangrove forest under Menai bay conservation area.

MATERIAL AND METHODS

Study site

The study was conducted in the Nyeke mangrove forest in the Uzi Island which lie along the Uzi Channel on the southwest coast of main Island of Zanzibar, south of the Jozani Chwaka Bay National Park (JCBNP) and within Menai Bay Conservation area. Uzi island is located in the

southern part of the main Island of Zanzibar in the Indian Ocean between 619' and 624` S and 39 25` E. The range annual temperature is between 17°C and 40°C. It is characterized by tropical climate with four distinct seasons namely hot season "kaskazi" between December and February with little or no rain, the long rain "masika" occur from March to May. The relatively cool dry season "kipupwe" occurs between June and September, and short rainy season "vuli" from October to November. The average precipitation varies from 1000mm to 2500mm per years.

Nyeke mangrove forest is found both in sandy and rocky shore in the northern tip and the southern part of the island, with eight species are reported to grow in this site (Mchenga and Rashid, 2010). These are *Rhizophora mucronata*, *Bruguiera gymnorrhiza,* Ceriops tagal, *Avicennia marina, Xylocarpus granatum*, *Lumnitzera racemosa, Sonneratia alba* and *Pemphis acidula.*

Data collection

All data were collected during the hot season (kaskazi) and heavy rain season (masika) between 2010 and 2012. Three plots of 10m x 10m were established each in the upper (Z1), middle (Z2) and lower (Z3) mangrove zone to investigate maco-fauna density, diversity and distributions. Within each sampling plots, 10 samples were taken randomly using quadrants of 1m x 1m and/or 25cm x 25cm. Crabs and gastropods were also collected from each zone (Z1, Z2 and Z3) and taken to the laboratory for identification to the genus or species level wherever possible, using field guide (Richmond, 1997). For fish abundance and distributions, three sampling stations were established based on fish habitat features. Station one (St1) located at the upper stream near by the coral rag road and mostly covered by water both at high and low tide with water depth of approximately 1.5m. It is dominated by *R. mucronata* and patches of rocks and algae. Station two (St2) located in the southern part of the upper stream covered with *R. mucronata*, rocks and algae but water are shallow about 1m depth. Station three (St3) has shallow water (~1m depth) located in the western part of the upper stream with mangrove and sea grass bed. Fish were caught with different fishing gear and traps (nets, line and basket) each were placed in all stations at a time. Fishing was done during high season (bamvua) at first and 3rd week of the lunar calendar. The collected fish species were identified using the manual of 'A Guide to the Seashore of Eastern Africa (Richmond, 1997), Coral Reef Fishes (Lieske & Myers, 1994) and FAO Fish Guide (Bianchi, 1985). Assistance of local fishermen was also taken for collection of fish and identifying the number of fishes present in each catch. Density was calculated for each fish species by repeatedly fishing at the same area and keeping track how many fish are caught with each gear.

For insect abundance and distributions, the sampling was conducted during hot dry season; the area was divided into three distinctive zones, zone A, B and zone C in each zone, the field was divided into two plots measuring 10 by 10 m^2. The distance between plots is 20 m and the distance between zones is 25m approximately. The insect catches practices were done early in the morning between 7 to 10 am when most of insects were very active. At each plot/zone the insect were randomly collected using swept net and hand catches. The collection exercise was carried out once a week for a period of three month. All collected insects were then placed into a small glass vials, labelled and preserved in 70% alcohol for identification at Kizimbani National Entomology Agricultural Research Station. The characterization and identification of insects Orders and Families was done using collected and classified reserved samples, of Plant Protection Division and Wageningen University (Insectaria Museum) with reference of ACTA Entomological Museum of 2008.

Data Analysis

A two-tailed paired Student's t-test was used to compare difference in species abundance between stations. Results were considered significant if $p < 0.05$. Only identified specimens to genus or species levels were included in statistical analysis.

The densities of abundant species for each of the sampling stations were calculated using the formula:

Density = Total number of animals/Area of Sampling Unit

Diversity of the mangroves macro fauna was determined using Shannon-Wiener's diversity and Simpson's diversity indices:

$$H = \sum_{i=1}^{s} - (Pi * \ln Pi)$$

Where:

H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

$\sum$ = sum from species 1 to species S

Then equitability was calculated: E=H/Hmax,

Where; H=Shannon index, Hmax=H/ln(s)

Simpson's diversity index: $D=1-\sum (Pi2)$,

Where pi=abundance of i^{th} species as proportion of total area (relative density), $\sum$ = sum of all total area of species in the community.

RESULTS & DISCUSSION

Results of Shannon Weiner index of diversity (H) accounted for a high value of 2.4, 1.7 and 1 indicating more diverse community within various habitats for fish, gastropods and crab species respectively). Species diversity was maximum in the station 4 with H = 2.4, E = 0.8 for fish species, followed by station 2 with H = 1.7, E = 0.3 for gastropods and the lowest value (H = 1, E = 0.2) were observed for crab species to all of the first three stations.

Sixteen species of mangrove crabs belonging to four families were recorded at three zones during study period (Table 1). The highest mean density in the middle zone (Z2) followed by lower zone (Z3) and the lowest at the upper zone (Z1) recorded for 200.3±41.4, 144.8±21.4 and 63.1±12.0 crabs/10m^2 respectively (Figure 1). Ocypodidae crabs *Uca lacteal annulipes* and *Uca urvillei* and sesarmid crab *Neosarmatium meinerti* were dominant at landward side St1 (48, 35 and 17 % respectively). Middle intertidal area (Z2) and Seaward area (Z3) was dominated by *Perisesarma ortmanni* (45 and 37% respectively) and *Perisesarma guttatum* (35.1 and 32.7% respectively). Overall, Z2 measured higher species abundance in terms

of mangrove associated fauna than the rest of sampling zones. Crabs are one of the most abundant and potentially the most important group of macro-fauna inhabiting mangrove forests (Kathiresan & Bingham, 2001).

TABLE 1. Species of crabs and gastropods identified at the Nyeke mangrove forest, Uzi Island, Zanzibar

No	SPECIES	FAMILY
	CRABS	
1	*Metograpsus messor*	Graspidae
2	*Eurycarcinus natalensis*	Xanthidae
3	*Perisesarma guttatum*	Sesamidae
4	*Perisesarma ortmanni*	Sesamidae
5	*Uca annulipes*	Ocypodidae
6	*Uca urvillei*	Ocypodidae
7	*Uca tetragonon*	Ocypodidae
8	*Uca inversa inversa*	Ocypodidae
9	*Neosarmatium meinerti*	Grapsidae
10	*Neosarmatium smithii*	Grapsidae
11	*Scylla serrata*	Portunidae
12	*Charybdis natator*	Portunidae
13	*Thalamita crenata*	Portunidae
14	*Thalamitoides tridens*	Portunidae
15	*Eriphia smithi*	Eriphiidae
16	*Platypodia granulosa*	Xanthidae
	GASTROPODS	
17	*Nerita lineate*	Neritidae
18	*Littoraria scabra*	Littorinidae
19	*Cerithidea micoptera*	Potamididae,
20	*Cerithidea decollate*	Potamididae,
21	*Littoraria glabrata*	Littorinidae
22	*Littoraria pallescens*	Littorinidae

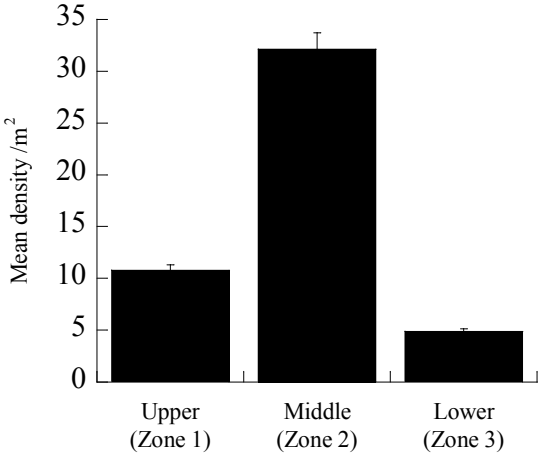

FIGURE 1. Comparison of the Gastropods density between sampling stations, Values are mean ± SE (n = 10).

They play an important role in the cycling of nutrients in mangrove ecosystems (Lee 1998). Under the Pete-Jozani Mangrove forest which is located nearby our study site, only nine species of crabs were observed (Wahira, 2005). However, the distribution and relative abundance of macro-fauna is not uniform, it depends upon the physico-chemical properties such as temperature, pH, grain size, salinity, food availability and oxygen condition (Gibson, 1982), and hence aggregations may occur at scales from a few millimeters to many kilometres (Odiete, 1999). Our findings of crab's zonation are concur with previous studies in Zanzibar, Machiwa & Hallberg (1995) found a horizontal zonation of crabs in East Africa where the terrestrial edge of the mangroves was occupied by grapsids while mixed associations of ocypodids dominated the open areas of sand and mud. Similarly, *Perisesarma guttatum* were reported to be abundant species in the Pete-Jozani mangroves (Akil & Jiddawi, 2001). A total of six species of mangrove gastropods belonging to three families were identified (Table 1). At the St1 the dominant species were *L. pallescens* accounted for 22.2% followed by *L. Scabra* 21.3%, while at the St2 *C. microptera* comprise of 21.8% followed by *C. decollata* 20.2% and at the St3 *L. scabra* was most abundant occupied 34.7%. With exception of *L. Pallescens*, the remaining species were found in all sampling stations.

TABLE 2. Fish species identified at the Nyeke mangrove forest, Uzi Island, Zanzibar

No	Species	FAMILY	Local name
1	*Epinephelus longispinis*	Serranidae	Shengwa
2	*Epinephelus miliaris*	Serranidae	Shengwa
3	*Epinephelus spp*	Serranidae	Shengwa
4	*Epinephelus spp*	Serranidae	Shengwa
5	*Epinephelus spp*	Serranidae	Shengwa
6	*Himantura uarnuk*	Dasyatidae	Taa
7	*Sigunus sutor*	Siganidae	Tasi
8	*Sigunus spp*	Siganidae	Tasi
9	*Lutjanus fulviflumus*	Lutjanidae	Janja
10	*Lutjanus bohar*	Lutjanidae	Janja
11	*Lethrinus mahsena*	Lethrinidae	Changu
12	*Lethrinus harak*	Lethrinidae	Change doa/bale
13	*Plectorinchus gaterinus*	Haemuliddae	Mlea
14	*Plectorinus sordidus*	Haemuliddae	Komba
15	*Parupeneus indcus*	Mulidae	Kundaji
16	*Parupeneus barberinus*	Mulidae	Kundaji
17	*Hipposcarus harid*	Scaridae	Pono
18	Unidentified spp	Scaridae	Pono
19	Unidentified spp	Scaridae	Pono
20	*Chaetedon spp*	Chaetedontidae	Kikande
21	*Chaetedon ocellicaudus*	Chaetedontidae	Kikande
22	*Chaetodon xanthocephalus*	Chaetedontidae	kitatange
23	*Chaetodon dolosus*	Chaetedontidae	kitatange
24	*Pomacentrus trichourus*	Pomacentridae	nyambuzi
25	*Abudefduf sparoides*	Pomacentridae	Patima
26	*Monodactylus argenteus*	Monodactylidae	Habiru
27	Unidentified spp	Unidentified	Dagaa ukuzi
28	*Zanclus cornutus*	Zanclidae	Ame mafua/chota
29	Unidentified spp	Unidentified	Dagaa mchele
30	*Sphyraena forsteri*	Sphyraenidae	mzia
31	*Hyporhamphus affinis*	Hemiramphidae	mzia
32	*Hemiramphus archipelagicus*	Hemiramphidae	Ngarara/ngobiro
33	*Sphaeramia orbicularis*	Apogonidae	-
34	*Geres oyena*	Gerreidae	Chaa

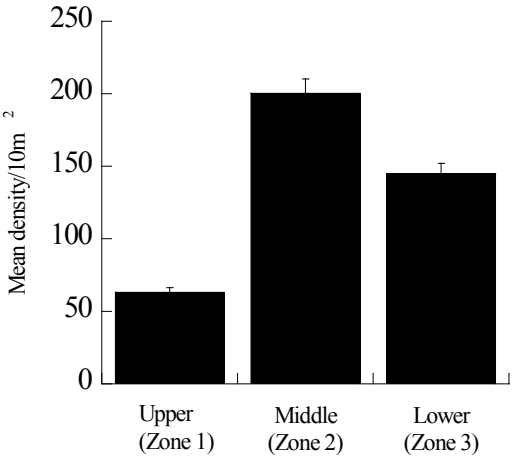

FIGURE 2. Comparison of the crab's density between sampling stations. Values are mean ± SE (n = 10).

There was significance different in species abundance of gastropods between sampling stations (t-test $p < 0.05$). The mean density was high in order of St2>St1>St3 (32.1±1.1, 10.8±0.4 and 4.9±0.5 individuals/m^2 respectively; Figure 2). The potential gastropods have been reported in various mangrove forest of Zanzibar (Akil & Jiddawi, 2001). They are found throughout most mangrove habitats, live on and in the muds, firmly attached to the roots, or forage in the canopy (Kathiresan & Bingham, 2001). The present finding of gastropods is contrary to other species reported

nearby forest of Pete-Jozani where only two species were found *Cerithedia decollate and Littoraria pallescens* (Wahira, 2005). However other species have been reported elsewhere, for instant nine species were observed at Maruhubi mangroves which include *Cerithidea decollate, Cerithidea micoptera, Littoraria pallescens, Littoraria scabra, Littoraria glabrata, Striostrea margaritcea, Terebralia palustris, Nerita lineate and Nerita polita* (Wahira, 2005; Akil & Jiddawi, 2001). There was significant different in fish abundance between stations (t-test, p=0.02) with highest fish catch recorded at St1 than St2 and St3. A total of 34 species belonging to 15 families observed (Table 2).

Out of all families encountered in the area, only two families of Serranidae and Lutjanidae occurred in both station 1 and 2. Serranidae composed of 5 species (*Epinephelus longispinis, E. miliaris and unknown Epinephelus spp)* were relatively more abundant in stations 1 and 2 accounted for 11 and 44% respectively. However, *Hipposcarus harid* (Scaridae), *Parupeneus indcus and P. Barberinus* (Mulidae) occurred only in stations 1 and 3 but the later observed more abundant (50%) in station 3. Another abundant species was *Lutjanus fulviflamus* with 16% and 33% at station 4 and 5 respectively, but were not observed in station 6. Generally, station 4 measured higher species richness, but most of fish species occurred less than 6%. The importance of mangrove ecosystems for its potential for fisheries and aquaculture has been described (Kathiresan1 & Bingham, 2001). According to Ngoile & Shunula (1992), the most common mangrove fish species were *Lethrinus harak* (Forskal) parrot fishes, *Chunos chunos* (Forskal) and fishes of the genus Sigunus. The present results concurred with the previous observation of the flora and fauna of nearby forest of Jozani-Pete mangrove creek where 31 fish species were recorded (Akil & Jiddawi, 2001). The mangrove associated fishes have been reports elsewhere (Kathiresan & Bingham, 2001), for example, 114 species of fish have been recorded from East African mangroves (Taylor *et al*., 2003).

The overall species composition of mangrove insect is given in Table 3. This study finding reported 103 of insects were collected and identified at Nyeke in different mangrove zones. The insect were identified into 10 orders and 49 families. The order Hymenoptera composed of 27 species dominated in ZA and ZB accounted for 10, 12 species respectively. A total of 19 species belonging to the order Lepidoptera were second abundant in the ZA accounted for 8 species. The third abundant was order Dipterans which composed of 12species, out of them 6 species were found at ZA, 3species at ZB and 3 species ZC. The least species were belonging to order Epherminipera and Plecoptera which composed of only single species each. Overall, there is significant high number of insects in order of ZA > ZB > ZC.

TABLE 3. Insect community identified at the Nyeke mangrove forest, Uzi Island, Zanzibar.

Orders	Families	ZONES			
Hymenoptera		Zone A	Zone B	Zone C	Total
	Apidae	5	5	2	12
	Spygidae	1	0	0	1
	Tiphiidae	1	1	1	3
	Formicidae	1	1	0	2
	Eumenidae	1	2	0	3
	Vespidae	1	0	0	1
	Sphecidae	0	3	0	3
	Pteromalidae	0	0	1	1
	Tryphonidae	0	0	1	1
	TOTAL	10	12	5	27
ORTHOPTERA					
	Tittigonidae	2	1	0	3
	Acrididae	1	0	0	1
	Tetrigidae	0	1	0	1
	TOTAL	3	2	0	5
DIPTERA					
	Muscidae	1	0	0	1
	Calliphoridae	1	0	0	1
	Phoridae	1	0	0	1
	Nemestrinidae	1	0	0	1
	Syrphidae	1	1	1	3
	Lauxaniidae	1	0	0	1
	Lonchaeidae	0	1	0	1
	Tabanidae	0	1	0	1
	Eumpididae	0	0	1	1
	Saturidae	0	0	1	1
	TOTAL	6	3	3	12
HEMIPTERA					
	Cicadidae	2	0	1	3

	Reduviidae	0	1	0	1
	Coreidae	1	1	0	2
	Berytidae	0	1	0	1
	Unkown	1	0	0	1
	TOTAL	4	3	1	8
COLEOPTERA					
	Anobiidae	1	0	0	1
	Carabidae	1	0	0	1
	Staphylinidae	1	0	0	1
	Crysomilidae	0	1	0	1
	TOTAL	3	1	0	4
ODONATA					
	Coenagriidae	1	0	0	1
	Corduliidae	1	0	0	1
	Aeschinidae	0	1	0	1
	TOTAL	2	1	0	3
DICTYOPTERA					
	Mantidae	1	0	0	1
	TOTAL	1	0	0	1
LEPIDOPTERA					
	Lycaenidae	2	1	0	3
	Pterophoridae	1	0	0	1
	Pieridae	2	0	1	3
	Pyralidae	1	0	0	1
	Micropterigidae	1	0	0	1
	Notodontidae	1	1	1	3
	Sphingidae	0	1	0	1
	Geometridae	0	1	0	1
	Endromidae	0	1	0	1
	Lymantriidae	0	1	0	1
	libytheidae	0	0	1	1
	Nymphalidae	0	0	2	2
	TOTAL	8	6	5	19
EPHIMEROPTERA					
	Parlodidae	1	0	0	1
	TOTAL	1	0	0	1
PLECOPTERA	Unkown	1	0	0	1
	TOTAL	1	0	0	1

Insects constitute a significant portion of the fauna in mangroves that play important roles in the ecology of the system and contribute to the unique character of these habitats Kathiresan & Bingham, 2001). For the first time 103 species of insects were recognized in the Nyeke mangrove forest. Geographical features of the Uzi Island provides unique micro habitats to various organisms, this could explained the occurrence of high species diversity in this forest. A comparison of the insect diversity with previous studies in Zanzibar is difficult because many of them have been focused on terrestrial habitats. However, most of insect species observed in this study area were reported elsewhere. According to Balasubramanian & Khan (2002) predominant insect species of Avicenniaceae in Pichavaram are leaf mini moth Phylloenistis species (Lepidoptera), leaf galls of Stephaniella falcaria. Felt (Diptera) and Monolepta species (Coleoptera) and those of Rhizophoraceae are caterpillars of Dasychira species (Lepidoptera).

CONCLUSION

In conclusion, the Nyeke mangrove Forest of Uzi Island is highly potential in biodiversity and significant important to the coastal community and economy of Zanzibar. It is obvious that this mangrove forest has high biodiversity potentials that are important to be conserved. This study provides baseline information on biodiversity, there is a need however, for in-depth study of the fauna and their interactions in mangrove ecosystems. It may contribute to a better and ecological sound management of the mangrove resources of Uzi Island.

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