

Diversity and Distribution of the Mangrove Gastropods of Kuala Selangor Nature Park, Selangor

A Jahid^{1,2}, H R Singh^{1*}

¹Department of Biology, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam Selangor

²Department of Biology, Faculty of Education, Kandahar University, Afghanistan

*Corresponding author E-mail: harinderrai.singh@gmail.com

Abstract

This study reports on the diversity and distribution of mangrove gastropods from Kuala Selangor Nature Park sampled from August to November 2017. The line transect with quadrat method was employed to sample gastropods which were handpicked from the various mangrove structures (root, stem, branch) and mangrove floor within 5m x 5m quadrats. Nineteen gastropod taxa were recorded from the *Bruguiera*, mixed (*Bruguiera*, *Avicennia* & *Rhizophora*), and *Avicennia* & *Rhizophora* zones. The Ellobiidae (*Ellobium aurisjudae* and *Cassidula aurisfelis*), Potamidae (*Cerithedia obtusa*, *Cerithidea cingulata* and *Telescopium telescopium*), Muricidae (*Chicoreus capucinus*) and Naticidae (*Nerita balteata*) were the most distributed gastropod families at the study site. Gastropod horizontal distribution varied between tree zones (*Bruguiera*; *Bruguiera-Avicennia-Rhizophora*; and *Avicennia-Rhizophora*) and tree type (*Bruguiera*, *Rhizophora* and *Avicennia*), while gastropod vertical distribution varied based on height on tree (0 – 120cm) and sub-habitats (roots, floor and trunk) as shown by the principle components analysis (PCA) biplots. The Margalef's species richness ($D=2.90$) and Shannon-Weiner diversity ($H^2=2.32$) was low which is typical of mangroves that are mature while Pielou's evenness ($J=0.77$) was high implying lack of dominance by specific gastropod taxa.

Keywords: Mangrove; Gastropods; Diversity; Distribution; Kuala Selangor

1. Introduction

Mangroves are unique ecosystems of considerable significance found usually at the confluence of marine and terrestrial environments having global distribution within the tropical and subtropical regions [1] [2] [3]. The Indo-West Pacific has the largest mangrove area and diversity especially in South East Asia (SEA) [4]. Within SEA, Malaysia is second to Indonesia in size and diversity of its mangroves [1]. This distinctly productive environment houses an extensive variety of fauna such as gastropods, arthropods, fish, birds, reptiles, amphibians, mammals [1] and plants [5]. Besides habitats for fauna and flora, mangroves offer ecological services such as feeding, breeding and nursery grounds for commercially important finfish and shellfish [6], for wood products, pollution and sewage abatement, coastline protection, recreation and tourism [7].

Among the mangrove fauna, gastropods are an important component of the community. There is however paucity on their literature related to community structure and distribution especially at Kuala Selangor Nature Park notwithstanding past works on the taxa in other mangrove habitats in Malaysia [8] [9] [10] [11] [12] [13] [14] [15] [16].

This paper reports on the gastropod community of the mangroves of Kuala Selangor Nature Park. The park houses habitats such as mangroves, mudflats, a man-made lake and a secondary forest. Even though the park was established in 1987 [17], studies related to its mangrove ecology is scanty, especially those related to gastropods.

2. Materials and methods

2.1. Study Site

The study site is located at Kuala Selangor Nature Park, Kuala Selangor, Malaysia (3.3390° N, 101.2448° E) (Fig.1). The park is noted for tourism, and education and awareness since its establishment. The main mangrove taxa that are found are *Avicennia*, *Rhizophora* and *Bruguiera* [17].



Figure 1: Location of Kuala Selangor Nature Park (source: Google Earth, 2018)

2.2 Gastropod Sampling

Gastropod sampling was conducted utilizing the line transect and quadrat method. The sampling area was subjected to representa-

tive transect lines with quadrats of dimensions 5m x 5m. The GPS coordinates of the transect lines are given in Table 1. Gastropods were collected by hand from the mangrove floor, roots and tree trunks. Sampled gastropods were put into labelled plastic bags and were brought back to the laboratory for identification, enumeration and measurement.

Table 1: Coordinates of Transect Lines at Kuala Selangor Nature Park

Transect Line	Starting point	Ending point
1	3°20'02.74"N 101°14'19.43"E	3°20'02.98"N 101°14'00.21"E
2	3°20'05.08"N 101°14'08.80"E	3°20'06.05"N 101°13'59.76"E
3	3°20'09.22"N 101°14'09.96"E	3°20'10.58"N 101°14'01.46"E
4	3°20'12.89"N 101°14'11.04"E	3°20'13.65"N 101°14'04.45"E
5	3°20'18.05"N 101°14'11.84"E	3°20'18.22"N 101°14'07.80"E
6	3°20'25.45"N 101°14'13.89"E	3°20'26.75"N 101°14'08.24"E

2.3 Identification

Gastropods were identified utilizing taxonomic keys in [18] [19] [20] [21] [22] [23].

2.4 Gastropod Community Analysis

The following indices were utilized to compute gastropod species diversity: Margalef's species richness [42], $D = (s-1)/\log_e s$; Shannon-Weiner diversity index [43], $H' = -\sum p_i \log_e p_i$; Maximum diversity, $H'_{max} = \log_e S$; and Pielou's equitability or evenness, $J = H'/H'_{max}$ [44].

2.5 Gastropod Distribution

Gastropod horizontal zones was based on mangrove tree abundance: *Bruguiera* sp. zone (0-50m), mixed species zone (*Bruguiera* sp., *Rhizophora* sp. and *Avicennia* sp.) (50-150m) and *Rhizophora* sp. and *Avicennia* sp. zone (150-200m). The horizontal distribution also expressed as quadrat distances from the coastal bund.

Gastropod vertical distribution was expressed as percentage number of gastropod species recorded from the roots, stem and branches of mangrove trees (sub-habitats) and as percentage number of gastropods along 10cm interval scales from the mangrove floor.

2.6. Statistical analysis

Principal Components Analysis (PCA) [24] was utilized to show the ordination of the correlation of gastropod taxa to their horizontal (mangrove tree zones and the quadrat distance from coastal bund to mudflat edge) and vertical (height and sub-habitats) distributions. XLSTAT [25] was utilised to run the PCA.

3. Result and discussion

3.1. Mangrove Tree Taxa

Among the mangroves, *Avicennia* sp., *Bruguiera* sp. and *Rhizophora* sp. were recorded within the sampling quadrats at Kuala Selangor Nature Park (Table.2). *Avicennia* sp. recorded the largest Girth at Breast Height (GBH) (mean=37.3±18.2 cm) while *Bruguiera* sp. recorded the smallest GBH (mean=22.36 ±8 cm). *Avicennia* sp. and *Rhizophora* sp. abundance increased from the bund towards the mudflat edge (50m – 200m from the bund). *Bruguiera* sp. abundance decreased from the landward side to-

wards the mudflat edge but its abundance was highest from the bund until 50m (Table. 2). *Avicennia* sp., *Bruguiera* sp. and *Rhizophora* sp. were also previously recorded from the mangroves at Kuala Selangor Nature Park [26].

Table 2: Mangrove Tree Distribution in Sampling Quadrats from Kuala Selangor Nature Park

Mangrove Taxa	<i>Bruguiera</i> zone (0 - 50 m) (no/ha)	Mixed zone (50 - 150 m) (no/ha)	<i>Avicennia</i> & <i>Rhizophora</i> zone (150 - 200 m) (no/ha)	Mean GBH (cm)
<i>Avicennia</i> sp.	333.3	810.1	3333.3	37.3 ±18.2
<i>Bruguiera</i> sp.	4166.6	2546.2	1166.6	22.36 ±8
<i>Rhizophora</i> sp.	250	1273.4	4000	35.12 ±13

3.2. Gastropod diversity

Nineteen gastropod taxa were sampled from the mangroves of KSNP (Table 3). The Ellobiidae (*Ellobium aurisjudae* and *Cassidula aurisfelis*), Potamidae (*Cerithidea obtusa*, *Cerithidea cingulata* and *Telescopium telescopium*), Muricidae (*Chicoreus capucinus*) and Naticidae (*Nerita balteata*) were the most distributed gastropod families at the study site (Table 3). The Margalef index was 2.90, Shannon index, H' was 2.32 and the Pielou evenness, J , was 0.77 (Table. 4). The Margalef index (2.9) at KSNP is low when compared to other mangrove sites (Table 4), considering the index not having a limit. The index is somewhat useful for baseline comparison of habitats [27]. The Shannon index (2.32) is higher when compared to other mangrove sites, but is low as the value is smaller than 3.0 noting that the index can go higher than 4 [28]. The Pielou index (0.77) indicates that the gastropod taxa at KSNP are somewhat evenly numbered within sampling quadrats as its value is closer to 1 [28] implying lack of dominance by a few species and its value is higher than other mangrove sites (Table 5). The diversity indices recorded larger values from the mixed and the *Avicennia* & *Rhizophora* zones, but higher at the latter (Table 4). The high mangrove molluscan diversity is generally attributed to microhabitat diversity and higher food availability [29].

3.3. Gastropod Distribution

3.3.1. Gastropod horizontal distribution

The PCA biplots show that *Chicoreus* copuchins, *Littoraria conica*, *Littoraria scabra*, *Littoraria undulata*, *Littoraria malanostoma*, *Nerita violacea*, *Nerita cornocopia* and *Telescopium mauritsi* correlate to the *Avicennia*-*Rhizophora* zone (150-200 m) (Fig. 2). *Cassidula aurisfelis*, *C. nucleus*, *C. obtusa*, *N. balteata* and *S. miniata*, correlate to the mixed zone (*Bruguiera*-*Avicennia*-*Rhizophora*) (50-150 m) while *C. cingulata*, *E. aurisjudae*, *P. plicata* and *T. telescopium* correlate to the *Bruguiera* zone (0-50 m) (Fig. 2).

With respect to tree type preference, the PCA biplots show that *Cassidula nucleus*, *L. melanostoma*, *L. undulata* and *Phythia plicata* correlate mainly to *Avicennia* trees; *N. balteata* correlate to *Rhizophora* trees; and *C. obtusa*, *C. copucius* and *E. aurisjudae* correlate to *Bruguiera* trees. *C. aurisfelis*, *L. conica* and *L. undulata* on the other hand correlate to both *Avicennia* and *Rhizophora* trees (Fig. 3).

Table 3: Gastropods Taxa Distribution by Mangrove Zones at Kuala Selangor Nature Park

Gastropod Taxa	<i>Bruguiera</i> zone 0-50 (m)	Mixed zone 50-150 (m)	<i>Avicennia</i> & <i>Rhizophora</i> zone 150-200 (m)

<i>Cassidula aurisfelis</i>	+	+	+
<i>Cassidula nucleus</i>	-	+	+
<i>Cerithidea cingulata</i>	+	+	-
<i>Cerithidea obtusa</i>	+	+	+
<i>Chichoreus copucinus</i>	+	+	+
<i>Ellobium arisjudae</i>	+	+	+
<i>Littoraria conica</i>	-	-	+
<i>Littoraria scabra</i>	-	-	+
<i>Littoraria undulata</i>	-	+	+
<i>Nerita balteata</i>	+	+	+
<i>Sphaerassiminea miniata</i>	-	+	+
<i>Telescopium mauritsi</i>	-	+	+
<i>Telescopium telescopium</i>	+	+	+
<i>Neritina cornocorpia</i>	-	-	+
<i>Nerita violacea</i>	-	-	+
<i>Haminoea sp</i>	-	-	+
<i>Littoraria melanostoma</i>	-	+	+
<i>Phytia plicata</i>	+	-	-
<i>Indothais rufotincta</i>	-	-	+

(Note: + = presence; - = absence)

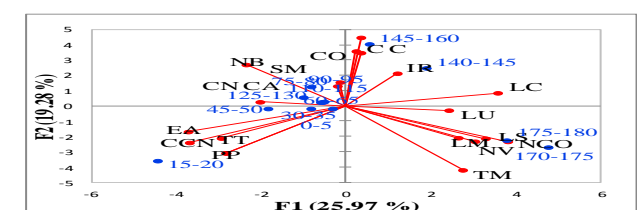
Table 4: Gastropod Diversity Indices Based on Mangrove Sampling Zones at Kuala Selangor Nature Park

Diversity Index	<i>Bruguiera</i> zone (0-50 m)	Mixed zone (50-150 m)	<i>Avicennia & Rhizophora</i> zone (150-200 m)
H, Diversity	1.34	2.27	2.39
D, Richness	0.91	2.49	2.6
E, Evenness	0.75	0.71	0.86

Table 5: Diversity indices from various mangrove locations along the Selangor coast, Malaysia (PKI-Pulau Klang; PTe-Pulau Tengah; Pke-Pulau Ketam; PCMZ-Pulau Che Mat Zin)

Location	Margalef's, D	Shannon-Weiner, H	Pielou, E	Reference
KSNP	2.9	2.32	0.77	present study
Sungai Merbok	4.75	1.23	0.55	[8]
PKI,Pte, Pke, PCMZ (Pristine)	3.9	2.26	0.69	[16]

Gastropod distribution in the mangrove ecosystem is affected by a variety of factors such as light, tidal exposure, salinity and substrate type [30].



The present study recorded wide distribution of Ellobiidae (*E. arisjudae*, *C. nucleus*, and *C. aurisfelis*), Muricidae (*C. capucinus*), Naticidae (*N. balteata*) and Potamididae (*C. obtusa*, *C. cingulata*, *T. telescopium*). The Littorinidae, Potamididae, and Ellobiidae are known to be widely distributed in mangrove ecosystems.

Figure 2: PCA plot of gastropod taxa horizontal distribution [value range (m) represents quadrat distance from the coastal bund]. [CO (*Cerithidea obtusa*), CN (*Cassidula nucleus*), CA (*Cassidula aurisfelis*), NB (*Neritidea balteata*), EA (*Ellobium arisjudae*), IR (*Indothais rufotincta*), LS (*Littoraria scabra*), LC (*Littoraria conica*), LM (*Littoraria melanostoma*), LU (*Littoraria undulata*), NCO (*Nerita cornocorpia*), NV (*Nerita violacea*), PP (*Phytia plicata*), TT (*Telescopium telescopium*), TM (*Telescopium mauritsi*), SM (*Sphaerassiminea miniata*), CC (*Chicoreus copucinus*), CCN (*Cerithidea cingulata*)]

groves of the Indo-Pacific [31].

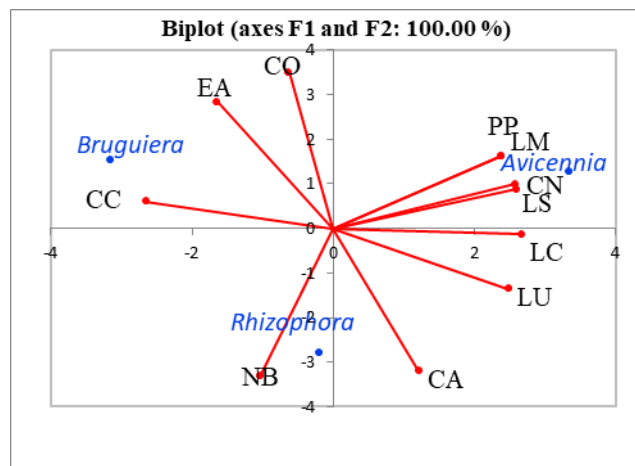


Figure 3: PCA plot of gastropod species distribution on mangrove trees. CO (*Cerithidea obtusa*), CC (*Chicoreus copucinus*), CN (*Cassidula nucleus*), CA (*Cassidula aurisfelis*), NB (*Nerita balteata*), PP (*Phytia plicata*), LS (*Littoraria scabra*), LM (*Littoraria melanostoma*), LC (*Littoraria conica*), LU (*Littoraria undulata*), EA (*Ellobium arisjudae*)

Most gastropods were recorded from the *Avicennia* and *Rhizophora* zone which is closer to the mudflats. The structure of these trees (roots, pneumatophores and stems) create microhabitats resulting in diverse niches for the gastropods to fill [21]. Gastropod predation from *Rhizophora* trees is higher than on *Avicennia* trees [21] and this may have accounted for the larger number of gastropod taxa recorded from the *Avicennia* and *Rhizophora* zone which has more *Avicennia* trees as compared to the mixed zone. Lower taxa distribution at the *Bruguiera* and the mixed zones may be related to lower food availability [32] and that mangrove sediments that are flushed less have higher salinity which may reduce food availability. Such conditions may prevail at the *Bruguiera* zone where the soil may have higher salinity due to lower flushing rates.

3.3.1. Vertical Distribution of Gastropods

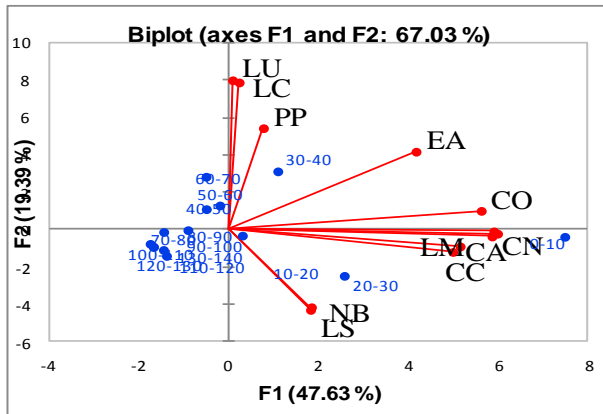
Eleven gastropod taxa were recorded from the roots and stems of the mangrove trees. The PCA plot (Fig. 4) (10cm vertical intervals) shows that *C. nucleus*, *C. aurisfelis*, *C. copucinus*, *L. scabra*, *L. conica*, *L. melanostoma* and *N. balteata* correlate to the 0-30 cm range; *C. obtusa*, *E. arisjudae*, *L. conica*, *L. undulata* and *P. plicata* correlate to the 30-40 cm range

With respect to sub-habitats, the PCA plot shows that *C. nucleus*, *C. aurisfelis*, *C. obtusa*, *C. cingulata*, *E. arisjudae*, *Haminoea sp.*, *I. rufotincta*, *N. cornocorpia*, *S. miniata*, *T. telescopium* and *T. mauritsi* correlate to mangrove floor; *Littoraria scabra*, *L. conica*, *L. melanostoma*, *L. undulata*, *N. violacea*, *P. plicata* correlate to mangrove tree trunk while only *N. balteata* correlate to mangrove roots (Fig. 5).

Most gastropods sampled were mainly from the mangrove floor. Only 20% of gastropods in mangroves are found on trees [33]. Almost all mangrove gastropods are categorized as tree climbers, moving up and down to follow the tide (vertical migration) but some move to the ground during low tide [34]. Tree-climbing behaviour is an adaptation to avoid predation by subtidal crabs and fish that forage at high tide [40] [39]) and also avoidance of physiological stress [41].

The mangrove gastropod vertical distribution indicates zonation patterns where they occupy a variety of microhabitats. While some species live on the mud surface, others live on tree trunks, roots and canopy [35] and the vertical distribution patterns among the gastropods may be related to diet preference as well as predator avoidance [9]. Gastropods are herbivores feeding on small algae distributed at different tide levels [36]. The littorinids, *L. scabra*, *L. conica*, *L. melanostoma* and *L. undulata* were recorded only from

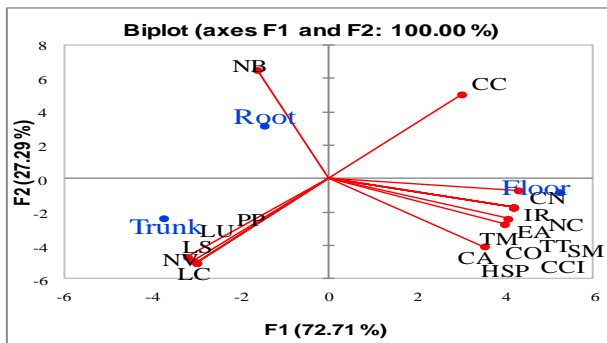
the mangrove trees in the present study. *Littoraria* sp. do not inhabit the mangrove floor because they feed on epibenthic films on stems and roots, and graze on the leaves for food. *Littoraria scabra* is an active gastropod and has the capacity to adjust within the intertidal zone such as adapting to desiccation and has better predator avoidance compared to other littorinids [37]. The Littorinidae show diverse vertical locations in response to the alterations in the tide levels [38]. The Potamididae, for example, *C. cingulata* and *C. obtusa*, can inhabit both the mangrove floor during low tide, seeking trees and roots during high tide above the water line while *T. telescopium* and *T. mauritsi* only inhabit the mangrove floor [39]. The latter's preference for the mangrove



floor could be related to its preference for moist conditions and diet specificity.

Figure 4: PCA plot of gastropod species vertical distribution (Values shown are height range of 10 cm interval. *CO* (*Cerithidea obtusa*), *CN* (*Cassidula nucleus*), *CA* (*Cassidula aurisfelis*), *CCO* (*Chicoreus capucinus*), *EA* (*Ellobium aurisjudae*), *LM* (*Littoraria melanostoma*), *LS* (*Littoraria scabra*), *LC* (*Littoraria conica*), *LU* (*Littoraria undulata*), *PP* (*Phythia plicata*), *NB* (*Nerita balteata*))

Climbing mollusks move downwards to lower zones as lunar-tidal-cycle change to neap tides, and crawl upwards as this cycle



change to the spring tides as well as to daily floods and ebbs. Vertical alterations in substratum moisture, wave energy, salinity and food distribution differ with each lunar-tidal cycle that may disturb the vertical zonation of mangrove mollusks [30]. Vulnerability to predation as well as to microclimatic limits sets the lower and upper limits of vertical distribution of gastropods [39] while horizontal distribution however, is indicative of physiological tolerance [37].

Figure 5: PCA plot of gastropod species distribution based on sub habitats (Floor, Root & Trunk) [*CO* (*Cerithidea obtusa*), *CC* (*Chicoreus capucinus*), *CCIN* (*Cerithidea cingulata*), *EA* (*Ellobium aurisjudae*), *IR* (*Indothais rufotincta*), *LS* (*Littoraria scabra*), *LM* (*Littoraria melanostoma*), *LU* (*Littoraria undulata*), *SM* (*Sphaerassimineia miniata*), *HSP* (*Haminoea* sp.), *NCO* (*Nerita cornocoropia*), *NV* (*Nerita violacea*), *NB* (*Nerita balteata*), *CN* (*Cassidula nucleus*), *NC* (*Neritina cornocoropia*), *TT* (*Telescopium telescopium*), *TM* (*Telescopium mauritsi*), *CA* (*Cassidula aurisfelis*)]

4. Conclusion

The Potamididae, Ellobiidae and Naticidae were the widely distributed taxa. Gastropod horizontal distribution was related to tree zonation patterns and species preference for tree type. Gastropod vertical distribution on tree trunk was related to height from the floor and species preference for sub-habitats (root, floor and tree trunk). The Margalef's species richness and Shannon-Weiner diversity was low probably indicating matured mangroves while Pielou's evenness was high implying low dominance by gastropod taxa.

Acknowledgement

The authors would like to thank the staff of Kuala Selangor Nature Park for assistance rendered and facilities during sampling. Thanks also to Universiti Teknologi MARA (UiTM) for use of space and equipment. This work would not have been completed without the help of Wan Mohammad Nabil in field sampling and Norashekin Kamal Baharin in species identification.

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