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Research paper

Distribution and Abundance of the *Onchidiidae* of the Coastal Mangroves of Selangor, Peninsular Malaysia

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Abstract

The Onchidiidae family is ideal for studying the biodiversity of marine invertebrate species from sea to wetland environments. However, biodiversity studies of Onchidiidae species are rare. This study aimed to determine the distribution and abundance of the Onchidiidae from the coastal mangroves of the Selangor, west coast of Peninsular Malaysia by utilising the quadrat sampling method. A total of 647 specimens from six taxa (Family: Onchidiidae) were recorded from eight fringing coastal mangroves in Selangor coast. The most abundant taxa was *Platevindex coriaceum* (35.08%), followed by *Peronina alta* (28.13%), *Platevindex luteum* (16.85%), *Platevindex* sp. (14.68%), *Onchidium tumidum* (3.71%), and *Onchidium typhae* (1.55%). *P. alta* was most abundant within <10 m distance from the water body (18.75%), *Platevindex* sp. (5.86%) within 10 – 20 m, *P. coriaceum* (10.16%) and *O. typhae* (1.76%) was highly distributed within 20 – 30 m, while *P. luteum* was most concentrated within 40 – 50 m from the water body. Onchidiidae was mostly abundant within <0.2 m from the mangrove floor where they were usually found on the mud, debris, mangrove tree roots and dead logs. The mean density for Onchidiidae at the fringing coastal mangroves in Selangor was 0.18 ± 0.03 no/m^2 and *P. alta* recorded the highest density (mean = 0.47 ± 0.14 no/m^2, total = 0.93 no/m^2). The principal components analysis (PCA) showed that four geomorphological parameters (mud floor, debris floor, tree, and dead logs) and five physicochemical parameters (temperature, humidity, precipitation, salinity, and pH) determined the distribution of six Onchidiidae taxa in the Selangor coastal area.

Keywords *Onchidiidae, mangrove, population structure, distribution, abundance, Selangor.*

1. Introduction

The mangroves are found in the tropical and subtropical regions subjected to periodic fresh and saltwater inundation. The inundation has resulted in patterns of spatial distribution [1] and dispersion of the marine intertidal invertebrates [2]. The zonation of intertidal gastropods in mangroves vary due to environmental cues such as light, tidal exposure, salinity, and substrate type [3] [4].

Among the mangrove gastropods, the Onchidiidae (slugs), a group of shell-less pulmonate gastropods is found in the intertidal coastal habitats of Malaysia. Onchidiidae are usually oval in shape with a dorsally arched notum bearing warts and papillae. The animals breathe air and are distributed between water and in the air in the mangroves. Respiration takes place via the pallial cavity, which is modified as a lung. They feed on organic detritus and unicellular algae in the surface mud [13].

The Onchidiidae of South East Asia include genera such as *Onchidium* Buchannan, 1800; *Peronina* Plate, 1893; *Platevindex* Baker, 1938; and *Melayonchis* Dayrat & Goulding, 2017 [5]. The Onchidiidae remained understudied for reasons such as not a popular and charismatic group, not externally distinguished in their natural environment and confusing nomenclature [6]. There is also scarcity of data of the Onchidiidae from the Malaysian mangroves for the reasons given above. This study aimed to determine the distribution and abundance of the Onchidiidae from the coastal mangroves of Selangor, west coast of Peninsular Malaysia.

2. Materials and method

2.1. Study area

The sampling were conducted at 8 stations along the fringing coastal mangroves of Selangor, Peninsular Malaysia from Sabak Bernam in the north (N3°50'31.66", E100°49'9.89") to Kuala Langat in the south (N2°48'45.42", E101°22'7.41") (Figure 1 & Table 1). Coastal mangroves are described as mangrove forest on the shore of the mainland of Selangor (excluding the small islands), with soft mud and silt (sometimes sandy) with open forest, young *Avicennia* sp. and *Rhizophora* sp. trees, some old *Sonneratia* sp. trees and plenty of washed-out debris and old logs (Figure 2). The Malacca Straits (including the Selangor coast) is a semidiurnal meso-macrotidal system, with tides ranging from 1–3 m during neap tides and and 3–5 m during spring tides [23]. Sampling stations were surveyed during spring tides.

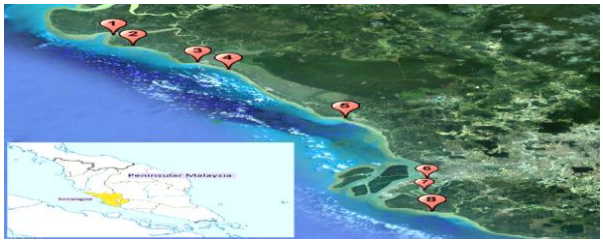

Figure 1: Sampling stations along Selangor coastline (Inset picture: Selangor, Peninsular Malaysia) (See Table 1 for sampling location)

Table 1: Sampling stations and their Global Positioning System (GPS) coordinates along the Selangor coast

ampling station	Sampling location	Coordinate	
		North	East
1	Sg. Ayer Tawar	3°50'31.66"	100°49'9.89"
2	Bagan Nakhoda Omar	3°46'35.65"	100°51'19.21"
3	Bagan Sungai Besar	3°40'13.27"	100°58'26.06"
4	Sungai Haji Dorani	3°37'34.00"	101° 1'47.90"
5	Kuala Selangor Nature Park	3°20'8.71"	101°14'7.71"
6	Pulau Indah 1	2°59'14.50"	101°21'16.30"
7	Pulau Indah 2	2°53'34.90"	101°17'47.50"
8	Pulau Carey	2°48'45.42"	101°22'7.41"

Figure 2: Fringing coastal mangrove in Bagan Sungai Besar (station 3) showing exposed mudflat during low tide.

2.2. Sampling and identification

Sampling was conducted by utilising the line transects and quadrat method as per Krebs [7]. At each sampling station, transect lines were set up and the distance between transect lines varied from 10 m to 70 m depending on the size of the mangrove forest. Along the transect line, 5 m x 5 m quadrats were placed where the distance between quadrats was 2 m apart. Onchididae (mangrove slugs) were hand collected from the mud, on the forest floor (leaves debris or algae logs), trees (roots, barks, branches or leaves), under woods, rocks and pebbles within each quadrats at the sampling stations. It was at times difficult to locate these animals due to their camouflaged bodies and one has to rely on their feeding trails in order to locate them. Field recordings included tree species, tree girth, and tree height within the quadrats. Height at which slugs were sampled (stems, roots, boulder) was also recorded. All slugs sampled were photographed to enhance identification [6] as the slugs curl on touch. All Onchididae sampled were identified according to keys in [6] and [8].

2.3. Environmental parameter

The physicochemical parameters (temperature, humidity, precipitation, salinity, and pH) and geomorphological parameters (mud floor, debris floor, tree, and dead logs) were recorded at each sampling station. The pH, and salinity (ppm) were measured *in-situ* at approximately 30 cm below the water surface using a YSI multi probe water sampler. The temperature, humidity, and rainfall precipitation data was obtained from Malaysian Meteorological Department (MMD). The geomorphological parameters were determined by taking into account the height where the slugs were found.

2.4. Principal Component Analysis

A PCA ordination was performed to analyse the relationship (correlation) between the environmental parameters and Onchidiidae abundance in order to determine which parameter in the set form coherent subsets that are relatively independent of each other [9]. The ordination was performed by using XLSTAT (Microsoft Excel) software.

3. Results

3.1. Onchidiidae abundance and distribution

In total 647 individuals of the Onchididae were sampled. Among the taxa identified, the most abundant was *Platevindex coriaceum* (35.08 %) (Figure 3), followed by *Peronina alta* (28.13 %), *Platevindex luteum* (16.85 %), *Platevindex* sp. (14.68 %), *Onchidium tumidum* (3.71 %), and *Onchidium typhae* (1.55 %) (Figure 3).

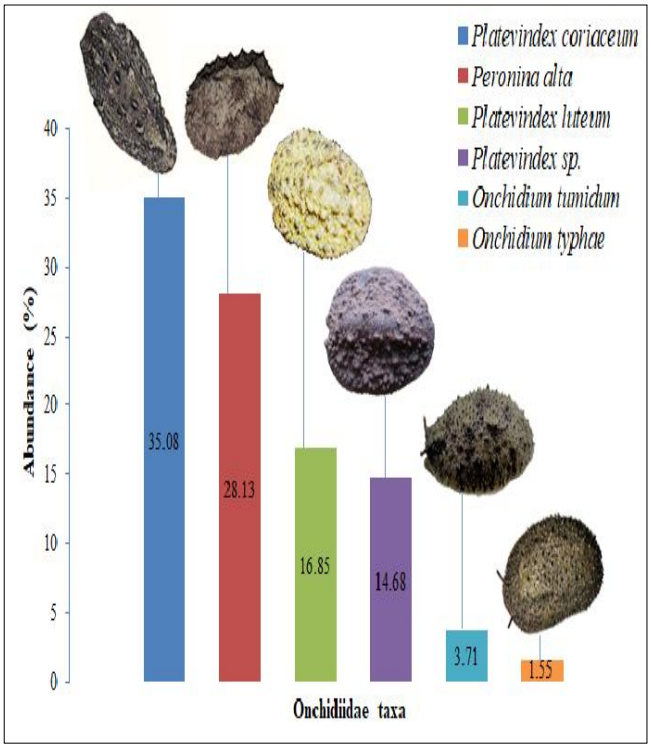

Figure 3: Onchidiidae taxa abundance in fringing coastal mangroves of Selangor.

With respect to horizontal distribution, *P. alta* (18.75 %) and *O. tumidum* (4.1 %) were most abundant within <10 m distance from the water body (Figure 4). *Platevindex* sp. (5.86 %) was abundant within 10 – 20 m, followed by *P. coriaceum* (10.16 %) and *O. typhae* (1.76 %) which were most distributed within 20 – 30 m, while *P. luteum* was most concentrated within 40 – 50 m from the water's edge. The Onchidiidae taxa were abundant within <0.2 m from the floor where they were usually found on mud floor surface, debris, tree roots and dead logs (Table 2 & Figure 5). *Peronina alta* (32.89 %) was abundant from the muddy floor and debris surface (<0.2 m), followed by *O. tumidum* (6.68 %) (Figure 5). Both taxa are identified as "floor-crawlers" slugs. *Platevondex coriaceum* (19.25%) and *Platevindex* sp. (13.37%) was mostly sampled from tree roots, tree trunks, debris and dead logs (Table 2) at the height of >0.2 m, followed by *O. typhae* (4.28%) and *P. luteum* (3.74%) (Figure 5). *Platevindex coriaceum* was the most abundant taxa >0.2 m (Figure 5).

Table 2 Onchidiidae taxa vertical distribution in fringing coastal mangrove of Selangor (+ = presence; - = absence)

Onchidiidae	Floor		Tree		Dead log
	Debris	Mud	Root	Trunk	
Peronina alta	-	+	-	-	-
Platevindex sp.	+	-	+	+	+
Platevindex coriaceum	+	-	+	+	+
Onchidium tumidum	-	+	-	-	-
Onchidium typhae	+	+	+	+	+
Platevindex luteum	+	-	+	-	+

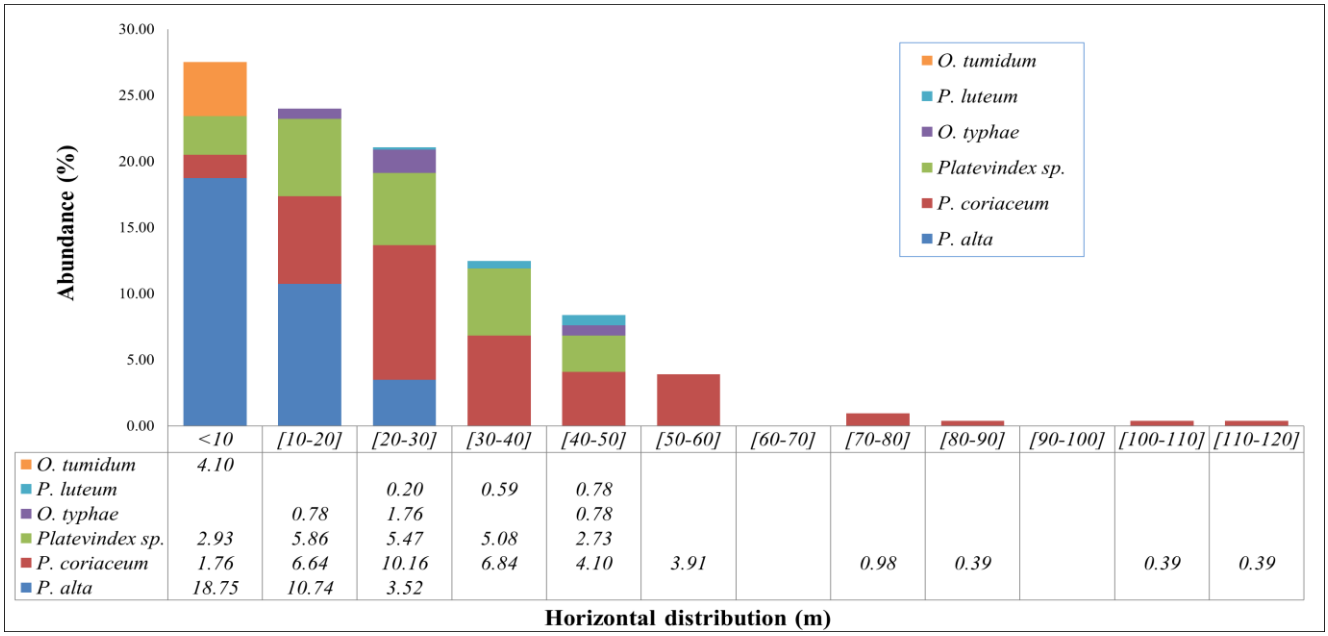

Figure 4: Onchidiidae horizontal distribution at fringing coastal mangrove of Selangor coast

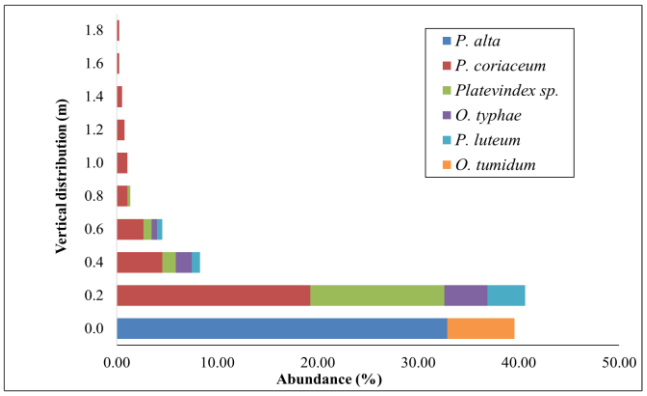

Figure 5: Onchidiidae vertical distribution at fringing coastal mangrove of Selangor coast

3.2. Onchidiidae density and biomass

The total mean density for Onchidiidae of the fringing coastal mangrove in Selangor was 0.18 ± 0.03 no/m^2 (total = 4.207 no/m^2). The larger mean density (> 0.19 no/m2) sampled were *P. alta* (0.47 ± 0.14 no/m^2) and *Platevindex* sp. (0.2 ± 0.06 no/m^2), while the smaller mean density (< 0.2 no/m2) sampled were *O. tumidum* (0.17 ± 0.13 no/m^2), *P. coriaceum* (0.14 ± 0.03 no/m^2), *O. typhae* (0.11 ± 0.07 no/m^2), and *P. luteum* (0.06 no/m^2) (Table 3). The total mean biomass of 6 Onchidiidae taxa sampled was 107.18 ± 1.03g (total = 857.45g) and the largest mean biomass was *P. coriaceum* (3.58 ± 0.07g), followed by *Platevindex* sp. (1.69 ± 0.09g), *P. luteum* (1.39 ± 0.22g), *O. typhae* (1.17 ± 0.35g), *P. alta* (0.83 ± 0.03g) and the least was *O. tumidum* (0.3 ± 0.03g) (Table 3).

Table 3 Onchidiidae density and biomass sampled from the fringing coastal mangrove of Selangor

Onchidiidae taxa	n	Mean density ± SE (no/m^2)	Mean biomass ± SE (g)
Peronina alta	182	0.47 ± 0.14	0.83 ± 0.03
Onchidium tumidum	24	0.17 ± 0.13	0.3 ± 0.03
Platevindex sp.	119	0.2 ± 0.06	1.69 ± 0.09
Platevindex coriaceum	263	0.14 ± 0.03	3.58 ± 0.07
Onchidium typhae	10	0.11 ± 0.07	1.17 ± 0.35
Platevindex luteum	9	0.06	1.39 ± 0.22

Note: SE = standard error

3.3. Principal Components Analysis (PCA) of Environmental Parameters and Onchidiidae Abundance

The principal component analysis (PCA) showed that four geomorphological parameters (mud floor, debris floor, tree, and dead logs) and 5 physicochemical parameters (temperature, humidity, precipitation, salinity, and pH) determined the distribution of the six Onchidiidae taxa in the Selangor coastal area (Figure 6). *Peronina alta* and *O. typhae* abundance correlate to the substrate floor to higher humidity and salinity. *Platevindex coriaceum* and *Platevindex* sp. Abundance correlate to mangrove trees, dead logs and leaves litter (debris) and higher salinity. *Platevindex luteum* abundance correlate to higher pH, temperature and precipitation as well as to lower salinity and humidity. *Onchidium tumidum* abundance correlate to higher precipitation, pH, and temperature and low salinity.

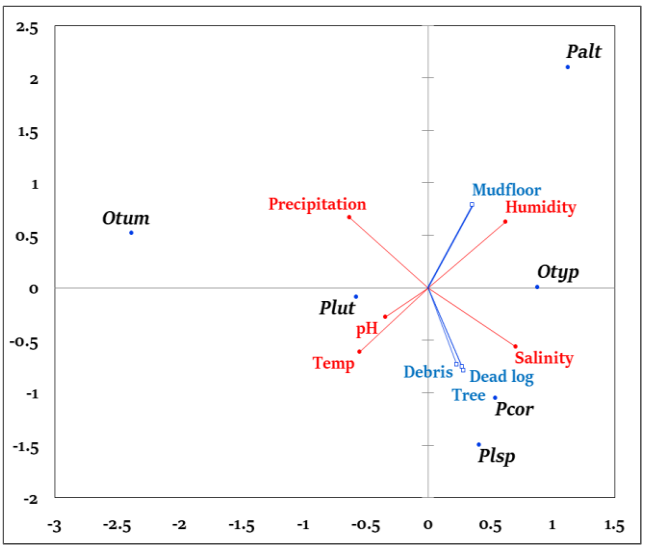

Figure 6 Principal Components Analysis Ordination of Onchidiidae Abundance with Environmental Parameters of Selangor Coast (*Otum = Onchidium tumidum*; *Palt = Peronina alta*; *Plut = Platevindex luteum*; *Pcor = Platevindex coriaceum*; *Plsp = Platevindex sp.*; *Otyp = Onchidium typhae*)

4. Discussion

Onchidiids have a worldwide distribution, with the exception of the Arctic and Antarctic [10]. Twelve genera are exclusively present in tropical Indo-West Pacific [6]. There were no new species or genera recorded from the present study. The taxa recorded are native to the region that ranges from the Andaman Sea to the South China Sea through the Strait of Malacca [11].

Platevindex (Baker, 1938) is within the clade with species having a distinctly flattened body and narrow foot, such *Platevindex coriaceum* (Semper 1885), *Platevindex luteum* (Semper 1885), and *Platevindex martensi* (Semper 1885). The genus *Platevindex* is widely distributed in the tropical Indo-West Pacific [5] and also throughout the coastal areas in China [13], and is abundant in the mid and upper intertidal zone [20] in estuaries sheltered by rocks, and also in mud [13]. According to Dayrat *et. al*. [11], *P. coriaceum* (Semper 1885) is distributed from Singapore, Malaysia (Penang), Philippines (Bohol, Manila & Zamboanga) to Australia (Brisbane) [5]. In this study, *P. coriaceum* was abundantly distributed in the mid-tide zone until high-tide zone from 20 to 30 m until 120 m distance from the water edge (Figure 4). It is found on tree trunks, tree roots, dead logs, and floor debris (leaves and wood litter) but not on the mud surface. *P. coriaceum* was the only species that was sampled higher than 1 m from the ground. The species prefers trees, old logs, debris, and less moisture (precipitation and humidity). This is due to its skin thickness (dorsal) and the number of blood sinuses compared to other taxa which can retain water longer thus mitigating desiccation [21] [22]. *Platevindex* sp. was sampled within 10 – 40 m distance from water body where the salinity, pH, and temperature was higher. Like *P. coriaceum*, *Platevindex* sp. was sampled from trees (roots & trunks), old logs, and floor debri (leaves and wood litter) which had thin layer of mud/algae. *Platevindex* sp. live in upper intertidal zone [13], can live in both shallow seawater and wetlands and has the ability to burrow in mud and climb on rocks [22]. There is not much information on *Platevindex luteum* (Semper 1885) distribution apart from it has the type locality in Singapore [1]. It was mainly found on the floor debri (wood), tree roots, and dead logs where the pH, temperature and moisture was higher.

Onchidium typhae Buchannan, 1800 is one of the two Onchidiidae that live in brackish habitats and tolerates fresh water. Historically, Buchanan (1800) [14] recorded *Onchidium*, a brackish water taxa from the swamps of Bengal, which he called *Onchidium typhae*. Its distribution spans from north-eastern India (West Bengal) to the Philippines, including the Strait of Malacca, Singapore, Thailand, Vietnam, eastern Borneo, and China. In West Bengal, *O. typhae* is found on soft mud and on *Avicennia* trees in the brackish waters of the Sundarbans in the east coast of India [15]. In the Andaman Islands, it is found on mud most often at the base of tree trunks and roots, old logs and exposed mud surfaces. In Malaysia (Matang and Langkawi), it is most often found on old logs and tree trunks and roots, as well as on the mud surface (especially that of the mud lobster mounds) [8]. *Onchidium typhae* is criptic and rare and is abundant at the pristine mangroves of Matang [8]. In this study, it was concluded that *O. typhae* prefers trees, logs, mud, and debris in habitats (Table 2) with high humidity and salinity, lower temperature and pH, and less precipitation. It was most abundant within 10 – 50 m distanced from the water body (Figure 4).

The genus *Peronina* is known from a single specimen, (*Peronina alta* Plate, 1893) collected in the 1800s from Madras, India [16]. *Peronina alta* is geographically restricted to the Bay of Bengal and the Strait of Malacca (Malaysia and Singapore) [16] [19]. *Peronina alta* prefers mudflats unlike *P. tenera* which prefers the brackish habitat [17]. In the present study, *P. alta* was exclusively collected from the exposed mud surface as in other mangrove areas [5] [18] [19]. It prefers mudflat habitat with higher humidity (Figure 6).

The spatial distribution of the Onchidiidae from the Selangor coast could be attributed to sub-habitats (mud floor, debris floor, tree, and dead logs) and physicochemical parameters (temperature, humidity, precipitation, salinity, and pH). The habitat preference of the Onchidiidae varies due to environmental cues, such as light, tidal exposure, salinity, food availability, and substrate type [4]. The free-swimming veliger larvae stage along with temperature and salinity which affects embryonic development [20] and competition for food [5] are factors that affect the distribution and abundance of the Onchidiidae. It is however unclear as to what extent each of these factors influence the Onchidiidae distribution and abundance because these factors could be interrelated.

5. Conclusion

Six Onchidiidae taxa were sampled from the coastal mangroves of Selangor. Horizontal and vertical distribution, and abundance was noted for the different taxa within the mangroves. The PCA showed that the Onchidiidae taxa have different preference of sub-habitats and that these preferences may be related to the local physicochemical parameters. Further studies on the spatial and temporal variations along with taxonomic studies of the Onchidiidae are needed to understand their ecology.

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