BIODIVERSITY AND POPULATION OF GHOST CRABS AT SELECTED SANDY BEACHES OF KUCHING DIVISION, SARAWAK

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Biodiversity and Population of Ghost Crabs at Selected Sandy Beaches of Kuching Division, Sarawak

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This report is submitted in partial fulfilment of the requirement for degree of Bachelor of Science with Honours (Aquatic Resource Science and Management)

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Special thanks to local people of Satang Island, Sematan beach and Kampung Pandan for helping me during field work.
DECLARATION

I hereby declare that no portion of this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

Norhakimi Bin Muhamad

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O. = Ocypode
CMR = Capture-mark-recapture
CL = Carapace length
CW = Carapace width
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Biodiversity and Population of Ghost Crabs at Selected Sandy Beaches of Kuching Division, Sarawak

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ABSTRACT

Ghost crabs under the genus *Ocypode* are one of the sandy beach communities. The genus consists of 26 species worldwide. The adults usually occupy terrestrial area while their juveniles can be seen on the beach until the edge of the water. They are nocturnal animals and practise scavenging, predating and detritus feeding behaviour. Generally they have unequal size of chelipeds and differ between each individual which are either their right or left chela is bigger. Three sites were chosen as study sites which are Satang Island (26 – 27 July 2010), Sematan beach (7 – 8 August 2010) and Teluk Pandan beach (30 January – 2 February 2011). The ghost crabs that inhabit those three beaches are *O. ceratophthalmus* and Satang Island is the only area to have another species which is *O. cordimanus*. Their handedness ratio is almost equal within the same sex nearly 1:1 and the male population is higher compared to female about 7:3. Their populations are estimated to be huge in each beaches based on the capture-mark-recapture method. Burrow counting method showed that supralittoral area has higher density of ghost crab while capture-mark-recapture method shows that ghost crabs density is higher at foreshore area.

Key words: Ghost crab, biodiversity, population, distribution, morphometric data

ABSTRAK


Kata kunci: ‘Ketam hantu’, biodiversiti, populasi, taburan, data morfometrik
1.0 INTRODUCTION

A sandy beach comprises of a large volume of sand detained between bed-rock, foreshore cliff and sea. The sand quantity is influenced by the wave energy in such a way that balance the sand input and the sand output (Morton and Morton, 1983). Sandy beaches support high diversity of living organisms and usually dominated by the aquatic invertebrates that live from the sand surface to deeper layer of soil where water is present. These beaches are also subjected to human exploitations as well as influence by the natural phenomena for example tides and waves. One of the common organisms that can be found at sandy beach is ghost crab. According to Trott (1999), ghost crab has become a successful colonizer of sandy beaches. McLachlan et al. (1996) suggest that ghost crabs (Ocypode cordimanus) occupy the area of supralittoral of the sandy beach and their juvenile lives towards the shore.

Ghost crabs are from the genus Ocypode which consist of 26 known species worldwide (Appeltans et al., 2011). Ghost crab is not listed under endangered or protected animals. Therefore they are vulnerable against exploitation by human. Based on Barros (2001), ghost crab has been affected by the recreational activities such as four-wheel driving on the beaches. He discovered that these ghost crabs did not run away from the vehicle that comes toward them and suggested that the ghost crabs are attracted to vehicle’s light. Other human activities on the beach area for examples recreation activities or shore fishing activity can also affect the habitat of ghost crab as well as their population. Based on Bertini et al. (2004), the basis of understanding the processes affecting the equilibrium of communities or ecosystems is to gather or collect information on species composition. Moreover, the species identification is an important key to identify or interpret disturbance event that are either anthropogenic or natural occurrence.
There were several studies being done related to the diversity and population of Ocypodidae or ghost crabs. Most of the studies observed the ecology of the ghost crab (Milne and Milne, 1946; Wolcott, 1978; Leber, 1982; Trott, 1988; Veloso et al., 1997; Strachan et al., 1999; Quijón et al., 2001; Portvell et al., 2003; Tureli et al., 2009 and Branco et al., 2010). The use of ghost crab as a key species for evaluating the condition of sandy beach also had been reported by Steiner and Leatherman (1981); Wolcott and Wolcott (1984); Barros (2001); Moss and McPhee (2006); Neves and Bemvenuti (2006); Schlacher and Lucrezi (2009). Several reports on the systematic arrangement of the ghost crab as well as the species occurrence (Abele and Kim, 1986; Ashton et al., 2003 and Grave et al., 2009). The ghost crab predation on turtle’s eggs and hatchlings especially the green turtle, *Chelonia mydas* was mentioned by Fowler (1979); Chan and Liew (1999) and Strachan et al. (1999).

Most studies about ghost crabs were conducted in other countries, while in Malaysia they appeared as side findings of other bigger topics. Therefore, the information about the ghost crabs and their characteristics are still lacking including their populations and distributions as well as their ecological functions in sandy beaches. Therefore, this study was conducted in order to: 1) make documentation on the ghost crab species and their characteristics that occur at selected sites within Kuching division of Sarawak; 2) study about their population density as well as their distribution along the beaches and 3) compare the findings obtained from each selected beaches.

The population study was conducted using two methodologies: 1) the capture-mark-recapture method and 2) the burrow counting. Species identification of the ghost crab was based on the published journals and books. The morphological characteristics were measured for the morphometric relationship analysis and documentation purposes. The observation during field work was noted as qualitative information.
2.0 LITERATURE REVIEW

2.1 Biodiversity

Biodiversity (short term for biological diversity) is the sum total of all biotic variation from the level of genes to ecosystem which now facing problems by human’s actions (Purvis and Hector, 2000). Biodiversity has multitude of facets that can be quantified which are numbers, evenness and difference (Purvis and Hector, 2000). Species richness is the most common facet of biodiversity which is calculating the number of species in a site, habitat or clade (Purvis and Hector, 2000). Species is a choice to measure density of unit because species is also sensible units to choose from biological perspective as they keep their genes within themselves and the same species also have variation between regions which is related to the ecosystem that they occupied (Purvis and Hector, 2000). This shows that each ecosystem produces their own biodiversity. Therefore, beaches ecosystem also has their own species diversity that usually consists of aquatic organisms and mostly belongs to the Order Decapoda, Brachyura which are invertebrates.

Focusing on sandy beaches, from the Family Ocypodidae, the most known species of crabs which is semi-terrestrial animal or amphibious are fiddler crabs and ghost crabs (Barnes, 1991). Fiddler crabs, under the genus *Uca* occur widely on tropical and semitropical regions which occupied sand and mud beaches and prefer intertidal area for their burrow and active during diurnal low tides (Barnes, 1991). Meanwhile, the ghost crabs under the genus *Ocypode* are several times larger than fiddler crabs but it did not occur in large aggregation and their burrows are widely separated and mostly being found at the supralittoral area or the upper beach (Barnes, 1991). Another species of crabs under the Family Mictyridae are similar to *Uca* in term of behaviour (Barnes, 1991).
2.2 Taxonomic Classification of the Ghost Crab

Taxonomic classification of ghost crab is based on Powers (1977); Manning and Holthuis (1981) and Martin and Hine (2004):

- **Kingdom**: Animalia
- **Phylum**: Crustacea
- **Class**: Malacostraca
- **Subclass**: Eumalacostraca
- **Order**: Decapoda
- **Infraorder**: Brachyura
- **Family**: Ocypodidae (Rafinesque, 1815)
- **Subfamily**: Ocypodinae (Rafinesque, 1815)
- **Genus**: *Ocypode* (Weber, 1795)

Table 1: List of known species of ghost crabs under the genus *Ocypode*. (Source: Appeltans et al., 2011)

<table>
<thead>
<tr>
<th>Species name</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ocypode stimpsoni</em></td>
<td>Ortmann, 1897</td>
</tr>
<tr>
<td><em>O. saratan</em></td>
<td>Forskal, 1775</td>
</tr>
<tr>
<td><em>O. africana</em></td>
<td>De Man, 1881</td>
</tr>
<tr>
<td><em>O. quadrata</em></td>
<td>Fabricius, 1787</td>
</tr>
<tr>
<td><em>O. brevicornis</em></td>
<td>H. Milne Edwards, 1837</td>
</tr>
<tr>
<td><em>O. ceratophthalmus</em></td>
<td>Pallas, 1772</td>
</tr>
<tr>
<td><em>O. convexa</em></td>
<td>Quoy &amp; Gaimard, 1824</td>
</tr>
<tr>
<td><em>O. cordimanus</em></td>
<td>Latreille, 1818</td>
</tr>
<tr>
<td><em>O. cursor</em></td>
<td>Linnaeus, 1758</td>
</tr>
<tr>
<td><em>O. fabricii</em></td>
<td>H. Milne Edwards, 1837</td>
</tr>
<tr>
<td><em>O. gaudichaudi</em></td>
<td>H. Milne Edwards &amp; Lucas, 1843</td>
</tr>
<tr>
<td><em>O. jousseaumei</em></td>
<td>Nobili, 1905</td>
</tr>
<tr>
<td><em>O. kuhlii</em></td>
<td>De Haan, 1835</td>
</tr>
<tr>
<td><em>O. pallidula</em></td>
<td>Jacquinot, in Hombroux &amp; Jacquinot, 1846</td>
</tr>
<tr>
<td><em>O. longicornuta</em></td>
<td>Dana, 1852</td>
</tr>
<tr>
<td><em>O. macrocera</em></td>
<td>H. Milne Edwards, 1852</td>
</tr>
<tr>
<td><em>O. madagascariensis</em></td>
<td>Crosnier, 1965</td>
</tr>
<tr>
<td><em>O. mortoni</em></td>
<td>George, 1982</td>
</tr>
<tr>
<td><em>O. nobili</em></td>
<td>De Man, 1902</td>
</tr>
<tr>
<td><em>O. occidentalis</em></td>
<td>Stimpson, 1860</td>
</tr>
<tr>
<td><em>O. pauliani</em></td>
<td>Crosnier, 1965</td>
</tr>
<tr>
<td><em>O. platytarsis</em></td>
<td>H. Milne Edwards, 1852</td>
</tr>
<tr>
<td><em>O. pygoides</em></td>
<td>Ortmann, 1894</td>
</tr>
<tr>
<td><em>O. rotundata</em></td>
<td>Miers, 1882</td>
</tr>
<tr>
<td><em>O. ryderi</em></td>
<td>Kingsley, 1880</td>
</tr>
<tr>
<td><em>O. sinensis</em></td>
<td>Dai, Song &amp; Yang, 1985</td>
</tr>
</tbody>
</table>
Ocypode means “swift – of – foot” (Milne and Milne, 1946) might be due to their rapid running behaviour (Burrows and Hoyle, 1973). According to Appeltans et al. (2011), in World Register of Marine Species (WoRMS) website, a total of 26 species of ghost crabs under the genus Ocypode had been described (Table 1).

Based on Little and Kitching (1996), scientific names might change over time when the taxonomy of organisms is revised due to earlier description of the type of species is discovered to have priority or the species consist of more than one taxon. For examples, there are few species under genus Ocypode but unaccepted by the taxonomic editor for examples: O. (Chasmagnatus) convexus (De Haan, 1835) accepted as Chasmagnatus convexus (De Haan, 1835); O. (Cleistostoma) dilatatum (De Haan, 1833) accepted as Cleistostoma dilatatum (De Haan, 1833); and O. (Gelasimus) arcuata (De Haan, 1833) accepted as Uca (Tubuca) arcuata (De Haan, 1833).

2.3 Ecology of Ghost Crab

Ghost crabs are burrowers and named after its pallid colouring invisible against the sand colour and their practice to running silently and swiftly (Morton and Morton, 1983). These crabs have the mechanism of rapid running and the maximum running speed of ghost crab (O. ceratophthalmus) is 2.1 m/sec (Burrows and Hoyle, 1973). According to Wolcott (1978) and Trott (1999), ghost crab lives in colonies on sandy beaches and can also occupied terrestrial habitat. They also can occupy protected harbour beaches, bays, intracoastal canals and lagoons (Powers, 1977). Ghost crab is a nocturnal animal which means that they only active at night. Usually this nocturnal behaviour is practiced only by the mature ghost crabs as they will stay in their burrows during daytime while the juveniles can be found scattering on the beaches during both day and night time (McLachlan et al., 1996). The burrows usually a metre deep or more, sloping landward as they go down and
can be identified by the seaward scatter of excavated sand. According to Antunes et al. (2010), the burrows are considered a safe refuge for the crabs due to its ability to minimize the variation in salinity, temperature and dissolve oxygen in water.

Based on Ng (1998) and Matsuura et al. (2000), the carapace shape of ghost crabs can be squarish, transversely rectangular, trapezoidal or transversely ovate. Their dorsal surface gently convex, usually either smooth or with grooves. The entire frontal margin moderately narrowed and possess broad orbit which occupying almost entire anterior borders excluding the front. The anterolateral and posterolateral margins of carapace usually not clearly demarcated. The lateral margins appearing almost straight or gently convex without armed. Ghost crabs have long eyestalks which are longer than the width of orbit. They seem not to have rhomboidal gap between third maxillipeds (mouth part) but possess numerous stiff setae on the dactylus of legs. They might possess tufts of fine setae on their ventral surface of abdomen or base of legs and the male abdominal segments are distinct and moveable. They also possess unequal size of chelipeds. The bigger cheliped can be either right side or left side of the ghost crab. The above mentioned morphology structures of the ghost crab as mention above are shown in Figure 1.

![Figure 1: The general morphological structure of ghost crab as described by Ng (1998). (Modified from Ng, 1998).]
Ghost crabs are predators, scavengers or even detritus feeding animals (Wolcott, 1978; Trott, 1999). Based on Morton and Morton (1983), the ghost crab is a sand siever but they are adapted to catch insects, small crustaceans and turtle hatchlings. They usually feed at intertidal area or on dead animals either big or small at the beaches such as Portuguese man-of-war jellyfish or stinging tentacles that washout by the waves to the beach (Wolcott, 1978) during night time as they are nocturnal animals (Steiner and Leatherman, 1981).

2.4 Related Studies in Malaysia

In Malaysia, the study of ghost crabs is more on their predation on turtle’s eggs and hatchlings especially the Green turtle, *Chelonia mydas* and Hawksbill turtle, *Eretmochelys imbricata* which were done by Chan and Liew (1999) in Redang Island, Terengganu. Chan and Liew (1999) also reported that there were ghost crab burrows found within the turtle incubation area in which 33% of the turtle’s nest was occupied by crabs especially the *Ocypode* ghost crab. The predation on turtle’s eggs by ghost crab was recorded during turtle’s nest excavation. Ghost crabs also prefer to colonize at upper shore that was above the high tides of sandy beaches in Bachok Kelantan (Sasekumar et al., 2010). The ghost crab burrows were observed under the *Casuarina* trees but most burrows were found at the upper shore down to about 30 m from the grass edge.

3.0 Materials and Methods

3.1 Study Site

The study was conducted at three different stations as shown in Table 2. Coordinate of each study site were obtained using Global Positioning System (GARMIN GPSmap 60CSx). Figure 2 showed the location of study sites.
Table 2: The locations of study sites, coordinates and the sampling dates.

<table>
<thead>
<tr>
<th>Place</th>
<th>Coordinates</th>
<th>Sampling Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Satang Island</td>
<td>N 01° 46.828' E 110° 09.882' to 26 &amp; 27 July 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 01° 46.762' E 110° 09.856'</td>
<td></td>
</tr>
<tr>
<td>2 Sematan beach</td>
<td>N 01° 49.416' E 109° 45.813' to 7 &amp; 8 August 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 01° 49.364' E 109° 45.950'</td>
<td></td>
</tr>
<tr>
<td>3 Teluk Pandan beach</td>
<td>N 01° 45.723' E 109° 45.236' to 30 January to 2 February 2011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 01° 45.756' E 109° 52.052'</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Locations of study sites are marked with the flags.
The Satang Island is one of the area where turtles come for nesting and this island has turtle eggs incubation area. The area has a few wooden chalets for visitors located near to the beach. Satang Island has small patches of sandy area as the island is covered more with rocky shores and vegetations. It also has sand dunes with very steep slope and small foreshore area but large backshore area (Figure 3a). The sandy areas sometimes are fully utilized by the tourists for recreational activities during daytime while at night, the beach is closed for the turtles that might land to lay eggs. In addition, all lights are switched off after midnight to prevent from disturbing the turtles to land on the beach.

Meanwhile, the Sematan beach is a place where people always do recreational activities as well as the local people do their daily routine. Several resorts exist along the beach and garbage can be seen everywhere. The beach has flat slope and broader compared to Satang Island (Figure 3b). The sand dune is higher at the supralittoral area which was covered by bushes and trees. Certain areas have been utilized for building chalets. During night time, the area was too dark for people to do their activities. Therefore, the beach is less disturbed during night time. During low tide occurrence, the beach might extend about several hundreds metres towards the ocean.

The third study site was Teluk Pandan beach, located in Lundu, Sarawak. The beach area is narrow during high tide and the slope is much steeper, forming the sand dunes (Figure 3c). There was a land clearing operation being done in upper reaches area of the beach nearby the village for the development project. During the study period, only road construction had finished and most of the trees were cut down. The beach was empty without people at night time as it is too dark while during daytime, in research period, there were lots of people utilizing the area for recreational activity. Higher frequency of human utilizing the beach was during evening session between 3 pm to 6 pm. Lots of garbage was found accumulated on the beach area especially on the supralittoral area. There were water
puddles on supralittoral area (the development area) since it rained very frequent lately.

Besides, sampling at Teluk Pandan beach was carried out during rough wind due to monsoon season.

Figure 3: The vertical view of each study beaches: a) Satang Island; b) Sematan beach; c) Teluk Pandan beach. The arrows indicate the capture-mark-recapture sites and circles indicate the burrow counting sites.
3.2 Population Study

The population study was carried out using two methods: 1) capture-mark-recapture (CMR); and 2) burrow counting.

3.2.1 Capture-mark-recapture

The capture-mark-recapture (CMR) was adopted from Asakura (1991) and Bruyn (2002). The pails and baits were chosen as traps for the ghost crabs. The pails were buried in each station before sunset as it is the suitable time for ghost crabs to come out to the shore for feeding. The pails were buried to the same level as the sand in order to trap the ghost crabs without affecting the chance for the ghost crabs not to go into the pails. The area chosen for Satang Island were the turtle hatchery, backshore and foreshore (in front of the sand dune). All the stations were set to be 30 m apart from each other (Figure 4a). At Sematan beach, the plot were conducted 100 m apart from each station for three stations horizontally and 30 m apart vertically on the beach (Figure 4b). For both beaches, Satang Island and Sematan beach, the CMR were conducted within 3 hour range between capture and recapture. Stations for Teluk Pandan beach were located in the supralittoral area (sand dune) only, horizontally to the beach with 50 m apart between stations (Figure 4c). The CMR for Teluk Pandan was conducted in three different night because of the bad weather (monsoon season) during the research period. This methodology was adopted from Spivak et al. (1991); Strachan et al. (1999); Neves and Bemvenuti (2006); and Schlacher and Lucrezi (2009) and was modified according to the beach structures.
Figure 4: The sampling structure for capture-mark-recapture study: a) Satang Island; b) Sematan beach; and c) Teluk Pandan beach. The circles represent the pails or traps and the square represent the plot.
The pails were chosen because it is deep enough to prevent the ghost crabs from escaping. The baits used were smelled fish's internal organs (stomach and gills) and food waste. The ghost crabs that were caught in the traps underwent some physical measurements and were marked using correction liquid on their carapace. Then, the ghost crabs were released back to the beach at the point of capture. Later, after three hours, the pails were observed again for the ghost crabs that trapped in the pails. The marked ghost crabs were noted while the new caught ghost crabs underwent the same procedure again. Then, it was identified as second captured. This method was made by maximized the needs of the CMR method assumptions according to Southwood and Henderson (2000) and Waite (2000).

The calculation for population estimation was done through CMR method based on Lincoln index or Petersen method:

Estimation of total population,

\[
N = \frac{(n_1 + 1)(n_2 + 1)}{m_2 + 1} - 1
\]

- \( N \) = population estimation
- \( n_1 \) = number marked and released
- \( n_2 \) = total number caught when the population is resampled
- \( m_2 \) = number of marked individuals present in the second sample

If \( m_2 < 8 \) the estimate of \( N \) is biased but if \( m_2 > 50 \), reasonably accurate 95% confidence limits. If the proportion of recapture marks \( (p) = \frac{m_2}{n_2} \) in the sample is greater than 0.1, limits about \( p \) may be read directly from charts of binomial distribution 95% confidence limits but if the \( p \) is less than 0.1, the recapture of marked individual is a rare event. Therefore, confidence limits about the number of animals recaptured \( m_2 \) may be set
using table of confidence limits for the Poisson frequency distribution. When \( p > 0.1 \) and the number of recaptured marks are greater than 50, a normal approximation may be used.

### 3.2.2 Burrow counting

The burrow counting was carried out during daytime. The method used was direct count of the ghost crab’s burrows found within the respectively plot size. Before the plots were set up, the beach was observed in order to identify the area which contained burrows of ghost crabs. Then, the plots were set up using range finder (Bushnell) to measure the distance and were marked using any natural materials available on the beach for example wooden stick and garbage (plastic bottles and plastic containers). This method is applied differently in each beach due to the condition of the beach itself (Figure 5a, b, and c). If the burrow count was done repeatedly in each plot (different counting days), the standard deviation is obtained from each area. The procedure was adopted and modified based on the studies from Steiner and Leatherman (1981); Wolcott and Wolcott (1984); Spivak et al. (1991); Barros (2001); Moss and McPhee (2006); Schlacher and Lucrezi (2009); Tureli et al. (2009) and Branco et al. (2010).

The results from both methods (CMR and burrow counting) were compared to find the relationship between the population density of the burrows and the population density of ghost crabs present within that area.