Tidal Migration of the Giant Mudskipper, *Periophthalmodon schlosseri* (Pallas, 1770) in a Singapore Mangrove

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ABSTRACT

The distribution, tidal migration pattern, and habits of the Giant mudskipper, *Periophthalmodon schlosseri* were investigated along an entire course of a stream from its source in the mangrove forest to the stream mouth at the Johor Straits. A grid system for visual censuses was established at 10 m intervals in the mangroves of Sungei Buloh Wetland Reserve, Singapore. Observations at low neap and spring tides showed the absence of *P. schlosseri* at the lower stream drainage with the whole population observed in the upper stream drainage. During rising and ebbing tides, *P. schlosseri* numbers gradually increased toward and away from the mangrove forest respectively. During high tides, *P. schlosseri* were mainly found in areas nearest to the mangrove forest. These distribution patterns demonstrated a clear tidal migration toward and away from the mangrove forest during a tidal cycle. Localisation of *P. schlosseri* also differed, with most observed in burrows during a low tide, in streams during a rising or ebbing tide, and on mangrove tree roots during a high tide.

INTRODUCTION

Many studies on *P. schlosseri* have been conducted but whether they exhibit tidal migration during a tidal cycle is yet to be studied. Other mangrove fauna in Singapore are affected by tides; vertical migration of tree-climbing crabs *Episesarma* spp. (Sivasothi, 2000), and the common nerite *Nerita lineate* (Ng & Sivasothi, 1999) from the mangrove forest floor occurs in response to high tides. Therefore, the first objective of our study is to examine the distribution of *P. schlosseri* along stream drainage. The second objective is to determine if *P. schlosseri* exhibits tidal migration during a tidal cycle based on population size and distribution patterns at low tide. From there, we hope to verify if tides have an influence on *P. schlosseri* localisation.

MATERIALS AND METHODS

The study area was the mangroves in Sungei Buloh Wetland Reserve (1° 42′53.5″ N, 103° 43′30.8″ E), Singapore. Mapping was conducted at low tide using Yamayo ‘MILLION’ fibreglass 100 m measuring tapes and Suunto bearing compasses, with bamboo pole markers to facilitate modular mapping as SBWR is covered by clouds on Google Earth, thus a fine resolution map had to be prepared. Boardwalk censuses were performed between 16th February

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and 11th March 2009 as preliminary observations from the muddy terrain resulted in disappearance of mudskippers into burrows. A grid of 20 rectangular transects were measured 10 m by 40.8 m each, giving a total observation area of 8160 m². Every 10 minutes, mudskippers in each transect were identified, counted, and specific locations noted. In the lower drainage system beyond the boardwalk, observations were conducted from sandbanks during low tide. In total, 15 day and three night observations were conducted. Opticron Imagic TGA WP 10 X 42 binoculars were used for all observations and Black Diamond Icon 3-Watt LED headlamps were employed for the night observations.

RESULTS AND DISCUSSION

Population Size of *P. schlosseri*

No *P. schlosseri* were observed in the lower stream drainage system during this study. A possible explanation could be the early inundation of this area, making it an unsuitable habitat for *P. schlosseri* and would demand more energy than beneficial to swim into the mangrove forest during a rising tide.

The population of *P. schlosseri* observed during this study was restricted to the upper stream drainage system and consisted of an average of 26 individuals during low tide (Table 1), the time of greatest visibility.

Table 1. Average number of *P. schlosseri* observed in the upper drainage system of the study site during various tidal cycles.

<table>
<thead>
<tr>
<th>Results &amp; Discussion Section</th>
<th>Neap/ Spring Tide</th>
<th>Day/ Night</th>
<th>Tidal Range</th>
<th>Number of <em>P. schlosseri</em> observed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low Tide</td>
<td>Rising/ Ebbing Tide</td>
</tr>
<tr>
<td>3.2.1 Neap</td>
<td>Day</td>
<td>LT-HT</td>
<td>25±2</td>
<td>29±2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HT-LT</td>
<td>27±3</td>
<td>30±3</td>
</tr>
<tr>
<td>3.2.2 Spring</td>
<td>Day</td>
<td>LT-HT</td>
<td>26±1</td>
<td>30±4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HT-LT</td>
<td>27±1</td>
<td>31±3</td>
</tr>
<tr>
<td>3.2.3 Spring</td>
<td>Night</td>
<td>LT-HT</td>
<td>25±2</td>
<td>36±1</td>
</tr>
<tr>
<td>Average (to nearest whole number)</td>
<td></td>
<td></td>
<td>26</td>
<td>31</td>
</tr>
</tbody>
</table>

Distribution, Tidal Migration Pattern and Habits of *P. schlosseri*

The majority of *P. schlosseri* were observed within areas furthest (80 to <120 m) from the start of the mangrove forest during low tide (Figure 1). This might be due to the soft muddy substrate at those areas which presents a suitable habitat for mudskippers to build burrows. This is supported by a large number (>60%) of *P. schlosseri* observed in burrows during low tide. Further, studies have reported that *P. schlosseri* forage at low tide during which they feed on an abundance of food prey such as small fishes and invertebrates (Murdy, 1986; Ghaffar et al., 2006). The absence of *P. schlosseri* at areas nearest (<40 m) to the start of the mangrove forest
during low tide could be explained by the dense vegetation in those areas whose tree roots prevent the building of deep burrows.

As the tide rose or ebbed, increased numbers of *P. schlosseri* observed in areas 40 to <80 m from the start of the mangrove forest from those recorded during low or high tide respectively, reflect a migration of *P. schlosseri* into or away from the mangrove forest. During rising or ebbing neap and spring tides, more than 60% of the *P. schlosseri* were observed in streams (Figure 6) swimming towards or away from the mangrove forest respectively. Further, territorial behaviour was displayed by some *P. schlosseri* as seen by threat postures like erecting fins and darkening of their black stripes (Murdy, 1986). This is probably due to crossing of territory boundaries, as they were pushed by the tides toward or away from the mangrove forest.

During high neap and spring tide, the bulk of *P. schlosseri* found in areas closest (<40 m) to the start of the mangrove forest is attributable to the dense vegetation at those areas as opposed to areas further away which contained fewer trees that allowed mudskippers to perch or rest on. Additionally, most of the *P. schlosseri* (>50%) were seen clinging to the roots of mangrove trees.
during high tides. Roots were preferred over tree trunks probably because of their almost horizontal surface (<90°) as compared to the vertical surfaces (90°) of tree trunks.

It maybe refuted that most *P. schlosseri* are found on mangrove tree roots or trunks during high tide because of vertical migration from the ground exhibited by other mangrove fauna like *Episesarma* spp. and *Nerita lineata*, but the movement of *P. schlosseri* landward during a rising tide suggests a tidal migration pattern instead. Furthermore, similar population numbers recorded at each tidal period (low, rising/ebbing, high tide) leads to the assumption that the same population is observed within the upper drainage system at any one time, thus substantiating this tidal migration pattern.

Reasons for tidal migration landward can be explained by physiological adaptations of *P. schlosseri*. The fact that Giant mudskippers exhibit the diving reflex, which is slowing down of the heartbeat when underwater (Schmidt - Nielsen, 1997), suggests that they more physiologically adapted to terrestrial than aquatic conditions. Further, Ng & Sivasothi (1999) reported that migration landward could be related to predator avoidance behaviour, especially with many aquatic predators that hunt with the incoming tide.

**CONCLUSION**

This is the first study on distribution, tidal migration patterns, and habits of the *P. schlosseri* mudskipper, *Periophthalmodon schlosseri*. The visual censuses in our study site in Sungei Buloh Wetland Reserve revealed tidal migration of *P. schlosseri* with evidence showing the migration towards and away from the back mangroves during a rising or ebbing tide. However, the mangroves in Singapore are particularly small and exhibits compression of zonation (Ng & Sivasothi, 1999). Thus, studies elsewhere are required before a generalisation about the species’ habits can be made. Future studies employing the use of tags should be performed as well to corroborate our results and to study the other ecological aspects of mudskippers.

**REFERENCES**


