OCCURRENCE AND VARIATION IN THE DEPTH OF BURROWS OF MANGROVE CRABS AROUND A TROPICAL CREEK IN NIGERIA

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ABSTRACT

Mangrove crabs are active burrowers in intertidal sediments of wetland, living beneath drifts and high-tide marks in lagoon shores in many parts of the world. The occurrence, distribution and burrow depths and diameters of the mangrove crabs, Cardisoma armatum and Goniopsis pelii collected from a mangrove wetland of the Lagos Lagoon were investigated between February and July, 2017. Burrows were counted biweekly on permanent square plots marked out in the six stations, while the appearance of new burrows as well as disappearance of old burrows, depths and diameters were recorded. C. armatum was present in all the study sites with a total of 848 specimens and occurred throughout the study period, while G. pelli with a total of 115 specimens occurred in two study sites and during the wet season only. Species ratio was 1: 0.37 while the Chi-squared value at 1 d.f and 5 % significant level was 557.93. The depth of the crab burrows across the stations ranged from 16.65 – 33.47 cm with diameter ranging between 4.0 – 6.40 cm. Crab burrows, its occurrence and distribution were observed to be affected by natural and anthropogenic factors. There was a rapid decline in burrows in the month of April when rainfall seized and anthropogenic factors like noise, refuse dumping and construction works also played major roles in determining the dispersion of burrows. Therefore, mangrove crabs and their burrows are greatly influenced by both abiotic and biotic factors.

Keywords: *Cardisoma armatum, Goniopsis pelii,* Mangrove wetland*,* Burrow, Depth and width, Occurrence*,* Distribution

INTRODUCTION

Mangroves are the dominant ecosystems that line the coasts of subtropical and tropical countries around the world. They function as nurseries for a wide variety of vertebrate and invertebrate marine species (Lawal-Are and Nwankwo, 2011). The mangrove invertebrates (brachyuran crabs, hermit crabs, gastropods, bivalves, barnacles, sponges, tunicates, polychaetes and sipunculids) often exhibit marked zonation patterns and colonize a variety of specific micro-environments while some species dwell on the sediment (Ajayi, 1994). Mangrove crabs play an important ecological role by their activities of burrowing in the sediment where they assist in flushing toxic substances and modifying the oxidation status of the surrounding sediment (Lee, 1998; Nagelkerken *et al.,* 2008). However, they are often viewed as threats to the successful regeneration or restoration of mangrove forests through their predation of propagules. They keep much of the energy within the forest by burying and consuming leaf litter (Dahdouh-Guebas *et al.,* 2004). The distribution of macrobenthos fauna are determined by a number of factors such as physical nature of substratum, depth, nutrient content, degree of stability and oxygen content of the water body (Esenowo and Ugwumba, 2010). In mangrove ecosystems, semi-terrestrial burrowing crabs are important bioturbators affecting the biogeochemistry of the sediment and carbon cycling. Crab burrows are central to predator avoidance, reproduction and protection from the natural elements such as winds and tides (Hemmi, 2005). Burrowing crabs are possibly one of the most important components of mangrove fauna not only because of their burrowing activities which can affect nutrient cycling and forest productivity but also their role as a link in the food web in mangrove ecosystems (Moruf and Ojetayo, 2017). Consequences of this burrow and bioturbation include increased vertical and horizontal movement of sediment and detritus (Morrisey *et al.*, 1999) and stimulation of microbial activity (Andersen and Kristensen, 1991).

Previous researches on the mangrove crab species of UNILAG Lagoon Front concern primarily on their composition and abundance (Onadeko *et al.*, 2015; Elegbede and Lawal-Are, 2015), biology (Lawal-Are and Nwankwo, 2011; Elegbede and Lawal-Are, 2013; Moruf and Ojetayo, 2017) and as environmental biomarker (Anagboso *et al.,* 2009; Usese *et al.,* 2018). The aim of this study was to provide baseline information with particular emphasis on unique burrowing habits and other burrow related behaviors of the dominant mangrove crab species, *Cardisoma armatum and Goniopsis pelii* in the mangrove environment / wetlands of the Lagos Lagoon.

MATERIALS AND METHODS

Study Sites: The study was carried out between February and July 2017 on a bi-weekly basis and covered both the dry and rainy seasons. Six different study sites (Figure 1) were surveyed and they include Guest house (Station 1), Faculty of Engineering (Station 2), Lagoon Front (Station 3), behind Faculty of Science building (Station 4), Faculty of Science Demonstration pond (Station 5) and High rise residential building (Station 6). These stations are all mangrove areas of the University of Lagos adjacent the Lagos Lagoon. The site is a typical estuarine water zone with extensive mangrove but low transparency and alkaline (pH>7) in nature (Moruf and Lawal-Are, 2015). Each station was mapped using a Magellan Sport Track Global Positioning System (GPS) with accuracy of a metre (Table 1).

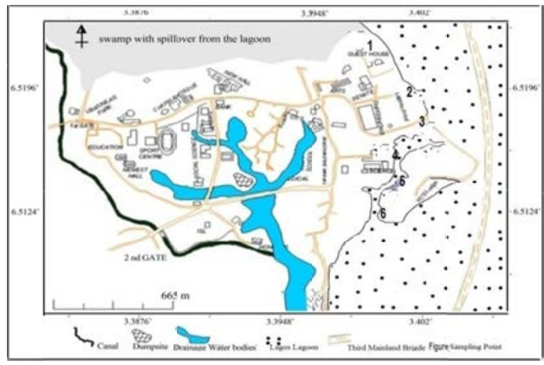

Figure 1: Map of UNILAG Lagoon Front showing the sampling site (1 – 6) (Source: Moruf *et al.*, 2018)

Table 1: GPS coordinates of sampling stations of mangrove crabs around a tropical creek in Lagos, Nigeria

Study area	Latitude	Longitude
Station 1 (Guest House)	6° 31′N	3° 24′E
Station 2 (Faculty of Engineering)	6° 31′N	3° 23′E
Station 3 (Lagoon Front)	6° 30′N	3° 23′E
Station 4 (Faculty of Science)	6° 30′N	3° 23′E
Station 5 (Demonstration Pond)	6° 30′N	3° 24′E
Station 6 (High rise residential building)	6° 31′N	3° 23′E

Samples Collection: The samples of *Cardisoma armatum and Goniopsis pelii* (Figures 2 and 3) were hand-picked with protective rubber gloves and put in a plastic container. They were preserved in a deep freezer prior to identification and measurement. The specimens were identified using taxonomic keys of Schneider (1990).

Species Ratio: The species ratio of the specimens was determined monthly. The ratio was tested for any deviation from the expected

1:1 ratio by using chi-square analysis. Level of significance was tested at 5 % level of significance.

Figure 2: Dorsal view of the land crab (*Cardiosoma armatum,* Herklots 1851)

Figure 3: Dorsal view of the purple mangrove crab (*Goniopsis pelii,* Herklots 1851)

Burrow Measurement: For each station, a plot of 300 x 300 cm^2 was marked out and the activity rhythms of the crabs, flora found, species composition and abundance, and frequency of burrow turnovers were studied in all six stations on a biweekly basis. The depth and diameter of each burrow opening was measured twice a month using a measuring tape in centimetres and the values recorded. Quadrats were placed randomly within the marked plot to estimate the number of holes that could be found per plot. The distance between the holes within the quadrats were measured and recorded.

Statistical Analysis: Data obtained were analyzed for their central tendencies using Microsoft Excel 2010 and bar graphs plotted. Test for goodness of fits was determined statistically using chi-square (χ^2) test for the significance species ratio of the mangrove crabs.

RESULTS

Occurrence and Abundance: Sediment deposit at entrances of burrows shows that there are crabs occupying the holes.

Applying the theory that each burrow represents one crab, burrows were counted and recorded in each station. *C. armatum* showed highest occurrence of all species as it was found across all the study while *Goniopsis pelii* was observed in only 2 stations, showing low occurrence and abundance (Table 2). A total of 963 crabs were recorded throughout the study with 447 in Station 1, 172 in Station 2, 198 in Station 3, 40 in Station 4, 41 in Station 5 and 65 in Station 6.

Chi-Square Test on the Species: The chi-square test was carried out to test if there is any significant difference in the species collected from the wetlands. The calculated χ^2 gave 10.89 for 1 *d.f.* at 5 % level of significance. This is more than the tabulated value of 3.84 for 1 *d.f.* at 5 % level of significance (Table 3).

Seasonality of the Mangrove Crabs: As shown in Table 4, of the two species found, only *C. armatum* was found during both wet and dry seasons and showed higher abundance in the wet season while *G. pelli* was seen only in the wet season (May – July) and only in Stations 2 and 5. Generally, there was a difference in the species abundance between the wet and dry seasons.

Measurement of the Crab Burrows: The results of the measured depths of crab burrows from Lagos Lagoon are illustrated in Figure 4. The highest mean burrow depth was seen in Station 6 in the month of July with a mean value of 33.47 cm while the least mean burrow depth for the species was found in Station 4 in the month of February with a mean value of 16.65 cm. The results of the measured diameter of crab burrows from Lagos Lagoon are illustrated in Figure 5.

Table 2: Abundance of mangrove crabs around a tropical creek in Lagos, Nigeria

Species	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6	
	No	%	No	%	No	%	No	%	No	%	No	%
Cardiosoma armatum	447	100	80	46.5	198	100	40	100	18	43.9	65	100
Goniopsis pelli	-	-	92	53.5	-	-	-	-	23	56	-	-
Total	447	100	172	100	198	100	40	100	41	100	65	100

***Key**: Station 1: Lagoon Front; Station 2: Guest House; Station 3: High Rise Residential building; Station 4: Faculty of Science; Station 5: Demonstration pond; Station 6: Faculty of Engineering*

Table 3: Chi-square test for species ratio of crabs collected from Lagos Lagoon from Feb., - July, 2018

Species	Observed Number	Expected Number	Calculated χ^2 Value	Tabulated χ^2 value
Cardiosoma armatum	848	481.5	557.93	3.48
Goniopsis pelli	115	481.5		
Total	963	963		

Table 4: Seasonality of mangrove crabs around a tropical creek in Lagos, Nigeria

Seasons	Station	*Cardiosoma armatum*	*Goniopsis pelli*
	1	184	0
	2	40	0
Dry Season	3	62	0
(Feb. – Apr., 2018)	4	15	0
	5	6	0
	6	30	0
	1	263	0
	2	45	80
Wet Season	3	136	0
(May – July, 2018)	4	25	0
	5	17	18
	6	35	0

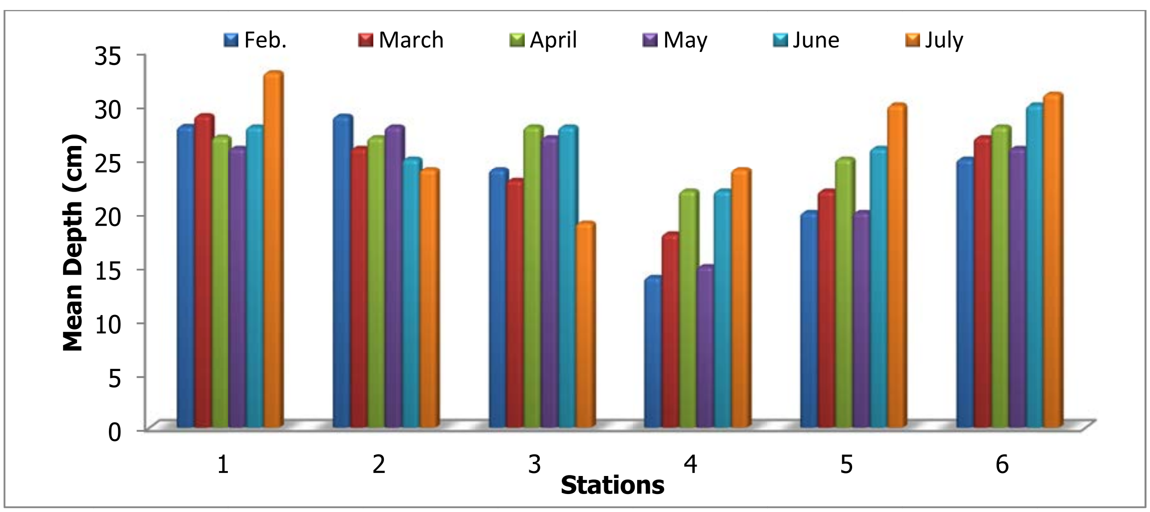

Figure 4: Monthly mean depth in burrows of mangrove crabs around a tropical creek in Lagos, Nigeria

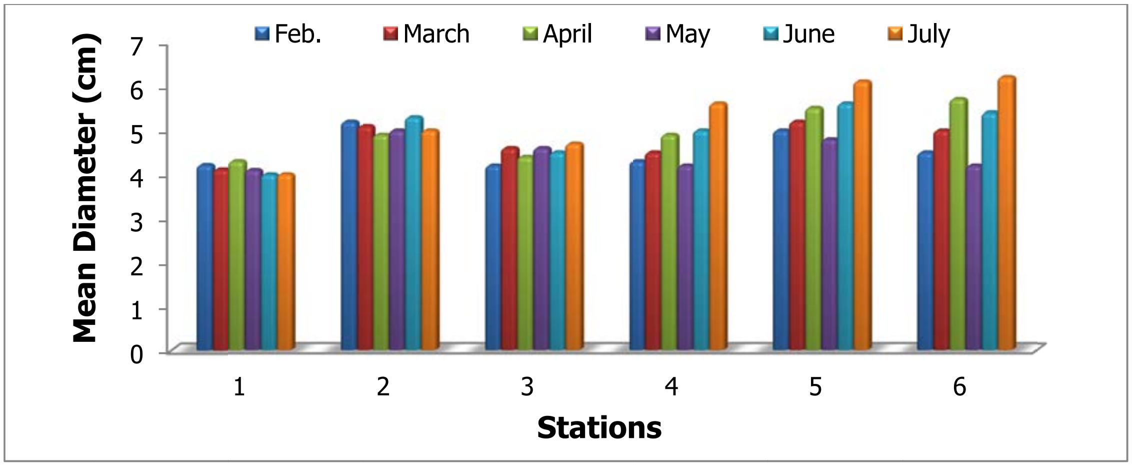

Figure 5: Monthly mean diameter in burrows of mangrove crabs around a tropical creek in Lagos, Nigeria

Figure 6: Abandoned burrows of mangrove crabs around a tropical creek in Lagos, Nigeria

The highest mean burrow diameter was seen in Station 6 in the month of July with a mean value of 6.40 cm while the least mean burrow diameter for the species was found in Station 1 in the months of March, June and July with a mean value of 4.0 cm.

Natural, Human and Anthropogenic Influnce on Crab Burrows: Random dispersion and abandoned burrows (Figure 6) were observed at various sampling stations where rainfall declined and where constructions, renovations and refuse dumpings took place. This prompted the mangrove crabs to burrow new holes (Figure 7).

Figure 7: Appearances of new crab burrows of mangrove crabs around a tropical creek in Lagos, Nigeria

DISCUSSION

The variations of the occurrence of the mangrove crab in this research is lower than the value obtained by Warner (2009), who worked on the mangrove swamps in Jamaica while the presence of *C. armatum* in all sampled stations was in agreement with Pinder and Smits (1996) who reported that terrestrial crabs especially *C. armatum* are excellent osmo-regulators and can survive adverse physico-chemical conditions.

However, *Goniopsis pelli* was dominant in areas where natural or human disturbances had occurred was similar to the report of Skov and Hartnoll (2002) that *G. pelli* occurred in areas where the mangrove has been destroyed, thus making this species a good indicator of mangrove destruction, pollution and degradation of mangrove forests by natural and human activities. The total observed species ratio for the period of study was 1: 0.37 (*C. armatum* : *G. pelli*) with chi-squared value of 557.93 indicating significant difference ($p<0.05$) in numbers of the two crabs species existing within the sampling points with *C. armatum* being dominant. The dominance of a crab species over other crab species inhabiting the same habitat has been demonstrated in southeastern Massachusetts beaches were *Hemigrapsus sanguineus* was dominant over *Carcinus maenas*, *Pagurus acadianis*, *Pagurus longicarpus*, *Rhithropanopeus harrisii*, *Eurypanopues depressus* and *Ovalipes ocellatus*, accounting for 78.3 % of the total crab caught (Westgate, 2011). Furthermore, the result of the study on species ratio was similar to the report of Onadeko *et al.* (2015) on habitat diversity and species richness of brachyuran crabs from similar studied sites. The authors reported that *C. armatum* had the highest occurrence of all the brachyuran carbs and was encountered in all their studied habitats.

The depths of the crab burrows observed in Stations 1 and 4 were not as deep as those measured in station 6. Stations 1 is entirely surrounded by water, while station 4 is just few feet from water. The juvenile *Cardiosoma* usually dig simple, shallow tubes as their burrows, which are temporary because they often wet their gills in water and as they grow larger and become more terrestrial, burrows are more permanent, allowing deeper, complex burrows with added functions in the form of chambers and secondary branches (Por, 2004) which may be associated with copulation, and/or provide a refuge against up-wash (Ysebaert *et al.,* 2003) or predators (Por, 2004). The measured burrow depths in this study showed that the burrows belonged to large sized crabs because they had greater burrow diameter. This conformed with the report of Lim (2006), who compared sympatric populations of *Uca annulipes* and *Uca vocans* and found that burrow architecture was similar except for wider burrow diameters of *U. vocans* and related this to significantly large carapace length to carapace width ratios of *U. vocans*. However, both the size of the crab and their environment affect burrow shape and depth (Pape *et al.,* 2008). Irrespective of age, burrowing behaviour may be affected by temperature, grain size and packing, slope and sand moisture (Ysebaert *et al.,* 2003). In all six stations, it was noticed that an increase in diameter resulted in an increase in depth. Alternatively, it can be said that the bigger the crab the deeper the burrows. Random dispersion patterns were observed in Stations 2 and 5, during the third month of sampling. This was attributed to the dumping of electronic wastes by the nearby printing press on the crab burrows. However, dispersion of burrows according to Pape *et al*. (2008), may be regular (where individuals are more evenly spaced than expected by chance), aggregated (where individuals are closer than expected by chance) or random (when there is an equal probability of any individual occupying any point in space irrespective of the position of others). According to Por (2004), dispersion of burrows is scale-dependant and is a function of both environmental factors, such as resource availability, which dictate where animals are distributed at a large scale perspective and behavioural factors, which dictate the spacing of conspecifics usually at a finer scale. In this study, habitat conversion into residential area (urbanization), indiscriminate degradation and reclamation of mangrove for development of several infrastructural facilities in order to satisfy the insatiable human wants were observed to be the problem facing the species in these areas. Mangrove crab ecology has been noted to revolve round both natural and man-made effects.

Conclusion: This research established the inter relationship between biotic and abiotic factors on mangrove crabs inhabiting the wetlands of the Lagos Lagoon. Natural and human- induced disturbances pose serious threats to the functioning of mangrove ecosystems. Conversions of mangroves due to industrialization and pollution load are major threat to the crab diversity in the study stations. An effective conservation strategy for mangrove needs to be supported by a better understanding of the processes operating within mangrove ecosystems. In addition, the maintenance of the undisturbed areas should be a primary objective for the management since it represents a more constant mangrove crab diversity and highest abundance and sustains the production of commercial important species.

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