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Sediment, Particle Size and Population Distribution of *Uca tangeri* (fiddler crab) from Two Brackish Water Ecosystems in Rivers State, Nigeria

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ABSTRACT
The influence of sediment particle size on the population distribution of *Uca tangeri* was studied at Bonny Rivers and the New Calabar River in Rivers State. A quadrant of 20 X 20m were made at the stations. The study stations were visited once a week for 12 weeks. A total of 24 (One) sediment samples was collected from the burrow upon each visit and analyzed for % particle size composition. A total of 720 (360) from each station. *Uca tangeri* samples were collected, age with sediment particle size. Spearman's correlation was used to check for the relationship between sediment particle size and population distribution of *Uca tangeri*. The result from Bonny samples showed that, there is strong correlation between adult male samples and silt-clayey sediment (silt 0.15 and clay 0.22) rich in organic matters (0.77). Samples collected from New Calabar Rives showed that, adult female and juvenile male samples show preference to sandy sediments (0.28 and 0.057). Juvenile female samples prefer silt sediment (o.076) It was concluded that resource sharing, strength of the setae and burrowing capacity influence habitat and sediment utilization.

Keywords: Population distribution, *Uca tangeri,* setae, brackish water, ecosystems

INTRODUCTION

The genus *Uca tangeri* Leach, 1804 are inhabitants of intertidal mud flats and marine habitats in tropical countries. In the Niger Delta, they are found in estuarine areas where they are submerged depending on tidal cycles. The species is a critical member of the mud flats playing key role in structure and function of the system. As a component of the intertidal mud flat, they are important in distribution of vegetation, substratum, food, salinity, tidal exposure and presence of other mammals (Ribeiro *et al.*, 2005; Cesar *et al*., 2005; Arruda, *et al.*, 2006). They serve as a link in the mangrove trophic level. They are food for young crocodiles, Otters, civets, birds, crustaceans, fishes and mammal (Coelho, 1965; Colpo and Negreiro-Fransozo, 2003, Castiglioni *et al*., 2010; Colpo and Negreiro-Fransozo, 2013; Numbere, 2020). *Uca tangeri* constitute a major component of zooplankton linking the food chain in the mangrove habitat. Mangrove habitats provide an excellent sediment and habitat structure for their development (Nielsen *et al.,* 2003; Kristensen, and Alongi, 2006). Although *Uca tangeri* modifies sediment particle size, porosity and water content of the mud flats through their activities of burrowing, they are one of the most effective aspects of the estuarine habitat (Numbere, 2020). Spatial variability of sediment properties and heterogeneity create different niches for different species to occupy. While some species may favour fine sand grains, some tends to occupy coarse grain areas (Ens *et al.,*1993; Daleo *et al*., 2003; Ribeiro *et al.,* 2005; Checon & Costa, 2017). Their ability to occupy different niches is dependent on the setae type on their second maxilliped. These setae have the ability to sort food from fine grains and to eliminate sand particles (Okon and Sikoki, 2014). Investigation into the seasonal abundance, population density and frequency distribution in size classes, birth rate, sex ratio, reproductive period, fecundity, burrow distribution, nutrient, sand grain and juvenile recruitment on the survivability of fiddler crabs in the ecosystem had been reported by Castiglioni and Negreiros-Fransozo, (2004); Masunari, (2006); Costa, (2000); Castigolini, *et. al.,* (2010); and Steibl, S. (2020) observe that while the geographical distribution of *Uca* is influenced primarily by regional hydrology, geomorphology and climate, ocean current patterns help regulate larvae dispersal and thus direct gene flow and affect connectivity. Connectivity according to him, in turn can influence intraspecific variation both with and among marine populations (Costa, (2000). Historically low intraspecific genetic diversity according to Felder and Station, (1994) is a hallmark in fiddler crabs.Study of the population abundance of fiddler crab in an estuary has been reported to be beneficial to the researcher and ecosystem service. The earlier reports of Koch, *et. al.,* (2005) was that adult *Uca* crabs could reach a population size of 260 individuals per square meter as well as 140 juveniles per square meter. Density of crab in an ecosystem could depict the healthiness of the habitat and area with high fiddler crab density and such habitat show high productivity level (Costa, 2000; Thanamalini and Shyla, 2018). The sex ratio of fiddler crab population has been a topic of high debate for many years. Some early sex ratio studies found that fiddler crab to be dominated by female in all size range (koga, *et al.,* 1995; Milner, *et al.,* 2010), while Ahmed, (1979) reported a dominant male situation. However, a more recent study by Kaeda (2004) reported an adult male dominant scenario, with percentage of male increasing with size while juvenile stage tends to be dominated by female. This was agreed by Bergey and Weis (2008). Previous studies by Diele, *et al.* (2005); Diele and Koch, (2010); and Numbere, (2020), suggested a size frequency population distribution change resulting from recruitment of larva and reproduction. In tropical region, they suggested a unimodal size-class distribution of individual population, suggestion a suitable population with constant mortality and recruitment rates (Fernando *et al.,* 2018). Geo-ecological factors have been studies as one of the factors affecting distribution and population abundance of *Uca tangeri.* There has been inadequate knowledge of the behaviour of *Uca tangari* with respect to geo-ecological factors particularly the impact of sediment grain size on the abundance of *Uca tangeri* in different habitats in Rivers State, Nigeria. This study therefore aimed at amongst others to elucidate the impact of particle size on abundance of *Uca tangeri* in the study stations.

Materials and Methods

Study Area

This study was carried out in two stations along the tributaries of New Calabar and Bonny River of Rivers State, Nigeria (Figure 1). The study stations along the New Calabar River are located on $04^{0}48^{1}33.7^{11}$ N and $06^{0}55^{1}43.2^{11}$E, while that along the Bonny River is located on $04^{0}46^{1}51.5^{11}$N and $006^{0}58^{1}41.1^{11}$E. All study stations are in Obio-Akpor Local Government Area of Rivers state. Red mangrove (*Rhizophora mangle*)characterize the study stations and other emerging vegetations such as *Nymphaea and Paspalum spp* are common along the study stations.The mangrove forests are inundated by saline water during tidal flow. During flooding usually in the rainy season, the water channel loses definition and become continuous with the floodplain. Like other tropical estuary, these rivers are under periodic tidal movement thereby exposing the intertidal area for approximately 6 hours daily. The study stations are importance to the local coastal communities as it serves majorly for transportation, aesthetics, recreation, cultural and fishing activities. The major communities along the study area include Rumulumini and Eagle Island. Fishing serves majorly as a source of protein supply and finance to the local communities. Artisanal fishing with small fish mesh seine, baited hook and line as well as basket traps are the basic fishing gear seen around the area.

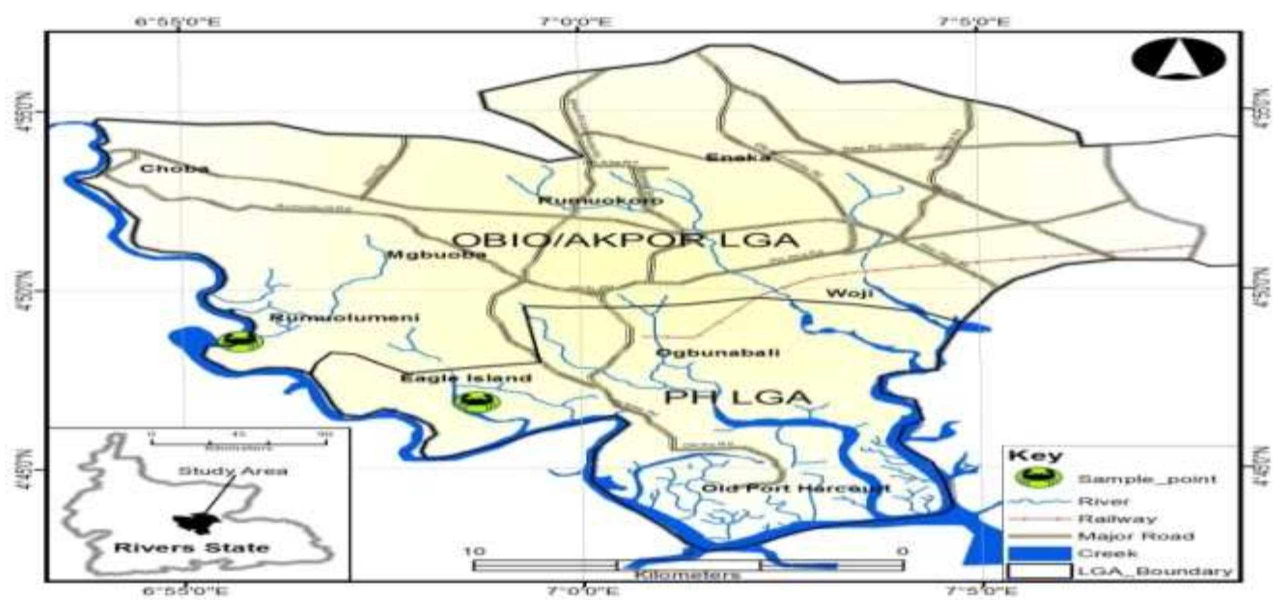

Figure 1: Map of Rivers State showing the study stations

Sampling Techniques and Data Analysis

An initial data of tidal flow at the study stations was Rivers State University of Science and Technology marine department. The tidal flow data was used to plan sampling during the study. During the sampling period, the study stations were visited once weekly for three months (September – November, 2019) at tidal ebbing. A quadrant of 20m X 20m were laid at the stations. Samples were collected from the study stations and transferred to the laboratory for further analysis in a cool box. Each sample was given a unique identifier.

Fiddler Crab (*Uca tangari*) Sampling

Thirty (30) fiddler crabs were randomly handpicked in each quadrant. A total of three hundred and sixty (360) fiddler crab samples were collected from each study stations during the study window.

Fiddler samples were transferred in coolbox to the laboratory for sexing and aging. The collected fiddler crabs were sexed as male, female and aged as adult and juvenile by morphological observation of claw size and abdominal regions for separation into male and female while juveniles were based on morphometric measuration (Ayo-Olalusi, 2014). These were used to estimate the population structure. Weighing scale was used to estimate their weight (specify model of weighing balance used) while morphometry was measured with vernier caliper and measuring tapes to the nearest ±00.1mm.

Sediment Particle Size Analysis

Sediment samples (N=12) were collected at 0.5cm and 0.8cm in each quadrant. Each sample collected were homogenize to have a representation of the stations. Each sample was given an identifier and transfer in cool box to the laboratory for analysis. Soil organic matters was determined by weighing 1.00g of soil and emulsified in 500ml flask containing 10ml of 1M $NK_2Cr_2O_7$ and stir gently to dispense soil. 20 ml $H_2SO_{4\ (conc)}$ was added to the mixture and stir gently until there is a homogenous mixture. This was allowed to stand for 30 minutes. 300ml distill water was added and allowed to stand for 30 minutes. 25 ml of 0.5M $FeSO_4.7H_2O$ was pipette and added in the solution (Gavlak, *et al*., 2005; Krzysztof, *et al*., 2018). A blank control solution was prepared without soil as in the steps described above. The suspension was titrated with 0.500M $KMnO_4$ using illumination from bulb-lamp. The end point was calculated from the titre value using the formula:

%OC =N(T-B)/W x 0.390; Where N= Normality (conc) of $KMnO_4$; T= Titre (sample); B= Titre (blank); W= Weight of soil used; %OC= percentage organic carbon. Percentage organic matter was calculated by multiplying % organic carbon by 1.724 (Laker, and Dupreez, 1982).

Statistical Analysis

The Spearman's ranking was used to correlate the abundance of fiddler crab with sediment particle size. All analyses were done at 95% significance level.

RESULTS

In this section, the result for sediment samples and population distribution of *Uca tangari* is presented. In Tables 1 and 4 is the result for soil particle size analysis for sediment samples collected from the Bonny and New Calabar River. Table 2 and 5 shows the population abundance of *Uca tangari* across the sample station. Table 3 and 6 is the Spearman's correlation between population abundance of *Uca tangari* and sediment particle size.

Sediment Particle Size

Sediment samples (N=12) collected for laboratory analysis. Sediment samples collected from Bonny River. The result is presented in Table 1 below.

Table 1: Sediment Collected from Bonny River (%Particle size)

s/no	Sample ID	%OC	%OM	%Sand	%Silt	%Clay	Textural Class
1	BR-1	0.78	1.34	89.7	3.5	6.8	Sand
2	BR-2	0.62	1.07	91.7	3.5	4.8	Sand
3	BR-3	0.7	1.21	89.7	3.5	6.8	Sand
4	BR-4	0.62	1.07	91.7	3.5	4.8	Sand
5	BR-5	0.47	0.81	89.7	5.5	4.8	Sand
6	BR-6	0.61	1.44	88.9	3.5	4.8	Sand
7	BR-7	0.33	1.09	90.6	3.2	5.3	Sand
8	BR-8	0.71	1.3	91.2	3.6	4.8	Sand
9	BR-9	0.79	1.39	87.7	3.5	6.8	Sand
10	BR-10	0.66	1.08	90.3	3.4	5.2	Sand
11	BR-11	0.67	1.23	89.6	3.7	5.1	Sand
12	BR-12	0.5	1.09	89.9	3.5	5.1	Sand
Mean		0.62	1.18	90.06	3.66	5.43	

BR=The identifier for Bonny River; OC=Organic carbon; OM=Organic matters

The result shows that the sediment is made of sand (90.06%), clay (5.43%) and silt (3.66%) while organic matter (1.18%) and organic carbon was (0.62%). Also, sediment samples collected from New Calabar River was analyzed to compose of sand (69.96%), silt (12.17%) and clay (17.52%) while organic carbon (3.63%) and organic matter (5.7%).

Table 2: Sediment particle size analysis for New Calabar study station

s/no	Sample ID	%OC	%OM	%Sand	%Silt	%Clay	Textural Class
1	NC-1	2.15	3.71	71.7	11.5	16.8	Sandy loamy
2	NC-2	4.29	7.4	73.7	11.5	14.4	Sandy Loamy
3	NC-3	2.93	5.05	75.7	9.5	14.8	Sandy Loamy
4	NC-4	3.51	6.05	71.7	11.5	16.8	Sandy loamy
5	NC-5	5.07	8.74	57.7	17.5	24.8	Sandy Clay Loamy
6	NC-6	4.86	7.6	72.18	11.2	16.7	Sandy loamy
7	NC-7	3.22	3.8	71.67	11.3	13.5	Sandy loamy
8	NC-8	2.16	5.2	75.4	8.5	15.6	Sandy loamy
9	NC-9	3.67	6.5	71.22	11.3	16.9	Sandy Clay Loamy
10	NC-10	2.92	5.3	57.67	18.2	25.3	Sandy Clay Loamy
11	NC-11	5.01	3.4	70.93	11.9	17.1	Sandy loamy
12	NC-12	5.2	6.3	76.02	8.4	14.8	Sandy Clay Loamy
		3.62	5.7	69.96	12.17	17.52	

BR=The identifier for Bonny River; OC=Organic carbon; OM=Organic matters

Geo-spatial Distribution of Fiddler Crab

A total of n=720 fiddler crabs were sampled from the study stations during the study window. At the Bonny River Study station, n=360 samples were collected. 230 samples were adults male, while 51 were juvenile male. 58 were adult female while 21 were juvenile female. Of the n=360, 221 were adult female collected from the New Calabar River, 83 were adult male, 35 were juvenile female while 21 were juvenile male. The relationship between soil particle size, organic matter and fiddler crab geospatial distribution across the study stations are presented in Tables 5 and 6.

Table 3: *Uca tangeri* collected from Bonny River

weeks	Nr of Samples	M	F	Ad M	Ad F	Ju M	Ju F
week 1	30	30	0	30	0	0	0
week 2	30	20	10	19	8	1	2
week 3	30	22	8	20	5	2	3
week 4	30	25	5	16	4	9	1
week 5	30	22	8	16	6	6	2
week 6	30	25	5	21	3	4	2
week 7	30	24	6	16	5	8	1
week 8	30	25	5	20	5	5	0
week 9	30	22	8	20	4	2	4
week 10	30	21	9	14	6	7	3
week 11	30	21	9	18	7	3	2
week 12	30	24	6	20	5	4	1
n=	360	281	79	230	58	51	21

M= Male; Ad M= Adult male; Ad F = Adult female; F = Female; Ju M = Juvenile Male; Ju F = Juvenile Female

Table 4: *Uca tangeri* collected from New Calabar River

weeks	Nr of Samples	M	F	Ad M	Ad F	Ju M	Ju F
week 1	30	11	9	2	19	18	1
week 2	30	8	7	1	22	18	4
week 3	30	8	5	3	22	20	2
week 4	30	7	5	2	23	17	6
week 5	30	6	3	3	24	23	1
week 6	30	12	11	1	18	16	2
week 7	30	9	7	2	21	18	3
week 8	30	3	2	1	27	23	4
week 9	30	13	11	2	17	14	3
week 10	30	12	11	1	18	15	3
week 11	30	9	8	1	21	17	4
week 12	30	6	4	2	24	22	2
n=	360	104	83	21	256	221	35

M= Male; Ad M= Adult male; Ad F = Adult female; F = Female; Ju M = Juvenile Male; Ju F = Juvenile Female

Table 5: Spearman's correlation of sediment texture and *Uca tangari* for samples collected from Bonny River

			OC	OM	Sand	Silt	Clay
Spearman's rho	Ad M	Correlation Coefficient	0.456	0.772**	-0.441	0.152	0.22
		Sig. (1-tailed)	0.068	0.002	0.075	0.319	0.246
	Ad F	Correlation Coefficient	-0.27	-.608*	0.301	0.227	-0.279
		Sig. (1-tailed)	0.198	0.018	0.171	0.239	0.19
	Ju M	Correlation Coefficient	-.569*	-0.449	0.407	-0.18	-0.388
		Sig. (1-tailed)	0.027	0.072	0.095	0.288	0.107
	Ju F	Correlation Coefficient	0.15	-0.005	-0.47	-0.1	0.269
		Sig. (1-tailed)	0.321	0.493	0.061	0.378	0.199

Table 6: Spearman's correlation of sediment texture and *Uca tangari* for samples collected from New Calabar River

			OC	OM	Sand	Silt	Clay
Spearman's rho	Ad M	Correlation Coefficient	-0.138	-0.057	-0.437	0.326	0.312
		Sig. (2-tailed)	0.669	0.861	0.155	0.301	0.323
	Ad F	Correlation Coefficient	0.06	-0.004	0.469	-0.339	-0.378
		Sig. (2-tailed)	0.853	0.991	0.124	0.282	0.226
	Ju M	Correlation Coefficient	0.072	0.06	0.057	-0.107	-0.055
		Sig. (2-tailed)	0.825	0.852	0.861	0.741	0.865
	Ju F	Correlation Coefficient	-0.086	-0.172	-0.016	0.076	-0.095
		Sig. (2-tailed)	0.791	0.593	0.96	0.815	0.769

*. Correlation is significant at the 0.05 level (1-tailed).

OC=Organic Carbon; OM=Organic Matter

DISCUSSION

Sediment, particle size and population distribution of fiddler crab (*Uca tangeri*) was studied across two stations (The Bonny and New Calabar Rivers) in Rivers State Nigeria. Sediment particle formation and *Uca tangeri* population were not evenly distributed across the study station. The Bonny Rivers sediment particle size analysis shows sand (90.06%), clay (5.43%) and silt (3.66%) while organic matter (1.18%) and organic carbon was (0.62%). Of the n-360 *Uca tangari* samples collected from Bonny Rivers, adult male dominated the population (n=230) followed by adult female (n=58), juvenile male (n=51) and juvenile female (n=21). Also, adult male show positive correlation with clayey sediment (0.22) and silty sediment (0.152) while adult female samples were positively correlated with silt (0.23) and sand (0.30), table 5. The preference of male *Uca tangari* to silt-clayey sediment rich in organic matters and organic carbon was not unconnected with their burrowing and foraging behaviour. The maxillary setae are well developed in adult male which enable them to sort food from within rich clayey sediment. The report of number and development of setae on the second maxilliped was responsible for high population and survivability of *Uca tangari* in muddy sediment Mokhtari *et al.* (2015). Silty-clayey sediment coupled with high organic matters and organic carbon content present an excellent substrate for burrowing and growth of suitable food sources. Burrowing increases the survivability as it serves for escape from predators, exploitation, copulation and hash environmental conditions (Coelho, 1965; Warner, 1969; Coasta, 2000).

Of the n=360 samples harvested from the study stations Adult female show dominance (n=256), followed by juvenile male (221), juvenile female (35) and adult male (21) respectively. The sediment granulometry presented organic carbon (3.62%), organic matters (5.7%), sand (69.96%), silt (12.17%) and clay (17.52%). Sand (69.96%), silt (12.17%), and clay (17.52%). In table 6, the correlation between sediment composition and population distribution of *Uca tangari* was presented. The New Calabar River sediment formation is basically silty-sand. There was more juvenile male (221) and positively correlated with sandy sediments rich organic matters (0.06) and high organic carbon content (0.07), than other age class. Adult female (n=256) show preference to silty (0.28) and sand (0.23) while juvenile female show positive correlation to silty sediment (0.076). This may be as a result of habitat speciation, poorly developed setae, escape from aggressive adults, environmental factor and harvesting. Juvenile prefer to forage in the open on sandy environment and can easily manipulate the sandy shore. Resources sharing may be responsible for juvenile and adult *Uca tangeri* to share the same habitat. The adult female samples were positively correlated with sediments rich in organic carbon and sandy shore while juvenile female show positive correlation with silt sediments (Mokhlesi, 2011). This result agrees with the reports of Coelho (1965) and Warner (1969) that female *Uca thayeri* was only in shaded areas composed of fine sand and very fine sand (Costa, 2001; Koch *et al.*, 2005).

Tables 3 and 5 show a low number of juveniles encountered in this study. This could result from habitat stratification (Negreiros-Fransozo, 2003), sampling techniques, overlooking, visual hand digging, brooding and breeding could account. Juvenile fiddler crabs use different habitat as trade-off of competition and aggressive behaviour of adults. The juvenile prefers to stay in a different habitat until maturity to compete.

Such alteration was earlier reported in some species such as *Uca purgilator* were juvenile were seen in muddy habitat and adults inhabit sandy areas (Mokhlesi, 2011). Such evasive mechanism is important according to Pardo *et al.* (2020), as they lack specialized mouth part to sieve through a more formed substratum. Sharing same habitat with adults could predispose them to fishing, predation, heat stress, cannibalism, competition, and desiccation (Numbere, 2020).

CONCLUSION

The research illustrated that sediment particle size affects the spatiotemporal distribution of *Uca tangeri* along the shores of Bonny and New Calabar Rivers in Port Harcourt, Rivers State. Sediment particle size and morphology influences habitat speciation. While juvenile prefer sandy sediment, adult male prefer clayey sediment. Burrow formation, which is used to escape from predation, habitat weather condition and copulation during reproduction window influences distribution. Sediment preference is also be connected with predation, aggressive behaviour and tidal action. The immatures are too feeble to compete and are driven by tidal action. The juvenile mouth parts are not well developed to burrow sediment rich in clay but can maneuver through sandy environment.

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