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Research Article

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Survey on Phytoplankton Biomass and Water Parameters in the Habitats of Invasive Tigers Shrimps (Penaeus Monodon) in Nigeria

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Abstract

Penaeus monodon is an invasive species found in the coastal waters of Nigeria. Although widely exploited with significant economic importance, investigation into its adaptation and potential ecological impact in the newly found environment is poorly known. This survey provides baseline information on the phytoplankton community and physico-chemical parameters in ten selected stations from five states where they are exploited in Nigeria. These include: Ibeno (Akwa Ibom State), Bonny (Rivers State), Kaa (Rivers State), Brass (Bayelsa State), Aiyetoro (Ondo State), Makoko (Lagos state), Folu (Lagos state), Apapa (Lagos state), Tin Can Island (Lagos state) and Tarkwa Bay (Lagos state). Total of 147 species of phytoplankton from six classes were recorded during the survey with diatoms being the most prevalent (70.4%), green algae (20.4%), Blue-green algae (5.6%), Chrysophyceae (1.9%). Water parameters recorded temperature (range: 27.33 ± 1.53°C-29.00 ± 1.00°C), pH (7.39 ± 0.08-8.13 ± 0.14), dissolved oxygen (5.40 ± 3.22 mgL^{-1}-8.00 ± 1.44 mgL^{-1}), Conductivity (11.22 ± 10.03 µS/cm-39.33 ± 5.87 µS/cm) and salinity (11.02 ± 15.56% -25.98 ± 2.02%). Lowest values for phosphate, nitrate-nitrogen and sulphate were 0.11 ± 0.07mgL^{-1}, 0.10 ± 0.07 mgL^{-1} and 523.67 ± 880.21 mgL^{-1} respectively. Generally, ecological factors in their newly found environment are similar to their native range. However, negative impact as an invasive species most be checked.

Keywords: Phytoplankton; Physico-chemical characteristics; *Penaeus monodon*; Invasive

Introduction

The new millennium has witnessed invasive species which have a renowned and most severe ecological and economic threat globally [1,2]. Generally they have great effects on native biodiversity and cause difficulties in natural ecosystems conservation and management. The Asian tiger shrimp (*Penaeus monodon Fabrizio*) is invasive to the coastal waters of Nigeria [3,4]. The first report of this incidence was about 16 years ago [5]. The Nigerian coastline itself spans approximately 853 km with seven states along the coastal zones namely Lagos, Ondo, Delta, Bayelsa, Rivers, Akwa Ibom and Cross River respectively from South-west to South-South coast. There are at least five families of shrimps contributing to the aquatic resources in Nigeria. These include Penaeidae, Atyidae, Palaemonidae, Alpheidae and Hippolytidae. However Penaeids (Penaeidae) and Macrobrachium species (Palaemonidae) are the predominant species found in Nigeria [6]. Chemonics [7] listed four members of the Penaeids from marine and brackish water namely; *Penaeus (Farfantepenaeus) notialis* (Pink Shrimp), *Penaeus Kerathurus* (striped or zebra shrimp), *Parapenaeopsis atlantica* (Brown Shrimp), *Parapenaeus longirostrics* (Red Shrimp). Not until the sudden emergence of P. monodon, all the aforementioned species, together with *Nematopalaemon hastatus*, formed the basis of the artisanal prawn fishery [8,9].

The black tiger shrimp is a widespread Penaeid shrimp native to the eastern hemisphere from longitude 30˚E to 155˚E and latitude 35˚N to 35˚S (Indo-West Pacific ocean of East Africa, Arabian Peninsula, India, China Japan, the Middle East and North Australia [10,11]. *P. monodon* is now established in many areas presumably due to escapement from aquaculture facilities outside its native range, including West Africa and and South East United States [12-14]. Other regions of invasion include, the Caribbean [15], northern and north-eastern coasts of South America [16-19]. The role of food and feeding habit of this shrimp cannot be overemphasized in its adaptation to novel habitat. Food must be exploited in the new environment and the adaptation for this is related to morphological traits connected to feeding [20]. A major source of food is phytoplankton which comprises complex community of floating micro-algae with size range from about 1 µm to a few millimetres [21,22]. They are microscopic organisms with chlorophyll a, floating on water surfaces or suspended in water column and are dependent on sunshine for photosynthesis [23,24]. Other essential inorganic nutrients dissolved in water are phosphates, nitrates are sulphates. As primary producers, carbon in the form of carbon dioxide is needed in the aquatic environment to initiate the food chain for secondary and tertiary producers [25]. In the native ecosystem of the tiger shrimps, extensive work has been reported on plankton community and physico-chemical parameters. [21] Described the Phytoplankton biomass and Community Structure of Kottakudi and Nari, South East of Tamil Nadu, India. Kannan and Vasantha [26] studied Microphytoplankton of the Pitchavaram Mangals, Southeast Coast of India. Diatoms domination amidst various groups of phytoplankton was reported in the two studies. Also, in the South Eastern coast of India, Uppanar Estuary, Cuddalore, physico-chemical parameters were reported by [27]. In North and North West Australia, Hallegraeff and Jeffrey [28] reported the Tropical phytoplankton species and pigments of the continental shelf waters. The nanoplankton (e.g., amphora species and Navicular species) were documented most abundant species.

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Many studies have also examined the phytoplankton biomass of some lagoons and surrounding creeks in Nigeria. [29,30] reported the phytoplankton of Lagos lagoon, eight cyanobacteria species in South Western coast of Nigeria and dinoflagellates list of Lagos lagoon. Diatoms of Olero creek and Lekki lagoon were reported [31]. The Cyanobacteria of a Tropical Lagoon (lekki), Nigeria was also reported by [32]. Many others reports [33-36] attributed seasonal changing hydro environmental characteristics as determinants of the phytoplankton and zooplankton standing crop at anytime. In the Niger delta, [37] studied Warri Forcados estuary phytoplankton and a similar study was earlier reported in the New Calabar river by [38]. Countries in West Africa are generally constituted by many physico-chemical characteristics that make them environmentally sustainable for shrimp farming and coastal areas have water suitable for farming many other aquatic species [39]. However further studies investigating the adaptability of specific shrimp species with climate are essential [40] documented the potentials of Andoni river for production of tiger shrimps in Nigeria haven studied the physico-chemical properties. The conditions were observed to be within satisfactory range limits for warm water fish and shellfish production. Furthermore the physico-chemical qualities of the Andoni River, coupled with the findings of [41] were reported suitable for the production of this alien species.

This survey on phytoplankton and physico-chemical parameters was carried out across selected station in Nigeria as a preliminary investigation to understand the ecology of the invasive tiger shrimp. The information will be useful for aquaculture and wild resource management on the invasive species.

Materials and Methods

Description of study sites

Following a pilot survey on prominent artisanal tiger shrimp fishing areas within the South-West and South-South coastal states of Nigeria, 5 states and 10 stations were selected for the study (between the dry seasons of November, 2013 and January, 2014). Table 1 and Figure 1 show the stations with geographic coordinates and map of South-West and South-South Nigeria.

Lagos State, Nigeria (latitudes 6˚23'N and 6˚41'N and longitudes 2˚42'E and 3˚42'E) is located in South-western part of the country on the West Coast of Africa. It is flanked from the north and east by Ogun State, to the west by the Republic of Benin and bounded southward by the Atlantic Ocean (Gulf of Guinea). Lagos Tarkwa-Bay (LT) is a key location that opens the Atlantic ocean as a source of salt water incursion to the Lagos lagoon-Makoko (LM), Apapa (LA) and Tin can island (LC) through the Lagos harbor Lagos-Makoko.

(LM) represents one of the largest fish and shrimp landing sites of the Lagos Lagoon while Folu (LF) is a foremost coastal community along the Atlantic Ocean [42]. Ondo state is bounded southward by the Atlantic Ocean and has many rivers such as R Owena and Oluwa which empties into the sea. Aiyetoro OA in Ilaja community is one of the major coastal settlements in the area [43]. Tarkwa-Bay LT, Folu (LF), Aiyetoro (OA), Brass (BB), Bonny (RB) and Ibeno (AB) are located in proximity to the Atlantic coast of their respective states in Nigeria. Tarkwa-Bay is a major point bounded in the North by the Cowrie creek, in the south by the Atlantic Ocean and the West by the Lagos Harbor. The east end of Tarkwa-Bay opens to the surrounding for water transportation to the rest of the Islands (including Tin can Island) and mainland in Lagos State. The Commodore Channel along the east end is the only significant connection between the Lagos Lagoon the Atlantic Ocean [42]. Makoko (LM) is located on the west of Lagos lagoon and is one of the major fish landing sites of the lagoon. The commodore channel also connects the Atlantic Ocean to Apapa and environs through the Lagos harbour. Kaa (RK) water front in Rivers is one of the two major landing sites for the obolo (Andoni) fishers that use un-motorized "dugout" canoe for their subsistence occupation.

State	Sampling stations	Coordinates	
		Long	Lat
Lagos	Folu (LF)	4°0'16.128"	6°26'50.438"
Lagos	Makoko (LM)	3°23'8.405"	6°28'35.00"
Lagos	Apapa (LA)	3°21'7.352"	6°27'0.520"
Lagos	Tarkwa Bay (LT)	3°23'42.392"	6°24'10.075"
Lagos	Tin can island (LC)	3°20'30.562"	6°26'8.401"
ONDO	Aiyetoro (OA)	4°40'11.91"	6°11'37.53"
BAYELSA	Brass (BB)	6°15'55.532"	4°17'33.431"
RIVERS	Bori-Kaa Water side (Rk)	7°30'53.352"	4°44'7.9553."
RIVERS	Bonny (RB)	7°9'21.926"	4°39'47.274"
AKWA IBOM	Eket-ibeno (AB)	8°0'30.974"	4°32'31.000"

Table 1: Sampling stations with coordinates.

The Andoni River sand Bonny River are connected with the Niger Delta which is one of the world's largest wetlands covering an area of approximately 70,000 km^2. The Niger Delta is rich in biodiversity with numerous oil exploratory activities [44].

According to [45] he basin of bonny river is enclosed eastward by Andoni basin, westward by the New Calabar basin and then northward is the coastal plain sand. The length of the upper bonny river to the bonny bar is approximately 80 km. Water depth generally decreases up stream. It represents one of the most stressed river system with great economic importance due to the intensity of several oil field, industrial and fishing activities Ibeno (AB) station has the highest number of fishing settlements in Akwa Ibom and represents one of the largest producers of fish in the country. The Southern part of Akwai Ibom is bounded by the Atlantic Ocean at a region commonly called the Bight of Benin [46].

Generally, the climate of the study sites is equatorial in nature with two distinct periods of rainfall: March-July, which peaked in July and Sept-October. The periods of dry season are January-February, August and November-December. The sampling sites are both marine and brackish waters with artisanal fishing being the predominant economic activity within the surrounding settlements.

Collection of water samples and analysis of physico-chemical parameters

Sampling took place between 7 am and 12 pm. For each station, sampling was done 3 times at different locations to obtain their mean values. Water samples for physico-chemical analysis were collected 0.50 m below the water surface, in 1 dm^3 water sampler and stored on ice chest in one litre water bottles. In the laboratory, the water samples were transferred into refrigerator (4˚C) and analysed within 24 hr of collection. Surface water temperature was measured in situ using mercury-in-glass thermometers, while pH, conductivity and salinity were analysed in the laboratory using a multi-meter water checker (Horiba U-10). Dissolved oxygen content was determined using Griffin digital meter Dissolve Oxygen (model 40) [47].

Figure 1: Map of South-West and South-South Nigeria showing the sampling stations.

Phytoplankton biomass

Samples for plankton analysis were collected using 55 µm mesh size standard plankton net and a 10 L plastic container. For each station, plankton samples were collected by filtering 100 L of surface water through the net. Plankton filtrates were then transferred (preserved with 4% formalin) into a well labelled 250 ml plastic container with a screw-cap. Plankton analysis and biomass were determined by counts. Plankton fixation lasted about 48 hr in the lab. The supernatant was decanted leaving behind a concentration of about 40 ml. With the aid of a dropper, two drops (0.2 ml) of each sample was placed on a glass slide with cover slip over the mount. Drop count method was used to analyze. This was done five times for each sampling station. Thorough investigation under light binocular microscope (Olympus BX51) was achieved. Examination, identification, counting and record of mean abundance of was done via varying magnification (x50-x400). A record of total organism was taken and equated per ml [31,32,47]. Authentication of species was confirmed using appropriate text (Hendey 1958, 1964; Patrick and Reimer, 1966, 1975; Wimpenny, 1966; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; Bettrons and Castrejon, 1999; Lange-Bertalot, 2001; Witkowski 2000; Siver, 2003; Rosowski, 2003).

Nutrient sampling

Nitrate, Phosphate Sulphate and silicate were measured with LaMotte SMART Spectrophotometer at different wavelengths using their appropriate colour development reagents. The Smart Spectro is an Environmental Protection Agency-Accepted instrument, meets the requirements for instrumentation as found in test procedures that are approved for the National Primary Drinking Water Regulations (NPDWR) or National Pollutant Discharge Elimination System (NPDES) compliance monitoring programs (GCLME-2009, LaMotte Operator's Manual-2012).

Instrumentation: Horiba U-10, LaMotte Smart Spectrophotometer, Centrifuge and Membrane filtration Unit.

Biological indices

- Shannon and Wiener diversity index (H´) according to Ogbeibu [48] was obtained as

$$H = -\sum p_i \ln(p_i)$$

where

p_i=proportion of observations species category

- Species Equitability or Evenness index (j) [49]

Formula for evenness is $J' = H'/H'_{max}$

Where $H'_{max} = \ln(S)$

Simpson Diversity Index (D) obtained with the formula $= \sum_{i=1}^{R} p_i^2$

- Gini Simpson index: (1-D) obtained as the transformation of Simpson index, D since the values of D will always reduce with increasing diversity.

Species Richness Margalef Index (d) assessment of community structures and obtained by

$$d = \frac{S-1}{\ln N}$$

where

d=Species richness index

S=Number of species in subpopulation

N=Sum total of individuals in S species [47,48]

Results

Physico-chemical parameters

The Physico-chemical characteristics of the study areas are presented in Tables 2 and 3. Mean temperature range was between 27.33 ± 1.53°C (station LM) and 29.00 ± 1.00°C (station RB). Mean pH values ranged between 7.39 ± 0.08 (station LA) and 8.13 ± 0.14 (station OA) (buffered ecosystems across sampling station). Range value for dissolved oxygen was 5.40 ± 3.22 mgL^{-1} (station AB)-8.00 ± 1.44 mgL^{-1} (station OA) while conductivity was 11.22 ± 10.03 μS/cm (station LM)-39.33 ± 5.87 μS/cm (station OA). The lowest values for phosphate-phosphorus, nitrate-nitrogen and sulphate were 0.11 ± 0.07mgL^{-1} (station RK), 0.10 ± 0.07 mgL^{-1} (station RK) and 523.67 ± 880.21 mgL^{-1} (station LM) respectively. Salinity recorded the least mean value of 11.02 ± 15.56% (station LC) and highest 25.51 ± 2.02% (station RB.

Phytoplankton biomass

Composition and distribution of phytoplankton across the 10 sampling stations are presented in (Tables 4-6). A total of 147 species of phytoplankton from 6 classes were recorded during the survey. Total number of species recorded per station ranged between 9 (station BB) and 42 (station LT). Furthermore the highest number of individual count was 952 per ml (station AB) and lowest 156 were observed in stations RK and LF.

(Table 7) depicts the phytoplankton assemblage and prevalence recorded in the survey. 6 classes of species vis-à-vis, Bacillariophyceae-Diatoms (70.4%), the Chlorophyceae-Chlorophytes (20.4%), Cyanophyceae-Blue-green algae (5.6%), Chrysophyceae (1.9%) Dinophyceae (1.1%) and Euglenophyceae (0.5%) were recorded.

(Table 8) however tabulates the phytoplankton community's biological indices. Margalef Index (d) Values were from 1.30 (station BB) to 6.14 (station RK), Shannon-Wiener Index (H^1).

were between 1.52 (station BB) and 3.03 (station RK), Equitability (j) values were between 0.52 (station AB) and 0.88 (station RK) and Simpson's Dominance Index ranged between 0.07 (station RK) and 0.32 (AB).

Discussion

In *P. monodon*, temperature is an essential environmental parameter having considerable impact not only on the success of culture, but also on survival and spread in areas of introduction. Temperature is known to influence rate of development, reproductive cycle and timing, migration patterns, growth, metabolism, sensitivity to toxins, susceptibility to parasites and diseases infection [50,51]. Optimum temperature range of 28°C-33°C is essential for survival and growth, but detrimental below 20°C. Although, tolerance between 13°C - 33°C and mortality at <13°C and >33°C were documented, fatal extremes have not been ascertained [52-54]. In this study, the least mean temperature recorded was 27.33°C at Lagos-Makoko. While the highest was 29°C at Rivers (Bonny and Kaa) station, according to Dublin-Green [45] and Komi and Sikoki [40] who reported Physico-chemical Characteristics

STATE	STATIONS	Water Temp (ºC)	pH	Cond (μS/cm)	Salinity (ppt)	D.O (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)	Chl a (μg/l)	Chl b (μg/l)	Chl c (μg/l)	Values
AKWA IBOM	AB(1)	27.00	7.78	19.30	26.34	1.80	0.23	0.08	1,980.00	0.0017	0.0019	0.0039	
	AB(2)	29.00	7.73	19.20	11.50	8.00	0.52	0.08	2,400.00	0.0209	0.0003	0.0004	
	AB(3)	28.00	7.49	8.00	30.76	6.40	0.72	0.44	1,960.00	0.0112	0.0055	0.0504	
		28.00	**7.67**	**15.50**	**22.87**	**5.40**	**0.49**	**0.20**	**2,113.33**	**0.01**	**0.00**	**0.02**	mean
		1.00	0.16	6.50	10.09	3.22	0.25	0.21	248.46	0.01	0.00	0.03	S.D
RIVERS	RB(1)	30.00	7.47	4.50	25.00	5.20	0.19	0.12	1,640.00	0.0039	0.0015	0.0024	
	RB(2)	29.00	7.34	22.90	22.02	4.40	0.77	0.15	2,440.00	0.0114	0.0137	0.0470	
	RB(3)	28.00	8.06	45.40	29.50	7.60	1.28	0.13	4,500.00	0.0259	0.0149	0.0421	
		29.00	**7.62**	**24.27**	**25.51**	**5.73**	**0.75**	**0.13**	**2,860.00**	**0.01**	**0.01**	**0.03**	mean
		1.00	0.38	20.48	3.77	1.67	0.55	0.02	1,475.53	0.01	0.01	0.02	S.D
	RK(1)	29.00	7.51	25.40	15.60	4.00	0.06	0.16	3,120.00	0.0187	0.0145	0.0586	
	RK(2)	30.00	7.47	23.89	27.28	5.20	0.19	0.12	1,640.00	0.0039	0.0015	0.0024	
	RK(3)	28.00	7.97	39.20	25.20	7.60	0.07	0.02	3,760.00	0.0295	0.0077	0.0125	
		29.00	**7.65**	**29.50**	**22.69**	**5.60**	**0.11**	**0.10**	**2,840.00**	**0.02**	**0.01**	**0.02**	mean
		1.00	0.28	8.44	6.23	1.83	0.07	0.07	1087.38	0.01	0.01	0.03	S.D
Bayelsa	BB(1)	29.00	7.35	10.40	25.67	8.40	0.16	0.30	3,920.00	0.0504	0.0200	0.0303	
	BB(2)	29.00	8.53	0.81	19.90	8.20	0.19	0.01	31.00	0.0559	0.0095	0.0089	
	BB(3)	28.00	8.01	35.90	22.80	6.79	0.23	0.21	1,960.00	0.0068	0.0078	0.0302	
		28.67	**7.96**	**15.70**	**22.79**	**7.80**	**0.19**	**0.17**	**1,970.33**	**0.04**	**0.01**	**0.02**	mean
		0.58	0.59	18.14	2.89	0.88	0.04	0.15	1,944.52	0.03	0.01	0.01	S.D
Ondo	OA(1)	28.00	8.06	35.70	22.60	9.20	0.98	0.62	3,500.00	0.0068	0.0027	0.0021	
	OA(2)	29.00	8.05	36.20	23.00	8.40	0.34	0.10	3,700.00	0.0060	0.0002	0.0008	
	OA(3)	27.00	8.29	46.10	30.00	6.40	0.01	1.02	440.00	0.0023	0.0007	0.0066	
		28.00	**8.13**	**39.33**	**25.20**	**8.00**	**0.44**	**0.58**	**2,546.67**	**0.01**	**0.00**	**0.00**	mean
		1.00	0.14	5.87	4.16	1.44	0.49	0.46	1,827.17	0.00	0.00	0.00	S.D

Table 2: Physico-Chemical parameters of water samples across stations.

STATE	STATIONS	Water Temp (°C)	pH	Cond (μS/cm)	Salinity (ppt)	D.O (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)	Chl a (μg/l)	Chl b (μg/l)	Chl c (μg/l)	values
	LA(1)	28.00	7.44	1.99	12.00	7.00	0.02	0.03	77.00	0.0057	0.0040	0.0122	
	LA(2)	27.00	7.30	23.55	13.56	6.65	0.67	0.12	1,540.00	0.0029	0.0015	0.0025	
	LA(3)	28.00	7.42	22.08	17.98	6.70	0.01	0.02	9.00	0.0105	0.0062	0.0126	
		27.67	**7.39**	**15.87**	**14.51**	**6.78**	**0.23**	**0.06**	**542.00**	**0.01**	**0.00**	**0.01**	mean
		0.58	0.08	12.05	3.10	0.19	0.38	0.06	864.96	0.00	0.00	0.01	S.D
	LM(1)	29.00	7.36	10.34	19.76	5.30	0.98	0.22	1,540.00	0.0039	0.0015	0.0024	
	LM(2)	26.00	7.95	21.66	0.20	7.00	0.33	0.3	24.00	0.7352	0.3256	0.1834	
	LM(3)	27.00	7.63	1.66	23.56	7.56	0.34	2.03	7.00	0.0117	0.0134	0.0375	
		27.33	**7.65**	**11.22**	**14.51**	**6.62**	**0.55**	**0.85**	**523.67**	**0.25**	**0.11**	**0.07**	mean
		1.53	0.30	10.03	12.53	1.18	0.37	1.02	880.21	0.42	0.18	0.10	S.D
	LT(1)	28.00	8.53	14.50	19.90	8.34	0.19	0.01	31.00	0.0560	0.0065	0.0089	
	LT(2)	28.00	7.22	12.53	12.00	6.34	0.03	0.01	161.00	0.0087	0.0076	0.0185	
Lagos	LT(3)	27.00	7.58	35.40	22.60	5.70	0.01	0.31	1,939.00	1.0029	0.1765	0.4179	
		27.67	**7.78**	**20.81**	**18.17**	**6.79**	**0.08**	**0.11**	**710.33**	**0.36**	**0.06**	**0.15**	mean
		0.58	0.68	12.67	5.51	1.38	0.10	0.17	1,066.04	0.56	0.10	0.23	S.D
	LC(1)	27.00	7.34	22.90	22.02	7.40	0.77	0.15	2,440.00	0.0114	0.0137	0.0470	
	LC (2)	29.00	7.13	24.66	0.00	6.70	0.52	0.33	34.00	0.0409	0.0130	0.0267	
	LC(3)	28.00	7.77	0.31	0.01	6.78	0.01	0.09	7.00	0.0078	0.0088	0.0402	
		28.00	**7.41**	**15.96**	**11.02**	**6.96**	**0.43**	**0.19**	**827.00**	**0.02**	**0.01**	**0.04**	mean
		1.00	0.33	13.58	15.56	0.38	0.39	0.12	1,396.96	0.02	0.00	0.01	S.D
	LF(1)	27.00	8.45	18.44	26.34	7.20	0.23	0.08	1,880.00	0.0017	0.0019	0.0049	
	LF(2)	28.00	7.42	20.99	23.80	7.88	0.18	0.32	11.00	0.0065	0.0045	0.0089	
	LF(3)	28.00	8.06	2.61	27.80	8.55	0.02	0.03	4.00	0.006	0.005	0.009	
		27.67	**7.98**	**14.01**	**25.98**	**7.88**	**0.14**	**0.14**	**631.67**	**0.00**	**0.00**	**0.01**	mean
		0.5774	0.52	9.9575	2.024	0.675	0.109697	0.155	1081.094	0.00264	0.00167	0.0024	S.D

Table 3: Physico-Chemical parameters of water samples across stations.

of the Kaa water station (part of the Andoni River) and its potentials for production of *P. monodon*, temperature varied between 27°C and 31°C. However previous work reported values of 26.2°C to 32.4°C [41]. Generally the temperature range was within satisfactory WHO (2006) and FEPA (1991) limits for warm water fish and shellfish production.

Apart from the temperature of coastal waters, salinity over the years has also been recognized as a key factor influencing the absence, presence and abundance of endemic species [22,55]. In the wild, high salinity in the marine habit may be an important factor in ovarian maturation and egg/embryo development of the tiger shrimp, which may account for the offshore movement of sub-adult in preparation for full maturation and breeding. This study reported the highest mean salinity of 25.98% in Lagos-Folu which is a marine habitat. While the lowest (11.02% and 14.51%) were reported in the brackish waters of Lagos-Tin can Island and Lagos-Makoko stations respectively. Ecologists have connected salinity gradients within lagoon and estuaries to two main factors; influx of floodwater from rivers and nearby creeks of wetlands and tidal seawater inflow [23,56,57]. In Lagos lagoon, it has been reported that rainfall distribution determines salinity gradient and same factor may apply to estuarine system. Least salinity recorded by Nwankwo and Gaya [58] during the dry season was 8.6%. While Onyema [34] reported an average of 18.0% in the months of November and December at Onijeji Lagoon, Lagos. Salinity plays essential role in controlling growth and survival of tiger shrimps. Though euryhaline, *P. monodon* is comfortable at optimum salinity. High salinity is reported to induce slow growth, but promotes high health and resistance to diseases. On the other hand, low salinity may encourage growth but with weak shell and disease susceptibility. In the wild, the need for low salinity may account for movement of larval and protozoa stages to the estuaries where they grow into sub-adults [59,60] observed that *P. monodon* obtained from their native spawning grounds (Indian Ocean) with salinity 33% yielded better maturation and egg fertilization compared with those from Songkhla lake (22-28%). However, lower salinity (15-25%) is optimum to stimulate growth in the grow-out phase [61]. In culture ponds, salinity range of 20-28 % has been demonstrated and survival rate was 87% [62]. In Nigeria, spawning of gravid females from wild invasive species was successfully at 35%. Out of four breeding trials, six were successful [4]. Moreover other authors recommended salinity range of 10-35%). Few reports have observed adaptation of *P. monodon* to freshwater conditions, which may be attributed to its wide range of salinity tolerance [63-65].

H has an important role in metabolism, physiological processes, indicator of presence of metabolites, photosynthetic activity and fertility of aquatic environment. It varies with dead algae, excretory and residual feed (in the case of culture medium). Maximum values for aquatic environment are obtainable at maximum photosynthetic activity. Whereas very high pH is an indication of high fertility and depletion of dissolved oxygen due to plankton bloom, suggestive of eutrophication (nutritive enrichment by nitrogen and phosphorous compounds generated by human activities) [66]. According to [67] pH 6.8-8.7 is optimum for peneaid shrimps. A range of 7.5-8.5, which is in consonance with the range reported in this study, was recommended by Reddy [68]. Alkaline values indicating high amount of CO_2 stored in Carbonate forms in seawater produces a buffering effect [32] A similar inference was reported by [33] for the Lagos lagoon and Onyema and Nwankwo [36] at Iyagbe lagoon.

The species composition of phytoplankton observed in the present study was dominated by the marine phytoplankton. Marine

State	Akwaibom	Rivers		Bayelsa	Ondo	Lagos					
Stations	AB	RB	RK	BB	OA	LF	LC	LT	LM	LA	TOTAL
CLASS BACILLARIOPHYCEAE											
A. coffeaeformis (Agardh) Kutzing	-	40	-		-	-	-	-	-	-	40
A. holsatica Hustedt	-	1	-	-	-	-	-	-	-	-	1
A. ovalis(Kutzing) Kutzing	-	-	1	-	-	-	-	-	-	-	1
A.veneta Kutzing	-	-	-	-	-	-	-	-	-	3	3
Amphora sp	-	-	-	-	-	-	-	1	-	-	1
Achnanthes exilis Kutzing	-	-	-	-	-	-	-	-	-	1	1
A. parvula Kutzing	-	-	-	-	-	-	-	5	-	-	5
Asterionella formosa Hassal	7	-	-	-	-	-	-	-	-	57	64
A. japonica Cleve	-	-	3	4	-	-	100	54	-	-	161
Bacillaria paxillifer (O.F. Muller) Hendey	-	237	10	-	-	-	-	150	-	-	397
Biddulphia aurita (Lyngbye) Brebisson	-	-	3	7	-	-		1	2	-	13
B. longricruris Greville	-	-	-	-	-	-	65	-	-	-	65
B. rhombus (Ehr.) W. M. Smith	-	-	-	98	-	-	-	-	-	-	98
B. regia Greville	-	-	-	-	-	2	77	9	-	-	88
B. sinensis Greville	-	-	2	125	-	-	70	-	-	-	197
Biddulphia sp	-	-	-	134	-	-	-	-	-	-	134
Caloneis permagna (Bailey) Cleve	-	-	2	-	-	-	-	-	-	-	2
Chaetoceros lorenzianum Grunow	-	-	-	1	-	1	2	-	-	-	4
C. placentula Ehrenberg	1	-	-	-	-	-	-	-	-	-	1
Cocconeis sp	-	1	-	-	-	-	-	-	-	-	1
Coscinodiscus sp	10	2	8	89	-	9	8	11	-	-	137
Cyclotella sp	-	-	5	-	-	-	5	9	-	-	19
*Cymbella amphicephala*Naegeli	-	1	-	-	-	-	-	-	-	-	1
C. ehrenbergii Kutz	-	19	-	-	-	-	-	-	-	-	19
C. prostrata (Berkeley)	-	-	-	-	-	-	-	-	-	3	3
C. silesiaca Bleisch	-	-	-	-	-	-	-	-	-	2	2
Cymbella sp	-	6	8	-	-	-	-	1	-	-	15
Diploneis didyma (Ehr.) Cleve	-	-	1	-	-	-	-	-	-	-	1
Entomoneis costata (Hustedt) Reimer	-	-	1	-	-	-	-	-	-	-	1
E. ornata (Bailey) Reimer	30	-	-	-	-	-	-	-	-	-	30
Entomoneis sp	1	-	1	-	-	-	1	-	-	-	3
Epithemia sp	1	-	-	-	-	-	-	-	-	-	1
Eunotia triodon Ehr.	1	-	-	-	-	-	-	-	-	-	1
Eunotia sp	2	1	-	-	1	-	-	-	-	1	5
Fragilaria capucina Desmarziers	-	-	2	-	-	-	-	-	-	-	2
Fragilaria sp	14	-	11	-	50	-	-	-	-	-	75
Frustulia rhomboides (Ehrenberg) de Toni	7	-	-	-	6	1	-	-	-	-	14
Frustulia sp	-	-	-	-	-	-	-	-	-	1	1

Table 4: Composition and abundance of phytoplankton species across sampling stations.

phytoplankton are mainly composed of microalgae know as diatoms (Bacillariophytes) though other algae (green and blue green algae) can be found in low prevalence as reported in this study. Microalgae are requisite for larval nutrition by direct consumption [69]. In tiger shrimp, larval stage is made up of 6nauplius, 3protozoea, 3mysis and 3-4 megalopa substages. Initially, nauplii utilize yolk granules within their body as food and subsequently feeding on microalgae begins at the protozoea stage [70]. Carbohydrates in microalgae are mostly obtainable as highly digestible starch or as glucose, sugars and other forms of polysaccharides. Protein and fatty acid contents are major factors determining the nutritional value of available microalgae and are essential for zooplankton growth and metamorphosis of larval stages [71]. Phytoplankton are by themselves able to synthesize all amino acids, hence can supply the essential ones to larva and other zooplanktons [72].

Examples of the prevalent microalgae reported are in this survey are: Nitzschia, Navicula, Thalassiothrix, Amphora, Fragilaria, Coscinodiscus, Asterionella, Bacillaria paxillifer, Biddulphia, Melosira, Tabellaria and Surirella species. Some of the green algae include Aulacoseira granulate, Chlorella, Closterium, Chaetoceros and Eudorina elegan. While the blue green algae was dominated by Oscillatoria Sp, Spirulina Sp and Merismopedia Glauca. A good number of the diatoms have been reported by earlier workers especially for the Lagos lagoon and allied tidal creeks [29-32,56]. The presence of Nitzschia, Biddulphia and Thalassiothrix species probably point to their source of recruitment (the marine). According to [56], salinity and floodwater conditions are known to influence the algal composition and abundance in the Lagos lagoon. A similar situation likely exists for the brackish stations under this study. However for the green algae, [29] has already related these species to primarily fresh water conditions in association with the wet

State	Akwaibom	Rivers		Bayelsa	Ondo	Lagos					
Stations	**AB**	**RB**	**RK**	**BB**	**OA**	**LF**	**LC**	**LT**	**LM**	**LA**	**TOTAL**
CLASS BACILLARIOPHYCEAE											
Gyrosigma acuminatum (Kutzing) Rabenhorst	-	-	4	-	-	1	-	-	-	-	5
G. balticum (Ehrenberg) Rabenhorst	-	-	6	-	-	-	1	-	-	-	7
G. obscurum (W. Smith) Griffith & Henfrey	-	-	3	-	-	-	-	-	-	-	3
G. scalproides (Rabh.) Cleve	-	26	4	-	-	-	-	-	-	-	30
G. strigilis (W. Smith) Cleve	-	1	5	-	-	1	-	-	-	-	7
G. peisonis(Grunow) Hustedt	-	-	-	-	-	-	-	4	-	-	4
G. wansbeckii (Donkin) Cleve	-	-	-	-	-	-	-	1	-	-	1
Mastogloia sp	-	-	-	-	-	-	-	-	-	1	1
Melosira sp	95	-	-	-	-	45	1	**125**	4	-	270
Navicula clementis Grunow	-	-	-	-	-	-	-	**1**	-	-	1
N. crucicula (W.Sm.) Donkin	2	-	-	-	-	-	-	1	-	-	3
N. decussis Oestrup	1	-	-	-	-	-	-	-	-	-	1
N. mutica Kutzing	1	-	-	-	-	-	-	-	-	-	1
N. radiosa Kutz	-	1	3	-	-	-	-	46	-	-	50
N. zeta Cleve	-	-	1	-	-	-	-	-	-	-	1
Navicula sp	-	-	5	-	-	-	1	-	-	-	6
Neidium apiculatum Reimer	-	3	-	-	-	-	-	-	-	-	3
*N. binodeformis*Krammer	-	7	-	-	-	-	-	-	-	-	7
N. iridis (Ehreberg) Cleve	6	-	-	-	-	-	-	-	-	-	6
N. ladogensis (Cleve) Foged	-	1	-	-	-	-	-	-	-	-	1
N.septentrionale Cleve-Euler	-	-	-	-	-	1	-	-	-	-	1
N. productum (W. Smith) Cleve	-	1	-	-	-	-	-	-	-	-	1
Neidium sp	12	-	-	-	-	-	1	2	-	-	15
Nitzschia acicularis W.Smith	1	2	2	-	1	18	-	-	1	-	25
N. ignorata Krasske	-	70	2	-	-	2	3	-	-	-	77
N. thermalis Kutzing	-	5	-	-	-	-	-	-	-	-	5
N. sublinearis Hustedt	-	-	-	-	-	-	-	1	-	-	1
*N. subtilis*Grun	-	-	-	-	-	1	-		-	-	1
N. obtusa W. Sm	-	21	-	-	-	-	1	3	-	-	25
N. palea (Kutz) W. Sm	-	2	-	-	-	-	-	-	-	-	2
Nitzschia sp	-	2	-	-	-	5	1	1	-	3	12
Pleurosigma angulatum (Quekett) W. Smith	-	1	35	-	-	-	-	3	-	-	39
P. elongatum W. Smith	-	-	4	-	-	-	-	5	-	-	9
P. salinarum Grunow	-	-	-	-	-	-	10	-	-	-	10
Pinnularia acrosphaeria Brebisson	1	-	-	-	-	-	-	-	-	1	2
P. dactylus Ehrenberg	-	-	-	-	-	-	-	1	-	-	1
P. divergentissima(Grunow) Cleve	1	-	-	-	-	-	-	-	-	-	1
P. gibba Ehrenberg	2	-	-	-	-	-	-	-	-	-	2
P. lundii Hustedt.	-	-	-	-	-	-	-	-	-	1	1
P. macilenta Ehr. Emend. Cleve	-	-	-	-	-	-	-	5	-	-	5
P. maior (Kutzing) Rabenhorst	8	-	-	-	-	-	-	-	1	-	9
P. microstauron (Ehrenberg) Cleve	-	-	-	-	-	-	-	-	2	-	2
P. stomatophora (Grunow) Cleve	2	-	-	-	-	-	-	-	-	-	2
Pinnularia sp	-	-	2	-	-	-	-	-	-	-	2
Stephanodiscus sp	3	-	-	-	-	-	-	-	-	-	3
Surirella elegans Ehr.	-	-	-	-	-	-	-	5	101	-	106
Surirella sp	41	5	-	-	-	-	-	114	18	-	178
Synedra sp	10	-	-	-	2	23	3	45	1	-	84
Tabellaria fenestrata(Lyng) Kutzing	522	2	-	-	4	-	-	9	2	58	597
T. flocculosa (Roth) Kut.	79	-	-	-	-	-	-	-	-	-	79
Thalassiothrix frauenfeldii Grunow	-	-	6	2	-	-	39	8	-	-	55
T. nitzschioides (Grunow) Van Heurck	-	-	-	-	-	-	-	-	-	5	5
Ulnaria ulna (Nitzsch) Ehrenberg	-	1	-	-	-	-	-	-	-	-	1
U. ulna var. *longissima* (W. Sm.) Brun	-	-	-	-	-	-	-	-	-	1	1
Ulnaria sp	-	1	-	-	-	-	-	-	-	-	1
TOTAL INDIVIDAL COUNT	**861**	**460**	**140**	**460**	**64**	**110**	**389**	**621**	**132**	**138**	**3375**

Table 5: Composition and abundance of phytoplankton species across the sampling stations.

State	**Akwaibom**	**Rivers**		**Bayelsa**	**Ondo**	**Lagos**					
Stations	AB	RB	RK	BB	OA	LF	LC	LT	LM	LA	TOTAL
CLASS CHLOROPHYCEAE											
Asterococcus sp	-	-	-	-	-	24	-	-	-	-	24
Aulacoseira granulata var. *angustissima* f. *spiralis* (Hust)	-	-	-	-	-	-	-	-	201	-	201
Chlorella sp	-	-	-	-	-	-	-	24	4	-	28
Closterium abruptum (Lynb.) Breb.	-	-	-	-	1	-	-	-	-	-	1
C. moniliferum Ehrenb.	-	-	-	-	-	-	-	-	-	1	1
C. setaceum f. *sigmoideum* Irenee- Marie	-	-	2	-	-	5	-	-	-	-	7
C. peracerosum Gay	-	-	-	-	-	-	-	-	20	-	20
Closterium sp	-	3	-	2	-	-	1	2	-	-	8
Cosmarium binum Nordst	-	-	-	-	-	-	-	1	-	-	1
Cosmarium sp	-	-	-	-	-	-	-	-	3	-	3
Desmidium sp	-	-	5	-	-	-	8	2	-	-	15
Euastrum sp	-	-	-	-	-	-	-	1	-	-	1
Eudorina elegans Ehrenberg	-	-	-	-	150	-	-	32	-	-	182
Gonatozygon sp	1	-	-	-	-	-	-	-	-	-	1
Scenedesmus acuminatus (Lag.) Chodat	-	-	-	-	-	-	-	36	8	-	44
S. armatus var. *bicaudatus* (Gugl. Print) Chodat	-	-	-	-	-	-	-	-	8	-	8
S.bijuga (Turp) Lagerheim	-	-	-	-	-	-	-	-	4	-	4
S. quadricauda (Turp) Brebisson	-	-	-	-	-	-	-	-	2	-	2
Scenedesmus sp	-	-	-	-	-	-	-	8	-	-	8
Selenastrum bibraianum Reinsch	-	-	-	-	-	-	-	-	6	-	6
Spirogyra sp	-	1	-	-	-	-	-	-	-	5	6
Staurastrum americanum (W. and G. S. West) G.M. Smith	2	-	-	-	-	-	-	-	-	-	2
S. cingulum var. *floridense* Scott and Gronblad	-	-	-	-	-	-	-	-	124	-	124
S. tetracerum Ralf	-	-	-	-	-	-	-	-	4	-	4
S. vestitum Ralfs	-	-	-	-	-	-	-	4	-	-	4
Staurastrum sp	1	-	-	-	-	-	-	-	10	-	11
Stigeoclonium sp	-	-	-	-	-	-	-	-	-	6	6
Tetradesmus cumbrucus G.S. West	-	-	-	-	-	-	-	-	16	-	16
Tetraedron gracile Hansgirg	-	-	-	-	-	-	-	-	7	-	7
Pandorina sp	-	-	-	-	-	2	-	-	135	-	137
Pediastrum sp	-	-	-	-	-	-	-	9	7	-	16
Micrasterias sp	-	-	-	-	-	-	-	1	-	-	1
Microspora sp	-	-	-	-	-	10	-	-	-	-	10
Mougeotia sp	-	-	-	-	67	-	-	-	-	-	67
TOTAL INDIVIDUAL COUNT	**4**	**4**	**7**	**2**	**218**	**41**	**9**	**120**	**559**	**12**	**976**
CLASS DINOPHYCEAE											
Ceratium sp	-	-	-	-	-	-	1	-	-	-	1
Gymnodinium sp	50	-	-	-	-	-	-	-	-	-	50
Perinidium cinctum (Muller) Ehrenberg	-	-	-	-	-	-	-	-	-	-	0
Perinidium sp	-	-	-	-	-	-	-	-	-	-	0
TOTAL INDIVIDUAL COUNT	**50**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**51**
CLASS EUGLENOPHYCEAE			-	-						-	
Euglena sp	-	-	-	-	-	-	-		2	-	2

Phacus sp	2	-	-	-	11	-	-	1	9	-	23
TOTAL INDIVIDUAL COUNT	**2**	**0**	**0**	**0**	**11**	**0**	**0**	**1**	**11**	**0**	**25**
CLASS CYANOPHYCEAE				-							
Lyngbya sp	-	2	-	-	-	-	-	-	-	1	3
O. agardhii Gom	20	-	3	-	-	-	-	-	-	-	23
O. amphibia Agardh	-	-	-	-	30	-	-	1	-	8	39
O. limosa (Roth) Ag.	-	1	-	-	-	-	-	-	-	-	1
*O. subuliformis*Gom	-	2	-	-	-	-	-	-	-	-	2
Oscillatoria sp	-	-	-	-	17	-	-	-	-	-	17
S. subsalsa Oersted	-	-	6	-	-	-	-	-	-	-	6
Spirulina sp	-	-	-	-	-	5	-	-	76	3	84
Merismopedia glauca (Ehr) Nageli	-	-	-	-	101	-	-	-	-	-	101
TOTAL INDIVIDUAL COUNT	**20**	**5**	**9**	**0**	**148**	**5**	**0**	**1**	**76**	**12**	**276**
CLASS CHRYSOPHYCEAE											
Dinobryon sp	15	-	-	-	-	-	-	76	-	-	91

Table 6: Composition and abundance of phytoplankton species across the sampling stations.

State	**Akwa ibom**	**Rivers**		**Bayelsa**	**Ondo**	**Lagos**						
Stations	AB	RB	RK	BB	AO	LF	LC	LT	LM	LA	Total	% prevalence
CLASS												
BACILLARIOPHYCEA	861	460	140	460	64	110	389	621	132	138	3375	70.400501
CHLOROPHYCEAE	4	4	7	2	218	41	9	120	559	12	976	20.358782
EUGLENOPHYCEAE	2	0	0	0	11	0	0	1	11	0	25	0.5214852
CYANOPHYCEAE	20	5	9	0	148	5	0	1	76	12	276	5.7571965
CHRYSOPHYCEAE	15	0	0	0	0	0	0	76	0	0	91	1.8982061
DINOPHYCEAE	50	0	0	0	0	0	1	0	0	0	51	1.0638298
											4794	

Table 7: Phytoplankton Class Prevalence Across the 10 stations.

States	**AKWA IBOM**	**RIVERS**		**BAYELSA**	**ONDO**	**LAGOS**				
Stations	**AB**	**RB**	**RK**	**BB**	**AO**	**LF**	**LC**	**LT**	**LM**	**LA**
BIO-INDICES										
Total species diversity (S)	34	32	32	9	13	18	22	42	28	20
Total individual abundance (N)	952	469	156	462	441	156	399	819	778	162
Margalef index (d)	4.81	5.04	6.14	1.30	1.97	3.37	3.42	6.11	4.06	3.37
Shannon-Weiner (H^1)	1.84	1.88	3.03	1.52	1.80	2.21	2.03	2.68	2.26	1.85
Simson Dominance index (D)	0.32	0.29	0.07	0.24	0.21	0.15	0.17	0.10	0.15	0.25
Gini Simson index (1-D)	0.68	0.71	0.93	0.76	0.79	0.85	0.83	0.90	0.85	0.75
Species evenness (J')	0.52	0.54	0.88	0.78	0.65	0.77	0.69	0.72	0.65	0.62

Table 8: Biodiversity indices across the 10 sampling stations.

season and much less salinities. In North and North West Australia (native range of tiger shrimp) prevalence of diatoms and dianoflagellates (*Amphora* species and *Navicula* species) were reported. Large diatoms and blue-green alga Trichodesmium were fairly abundant, with the large dinoflagellates less significant [28]. It was further observed that the large tropical diatoms and dinoflagellates forms were markedly dissimilar from species in subtropical and temperate waters. Possession of large spines, horns, setae and wing-like structures in tropical forms, common symbiotic associations and greater species diversity accounted for the differences. Moreover, [21] also documented diatoms (Thalassiothrix fraunfeldii and Thalassiothrix nitzschioides) and dinoflagellates (*C trichoceros* and *P depressium*) as the most prevalent species composition of phytoplankton observed in waters of South East of Tamil Nadu, India. Conversely, diatoms domination amidst a range of phytoplankton were reported in [73], Pichavaram mangroves, India [74] and Kollidam estuary, India [75].

Phytoplankton biomass is positively correlated with primary productivity. The upwelling (estuaries, mangroves) and the coastal regions have the highest productivity compared with open sea. One of the major factors responsible for this is nutrient availability in which run-offs from land & sediment disturbance reaches the upwelling region before the coastal and open sea. Consequently higher fish production is found in upwelling region [25,76,77]. Nigeria is a tropical country whose coastal waters, brackish and lagoon systems seem to have favoured the establishment and widespread populations of *P. monodon* in the last 16 years. Hypothetical introductions of *P. monodon* into the Nigerian coastal waters must have been movements or migration (through the trans-Atlantic Guinea current) from established populations in

Gambia, Senegal or Cameroon. These countries have culture facilities for tiger shrimp from which accidental introduction into the Atlantic Ocean must have occurred [77,78]. The same population in Gambia is suggestive of invasion in South East United States through the trans-Atlantic North equatorial current [12,53]. Another possible source is ballast waters (containing a variety of non-native living aquatic organisms). Reports of many decapod crustacean larval stages in viable conditions were documented to be recovered from ballast tanks [12,79]. Regardless of the mode of entry, the aquatic ecosystem is dynamic and for an invader to appear in a system it must first arrive via a transport vector, and then it must be documented [80]. On few accounts, it is likely that the detection of new invaders will be virtually simultaneous with their entry into a system as in the case of premeditated introductions or invasion of large or noticeable species. However, in most cases, time lapse is possible between initial invasion and eventual discovery of the invaders, as there is a strong predisposition for sighting invaders only after they become abundant [81,82]. These lags in detection are critical and could presumably be the case of the tiger shrimp in Nigeria as the invaders were only detected when they were already in abundance. First report of their capture was in [5]. The precise year, exact time and specific source of first introduction into the Atlantic coast of Nigeria is poorly documented. However, in the United States, precise year, time and source of first introduction was detected and reported. About 27 years ago (1988) at Waddell Mariculture Center, South Carolina, a number of tiger shrimps (originally from Hawaii) were inadvertently released into the Atlantic coast. They were initially assumed not to be established. However, two months later close to 300 of the shrimps were recovered in trawl nets off the coasts of South Carolina and two other coastal states. Not until after a time lag of 18 years (September 2006) a single adult male was caught in Mississippi Sound near Dauphin Island, Alabama. Subsequent catches were further reported in increasing amount over the years; (4) 2007, (45) 2009, (32) 2010 and (678) 2011 [12,83,84].

Initial introduction and population explosion have a time lapse (gap observed between an event and the period when its effects are visible) which is critical in ecological studies [80]. Mostly like during this period the invasive species develop adaptation, reproduce and spread throughout the newly colonized region. The time lapse of *P. monodon* invasion in Nigeria is not clear but suggestive of short period. This is not surprising as the invaders themselves have high adaptability to new environment, fecundity (up to 500, 000 eggs per spawn) and fast growth rate [59,85]. Time lag also appears to have coincided with the time, late 1990's when stocks of the most abundant and exploited native marine shrimp, Farfantepenaeus notialis plummeted leading to near collapse of the vibrant shrimp subsector [78]. At the end of 90s and beginning of the 21st century (year 2000), *Penaeus monodon* invasion suddenly became apparent in coastal and creek environments, with populations that surprisingly complemented *P. notialis* in a way significant enough to maintain industrial production. Could there possibly be an interaction between these two events of *P. monodon* explosion and *P. notialis* depletion around the same period [2] reported that invasive species can possess the ability to be well adapted and compete better than native species. The tiger shrimp is a host for the White spot syndrome virus of crustaceans (WSSV) which can be transmitted. *P. notialis* might be at risk of infection and may take some time to develop resistance. Furthermore, [86] reported higher condition factor index in *P. monodon* compared with *P. notialis*. The condition factor is a quantitative parameter of the wellbeing state of a fish reflecting recent feeding condition. Thus delineates weighty fish of a known length are somewhat in better condition. It represents an index of growth and feeding intensity [3,87,88]. Have also compared the weight of the two species observing significant difference stating that higher values obtained for *P. monodon* is due to its ability to grow larger and at a faster rate than other *Peneaids shrimp*.

Conclusion

Invasion of *P. monodon* is known worldwide, stimulating the interest of scientists. This is because the impression that aquatic invasive species rarely possess noticeable ecological impact in the newly found ecosystem was disputed by Carlton [80], highlighting that there is no sufficient experimental research on ecology of known marine crustacean invasions. Ironically, utilization of the tiger shrimp in aquaculture might have declined in the last 10 years due to disease susceptibility and hence low fitness in cages, but they are fast spreading in the wild as they invade new territories across the Pacific, off the coasts of West Africa, South East U.S, Mexican Gulf and the Caribbean. The giant size of this species is suggestive of greater nutritional requirements and higher competitive advantage over native faunas. The high fecundity is suggestive of pressure on limited available plankton and other resources for larval and post larval stages of organisms. If the giant tiger shrimp is known to be a predator, predation on indigenous organism is a concern. In addition, the species is also known to be a host vector of the most deleterious crustacean virus, WSSV that causes White Spot Syndrome, thus the risk of transmitting the disease to other native crustacean species. This and several other ecological studies are grossly inadequately and therefore must be checked.

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