

Isolation of Parasites from Black Tiger Prawn; *Peneaus monodon* from Isaka River, Okirika Local Government Area, Rivers State, Nigeria

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Authors' contributions

All the authors collaborated in the execution of this research. Author SON designed the study, wrote the protocol and interpreted the data. Author FON proof read the final draft while authors MNW and JIM anchored the field study, gathered the initial data and performed preliminary data analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the parasitic fauna, site-specificity of the parasites in the host and the parasite load in relation to length, weight and sex of *P. monodon*.

Study Design: The study is a survey using prawns from Isaka River as a case study.

Place and Duration of Study: The study area is an armlet of the Nigerian Ports Authority highway-sea and samples were collected between December 2014 and January 2015.

Methodology: Cast and spread technique was adopted in the study. Fishing-net was used to collect samples from the River. The stratified random sampling method was used in selecting the 103 prawns examined in the study. The hemolymph of the prawn was extracted using a 2 ml syringe at the site of collection to maintain the integrity of the specimen and preserved in EDTA bottle. Samples were then preserved in an ice chest and transported to the laboratory for morphometric and growth parameters evaluation. Exo-secretions, gills, appendages and gastrointestinal contents of the prawns were evaluated using standard parasitological techniques.

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Identification of parasites was achieved using the compound light microscope and standard guides. Physicochemical parameters of the River were determined using standard techniques and equipment. Data was analyzed with Measures of Central tendencies and Analysis of Variance.

Results: The data revealed an overall prevalence of 97.09% in the study. However, females harbored (58%) more parasites than males (42%). Parasites belonging to four phyla; Nematoda 111(17.03%), Platyhelminthes 32(4.08%), *Arthropoda* 73(10.63%) and *Protozoa* 469(68.27%) were recovered from the study. Phylum *Protozoa* had the highest abundance of 475(68.27%) and had the highest parasite diversity of up to eight species. Faunal specificity revealed a total of 742 parasites comprising of (11.05%), *Trichuris* spp. (4.16%), *Ascaris* spp. (2.15%), *Spirocamallanus* spp. (2.82%), *Hysterothylacium* spp. (1.62%), *Capillaria* spp. (0.80%), *Enterobius* spp. (4.17%), *Lernaea* (3.23%), Trematode (5.64%), *Nematopsis* spp. (9.7%), *Porospora* spp. (11.96%), *Haplosporidium* spp. (11.29%), *Blastodinium* spp. (11.02), *Vahlkampfia* spp. (3.36%), *Colacium* spp. (5.64%), *Paramoeba* spp. (6.04%), *Pekinsus* spp. (3.62%), Tapeworm (1.21%), Diatoms (4.56%) and *Myzomolgus* spp. (6.61%) were recovered. There were significant differences ($P>0.05$) in parasite loads in the examined animals in relation to the sex, body length, and weight. Site specific parasitism showed that the hemolymph had the highest parasite load of (80.58%) while the gastrointestinal tract had the highest diversity of parasites in the study. The physicochemical parameters of the water body varied from standards permissible in brackish water ecosystem.

Conclusion: The study revealed that *P. monodon* was highly susceptible to a wide range of parasites, attributable to the compromised ambient environmental status of the habitat and trophic affiliation of the prawns. The study states that the lipoproteins enriched hemolymph of *P. monodon* may have predisposed it to heavy parasitism.

Keywords: *Exo-secretions; P. monodon; site specific parasitism; diversity of parasites; environmental health status.*

1. INTRODUCTION

Seafood in comparison to meat is more expensive though it is more available and consumed mostly in the Niger Delta area. The demand placed on seafood has led to its culture and farming thus making most of them available to augment the ones caught from the wild. The short supply of animal protein to a level almost beyond the reach of low income earners has thus led to an increase in the demand for prawns. Fish and fisheries are veritable sources of animal protein for healthy living [1]. Food insecurity encompassing inadequacy of available protein sources in Nigeria has led to the exploitation available sources and an aggressive search for alternatives. Prawns fall into this alternative class as their muscles are regarded as one of the safest forms of muscle protein in a worldwide scale [2] due to its high quality protein, mineral and vitamin content. Many of the vitamins found in *P. monodon* are essential for healthy skin, bones and teeth.

Prawns are extremely perishable and quality loss can occur very rapidly after catch [3,4] however, they remain one of the most delicious seafood and constitutes a part of almost every nation's traditional meal [5]. Seafood generally is constantly exposed to numerous factors from the

water they live to the consumers table that can compromise the health status of the consumers. Some of the factors include biological agents such as bacteria, parasites, viruses, natural toxins, chemical contaminations including; crude oil spill etc.

Since prawns are highly rich in protein and are widely accepted and eaten in preference to meat, the possibility of transferring a number of parasites to human population is now eminent [6].

1.1 *P. monodon* as a Parasite Host

Studies by Overstreet [7], stated that the Black tiger shrimp; *P. monodon* serves as a host to a wide range of protozoans and commensals. Protozoan parasites and commensals occur both inside and outside the host body. Peritrichous ciliates like *Zoothamnium* spp. and *Voritcella* spp. are ecto-commensals while microsporidia and gregarines are endo-commensals. The ecto-symbionts peritrichous ciliates usually remain attached to the gills and limbs of their crustacean hosts. A possible relationship between the peritrich ciliate, *Zoothamnium* spp. and mortality of host following stress was reviewed previously by Overstreet, [7]. Also, Gregarine belonging to the phylum Apicomplexa, class Sporozoea, order

Eugregarinida are all pathogenic although they cause some local damage and occlude passage in the inhibited organ with serious results [8]. They reside in the gut of the decapods crustaceans and may lead to reduced absorption of food or occasional intestinal blockage and possibly mortality of their host [9]. Two types of gregarines, *Nematopsis* spp. and *Cephalolobus* spp. are encountered in penaeid shrimps [10,11]. An invasion with gregarinids always varies with temperature making the infection rate with gregarinids high in summer than winter [12]. Microsporidians belonging to the phylum Microspora, class Microsporea, order Microsporida are another type of obligate, intercellular parasites of shrimps and prawns [6]. They can infect a wide range of invertebrates and vertebrate taxa [13] but almost half of the described species have insect as the host [14]. They may infect gut, hepatopancreas, muscle, reproductive tissue, and nervous tissue [14-16]. It is based on the high susceptibility of the *P. monodon* and its position in the diet of the Niger Delta inhabitants that this work is designed to evaluate the parasitic fauna of *P. monodon* in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

Isaka River is a brackish water body of Isaka village in Okirika Local Government Area of Rivers State, Nigeria. Isaka River is an armlet of the National Ports Authorities highway-sea which lies between Latitude 4073'9" North and Longitude 6099'9" East. The river is adorned on both banks by mangrove vegetation however, the disarray created by abandoned boats, household open-bathrooms and a lot of municipal wastes escalate the unhygienic status of the environment.

2.2 Collection of Samples

Samples for the study were collected for a period of two months-December 2014 to January 2015 without consideration to seasonality. Live samples of *P. monodon* were randomly collected using the fishing net technique. Water samples were also collected from the river physicochemical analysis.

2.3 Physical Examination of Shrimps

Shrimps were laid on a flat plane laterally with the rostrum pointing towards the left hand of the

examiner. A x10 hand lens was used to observe the external anatomy of the animal for colour changes such as dark blotches on the shell segments and appendages. Forceps were used to spread apart the operculum to expose the gills for examination according to Johnson [17].

2.4 Collection of Hemolymph

Hemolymph of selected prawns were extracted with syringes immediately and preserved in designated EDTA bottles to avoid agglutination of the hemolymph and death of parasites. The needle of the syringe was inserted at the first pair pereopod (walking legs). After which the prawns were stored in blister polyethylene bags and put into ice chests for onward transportation to the laboratory.

2.5 Dissection for Sub-samples

The properly designated samples were weighed using an Electronic Sensitive Weighing Balance (model number HX-Z) while the standard and total lengths of the shrimps were determined using a measuring tape. The prawns were dissected from the dorsal region following the cephalo-caudal plane to extract the gastrointestinal contents which were preserved in 4% formal-saline and stored in sterile vials. Samples were sub divided into four comprising; hemolymph, gill, appendage (limbs) and digestive system. These sub samples were preserved in properly labeled vials and fixed in 4% formalin except the hemolymph which was preserved in EDTA.

2.6 Physiochemical Parameters of the Water

Water samples were taken from the river and tested for physiocho-chemical parameters such as temperature (temperature meter-model PHS), pH (Electronic pH), salinity (Potassium chromate method) and dissolved oxygen (Modified Winkler Method).

2.7 Examination of the Sub-samples

The appendages were inundated with a flood of water from a wash bottle into designated petri dishes. 0.1 ml of the residual was put in a slide, covered with a cover slip and viewed under x10 objective of the compound light microscope. Lugol's iodine was used to enhance clarity. The gills were observed under a dissecting microscope with x40 magnification. The digestive

tract and contents were teased out into a petri-dish with a teasing needle and processed using the concentration method for faecal examination by Cheesborough, [18].

The thick and thin smears were used to examine the hemolymph according to the procedure by Cheesborough, [18]. Identification of parasites in the hemolymph was done using the x40 and x100 objectives and laboratory guides by Johnson [17] and Cheng, [19].

2.8 Analysis of Data

Measures of Central Tendency and ANOVA were used in analyzing the data in the study. The prevalence in-relation to sex, weight, length and site specificity of the parasites was expressed as percentage of the total number of animals sampled or the total number of sub-samples.

3. RESULTS AND DISCUSSION

3.1 Prevalence of Parasites in *P. monodon*

The study reveals that out of 103 samples of *P. monodon* examined, 100 (97.09%) were positive for parasites of various specificity (Table 3.1). Data state that the hemolymph of the prawn had the highest infection of 83(80.58%) followed by the gastrointestinal tract; 57 (55.34%), the gills 48 (46.60%) and the appendages 39 (37.86%).

3.2 Sex Related Prevalence of *P. monodon*

Table 3.2 shows the sex related prevalence of parasites in *P. monodon*. Out of the 103 samples collected, 60 (58.25%) were females and 43 (41.75%) were males. The overall parasitic load

in *P. monodon* was 97.09% of which 42.00% were from males and 58.00% were from females. This trend was also observed in the hemolymph, gastrointestinal tract and the gills where females also exhibited higher prevalence of 48.54%, 31.06% and 28.15% and the males 32.03%, 24.27% and 18.44% respectively. Although males exhibited higher prevalence of parasites (19.41%) at the appendages than the females (18.44%), the relationship between the sex of the prawns and parasite burden was statistically insignificant ($P>0.05$).

3.3 Weight Related Prevalence of *P. monodon*

Weight related prevalence of parasites in *P. monodon* varied consistently as weight increased. This observed variability was statistically significant ($P<0.05$) at the specific sites of infection. However, prawns within the weight range; 91-110.99 g exhibited the highest parasite load at the various sites of infection amongst the infected (Fig. 1).

3.4 Length Related Prevalence of *P. monodon*

Length related parasitism in *P. monodon* revealed parasite accumulation as length increased. In this study, although prawn length (cm) did not entirely signify age, however, age was rationally associated with prawn length if growth (permanent increase in length and weight) must be associated to time as was the case in this study. Data showed that the larger prawns (± 14 -15.66 cm) harbored more parasites than the smaller prawns (± 6 -13.99 cm). Observations showed that the length class; 14-15.99 cm harbored more parasites at all sites of



Fig. 1. Arrow showing the study area (Isaka)

infection, however, slight variations in parasite load manifested at the various sites of infection in the prawns. The length class; 8-9.99 cm had the highest parasite load; 54.54% occurring at the appendages. The length related prevalence in the various infection sites of the prawns was significantly different ($p < 0.05$) across the various length classes but was not statistically significant ($P > 0.05$). within the individual length classes.

3.5 Parasitic Fauna in *P. monodon*

The parasitic fauna of *P. monodon* in the study comprised nineteen (19) species belonging to four (4) phyla. There was variability amongst the parasites recovered from the study however, the platyhelminthes had a prevalence of 6.10%; arthropod had 10.63% prevalence, nematodes; 17.03% and 68.27% for protozoa. *Trichuris* spp., *Ascaris* spp., *Spirocamallanus* spp., *Hysterothylacium* spp., *Capillaria* spp. and *Enterobius* spp. were amongst the nematodes recovered from the animals as shown in Table 3.3. *Lernaea* spp. and *Myzomolgus* spp. were the only arthropods recovered in the study which are common ectoparasites of ectotherms. A total of 469 (68.27%) protozoans comprising 9 species were recovered showing the highest species abundance and diversity in the study. Amongst the protozoans recovered include; *Blastodinium* spp., *Colacium* spp., *Haplosporidium* spp., *Vahlkampfia* spp., *Paramoeba* spp., *Nematopsis* spp., *Porospora* spp., and *Pekinsus* spp. (Table 3.3).

3.6 Site Specificity of Parasites in *P. monodon*

The overall site specific occurrence of organisms (including none parasites) in *P. monodon* showed a total of 744 organisms (parasites) (Table 3.4). The hemolymph manifested as the most preferred site of infection in the sampled prawns with a parasite load of 356 (47.84%); followed by the GIT, 209 (27.76%). However, the GIT had the highest parasite diversity comprising nine species. The gills harboured parasite load of 356(47.84%) while the appendages had a parasite load of 22 (2.96%). Amongst the parasites recovered include; *Ascaris* spp. (7.65%), *Trichuris* spp. (4.16%), *Spirocamallanus* spp. (2.82%), *Hysterothylacium* spp. (1.62%), *Capillaria* spp. (0.80%), *Colacium* spp. (5.64%), *Paramoeba* spp. (6.04%), *Perkinsus* spp. (3.62%) which were seen in the GIT, Tapeworm (1.21%), *Vahlkampfia* spp. (3.36%), *Lernaea* (3.23%), *Myzomolgus* spp. (6.61%) as well as

some Diatoms (4.56%). *Enterobius* spp. (4.17%), were seen in the gills, Trematodes had a prevalence of (5.64%), *Nematopsis* spp. (9.7%), *Blastodinium* spp. (11.02%), *Porospora* spp. (11.96%), *Haplosporidium* spp. (11.29%) were seen in the hemolymph. The appendages harboured majorly *Enterobius* spp. *Porospora* spp. 89 (11.96%) had the highest abundance and *Capillaria* spp. had the least abundance 6(0.80%) in the entire study.

3.7 Physiochemical Parameters of Isaka River

The physiochemical parameters of the water body were determined and compared with FEPA standards. Data showed that Isaka river as a brackish water because as at the time of the sampling it had a salinity of 32.49 mg/L, temperature of 29.6°C, a pH of 7.56 and low dissolved oxygen of 0.003 mg/L (Table 3.5).

Table 3.6, shows the life stages and sites of infection of parasites recovered from *P. monodon* in the study. The manifestation of nematodes eggs in the gill of the prawns indicate poor water quality and considering the peculiarity in nutrition and respiration of the host the eggs are easily trapped at the respiratory site. Majority of the protozoans found in the study were from the alimentary canal which is an indication of compromised water integrity especially by organic pollution (faecal, abattoir waste etc.). The external parasites existed as adults because the shrimps are their suitable and definitive hosts however most of the nematodes and platyhelminthes used the shrimp as intermediate host as observed the predominance of the juvenile forms of the worms. The dominance of the gut parasites in the study indicates the influence of organic pollution on site parasite specific parasitism in crustacean and fisheries. The hemolymph as suggested by the study exhibits a great degree of specificity and harboured no aberrant parasites as the gastrointestinal tract.

Table 3.1. Prevalence of parasitic occurrence in prawn, *P. monodon*

Studied sample	Total examined	Number infected (%)
Appendages	103	39 (37.86%)
Gills	103	48 (46.60%)
Gastrointestinal tract	103	57 (55.34%)
Hemolymph	103	83 (80.58%)

4. DISSCUSSION

The study documents great variability in parasite load and diversity in *P. monodon*. This observation spells danger to the high population of consumers that cherish sea foods especially, the shrimps. It is envisaged that the consumption of the shrimps from the study area may present a veritable avenue for zoonoses in the populace thereby further deteriorating the fragile public health status of the people of the area and Nigeria at large. The study attributes the heavy parasite load and diversity in the examined shrimps to the suitability of the shrimps to parasitism occasioned by the nutritional affiliation of the animals and the poor physicochemical characteristics especially dissolved oxygen, temperature and conductivity of the water body. The study buttresses the result of the work by Jayati and Probir [20] who report heavy site specific parasitism in shrimps.



Plate 1.1. Showing the prawn during measurement in the laboratory

The rich nutrient statuses of the hemolymph and gastrointestinal tract made them preferred sites of infection in the study. The hemolymph alone harboured 48.11% of the overall parasites belonging to five species while the GIT recorded 27.76% of parasites belonging to nine species (Table 3.4). The presence of more parasites in the hemolymph obtained from the female shrimps was associated to higher degree of lipoproteins in the females believed to be a veritable oxidative substrate for endoparasites oxidation [19]. The pattern of parasitism in the shrimps in the hemolymph and gastrointestinal tract depict accumulation of parasites due to repeated infection overtime. However, this scenario was not replicated at the appendages where younger and older shrimps harbored fewer parasites than the intermediate length classes. This disparity in parasite load was associated with age induced parasite burden. The researchers are of the opinion that the frequent

shedding of the shells of the crustacean might have played a role in reducing the population of the externally located parasites.

There was variability in the parasite load and the specificity at the appendages and gills. The most abundant ectoparasite was the *Lernaea* spp. which is common in fish and fisheries. However, the occurrence of helminthes eggs; *Enterobius* spp. at the gills was very unusual due to the fact that the parasite is an endoparasite of the gut in humans. However, the occurrence of the nematode on the meshy gills could be due to the feeding mode of the animals. Considering that the geographical specificity of the *Enterobius* spp. excludes the tropics of Africa, its presence in the study is accidental and attributed to importation by human hosts. Protozoans; *Myxomoligus* spp., *Vahlkampfia* spp. and *Pekinsus* spp. were common on the gills. This is not in total agreement with the findings of Rodriguez et al. [21] who found ciliate; *Vorticella* and *Epistylis* on the gills of *Macrobrachium rosenbergii*; the freshwater giant prawn in Venezuela. Also in a study carried out on *Macrobrachium rosenbergii* by Paul et al. [22] in West Bengal showed the exoskeleton to be rich in parasites, comprising species as *Zoothamnium* and *Epistylis*. This may imply that the exoskeleton and gills of the prawn; *P. monodon* may not be susceptible to these species of parasites due to the water condition of its habitat. Also in comparison with the parasites found in this study and those found in the study of freshwater prawn *Macrobrachium rosenbergii*, it can be said that the water in which a prawn lives in plays a major role in the type and abundance of parasites it harbours. Again, the physico-chemical characteristics of the water body support the transmission pattern of the protozoan parasites of the shrimps as stated by Ray and Chandler [23], Dungan and Hamilton [24] and Tarnowski, [25].

The presence of some of the parasites in the prawn can be attributed to the anthropogenic activities carried out in the river system. The heavy infection of the protozoans; Apicomplex and Sarcocystidophora indicate that the water body has a low health integrity which may be appropriate for parasites transmission [25,26]. Most of the intestinal parasites recovered could be attributed to the lifestyle and sewage disposal system of the habitants suggesting that the infection may be accidental. Furthermore, the physicochemical environmental conditions of the water had the temperature at 29.4 ± 0.5 with a pH

of 7.56, salinity of 32.49±1.50 mg/L and DO of 0.003 mg/L as against the FEPA standards of brackish water; of 27±1°C temperature, pH of 6.5±1, salinity of 20 mg/L and DO of 5 mg/L. This disparity in ambient physiochemical

characteristics of the water body is attributed to aggressive anthropogenic activities which convert the water body to a receptacle for municipal wastes and hydrocarbon fractions.

Table 3.2. Sex related site specific prevalence of parasites in the prawn, *P. monodon*

Studied sample	Number of infection (%)		Overall infection (%)
	NE= 43(41.75%) Male	NE=60 (58.25%)Female	
Appendages	20 (19.41%)	19 (18.44%)	39 (37.86%)
Gills	19 (18.44%)	29 (28.15%)	48 (46.60%)
GIT	25 (24.27%)	32 (31.06%)	57 (55.34%)
Hemolymph	33 (32.03%)	50 (48.54%)	83 (80.58%)
Total (%)	42 (42%)	58 (58%)	100 (97.09%)

NE= Number examined

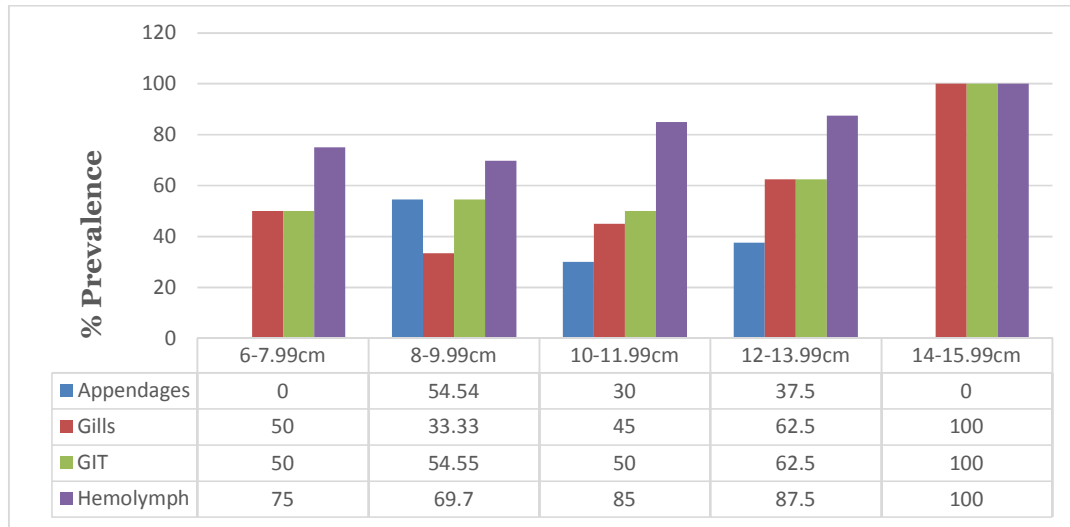


Fig. 2. Length related prevalence of parasites in *P. monodon*

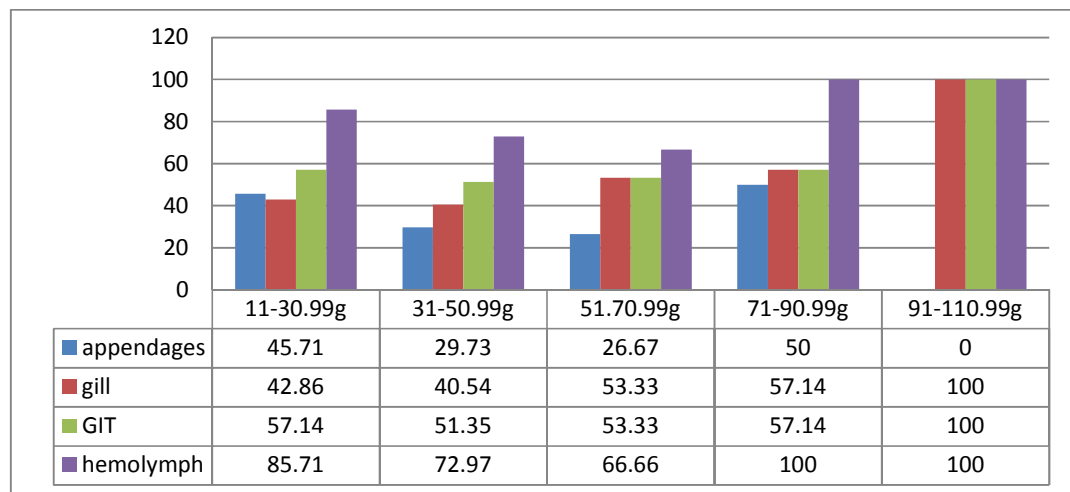


Fig. 3. Weight related prevalence of parasites in *P. monodon*

Table 3.3. Inventory of parasitic fauna of *P. monodon*

Phylum	Class	Order	Family	Genus	Abundance	Total (%)	
Arthropoda			Lernaeidae	<i>Lernaea</i>	24	24(32.9)	73 (10.63)
		Copepoda	Cyclopoida	<i>Myzomolgus</i>	49	49(67.1)	
Platyhelminthes	Cestoda			Tapeworm	9	9(21.4)	42 (6.1)
	Trematoda		Opecoelidae	<i>Opecoeloides</i>	23	23(54.7)	
Nematoda	Secernentea	Ascaridida	Ascarididae	<i>Ascaris</i>	16	16(13.6)	117 (17.03)
			Oxyuridae	<i>Enterobius</i>	31		
			Camallanoidae	<i>Spirocallamanus</i>	21	64(54.7)	
	Adenophora	Rhabditida	Raphidascarididae	<i>Hysterothylacium</i>	12		
		Trichocephalida	Trichuridae	<i>Trichuris</i>	31	31(17.5)	
Protozoa	Sacromastigophora	Mastigophora	Capilariidae	<i>Capillaria</i>	6		469 (68.27%)
			Peridiniaceae	<i>Blastodinium</i>	82		
			Euglenaceae	<i>Colacium</i>	45	275(58.6)	
		Rhizopoda	Vahlkampfiidae	<i>Vahlkampfia</i>	25		
		Rhizopoda	Paramoebidae	<i>Paramoeba</i>	45		
	Apicomplexa	Sporozoea	Porosporidae	<i>Nematopsis</i>	72		
			Perkinsidae	<i>Porospora</i>	89		
		Asctospora	Perkinsea	Perkinsidae	<i>Pekinsus</i>	27	116(24.7)
			Stellatosporea	Haplosporidiidae	<i>Haplosporidium</i>	84	84(17.9)
Total						687	

Table 3.4. Site specificity of organisms recovered from *P. monodon* in Ishaka River

SITE	Parasite Speciation (%)																Total (%)					
	AS	BLT	CP	COL	DIA	ENT	HAP	HYS	LER	MYZ	NM	PAR	PEK	POR	SPIC	TP		TR	TRI	VAH		
APP						21 (95.45)														1 (4.54)	22(2.96)	
GIL					34 (21.65)	10 (6.36)				24 (5.28)	49 (31.21)			12 (7.64)						3 (1.91)	25 (15.92)	157(21.10)
GIT	16 (7.65)		6 (2.87)	45 (21.53)						12 (23.59)				45 (25.50)	15 (7.17)		21 (10.04)	9 (4.30)	9 (4.30)	31 (14.83)	209 (47.84)	
HML		82 (3.63)					84 (65.05)				72 (20.22)						89(25.0)			29 (8.14)	356 (47.84)	
Total	16 (2.15)	82 (11.02)	6 (0.8)	42 (5.64)	34(4.58)	31 (4.17)	84 (11.32)	12 (1.62)	24 (3.23)	49 (6.61)	72 (9.7)	45 (6.04)	27 (3.62)	89 (11.96)	21 (2.82)	9 (1.21)	42 (5.64)	31 (4.16)	25 (3.36)		744	

KEYS: AS: *Ascaris* spp., BLT: *Blastodinium* spp. CP: *Capillaria* spp., COL: *Colacium* spp., DIA: Diatoms, ENT: *Enterobius* spp., HAP: *Haplosporidium* spp., HYS: *Hysterothylacium* spp., LER: *Lernaea*, MYZ: *Myzomolgus* spp., NM: *Nematopsis* spp., PAR: *Paramoeba* spp., PEK: *Pekinsus* spp., POR: *Porospora* spp., SPIC: *Spirocamallanus* spp., TP: Tapeworm, TR: Trematode, TRI: *Trichuris* spp., VAH: *Vahlkampfia* spp., APP: Appendages, GIL: Gills, GIT: Gastrointestinal tract, HML: Hemolymph

Table 3.5. Physicochemical parameters of Isaka River

Parameter	New Calabar River	*FEPA
Dissolved Oxygen (DO; mg/L)	0.003	Not < 0.20
Temperature (°C)	29.6±1	26
pH	7.56±0.04	6-9
Salinity (mg/L)	32.49	30

*FEPA= Federal Environmental Protection Act of Nigeria [26]

Table 3.6. The life stages and sites of infection in *P. monodon*

Parasites	Stage	Location in host
<i>Lernaea</i> Spp.	Adult	Gill
<i>Myzomolgus</i> Spp.	Adult	Gill
Tapeworm	Larval form	Gut
Trematode	Metacercariae	Under cuticle Cephalothorax
<i>Ascaris</i> Spp.	Juvenile	Gut
<i>Enterobius</i> Spp.	Egg	Gill
<i>Spirocallamanus</i> Spp.	Juvenile	Gut
<i>Hysterothylacium</i> Spp.	Juvenile	Gut
<i>Trichuris</i> Spp.	Egg	Gill
<i>Capillaria</i> Spp.	Egg	Gut
<i>Blastodinium</i> Spp.	Trophozoite	Hemolymph
<i>Colacium</i> Spp.	Cyst	Gill/ body surface
<i>Vahlkampfia</i> Spp.	Cyst	Gut
<i>Paramoeba</i> Spp.	Cyst	Intestine
<i>Nematopsis</i> Spp.	Trophozoites	Gut
<i>Porospora</i> Spp.	Trophozoite	Gut
<i>Pekinsus</i> Spp.	Spore	Cephalothorax/ gills /Hemolymph and Intestine
<i>Haplosporidium</i> Spp.	Spore	Gut
Diatoms	Filaments/Colony	Gill

5. CONCLUSION

In this study, the hemolymph of the prawns had the highest parasite load due to the occurrence of lipoproteins in their tissues. However, the sex related parasite burden that skewed towards the females in the hemolymph was associated with higher concentration of lipoproteins in the females believed to be a veritable oxidative substrate for endoparasites' oxidation. The rich nutrient statuses of the hemolymph and gastrointestinal tract made them preferred sites of infection; (abundance and diversity) in the study. However, the study indicates that the periodic shedding of the calcareous outer coat may have affected the population of the external parasites. The study attributes the occurrence of *Enterobius* spp. of nematodes to accidental importation of parasites occasioned by the unsanitary use of the water for sewage and refuse disposal. This unusual occurrence presents health risks to humans.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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