Endoparasitaemia of *Chrysichthys Nigrodigitatus* in a Tidal Freshwater Body in the Niger Delta, Nigeria

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Received 04 April 2014; Accepted 27 June 2014

**Abstract.** One hundred *Chrysichthys nigrodigitatus* were randomly selected from the New Calabar River to determine the effect of size and sex on the endoparasitaemia in the blood, heart, liver, kidney and Gastro-intestinal tract. The formol-ether concentration method was used to examine the samples. Data revealed an overall parasitaemia of 18 (18.0%). The size classes 301-400mm, 201-300mm and >169-200mm had 5(55.6%), 12(15.2%) and 1(11.1%) respectively while the size class <169mm had no infection. Sex related endoparasitaemia was statistically not significant (p>0.05), however the females had 11(20.4%) and the males had 7(15.2%) of their respective populations. Site specific endoparasitaemia showed that the gastro-intestinal tract harboured the highest (38.9%) parasitic load, while the kidney had the lowest (5.6%). The heart had (33.3%) and the blood and liver had (11.1%) parasitic load each. Fourteen (14) parasite species from 5 phyla were recovered from the fish samples namely: Protozoa - Coccidia sp. and *Thelohannellus piriformis*; Platyhelminth - Ascocotyle ceolostoma, *Sanguinicola inermis*, *Sanguinicola armata*, *Atalostropion sp.*, *Tetrochetus coryphaenae*, *Biaecetabulum appendiculatum* and *Tetraonchus monenteron*; Nematoda - *Strongyloides sp.*; Acanthocephala - *Acanthocephalus lucii* and *Neoechinorhynchus rutili*; and Crustacea - Alebian elegans. Endoparasitaemia in the sampled population was influenced by the physico-chemical properties of the water body which is greatly affected by the intrusion of salt into the river due to its tidal conditions. However, the relatively high endoparasitaemia in the gastro-intestinal tract was associated with the nutrient rich ambience of the intestine which may allow easy establishment and multiplication of parasites.

**Keywords:** Tidal freshwater, endoparasitaemia, physico-chemical, Niger Delta

1. INTRODUCTION

Parasites are ubiquitous in freshwater and marine ecosystems. Studies by Baker (1961) and Bruce (2006) showed that almost every part of a fish (e.g. *Chrysichthys nigrodigitatus*) and shellfish (*Paenus notialis*) are infected with specific parasites. Parasites of fish in natural water systems constitute a major threat to artisanal fishing and aquacultural practices in the Niger Delta and Nigeria in general (Awharitoma and Okaka, 2004; Edema and Okaka, 2008; Olofintoye, 2006; Omeji et al., 2011). The economic implications of fish parasites are of great importance to man and animals because fish plays an important role in global food supplies (source of protein) and its demand is expected to increase due to growing world population (Sikoki, 2013). The effects of parasites on fishes in aquaculture and in the wild result in reduced fish stock and in market value, in severe cases, diseases exploit the resources of the farmer due to expensive treatment regimes. Economic importance of fish parasites includes: massive fish kills in the wild and in culture. Diseases in fish which often become zoonotic infections can result in great monetary loss as treatments are expensive (Okaeme et al., 1987; CDC, 2012). Fish parasites like: *Ichthyophthirius spp.*, *Ichthyobodo spp.*, *Trichodina spp.*, *Chilodonella spp.*, *Trypanosoma spp.*, *Dacytrosoma spp.*, *Gyrodactylus spp.*, *Ligicalturalis spp.*, *Cleidodiscus spp.*, *Dactylogyrus spp.*, *Posthodiplostomum minimum*, *Uvulifer ambloplitis*, *Clinostomum complanatum*, *Bivesicula tarponis*, *Echinocochus donaldsoni*, *Hymenocotta manteri*, *Stephanostomum spp.*, *Brachyphallus parvus*, *Diphyllobothrium spp.*, *Anguillicola spp.*, *Philometra spp.*, *Skjrabillanus spp.*, *Anisakis spp.*, alongside many others have been known to cause a number of disorders like anaemia, listlessness, emaciation, pop-eye, immunosuppression, retarded growth, loss of appetite, cardiac lesions,
abdominal distension, depressed reproductive performance, fin rot, fish dropsy, velvet disease, hole in the head (HITH), black-spot disease, with heavy infections resulting in death (Paperna, 1996; Food and Agricultural Organization (FAO), 2003; Zhang et al., 2003; Hassan et al., 2007; Pozdnyakov and Gibson, 2008; Christoph and Ralf, 2009; Roberts et al., 2009; Scholz, 2009; Dhan et al., 2010; CDC, 2012; Woo, 2011a; 2011b).

A common fish species in the Niger Delta water bodies is the Silver catfish (*Chrysichthys nigrodigitatus* Lacepede, 1803) belonging to the family Bagridae which are native to Africa. They are highly valued sources of animal protein and are amongst the dominant commercial catches exploited in major rivers in Nigeria, they make up about 80% of the catches by artisanal fishermen fishing in inland water bodies, including the New Calabar River (Holden and Reed, 1978; Nelson, 2006; Ikomi, 2012). Their omnivorous feeding habit exposes them to varieties of parasites which negatively impact on their health (Omeji et al., 2011).

The epidemiology of parasitic infections in aquacultural practices in Nigeria is of great public health concern as some helminthes of fish and fisheries can be infective to humans, causing zoonotic infections (McCarthy and Moore, 2000; Keiser and Utzinger, 2005; Thu et al., 2007). Schantz, (1989) and Dhan et al. (2010) stated that most of the people at risk are those who consume infected raw, undercooked, or inadequately preserved fish regularly (Disease Fact Sheets, 2007; WHO, 2002).

The objectives of this study are to determine: the prevalence of endoparasites in the fresh water fish, *Chrysichthys nigrodigitatus* in the New Calabar River; species of parasites that infect the blood, heart, liver, kidney and gastro-intestinal tract of the fish; and the effects of sex and size on the occurrence of endoparasites on the fish species.

2. MATERIALS AND METHODS

2.1. Description of Study Area

The study area comprises of two points along the New Calabar River, Choba (longitude 006° 53' 53.896" E and latitude 04° 53' 09.020" N) and Aluu (longitude 006° 53’ 54.54” E and latitude 04° 54’ 07.46” N) in Rivers State, Nigeria (Figure 2). The entire river course is situated between longitude 7° 60 E and latitude 5° 45’ N in the coastal area of the Niger Delta from where it empties into the Atlantic Ocean (Figure 1). The river is used as a domestic and industrial waste disposal point for companies and people living close to it. The river houses an abattoir, poultry, a fabrication company and a weekly market. A small cluster of houses can be seen close to its bank where toilets and bathrooms are also created close to the river bank. Dredging and fishing activities are still ongoing alongside numerous other human activities (such as waste disposal, bathing, washing etc). All afore mentioned pollute the water body in varying degrees.

Fig. 1: Map of the Niger Delta region of Nigeria
2.2. Collection of Samples

2.2.1. Collection of Fish

A total of 100 freshly caught fish (*Chrysichthys nigrodigitatus*) were sampled from the New Calabar River using the Stratified Random Sampling method whereby the third fish from every four was selected (Neville and Sidney, 2004). This stratified random sampling was done to eliminate any form of bias. In the field, identification of fish samples was done using guides by Olaosebikan and Raji (2013) and Idodo-umeh (2003). The morphometric measurements such as standard length (SL) and weight were determined to the nearest 0.1mm and 0.1g respectively in the laboratory by means of a measuring board and FiveGoats weighing balance while the fish samples were still alive (Ostrander, 2000). Samples collected were made up of 54 females and 46 males based strictly on stratified random sampling.

2.2.2. Collection of Blood Samples

In the laboratory, blood samples were collected using the caudal peduncle puncture technique, where the fish was stunned by a blow to the head before inserting a 2ml syringe through the medial line just behind the anal fin in a dorso-cranial direction. The needle was run quite deep into the fish tissue until it touched the vertebrae and punctured the blood vessel that runs below the vertebrae. About 2ml of blood samples were collected and stored in sterile heparinised sample bottles pending further investigation (Hrubec and Smith, 2006).

2.2.3. Preparation of Blood Smears for Endoparasitic Identification

Blood (0.1ml) was applied to a grease free glass microscope slide with a clean spreader slide. A thin blood smear was made by pushing the spreader forward rapidly and smoothly (Zdenek, 1977). This was kept in a cool dry surface to dry and was then fixed in absolute methanol and subsequently stained with Field’s stain A and B. The slide was dipped in Field stain B, after which it was washed under a running tap by allowing water to flow over it for 5seconds. The Field stain B stained slide was likewise dipped in Field stain A and also washed under a running tap. Microscopic examination was done using the x10, x40 and the oil immersion for *Microsporidia* identification (Valkiunas, 2005).
2.2.4. Fish Dissection

Each fish was laid on its back on a dissecting board and the abdominal cavity was cut open using a scissors which was inserted through the urogenital opening and a slit was made to the “breast”. The internal organs (gastro-intestinal tract, heart, liver and kidney) were carefully extracted and placed in properly labelled sterile bottles filled with normal saline (0.9% salt concentration), pending further investigation (Zdenek, 1977).

2.3. Examination of Internal Organs

2.3.1. Examination of the Gastro-Intestinal Tract

The gastro-intestinal tract was laid out in a petri dish and was examined using x10 hand lens. After the examination, the gastro-intestinal tract was cut open starting from the rectum and was spread out before the entire wall was carefully scrapped to dislodge any parasite present. The resulting contents were allowed to mix with the normal saline. The gastro-intestinal content was then processed for microscopic examination using the formol-ether concentration method (Zdenek, 1977; Al Mofarreh et al., 2000).

2.3.2. Examination of the Heart

The heart was placed in a watch glass and examined using x10 hand lens. After the examination, the heart muscle was severed to allow the heart contents (blood trapped inside the heart) to flow out and mix with the normal saline which was then examined microscopically (Zdenek, 1977).

2.3.3. Examination of the Liver

The liver was examined using x10 hand lens for the presence of epithelia parasites. After the examination, the liver was macerated to allow the contents to flow out and mix with the normal saline which was then examined microscopically (Zdenek, 1977).

2.3.4. Examination of the Kidney

The kidney was examined using x10 hand lens for epithelia parasites. After the examination, the kidney was macerated to allow the contents to flow out and mix with the normal saline which was then examined microscopically (Zdenek, 1977).

2.4. Identification of Parasites

Parasites were identified with the aid of fish parasite guides by Zdenek (1977) and Williams and Bunkley-Williams (1996).

2.5. Physicochemical Parameters Determination

Five (5) parameters were determined in the Choba (lower reaches) and Aluu (upstream) sections of the New Calabar River using handheld electronic devices (Martini Instrument, model: MI 806 and Milwaukee DO portable meter). These include: dissolved oxygen (DO - mg/L), salinity (°/°°), conductivity (s/m-1), temperature (°C) and pH. A total of ten water samples (five water samples from Choba and five water samples from Aluu) were collected from the New Calabar River using 50cl DO bottles by immersing them completely into the water body and allowing the bottle to fill to the brim and replacing the cap firmly while the bottle was still completely immersed in the river, ensuring no air bubbles were trapped in the bottle.

2.6. Data Analysis

The data obtained were analyzed using Measures of Central Tendency and Analysis of Variance (ANOVA).

3. RESULTS

3.1. Physico-Chemical Characteristics of the New Calabar River

Table 1 shows the physico-chemical parameters of ten (10) randomly selected points along the New Calabar River. In the Choba section of the river (located in the lower reaches), the DO level ranged from 5.80 to 5.92 mg/L; salinity level from 0.02 to 0.05 °/°°; the conductivity from 0.05 to 0.09 ms/m-1; temperature from 24.5 to 25.7°C and the pH from 5.15 to 5.92. However, in the Aluu section of the river (which is located upstream), the values were: DO from 5.90 to 5.97 mg/L; salinity from 0.02 to 0.03 °/°°; conductivity from 0.04 to 0.07 S/m-1; temperature from 24.5 to 25.3°C and the pH from 4.89 to 5.40.

3.2 Size and Sex Related Endoparasitaemia of C. Nigrodigitatus in the New Calabar River

Table 2 shows the endoparasitaemia in C. nigrodigitatus from the New Calabar River in relation to size and sex. Data revealed that out of a total of 100 C. nigrodigitatus specimens investigated, 18(18.0%) specimens were infected. Size related prevalence
showed that the size class 301-400mm had the highest parasitic load of 5(55.6%) while the size class >169-200mm had the lowest 1(11.1%) value. The size class 201-300mm had 12(15.2%) while the size class <169 had no parasitic load. Data shows that 54(54.0%) of the specimens were females, while 46(46.0%) were males.

However, sex related prevalence showed that 11(20.4%) of females and 7(15.2%) of males were infected, depicting a higher parasitic load in females than males.

Analysis of variance (ANOVA) showed that there was no statistical difference (P>0.05) between the sexes in the infection rate.

### 3.3. Sites Specificity and Parasites Recovered from C. Nigrodigitatus in the New Calabar River

Figure 3 shows the parasite species present in the various internal organs of C. nigrodigitatus in the New Calabar River. A total of eighteen (18) parasites belonging to fourteen (14) species were extracted from the specimens. The intestine harboured the highest number of parasites, 7(7.0%) while the liver had the lowest number of parasites, 1(1.0%). The heart had 6 (6.0%) parasites and the blood and kidney had 2(2.0%) parasites each. The fourteen (14) species of parasites recovered in the study belong to Five (5) phyla; Platyhelminthes, Nematoda, Acanthocephala, Protozoa and Crustacea; and seven (7) classes of parasites: Trematoda, Acanthocephala, Nematoda, Cestoda, Myxosporida, Apicomplexa and Maxillopoda.

The parasites include: *Alebion elegans*, *Sanguinicola inermis*, *Sanguinicola armata*, *Strongyloides sp.*, *Acanthocephalus lucii*, *Coccidia sp.*, *Atalostropion sp.*, *Thelohanellus piriformis*, *Silurotaenia siluri*, *Tetrochetus coryphaenae*, *Biacetabulum appendiculatum*, *Neoechinorhynchus rutili*, *Ascocotyle ceolostoma*, and *Tetraonchus monteron*.

<table>
<thead>
<tr>
<th>LOCATIONS</th>
<th>DISSOLVED OXYGEN (mg/L)</th>
<th>SALINITY (°/°°)</th>
<th>CONDUCTIVITY (S/m-1)</th>
<th>TEMPERATURE (°C)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOB A 1</td>
<td>5.80</td>
<td>0.05</td>
<td>0.08</td>
<td>24.8</td>
<td>5.82</td>
</tr>
<tr>
<td>CHOB A 2</td>
<td>5.82</td>
<td>0.05</td>
<td>0.09</td>
<td>25.7</td>
<td>5.92</td>
</tr>
<tr>
<td>CHOB A 3</td>
<td>5.97</td>
<td>0.03</td>
<td>0.05</td>
<td>25.5</td>
<td>5.15</td>
</tr>
<tr>
<td>CHOB A 4</td>
<td>5.98</td>
<td>0.02</td>
<td>0.05</td>
<td>25.2</td>
<td>5.18</td>
</tr>
<tr>
<td>CHOB A 5</td>
<td>5.94</td>
<td>0.03</td>
<td>0.06</td>
<td>24.5</td>
<td>5.38</td>
</tr>
<tr>
<td>ALUU 1</td>
<td>5.93</td>
<td>0.03</td>
<td>0.06</td>
<td>24.5</td>
<td>5.31</td>
</tr>
<tr>
<td>ALUU 2</td>
<td>5.97</td>
<td>0.02</td>
<td>0.04</td>
<td>23.8</td>
<td>4.89</td>
</tr>
<tr>
<td>ALUU 3</td>
<td>5.97</td>
<td>0.02</td>
<td>0.05</td>
<td>23.8</td>
<td>5.14</td>
</tr>
<tr>
<td>ALUU 4</td>
<td>5.92</td>
<td>0.02</td>
<td>0.05</td>
<td>24.9</td>
<td>5.02</td>
</tr>
<tr>
<td>ALUU 5</td>
<td>5.90</td>
<td>0.03</td>
<td>0.07</td>
<td>25.3</td>
<td>5.40</td>
</tr>
</tbody>
</table>

*Acceptable levels: Temperature (NA); pH (6.5-8.5); DO (>4); Salinity (<0.05); Conductivity (0.001-0.3)*


<table>
<thead>
<tr>
<th>Size class (mm)</th>
<th>Population Examined</th>
<th>Female Examined (%)</th>
<th>Female Infected (%)</th>
<th>Male Examined (%)</th>
<th>Male Infected (%)</th>
<th>Overall Infection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;169</td>
<td>3</td>
<td>(33.3)</td>
<td>(0.0)</td>
<td>(266.7)</td>
<td>(0.0)</td>
<td>(0.0)</td>
</tr>
<tr>
<td>&gt;169-200</td>
<td>9</td>
<td>(44.4)</td>
<td>(25.0)</td>
<td>(55.6)</td>
<td>(0.0)</td>
<td>(11.1)</td>
</tr>
<tr>
<td>201 – 300</td>
<td>79</td>
<td>(55.7)</td>
<td>(715.9)</td>
<td>(344.3)</td>
<td>(14.3)</td>
<td>(1215.2)</td>
</tr>
<tr>
<td>301 – 400</td>
<td>9</td>
<td>(55.6)</td>
<td>(360.0)</td>
<td>(44.4)</td>
<td>(250.0)</td>
<td>(555.6)</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100</td>
<td>(545.0)</td>
<td>(1120.4)</td>
<td>(464.0)</td>
<td>(715.2)</td>
<td>(1818.0)</td>
</tr>
</tbody>
</table>

*SL = Standard Length, mm = Millimetre
* Values with the same superscript are not statistically significantly different at P>0.05
4. DISCUSSIONS

The study revealed an overall prevalence of 18.0% occurrence of endoparasites in *C. nigrodigitatus* of New Calabar River (Table 1). This is in line with studies by Ugwuozor (1987) and Ekanem et al. (2011), who reported a low infection rate of 13.6% and 3.3% in Imo River and River Kwa respectively. Obiekezie and Eyenini (1988) also reported a low prevalence of endoparasites in the *C. nigrodigitatus* of Cross River Estuary. However, this contradicts with studies by Sikoki et al. (2013), were a high overall parasitic prevalence of 59% (54% endoparasites and 5% ectoparasites) was observed.

It was also observed that the parasitic load was more in the females (20.4%) than in the males (15.2%) which was not statistically significant (p>0.05). This is in line with studies by Thomas, (1964) and Thomas, (2002) who reported higher endoparasitaemia in female samples than their male counterparts. However, studies by Awharitoma and Okaka, (1999), Obano and Odiko, (2004) and Sikoki et al. (2013) showed a higher overall prevalence of parasites in males than females which contradict Hassan et al. (2007) and Olurin, (2012). Studies have shown that sex related prevalence in fish has been a constant topic of argument by different scientists over time (Price and Clancy, 1983; Olurin and Somorin, 2006; Sikoki et al., 2013). In this study, the physiological preference of parasites of *C. nigrodigitatus* could be attributed to host specific factors. However, testosterone immunosuppression, corticosteroid-based immune suppression and differences between the size and behaviour of the sexes could also influence sex related parasitaemia in fish (Thomas, 2002; Sikoki et al., 2013).

The pattern of parasitaemia in relation to size in this study is widely accepted in fish parasitology (Paperna, 1996; Obano and Odiko, 2004; Bello-Olusoji et al., 2011; Ekanem et al., 2011; Sikoki et al., 2013). The size related prevalence could be attributed to repeated infections and accumulation of parasitic load as growth (increase in size) occurred over time (Sikoki et al., 2013).

The site specificity of endoparasites (Figure 3) also revealed that the intestine had the highest (0.07%) infection while the kidney had the lowest (0.01%) infection. The heart had 6 (0.06%) infections, while the liver and blood had 2 (0.02%) infection each. These findings agree with the studies by Awharitoma and Okaka (2004); Obano and Odiko (2004); Chanda et al. (2011) and Ekanem et al. (2011). The relatively high parasitaemia in the intestine could be attributed to the nutrient rich ambience of the intestine which may be suitable for parasite establishment and multiplication (Sikoki et al., 2013).
Fourteen (14) species of parasites belonging to 5 phyla that were extracted from the samples. The phyla includes: Protozoa - Coccidia sp. and Thelohanellus piriformis; Platyhelminth - Ascochylea celostoma, Sanguinicolafina inermis, Sanguinicolagama armata, Atlatostrion sp., Silurotaenia siluri, Tetrochetus coryphaenae, Biaecetabulum appendiculatum and Tetraanchoemonenteron; Nematomata - Strongylodies sp.; Acanthocephala - Acanthocephalus lucii and Neoechinorhynchus rutili; and Crustacea - Alebion elegans. The most prevalent parasites in the liver, intestine and heart were Biaecetabulum appendiculatum 2(14.3%), Silurotaenia siluri 2(14.3%), Thelohanellus piriformis 2(14.3%) and Neoechinorhynchus rutili 2(14.3%). However, the intestine had a relatively high parasitaemia (Figure 3).

The specific parasitaemia recorded in this study, as shown on Figure 3, revealed that Platylelminthes were more prevalent 10(0.1%), followed by acanthocephalans and the protozoans 3(0.03%) while Nematoes and copepods had the least prevalence1(0.01%). This is in agreement with the study by Awharitoma and Okaka (2004) who reported more Platylelminthes in the sampled fishes of Ikpoba and Ogba Rivers respectively.

The low endoparasitaemia recorded in the examined fish of the New Calabar River could be attributable to ecological conditions (Table 1). The river is influenced by its tidal characteristics which accelerated the dispersal of pollutants that invariably affected the salinity of the river. The interaction between the river and the Atlantic Ocean may also periodically influence its salinity. This tidal phenomenon may have influenced the suitability of the river which resulted in the survival of most eggs, miracidia, metacercaria, cercaria, coracidia, oncospheres and other free living larval stages of endoparasites which are delicate and fragile (Pietrock and Marcogliese, 2003; Wogu and Okaka, 2012). The potadromous nature of fishes (e.g C. nigrodigitatus) prevents them from staying in an area long enough to ingest many prey that might harbour high load of infective stages of parasites (Offem et al., 2008). This may have contributed to the relatively low parasitaemia recorded in this study. Also, the possible reasons for the low parasitic prevalence could be linked to high productivity, increased acidity (Table 1) and habitat degradation linked to changes in land use as suggested by Thomas (2002).

Survival and infectivity of transmission stages, even between closely related taxa, sometimes differ considerably when there are variations in pH (Sawabe and Makiya, 1995). Although majority of parasites can tolerate a wide range of deviations in hydrogen ion concentrations (pH) outside their hosts (Nollen, 1979; Sawabe and Makiya, 1995; Ford, 1998), the more the hydrogen ion concentration deviates from a species-specific optimum, the more it will affect physiological properties of the free-living stages, leading to impaired survival and/or reduced infectivity. Studies have shown that an increase or a decrease in hydrogen ion concentration in the aquatic ecosystem may have negative consequences for survival, infectivity and, ultimately, for transmission success of parasites. In some cases, free-living stages resist alkaline better than acidic conditions or vice versa (Nollen, 1979; Pietrock and Marcogliese, 2003). However, the pH recorded in this study was more acidic and was above the standard pH of freshwater bodies (Table 1). This may have affected the infective stages of most parasites present and as such the low prevalence encountered.

Vulnerability of free-living stages to salinity is strongly related to whether a parasite inhabits a marine or freshwater habitat. Whereas parasites completing their life cycles (or parts of them) in a limnetic environment are harmed by increased salt concentrations, longevity and infectivity of free-living stages of marine parasites are reduced after exposure to freshwater dilutions (Pietrock and Marcogliese, 2003). Generally, during the free-living phases of parasites, many freshwater parasites can withstand slight salt concentrations without affecting their survival (Nollen, 1979; Shostak, 1993). However, cercarial infectivity, in particular, is reduced after short-term salt exposure (less than an hour) or after exposure to low-salt concentration (Hynes and Nicholas, 1963; Moller, 1978; Lwambo, 1987). In cases when endohelminth embryos are surrounded by egg shells or cuticles, the protective membranes will shelter them from increased or reduced salinities for a certain period. However, the integuments do not provide complete protection against high- or low-salt concentrations (Measures, 1996; Pietrock and Marcogliese, 2003). Although the salinity level in this study (Table 1) was within range (as at the time of sampling), the river has been noted for salt intrusion due to its tidal characteristic and interaction with the Atlantic Ocean.

5. CONCLUSION

The endoparasitaemia of Chrysichthys nigrodigitatus in the New Calabar River is relatively low (18.0%). This shows that the water body is not heavily infiltrated with parasites and as such can be said to be healthy. However, there is need to be precautious of the fact that consumption of raw or improperly cooked fish from this river should be avoided in other to prevent the outbreak of zoonotic infections and diseases and landed fish from this location should be...
properly cooked to avoid ingestion of parasites by fish consumers and stall zoonoses in humans.

Acknowledgment

We wish to thank the staff of parasitology laboratory and hydrobiology laboratory in Animal and Environmental Biology Department, Faculty of Biological Sciences, University of Port Harcourt, Nigeria. Our profound appreciation also goes to the Centre for Marine Pollution Monitoring and Seafood Safety, University of Port Harcourt, Nigeria.

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Professor Francis D. Sikoki holds B.Sc and M.Sc from University of Michigan in 1977 and 1979 respectively, and a Ph.D in Fish Reproductive Biology from the University of Jos, 1987 with extensive teaching and research experience with international perspective spanning over three decades. He has supervised over 50 post graduate students and has served as a consultant in fisheries development, research and environmental assessment to several national and international agencies.

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