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The parasite prevalence in *Clarias gariepinus* from artificial and natural habitats in Oguta imo state Nigeria

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Abstract

This study revealed the presence of parasites in the two habitats under study. The endoparasites recovered were found to belong to *Cammallanida, Pseudophyllida*, and *Plagiorchiida* taxonomic group. Both habitats were noted to be sparingly infected; however, the natural habitat was more infected than the cultured habitat. The physicochemical parameters assayed in this study of the water and sediment samples from all the locations indicate that the water samples fall within the stipulated range of acceptability by the World Health Organization (WHO). The heavy metal concentrations in fish tissues were also within WHO set limits for the survival of aquatic organisms. However, prolonged consumption of the fish species will have adverse effects since heavy metals can bioaccumulate overtime. By implication, from the current result it may be confirmed that catfish obtained from fish pond is healthier than the uninhabited fish type in relationships of nutrient substances for human feeding. This could be due to the fact different habitat of different species the body pattern varies nutritionally. Findings from this work showed that constant monitoring of water parameters provide insight to the health of fish and aquatic ecosystems as whole. Finally, it can be inferred from the results of this study that for consumers purchasing the products in large quantities on a regularly basis, a public health hazard will definitely exist especially from natural catfish where pollution is more pronounced as a result of human activities. On the other side, no hazard might exist through the consumption of average amount of such fishes since it is within WHO permissible limits.

Keywords: *Clarias gariepinus*; Artificial and Natural Habitats; Cammallanida; Pseudophyllida; Plagiorchiida

1. Introduction

Fish is regarded as the cheapest and important source of protein which also contains calcium, lipids, minerals, vitamins and oils with desirably low cholesterol levels in the diets of fish lovers. Economically, it is a source of income and it has continued to be the most affordable source of animal protein to an average Nigerian family where malnutrition is a major problem (Abeywanden and Patten, 2021). In most part of the world, fish production is mainly from wild but as the population grows, fish resources are being depleted at an ever-increasing rate as a result of environmental degradation, over harvesting and water pollution and the demand for fish as a source of protein increases as well. Therefore, in attempt to increase fish supply as protein source, there has been tremendous increase in the development of fish farming (Adam, 2019).

The African catfish *Clarias gariepinus* Burchell 1822 (the air breathing catfish) belonging to the family claridae is generally considered to be one of the most important tropical catfish species for aquaculture in West Africa, with many names such as *C. mossambicus* Peters 1852 and *C. lazera* Valenciennes 1840 being recognized as its junior synonyms (Adefemi and Awokumni, 2020). They are a diverse group of rays finned fish named for their prominent barbells which resembles a cat's whiskers. Catfish range in size and behaviour from the heaviest and longest Mekong giant catfish of south east Asia to the smallest parasitic fish commonly known as Candiru.

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All catfishes have either smooth or armored naked bodies with bony plate. The dorsal and pectoral fins are often edged with sharp spines that are used for defence. This African catfish is widely distributed throughout Africa, inhabiting tropical swamps, lakes, still water, pools and rivers but may also be found in fast flowing rivers and it is the main fish fisherman catches. They can also survive in dry season due to the possession of accessory breathing organ. *C. gariepinus* hold great promise in fish farming in Africa due to its wide geographical spread, high growth rate and it resistant to stress (Adekanmi, 2022). It is well appreciated, highly priced and requested for by both fish farmers and consumers in Nigeria in either smoked or fresh form. It is found throughout Africa, Nigeria inclusive and live in freshwater and human-made habitat, such as the earthen pond or concrete ponds. In Nigeria, the rearing of African catfish (*Clarias gariepinus*) is proving to be a lucrative option for small-scale inland fisheries and its consumption is on the increase. It is also known as the African sharp tooth catfish which is a large eel-like fish, usually of dark grey or black coloration on the back fading to a white belly. The fish was introduced all over the world in the early 1980's for aquaculture purposes (Adel et al., 2020).

The consumption of catfish has been regarded as part of exclusive delicacies for the upper class, although the cost is within the rich of the majority. Catfish is one of the major sources of omega-3 fatty acid, which is very important nutrient that protect the body against some of the most common deadly non-communicable diseases especially cardio-vascular disease, Omega-3 fatty acid consist of Docosahexaenoic Acid (DHA) and Eicosapentaenoic acid (EPA), which are essential fatty acid that need to be supplied regularly in human diet (Adekanmi, 2022).

Like humans and other animals, fish suffer from diseases and parasites, which is a natural occurrence. Parasitic diseases are one of the most serious problems in fishes, though not of much concern among the wild fish stock because in most instances, no significant harm appears to be caused to them. However, parasites often cause serious disease outbreaks among farmed fish. With the exception of cases of mass mortalities caused by outbreaks of parasites, assessment of the effects of parasite infection in natural fish populations is particularly difficult because of the presence of predators or scavengers which rapidly remove moribund or dead fish. Majority of the fish parasites belong to three major groups, protozoan, helminths and arthropods bring dominated by crustaceans (Adesulu, 2019). These parasitic infections are some of the factors hindering high fish productivity in fish farming. Fish defenses against disease are specific and non-specific. Non-specific defenses include skin and scales, as well as the mucus layer secreted by the epidermis that traps microorganisms and inhibits their growth.

If pathogens breach these defenses, fish can develop inflammatory responses that increase the flow of blood to infected areas and deliver white blood cells that attempt to destroy the pathogens (Adewuyi et al., 2020). Fish can serve as definitive, intermediate, or paratenic (transport) hosts in the life cycle of many species of protozoan, metazoan, and crustacean parasites. Most of these parasites can be readily identified grossly or microscopically, and as with mammalian parasites, the correct identification and an understanding of their life cycle are important in the prevention or management of an outbreak of disease due to parasites (Adewuyi, , 2020).

Protozoan parasites probably cause more disease in both ornamental and cultured fish than any other group of parasites. An example of a common protozoan disease in fish is white spot disease, or "ich," caused by *Ichthyophthiriusmultifiliis* in freshwater fish or by *Cryptocaryon irritans* in marine species. Other protozoan parasites that commonly occur on fish include *Tetrahymena spp, Trichodina spp., Trichophyra spp., Amyloodiniumspp.* and *Ichthyobodo* spp. Metazoan parasites can be found as larval or adult forms in almost every tissue of fish. Most can be grossly identified as monogeneans, digenetic trematodes, nematodes, cestodes, acanthocephalans, or crustaceans, but specific identification generally involves special staining techniques or clearing of specimens. Examples of common fish helminths include monogeneans on the gills and skin; larval digenetic trematodes (metacercariae) in the eyes, skin, musculature, and abdominal cavity; larval cestodes and nematodes in the visceral organs and abdominal cavity; and an assortment of adult trematodes, nematodes, cestodes, and acanthocephalans in the lumen of the gastrointestinal tract. In addition, a number of arthropod parasites and leeches can be found occurring on or attached to the skin and fins of fish (Adeyemi, 2019).

The aim of the study is to determine the parasite prevalence in *Clarias gariepinus* from artificial and natural habitats in Imo State Nigeria. The information obtained from this study will be useful to aquaculturalists in understanding the prevalence of different types of parasites in catfish and the state of water quality. Fish is an important form of food nutrition for all human populace globally; hence the study addresses an important area of food safety and security. Creating evidence-based disease control policies that are required to protect humans and animal health requires understanding the interaction between people and aquatic organisms with their environment and the transmission of diseases between them.

2. Overview of *Clarias gariepinus*

Clarias gariepinus is indigenous to the inland waters of much of Africa and is cultured commercially in about 15 African countries including Nigeria, Zambia, Ghana and South Africa (Agbon*,* 2018), making it the most cultured catfish on the African continent. Despite being endemic to Africa, commercial culture of this catfish only started there in the early 1970s. *C. gariepinus* is also endemic in Asia Minor in countries such as Israel, Syria and the south of Turkey. *C. gariepinus* has been widely introduced to other parts of the world including the Netherlands, Hungary, much of South-East Asia and East Asia. The introduction of this African species for aquaculture in many parts of Asia, and its successful hybridization with Asian species such as *Clarias macrocephalus* has led to increased interest in the commercial culture of clariid catfishes. These African catfish and African-Asian *Clarias* hybrids are rapidly replacing the aquaculture production of many native catfish species in Asia. World production of clariid catfishes is second only to ictalurid catfishes and amounted to about 80,000 tons in the late 1990s (Agumassie et al., 2018) and is expanding rapidly worldwide.

Many researchers and fish farmers agree that *C. gariepinus* is probably one of the most ideal aquaculture species in the world. Its many positive attributes such as wide native distribution, air-breathing ability, high fecundity, fast growth rate, resistance to disease, tolerance of high stocking density and high feed-conversion efficiency have been reviewed by Agbon, *et al.,* (2018). Much research has been done in various countries on important culture parameters of this species which has contributed to the successful farming of *C. gariepinus* and its hybrids in various parts of the world (Aharur-Rahman, & Khan, 2019).

2.1. Description of *Clarias gariepinus*

Clarias gariepinus are readily recognized by their cylindrical body with scaleless skin, flattened bony head, small eyes, elongated spineless dorsal fin and four pairs of barbells around a broad mouth. The upper surface of the head is coarsely granulated in adult fishes but smooth in young fish (Aines, & Watts, 2022). The anal, caudal and dorsal fins are not united. The males can be easily recognized by a distinct sexual papilla located immediately behind the anal opening. This sexual papilla is not present in female fish.

The body is greyish-black with the underside of the head and body a creamy-white colour (Akel, 2022), with a distinct black longitudinal band on each side of the ventral surface of the head (which is absent in young fish of less than 9 cm long). Larger fish (more than 9 cm) are mottled with an overall grey-khaki colour. Skin coloration is known to change slightly according to substrate and light intensity in culture systems.

2.1.1. Scientific Classification

- Domain: Eukaryota
- Kingdom: Animalia
- Phylum: Chordata
- Class: Actinopterygii
- Order: Siluriformes
- Family: Clariidae
- Genus: *clarias*
- Species*: c. gariepinus*

2.1.2. Distribution

Clarias gariepinus is indigenous to the inland waters of much of Africa and they are also endemic in Asia Minor in countries such as Israel, Syria and the south of Turkey. *C. gariepinus* has been widely introduced to other parts of the world including the Netherlands, Hungary, much of South-East Asia and East Asia. This species can be cultivated in areas with a tropical climate, areas with access to geothermal waters or with the use of heated recirculating water systems. It is a hardy fish that can be densely stocked in low oxygen waters making it ideal for culture in areas with a limited water supply. Its air-breathing ability, high fecundity, fast growth rate, resistance to disease and high feed conversion efficiency makes *C. gariepinus* the freshwater species with the widest latitudinal range in the world.

2.1.3. Geographic Range

North African catfish have been widely introduced around the world. They are found as far as south Africa north into northern Africa. They have also been introduced in Europe, the middle East, and in parts of Asia. They are potamodrous, which means migrate within streams and rivers. (Akinrotomi et al., 2021).

2.1.4. Habitat

North African catfish live in a variety of freshwater environments, including quiet waters like lake, ponds, and pools. They are also very prominent in flowing rivers, rapids and around dams. They are very adaptive to extreme environmental conditions and can live in Ph range of 6.5 – 8.0. They are able to live in very turbid waters and can tolerate temperature of 8 – 35c. Their optimal 5io temperature for growth is 28 – 30 °C (Akinrotomi *et al.,* 2021).

They are bottom dwellers and do most of their feeding there. They are also obligate air breathers, which means they do spend some time on the surface. This specis can live in very poorly oxygenated waters and is one of the last species to live in such a uninhabitable place (Pienaar 1968). They are also able to burrow in the muddy sus-bstrate of a drying body of water (Akinrotomi et al., 2021). Habitat regions: tropical; fresh water Aquatic biomes: pelagic; benthic; lakes and ponds; rivers and streams; temporary pools, brackish water.

2.2. Ecological Distribution of *Clarias gariepinus*

Of the over 33,500 species of fishes (Akinwande et al., 2019), the Catfish (*Clarias gariepinus*) is among the most popular in Nigeria's wild waters and aquaculture media, this is primarily due to their fast growth, hardiness, resistance to diseases, ease to breeding both in captivity and wild. The African catfish have almost pan-African distribution (but are naturally absent from the Maghreb, Upper and Lower Guinea and Cape provinces) (Al- Masri et al., 2020).). They are equally present in Jordan, Lebanon, Israel and Turkey.

Clarias gariepinus has also been introduced into most other countries in Africa, as well as several in Europe, Asia and South America. Similar to other species like common carp, crucian carp, bighead, European crucian carp, mirror carp, loach, rain bow trout, Xenocyprinus and snakehead (*Ophicephalus argus*), China has also adopted *Clarias gariepinus* within its rice-fields and is currently among the main producing countries (Alam et al., 2018). This species is found in lakes, streams, rivers, swamps and floodplains, many of which are subject to seasonal drying. The most common habitats are floodplain swamps and pools where they can survive during the dry season(s) due to their accessory air breathing organs. *Clarias gariepinus* undertake lateral migrations from the larger water bodies, in which they feed and mature at about the age of 12 months, to temporarily flooded marginal areas in order to breed. These reproductive migrations typically take place shortly after the onset of the rainy season(s).

3. The study area

Figure 1 Map of study area

The study was carried out in Oguta Imo state Nigeria, lying within latitude $4^0 45^1$N and$7^0 15^1$ N and longitude $6^0 50^1$ E and $7^0 25^1$ E. It has a total area of 5,100 square kilometres and a population of 4.8 million persons. The capital city is

Owerri. Imo has three geopolitical zones namely; Owerri, Orlu, and Okigwe and twenty-nine local government areas. There are two distinct seasons within this area, namely; rainy seasons, which begins in the month of April and lasts until October, with annual rainfall varying from 1,500-2,200mm (60-80inches), while the dry seasons is ushered in by harmattan period and are characterized by hot weather and low humidity. The rainy season is associated with very high humidity of about 80-85% with very heavy rainfall. Temperature varies according to season between 25^0c to 32^0c in sunny days. The forest/vegetation in Owerri is a rain forest with lots of plants diversity, growing under the described climatic conditions. The population is predominantly Igbos and Christians.

4. Laboratory procedures

This section presents the detailed description of the laboratory procedures for parasite examination and physicochemical analysis of water samples can be included, as it provides the methodological foundation for the study.

4.1. Physicochemical Analysis

The assessment of physicochemical parameters was carried out according to the methods described by Teame (2019) and WHO (2008). The instrument used was in the limit of précised accuracy (Temesgen 2018). Appearance, colour, odour, taste, temperature, EC and Ph were measured in-situ. Appearance and colour were determined with spectrometer, taste with osmoscope and odour with physiological sense. Thermometer was used to determine temperature. Known buffer solutions of Ph were prepared and used in standardization of PH reading of water samples was immediately taken. Turbidity was determined by using nephelometer. TDS was determined by subtracting the values of the suspended solid from the corresponding total solid of samples. TSS was determined by using a Whitman filter paper rinsed in distilled water and was dried in oven at 105c for exactly one hour and cooled in desicators. Its residue weight (WI) was determined using a digital weighing balance. The sample of 100ml of water was filtered through the resin paper and was evaporated at 105c for one hour. The weight which represents W2 of the filter paper containing the residues was noted and TSS was calculated using (W2-WI) 100m/l. Alkalinity values were determined by titration methods. 50ml of the water sample was taken in a clean 150ml conical flask and three drops of the phenolptaline indication were added and titrated with 0.5m of H_2SO_4 until colour disappeared. To the colourless solutions, three drops of methyl orange indicator were added and titrated further until colour changed from yellow to permanent reddish or orange red and then titre values were recorded and alkalinity was calculated. BOD was determined by modification of Winkler's method. BOD bottle was prepared and incubated at 20c for 5 days in the dark. After 5 days, incubated BOD bottle was poured with mixing 2ml of orthophosphoricc acid. This was shaken gently and titrated with sodium thiossulphate to the end point where the colour was observed. Titre value represents the DO on day one and that on day five. The DO was determined using azide modification of Winkler's method. 200ml of the water sample was carefully transferred into a 300ml BOD bottle and 1ml of manganese sulphate solution was added followed by 1ml of alkaline alkali-iodide-azide reagent. The resulting mixture was titrated against 0.025N thiosulphate to the end point where there was a change in colour. The titre value was recorded as DO. Determination of nitrate was done by phenoldisulphonic acid methods and phosphate was determined by colorimetric method. 2ml aliquot of water sample was taken in a 25ml volumetric flask, and one drop of the phenolphthalein indicator was added followed by 2ml of ammonium molybdate and 1ml of freshly diluted stannous chloride solution was given 25ml volume with distilled water mixed thoroughly. After 5 to 6 minutes, the absorbance was measured at wavelength of 660nm in a spectrophotometer.

4.2. Heavy Metal Analysis of Fish Tissues

This presents the procedures for collecting and analyzing heavy metals in fish tissues, water samples, and sediments are pertinent if the study aims to investigate any potential correlations between heavy metal contamination and parasite prevalence.

- **Legend**: Lead (Pb), Cadmium (Cd), Arsenic (As), Mecury (Hg), Nickel (Ni), Manganese (Mn), Milligram per liter Mg/L, Milligram per gram Mg/g, Water w, Sediments.
- **Extraction of tissues from samples**: Fish samples were selected at random from Oguta lake and fish pond in Imo state. The weight of the fish samples were measured on a digital scale. Samples weighed 70+60.23g. The fish were dissected and the tissues of interest (liver, Heart, and kidney) were isolated. The tissue collected were cleaned with saline water (sodium chloride) and weighed before being packed in sachets and stored in a refrigerator while waiting for digestion.
- **Digestion**: Frozen samples of Liver, heart and kidney were allowed to thaw at room temperature. An average wet weight of 0.5g was used for each sample. Each sample was pulverized in a Mortar. Each pulverized sample (0.5g) was mixed with 6ml HN03 (ANALAR) and 2ml of H202.

4.3. Determination of heavy metal concentrations

Preparation of subsamples and analysis were made according to FAO Technical Paper No 212 and analysed for pb, cd, As, Hg, Ni, and Mn using the Atomic Absorption Spectrophotometer (AAS model GPC A932 ver. 1.10). the obtained results were expressed as Mg/g wet weight. All reagents were of analytical grade; glassware were soaked in 10% nitric acid and rinsed with distilled water prior to use in order to avoid metal contamination.

4.4. Water samples

Surface water samples were collected using a plastic container. 5ml of concentrated hydrochloric acid was added to 250ml of water sample and evaporated to 25 ml. The concentrate was transferred to a 50ml flask and diluted to mark with distilled water. Metal content were determined using AAS to assess the presence of Pb, Cd, As, Hg, Ni, and Mn.

4.5. Sediment samples

Bottom sediment from each study sites was collected into pre-cleaned polythenebag using a stainless van-vengrab, samples were air dried and then sieved with 200mm mesh screen. 5 g of the sediment were taken into 150ml conical flasks. 50 ml of HCL was added and the flask was agitated on an orbital shaker for 30 mins at 200rev/min. The content was filtered into 50 ml standard flask and made up to mark with 0.1 HCL for the determination of Pb, Cd, As, Hg, Ni, and Mn

5. Parasite examination

The detailed methods for examining ectoparasites and endoparasites, as well as the examination of stomach, intestine, and gills for parasites, are crucial for understanding the prevalence and types of parasites infecting the catfish.

5.1. Ectoparasites

The presence of ectoparasites were done by examining the whole body of the fish carefully with the aid of hand lens on fin, back and chest.

5.2. Endoparasites

The catfish was placed on a tray with the back cut open with a scissors on the central side. The dissection was carefully done and exposed the whole internal organs of the fish. Careful examination of the whole internal organ system was made to identify the presence of any parasite. Specific internal organs like the stomach, intestines and the gills were cut off and placed on petri dish containing 6ml of normal saline water and examined. The stomach, intestine and the gill were carefully cut open along the whole length.

5.3. Examination of stomach contents

Stomach contents were carefully teased out and examined. The stomach contents were removed and placed inside a petri dish with 4ml of normal saline water. The stomach contents were carefully examined for possible parasites.

5.4. Examination of intestine and gills

The intestine and gill content were carefully examined under luminous environment for parasites. Scissors was used in cutting 4cm of intestines and this was placed on a slide and 3 drop of normal saline was added on top and it was examined under the microscope. The cut intestine together with 1ml of water was put into a sterile and 2ml of normal saline water was added making 3ml. the mixture were loaded on a centrifuge and centrifuged for 30 minutes the supernatants were collected placed on a slide and examined under the microscope. Extracted helminthes parasites were identified.

6. Statistical analysis and results

The date generated was subjected to descriptive statistical analysis using percentages and analysis of variance and chat and chi-square analysis were used in determining the parasitic prevalence rate from the different location indicative of a statistically differences were considered at $p < 0.05\ level$.

6.1. Results

Tables and descriptions of the species of endoparasites identified (Table 1), monthly prevalence of ectoparasites (Table 2), and endoparasites (Table 3)

Table 1 Species of endoparasites identified

S/N	Order	Family	Genus	Species
1	*Cammallanida*	*Cammallanidae*	*Procammalanus*	*Procammalanus laevionchus*
2	*Pseudophyllida*	*Ptychobothriidae*	*Poilonchobotrium*	*Polyonchobothrium clariae*
3	*Plagiorchiida*	*Plagiorchiidae*	*Alloglossidium*	*Alloglossidium corti*

6.2. Species of endoparasites encountered in the study areas

The species of endoparsites identified in the study areas is shown in Table 1. Results obtained showed that a total of three (3) species of endoparasites belonging to three different families were identified. The results further revealed that the species identified were: *Procammalanus laevionchus Polyonchobothrium clariae* and *Alloglossidium corti.*

Table 2 Monthly prevalence of ectoparasites of cat fish from natural (Oguta lake) and artificial pond (fish pond)

Months	Number of fish examined	Oguta lake				Fish pond				
		Number of fish infected	Number of ectoparasites identified	% Infection	Observable signs	Number of fish examined	Number of fish infected	Number of ectoparasites identified	% Infection	Observable signs
January	12	0	0	0.0	Necrosis, spot, sore	12	0	0	0.0	Necrosis
February	12	0	0	0.0	None	12	0	0	0.0	None
March	12	0	0	0.0	Necrosis, spot, sore	12	0	0	0.0	None
April	12	0	0	0.0	None	12	0	0	0.0	None
May	12	0	0	0.0	Necrosis, spot, sore	12	0	0	0.0	Necrosis
June	12	0	0	0.0	Necrosis, spot, sore	12	0	0	0.0	None
Total	72	0	0	0.0		72	0	0	0.0	

6.3. Monthly prevalence of ectoparasites of cat fish from natural (Oguta lake) and artificial pond (fish pond)

Monthly prevalence of ectoparasites of catfish obtained from natural (Oguta Lake) and artificial pond is presented in Table 2. The results revealed that in Oguta Lake, out of a total of 72 fishes examined across the sampled months, none of the fishes were found infected with ectoparasites. However, observable physiological signs of infection in the examined fishes showed signs such as Necrosis, spot and sore. At the fish pond, results obtained indicated no ectoparasite infection with similar signs of observable physiological infections such as Necrosis, spot, sore as obtained in Oguta Lake.

Table 3 Monthly prevalence of endoparasites of cat fish from natural (Oguta lake) and artificial pond

Months	Number of fish examined	Oguta lake							Fish pond					
		Number of fish infected (%)	Number of endoparasites identified (%)	Pl(%)	Ac(%)	Pc(%)	Total (% Infection)	Observable signs	Number of fish infected(%)	Number of endoparasites identified(%)	Ac (%)	Pc (%)	Total % Infection	Observable signs
January	12	4(9.30)	5(11.63)	1(2.33)	1(2.33)	3(6.98)	5(11.63)	None	1(2.33)	2(4.65)	2(4.65)	0(0.0)	2(4.65)	None,
February	12	3(6.98)	4(9.30)	2(4.65)	0(0.0)	2(4.65)	4(9.30)	None	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	None
March	12	5(11.63)	7(16.28)	2(4.65)	2(4.65)	3(6.98)	7(16.28)	Necrosis, spot,	2(4.65)	2(4.65)	1(2.33)	1(2.33)	2(4.65)	None
April	12	3(6.98)	5(11.63)	1(2.33)	1(2.33)	3(6.98)	5(11.63)	Sore	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	None
May	12	6(13.95)	8(18.60)	1(2.33)	3(6.98)	4(9.30)	8(18.60)	Spot, sore	1(2.33)	2(4.65)	0(0.0)	2(4.65)	2(4.6)5	None
June	12	6(13.95)	7(16.28)	2(4.65)	2(4.65)	3(6.98)	7(16.28)	Necrosis	1(2.33)	1(2.33)	0(0.0)	1(2.65)	1(2.33)	Necrosis
Total	72	27(62.79)	36(83.72)	9(20.93)	9(20.93)	18(41.86)	36(73.72)		5(11.63)	7(16.28)	3(6.98)	4(9.30)	7(16.28)	

Pl = *Procamallanus laevionus*, Ac = *Alloglosidium corti* Pc= *Polyonchobothrium clariae*

6.4. Monthly prevalence of endooparasites of catfish from natural (Oguta lake) and artificial pond

The monthly prevalence of endoparasites of catfish identified from natural (Oguta lake) and artificial pond in presented in Table 3. Results obtained revealed that in Oguta, the highest prevalence of endoparasites were obtained in May with a value of 8(18.60%) while the least number of infected fishes were recorded in February with a value of 4(9.30%). However, *Polyonchobothrium clariae* had the highest species prevalence rate 4(9.30), followed by *Alloglosidium corti* 3(6.98) while the least prevalence rate was obtained in *Procamallanus laevionus* 1(2.33). In fish pond, the highest endoparasites were recorded in the months of January 2(4.65); March 2(4.65); and May 2(4.65); while the minimum prevalence rate was obtained in June with a value of 1 (2.33). *Alloglosidium corti* recorded the highest prevalence rate 2(4.65), while the least value of percentage prevalence was obtained in *Procamallanus laevionus* (2.33). Overall, Oguta Lake fish samples recorded the highest value of endoparasites in catfish (73.72%) compared to catfish gotten from fish pond (16.28%). Observable signs of infection from catfish obtained from both aquatic environments were Necrosis and spot respectively.

7. Conclusion

From this study, it is revealed that there is presence of parasites in the two habitats under review. The endoparasites recovered were found to belong to *Cammallanida, Pseudophyllida*, and *Plagiorchiida* taxonomic group. Both habitats were noted to be sparingly infected; however, the natural habitat was more infected than the cultured habitat. The physicochemical parameters assayed in this study of the water and sediment samples from all the locations indicate that the water samples fall within the stipulated range of acceptability by the WHO. The heavy metal concentrations in fish tissues were also within WHO set limits for the survival of aquatic organisms. However, prolonged consumption of the fish species will have adverse effects since heavy metals can bioaccumulate overtime. These results further show marginal contamination of water, fish and sediment with heavy metals, leading to fish's ability to bio-concentrate and bioaccumulate, all of which are risk factors for the life of the fish and for human health. All the heavy metals determined (Pb, Cd, As, Hg, Ni, and Mn) recorded higher values in the natural environment (Oguta lake) compared with the fish pond samples. Sediment samples also recorded higher compared with the water samples.

However, a strong positive correlation exists between heavy metals in water and sediments indicating that the pollutants might have emanated from one source such as dump sites, industries, and agricultural lands within the environs of the study sites. Pearson correlation showed a strong influence of metal levels in water on bio-concentration. The bioaccumulation factor indicated almost zero bioaccumulation for metals studied. However, the values of the Pearson coefficients showed that the concentration of heavy metals in the water and sediment influenced its bioaccumulation in fish tissues. The bio-concentration factors indicating the transfer of metals from water and sediment to fish were superior to those indicating the transfer of metals from sediment to fish. This allows concluding that the accumulation of these metals in the tissues of the fish is largely due to water and sediment content pollution.

By implication, from the current result it may be confirmed that catfish obtained from fish pond is healthier than the uninhabited fish type in relationships of nutrient substances for human feeding. This could be due to the fact different habitat of different species the body pattern varies nutritionally.

Findings from this work showed that constant monitoring of water parameters provide insight to the health of fish and aquatic ecosystems as whole. Finally, it can be inferred from the results of this study that for consumers purchasing the products in large quantities on a regularly basis, a public health hazard will definitely exist especially from natural catfish where pollution is more pronounced as a result of human activities. On the other side, no hazard might exist through the consumption of average amounts of such fishes since it is within WHO permissible limits.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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