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Comparative Studies on Parasitic Burden of the African Catfish *Clarias gariepinus* (Burchell, 1822) and the Cichlid *Oreochromis niloticus* (Linnaeus, 1758) Under Polyculture Conditions

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ABSTRACT

This study was conducted at the Fisheries and Aquaculture Research Farm, Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri, Imo State, to compare the parasitic burden of the African catfish (*Clarias gariepinus*) and Cichlid (*Oreochromis niloticus*) under polyculture conditions. Among 15 *Clarias gariepinus* examined, Protozoa recorded the highest infection rate (100%), followed by Crustacea (80%), bacteria (40%), fungi (26.70%), helminths (20%), and Annelida (13.33%). Among 14 *Oreochromis niloticus* examined, Protozoa recorded an infection rate of 93.3%, followed by Crustacea (60.0%), helminths (33.3%), fungi (16.7%), and Annelida (6.67%), while no bacterial infection was recorded. Comparative analysis showed significant differences ($P < 0.05$) in the infection rates of the six parasite taxa between the two fish species, except for Protozoa. The findings indicate that both fish species harbour diverse parasitic taxa under polyculture conditions, with *Clarias gariepinus* generally exhibiting a higher parasitic burden than *Oreochromis niloticus*.

Keywords: Polyculture, Parasitic burden, *Clarias gariepinus*, *Oreochromis niloticus*, Prevalence

1. INTRODUCTION

The African Catfish *Clarias gariepinus* and the cichlid, *Oreochromis niloticus*, are two of the most culturally significant fish species in sub-Saharan Africa due to their exceptional culturable qualities, which include fast growth rate, ability to accept artificial food, good table size, resistance to diseases, and tolerance of diverse environmental conditions in captivity (Njoku, 2013). These species are highly palatable and command premium prices as food fish in many countries of the world, including Nigeria (Mougin et al., 2023). The polyculture of African catfish with *Oreochromis niloticus* or other species of tilapia has increasingly drawn attention in Nigerian aquaculture over the past decade (Fagbenro, 2004).

This practice is adopted primarily for two reasons: to reduce the precocious reproductive nature of tilapia, which often leads to overpopulation and stunted growth in ponds (Fagbenro, 2004; Shoko et al., 2014; Limbu et al., 2017), and to provide extra income for farmers through diversified production (Limbu et al., 2015; Shoko et al., 2016). Fish farms that receive natural water supply from sources such as rivers and streams may experience an influx of tilapia into ponds, thereby creating unplanned polyculture systems. However, this practice also carries risks, as polyculture can lead to cross-infection and interspecies transmission of infectious diseases (Ibrahim et al., 2011).

Despite the numerous advantages of polyculture, some factors ranging from poverty and attendant lack of capital for investment in fish production, dearth of skilled manpower, and most importantly, parasitic infestation and disease outbreaks, militate against catfish production in developing countries including Nigeria. Cultural practices associated with fish farming, such as supplementary feeding and the subsequent decay of leftover foods, not only negatively impact water quality but also predispose cultured fish to parasitic infections that thrive under such unhealthy water conditions (Mougin et al., 2023). Consequently, fish culture systems provide a reservoir for parasitic pathogens that can affect the cultured fish population.

The polluted water, together with bottom sediments, creates favorable environmental conditions for parasites to thrive, increasing the risk of disease outbreaks that can compromise fish health, reduce growth rates, and cause significant economic losses for farmers (Omeji et al., 2011; Mougin et al., 2023).

Parasitism is a relationship between two organisms in which one organism (the parasite) benefits while the other organism (the host) is harmed (Akoll et al., 2012). Harm to the host can be caused by tissue damage during the parasite's various life cycle stages, which is detrimental to the host and can also make the host more susceptible to other diseases. Parasites can harbor bacteria or viruses and transmit them to the host organism (Lasee, 1995). Parasites are common in most ecological systems, and all free-living organisms can be potential hosts; parasitism itself is one of the most common lifestyles on Earth (Madaniere-Moyo and Barson, 2010). Parasites are divided into two distinct groups: ectoparasites, which are located on the external surfaces of the host such as the skin, scales, fins, gills, and oral cavity, and endoparasites, which are located within the flesh and cavities of the host organism, including muscles, organs, and membrane linings (Akoll et al., 2012). Examples of both groups include species of trematodes, cestodes, nematodes, and protozoans. According to Plumb (1999), there are two peak seasons for diseases and parasites of warm freshwater fish: in the spring from March to June and again in the fall from September to October.

A number of parasites have been associated with African catfish in cultured systems, including *Procamallanus laevioncus* and *Ichthyophthirius multifiliis* (Enyidi and Enehe, 2015;

Enyidi and Maduakar, 2017). Some common monogeneans that infect African catfish are *Gyrodactylus* spp. (Walakira et al., 2014). *Gyrodactylus* is another group of ectoparasites that attacks both tilapia (Garcia-Vasquez, 2015) and African catfish (Mohammadu et al., 2010), and this parasite can easily be transmitted to culture systems. *Gyrodactylus* has been known to infect African catfish *C. gariepinus*, causing serious damage to the mucus layer and the skin (Maduenyane et al., 2022). Monogeneans such as *Cichlidogyrus* (*C. halli*, *C. mbirizei*, *C. sclerosis*, *C. thurstonea*, *C. tilapiae*) and *Scutogyrus* (*S. longicornis*) have been found as major parasites of both wild and cultured *O. niloticus* and red tilapia (Lim et al., 2016). These parasites are worrisome since they often produce a weakening of the host's immune system, thereby increasing susceptibility to secondary infections, resulting in the nutritive devaluation of fish and subsequent economic losses (Onyedineke et al., 2010). Parasites also compete for food with fish, depriving them of essential nutrients and inhibiting growth, leading to morbidity and mortality with consequent economic losses (Khalil and Polling, 1997). Fish parasitic infections are some of the factors hindering high productivity in fish farming (Akoll et al., 2012). These parasites attack the fish, causing massive destruction of their skin and fin epithelium, and are capable of causing harm to the fish host either through injury to tissue or organs in the process of burrowing or consuming food, or through the removal of proteolytic enzymes. In aquaculture, some parasites may be pathogenic and contribute to fish mortality and economic losses, while in natural systems, fish parasites and bacteria threaten the abundance and diversity of indigenous species (Mashego, 2001).

Parasitic diseases of fish are of particular importance in the lives of fish. Among animals, fishes are the most important hosts for the maintenance of helminth parasites (Chandra, 2004). Helminths seriously disrupt the structure of the gut wall and interrupt communications between the nervous and endocrine systems (Akoll et al., 2012). These parasites render the host weak and may eventually lead to death by attacking their organs, tissues, and cells. They also cause a decrease in growth rate, weight loss, emaciation of fish, reduction in yield of fish products (liver oil, etc.), infectious diseases in humans and animals, delay in sexual maturity of fish, and mortalities (Chandra, 2006).

In the past two decades, there has been a dramatic increase in the use of polyculture of *Clarias gariepinus* and *Oreochromis niloticus* as a means of controlling overpopulations of fish ponds that arise from uncontrolled reproduction of tilapia and the associated stunted growth of cultured fish (Mougin et al., 2023). The present study was therefore carried out to determine the relative parasitic burden of *Clarias gariepinus* (Burchell, 1822) and *Oreochromis niloticus* (Linnaeus) reared together in polyculture ponds. Specifically, the study aimed to investigate the parasitic burden of *Clarias gariepinus* under polyculture conditions, investigate the parasitic burden of *Oreochromis niloticus* under polyculture conditions, compare the parasitic burden of both species under polyculture conditions in fish ponds, and proffer recommendations based on the findings. It is expected that this study, which seeks to find out the relative susceptibility of the two fishes under polyculture conditions, will help advise fish farmers appropriately on the prevention and control of parasites and contribute to the development of aquaculture practices. The study was carried out in the Fisheries and Aquaculture Research Farm of the Department of Fisheries and Aquaculture Technology, Federal University of Technology Owerri, Imo State, between January and March 2022. A total of 30 adult fish (15 of each species) were collected from earthen polyculture ponds and examined for ectoparasites and endoparasites using standard parasitological techniques, including wet preparation, staining, and culture methods. Parasitic burden was assessed in terms of prevalence, intensity, and abundance across six taxa:

Protozoa, Bacteria, Fungi, Crustacea, Helminths, and Annelida. Data were analyzed using simple descriptive statistics and a paired-sample t-test to determine significant differences between the parasitic infections of the two fish species.

2. MATERIALS AND METHODS

2. 1. Study Area Description

The study was carried out in the Fisheries and Aquaculture Research Farm of the Department of Fisheries and Aquaculture Technology, Federal University of Technology Owerri, located at Ihiagwa in Owerri North Local Government Area of Imo State, Nigeria, as seen in Figure 1.

Owerri is located between latitudes 5°45' and 6°35' North of the Equator and between longitudes 6°35' and 7°28' East of the Greenwich Meridian (Ministry of Lands and Survey Imo State, 2003). It occupies a total land area of 100 km² (40 square miles), and is located in the rainforest zone of Nigeria with an annual temperature of 28 °C and annual rainfall of 1800 mm to 2500 mm. It is situated at an altitude of about 100 mm above sea level (Imo ADP, 2007). The population of Owerri, according to the 2006 census, is 401,879 people.

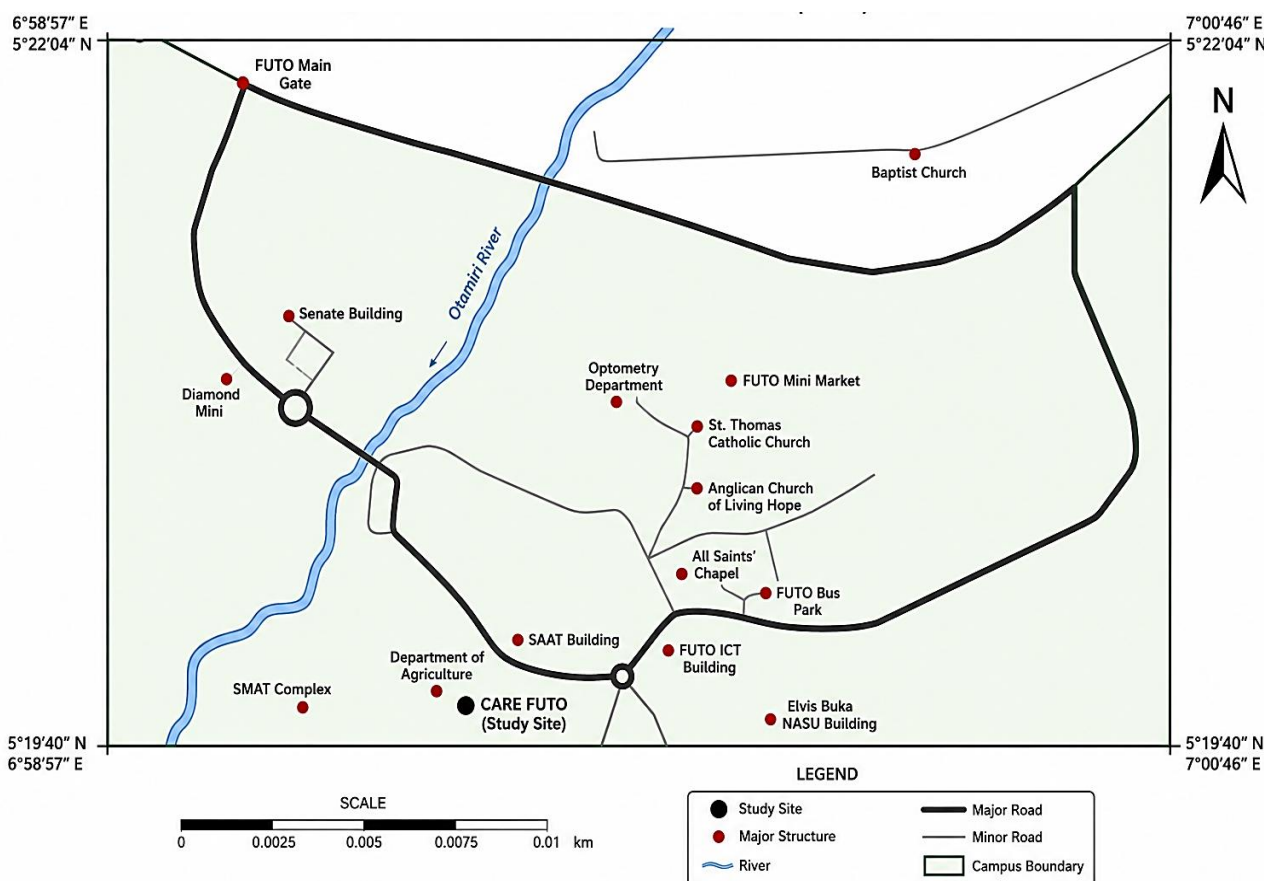


Figure 1. Map of FUTO Showing the Study Area.
(Source: Google)

The Teaching and Research Farm of the Department of Fisheries and Aquaculture has the necessary facilities for research, including a borehole for regular water supply, a generating set for power, and good security. The farm has competent farm officers and attendants.

2. 2. Experimental Design and Fish Sampling

Fish sampling for parasites was carried out on a monthly basis between January and March 2022 from specimens collected from the earthen polyculture ponds of the Fisheries and Aquaculture Research Farm of the Department of Fisheries and Aquaculture, Federal University of Technology, Owerri, using the Seine net. A total of 30 adult fish of *Clarias gariepinus* and *Oreochromis niloticus* were collected from the fish pond and investigated for parasites on a monthly basis for three months between January and March 2022.

Table 1. The Design Layout of the Parasitic Survey.

Months of Sampling	Number of fish per species		Total per month
	<i>Clarias gariepinus</i>	<i>Oreochromis niloticus</i>	
January	5	5	10
February	5	5	10
March	5	5	10
Total per fish	15	15	30

Five specimens of each species were investigated per month. The fish specimens were identified in the field with a combination of fish identification keys for freshwater species by Daget and Iltis (1958), Reed et al (1967), and Olasebikan and Raji (1992).

After this, the length (cm) and weight (g) were recorded using a metric rule and a weighing balance, respectively. The fish were then transported in iced boxes to the Fisheries Wet and Dry Laboratories of the Departments for further analysis. The layout of the design is shown in Table 1.

2. 3. Laboratory Procedure and Data Collection

Data collection was based on isolation and examination of parasites from the two species of fish. This includes the examination of the skin surface, scales, and gills for ectoparasites and the stomach, intestines, kidneys, and liver for endoparasites. Using the dissecting kit, the organs were harvested in the Fisheries and Aquaculture wet laboratory of the Department and preserved in 0.9% saline solution.

Isolation and identification of parasites followed three parasitological techniques by King (1996), Enyidi and Maduakar (2017), and Mougin et al., (2023). Bacterial parasitic isolation was carried out at the microbiology laboratory of the Federal Medical Center (FMC), Owerri.

2. 3. 1. Wet Preparation and Staining Method

This was employed in investigating the ectoparasites. Smear scrapings of the skin (slime), the fin, and the gill were obtained using a surgical blade for microscopic investigation. This was augmented by the use of the swab stick method. 3 mL of 0.9% saline solution was mixed with the swab and the smear samples properly using a sterile pipette; a drop of the mixture was placed in the Centre of a clean, grease-free microscopic slide and covered with a coverslip, avoiding air bubbles and overfilling.

It was viewed under the light microscope at a lower power of 10X objective and was later stained with Giemsa stain and viewed under the 40X objective with a drop of immersion oil and with the condenser sufficiently closed to give a good contrast.

The parasites seen were identified by making their sketches on paper while under the microscope. The sketches were later compared with the pictorial guide on the identification keys for fish parasites by Barzegar et al., (2023) and Meyer et al., (2008). Parasitic organisms identified (Protozoa, arthropods, mollusks, annelids and helminths) were recorded and classified.

2. 3. 2. Use of Culture Method

Bacteria and fungi were isolated and identified using culture media, which were prepared using nutrient agar, MacConkey agar, or chocolate agar for bacteria, while Sabouraud dextrose agar was used for fungi. Using a sterile wire loop, the plates were streaked from the primary inoculum to get discrete colonies. The culture plates were incubated at 37 °C for 48 hrs. Identification of the parasitic isolates of bacterial and fungal growth was carried out using the key for fish parasites by Barzegar et al., (2023) and Meyers et al., (2008). Parasitic isolates were recorded and classified accordingly,

2. 3. 3. Use of Stain Technique

A drop of smear mixture with 3 mL of 0.9% saline solution was placed on a clean microscope glass slide. A colony was picked from the culture plate using a sterile wire loop and emulsified with the normal saline placed on the slide. It was allowed to air-dry and then fixed by briefly passing over the flame. The smear on the slide was covered with Crystal violet for 1 minute, and then washed with water and decolorized briefly with acetone and washed with water.

The back of the slide was wiped and placed in a draining rack for the smear to air dry. After air drying, it was examined under the microscope with a 10X objective to check the staining and to see the distribution of material. With a drop of immersion oil, the organisms were viewed under 40X objectives to ascertain the parasites. Observed parasites were identified using the appropriate identification key and classified accordingly.

2. 3. 4. Examination of Fish for Ectoparasites

The whole body of the fish (*C. gariepinus* and *O. niloticus*) samples were examined for the presence of ectoparasites. The operculum of the fish was excised using a scalpel and placed in a Petri dish containing 5 ml of 0.9% saline water. The opercula were examined for the possible presence of ectoparasites. The whole gill arch was cut off, and gill lamellae were placed in a Petri dish with 5 ml of 0.9% saline water.

2. 3. 5. Examination of Stomach and the Internal Organs for Endoparasites

The fishes were examined for endoparasites by gently cutting the fish on the ventral side between the pectoral and pelvic fins, exposing the whole internal organs. The gastrointestinal tracts were examined by cutting the fish through the oesophagus to the anus. The stomach was opened and scraped into a Petri dish that contained 5 mL of normal saline water.

The stomach content was probed for the presence of parasites by a thorough search of the contents under a light microscope. The stomach contents were mixed with 15 mL of normal saline and centrifuged. The supernatant was discarded while the sediments were examined for parasites.

2. 3. 6. Examination of The Intestine

The intestines were also cut open for the whole length and examined for the presence of endoparasites. The contents were scraped into a Petri dish containing 10 mL of normal saline solution, and the contents were examined for the presence of parasites. The intestinal contents were mixed with water, centrifuged, and the supernatants poured into a Petri dish. The contents were examined for the presence of parasites under a light microscope at 10X magnification and 40X magnification for sharper resolution.

2. 3. 7. Identification of Parasites

Identification of parasites followed the standard methods by Pounder et al., (2005) and Mougin et al., (2023). Sketches of parasites seen under the microscope were made on a piece of paper. The sketches were later compared with the pictorial guide on identification of parasites of freshwater fishes by Meyer et al., (2008) and Pounder et al., (2017). Parasitic organisms identified were recorded and classified in accordance with Mougin et al., (2023).

2. 4. Data Analysis and Presentation

Indices of parasitic burden of *C. gariepinus*, which include the prevalence of a particular parasite, intensity, and abundance, were calculated as follows;

- a) $\text{Prevalence} = (\text{Number of fish infected} \times 100) / \text{Number of Fish Examined}$
- b) $\text{Percentage abundance} = (\text{Number of a particular parasite} \times 100) / \text{Number of parasites observed}$
- c) $\text{Percentage intensity} = (\text{Number of parasites implicated} \times 100) / \text{Number of fish infested}$

Simple descriptive statistical methods such as means, percentages, histograms, pie charts, and bar charts were used to summarize the data obtained. The means of these variables were subjected to paired-sample t-test analysis to determine the differences between the parasites in terms of prevalence, abundance, and intensity of *C. gariepinus* and *O. niloticus*. The null hypothesis formulated for this analysis is as follows:

H₀: There is no significant difference in the prevalence, abundance, and mean intensity of the parasites harboured by *C. gariepinus* and *O. niloticus*.

H_A: There is a significant difference in prevalence, abundance, and mean intensity of the parasites harboured by *C. gariepinus* and *O. niloticus*.

3. RESULTS AND DISCUSSION

Results of the comparative studies of parasitic burden of the catfish *Clarias gariepinus* and *Oreochromis niloticus* from a polyculture pond are presented in Tables 2 to 6 and Figures 2 to 5 and discussed below.

3. 1. The Parasitic Burden and Intensity of Infection of *Clarias gariepinus* from the Polyculture Pond

3. 1. 1. Parasitic Burden of *Clarias gariepinus*

Tables 2 and 3 present the parasitic burden of *Clarias gariepinus* in a polyculture pond.

Table 2. Parasites of *Clarias gariepinus* from polyculture ponds and prevalence of infection (N = 15).

		Parasite Species	Gill	Skin	Fin	Total (Organ Count)	Taxa Total
Kind of Parasite	Protozoa	<i>Ichthyophthirius multifiliis</i>	+	+	+	3	4
		<i>Trichodina</i> spp.	+	-	-	1	
		<i>Ichthyobodo</i> spp.	-	-	-	0	
		<i>Chilodonella</i> spp.	-	-	-	0	
	Bacteria	<i>Aeromonas salmonicida</i>	+	+	-	2	5
		<i>Flavorescens</i>	-	+	+	2	
		<i>Tuberculosis</i>	+	-	-	1	
		<i>Lisionella anguillarum</i>	+	-	-	1	
		<i>Flexibacter columnaris</i>	-	-	+	1	
	Fungi	<i>Branchiomyces</i> spp.	+	-	-	1	4
		<i>Ichthyophonus hoferi</i>	-	-	+	1	
		<i>Saprolegnia parasitica</i>	-	+	+	2	
	Crustacea	<i>Ergasilus</i> spp.	-	-	-	0	2
		<i>Argasilus</i> spp.	-	+	+	2	
	Helminthes	<i>Gyrodactylus</i> spp.	-	-	-	0	0
	Annelida	<i>Piscicola</i> spp.	-	-	-	0	0
% Invasion of Organ		Number of Fish Infected (Prevalence)	6	5	4		15
		Percentage Infected (%)	40.0	33.33	26.70		100

Key: + = present, - = Absent

Table 3. Parasitic burden (by taxa) of *Clarias gariepinus* from polyculture ponds (N = 15).

Parasitic Taxa	Number Infected	Percentage Infection (%)
Protozoa	15	100.0
Bacteria	6	40.00
Fungi	4	26.70
Crustacea	12	80.00
Helminthes	3	20.00
Annelida	2	13.33

The results show that *Clarias gariepinus* from the polyculture pond were infected by four groups (taxa) of parasites, namely protozoa, bacteria, fungi, and crustacea. 4 protozoan parasites isolated included *Ichthyophthirius multifiliis*, *Trichodina* spp., *Ichthyobodo* spp., and *Chlodonella* spp., while bacterial organisms included *Aeromonas salmonicida*, *Pseudomonas fluorescens*, *Mycobacterium tuberculosis*, *Listonella anguillarum*, and *Flexibacter columnaris*. 3 fungi organisms were isolated, including *Branchiomyces* spp., *Ichthyophonus hoferi*, and *Saprolegnia parasitictia* while the phylum Crustacea organisms included the organism *Ergasilus* spp.

The parasitic burden in terms of taxa of *Clarias gariepinus* (Table 3) shows that 15 specimens of the fish examined were all infected by the phylum Protozoa with percentage infection of 100%, 6 fish specimen were infected by bacteria out of a total of 15 fish samples with parasitic burden of 40%, 4 fish samples were invaded by fungi with percentage infection (parasitic burden) of 26.70%, the phylum crustacea were isolated from 12 out of 15 fish samples examined with parasitic burden (percentage infection) of 80%. Helminthic worms were isolated in 3 fish samples of *Clarias gariepinus*, constituting 20% in terms of percentage infection, while the phylum Annelida was isolated in 2 fish specimens, giving a percentage infection of 13.33%.

3. 1. 2. Prevalence of Parasitic Infection in *Clarias gariepinus*

The prevalence of parasitic infection in *Clarias gariepinus* is presented in Figure 2

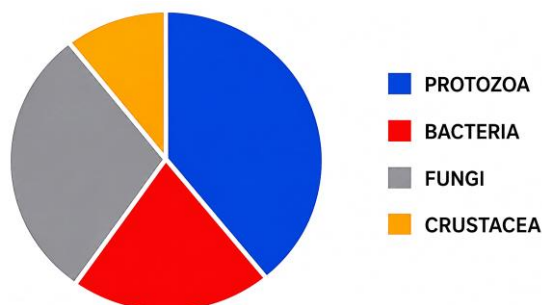


Figure 2. Pie chart showing the prevalence of parasites of *Clarias gariepinus* by taxa in a polyculture pond.

The results show that the phylum Protozoa invaded 4 fish samples out of 15, with a percentage infection of 26.7%, while bacteria attacked 5 samples given parasitic prevalence of 33.3%; 4 fish samples were invaded by fungi, with a parasitic prevalence of 26.7%, while organisms of the phylum Crustacea were isolated in 2 fish samples with a prevalence of 13.3%. Figure 2 summarizes these results.

3. 1. 3. Invasive Organs of *Clarias gariepinus* by Parasites in the Polyculture Pond

The rate of parasitic invasion of different organs of *Clarias gariepinus* under polyculture conditions is shown in Table 2 and Figure 3.

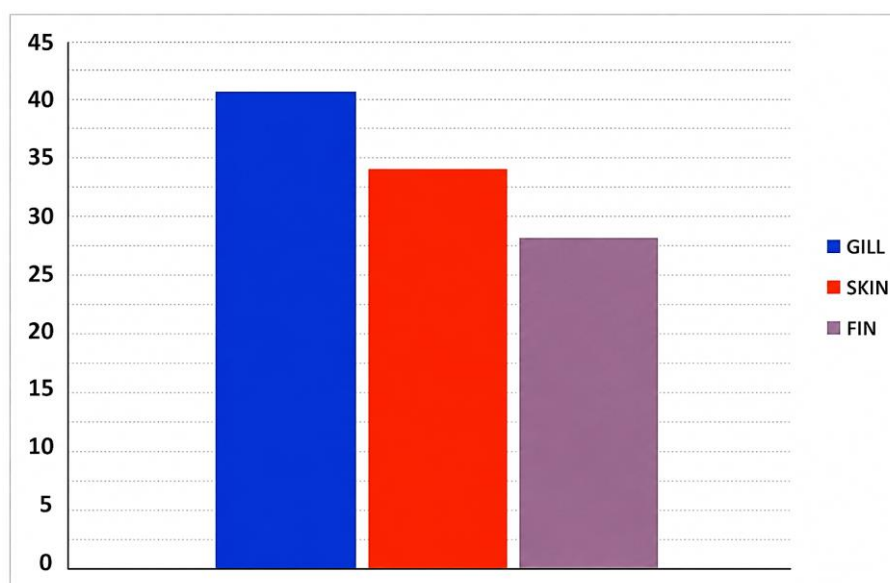


Figure 3. Multiple Bar Chart showing the rate of parasitic invasion of different organs of *Clarias gariepinus* in the polyculture pond

The results show that three organs of *Clarias gariepinus* - the gills, skin, and fin—were invaded by four groups of parasites, namely: protozoa, fungi, bacteria, and crustacea. Parasitic infestation in the gills was associated with 6 fish samples, representing a 40% infection rate. The skin was infected in 5 fish samples, accounting for 33.3% of the examined fish, while the fin was invaded in 4 fish specimens, with a percentage infection of 26.70%. This distribution indicates that the gills were the most heavily infected organ, followed by the skin and then the fin. The high rate of parasitic invasion in the gills may be attributed to the fact that gills are in direct and continuous contact with the surrounding water, and they serve as a primary site for gaseous exchange and filter feeding, thereby providing an ideal environment for parasite attachment and proliferation. The skin, being the outermost physical barrier of the fish, is also frequently exposed to parasitic infections, while the fins, although less exposed than the gills and skin, still harbored a considerable parasite load. It is noteworthy that the sum of the infected fish across the three organs equals the total number of fish examined (15), suggesting that every fish sampled had at least one organ infected by parasites.

This finding underscores the high parasitic burden in the polyculture pond and highlights the importance of organ-specific examination in parasitological studies. The multiple bar chart (Figure 3) clearly illustrates this distribution, with the gills showing the highest bar, followed by the skin and then the fin. Such organ-specific infestation patterns are critical for understanding the pathogenesis of parasitic infections and for designing targeted control and management strategies in polyculture systems.

3. 2. The Parasitic Burden and Intensity of Infection of *Oreochromis niloticus* from the Polyculture Pond

3. 2. 1. Parasitic Burden of *Oreochromis niloticus*

Tables 4 and 5 present the parasitic burden of *Oreochromis niloticus* in the polyculture pond.

Table 4. Parasites of *Oreochromis niloticus* from polyculture ponds and prevalence of infection (N=15).

	Kind of Parasite											% Invasion of Organ	
	Protozoa				Fungi			Crustacea		Helminthes	Annelida		
Organs	<i>Ichthyophthirius multifiliis</i>	<i>Trichodina</i> spp	<i>Ichthyobodo</i> spp	<i>Chilonella</i> spp	<i>Branchiomyces</i> spp	<i>Ichthyophonus hoferi</i>	<i>Saprolegnia parasitica</i>	<i>Ergasilus</i> spp	<i>Argasilus</i> spp	<i>Gyrodactylus</i> spp	<i>Piscicola</i> spp	Number of Fish Infected (Prevalence)	Percentage Infected (%)
Gill	+	+	+	+	+	-	-	+	+	+	-	9	60.0
Skin	+	-	+	-	-	-	+	-	+	-	+	5	33.33
Fin	+	-	-	+	-	-	-	-	-	-	-	4	26.70
Total	3	1	2	2	1	0	1	1	3	1	2	15	100
Taxa Total	6				2			4		1	2		

Key: + = present, - = Absent

The results show that *Oreochromis niloticus* from the polyculture pond were infected by 5 groups of (taxa) parasites namely protozoa, fungi, Crustacea, helminths and Annelida. 4 protozoan parasites isolated includes *Ichthyophthirius multifiliis*, *Trichodina* spp., *Ichthyobodo* spp, *Chlodonella* spp. while 3 fungi organism includes *Branchiomyces* spp., *Ichthyophonus*

hoferi, *Saprolegnia parasitic*, 2 phylum crustacea includes *Ergasilus spp*, *Argasilus spp*, 1 helminthic worm include *Gyrodactylus spp*. and annelida organism include *Pisciola spp*.

Table 5. Parasitic Burden (by taxa) of *Oreochromis niloticus* from polyculture ponds (N = 15).

Parasitic Taxa	Number Infected	Percentage Infection %
Protozoa	14	93.3
Bacteria	-	-
Fungi	2	16.7
Crustacea	9	60.0
Helminthes	5	33.3
Annelida	1	6.67

The parasitic burden in terms of taxa in *Oreochromis niloticus* shows that the 14 specimens of fish examined were all infected by the phylum Protozoa, with a percentage infection of 93.3%; none of the fish specimens here in *Oreochromis niloticus* were affected by bacteria; 2 fish samples were attacked by fungi, with a percentage infection of 16.7%; the phylum Crustacea was isolated from 9 out of 15 fish samples examined, with a parasitic burden of 60.0%. Helminthic worms were isolated in 5 fish samples of *Oreochromis niloticus*, constituting 33.3% in terms of percentage infections, while the phylum Annelida was isolated in 1 fish specimen with a percentage infection of 6.67%.

3. 2. 2. Prevalence of Parasitic Infection in *Oreochromis niloticus*

The prevalence of parasitic infection in *Oreochromis niloticus* is presented in Figure 4.

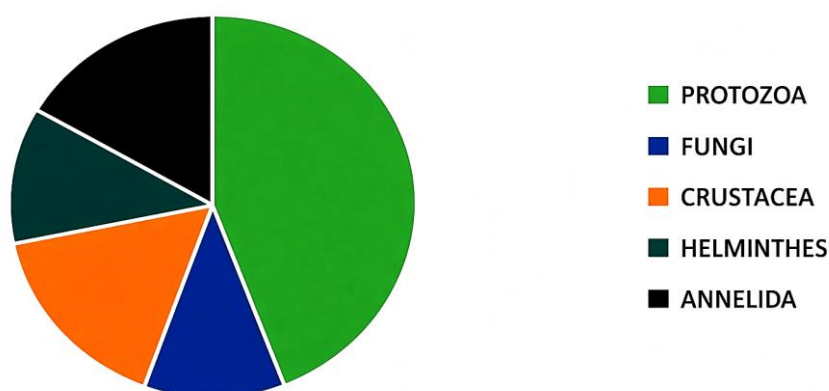


Figure 4. Pie Chart showing the prevalence of parasites of *Oreochromis niloticus* by taxa in a polyculture pond

The results show that the phylum Protozoa invaded 5 fish samples out of 18, with an infection rate of 90.0%, while fungi invaded 12 samples, giving a parasitic prevalence of 60.0%; organisms of the phylum Crustacea were isolated in 9 fish samples with infection percentages of 45.0%, and helminthic worms invaded 2 fish samples with 10.0% infections. The phylum Annelida was isolated in 1 fish sample with a prevalence of 5.0% infections.

3. 2. 3. Invasive Organism of *Oreochromis niloticus* by Parasite in the Polyculture Pond

The rate of parasitic invasion of different organs of *Oreochromis niloticus* under polyculture is shown in Table 5 and Figure 5.

The results show that three organs of *Oreochromis niloticus* — the gills, skin, and fin — were invaded by five groups of parasites, namely: protozoa, fungi, crustacea, helminths, and Annelida. Parasitic infestation in the gills was associated with 9 fish samples, representing a 60.0% infection rate. The skin was infested in 5 fish samples, accounting for 33.33% of the examined fish, while the fin was invaded in 4 fish samples, with a percentage invasion of 26.70%. This pattern indicates that the gills were the most heavily infected organ, followed by the skin and then the fin. The higher parasitic load in the gills could be attributed to their direct and constant contact with the pond water, as well as their role in respiration and filter feeding, which exposes them to a wide range of parasitic infective stages.

The skin, being the primary external barrier, also showed a considerable level of infection, while the fins, though less exposed, still harbored a notable parasite burden. The sum of infected fish across the three organs ($9 + 5 + 4 = 18$) exceeds the total number of fish examined (15), indicating that some fish had multiple organs infected simultaneously. This finding highlights the systemic nature of parasitic infections in *O. niloticus* under polyculture conditions and reinforces the need for holistic health management strategies that target multiple organs rather than focusing on a single site of infection.

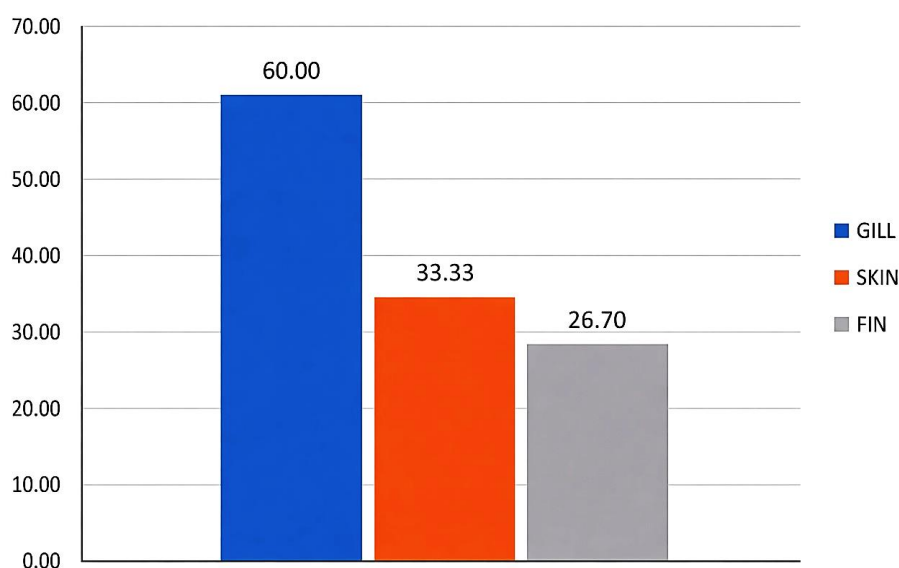


Figure 5. Multiple Bar Charts showing the rate of parasitic invasion of different organs of *Oreochromis niloticus* in a polyculture pond.

3. 3. Comparative Analysis of Parasitic Burden by Taxa of *Clarias gariepinus* and *Oreochromis niloticus* in Polyculture Ponds (Values = $\bar{X} \pm \text{SD}$ from Duplicate Samples)

The comparative analysis of parasitic burden by taxa of *Clarias gariepinus* and *Oreochromis niloticus* under polyculture conditions, as presented in Table 6, shows that the phylum Protozoa infected all 15 (100%) fish samples of *Clarias gariepinus*, while in *Oreochromis niloticus*, 14 (93.3%) fish were infected. There is no significant difference ($P>0.05$) in the rate of infection by protozoa in the 2 species of fish. For bacteria, 6 (40.00%) fish samples were infected, while in *Oreochromis niloticus*, 2 fish samples (16.7%) were infected, which was significantly different ($P<0.05$) from *Oreochromis niloticus*, which was infected with only 2 specimens (16.7%) infested by bacteria. For fungi, 4 (26.70%) of fish samples of *Clarias gariepinus* were infected, while in *Oreochromis niloticus*, 2 fish samples (16.7%) were infected, which was significantly different ($P<0.05$). For Crustacea, 12 (80.00%) fish samples of *Clarias gariepinus* were infected, while in *Oreochromis niloticus*, 9 (60.0%) were infected, which was significantly different ($P<0.05$). While in helminths, 3 (20.00%) specimen where infected in *Clarias gariepinus*, while in *Oreochromis niloticus*, 5 (33.3%) fish were infected, which was significantly different ($P<0.05$). Then, in Annelida, 2 fish specimens (13.33%) were infected in *Clarias gariepinus*, and 1 (6.67%) fish specimen of *Oreochromis niloticus* was infected, which was significantly different ($P<0.05$).

Table 6. Comparative analysis of parasitic burden of taxa of *Clarias gariepinus* and *Oreochromis niloticus* in polyculture pond (values = $\bar{X} \pm \text{SD}$ from duplicate samples)

Parasitic Taxa	<i>Clarias gariepinus</i>		<i>Oreochromis niloticus</i>	
	Number Infected	% Infected	Number Infected	% Infection
Protozoa	15	100.0 $\pm$ 0.00 ^a	14	93.3 $\pm$ 4.05 ^a
Bacteria	6	40.00 $\pm$ 3.0a	-	-
Fungi	4	26.70 $\pm$ 1.50 ^a	2	16.7 $\pm$ 0.65 ^b
Crustacea	12	80.00 $\pm$ 3.05 ^a	9	60.0 $\pm$ 2.25 ^b
Helminthes	3	20.00 $\pm$ 1.15 ^a	5	33.3 $\pm$ 2.00 ^b
Annelida	2	13.33 $\pm$ 0.5 ^a	1	66.7 $\pm$ 0.60 ^b

The mean values in the same row with different superscripts are significantly different at $\alpha = 0.05$.

3. 4. Parasites and Rate of Infection

The result shows that the *Ichthyophthirus multifiliis* was found to be of the most economic importance parasite to *Clarias gariepinus* which account for the highest parasitic load (% infection) with 4 (26.70%) which occurred on the gills, skins and find where chronic infection of the fishes were observed which is in agreement with the reposted work of Francis- Floyd and

Reed (1991), Meyer (1996) and Omeji (2011) who reported *Ichthyophthirius multifiliis* as the most prevalent parasitic infection on fish worldwide, hence they easily adapt to any environment and attach themselves to a host(fish) and circulates in a wider proportion. *Trichodina* spp. was observed to ingest only the gills, while *Ichthyobodo* spp., *Ergasilus* spp. and *Chlodonella* spp. did not infect any of the organs of the fish. The gills were observed to harbour the highest parasitic load, which could be as a result of the gills being the centre for filter feeding and also sites for gaseous exchange (Omeji, 2013; Bichon and Ibrahim, 2009). This is followed by the skin and then the fin.

The observation disagrees with the reported work of Omeji et al., 2011 who reported the highest load of parasites on the skin and not the gills, while it agrees with the reported work of Emere and Egbe (2006), who reported the highest load of parasites in the gills of *Synodontis Clarias*, and Njoku (2007), who reported the highest load of parasites in the gills of the same species. The heavy load of parasites on the gills relative to other parts of the body impaired the gills from functioning well as an organ for respiration; hence, death could result. This agrees with reported work of Borg (1960), Akoll et al., (2012), and Rahman (2002). The work also disagrees with the reported work of Hines and Spiral (1973), Iman and Dewy (2010), and Omeji et al., (2011), who reported the skin as the site with the highest load of parasites. They said this might be as a result of the skin being easily accessible to parasites due to their direct contact with the surrounding water.

3. 5. Rate of Parasitic Infection by Taxa

The study shows that protozoan parasitic taxa make up the highest infestation rate of parasites found to be prevalent in the fish pond. Protozoan parasites are of economic importance to the fish; hence, they easily adapt to any environment and attach themselves to a host (fish) and circulate in a wider proportion (Barzegar et al., 2023). Of all the parasites identified, *Ichthyophthirius multifiliis* was found in the gill, skin, and fin of *Clarias gariepinus*, while *Trichodina* spp. was identified only at the gill with a high occurrence of infection.

However, 80% of the bacterial parasites identified in *Clarias gariepinus* were found to gram negative which includes *Aeromonas salmonicida*, *Pseudomonas fluorescens*, *Mycobacterium tuberculosis*, *Listonella anguillanum*, and *Flexibacter columnaris*. The fungal parasites occurred mostly in secondary infections. This is because there occurrence are mostly as a result of existing injury, which weakens the host and exposes them to a secondary infection (Klinger and Floyd, 1996). In *Oreochromis niloticus*, the protozoan parasites identified include *Ichthyophthirius multifiliis*, *Trichodina* spp., *Ichthyobodo* spp. and *Chlodella* spp. which *Ichthyophthirius multifiliis* infected the gill, skin, and fin; *Trichodina* spp. was identified only on the gill. The Fungi infected the gill of the fish; the Crustacea infected the gill, skin, and fin of the fish sampled. Helminthic worms infected only the gill of the fish, and the Annelida infected the skin and fin of the fish sampled.

3. 6. Damaging Effects of Parasites

Several damages were observed to have been caused by the parasites found on the body Parts of the fish sampled. These caused restriction of oxygen flow from the water to the blood in the gills of infected fish. Bacteria and Fungi parasites like *Flexibacter columbaria*, *Mycobacterium tuberculosis*, *Saprolegnia parastica* and *Ichthyophonus hoferi* respectively also invade the fish more easily while it is impaired from the *Ichthyophthirius multifiliis* infection.

These damaging effects, which are the economic importance of parasites to the fish, result in the decrease in protein content of the fish, reduction in protein availability, reduction in total yield of fish production for consumption, and decrease in income and revenue (Omeji et al., 2011).

4. CONCLUSIONS

From the study at the Fisheries and Aquaculture Research Farm, Federal University of Technology, Owerri, 15 specimens were sampled for parasites of *Clarias gariepinus* as well as *Oreochromis niloticus*, and about 15 infections were identified. Among the 5 taxa (protozoa, Fungi, Crustacea, Helminthites, and Annelida) identified in *Oreochromis niloticus*, protozoa occurred most, while Annelida occurred the least. In *Clarias gariepinus*, protozoa occurred most, while Crustacea was the least. The gills, skin, and fin were the organs examined for parasitic infection; the gills accounted for the site with the highest parasitic infection (percentage occurrence).

Comparative analysis of parasitic burden of *Clarias gariepinus* and *Oreochromis niloticus* under polyculture conditions revealed that the percentage infection from the six taxa of parasites in *Clarias gariepinus* and *Oreochromis niloticus* were significantly different ($P < 0.005$) for *Oreochromis niloticus*, except for protozoa.

More research and studies on parasitic infection of *Clarias gariepinus* and *Oreochromis niloticus* should be encouraged and undertaken, so as to reduce the prevalence of these parasites in the pond. Though, many reports have indicated that *Clarias gariepinus* may have higher tolerance and resistance to parasitic infection than *Oreochromis niloticus*. Adequate care should be taken in the management of Aquaculture because this is where infections spread without being noticed, and also as a result of poor management conditions. New stocks should be quarantined before being introduced into the main pond with others so as to check the rate of parasitic infection, these could help in the reduction of parasites in the pond.

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