COMPARATIVE ASSESSMENT OF PARASITES AND BACTERIA ASSOCIATED WITH WILD AND CULTURED FISH IN SELECTED PARTS OF NIGER STATE

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MTech/SLS/2018/7949

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ABSTRACT

Parasites and pathogens in fishes are of great concern as they affect the host or consumers despite the high benefits of fish to man. This study assessed the parasites and bacteria infecting 5 different species of fish host over a period of 8 months to determine the prevalence of parasite and bacterial infection in the various fish host. Fish species include *Clarias garinpius*, *Heteroclarias sp* (hybrid), *Lates niloticus*, *Mormyrus rume* and *Bagrus bayad*, Fish specimen were collected using drag net, line and cast net. Sites examined for parasites were gill, stomach and intestine while the skin was examined for bacteria. Water samples were collected for determination of 10 water quality parameters. Results revealed significant variation in physicochemical parameters in both environments during the study period. Total hardness, conductivity, alkalinity and total dissolved solids contents varied significantly ($p<0.05$) across the months in both environments. There was significant monthly variation in body morphometries of the fish species throughout the collection period from both environments. Among the months, the highest microbial load was recorded in February 2020 (range = 94.75±49.73 to 131.80±7.36 x 10^6 CFU/g). Lowest microbial load was in August 2020 (range = 20.40±7.92 to 45.20±18.57 x 10^6 CFU/g). Analysis of parasites found in wild environment revealed significant ($p<0.05$) difference between parasite in fishes. *Opisthorchis sp* (21.49 %) was higher compared to other parasites species of which *Trichodina sp* (3.51 %) when the least of all. *Capillaria sp* from the ponds studied had higher percentage of infecting the fishes although pond B (58.33 %) recorded a little higher than pond A (50 %) followed by *Camallanus sp* with pond A (36.61 %) having higher percentage compared to pond B (16.67 %). C. *gariepinus* (75 %) had the highest number of parasite infection compare to *Heteroclarias* (25 %). This study revealed the presence of parasites and bacterial infection from the study areas which are indicators of potential organisms that can cause harm if not properly managed. Routen research is encouraged to monitor various water bodies either river, dam or pond in the State to reduce health risk, fish loss and economic loss.

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LIST OF ABBREVIATIONS

i. APHA - American Public Health Association
ii. EDIS - Educational and Developmental Intervention Services
iii. FAO - Food and Agriculture Organization.
iv. FDF - Federal Department of Fisheries
v. SON - Standard Organization of Nigeria
vi. USEPA - United States Environmental Protection Agency

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Fishes are found both in lentic and lotic environment making it easily accessible, At least 32,000 fish species show greater species difference than any other group of vertebrates (Fish Base, 2011). Ashade *et al*. (2013) reported that fish act with different levels of food chain and control the formation of small streams, becks and coastal water body since they are usually limited to a particular way of life related to their food sources and reproductive requirements.

Fish is an important part of a healthy diet that provides nutrients and micronutrients that are necessary to build the cognitive and physical development in human especially children. It is one of the cheapest source of protein that man can get as both the rich, middle class and poor citizens can afford it. Fish is not only rich in protein but the oil contains Omega-3-essential fatty acids. Majority of Nigerians eat fish as one of their main requirement for protein because of its balanced amino acids contents, digestibility and low cholesterol level (Bichi and Yelwa, 2009; Ebewore,2013; Ejere *et al.*, 2014; Agbabiaka *et al.*, 2017).Report from healthfacts.org says fish provides essential vitamins, minerals and oil vital for human balanced diets. The food and agricultural organization (FAO, 2010) recorded that in some densely populated counties where overall protein intake may be low, fish proteins consumptions are essential and critical in their diet because of it health benefits for adults and children especially the fish oil which is known for lowering the possibility of coronary heart disease (CHD). Compared to beef, pork and different animal sources of protein in Nigeria, fishes are excellent, cheap source of protein (Akinrotimi and Olaleye, 2011).

According to Okafor (2010), promotion of fish farming has been advocated as one of the means to make-up for the short fall in the protein requirements of the ever-growing Nigerian population. Economically, it is a source of income, with a nutrient profile superior to all other terrestrial meats, fish meat has a high digestible energy that can meet human nutritional requirements (Schonfeldt *et al*., 2013).The demand for fish keep increasing due to it oily flesh and low level of cholesterol which has being presented to be one of the promising aspect of investment in Africa as fish aquaculture over the years remain the most effective and dependable increasing food producing sectors, providing a decent addition and exchange to fishes in the wild (Adebayo *et al*., 2012). Miller (2011) mention that around 200 million Africans benefit nutritional security and food from the fisheries sector in addition, creates pay for more than 10 million individuals who are into fish production, processing and marketing.

Although like other living things, fish harbour parasites both external or internal which cause a host of pathological weakness in them. These parasites have huge effect on them and affect them negatively on profitability and cause animal ailment in different areas of the world (Onyishi and Aguzie 2018). Parasites live in close connection and obtain benefits like nutrition at the host's expense, normally without killing its host. They use energy meant for the growth, sustenance, development and reproduction of the fish hosts which may harm the hosts in various ways and affect fish production. The common parasites of fishes include the unicellular microparasites (viruses, bacteria, fungi and protozoans). Parasites are significant components of host biology, population structure and useful ecosystem. They can be seen in any fish species and within different wild and culture environments (Marshet, 2017). It is said that parasites are significant part of water environment and form an important role to aquatic life which influence their host or the environment directly or indirectly (Palm *et al*., 2011).

Parasitic infection is referred to disease condition in fish resulting from organism living in or on the fish. Parasites are invertebrate organisms of which some are free-living which eventually may become opportunistic parasites while the obligate parasites require hosts for their survival and reproduction. Either obligate or opportunistic, parasites are found in fish hosts though most parasitic diseases in fish are generally caused by the obligate ones (Ejere *et al*., 2014). Fish harbour parasites, many fish species serve as intermediate hosts for these parasites, carrying larval stages and sometimes involving man as the definitive host. Ratnabir *et al.* (2015) reported that growth retardation, tissue interruption, metabolic disturbances are cause by worm larvae on host fish and can results to death if the infections are heavy. Because of their frequent weaken in host immune system which can expose the fish to secondary infections, parasites in fish are of great concern, it usually results to low nutrient in fish and can lead to economic losses through mortality in fishes, growth reduction in fishes, increased susceptibility to its enemy and through high cost of treatment (Onyedineke *et al*., 2010; Omeji *et al.*, 2013; Salawu *et al*., 2013). In the tropics, parasitic diseases in fish are of particular interest as they are usually very common all over the world (Soliman and Nasr 2015). Different parasites are associated with different species in the aquatic environment causing different diseases, death and economic losses especially in aquaculture practices in different parts of the world (Biu and Akorede, 2013). Awareness is on the increase on the importance of parasitic diseases which is one of the major harmful factors in fish farming (Keremah and Inko-Tariah, 2013).

According to Omeji *et al*., (2011) in Nigeria, the major group of parasites of fish are helminths and protozoan. Helminths are parasites that are worm-like, they live by feeding on a living host to get nutrients and protection which may lead to sickness of the host. There are varieties of various worms from the very big ones to the microscopic ones. Helminths in a broad term means worm, they are completely invertebrates having long, flat or round bodies that infect their hosts, effects of this helminths can lead to physical, nutritional or cognitive weakening in growing children. Helminths parasites often occur within the viscera and body cavity of fish especially intestine therefore, they usually damage the gastrointestinal tract. Internal helminth parasites depend on the presence of swallowed intake of food materials in the cavity of the gut. In determining the type of parasite and it occurrence or existence in fish specimens, it all depends on some certain classes of nutrient and their various digestion and absorption site (Onyedineke *et al*., 2010). Bamidele (2015) stated that fish suffer from various diseases and parasitic infections, in many part of the world, due to increase in the world population, fish resources are used up at a very fast rate due to environmental degradation, increase in harvesting and pollution there for production of fish decreases and cannot meet the requirement of the large population, This brought about the increase in stakeholders involving in aquaculture, this initiative has been afflicted by the problems of overcrowding, poor conditions in the environment and pollution which often lead to decrease in immune system of the fish and increase susceptibility to parasites and pathogens (Biu *et al*., 2014).

Fish farming is from the lentic or lotic environments, an important source of protein on a global scale are fish and its products and an estimate of more than 30% of fish for man's consumption comes from the cultured environment. Fish products are significant not just because of it nutrients but can be seen as a means for international trade and foreign exchange for many countries at large. Fish and shell fish are extremely ephemeral and nuel to wide variations in characteristic due to difference in species, habitants, eating habits, they can also be carriers of microorganisms and other health hazards (Adebayo *et al*., 2012). According to Adebayo *et al.* (2012) Gram-negative bacteria which is the most common, Gram-positive bacteria and acid-fast bacteria are the aquatic bacteria that infect fish, they are obtained from food or from the environment. Most of the fish diseases in the tropical are caused by the gram-negative bacteria, some of which are opportunistic pathogens while others are obligatory pathogens. Apart from passing diseases to man, fish and shell fish are themselves subject to different diseases and are capable of causing different type of food borne microbial infections and intoxications. Fish ingest huge number of bacteria into their alimentary canal from water sediment and food (Adeleye *et al*., 2010). It has been established that both brackish and fresh water fishes can harbor human disease bacteria, especially the group called the coliform group. Faecal coliform in fish shows the volume of pollution in that environment (Adebayo *et al*., 2012). Ahmed-Hamid *et al*. (2012) mentioned that fish are vulnerable to pathogens and parasitic infections, an observation that depends on species of fish and type of water inhabited including certain values water quality such as dissolved oxygen, increased organic matter content and poor environmental conditions.

The effects of water pollution have great implication which cannot be over emphasized as waste water from municipalities may be sources of bacteria and other microorganisms capable of producing diseases in man and livestock (Odoh, 2009). Amadi (2011) revealed that where lotic water serve as source of drinking water and is being endangered through human activities, the quality of the water becomes necessary to be track to keep check. It is said that water generally is a very significant natural resource that call for suitable management in a way to protect its quality and sustainability. Palm *et al*., (2011) reported that one of the most unprotected system on earth that continue to face high anthropogenic stress in form of environment degradation is the aquatic ecosystem, he further stated that aquatic environment can be studied by regular monitoring of the physicochemical parameters. Physical and chemical characteristics like temperature, transparency, DO and nitrate are constant change that gives vital information on the quality of an aquatic environment. The physical characteristics of water are suspended solids, turbidity, colour, taste and odour and temperature. Characteristics of water are determined by senses of sight, touch, taste or odour which are physical parameters. Human consumption including other environmental use by humans are areas to look out for when studying water quality assessment. Anthropogenic activities have led to great pressure on most water body in our environments which subsequently has led to degradation of aquatic ecosystem.

1.2 Statement of the Research Problem

It has been reported that in Nigeria and the world at large, parasites and pathogens in fish remain a major problem confronting fish, these parasites could be internal (endo-parasites) or external (ecto-parasites). As reported by several researchers, Parasites serve as threat to human health which could lead to ulceration and blockage, economic loss to farmers, reduction in the availability of fish to humans it also increases the danger of fish parasite present in human meals (Onyedineke *et al.,* 2010; Biu and Akorede, 2013; Mokhtar *et al.,*2014; Sinaré *et al*., 2016; Onyishi and Aguzie02018). Fishes being an aquatic creatures depend on dissolved oxygen in water for their survival, due to anthropogenic activities, water quality increasingly deteriorates as water travels from one site to another site (Keke *et al*., 2015). Poor physicochemical quality of water can affect or change the parasite host equilibrium which can result to either disease or mortality in the population, sometimes it may only affect a particular species in the population (Ayanwale *et al*., 2014). Management practices of fish can affect the quality of its product. Various parasites and bacteria species are associated with fish which can lead to morbidity, mortality, economic and human losses. The villagers in

Zumba village where Shiroro dam is located are majorly farmers and rural activities such as agriculture, fishing, trading and other domestic activities takes place along the dam. However, there is dearth of information to establish or state the current health status of fish and the quality of water in the study areas.

1.3 Aim and Objectives of the Study

The aim of this study was to comparatively investigate the parasites and bacterial organisms infecting cultured fishes in Minna and wild fishes from Shiroro dam, Niger State, Nigeria.

The objectives of the study were to determine the

i. physicochemical parameters of the water in wild and cultured environments.

ii. morphometric parameters in wild and cultured fishes.

iii. isolate and quantify the pathogenic bacteria associated with wild and cultured fishes

iv. prevalence of parasites found in fishes from both environments.

1.4 Justification for the Study

Several researchers have reported fish morbidity and mortality due to their environmental habitants, feeding habits leading to parasitic and microbial infections (Ahmed-Hamid *et al.*,2012; Adebayo *et al*., 2012; Ashade *et al*., 2013; Ogbeibu *et al*., 2014; Okoye *et al.*, 2014; Bamidele, 2015). Fish is an important protein source and is being consumed by many in Nigeria and the world at large, hence the need for the present study to ensure healthy fishes in the study areas. Results from the study will bring to spotlight information on the parasites and pathogens from these three locations especially from the wild environment as there is little or no information about the parasites and pathogens infecting the fish species for proper monitoring of the dam which will help not just the fishes but other aquatic organisms inhabiting the environment. Also results of the study will play vital role in the management and conservation of fish in their environment. The study will also compute information about the water quality from the study areas of any buildup of certain parameters that may affect the lives of fishes or the aquatic environment. It will provide adequate information for the fish farmers on ways to improve fish health which will lead to better production and reduce morbidity and mortality in the field. Results from this present study will add to the pool of information on ground on parasites, pathogens and physicochemical parameters in Parasitology and Hydrobiology research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Fish and Fish Disease

In a simple term, Fish is a cold-blooded vertebrate animal that lives in water which moves around with the help of fins and breath with gills. Fish are important to people all over the world as a source of nutrition. Sigei (2017) mention that about 40% of all fish species are found in fresh water where they are subject to a wide range of diseases and parasites. Fishes suffer from several diseases and parasites like humans and other animals all over the world, fish protection versus disease are specific and non-specific. Non-specific protection include skin and scales and the mucus layer that is secreted by the epidermis which traps microorganisms and restrain their growth. If pathogens breaks these defences, then fish develops inflammatory reactions that increase the flow of blood to infected areas and free the white blood cells that try to destroy the pathogens (Coffee *et al.*,2013).Every fish carries either pathogens or parasites, usually this is at the expense of the fish, things that causes stress in fishes like natural droughts, pollution or predators, can also cause outbreak of several diseases in them. Disease is the main agent affecting fish mortality, most especially when fishes are young, they can however limit the influence of pathogens and parasites through behavioural or biochemical ways, such fish have reproductive advantages. When pathogens and parasites carried by introduced species affect native species, disease may become complex. An announced species may find invading easier if potential predators and competitors have been destroyed by disease. Pathogens which brings about fish diseases include: Viral infections like *Esocid lymphosarcoma*, Bacteria infections like *Pseudomonas fluorescens* leading to fin rot and fish edema, Fungal infections, Water mould infections like *Saprolegnia sp.*, Metazoan parasites such as small crustaceans, Unicellular parasites like *Ichthyophthirius multifiliis* leading to itching and some parasites like Helminths for instance nematodes.

2.2 Parasites of Fish

Since parasites are small animals, in order for them to complete their life-cycle they need one or more host animals because generally, they cannot live outside their host. Parasites presence may or may not cause health effects in the animal host. Parasites in fish are common natural happenings and they can provide information about host population ecology. For instance in fisheries biology, parasite population can be used to differentiate vivid populations of the same fish species co-inhabiting in a place. Parasites also have different specific traits and life-history strategies that makes them to colonize hosts. Even though they are considered generally to be harmful, the destruction of all parasites would not necessarily be beneficial. Parasites account for more than half of life's diversity as they execute an important ecological role by weakening their prey which might take some time for the ecosystem to adapt to and without parasites, organisms may eventually tend to asexual reproduction, reducing diversity of sexually dimorphic traits. Opportunity are provided by parasites for the transfer of genetic material between species. On rare but significant occasions, this may bring about evolutionary changes that would not otherwise occur, or that would contrarily take even longer (Holt, 2010). Symbiotic relationship between species is called parasitism in evolutionary biology where one organism which is the parasite lives on or in another organism called the host and causing it some harm which is adapted structurally to this way of life. Parasites may be ectoparasites which lives on the surface of the host body or endo parasites which may be occupying spaces in the host body (intercellular) or residing in cells in the host body (intracellular). Sigei (2017) mention that parasites make use of energy meant for the host growth, sustenance, development, establishment, reproduction and may harm their host in several ways which can affects the hosts production.

Roundworms (nematodes), flatworms or flukes (trematodes) and tapeworms (cestodes) are three types of fish parasites that are significant in public health. Human parasitic infection are usually from fresh water fishes. From human infection point of view, the most widespread roundworms in fish are from the family of Anisakidae and these include *Anisakis* spp., *Pseudoterranova* spp., *Phocascaris* spp. and *Contracaecum* spp. Liver fluke worms belonging to the family Opisthorchiidae are the most common flatworms or flukes associated to human infection and some other species of intestinal fluke worms belonging to the families Heterophyidae and Echinostomatidae. Human infections which is caused by fish tapeworm are majorly genus *Diphyllobothrium.* In Nigeria, protozoan and nematodes are said to be the major group of parasites of fish involved in parasitism (Omeji *et al*., 2011). Pouder (2005) revealed that fish hosts involve both living and non-living agents that can lead to parasite occurrence. The biotic factors include the age, size, weight, maturity and sex of the host including the parasite life cycle while air and water temperature, season, oxygen, pH and depth of water among others are the abiotic factors. Deterioration of the muscle, liver dysfunction, interference with nutrition, cardiac disorder, nervous system weakening, mechanical interference with pawning, weight loss and gross distortion of the body are all effects of parasite in fish. Other serious pathological disorders include inflammation and wither of the viscera, resulting from organs compression by the parasites often together with accumulation of blood stained ascetic fluid. In natural water bodies, parasitic infection is rampart which affect fish growth, development and reproduction. These diseases in addition to other factors causes steady decline in fishery resources (World book, 2016). Human health is also threatening due to occurrence of fish parasites in human food; this could lead to reduction in availability of fish for human consumption (Okoye *et al*., 2016).

2.2.1 Helminthes parasites

Helminthic parasites have been generally reported in fresh water fish by several researchers, these include: Monogeneans (flatworms), Trematodes (flukes), Cestodes (tapeworms), Nematodes (roundworms), Acanthocephalans (spiny headed worms), (Edeh and Solomon, 2016) mentioned that with the exception of the roundworms, all these parasites have a head region with a distinct attachment mechanism which is followed by a body region. These parasites could be free living in the environment which they are eventually picked up by an organism (its host). Others shows an indirect life cycle meaning that the parasite will transfer to a different host (usually involving a crustacean or insect vector) between different stages of its life in order to live. Humans can accidentally be infected with larval stages of nematodes, leadings to a serious disease known as *Anisakidosis*. *Anisakidosis* is a zoonotic infection which causes stomach pain, fever, diarrhea and vomiting. Although helminth infection is asymptomatic and tolerated by the host. sub-clinical infections have been linked with significant loss of condition in infected host. Clinical signs of infection depend on the site and length of time of infection. Either larval or adult nematodes moves and lodge within tissues causing inflammation, hindrance, dropsy, lesions, anemia and granuloma (Sigei, 2017).

2.2.2 Parasites of nematode

Nematodes are described as smooth, cylindrical and relatively long worms. Roundworms as they are called, infect different species of aquaculture and wild fish. Few numbers of nematodes often occur in healthy fish, but when it becomes high in number it causes illness or even death. In aquaculture systems, brood stock infected with a small number of nematodes may not even show signs of illness, but often reduces reproductive capacity. On the other hand, juvenile fish infected by small numbers of nematodes are definitely likely to show signs of disease also have reduction in growth rates. Adult nematodes are typically found in fish digestive tracts. However, it all depends on the species of nematode and the species of infected fish, adult and other life stages of nematodes can be found in almost any part of the fish, including the coelomic (body) cavity, internal organs, the swim bladder, deeper layers of the skin or fins, and external muscle layers (EDIS, 2019). In aquaculture situations, once fish is fed with live foods containing infective life stages or if they are raised in culture settings that promote the growth of other animals that carry the infective stages of the nematode (vector) or allow nematodes to complete their life cycle in it intermediate hosts they become infected with nematodes. Transmission of some nematodes can be directly from fish to fish.*Eustrongylides, Camallanus* and *Capillaria* are the three common nematodes affecting fish (Soliman and Nasr 2015).

2.2.3 Parasites of trematode

Unsegmented flatworms are Trematodes belonging to Phylum Platyhelminthes, Class Digenea, from Heterophyidae family. Many species of trematodes exit, and they can commonly be seen on the body of fish as "black spots", also they can appear as small white, yellow or black spots in the skin or fins and fish muscles. The spots are the immature stage (metacercaria) of the parasite, which must be eaten by a bird before developing into adult trematodes. Adult trematodes in the bird produces eggs which are shed into the environment. Eggs then hatch to form a swimming miricidium stage which infects the third host called snail. Within the snail host, the trematodes multiply and change into cercaria which swim out of the snail to find a fish host. Depending on the trematode species, the cercaria infect fish and either mature to become an adult worms or become encysted as metacercariae. Unless they become seriously infected, fish are unaffected normally by immature stage of the worm. Adult worms barely cause harm to the host and can be found in intestine, stomach, blood, gall bladder, and urinary bladder. Metacercariae are the main source of illness and can be found in skin, gills, fins, muscle and internal organs. Commonly encountered species include: *Neascus sp.*, *Apophallus brevis*, *Cryptocotyle lingua* (Fish Pathogens, 2019). Monogenean trematodes are also known as flatworms or flukes, they usually infest the gills, skin, and fins of fish. Monogeneans have a direct life cycle as they have no intermediate host and are host- and site-specific. Freshwater fish plague with skin-inhabiting flukes become lethargic, swim near the surface, seek the sides of the pool or pond, and their craving decreases. The skin where the flukes are attached shows areas of scale loss and may secrete a pinkish fluid. Swollen and pale gills sometimes, increased in respiration rate may occur, low oxygen conditions tolerance. Large numbers of monogeneans on both the skin or gills could result in large damage and mortality. Monogenean tissue damage lead to secondary infection of bacteria and fungus. *Gyrodactylus* and *Dactylogyrus* are the two most occurring genera of monogeneans that infect freshwater fish. Eyespots absent in *Gyrodactylus*, two pairs of anchor hook present, and are usually found on the skin and fins of fish while *Dactylogyrus* prefers to hook to gills, two to four eyespots present, one pair of big anchor hooks present (Soliman and Nasr 2015). Digenean trematodes have a complicated life cycle which involve a number of hosts. Depending on the digenean species, fish host can be primary or intermediate host, they can be found either on the surface or within any organ, although disease by majority digenean trematodes is limited to the host. In ornamental fish industry, digenetic trematodes from the family Heterophyidae, have been responsible for existing death in cultured fish. These digeneans become enclosed into gill tissue and eminent respiratory distress. *Posthodiplostonum* or the white grub is another example of a metacercaria that can cause problems in pond fish, this has caused deaths in baitfish, but usually the only negative effect is reduction in growth rate in the affected fish, even when there is increase in infection rate. In situation where death occur, there are unusually high numbers in the eye, head, and all over the visceral organs *Clinostonum* is another fluke usually called yellow grub. It is a big trematode though it does not cause any major problems in fish, it is easily seen and make fish unmarketable for aesthetic reasons.

2.2.4 Parasitesof cestode

Cestodes or tapeworms are many species of flat worms that lives in human gastrointestinal tract. The adult worm, which is segmented is usually attach to the wall of the intestine. *Diphyllobothriasis* occurs worldwide, especially where cool lakes are contaminated by sewage. The tapeworm may reach a length of 30 feet (9 meters). They are ribbon-like worms. Diphyllobothriidae are many members of the Cestode family known to infect humans, Cestode are divided into two classes; Pseudophyllidean and Cyclophyllidean. Scolex bearing bothria (grooves) present in Pseudophyllidean cestodes instead of suckers as in the Cyclophyllidean cestodes, the group include nearly all human-infecting species (Center for Disease Control and Prevention). Plerocercoids are larval cestodes and are the most damaging parasites of fish in freshwater. Plerocercoids reduces carcass value when present in the muscle, and reduces reproduction when they infect gonadal tissue also the cestode can destroy vital organs such as the brain, eye or heart. Members of human *diphyllobothriid* infections have aquatic life cycles and transmission happens via ingestion of raw or undercooked fish. Usually the tapeworm sucks up the nutrition from the food that an infected person eats. This may lead to pernicious anemia caused by vitamin B_{12} deficiency others effects include intestinal blockage, gallbladder disease (Soliman and Nasr 2015).

2.3 Parasites of protozoa

Protozoans are one of the known encountered fish parasites, they are single-celled organisms of which many are free-living in the aquatic environment. Normally no intermediate host is needed for the parasite to reproduce which means they have direct life cycle. They can increase in numbers when fish are crowded which can lead to weight loss, weakness and death. Five groups of parasitic protozoans include: Ciliates, Flagellates, *Myxozoans*, *Microsporidians*, and *Coccidians* (Soliman and Nasr 2015). Ciliates are organisms having tiny hair-like structures known as cilia which they used for feeding or locomotion. Majority live in pond-reared fish; they have a direct life cycle. Many of the species in small numbers do not disturb their fish host until they become large in their numbers. Ciliates are transmitted from pond to pond by nets, hoses, caretakers wet hands easily. Some examples of Ciliated Protozoan Infections are: *IchthyophthIrIus multIfIlIIs*: This disease called “Ich” or “white spot disease” has been a difficult disease to the aquarists to solve for years. Infected fish normally develop small blister-like raised injury along the body wall or fins. If the infection only affects the gills, there will be no white spots seen. Usually gills will be covered with thick mucus and appear swollen. *Tetrahymena* are teardrop-shaped ciliate that moves on the outside of its host and its usually seen living in organic debris at the bottom of an aquarium. *Chilodonella* is a ciliated protozoan that causes infected fish to secrete excessive mucus. It is a big, heart-shaped ciliate (60 to 80 m) with bands of cilia along the long axis of the organism. *Trichodina* is one of the most occurring ciliates seen on the skin and gills of pond-reared fish although lower number are not injurious but when fish are crowded or stressed, and water quality worsen, this parasite multiplies quickly and causes serious damage, fishes that are heavily infested cannot eat well, loses condition and become weak fish easily expose to opportunistic bacterial pathogens in the environment. *Epistylis* are stalked ciliate that stick to the skin or fins of the fish host. *Epistylis* is a major concern than many of the ciliates because it is believed to secrete *proteolytic* ("protein-eating") enzymes that create injury, fit for spread of bacteria at the attachment site. Flagellated protozoans are small parasites that can infect in or outside of fish. The parasite moves in a whip-like or jerky motion either with one or more flagella, regular flagellates that infest fish are as follows; *Hexamita spironucleus* which are microscopic intestinal parasite that are usually found in the intestinal tract of fish in freshwater. Infected fish are extremely thin and the abdomen may become swollen. A yellow mucus-like material may be seen in the intestines. Recent studies in taxonomy labeled this intestinal flagellate of freshwater as *Spironucleus*. The flagellates are found when the mucosa (intestinal lining) is broken moving spiraling. *Cryptobia* is a flagellated protozoan common in cichlids which is usually mistaken for *Hexamita* because they appear similar. However, *Cryptobia* are seen to be more drop-shaped, with two flagella, located on each end. The difference is that *Cryptobia* "wiggles" in a dart-like manner and *Hexamita* "spirals". *Cryptobia* usually is associated with granulomas in which the fish "walls off" the parasite. These parasites are noticed primarily in the stomach, though may be present in other organs. Fish suffering from *Cryptobia* may become thin, sluggish and develop a dark skin pigmentation. *Piscinoodinium is* an immobile flagellate that attaches to the skin, fin, and gills of fish. "Gold Dust" or "Velvet" Disease is the common name given to *Piscinoodinium* infection. This parasite has an amber pigment that is seen on heavily infected fish. Fish affected usually flash and stop feeding then die. Young fishes are mostly pathogenic to *Piscinoodinium*. *Myxozoa* are parasites affecting a large range of tissues. Two classes of *Myxozoan* are the

Myxosporea and the *Malacosporea* having around 64 genera with approximately 2000–2500 species, *Myxozoans* have been described in hosts from tropical, temperate and Polar Regions. These parasites are commonly scattered in native and pond-reared fish populations and are extremely plentiful and are distinct organisms. *Microsporidians* are intracellular parasites that need host tissue for reproduction. Fish get this parasite by eating infective spores from infected fish or food. Replication within spores (schizogony) leads to enlargement of host cells (hypertrophy). Infected fish may develop small tumor-like masses in different tissues. *Coccidia* are potential pathogens and they are intracellular parasites which are seen in freshwater and pond fishes. Infection sites include reproductive organs, liver, spleen, and swim bladder, although, the most known species encountered in fish are intestinal infections. Inflammation and death of the tissue may occur which can affect organs from functioning.

2.4 Parasitic crustacean

Parasitic crustacean is also a serious problem in rear fishes and can impact large populations. Most parasitic crustacean of freshwater fish can be noticed without a microscope as they are attach to the gills, body and fins of the host. Three major genera include: *Ergasilus* which are often seen in freshwater or rear fish incidentally and may cause little problems in small numbers. However, their feeding activity causes severe focal damage and heavy infestations lead to weaken of infected fish. Most *ergasilus* affect the gills of freshwater fish and are mostly seen in warm weather. *Argulus* or fish louse is a macro parasite that attaches to the outer surface of the host and can be seen easily with a naked eye, although *argulus* is uncommon in freshwater aquarium fish but may occur if wild or rear fish are introduced into the tank. *Lernaea* also called anchor worm is a known parasite of goldfish. *Lernaea* female are the ones that usually enter under the skin of fish and differentiates into an adult. Heavy infections lead to weaken and secondary bacterial or fungal infections of the fish.

2.5 Parasitic Fauna of Freshwater Fish

According to Agbabiaka *et al.*, (2017) unlike other animals, some fishes are afflicted by ectoparasites or endoparasites, mostly protozoans and helminths causing death. Cultured and wild fish are host of different parasitic species that causes large number of mortalities. The consequences of the parasitic infections on fish cannot be overemphasized as the study of fish has become very important since the parasites affect fish production directly by inducing stress and disease conditions in fishes, these diseases cause sluggish behavior, swirling, spiral or erratic movements, gill damage, white nodules on the gills. Parasite and disease associated with fish remain a major problem of the fishery sector to be address as an important constraint in improving the productivity of the sector in both wild and cultured fish, these parasites compete in feeding thereby denying the fishes of essential nutrients and hinders growth that may lead to diseases and deaths which results to economic losses. Three under intensive fish culture conditions, parasites tend to spread rapidly because of compromised water quality and other stress imposing factors. El-Shahawy *et al.*, (2017) in a review on endoparasitic fauna of some commercially important fishes of the River Nile, Southern of Egypt reported that fish parasites and diseases make up one of the most significant problems facing fish farmers today as the pathological conditions that result from parasites and pathogens causes high number of epidemics under crowded and other unnatural conditions. According to Thomas (2014) parasites does not just affect the existence of fish directly by reducing fish size or changing its behaviour or exposing them to infection but can also lower it ability for swimming, decreases their growth rate and increases their chances to deaths.

Simon-oke (2017) reported that at most one parasite host nearly 50 to 90% of freshwater fish, if not controlled it can lead to disastrous proportions due to losses gotten from these parasites existing in large density conditions. Even though only little infectious agents in fish are able to infect humans, some exceptions exist that may result to mortality. However, the biggest risk to man's health is due to eaten raw or not well processed fish and fish products (Adebayo *et al*., 2012; Adedeji *et al*., 2012).Zoonotic diseases that result from the ingestion of raw or undercooked fish include *opisthorchiasis, diphyllobothriasis, clonorchiasis, gnathosomiasis, helminthiasis* and *anisakiasis* (Ito, 2014), though the role of freshwater fish in transmitting parasites to humans had been known for a long time (Ogbeibu *et al.*,2014),According to Bekele and Hussien, (2015) awareness of fish parasites have been established both in cultured and wild fish as attention have been moved to fish parasites because of the increased in aquaculture practices, Reports of fish parasite from various rivers, streams and dams and many other freshwaters have been documented in Nigeria by several researchers from different parts of the world (Onyedineke *et al.*,2010; Omeji *et al.*,2013; Biu *et al.*,2014; Ito, 2014; Sinaré *et al*., 2016; Onyishi and Aguzie2018).

Okoye *et al*. (2016) reported some parasites from three different ponds in*Clarias gariepinus* from the western part of Owerri. Smears from intestine, stomach, liver and kidney were used for the examinations using staining method (Giemsa stain) of which the stomach had the most endo-parasitic invasion. 5 endo-parasites were identified and isolated, they include Nematode: *Contracaecum* sp (11.67%), *Camallanus* sp (48.33%), Protozoa: *Cryptobia iubilans* (40%), *Trypanosoma* sp (35%), *Acanthocephalans*: *Acanthocephalus* sp (21.67%).Bigger fishes were observed to harbor higher endoparasites than the smaller ones. Ecto and endo parasites of *Tilapia Zillii* (Gervias) was examined in Tiga Lake, Kano, Northern Nigeria, between July, 2007 and June 2008 for parasites by (Bichi and Yelwa 2009), 782 (53.4%) were infected out of 1800. *Clinostomum* spp. 74(4.1%) was the least parasite, *Procamellanusspp*. 111 (6.1%), while Protozoa Cyst 198 (11.0%) was the highest parasites recovered. Also adult fishes were more infected than the younger ones, it was noticed that parasites increase with length and body weight. Tachia *et al*. (2010) also carried an examination on ectoparasites of *Clarias gariepinus* gotten from the University of Agriculture research fish farm, Makurdi. Benue State, Nigeria in the month of October – December 2010. Of the one hundred and twenty (120) fish samples examined, it was recorded that 40 (33.3%) were invaded and were seen to harbour forty-three (43) ectoparasites. Ectoparasites include; *Pisciola geometra* 59.1% while Midge larvae had 40.9%. These parasites were noticed to appear only on the skin of the infected fish. In the study, the male species were more infected (65.12%) compare to the female species (34.89%). Bigger fishes were also seen to have higher ectoparasites than the smaller ones as observed by Okoye *et al*., (2016); Bichi and Yelwa, (2009) in Owerri and Kano respectively. Fish gastrointestinal parasites isolated from Ebonyi River at Ehaamufu, Enugu State, Nigeria by (Onyishi and Aguzie2018) shows that 78(65.0%) were infected out of 121 examined from February to July 2016. parasites isolated from this study were of three species, *Camallanus* sp., *Neo echinorhynchus africanus* and *Acanthocephalus* sp. *Camallanus* sp was higher compared to *N. africanus* and *Acanthocephal* sp which were slightly lower. In this investigation, infection was not significantly dependent on sex or season sampling. Agbabiaka *et al.* (2017) reported parasitic infection in African catfish within Owerri Metropolis. In the study, Dinoflagellate *Piscinoodinum* sp (88.30%) was more common followed by *Ichthyobodo necator* (11.70%). Meanwhile the highest endoparasite residing in the stomach and intestine of the fish sampled were *Camallanus anabantis* (29.16%), followed by *Camallanus pearsei* (20.83%) though intestine harbored the highest number of parasites compared to the other parts of the sampled fish. while *Trypanosoma* (2.08%) was found to be the least endoparasites from the sampled fish blood. Statistical analysis revealed low but positive correlation between the ecto and endoparasites infection among the investigated fish farms. *Oreochromis niloticus* was investigated over a period of two months and low rainfall by (Ashade *et al*., 2013), Epe water side, Ikorodu river and Makoko water side was used for the study, adult and juvenile fish were selected randomly from the three river systems in Lagos State, Nigeria. Parasites identified include Cestode, Digenea, Monogenea, Protozoa and Nematodes. From the study, Nematode spp were more predominant followed by Protozoan spp. Nematodes identified were *Capillaria* sp, *Camallanus* sp, *Contracaecum* sp,, *Eustrongylids* sp, *Trichris* sp and *Philometra* sp. Cestodes identified are *Diphylobothrium latum* and *Bothricephalus* sp other parasites encountered were *Clinostomum, Marinatum* and *Heterophyes* sp all digenetic trematodes. This study revealed that the prevalence in infestation of parasites increased with age, size and length of the fish. Edeh *et al*. (2016) worked on Endoparasites of *Oreochromis niloticus* and *Clarias gariepinus* found in Utako flowing gutter using standard parasitological methods. A total of 120 fish (60 each) was sampled. The results of this work revealed that of the total number of the African sharp tooth catfish (*C. gariepinus)* examined, 21(35%) were infested with 2 classes of parasites Nematodes (*Polyonchobothrium latum*) and Cestodes (*Diphyllobothrium latum* and *Procamallanus* spp) while Nile Tilapia (*O. niloticus*) was infected with only one class of Cestodes parasite (*Diphyllobothrium latum*) 14(23.33%). However, there were no significant difference between the prevalence of infection in sex, length and weight of fishes examined. A total number of 60 specimens of *Clarias gariepinus* (Clariidae) was selected randomly from a man-made pond in Kubwa for the examination of Endo

Parasites by (Ikechukwu *et al.,* 2017). Three Cestode helminths and a Nematode were recovered these include: *Polyonchobothrium Clarias, Stocksia pujehuni, Wenyonia acuminate* and *Paracamallanus cyathopharynx* including a round worm. The study revealed that the nature of the man-made, physical and physcio-chemical of the pond influenced the prevalence of endoparasites of *Clarias gariepinus* and the high prevalence of the parasites also the results showed that the female had higher level of infestation than the male. Gastrointestinal Parasites of Fish as Bio-indicators of the Ecology of Chanchaga River, Minna, Niger State was carried out over the period of 4 months, (Omalu *et al*. 2017) examined 100 specimens of 4 fish species; *Tilapia zilli, Auchenoglanis occidentalis, Clarias gariepinus* and *Mormyrus rume.* Parasites found include Nematodes (52.00%) with mean intensity of (57.03), Cestodes (28.00%) having mean intensity (4.14) and some unidentified species of insects and Copepods were recorded as (12.00%) and mean intensity as (7.85). Result from the study shows the presence of gastrointestinal parasites in fish indicating that Chanchaga River is slightly polluted. From the study it was stated that fish parasites are of specific interest in relation not only to fish health but also in the understanding of ecological problems, at the end of the study, it was established that gastrointestinal parasites are present in fish from Chanchaga River. A survey was undertaken by Okoye *et al.,* (2014) to study the abundance and seasonality of fish parasites from Agulu Lake, Southeast Nigeria. Total number of 1191 fish specimen from four families (*Cichlidae, Bagridae, Hepsetidae* and *Channidae*), seven genera and nine species were examined from the lake and examined for parasites. Eleven (11) species of parasites comprising metacercariae of three digenetic trematodes, one cestode, five nematodes and two acanthocephalans were isolated. Highest range of infection was *Clinostomoides* sp. while the operculum significantly had more worm burden compare to other sites. The study revealed that the high number of species of parasite and heavy worm burden is expressed through mean intensity and abundance of some species supports high productivity of the lake also the study shows the level of risk the fish species faced in the lake. Solomon and Olawale (2018) examined the prevalence of Ecto and Endo parasites in some fresh water fishes in Jabi Lake, Abuja, (FCT), Nigeria in the month July to September 2015. Total of four hundred and fifty (450) species were examined. *Clarias gariepinus*, *Chrysichthys nigrodigitatus, Tilapia zilli, Gnathonemus cyrinoides* and *Mormyrus deliciosus,* ninety (90) specimens each were the fish species examined with a total of 290 female and 160 male species. Results from the study revealed that parasitic prevalence of *C. gariepinus* female and male was 55% and 45%. *Tilapia zilli* female had 51% while male was 49%. For *C. nigrodigitatus*, female recorded 74% and the male was 60%. *G. cyprinoides*, female parasitic level was 37%, while the male was 62%, and for *M. deliciosus*, female parasitic level was 36% while the male was 64% respectively. Meanwhile Ecto parasites found include *Flexibacter litoralis, Argulus japonicas, Diplostomulum flexicaudum, Saprolegnia ferax* and *Ichthyophthirius multifilis* and some of the Endo parasites found are *Lingula anatina, Clinostomum marginatum, Diphyllobothrium latum* and C*ontraceacum spiculigerium.* Parasites of *Clarias gariepinus* and *Oreochromis niloticus* Polycultured in Earthen Ponds Nigeria was carried out by Uchechukwu and Okoli.(2019) in three large earthen ponds to examine the Ecto and Endoparasite of *Clarias gariepinus* and *Oreochromis niloticus* polycultured. The study reviewed that feeding pattern of the fish seems to influence the type of parasite that are harboured by the fish. The following parasites were recorded *Trichodina heterodentata. Camallanus polypteri Lernea cyprinacea, Dactylogyrus extensus, Gyrodactylus limnonephrotus* and leech. Another study of piscine ecto and intestinal parasites of *Clarias* species sold at Galadima road fish market, Kano metropolis, Nigeria was studied by Iman and

Dewu(2010), Nematodes (*Procamallanus* spp and *Cystacanthus* spp), Cestodes (Pleurocercoid) and Protozoa (*Ichthyopthirius* spp, *Trichodina* spp, *Eimeria* spp and *Chilodonella* spp) were parasites observed, Iman and Dewu reviewed that there is need for proper health inspection and control of the parasitic fauna by the government agency concerned as well as individuals. Helminth parasites of some freshwater fish from River Niger in Ihishi, Edo State was reported by (Onyedineke *et al.*, 2010), report from the study shows that the intestine was the preferred organ for infection for the helminth parasites although other organs like the gills and muscles were infected too. 71 fish samples belonging to 14 genera, revealed 60.6% prevalence infection including infection rate of 59.15%. Endoparasites identified include Cestodes (*Bucephalus sp,Proteocephalus sp, Diphyllobothrium sp*), Nematodes, Trematodes (*Paraamphistomum sp*) and Acanthocephalans(*Quadrigidae, Neoechinorhyncus*). Freshwater fishes in this study were *Synodontis eupterus, Lates niloticus, Tilapia galileus, Ctenopoma kingsleye, Distochondus engycephalus* and *Chrysichthys nigrodigitatus.* Fish of 10-30cm standard length shows high prevalence in parasites. Ekanem *et al.*, (2014) carried out a Parasitological examinations of 180 fish samples from Kwa River in Calabar, Cross River State, Nigeria. Fish species were *Clarias gariepinus, Heterotis niloticus, Chrysicthys nigrodigitatus and Tilapia galileus* respectively. Report from the study revealed that the intestine and stomach had more parasites. Nematodes (*Camallanus* sp), Cestodes (*Diphyllobothrium* sp) and some protozoan cysts were the parasites recovered from this study. (Ekanem *et al*., 2014) again investigated the abundance and prevalence of endoparasites of landed food-fishes from the Calabar River, Cross River State, Nigeria and the public health implications to fish consumers. Parasites recorded were Nematodes (*Camallanus kirandensis*), Trematodes (*Clinostomum complatanum*), Cestodes (*Diphyllobothrium latum*) and

Acanthocephalan (*Pomporhynchus laevis*). Preferred organs for these parasites were intestine and stomach. A total prevalence of 60% of *Bathygobius soporate*, 25%, *Synodontis clarias*, 15%, *Chrysicthys nigroditatus* and 10% of *Clarias gariepinus* was recorded.

Work has been carried out elsewhere on the identification of parasites associated with freshwater fishes by (Saha *et al*., 2011) in Agartala, India over a period of one year using five fish farms and four fish markets. 15 parasites were identified from the different fish and prawn specimens. Parasites include Nematodes, Acanthocephala Protozoans, Monogenea, Cestodes, Digenea and Anthropoda Crustecea. Also seasonal variation of parasitic infections in fish was conducted *Johniuss dussumieri* 534 individuals were studied from January 2015 to December 2015 for helminth infection. Of the 534 fish samples, 289 were infested with helminth parasite and prevalence rate was 63%. In August and September maximum prevalence of trematodes infection was 92% and 40% was minimum in January. Bozorgnia *et al*. (2012) isolated 30 species of parasites from twelve species of fishes collected from Gheshlagh (Vahdat) Reservoir, situated in Kurdistan Province, Iran, and recorded five species of protozoans, 15 species of monogeneans, a species of trematode, three species of cestodes, both nematode and acanthocephalan had one species, and four species of crustaceans. Rasouli *et al.*, (2012) recorded seven species of parasites from *Carassius carassius* collected from four rivers in West Azerbaijan Province in Iran, included three species of protozoans (*Chilodonella* sp., *Ichthyophthirius multifiliis* and *Trichodinia* sp.), (*Dactylogyrus* sp. and *Gyrodactylus* sp.) were the two species of monogeneans, one species of trematode (*Diplostomum spathaceum*) and a species of crustacean (*Argulus* sp.). Yakhchali *et al*., (2012) isolated three helminthes parasites from intestine of *Silurus glanis* collected from Zarrine-roud riverIran, included two species of trematodes (*Orientocreadium siluri* and

Crowcrocoecum skrjabini) and one species of cestode (*Bothriocephalus gowkongensis*). Raissy *et al*. (2010) recorded the ciliated protozoan *Ichthyophthirius multifiliis* from *Capoeta aculeata*, *C. damascina, C. capoeta, Barbus barbulus, B. grypus* and *Glyptothorax silviae* from Armand river in Iran and (El-Tantawy and El-Sherbiny, 2010) recorded three species protozoans from *Clarias gariepinus* collected from Nile Delta water near Mansoura city in Egypt, the protozoa included: *Trypanosoma alhussaini, Amphileptus* sp. and *Chilodonella hexasticha*. Dhole *et al*. (2010) carried out a study on parasitic helminth of four species of fishes collected from Marathwada region in India, and isolated *Allocreadium* sp. and *Orientocreadium* sp. (trematodes), *Senga* sp., *Circumoncobothrium* sp., *Lytocestus* sp. and *Gangesia* sp. (cestodes) and *Procamallanus* sp. (nematode). Enayat (2011) made a study on the protozoan parasites that infected two species of fishes *Sarotherodon galilaeus* and *Tilapia zillii*, from Damietta branch of river Nile, El-Sahel canal and Nile tributary in Egypt, and recorded Apiosoma piscicolum, A. conica, Scopulata epibranchialis, Ambiphrya ameiuri, Amphileptus sp., Chilodonella hexasticha, Tetrahymena corlissi, Trypanosoma mansouri, T. syanophilum and Trypanosoma sp.A cross-sectional study was conducted by (Tiya *et al*., 2019) during the month November, 2016 to April, 2017 to find out the prevalence, parasite genera and associated risk factors of fingerling fish parasites in small scale fish farms from South West Shewa Zone, Oromia. About 77.60% were infected with different parasites out of the total Nile tilapia sampled fish from the study. Prevalence of ecto-parasites (32.29%) was higher compare to the endo-parasites (20.31%) from the study. Different parasites belonging to various taxonomic groups were recovered from the infected fish sampled, these include *Trichodina* (8.85%), *Euclinostomum* spp (7.81%), *Dactylogyrids* spp (4.95%), *Plerocercoid* spp. (2.34%), *Acanthocephala* spp. (2.08%), *Contracaecum* spp. (2.08%), *Clinostomum* spp (1.30%)

and Black spot (0.52 %). The study recorded very high proportion of mixed infection (47.66 %). Distribution of parasitic genera was statistically significant (P < 0.05) in male and female, body weights, total lengths. Male fish (79.71 %), with body weight of 50-100 g (81.00 %), fish with total length of > 20 cm (92.00 %) were observed to be more infected with parasites. Higher prevalence of temporal variation in fish samples collected was observed from January-February (93.91 %). It was concluded that much attention should be given to prevent and reduce parasite burden in the study area. Ratnabir *et al*., (2015) examined fishes in Dolu Lake, Silchar, Assam from three freshwaters. Three parasites were recorded. Infection rate was 62.5 % for females and male 45.45 % in *Notopterus notopterus,* for *Channa punctata* females had 31.25 % while males was 17.46 %, for *Heteropneustes fossili* 10 % females and 8.33 % males respectively. Results from the study revealed high parasitic infection in females than males also it was observed that the degree of infection increases with increasing length of *Notopterus notopterus*. In *Channa punctata*, the degree of infection was high in an intermediate length group while the degree of infection in *Heteropneustes fossilis* was higher in lower length group. However, different trends of parasitic infection were revealed in various sex and length groups of fish species at different seasons in the year.

2.6 Microbial Contamination of Fish

Pathogens: The most common disease initiation and primary focus alternation in infectious diseases are probably the Biological agents. In an aquatic environment, viruses, bacteria, fungi, protozoa, parasitic crustaceans, helminths and other worms are known to be the potential pathogens that are always present. The virulence or pathogenicity of any agent is a relevant factor when determining the health hazards, this depends on the physical or biochemical characteristic of the agent. Bacteria with flagella or with capsules are generally well fit to infest the host and oppose a diverse condition while other bacteria are able to develop toxins, which cause hemorrhage or affect the nervous system of the host. Microbial counts in food is occasionally used in the retrospective assessment of microbiological quality or to assess the presumptuous safety of foods. This method demand food sampling and microbiology analyses are performed which the results are assessed by comparing them with the already established microbiological specification (FAO, 2010). Microbial tests are carried out to examined the presence of pathogenic bacteria (*V. parahaemolyticus, E. coli*) or for microorganisms which shows indications of faecal contamination or any type of general contamination or poor hygienic practices (coliform bacteria, faecal *Streptococci*). Tivkaa and Sampson (2013) reviewed that bacterial agents are amid the highly known causes of diseases in warm water aquaculture that is stressed also aquatic microorganisms not only known to affect the quality of water but are known to be identified with the physiological conditions of the fish and the quality of fish after harvest. Fish health and it produce depends on the water quality from which the fish was harvested from. Some bacteria presence in fish could be beneficial to the fish itself while the presence of some bacteria species could lead to post harvest spoilage and unfavourable health conditions. The contamination of fish always comes from different sources as freshly caught fish from unpolluted water is mostly sterile. Depending on the environment where fishes are caught, contamination of the skin, viscera and gills differs also contamination of fish may be from the canoes or on land. Fish may get contaminated on land through unloading, sorting, filleting, gutting, portioning, packing and transporting. The application of a Good Manufacturing Practices depends on the level of contamination that will take place on board through eviscerating, rinsing and storage in ice. Uncontaminated fish in water may contain 10^2 CFU/ g and 10^3 CFU/ g on skin and viscera, respectively. In tropical and sub-tropical polluted waters, bacterial contamination may increase from 10^7 to 10^9 in the skin and viscera. Shellfish contains 10^5 bacteria per gram in cold water while that of warm water contains 10^5 to 10^6 bacteria per gram. Fresh fish gotten from warm tropical water may be infected with Gram positive bacteria such as Corynebacterium, Bacillus, and Micrococcus. When fresh fish is caught in an area that the water is polluted or treated unhygienically on land, such fish will be contaminated with pathogens like *Salmonella, Enterococci, Staphylococcus aureus, Clostridium botulinum* type E. the study of (Hamed *et al*., 2013) shows that *E. coli* and faecal coliform bacteria can be discovered in an unpolluted warm tropical waters and *E. coli* can survive for a long time in this type of environment.

Wamala *et al*., (2018) carried out a study on *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (African catfish) to identify the bacteria diseases infecting the sample species and to find out the antibiotic that can weaken the fish bacteria in Uganda. From 40 fish farms comprising of ponds, cages, and tanks a total of 288 fish samples and 8 wild water sites were collected with cation and bacteria were isolated from the head, kidney, liver, brain and spleen. Isolates were established by their distinctive feature, conventional biochemical tests and Analytical Profile Index test kits. Fish pathogens identified include *Aeromonas hydrophila* (43.8 %), *Aeromonas sobria* (20.8 %), *Edwardsiella tarda* (8.3 %), *Flavobacterium* spp. (4.2 %) and *Streptococcus* spp. (6.3%). Other bacteria isolated from the fish are *Plesiomonas shigelloides* (25.0 %), *Chryseobacterium indoligenes* (12.5 %), *Pseudomonas fluorescens* (10.4 %), *Pseudomonas aeruginosa* (4.2 %), *Pseudomonas stutzeri* (2.1 %), *Vibrio cholerae* (10.4 %), *Proteus spp*. (6.3 %), *Citrobacter* spp. (4.2 %), *Klebsiella* spp. (4.2 %) *Serratia marcescens* (4.2 %), *Burkholderia cepacia* (2.1 %), *Comamonas testosteroni* (8.3 %) and *Ralstonia picketti* (2.1 %). *Aeromonas* spp., *Edwardsiella tarda* and *Streptococcus* spp. It was revealed that the study was the first to confirm other bacteria species infecting fish. Study carried out by Tivkaa *a*nd Sampson, (2013) showed sum of heterotrophic bacteria count of pond water, skin, gills and intestine of *Clarias gariepinus* which ranged from 1.2 x 10^4 cfu/g in gills to 2.16 x 10^6 cfu/cm^2 on the skin while the coliform count total ranged from nil in pond water is 3.5 x 10^4 cfu/g of the gills. In the intestine of the catfish, *Salmonella* and *Shigella* count was higher from all the ponds investigated while the vibrio total count was higher in pond water and intestine of the catfish from all the pond stations but count was low in the gills and skin. The bacteria flora included *Streptococcus* sp., *Escherichia coli*, *Salmonella* sp., *Staphylococcus* sp., *Vibrio* sp., *Pseudomonas* sp., *Serratia* sp., *Klebsiella* sp., *Shigella* sp., *Enterococcus* sp. and *Proteus* sp. The highest frequency occurrence was *Enterococcus* sp. (77 %) followed by *Salmonella* sp. (75 %) while *Klebsiella* sp. had the least count of 8%. Bacteria flora from the study comprises of potential spoilage and pathogenic organisms that could establish public health risk and economic loss. Abu and Uwadirioha, (2016) studied bacterial load in the intestine, gills and skin of pond African catfish (*Clarias gariepinus*) from three different stations (Agip, Aluu and Woji) in Rivers State. The result from the study revealed that the species *Staphylococcus* had the highest bacterial count (42.9 %) while *Pseudomonas* spp. and *E. coli*. were the lowest (7.14 %). Intestine of the fish sampled from Aluu environment showed highest bacteria count ($0.0129 \pm 0.0040 x 10^5$ CFU/g) while the lowest count was recorded from the skin of sampled fish from Agip estate (0.0046 ± 0.0019 x10^5 CFU/g). *C. gariepinus* from all the three sampled areas revealed very high degree of bacteriological contamination in the different organs examined. It was concluded that these pathogenic organisms in the fish samples could constitute a serious threat and danger to its consumers. Danba *et al*., (2014) carried out a study to ascertain the quality condition of *Clarias gariepinus* comparing the pathogenic bacteria of two fish farms in Kumbotso

Local Government Area of Kano State, Nigeria. Different pathogenic bacteria were isolated and identify in the study. Skin (1cm^2) and gill (1g) were subjected to microbiological examination A total comprising. The highest mean of Aerobic plate count (APC) of the 132 samples was 1.2^6 x 10^4 cfu/1 m while the highest mean of *Escherichia coli* MPN/1cm^2 was 8.75. From the highest *Escherichia coli* (54.27 %), *Stapholococcu saureus* (22.48 %), *Pseudomonas aeruginosa* (10.85 %); *Salmonella paratyphi* (9.30 %) and *Enterobacter aerogenes* (3.10 %) were bacterial pathogens isolated. A case study of rural aquaculture projects feeding livestock manure to fish was carried out by Petronillah *et al*., (2014) in Zimbabwe to isolate and identify the pathogenic bacteria in edible fish. *Salmonella typhi*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* and *Enterococcus faecalis* were the human pathogenic bacteria isolated. It was revealed that these bacteria in fish sampled are indicators of organisms of faecal contamination or water pollution. Bacteria presence may represent a potential hazard to humans. It was observe that the bacterial load of the isolates from the study was markedly lower than the recommended public health and standard value of 5.0 x 10^5 CFU/ ml which many countries adopt. An in-vitro study was conducted to find out and establish the major bacterial contaminating *Clarias gariepinus* which had form an imported dietary intake of the people. Both fresh and smoked fish samples were gotten from three different markets in Minna Metropolis, Nigeria, the bacteria load of the fish samples were determine using the pour plate method. Gram-staining technique and biochemical tests was used for the Identification and characterization. In-vitro test result showed contamination of six bacteria species, these include *Staphilococcus aureus, Bacillus subtilis, Staphilococcus epidermis, Salmonella epidermis, Salmonella typhii, Streptococcus* spp. and *Shigella* sp. The mean bacteria load for the fresh fish was 1.84 x 10^6 cfu/ ml. while 2.06 x 10^6 for the smoked fish cfu/ ml (Ibrahim, 2014).

2.7 Water Quality Assessment

Water is very important to lives but known to be the most common way infectious diseases are being transmitted. Up to 80 % of all illnesses or ailment in the world is caused by inadequate hygienic measures and polluted water has estimated by World Health Organization (Ranjana, 2010). Ehiagbonare and Ogunrinde (2010) mentioned that fish reside in water and water quality in pond management is one of the most unnoticed aspect until it began to affect fish production. Furthermore, basically water quality is the makeup of water which must be present for favourable growth of aquatic organisms. Water quality is made up of physical, chemical and biological factors which determine the use of water for production of culture fish purposes, these factors include dissolved oxygen (DO), ion concentration (pH), hardness, turbidity, alkalinity, ammonia and temperature. However, parameters like biological oxygen demand (BOD) and chemical oxygen demand (COD) shows the level of pollution in a water body. Research work has been done and it is still on for different water environments in Nigeria and other countries due to anthropogenic activities by humans. Polluted water precisely interferes with the health of the fish therefore it can change the pattern and distribution of parasite in the water hence parasite infection in fish may occur. There is increase interest amidst scientists in the awareness about environmental pollution and its unfavourable influence on the biotic fauna world (Orina *et al*., 2014).

Palm *et al*., (2011) revealed that aquatic environment can be studied by regular monitoring of the physicochemical parameters since water ecosystem is among the most exposed structure on earth that continuously facing high stress due to human activities in the form of environmental degradation. Distinct changes in physical and chemical factors like the Dissolved Oxygen, temperature, transparency and nitrate gives a meaningful information about the quality of a water body. Amadi (2011) revealed that where river/water body becomes a source of drinking water and is being endanger due to activities by humans, the characteristic of such aquatic environment becomes necessary to monitor since water generally is a vital natural resource that needs standard management in order to safeguard its quality for man's welfare. Bayoumy *et al*. (2015) revealed that organic and inorganic pollutants introduced through various human activities reduces the quality of water in an aquatic environment while (Abdus-Salam *et al*., 2010) revealed how natural and anthropogenic activities like oil spills industrial, agricultural and domestic activities have negatively affected water bodies of five different oil producing communities' areas in Ilaje, Nigeria by assessing the physicochemical quality of the water. Further studies have showed that human activities and other natural processes such as transportation of weathering and sediment lead to waste products which later alter the quality of the water. Ewemoje and Ihuoma, (2014) carried out a survey on water samples collected from five different sampling locations to study the physicochemical changes in the quality of the surface water due to sewage discharges along river Zik in University of Ibadan, South-Western Nigeria, the collection over a period of three months was repeated three times. Entire mean values of some of the parameters recorded include p^H (6.1); BOD (381.1mg/L); DO (3.9 mg/L); EC (618.5µs/cm) and Nitrates (59.8 mg/L). the study revealed very high concentration of BOD, EC and Nitrates at the spot of sewage discharge into the water body with data result showing a noticeable deviation from the standard of WHO ($p < 0.05$) this means that sewage release due to different human activities along Zik river have polluted the water body and can lead to health and environmental hazards by the users. Most physicochemical parameters from downstream Kaduna River in Zungeru, Niger State, Nigeria carried out by Keke *et al*., (2015) revealed that (BOD, EC, P^H, Phosphates, Nitrates and water temperature) were within the acceptable limits for the requirement of aquatic life. Although, water transparency and DO fell short the recommended limits and it has been linked to anthropogenic activities by the water body, however, it was concluded that there should be support for proper monitoring of human activities along the river coast.

The Physicochemical parameters from five different LGA in Bayelsa State, Nigeria was carried out in earthen fish ponds for 5 months to ascertain the quality of the water for pond fish practice. Results from different sampling sites revealed variation in the values observed. Temperature values was from 24.9 ± 0.3^{o}C to 25.3 ± 0.30^{o}C, pH 6.24 ± 0.02 to 6.68 ± 0.10, Ammonia-nitrogen (NH_3-N), 0.34 ± 0.20-0.55 ± 0.20 mg/l, DO values were 2.8 ± 0.20 to 6.6 ± 0.18 mg/l, BOD range from 2.9 ± 0.60 to 4.52 ± 0.90 mg/l, Total alkalinity range 43.1 ± 18.093 to 70 ± 46.53 mg/l, TDS varied from 27.9 ± 4.7 to 145.40 ± 91.01 mg/l while Total hardness was 19.7 ± 4.144.3 ± 15.07 mg/l, Turbidity as 20.6 ± 3.2-45.1 ± 15.07 ppm, Electrical conductivity was from 117.3 ± 91.01378.4 ± 130.2 µmhos/cm. The values for NH_3-N were higher than recommended values for fish culture while those of other parameters is suitable for good fish production. Observations from the study state that practice without adverse effects posed by the quality of water can insinuate production of pond fish in some freshwater areas in Bayelsa State, Nigeria (Keremah *et al*., 2014). A design study to express the "water quality standard of River Panjkora at Lower Dir" was analyzed to assess the water temperature, pH, electrical conductivity, total dissolved solids, dissolved oxygen, total hardness, alkalinity, ammonia, sodium and potassium ions, lead, copper, zinc and nickel for a duration of six months (July to December 2012). The physicochemical parameters were within the recommended limits during the study period. However, pH and Ni parameters were beyond the limits permit for drinking water quality. Results showed different physical and chemical values which include: temperature (8-21 °C), pH (6.53-7.14), electrical conductivity (136.6-255 mg/l), total dissolved solids (86.33-175 mg/l), dissolved oxygen (6.23-8.33 mg/l), total hardness (90.44-138 mg/l), alkalinity (60.67-104mg/l), ammonia (00.81 mg/l), sodium ions (6.90-12.07 ppm), potassium ions (2.47-3.13 ppm), lead (0-0.43 ppm), copper (0-0.14 ppm), zinc (0-0.87 ppm) and nickel (0-0.18) were all within permissible limits of Pakistan National Environmental Quality Standards. The observed physicochemical parameters in the study are safe according to water quality standards of American Public Health Association (Muhammad *et al*., 2015).

2.8 Fish Specimen

The African catfish *Clarias gariepinus* (Plate 1) and *Heteroclarias* sp (hybrid) (Plate 2) belong to the family claridae. These species are the most popular fish food which is said to be one of the most important tropical fish in Nigeria for aquaculture farming. They live in freshwater and different types of man-made ponds. The fish was introduced all over the world in the early 1980's for the purpose of aquaculture. It is very common in swamps, lakes and rivers throughout Africa. *C. gariepinus* possess great promise in aquaculture farming in Africa because of its wide geographical spread, increase growth rate and it resistant to stress. It is well valued, highly priced and purchase by both fish farmers and consumers in Nigeria (Froese and Pauly, 2014).

Plate 1: ***Clarias garinpius***

Source: Field Photograph

Plate 2: ***Heteroclarias sp*** **(hybrid)**

Source: Field Photograph

Lates niloticus (Nile perch) is an important commercial freshwater fish species in Africa occurring commonly in all major river basin, they live in different kind of freshwater, warm tropical water favours this species of fish where they increase to large sizes and occur in high densities. The adults live in all habitats in lakes and rivers where there is sufficient oxygen with the restriction of rocks, swamps and the pelagic zone. The young of this species are restricted to shallow near shore environments. They are silver in colour with a blue tinge, they have a distinctive dark black eye with a bright yellow outer ring. Their diet consists of fishes, insects, crustacean and mollusks ((Fish Base, 2011).

Plate 3: *Lates niloticus*

Source: Field Photograph

Mormyrus species all belong to the family mormyridae. There are 200 known mormyrid fish species of Africa, *Mormyrus* species have electric organs which they used for communication and electrolocation. These organs are position in the caudal peduncle which ends in a forked tail fin which provides the main force for locomotion. The tail fin trunk muscles operate through tendons which passes through the electric organ, it does not carry mechanical functioning muscle cells itself but is stiffened by Gemminger bones. Mormyrids can be recognized easily in the field by their tail fin shape feature and by their swimming mode reminiscent of pikes. These genus *Mormyrus* have about 24 species and are notable from the rest mormyrids by their long dorsal and short anal fins. *Mormyrus* species are relatively big fishes, hence they are of commercial interest. *Mormyrus* species prefer deep water, and are hardly caught in great numbers (Kramer, 2013).

Plate 4: *Mormyrus rume*

Source: Field Photograph

Bagrus bayad belong to the family Bagridae. The Bagrid fishes are commonly known as naked catfishes. They have four pairs of barbells enriched with well-developed taste bud. *Bagrus bayad* is a benthic omnivorous feeder (bottom feeder) (El-Drawany and Elnagar, 2015).

Plate 5: ***Bagrus bayad***

Source: Field Photograph

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Study Area

Three locations were targeted for the study which include Shiroro dam in Zumba village, (Fig. 3.1)Water resources Aquaculture and Fisheries Technology Gidan kwanu (Plate 6), Federal University Technology Minna fish farm and Lapan-gwari fish farm all in Niger State (Plate 7). Shiroro dam (Plate 8a and 8b) is a man-made hydro-electric power generation dam of Kaduna River in Niger State. It is located on latitude 9°57´N Longitude 6°13´E having an installed power generating capacity of 600 MW (Kolo, 1996). The dam has a surface area of about 320 km^2, a maximum length of 32m and a total storage capacity of 7 billion m^3 (Suleiman and Ifabiyi, 2015). It is approximately 90km southwest of Kaduna town and 66km from Minna the Niger State capital. About 70 % of inflows into the reservoir is from River Kaduna, with lateral contributions from Rivers Dinya, Sarki-pawa, Erena and Muyi The climate of the catchment is consistent with the rest of the country, and Rainfall in the area is controlled by the maritime (Mt) air mass. During the dry season the area is control by the tropical continental (Ct) air mass. The dry season is between the month of November and March, while the rainy season starts in April or May and last till October (Jimoh and Ayodeji, 2003). Minna is located in the North Central geopolitical zone of Nigeria, is located on latitude $9^o36'$ north and longitude $6^o34'$east. It covers a land area of 88 square kilometers with an estimated human population of about 348, 788. The area has a tropical climatic condition with mean annual temperature, relative humidity and rainfall of 20-30 ^oC, 61 % and 1334cm respectively. The climate shows two separate seasons: rainy season is between May and October while dry season is between November and April each year.

The vegetation in Minna is a typical Guinea Savannah type consisting majorly of grassland with scattered trees (FDF Bulletin, 20).

The residents of Zumba village mostly use the dam for fishing activities, washing, bathing, and farming. There is a market along the dam where villagers bring their farm products and other things to sell every Saturday exposing the dam to anthropogenic activities like slaughtering of animals, pouring of different solid and liquid waste materials. Water resources, Aquaculture and Fisheries Technology FUT, Minna is a department in School of Agriculture and Agricultural Technology FUT, Minna, the fish farm though in small scale but is a source of income to the department. The Lapan-gwari fish farm is a big scale business with lot of ponds, buyers come from outside and within the state to buy mostly in large quantities. The study areas are divided into three sampling units:

i. Zumba village where Shiroro dam is located, Shiroro LGA.

ii. Water resources, Aquaculture and Fisheries Technology FUT Minna fish farm.

iii. Lapan-gwari fish farm, Minna.

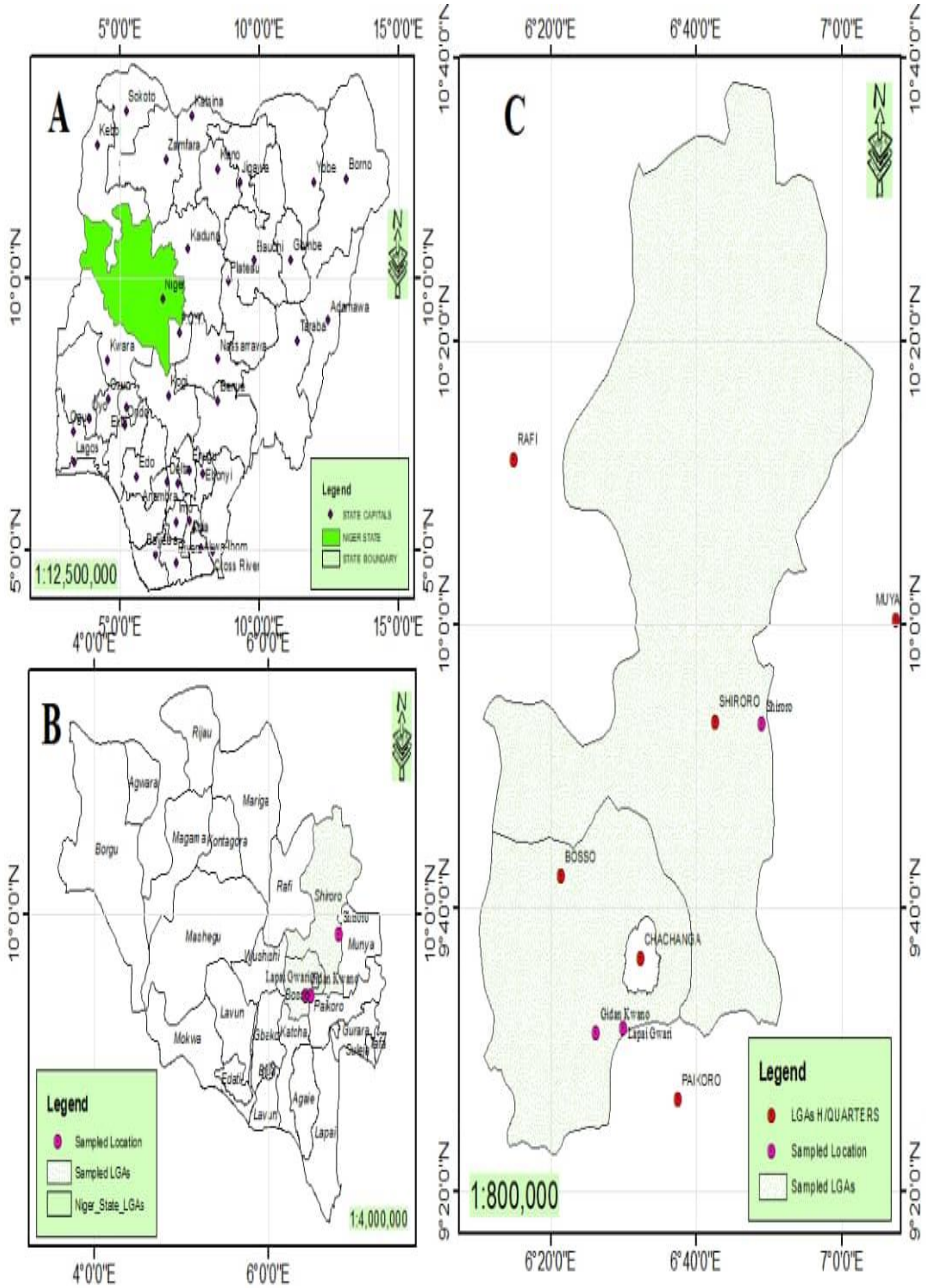

Figure 3.1: Map of study area.

Source: Google

3.2 Sampling Stations

Six sampling stations were established from the three locations on the basis of different degrees of human activities

Plate 6: Pond A, WAFT fish farm, Gidan kwano, FUT.

Source: Field Photograph

Plate 7: Pond B, Lapan gwari fish farm.

Source: Field Photograph

Plate 8a: A Section of Shiroro Dam

Source: Field Photograph

Plate 8b: Section of Shiroro Dam showing human activity

Source: Field Photograph

3.3 Water Sampling

Water samples were collected from Shiroro dam, Lapan Gwari and WAFT fish farm ponds over a period of eight (8) months December, 2019 to September, 2020. There was on sampling in (April and May, 2020 because of the lock down due to Covid- 19). Temperature was measured on site using a mercury-in-glass thermometer according to standard procedures (APHA, 2005). Water samples were collected carefully without air bubbles using 1litre bottles at various stations. The samples for Dissolved Oxygen (DO) concentration was collected in 250ml bottles and fixed by the addition of Wrinkler's reagents immediately after collection on the field. Samples for Biochemical Oxygen Demand (BOD) were also collected in 250ml (BOD) bottles and stored in the dark. Water samples were taken to the laboratory for analyses.

3.4 Physicochemical Parameters

The methods adopted for the physical analyses of the water are presented in Tables 3.1 and 3.2

Table 3.1: Instrumental Methods Adopted for the Physicochemical Analyses of Water Quality

Parameter	Method of Measurement	Wavelength	Unit of estimation	Reference
Conductivity	Conductivity meter	Na	uS/cm	Golterman *et al*., (1978)
pH	pH meter	Na	pH unit	Golterman *et al*., (1978)
Temperature	Thermometer	Na	°C	Golterman *et al*., (1978)
Phosphate(PO_4^{3-})	Ascorbic Acid blue method	880nm	mgl^{-1}	APHA *et al*., (2005)
Nitrate (NO^{3-})	Phenol-disulphonic acid method	510nm	mgl^{-1}	APHA *et al*., (2005)
Total Hardness	EDTA Method			APHA *et al*., (2005)

Table 3.2: Titrimetric methods adopted for the physicochemical analyses of water quality.

Parameter	Method	Titrant	Indicator	Colour change	Reference
Dissolved Oxygen (DO)	Winkler-Azide	$Na_2S_2O_3$ (0.025N)	Starch solution	Blue-black to colourless	Golterman *et al.* (1978)
Biochemical Oxygen Demand (BOD5)	Winkler-Azide	NaS2O3 (0.0142N)	Starch solution	Blue-black to colourless	Golterman *et al.* (1978)
Alkalinity (CaCO3)	Acid-Base	H_2SO_4 (0.02N)	Methyl Orange indicator	Yellow to Orange	APHA *et al.* (2005)

3.5 Fish Sampling

Two hundred and forty fishes were collected from the three sampling stations, five each of the four fish species (*Lates niloticus, Mormyrus rume, Bagrus bayad* and *Clarias gariepinus*) from Shiroro dam making it twenty fishes and five each from the WAFT fish pond and Lapan Gwari pond (*Clarias gariepinus* and *Heteroclarias* sp (hybrid)) making 30 per month, the fishes were collected by fishermen using drag net, line and cast net once in a month over a period of eight months (December, 2019 to September, 2020). Specimens were transported in ice box (Meye and Ikomi, 2008) as described by Ayanwale *et al*., (2013) to the WAFT laboratory for proper Identification, each labelled and examination. The specimens were all identified using guidelines by (Olaosebikan and Raji, revised edition. 2013) and recorded.

3.6 Measurement and Dissection of Fish

The fishes were sacrifice in the laboratory by vertebral dislocation and specimen were mounted on a dissecting board then morphometric measurements were taken using a meter rule, this include the Standard Length (SL) which is the distance from the snout to the base of the caudal fin and the Total Length (TL) which is the distance from the snout to the tip of the caudal fin and was recorded. Anelectronic weighing balance was used to take the weights of each fish and recorded (Arimoro and Utebor, 2013; Onyishi and Aguzie, 2018). Then each fish was dissected exposing the internal organ, the heart, liver and guts of each fish were weighed using an electronic weighing balance while the intestine were carefully removed and measured from one end to the other end then recorded.

3.7 Parasite Survey and Identification

With the help of a dissecting kit, fish body cavity was opened from the genital papillae down to the gill region. Each fish intestine, stomach, and gill was removed and open up then placed in separate petri-dishes containing 3mls of 0.9% saline solution. Each of the residue was placed on a clean slide then viewed using a light microscope to check for parasite. The parasites of each organ recovered were identified, counted, recorded, photomicrograph, and preserved in vials with 70% ethanol (Omeji, *et al*., 2010 and Alade *et al.*, 2015). The keys of fresh water fish parasite pictorial guide was used for the identification and comparison of each parasites (Pouder *et al*., (2005).

3.8 Bacteriological Analyses

Nutrient agar (28 g) was measured into 1000ml a conical flask and 1000ml of distilled water was added then corked also 9ml of distilled water was pipetted into different test-tubes and cork too. At a temperature of 121 ^{o}C using an autoclave, the tubes and the media were all autoclaved for 15minutes. Serial dilution was done on each samples (little skin cut each from the fishes) with the aid of micropipette, 1 ml of each sample was drop into the first test-tube which was then mixed; sample aliquot was again taken from the first test-tube to the second and was repeated until the last test-tube was achieved then 1 ml of the diluted sample was taken and put into the sterile petri-dish after which molten agar of about 20 ml was then poured into the petri-dish and rock softly for uniformity. The petri-dish culture was left to solidify and then transfer into an incubator. For 24 hours, the culture plate containing the nutrient agar was cultured at 37 ^{o}C while the one containing sabouroud dextrose agar (SDA) was cultured at 28 ^{o}C between 48-72 hours. The culture growth was counted to the colony forming unit per mil Coliform forming unit (CFU/g) (Onwuka, 2005).

3.9 Characterization and identification of isolates

The characterization of the resulting organisms was on the basis of colonial, morphological and biochemical representative of colonies. To determine the colour, edge, elevation, surface, shape and arrangement of microorganisms, macroscopic examination of the surface colonies on nutrient agar medium was used. After gram staining, morphological features were studied on the oil immersion slide under the microscope. Based on the gram staining technique, the gram staining method was used to differentiate in between the gram positive and gram negative isolates (Willey *et al*., 2008). The principle of the test is based on the cell wall properties of the two bacterial classes. A smear of the isolate was made and fixed on a grease free slide and passed over a flame. Crystal violet was initially poured on the smear for one minute after which it was then rinsed of, lugos iodine (which is the mordant) was later poured on the smear and rinsed off after one minute. Few drops of ethanol was used to decolorize the smear for 5 seconds and then rinse off immediately. Finally, fuchsin (which is the counter stain) was added to the smear and rinsed off after one minute. The slide was allowed to air dried then a drop of immersion oil was dropped on the slide and viewed under the microscope using a magnification of x100.

3.10 Biochemical test

Indole, Urease, Coagulase, Oxidase, Citrate Utilization, Methyl-Red and Voges-Proskauer tests were the biochemical tests that were carried out on the bacteria isolates.

3.10.1 Indole test

For 48 hours, sterile nutrient broth in a test tube was inoculated aseptically with a loopful of the isolate and was inoculated at 37 ^{O}C, Kovac's reagent of 0.5 ml was added to the 48hours old broth culture and shaken then examined after 1 minute. A red colour in the layer indicates indole production (Cheese borough, 1985).

3.10.2 Urease test

This test was performed to determine the ability of the isolated organism to bring forth the enzyme urease for the decomposition of urea. Urea agar slant was inoculated with the different isolate, living one slant un- inoculated to act as a control. Slants were inoculated at 37 ^{o}C for 48 hours, when the colour of the medium changes from dark brown to red or purple urease culture is positive but if no colour change is observed then urease cultures is negative (Cheeseborough, 1985).

3.10.3 Coagulase test

The enzyme coagulase identifies *Staphylococcus aureus*. It is the same procedure with that of catalase test except that human plasma is used. With the aid of a wire loop, little portion of the culture was emulsified on a clean slide then three drops of undiluted human plasma was added to the slide and observed for cluster. Positive result shows coagulation while absence of clumping mean negative (Cheeseborough, 1985).

3.10.4 Oxidase test

This test shows the presence of oxidase enzymes in the isolates that will catalyse the transport of electrons between electron donors in the bacteria and a redox dye (Tetramethy–p–phenylenediamine) to reduce the dye to deep purple. Wet filter paper procedure was used. A strip of filter paper was soaked with oxidase reagent and placed in a petri dish after which a tiny spot of culture was smeared on it using glass rod. Deep intense purple colour represent a positive test while absent of colour means negative (Cheeseborough, 1985).

3.10.5 Citrate utilization test

This test was carried out by preparing a citrate agar on a petri dish and making a smear on the isolates with sterile wire loop which was then incubated at 37 ^{o}C for 48 hours. A bright blue colour in the medium indicates a positive result (Cheeseborough, 1985).

3.10.6 Methyl red – vogues poskauer test

Isolate broth of 1ml was inoculated into 5 ml of methyl red -Vogues Proskauer broth which was then incubated for 24 hours at 37 ^{o}C and after a period of incubation, 1ml of the broth was transfer to a small serolical tube then 2 drops of methyl red was added to it. A positive result shows methyl red colour but when negative a yellow colour is observed. To the rest of the broth in the original test tube, 5 drops of 40 % Potassium hydroxide (KOH) was added then 15 drops of 5 % Naptha in ethanol was added too. A positive Vogues Proskauer test shows red colour within one hour while no colour change indicated negative test (Cheeseborough, 1985).

3.11 Data Analysis

SPSS version 22.0 was used for the data analysis to determine the various parameters values from the sample locations. One-way and two-way Analysis of Variance (ANOVA) at 95 % level of significance was used for the data analysis. Standard deviation was used to determine the physicochemical parameters of the water in wild and cultured environment, the morphometric parameters in wild and cultured fish and the isolate and identification of the pathogenic bacteria associated with wild and cultured fish. While chi-square was used to determine the prevalence of parasites in the fish from both environments.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Monthly variation in physicochemical parameters in wild environment

Monthly variation in physicochemical parameters in wild environment is shown in Figure 4.1 to 4.3

Analyses revealed significant ($p < 0.05$) variation in physicochemical parameters recorded in the wild during the study period (Figures 4.1 to 4.3). Water temperature was highest in June and September 2020 (27.75±0.35 ^{o}C) and lowest in February 2020 (23.25±0.35 ^{o}C). There was no significant difference in water pH throughout the study period (range = 7.11±0.23 to 7.83±003). Dissolved oxygen was highest in September 2020 (12.00±0.00 mg/L) and lowest in December 2019 (6.25±0.35 mg/L). There were, however, no significant ($p > 0.05$) difference in Biochemical Oxygen demand throughout the months in wild (range = 3.00±0.00 to 4.05±0.63 mg/L) (Figure 4.1).Total hardness, conductivity, alkalinity and total dissolved solids contents of the wild studied varied significantly ($p < 0.05$) across the months. Total hardness ranged from 16.00±0.00 to 26.50±0.71 mg/L, conductivity, 58.50±9.19 to 85.00±1.41µs/cm, total alkalinity, 12.00±0.00 to 27.50±3.54 mg/L, and total dissolved solid, 24.32±0.45 to 36.11±0.09 mg/L (Figure 4.2). Similarly, nitrates and phosphorus contents varied significantly ($p < 0.05$) among the months throughout the study period; with range of values of 0.21±0.01 to 0.35±0.02 mg/L, and 0.07±0.01 to 0.16±0.01 mg/L, respectively (Figure 4.3).

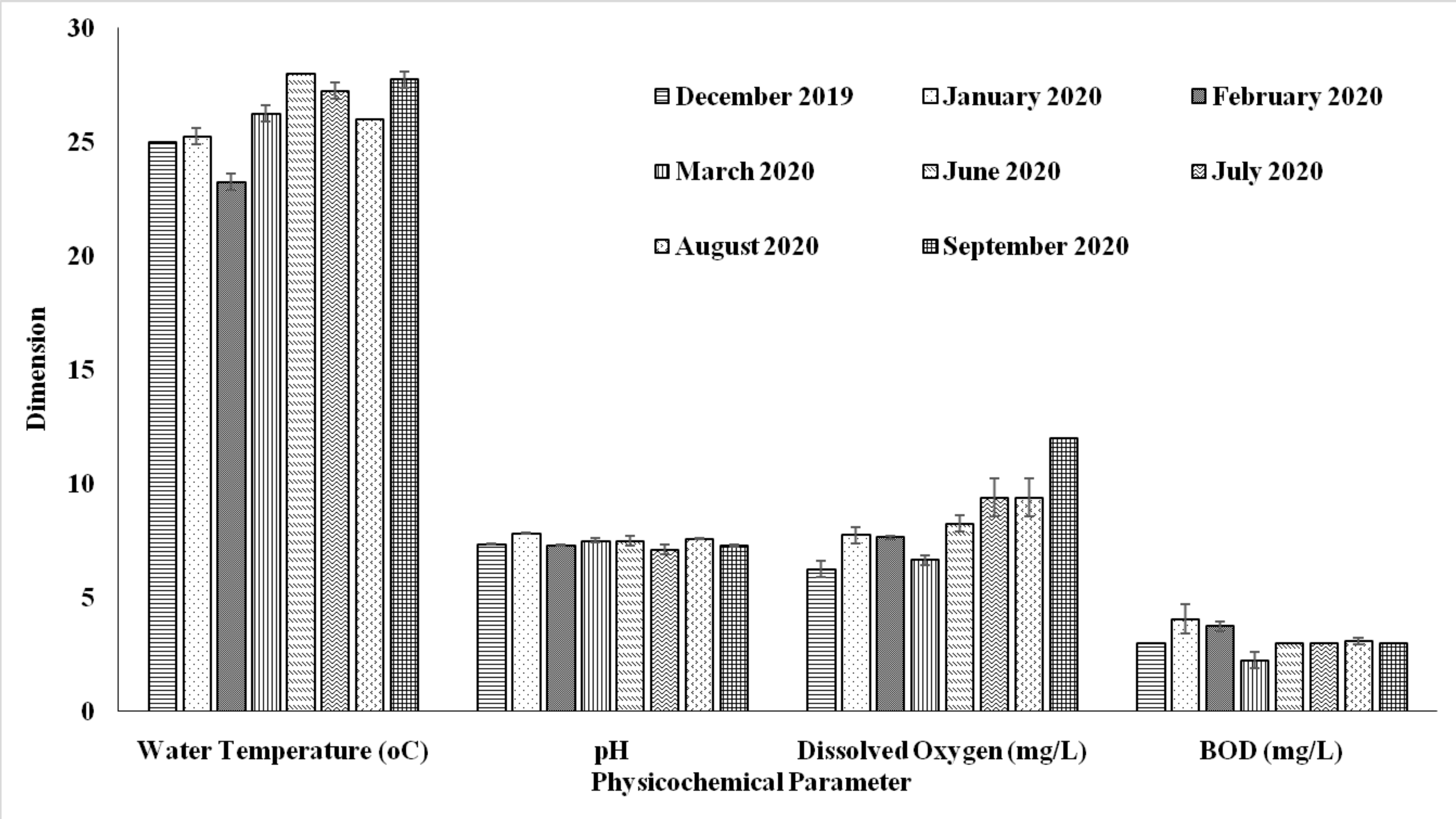

Figure 4.1: Monthly Variation in Physicochemical Parameters in Wild Environment

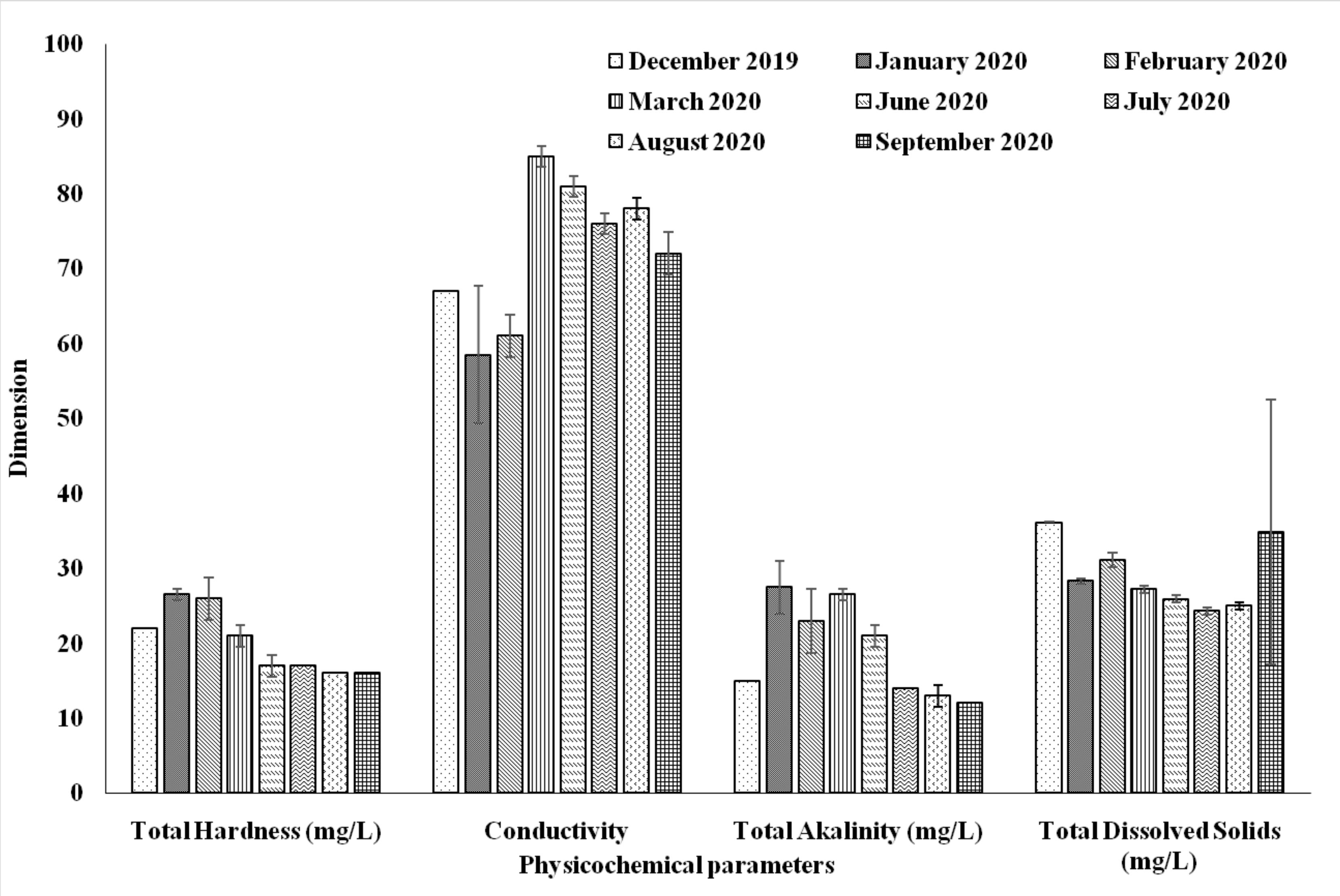

Figure 4.2: Monthly Variation in Physicochemical Parameters in Wild Environment

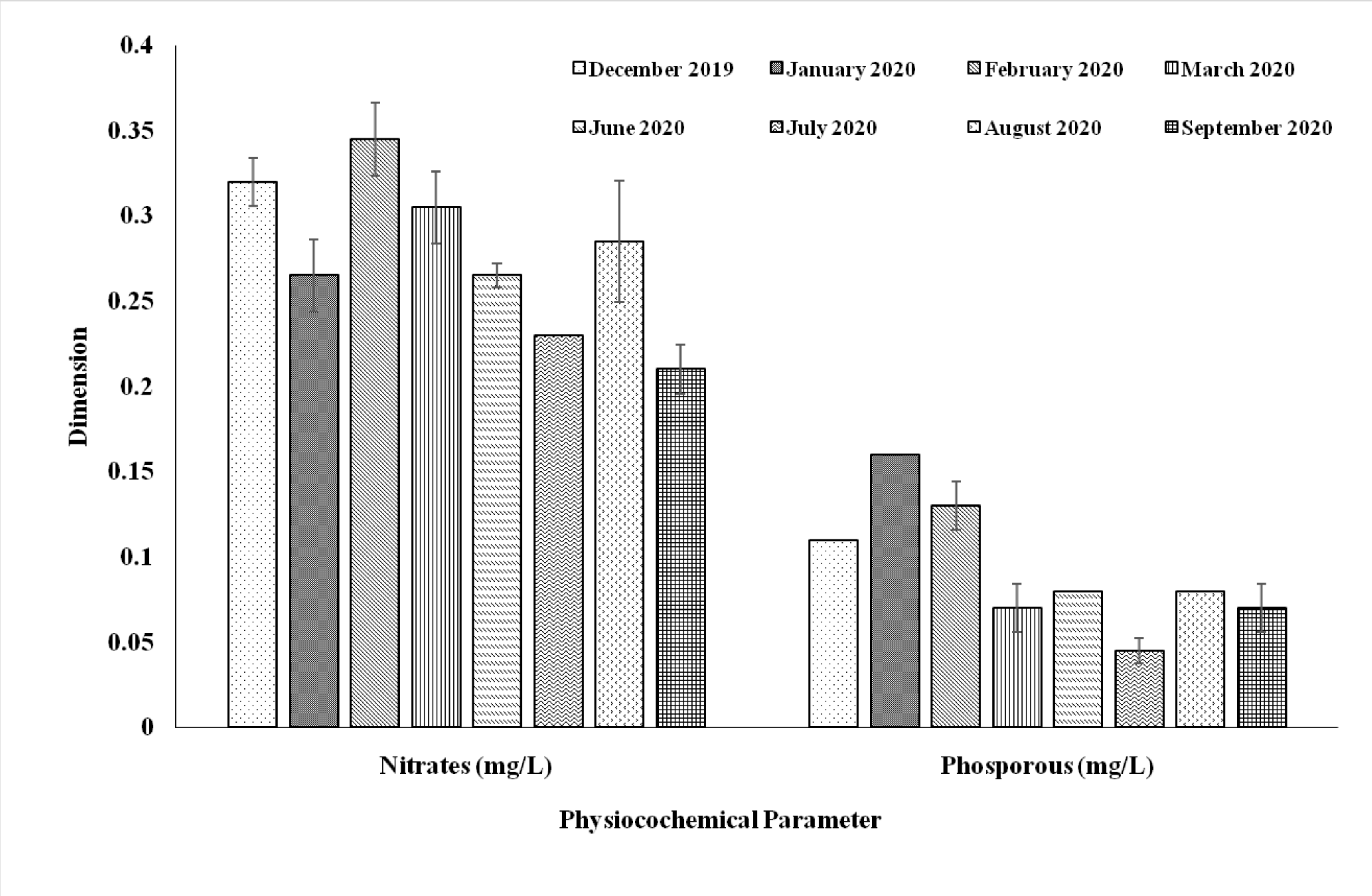

Figure 4.3: Monthly Variation in Physicochemical Parameters in Wild Environment

4.1.2 Monthly variation in physicochemical parameters in culture environment

Monthly variation in physicochemical parameters in the culture environment is shown in Figure 4.4 to 4.6

Analyses revealed no significant variations in water temperature, pH, dissolved oxygen and biochemical oxygen demand (Figure 4.4). Temperature ranged from 25.88±0.25 to 27.88±0.25 ^{o}C. Water pH ranged from 7.690.19± to 8.05±0.40. Dissolved oxygen and biochemical oxygen demand ranged from 6.10±0.20 to 6.90±0.62 mg/L, and 4.00±0.33 to 5.13±0.50 mg/L, respectively (Figure 4.4). Although, total hardness, conductivity, alkalinity and total dissolved solids varied across the months, there were no significant difference ($p > 0.05$) in total alkalinity and total dissolved solids in the months of March, June through to September 2020 (Figure 4.5). Total hardness ranged from 93.75±24.64 to 172.50±18.21 mg/L, conductivity, 427.50±127.74 to 811.25±121.83 μs/cm, alkalinity, 74.75±11.87 to 575.00±129.34 mg/L and total dissolved solids, 190.00±35.06 to 388.39±4.78 mg/L. Nitrates and phosphorus contents also varied significantly ($p < 0.05$) among the months throughout the study period; with range of values of 2.65±0.16 to 5.51±1.17 mg/L, and 1.32±0.29 to 2.61±036 mg/L, respectively (Figure 4.6).

4.1.3 Body morphometries in fish specimen

The body morphometries in the sampled fish species from the two environments (wild and culture) is shown in Table 4.1 to 4.5

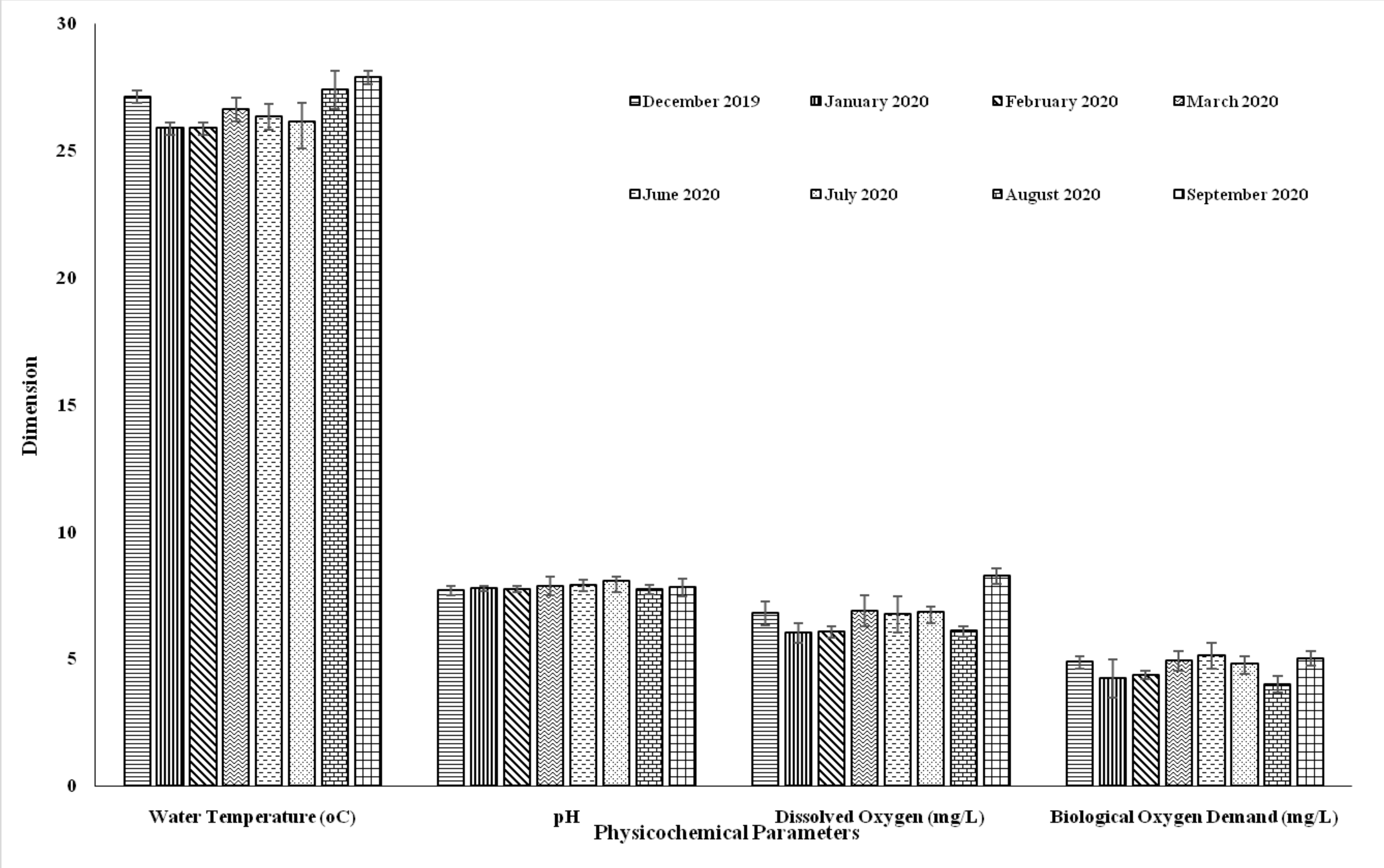
30
25
20
15
10
5
0
Dimension
December 2019
January 2020
February 2020
March 2020
June 2020
July 2020
August 2020
September 2020
Water Temperature (oC)
pH
Dissolved Oxygen (mg/L)
Biological Oxygen Demand (mg/L)
Physicochemical Parameters

Figure 4.4: Monthly Variation in Physicochemical Parameters in Culture Environment

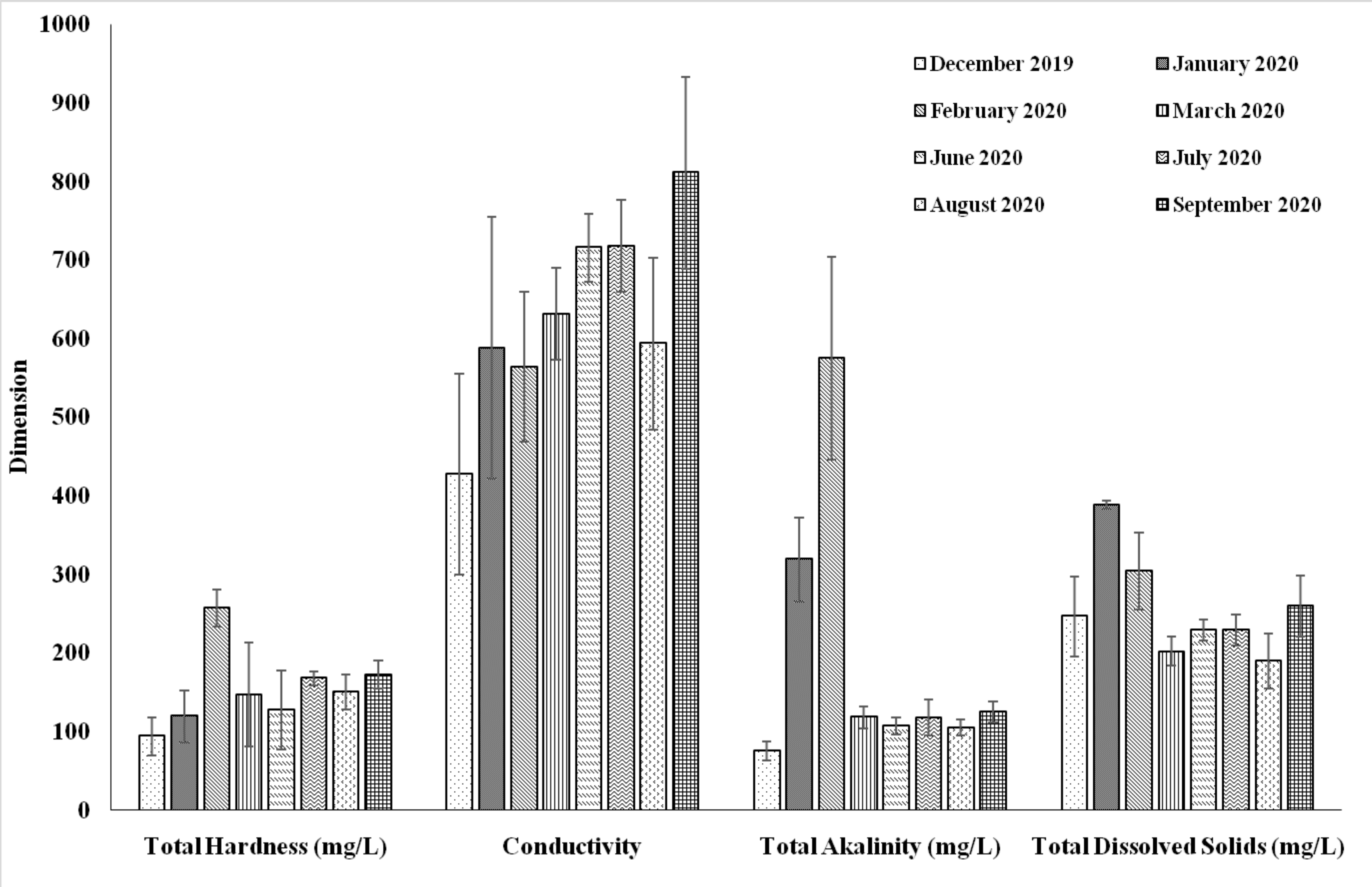

Figure 4.5: Monthly Variation in Physicochemical Parameters in Culture Environment

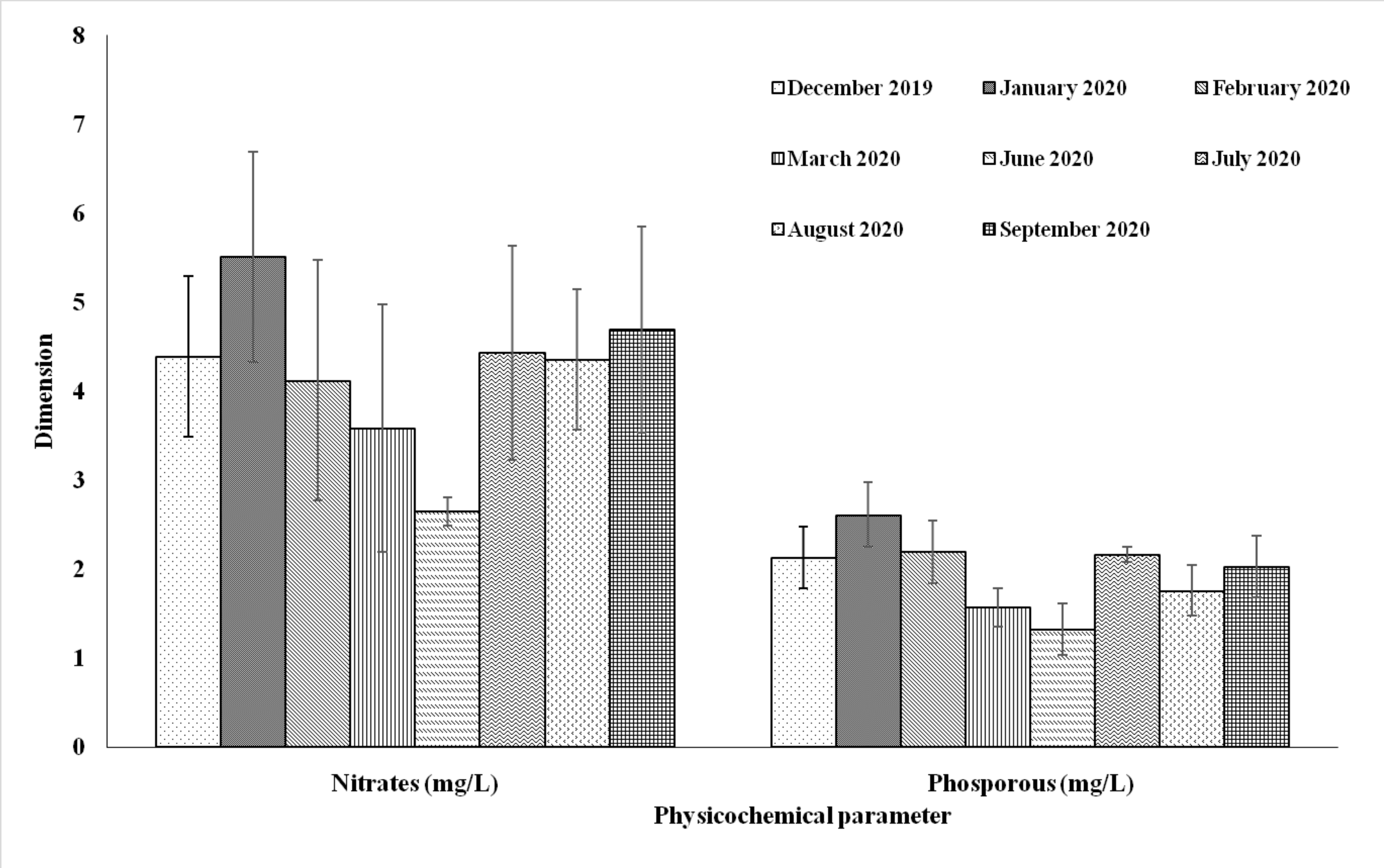

Figure 4.6: Monthly Variation in Physicochemical Parameters in Culture Environment

4.1.4 Variation in body morphometries in *Mormyrus rume* in wild environment

Analyses revealed significant monthly variation in the body morphometries of the species throughout the collection period. Total weight was lowest in January 2020 (187.80±33.34 g) and highest in August 2020 (314.00±80.05 g). Total length did not vary significantly throughout the months (range = 29.14±2.02 to 35.62±3.33 cm). Length of intestine was lowest in August 2020 (14.31±4.41 cm), though, the value did not vary significantly ($p>0.05$) with those of February and June 2020. Liver, heart and gut weights were lowest in January 2020 (2.04±0.69, 0.16±0.05 and 11.72±5.61 g, respectively). The weights of the liver and heart of the species were highest in July 2020 (3.30±2.39 g) and August 2020 (0.28±0.10 g), respectively. Gut weight, on the other hand, was highest in the months of February, March, and August 2020 (range = 21.00±5.18 to 22.32±6.14 g). (Table 4.1)

Table 4.1 Variation in Body Morphometries in *Mormyrus rume* in Wild Environment

Body Dimension	Month								
	Dec 2019	Jan 2020	Feb 2020	Mar 2020	June 2020	July 2020	Aug 2020	Sep 2020	
Total weight	246.20±51.81^{b*}	187.80±33.34^{a}	302.50±81.67^{c}	283.40±81.97^{c}	261.00±104.10^{b}	286.20±86.01^{c}	314.00±80.05^{d}	246.20±51.81^{b}
Total length	31.54±2.50^{a}	29.14±2.02^{a}	35.62±3.33^{a}	34.02±5.73^{a}	31.06±4.77^{a}	32.62±5.11^{a}	34.16±4.43^{a}	31.54±2.50^{a}
Standard length	29.00±2.66^{a}	26.86±2.33^{a}	32.32±3.66^{b}	30.62±5.21^{b}	28.94±4.72^{b}	29.84±4.64^{b}	30.94±4.36^{b}	29.00±2.66^{a}
Length of Intestine	19.84±4.23^{b}	26.10±4.56^{c}	15.60±5.42^{a}	18.66±4.92^{b}	21.44±2.91^{b}	16.56±4.65^{a}	14.32±4.41^{a}	19.84±4.23^{b}
Weight of Liver	2.54±0.68^{b}	2.04±0.69^{a}	3.02±0.55^{c}	3.00±0.91^{c}	2.86±0.85^{c}	3.30±2.39^{d}	2.44±0.90^{b}	2.54±0.68^{b}
Weight of Heart	0.22±0.08^{b}	0.16±0.05^{a}	0.22±0.09^{b}	0.22±0.10^{b}	0.24±0.11^{b}	0.18±0.08^{a}	0.28±0.10^{c}	0.22±0.08^{b}
Gut weight	17.72±4.38^{b}	11.72±5.61^{a}	22.30±3.72^{c}	22.32±6.14^{c}	19.72±5.70^{b}	17.64±3.76^{b}	21.00±5.18^{c}	17.72±4.38^{b}

[*]Values followed by same superscript alphabet in a row for a parameter are not significantly different at $p = 0.05$

4.1.5 Variation in Body Morphometries in *Bagrus bayad* in Wild Environment

Analyses revealed significant monthly variation in the body morphometries of the species throughout the collection period. Total weight was lowest in the months of July and September 2020 (range = 296.60±93.29 to 440.00±155.72 g) Total and standard lengths varied significantly throughout the months being lowest in the months of June to September 2020 and longest in the months of December 2019 through to June 2020. There was no significant ($p > 0.05$) difference in total and standard lengths in the months of December 2019 through to June 2020. The intestine of the species was shortest in December 2019 (17.24±5.22 cm) and longest in August 2020 (29.80±18.19 cm). Weights of liver and heart of the species were highest in January 2020 (3.92±1.88, and 0.42±0.10 g, respectively). The gut weight, on the other hand, was highest in the month of March 2020 (26.40±13.10 g). The weight of the liver was lowest in June 2020. The heart of the species weighed lowest in the months of December, 2019, March, July and September 2020. Gut weight was also lowest in the months of December, 2019, August and September 2020. (Table 4.2).

Table 4.2 Variation in Body Morphometries in *Bagrus bayad* in Wild Environment

Body Dimension	Month							
	Dec 2019	Jan 2020	Feb 2020	Mar 2020	June 2020	July 2020	Aug 2020	Sep 2020
Total weight	306.00±72.55^{a*}	394.40±172.61^{b}	440.00±155.72^{c}	370.40±182.67^{b}	310.60±118.36^{a}	296.60±93.29^{a}	345.60±149.54^{b}	297.20±37.91^{a}
Total length	40.60±3.33^{b}	43.48±10.95^{b}	41.70±8.64^{b}	40.18±10.43^{b}	41.92±6.71^{b}	37.44±3.82^{a}	38.66±7.96^{a}	38.54±4.53^{a}
Standard length	35.44±3.73^{b}	37.06±7.98^{b}	34.98±7.17^{b}	33.56±7.64^{b}	37.08±8.54^{b}	31.56±5.84^{a}	30.42±3.88^{a}	31.24±3.74^{a}
Length of Intestine	17.24±5.22^{a}	20.42±4.59^{b}	17.92±2.08^{a}	20.82±11.00^{b}	18.56±3.55^{a}	18.3±4.26^{a}	29.80±18.19^{c}	20.28±6.48^{b}
Weight of Liver	2.76±1.07^{c}	3.92±1.88^{d}	2.94±0.96c	3.24±1.25^{d}	1.86±0.37^{a}	2.18±1.14^{a}	2.98±1.75^{c}	2.46±0.81^{b}
Weight of Heart	0.28±0.08^{a}	0.42±0.10b	0.36±0.18^{ab}	0.26±0.11^{a}	0.36±0.15^{ab}	0.22±0.13^{a}	0.40±0.21^{b}	0.24±0.05^{a}
Gut weight	15.68±4.23^{a}	22.76±7.46^{b}	23.72±6.09^{b}	26.40±13.10^{b}	20.54±4.58^{ab}	20.96±9.11^{ab}	16.80±3.66^{a}	16.88±5.17^{a}

*Values followed by same superscript alphabet in a row for a parameter are not significantly different at $p = 0.05$

4.1.6 Variation in Body Morphometries in *Lates niloticus* in Wild Environment

Analyses revealed significant monthly variation in the body morphometries of the species throughout the collection period. Total weight was lowest in the months of July, August and September 2020 (range = 262.60±75.08 to 278.40±68.45 cm). Total weight was highest in March 2020 (464.20±152.27 g). Total length was highest in the months of January, February and March 2020. Similarly, standard length was highest in the months of January and March 2020. There was no significant ($p > 0.05$) difference in total length in the months of December 2019, June through to September 2019. Likewise, standard length also did not vary in these months. The intestinal length of the species was shortest August and September 2020 (15.92±6.31 and 16.50±7.75 cm, respectively). However, there was no significant difference ($p > 0.05$) in the intestinal length during other months of the study (range = 20.18±7.52 to 22.58±5.65 cm). Weights of Liver and heart of the species varied significantly among the months of study. Weight of liver was lowest in the month of July 2020 (2.10±1.02 g) and highest in February and March 2020 (5.00±2.59, and 5.02±2.66 g, respectively). The heart of the species, was also lowest in July 2020 (0.26±0.05 g). Gut weight was lowest in the June 2020 and highest March 2020 (Table 4.3).

Table 4.3 Variation in Body Morphometries in *Lates niloticus* in Wild Environment

Body Dimension	Month							
	Dec 2019	Jan 2020	Feb 2020	Mar 2020	June 2020	July 2020	Aug 2020	Sep 2020
Total weight	280.40±63.36^{a*}	382.60±102.59^{c}	427.40±142.31^{d}	464.20±152.27^{d}	301.00±133.99^{b}	262.60±75.08^{a}	263.20±78.78^{a}	278.40±68.45^{a}
Total length	30.02±3.60^{a}	32.24±5.38^{b}	33.30±3.09^{b}	36.06±4.09^{b}	28.92±4.76^{a}	29.34±6.58^{a}	29.98±5.45^{a}	27.78±2.64^{a}
Standard length	26.58±3.10^{a}	30.66±3.24^{b}	28.44±1.63^{a}	31.92±3.97^{b}	25.14±4.15^{a}	26.62±7.18^{a}	26.78±6.21^{a}	24.00±2.93^{a}
Length of Intestine	20.18±7.52^{b}	20.46±4.66^{b}	21.86±8.39^{b}	22.14±2.71^{b}	22.58±5.65^{b}	20.32±2.40^{b}	15.92±6.31^{a}	16.50±7.75^{a}
Weight of Liver	3.18±1.79^{b}	4.44±1.23^{c}	5.00±2.59^{d}	5.02±2.66^{d}	3.40±1.75^{b}	2.10±1.02^{a}	2.54±0.77^{ab}	3.56±1.27^{b}
Weight of Heart	0.32±0.14^{b}	0.46±0.20^{c}	0.48±0.25^{c}	0.44±0.28^{c}	0.34±0.11^{b}	0.26±0.05^{a}	0.58±0.08^{c}	0.38±0.10^{b}
Gut weight	23.26±8.17^{c}	23.00±6.48^{c}	24.14±7.49^{c}	28.32±2.06^{d}	14.30±2.70^{a}	18.94±7.96^{b}	15.76±7.39^{ab}	15.76±5.85^{ab}

*Values followed by same superscript alphabet in a row for a parameter are not significantly different at $p = 0.05$

4.1.7 Variation in Body Morphometries in *Heteroclarias* in Cultured Environment

Analyses revealed significant ($p < 0.05$) monthly variation in the body morphometries of the species throughout the collection period, except total and standard lengths of the species. Total weight was lowest in the months of February, June through to August 2020 (range = 242.40±88.12 to 295.60±53.26 g) and highest in March 2020 (430.00±138.51 g). There were no significant ($p > 0.05$) difference in the monthly values of total and standard lengths, with range of values of 32.00±2.75 to 37.92±5.32 cm and 28.58±2.12 to 32.70±3.62 cm, respectively. The length of intestine was not significantly ($p > 0.05$) different in the months of February, June through to September 2020. These values were, however, significantly ($p < 0.05$) lower than those of other months. The weight of liver was lowest in December 2019 and January 2020 and highest in August and September 2020. Weight of heart was, however, highest in December 2019 (0.50±0.18 g) and lowest in February 2020 (0.22±0.04 g). The weight of the gut was significantly ($p < 0.05$) lowest in January and September 2020. There were, however, no significant ($p > 0.05$) difference in gut weights in the months of February, March and August 2020. These values were significantly ($p < 0.05$) higher than in other months of the study period (range = 23.60±8.34 to 25.54±5.25 g) (Table 4.4).

Table 4.4 Variation in Body Morphometries in *Heteroclarias* in Cultured Environment

Body Dimension	Month							
	Dec 2019	Jan 2020	Feb 2020	Mar 2020	June 2020	July 2020	Aug 2020	Sep 2020
Total weight	386.60±167.04[b*]	363.80±89.87[b]	242.40±88.12[a]	430.00±138.51[c]	251.60±69.31[a]	282.00±43.96[ab]	295.60±53.26[ab]	355.8±31.68[b]
Total length	37.50±5.71[a]	35.58±3.38[a]	32.00±2.75[a]	37.92±5.32[a]	33.68±3.73[a]	34.10±2.72[a]	33.54±3.72[a]	35.72±2.15[a]
Standard length	32.38±4.64[a]	30.68±3.11[a]	28.58±2.12[a]	32.70±3.62[a]	29.88±3.11[a]	30.32±3.13[a]	29.66±2.62[a]	30.24±1.41[a]
Length of Intestine	35.76±11.54[b]	31.30±5.61[b]	23.28±3.32[a]	31.94±8.58[b]	24.94±1.69[a]	23.82±4.86[a]	20.60±6.41[a]	23.98±6.51[a]
Weight of Liver	2.70±1.57[a]	2.10±0.94[a]	2.82±2.11[b]	4.22±2.24[c]	2.16±0.63[b]	2.90±1.25[b]	4.68±1.05[c]	4.72±1.85[c]
Weight of Heart	0.50±0.18[a]	0.48±0.21[a]	0.22±0.04[a]	0.32±0.10[a]	0.28±0.08[a]	0.30±0.10[a]	0.34±0.13[a]	0.42±0.13[a]
Gut weight	18.10±8.16[b]	12.88±3.24[a]	24.12±12.63[c]	23.60±8.34[c]	16.30±4.85[b]	17.62±6.11[b]	25.54±5.25[c]	14.08±4.08[a]

[*]Values followed by same superscript alphabet in a row for a parameter are not significantly different at $p = 0.05$

4.1.8 Variation in Body Morphometries in *Clarias garipinus* in Wild and Cultured Environment.

Total weight of the species in wild ponds was lowest in December 2019 (279.40±138.80 g) and highest in March 2020 (398.00±187.57 g). In cultured ponds, total weight was lowest in August 2020 (154.80±49.03 g) and highest in December 2019 (350.60±145.98 g). Total length of the species in the wild was lowest in February 2020 (32.50±5.88 cm) and highest in March 2020 (40.80±9.64 cm). In cultured ponds, total length was lowest in January 2020 (29.02±3.68 cm) and highest in March 2020 (34.92±5.83cm). Standard length of the species in the wild was lowest in July 2020 (30.26±3.35cm) and highest in March 2020 (36.54±8.34 cm). In cultured ponds, standard length was lowest in August 2020 (25.04±4.29 cm) and highest in December 2019 (33.36±3.56 cm). Length of intestine of the species in the wild was lowest in March 2020 (19.50±9.23 cm) and highest in December 2019 (36.50±14.62 cm). In cultured ponds, length of intestine was lowest in July 2020 (13.80±2.47 cm) and highest in December 2020 (39.82±8.35 cm). Weight liver of the species in the wild was lowest in December 2019 (2.48±1.78g) and highest in March 2020 (4.32±1.08 g). In cultured ponds, weight of liver was lowest in August 2020 (1.50±0.65 g) and highest in December 2019 (4.70±2.67 g). Weight of heart of the species in the wild was lowest in January 2020 (0.28±0.08 g) and highest in March 2020 (0.42±0.22 g). In cultured ponds, heart weight was lowest in February 2020 (0.20±0.12 g) and highest in December 2020 (0.36±0.11 g). Gut weight of the species in the wild was lowest in July 2020 (13.60±5.17 g) and highest in March 2020 (26.78±9.13 g). In cultured ponds, gut weight was lowest in February 2020 (9.86±4.75 g) and highest in December 2019 (32.58±18.39 g) (Table 4.5).

Table 4.5 Variation in Body Morphometrics in *Clarias garipinus* in Wild and Cultured Environment

Body Parameter	Habitat	Month							
		Dec 2019	Jan 2020	Feb 2020	Mar 2020	June 2020	July 2020	Aug 2020	Sep 2020
Total weight	Wild	279.40±138.8$^{a*}_{a**}$	303.60±66.25$^{b}_{a}$	342.80±59.98$^{b}_{b}$	398.00±187.57$^{b}_{c}$	381.40±188.53$^{b}_{c}$	345.80±133.94$^{b}_{b}$	349.80±94.59$^{b}_{b}$	295.00±95.50$^{a}_{a}$
	Cultured	350.60±145.98$^{b}_{c}$	204.00±86.70$^{a}_{a}$	195.40±10.23$^{a}_{a}$	360.00±155.60$^{a}_{c}$	207.20±56.13$^{a}_{a}$	201.40±65.38$^{a}_{a}$	154.80±49.03$^{a}_{a}$	270.80±106.37$^{a}_{b}$
Total length	Wild	37.36±12.68$^{a}_{b}$	35.46±2.73$^{b}_{ab}$	32.50±5.88$^{a}_{a}$	40.80±9.64$^{a}_{b}$	35.40±4.36$^{a}_{ab}$	33.92±3.03$^{a}_{a}$	34.88±3.36$^{a}_{a}$	35.22±4.57$^{a}_{ab}$
	Cultured	38.38±4.82$^{a}_{c}$	29.02±3.68$^{a}_{a}$	33.34±4.82$^{a}_{b}$	34.92±5.83$^{a}_{b}$	32.10±4.35$^{a}_{b}$	29.56±3.75$^{a}_{a}$	28.70±4.90$^{a}_{a}$	34.22±5.35$^{a}_{b}$
Standard length	Wild	34.14±12.44$^{a}_{b}$	31.78±2.93$^{b}_{a}$	29.38±5.94$^{a}_{a}$	36.54±8.34$^{b}_{b}$	32.26±5.01$^{a}_{a}$	30.26±3.35$^{a}_{a}$	31.34±3.65$^{a}_{a}$	30.70±4.04$^{a}_{a}$
	Cultured	33.36±3.56$^{a}_{b}$	25.16±2.68$^{a}_{a}$	28.38±3.18$^{a}_{ab}$	30.62±5.53$^{a}_{b}$	28.20±3.54$^{a}_{a}$	27.34±3.96$^{a}_{a}$	25.04±4.29$^{a}_{a}$	29.96±4.45$^{a}_{ab}$
Length of Intestine	Wild	36.50±14.62$^{a}_{d}$	26.14±18.25$^{a}_{b}$	21.70±4.57$^{a}_{a}$	19.50±9.23$^{a}_{a}$	21.24±7.10$^{a}_{a}$	18.10±5.00$^{b}_{a}$	38.52±10.40$^{b}_{d}$	32.52±7.78$^{a}_{c}$
	Cultured	39.82±8.35$^{a}_{d}$	23.28±10.53$^{a}_{b}$	20.24±4.37$^{a}_{b}$	33.18±14.06$^{b}_{c}$	23.30±4.51$^{a}_{b}$	13.80±2.47$^{a}_{a}$	13.06±1.81$^{a}_{a}$	24.96±11.89$^{a}_{b}$
Weight of Liver	Wild	2.48±1.78$^{a}_{a}$	3.02±0.82$^{a}_{a}$	3.38±0.95$^{b}_{ab}$	4.32±1.08$^{a}_{b}$	3.24±1.07$^{a}_{ab}$	3.14±0.98$^{b}_{a}$	3.44±0.61$^{b}_{ab}$	3.10±1.53$^{a}_{a}$
	Cultured	4.70±2.67$^{b}_{c}$	3.26±1.18$^{a}_{b}$	1.72±0.96$^{a}_{a}$	3.80±2.29$^{a}_{b}$	2.02±1.42$^{a}_{a}$	1.78±0.65$^{a}_{a}$	1.50±0.65$^{a}_{a}$	3.46±3.04$^{a}_{b}$
Weight of Heart	Wild	0.32±0.24$^{a}_{a}$	0.28±0.08$^{a}_{a}$	0.32±0.08$^{a}_{a}$	0.42±0.22$^{a}_{a}$	0.26±0.11$^{a}_{a}$	0.36±0.11$^{a}_{a}$	0.40±0.07$^{a}_{a}$	0.32±0.13$^{a}_{a}$
	Cultured	0.36±0.11$^{a}_{a}$	0.22±0.08$^{a}_{a}$	0.20±0.12$^{a}_{a}$	0.28±0.13$^{a}_{a}$	0.34±0.05$^{a}_{a}$	0.24±0.13$^{a}_{a}$	0.24±0.13$^{a}_{a}$	0.32±0.13$^{a}_{a}$
Gut weight	Wild	18.88±9.21$^{a}_{b}$	17.44±3.50$^{b}_{b}$	19.6±3.62$^{b}_{b}$	26.78±9.13$^{a}_{c}$	19.66±7.91$^{b}_{b}$	13.60±5.17$^{a}_{a}$	18.16±4.50$^{b}_{b}$	18.52±6.11$^{a}_{b}$
	Cultured	32.58±18.39$^{b}_{c}$	11.32±4.37$^{a}_{a}$	9.86±4.75$^{a}_{a}$	29.08±14.96$^{a}_{c}$	16.64±6.42$^{a}_{b}$	15.14±5.66$^{a}_{b}$	12.12±2.05$^{a}_{a}$	17.62±10.18$^{a}_{b}$

[*] Values followed by same superscript alphabet in a column among habitats for a parameter are not significantly different at p = 0.05

[**] Values followed by same subscript alphabet in a row for a parameter in a habitat are not significantly different at p = 0.05

4.1.9 Bacteria species in fish specimen

Bacteria species identify and microbial load in fish specimen from wild and culture environment is shown in Table 4.6 to 4.7

4.1.10 Monthly qualitative distribution of bacteria species in wild and cultured environment

Analyses of monthly presence of bacteria on fish species in both wild and cultured ponds revealed monthly variation in the presence of the bacteria species on the fish species. *Staphylococcus aureus, Klebsiella, Escherichia coli, Pseudomonas aeruginosa* and *Shigella dysentrea* were encountered throughout the months (of study) in both wild and cultured ponds. *Bacillus subtilis* and *Streptococcus faecalis* were less preponderant. Both bacteria species were absent in both pond types in December 2019, both were, however, encountered in both pond types in February 2020. Interestingly, between the two species, *Bacillus subtilis* was the most encountered (Table 4.6)

Table 4.6: Monthly qualitative distribution of bacteria species in wild and cultured environment

Bacteria species	December 2019		January 2020		February 2020		March 2020		June 2020		July 2020		August 2020		September 2020	
	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond	Wild pond	Cultured Pond
Staphylococcus aureus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Klebsiella	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Escherichia coli	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pseudomonas aeruginosa	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Shigella dysentrea	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Bacillus subtilis	-	-	-	+	+	+	+	+	+	-	+	+	+	+	+	-
Streptococcus faecalis	-	-	+	-	+	+	+	-	-	+	-	-	-	-	-	+

± = present, - = absent

Table 4.7 Monthly variations in microbial load

Habitat	Fish Species	Month							
		Dec 2019	**Jan 2020**	**Feb 2020**	**Mar 2020**	**June 2020**	**July 2020**	**Aug 2020**	**Sep 2020**
Wild	*Mormyrus rume*	$44.2\pm17.49^{b*}_{c**}$	$40.40\pm16.19^{b}_{c}$	$94.75\pm49.73^{a}_{f}$	$70.60\pm25.53^{b}_{e}$	$43.00\pm17.52^{c}_{c}$	$49.20\pm13.37^{d}_{d}$	$27.20\pm7.05^{b}_{a}$	$38.00\pm12.08^{b}_{b}$
	Bagrus bayad	$59.60\pm13.95^{c}_{d}$	$62.60\pm40.91^{c}_{d}$	$108.40\pm20.51^{ab}_{e}$	$48.20\pm24.00^{a}_{c}$	$40.80\pm8.41^{b}_{b}$	$34.40\pm14.59^{b}_{ab}$	$21.40\pm11.70^{a}_{a}$	$37.60\pm12.97^{b}_{ab}$
	Lates niloticus	$59.40\pm14.34^{c}_{d}$	$63.320\pm14.60^{c}_{d}$	$100.40\pm12.44^{ab}_{e}$	$63.60\pm36.83^{b}_{d}$	$47.80\pm12.17^{c}_{c}$	$30.60\pm22.38^{b}_{b}$	$27.80\pm13.72^{b}_{a}$	$41.40\pm7.40^{b}_{b}$
	Clarias garipinus	$44.00\pm5.70^{b}_{c}$	$36.00\pm8.34^{a}_{b}$	$99.60\pm22.28^{ab}_{d}$	$44.60\pm23.51^{a}_{c}$	$23.60\pm4.39^{a}_{a}$	$24.80\pm10.83^{a}_{a}$	$21.40\pm7.92^{a}_{a}$	$41.00\pm10.86^{b}_{c}$
Cultured	*Clarias garipinus*	$28.60\pm6.69^{a}_{a}$	$36.60\pm12.36^{a}_{b}$	$125.80\pm25.36^{b}_{e}$	$32.00\pm7.62^{a}_{ab}$	$48.00\pm23.55^{c}_{c}$	$51.60\pm18.45^{d}_{d}$	$45.20\pm18.57^{c}_{c}$	$35.60\pm8.02^{a}_{b}$
	Heteroclarias	$44.80\pm10.05^{b}_{b}$	$59.60\pm39.61^{c}_{c}$	$131.80\pm7.36^{b}_{d}$	$45.80\pm25.22^{a}_{b}$	$31.20\pm11.07^{b}_{ab}$	$44.20\pm18.47^{c}_{b}$	$25.60\pm6.73^{b}_{a}$	$46.40\pm14.28^{c}_{b}$

*Values followed by same superscript alphabet in a column are not significantly different at $p = 0.05$

**Values followed by same subscript alphabet in a row for a species in a habitat are not significantly different at $p = 0.05$

4.1.11 Fish parasitesin fish specimen

Parasites found in fish specimen from wild and culture environment is shown in Table 4.8 to 4.9

4.1.12 Prevalence of fish parasites found in the wild environment

Analysis of parasites found in wild environment revealed significant ($p < 0.05$) difference between parasites in fishes. *Opisthorchis* sp (21.49 %) was higher compare to other parasites species of which *Trichodina* sp (3.51 %) is the least of all. Parasite species with high number of percentage include *Diphillobothrium* sp (19.74 %), *Camallanus* sp (18.86 %) and *Capillaria* sp (17.11 %). Also there were significant ($p<0.05$) difference in the site of infection with the intestine (54.39 %) having the highest number of infection while the stomach had (26.32 %) and the gut (19.28 %). (Table 4.8) Analysis shows no significant ($p > 0.05$) difference in infection rate between *Mormyrus rume* (22.81 %), *Bagrus bayad* (22.81 %) and *Lates niloticus* (21.93 %). However, *Clarias gariepinus* (32.46%) was the most infected fish species. (Table 4.8a/b, 4.9a/b)

Table 4.8a Prevalence of Fish Parasites Found in Wild Environment in Relation to Species

Parasite Species	**Location of parasites**					
	Gills (%)	**Stomach (%)**	**Intestines (%)**	**Total (%)**	χ^2 – value	P – value
Capillaria sp	3(7.68)	21(53.85)	15(38.46)	39(17.11)		
Camallanus sp	6(13.95)	21(48.84)	16(37.21)	43(18.86)		
Trichodina sp	2 (25)	0 (0.00)	6 (75)	8 (3.51)		
Cestode sp	9 (45)	6 (30)	5 (25)	20 (8.77)		
Eimeria sp	21(87.5)	3(12.5)	0 (0.00)	24(10.53)		
Opisthorchis sp	0(0.00)	5(10.20)	44(89.79)	49 (21.49)		
Diphillobothrium sp	3 (6.67)	4(8.89)	38(84.4)	45(19.74)		
Total	**44(19.28)**	**60(26.32)**	**124(54.39)**	**228(100)**	**154.64**	**21.03**

Table 4.8b Prevalence of Fish Parasites Found in the Wild Environment

Fish species	Location of Parasites					
	Gills (%)	**Stomach (%)**	**Intestines (%)**	**Total (%)**	χ^2 – value	P – value
Mormyrus rume	7(13.46)	16(30.77)	29(55.77)	52(22.81)		
Bagrus bayad	6(11.54)	13(25)	33(63.46)	52(22.81)		
Lates niloticus	11(20)	14(28)	25(50)	50(21.93)		
Clarias gariepinus	20(27.02)	17(22.97)	37(50)	74(32.46)		
Total	**44(19.29)**	**60(26.32)**	**124(54.39)**	**228(100)**	**7.06**	**12.59**

4.1.13 Prevalence of fish parasites found in culture environment

Analysis revealed significant ($p < 0.05$) difference in parasite species from the ponds, *Capillaria* sp from the two ponds studied had higher percentage of infecting the fishes although pond B (58.33 %) recorded little higher than pond A (50 %) followed by *Camallanus* sp with pond A (36.61 %) having higher percentage compare to pond B (16.67 %). *Trichodina* sp (2.77 %) was the least parasite recorded in pond A while the cestodes sp was least in pond B. (12.5 %). However, the following parasites were absent in Pond A*Cestode* sp and *Eimeria* sp while *Trichodina* sp, *Eimeria* sp and *Opisthorchis* sp were absent in pond B. however, analysis shows no significant ($p > 0.05$) difference in *Capillaria* sp. infection in both ponds. Analysis of fish species reveled that *C. gariepinus* (75 %) had the highest number of parasite infection compare to *Heteroclarias* (25 %). (Table 4.10, 4.11).

Table 4.9a Prevalence of fish parasites found in culture environment

Location	Parasite Spp	Location of Parasites Gills (%)	Stomach (%)	Intestines (%)	Total (%)	χ^2- value	P- value
Pond A	*Capillaria* sp	7(19.44)	8(22.22)	21(58.33)	36(50)		
	Camallanus sp	0(0.00)	14(82.35)	3(17.64)	17(36.61)		
	Trichodina sp	2(100)	0(0.00)	0(0.00)	2(2.77)		
	Cestodes sp	0(0.00)	0(0.00)	0(0.00)	0(0.00)		
	Eimeria sp	0(0.00)	0(0.00)	0(0.00)	0(0.00)		
	Opisthorchis sp	0(0.00)	1(16.67)	5(83.33)	6(8.33)		
	Diphillobothrium sp	0(0.00)	2(18.18)	9(81.81)	11(15.28)		
	Total	**9(12.5)**	**25(34.72)**	**38(52.78)**	**72(100)**	**29.89**	**21.03**
Pond B							
	Capillaria sp	0(0.00)	3(21.43)	11(78.57)	14(58.33)		
	Camallanus sp	0(0.00)	2(50)	2(50)	4(16.67)		
	Trichodina sp	0(0.00)	0(0.00)	0(0.00)	0(0.00)		
	Cestodes sp	2(66.67)	0(0.00)	1(33.33)	3(12.5)		
	Eimeria sp	0(0.00)	0(0.00)	0(0.00)	0(0.00)		
	Opisthorchis sp	0(0.00)	0(0.00)	0(0.00)	0(0.00)		
	Diphillobothrium	0(0.00)	0(0.00)	3(100)	3(12.5)sp		
	Total	**2(8.33)**	**5(20.83)**	**17(70.83)**	**24(100)**	**19.11**	**21.03**

Table 4.9b Prevalence of fish parasites found in culture environment in relation to fish species

Fish species	Location of Parasites					
	Gills	**Stomach**	**Intestines**	**Total**	χ^2 – value	P – value
	(%)	**(%)**	**(%)**	**(%)**		
Clarias gariepinus	9(12.5)	25(34.72)	38(52.78)	72(75)		
Heteroclarias	2(8.33)	5(20.83)	17(70.83)	24(25)		
Total	**11(11.49)**	**30(31.25)**	**55(57.29)**	**96(100)**	**5.09**	**2.41**

Classification and categorization of the different fish parasites of the fish species

Plate 9: Nematode *Capillaria* sp (A)

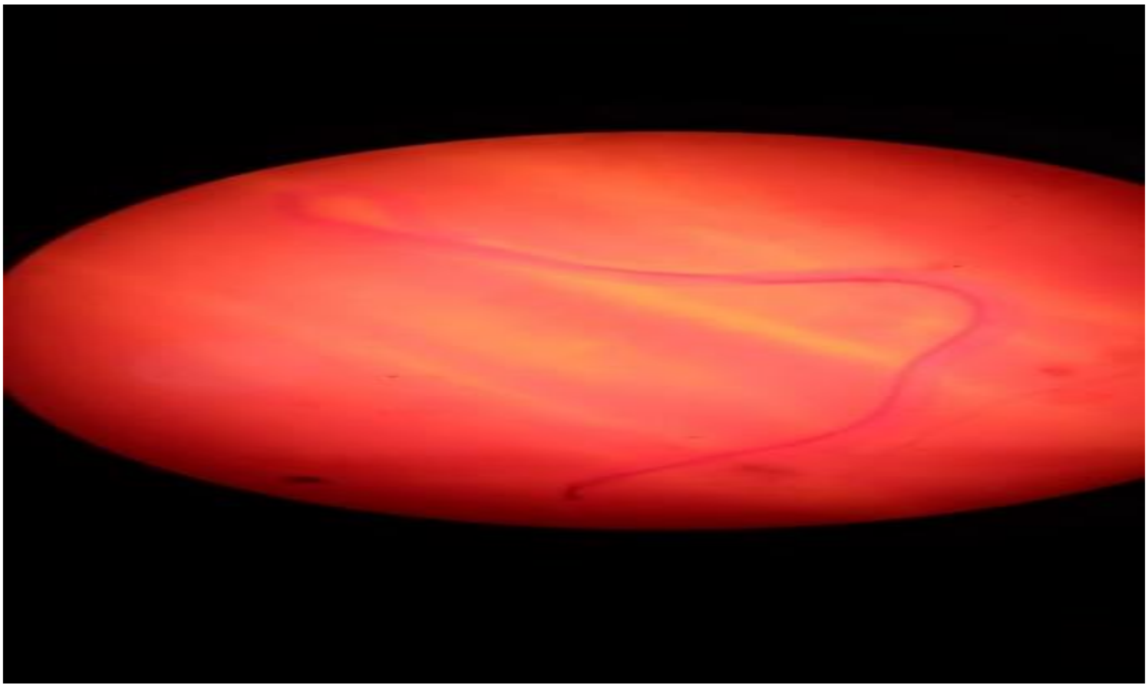

Plate 10: Nematode *Camallanus sp* (B)

Plate 11: Protozoan *Trichodina sp* (C)

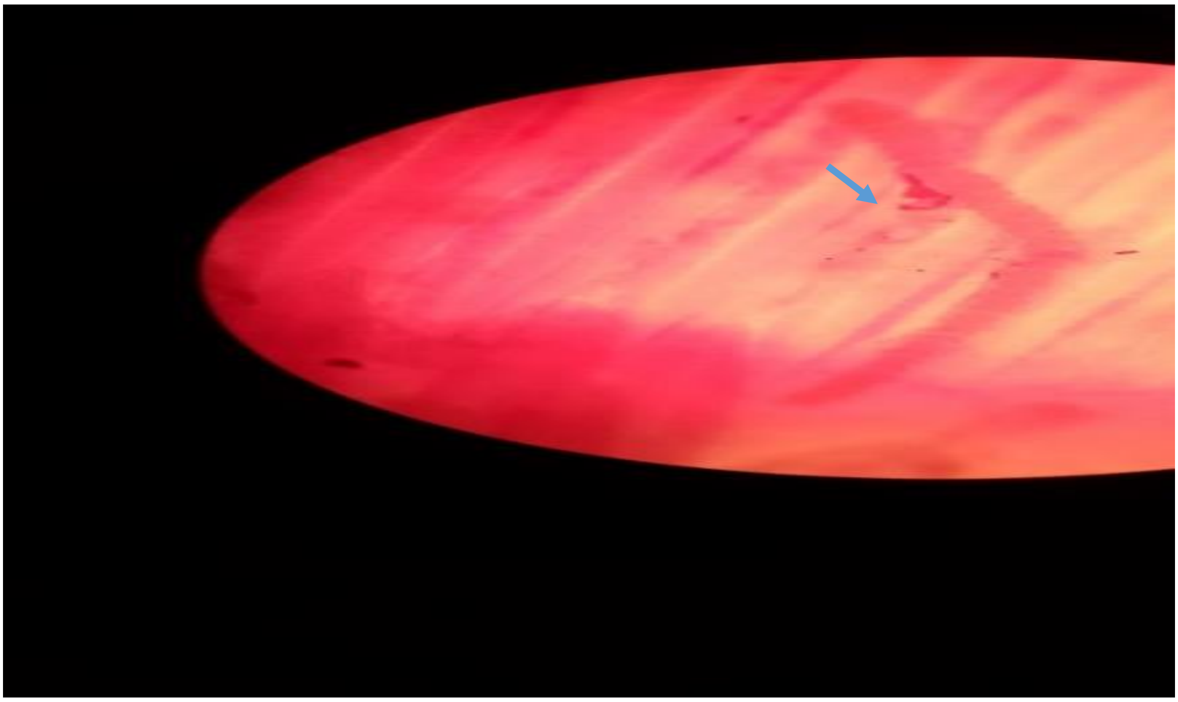

Plate 12: Cestode sp (D)

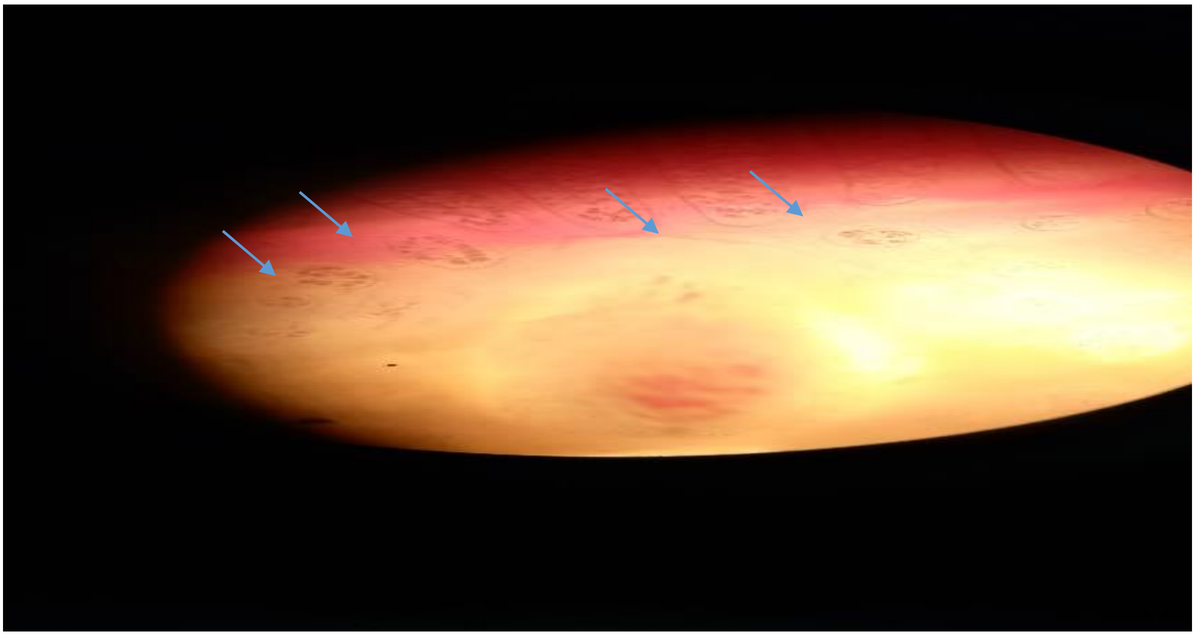

Plate 13: Protozoan *Eimeria* (E)

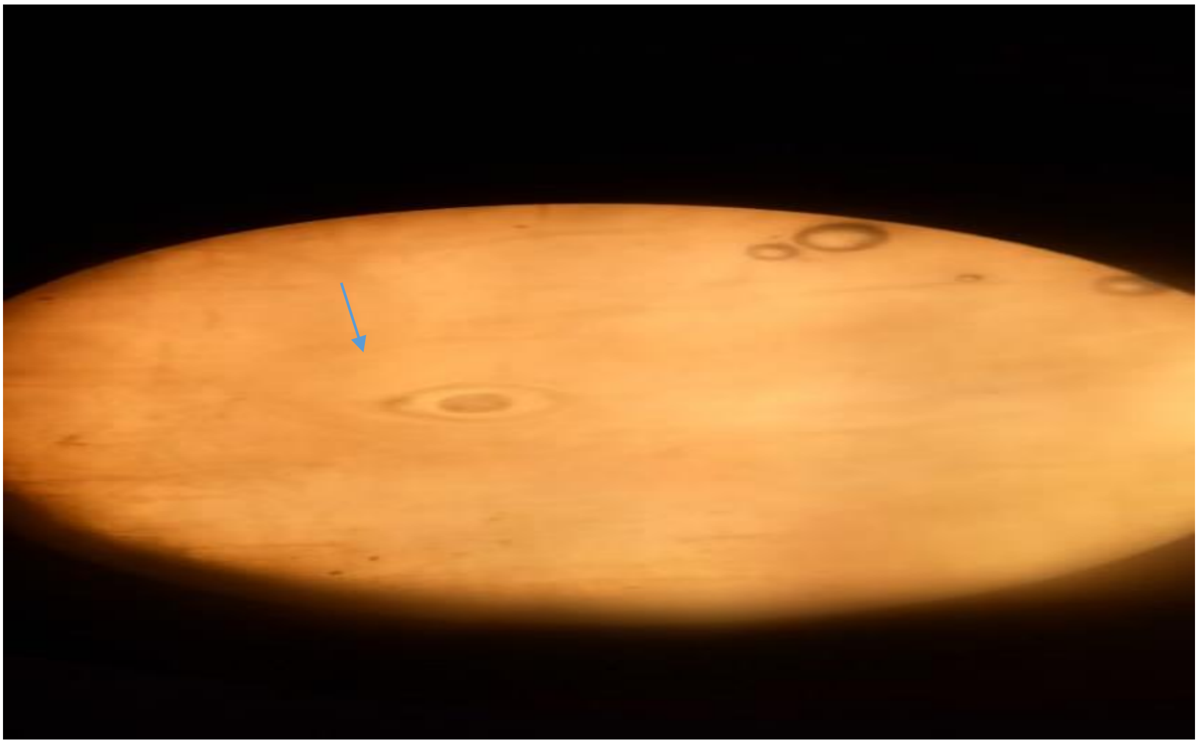

Plate14: Trematode Fluke *Opisthorchis sp* (F)

Plate 15: Cestode *Diphillobothrium sp*(G)

Source: Field Photograph (x40 Magnification)

4.2 Discussion

4.2.1 Monthly variation in physicochemical parameters in wild environment

Physical, Chemical and Biological factors determine quality of a particular water body, all of these factors interact with each other to control its productivity (Akponine and Ugwumba, 2008).Analyses revealed in this study shows significant variation in physicochemical parameters recorded in the wild during the study period (Figures 4.1 to 4.3). In the wild environment, the high temperature observed in the month of June and September, could be due to the increase in depth of water leading to increase in the water volume as a result of rain and wind during the period, this water temperature values are in line with some researchers who worked around some stream in Niger State. Keke *et al.,* (2015) observed a temperature range of 27 ^{o}C to 29 ^{o}C from downstream Kaduna River, Zungeru, Niger State, Nigeria while Mohammed *et al*. (2020) carried out research on Assessment of some physicochemical parameters of Moussa stream, Bida, Niger State Nigeria observed temperature of 24.6 ^{o}C to 27.8 ^{o}C. pH is an important parameter which helps to determine the acid–base balance of river water (Bhalla and Waykar, 2012) thus, it determines the growth of microorganisms also it helps to determine the corrosive nature of water. The pH value observed in this study is within the recommended range of 6.5 to 8.5 (SON, 2007 and USEPA, 2010). Dissolved oxygen is carried out to determine the quantity of oxygen present in a water body. Dissolved oxygen was highest in September 2020 (12.00±0.00 mg/L) and lowest in December 2019 (6.25±0.35 mg/L). this result is in contrast with Muhammed *et al.* (2015) who recorded maximum DO in December (8.5mg/l) although DO recorded in this study is higher compare to the valve of Keke *et al.,* (2015) (3.50 to 8.2 mg/l).

Dissolved oxygen in water fluctuates, this depends on the depth of water, the temperature and amount of biological activities in and around the water. The decrease in DO valve observed in the month of December could be due to the low level of water by that time and level of influx of organic waste leading to biological respiration and decomposition processes which may have led to the reduction. Biochemical Oxygen Demand is used for assessing the organic pollution that is the measurement of the amount of organic materials of an aquatic system supporting the growth of microorganisms. BOD observed in this present study indicate that the water body from the stations are well oxygenated. Conductivity and Total dissolved solids was carried out to determine the concentration of dissolved mineral salt and to determine ionic effect in water. Conductivity valve was high in march and this could be due to the fact that the water level was very low considering the season and the influx into the dam did not reduced which may have led to the increase in the month.

4.2.2 Monthly variation in physicochemical parameters in culture environment

In the culture environment, the analyses revealed no significant variations in water temperature, pH, dissolved oxygen and biochemical oxygen demand total hardness, conductivity, alkalinity and total dissolved solids varied across the months. (Figure 4.4 to 4.5). Also nitrates and phosphorus contents also varied significantly among the months throughout the study period, (Figure4.6).pH obtained from the cultured environment is good for aquaculture, this values is similar to (Olukunle and Oyewumi2017) who recorded 7.0 to 10.0 mg/l for pH in a research title Physicochemical Properties of Two Fish Ponds in Akure, Implications for Artificial Fish Culture. DO obtained from this study is lower compare to this valves 41.67 to 62.77 mg/l (Olukunle and Oyewumi 2017) recorded from two ponds. Though, the DO from the study was higher than that of Onome and Ebinimi, (2010) who recorded 4.34

to 6.33 mg/l. The minimum DO for tropical fish as suggested by Saloom and Duncan, (2005) is 5 mg/l, this shows that the DO gotten from this present study is within the recommended range. High valvein Conductivity in the month of September in the culture environment could be as a result of the flood that was witness at that period. Arimoro *et al*. (2015) stated that when there is high content of nutrient such as nitrate and phosphate, this may be as a result of surface run off either from farms or decomposition of organic matters which goes into the water and different anthropogenic activities around the water body. Values of the physicochemical parameters obtained from the two environments (wild and Culture) in this present study were within the recommended range for good fish production.

4.2.3 Variation in fish body morphometries in wild and culture environment

The study revealed significant monthly variation in the body morphometries of the fish species in both environments throughout the collection period, the morphometries measured include total weights, total lengths, standard lengths, length of intestines, weight of livers, weight of hearts, gut weight of the species. (Table 4.1 to 4.5).The differences in condition in fish generally may be due to the fitness of the fish species in its environment and how well the fish exploit it, which means variation in morphometric parameters in fish can be controlled by its environmental and physiological factors, this statement is in line with (Nitin and Vishal,2019) who mentioned that the cause of differences in the morphometric and meristic characters of fish may range from variability to the intraspecific which is under the control of environmental parameters. Also Nitin and Vishal, (2019) mention that various environment factors like thermal factor influence morphometric character of fish species. Wimberger (1992) stated that morphometric characters of fish can show a high degree of plasticity in response to environmental conditions. variation in length of fish could be due to the fact that different sizes were sampled during the time of study apart from environmental and physiological factors, this similar observation was made by Mansor *et al.,* (2010) who stated that selection of mesh sizes of net could contribute to the various sizes of fish caught and hence resulting in different growth. Zafar *et al.,* (2002) mentioned that Morphometric parameters is independent of fish body length, in agreement to the statement, relationship existed in total length of fish with different morphometric parameters, this shows that the length of a fish determines the growth of other organs in the fish as this was seen in this study, variation in the internal organs could be attributed to their food intake. Ujjania *et al.,* (2012) observed a positive growth which was recorded in morphometric parameter with increase in fish length, similar observation was made by Johal *et al.,*(2003), Badkur and Prashar,(2015), Nitin and Vishal, (2019). The weight of fish increases when it utilizes the food items that are available for growth and energy (Kamaruddin *et al*., 2012), this statement agrees with the present study as it was seen that there was increase in the internal organs in relation to the fish weight. Though there was decrease in condition factor with increase in length in some fishes. Nikosky (1963) revealed that the higher the condition factors the better the condition of the fish. This means that increase in length did not bring about proportional increase in weight in the affected fishes. Fawole, (2002). Characterised the differences in condition factor to the deposition of materials for the development of gonad, which led to increase in weight and actual spawning which led to decrease in fish weight.

4.2.4 Monthly qualitative distribution of bacteria species in wild and cultured environment

The present study shows monthly presence of bacteria on fish species in both wild and cultured environments which varied monthly. *Staphylococcus aureus, Klebsiella, Escherichia coli, Pseudomonas aeruginosa, Shigella dysentrea, Bacillus subtilis* and *Streptococcus faecalis* were the bacteria species encountered. (Table 4.6).Gram negative bacteria belonging to the family enterobacteriaceae was encounted in both environments (wild and pond). Tivkaa and Sampson, (2013) mention that micro/bacteria flora of fish harvest and other aquatic organisms are largely reflection of the microbial water quality. Bacterial count in cfu in this study was 10^6 obtained from the skin, this count is in line with (Tivkaa and Sampson, 2013) study on catfish (*Clarias gariepinus*) harvested from Ponds in Uyo South-South Nigeria. The human bacteria pathogens isolated and identified in this present study from the two environments include *Escherichia coli, Pseudomonas aueriginosa, Staphylococcus aureus, Klebsiella, Shigella, Bacillus subtilis* and *Streptococcus faecalis.* this is evidence assome researchers also recorded similar species in their various studies on bacterial flora in both ponds, fresh and marine water fishes, (Musefiu *et al*., 2011; Tivkaa and Sampson,2013; Petronillah *et al*., 2014; Abu and Uwadirioha,2016) though the present study used other fish species apart from *Clarias gariepinus*. Meanwhile the bacteria species identified in the present study did not cause mortality to the fish species, this is in agreement with the study of (Efuntoye *et al*., 2012) who stated that Bacteria species may not cause mortality in fish if the host fish have a strong defense response but the species are both opportunistic and pathogenic species which can cause fish disease. Contamination of fish species may be as a result of human handling, human activities, water and other source, this is in agreement with (Tivkaa and Sampson, 2013) who stated that pond water may be source of contamination of cat fish cultured in them. Adedeji *et al*. (2012) also stated that contamination of water may be from deposition of excretes from both humans and animals when there is rain fall, different waste is being washed into water bodies which could be the reason why these organisms were isolated from the studied fish species. Danba *et al*. (2014). Mention that the timing of bacteria presence on fish is to some extent controlled by seasonal changes with the inference changes in climatic conditions.

That is some bacteria organisms can survive in some weather condition, this could be the reason why *Bacillus subtilis* and *Streptococcus faecalis* were both absent in both water environments in December 2019 and present in February 2020.*Staphylococcus aureus, Pseudomonas aueriginosa, Escherichia coli* and *Shigella* found in the fish samples indicates faecal contamination of the water body, this agrees with Petronilah *et al*. (2014) in a research report that *Staphylococcus aureus, Shigella, Pseudomonas aueriginosa, Escherichia coli* and *Salmonella* presence were attributed to the contamination of the fish pond water by animal waste. Sujatha *et al*. (2011), also mention that members of the genus *Pseudomonas* are found in the soil and natural sources of water and are important phytopathogens and agents of human infections being considered opportunistic pathogens. Abu and Uwadirioha, (2016) stated that *Bacillus sp, Staphylococcus* are known for serious illness to humans, other bacteria species as *Pseudomonas* and *E. coli* could cause disease in some particular fish species or could be a source of zoonosis to man. *Staphylococcus aureus* has been associated with different clinical conditions. For instance, it is still one of the most frequently encountered single bacteria species in hospitals and continues to be the common cause of burns and sepsis (Udeze *et al*., 2012). *Klebsiella* are found in many environment and are part of the natural microflora of soils effluents and surface water, the presence of *Klebsiella* could be associated with human handling, this is in agreement with (Adebayo *et al*., 2012) who reported that fish skin was one of the major locations of *Klebsiella* in a paper titled occurrence of *Klebsiella spp* in cultured African Catfish in Oyo State, South-west Nigeria.

4.2.5 Monthly variation in microbial load

The present study shows monthly variation in microbial load in the fish species collected during the study period and it revealed significant monthly and species variations in microbial load. *Clarias gariepinus* from the two environment had the lowest microbial load, this may be due to the fact that this species of fish has a strong immune system to fight bacteria organisms while *L. niloticus* had highest microbial load across the month, this may imply that *L. niloticus* are easily attracted to bacteria organisms although there was no mortality in these fish species which means they havestrong immune system. Microbial load was recorded low in the month of February, 2020 while lowest was in the month of August, 2020, all of these could be attributed to the level of water and the weather condition as at the time of sampling, this may have had effect on the fishes from both environments.

4.2.6 Prevalence of fish parasites found in both environments and in relation to fish species

Several studies on fish parasite by different researchers propose that parasite load in an ecosystem poses high risk of fish infection and other aquatic organisms also to it consumers especially man as stated by (Okoye *et al*., 2014). The three locations in this study are not left out has some of the fishes were infected with different parasites. Analysis of parasites found in wild and culture environment reveal significant difference between parasites in fishes in the current study (Table 4.8a/b, 4.9a/b).Due to seasonal changes in water temperature, abiotic factors could lead to parasitic infection which may have effect on fish and the temperature effect is a significant factor for the prevalence rate of parasites ((Palm *et al.,* 2011). In this study, most parasites were cited in the intestine followed by the stomach, prevalence of parasites in these regions shows that it is a more favoured place for them, this could be due to the favourable condition in the regions that help these parasites to survive and even reproduce. Similar report by several researchers stated that preference for intestine and stomach regions as sites of attachment could be attributed to the availability of food in the regions (Aliyu and Solomon, 2012; Kawe *et al*., 2016; El-Shahawy *et al*., 2017; Edore, 2017; Udechukwu, 2018). Agbabiaka *et al*. (2017) mentioned that the gills are center of filter feeding and are the place for gaseous exchange so the sieving capacity of the gill rakes may help to trap some organisms and heavy load of parasites on the gills than other part of the body thereby render the gills not to function well as an organ of respiration hence could result to death. This statement agrees with this study has parasites were found in the gills of some of the fishes examined. However, the gills were observed to have high number of protozoan parasite, this observation is in line with the works of (Omeji *et al*., 2011) who reported highest load of protozoan parasites in the gills of *Clarias gariepinus*. It was observed that nematode occurrence was higher compared to cestode, protozoa and trematode, this finding supports earlier work of Ratnabir *et al.* (2015) who discovered a higher number of nematode infection on the freshwater fish *Channa punctate.* Also Omalu *et al.* (2017) recorded nematodes in all the sampled fish species, this shows that this parasite can be found in any type of fish species has seen to appear in the present studied fish species. Agbabiaka *et al.,* (2017) reported that nematodes are said to interfere with absorption of nutrients in fish intestine and may reduce food intake and bio-utilization, also the metabolites produced by some of these parasites could adversely affect vital systems of the fish. This finding is in accordance with previous work reported by Okoye *et al*. (2014) and Abdel- Gaber *et al*. (2015). *Camallanus* sp. one of the parasites recovered from this present study was previously reported by some researchers, the occurrence of this intestinal parasite is in line with the study of other researchers, incidence of *Camallanus sp*. is explained in terms of dietary variations, immune-suppression, or host suitability for establishment of the parasite (Iman and Dewu, 2010; Kelly *et al*., 2010 and Okoye *et al.*, 2014). The various reports show that helminths infections are quite common in fish. *Clarias gariepinus* been the most infected fish species could be due that the fish species were more available for infestation.

CHAPTER FIVETT

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The physicochemical parameters values obtained in this present study were significantly different ($p \leq 0.05$) but mostly within the recommended range for good fish production, though there is need to properly manage wastes within the community and monitor human activities around the dam since the dam serves as a source of drinking water and fishing to the community also farmers should be educated on better managerial practices bordering on feeding practices, pond management, good water exchange practice in order to minimized organic load and waste accumulation so that some of these parameters do not exceed the levels that will/could be harmful to the fish in the various environment. There was variation in morphometric parameters in the sample fish species which was revealed that they could be controlled by their environmental and physiological factors. The human bacterial pathogens that were isolated and identified include *Escherichia coli, Pseudomonas aueriginosa, Staphylococcus aureus, Klebsiella. Shigella*, *Bacillus sp* and *Streptococcus faecalis*these bacteria could be cause through anthropogenic activities by humans and poor handling of the harvested fish. The findings in the study shows parasites in some fish species studied in three different locations of Niger State. Fish examined during this study were *Mormyrus rume, Bagrus bayad, Lates niloticus, Clarias gariepinus* and *Heteroclarias.* Affected host fish were infected with ecto and endo parasites, which include Protozoa (*Trichodina sp, Eimeria* *sp),* Cestode (*Diphillobothrium sp),* Nematode (*Capillaria sp, Camallanus sp)* and Trematode (*Opisthoorchis sp)* taxonomic groups. There were significant differences between prevalence of parasite infection of the fishes in the two environment. The presence of these parasites and bacterial are potential pathogenic organisms to the aquatic environment and equally constitute a public health risk to its consumers and can also lead to economic loss. Further research on parasites and pathogens including physicochemical analysis in water bodies around Niger State is therefore encourage to ensure human safety also the findings of this study are expected to contribute to future studies from the various locations.

5.2 Recommendations

1. Fish farmers, sellers and buyers should be enlightened on the potential risk of parasitic and bacteria infestation in fishes in order to reduce harm when consume or avoid economic loss.
2. Consumers are advised to cook/process their fish food very well so as to destroy any form of parasite harbored in the fish before consumption.
3. Research on increased production of healthy fish should be encouraged and adopted in the country especially in Niger State has fish is one of their major source of protein.
4. Constant surveillance of fish-borne parasites/pathogens and their epidemiological distribution should to encourage in Nigeria.
5. Regular monitoring of the aquatic ecosystem will guarantee the safety of aquatic lives and humans, this will make the environment fit for good and healthy production of fish for consumption.

6. In order to reduce the influence of anthropogenic activities by humans, this kind of studies should be encouraged often in order to develop new ways to reduce aquatic pollution.
7. The State government should always encourage the kings/chiefs in the communities where there is water body to always engage in awareness on the importance of the anthropogenic activities that could affect the water in order not to degrade the aquatic ecosystem.

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