GILL AND DIGESTIVE TRACT PARASITES OF *CLARIAS* SPECIES IN THE TELLA AREA OF RIVER TARABA, TARABA STATE, NIGERIA

BY

MATHIAS SIMON BINGARI

DEPARTMENT OF BIOLOGICAL SCIENCES,

FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY, ZARIA

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DEPARTMENT OF BIOLOGICAL SCIENCES, FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

SEPTEMBER, 2014

DECLARATION

I declare that the work in this thesis entitled “GILL AND DIGESTIVE TRACT PARASITES OF *CLARIAS* SPECIES IN THE TELLA AREA OF RIVER TARABA, TARABA STATE, NIGERIA” was carried out by me in the Department of Biological Sciences. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

Mathias Simon BINGARI ________________________ ________________

Signature Date

CERTIFICATION

This thesis entitled "GILL AND DIGESTIVE TRACT PARASITES OF *CLARIAS* SPECIES IN THE TELLA AREA OF RIVER TARABA, TARABA STATE, NIGERIA'' by Mathias Simon BINGARI meets the regulations governing the award of the degree of Master of science in Fisheries of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

PROF. T.O.L AKEN'OVA Chairman, Supervisory Committee, Department of Biological Sciences, Ahmadu Bello University, Zaria	____________________ Signature	______________ Date
PROF. J. AUTA Member, Supervisory Committee, Department of Biological Sciences, Ahmadu Bello University, Zaria	____________________ Signature	______________ Date
PROF. A.K. ADAMU Head, Department of Biological Sciences, Ahmadu Bello University, Zaria	____________________ Signature	______________ Date
PROF. A. Z. HASSAN Dean, School of Postgraduate Studies, Ahmadu Bello University, Zaria	____________________ Signature	______________ Date

DEDICATION

This research work is dedicated to the memory of my late father Chief Simon Bingari (ASP Rtd.), who laid the solid foundation for my education.

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ABSTRACT

There is an emerging need to culture fish for the teeming rapidly growing population, but infestation by parasites sometimes lead to reduction in fish aesthetic value, its reproductive capacity and mortality if there is high infestation. Information on gill and digestive tract parasites in River Taraba are needed because parasites that infest wild fish can also infest cultured ones. Two hundred and sixty (260) *Clarias* specimens obtained from River Taraba, Taraba State were examined for gill and digestive tract parasites from January to October 2013. One hundred and forty (140) of them were *Clarias gariepinus* and one hundred and twenty (120) *Clarias anguillaris.* Two gill parasites, *Macrogyrodactylus* sp. a monogeneans, and *Ergasilus sarsi*, a copepod were recovered. Three parasite species, *Tetracampos ciliotheca* and *Monobothrioides woodlandi,* which are cestodes and *Procamallanus laevionchus*, a nematode were recovered from the digestive tract of both *Clarias* species in the river. The relationships between sex and size of fish and the gill and digestive tract infestation was not significant ($P>0.05$). However, the relationship between infestation and seasons was significant for both gill and digestive tract infestations in *C. gariepinus* and *C. anguillaris* ($P<0.05$). The relationship between digestive tract parasite infestation and the seasons in *C. anguillaris* was not significant ($P>0.05$), but was significant in *C. gariepinus* ($P<0.05$). *Macrogyrodactylus* sp and *Ergasilus sarsi* (gill parasites) and *Tetracampos ciliotheca, Monobothrioides woodlandi* and *Procamallanus laevionchus* (digestive tract parasites) of *Clarias gariepinus* and *Clarias anguillaris* are reported in the Tella area of River Taraba for the first time. Therefore, fish farmers that may want to obtain their brood stocks from River Taraba are advised to quarantine them. For the overall benefit of academics and for record, further work on parasites of *Clarias* species and other fish species in River Taraba should be carried out.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Clarias gariepinus is generally considered to be one of the most important tropical fish species for aquaculture in West Africa (Clay, 1979; Akinsanya and Otubanjo, 2006). *Clarias* species inhabit calm freshwaters ranging from lakes, streams, rivers, swamps to flood plains, many of which are subject to seasonal drying up. They can survive during the dry season due to the possession of accessory air-breathing organ (Clay, 1979, Gertjan *et al.,* 1996; Skelton, 2001). *Clarias gariepinus* has an almost Pan-African distribution, from the Nile to West Africa and from Algeria to Southern Africa (Gertjan *et al.,* 1996); it also occurs in Minor-Asia. *Clarias anguillaris* has a more restricted distribution and is found in Mauritania, in most West African basins and in the Nile. Generally, *C. gariepinus* lives in most river basins with *C. anguillaris*. Since the last three decades, *C. gariepinus* has been considered to hold great promise for aquaculture in Africa; it has a wide geographical spread, high growth rate, resistance to handling and stress, and it is well appreciated in a wide number of African countries both for food and aquaculture (Gertjan *et al.,* 1996).

Virtually all free-living organisms are hosts to parasites, and parasitism, in its broadest sense, is considered to be the most common lifestyle on Earth (Price, 1980; Windsor, 1995). Thus, healthy ecosystems can be hardly considered disease free. The fact that parasites possess complex life-cycles makes them extremely valuable information units about environmental conditions, because their presence or absence tells us a great deal about not only their host ecology but also food web interactions, biodiversity and environmental stress (Overstreet, 1997; Marcogliese, 2004).

Most fish in the wild are infested by parasites. These are sometimes obvious but more often are difficult to detect other than by special techniques and usually appear to have little effect on the host fish (Tonguthai, 1997). Parasitic fauna of fishes have been studied in many parts of the world (Mwita and Nkwengulila, 2001; Dove and O'Donoghue, 2005; Eva and Harry, 2006 and Hassan, 2008). Some parasites are transmitted directly from fish to fish, such as some ectoparasitic protozoa and skin/gill flukes, however, they often involve a free-living phase. Other parasites such as digenean often have a complex life-cycle involving two or more hosts, including a fish. It is important to have this information, as it will have an effect on treatment methods on whether or not there will be success or failure when treating parasites, especially in the cultured species. In Africa, over 40 species of adult tapeworms have been reported to occur in African catfish *C. gariepinus.* (Van As and Basson, 1984). Some parasites are harmful to their hosts; others are not. A parasite that might be harmful if present in large numbers might not be harmful if just a few has parasitized the host.

Hudson *et al.* (2006) have argued that many ecological factors affecting fish parasite life-cycles and the complexity of aquatic food webs are important in determining ecosystem health, while Blanar *et al*. (2009) investigated associations and responses of specific fish-parasitic taxa to different contaminants to come up with a quantitative approach that will be important in studying parasite–host– pollution interactions. Madanire-Moyo and Barson (2010) worked on the diversity of metazoan parasites of the African catfish *Clarias gariepinus* (Bürchell, 1822) as indicators of pollution in a subtropical African river system in Harare, Zimbabwe and found out that the parasitic species richness was high in unpolluted sites than in polluted sites.

Development of aquaculture during the last few decades has resulted in much greater attention being paid to problems posed by parasites and their importance for fishery, leading to constraints in the productivity of aquaculture (Kennedy, 1994). Aside from direct losses caused by mortality, parasites may have considerable impact on growth and behaviour of fish, their resistance to other stressing factors and susceptibility to predation; their presence may also reduce the marketability of fish (Williams and Jones, 1994; Woo, 1995).

1.2 Statement of the Research Problem

The emerging need to culture fish for protein consumption for the teeming rapidly growing populations in the developing countries has made it necessary to intensify studies on the parasite fauna of African freshwater fishes (Akinsanya and Otubanjo, 2006).

River Taraba, a tributary of River Benue is one of the inland rivers that supply fish and fishery resources in Taraba State and beyond. Parasites, especially ecto parasites cause lesions on the skin and gills surfaces of fish, reducing its market and aesthetic value. When the external lesions are extensive, people tend to reject such fish.

Anaemia is a consequence of some monogenean infestations which may lead to weight loss. Parasites that live in the gastro-intestinal tract cause ulceration and blockage. Parasites reduce the reproductive capacity of fish by loss of oogenic tissues caused by scarring of the ovary, fibrosis or direct oocyte destruction (Williams and Jones, 1994).

1.3 Justification

Knowledge of parasites that infect/infest different species of fish is very crucial for the management, prevention and control of the parasites. Documented literature on parasites of wild and cultured fish species in Taraba is lacking. With the current interest in aquaculture, information on the types of parasites that infect *Clarias* species will be desirable since parasites that infect wild species can also infect the cultured ones; also, parasites of fish form an integral part of their biology and reflect the life habits of the fish, including their interactions with the benthic, planktonic and other fish communities (Landsberg *et al*., 1998). Parasites of fish may rank among the most sensitive of bio indicators because their parasitic infestations reflect the health of the entire aquatic community (MacKenzie *et al*., 1995; Marcogliese and Price, 1997).

With the establishment of Universities in Taraba State, this research will be an invaluable reference material for the upcoming researchers in the area of fish parasitology.

This study will also seek to provide baseline information on the gill and digestive tract parasites of *Clarias* species in a segment of River Taraba.

1.4 Aim of the study

To investigate the prevalence and assortment of gill and intestinal parasites in species of *Clarias* in River Taraba, Taraba State.

1.5 Objectives

1. Determine prevalence of gill and digestive tract parasites of *Clarias* species in River Taraba.
2. Determine prevalence of parasitic infections in relation to sex of fish.

3. Determine prevalence of parasitic infections in relation to size of fish.
4. Determine site- specificity and mean intensity of infestation of parasites in species of *Clarias* in River Taraba.
5. Determine association between gill and digestive tract parasite infestation and seasons.

1.6 Hypotheses

i. Gill and digestive tract parasites do not infest *Clarias* species in River Taraba.

ii. There is no relationship between sex of fish and parasitic infections.

iii. There is no relationship between size of fish and the prevalence of parasitic infections.

iv. The parasites of species of *Claria*s in River Taraba do not show site-specificity.

v. There is no association between gill and digestive tract parasite infestation and season

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Parasites of Freshwater Fishes

Parasites found in freshwater are primarily protozoans, myxozoans, helminths, (platyhelminths, nematodes and acanthocephalans), hirudeneans and crustaceans (Tonguthai, 1997). Both ectoparasites and endoparasites attack fish, but the endoparasites are able to cause greater damage to their hosts than the external ones (Tonguthai, 1997; Ayanda *et al.*, 2009). In most parts of the world, fish production is mainly from the wild. As the world's population grows, fish resources are being depleted at an increasing rate due to environmental degradation, and over harvesting; fish production can therefore no longer meet the demand of the growing population, thereby leading to an increase in the involvement of stakeholders in aquaculture (Murray, 2005).

2.1.1 Parasites of Nigerian freshwater fishes

There is an appreciable documentation of the parasite fauna of freshwater fishes in Nigeria. Some of the earliest reports from inland waters include those of Awachie (1966), Ukoli (1972) and Shotter (1977), to mention just a few. Awachie (1966) documented preliminary information on the parasites of fish in the Kainji reservoir in which he recorded a few infested fish. Contrary to the findings of Awachie (1966), Ukoli (1969) recorded heavy infestation of fish from the same reservoir. Ukoli (1972) recovered two amphistome trematodes, *Brevicaecum niloticum* McCleland, 1957 and

Sandonia sudanensis McCleland, 1957; he also recovered caryophyllaeid cestodes of the Genus *Wenyonia* Woodland, 1923 and described four new species: *Wenyonia youdeoweli, W. synodontis, W. kainjii* and *W. mcconnelli,* from fishes in River Niger. Shotter (1977) examined fishes for copepod parasites. He recovered four species *Ergasilus,* one of *Paraergasilus*; five species of *Lamproglena* and *Lernaea hardingi* from the different fish species he examined.

In the last decade Olofitoye (2006) worked on parasitofauna of some freshwater fish species in Ekiti State, Nigeria. A total of 617 freshwater fishes comprising 181 *Tilapia zillii*, 211 *C. anguillaris* and 225 *C. gariepinus* were examined for helminth parasites. Parasites recovered were *Monobothrioides*, *Polyonchobothrium clariae* and an acanthocephalan *Neonchorhynchus rutili.* Other works include those of Awharitoma and Ehigiator (2012) on helminth parasites of fishes from some rivers in Southern Nigeria; Ashade *et al.* (2012) on isolation, identification and prevalence of parasites of *Oreochromis niloticus* from three rivers in Lagos State; Okoye *et al.* (2014) worked on prevalence and seasonality of parasites of fish in Agulu Lake, South-East, Nigeria.

2.2 Types of Fish Parasites

2.2.1 Protozoans

Ectoparasitic protozoa represent one of the most hazardous threats to fish health. These parasites attack the fish and cause massive destruction of the skin and gill epithelium (Sterud *et al*., 2003; Enayat *et al*., 2008). Even moderate infections of these organisms may be fatal, since the infected fish lose their appetite and stop feeding (Sterud *et al*., 2003).

2.2.2 Copepods

Copepods are found in both fresh and sea water and are members of the phylum Arthropoda (subphylum Crustacea, class Maxillopoda and subclass Copepoda) (Brusca and Brusca, 2003). Most copepods are free-living and are very important food items for a variety of aquatic life. Body shapes vary tremendously from generally cylindrical to flatten or saucer shaped. The body is divided into cephalothorax and abdomen (Bunkley-Williams and Williams, 2004). One pair of thoracic appendages is modified into mouthparts, and five pairs are unmodified. The abdomen has no appendages, and usually terminates in a bifurcate tail. In parasitic forms, the life-cycle is direct, but typically involves a series of planktonic stages off the host. Sexes are separate with males often much smaller than the females (Bunkley-Williams and Williams, 2004).

Parasitic copepods generally occur on the gills or skin of fishes, but may burrow into the flesh or head sinuses, or crawl into the nose (nares) or eyes (orbits) (Bush *et al.*, 2001). Those on fishes are permanent parasites, feeding on mucus, sloughed epithelial cells and tissue fluids (Bush *et al.*, 2001). Copepods have not been found to directly transmit microbial diseases, but the lesions they cause may facilitate secondary infections. Most of the copepods recorded from freshwater have been carried in from the saltwater environment by their euryhaline hosts (Bunkley-Williams and Williams, 2004).

2.2.3 Helminths

Helminths may have direct or indirect life-cycles. Direct life-cycle involve a single host, with sexual reproduction occurring on or in the host and eggs or larvae usually leaving the host and spending some time in a free-living state in the environment before infecting the same species of host as the one from which it was discharged, without obligatory involvement of any other host (Hassan, 2008). Helminths with direct life-cycle are most important in dense populations of fish, and heavy parasite burdens are sometimes found. Many parasites have more complex or an indirect life-cycle which involves two or more hosts. Larval stages occur in one or more intermediate hosts, followed by sexual reproduction of matured adults in the definitive host. Intermediate hosts are essential for the completion of larval development and the parasite sometimes undergoes a period of asexual multiplication within them. In general, heavy parasite burdens seem to be more common in fish originating from wild sources (Hassan, 2008).

The damage caused by helminths to their host is generally related to the intensity of infection and the depth of parasite penetration within the host tissue (Hassan, 2008). Most intestinal helminths, such as trematodes, cestodes and nematodes, do not induce severe damage to the vertebrate's gastrointestinal tracts (Williams and Jones, 1994; Dezfuli *et al.*, 2003), unless they are present in large numbers, where they can cause growth retardation. The larval stages of some trematodes infect fish gills and may disrupt the respiratory system leading to high mortalities (Hassan, 2008).

2.2.3.1 Monogeneans

Monogeneans are ectoparasitic on the gill filaments of their fish hosts, but some are present on fins, body surfaces, in the nostrils, and buccal cavity of fish (Hendrix, 1994). These flukes are classified in the Phylum Platyhelminthes and Class Monogenea (Brusca and Brusca, 2003). They are small to medium sized flatworms and have direct life-cycle (Hoffman, 1999). The life-cycles of most monogeneans include an egg, free swimming larval stage (oncomiracidium) and the adult. The exception to this pattern is the gyrodactylids which are viviparous (Bush *et al.*, 2001). Monogenea that have direct life-cycles are common, highly pathogenic, obligatory parasites of the skin and gills and are generally host specific (Buchmann and Bresciani, 2006). They are 0.1-0.8 mm long and are best seen microscopically. The worms can be identified by their characteristic hold-fast organ, the opistohaptor, which is armed with large and small hooks. They hold onto their hosts via a combination of hooks, anchors, and suckers at their posterior end (haptor), and use the anterior end for feeding and assisting in moving for temporary attachment to other locations on the host (Hendrix, 1994). Monogeneans generally display high levels of host-specificity, and many species seem restricted to a single or several closely related host species (Cheung, 1993; Benz and Bullard, 2004; Hayward, 2005). They are diverse both in terms of morphology and numbers and their phylogeny is well resolved, at least to the family level (Poulin, 2001).

In the natural environment they usually do not cause many problems unless the host is stressed (Poulin, 2001). Monogeneans affect the host (1) through ingestion of mucus, skin, and blood so that much of the fish's protective coating is destroyed and then potentially dangerous secondary infections can set in; (2) by injury to gill tissue that leads to fusion and hyperplasia and subsequent decrease in gill surface area and thus a decrease in efficiency of respiration, and (3) by mechanical blockage of respiratory surfaces due to large numbers (Lawler 2003).

The two most common genera are *Gyrodactylus* and *Dactylogyrus*. *Gyrodactylus* gives birth to live young, and is frequently a skin parasite; *Dactylogyrus* lays eggs and is principally a parasite of the gills. Fish infected by monogeneans show hyperactivity and erratic swimming, often flashing above the water surface or rubbing the sides of their bodies against an object in the aquarium to dislodge the worms (Poulin, 2001). They breathe rapidly and distend their gill covers, exposing swollen, pale gills. Localized skin lesions appear with scattered haemorrhages and ulcerations. Mortality may be high. To prevent the disease, introduction of infected fish should be avoided.

There are about 50 families and thousands of described species of monogenea divided between two subclasses (Monopisthocotylea and Polyopisthocotylea) based on the complexity of their haptor. The Monopisthocotylea have one main part to the haptor, often with hooks or a large attachment disc, whereas the Polyopisthocotylea have multiple parts to the haptor, typically clamps.

Fish appear to co-exist with their specific monogeneans, in natural habitats as well as in culture conditions, even when infestations are intense. A few monogeneans, notoriously gyrodactylids, are, however, pathogenic to their host fish, usually to younger fish and in intensive culture conditions. Histopathological changes in the gills are hardly detectable in most instances even in relatively intense infections. In *Lates albertianus*, intense hyperplasia developed around *Diplectanus lacustris* attached to gills; diplectanid infections are nonetheless pathogenic to cultured marine fishes (Paperna, 1996).

2.2.3.2 Digeneans

Digeneans are members of the phylum Platyhelminthes (class Trematoda, subclass Digenea). They are among the most common and abundant parasitic worms, second only to parasitic nematodes in their distribution (Roberts and Janovy 2000). Khalil and Polling (1997) listed 55 genera from 26 families, occurring in freshwater fish in Africa. Digeneans are relatively host-specific, heterogeneous flatworms which require typically a snail as the first intermediate host (Paperna, 1996). Adult digeneans usually have oval, dorso-ventrally flattened bodies with a smooth, spiny or corrugated surface. An oral sucker is usually present antero-ventrally and a ventral sucker is usually found mid-ventrally, both used for attachment. The digestive system consists of a mouth opening, pharynx, short oesophagus and two blind caeca. Most adults contain both male and female reproductive organs (Williams and Jones 1994).

Digeneans can infect fish either as adults or as metacercariae (Bartoli and Boudouresque, 2007). Metacercarial infections in fish have been recorded during various freshwater studies in Africa (Paperna and Thurston, 1968; Van As and Basson, 1984; Mashego and Saayman, 1989; Paperna, 1996; Aken'Ova, 1999a). Piscivorous birds, crocodiles, water monitor lizards and occasionally humans are hosts of the metacercariae found in fish. Most of the metacercariae form cysts in the flesh, on the gills and under the skin of fish. Others occur freely in the gall bladder, swim bladder, brain and the eyes. At low levels of infestation the host suffers no ill effects. However when infestations are heavy, the fish may become morbid and loose condition.

According to Bartoli and Boudouresque (2007) the more the digenean load increases, the more the movement of the fish is disturbed, which increases the probability of its capture by the final host. In addition, species of the genus *Diplostomum* can be significant pathogens causing a range of disease symptoms (i.e. exophthalmia, local haemorrhage, lens cataract and growth reduction) which may lead to fish mortality (Chappell *et al.*, 1994; Dorucu and Yspir, 2001).

A diagnosis usually can be established by gross or microscopic examination that reveal the cercarial, metacercarial, or adult worms in any of the tissues or body cavities of the fish. Fish tend to form pigmented tissue encapsulations that encyst the parasites. Depending on the colour of the cysts in the skin, the condition is called black, white, or yellow grub disease. Heavily infested fish are often weak, lean, inactive, and feed poorly (Hassan, 2008).

2.2.3.3 Cestodes

The Cestoda or tapeworms form a large endoparasitic class of the flatworms belonging to phylum Platyhelminthes (Brusca and Brusca, 2003). Their life-cycles are indirect, involving one or more intermediate hosts. Fish may act as either definitive, paratenic or intermediate hosts. Both larval and adult tapeworms are common in fish. Larval forms encyst in visceral organs and muscles, while adults are usually found in the digestive tract and are more host-specific than larval cestodes (Dick *et al*., 2006). Adult cestodes in the gastrointestinal tract of *Clarias* species or any other fish species it infest may cause mechanical damage or reduce nutrient absorption, but most serious pathology in fish host is caused by migrating larvae (Dick *et al.*, 2006; Barson and Oldewage, 2006b). Aquatic Crustacea are the most common intermediate host for fish cestodes; accordingly, wild and cultured pond fish may be heavily infected.

Diphyllobothrium latum (the broad fish tapeworm) infection of humans is acquired by eating larval tapeworms in the flesh of food fish. This is most common in marine fish species. Aquarium fish may be purchased with heavy cestode infections but have limited exposure once in the aquarium (unless fed infected intermediate hosts). There is no safe, effective treatment for larval tapeworm infections. *Corallobothrium* species are tapeworms occasionally found in the intestinal tract of channel catfish; however, their clinical significance is minimal. Larval migrations of the bass tapeworm, *Proteocephalus ambloplites* have been associated with reproductive failure in free-ranging populations of largemouth bass. Although usually an incidental finding, heavy infestations of tapeworms have been associated with mechanical obstruction of the lumen of the gut.

The life-cycle of cestodes is extremely varied with fish used as the primary or intermediate host. Cestodes infect the alimentary tract, muscle or other internal organs. Larval cestodes (plerocercoids) are some of the most damaging parasites to freshwater fish. They decrease carcass value if present in the muscle, and impair reproduction when they infect gonadal tissue (Williams and Jones, 1994).

2.2.3.4 Nematodes

Nematodes are endoparasites that may have direct life-cycles, such as *Camallanus* species (Levsen, 2001), although most species that infect fishes have indirect life-cycles, with single intermediate or paratenic hosts. Nematodes are common in wild fish that are exposed to the intermediate hosts. Fish may be definitive hosts for adult nematodes, or they may act as transport or intermediate hosts for larval nematodes (e.g. anisakids, eustrongylids) that infect higher vertebrate predators, including humans (Coyner *et al*., 2001; Akther *et al.*, 2004; Barson and Oldewage, 2006a). Adult parasites are usually found in the gastrointestinal tract and larvae in a variety of organs (Molnar *et al*., 2006).

When fish are intermediate hosts, definitive host are typically fish-eating birds (Perez-Ponce de Leon *et al*., 2000; Coyner *et al*., 2001). Encysted or free nematodes can be found in almost any tissue or body cavity of fish. Aquarium and cultured pond fish may be heavily infected if crustacean intermediate hosts are present (Coyner *et al*., 2001).

Larval nematodes either occur encysted in the tissue or free in the body cavity, but hardly, if ever, severely affect the fish (Paperna, 1996). The occurrence of larval *Contracaecum* species has been widely reported in cichlids and catfish from several African countries such as Egypt (Amin 1978), East Africa (Aloo 2001; Yanong, 2002), and South Africa (Mashego and Saayman 1981; Van As and Basson, 1984; Boomker 1994; Barson, 2003). Those that occur in the alimentary tract of the definitive host may in many cases cause lesions, ulcerations and tumours (Nagasawa *et al*., 1998). *Contracaecum* species that infect fish are found as adults in the gut of the final host (piscivorous birds, notably pelicans, cormorants, herons and darters) (Nagasawa *et al*., 1998).

. The most common fish-borne zoonotic diseases is anisakiasis caused by larval anisakid nematodes, usually of the species *Anisakis simplex* or *Pseudoterranova decipiens*. Anisakiasis can take a number of different clinical forms, depending on the location of the histopathological lesions caused by the larvae (Lymbery *et al*., 2007). Other zoonotic diseases caused by nematodes transmitted to people from fish include capillariasis caused by *Capillaria philippinensis,* marked by diffuse abdominal pain and intermittent chronic diarrhoea (Suankratay *et al*., 2001; Ko, 2006).

2.2.3.5 Acanthocephala

This is a small phylum comprising thorny-headed worms. The classes of Acanthocephala include the Palaeacanthocephala, Archiacanthocephala and Eoacanthocephala (Brusca and Brusca, 2003). Compared to parasitic platyhelminthes and nematodes, they are considered fairly rare (Roberts and Janovy, 2000). Acanthocephalans are dioecious, oblong worms that lack a mouth and digestive tract and possess an eversible, spiny proboscis and a pseudocoel (Nickol, 1995). They are bilaterally symmetrical, unsegmented, or only partially segmented externally and unsegmented internally. They attach in the gut of their host with a globular or cylindrical, protrusible, thorny proboscis. Sexes are separate, fertilization is internal, and embryos develop in the body of the female (Bunkley-Williams and Williams, 2004).

The larva is enclosed within a shell (egg) and passes out with faeces of the vertebrate host (Bush *et al*., 2001). If the egg is eaten by certain insects (roaches or grubs) or by aquatic crustaceans (amphipods, isopods, ostracods), the larva bores through the gut wall of host and become lodged in the haemocoel (Brusca and Brusca, 2003). The intermediate host is eaten by fishes, birds or mammals and the worm attaches to intestinal wall of vertebrate host. They can cause considerable damage to the intestinal wall when they occur in large numbers.

2.3 Fish Parasites as Bio-indicators

Biological communities are sensitive indicators of the relative health of their aquatic ecosystems and the surrounding catchments. The use of parasitological community data as a bio-indicator of environmental health underlines the need to study parasite communities at comparable localities with known pollution levels. The comparison of the conditions in different habitats might be helpful to differentiate between normal fluctuations in ambient conditions and pollution mediated effects (Fausch *et al*., 1990; McCormick *et al*., 2000). The relationship between the biological, physical and chemical components of aquatic ecosystems is the basis of biological monitoring (Joy and Death, 2002).

Fish are potentially effective biological indicators of the condition of aquatic ecosystems because different species exhibit diverse ecological, morphological and behavioural adaptations to their natural habitat (Karr *et al*., 1986; Fausch *et al*., 1990; McCormick *et al*., 2000). Fish communities integrate the ecological processes of streams across both temporal and spatial scales (Hynes 1970; Harris, 1995) and they can be useful indicators of aquatic degradation (Karr *et al*., 1986; Berkman *et al*., 1986; Steedman, 1988; Fausch *et al*., 1990).

Furthermore, because fish are a visible part of a stream's biological integrity, they represent a measure of stream quality which is easily and intuitively understood by the public (McCormick *et al*., 2000). The parasites of fish form an integral part of their biology and reflect the life habits of the fish, including their interactions with the benthic, planktonic and other fish communities (Landsberg *et al*., 1998).

Ecosystems with a high degree of biotic integrity (healthy ecosystems) are composed of balanced populations of indigenous organisms with diverse structural and functional organizations. Healthy ecosystems have a complex trophic structure with many species forming the food web. In the aquatic ecosystem fish are at or near the top of that food web and their parasites are also an indigenous component of the food web (Landsberg *et al*., 1998).

Parasites of fish may rank among the most sensitive of bioindicators because parasitic infections of fish reflect the health of the entire aquatic community (MacKenzie *et al*., 1995; Marcogliese and Price, 1997). Most fish parasites have complex life-cycles, e.g. a typical parasitic life-cycle may include the fish as definitive host with one or more intermediate invertebrate hosts. For the parasite to survive, all hosts must co-occur in a stable community structure (Marcogliese and Cone, 1997). Furthermore most parasites are specific to a host species or to a group of closely related hosts (Marcogliese and Price, 1997). How specific a parasite is to its host can depend on the type of parasite and/or on the stage in its life-cycles. Trematodes, for example, complete their development in at least two hosts, with the first intermediate host usually a mollusc (Roberts and Janovy, 2000).

Parasites of fish could therefore be more sensitive indicators of environmental stressors than fish themselves. The adverse environmental conditions may decrease the ability of organisms to maintain an effective immunological response system. Poor water quality can cause a reduction in the level of unspecific immunity to disease (Sures, 2007). As such, if the immune system of the fish is suppressed then the opportunistic diseases and parasitic infections may accumulate (Sures, 2007). This is also supported by Möller (1987) who stated that fish in polluted waters tend to harbour more endoparasites than those from less polluted environments. In addition, high parasitic loads can be fatal to the host (Poulin, 2000).

Khan (1990) reported an increased rate of infection in monogeneans associated with oil pollution. It has been suggested that at chronic, sub-lethal levels of exposure, fish skin and gills secrete abundant mucus, which in turn may act to enhance monogeneans and trichodinid rates of infection (MacKenzie *et al.*, 1995). According to Marcogliese and Cone (1997) the apparent inconsistency of their findings with above mentioned reports may perhaps be explained by the variable susceptibility of parasite species, length of exposure time, and concentrations and the nature of the pollutant. Oil, heavy metals and anaerobic conditions have been found to be toxic to adult trematodes inside their fish host (Overstreet 1997; Khan and Thulin 1991; Valtonen *et al.*, 1997) and lethal to free-living stages (e.g. cercariae and miracidia) as well as to the mollusc intermediate hosts (Evans, 1982; Siddall *et al.*, 1993). Furthermore, parasite species that are directly or indirectly sensitive to pollution may disappear as the pollution levels increase, and may thus be considered good indicators for early detection of adverse environmental effects (Dzikowski *et al.*, 2003).

2.4 Parasites of *Clarias* Species

Clarias species have a world-wide spread; they are found in virtually all parts of the world because of its desirable characteristics especially its ability to thrive well in culture (Gertjan *et al.,* 1996). Because of this, a lot of attention had been given to the fish to enhance its desirable qualities, which has led to many researchers working on parasites that infest the fish.

Erhan and Yilmaz (2005) worked on metazoan parasites of *Clarias lazera* (now *C.gariepinus*) and *Carassius carassius* from Kepaz I Hydro Electric Power Plant loading Pond, Antalya, Turkey. They worked on 38 *C. lazera* (now *C. gariepinus*) and recovered *Quadriancanthus clariadis* (Paperna, 1961) a monogenean and *Polyonchobothrium magnum* (Zme'ev, 1936), a cestode from the fish.

Barson and Avenant-Oldewage (2006) worked on digeneans, nematodes and cestodes of *C. gariepinus* from Rietviel Dam, South Africa and recovered two species of nematodes, *Procamallanus laevionchus* from stomach and *Contracaecum* sp. from the abdominal cavity; two cestodes, *Polyonchobothrium clariae* and *Proteocephalus glanduliger* and *Ornithodiplostomum* sp. a digenean.

De Chambrier *et al.* (2009) discovered a new genus and species of Proteocephalidea (Cestoda) in *C. gariepinus* and *C. anguillaris* from Sudan, Tanzania, Ethiopia and Zimbabwe.

Eissa *et al.* (2010) from Ismailia province in Egypt examined 100 fish and recovered *Henneguya*, a protozoan, *Orientochriidum betrachoid*, *Astitrema* sp. and *Allocreadium* sp. (trematodes), *Monobothrioides* sp. and *Polyonchobothrium* sp. (cestodes) *Spinitectus allaeri, Procamallanus laevionchus* and *Procamallanus cyathopharynx* (nematodes).

They also investigated the seasonal prevalence of these parasites and the gross histopathological changes they caused.

In Nigeria, a lot of work has been carried out on the parasites of *Clarias* species. Shotter (1980) worked on aspects of the parasitology of the catfish *Clarias anguillaris* from a river and a lake in Zaria, Kaduna, Nigeria; Aken'Ova (1983 and 1999a), on copepods parasites of the gills of three species of *Clarias* in two lakes and a river in Zaria and helminth infections of the gills of three species of *Clarias* species also in Zaria, Nigeria (Aken'Ova, 1999b). Others include Yakubu *et al.* (2002) in Plateau State, Ibiwoye *et al.* (2004) in Bida, Oniye *et al*. (2004) in Zaria and Akinsanya and Otubanjo (2006) in Lagos, Ayanda and Opeyemi (2009) in Ilorin and Omeji *et al.* (2011) in Benue State, to mention just a few.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

River Taraba is located on latitude 8° 34'N and longitude 10°15'E and Tella on latitude 8° 24'N and10°32'E (Fig.1). A 100 square kilometre around River Taraba has an approximate population of 14,326 people and an average elevation of 178 meters above sea level. The river has its source in the Mambilla Plateau of Sardauna Local Government Area of Taraba state. The river traverses the three districts of Gashaka, Bukundi and Gassol, in the Gashaka, Bali, and Gassol Local Government Areas. The Northern border of Gassol are the River Benue and River Taraba; the latter flows north through the area to its confluence with the River Benue.

Like most parts of northern Nigeria, Taraba State has wet and dry seasons. The wet season lasts, on the average, from April to October. Mean annual rainfall varies between 1058mm in the north around Jalingo and Zing, to over 1300mm in the South around Serti and Takum. The wettest months are August and September. (www.getamap.net/map/nigeria). The dry season lasts from November to March. The driest months are December and January with relative humidity dropping to about 15%. Mean annual temperature around Jalingo is about 28°C with maximum temperatures varying between 30°C and 39.4°C. The minimum temperatures range between 15°C to 23°C. The Mambilla Plateau has climatic characteristics typical of a temperate climate. (www.getamap.net/map/nigeria).

Rainfall distribution and topography are the most important factors influencing the pattern of vegetation in Taraba State. The vegetation may be classified into three broad

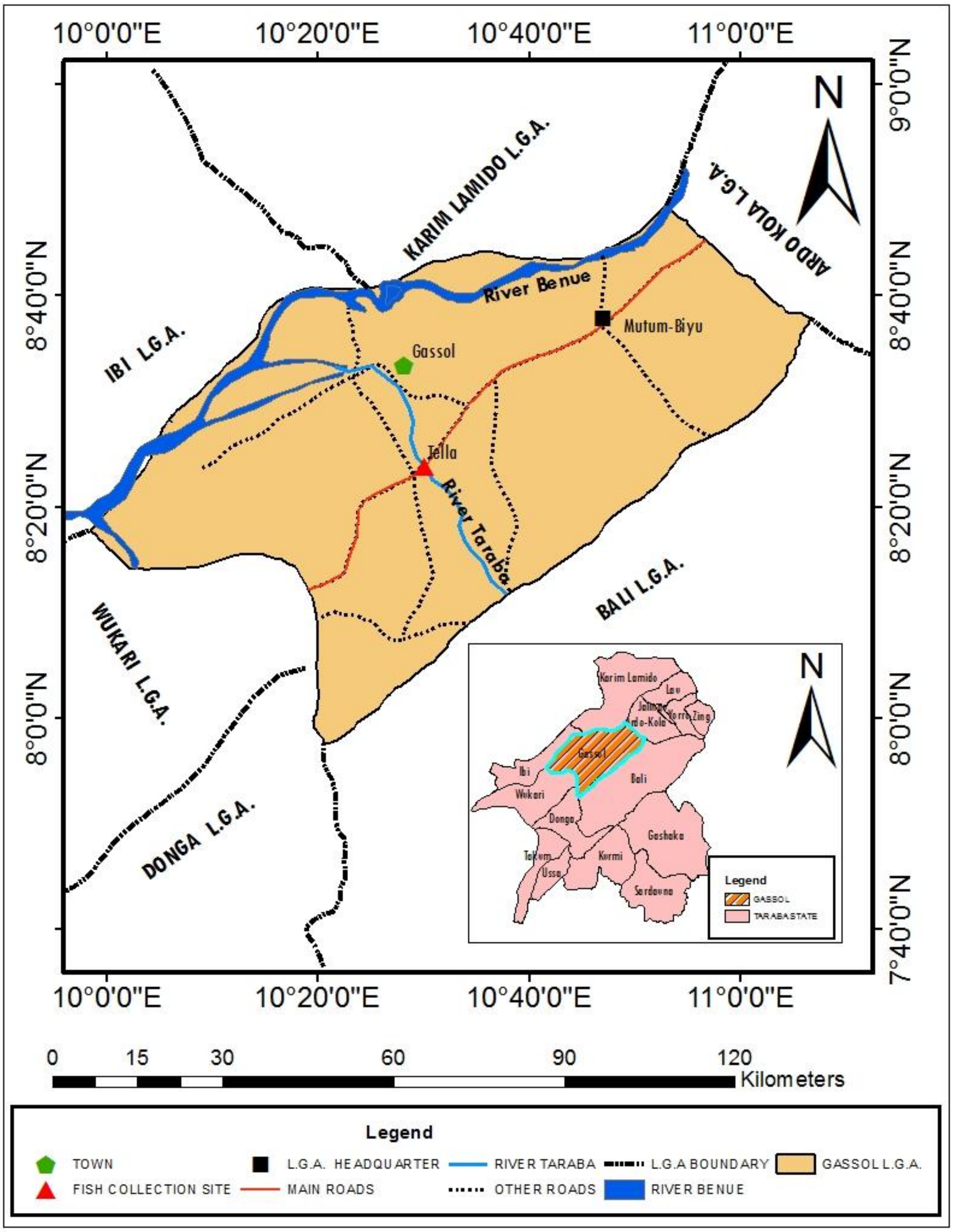


Fig. 1. Map of Gassol Local Government Area showing site of fish collection (▲)

Source: Modified from the administrative map of Taraba State.

types: the Northern Guinea, the Southern Guinea and the Mountain Grassland and forest vegetation (www.getamap.net/map/nigeria).The fish collection point falls within the Northern Guinea savannah.

3.2 Collection of Fish

Clarias species were purchased alive from the artisanal fisher folk at a fish-landing site along River Taraba at Tella between January 2013 and October 2013. The fish were then placed in a water-filled plastic container and taken to the Biology laboratory of the Taraba State University for parasitic examination. A total of 260 fish were collected and examined.

3.3 Identification of *Clarias* Species (Plates I, II, III and IV)

Fish identification started in the field. Black spots/patches on the caudal fins and sometimes on the body were used to identify *C. anguillaris* and their absence, *C. gariepinus*. To confirm the identification made in the field, the gill rakers of the two species were examined; *C. anguillaris* has fewer and thicker gill rakers than *C. gariepinus* (Plates III and IV).

3.4 Measurement and Weighing of Fish

The total and standard lengths of fish were measured to the nearest millimetre using a metre rule. The total length was taken from the anterior tip of the snout to tip of the caudal fin and the standard length is from tip of the snout to the end of the caudal peduncle (hypural bone). Total weight was taken to the nearest gram using a 22 Adam PGW 1502i electronic weighing balance, model number AE443185.

Plate I. Dorso-lateral view of *Clarias gariepinus*. There are no black spots on the caudal peduncle or caudal area

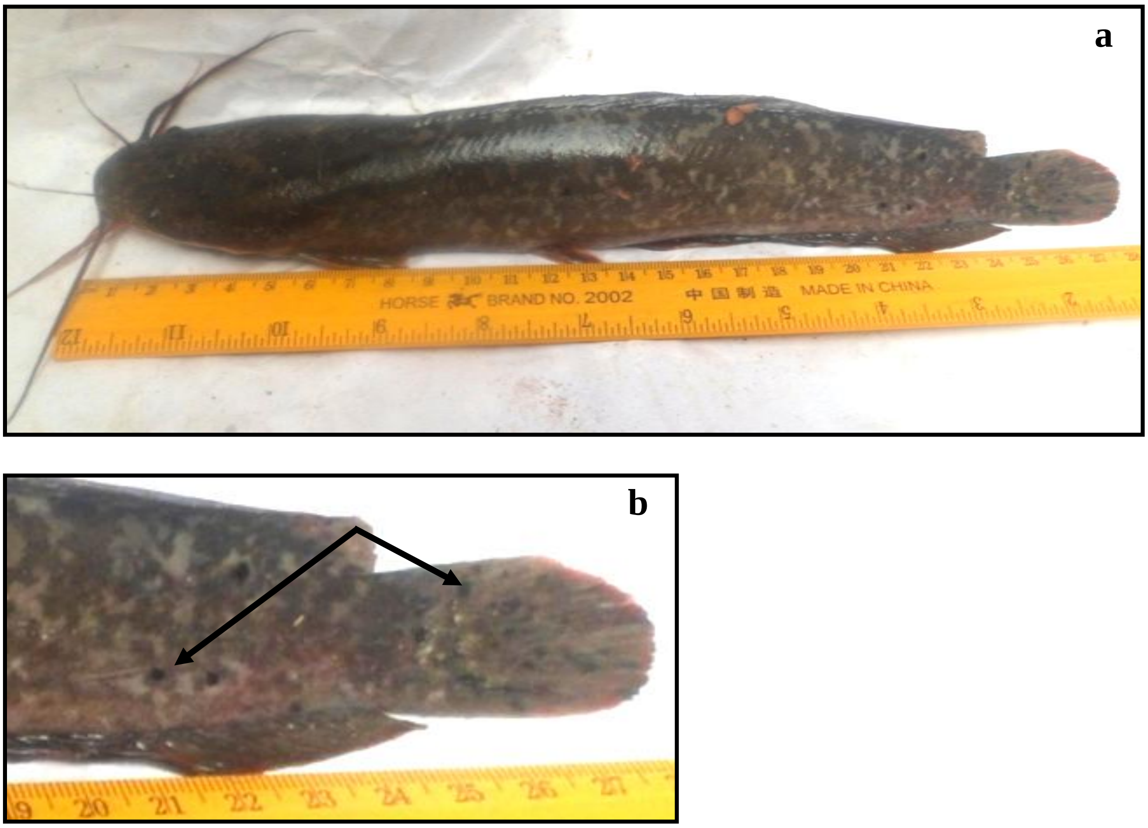


Plate II a, b. Dorso-lateral view of *Clarias anguillaris* (a). This species has black spots on the caudal fin and caudal area (b, arrows)

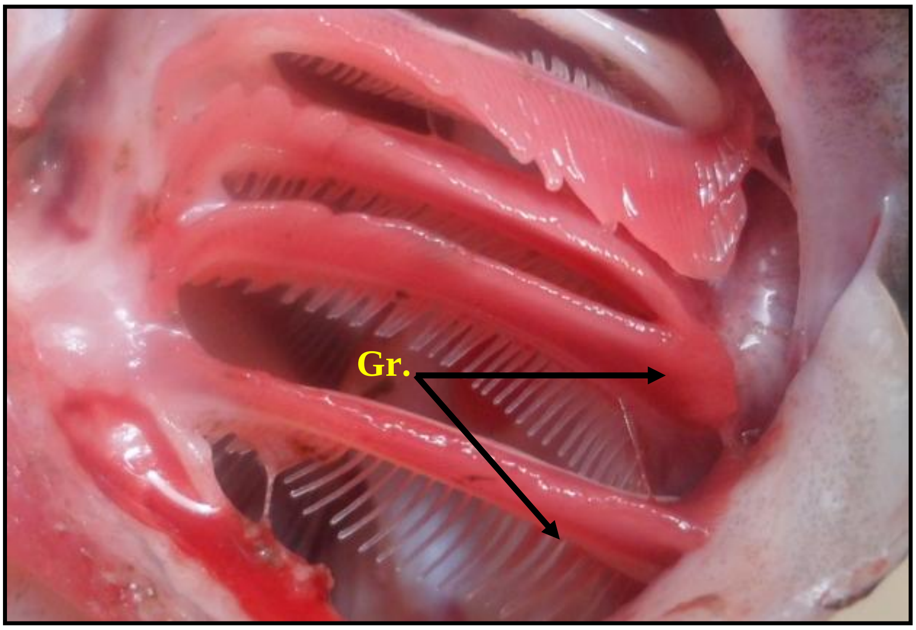


Plate III. Gills of *C. anguillaris* showing fewer, shorter and thicker gill rakers (Gr.; Arrows) than in *C. gariepinus*

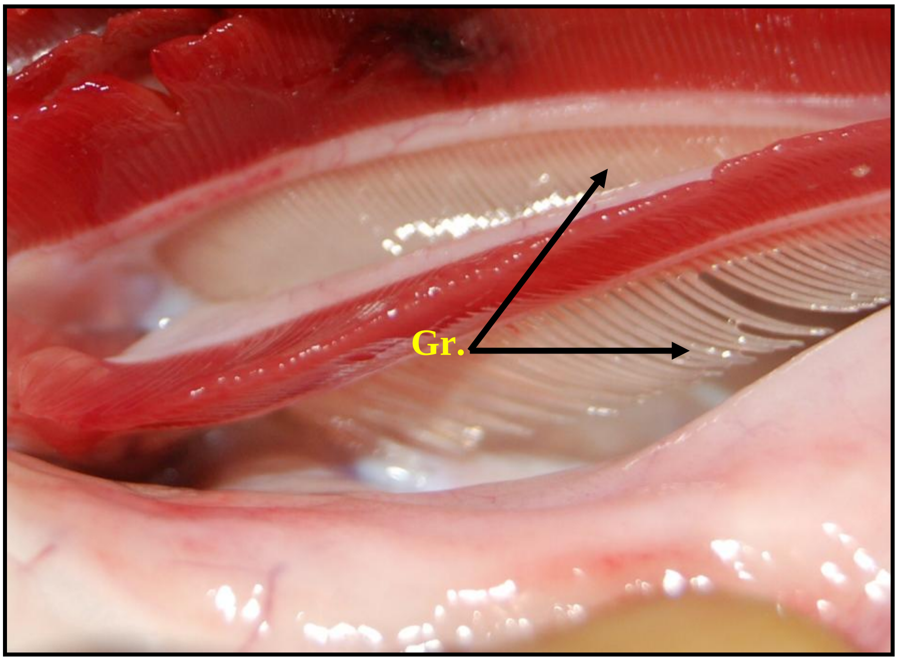


Plate IV. Gills of *Clarias gariepinus* showing more, longer and finer gill rakers (Gr.; Arrows) than in *Clarias anguillaris*

3.5 Sex Determination

The sex of fish was determined by external examination of their genital apparatus; the males have a genital papilla while the females have none. The sexes were confirmed by internal examination after dissection to expose the paired testes in the males and paired ovaries in the females.

3.6 Collection and Preservation of Gill Parasites

Gills were obtained by cutting them out at their upper and lower extremities. They were placed in a Petri dish containing distilled water and separated into individual gill arches using a pair of dissecting scissors and forceps. The gill filaments of the arches were examined in succession for parasites under a dissecting microscope.

Infested gills, along with attached parasites were placed in a specimen bottle. The parasites were fixed by pouring hot water on them, and then left for 1-2 minutes. Water from the bottle was then discarded, making sure no solids were discarded. Ten percent (10%) formalin was then added up to the top of the bottle. The specimen bottle was then labelled with the fish's autopsy number, number of parasites and date of collection written in pencil on a piece of paper and inserted into the specimen bottle. The bottle was finally capped and kept in a safe cupboard in the laboratory.

3.7 Collection and Preservation of Digestive Tract Parasites

The abdominal cavity of the fish was opened from the anus to just anterior to the area below the pectoral fins. The digestive system was cut around the anus and the oesophagus. All organs were extracted and placed in a Petri dish; the liver and spleen were discarded. The intestine was untangled using the fingers, the slit open longitudinally from anus to the oesophagus, including the stomach with a pair of scissors. The gall bladder was opened as well. Large undigested food materials in the stomach were noted and discarded. The entire digestive system was examined section by section under a dissecting microscope.

Parasites found were carefully removed and placed in a cavity block containing distilled water. The parasites that were firmly attached to the intestinal wall were cut out along with a small portion of the host tissue at the attachment site. The live parasites were allowed for about two minutes in distilled water and fixed by popping them into hot water (70-80°C). Contents of the cavity block were then transferred using a pipette or a pair of forceps into a specimen bottle containing 5% formalin. A piece of paper labelled in pencil with fish autopsy number, sex, and date examined was inserted into the specimen bottle containing the parasites.

3.8 Processing of Preserved Parasites

The preserved parasites recovered from the fish were taken to the Parasitology and Entomology Laboratory of the Department of Biological Sciences, Ahmadu Bello University, Zaria, for preparation of permanent slides.

3.8.1 Copepods

Preserved copepods were poured along with the gills into a Petri dish. Distilled water was used to wash off preservative. The parasites were extracted from the gills and transferred to a cavity block containing distilled water to wash off the preservative. The copepods were then placed on a slide and dabbled with a filter paper to remove excess distilled water. A drop of Belise’s fluid was placed on the copepod and covered with a cover slip. Berlise’s fluid acts both as a clearing agent and mountant.

3.8.2 Nematodes

Preserved nematodes were washed with distilled water to remove the preservative. The distilled water was then drained and replaced with glycerine to clear them. They were then mounted on a slide using glycerine-gelatine.

3.8.3 Monogeneans and Cestodes

The monogeneans found on the gills of *Claria*s species were preserved along with the gills as proposed by Justine *et al.* (2012). The infested gills along with the formalin were poured into a Petri dish and the formalin drained using a plastic pippette. The gills were washed with distilled water to remove the preservative, and then examined under the dissecting microscope; the parasites in the debris were sucked up with a pipette and placed in a cavity block containing distilled water. The distilled water was drained using a pipette under a dissecting microscope to avoid missing the parasite. The cestodes on the other hand were picked from the specimen bottle using a disposable pipette and placed in a cavity block. They were washed with distilled water to remove the preservative. Distilled water was then added along with two drops of Mayer's acid haematoxylin to the parasite and left to stain overnight. The diluted stain was drained carefully using pipette the next day and worms were rinsed with distilled water. A drop of 0.3% hydrochloric acid was added to distilled water in the cavity block to de-stain the parasite. Worms were then rinsed with distilled water; fresh distilled water was added to the worm in the cavity block then a drop of ammonia (0.03%) was added to stop the de-staining. Worms were rinsed with distilled water and dehydrated in a graded series of ethanol (30%, 50%, 70%, 90% and absolute) in succession for forty minutes each. The cavity block was kept covered during this process to prevent rehydration from the atmosphere. After about forty minutes, the absolute ethanol was replaced gradually with methyl salicylate. The dehydration time for the monogeneans in the graded series of alcohol was reduced to fifteen minutes each because of their small size. Individual parasites were transferred onto a glass slide and mounted in thinned Canada balsam.

3.9 Measurement and Identification of Parasites

Permanent slide was prepared for each of the processed parasites and were snapped under the microscope using a digital camera. The parasites were thereafter measured using a calibrated ocular micrometer and the measurements recorded in micrometers. Parasites were identified with the assistance of (Professors. T. O. L. Aken'Ova and J. Auta) my supervisors and with the publications of Mackiewicz and Beverly-Burton (1967) and Paperna (1996).

3.10 Data Analysis

IBM SPSS version 20 statistical package was used for statistical analysis. Chi-square was used to test the significance of the relationships between sex, size and seasons, gill and digestive tract parasites of *Clarias* species at 0.05 confidence interval.

CHAPTER FOUR

4.0 RESULTS

4.1 Descriptions of the Parasites Recovered

The parasites recovered from the gills and digestive tract of the two species of *Clarias* species are described below. All the measurements are expressed in micrometers unless otherwise stated.

4.1.1 *Ergasilus sarsi* (Plates V, VI and Fig. 2)

Body grey-white, broader at cephalothorax, tapers posteriorly. Second pair of antennae modified into clawed hooks. Curved end of clawed hook 12.5 µm, second segment of hook 22.5 µm, upper segment 25.8 µm. Cephalothorax 43.4µm long 42 µm wide. Abdomen 82.6 µm long; width at upper section 40.6 µm, middle 35 µm lower 30µm. Swimming leg/swimmeret 16.8 µm long; caudal whisker-like finneret 39.2 µm long.

4.1.2 *Tetracampos ciliotheca* (Plates VII, VIII and IX)

Body white, elongated, flattened; 1,252 µm long; scolex 38 µm long, 28 µm wide with 18-22 hooks; single hook 4.2 µm long. First proglottid after scolex 23.8 µm long; first gravid proglottid 42 µm long, 29.4 µm wide.

4.1.3 *Monobothrioides woodlandi* (Plates X and XI; Figs. 3a and b).

Body white, tappers anteriorly, broadly rounded posteriorly, margins ruffled; 1000 µm long. Scolex well defined, sucker anteriorly placed. Scolex 220 µm long, upper part 126 µm wide, mid section, 315 µm wide; posterior 273µm wide. Distance between ovary and posterior end 120 µm. Egg 5.6 µm long, width 4.2 µm.

4.1.4 *Procamallanus laevionchus* (Plates XII and XIII)

Body of live worm reddish, elongate tapering at both ends; 1022 µm long, 33.6 µm wide. Anus sub terminal, 103.6 µm from posterior extremity.

NB. Preparation of permanent mounts of *Macrogyrodactylus* species was not successful because the parasite was lost during several attempts to process it.

Plate Va. *Ergasilus sarsi*. Anterior part of the body showing attachment organs encircling a gill filament

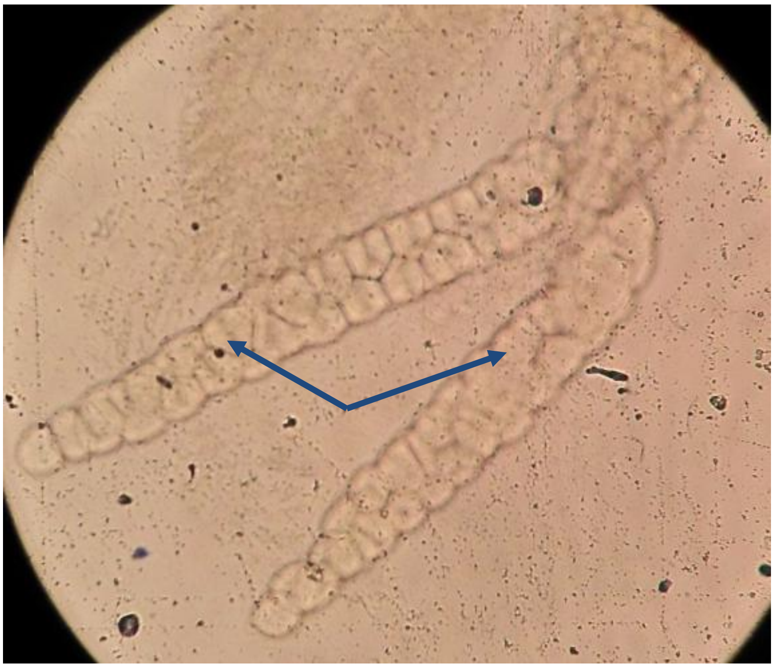


Plate Vb. Posterior part of the body of *Ergasilus sarsi* showing egg sacs with eggs

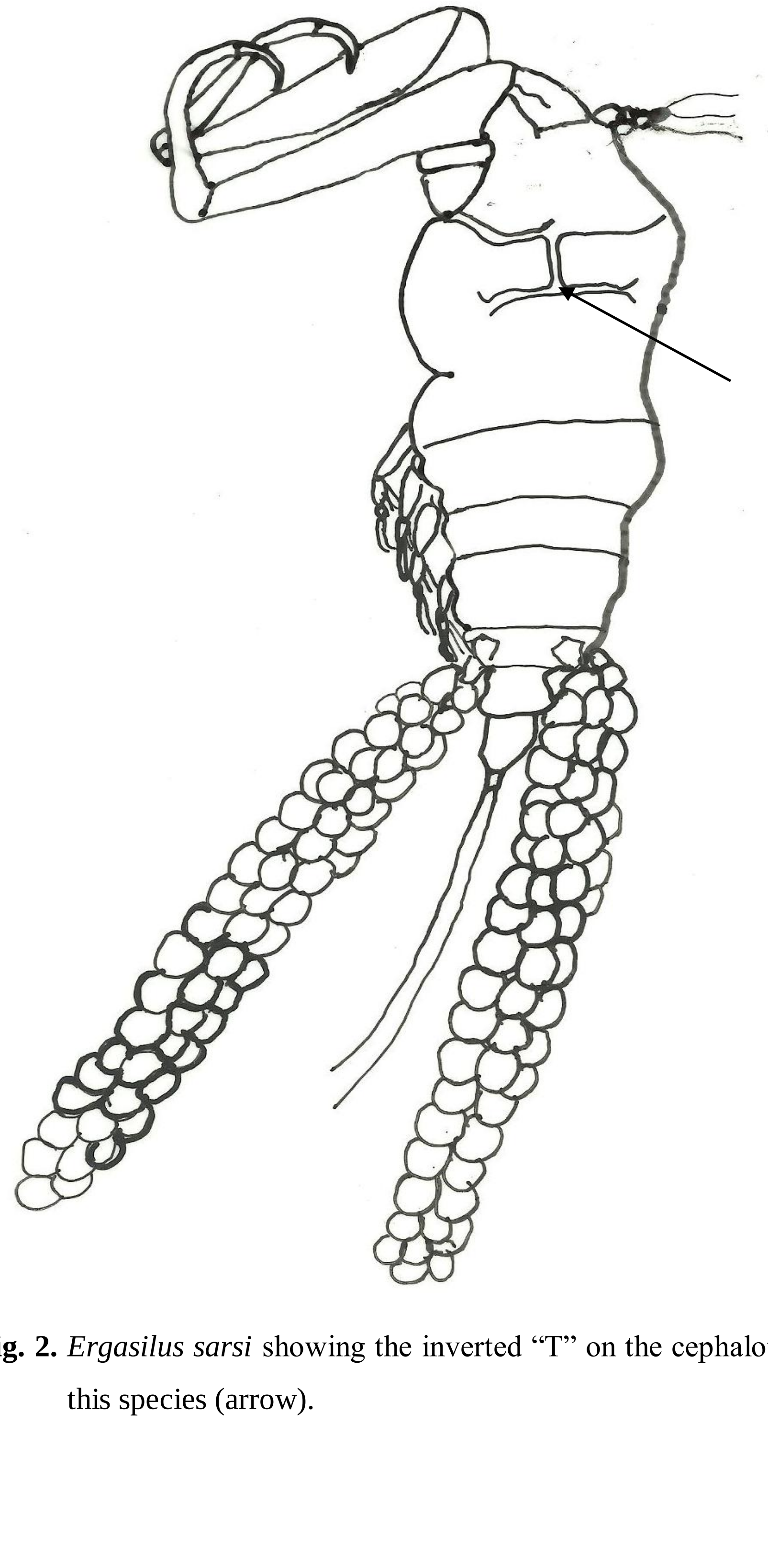


Fig. 2. *Ergasilus sarsi* showing the inverted “T” on the cephalothorax, characteristic of this species (arrow).

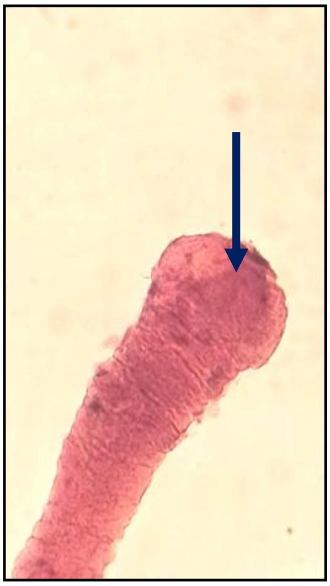
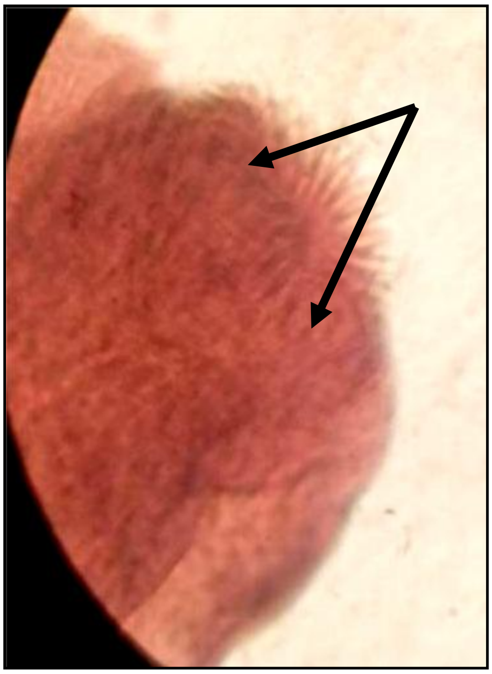


Plate VIa. The scolex of *Tetracampos ciliotheca* (syn. *Polyonchobothrium clariae*).



PlateVIb. The scolex of *Tetracampos ciliotheca* showing attachment hooks

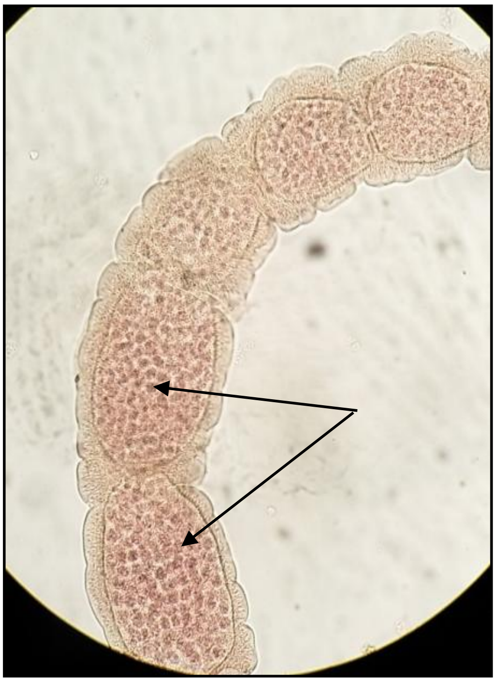


Plate VIc. Gravid proglottids of *Tetra-campos ciliotheca* showing eggs (ar-rows)

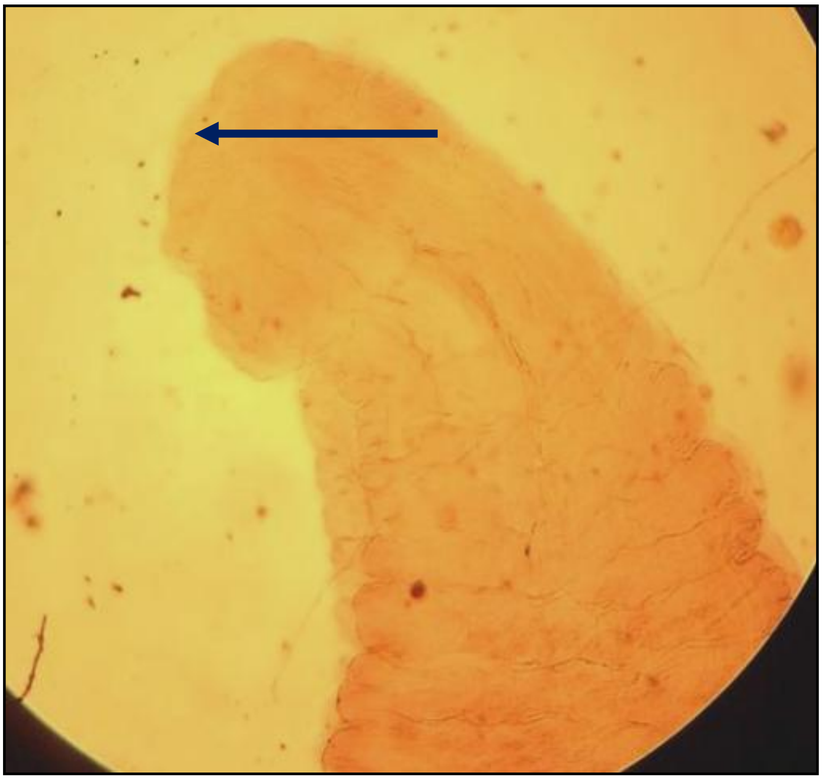


Plate VIIa. Anterior portion of *Monobothrioides woodlandi* showing the scolex, longitudinal ridge and bothria

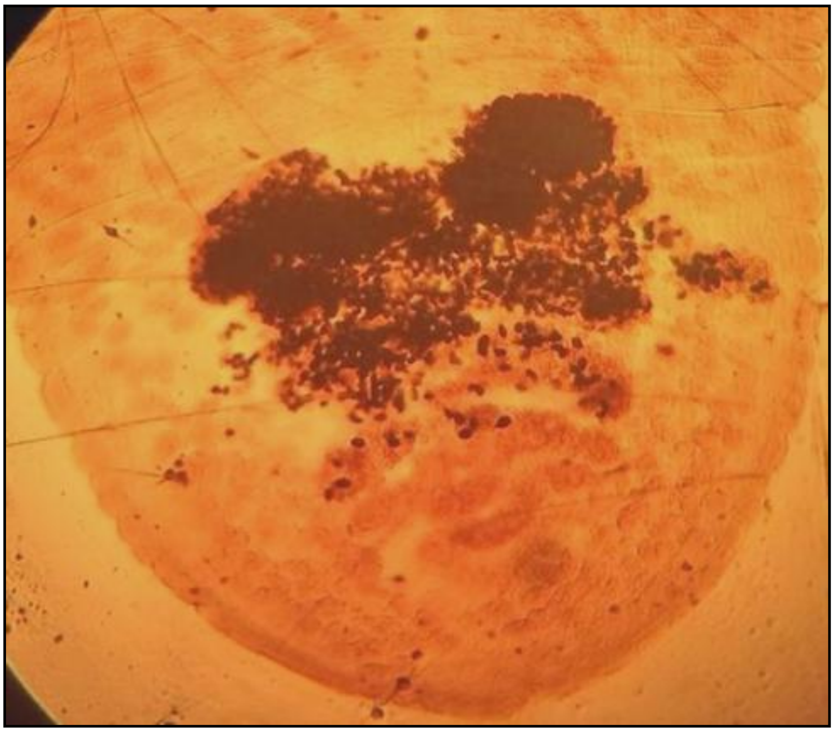


Plate VIIb. Posterior portion of *Monobothrioides woodlandi* showing uterus filled with eggs

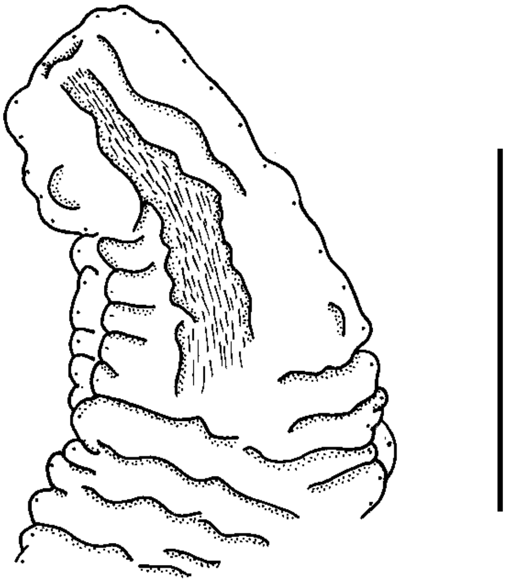


Fig. 3a. *Monobothrioides woodlandi*. Anterior portion of the body showing the scolex.

Scale Bar = 250 µm

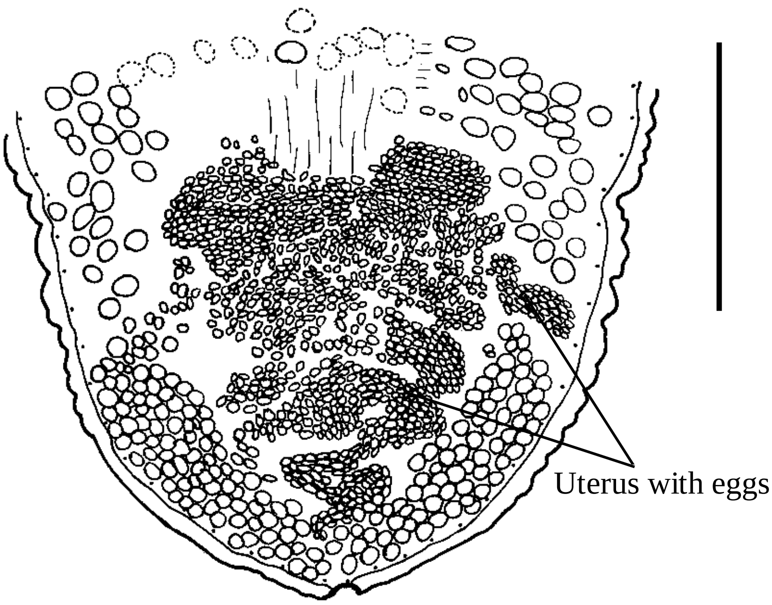


Fig. 3b. *Monobothrioides woodlandi*. Posterior portion of the body showing the uterus containing many eggs. Scale Bar = 150 µm

Plate VIIIa. The anterior section of *Procamalanus laevionchus*

Plate VIIIb. Posterior portion of *Procamalanus laevionchus* showing the sub-terminal anal opening (arrow)

4.2 Overall Prevalence of Gill and Digestive Tract Parasites of *Clarias* Species

The overall prevalences of gill and digestive tract parasites of *Clarias gariepinus* and *Clarias anguillaris* are shown in Table 4.1. Out of the 140 *C. gariepinus* and 120 *C. anguillaris* examined; 23 (16.4%) and 23 (19.2%) respectively, were infested by gill parasites, and 52 (37.1%) *C. gariepinus* and 46 (38.3%) *C. anguillaris,* by intestinal parasites.

4.3 Gill Infestation in Relation to Sex of Fish

Sex-related gill and digestive tract parasite infestations of *C. gariepinus* and *C. anguillaris* are shown in Table 4.2. Out of 71 male and 69 female *C. gariepinus* examined for gill parasites, 8(11.3%) and 15 (21.7%) respectively were infested. Chi-square showed that the relationship between sex and infestation of the gills of *C. gariepinus* was not significant (P>0.05).

On the other hand, gill infestation in relation to sex in *C. anguillaris* showed that 11(16.4%) of the 67 male fish and 12 (22.6%) of the 53 female fish examined were infested. Chi- square showed that the relationship between sex and gill infestation in *C. anguillaris* was not significant (P> 0.05).

4.4 Digestive Tract Infestation According to Species and Sex of *Clarias*

Table 4.3 shows digestive tract infestation in relation to sex of *C. gariepinus* and *C. anguillaris*. 30 (42.3%) of the 71 male examined 22 (31.9%) of 69 female fish examined were infested. The relationship between sex of fish and digestive tract infestation in *C. gariepinus* was not significant (P>0.05).

In *C. anguillaris*, 26 (38.8%) of 67 males and 20 (37.7%) of 53 females were infested. The relationship between digestive tract infestation and sex of fish was not significant (*P*>0.05).

4.5 Gill Infestation in Relation to Size According to Species of *Clarias*

The relationship between gill and digestive tract infestations and size of fish are shown Tables 4.4 and 4.5 (size here refers to the standard length of fish). Out of the 140 fish examined based on size only 25 were infested (Table 4.4). Chi-square showed that the gill infestation to size of fish relationship was not significant (*P*>0.05).

In *C. anguillaris,* 120 fish were examined across the various size ranges of fish and 23 were infested (Table 4.4). Chi-square showed that the size to gill infestation relationship in *C. anguillaris* was not significant (*P*>0.05).

Table 4.5 shows digestive tract infestation in relation to size of *C. gariepinus* examined. Out of 140 fish examined, 49 were infested across the various size ranges. However, Chi-square revealed that the digestive tract infestation in relation to the size of fish was not significant (*P*>0.05).

Table 4.5 also shows digestive tract infestation in relation to size of C. *anguillaris.* 120 fish were examined across size ranges in which 42 fish were infested across the age ranges. Chi-square, however, showed that digestive tract infestation in relation to size of *C. anguillaris* was not significant (*P*>0.05).

Table 4.1. Overall prevalence of gill and digestive tract infestation in *Clarias* Species

Site of infestation	*Clarias* species	NE	NI	NP	MI±SE	PREV. (%)
Gills	*C. gariepinus*	140	23	64	2.78±0.63	16.4
	C. anguillaris	120	23	59	2.51±0.72	19.2
DT	*C. gariepinus*	140	52	227	4.37±0.92	37.1
	C. anguillaris	120	46	176	3.83±0.87	38.3

KEY:

NE = Number examined

NI = Number infested

NP = Number of parasites

PREV = Prevalence

DT = Digestive tract

MI = Mean intensity

SD = Standard Error

Table 4.2. Gill infestation in species and sex of *Clarias*

Clarias species	sex	NE	NI	NP	MI±SD	PREV.(%)
C. gariepinus	M	71	8	24	3.00±0.55	11.3
	F	69	15	40	2.67±0.67	21.7
C. anguillaris	M	67	11	25	22.27±0.45	16.4
	F	53	12	34	2.83±0.46	22.6

χ^2 =1.42; P> 0.05 for *C. gariepinus* χ^2 =0.740; P> 0.05 for *C. anguillaris*

KEY:

M = Male

F = Female

NE = Number examined

DT = Digestive tract

NI = Number infested

MI = Mean intensity

NP = Number of parasites

SE = Standard Error

PREV = Prevalence

Table 4.3. Digestive tract infestation in species and sex of *Clarias* species

Clarias species	Sex	N.E	N.I	NP	MI±SE	PREV. (%)
C. gariepinus	M	71	30	141	4.70±0.45	42.3
	F	69	22	86	3.91±0.34	31.9
C. anguillaris	M	67	26	103	3.96±0.56	38.8
	F	53	20	73	3.65±0.48	37.7

χ^2 =0.140; *P*> 0.05 for *C. gariepinus* χ^2 =1.64; *P*> 0.05 for *C. anguillaris*

KEY:

M = Male

F = Female

NE = Number examined

DT = Digestive tract

NI = Number infested

MI = Mean intensity

NP = Number of parasites

SE = Standard Error

PREV = Prevalence

4.6 The Prevalence and Mean Intensity of Infestation of the Individual Parasites of the Gills and Digestive Tract

Table 4.6 shows that of the 140 *C. gariepinus* and 120 *C. anguillaris* examined, 18(12.9%) and 14(11.7% respectively, were infested with *Macrogyrodactylus* sp. The total number of *Macrogyrodactylus* sp. isolated from infested fish was too high to count. 13(9.3%) and 10(8.3%) of *C. gariepinus* and *C. anguillaris* respectively, were infested with *Ergasilus* sp. The number of parasites recovered was 64 in *C. gariepinus* and 56 in *C. anguillaris*.

Three digestive tract parasites were recovered from *C. gariepinus* and *C. anguillaris*; 26 (18.6%) *C. gariepinus* were infested with *Tetracampos ciliotheca* out of the 140 fish examined; a total of 67 of these parasites were recovered with a mean intensity of infestation of 2.58. Out of the 120 *C. anguillaris* examined, 20(16.7%) were infested with 59 *T. ciliotheca* with 2.95 as mean intensity of infestation; they were recovered from duodenum and gall bladder of fish.

The mid-intestine (jejunum) of 29(20.7%) *C. gariepinus* and 22(18.3%) *C. anguillaris* were infested with a total of 117 and 78 *Monobothrioides woodland*, respectively; the mean intensities of infestation were 4.03 and 3.55. *Procamallanus laevionchus* the third and only nematode parasite recovered from the rectum of the fish had a prevalence of 13.6% in *C. gariepinus* and 15% in *C. anguillaris*, with mean intensities of infestation of 2.26 and 2.17 respectively (Table 4.7).

Table 4.4. Gill infestation in relation to size (standard length) of *Clarias* species

Clarias species		Standard Length (cm)			
		10-19.9	20-29.9	30-39.9	40-49.9
C. gariepinus	N.E	91	38	6	5
	N.I	20	4	0	1
	NP	33	25	0	6
	MI±SE	1.65±0.62	6.25±0.75	0	6.00±0.56
	PREV (%)	22	10.5	0	20
C. anguillaris	N.E	75	38	4	3
	N.I	16	6	1	0
	NP	30	27	2	0
	MI±SE	1.88±0.25	4.50±0.17	2.00±0.45	0
	PREV (%)	21.3	15.8	25	0

χ^2 =3.77; df=3; P>0.05 *C. gariepinus* χ^2 =1.31; df=3; P>0.05 *C. anguillaris*

KEY:

NE = Number examined

NI = Number infested

NP = Number of parasites

PREV = Prevalence

DT = Digestive tract

MI = Mean intensity

SE = Standard Error

Table 4.5. Digestive tract infestation in relation to size (standard length,) of *Clarias* species

Clarias species	SL (cm)	NE	NI	NP	MI±SE	PREV (%)
C. gariepinus	10-19.9	91	33	110	3.33±0.22	36.3
	20-29.9	38	14	89	6.36±0.36	36.8
	30-39.9	6	1	10	10.00±0.16	16.6
	40-49.9	5	1	18	18.00±0.22	20
C. anguillaris	10-19.9	75	26	102	3.92±0.23	34.7
	20-29.9	38	15	68	4.53±0.79	39.5
	30-39.9	4	0	0	0	0
	40-49.9	3	1	6	6.00±0.5	33.3

χ^2 =1.50; df=3; P>0.05 *C. gariepinus*

χ^2 =3.74 df=3; P>0.05 *C. anguillaris*

KEY:

NE = Number examined

NI = Number infested

NP = Number of parasites

MI = Mean intensity

SE = Standard Error

PREV = Prevalence

Table 4.6. Gill infestation in *Clarias* and parasite species

Clarias species	Parasite species	NE	NI	PREV	NP	MI±SE
C. gariepinus	*Macrogyrodactylus* sp.	140	18	12.9	∞	∞
	Ergasilus sp.	140	13	9.3	64	4.9±0.16
C. anguillaris	*Macrogyrodactylus* sp.	120	14	11.7	∞	∞
	Ergasilus sp.	120	10	8.3	56	5.6±0.15

KEY:

NE = Number examined

NI = Number infested

NP = Number of parasites

MI = Mean intensity

SD = Standard Error

PREV = Prevalence

∞ = Infinity

Table 4.7. Digestive tract infestation in *Clarias* and parasite species

Clarias species	Parasite	NE	NI	PREV	NP	MI±SE
C. gariepinus	*T. ciliotheca*	140	26	18.6	67	2.58±0.14
	M. woodlandi	140	29	20.7	117	4.03±0.13
	P. laevionchus	140	19	13.6	43	2.26±0.05
C. anguillaris	*T. ciliotheca*	120	20	16.7	59	2.95±0.15
	M. woodlandi	120	22	18.3	78	3.55±0.14
	P. laevionchus	120	18	15	39	2.17±0.06

KEY:

NE = Number examined NI = Number infested NP = Number of parasites MI = Mean intensity

PREV = Prevalence, SD = Standard Error

4.7 Gill and Digestive Tract Infestation in Relation to Seasons

The data of the dry and the wet season months within the research period were pooled separately to create wet and dry season data. The research period was between January to October. January, February and March were the dry months; and April to October the wet months.

4.7.1 Gill parasites

Table 4.8 shows seasonal infestation of the gills by parasites. *Macrogyrodactylus* sp. had the highest prevalence during the dry season, 13(18.05%) fish were infested out of the 72 examined. In the wet season however no fish was infested with the parasite. The prevalence of infestation was higher in *Ergasilus* sp. in the wet season with 8(11.76%) of the 68 fish examined infested against 5(6.94%) in the dry season. Chi-square showed that there was relationship between infestation and seasons in *C. gariepinus (P*<0.05).

The seasonal gill infestation in *C. anguillaris* also showed that *Macrogyrodactylus* sp. infestation was higher in the dry season with 10(17.24%) and 1(1.61%) in the wet season. *Ergasilus* sp. infestation was higher in the wet season with [7(11.29%)] than in the dry season, [4(6.90%)]. The relationship between gill infestation and season in *C. anguillaris* was significant (*P*<0.05)

4.7.2 Digestive tract parasites

Table 4.9 shows more *C. gariepinus* were infested with *T. ciliotheca* in the dry than in the wet season 6(8.33%) and 1(1.47%) respectively. *Monobothrioides woodlandi* and *P. laevionchus* showed higher infestation in the wet season than in the dry season (22.06% and 19.12%) and (12.5% and 6.94%) respectively. The relationship between digestive tract infestation and seasons was significant (*P*<0.05).

Table 4.8. Gill parasite infestation of species of *Clarias* in relation to the Dry and Wet Seasons

Fish species	Parasite species	NE		NI		NP		MI±SE		PREV	
		Dry	Wet	Dry	Wet	Dry	wet	Dry	Wet	Dry	Wet
C. gariepinus	*Macrogyrodactylus* sp.	72	68	13	0	∞	∞	0	0	18.05	0
	Ergasilus sp.	72	68	5	8	28	36	5.6±0.5	4.5±0.1	6.94	11.76
C. anguillaris	*Macrogyrodactylus* sp.	58	62	10	1	∞	∞	0	0	17.24	1.61
	Ergasilus sp.	58	62	4	7	20	39	5.0±0.3	5.6±0.1	6.90	11.29

χ^2 =11.6; *P*< 0.05 *C. gariepinus* χ^2 =7.07; *P*< 0.05 *C. anguillaris*

KEY:

NE = Number examined; NI = Number infested; MI = Mean intensity; ∞ = Infinity

PREV = Prevalence SE = Standard Error NP = Number of parasite

Table 4.9 Digestive tract infestation of *Clarias* species in River Taraba in relation to the Dry and Wet Seasons

Fish species	Parasite species	NE		NI		NP		MI±SE		PREV	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
C. gariepinus	*T. ciliotheca*	72	68	6	1	59	8	9.3±0.15	8±0.14	8.33	1.47
	M. woodlandi	72	68	9	15	56	61	6.2±0.13	4.1±0.13	12.5	22.06
	P. laevichoncus	72	68	5	13	10	3	2.0±0.13	0.2±0.13	6.94	19.12
C. anguillaris	*T. ciliotheca*	58	62	9	3	30	19	3.3±0.15	6.3±0.14	15.52	4.83
	M. woodlandi	58	62	11	10	44	32	4.0±0.13	3.2±0.13	18.97	16.13
	P. laevichoncus	58	62	6	13	11	28	1.8±0.12	2.6±0.13	10.34	20.97

χ^2 =7.22; DF=2; $P< 0.05$ *C. gariepinus* χ^2 =5.63; DF=2; $P> 0.05$ *C. anguillaris*

KEY: NE = Number examined, NI = Number infested, MI = Mean intensity, NP = Number of parasite
PREV. = Prevalence, DF = Degree of freedom SD = Standard Error

Tetracampos ciliotheca and *M. woodlandi* showed a higher prevalence in the dry than in the wet season in *C. anguillaris*. *Tetracampos ciliotheca* infested 9(15.52%) fish in the dry season and 3(4.83%) in the wet season, and *Monobothrioides woodlandi* 11(18.97%) in the dry season and 10(16.13%) in the wet season. *Procamallanus laevionchus* on the other hand showed a higher prevalence of infestation in the wet season 13(20.97%) than the dry season, 6(10.34%). The relationship between digestive tract infestation and seasons in *C. anguillaris* was not significant ($P>0.05$).

CHAPTER FIVE

5.0 DISCUSSION

The recovery of gill and digestive tract parasites from two *Clarias* species in River Taraba at Tella has established that these fish species are infested by at least 2 gill parasites and at least three intestinal parasites. It is not unlikely that more parasites than those recovered in this study infested *Clarias* species and other fish species in the river. The same groups of parasites recovered from the two species of *Clarias* have also been recovered from other parts of northern Nigeria by Shotter (1977, 1980); Aken'Ova (1999a, 1999b) in Zaria; Yakubu *et al.* (2002) in Jos; Oniye *et al.* (2004) in Zaria and Ayanda (2009) in Ilorin. This implies that host identity plays a very important role in the establishment of the parasitic fauna characteristic of particular fish host species.

Macrogyrodactylus sp. and *Ergasilus sarsi* recovered from the gills of both *Clarias* species in River Taraba have also been recovered from *Clarias* species by a number of workers (Shotter, 1977; Aken'Ova, 1983) in Zaria, northern Nigeria. The descriptions of the parasites agree with those given by these workers and with the original descriptions by Prudhoe (1957); Paperna (1969) and Thurston (1970).

Two of the three helminth species recovered from the digestive tract of the two species of *Clarias* in River Taraba, i.e the cestode *Tetracampos ciliotheca* (syn. *Polyonchobothrium clariae*) and the nematode *Procamallanus laevionchus* have been found in *Clarias* species in Zaria by Shotter (1980) and Oniye *et al.* (2004) *Monobothrioides woodlandi*, the second of two cestodes from *Clarias* in River Taraba, does not appear to have been reordered from any species of *Clarias* in Zaria or any part of northern Nigeria for that matter, by any of the workers mentioned earlier. The morphology of this worm conforms to that described by Mackiewitcz and Beverley-Burton (1967), which they recovered and described from a related species, *Clarias mellandi* in Lake Chali, Bangweulu, in northern Zambia. The identification of this worm to species is not quite conclusive until more material and description of other species of *Monobothrioides* are available for comparison. A species of a monozoic cestode was recovered from the digestive tract of *Clarias gariepinus* by Oniye *et al.* (2004), and identified as *Monobothrium* but it was not described so it is not possible to say whether their species and *Monobothrioides* are one and the same.

The finding in this study that more of both species of *Clarias* were infested by intestinal parasites than by gill parasites is surprising because the gills are continuously exposed to any potential infective stages of parasites in water, which infest the gills directly. On the other hand, many parasites of the digestive tract such as some helminths generally use an intermediate host that is consumed by the definitive host to acquire infection. The chances of acquiring digestive tract parasites and gill parasites should therefore be similar since they may both result from feeding and respiration respectively, which are vital for the survival of the fish, and are continuous. One reason that may explain the disparity in the prevalence of the two categories of parasites is the availability of infective stages of the gill parasites and infected intermediate hosts of the intestinal helminths recovered (Paperna 1996; Aken'Ova 1999a and 1999b).

More female than male *C. gariepinus* and *C. anguillaris* being infested with gill parasites as observed in this study can be explained by the fact that female fish actively look for breeding places during the rainy season, increasing their chances of coming in contact with infective stages of the parasites. The monogenean life-cycle is direct, so it would have a greater chance of infesting the fish, unlike parasites that need an intermediate host. Paperna (1996) stated that the majority of *Ergasilus* species infest different species of fish, except those of cichlids which are host-specific. Though the infestation of the gills according to sex of fish was not significant, more female fish than males were infested. Goselle *et al.* (2008) in contrast obtained higher infestation in male than female fish. The reason they gave was that male fish were more active than females during the breeding period, and so are more prone to infestation by the parasite or its infective stage. The probable reason for the findings of this study may also concur with that of Goselle *et al.* (2008), since the difference between male and female fish was not significant.

Unlike infestation of the digestive tract, infestation of the gills showed that male fish had a higher prevalence. This might likely be due to the fact that the fish collection period had entered host's breeding period during which the male fish are more active searching for mates. Anosike *et al.* (1992) in Plateau state and Oniye *et al.* (2004) in Zaria also observed higher infestation in the male fish. Ayanda (2009) however, obtained equal infestation in males and females when he worked on the intestinal helminths of wild *Clarias gariepinus* in a reservoir at Ilorin. The reason Ayanda gave for equal prevalence in male and female fish was that all the fish used in the investigation were collected during the breeding period, when both were actively swimming about and so had similar chances of being infested by intestinal parasites.

Gill infestation in relation to size of fish as a measure of age using the standard length of fish showed that smaller sized fish had the highest infestation followed by those in the next size range. This agrees with the findings of Aken'Ova (1999a) in which medium-sized fish had higher infestation than the smaller sized fish. The reason for higher gill infestation in this study might probably be due to collection period where greater majority of the infested fish were collected during the dry season when the source of fish was from the pools and fadamas created by the river overflowing its banks during the wet season.

The same trend was observed in the digestive tract infestation as for gill infestation. Oniye *et al.* (2004) in Zaria and Goselle *et al.* (2008) in Jos, Plateau State worked on intestinal helminths of *C. gariepinus* and observed higher infestation in larger than smaller sized fish. This, they suggested might be due to the fact that as the fish grows, there is possibility of re-infestation by parasite. The work of Madinere-Moyo and Avenant-Oldewage (2012) on *C. gariepinus* in Vaal Dam, South Africa also showed bigger sized fish with higher infestation. The result obtained in this study where smaller sized fish had more infestation might be, as Hassan (2008) suggested, that the immune system of the smaller fish is not as developed as that of the bigger fish.

The preference of attachment sites demonstrated by both the gill and digestive tract parasites is well known and not unusual. The gill parasites, *Macrogyrodactylus* and *Ergasilus* species preferred the gill filaments. Monogeneans are browsers, moving about the body surface and feeding on dermal mucus or gill debris (Peggy *et al.,* 2009). The gill with its rich supply of nutrients is a good site for such organisms. *Ergasilus* sp. are adapted to parasitism through the modification of their antennae to form hooks for attaching to the gills on whose epithelium they feed. Once they attach to the host, they rarely leave it. The gill chamber and gill filaments offer both protection and the required nutrients to such parasites.

The digestive tract parasites also displayed choice of attachment sites. *Tetracampos ciliotheca* favoured the duodenum and gall bladder. *Monobothrioides woodlandi* was found in the mid intestine and *P. laevionchus* preferred the rectum. The first two being cestodes have no well-defined digestive tract, but use their entire body surface to absorb nutrients from the surrounding medium. This is the reason they prefer those sites since digesting and digested food items are readily available. The parasites of the digestive tract are located in different parts of the intestine, not only for food but to avoid interspecific competition (Lagrue and Poulin, 2008). Madanire-Moyo and Avenant-Oldewage (2012) and indeed many researchers also recovered these parasites from the sites as in this study.

Gill infestation by *Macrogyrodactylus* species was higher in the dry season in both *Clarias* species, although individuals were too numerous to count. The parasites were observed all over the gills under the dissecting microscope. The reason for higher infestation in the dry season might probably be due to the fact that the fish obtained during the dry season were caught from pools, ponds and fadamas that were formed along the course of River Taraba when it overflowed its banks during the wet season. Fish in such pools or ponds are in confinement. *Macrogyrodactylus* is viviparous and its population would build up on infested fish due to reinfestation during the dry season period, resulting in the higher numbers observed. The statement of Peggy *et al.* (2002) sheds more light on the reason given above; they noted that monogeneans found on wild fish, seldom cause disease in free ranging populations because they may not be in large numbers on individual fish. However, any change that may result in overcrowding which could include diversion of water may increase the density of the parasite. Since the monogeneans have a direct life-cycle and are viviparous, there is high possibility of re-infestation and also infestation of healthy fish.

The higher infestation of *Ergasilus* sp. during the wet than dry season can be linked to its life-cycle. Higher fish infestation during the wet season might be because both the fish and the parasite were active; the fish in search for breeding space and mate and the parasite in search of suitable host. The nauplii (larvae) of the parasite actively swim around at this time and feed while the fish host is also actively swimming around either looking for a breeding site or a mate. The chances of the nauplii and potential fish host meeting at this time are therefore enhanced. It should be noted that although prevalence is higher in the rainy season, it did not necessarily correspond to a higher mean intensity of infestation, since more hosts are available for infestation at this time. Shotter (1978) and Aken'Ova (1999b) also observed that prevalence with this parasite was higher during the wet than during the dry season. The latter suggested that this phenomenon could have been caused by changes in host population, which is higher in the rainy season due to spawning and abundance of food.

Infestation of digestive tract was higher during the wet season, both in terms of prevalence and the number of parasites recovered. More of *M. woodlandi* were recovered from *C. gariepinus* during the wet season, although fewer in *C. anguillaris*. This difference in number of the parasites recovered might likely be due to the difference in the number of fish examined, the number of *C. gariepinus* being more than that of *C. anguillaris*. *Procamallanus laevionchus* on the other hand was recovered more from *C. anguillaris* than *C. gariepinus* despite the difference in sample size. Infestation with digestive tract parasites was moderately high in all the parasites.

Tetracampos ciliotheca was recovered more from *C. anguillaris* both in the wet and dry season.

The infestation by the three digestive tract parasites was higher in both species during the wet season. This might be due to availability of the intermediate hosts of these parasites. The wet season offers a favourable environment for the intermediate host to thrive in terms of food availability and a suitable condition for their reproduction. Both gill and digestive tract infestation in relation to season were mostly statistically significant except for digestive tract infestation in *C. anguillaris*.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

River Taraba is a new locality for *Ergasilus* sp. and *Macrogyrodactylus* sp., which are gill parasites, and *Tetracampos ciliotheca, Monobothrioides woodlandi* and *Procamallanus laevionchus*, intestinal parasites.

Gill and digestive tract parasites infest *C. gariepinus* and *C. anguillaris* in River Taraba. There is no significant relationship between sex of fish and parasitic infestation of the gills and digestive tract of *Clarias* species in River Taraba (P>0.05).

Size of fish has no significant relationship with gill and digestive tract parasitic infestation of *Clarias* species in River Taraba (P>0.05).

Ergasilus sp. and *Macrogyrodactylus* sp. infest the gills and *Tetracampos ciliotheca, Monobothrioides woodlandi* and *Procamallanus laevionchus* infest the digestive tract of *Clarias* species in River Taraba.

Macrogyrodactylus sp. and *Ergasilus* sp. attach to gill filaments, *T. ciliotheca* lives in the duodenum and gall bladder; *P. laevionchus* occupies rectum and *M. woodlandi* the mid intestine of infested *Clarias* species, showing site preference.

Null hypotheses 2-4 are accepted because Chi-square analysis was not significant in the cases of the relationships between sex, and size with infestation of the gill and digestive tract and also the choice of attachment sites by parasites. Hypotheses 1 and 5 are rejected because gill and digestive tract parasites occur in fish of River Taraba and the relationship between their infestation and the dry and wet seasons was significant.

6.2 Recommendations

From the findings of this research, fish farmers that may want to obtain their brood stock from River Taraba must quarantine and treat them. This will help curtail the spread of these parasites into culture systems. Further research on the same species should look extensively into the seasons for at least two years to establish a proper trend in parasitic infestation. For the overall benefit of the academic world and for record, further work on parasites of *Clarias* species and other fish species in River Taraba should be carried out.

The establishment of the occurrence of gill and digestive tract parasites in River Taraba for the first time calls for periodic monitoring to observe their dynamics since it is known that these can be indicative of changes in the environment.

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