Parasites and their Freshwater Fish Host

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Abstract

This study reviews the effects of parasites of fresh water fish hosts. Like other living organisms, fish harbour parasites either external or internal which cause a host of pathological debilities in them. The parasites live in close obligate association and derive benefits such as nutrition at the host's expense, usually without killing the host. They utililize energy otherwise available for the hosts growth, sustenance, development, establishment and reproduction and as such may harm their hosts in a number of ways and affect fish production. The common parasites of fishes include the unicellular microparasites (viruses, bacteria, fungi and protozoans). The protozoans i.e. microsporidians and mixozoans are considered in this review. The multicellular macroparasites mainly comprised of the helminthes and arthropods are also highlighted. The effects of parasites on their fish hosts maybe exacerbated by different pollutants including heavy metals and hydrocarbons, organic enrichment of sediments by domestic sewage and others such as parasite life cycles and fish population size.

Keywords: Parasites, Helminths, Protozoans, Microparasites, Macroparasites, Debilities, Freshwater fish

Introduction

Several studies have revealed rich parasitic fauna in freshwater fishes (Onyia, 1970; Kennedy *et al*., 1986; Ugwuzor, 1987; Onwuliri and Mgbemena, 1987; FAO, 1996; Kadlec *et al*., 2003) ranging from ectoparasites (Fryer, 1968, 1970; Sakiti *et al*., 1999; Oniye *et al*., 2004) to endoparasites (Basu *et al*., 1993; Umoren *et al*., 1998; Auta *et* al., 1999) which affect fish health, growth and survival. In the survey of freshwater parasites, the economic important parasitic groups include the microparasites; protozoans - microsporideans and myxozoans while the macroparasites group is comprised of helminths such as monogenea and the diagenes trematodes (flukes), cestodes (tapeworms), nematodes (roundworms) and Acanthocephala (thorny headed worms) The arthropod parasites are represented mainly by the copepods (Marcogliese, 2002), while the annelid parasites are the leeches.

Materials and Methods

A comprehensive literature search was made from the Internet and serial materials of Nnamdi Azikiwe Library, University of Nigeria, Nsukka. Various journal articles, proceedings of learned societies of fisheries and parasitology, World Health Organization and Food and Agricultural Organization documents and textbooks were consulted vis-à-vis of the parasites and their freshwater fish host. The data collected were synthesized into tables.

Results and Discussion

Protozoa: Protozoan parasites are commonly encountered in fish (Klinger and Floyd, 2002). The main groups include the ciliates, flagellates, microsporidians and myxozoans (Table 1). These can build up to very high numbers when fish are crowded, causing weight loss, debilitation and mortality (Klinger and Floyd, 2002). The ciliates and the flagellates have direct life cycles and affect especially the pond reared fish populations. Microsporidians are obligate intracellular parasites that require host tissues for reproduction (FAO, 1996). Fish hosts acquire the parasites by ingesting infective spores from infected fish or food (Klinger and Floyd, 2002). Infected cells usually enlarge (xenomas) to accommodate the proliferating parasite. According to Canning and Lom (1986) and Lom and Dykova (1992) the parasites undergo merogonous and sporogonous development within the xenomas, culminating in the spore production. The spores are thick walled and contain a characteristic coiled polar filament and one (Pleistophoridida) or two nuclei (Nosematidida) (Weiser, 1989). Replication within spores (schizogony) causes enlargement of host cells (Hypatrophy) and the infected fish may develop small tumor like masses in various tissues (Klinger and Floyd, 2002).

Hypertrophic infected cells which may reach macroscopic sizes often yielding characteristic gross pathological signs; multiple whitish nodules in tissues or in case of bladder, a significant thickening of the walls (FAO, 1996). The effect of microsporidian infection on fish hosts is variable. Some fish hosts seem to survive even in the presence of huge xenomata pressing on organs while in others microsporidians have morbid effect (Putz and McLaughlin, 1970; Morrison and Sprague, 1981). Intranuclear infection of haemopoietic cells is often associated with acute anaemia (Elston *et al*., 1987).

Myxozoan parasites affect many fish families and are common in Cichilidae, Cyprinidae and Mugilidae (FAO, 1996). In Africa, more than 135 species of myxozoans are known to infect freshwater, brackish water and marine fishes (Kostroingue *et al*., 2001). Sakiti *et al*., (1999) observed and described 17 species, prominent among which were the following parasitic protozoan genera: *Henmeguya, Myxobolus, Myxobilatus* and *Parahenmeguya*. Prevalence of infection can be

Table 1: Protozoan parasites and their effects on freshwater fish host

Protozoan Group	Protozoan Species	Fish species infected	Site of infection	Symptoms	Source
Ciliates	*Ichthyophthirius Chilodonella Tehrahymena Trichodina Ambiphyra Apiosoma Epistylis Capriniana*	*Clarotis, Schilbe, Clarias, Bagrus, Auchinoglanus Synodontis, Heterobranchus*	Intestine, Gills Skin, Fins	Skin and gill irritation displayed by flashing, rubbing, rapid breathing, white spot, excessive mucus secretion in gill, and enlarged eye	Klinger and Floyd, (2002)
Flagellates	*Hexamita, Ichthyobodo, Piscinoodinum, Cryptobia*	Angelfish, Channel catfish, Tilapia	Intestine, gills, skin, fins and stomach	Mucus secretion	Klinger and Floyd, (2002)
Microsporideans	*Plestophora, Enterocytozoans Glugea*	*Tilapia. Haplochromis Sarotherodon* Eels Rainbow trout, Carps, *Clarias* Gold fish	Cysts in lymphs Epithelia cells, swim bladder, gills, viscera, kidney	Hypertrophy of tissues, thickening of kidney walls, tumour-like masses of tissues.	Paperna (1973); FAO (1996), Sakiti and Bouix (1987); Loma and Dykova (1992)
Myxozoans	*Myxozoma, Sphaerospora Mitraspora Thelohanellus, Hennegya Myxobolus*	Salmon, Mullets, *Lates* Channel catfish, *Channa Heterotis niloticus, Clarias Distichodus Haplochromis*	Cysts in muscles, connective tissue, epithelia lining of bladder, kidney tubules and gut lining	Hypertrophy of cells, turmor- like masses of tissues	FAO (1996); Klinger and Floyd (2002); Dzulinsky *et al.* (1999)

high (Table 1) (Dzulinsky *et al*., 1999, Marcogliese and Cone, 2001) and the number of species infected in a host population can be very significant (Cone and Anderson, 1977; Li and Dresser, 1985; Salim and Dresser, 2000). Myxozoan parasites as such, have the potential to form species rich infracommunities and component communities that might equal or surpass those formed by other groups of fish parasites (Marcogliese and Cone, 2001). They cause both histozoic (in tissue) and coelozoic (internal cavities e.g. gall and urinary bladders) infections (FAO, 1996). Signs of histozoic infections are whitish cysts with a milky substance containing microscopic spores (Current and Janovy, 1976). In African fish, histozoic myxosporideans occur as skin infections with cysts formed in the dermis under the scales extending to the surface of the head, face, and lips or on the fins. (*Myxobolus* sp. have been reported in Cyprinids, Siluroids, Characids and juvenile Cichlids. *Henneguya laterocapsulata* has been reported in the gill filaments of *Clarias lazera.* Other Henneguya sp were found in both Cyprinids and Siluroids while *Thelohanellus* sp. has been reported in Cyprinids (Paperna, 1973; Abolarin, 1974; Fomena *et al*., 1985; 1994; Landsberg, 1986). Visible or suspected pathogenic effects of gill infections are different according to the type of gill engraft and may result in liquefaction of cartilage of gill arches due to *Myxobolus dosoni, M. sarotherodoni* and *M. oueensis,* in *Tilapia zilli, Sarotherodon melanotheron* and *Synodontis gambiensis* respectively (Sakiti *et al*., 1999). Sakiti *et al*. (1999) further stated that the weakening of arches subsequently ends at their breaking thus disturbing the respiratory function of the gills, while the fusion of secondary lamellae considerably reduces the breathing surface and prevents adequate gaseous exchange in the fish. Coelozoic myxozoans of the urinary and cavities are small and produce few spores (FAO, 1996). Premature plasmodium are attached by pseudopodia to the epithelial lining of the bladder (Paperna *et al.*, 1987). According to Lom and Arthur (1989) diagnosis to species level is based mainly on measurements of fresh unfixed spores, their polar capsules dimensions as well as the length of the extruded polar filaments. Several myxozoan infections in cultured fish have been reported to be pathogenic, causing skeletal deformities, locomotory disturbances, emaciation and sunken eyes in brain infections (Dykova *et al.,* 1986) anaemia, haemorrhagic dropsy and mortality in heavy cardiac infection (Bauer *et al*., 1991) and circulatory dysfunctions in infections at the base of the gill lamellae (Kovac-Geyer and Molner, 1983). Paperna and Thurston (1968) found that body deformities or curvatures in *Barbus lineatus* and cichlids were caused by large myxobolus cysts. They also discovered that ovarian infection in female cichlids from Lake George enlarged the ovary while displacing the entire ovarian tissue, evidently causing castration. Cone *et al.* (2005)

found that the study of myxozoan parasites in fish was traditionally labour intensive rendering the compilation of community data difficult and rare. Although the life histories of myxozoans in African fish are unknown (FAO, 1996), it has been shown from studies in other parts of the world (Wolf and Markiw, 1984; El-Matboulina and Hoffman, 1989) that transmission of myxozoan parasites of trout and other fishes involves tubicifid oligochaetes as intermediate hosts.

Trematoda: The class trematoda comprises of monogeneans and the digeneans (Table 2). Monogenean trematodes are also referred to as flatworms or flukes (Klinger and Floyd, 2002) and commonly invade the gills, skin and fins of freshwater and brackish water fish from most families of Teleostei (Khalil, 1971; Paperna, 1979; Whittington *et al.* 2000).

Monogeneans have direct life cycles (no intermediate hosts) and are host and size specific (Klinger and Floyd, 2002) throughout their distribution range (FAO, 1996). According to Whittington *et al.* (2000) monogeneans can live on the epidermis, scales, fins, lipfolds, nares, branchiostegal membranes and gills of their hosts.

Their anterior end contains apical sensory structures, a mouth with or without accessory suckers and special glands and clamps for the attachment and they are all haemaphrodite (FAO, 1996).

Monogeneans are subdivided into three major taxa: Dactylogyroidae, Caspaloidae and Polyopisthacotylea (Noble and Noble, 1982; FAO, 1996). Most monogeneans found in inland water fish are of the family Dactylogyroidae while the other two families usually lager in size, are predominantly marine fish parasites (FAO, 1996). Dactylogyroids are oviparous with one or two anterior-dorsal pairs of eyes, a posterior- ventral opisthaptor and are mostly gill parasites of fish. Gyrodactylidae are viviparous with no eyespots, two pairs of anchor hooks and generally found on the skin and fins of fish (FAO, 1996). A few are specialized endoparasites inhabiting the nasal cavities, stomach and urethra of freshwater fish hosts (Table 2) (Du Plessis, 1948; Paperna, 1963b; Ergens, 1988).

Fish appear to co-exist with their specific monogeneans in natural habitats as well as in culture conditions even when infestations are intense (FAO, 1996). A few, especially the gyrodactylids are pathogenic to their fish hosts, usually to younger fish and in intense culture conditions (Chapman *et al*., 2000). *Dactylogyrus vastator* infection in the gills of carp fry according to Paperna (1963b, 1964), Chan and Wu (1984), Barker and Cone (2000) induces severe hyperplasia of the gill filament epithelium, which interferes with respiratory function at extreme proliferation and seems to be the cause of death. *Dactylogyrus extensus* were found to be fatal to both young and fully-grown fish (Prost, 1963; Sarig, 1971). Obiekezie and Taege (1991) reported severe mortalities (up to *90*%) of two weeks old *Clarias gariepinus* fry in a hatchery in Nigeria due to severe infestation of *Gyrodactylus groschefti*.

Species of *Macrogylodactylus* has been reported in fish with potentials for aquaculture in Africa: such as *Clarias sp.*, *Lates niloticus* and Anabantidae (Paperna, 1979). In natural habitats, increase in infestation is inhibited due to physical (depth, currents, temperature) and chemical (oxygen and salinity) factors (FAO, 1996).

Studies on the seasonal occurrence of monogenetic trematode parasites of fishes in the tropics, according to Obiekezie *et al.* (1987) generally abound. Chubb (1977) had earlier identified temperature as the most important single factor controlling the seasonal prevalence of dactylogyrids and gyrodactylids.

Digenean trematodes are numerous. Over 50 species from 15 families have been listed (Khalil, 1971), occurring in a variety of freshwater fish hosts in Africa. They have complex life histories involving larval stages, which infect mostly juvenile fish, bottom dwellers and shallow water habitats in inland water bodies of Africa (Fahmy and Selim, 1959; Williams and Chaytor, 1966; Van As and Basson, 1984). FAO, (1996) stated that the life histories of trematodes which infect African fish have so far not been studied and their primary molluscan or intermediate hosts remain yet unknown. They are however heteroxenous with multiple host life cycles involving both bivalves and gastropod molluscs as intermediate hosts (FAO, 1996). Fish can also be the primary or intermediate host, depending on the digenean species and they can be found externally or internally in any organ (Klinger and Floyd, 2002). Shaw *et al.* (2005) reported several trematode metacercariae infecting more than one tissue or organ in the fish hosts. Metacercariae maybe distributed throughout the host with mean intensity of several hundreds per fish. Only the extra intestinal species are however potentially harmful to fish hosts (FAO, 1996). Species of *Sanguinicola* (the blood flukes) are reported to infect *Synodontis schall* and *Auchinoglanus occidentalis* in the Sudan (Table 2) (Khalil, 1969) *Clarias lazera* and *Oreochromis sp*. in Israel (Paperna, 1964). Adult *Sanguinicola* worms and trapped eggs can physically obstruct the passage of blood causing thrombosis and subsequent necrosis (Hoffman *et al.* 1985) while escape of miracidia through the gills epithelium causes loss of blood and may lead to anaemia (Evans, 1974). According to Sandland and Goater (2003), trematode metacercarie have been shown to modify the morphology of fish hosts by disrupting the heart (Coleman, 1993) the brain (Hoffman and Hoyne, 1958) and the eye lens (Larsen, 1965) (Table 2). The digenean *Syphodera ghanensi*s and the aspidogastrid, *Aspidogaster africanus* occurred occasionally in the intestines of *Chrysichthyes nigrodigitatus* from the Cross River estuary Nigeria, where they cause general debilities (Table 2) (Obiekezie *et al.,* 1987). In many systems, the extent of the alteration in host traits is dependent on the intensity of the infection and on the specific tissues affected (Sandland and Goater, 2003).

Nematoda: Nematodes occur worldwide particularly the species utilizing fish as intermediate or transient hosts and can infect all organs of their

Table 2: Trematode parasites and their effects on fresh water fish host

Trematode Group	Trematode Species	Fish species infected	Site of infection	Symptoms	Source
Monogenean	*Paraguadriacanthus Enterogyrus, Acolpenteron Dactylogyrus extensus Gyrodactylus groschefti, Macrogylodactylus*	Most families of fish from fresh water and brackish water.	Skin, gills, fins, epidermis, lipfolds, nares, branchiostegal membranes, stomach and urethra.	Hyperplasia of gill epithelium and interference with respiratory function.	Paperna (1963); Baker and Cone (2000); Prost (1963); Sarig (1971); Obiekezie and Taege (1991) FAO (1996)
Digenean	*Sanguinicola Syphodera Aspidogaster*	*Synodontis Auchinoglanus Clarias Oreochromis Chrysichthyes*	Tissues, Organs, Blood passages, Heart, Brain and Eye lens.	Rupture of gills epithelium causing anemia, disruption of the heart, brain and eye lens and general disabilities.	Agure-Macedo *et al.* (2005); Khalil (1969) Paperna (1964); Hoffman *et al.*(1985), Sandland and Goater (2003); Obiekezie *et al.* (1987)

Table 3: Nematode parasites and their effects on fresh water fish host

Nematode Group	Nematode Species	Fish species Infected	Site of Infection	Symptoms	Source
Oxyuroidea	*Oxyuris Enterobius*	*Distichodus Synodontis Citherinus Oreochromis Barbus*	Intestine and Stomach	Worms locked in the abdomen or trapped in tissue provoke severe inflammatory responses.	Khalil (1971)
Camallanidae	*Procamallanus Spirocamma-llanus Paracamallanus Camallanus Cucullanus*	*Clarias, Synodontis* and other Catfishes	Intestine and stomach	Worms locked in the abdomen or trapped in tissue provoke severe inflammatory responses.	Boomker (1982); Paperna and Zwerner (1976)
Philometridae	*Nilonema Twastia Anguilicola*	*Gymnarchus Bagrus Anguilla*	Tissues or Inner cavities and swim-bladder	Granuloma and fibrosis	Moravec and Tarasc-hewski (1988)
Anisakidae	*Amplicaecum Contracaecum Porocaecum*	*Synodontis Clarias Heterobranchus*	Larval forms Encyst in tissues, free in body cavities	Localized tissue inflammation and fibrosis encapsulation	Mbahinzireki (1980)
Dioctophymidae	*Eustrongyloides*	*Synodontis Clarias Heterobranchus*	Larval forms Encyst in tissues, free in body cavities	Localized tissue inflammation and fibrosis encapsulation	Mbahinzireki (1980)
Rhabdochonidae	*Rhaditis Rhabdochona Spinitectus*	*Synodontis Clarias Heterobranchus*	Larval forms Encyst in tissues, free in body cavities	Localized tissue inflammation and fibrosis encapsulation	Mbahinzireki (1980)

hosts with heavier infections in predatory fishes (Table 3) (Klinger and Floyd, 2002; FAO, 1996). Khalil (1971) reported 40 species of adult nematodes, representatives of 9 families from fish in Africa with majority occurring in the alimentary system and a few in tissues or inner cavities (Table 3). Nematode worms are very distinctive in shape; with solid resistant cuticle, which enables them last longer than flatworms in post-mortem conditions (FAO, 1996).

Oxyuroidae are monoxenous (single host) and occur in the intestines of detritus feeders (*Citharinus, Distichodus*) and omnivorous fish (*Synodontis, Oreochromis* and *Barbus*) (Khalil, 1971). Camallanidae, Cucullanidae, Philometridae and Anguillicolidae have copepods as their intermediate hosts (FAO, 1996). Within the copepod host, nematodes are often fastidious in their choice and will not develop in species of Cyclops, Diaptomus or Cladocerans.

Host specificity of nematodes is variable in their definitive hosts. Among the Camallanidae, *Procamallanus laevionchus* has been reported from fish hosts of six different families while

Spirocamallanus spiralis has only been reported from species of *Clarias* and *Synodontis*, *Paracamallanus cyathopharynx* only from species of *Clarias* and *Camallanus kiradensis* only from *Barbus* sp (FAO, 1996). Species of *Capillaria*, most *Oxyurids* and the Philometrids *Nilonema gymnarchi* and *Thwatia bagri* are very host specific (Khalil, 1969; 1971; Moravec, 1974).

Infections by Camallanids are abundant and heavy up to 20 or more particularly in the stomach of *Clarias sp* and in many other catfishes (Paperna, 1964; Khalil, 1969; Mashego and Saayman, 1980; Boomker, 1982). None of these were reported to be pathogenic inspite of the firm attachment of their buccal capsule to the stomach mucosa.

In aquarium reared Neotropical cichlids and silurids, massive infections by *Capillaria* and *Capillostrongyloides* caused emaciation and mortalities as they attach and feed on the intestinal mucosa (Moravec and Gut, 1982; Moravec *et al.,* 1987). Similar findings were reported by Moravec and Rehulka (1987) on massive infection of cosmocercoid nematodes *Railetrema synodontis* in aquarium held *Synodontis eupterus* of African origin. Aged and dying worms, lodged in the abdomen or trapped in tissue provoked severe inflammatory responses, geranuloma and fibrosis (Paperna and Zwerner, 1974). Larval nematodes are potential parasites in all fresh and brackish water fish with heavier infections occurring in fish occupying higher positions in the food chain (FAO, 1996). Larval nematodes reported in fish are of the Anisakidae (Heterocheiliadae) and include the genera: *Amplicaecum, Contracaecum* and *Porocaecum.* Dioctophymidae includes the genus *Eustrongylids* and *Rhabdochonidae* includes the genera *Rhabdochona* and *Spinitectus* (FAO, 1996). These larval nematodes occur either encysted in the tissues or free in the body cavities, most often in the abdominal or pericardial cavity (FAO, 1996; Ibiwoye *et al*., 2004)

Cestoda: Tapeworms are widespread in all major water systems of Africa and demonstrate a high degree of host specificity (FAO, 1996). There are two main forms; the monozoic forms notably *Caryophyllaeidae* and the amphilinid represented by the segmented Pseudophyllideans and Proteocephalideans (Khalil, 1971; Van As and Basson, 1984). Siluriform fish are the most common hosts for both monozoic and segmented cestodes (Table 4) (FAO, 1996).

All cestodes occur in the digestive tracts, except the amphilinid *Nesolecithus africanus,* which occurs in the coelomatic cavity of its fish host, the mormyrid *Gymnachus niloticus* (Donges and Harder, 1966) and *Polyonchobothrium clarias* in the gall bladder of *Clarias mossambicus* (Wabuke-Bunoti, 1980). The Asian tapeworm, *Bothriocephalus acheilognothii* affects fish of the families Cyprinidae, Poecillidae, Cichlidae and Centrachidae (Table 4) (FAO, 1996). Infections are widespread in farmed fish as well as in a variety of wild fish in Europe and Asia (Bauer and Hoffman, 1976).

In naturally occurring infections among fish in African aquatic habitats, damage to the host is rarely evident (FAO, 1996) but pose a potential risk to native fish species such as *Clarias* sp and *Heterotis niloticus* introduced to farming. Hanzelova *et al.* (2005) affirmed that adult cestodes usually cause little or no noticeable damage to their hosts but chronic *Eubothrium* has been shown to significantly reduce fitness of farmed fish. Wabuke-Bunoti (1980) reported some tissue response (inflammation) due to attachment of *P. clarias* to gut mucosa in infected *C. mossambicus* of lake Victoria. He further observed that bothridal penetration into the gall bladder mucosa caused pronounced nodules containing granulomatous and fibrous tissues (Table 4).

Larval cestodes of the pleurocercoids and cysticercoids are among the most damaging parasites of freshwater fish (Klinger and Floyd, 2002). Infections by Ligula pleurocercoids in the body cavity and encysted Cyclophyllidean cysticercoids are widespread in African fish (Table 4) (Mashego, 1982; Van As and Basson, 1984). Ligula infections are very common in *Barbus s*p, *Cyprinid* sp in Lake Victoria and rarely in Cichlid sp of Israel, while Cyclophyllidean cysticercoids are common and numerous in the mesenteries of siluriforms, *Clarias* and *Bagrus* sp (FAO, 1996). Ligula pleurocercoids from African fish are referred to as *L. intestinalis* (Table 4) (Prudhoe and Hussey, 1977; Mashego, 1982). These larval tapeworms have their definitive hosts as piscivorous birds such as gulls and cormorants.

The infected species of Barbus by Ligula pleurocercoids in southern Africa were observed with considerable distention of their abdomen and diffuse haemorrhages in the abdominal wall in some fish (Table 4) (FAO, 1996). Infection with Ligula pleurocercoids according to Sweeting (1977) leads to interruption of the reproductive functions but this has not been confirmed.

Acanthocephala: Acanthocephalan worms are present in representatives of diverse African fish families (Table 5) (Golvan, 1965; Khalil 1971).

They are easily recognized by their evaginable proboscis crowned with several rows of recurved hooks (FAO, 1996). The number and arrangement of the hooks on the proboscis are the main criteria for differentiation of species; although a wider range of anatomical details are considered for determination of higher taxa (Kabata, 1985). Acanthocephalans lack alimentary canal and are heteroxenous, adult worms are gut parasites (FAO, 1996). Eggs laid in the intestinal lumen are evacuated via the feaces and ingested by the first intermediate hosts such as the amphipods, isopods, copepods or ostracods (FAO, 1996) where they hatch to first stage larvae, the acanthella or acanthor. George and Nadakal (1973) and Schmidt (1985) reported the development to adult stage of some species when their larvae in the intermediate hosts are ingested by the definitive vertebrate hosts, which may be fish, amphibians or reptiles.

Pathogenic effects of acanthocephalans are due to attachment of the adult parasite in the digestive tract and also to the encapsulation of

Table 4: Cestode parasites and their effects on fresh water fish host

Cestode Taxa	Cestode Species	Fish species Infected	Site of Infection	Symptoms	Source
Caryophallaeidae (Unsegmented)	*Caryophylleus* *Khawia* *Ligula*	Siluriform fishes	Digestive tract of hosts	Obstruction of intestines Nodules in the gall bladder	Khalil (1971); Van As and Basson (1984)
Pseudophyllidae (segmented)	*Proteocephalus* *Bothriocephallus* *Nesolecithus*	*Alestes,* *Barbus,* *Mormyrids,* *Tilapia* Siluriform fishes	Digestive tract of hosts. Coelomatic cavity	Tissue inflammation and atrophy around site of bothria penetration	Sweeting (1977); Mitchel and Hoffman (1980); Woodland (1937)

Table 5: Acanthocephala parasites and their effects on the fresh water fish host

Acanthocephala Taxa	Acanthocephala species	Fish species Infected	Site of infection	Symptoms	Source
Acanthocephala	*Acanthocephalus* *Paragorgorhynchus* *Termisentic* *Neoechinorhynchus*	*Tilapia* *Barbus* *Heterotis niloticus* *Citherinus* *Synodontis*	Guts of hosts where they attach to the walls by proboscis	Granuloma and fibrosis inflammation, Peritonitis, Obstruction and perforation of the digestive tube.	Khalil (1969, 1971); Paperna and Zwerner (1976)

larval stages in the tissues where the extent of damage is proportional to the depth of penetration of the proboscis (FAO, 1996; Oniye *et al.,* 2004). Damages become extreme with extensive granulloma and subsequent fibrosis when the worms proboscis is anchored in the muscle layer or entirely perforates the intestinal wall (Paperna and Zwerner, 1974; McDonough and Gleason, 1981; Kabata, 1985), which may vary in different host fish (Taraschewski, 1988). Dovellou (1992a, b) observed a single attached specimen of *Acanthogyrus tilapia* in juvenile cichlids (Table 5) (<*60*mm) obstructed the digestive tube in farmed fish apparently with no clinical implications. In Africa, information on infection among fish is very limited and none of the conditions described above has been reported (Table 5).

Host specificity of acanthocephalans is variable as they infect several fish families (Khalil, 1971; Troncy and Vassillides, 1973; Troncy, 1974; 1977; Batra, 1984; Dovellou, 1992a, b; and Oniye *et al.* 2004)

Copepoda: Parasitic crustaceans are increasingly becoming serious problems in both cultured and wild fish populations (Klinger and Floyd, 2002). They are ectoparasites, which attach to gills, body and fins of the fish hosts. Klinger and Floyd (2002) listed three main genera that are of economic importance: *Ergasilus, Lernaea* and *Argulus*.

Ergasilus species are widely distributed. Twenty-one species have been described from different hosts in Brazil (Table 6) (Motta *et al*., 1995; Thatcher, 1998; Engers *et al*., 2000). *Ergasilus sp* are often incidental findings on wild or pond raised fish and probably causes little problems in small numbers but their feeding activities in heavy infestation can be debilitating. *Ergasilus sieboldi* and other *Ergasilus sp* have caused problems among captive freshwater fishes (including eels) in Europe (Grabda, 1991; Tuuha *et al*., 1992) and North America (Kabata, 1981; Hogans, 1989). In African fishes, heavy infestations of *Ergasilus sp* cause severe haemorrhaging and gill inflammation that are associated with attachment and feeding of the parasite (Paperna, 1975). Chronic infections cause blockage of lamellar blood vessels and excessive production of gill mucus (Paperna and Zwerner 1974) leading to both respiratory and osmoregulatory failure (Hogans, 1989; Barker and Cone, 2000). Secondary infections of the fungus *Saprolegnia* sp have also been reported with *Ergasilus* sp infections (Table 6) (Reichenbach-Klinke and Landolt, 1973)

Lernaea sp also known as anchor worms are common parasites of freshwater fishes (Klinger and Floyd, 2002). The copepod attaches to the fish hosts, mates and the male dies while the zygote then penetrates under the skin of the fish and differentiates into an adult. The copepod develops holdfasts that penetrate deeply into the hosts (Kabata, 1979; 1988). The genitoabdominal trunk and egg strings of ovigerous pennellids protrude from their fish host musculature as in *Pennella* sp (Hogans *et al*., 1985; Hogans, 1989) or gill regions as in *Lernaeocera* sp and *Haemobaphes* sp infestations (Table 6) (Kabata, 1958, 1967). The last two genera are haematophagus and their holdfasts often penetrate into the heart of fish hosts (Goater and Jepps, 2002) causing serious debilities. Heavy infections often lead to secondary bacterial or fungal infections (Klinger and Floyd, 2002).

Argulus or fish louse, a Brachiurid, is a large parasite that attaches to the external surface of the host and can be easily identified with unaided eye (Klinger and Floyd, 2002).

Table 6: Copepod parasites and their effects on the fresh water fish host

Copepod taxa	Copepod species	Fish species Infected	Site of infection	Symptom	Source
Ergasillis	Ergasilus	Fresh water fish Species(in captivity)	Gills	Gill inflammation, haemorrhaging, excessive mucus, blockage of blood vessels leading to respiratory and osmoregulatory failure.	Grabda (1991); Tuuha *et al* (1992); Hogans (1989); Barker and Cone (2000)
Lernaea	Pennella, Lernaeocera, Haemobaphes.	Freshwater Fish	Skin, muscles, heart.	Anaemia and general disabilities.	Goater and Jepps (2002); Klinger and Floyd (2002)
Argulus	Argulus	Fresh and brackish water fish	Skin, gills	Skin necrosis, haemorrhages general disabilities	Bowen and Putz (1966)

Table 7: Hirundinea parasites and their effects on fresh water fish host

Hirundinea Taxa	Hirundinea Species	Fish species infected	Site of infection	Symptom	Source
Glossiphoniidae	Batrachobdelloides	*Bagrus, Protopterus, Clarias* and *Synodontis* species	Around the mouth, external, internal. Palate, corners of the jaw and skin	Wounds, Inflammation, haemorhage based on hyperplexia erosion of the mucus membrane	Oothuizen (1989); Paperna and Zwerner (1974); Roubal (1986); Khalifa (1985); Kabata (1985); Volonterio *et al,* (2004)
Piscicoliidae	Phyllobdella, Myzobdella	Mormyrids Chichlids Mugilids	Around the mouth, external, internal. Palate, corners of the jaw and skin	Wounds, Inflammation, haemorhage based on hyperplexia erosion of the mucus membrane	Oothuizen (1989); Paperna and Zwerner (1974); Roubal (1986); Khalifa (1985); Kabata (1985); Volonterio *et al,* (2004)

They have compound eyes, lateral carapace-like head lobes fused to the sides of the first thoracic somite, an opening for genital products and a proximal overhang of some of the thoracic expodites (Noble and Noble, 1982). Both males and females are parasitic and require blood meals. They are skin and gill parasites of both fresh and brackish water fish hosts, where they cause serious skin necrosis, haemorrhages and other debilities (Bowen and Putz, 1966; Noble and Noble, 1982).

Hirudinea: Leeches are freshwater ectoparasites of a wide range of fish genera including Clariidae, Synodontidae, Mormyridae, Cichlidae and Mugilidae (Oothoizen, 1989). Leeches feeding on fish are of the genus *Rhynchobdellae* and belong either to the family Glossiphoniidae or the Piscolidae (Table 7) (Mann, 1962).

Glossiphoniids have a depressed body with no distinct anterior or posterior regions but taper at the anterior end with a sucker and eyes. Piscicolids have cylindrical body divided into district anterior and posterior regions with head sucker marked off from the body (Mann, 1962).

Heavy leech infections have variable effects on fish hosts (FAO, 1996). In Lake Victoria *19*% of all studied *Bagrus docmac* harboured leeches at the external perimeters of the mouth region with a mean of 26 per infected fish. According to FAO (1996) pathological changes were restricted to bite signs and mild tissue changes even in the most heavily infected individuals habouring over 100 leeches. Among fresh water fish hosts, piscicolid species attached to different sites generally produce serious damages at the sites of infection (Table 7) (Roubal, 1986; Sawyer, 1986).

Volonterio *et al*. (2004) observed the effects of the leech *Myzobdella urguayensis* infesting the gill filaments of *Hoplias alabaricus* (Characiformes, Erythrinidae) and *Rhamdia quelen* (Siluriformes, Pimelodidae), haemorrhage with clot formation and fibrin deposition at the attachment sites. They equally observed inflammed gill filaments exhibiting oedema and infiltration of mononuclear leukocytes. Damages to skin comprised of bite wounds, haemorrhages, erosion of mucus membranes, the epidermis and basal hyperplasia (Table 7) (FAO, 1996; Volonterio *et al.*, 2004). Apart from the mechanical injuries and pathological effects leeches have on fish hosts; they have also been discovered to be vectors of haemoprotozoans (FAO, 1996). For example *Piscicola geometrea* was shown to transmit viral disease to carp (Ahne, 1985). Bleeding wounds may also become contaminated by opportunistic bacteria and fungi (Table 7) (Kabata, 1985).

Conclusion: The effects of parasites on fish hosts in the wild may be difficult to isolate and quantify. However, studies of fish in captivity or under culture conditions have provided much information about the effects of parasites on fish survival. From the review, it is evident that parasites can act as severe pathogens causing direct mortality or rendering the fish more vulnerable to predators (Kunz and Pung, 2004). Other effects of parasites on fish hosts, according to Sindermann (1987) include muscles degeneration, liver dysfunction, interference with nutrition, interference with respiratory functions, cardiac disruption, nervous system impairment, castration or mechanical interference with spawning, weight loss and gross distortion of the body.

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