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The Effects of Fish Parasites in Freshwater Culture and Capture Fisheries and their Treatment Mechanisms

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Abstract

The increasing interest of fish culture development in recent world has increased the interest on awareness and experience on fish parasites. Fishes in freshwater are affected by different types of parasites in different ways and causes various problems depending on the interaction between the parasite species, the host species and environmental conditions. The major parasitic groups found in the freshwater fishes include trematodes, nematodes, acanthocephalans and cestodes. Based on the existence of suitable biotic and abiotic factors parasites can envied fishes and alter their host fish's health through mechanical, physical and reproductive damage. These changes can affect growth rate, fecundity and survival, change behavior and sexual characteristics and result in many other maladaptive alterations of the infected host. These changes could have significant consequences at not only the individual level, but population, community and ecosystem levels as a whole. In most cases parasitic infection of fishes occur due to environmental problems such as poor water quality, crowding, dietary deficiencies or stress particularly in the developing countries aquatic habitats. As a result the best cure for any fish health problem could be prevention or good water quality management rather than medication after infection has already occurred.

Keywords: Fish Parasites; Prevention; Occurrence

Introduction

The term parasite describes any organism that lives in or on another host organism from which it gets its food and other benefits in the expense of its host [1]. Parasitic organisms can be found everywhere and on every living organism. Their presence in their host is generally at equilibrium in aquatic organisms and the most common lifestyle on the planet [2]. Aquatic ecosystem usually offers ideal condition such as physiologically stable, buffered and viscous condition for the dispersal and survival of eggs and larvae of parasites and free movement of adult stages in or on the bodies of host fishes. The complex food and feeding interaction of aquatic organisms may also trigger the development of complex parasites life cycle. Since, fishes play the central role in aquatic ecosystems especially with respect to their role as consumers in food chains and offer a large surface area for encounter and colonization they are frequently utilized as hosts by parasitic organisms. Probably for all of these reasons, fish that lives in wild as well as in artificial fish farms are rarely found to be free from parasitic infections [3].

Fish parasites usually affect the fry and fingerlings of fishes and they can cause significant damage in fish industry [4]. Fish parasites are known as the major pathogens that spoil the normal physiology of fishes, thus resulting in consumer rejection Kayis, et al. [5] and cause for mass fish mortalities [6]. However, only few studies were carried out to estimate status of disease causing pathogens mainly parasites in most part of the world especially in Sub-Saharan African Aloo, et al. [7] including our county Ethiopian. It is evident that parasites can act as severe pathogens causing direct mortality or rendering the fish more vulnerable to predators or other opportunistic diseases. In addition, fish parasites may cause 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 Iyaji, et al. [8] which leads to loss of benefits that may obtained from fishery.

Biodiversity and species composition of fish parasites in the aquatic ecosystem depends on intermediate or definitive host species richness and presence of suitable environmental conditions [9]. About 1211 known freshwater fish parasites species representing in 5 phyla and 11 classes of invertebrates have recorded Bykovskaya IE, et al. [10]. The major parasitic groups found in the freshwater fishes include trematodes, nematodes, acanthocephalans and cestodes. For epidemiological purpose economically most important freshwater fish parasites are traditionally grouped as microparasites: *protozoans-microsporideans* and *myxozoans,* while the macroparasites group is comprised of helminths such as *monogenean* and the *digenean* trematodes (flukes), cestodes (tapeworms), nematodes (roundworms) and acanthocephala (thorny headed worms) [11]. The arthropod parasites are represented mainly by the parasitic copepods and true lice, while the annelid parasites are the leeches. In Ethiopian lakes also helminthes, nematodes, cestodes, trematodes, protozoan and crustaceans have reported in different fish species of Lakes Koka, Hayk, Ashenge, Ziway and Koftu [12-16].

The recently emerging sector of manmade fish farms are usually constructed from freshwater resources but increasing fish production without improving management of the fish farm may result in bacterial, viral, fungal and parasitic origin infestations. Surprisingly, on average 80% of fish diseases are parasitic especially in warm water fishes and severe fish mortalities as a result of parasites as a report of Barber, et al. [3]. The study conducted by Ali, et al. [17] on the (*O. niloticus*) and (*C. gariepinus*) production farms in Kenya also prove that, majorities of fish farmers complained with small and low production of quality fish in relation with parasitic infection. As a result, the concept of fish parasites has got a good attention throughout the world. For instance, promotion of commercialization of aquaculture in Uganda is now addressing the importance of parasitic diseases as a production risk factor that can significantly negate the marketability of aquaculture products [18].

Major Parasites of Freshwater Fishes

Ecto-Parasites

According to Hecht, et al. [19], ecto-parasitic species can be either host-specific or omnipresent and opportunistic. The ecto-parasites, which are known to be problematic in African aquaculture, include protozoans, monogeneans, leeches, crustaceans and larval bivalve mollusks.

Protozoa

Protozoans are the most commonly encountered fish parasites that can be among the easiest to identify and to control. They are single-celled organisms, many of which are free-living in the aquatic environment which means they have no intermediate host to maintain their life cycle. Consequently, they can build up to very high numbers when environmental degradation occurred and/or fish are crowded causing weight loss, debilitation and mortality. The five major groups of protozoans are ciliates, flagellates, *myxozoans*, *microsporidians*, and *coccidians*. Parasitic protozoans in the latter three groups are considered as the most difficult to control [8]. Ciliate protozoans are mostly obtained on eye, skin and gills of pond-reared fish. Clinical symptoms which may typically seen in infected fish species by ciliates include skin and gill irritation displayed by mucus secretion, flashing, rubbing, and rapid breathing. *Trichodina spp* of protozoan has also reported in *O. niloticus* fish species of Lake Koftu, Sebeta ponds and private fish farms in Ethiopia, by Marshet Adugna, et al. [21].

Monogenean Trematodes

The class trematoda comprises of monogeneans and the digeneans fish parasites. Monogenean trematodes are small flatworms or flukes that are commonly invade the gills, fins or skin of fish using an organ on their back end called a "haptor" which is studded with hooks or has a clamping arrangement of spines. Although some monogeneans are endoparasites, most are ectoparasitic on the gills, buccal cavity, body surface and fins [22]. Monogeneans have a direct life cycle (no intermediate host) with tiny free-swimming larvae (oncomiracidium). The adults, which parasitize fish, are typically less than a centimetre long and are seldom seen by the casual observer and are host- and site-specific [1].

Gyrodactylus and *Dactylogyrus* are the two most common genera of monogeneans that infect freshwater fish. They differ in their, morphology, reproductive strategies and their method of attachment to the host fish. *Gyrodactylus* have no eyespots, two pairs of anchor hooks, generally found on the skin and fins of fish and they are viviparous. While, *Dactylogyrus* prefers to attaches to fish gills. They have two to four eyespots, one pair of large anchor hooks, and are egg layers. Most monogeneans found in inland water fish are of the family Dactylogyroidae with few pathogenic species to young fishes [23]. For instance the study conducted by Obiekezie, et al. [24] reported severe mortalities (up to 90%) of two weeks old *Clarias gariepinus* fry in a hatchery of Nigeria due to severe infestation of *Gyrodactylus groschefti* species. Secondary infection by bacteria and fungus is common on tissue with monogenean damage [8]. In some Ethiopia water bodies such as two species of monogeneans called *Dactylogyrus* from the gill of *Lebeobarbus intermedius* and *Cichlidogyrus* from the skin scrapings of *Oreochromis niloticus* of Gilgel Gibe-1 Dam by Marshet Adugna, et al. [16], *Gyrodactylus* in *Barbus intermidius* and *Claries gariepinus* of Lake Koka by Yewubdar Gulelat, et al. [12] and *Cichlidogyrus* from the gills of *O. niloticus* at Lake Koftu, Sebeta ponds and private farms by Marshe Adugna, et al. [21] were reported in Ethiopia.

Crustacean Diseases (Copepoda)

Several crustaceans are parasitic to fish and have caused losses in wild fishes and aquaculture hosts. Most commonly reported and important species infesting freshwater fishes belong to the Copepoda, e.g. Ergasilidae, Lernaea, Caligidae, Lamproglena and Branchiura (leeches) [25]. Recently parasitic crustacea are increasingly serious problems in cultured freshwater fish and wild populations also. Most parasitic crustacea of freshwater fish are ecto-parasites and can be seen with the naked eye as they attach to the gills, body and fins of the host [8,20]. Three major genera are discussed below.

Ergasilus: Ergasilus has a flattened, oval body which is almost entirely covered by a wide carapace. Compound eyes are prominent and the mouth parts and the first pair of antennae are modified to form a hooked, spiny proboscis armed with suckers [4]. They are often incidental findings on wild or pond-raised fish and probably cause few problems in small numbers. However, their feeding activity causes severe focal damage and heavy infestations can be debilitating. Most affect the gills of freshwater fish, commonly seen in warm weather.

Lernaea: Lernaea, also known as anchor worm is a common parasite of goldfish and koi, especially during the summer season. The copepod attaches to the fish, mates, and the male dies while, the zygote penetrates under the skin of the fish and differentiates into an adult. Heavy infections lead to debilitation and secondary bacterial or fungal infections [20]. The study conducted by Marshet Adugna, et al. [16] in Gilgel Gibe-I Dam reported that, the genus Learnea was the most common external copepod parasite found attached on gills, operculum, fin and the skin on both O. niloticus and L. intermedius fishes.

Argulus: Argulus or fish louse is a large parasite that attaches to the external surface of the host and can be easily seen with the necked eye. It is uncommon in freshwater aquarium fish but may occur if wild or pond-raised fish are introduced into the tank. It is especially common on goldfish and koi. Clinical signs in infected fish include intense irritation which causes fish to rub or scrape against objects in the aquarium walls, erratic swimming and poor body growth. It causes pathological changes due to direct tissue damage and secondary infections [19]. Argulus spp. had also reported from the fins of the O. niloticus in Gilgel Gibe-I Dam by Marshet Adugna, et al. [21].

Endo-parasites

Several endo-parasites have been recorded in wild and culture freshwater fishery. These include some protozoans, e.g. haemoprotozoa, coccidians, myxosporeans, microsporeans, as well as digenean trematodes, cestodes and nematodes [19].

Nematoda: Nematodes or round worms are transparent or white, unsegmented worms. They are common in worldwide particularly the freshwater fish species utilizing as intermediate or transient hosts such as detritus feeders (*Citharinus*, *Distichodus*) and omnivorous fish (*Synodontis*, *Oreochromis* and Barbus) and can infect all organs of their hosts with heavier infections in predatory fishes [26]. Adult nematodes occur mainly in fish intestines, while larval stages occur in the viscera, muscles, gonads, liver and in the swim bladder and adult parasites usually cause low pathology [27].

Nematodes are common parasite in Ethiopian water bodies. For instance, nematodes species *Conracacum* larval stage in *O.niloticus* and *L. intermedius* fish species of Gilgel Gibe-1 Dam, in *O. niloticus* and *C. gariepinus* of Lake Ziway and in *B. intermedius*, *C. gariepinus* and *O. niloticus* of Lake Koka was reported by Yewubdar Gulelat, et al. [12]; Jossy Bekele, et al. [28]; Marshet Adugna, et al. [16]. *Procamallanus* adult stage also repoted in the intestine of *L. intermedius* of Gilgel Gibe-I Dam by Marshet Adugna, et al. [21].

Digenean Trematodes: Digenean are small parasites infect the external or internal organs of fish that can be the primary or intermediate host depending on the digenean species variety. The adults attach to their hosts using suckers on the anterior and ventral surfaces. They have an indirect life cycle with at least one intermediate host, typically a snail or clam [1].

They have complex life histories involving larval stages, which infect mostly juvenile fish, bottom dwellers and shallow water habitats in inland water bodies like tropical countries in Africa [8]. For instance, species of *Sanguinicola* (the blood flukes) are reported to infect *Synodontis schall* and *Auchinoglanus occidentalis* in the Sudan [29]. The life stage most commonly observed in fish is the metacercaria, which encysts in fish tissues. Three genera of digenean, namely, *Clinostomum*, *Euclinostomum* and *Tylodelphys* in *O. niloticus* and one genera in *L. intermidus* were reported in Gilegel Gibe-I Dam by Marshet Adugna, et al. [16]. Trematode species, *Clinostomum* in gill filaments and thoracic cavity of *O. niloticus* and *C. gariepinus* in Lake Ziway and *Diplostomum, Euclinostomum* and *Clinostomum* in *B. intermedius*, *C. gariepinus* and *O. niloticus* of Lake Koka were reported by Jossy Bekele, et al. [28]; Yewubdar Gulelat, et al. [12] respectively.

Cestodes: Cestodes, also called tapeworms, are found in a wide variety of animals, including fish which are used as primary or intermediate host for complex life cycle of cestodes. Tapeworms are widespread in all major water systems of Africa and demonstrate a high degree of host specificity [26]. Cestodes infect the alimentary tract, muscle, brain, eye, heart or other internal organs of the adult and larval fishes. Larval cestodes called *plerocercoids* are some of the most damaging parasites to freshwater fish. These larval tapeworms have their definitive host, piscivorous birds such as gulls and cormorants [30].

Adult and larval cestodes in the gut lumen, intestinal wall and liver of *L. intermedius, C. gariepinus* and *O. niloticus* fish species of Lake Koka, Lake Ziway and Gilgel Gibe-I Dam were reported by Yewubdar Gulelat, et al. [12]; Temesgen Bihonegn, et al. [15]; Marshet Adugna, et al. [21] respectively.

Factors for the occurrence of fish parasites: The existences of fish parasites in their host fishes can be determined by several biotic and abiotic factors. The biotic factors relate with species type, sex, size and feeding habit of the host fishes and the associated intermediate or definitive hosts. Fish hosts may acquire the parasites by ingesting infective spores from infected fish or food [20]. As a result top predator or fish species that have numerous food sources are more vulnerable than others. For instance, the study conducted by Shaheen, et al. [31] regarding the total prevalence of internal parasitic diseases in four fishes; the infestation rate was higher in *L. niloticus* (85.5%) followed by *C. gariepinus* (74.88%) then *O. niloticus* (67.5%) of wild fishes, while lower rate was recorded in cultured *O. niloticus* (30%). This is related to the feeding habits of the fish species and the chance to get various food sources. The lowest rate was detected in cultured *O. niloticus* could be attributed to its feeding depends mainly on well threatened artificial food and its probability to get natural food is very limited.

The existence of conductive environments for various birds such as kingfishers, herons, cormorants and stocks, copepods, snails and human beings which are known as intermediate or definitive hosts of parasites can lead to parasitize fish hence maintaining complete life cycle required by parasites to survive [32]. For example, *Cercariae* are asexually produced in the snail and released into the water, infecting a suitable second intermediate fish host like *Pacific killifish* upon contact. The parasite then encysts as a metacercaria in the brain of fish and completes its life cycle in piscivour birds which eats infected fish [11].

Abiotic factors like accumulation of organic wastes in water bodies are also important factors for the occurrence of fish parasites. This could be due to the fact that, the recharge of organic waste in to water bodies may contain eggs of parasites from intermediate or definitive hosts in the surrounding environments or may create stress on host fish and decrease its resistance ability, while providing tolerable conditions for the existence of parasites. Hence, prevalence of fish parasites may be associated with decreasing of water quality, while fish production decreases. For example the study conducted by Gashaw Tesfaye, et al. [33] in Lake Ziway especially since 2000s and by Abreha Tesfaye, et al. [14] in Lake Ashenge indicates the drastic decrease of fish production from year to year. Consequently prevalence of parasites shows an increasing pattern. In Lake Ziway *Clinostomum* parasitic species reported in 50(8.16%) individuals from 613 specimens by Eshetu Yimer, et al. [34], in 50(13.02%) individuals from 384 specimens by Josy Bekele, et al. [28] and in 277 (69.25%) individuals from 400 specimens by Temesgen Bihonegn, et al. [15]. Furthermore, in Lake Ashenge the study conducted by Abreha Tesfaye, et al. [14] reported, the prevalence of helmets 37.6%, while Habtom Abay, et al. [35] reported, 65.11% in the same lake within one year gap, while the quality and quantity of Lakes Ziway and Ashenge water shows a drastic decreasing due to several anthropogenic factors around the lakes.

Since natural environments are more vulnerable for various anthropogenic factors and difficult to manage, capture fishery are more susceptible for parasitic infection than culture fishery. For instance, the study conducted by Marshet Adugna, et al. [16] in the overall prevalence of parasites of *O. niloticus* at Lake Koftu, Sebeta ponds and private fish farms reported that 100%, 71.1% and 82.2% respectively.

Effects of Fish Parasites on Hosts

Health Effects

The health of host fish species may affect in different way based on the nature of parasites. For instance, brain deformity; impair vision and movement due to *Diplostomum mordax metacercariae* [36]; skeletal deformities, locomotory disturbances, emaciation and sunken eyes in brain infections [37]; anemia, haemorrhagic dropsy and mortality in heavy cardiac infection due to several myxozoan infections in cultured fish [38].

According to Sandland, et al. trematode metacercariae have been shown to modify the morphology of fish hosts by disrupting the heart, brain and eye lens. 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 of some fish Abbass, et al. [39] reported that heavily infested fish with Tapeworm (Cestodes) and digenetic trematodes have a distended abdomen that led to pathological changes in infested organs, while pathogenic effects of acanthocephalans are due to attachment of the adult parasite in the digestive tract by the proboscis which causes weight loss even death of the host. According to Ali, et al. [17] *Diphyllobothrium dendriticum* and *Diphyllobothrium latum* are only larvae of tapeworms which can infect people. When *D. dendriticum* consumed by human within the infected fish, the cysts walls are digested and larvae emerge that grow into mature tapeworms in the infected individual's intestine [17].

In many fish health assessments, the roles of parasites on fish health were overlooked throughout the world. Even, their presence usually gets a concern when they affect a fish species of interest or cause detrimental effects to the economy or a recreational activity or on commercial fishery rather than taking preliminary actions. For instance the, in Bishoftu lakes of Ethiopia the death of several fish due to parasitic effect were reported by Kibru Teshome, et al. [40] after large number of fish were lost.

Mechanical Damage

Many species of parasites invade the organ of fishes such as gills, scales, fins and other organs and causes morphological deformity. Some parasites range from microscopic tubulinea or monogenea, to macroscopic annelida and arthropoda, can be viewed on the gill arches or nestled between the gill filaments. The grossly visible reactions of these parasites on the fish may be noncritical and include a mild discoloration of the gill filaments or create white spots on the host fish body. In more critical cases, the fish may display heavy eroding, massive discolorations, numerous white spots and increased mucus secretion [41].

Behavioral Effect on Host Fishes

Parasites alter the behavior of hosts by direct or indirect mechanisms. Direct method means just by affecting the neuro-endocrine system of the host by the release of hormone or neurotransmitter analogues, while indirect manner means by changing some other physiological parameter that invokes a certain behavioral response in the host [42]. An example of indirect manipulation would be the increased feeding of fish infected with nutritionally demanding parasites such as larval cestodes, induced by the low levels of circulating nutrients in the host [3].

The normal behavior of an individual fish under a given situation may be explained conveniently as a result of motor responses brought by the complex integration and neurological processing of inputs from many sensory systems. Hence alteration of individual behavior may sometimes be coincidental to parasitic infection that may damages any or all of these factors and infection-associated pathology may be an inevitable consequence of being colonized or inhabited by another organism [43,44]. The behavior of parasitized individuals usually resulted from combination of both the host and parasites genotype, so described as a 'mixed phenotype', which may also cause alteration in the ecology as a whole [45].

The infection of fish by parasites most of the time increases susceptibility for predation since they may lower their swimming ability and other escaping mechanisms. For instance, laboratory experiment done by Kramer, et al. [46] using a heron as a predator confirm the suggestion that the risk of predation increases for fish nearer the surface due to parasitic infection. Furthermore, the trematode parasitic species *Euhaplorchis californiensis* are known to infest *California killifish* brains, which alter their behavior and causes the fish to swim slowly and in circles at the water surface. Hence, the infected fish were 10–30 times more susceptible to predation by the birds that serve as definitive hosts [47]. In contrast, some directly transmitted parasites may alter host behaviour to actually reduce their hosts' risk of fatal predation. For instance Milinski, et al. [44] showed that sticklebacks infected with *Schistocephalus* fed lower than uninfected fish by potentially-predatory cichlid. In addition, many fish parasites affect their hosts in ways that may alter competitive ability for food, shelter as well as for mating.

Effects on Fish Growth

The study conducted by Barber, et al. [48] states that, altered fish growth (delayed growth, stunting) only occurs in extreme laboratory conditions, but not observed in the wild. This might be due to the fact that, parasitic infested or stunted fish might not survive in the wild and they might be taken more readily by predation. On the other hand, parasites are mostly dependant on host-derived energy for growth and development, so they are potentially affected by the host's ability to acquire nutrients under competitive foraging scenarios. Hence, the fastest growing fish developed the largest parasites; therefore, faster growing hosts apparently provide ideal environments for growing parasites.

In general the effects of parasites infection in fishes are frequently manifest as a change in energy expenditure and subsequently alter appetite and feeding behavior which can lowers the growth rates of the fish. For example, fish parasites specifically cestodes are known to inhibit fish nutrient absorption and is more pronounced in cultured species due to overstocking coupled with poor water quality management El seify, et al. [49]; Abrha Tesfaye, et al. [14] also reported that, the high infestation of internal fish parasites in Lake Ashenge significantly affected or reduced the body weight and length or size of fishes.

Effects on Fish Reproduction

According to Read, et al. [50] there are two broad mechanisms by which parasites may alter the sexual behaviour of their host fishes. Firstly, many infections impair reproductive organs development of hosts or have other effects that prevent hosts engaging in reproduction at all. Secondly, for hosts that are capable of reproduction and attempt it, parasites may have a role in determine their mating success. Parasitic infection may influence intrasexual competition for limiting resources essential to courtship or may affect sexual attractiveness and thereby intersexual choice affected in some way. For instance, Cyprinid fish infected with *Ligula intestinalis plerocercoids* do not undergo changes associated with the sexual phase and it appears that gonad development is suppressed by medications to the host pituitary that interferes with normal gonadal hormone production [51], which reduces selection of male fish by female for mating. On the other hand, many fish parasites are associated with a reduction in host reproduction energy and they appear to achieve this either through the energetic demand they place on their host or by the release of hormone analogues that block sexual maturation.

Commercial Effect

According to Stewart, et al. [1] the effect of parasites on the value of the fish is perhaps greater than their impact on human health. Usually parasites can reduce the value of fish to harvesters by damaging the skin, infecting the meat or spoiling the flavor or condition of the fish. People do not want to buy or eat fish with visible evidence of parasite infection despite the fact that the parasite will not infect them and dump as a waste. Hence, parasitic diseases are considered as the major biotic constraint for global or local economic development through production loss from massive fish mortality, lower reproduction potential and deterioration in the food value of fish as well as effects on human health [11]. It also increase farm cost through increased treatment expense and cause reduction in growth rate and weight loss during or after parasitic infection [14]. Most of the economic damage is caused by tapeworm larvae. According to Abd El-Laatif, et al. [52], the encysted metacercariae infestation of *C. gariepinus* appeared as nodules of varied sizes and reached to hundreds in number in heavily infested cases. Therefore, the presence of encysted metacercariae lead to low weight gain, immarketability of infested fish and high mortality that causes loss commercial values.

Treatment and Prevention Mechanisms of Fish Parasites

Chemical Method

Chemical method is one of the ways that applies to medicate fish farms based on clinical symptoms observed on the fish and it is mostly applicable in culture fishery. The most useful therapeutic recommendation means is accurate diagnosis of fish health problems. However, a common mistake of fish culturists is misdiagnosing disease problems and treating the sick fish with the wrong medication or chemical. Selecting the wrong treatment because of misdiagnosis lead to waste of time and money and may be more detrimental to the fish than no treatment at all. Hence appropriate equipments and well experienced person are the basic inputs to implement chemical method to medicate fish farms [20].

Copper sulfate is an excellent compound for use in ponds to control external parasites and algae; however, it is extremely toxic to fishes. It is mostly applicable in African aquaculture to control snails at concentrations of up to 5 μg/g [19]. Its killing action is directly proportional to the concentration of copper ions (Cu^{++}) in the water. As the alkalinity of the water increases, the concentration of copper ions in solution decreases. The amount of copper sulfate needed in mg/L is the total alkalinity (in mg/L) divided by 100. Copper sulfate should never use in water that has a total alkalinity less than 50 mg/L [20]. Potassium permanganate is another effective chemical and mostly applicable against ciliates fish parasites as well as fungus and external *columnaris* bacteria and it can be used in a pond. However, multiple treatments with potassium permanganate are not recommended as it can burn gills. Potassium permanganate at the prescribed dosage (2 mg/L) does not seem to affect the nitrifying bacteria in a biological filter; however, ammonia, nitrite and pH should be closely monitored following treatment [23].

Both copper sulfate and potassium permanganate are algicide and can cause oxygen depletion in the applied water body particularly in warm weather. As a result, emergency aeration should always be available when copper sulfate or potassium permanganate is applied to a given system or ponds [23].

Formalin is an excellent parasiticide for use in small volumes of water such as vats or aquaria to control flagellate and ciliate protozoans and massive infection of all worms. It is not recommended for large ponds use because it is a strong algicide and chemically removes oxygen from the water. Vigorous aeration should always be provided when formalin is used. Proper amount of salt solution is also effectively controls protozoans on the gills, skin, and fins of fish as well as crustaceans or copepods such as *Ergasilus*, *Lernaea*, *Argulus* and *leeches*. It is applicable for small volume of water like aquaria or tanks. However, it is not recommended for pods due to the large amount of salt and high cost of treatment that would be needed to be effective [53].

Febendazole is also utilized as treatment mechanisms for parasites like *camillanus* which is easily recognized as a small thread-like worm protruding from the anus of the fish. Control of this nematode in non-food fish is with fenbendazole by mixing with fish food using gelatin as a binder at a rate of 0.25%. Another parasite called *capillaria* which is a large roundworm commonly found in the gut of angelfish can also threatened using fenbendazole [19].

According to Akoll, et a. [54] reviews on five east African countries, namely, Burundi, Kenya, Rwanda, Tanzania and Uganda there is limited knowledge to diagnose fish diseases. As a result, local farmers mostly apply the three chemicals (copper sulfate, potassium permanganate and formalin) for any suspected fish parasites which may cause loss of money, loss of fish as well as health risk on fish users.

Biological Methods

Effect of fish parasites can be controlled using biological method which will be difficult but effective if applied in both capture and culture fishery. Biological method can be applied through breaking the life cycle of parasites, especially for parasites which have complex life cycle and make them unable to sustain their generation and immature to infect fishes. This can be done through introduction of predator organisms on the intermediate or definitive host of parasites or removing of such intermediate or definitive host of parasites. For instance, the elimination of intermediate hosts such as snail for digenean parasites and vectors like wading birds which are definitive host of nematode parasite called *Eustrongylides* can prevent fishes from being infected. This can be done through elimination of certain microhabitats which are highly susceptible for higher risk of parasitic infections [8].

Physical Methods

Physical method is the cheapest and easiest method with low success to control parasitic infection of host fishes. This can be achieved through removing of large parasites such as Lernaea and Argulus from the body of infected fish using forceps, avoiding of the infected fish from the environment or transforming the fishes into new and healthy environment and drying the infected water body until the parasites eggs and larvae disappeared particularly in small water bodies such as tanks, vats or small ponds. Fish parasites which infect human beings can also killed by proper cooking or freezing of fish flesh up to -21°C [1]. This one is better for poor countries like Ethiopia and who have a tradition of eating raw or inadequately cooked fish.

Even though, parasitic infection of fishes can be controlled using chemical, biological and physical treatment methods prevention could be the best. Prevention can be done through controlling of condition factors which causes stress on fish and predispose for parasitic infection. For example, in Ethiopia providing comprehensive information on existing parasites and their epidemiological aspect to increase knowledge of concerned bodies about fish parasites and to break the life cycle of parasites through proper waste disposal and sanitation is considered as a better prevention mechanism.

Conclusion and Recommendations

The effect of fish parasites becomes an interesting concept throughout the world in relation to an increasing interest on aquaculture development and some countries like Uganda are giving a big attention for the effect of fish parasites on aquaculture production. While, other countries like Ethiopia are not yet concerning the effect of fish parasites. Even, most of the existing studies in Ethiopia were focused on simple epidemiology rather than on its complex effects. Hence, it would be better if further studies have to be done on the effects of fish parasites on commercial value, human health and other socio-economic activities to provide comprehensive information for managers and law makers.

References

1. Stewart DB, Bernier LMJ (1999) Common parasites, diseases and injuries of freshwater fishes in the Northwest Territories and Nunavut. Arctic Biological Consultants, Winnipeg, for the Department of Fisheries and Oceans, Central and Arctic Region, pp: 6-26.

2. Marcogliese DJ (2005) Parasites of the superorganism: Are they indicators of ecosystem health? International Journal of Parasitology 35(7): 705-716.

3. Barber I, Hoare D, Krause J (2000) Effects of parasites on fish behavior: a review and evolutionary perspective. Reviews in Fish Biology and Fisheries 10: 131-165.

4. Iyaji M, Bandyopadhyay PK (2018) Identification of a new myxosporean parasite *Thelohanellus indiana* (Myxosporea: Myxobolidae) isolated from three major organs of goldfish, *Carassius auratu*s L. highlighted with its morphological and SSU rDNA sequence based molecular description. Microbial pathogenesis 122: 191-199.

5. Kayis S, Ozcelep T, Capkin E, Altinok I (2009) Protozoan and metazoan parasites of cultured fish in Turkey and their applied treatments. The Israeli J of Aqu Bamidgeh 61: 93-102.

6. Abowei JFN, Briyai OF (2011) A review of some bacteria diseases in Africa culture fisheries. Asian Journal of Medical Sciences 3: 206-217.

7. Aloo PA (2002) A comparative study of helminth parasites from the fish Tilapia zillii and Oreochromis leucostictus in Lake Naivasha and Oloidien Bay, Kenya. J Helminthology 76(2): 95-102.

8. Iyaji FO, Eyo JE (2008) Parasites and their Freshwater Fish Host. Bio Research 6(1): 328-338.

9. Palm WH (2011) Fish parasites as biological indicators in a changing world: Can we monitor environmental impact and climate change?. In: Progress in Parasitology, Parasitology Research Monographs Mehlhorn H, et al. (Eds.), pp: 120-143.

10. Bykovskaya IE, Pavlovskaya AV, Gusev MN (1964) Key to parasites of freshwater fish of the U.S.S.R. Israel Program for Scientific Translations, Jerusalem.

11. Marcogliese DJ (2004) Parasites: Small players with crucial roles in the ecological theater. Eco Health 1: 151-164.

12. Gulelat Y, Yimer E, Asmare K, Bekele J (2013) Study on parasitic helminths infecting three fish species from Koka Reservoir, Ethiopia. SINET Ethiop J Sci 36(2): 73-80.

13. Amare A, Alemayehu A, Aylate A (2014) Prevalence of internal parasitic helminthes infected *Oreochromis niloticus* (Nile Tilapia), *Clarias gariepinus* (African Catfish) and *Cyprinus carpio* (Common Carp) in Lake Lugo (Hayke), Northeast Ethiopia. J Aquac Res Development 5.

14. Tesfaye A, Teklu A, Bekelle T, Tkue T, Kebede E, et al. (2017) A survey on occurrence of internal and external fish parasites and causes of fish population reduction in Lake Hashenge, Tigray, Ethiopia. Ethiop Vet J 21(2): 75-91.

15. Bihonegn T, Tilahun G (2017) Study on helminth parasites in Tilapia nilotica from Lake Zeway, Ethiopia. Int J Adv Res Biol Sci 4(10): 21-25.

16. Adugna M, Teklu A, Tadesse Z (2018) Prevalence of Parasites of Nile Tilapia (*Oreochromis niloticus*) and African Big Barb (*Labeobarbus intermidus*) Fish in Gigel Gibe-I Dam, Jimma Zone, Ethiopia. American-Eurasian Journal of Scientific Research 13: 18-24.

17. Ali A, Orina PS (2017) Prevalence and diversity of internal cestode parasites of the Nile Tilapia (*Oreochromis Niloticus*) and African Catfish (*Clarias Gariepinus*) in different altitudes and ponds in Kenya. International Journal of Innovative Research and Advanced Studies (IJIRAS) 34(1).

18. Walakira P, Akoll M, Engole M (2014) Majalija common fish diseases and parasites affecting wild and farmed Tilapia and Catfish in Central and Western Uganda. Uganda Journal of Agricultural Sciences 15: 113-125.

19. Hecht T, Endemann F (1998) The impact of parasites, infections and diseases on the development of aquaculture in sub-Saharan Africa. J Appl Ichthyol 14(3-4): 213-221.

20. Klinger R, Floyd RF (2002) Introduction to Freshwater Fish Parasites. University of Florida IFAS extension CIR716.

21. Adugna M, Konecny R, Lakew A (2018) Parasites of Nile tilapia (*Oreochromis niloticus*) from selected fish farms and Lake Koftuin central Ethiopia. Ethiop Vet J 22(2): 65-80.

22. Pariselle A, Euzet L (2009) Systematic revision of *dactylogyridean* parasites (Monogenea) from cichlid fishes in Africa, the Levant and Madagascar. Zoosystema 31(4): 849-898.

23. Sharma M, Shrivastau AB, Sahni YP, Paandey G (2012) Overview of the treatment and control of common fish diseases. IRJP 3(7).

24. Obiekezie AI, Taege M (1991) Mortality in hatchery reared fry of the African Catfish, *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschaft*. Bulletin of European Association of Fish Pathology 11: 82-85.

25. Taylor NGH, Sommerville C, Wootten R (2006) The epidemiology of Argulus spp. (Crustacea: Branchiura) infections in still water trout fisheries. Journal of Fish Diseases 29(4): 193-200.

26. FAO (2016) FAO Aquaculture Newsletter No 55 (September) Rome.

27. Dick TA, Choudhury A (1995) Phylum Nematoda. In: Fish diseases and disorders: protozoan and metazoan infections Volume 1, Woo PTK, et al. (Eds.), Wallingford: CAB International pp: 415-446.

28. Bekele J, Hussien D (2015) Prevalence of internal parasites of Oreochromis niloticus and Clarias gariepinus fish species in Lake Ziway, Ethiopia J Aquac Res Development 6: 2.

29. Khalil LF (1969) Studies on the helminth parasites of freshwater fishes of the Sudan. Journal of the Zoological Society of London. 158(2): 143-170.

30. Oniye SJ, Adebote DA, Ayanda AI (2004) Helminth parasites of *Clarias gariepinus* (Teugels) in Zaria, Nigeria. Journal of Aquatic Sciences 19(2): 17-75.

31. Shaheen AA, El Asely AM, Gawad EA, Farag AF, Abbass AA, et al. (2014) Diagnosis of some internal parasitic diseases in some freshwater Fishes. Global Journal of Fisheries and Aquaculture Researches 1: 1-17.

32. Marcogliese DJ (2003) Food webs and biodiversity: are parasites the missing link?. Journal of Parasitology 89: 106-113.

33. Tesfaye G, Wolff M (2014) The state of inland fisheries in Ethiopia: a synopsis with updated estimates of potential yield. Ecohydrology and Hydrobiology 14(3): 200-219.

34. Yimer E (2000) Preliminary survey of parasites and bacterial pathogens of fish at Lake Ziway. SINET Ethiop J Sci 23(1): 25-33.

35. Abay H (2018) A Study of Prevalence of Fish Parasite in Hashenge Lake, Tigray Ethiopia. Journal of Veterinary Science and Animal Husbandry.

36. Szidat L (1969) Structure, development and behaviour of new strigeatoid metacercariae from subtropical fishes of South America. J Fish Res Bd Can 26(4): 753-786.

37. Dykova I, Lom J, Circovic M (1986) Brain myxoboliasis of common carp (*Cyprimus carpio)* due to *Myxobolus encephalicus*. Bulletin of European Association of Fish Pathology 6(1): 10-12.

38. Bauer ON, Voronin VN, Yunchis ON (1991) Infection of the heart in carp caused by *Myxobolus dogidi* (Myxosporea, Myxobolidae). Angewandte Parasitologie 32(1): 42-44.

39. Abbass A, Lashein A, Tantawy GHA (2006) The prevailing endoparasitic diseases of catfish (*Clarias gariepinus*) with special reference to the associated pathological changes. Zag Vet J 1: 120-139.

40. Teshome K, Dagne A, Degefubru F, Adugna M (2014) Selective predisposition of Nile tilapia (*Oreochromis niloticus L.*) to bacterial and parasitic infection-evidence from the crater lakes Babogaya and Hora- Arsedi, Ethiopia. International Journal of Aquaculturte 4(24): 1-8.

41. Toksen E (2007) Lernanthropus kroyeri van Benden, 1841 (Crustacea: Copepoda) infections of cultured sea bass (*Dicentrarchus labrax* L.). Bulletin of the European Union of Fish Pathologists 27(2): 49-53.

42. Milinski M (1990) Parasites and host decision-making. In: Parasitism and Host Behaviour Barnard CJ, Behnke JM, et al. (Eds.), Taylor and Francis, London, pp: 95-116.

43. Poulin R (1992) Toxic pollution and parasitism in freshwater fish. Parasitol 8(2): 58-61.

44. Minchella DJ (1985) Host life-history variation in response to parasitism. Parasitology 90: 205-216.

45. Dawkins R (1982) The Extended Phenotype. Oxford University Press, Oxford.

46. Kramer DL, Manley D, Bourgeois R (1983) The effect of espiratory mode and oxygen concentration on the risk of aerial predation in fishes. Can J Zool 61(3): 653-665.

47. Lafferty KD (2008) Ecosystem consequences of fish parasites. Journal of Fish Biology 73: 2083-2093.

48. Barber I (2005) Parasites grow larger in faster growing fish hosts. International Journal of Parasitology 35(2): 137-143.

49. El seify MA, Zaki MS, Desouky ARY, Abbas HH, Hady OK, et al. (2011) Seasonal variations and prevalence of some external parasites affecting freshwater fishes reared at Upper Egypt. Life Science Journal 8(3): 397-400.

50. Read AF (1990) Parasites and the evolution of host sexual behaviour. In: Parasitism and Host Behaviour Barnard CJ, Behnke JM, et al. (Eds.), Taylor and Francis, London, pp: 95-116.

51. Thompson SN, Kavaliers M (1994) Physiological bases for parasite-induced alterations of host behaviour. Parasitol 109: 119-138.

52. Abd El-Latif AM (2007) Gill parasitic diseases of some freshwater fishes. Ph. D. thesis (Fish diseases and management), Fac Vet Med Benha Uni pp: 218.

53. Van As JG, Basson L (1984) Checklist of freshwater fish parasites from Southern Africa. S Afr J Wild Res 14(2): 49-61.

54. Akoll P, Mwanja WW (2012) Fish health status, research and management in East Africa: past and present. African Journal of Aquatic Science 37(2): 117-129.