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# Major fish-borne bacterial and parasitic zoonoses in Ethiopia: A review

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## Abstract
Fish is a food of excellent nutritional value, providing high quality protein and wide variety of vitamins and minerals. It has valuable contribution to an economy and food security. However, there are safety concerns related to presence of bacterial and parasitic hazards in fish. The objective of this paper is therefore, to review major fish-borne zoonotic bacteria and parasites in Ethiopia. Accordingly, pathogenic and zoonotic bacteria such as *Edwardissiella, Salmonella, Escherichia, Staphylococcus, Vibrio* and *Aeromonas* have been recorded in fish. Several fish-borne zoonotic parasites were also reported in fish in the country. The most common zoonotic nematodes encountered in fish include *Contracaecum, Eustrongylide,* and *Capillaria. Clinostomum* was fish-borne zoonotic trematode frequently found in fish. Among fish-borne zoonotic cestodes, *Ligula intestinalis* has been reported. Even though several zoonotic bacteria and parasites of fish have been prevalent in the country, there was no data on investigation of zoonotic links in humans. The potential risk factors for the transmission of fish-borne zoonoses for human are consumption of raw or undercooked infected fish, contact with contaminated water or infected fish. Therefore, there is a need for detail epidemiological surveillance of zoonotic bacteria and parasites in fish and its public health significances.

**Keywords:** Bacteria, Ethiopia, fish, parasites, prevalence and zoonoses

## 1. Introduction
Fish is an important food for over 400 million Africans, contributing essential proteins, minerals and micronutrients to their diets. Paradoxically, despite the high dependence on fish as a source of animal protein, fish consumption in sub-Saharan Africa is the world's lowest [75].
Ethiopia being a land locked country its fish production is entirely based on inland water bodies like lakes, reservoirs and rivers for fish supply for its population. The fish catch 75% of the total originates from main water bodies such as Tana, Ziway, Langano, Awassa, Abaya and Chamo. The remaining 25% originates from minor lakes (Beseka, Lugo, Hashengie, and Small Abaya) and reservoirs (Koka, Fincha-Amerti, Denbi, Melka-Wakena, Alwero, Tekeze, Gilgel Gibe I) and rivers [46].
Fish production potential of Ethiopia was estimated to be over 51,000 tons per year [14]. Despite the fact that the country has huge potential, the contribution of the sector to the national economy is immaterial due to artificial and natural constraints. Poor management systems, limited trained human resource in the area are among the major contributing factors [14]. Furthermore, the low fish production level of the country could be attributed to the occurrence of pathogenic parasites and other disease causing agents in fish.
The increasing interface between humans and aquatic animals like fish which may harbor infectious agents is a potential public health concern [25]. It is documented that among the pathogenic parasites and bacteria infecting fish, majority of them are zoonotic. Zoonoses from aquatic animals occur through two major exposures, namely ingestion and topical contact with infected fish or water through open wounds or skin abrasions [57].
In Ethiopia, there are very bitty reports on epidemiological data concerning fish-borne zoonotic bacteria and parasites. Such fragmented reports are not easily reachable and convincible to policy makers to take appropriate mitigation strategies to prevent or control these zoonotic fish borne diseases. Hence, the objectives of this paper are therefore,
To give an overview of the prevalence of zoonotic bacteria of fish and
To review the available data on fish-borne parasitic zoonoses in the country

## 2. Fish-Borne Bacterial Zoonoses in Ethiopia
Potential biological contamination of aquaculture can occur from parasites, bacteria, viruses, biotoxins and others [29].

These may arise either from indigenous environment of the aquatic or as the result of environmental contamination. Zoonotic infections related to fish and fish products can be either those that topically acquired infections caused by contact with aquatic animals or food borne infections by the ingestion of raw or undercooked aquatic products like fish [25].
In Ethiopia, the inland water bodies used as a source of fish receive many contaminant inflows from the nearby farm lands with fertilizers and untreated industrial wastes, municipal sewages, leaching from pit latrines and septic tankers [77].
Bacterial diseases are considered the main cause of high mortalities and economic losses in fish worldwide [20]. Several bacteria are reported to cause infection and mortality in both fish and humans [6]. Of bacteria generally described as fish-borne zoonoses, *Mycobacterium* species, *Streptococcus iniae, Clostridium botulinum*, and *Vibrio vulnificus* appear to be well-supported as zoonoses in the strict sense [17] in addition to the occurrence of human pathogenic bacteria such as *Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus,* and *Enterococcus faecalis* from edible fish and water samples.
Ethiopians are traditionally meat eaters and fish consumption patterns are seasonal which implies that both fish demand and fish supplies are concentrated within a period of 80 days per year [46]. In the country, very scanty information is available with regard to bacterial zoonoses attributed to fish. However, this limited available information on prevalence of pathogenic and zoonotic bacteria showed that there is relatively high occurrence in fish and fish products [1; 28; 67].
Even though no study has been undertaken to see the zoonotic link between bacterial pathogens affecting fish and human in Ethiopia, the recovery of organisms, which are potentially pathogenic to humans, in fish ready for human consumption suggest that if they are improperly handled, consumed raw or undercooked infected fish may cause diseases to susceptible individuals. The previous prevalence reports of fish pathogenic and zoonitic bacteria in fish from different parts of the country is presented and discussed below.

### 2.1 *Edwardsiella*
*Edwardsiella tarda* (*E. tarda*) causes a disease commonly known as fish gangrene which is emphysematous putrefactive disease. It occurs sporadically in both fish and humans [23]. It causes severe economic losses in fish in many countries. The organism is frequently found in polluted and poor quality water [71]. In humans it usually causes diarrhea, gastroenteritis, wound infection and even death [56]. *E. tarda* was among mostly reported pathogenic bacteria in fish from different Lakes in Ethiopia (Table 1).

**Table 1:** Prevalence of *Edwardsiella* in fish in Ethiopia

| Place | Bacteria | Site of recovery | Prevalence | References |
|---|---|---|---|---|
| Lake Hawasa | *Edwardsiella tarda* | Kidney, liver & intestine | 19.05% | [1] |
| Bishoftu Lakes | *Edwardsiella tarda* | Kidney, liver &intestine | 2.72% | [1] |
| Lake Tana | *Edwardsiella tarda* | Kidney and Intestine | 1.90% | [53] |
| Lake Hayike | *Edwardsiella tarda* | Skin and intestine | 3.44% | [67] |
| Lake Ziway | *Edwardsiella tarda* | Kidney, liver &intestine | 20.59% | [35] |
| Lake Langano | *Edwardsiella tarda* | Kidney, liver &intestine | 5.56% | [35] |

The isolation and identification of *E. tarda* from freshwater fish from different water bodies destined for human consumption in Ethiopia implied that the public is at higher risk of contracting edwardsiellosis. Therefore, detail epidemiological study should be carried out for the better understanding and effective control and prevention of edwardsiellosis.

### 2.2. *Escherichia coli*
Pathogenic strains of *Escherichia coli,* are among fish-borne bacterial zoonoses. According to Thampuran *et al.* [68], *E. coli* is commonly associated with seafood contamination in the tropics. Pathogenic *E. coli* was reported in fish samples from different countries of the world. Mostafa *et al.* [47] reported 4.50% from Egypt, and Chandraval and Chandan [16] 65% from India, in different species of fish. Generally, the presence of coliform in fish as *E. coli* serves as index of sanitation problem indicator like faecal contamination of the lakes from which fish are originated as a source of food for consumption [7].
The prevalence of *E.coli* from fish samples in Ethiopia is relatively high ranging from 2.4% [53] to 53.30% [28] as depicted in (Table 2).

**Table 2:** Prevalence of *Escherichia coli* in fish in Ethiopia

| Place | Bacteria | Site of recovery | Prevalence | References |
|---|---|---|---|---|
| Lake Tana | *Escherichia coli* | Intestine | 2.40% | [53] |
| Lake Hayke | *Escherichia coli* | Skin, gill, intestine | 25.00% | [67] |
| Lake Adelle | *Escherichia coli* | Heart, intestine, liver, gill | 53.30% | [28] |
| Lake Tinike | *Escherichia coli* | Kidney, Oral cavity | 20.00% | [28] |
| Abaya and Chamo | *Escherichia coli* | Raw fillet (Muscle) | 42.50% | [66] |

The relatively high prevalence of pathogenic *E. coli* in fish in Ethiopia shows the public is at high risk of contracting the disease.

### 2.3. *Salmonella*
*Salmonella* is a second leading cause of food-borne illness worldwide [74]. The majority of 1.3 billion annual cases of *Salmonella* cause human gastroenteritis, through the ingestion of undercooked fish [8]. *Salmonella* spp. may be present naturally in tropical aquatic environments [48]. It is well known that aquatic birds spread *Salmonella* and other pathogens in the environment that are associated in fish-borne diseases of humans. During handling of fishes, the natural flora of aquatic environment will be contaminated with

organisms associated with human, like *S. typhiiand* [31]. It was evidenced that pathogenic *Salmonella* was isolated and reported from smoked fish by Mailoa and Sabahannur [40]. Moreover, Mostafa *et al*. [47] reported a prevalence of 13.75% *Salmonella* in fish from Egypt.

In Ethiopia, Teka *et al*. [66], reported a prevalence of 7.50% in raw fillet (muscle) fish from Abaya and Chamo Lakes, Tesfaye *et al*. [67] also reported a prevalence of 5.17% in skin, gill and intestine samples of fish from Lake Hayike, and Hiko *et al.* [28], identified prevalence 30% *Salmonella* from kidney and oral cavity samples of fish obtained from Lake Tinike.

Similar to other zoonotic bacteria infecting fish there was no any report of human salmonellosis related to consumption of fish or fish products in Ethiopia. However, the practice of consuming raw or partially cooked fish meals, manual handling of fish and unhygienic practice during filleting of fish could expose human to the disease.

### 2.4. *Staphylococcus aureus*

Fish is a highly perishable food item and the biological degradation is faster than vegetables. Therefore, it has to be handled, stored and marketed with extreme care. Best hygiene has to be maintained in the fish handling areas for prevention of contamination and loss of quality of fish. Cross contamination with harmful agents through bad handling and unhygienic practices cause illness to the consumers [15].

*Staphylococcus aureus* is not found in the normal microflora of fish. The presence or absence of food borne *S. aureus* in a fish product is a function of the harvest environment, sanitary conditions, and practices associated with equipment and personnel in the processing environment [29]. The handling of fish products during process involves a risk of contamination by pathogenic bacteria like *S. aureus,* causing foodborne human intoxication. This bacterium is salt-tolerant and therefore can contaminate all cured preparations such as cold smoked fish, and fish-based preserves. It was also evidenced that *S. aureus* in fish can survive a temperature of -50ºC to -100ºc [41].

Different authors reported the presence of enterotoxigenic *S. aureus* in fish and fishery products with prevalence rate ranging from 6.50% [47] from Egypt to 24.47% [15] from India. More specifically, Simon and Sanjeev [62] isolated 10% *S. aureus* in samples of fresh and frozen fillets collected in local markets and in a fish processing plant in Cochin, India, Haifaa [26] identified *S. aureus* with rate of 17.75% prevalence in fish samples from Iraq, and over all prevalence of 14% of *S. aureus* from both smoked and non smoked fresh fish in Iran by Tavakoli *et al.* [65]. As the *S. aureus* is an indicator of hygiene and sanitary conditions, the presence of this organism indicates the unhygienic condition during processing, storage and consumption of such products may cause a risk of *S. aureus* intoxication in consumers [52].

In Ethiopia, even though limited work is there on investigation of prevalence of *S. aureus* in fish and fish products, the available data indicated that the prevalence is very high which was 65% as reported by Teka *et al.* [66] in frozen raw fillet collected from Lakes Abaya and Chamo. This could also show that *S. aureus* can survive freezing temperature and pose threat to public health.

### 2.5. *Aeromonas*

*Aeromonas* species are ubiquitous in aquatic ecosystems [64] and frequently isolated from surface water, freshwater fish, healthy and diseased fish and has the potential to be a foodborne pathogen in humans [19]. Fish are highly prone to contamination with *Aeromonas hydrophila* and become a means of transmitting pathogenic bacteria [60]. *A. hydrophila* infects several species of fish and other terrestrial animals including humans. *A. hydrophila* is considered to be the principal cause of bacterial hemorrhagic septicemia in freshwater fish and has been reported in association by numerous ulcerative syndrome and red spot disease. These infections can cause high mortalities in fish hatcheries and in natural waters. *Aeromonas* has been involved in wound infections, sepsis, outbreaks of water and food-borne gastroenteritis [79].

Some authors indicated public health significance of consumption of fresh fish contaminated with especially *A. hydrophila* for sensitive populations, such as children, elderly persons and immunocompromised people [36]. It can develop in refrigeration temperatures and are responsible for food and waterborne diseases that can cause a range of human diseases that vary in severity from a self-limiting gastroenteritis to potentially fatal septicemia [50]. Over 85% of gastroenteritis cases are attributed to three *Aeromonas* species, one of them is *A. hydrophila* [54].

In Ethiopia, some authors reported prevalence of *Aeromonas* species in fish samples. Nuru *et al.* [53], reported 10.30% prevalence in fish from Lake Tana and Tesfaye *et al.* [67] 7.80% from Lake Hayike. This shows that there could be public health risk if undercooked contaminated fish is eaten.

### 2.6. *Vibrio* species

Different authors pointed out that people may get infected by *Vibrio vulnificus* sourced from fish or fish products through contact with infected fish while handling them, water or other constituents of fish life environment [5], after getting injured by cleaning aquarium with bare hands, after exposure to fish tank water, by handling tropical fish ponds, and contact with rare tropical fish after fish bite, through contact with fish living in the wild, through processing fish in the food industry and preparation of dishes or by consumption infected fish or related products or food contaminated with [11].

In Ethiopia, Nuru *et al*. [53] reported a prevalence of 7.8% from Lake Tana and Tesfaye *et al.* [67] reported 6.90% prevalence from Lake Hayike. However, there is no any report from humans. This needs further investigation as to zoonotic importance of *Vibrio* species infecting freshwater fish in the country.

## 3. Fish-borne parasitic zoonoses in Ethiopia

Parasites usually influence the quality and marketing of commercially produced fish and may contribute to high fish mortalities and economic losses or threaten the abundance and diversity of fish species [9]. There are a moderate number of these parasites which have been reported in humans, but only a few of them cause serious diseases. *Nematodes* and *Trematodes* are the most important while *Cestodes* have been reported from humans on rare occasions [37]. Therefore, this review focuses on fish-borne zoonoses of *Nematodes, Trematodes,* and *Cestodes* in Ethiopia.

### 3.1. Fish-borne zoonotic *Nematodes*

Some nematodes of fish are known to infect humans following consumption of raw or poorly cooked fish and handling of infected fish [18]. *Contracaecum* [61], *Eustrongylides* [51] and *Capillaria* species are among the most frequently reported and the most significant freshwater fish zoonotic nematodes worldwide.

In Ethiopia, there are various zoonotic nematodes reported by different authors as summarized in (Tables 3 and 4). The prevalence of zoonotic nematodes reported by these authors from fish in the country is significantly high ranging from 0.90% as reported by Bekele and Hussien [10] from Lake Ziway to 77.8% by Amare *et al.* [4] from Lake Lugo (Hayike). However, there is no any attempt to investigate the prevalence of these fish borne zoonotic nematodes in humans in Ethiopia. These reports indicated *Contracaecum* species were found to be the most dominant followed by *Eustrongylides* [22; 76; 4; 44; 49].This higher prevalence of *Contracaecum* might be because of the parasite infects a wide range aquatic fish eating birds such as cormorants and pelicans that can serve as a final and intermediate host.

### 3.1.1 *Eustrongylides*

Larval infestations with *Eustrongylides* species have been reported in marine, and freshwater fish species, worldwide. Although a total of 19 *Eustrongylides* species have been described based on the morphology of the adult and larval stages [45] three species are commonly known *E. tubifex, E. ignotus* and *E. excises* [30].

Infestations with *Eustrongylides* in fish are alleged to generate economic loss through impairment of reproduction, alteration of flesh coupled with sensorial devaluation of the meat, commercially displeasing appearance and faster deterioration of the fish or fish products, which all lead to marketer/consumer rejections [39]. Humans become infested by consumption of raw or undercooked infested and/or contaminated fish or fish products. An increasing number of reports of eustrongylidosis in humans have been recorded in Africa, Asia, U.S. and Europe, with more frequent report in fish meal-based, less developed countries [30].

The life cycle of *Eustrongylides* spp. is complex involving multiple hosts. The first larval stage develops within the egg and is shed in the faeces by the infected bird, then is ingested by aquatic oligochaetes, such as *Lumbriculus variegatus, Tubifex* or *Limnodrilus* spp., which are the first intermediate hosts. Inside the oligochaete, the parasite develops into the second and third larval stages [13].The second intermediate hosts are fish in which the third-stage larvae transform and moult into the fourth larval stage and remain in the fish, most frequently in the muscles, to be ingested by wading birds such as cormorant, the definite hosts [63].Predatory fish which consume infected fish, can serve as paratenic or transport hosts and are capable of infecting birds or accidentally humans through the consumption of raw or undercooked freshwater fish.

In Ethiopia, *Eustrongylide* species are the second most abundant zoonotic nematodes of fresh water fish next to *Contracaecum* species (Table 3).

**Table 3:** Prevalence of *Eustrongylides* in fish in Ethiopia

| Lakes/River/Reservois | Fish Spps | Genera /Species/ | Fish organs infected | Prevalence | References |
|---|---|---|---|---|---|
| Lake Ziway | *Oreochromis niloticus* | *Eustrongylides* | Thoracic cavity | 0.90% | [10] |
| | *Clarias gariepinus* | *Eustrongylides* | Thoracic cavity | 1.84% | [10] |
| Lake Hawasa | *Clarias gariepinus* | *Eustrongylides* | Musculature | 16.50% | [80] |
| Lake Elan | *Clarias gariepinus* | *Eustrongylides* | Mesentery | 4.00% | [24] |
| Lake Lugo | *Oreochromis niloticus* | *Eustrongylides* | Body cavity & GIT | 2.70% | [4] |

GIT=Gastrointestinal tract

### 3.1.2. *Contracaecum*

A complex life cycle consists of four larval stages and involves copepods, aquatic vertebrates and fish as intermediate hosts. Human is not directly involved in the life cycle but may accidentally acquire the parasite through ingestion of L3 larva within fish muscle [34]. If the larvae are accidentally taken by humans by consuming raw or undercooked fish meat, they may cause anisakiasis, a zoonotic infection characterized by stomach pains, fever, diarrhea and vomiting [78].

In Ethiopian, *Contracaecum* species are widely distributed, and their prevalence among a variety of fish species is very high. Amare *et al.* [4], for example, found 77.80% in *Clarias gariepinus* fish species and 20.90% in *Oreochromic niloticus* fish from Lake Lugo. Rashid *et al.* [58] also found 35.90% prevalence in *Oreochromic niloticus* fish from Lake Small Abaya. Moreover, Eshetu and Mulualem [22] found 59.80%, Moa and Anwar [44] 39.90%, Necho and Aweke [49] 49.50% in *Oreochromic niloticus* fish from the same Lake Tana. Yewubdar *et al*. [76] also found prevalence of 5.48%, 24.82%, and 16.49% in *Oreochromic niloticus, Clarias gariepinus,* and *Barbus intermedium* species of fish, respectively from Koka reservoir (Table 4).

**Table 4:** Prevalence of zoonotic *Contracaecum* in fish in Ethiopia

| Lakes/River /Reservois | Fish Spps | Genera/Species | Fish organs infected | Prevalence | References |
|---|---|---|---|---|---|
| Koftu Lake | *Oreochromis niloticus* | *Contracaecum* | Liver & intestinal wall | 50.98% | [42] |
| Lake Lugo | *Oreochromis niloticus* | *Contracaecum* | Body cavity & GIT | 20.90% | [4] |
| | *Clarias gariepinus* | *Contracaecum* | Body cavity & GIT | 77.80% | [4] |
| Small Abaya | *Oreochromis niloticus* | *Contracaecum* | Body cavity & Mesentery | 35.90% | [58] |
| Lake Ziway | *Oreochromis niloticus* | *Contracaecum* | GIT | 8.60% | [10] |
| | *Clarias gariepinus* | *Contracaecum* | GIT | 19.02% | [10] |
| | *Oreochromis niloticus* | *Contracaecum* | Pericardial cavity | 15.56% | [21] |
| | *Clarias gariepinus* | *Contracaecum* | Mesentery | 5.33% | [21] |
| Lake Hawassa | *Oreochromis niloticus* | *Contracaecum* | Body cavity | 39.67% | [80] |
| | *Clarias gariepinus* | *Contracaecum* | Body cavity | 36.00% | [80] |

| | | | | | |
|---|---|---|---|---|---|
| Koka Reservoir | *Oreochromis niloticus* | *Contracecum sp* | Mesentery | 5.48% | [76] |
| | *Clarias gariepinus* | *Contracecum sp* | Mesentery& Pericardial | 24.82% | [76] |
| | *Barbus intermedius* | *Contracaecum* | Mesentery &Pericardial | 16.49 % | [76] |
| Lake Tana | *Oreochromis niloticus* | *Contracaecum* | NA | 59.80% | [22] |
| | *Oreochromis niloticus* | *Contracaecum* | NA | 39.90% | [44] |
| | *Oreochromis niloticus* | *Contracaecum* | NA | 49.50% | [49] |
| | *Clarias gariepinus* | *Contracaecum* | NA | 41.94% | [22] |
| Lake Hashengie | *Oreochromis niloticus* | *Contracaecum* | Pericardial cavity | 17.14% | [43] |
| Lake Elan | *Clarias gariepinus* | *Contracaecum* | Mesentery | 5.93% | [24] |

The finding of *Contracaecum* species in fish in different lakes and reservoirs represents the potential public health risks, as these parasites are recognized to infect humans from consumption of raw or inadequately cooked fish. Therefore, appropriate control measures should be put in place to avoid or minimize infection of the fish. Moreover, public awareness creation activities should be conducted on zoonotic nature of fish parasites and danger of consumption of raw or undercooked fish.

### 3.1.3. *Capillaria* species

The genus *Capillaria* is a nematode with some 250 different species, from which three are mostly human pathogens (*C. hepatica, C. aerophila,* and *C. philippinensis*) [55].The life cycle of *Capillaria* involves fish as intermediate host, human as only demonstrated host, and fish eating birds (*Piscivorous*) as natural definitive host. Ingestion of raw or undercooked fish results in infection of the human host. The adult *Capillaria* reside in the human small intestine, where they burrow in the mucosa. The females deposit unembryonated eggs. Some of these become embryonated in the intestine, and release larvae that can cause autoinfection. It has been evidenced that there are report of cases of human intestinal capillariasis related to consumption of raw or undercooked fish. Phonepasong *et al*. [55] for example, confirmed three human cases intestinal capillariasis from individuals with frequent consumption of undercooked fish in Lao Peoples' Democratic Republic. Moreover, Ali *et al*. [3] also reported human case of intestinal capillariasis of 5.8% prevalence using microscopically and 11.6% (14/121) of prevalence using molecular detection technique from Egypt.

In Ethiopia, the only available published data on prevalence of *Capillaria* species in fish is the report of Yewubdar *et al*. [76].They found a prevalence of 2.06% and 6.20% in mesentery of *Barbus intermedius* and *Clarias gariepinus,* respectively from Koka reservoir. The presence of this zoonotic parasite in fish in Koka reservoir could be a risk to fisher men and other people in the area who may consume undercooked or raw fish. However, there is no available data on prevalence of intestinal capillariasis in human in the country.

## 3.2. Fish-borne zoonotic *Trematodes*

Fish-borne zoonotic trematodes, are significant public health problems worldwide, especially in countries where fish consumption and aquaculture is common [72].The World Health Organization (WHO) has estimated that the number of people infected with fish-borne zoonotic trematodes exceeds 18 million [72] worldwide in 2002. *Clinostomum* requires two intermediate hosts (snail and fish) and one definitive host (bird). Humans contract *Clinostomum* infection when *Clinostomum* infected fishes are eaten raw or under cooked [2]. In Ethiopia, even though no report of human case of fish-borne trematode parasites, a number of cases have been reported from fish captured from different Lakes for human consumption as shown in (Table 5). Mainly the zoonotic trematode parasite reported from fish in the country was *Clinostmum* with prevalence rate ranging from 2.06% to 75.7% as reported by Yewubdar *et al*. [76] and Zekarias and Yimer, [80] respectively. Such reports demonstrate that these parasites are widespread in fish of Ethiopian Lakes, reservoirs and rivers.

**Table 5:** Prevalence of zoonotic Trematodes of fish in Ethiopia

| Place | Fish spps | Parasite genera (spps) | Organs of fish infected | Prevalence | References |
|---|---|---|---|---|---|
| Lake Ziway | *Oreochromis niloticus* | *Clinostomum* | GIT, Liver, Heart | 7.24% | [10] |
| | *Clarias gariepinus* | *Clinostmum* | GIT, Liver, Heart | 5.52% | [10] |
| | *C. gariepinus* | *Clinostmum* | | 4.00% | [21] |
| Lake Elan | *C. gariepinus* | *Clinostomum* | | 2.75% | [24] |
| Koka Reservoir | *C. gariepinus* | *Clinostomum* | Pericardial cavity and muscle | 6.90% | [76] |
| | *O. niloticus* | *Clinostomum* | Pericardial and brachial cavity | 27.39% | [76] |
| | *B. intermedius* | Clinostomum | Kideny | 2.06% | [76] |
| Lake Tana | O. niloticus | *Clinostomum* | | 57.47% | [22] |
| Small Abaya | *O. niloticus* | *Clinostomum* | | 18.80% | [58] |
| Lugo (Hayke) | *O. niloticus* | *Clinostomum* | Body cavity | 33.80% | [4] |
| Lake Zeway | *O. niloticus* | *Clinostomum* | GIT, Liver | 9.09% | [21] |
| Lake Awassa | *O. niloticus* | *Clinostomum* | | *75.70%* | [80] |
| Gilgel Gibe | *O. niloticus* | *Clinostomum* | | *3.90%* | [27] |
| Lake Hashengie | *O. niloticus* | *Clinostomum* | *Brachial cavity* | *25.71%* | [43] |
| | *C. carpio* | *Clinostomum* | *Brachial cavity* | *7.40%* | [43] |

## 3.3. Fish-borne zoonotic *Cestodes*

Crustaceans serve as the first intermediate hosts and harbor larvae (procercoids) in their body cavity. Freshwater fish serve as the second intermediate host and become infected after consuming crustacean containing procercoid larval stage. The definitive host get infected after consumption of raw the second intermediate host (fish) harboring the infective stage of larvae plerocercoids [38]. Freshwater fish [32] is the second intermediate host, and plerocercoid larvae are the infective stage for humans and human can acquire the parasite by eating raw or undercooked second intermediate host [38].

Cestodes cause severe infection in fish affecting the fish population dynamic because it influences reproductive potential, predation and competition within and between species [22]. Fish-borne cestodes capable of infecting humans are almost exclusively represented by broad tapeworms, members of the order *Diphyllobothridea.* Even though Diphyllobothriosis itself is not life threatening disease, it is considered as the most important fish-borne zoonosis caused by cestodes with up to 20 million people estimated to be infected worldwide [59].

In Ethiopia, relatively few reports have been available on prevalence of cestodes affecting fish as summarized in (Table 6) below.

**Table 6:** Prevalence of zoonotic Cestodes of fish in Ethiopia

| Place | Species of Fish | Genera/Spp | Prevalence | References |
|---|---|---|---|---|
| Lake Tana | *Barbus intermedius* | *Ligula intestinalis* | 22.50% | [49] |
| | *Barbus intermedius* | *Ligula intestinalis* | 8.14% | [22] |
| | *Small barbus* | *Ligula intestinalis* | 40.00% | [22] |
| | *Barbus trispilopleura* | *Ligula intestinalis* | 54.24% | [11] |
| | *Barbus intermedius* | *Ligula intestinalis* | 3.09% | [81] |
| | *Barbus intermedius* | *Ligula intestinalis* | 29.00% | [69] |
| | *Barbus intermedius* | *Ligula intestinalis* | 8.60% | [73] |
| Lake Lugo | *Cyprinus carpio* | *Ligula intestinalis* | 15.70% | [4] |
| Koka reservoir | *Barbus. intermedius* | *Ligula intestinalis* | 3.09% | [76] |
| | *Clarias gariepinus* | *Ligula intestinalis* | 35.86% | [76] |
| | *Oreochromic niloticus* | *Ligula intestinalis* | 2.73% | [76] |
| Koftu Lake | *Oreochromic niloticus* | plerocercoid larvae | 20.59% | [76] |
| Sebeta Pond | *Oreochromic niloticus* | Plerocercoid larvae | 7.03% | [76] |
| Lake Babogaya | *Oreochromic niloticus* | encysted Plerocercoids | 26.30% | [12] |
| Lake Hawasa | *Clarias gariepinus* | Plerocercoid larvae | 15.00% | [12] |

## 4. Prevention and Control

The control of fish diseases is difficult because fish are cultured in a system where production is dependent on natural environmental condition. Deterioration in the aquatic environment cause the occurrence of most fish diseases and also environmental effects play a great role in influencing the health status of fish. Therefore, the multidisciplinary approaches involving the characteristics of potential pathogenic microorganisms for fish, aspects of the biology of fish as well as a better understanding of the environmental factors will allow the application of adequate measures to prevent and control the diseases limiting fish production [70].

Since ponds that have not been cleaned and unsterilized prior to restocking are at greater risk of harboring large numbers of intermediate hosts, cleaning and sterilizing the ponds is an effective way of reducing the number of the intermediate hosts of some nematode species in order to disrupt the lifecycle. However, eliminating a link in the transmission cycle may not be feasible, because it may mean the elimination of protected animals or birds or other intermediate hosts which cannot be eliminated 33].

For the Ethiopia context, since fishing is almost exclusively based on natural environment it is better to avoid contamination of natural environments in order to prevent the diseases. Hence, as the most important risk factors for fish-borne zoonoses are consumption of raw or undercooked infected fish and fish products, and contact with contaminated water or infected fish, the most effective and simple preventive measures to control the diseases is avoiding consumption of raw fish products. Furthermore, food safety measures like proper inspection of fish meat before consumption is important to decrease the risk of human infection with plerocercoids of fish tapeworms [59].

## 5. Conclusion

In conclusion, this review has demonstrated that fish-borne zoonotic bacteria and parasites are common in different freshwater fish species mainly *Oreochromic niloticus, Clarias gariepinus,* and *Barbus intermedius* in Ethiopia. Among the major fish-borne zoonotic bacteria, *E. tarda*, *S. typhi*, *E.coli*, *S. aureus*, *Vibrio* species, and *Aeromonas* species were reported. Zoonotic fish borne parasites identified include: Nematodes (*Contra caecum, Eustrongylides*, and *Capillaria*), Trematode (*Clinostomum*), and Cestode (*Ligula intestinalis*). The presence of these zoonotic bacteria and parasites in fish in the country could impose a potential risk to human health. The potential risk factors for these zoonoses are consumption of raw infected fish and fish products, and contact with contaminated water or infected fish. There was no attempt to investigate transmission link of fish-borne zoonotic bacteria and parasites in humans in the country. This can infer that fish-borne zoonoses are among the most neglected fish diseases in the country. Therefore, based on these concluding remarks the following recommendations are suggested:

Since consumption of fish and fish products goes on increasing from time to time in the country than ever before, due attention should be given to zoonotic bacteria and parasites related to fish,

Detail studies are needed to assess the epidemiological and biological status of fish zoonotic bacteria and parasites in the country, and

Finally public awareness creation activities should be conducted on zoonotic nature of fish parasites and danger of consumption of raw fish.

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