

Cestodes infestation in fishes- A review

Komal Thakur, Sonika Sharma*

Division of Zoology, Department of Bio-Sciences, Career Point University, Hamirpur, Himachal Pradesh, India

Abstract

Fish are the nutritional source for humans worldwide. Fish infected with parasites and loss of fish production. Enormous parasite infection can cause ulceration and disturb the common way of reproduction. The helminths group is one of the essential groups of fish parasites. Maximum parasites are situated in the intestines of fish. Seasonal variations are reflected in the infestation of cestode parasites. Due to the rapid population growth rate and depletion of freshwater resources, marine aquaculture is one of the most important promising futures for supplying animal protein. The prevalence and intensity of parasites depend on several factors such as the host and its feeding habits, life cycle, and the physical aspects of the water body where the fish live. Infected fish with parasites have been recognized as a significant public health issue with serious economic consequences such as morbidity, lost productivity, and medical expenses. Cestodes are commonly known as flatworms. Cestode parasites were found in both freshwater and marine fishes. All cestodes are endoparasites. The life cycle of cestode parasites is very complex. Parasitic diseases also present a potential threat to fish's health, and public health awareness should be raised to prevent the spread of zoonotic parasites through undercooked fish.

Keywords: Fish, parasites, helminths, cestode parasites, parasitic infection

Introduction

Fish is an aquatic and gill-bearing animal. Fishes are the most numerous vertebrates on this earth and an estimated 27,977 fish species are described (Nelson, 2006) [30]. Humans have used fish as a food for dietary protein. The value of fish food has become less due to the ingestion of various worms and their larval stages. Fish suffer from various parasites like other animals. One of the major issues confronting freshwater and marine fishes all over the world especially are parasites (Bichi and Dawaki, 2010) [9]. Freshwater fishes suffer from different diseases while 10-20% have parasitic infections (Chowdhury, 1998) [11]. Fishes are infected with the minimum two kinds of parasites i.e. endoparasites and ectoparasites (Bellay *et al.*, 2020) [6].

Fish are an indispensable portion of the human diet and play a significant role in worldwide food security. In any case, using fish also increases the hazard of parasitic zoonosis. With the worldwide demand for seafood and the development of aquaculture practices, parasitic zoonotic diseases in fish have picked up expanded consideration (Shamsi, 2020) [42]. Parasitic zoonosis refers to diseases caused by parasitic organisms that can spread from animals to humans and cause serious hazards to public health (Alam, 2023) [2]. A parasite is an organism that lives on or inside a host organism and obtains its food from the host. The study of parasites is called parasitology.

Internal parasites can disrupt food digestion and absorption, leading to reduced growth, injuries, or death. There are three main classes of parasites *viz.* protozoa, helminths, and ectoparasites. Most fish species such as wild or cultured, are infected with parasites. They not only act as a host to various parasites but also as carriers of different parasitic larvae that cause serious diseases in different vertebrates (Faruk, 2018) [18].

Among different parasites, the Helminths group is one of the significant categories of fish parasites that cause a serious loss in fish production (Jeronimo *et al.*, 2022) [24].

Helminth parasites are commonly found in all types of freshwater fishes. Helminths is a common term known as worm. Helminths have three stages such as egg, larval, and adult stages. The parasitic infestation of fish depends on various components like its life cycle, host, feeding habits, and physical factors of the water body. It also depends on its intermediate hosts to spread the cestode infection (Zaidi and Khan, 1976) [50]. Helminth parasites have four major classes: Trematodes (Monogenea and Digenea), Cestodes, Nematodes, and Acanthocephalan (Williams and Jones, 1994) [48]. These parasites can affect the host's nutrition, metabolism, and various functions of the alimentary canal and can also harm the host's nervous system (Mohan and Bhargav, 2022) [29].

Cestodes Infestation

Cestodes are commonly called tapeworms. Cestodes are flat and multi-segmented worms. It belongs to the phylum Platyhelminthes and class Cestoda. Cestodes are hermaphroditic in nature. In Cestodes, the digestive tract is absent, and nutrients are absorbed directly from the hosts. The scolex organ is attached to the intestinal mucosa. The neck is a region without segmented with a high capacity of regenerative. Cestodes found within the summer season (PFI, 16.90%) expressed as 'occasional'. They were not found in the rest of the seasons. Dhole *et al.* (2010) [15] recorded cestode infections were highest in the summer season. During the summer season, the infestation of cestode parasites was highest due to the temperature which helps to hatch eggs of parasites and increases the rate of parasites while the rainy shows much less infestation of the parasites.

Cestodes were found in *Barbus bynni*, *Clarias lazera*, and *Malopterurus electricus*. The highest prevalence was found in *Malopterurus electricus* (96%) while the lowest was in *Clarias lazera* (5%) (Saoud and Wannas, 1984) [44]. Cestodes are also known as tapeworms and ribbon-like

flatworms. Cestode parasites affect the alimentary canal, muscle, or other internal organs of fish. All Cestodes are endoparasites of the vertebrates and need at least one intermediate host. Its life cycle is complete in the definitive hosts as adults. The life cycle of the cestode parasite is complex. Adults are found in the intestine of the host and plerocercoid larvae are found in the viscera and musculature. The first larvae stage are commonly found in aquatic crustaceans (Woo, 1995)^[49].

Infestation was higher in immature fish as compared to mature fish. *Caryophyllaeidea* species were found in males (83.30%) with the lowest prevalence being internal cestodes parasites i.e. *Diphyllobothrium latum* (58.7%). *Diphyllobothrium latum* (41.30%) has the highest prevalence in females, while *Caryophyllaeidea* species have the lowest prevalence (16.7%). (Haji *et al.*, 2017)^[21].

Three cestode parasites were found in various water bodies of the Meerut region such as *Lytocestus sp.*, *Proteocephalus sp.*, and *Gangesia sp.* in *Channa punctatus* (Sharma, 2016)^[43]. Three species of cestode parasites *Senga sp.*, *Circumonchobothria sp.*, and *Gangesia sp.* were found in *Cyprinus carpio*, *Cirrhina mrigala*, *Wallago attu*, and *Channa sp.* (Deshmukh *et al.*, 2019)^[13]. The six species of cestode parasites such as *Senga sp.*, *Gangesia sp.*, *Proteocephalus sp.*, *Bothriocephalus sp.*, *Polyonchobothrium sp.*, *Ptychobothrium sp.* were found in *Mastacembelus armatus*, *Mystus seenghala*, *Wallago attu*, *Channa sp.*, *Clarias batrachus*, *Cirrihana mrigala* (Deshmukh *et al.*, 2013)^[14].

The gastrointestinal helminth parasites were recorded in *Clarias gariepinus*. These parasites are two species of nematodes *Procamallanus laevionchus* and *Rhabdochona congolensis*; a species of cestode *Polyonchobothrium clariae* and two species of trematodes *Allocreadium spp.* and *Heterophyidae spp.* (Kawe *et al.*, 2016)^[25]. The freshwater fishes were infected with *Caryophyllidean* tapeworms. The two genera were found in *Caryophyllidean* tapeworm i.e. *Lytocestus* and *Lytocestoides*. The development of parasites needs high temperatures and sufficient moisture. Environmental variations are reflected in the incidence of diseases (Borde and Jawale, 2012)^[10].

Cestoda belongs to the family of Platyhelminthes and there are two groups *viz*: Cestodaria and Eucestoda. The various genus and species of cestodes were recorded in Ethiopia. The species of parasite i.e. *Ligula intestinalis*, *Proteocephalus*, *Bothriocephalus*, Encysted cestodes larvae, *Amirhalingamia macracantha* were found in different sites of infected fishes i.e. *B. tsanensis*, Small Barbus, *B. trispilopleura*, *Cyprinus carpio*, *C. gariepinus*, Barbus fish, *B. intermidius*, *O. niloticus* (Gebremedhn and Tsegay, 2017)^[20].

The prevalence rate of cestode parasites depends on the length range and body weight (Haji *et al.*, 2017; Kawe *et al.*, 2016; Farhaduzzaman *et al.*, 2009)^[17, 21, 25]. The highest prevalence was recorded in the summer season followed by the monsoon season whereas lowest prevalence was recorded in the winter season (Kawe *et al.*, 2016; Sharma, 2016; Suryawanshi, 2021; Wali *et al.*, 2016)^[25, 43, 45, 47]. The highest prevalence showed in the summer season followed by the winter season whereas lowest prevalence was reported in the monsoon season (Deshmukh *et al.*, 2019; Bhure and Nanware, 2014; Borde and Jawale, 2012; Maske and Pradhan, 2020; Bhure *et al.*, 2018)^[7, 8, 10, 13, 28].

Piscean cestodes were found in *Channa punctatus*. Three cestode parasites were reported as *Senga sp.*, *Gangesia sp.*, and *Proteocephalus sp.* The environmental factors and feeding habitats directly or indirectly affect the seasonality of parasitic infection (Bhure and Nanware, 2014)^[7]. Three cestode parasites were reported as *Circumonchobothria sp.*, *Gangesia sp.*, and *Senga sp.* in *M. armatus*, *Channa punctatus*, and *Wallago attu* (Maske and Pradhan, 2020)^[28].

The cestode parasite *Trypanorhynch plerocerci* was found in marine fish *Epinephelus marginatus* and their prevalence was 96%. The various larvae-filled cysts and nodules were found in the abdominal cavity and implanted in extensive fibrosis, resulting in visceral adhesions. Histologically, they affected the peritoneum, stomach, and intestine there were numerous degenerated encysted plerocerci and extensive deposition of mature connective tissue. *Trypanorhyncha* is highly prevalent in adults and produces a progressive and chronic response (Ribeiro *et al.*, 2021)^[12].

78% of teleost tapeworms are especially freshwater species, and only 3% of elasmobranch tapeworms are in freshwater rays from South America and Asia (Borneo). Molecular data, mainly 28S rDNA, are present, but 18S and *cox1* are also available for about 40% of fish tapeworm species (Scholz and Kuchta, 2022)^[40].

Cestode parasites are in freshwater (*Gasterosteus aculeatus*), estuarine (*Salvelinus fontinalis*), and marine (*Gadus ogac*) fish were used to investigate the hypothesis are ¹³C and ¹⁵N enriched proportionate host food sources, but ¹⁵N depleted concerning host muscle tissue as a result relating to enrichment during the absorption of common nutrient sources. In the case of Greenland cod, cestode parasites were ¹³C enriched proportionate host tissue, and no significant ¹⁵N enrichment proportionate host dietary signature was observed and those isotope enrichment paradigms elaborated for the study of aquatic foodwebs cannot be regularly applied to quantitatively evaluate the role of parasites in aquatic foodwebs (Power and Klein, 2004)^[36].

The seasonal change occurs in the cestode parasite *Lytocestus vyasaiei* found in the fish *Clarias batrachus*. Catfish were infested with numerous parasites in the winter season due to favorable environmental conditions in the water. At adequate temperatures, the fauna of zooplankton may be abundant compared to summer. These correspond to the fish's peak in the feeding activity richness in the fauna of intermediate hosts which may be the crustaceans, smaller mollusks, and fish leading to high infestations (Pawar, 2022)^[35]. The average annual variation in the infestation, mean intensity, and relative density of cestode infection depends on the sex of the host fish (Khare, 2021)^[26].

The high incidence occurs in the summer season (47.5%), adequate in winter (29.16%) and during the rainy season, no incidence occurs because the development of the parasites needs high temperatures, low humidity, and less rainfall. It is a good environment for the development of parasites and feeding habitats. *Tetragonocephalum* parasite was observed in *Trygon zugei* (Anarse *et al.*, 2011)^[4]. The infestations occur according to the length of the host fish (Pandey *et al.*, 2012)^[34]. The potential of zoonotic parasitic infestation mainly depends on the numerous intermediate hosts and favorable environmental conditions (Rehab *et al.*, 2021)^[38]. The healthy intestine of the host showed, healthy villi, and all layers were observed. The infected intestine of the host

fish was observed as the worm attached to the mucosal layer of the intestine and slowly invaded the deeper layers of the host tissue (Khodke, 2020)^[27]. The parasite intensity is high due to the presence of physical factors that favor the completion of the life cycles of the parasites (Ahmed *et al.*, 2007)^[1]. Cestode parasites i.e. *Senga sp.* were carried out for biochemical estimation of primary metabolites such as protein (12.92mg/g), glycogen (13.17mg/100ml), and lipid (22.56mg/gm). The concentration of lipids is high compared to protein and glycogen (Saraf and Katyayani, 2016)^[39].

The cestode species is *Synbranchiella megacirrus* belonging to the subfamily Monticelliinae and the genital organs are in a cortical position. A robust scolex lacks a metascolex and has a dome-shaped apex. The biloculate suckers are present, vitelline follicles are present in 2 narrow lateral bands, a vagina regularly anterior to the cirrus sac, and a genital pore is pre-equatorial that is very near to the anterior margin of proglottids (Scholz *et al.*, 2019)^[37].

The parasitic infection was higher in male fishes than in female fishes. The presence of the parasites decreased the condition coefficient of the infected fishes. Some physicochemical features and a vital positive correlation with the prevalence were also observed (Wali *et al.*, 2016)^[47].

There is no crucial impact on the growth rate of infected and non-infected fish due to cestode parasites. It prevails in the fish's non-edible part (intestine) (Alkareem *et al.*, 2023)^[3]. *Senga muleasis n.sp.* and *Senga rahuriasisn. sp.* collected from the freshwater fish *Mastacembelus armatus*. These species were different in the general topography of taxonomy. This study found that all these tapeworms were long, consisting of scolex, immature, mature, and gravid proglottids (Netane and Shaikh, 2022)^[31].

The infection level of examined parasites varied seasonally. A higher prevalence of parasites was observed in males than females, and the contrast for the mean intensity was vitally different between females and males in the mean abundance. There were differentiations in the host condition factor and pathogenic infection (Tantawy *et al.*, 2023)^[16].

The parasites *C. solidum* and *Proteocephalus sp.* from *M. electricus* and *H. bidorsalis* hosts was examined. *C.*

solidum and *Proteocephalus sp.* have a genuine obsessive effect on the host, especially in the intestine. Adult *C. solidum* was observed in the intestine of *M. electricus* while their plerocercoids were found in the coelomic cavity and beneath the skin, *Proteocephalus sp.* infect *H. bidorsalis* which was also found in the intestine. The edible musculature of the infected *M. electricus* and *H. bidorsalis* was free from cestode parasites, even in highly infected fish (Hamouda and Younis, 2024)^[22].

The distinctive parasites are highly prevalent among freshwater fish and directly affect fish health and meat quality. It also affects the production of fish and the economy (Garba and Jega, 2023)^[19]. The incidence of parasites was found in the gills, skin, operculum, muscle, liver, gut, intestine, and stomach of *Clarias gariepinus*. Cestode parasites such as *Diphyllobothrium latum* larva, *Triaenophorus nodulus* larva, and *Scolex pleuronectis* were found in infected fish. Parasites can cause weight loss, weakness, and even death, eventually reducing to low efficiency (Olubiyo *et al.*, 2023)^[33]. *Tetracampos sp.* was found in *C. gariepinus*. In the short wet season, there was a higher prevalence in males (30.55%) than females (25.8%), while in the short dry season, a low prevalence was recorded at 9.43%. Climatic period change did not impact host infection either in sexes or in body weight. The physicochemical quality of water is not affiliated with the incidence of infections. The infection rate was not impacted by either the environment or the morphometric parameters of the fish (Tossavi *et al.*, 2024)^[46].

Endoparasites, especially gastrointestinal parasites, are one of the critical issues for fish production, as they have an indirect or sometimes direct impact on fish productivity worldwide. Parasitic diseases also pose a potential threat to the fish's health. The effects of parasites on fish worldwide can be difficult to isolate and quantify. The studies conducted on fish in captivity or under rearing conditions have provided much information on the effects of parasites on fish survival (Banyigyi *et al.*, 2023)^[5]. Furthermore, public health awareness should be raised among fish-related occupational groups to prevent the spread of zoonotic parasites through undercooked fish.

Table 1: Distribution of Cestode Parasites of Fish

Fish species	Parasite species	Site of infection
<i>Oreochromis niloticus</i>	<i>Caryophyllaeidea sp.</i> , <i>Proteocephalus sp.</i> , <i>Diphyllobothrium latum sp.</i> <i>Amirthalinghamia macrocantha</i>	Stomach, Intestine, and Liver
<i>Clarias gariepinus</i>	<i>Caryophyllaeidea sp.</i> , <i>Proteocephalus sp.</i> , <i>Diphyllobothrium latum sp.</i> , <i>Polyonchobothrium clariae</i> , <i>Bothriocephalus sp.</i> , <i>Triaenophorus sp.</i> , <i>Scolex pleuronectis</i>	Stomach, Intestine, and Liver
<i>Channa sp.</i>	<i>Lytocestus sp.</i> , <i>Proteocephalus sp.</i> , <i>Gangesia sp.</i> , <i>Circumonchobothria sp.</i> , <i>Senga sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polyonchobothrium sp.</i> , <i>Ptychobothrium sp.</i>	Intestine

<i>Cyprinus carpio</i>	<i>Senga sp.</i> , <i>Circumonchobothria sp.</i> , <i>Gangesia sp.</i> , <i>Ligula intestinalis</i>	Intestine and Body cavity
<i>Cirrhinus mrigala</i>	<i>Senga sp.</i> , <i>Circumonchobothria sp.</i> , <i>Gangesia sp.</i> , <i>Proteocephalus sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polygonchobothrium sp.</i> , <i>Ptychobothrium sp.</i>	Intestine
<i>Wallago attu</i>	<i>Senga sp.</i> , <i>Circumonchobothria sp.</i> , <i>Gangesia sp.</i> , <i>Proteocephalus sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polygonchobothrium sp.</i> , <i>Ptychobothrium sp.</i>	Intestine
<i>Mastacembelus armatus</i>	<i>Senga sp.</i> , <i>Circumonchobothria sp.</i> , <i>Gangesia sp.</i> , <i>Proteocephalus sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polygonchobothrium sp.</i> , <i>Ptychobothrium sp.</i>	Intestine
<i>Mystus seenghala</i>	<i>Senga sp.</i> , <i>Gangesia sp.</i> , <i>Proteocephalus sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polygonchobothrium sp.</i> , <i>Ptychobothrium sp.</i>	Intestine
<i>Clarias batrachus</i>	<i>Senga sp.</i> , <i>Gangesia sp.</i> , <i>Proteocephalus sp.</i> , <i>Bothriocephalus sp.</i> , <i>Polygonchobothrium sp.</i> , <i>Ptychobothrium sp.</i> , <i>Lytocestus vyasaiei n. sp.</i>	Intestine
<i>Labeobarbus tsanensis</i>	<i>Proteocephalus sp.</i> , <i>Ligula intestinalis</i>	Mesentery and intestinal lumen
<i>Barbus barbuis</i>	<i>Proteocephalus sp.</i> , <i>Ligula intestinalis</i> , <i>Bothriocephalus sp.</i>	Intestine and intestinal lumen
<i>Labeobarbus intermedius</i>	<i>Proteocephalus sp.</i> , <i>Ligula intestinalis</i> , <i>Bothriocephalus sp.</i>	Intestine
<i>Epinephelus marginatus</i>	<i>Trypanorhynch plerocerci</i>	Intestine
<i>Trygon zugei</i>	<i>Tetragonocephalum</i>	Intestine
<i>Malapterurus electricus</i>	<i>Corallobothrium solidum</i> , <i>Proteocephalus sp.</i>	Intestine wall
<i>Heterobranchus bidrosalis</i>	<i>Corallobothrium solidum</i> , <i>Proteocephalus sp.</i>	Intestine wall

Life cycle

Cestodes have three stages in their life cycle viz. eggs, larvae, and adults. These parasites have complex life cycles, involving three hosts: the copepods are the first intermediate host, the second intermediate host is a fish, and the final host is a piscivorous bird, mammal, or other fish. Larvae are located in the tissues outside the intestine and produce systemic infections with clinical effects related to cysts' size, number, and location. The cestode infection occurs when eggs laid by adult tapeworms in the definitive host's intestine, are excreted into the environment through feces and are ingested by an intermediate host (usually another species).

Eggs hatch into larvae, which then develop and enter the bloodstream of the intermediate host, where they encyst in the muscles or other organs. When the definitive host consumes the intermediate host in a raw or undercooked state, the parasites hatch from the cysts in the intestines and develop into adult tapeworms, beginning the cycle again. In some cestode species, the definitive host also serves as an intermediate host. If eggs are ingested instead of tissue cysts, they develop into larvae, which enter the circulation and encyst in various tissues. Adult tapeworms are multi-segmented flatworms that lack a digestive tract and absorb nutrients directly from the small intestine of the host. Adult tapeworms become larger in the digestive tract of the host. The longest tapeworm parasite in the world is the whale tapeworm i.e. *Tetragonoporus calyptocephalus*.

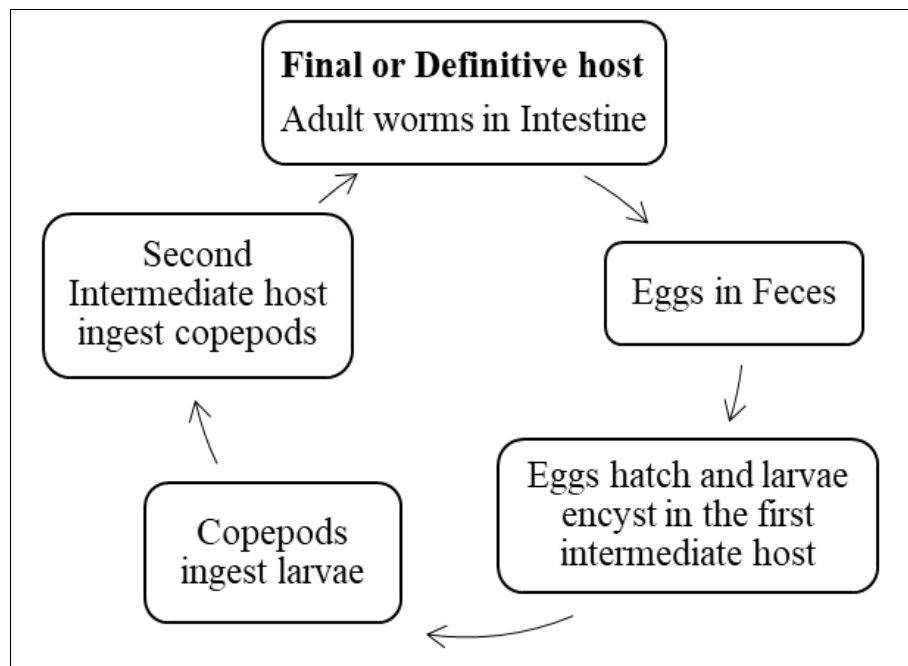


Fig 1: Life cycle of Cestode parasite

Pathogenicity

Pathology due to adult worms arises from the physical presence and exertion. Occasionally, caustic action by scolex hooks (*T. solium*, *H. nana*), leads to original inflammation, or host consumption of vitamin B₁₂ may be reduced due to *Diphyllobothrium latum*. Allergic responses showed symptoms such as headache, unsteadiness, exhaustion, and nasal irritation (Heyneman, 1996) ^[23]. Pathogenicity of adult tapeworm infection is due to toxic products of the worm, nutrient deficiency, obstruction, and migration to abnormal sites. The larval stages of cestodes may be found in the brain or eyes, causing serious illness or growing into large groups and exerting pressure on vital organs. The adult parasite is generally present in the digestive tract, and adult parasite infestations in fish are generally asymptomatic, although weight loss may occur in severe infections in several species. The larval stage of cestode is Metacestode present in the muscles of fish reducing the quality and market value of the fish (Norbury *et al.*, 2022) ^[32].

Tapeworms (Cestoda) consist of approximately 5000 species. They are common fish parasites, such as adults and metacestodes. While only some adult tapeworms are dangerous to their fish hosts. In contrast, cestodes larvae can harm fish by relocating to their tissue and internal organs, especially plerocercoids. Our understanding of the relationships between host and parasites, including the immune reaction of infected fish with cestodes, is insufficient for effective control of cestodes. The majority of the data available was collected several decades ago. Analysis with praziquantel is virtual for fish infected with adult tapeworms, whereas the analysis of metacestodes is problematic (Scholz *et al.*, 2021) ^[41].

Conclusion

This review provided information about some cestode parasites that affect different kinds of fish from different regions. The likelihood of zoonotic parasitic infection depends primarily on the affluence of the intermediate host's

suitable environmental conditions. Infected fish are generally rejected by consumers, and eating raw infected fish meat poses a high risk of infection and allergy in humans. Environmental factors and dietary habitat may directly or indirectly influence the seasonality of parasitic infection. During heavy infestation of cestode parasites, severe injuries in the intestine, gills, and body mass of the host fish. The helminth parasite's infection of fish affects its productivity and marketability has decreased. Fish parasites are a major threat to the fish culture system.

Acknowledgment

The authors of this paper are highly thankful to all those persons who in one or another way have helped in the compilation of this review regarding cestode infestation in fishes.

References

1. Ahmed MS, Iqbal T, Mahmood A, Gulzarin M, Abid M. Helminth parasites of some freshwater fishes. Punjab Univ J Zool, 2007;22(1-2):1-6.
2. Alam S, Afzal G, Siddique AB, Hussain R, Rizwan M, Iqbal R, *et al.* Zoonotic parasitic infestations in fish and their impact on public health and aquatic ecosystems. Zoonosis, 2023;2:394-409. doi: 10.47278/book.zoon/2023.78.
3. Alkareem A, Mohamed O, Eldeeb MAE. Seasonal variation of Cestoda parasite infection in some common fishes in Lake Nasser. Aswan Univ J Environ Stud, 2023;3(4):392-400. doi: 10.21608/ajes.2022.168908.1101.
4. Anarse S, Jawale S, Borde S. Population dynamics of cestode parasite in *Trygon zugei* from Ratnagiri district (MS), India. Int Multidiscip Res J, 2011;1(8):24-6.
5. Banyigy AH, Ameh SM, Isah MH. Incidence of gastrointestinal parasites of catfish (*Clarias gariepinus*) from River Nasarawa, Nigeria. FUDMA J Sci, 2023;7(4):90-94. doi: 10.33003/fjs-2023-0704-1893.

6. Bellay S, de Oliveira EF, Almeida-Neto M, Takemoto RM. Ectoparasites are more vulnerable to host extinction than co-occurring endoparasites: evidence from metazoan parasites of freshwater and marine fishes. *Hydrobiologia*,2020;847:2873-2882. doi: 10.1007/s10750-020-04279-x.
7. Bhure DB, Nanware SS. Studies on prevalence of cestode parasites of freshwater fish, *Channa punctatus*. *J Entomol Zool Stud*,2014;2(4):283-285.
8. Bhure DB, Nanware SS, Shaikh KM. Studies on prevalence of cestode *Gangesia marathwadensis* Bhure *et al.*, 2011 parasitic in freshwater fish *Wallago attu*. *Int J Emerging Technol Innov Res*,2018;12(5):164-7.
9. Bichi AH, Dawaki SS. A survey of the ectoparasites on the gills, skin, and fins of *Oreochromis niloticus* at Bagauda fish farm, Kano, Nigeria. *Bayero J Pure Appl Sci*,2010;3(1):83-86. doi: 10.4314/bajopas.v3i1.58720.
10. Borde SN, Jawale SS. Population dynamics of caryophyllidean tapeworms in *Clarias batrachus* from Aurangabad district (MS), India. *Trends Parasitol Res*,2012;1(1):25-28.
11. Chowdhury MBR. Involvement of aeroimionads and pseudomonads diseases of farmed fish in Bangladesh. *Proc Int Symp Dis Mar Aquacult*,1997 Oct 3-6: Hiroshima: Gyobyokenkyu. *Fish Pathol*,1998;33:247-254.
12. de Sales-Ribeiro C, Rivero MA, Fernández A, García-Álvarez N, González JF, Quesada-Canales O, *et al.* A study on the pathological effects of *Trypanorhyncha* cestodes in dusky groupers *Epinephelus marginatus* from the Canary Islands. *Animals (Basel)*,2021;11(5):1471. doi: 10.3390/ani11051471.
13. Deshmukh KA, Gaikwad JM. Studies on prevalence of cestode parasites in freshwater fishes from Parbhani district (M.S), India. *Adv Fish Biol Allied Res*,2019;1(1):81-83.
14. Deshmukh V, Nanaware S, Shinde SM, Bhure DB. Studies on prevalence of cestode parasites of freshwater fishes from Nanded region (MS) India. *Indian J Appl Res*,2013;3:1-2.
15. Dhole J, Jawale S, Waghmare S, Chavan R. Survey of helminth parasites in freshwater fishes from Marathwada region, MS, India. *J Fish Aquacult*,2010;1(1):1.
16. El-Tantawy AF, Mashaly MI, El-Naggar MM. Community structure, seasonal dynamics, and impact of some biological parameters of the African catfish *Clarias gariepinus* on the infection level of the helminth parasites. *J Parasit Dis*,2023;47(4):707-717. doi: 10.1007/s12639-023-01617-3.
17. Farhaduzzaman AM, Alam MM, Hossain M, Hussain MA, Rahman MH. Prevalence of parasites in the Indian major carp, *Labeo rohita* (Hamilton) in Rajshahi, Bangladesh. *Univ J Zool Rajshahi Univ*,2009;28:65-68.
18. Faruk MAR. Fish parasite: infectious diseases associated with fish parasite. In: *Seafood Safety and Quality*. CRC Press, 2018, 154-176.
19. Garba B, Jega IS. Effects of age and season on prevalence of helminths of family Cichlidae in Sabiyel Lake, Aliero, Nigeria. *Int J Adv Acad Res*,2023;9(8):96-104. doi: 10.3390/ani13061088.
20. Gebremedhn HG, Tsegay AK. Review on distribution of endo-parasites of fish in Ethiopia. *Parasite Epidemiol Control*,2017;2(4):42-47. doi: 10.1016/j.parepi.2017.10.002.
21. Haji M, Luswet D, Orina PS. Prevalence and diversity of internal cestode parasites infected Nile Tilapia (*Oreochromis niloticus*) and African Catfish (*Clarias gariepinus*) in farmers' freshwater ponds in Kenya. *Am Sci Res J Eng Technol Sci*,2017;34(1):123-137.
22. Hamouda AH, Younis AE. Two proteocephalid cestodes in the fish *Malapterurus electricus* and *Heterobranchus bidorsalis* from Lake Nasser, Egypt: a morphological, molecular, and histopathological study. *BMC Vet Res*,2024;20(1):213. doi: 10.1186/s12917-024-04048-1.
23. Heyneman D. Cestodes. In: Baron S, editor. *Medical Microbiology*. 4th ed. Galveston (TX): University of Texas Medical Branch, 1996. Chapter 89. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK8399/>.
24. Jerônimo GT, da Cruz MG, Bertaglia EDA, Furtado WE, Martins ML. Fish parasites can reflect environmental quality in fish farms. *Rev Aquacult*,2022;14(3):1558-1571. doi: 10.1111/raq.12662.
25. Kawe SM, God'spower RO, Balarabe MR, Akaniru RI. Prevalence of gastrointestinal helminth parasites of *Clarias gariepinus* in Abuja, Nigeria. *Sokoto J Vet Sci*,2016;14(2):26-33. doi: 10.4314/sokjvs.v14i2.4.
26. Khare RK. Study of cestode infection in relation to the sex of the host fish, *Mastacembelus armatus*. *Flora Fauna*,2021;27(2):308-310. Available from: <http://doi.org/10.33451/florafaua.v27i2>
27. Khodke AB. Histopathological studies on cestode parasites in marine fishes. *Biosci Discov*,2020;11(4):249-251.
28. Maske M, Pradhan R. Seasonal infections of intestinal cestodes in freshwater fishes from Yeldari Dam, India. *Int J Entomol Res*, 2020, 156-159.
29. Mohan A, Bhargav KM. Host-Parasite Relationship and Clinical Manifestations. In: Parija SC, Chaudhury A, editors. *Textbook of Parasitic Zoonoses*. Microbial Zoonoses. Singapore: Springer, 2022, 1-23. Available from: <https://doi.org/10.1007/978-981-16-7204-02>
30. Nelson JS. *Fishes of the World*. 4th ed. Hoboken, NJ: John Wiley & Sons, Inc., 2006, 601.
31. Netane MAS, Shaikh JD. Studies on some cestode parasites from freshwater carnivorous fishes of Mula Dam Rahuri, Dist: Ahemadnagar. *J Surv Fish Sci*,2022;8(2):147-148. Available from: <http://doi.org/10.53555/sfs.v8i2.1404>
32. Norbury LJ, Shirakashi S, Power C, Nowak BF, Bott NJ. Praziquantel use in aquaculture – Current status and emerging issues. *Int J Parasitol Drugs Drug Resist*,2022;18:87-102. Available from: <https://doi.org/10.1016/j.ijpddr.2022.02.001>
33. Olubiyo CK, Audu PA, Adang LK, Olubiyo GT. Occurrence of helminthes on *Clarias gariepinus* in Omi Dam, Omi, Yagba West Local Government Area, Kogi State. *J Surv Fish Sci*,2023;10(1S):6722-6727. Available from: <http://doi.org/10.53555/sfs.v10i1S.2252>
34. Pandey M, Saxena RM, Handa P. Demography of helminth parasites in relation to biometric characteristics of *Mastacembalus armatus*. *J Appl Nat Sci*,2012;4(1):56-59.
35. Pawar RT. Studies on the prevalence and seasonal variation of cestode parasites from freshwater fish, *Clarias batrachus* (Linnaeus). *Int J Zool Appl*

- Biosci,2022:7(3):8-12. Available from: <http://doi.org/10.55126/ijzab.2022.v07.i03.002>
36. Power M, Klein GM. Fish host–cestode parasite stable isotope enrichment patterns in marine, estuarine, and freshwater fishes from Northern Canada. *Isotopes Environ Health Stud*,2004;40(4):257-266. Available from: <http://doi.org/10.1080/10256010410001678062>
 37. Scholz T, Choudhury A, Brooks DR. A new species of *Synbranchiella* (Cestoda: Proteocephalidae) from the mountain mullet (*Dajaus monticola*) in Costa Rica. *J Parasitol*,2019;105(1):79-84. Available from: <http://doi.org/10.1645/18-17>
 38. Rehab R, Abd El Maged RA, Abo-Esa JF, El Moghazi DF. Identification of selected cestodes affecting some marine fish. *Egypt J Anim Health*,2021;1(3):21-29. Available from: <http://doi.org/10.21608/ejah.2021.184705>
 39. Saraf S, Katyayani R. Biochemical studies of cestode parasite in freshwater fish *Mastacembalus armatus* from Paithan region. *Indian J Appl Res*, 2016, 324-325.
 40. Scholz T, Kuchta R. Fish tapeworms (Cestoda) in the molecular era: achievements, gaps and prospects. *Parasitology*,2022;149(14):1876-1893. Available from: <http://doi.org/10.1017/S0031182022001202>
 41. Scholz T, Kuchta R, Oros M. Tapeworms as pathogens of fish: A review. *J Fish Dis*,2021;44(12):1883-1890. Available from: <https://doi.org/10.1111/jfd.13526>
 42. Shamsi S. Seafood-borne parasites in Australia: human health risks, fact or fiction? *Microbiol Aust*,2020;41(1):33-37. Available from: <https://doi.org/10.1071/MA20009>
 43. Sharma B. Studies on prevalence of cestode parasites in freshwater fish, *Channa punctatus* from Meerut (Uttar Pradesh) India. *J Appl Nat Sci*,2016;8(1):485-488. Available from: <http://doi.org/10.31018/jans.v8i1.822>
 44. Soud AQ, Wannas MQA. A qualitative and quantitative survey on the helminth parasites of fishes from the Aswan high dam lake in Egypt. *Qatar Univ Sci Bull*,1984;4:129-142. Available from: <http://hdl.handle.net/10576/10063>
 45. Suryawanshi RB. Incidence of cestode parasites in freshwater fishes from Sonvad Dam, Dist. Dhule Region (M.S.), India. *J Emerg Technol Innov Res*, 2021, 79-80.
 46. Tossavi ND, Attindéhou S, Oké V, Bouko B, Sakiti N. Occurrence of *Tetracampos* sp. (Cestoda) and *Paracamallanus* sp. and *Rhabdochona* sp. (Nematoda) in the catfish *Clarias gariepinus* in Ouémé River in Benin (West Africa). *Acad Biol*,2024;2(2):1-7. Available from: <https://doi.org/10.20935/AcadBiol6195>
 47. Wali A, Balkhi MUH, Maqbool R, Darzi MM, Shah FA, Bhat FA, *et al.* Distribution of helminth parasites in intestines and their seasonal rate of infestation in three freshwater fishes of Kashmir. *J Parasitol Res*, 2016, 8901518.
 48. Williams H, Jones A. *Parasitic Worms of Fish*,1st ed. Bristol: Tylor and Francis Ltd., 1994, 539.
 49. Woo PTK. Fish disease and disorder: Protozoan and Metazoan Infection. Volume 1. Wallingford: CABI International, 1995, 45-46.
 50. Zaidi DA, Khan D. Cestodes of fishes from Pakistan. *Biologia (Lahore)*,1976;22:157-179.