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The spectrum of helminthes infection in freshwater fishes (Order: *Siluriformes*) of India: A comprehensive review

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Abstract
The Northeastern region of India is endowed with fishery in the form of capture and culture fisheries. Because they include protein, vitamins, calcium, phosphorus, and other minerals essential to human health and growth, fish are regarded as a good source of nourishment in the Northeast. Throughout their lives, fish can become infected with a variety of parasites. In fish and aquaculture, parasites play a significant role in disease transmission and fish mortality. Thus, research on fish health is very vital. The overview of the helminthes parasites that affect catfish from multiple authors' studies is the focus of this work. Within the family *Siluriformes*, which includes Heteroneustidae, Bagridae, *Siluriformes*, and Claridae, catfish are classified under the well-defined order Siluriformes. According to research conducted by a number of authors, fish are primarily infected with helminthes parasites, which include monogenean (like *Bifurcohaptor indicus*), digenean (like Allocreadium wallagoensis), cestode (like *Lytocestus birmanicus*), nematode (like *Polyonchobothrium cyathopharynx*), and acanthocehalan (like *Pallisentis sp.*). Of all the catfish species, Clarius batrachus contains the most diverse range of parasites, including Wallago Attu, Mystus vittatus, and Heteropneutes fossilis. The infection resulted in tissue damage, persistent inflammatory reactions, immune cell infiltration into the cyst wall, muscular atrophy, and other symptoms in the hosts. Fish mortality is reduced and economic loss is minimized when parasites are identified and prevented.

Keywords: Human health, parasite, helminthes, *Siluriformes*, cat fish

Introduction

India has an abundance of capture and culture fisheries, which make up its fishery resources. Fish are raised in captivity in culture fisheries, whereas fish are harvested from the wild in capture fisheries. Given the abundance of rivers in India—Yamuna, Ganga, Brahmaputra, Krishna, Cauvery, and Godavari, along with their principal tributaries—about 11.5% of the world's fish species can be found there (FAO, 2015). The exclusive economic zone (EEZ) of India is 2.02 million square kilometres. India ranked second globally in terms of overall production from fisheries and aquaculture in the years 2008–2010 and 2012 (FAO, 2019). In 2017, 11.6 million tonnes of fish were produced in the nation, according to estimates (FAO, 2019). Freshwater fish, such as carps, account for about 88% of fish farmed for human consumption. Due to their high protein, vitamin content, calcium, phosphorus, and other elements that are essential for human growth and health, fish are regarded as a valuable source of nourishment in the nation, particularly in the northeastern quarter. In addition, these fish are rich in minerals, vitamins, and omega-3 fatty acids (Tilami *et al.,* 2017). According to scientific studies, omega-3 fatty acids have several health benefits, and fish oil has been found to dramatically reduce blood pressure, protect against blood vessel constriction, and prevent thrombosis (Williams *et al*., 2003).

The catfish are found all over the world and are members of the well-defined order Siluriformes (family: *Siluriformes*; *Sisoridae*; *Bagridae*; *Heteropneustidae*; *Claridae*) (Pawara *et al.,* 2014). The *Silurus glanis* is the first catfish to be identified scientifically. It was initially discovered in lakes in Europe and Sweden (Yakhchali *et al.,* 2012) [3]. They comprise one-third of all freshwater fish species worldwide. The Siluroid Fishes Group, which includes about 35 families, 437 genera, and 2734 species over the entire globe, is known as the Siluroid Fishes Group (Pramod, 2008) [5]. Thirteen of the thirty-five families are thought to be in India.The second largest class of freshwater fishes is the catfish family. With its immense diversity, India is home to 197 species in 52 genera. *Heteropneustidae* (air sac catfishes), *Claridae* (air breathing catfishes), *Bagridae* (bagrid catfishes), and *Chacidae* (square head or angler catfishes) are among the Indian families. Catfish are highly valuable economically, and the North East region of India produces them through both the capture and culture systems of inland resources. They are not contaminated because nearly every group of animal is naturally infested with a few parasites. An organism that feeds on its host and lives on it or within it is called a parasite. The host suffers damage even though the parasites gain from it. Parasite infestation is one of the biggest issues and concerns facing fisheries worldwide. Fish health, productivity, quality, and quantity are all significantly impacted by parasitic diseases (Verma & Saxena, 2018) [5]. The three main categories of fish parasites are helminthes, arthropods, and protozoa, with crustaceans being the dominant category. A significant class of parasites known as helminthes is responsible for infections and illnesses in fish kept in both fresh and saltwater (Jyrwa *et al*., 2014) [6]. Fish are home to two phyla of parasitic helminthes: the Nemathelminthes (roundworms) and the Platyhelminthes (flatworms). They are further separated into two categories, such as endoparasites and ectoparasites. Trematoda is one of the classes of platyhelminthes. Digeneans and monogeneans make to the class Trematoda. Monogenean trematodes, often known as flatworms or flukes (Klinger and Floyd, 2002) [7], frequently

infiltrate the skin, fins, and gills of fish from most Teleostei groups that are found in freshwater and brackish water (Francova *et al.,* 2019). While their larval stages may encyst on the skin and gills, digeneans and tapeworms (Cestoda) are endoparasites of the host's body cavity and organs, whereas monogeneans are ectoparasites (Jyrwa *et al*., 2014) [6]. This correspondence provides a thorough discussion of the infection range of three important helminthe species, namely trematodes and cestodes in the Siluriformes family, with specific reference to northeastern India.

Aquaculture and parasitism

Fish, molluscs, crustaceans, and aquatic plants are among the aquatic organisms that are farmed in aquaculture (FAO, 1995). The United Nations Food and Agriculture Organisation (FAO) released data in 2018 that shows the total production of fish, crustaceans, molluscs, and other aquatic animals (apart from mammals and reptiles) increased to approximately 171 million tonnes worldwide. Fisheries, both capture and culture, are abundant in India. Over three million Indians are either directly or indirectly dependent on fishing (Pramod, 2008) [4]. In its broadest sense, the term "parasitism" refers to any living thing (including bacteria, fungi, viruses, and animals) that inhabits, feeds on, or otherwise harms another living thing (Molnar *et al*., 2019). Certain parasites live their entire life within or on top of the same host, while others have more intricate life cycles. They could have one or more intermediate hosts, where they develop during their ensuing developmental stages, until they find the final host where they mature. According to Molnar *et al*. (2019) and the FAO (2019), the organism in which they attain sexual maturity is the primary or final host among them. Numerous authors (Mashego & Saayman, 1981; Chandra, 2006; Malhotra & Chauhan, 1984; Nimbalkar *et al*., 2010; Jadhav *et al*., 2011) [10, 11, 12, 13, 14] have studied the helminthes parasite fauna of freshwater fishes, its frequency, and distribution in various parts of the world. Fish are home to two phyla of parasitic helminthes: the Platyhelminthes (flatworms) and the Nemathelminthes (roundworms). Additionally, they are split into two categories: endoparasites and ectoparasites. Fish are commonly infected with Platyhelminthes, which include fish-infesting members of the families Nematoda (roundworms) and Acanthocephala (spiny-headed worms), as well as members of the class Trematoda and Cestoda (Amin *et al*., 2019) [15]. Certain worms pose a serious threat to fish health. The most well-known of them are the monogenean gill worms, which include numerous species that are peculiar to a given host, but other infections that can affect cyprinid fish include intestinal tapeworms and fluke larvae, which can also kill fish populations and result in financial losses (Jyrwa *et al*., 2014) [6]. Fish roundworm parasites most commonly discovered in internal organs include nematodes and acanthocephalans (Amin *et al*., 2019) [15]. The majority of parasitic helminthes have indirect life cycles that involve one or more intermediate hosts, which can be aquatic invertebrates or fish. Fish-eating birds and mammals are the ultimate hosts of most nematode, digenean, and even some cestode parasites. Thus, to track the life stages, a comprehensive parasitological study of aquatic environments should include all hosts. Fish with parasitic infections typically have slower growth rates, and the harm helminthes inflict on their hosts is largely determined by the degree of infestation and the depth to which the parasites penetrate the host tissue, which includes the gills, mouth, skin, fin surfaces, and gastrointestinal tracts. Trematodes are the predominant category of parasites that cause sickness, mortality, and retarded growth, particularly in young fish (Abidi *et al*., 2015) [16]. When compared to microbiological diseases, parasitic diseases are more common (approximately 78%) and more commonly encountered in India; nevertheless, the severity and losses resulting from these diseases vary greatly (Abidi *et al*., 2015) [16]. Numerous researchers in various North East Indian locales have examined the diversity of helminth fauna (Jyrwa *et al*., 2014) [6].

Trematodes infestation in freshwater fishes

Monogeneans and digeneans make to the class Trematoda. Invading freshwater and brackish water fish from most families of Teleostei, monogenean trematodes are also known as flukes or flatworms (Klinger and Floyd, 2002) [7]. They typically infect the fish's gills, skin, and fins (Whittington *et al.,* 2000) [17]. Three primary taxa comprise monogeneans, which are classified as ectoparasites: *Polyopisthacotylea*, *Dactylogyroidae*, and *Caspaloidae*. It is a straight life cycle for the monogenean. (Frascajr *et al.,* 2018) Dactylogyrids and caspalids are oviparaous, but the majority of gyrodactylogyrids are viviparous. The majority of endoparasites, which include the considerably larger group known as "digenetic flukes," employ vertebrates as their final hosts after molluscs as their original hosts (Roberts and Janovy, 2000) [18]. They mostly infect young fish, bottom dwellers, and shallow water habitats in inland water bodies, and they have intricate life cycles that involve larval stages (Iyaji, 2009). They can serve as biological tags to track fish migration paths and as markers of the compositional quality of fish stocks.

The study of fish health took off in the prehistoric era. As is known from the contributions of numerous writers (Jacob & Thomas 1968; Van & Barson 1984, Mashego *et al.,* 1981) [10, 19, 20], etc., the study has been expanded to the different regions of the world. Numerous studies have been conducted on numerous helminth parasite groups that affect freshwater fishes across the globe. In Bangladesh, P. folium was initially identified from the siluroid fish *Rita rita*'s gut (Khanum *et al.,* 2008) [21]. Helminthes parasites were found in the gastrointestinal tract of catfish (*Siluris glanis*) in Iran; Yakhchali *et al.,* (2012) [3] conducted research on this topic. Between infection rate, body size, and weight, they discovered a strong link. They said that the majority of the catfish lesions found were not expected to affect the survival of the host. In certain circumstances, a number of the documented species may be harmful and result in financial loss. The mucosal folds' denudation appeared to be the extent of the infections' negligible pathogenicity. In a study of freshwater fish in Patagonia, Argentina, researchers detected 15 digeneans and 14 monogeneans helminthes parasites (Raque *et al.,* 2018). Ghana has been reported to harbour the digenean trematode *Eumasenia ghanensis*. *Heterobranchus longifilis* (Vundu) may have accidentally consumed a fish that was harbouring the encysted stage, as evidenced by the presence of an unencysted metacercaria in the fish's small intestine (Jacob *et al.,* 1968) [19]. *Heterotis niloticus* (Nile Arowana) and *Clarias gariepinus* (Sharptooth catfish) were the sources of the dinetic trematodes, *Clinostomum* and *Euclinostomum* species, which are adult trematodes found in the digestive system,

liver, gall bladder, and urine bladder (Ahmed *et al.*, 2013) [23]. Workers who used the histopathology method to conduct studies reported alterations to several tissues within the diseased organ. A potent technique for validating the histoarchitecture of different tissues during parasite infection is histopathological examination (Shareef & Abidi, 2015) [16, 24]. El-Mansy and her colleagues investigated the histopathology of freshwater fish raised for food that were infected with several helminthes in Egypt. They stated that the two types of parasites are digeneans (*Orientocreadium batrachoides*) and monogeneans (*Ciclidogyrus halli typicus*). Because it detached from the intestinal villi, the parasitic fluke Orientocreadium batrachoides infiltrated the intestine of the catfish *Clarias gariepinus*, causing little damage to the mucosal epithelia (El-Mansy *et al*., 2011) [25]. In the gallbladder of the host catfish, *Mystus cavasius*, seven trematodes from the genus *Pseudophyllodistomum* were discovered in Pakistan (Soofi *et al.,* 2017) [26]. It was observed that specimens from this genus resembled those from *Pseudophyllodistomum johnstoni*. Numerous researchers examined the health of Ethiopian fisheries, identifying various endoparasites in freshwater fish and characterising them as digenean trematodes in *Clarias gariepinus*, such as *Euclinostomum* and *Diplostomum* (Gebremedhn & Tsegay, 2017) [27]. Many authors have outlined the various ways that environmental conditions impact the histological changes that are seen in fish organs. The ecological factors influencing fish pathology have been studied by a significant number of writers in Switzerland. Bern *et al*. (1999) found that water contamination and the number of histopathological lesions in organs are correlated. On the other hand, a Nigerian study (Barson *et al.,* 2014) [28] looked at the African catfish (*Clarius gariepinuns*) and the histology of helminthes parasites and how it related to heavy metal contamination in the local river system. The World Health Organisation (WHO) estimates that over 18 million people may be affected by fish-borne trematodes alone, and many more may be at risk (WHO, 2004). The helminthes parasite is consequently turning into a threat to international public health. Food-borne parasitic diseases are extremely common worldwide. A recent study conducted in China by Liu *et al.,* (2019) on a number of food-borne trematodiases mainly determined that the trematode *Clonorchis sinensis* was the cause of clonorchiasis. The sickness was brought on by eating uncooked freshwater fish that included encysted organisms.

Similar conditions are seen in India, where the tropical climate offers the best opportunities for helminthes parasite growth and spread (Ghosh & Chauhan, 1975) [30]. Gilchrist (1841–1846) made the earliest known account of helminthes in India from a modern, methodical perspective. Fish helminthes was originally reported by an Indian worker, Dr. B. Prasad, in 1918. The history of research conducted in the Zoological Survey of India by many researchers (Swell, 1918–22; S.W. Kemp 1919–22; Southwell, 1918–26; Chauhan, 1945–69; Mukherjee, 1960–69; Srivastava, 1961–69; Soota, 1954–69 and Gupta 1962–69) is intriguing and extremely interesting to follow. Subsequently, numerous diverse works contributed to this field. Researchers from the different Indian states have made significant contributions to the science of helminthology. The monogenean and digenean trematode found in freshwater catfish across the nation was documented by multiple authors (Table 1). In the Aligarh region of North India, the epidemiology and histology of *Euclinostomum heterostomum* infecting *Channa punctata* were studied (Abidi *et al.,* 2017) [16]. The thick, fibrous cyst wall capsule that encloses the parasites is shown by the histology of the affected organs. The same work trend was documented by Reddy and Benarjee (2014) [31]. They discussed the seasonal change of the trematode *Genarchopsis goppo* in *Channa Punctatus* (fresh water murrel) and the histology of the intestinal tract. According to their research, serious histological alterations include blood vessel dilatation, fibrosis, inflammation, and damage to the villi. In Maharastra, the stomach of the catfish *Clarias batrachus* was infected by the trematodes *Azygia angusticauda*. These trematodes harm the host by absorbing vital nutrients from the stomach of the host (Tambe *et al.,* 2020).

Table 1: Distribution of Trematode parasites in freshwater Siluroid fishes in India

Trematode groups	Trematode species	Host species	Site of infection	Locality	References
Monogenean	*Silurodiscoides sudhakai*	*Arius arius* (Hamilton-Buchanan) *Arius subostratus* (Valenciennes)	Gill filaments	Kerala	Pramod, 2008 [4]
	Bifurcohaptor indicus	*Mystus vittatus, M. tengara*	Gill filament	Meghalaya	Jyrwa *et. al.*,2014 [6]
	Thaparocleidus longiphallus	*Wallago attu*	Gills	Meerut,UP	Chaudhary & Singh,2013 [40]
Digenean	*Tylodelphys*	*Heteropneustes fossilis*	Body cavity, muscle tissue, oesophagus	Byrnihat, Meghalaya	Jyrwa *et al.*,2014 [6]
	Allocreadium wallagoensis	*Wallago attu*	Internal wall of the stomach	Jaikwadi Dam, Maharastra	Deolalikar, 2016 [33]
	Euclinostomum	*Heteropneustes fossilis*	Skin	Chandausi, Uttar Pradesh	Roy & Kumari, 2018 [38]
	Glossidium Pedalum	*Clarias batrachus, Heteropneustes fossilis*	Stomach, skin	Jaikwadi Dam, Maharastra	Nimbalkar *et al.*,2010 [13]
	Astiotrema reniferum	*Clarias batrachus*	Stomach	Tripura	Koiri & Roy,2016 [39]

Cestodes infestation in freshwater fishes

Tapeworms, or cestodes, are common in all of the world's main water systems and exhibit a high degree of host specificity (FAO, 1996). A highly diverse group of only parasitic flatworms (Platyhelminthes) with a distinctive shape and intricate life cycle are known as tapeworms. The amphilinid, which is represented by the segmented Pseudophyllideans and Proteocephalideans, and the monozoic forms, such as Caryophyllaeidae, are the two primary forms. The most prevalent hosts for segmented and monozoic cestodes are silibiniform fish (FAO, 2000). With the exception of the amphilinid Nesolecithus africanus, which inhabits the coelomatic cavity of its fish host, the mormyrid Gymnachus niloticus (Iyaji, 2008), and Polyonchobothrium clarias, which resides in the gall bladder of the catfish Clarias mossambicus, all cestodes are found in the digestive tracts. Among the parasites that harm freshwater fish the most are the larval cestodes of the pleurocercoids and cysticercoids (Klinger and Floyd, 2002) [7]. In the mesenteries of siluriforms, Clarias, and Bagrus sp., cysticercoids belonging to the cyclophyllidean family are prevalent and numerous (FAO, 1996). The stomach of Clarias gariepinus was invaded with the cestode Polyonchobothrium clarias in the pyloric region (El-Mansy *et al*., 2011) [25]. Because the parasite's scolex deeply embedded itself in the infected tissue, creating a deep cavity-like depression inside the mucosal tissue, it destroys the mucosal epithelia surrounding the infection site, comparable to uninfected tissue, causing the infected tissue's blood capillaries to dilate (El-Mansy *et al*., 2011) [25]. There were times when it was believed that the primary cause of the illness was the digestive system parasites Bothriocephalus gowkongensis, which were found in catfish. The digestive tract's foregut and midgut were the most damaged, per Yakchali *et al*. (2012). Out of 110 cases of Clarias gariepinus, 302 cases of helminthes have been reported in Nigeria. Helminthes are mainly found in the digestive tract, which consists of the stomach, oesophagus, and intestines. Cestodes of Wenyonia spp. are also frequently seen in the oesophagus (Ahmed *et al*., 2013) [23].

Fish parasites that Southwell and Prashad (1918) first detected in India included *Carcharinus gangeticus*, a novel cestode called *Rhynchobothrious ilisha*, and *Hilsha ilisha*. This was also the first reliable study on the life-history of a cestode in India (Chauhan and Ghosh, 1975) [30]. Ash *et al.*, (2010) identified 15 genera of walking catfish (*Clarias batrachus*) found in the Indo-Malayan region, belonging to three families: *Capingentidae*, *Caryophyllaeidae*, and *Lytocestidae*. Their study included 59 species. Furthermore, they clarified that *Bovienia indica* and all tapeworms identified as *Bovienia serialis* from *Clarias batrachus* from India (Table 2) are conspecific, including the ones that Mackiewicz and Murhar (1972) redescribed. (Ash *et al.*, 2011) [32]. According to Negbelkar *et al*. (2010), there are nine helminthes species known to exist in Maharashtra, three of which are cestodes from the *Clarias batrachus* and *Heteropneustes fossilis* species (*Bothriocephalus acheilognathi*, *Polyonchobothrium clarias*, and *Proteocephalus glanduliger*). In contrast to other fish species, the highest worm burdens were found in *Clarias batrachus*, which has been linked to the species' preferred habitat, which includes turbid environments and coastline regions with vegetation, such as the Jaikwadi Dam (Nimbalkar *et al., 2010*) [13]. Twelve different species of *Lytocestus mystusensis* have been identified in *Mystus seenghala* in the Maharashtra dam, according to research conducted along the same lines. Winter was the season when these parasites were at their most intense and plentiful. From *Ophiocephalus gachua*, 17 species of *Circumonchobothrium ratnaensis* were discovered. The summer was the best time to collect the most species (Deolalikar, 2016) [33]. The heminth parasites that infect freshwater fish in North-East India have been the subject of extensive research by several authors. Four new species of cestodes from the genus *Lytocestus* (*Caryophylladae*, *Lytocestedae*) have been discovered in the Assam and Meghalaya region: edible catfish *Heteropneustes fossilis* and *Clarias batrachus* (Tandon *et al.*, 2005) [34]. Meghalaya has reported a similar tendency in siluroid fish study (Jyrwa *et al.*, 2014) [6] (Table 2).

Table 2: Distribution of Cestode parasites in freshwater catfishes in India

Cestode speices	Fish species infected	Site of infection	Locality	References
Lytocestus indicus	*Clarias batrachus*	Small Intestine	Madhya Pradesh	Ash *et al.*,2011 [32]
Lytocestus clariasae	*Clarias batrachus*	Small Intestine	Assam, Meghalaya	Tandon *et al.*,2005 [34]
Bovienia indica	*Clarias batrachus*	Intestine	West Bengal	Ash *et al.*,2011 [32]
Lytocestus birmanicus	*Clarias batrachus*	Intestine	Byrnihat, Dawki, Hatmawdo n, Jowai, Tura, Balat	Jyrwa *et al.*,2014 [6]
Polyonchobothrium clarias	*Clarius batrachus*	Internal wall of the stomach	Jaikwadi Dam, Maharastra	Nimbalkar *et al.*, 2010 [13]
Polyonchobothrium glandulgar	*Clarius batrachus*	Stomach	Maharastra	Nimbalkar *et al.*, 2010 [13]
Lytocestus attenuatus	*Clarius batrachus*	Intestine	Assam	Tandon *et al.*, 2005 [34]
Lytocestus assamensis	*Clarius batrachus*	Intestine	Assam	Tandon *et al.*, 2005 [34]
Lytocestus heteropneustii	*Heteropneustes fossilis*	Intestine	Meghalaya	Jyrwa *et al.*,2014 [6]
Neogryporhynchus Sp.	*Mystus oculatus,*	Gall bladder	Thiruvanthapuram	Pramod, 2008 [5]
Djombangia penetrans	*Heteropneustes fossilis, Clarius batrachus*	Intestine	Meghalaya	Thapa *et al.*, 2011[36]

Nematodes Infestation in Freshwater Fishes

Nematodes, or round worms, comprise 256 families and over 40,000 species, making it one of the largest phyla in the animal kingdom. The classes Adenophorea and Secernentea make up the phylum Nematoda, and parasitic nematodes are members of both subclasses (Anderson, 2000). Fish endoparasitic worms are commonly known as nematodes (Pramod, 2008) [4]. Because of their unique form and strong, tough cuticle, nematode worms can survive longer in post-mortem settings than flatworms (FAO, 1996). The families *Dioctophymatidae*, *Cystiopsidae*, *Camallanidae*, and *Cappillaridae* comprise the nematode taxonomic group. The class Adenophora comprises mostly free-living freshwater and marine species, with a little amount of parasitic terrestrial soil worms. The Secernentea class includes some free-living species as well, but the vast majority of them are parasitic.

In South Africa Nematodes have been recorded from *Clarias* spp. (Fernando & Furtado, 1963). The *Camallanidae* family includes the adult nematodes that were found, while the Heterocheilidae family includes the larval worms. In South Africa, the catfish species Clarias spp. frequently harbour the worm *Paracamallanus cyathopharynx* (Meshego *et al*., 1980). El-Mansy *et al*. (2011) [25] showed that the nematode species *Paracamallanus cyathapharynx* caused harm to the posterior region of the intestine by separating epithelial tissue between its ribs of *Clarias gariepinus* through its buccal capsule. In Nigeria, 11.82% of catfish, *Clarias gariepinus*, have been shown to contain the nematode P. lavionchus in their stomach and intestine. Fish that were older had the highest level of infection, while fish that were younger had none (Ahmed *et al*., 2013) [23]. The same species of nematode, *Procamallanus laeviconchus*, caused damage and rupture to the mucosal tissue surrounding the parasite buccal capsule as well as haemorrhage at the attachment site when it implanted its buccal capsule in the cardiac region of Clarias gariepinus's stomach. It is possible for larval nematodes to parasitise fish in both fresh and brackish waters. It's noteworthy to note that fish larval nematodes belonging to the *Anisakidae* (*Heterocheiliadae*) family, which includes the genera *Amplicaecum*, *Contracaecum*, and *Porocaecum*, have been reported. In Nigeria, the genera *Rhabdochona* and *Spinitectus* belong to the *Rhabdochonidae* family, while the genus *Eustrongylids* is part of the *Dioctophymidae* family (Iyaji *et al.*, 2008). Rarely do larval nematodes appear in the belly cavity; instead, they are either ensnared in tissues or free within bodily cavities (FAO, 1996; Iyaji *et al.*, 2008). In Karachi, Pakistan, the nematode parasites *Raphidascaris acus larvae*, *Metabronema magnum*, *Haplonema immutatum*, and *Hedruris bryttosi* were found in the stomach of an *Arius Arius* catfish. The parasites were found in the host fishes' alimentary canal. Numerous factors, including contaminants, the physiochemical characteristics of water, and the availability of a suitable host for parasites, influence the prevalence, intensity, and infection rate, which differ from place to place (Satter *et al.*, 2016). Infections of *Clarias batrachus* with *Paracamallanus cyathopharynx* have been documented in Jaikwadi Dam, Maharashtra (Nimbalkar *et al.*, 2010; Deolalikar, 2016) [13, 33]. Fish that are farmed are susceptible to coccidiosis, which usually shows up as a chronic infection with a progressive death rate (Nimbalkar *et al.*, 2010) [13]. Human-infecting fish nematodes are primarily found in tropical regions (Jyrwa *et al.*, 2014) [6], with *Procamallanus* sp. being identified in North East India. The parasitic helminthes not only alter the host's morphology but also harm the nervous system. They also brought about alterations in the cardiovascular and metabolic systems (Reddy and Banerjee, 2014) [31]. Adult and larval endoparasites only infect fish in the intestine during their indirect life cycle; acanthocephalans are thorny or spiny-headed worms. They fall into four classes: Polyacanthocephala, Palaeacanthocephala, Eoacanthocephal a, and Archiacanthocephala. Candhocephalans inflict serious damage on a range of vertebrates by adhering to the inside wall of the host's gut with their hooked proboscis (Verma and Saxena, 2018) [5]. *Acanthogyrus* (*Acanthosentis*) *fusiformis* was discovered to be harboured by *Arius sp.* (*Ariidae*: *Siluriformes*) catfish from the Pacific Coast of Vietnam near BAC Lieu in the Gulf of Thailand (Amin *et al.*, 2019) [15]. In general, the intestinal fold and muscle layer sustain greater damage from acanthocephalans. Metabolic diseases arise from the interference of acanthocephalan infections with food digestion and absorption. Numerous writers in India have conducted noteworthy research on the acanthocephalan parasite (Table 3).

Table 3: Distribution of Nematode and Acanthocephalan parasites in freshwater Siluroid fishes in India

Helminthes groups	Parasite species	Host species	Site of infection	Locality	References
Nematode	*Polyonchobothrium cyathopharynx*	*Clarias batrachus*	Stomach	Maharastra	Nimbalkar *et al.*,2010 [13]
	Procamallanus sp.	*Heteropneustes fossilis*	Intestine	Meghalaya	Jyrwa *et al.*,2014 [6]
	Procamallanus spiculogubernaculus	*Heteropneustes fossilis*	Intestine	Delhi	Chaudhary *et al.*,2016
Acanthocephalan	*Pallisentis nagpurensis*	*Heteropneustes fossilis*	Intestine, Mesenteries	Thiruvananthapuram	Pramod, 2008 [4]
	Raosentis ivanisoni	*Arius arius*	Small Intestine	Thiruvananthapuracm	Pramod, 2008 [4]
	Raosentis podderi	*Mystus gulio*	Intestine	West Bengal	Guchhait *et al.*,2017 [37]
	Pallisentis sp	*Mystus gulio*	Intestine	West Bengal	Guchhait *et al.*,2017 [37]

Conclusion

Literature from various authors indicates that parasites play a significant role in diseases affecting fish, higher vertebrates, and humans, with fish serving as vectors for these diseases. The range of helminthes parasites found in Northeast Indian edible freshwater fish is the main topic of this review. A significant amount of information is available regarding the parasites that afflict Indian siluroid fish.

Heteropneustes fossilis, *Mystus oculatus*, *Mystus gulio*, *Arias arias*, *Wallago Attu*, and *Clarias batrachus* are notable examples of infected siluroid species (Pramod, 2008; Nimbalkar *et al.,* 2010) [4, 13]. It has been noted that *Clarias batrachus*, one of these catfish species, harbours the most variety of helminth parasites (Nimbalkar *et al.,* 2010) [13]. According to Shareef and Abidi (2015) [16, 24], the effects of parasites on fish hosts include tissue damage, persistent inflammatory reactions, immune cell infiltration into the cyst wall and granulomatous lesions, muscle degeneration, and more. Fish hosts *Mystus vittatus* and *Mystus tengara* have elongated, deeply bifurcated gill filaments infected by the monogenean trematode *Bifurcohaptor indicus* (Thapa *et al.,* 2011) [36]. Among marine and brackishwater fishes, *Dactylogyrus*, *Gyrodactylus*, *Diplectanum*, *Benedenia*, and other monogenean parasites are the most prevalent. They mostly infected fish hosts, including mullet, carp, tilapia, and catfish. Digeneans are endoparasites that differ according on the species. Since the pathophysiology of adult trematodes is limited to irritation and inflammation at the site of attachments, they are usually benign even though they can infect a fish's intestine or gall bladder. The intestine of the siluroid fish *Mystus gulio* contained the acanthocephalans *Pallisentis sp*. and *Raosent podderi* (Guchhait *et al.,* 2017) [37]. The host's bowel developed necrotic hemorrhagic ulcers as a result of the acanthocephalan. The primary cause of pathogenicity is the mechanical damage that results from the spiny proboscis's attachment to the intestinal wall. The severity of the harm helminthes do to catfish could result in huge financial losses because these fish are important to India's commercial fish sector. Therefore, it is necessary to ascertain the range of pathogenicity as well as their severity index in order to act accordingly at the appropriate moment in order to regulate and manage them.

Conflict of interest

Authors declare there is no conflict of interest.

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