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Cover: Dorsal view of Mantis Shrimp *Cloridina ichneumon* (Fabricius, 1798) & *Gonodactylus demanii* (Henderson, 1893). © Fisheries Research Station, Junagadh Agricultural University, Sikka.



Ichthyo-parasitological studies in northeastern India

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Abstract: Fish constitutes an essential component of the diet for most of the people of northeastern India. It provides nutrition and employment opportunities for most of the population of the region. Still, fish diseases due to helminth parasites pose a severe threat to fish health and the fishery industry. Helminths are worm-like parasites affecting the fishes and thus reduce their food value. Fishes are mostly infected with four groups of helminths, viz., Trematoda, Cestoda, Nematoda, and Acanthocephala. The article reviews the investigation and research on the trend of helminth parasites in the freshwater fishes of northeastern India through the study of available literature. For the present study, secondary data was collected from published research articles, journals, reports, and books on this major issue and compiled together. Google Scholar is the leading search engine used to search for scholarly literature in this area broadly. The study revealed that helminth parasites are extensively distributed in the freshwater fishes of different regions of northeastern India and are primarily found in the intestine of the fishes. Females are found to be highly infested than males. Also, the seasonal influence was observed on the occurrence of parasites. Several workers have conducted considerable works in Assam, Meghalaya, Arunachal Pradesh, Manipur, Mizoram, and Tripura. But to date, there is no published record on the occurrence of helminth parasites in the fishes of Sikkim and Nagaland. Therefore, it is imperative to conduct further research on the current topic that could help the scientific community and pisciculturists understand the biodiversity of parasites in different host fishes for proper aquaculture management.

Keywords: Acanthocephalans, aquaculture, cestodes, freshwater fish, helminths, nematodes, parasites, trematodes.

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INTRODUCTION

Global fish production has been increasing steadily over the past five decades. It reached an all-time high production of 73.8 million tonnes in 2014. Additionally, the fisheries sector of India has witnessed a several-fold increase in fish production from 0.75 million tonnes in 1950–51 to 10.07 million tonnes in 2015–16 (Debnath et al. 2019). Fish is one of the most important and easily digestible protein-rich food items of humankind worldwide. The northeastern region of India comprises the eight states—Assam, Arunachal Pradesh, Manipur, Mizoram, Tripura, Sikkim, Meghalaya, and Nagaland—covers an area of about 262,179 km² which is almost eight percent of that of India and lies between 25.5736° N, and 93.2473° E. This region has been gifted with vast aquatic resources (Barman et al. 2012) comprising floodplain wetlands, locally known as beels, swamps, ponds, and paddy fields. Therefore, aquaculture has been increasing rapidly in this region (Munilkumar & Nandeeshia 2007). Moreover, the northeastern part of India enjoys a favourable climate for aquaculture with annual rainfall exceeding 2,000 mm. Additionally, more than 60% of the area is covered by forest, where the soil is primarily acidic with pH ranging from 4.5–5.0 (Munilkumar & Nandeeshia 2007). Northeastern India has been blessed with a wide variety of ichthyofauna and is considered one of the hotspots of freshwater fish diversity globally. Out of the nearly 806 species of freshwater fishes in India, the northeastern region represents 267 species belonging to 114 genera and 38 families and 10 orders, which constitutes approximately one-third of the Indian freshwater fishes (Jyrwa et al. 2016). Fish includes a significant diet component for most people of northeastern India (Debnath et al. 2019). The demand for fish is high as more than 90% of the population are fish-eaters (Munilkumar & Nandeeshia 2007). Moreover, fish provide nutrition and employment opportunities for most people. However, fish disease due to helminth parasites poses a severe threat to fish health and the fishery industry directly or indirectly. The disease causes poor growth, poor quality, and the low market price of the products, thus affecting the livelihood and living standards of the people due to loss of income and employment. Fish diseases led to a loss of about 15% of production in China (Debnath et al. 2019). About 30,000 helminth species have been estimated as parasites of fishes, most known to be of serious threat to their hosts. The word ‘helminth’ is a general term meaning ‘worm’. They are worm-like parasites that constitute a significant group of pathogens, causing infection

and diseases of fish both in freshwater and marine environments (Jyrwa et al. 2016). Fish serve as hosts for a wide variety of taxonomically diverse parasites (Barber et al. 2020). They are mostly infected with four groups of helminths, viz., trematodes, cestodes, nematodes, and acanthocephalans. As estimated by the World Health Organisation (WHO), the number of people currently infected with fish-borne trematodes alone exceeds 18 million, and many more are at risk. People who eat raw, lightly smoked, lightly salted, dried, and pickled fish are the most at risk (Jyrwa et al. 2016). The occurrence of fish disease due to helminthic infestations has become a major constraint in aquaculture. It affects the usual health conditions of fish, thus causing fish mortality and resulting in significant economic loss to fisheries. Therefore, successful fish parasitological research is essential in various fishery development programs as fish yield improvement can mainly be achieved from healthy fish stock (Chandra 2006). Various workers and researchers have studied the occurrence and distribution of helminth parasitic fauna in the freshwater fishes of northeast India. Also, several workers have described newer species of parasites from different fish hosts and made further advancements in this field. With the importance of aquaculture as a source of livelihood for most people in northeastern India and economic loss due to fish diseases, this review aims to summarize the helminth parasitological studies in fishes conducted in northeastern India and give suggestions for future research directions for further research in this field for proper aquaculture development.

NATURE OF STUDIES CONDUCTED IN THE STATES OF NORTHEASTERN INDIA

Assam

Assam is bountiful in aquatic resources, thus supporting the fisheries sector as a potential economic activity. The state covers 78,438 km² with two major river systems, viz., the Brahmaputra and the Barak River, with their tributaries (Chakravarty et al. 2017). In the context of Assam, there are sufficient pieces of evidence on the occurrence of helminth parasites in freshwater fishes. Several workers and researchers have conducted studies in various aspects of fish pathology. In the Cachar district, the intensity of cestode parasites of *Monopterus albus* was studied, which showed fourteen infected specimens out of 30 samples examined, and most of the infection was restricted to the intestine of the hosts. A considerable number of helminth parasites

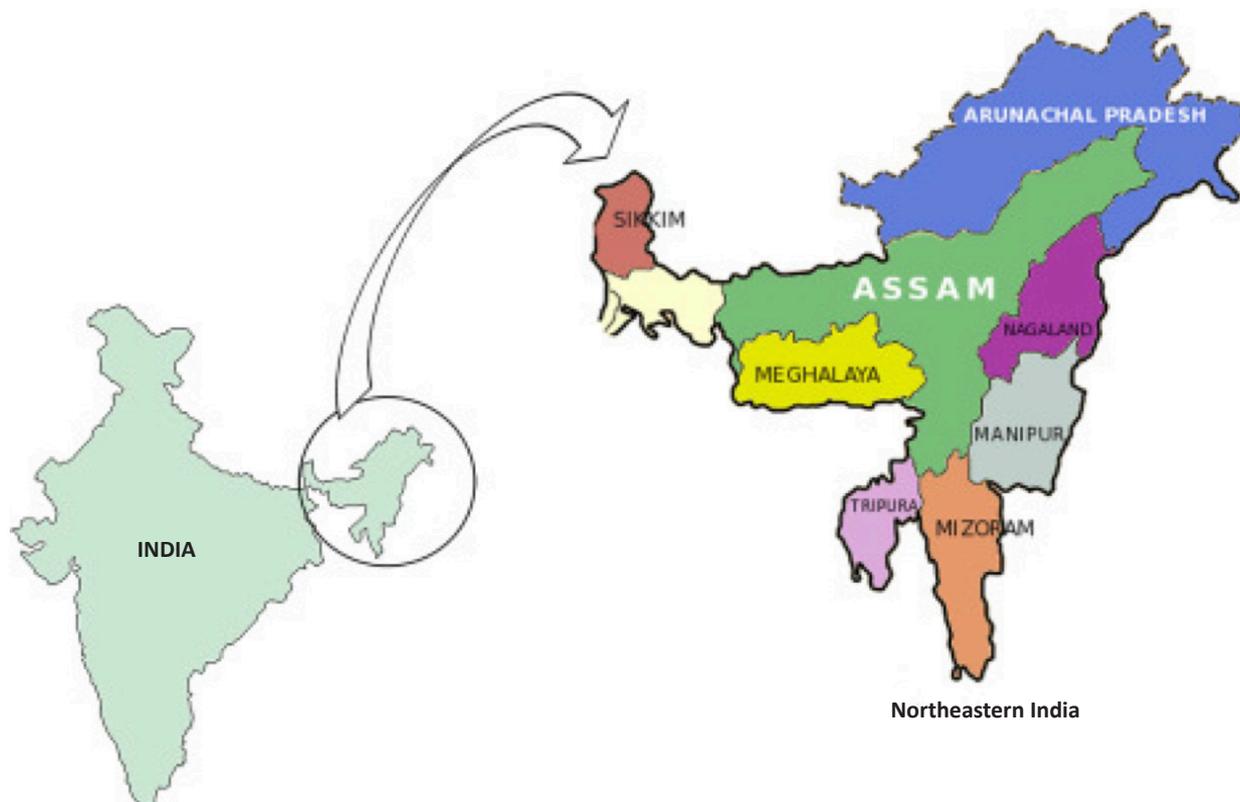


Figure 1. Map of northeastern India showing its eight different states. (Map source: <https://images.app.goo.gl/TV3RFq1YNAFQ4yee9>)

were also reported from freshwater fishes of Goalpara revealing seasonal variation in the prevalence, mean intensity, and abundance of parasitic infestation of fishes. The fishes of the Sone Beel of Karimganj district were investigated for the occurrence of parasites. The Sone Beel contains about 42 species of fishes belonging to 27 genera, 16 families, and six orders. The common fishes found in this lake are *Channa* sp., *Puntius* sp., *Trichogaster* sp., *Amblypharyngodon mola*, *Channa* sp., and *Mystus* sp. A total of 238 helminth parasites were recorded from this wetland (Beel), out of which 16 were nematodes, 132 were cestodes, and 22 were trematodes, and 168 of acanthocephalans, respectively. The highest infection was observed in *Channa striata* and the lowest infection in *Macrornathus aral* (Ngasepam & Kar 2014). The diversity of helminth infection in the fishes of the Jatinga River was recorded from where 14 different species of parasite groups belonging to nematodes, acanthocephalan, and cestodes were found. Maximum infection was observed in *Mastacembelus armatus* & *Mystus cavasius* and lowest in *Tenualosa ilisha*, *Channa punctata*, & *Sperata aor* (Singh et al. 2015). Three freshwater fishes, viz., *Notopterus notopterus*, *Channa punctata*, and *Heteropneustes fossilis* from

Dolu Lake, Silchar was found to be infested with 358 helminth parasites out of which 270 were nematode, six were cestodes, 50 were trematodes, and 32 were acanthocephalan. The degree of infestation was higher in *Notopterus notopterus* and lower in *Heteropneustes fossilis*. The degree of infection in females was higher in all three fish species. Also, different trends were observed in the occurrence of parasites in different sex and length groups of host fishes during different seasons of the study period. The morphological features of a digenetic trematode *Isoparochis hypselobagri* recovered from three freshwater bottom-dwelling fishes, viz., *Mastacembelus armatus*, *Notopterus notopterus*, and *Wallago attu* of Kolong river are described (Tamuli et al. 2017).

Meghalaya

Meghalaya, a hilly state in the north-eastern region of India, with its numerous hill streams and rivers, is enriched with variety of ichthyofauna (Jyrwa et al. 2016). The platyhelminth spectrum of some edible fishes of Meghalaya was documented where several fishes were examined belonging to *Labeo*, *Cyprinus carpio*, *Cirrhinus reba*, *C. mrigala*, *Danio* sp., *Puntius sarana*, *Garra* sp.

(Cypriniformes), *Channa* sp. (Channiformes) and *Clarias batrachus*, *C. gariepinus*, *Heteropneustes fossilis*, *Rita rita*, *Monopterusuchia*, *Ompak* sp., *Bagarius bagarius*, and *Mystus tengara* (Siluriformes). Four new species of the genus *Lytocestus* were reported from the edible catfishes *Clarias batrachus* and *Heteropneustes fossilis* in Assam and Meghalaya (Tandon et al. 2005). A study on the helminth parasite spectrum of freshwater food fishes in Meghalaya was conducted for which a total of 1,674 host fishes were examined belonging to 17 genera and 26 species, including *Labeo* sp., *Cirrhinus* sp., *Cyprinus* sp., *Puntius* sp., *Neolissocheilus* sp., *Botio* sp., *Garra* sp., and *Catla* sp. (Cypriniformes), *Channa* sp. (Channiformes), *Mystus* sp., and *Clarias* sp., *Heteropneustes fossilis*, *Rita rita*, *Chaca chaca*, and *Bagarius bagarius* (Siluriformes), *Monopterusuchia* (Symbbranchiformes), and *Anguilla anguilla* (Anguilliformes). The helminth parasites recovered from the various host species in the study area comprised of two monogeneans, eight trematodes, 12 cestode, six nematode, and one acanthocephalan species (Jyrwa et al. 2016).

Tripura

Tripura has rich fish diversity and fishery resources in the form of rivers, streams, ponds, lakes and mini barrages and paddy fields. Freshwater aquaculture is promising source of economy of the state (Singh et al. 2009). A study conducted on the seasonal incidence of parasitic helminth infestation in *Clarias batrachus* of Tripura reported 606 fishes to be infected with parasites out of 868 host fishes examined. Of the recovered parasites, one was trematode, i.e., *Astiotrema reniferum*, seven were cestodes, *Lytocestus indicus*, *L. birmanicus*, *L. longicollis*, *L. attenuates*, *L. filiformes*, *L. clariae*, *Djombangia penetrans*, and one larval nematode species of the genus *Anisakis* (Koiri & Roy 2016).

Manipur

Manipur covers 22,327 km² and has four major river basins with rich fish diversity (Vishwanath et al. 2007). Documentation on the intensity of nematode infections in the fishes of Ultra Lake revealed 121 fishes heavily infected with nematodes out of the 183 fishes examined. The study indicated maximum infection in *Anabas testudineus* by *Camallanus anabantis* (Geetarani et al. 2010). There is evidence of the occurrence of trematode parasites in the fishes of Awangsoi Lake. A total of five species of trematodes were collected in the study, namely, *Clinostomum complanatum*, *Allocreadium handia*, *Allocreadium fasciatus*, *Astiotrema reniferum* and *Genarcopsis goppo* from the fish species *Channa*

punctatus, *Clarias batrachus*, *Channa striatus*, *Channa orientalis*, *Anabas testudineus*, and *Heteropneustes fossilis*. The abundantly found parasite is *Astiotrema reniferum*. *Anabas testudineus* was found to be mostly infected with the parasites (Puinyabati et al. 2010). A good number of helminths have been reported from Awangsoi fishery including four nematodes *Procammallanus saccobranchi*, *Camallanus anabantis*, *Paraquimperia manipurensis* and one juvenile stage belonging to genus *Syphacia*, five trematodes *Allocreadium handia*, *A. fasciatus*, *Astiotrema reniferum*, *Clinostomum complanatum* and *Genarcopsis goppo*, three cestodes *Djombangia penetrans*, *Capingentoides Singhi*, *Lytocestus bishnupurensis* and two acanthocephala namely *Pallisentis ophiocephali* and *Acanthocephalus* sp. (Puinyabati et al. 2013). Seasonal variation in the prevalence, intensity, and abundance of infection of nematode parasite *Camallanus anabantis* was revealed in the fish *Anabas testudineus* of Loktak Lake; 335 fishes were infected with the nematode parasites out of 460 fishes examined having maximum prevalence and intensity of infection in summer (Ranibala et al. 2013). Nine species of nematodes were recovered from the fishes of Oinam Lake. They are *Camallanus anabantis*, *Procammallanus saccobranchi*, *Paraquimperia manipurensis*, *Paragendria* sp. juvenile stage of *Syphacia*, *Haplonema*, *Spinitectus*, *Philometra* and *Parascarophis* sp. (Sangeeta et al. 2011).

Mizoram

In the recent years, Mizoram has witnessed a positive growth in aquaculture. An attempt to document the distribution and diversity of helminth infection in Freshwater Garfish *Xenentodon cancila* was made where a total of 40 specimens of host fishes were examined that reported only two taxonomic groups of helminth parasites namely trematodes and Acanthocephala. No cestodes and nematodes were recorded from the hosts in their study .

Arunachal Pradesh

Arunachal Pradesh is a network of watercourses has significant fish habitats (Nath & Dey 2000). The investigation of parasites in different catfishes of River Siang revealed maximum cestode infection in all the samples of fish species. The highest parasite burden was observed in the intestine of the fishes. Also, host fishes of the intermediate length group were mostly infected than the smaller length groups (Das et al. 2014). *Dactylogyrus barnae*, a platyhelminth (Monogeneoidea), was found infecting the gills of *Barilius barna* (Cyprinidae) captured

Table 1. The most common parasite groups in the fishes of the states of northeastern India.

State	Fish species	Most common parasite group
Assam	<i>Monopterus couchia</i>	Cestode
	<i>Anabas testudineus</i>	Nematode
	<i>Colisa fasciata</i>	Nematode
	<i>Trichogaster lalius</i>	Trematode
	<i>Trichogaster fasciatus</i>	Monogenea
	<i>Channa punctata</i>	Trematode
	<i>Channa striata</i>	Acanthocephala
	<i>Notopterus chitala</i>	Nematode
	<i>Macroglythys aral</i>	Cestode
	<i>Ompok bimaculatus</i>	Cestode
	<i>Wallago attu</i>	Cestode
	<i>Clarias batrachus</i>	Cestode
	<i>Heteropneustes fossilis</i>	Cestode
	<i>Notopterus notopterus</i>	Nematode
Meghalaya	<i>Clarias batrachus</i>	Cestodes
	<i>Heteropneustes fossilis</i>	
	<i>Labeo</i> sp.	
	<i>Cirrhinus</i> sp.	
	<i>Cyprinus</i> sp.	
	<i>Puntius</i> sp.	
	<i>Neolissocheilus</i> sp.	
	<i>Botio</i> sp.	
	<i>Garra</i> sp.	
	<i>Catla</i> sp.	
<i>Channa</i> sp.		
Arunachal Pradesh	<i>Barilius barna</i>	Monogenea (<i>Dactylogyrus barnae</i>)
Manipur	<i>Anabas testudineus</i>	Nematode, Trematode
	<i>Channa punctatus</i>	Trematodes
	<i>Channa striatus</i>	
	<i>Channa orientalis</i>	
	<i>Heteropneustes fossilis</i>	
	<i>Clarias batrachus</i>	
Mizoram	<i>Xenentodon cancila</i>	Trematode, Acanthocephala
Tripura	<i>Clarias batrachus</i>	Cestode

from the local rivers of Arunachal Pradesh. *Barilius barna* is one of the commonly exported indigenous species of ornamental fish of northeastern India (Wangchu et al. 2017).

Sikkim and Nagaland

To date, there is no published record on the occurrence of helminth parasites in the fishes of Sikkim and Nagaland.

CONCLUSION

Helminth parasites are extensively distributed in the freshwater fishes of different regions of northeastern India. Fish diseases due to helminth parasites pose a serious threat to fish health and the fishery industry. Parasitic infestation affects the physiology of the fishes, thus reducing their food value. It has been observed that most of the parasites were recovered from the intestine of the host fishes, and females were found to be mostly infested than the males. It also provides information on the variation in the prevalence, intensity, and abundance of infection seasonally. Cestode and trematode infections are comparatively higher in the fishes than nematodes and acanthocephalans. Among the studies conducted it has been observed that cestodes are the most common parasites of the fishes especially in the catfishes, however, acanthocephalans are less common. But insufficient information of most of the parasites greatly handicaps the efforts at their positive control. Therefore, it is necessary to assess the potential impact of helminth parasites in fishes to recognize the fish diseases so that essential control measures can be taken up to interrupt the steps of parasitic transmission from one host to another. Emphasis should be given to increase protein production and the rapid growth of fish. Moreover, further studies in the present study could help the scientific community and pisciculturists understand the biodiversity of parasites in different host fishes for proper aquaculture management.

Future perspectives

There is a wealth of evidences on the occurrence of helminth parasites in the freshwater fishes of northeastern India except for two states from where there is no published record on the occurrence of parasites. However, no planned investigations have been carried out to incur the loss in fish production due to parasites. Therefore, it is imperative to conduct a further ichthyo-parasitological investigation to assess the nature of parasitism and its effect on fishes. Also, preventive and therapeutic measures appropriate for farms should be taken for proper aquaculture management.

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