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REVIEW ARTICLE

A checklist of the monogenean parasites (Platyhelminthes) of fishes of northeast India

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Abstract
A checklist was generated by compiling a database of all available published accounts of the monogenean parasites of fish from northeast India. The checklist is presented as a host-parasite list, including 35 nominal species from 14 genera and 3 families of monogeneans. Ten of the monogenean species listed here have been described from native fishes in the region, while 25 had previously been described from other parts of India. Dactylogyridae was the dominant family with 33 species, followed by one species each from the family Sundanonchidae and Diplozoidae. *Wallago attu* was the most examined fish and was represented by five parasite species. This study is an important step for managing and controlling parasite diseases in regional aquaculture and also for future research on the ecology, evolutionary biology, and biogeography of monogenean parasites and their hosts. More significant efforts are needed to fully understand the diversity of monogenean parasites from the rich fish fauna of northeast India.

Keywords Monogenea · Fish parasites · Arunachal Pradesh · India

Introduction

Monogeneans (phylum Platyhelminthes) are predominantly gill parasites of fish, although some species are endoparasitic, living in the cloaca or urinary bladder of frogs (Whittington and Chisholm 2008). They are hermaphroditic, usually oviparous (with the exception of gyrodactylids), and have a direct life cycle. They are regarded as important pathogenic parasites, particularly of captive fishery (Thoney and Hargis 1991). Pandey and Agrawal (2008) estimated known nominal monogenean species from India more than 300.

The northeast India (25.5736° N, 93.2473° E), with its major drainage systems (the Brahmaputra, the Barak and the Kaladan) has an extensive ichthyofaunal diversity with 422 known species, belonging to 133 genera and 38 families (Goswami et al. 2012) (Fig. 1). These fish play a crucial role in sustaining livelihoods of the local people and contributing to economic prosperity of the region (Kumar et al. 2016). However, one of the bottlenecks in the development of fishery sector in northeast India is the increasing occurrence of parasite diseases and their poor diagnosis and management. In response to this, a host-parasite checklist of monogenean parasites from region was generated. This checklist will not only help with the surveillance of parasite diseases in regional aquaculture by identifying monogenean parasites rapidly and accurately, but it will also facilitate future research on taxonomy, biogeography, ecology, and biodiversity.

Materials and methods

All published records on monogenean species in northeast India were compiled from electronic databases such as Web of Science, Google Scholar, Scopus, and Zoological Record. In addition, a monograph authored by Pandey and Agarwal's (2008), regional literature as well as data from our own research was also included to ensure that we obtained all relevant information. The fish species names were used in

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Fig. 1 A map of northeast India along with its major river systems

accordance with Froese and Pauly (2023). The findings of this study are provided in an alphabetically arranged host-parasite list (Table 1), with hosts organised by order following Froese and Pauly (2023), and parasites organised by family following Boeger and Kritsky (1993). Monogenean species in each family are followed by the authors name and year. The next category is the location where each parasite species was found. The final category includes the bibliographical reference from which the information was taken. Host species with several parasites are only listed once.

Results and discussion

Study shows that 35 monogeneans species have been reported from 25 fish species examined to date in northeast India. Ten of 35 species have been described from the native fish of the region, while rest 25 had previously been described from other parts of India (Table 1). Dactylogyridae Bychowsky, 1933 was the dominant family with 33 species, followed by one species each from the family Sundanonchidae Malmberg, 1990 and Diplozoidae Palombi, 1949. *Wallago attu* (Bloch and Schneider, 1801) (Siluriformes, Siluridae) was represented by maximum five parasite species (*Mizellius indicus* Jain, 1957; *Thaparocleidus gomtius* (Jain, 1952) Lim, 1996; *Thaparocleidus indicus* (Kulkarni, 1969) Lim, 1996; *Thaparocleidus sudhakari* Gusev, 1976; and *Thaparocleidus yogendrai* Agarwal, 1981).

Thapa et al. (2011) conducted the first investigation of monogenean parasites in the region, reporting *Bifurcohaptor indicus* Jain, 1958 from *Mystus tengara* (Hamilton, 1822) (Siluriformes, Bagridae) and *Diplozoon cauvery* Tripathi, 1959 from *Labeo gonius* (Hamilton, 1822) (Cypriniformes, Cyprinidae) in Meghalaya. Porwal et al. (2012) described two new species of *Ancyrocephalus* Creplin, 1839 from the gills of motled loach *Acanthocobitis botia* (Hamilton, 1822) (Cypriniformes, Nemacheilidae) from Arunachal Pradesh. Chairy et al. (2013) identified 14 monogenean species from 12 hosts species collected from the Brahmaputra River in Assam. These species belonged to 10 distinct genera, indicating a rich diversity of monogenean parasites in

Table 1 Host-parasite list of monogeneans from northeast India (species described exclusively from the northeast India have been marked with an asterisk)

Sl. No.	Hosts	Parasite	Locality	Reference
Order: Anabantidae				
1.	*Anabas testudineus* (Bloch, 1792)	*Trianchoratus kearni* Price & Berry, 1966	Assam	Chairy et al. (2013)
Order: Bagridae				
2.	*Mystus bleekeri* (Day, 1877)	*Cornudiscoides agarwali* Agarwal & Vishwakarma, 1996	Arunachal Pradesh	Wangchu et al. (2021)
3.	*Mystus tengara* (Hamilton, 1822)	*Bifurcohaptor indicus* Jain, 1958	Meghalaya	Thapa et al. (2011)
4.	*Mystus vittatus* (Bloch, 1794)	*Cornudiscoides proximus* Gusev, 1976	Assam	Chairy et al. (2013)
5.	*Sperata aor* (Hamilton, 1822)	*Thaparocleidus aori* (Rizvi, 1971) Lim, 1996	Arunachal Pradesh	Wangchu et al. (2021)
Order: Belonidae				
6.	*Xenentodon cancila* (Hamilton, 1822)	*Xenentocleidus xenentodoni* (Jain, 1961) Tripathi et al. 2007	Assam	Chairy et al. (2013)
Order: Cyprinidae				
7.	*Bangana dero* (Hamilton, 1822)	*Dactylogyrus siangensis* Narba and Wangchu 2015*	Arunachal Pradesh	Narba and Wangchu 2015
8.	*Catla catla* (Hamilton, 1822)	*Dactylogyrus labei* Achmerow, 1952	Assam	Chairy et al. (2013)
9.	*Cirrhinus cirrhosis* (Bloch, 1795)	*Dactylogyrus chauhani* Gusev & Musselius, 1975	Assam	Chairy et al. (2013)
10.	*Cyprinus carpio* Linnaeus, 1758	*Dactylogyrus extensus* Mueller & Van Cleave, 1932	Assam	Chairy et al. (2013)
11.	*Garra nasuta* (Mc Clelland, 1838)	*Dactylogyrus nasutai* Narba and Wangchu 2015*	Arunachal Pradesh	Narba and Wangchu 2015
		Dactylogyrus yachuliensis Narba and Wangchu 2015*	Arunachal Pradesh	Narba and Wangchu 2015
12.	*Garra annandalei* Hora, 1921	*Dogielius kaelensis* Narba et al. (2022a) *	Arunachal Pradesh	Narba et al. (2022a)
13.	*Labeo gonius* (Hamilton, 1822)	*Dactylogyrus subtilis* Gusev, 1976	Assam	Chairy et al. (2013)
		Diplozoon cauvery Tripathi, 1959	Meghalaya	Thapa et al. (2011)
14.	*Osteobrama cotio* (Hamilton, 1822)	*Dactylogyrus kolodynensis* Trivedi et al. (2022) *	Mizoram	Trivedi et al. (2022)
15.	*Puntius sophore* (Hamilton, 1822)	*Dactylogyroides longicirrus* (Tripathi, 1959) Gusev, 1973	Assam	Chairy et al. (2013)
16.	*Tor tor* (Hamilton, 1822)	*Dactylogyrus sphyrnoides* Gusev, 1976	Arunachal Pradesh	Tripathi et al. (2016)
Order: Danionidae				
17.	*Barillus barna* (Hamilton, 1822)	*Dactylogyrus barnae* Wangchu et al. (2017) *	Arunachal Pradesh	Wangchu et al. (2017)
Order: Mastacembilidae				
18.	*Macrognathus aculeatus* (Bloch, 1786)	*Mastacembelocleidus bam* (Tripathi, 1959) Kritsky et al. 2004	Assam	Chairy et al. (2013)
Order: Nandidae				
19.	*Nandus nandus* (Hamilton, 1822)	*Sundanonchus behuri* (Agrawal & Singh, 1982) Tripathi et al. 2009	Assam	Chairy et al. (2013)
Order: Nemacheilidae				
20.	*Acanthocobitis botia* (Hamilton, 1822)	*Ancyrocephalus botia* Porwal et al. (2012) *	Arunachal Pradesh	Porwal et al. (2012)
		Ancyrocephalus cruciformes Porwel et al. (2012) *	Arunachal Pradesh	Porwal et al. (2012)
Order: Notopteridae				
21.	*Notopterus notopterus* (Pallas, 1769)	*Notopterodiscoides notopterus* (Jain, 1952) Agrawal & Vishwakarma, 1999	Assam	Chairy et al. (2013)
		Malayanodiscoides indicus Agrawal et al. (1998)	Assam	Chairy et al. (2013)
Order: Siluridae				
22.	*Ompok pabda* (Hamilton, 1822)	*Thaparocleidus malabaricus* (Gusev, 1976) Lim, 1996	Arunachal Pradesh	Wangchu et al. (2021)
		Thaparocleidus octoylus (Kulkarni, 1969) Lim, 1996	Arunachal Pradesh	Wangchu et al. (2021)
23.	*Pterocryptis indicus* (Datta et al. 1987)	*Thaparocleidus motumensis* Wangchu & Narba 2015*	Arunachal Pradesh	Wangchu & Narba 2015
		Thaparocleidus pterocriptissi Wangchu & Narba 2015*	Arunachal Pradesh	Wangchu & Narba 2015
24.	*Wallago attu* (Bloch and Schneider, 1801)	*Mizellius indicus* Jain,1957	Arunachal Pradesh	Wangchu et al. (2021)

Table 1 (continued)

Sl. No.	Hosts	Parasite	Locality	Reference
		Thaparocleidus gomtius (Jain, 1952) Lim, 1996	Arunachal Pradesh	Wangchu et al. (2021)
		Thaparocleidus indicus (Kulkarni, 1969) Lim, 1996	Arunachal Pradesh	Wangchu et al. (2021)
		Thaparocleidus sudhakari Gusev, 1976	Arunachal Pradesh	Wangchu et al. (2021)
		Thaparocleidus yogendrai Agarwal, 1981	Arunachal Pradesh	Wangchu et al. (2021)
Order: Xenocyprididae				
25.	*Ctenopharyngodon idella* (Valenciennes, 1844)	*Dactylogyrus lamellatus* Achmerow, 1952	Assam	Chairy et al. (2013)

the northeast. Narba and Wangchu (2015) described three new species of *Dactylogyrus* Diesing, 1850: *D. siangensis* from the gills of *Bangana dera* (Hamilton, 1822) (Cypriniformes, Cyprinidae) and *D. nasutai* and *D. yachuliensis* from the gills of *Garra nasuta* (Mc Clelland, 1838) (Cypriniformes, Cyprinidae). Wangchu and Narba (2015) described two new species of *Thaparocleidus* (Jain, 1952) (*T. motumensis* and *T. pterocriptissi*) from the gills of *Pterocryptis indicus* (Datta, Barman and Jayaram, 1987) (Siluriformes, Siluridae).

Tripathi et al. (2016) recorded *Dactylogyrus sphyrnoides* Gussev, 1976 from the gills of the near threatened freshwater fish *Tor tor* (Hamilton, 1922) (Cypriniformes, Cyprinidae) from Arunachal Pradesh. This species was originally described from the gills of *Barbus sarana* Hamilton, 1822 (Cypriniformes, Cyprinidae) in southern India. Wangchu et al. (2017) described *Dactylogyrus barnae* from the gills of *Barillus barna* (Hamilton, 1822), which was a new host record for *Dactylogyrus* spp., and possibly the host record report for any parasite. Tripathi et al. (2019) recovered *Cornudiscoides agarwali* Agarwal and Vishwakarma, 1996 on the gills of *Mystus bleekeri* (Day, 1877) (Siluriformes, Bagridae) from Arunachal Pradesh and also investigated the relationship between host size, seasons, and water quality parameters with the prevalence and intensity of *C. agarwali*.

Wangchu et al. (2021) documented the diversity and distribution of monogenean parasites of catfishes (Siluriformes) from Arunachal Pradesh, India, and reported 14 new species (unpublished) and 10 previously known monogeneans. Using high-resolution microscopy imaging of specimens, Narba et al. (2022a) redescribed *Dactylogyrus nasutai* Narba and Wangchu (2015) from the gills of *Garra annandalei* Hora, 1921 (Cypriniformes, Cyprinidae) (first host for a monogenean parasite) in Arunachal Pradesh. Earlier, this species was described from *G. nasuta* in Arunachal Pradesh. Narba et al. (2022b) also described *Dogielius kaelensis* from the gills of *Garra annandalei* (Hora, 1921) in Arunachal Pradesh. Trivedi et al. (2022), using morphological examination and sequencing of partial 28 S rRNA gene, described *Dactylogyrus kolodynensis* infecting the gills of *Osteobrama cotio* (Hamilton, 1822) (Cypriniformes, Cyprinidae from Mizoram.

Northeast India has a total of 422 different species of freshwater fish, which makes up 39.29% of the entire freshwater fish population in the country. With this rich diversity of fish fauna, northeast India is expected to boast a high diversity of monogeneans from the region. However, the current state of knowledge reveals a significant gap, since just 35 species of monogeneans have been recorded from 25 different fish species. This disparity becomes even more pronounced when one consider that out of the documented monogenean species, only 10 species (28.57%) were first described from northeast India, while the remaining 25 species (71.42%) consist of species that were originally described from other parts of India. Furthermore, there is a discrepancy in the contributions of regional geography. Thus, monogeneans have only been studied in Assam, Meghalaya, Arunachal Pradesh, and Mizoram. There have been no reports of monogenean parasites in the northeast Indian states of Manipur, Nagaland, Sikkim, and Tripura. Based on a reasonable assumption that each fish species harbours at least one species of monogenean parasite species (Whittington 1998), northeast India is expected to support at least 422 monogenean species. Inevitably, a substantial number of new monogenean species are awaiting their discovery from this part of the country (Tripathi 2011).

This slow pace of monogenean research has been partly due to a lack of professional parasite taxonomists in the region. This was likely caused by two things. First, the recognition and delimitation of monogenean species has traditionally relied on a highly skilled morphological examination of their sclerotised haptoral and reproductive components (Malmberg 1970; Wong et al. 2006), but the number of such specialised researchers is diminishing throughout world, including northeast India (Pearson et al. 2011). Second, the low rate of appointment of young PhDs as parasite taxonomists in the regional academic establishments has also impeded the growth of fish parasitology in general, and monogenean taxonomy and systematics in particular, in northeast India.

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Declarations

Ethical approval Since this was a review work where no animal was harmed, no ethical approval was required.

Informed consent No informed consent was required for the present study.

Conflict of interest The authors have no conflict of interest.

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