

Checklist of nematodes parasitizing fish in the Brazilian Amazon

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Review Paper

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Abstract

This study presents a list of parasitic fish nematodes from the Brazilian Amazon based on the previous Brazilian list including scientific assessments carried out between 2010 and 2021. A total of 16 families, 48 species and 28 undetermined species of nematodes associated with fish are included in the checklist, in addition to 93 host species and 15 geographical records.

Introduction

Studies on fish parasitic nematodes from the Brazilian Amazon are extremely relevant, especially in this tropical area, which still lacks taxonomic distribution and ecological data (Centers for Disease Control, 2021). Poulin (2021) discusses functional biogeography as the study of distributional or spatial patterns in biodiversity and their generating processes, where geographical patterns in parasite traits probably emerged in parallel patterns in their hosts, with the direct influence of bioclimatic factors playing a secondary role. The climate in the Amazon biome is humid equatorial with well-defined rainy and dry seasons. River levels rise and according to rainfall intensity, and some areas can become flooded, probably affecting host–parasite interactions and distributions. Updated fish nematode inventories in this specific biome are, therefore, paramount considering host–parasite interactions and their spatial distributions, especially one decade after the last checklist reported by Luque *et al.* (2011).

It is also relevant to outline that zoonotic species as food resources for low-income populations are based on artisanal fishing activities, and that health surveillance services in markets are still precarious (Cardia & Bresciani, 2012; Rodrigues *et al.*, 2017a). The generated data can be useful for planning, implementing and managing fish breeding systems and planning pest management protocols in the investigated areas, in addition to comprising an essential basis for human food security monitoring (Jennings *et al.*, 2016).

In Brazil, Rudolphi (1819), carried out the first studies on parasitic marine fish nematodes, describing a *Thunnus thynnus* (Linnaeus, 1758) parasite. Concerning freshwater fish, the first study was carried out by Diesing (1839) on *Arapaima gigas* (Schinz, 1823) nematodes, followed by Travassos *et al.* (1928) who carried out the first review of freshwater nematode fish in Brazil. More recently reviews and checklists have been published by Vicente *et al.* (1985), Thatcher (1991, 2006), Moravec (1998), Eiras *et al.* (2010) and Luque *et al.* (2011). Since then, several species have been recorded and new ones described.

Despite being considered a megadiverse area, with estimates of three million fish species (Reis *et al.*, 2016), knowledge about parasitic fish nematodes in the Amazon region are still incipient. After Moravec (1998), Thatcher (2006) reported 19 species of fish parasitic nematodes for the area, and Luque *et al.* (2011) reported 140 named species for Brazil and 41 for the Brazilian Amazon region in a review. In this context, the aim of this study is to present an updated list of fish nematodes for the Brazilian Amazon biome in addition to data contained in the last parasitic fish nematode review (Luque *et al.*, 2011), with data on hosts and geographical distribution separated by Brazilian States.

Materials and methods

A bibliographical survey on fish nematode species, host records and geographical distributions was performed considering studies in the Brazilian Amazon region from 2010 to 2021, adding these new data to those previously recorded by Luque *et al.* (2011). The searches were carried out in Zoological Records Index, PubMed, Google Scholar, Scopus and Periodicals Capes database, which makes international scientific production available for teaching and research institutions in Brazil (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, 2021).

Table 1. List of species of fish parasitic nematodes recorded in the Amazon region of Brazil, including reports by Luque *et al.* (2011) and information published until September 2021. Geographical regions: Acre (AC); Amazonas (AM); Amapá (AP); Maranhão (MA); Mato Grosso (MT); Pará (PA); Rondônia (RO); and Tocantins (TO).

Parasite family	Parasite species	Geographical region	Host	Site	Reference
	Nematoda gen. sp. ^a	AM; AP; MT	<i>Acestrorhynchus lacustris</i> (Lütken, 1875) <i>Arapaima gigas</i> (Schinz, 1822); <i>Pseudoplatystoma corruscans</i> (Spix & Agassiz, 1829)	stomach; intestine; mesentery	Rêgo & Gibson, 1989; Araújo <i>et al.</i> , 2009; Silva-Júnior & de Souza 2011
	Ascaridoidea gen. sp. ^a	AC	<i>Arapaima gigas</i>	intestine	Silva <i>et al.</i> , 2016
Anisakidae	Anisakidae gen. sp. ^a	AC; AP; PA	<i>Aequidens tetramerus</i> (Heckel, 1840); <i>Calophrys macropterus</i> (Lichtenstein, 1819); <i>Iguanodectes spilurus</i> Günther, 1864; <i>Iguanodectes spilurus</i> Günther, 1864; <i>Pellona castelnaeana</i> Valenciennes, 1847; <i>Satanoperca jurupari</i> (Heckel, 1840)	stomach; intestine; mesentery; caecum	Melo <i>et al.</i> , 2011a; Fujimoto <i>et al.</i> , 2013; Tavares-Dias <i>et al.</i> , 2014a; Rabelo <i>et al.</i> , 2017; Negreiros <i>et al.</i> , 2019a
	<i>Anisakis</i> sp. ^a	AC, AM, PA	<i>Acestrorhynchus falcatus</i> (Bloch, 1794); <i>Pimelodus blochii</i> Valenciennes, 1840; <i>Plagioscion squamosissimus</i> (Heckel, 1840); <i>Pygocentrus nattereri</i> Kner, 1858; <i>Serrasalmus altispinis</i> Merckx, Jégu & Santos, 2000; <i>Triportheus angulatus</i> (Spix & Agassiz, 1829)	gastrointestinal tract	Fontenelle <i>et al.</i> , 2016; Murrieta Morey & Oliveira Malta, 2016, 2018; Moreira <i>et al.</i> , 2017; Morais <i>et al.</i> , 2019; Cavalcante <i>et al.</i> , 2020
	<i>Contracaecum</i> sp. ^b	AC; AM; AP; MA; MT; PA	<i>Acestrorhynchus falcatus</i> ; <i>Acestrorhynchus falcirostris</i> (Cuvier, 1819); <i>Ageneiosus ucayalensis</i> Castelnau, 1855; <i>Astronotus ocellatus</i> (Agassiz, 1831); <i>Astronotus crassipinnis</i> (Heckel, 1840); <i>Astyanax</i> sp.; <i>Astyanax abramis</i> (Jenyns, 1842); <i>Brycon amazonicus</i> (Spix & Agassiz 1829); <i>Brycon hilaarii</i> Valenciennes, 1850; <i>Brycon melanopterus cope</i> , 1872; <i>Hemibrycon surinamensis</i> Géry, 1962; <i>Hoplias malabaricus</i> Bloch, 1794; <i>Hoplerythrinus unitaeniatus</i> Agassiz, 1829; <i>Macrodon ancylodon</i> (Bloch, 1801); <i>Metynniss lippincottianus</i> (Cope, 1870); <i>Metynniss hypsauchen</i> Müller & Troschel, 1844; <i>Mylossoma duriventre</i> (Cuvier, 1818); <i>Pachyurus bonariensis</i> (Boulenger, 1895); <i>Plagioscion squamosissimus</i> ; <i>Plagioscion ternetzi</i> (Steindachner, 1879); <i>Piaractus brachypomus</i> (Cuvier, 1818); <i>Pimelodus blochii</i> ; <i>Pseudoplatystoma corruscans</i> (Spix & Agassiz, 1829); <i>Pygocentrus nattereri</i> ; <i>Serrasalmus rhombeus</i> (Linnaeus 1766); <i>Triportheus angulatus</i> (Spix & Agassiz, 1829)	gastrointestinal tract; mesentery, muscle and liver	Vicente & Fernandes, 1978; Thatcher, 1981; Martins <i>et al.</i> , 2005; Saraiva <i>et al.</i> , 2006a; Lacerda <i>et al.</i> , 2009, 2012; Hoshino <i>et al.</i> , 2014, 2016; Tavares-Dias <i>et al.</i> , 2014b; Oliveira <i>et al.</i> , 2015, 2016, 2020; Oliveira & Tavares-Dias, 2016; Oliveira Ferreira & Tavares-Dias, 2017; Ribeiro <i>et al.</i> , 2016; Santos <i>et al.</i> , 2018; Brito-Junior & Tavares-Dias, 2018; Corrêa <i>et al.</i> , 2019; Cavalcante <i>et al.</i> , 2020; Carvalho <i>et al.</i> , 2020
	<i>Pseudoterranova</i> sp. ^a	AP	<i>Brachyplatystoma vaillantii</i> Valenciennes, 1840	intestine	Brito-Junior & Tavares-Dias, 2021
	<i>Terranova serrata</i> (Drasche, 1884) ^b	AM	<i>Arapaima gigas</i>	intestine	Araújo <i>et al.</i> , 2009

	<i>Terranova trichiuri</i> (Chandler, 1935) ^b	MA	<i>Bagre bagre</i> (Linnaeus, 1766); <i>Macrodon ancylodon</i> (Bloch, 1801)	intestine	Vicente & Fernandes, 1978
	<i>Terranova</i> sp. ^a	TO	<i>Plagioscion squamosissimus</i> (Heckel, 1840).	mesentery	Tavares <i>et al.</i> , 2007
Raphidascaridae	<i>Goezia spinulosa</i> (Diesing, 1839) ^b	AC; AM; MT; PA	<i>Arapaima gigas</i> ; <i>Astronotus ocellatus</i>	stomach, intestine and caecum	Santos <i>et al.</i> , 1979, 2008a; Thatcher, 1981; Araújo <i>et al.</i> , 2009; Santos & Moravec, 2009a; Menezes <i>et al.</i> , 2011; Silva <i>et al.</i> , 2016, 2017
	<i>Goezia</i> sp. ^a	PA	<i>Macrodon ancylodon</i> (Bloch & Schneider, 1801)	intestine	Fujimoto <i>et al.</i> , 2012
	<i>Hysterothylacium</i> sp. ^a	AC; AM	<i>Arapaima gigas</i> ; <i>Pimelodus blochii</i>	stomach, intestine and caecum	Andrade-Porto <i>et al.</i> , 2015; Silva <i>et al.</i> , 2016; Cavalcante <i>et al.</i> , 2020
	<i>Raphidascaris</i> (<i>Sprentascaris</i>) <i>lanfrediae</i> Melo, Giese, Santos, Santos & Portes Santos, 2011 ^b	PA; AP	<i>Geophagus argyrostictus</i> Kullander, 1991; <i>Geophagus proximus</i> (Castelnau, 1855); <i>Satanoperca jurupari</i> .	intestine	Melo <i>et al.</i> , 2011b; Pereira & Luque, 2017
	<i>Raphidascaris</i> sp. ^a	AC; PA	<i>Macrodon ancylodon</i> (Bloch, 1801); <i>Pimelodus blochii</i>	intestine	Fujimoto <i>et al.</i> , 2012; Negreiros <i>et al.</i> , 2018
	<i>Raphidascaris</i> (<i>Sprentascaris</i>) sp. ^a	AP	<i>Ancistrus</i> sp.; <i>Ancistrus leucostictus</i> ; <i>Hemiancistrus</i> sp.	intestine	Borges <i>et al.</i> , 2018
	<i>Raphidascaroides brasiliensis</i> Moravec & Thatcher, 1997 ^b	AM; PA	<i>Megalodoras uranoscopus</i> (Eigenmann & Eigenmann, 1888); <i>Platydoras costatus</i> (Linnaeus, 1758); <i>Pterodoras granulosus</i> Valenciennes, 1821	intestine	Moravec & Thatcher, 1997a; Pereira <i>et al.</i> , 2015
	<i>Raphidascaroides</i> sp. ^a	PA	<i>Satanoperca jurupari</i>	intestine	Melo <i>et al.</i> , 2011b
Ascarididae	<i>Porrocaecum</i> sp. ^a	AM; AP; PA	<i>Mylesinus paraschomburgkii</i> Santos & Ferreira, 1989	caecum	Moravec & Thatcher, 1997b
Atractidae	<i>Klossinemella iheringi</i> (Travassos, Artigas & Pereira, 1928) ^b	AM	<i>Pseudoplatystoma corruscans</i>	mesentery	Thatcher, 1981
	<i>Orientattractis moraveci</i> Cavalcante, Silva, Santos, Chagas-Moutinho, Santos, 2017 ^b	AC	<i>Pimelodus blochii</i>	intestine	Cavalcante <i>et al.</i> , 2016, 2020
	<i>Rondonia rondoni</i> Travassos, 1920 ^b	AC; MT; PA	<i>Doras granulosus</i> Valenciennes, 1821; <i>Milossoma bidens</i> ; <i>Myletes bidens</i> ; 'Pacu'; <i>Piaractus brachypomus</i> ; <i>Pimelodus clarias</i> Geoffroy Saint-Hilaire, 1809; <i>Pimelodus blochii</i> ; <i>Zungaro zungaro</i> (Humboldt, 1883)	intestine	Costa, 1963; Santos <i>et al.</i> , 1979; Cavalcante <i>et al.</i> , 2016, 2020
Camallanidae	Camallanidae gen. sp. ^a	AC	<i>Arapaima gigas</i> (Schinz, 1822).	intestine	Silva <i>et al.</i> , 2016
	<i>Camallanus</i> (<i>Camallanus</i>) <i>tridentatus</i> (Drasche, 1884) ^b	AM; PA	<i>Arapaima gigas</i> ; <i>Osteoglossum bicirrhosum</i> (Cuvier, 1829)	stomach; caecum; intestine	Ferraz & Thatcher, 1990; Araújo <i>et al.</i> , 2009; Santos & Moravec, 2009b
	<i>Camallanus acaudatus</i> Ferraz & Thatcher, 1990 ^b	AM; AP	<i>Osteoglossum bicirrhosum</i>	intestine	Ferraz & Thatcher, 1990; Rodrigues <i>et al.</i> , 2014
	<i>Camallanus</i> sp. ^a	AM; AP	<i>Astronotus ocellatus</i> ; <i>Corydoras amapaensis</i> Nijssen, 1972; <i>Corydoras ephippifer</i> Nijssen, 1972; <i>Corydoras melanistius</i> Regan, 1912; <i>Corydoras spilurus</i> Norman, 1926; <i>Hyphessobrycon amapaensis</i> Zarske & Géry, 1998; <i>Hyphessobrycon takasei</i> Géry, 1964	intestine	Thatcher, 1981; Ferreira <i>et al.</i> , 2019; Pereira <i>et al.</i> , 2019

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Table 1. (Continued.)

Parasite family	Parasite species	Geographical region	Host	Site	Reference
	<i>Paracamallanus amazonensis</i> Ferraz & Thatcher, 1992 ^b	AM	<i>Hypophthalmus edentatus</i> Spix, 1829	intestine	Ferraz & Thatcher, 1992
	<i>Procamallanus (Denticamallanus) dentatus</i> Moravec & Thatcher, 1997 ^b	AM	<i>Bryconops alburnoides</i> Kner, 1859	intestine	Moravec & Thatcher, 1997c
	<i>Procamallanus spiculastratus</i> Pinheiro, Melo, Monks, Santos & Giese, 2018 ^b	PA	<i>Astronotus ocellatus</i>	intestine	Pinheiro <i>et al.</i> , 2018a
	<i>Procamallanus</i> sp. ^b	AM; MT; PA	<i>Astronotus ocellatus</i> ; <i>Colossoma macropomum</i> ; <i>Iguanodectes spilurus</i> Günther, 1864; <i>Leporinus</i> sp.; <i>Leporinus copelandii</i> Steindachner, 1875; <i>Leporinus octofasciatus</i> Steindachner, 1915; <i>Leporinus striatus</i> Kner, 1858; <i>Pimelodus clarias</i>	stomach; intestine	Pinto <i>et al.</i> , 1975; Thatcher, 1981; Fischer <i>et al.</i> , 2003; Fujimoto <i>et al.</i> , 2013
	<i>Spirocamallanus belenensis</i> (Giese, Santos & Lanfredi, 2009) ^b (= <i>Procamallanus</i> (S.) <i>belenensis</i>)	PA	<i>Ageneiosus ucayalensis</i>	intestine	Giese <i>et al.</i> , 2009
	<i>Spirocamallanus inopinatus</i> (Travassos, Artigas & Pereira, 1928) (= <i>Procamallanus</i> (S.) <i>inopinatus</i>) ^b	AC; AP; AM; MT; PA	<i>Acestrorhynchus falcatus</i> ; <i>Acestrorhynchus falcirostris</i> ; <i>Anostomoides passionis</i> Santos & Zuanon, 2006; <i>Arapaima gigas</i> ; <i>Astronotus ocellatus</i> ; <i>Auchenipterus nuchalis</i> (Spix & Agassiz, 1829); <i>Brycon hilarii</i> ; <i>Brycon lundii</i> Lütken, 1875; <i>Brycon amazonicus</i> (Spix & Agassiz, 1829); <i>Brycon cephalus</i> (Günther, 1869); <i>Bryconops melanurus</i> Bloch, 1974; <i>Calophysus macropterus</i> ; <i>Colossoma macropomum</i> (Cuvier, 1818); <i>Corydoras amapaensis</i> ; <i>Corydoras ephippifer</i> ; <i>Corydoras melanistius</i> ; <i>Corydoras spilurus</i> Norman, 1926; <i>Harttia duriventris</i> Rapp Py-Daniel & Oliveira, 2001; <i>Hoplerythrinus unitaeniatus</i> Spix & Agassiz, 1829; <i>Hyphessobrycon takasei</i> ; Hybrid (<i>Colossoma macropomum</i> × <i>Piaractus brachypomus</i>); <i>Leporinus macrocephalus</i> Garavello & Britski, 1988; <i>Metynnis lippincottianus</i> (Cope, 1870); <i>Metynnis hypsauchen</i> ; <i>Pygocentrus nattereri</i> ; <i>Semaprochilodus insignis</i> (Jardine, 1841); <i>Squaliforma emarginata</i> (Valenciennes, 1840); <i>Triportheus angulatus</i> ; <i>Triportheus rotundatus</i> (Jardine, 1841); <i>Triportheus angulatus</i> (Spix & Agassiz, 1829)	stomach; intestine; caecum	Pinto & Noronha, 1976; Santos <i>et al.</i> , 1979; Andrade <i>et al.</i> , 2001; Andrade & Malta, 2006; Saraiva <i>et al.</i> , 2006a; Silva <i>et al.</i> , 2011; Gaines <i>et al.</i> , 2012; Gonçalves <i>et al.</i> , 2014; Tavares-Dias <i>et al.</i> , 2014b; Alcântara & Tavares-Dias, 2015; Dias <i>et al.</i> , 2015a, b; Oliveira <i>et al.</i> , 2015, 2016; Hoshino <i>et al.</i> , 2016; Santos & Tavares-Dias, 2016; Moreira <i>et al.</i> , 2017; Tavares-Dias, 2017; Ferreira <i>et al.</i> , 2019; Fujimoto <i>et al.</i> , 2018; Negreiros <i>et al.</i> , 2019a; Pereira <i>et al.</i> , 2019; Carvalho <i>et al.</i> , 2020; Ailán-Choke <i>et al.</i> , 2020
	<i>Spirocamallanus paraensis</i> (Pinto & Noronha, 1976) (= <i>Procamallanus</i> (S.) <i>paraensis</i>) ^b	PA	'Jeju'	intestine	Pinto & Noronha, 1976

	<i>Spirocamallanus pimelodus</i> (Pinto, Fábio, Noronha & Rolas, 1974) (=Procamallanus (S.) <i>pimelodus</i>) ^b	AC	<i>Pimelodus blochii</i>	intestine	Negreiros <i>et al.</i> , 2018; Cavalcante <i>et al.</i> , 2020
	<i>Spirocamallanus probus</i> (Pinto & Fernandes, 1972) (=Procamallanus (S.) <i>probus</i>) ^b	MT; RO	<i>Brycon brevicaudatus</i> ; <i>Brycon hilarii</i> ; <i>Brycon</i> sp.	intestine	Pinto <i>et al.</i> , 1974, 1976
	<i>Spirocamallanus rarus</i> (Travassos, Artigas & Pereira, 1928) (=Procamallanus (S.) <i>rarus</i>) ^b	AC; PA	<i>Pimelodus blochii</i> ; <i>Satanoperca jurupari</i>	intestine	Melo <i>et al.</i> , 2011a; Negreiros <i>et al.</i> , 2018; Cavalcante <i>et al.</i> , 2020
	<i>Spirocamallanus solani</i> (Pinto, Fábio, Noronha & Rolas 1975) (=Procamallanus (S.) <i>solani</i>) ^b	PA	Siluriformes fam. gen. sp.	intestine	Pinto <i>et al.</i> , 1975.
	<i>Spirocamallanus</i> sp. (=Procamallanus (S.) sp.) ^b	MT; PA	'Cará-cachimbo'; <i>Chalcinus nematurus</i> Kner, 1858 'Jatuarama'; <i>Lutjanus synagris</i> (Linnaeus, 1758); <i>Satanoperca jurupari</i> ; 'Peixe-Cachorro'	intestine	Pinto & Noronha, 1976; Santos <i>et al.</i> , 1979; Saraiva <i>et al.</i> , 2006a
	<i>Spirocamallanus krameri</i> (Petter 1974) ^b	PA	<i>Hoplerythrinus unitaeniatus</i>	intestine; caecum	Pinheiro <i>et al.</i> , 2020
	<i>Spirocamallanus</i> sp. ^b	AM	<i>Brycon</i> sp.	intestine	Thatcher, 1981.
Capillariidae	Capillariidae gen.sp. ^a	AM	<i>Pygocentrus nattereri</i>	intestine	Morais <i>et al.</i> , 2019.
	<i>Capillostrongyloides arapaimae</i> Santos, Moravec & Venturieri, 2010 ^b	AC; PA	<i>Arapaima gigas</i>	stomach; intestine; caecum	Santos <i>et al.</i> , 2008b; Silva <i>et al.</i> , 2016
	<i>Capillaria</i> sp. ^a	PA	<i>Iguanodectes spilurus</i>	intestine	Fujimoto <i>et al.</i> , 2013
Cucullanidae	<i>Cucullanus ageneiosus</i> Giese, Furtado, Lanfresi & Santos, 2010 ^b	PA	<i>Ageneiosus ucayalensis</i>	intestine	Giese <i>et al.</i> , 2010
	<i>Cucullanus colossomi</i> Diaz-Ungria, 1968 ^b	AP	Hybrid (<i>Colossoma macropomum</i> × <i>Piaractus brachypomus</i>)	intestine	Silva <i>et al.</i> , 2013
	<i>Cucullanus grandistomis</i> (Ferraz & Thatcher, 1988) (=Bacudacnitis <i>grandistomis</i>) ^b	AM	<i>Pseudodoras niger</i> (Vallenciennes 1833)	intestine	Ferraz & Thatcher, 1988
	<i>Cucullanus marajoara</i> Pinheiro, Santana, Monks, Santos & Giese, 2018 ^p	PA	<i>Colomesus psittacus</i> (Bloch & Schneider, 1801)	intestine	Pinheiro <i>et al.</i> , 2018b
	<i>Cucullanus opisthoporus</i> Pereira & Luque, 2016 ^p	PA; RO	<i>Cichla melaniae</i> Kullander & Ferreira, 2006; <i>Cichla piquiti</i> Kullander & Ferreira, 2006	intestine	Pereira & Luque, 2016
	<i>Cucullanus oswaldocruzi</i> Santos, Vicente & Jardim, 1979 ^b	PA	<i>Zungaro zungaro</i>	intestine	Santos <i>et al.</i> , 1979
	<i>Cucullanus (Cucullanus) pinai pinai</i> Travassos, Artigas & Pereira, 1928 ^b	AC	<i>Calophysus macropterus</i> ; <i>Pimelodus blochii</i>	intestine	Negreiros <i>et al.</i> , 2018; 2019a; Cavalcante <i>et al.</i> , 2020
	<i>Cucullanus tucunarensis</i> Lacerda, Takemoto, Marchiori, Martins & Pavanelli, 2013 ^b	TO	<i>Cichla piquiti</i>	intestine	Lacerda <i>et al.</i> , 2015

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Table 1. (Continued.)

Parasite family	Parasite species	Geographical region	Host	Site	Reference
	<i>Cucullanus</i> sp. ^b	AP; MA; PA	<i>Hemibrycon surinamensis</i> ; <i>Macrodon ancylodon</i>	stomach; intestine	Vicente & Fernandes, 1978; Fujimoto <i>et al.</i> , 2012; Hoshino <i>et al.</i> , 2014
	<i>Neocucullanus neocucullanus</i> Travassos, Artigas & Pereira, 1928 ^b	MT	<i>Brycon hilarii</i>	intestine; caecum	Saraiva <i>et al.</i> , 2006a, b
Cystidicolidae	<i>Cystidicoloides</i> sp.a	AP	<i>Hoplias malabaricus</i>	stomach; intestine; abdominal cavity	Gonçalves <i>et al.</i> , 2016
	<i>Cystidicoloides vaucheri</i> Skinker, 1931 ^b	AC	<i>Phractocephalus hemiliopterus</i> (Bloch & Schneider, 1801)	stomach	Pereira <i>et al.</i> , 2017
	<i>Pseudoproleptus</i> sp. ^a	AP; AM; PA	<i>Ageneiosus ucayalensis</i> ; <i>Acestrorhynchus falcatus</i> ; <i>Aequidens tetramerus</i> ; <i>Chaetobranchius flavescens</i> Heckel, 1840; <i>Hoplerhynchus unitaeniatus</i> ; <i>Plagioscion squamosissimus</i> ; <i>Pygocentrus nattereri</i> ; <i>Satanoperca jurupari</i>	gastrointestinal tract; mesentery	Melo <i>et al.</i> , 2011c; Tavares-Dias <i>et al.</i> , 2014b, 2017; Oliveira <i>et al.</i> , 2018; Murrieta Morey & Malta, 2018; Morais <i>et al.</i> , 2019; Souza <i>et al.</i> , 2020
Diectophymatidae	<i>Eustrongylides</i> sp. ^a	AP; AM; PA	<i>Arapaima gigas</i> ; <i>Cichla monoculus</i> Agassiz, 1831; <i>Mylossoma duriventre</i> ; <i>Serrasalmus rhombeus</i>	intestine; musculature; body surface	Santos & Moravec, 2009a; Silva & Tavares-Dias, 2012; Oliveira <i>et al.</i> , 2020
Filariidae	Filariidae gen. sp. ^b	MT	<i>Hoplias malabaricus</i>	intestine	Travassos, 1940
Gnathostomatidae	<i>Gnathostoma</i> sp. ^{a,c}	MT; PA	<i>Cichla</i> sp.; <i>Colomesus psittacus</i>	intestine	Pinheiro <i>et al.</i> , 2017; Haddad <i>et al.</i> , 2020
Guyanemidae	<i>Travassosnema travassosi paranaensis</i> Moravec, Kohn & Fernandes, 1993 ^b	AM	<i>Acestrorhynchus falcatus</i>	gastrointestinal tract	Murrieta Morey & Malta, 2018
Kathlaniidae	<i>Myleusnema brasiliense</i> Moravec & Thatcher, 1999 ^b	PA	<i>Myleus</i> sp.	intestine	Moravec & Thatcher, 1999
Pharyngodonidae	<i>Brasilnemas</i> sp. ^b	AC	<i>Pimelodus blochii</i>	intestine	Cavalcante <i>et al.</i> , 2020
	<i>Ichthyuris bursata</i> Moravec & Prouza, 1995 ^b	AM	<i>Mesonauta festivus</i> (Heckel, 1840)	intestine	Cárdenas <i>et al.</i> , 2018.
	<i>Ichthyuris nunani</i> Cárdenas, Fernandes, Justo & Cohen, 2019 ^b	MA	<i>Curimata acutirostris</i> Vari & Reis, 1995; <i>Laemolyta taeniata</i> (Kner, 1859)	intestine	Cárdenas <i>et al.</i> , 2019
	<i>Ichthyuris ovifilamentosa</i> Moravec, 2001 ^b	AM	<i>Cichlasoma</i> sp.	intestine	Moravec & Thatcher, 2001
	<i>Ichthyuris ro</i> Inglis, 1962 ^b	AM	<i>Mesonauta festivus</i>	intestine	Cárdenas <i>et al.</i> , 2018
	<i>Ichthyuris</i> sp. ^b	AM	<i>Cichlasoma</i> sp.	intestine	Moravec & Thatcher, 2001
	<i>Oxyuricassis coronatus</i> Rodrigues, Furtado, Melo & Santos, 2017 ^b	PA	<i>Lasiancistrus saetiger</i> Armbruster, 2005	intestine	Rodrigues <i>et al.</i> , 2017b
	<i>Oxyuricassis ekstromi</i> Rodrigues, Wilkens, Melo, Gardner & Santos, 2020 ^b	PA	<i>L. saetiger</i>	intestine	Rodrigues <i>et al.</i> , 2020

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	<i>Oxyuricassis hexaspinatus</i> Rodrigues, Furtado, Melo & Santos, 2017 ^b	PA	<i>L. saetiger</i>	intestine	Rodrigues <i>et al.</i> , 2017 ^b
	<i>Spinoxyuris oxydoras</i> Petter, 1994 ^b	AP	<i>Metynnis hypsauchen</i> ; <i>Metynnis lippincottianus</i>	intestine; abdominal cavity	Hoshino & Tavares-Dias, 2014; Oliveira <i>et al.</i> , 2015
Philometridae	<i>Nilonema senticosum</i> (Baylis, 1927) ^b	MT; PA	<i>Arapaima gigas</i>	general cavity; gall bladder;	Santos <i>et al.</i> , 1979; Santos <i>et al.</i> , 2008a
	<i>Philometroides acreanensis</i> Cavalcante, Moravec, Santos, 2017 ^b	AC	<i>Pimelodus blochii</i>	external wall of stomach and intestine	Cavalcante <i>et al.</i> , 2018; Negreiros <i>et al.</i> , 2019b; Cavalcante <i>et al.</i> , 2020
	<i>Philometra mirabilis</i> Moravec & Diggles, 2015 ^b	MT	<i>Cichla miriana</i> e Kullander & Ferreira, 2006	ovary	Moravec & Diggles, 2015
	<i>Philometra nattereri</i> Cárdenas, Moravec, Fernandes & Morais, 2012 ^b	AM	<i>Pygocentrus nattereri</i>	oculo-orbits; nasal mucosa	Cárdenas <i>et al.</i> , 2012
	<i>Rumai rumai</i> Travassos, 1960 ^b	PA	<i>Arapaima gigas</i>	encapsulated in tissues of mouth, tongue, operculum and head	Santos & Moravec, 2009c
Rhabdochonidae	<i>Rhabdochona (Rhabdochona) acuminata</i> Molin, 1860 ^b	AC; AP	<i>Leporinus macrocephalus</i> ; <i>Pimelodus blochii</i>	intestine	Cavalcante <i>et al.</i> , 2020; Negreiros <i>et al.</i> , 2021
	<i>Rhabdochona</i> sp. ^b	AP	<i>Callichthys callichthys</i> (Linnaeus, 1758); <i>Megalechis thoracata</i> (Valenciennes, 1840)	intestine	Cardoso <i>et al.</i> , 2018

OBS: ^alarvae; ^blarvae and adults; all others are adults; ^chuman parasite.

The following keywords were used: ‘Brazil, Amazon, fish and nematodes’. The Brazilian states that comprise the Amazon region are: Acre; Amazonas; Amapá; Maranhão; Mato Grosso; Pará; Rondônia; and Tocantins. The data are listed following parasite family and species, geographical region, host, site and related references.

Results

The new bibliographical search carried out on studies published from 2010 to 2021 on nematodes associated with fish for the Brazilian Amazon area added 80 articles, including new species descriptions, redescrptions and new geographical and host records. Forty-two of these articles reported the parasite identification at generic level and nine at the suprageneric level.

The new complete list reported herein complements the previous list by Luque *et al.* (2011) adding 14 species, four redescrptions, 125 hosts and 15 geographical records and host–parasite associations to the Brazilian Amazon Region. The overall information on the Amazon Region now contained in this checklist adds the Capillariidae Railliet, 1915 and Guyanemidae Petter, 1974 families, 35 genera comprising 48 named and 28 undetermined larval and adult nematode species belonging to 93 host species and 20 undetermined host species. All data are presented in table 1.

Discussion

In the last decade, efforts have been made by governmental institutions to form taxonomists in the field of fish parasitology and perform sampling expeditions in the area. These new researchers based in different institutions in the Brazilian states of the Amazon biome were trained and improve the research in the area. Additional expeditions in collaboration with international partners also improved the partial reports described herein. Concerning fish parasitic nematodes, our search and the 80 new articles present a current scenario different from the one seen a decade ago (Luque *et al.*, 2011) with an addition of two families and 29 species, corresponding to a 52.89% increase.

Three families presented in the Brazilian Amazon region are noteworthy: Camallanidae Railliet & Henry, 1915; Anisakidae Skrjabin & Karokhin, 1945; and Guyanemidae Petter, 1974. Camallanidae species are widely represented in the Neotropics (Moravec, 1998), infecting not only fish but also amphibians and reptiles (Anderson *et al.*, 2009). Until recently, the most accepted system for diagnosing Camallanidae genera and subgenera was based on buccal capsule morphology (Moravec, 1998) but as genetic markers became a part of integrative studies, *Procamallanus* Baylis, 1923 and *Spirocamallanus* Olsen, 1952 were considered valid as independent genera (Ailán-Choke & Pereira, 2021). Therefore, their generic names were adjusted in the current list.

Anisakidae, the largest family of nematodes, displaying zoonotic importance, currently represented by 46 species worldwide (Ángeles-Hernández *et al.*, 2020), presents 23 fish parasitic species reported in Brazil, five of them in the Amazon region (Luque *et al.*, 2011). A record of *Anisakis* sp. larvae for freshwater fish may sound strange as most species are associated to marine and brackish water. However, the ventriculus typology, without appendices, in addition to the shape of the lips and tail, may confirm the generic identification, bearing in mind that some possible definitive hosts are noted, such as the river dolphin *Inia*

geoffrensis (Blainville, 1817), widely distributed in the Amazon Basin (Silva & Martin, 2018).

Guyanemidae, with 166 valid species (Moravec, 2004), was reported by Luque *et al.* (2011) and included three parasitic fish species in Brazil, none of which were in the Amazon region. However, this family was recently recorded by Murrieta Morey & Malta (2018) in the Amazon, from a single parasitic nematode species of no zoonotic importance in the Red-tailed Freshwater Barracuda *Acestrorhynchus falcatus* (Bloch, 1794).

These data undoubtedly represent a progress concerning Brazilian research on helminthological fish parasite studies in the last decade, following global trends of increased taxonomic studies and ecological knowledge (Luque *et al.*, 2017). On the other hand, these data, when related to the size of the study area and considering that it is acknowledged as megadiverse, also indicate that the number of produced articles is still low, indicating a still-significant knowledge gap in this area. Hence, efforts to explore this megadiverse area are still required.

Conclusion

This study highlights the progress and the lack of studies on fish parasitic nematodes in the Amazon Biome region and emphasizes the need for studies in this geographical area and the need to implement and strengthen taxonomic and ecological assessments.

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Conflicts of interest. None.

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