Parasite diversity in *Oxydoras niger* (Osteichthyes: Doradidae) from the basin of Solimões River, Amazonas state, Brazil, and the relationship between monogenoidean and condition factor

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Abstract

This study describes the parasitic fauna of *Oxydoras niger* from the Coari Lake, tributary of the medium Solimões River, State of Amazonas, Brazil, and the relationship between the number of Monogenoidea and the condition factor. From a total of 27 examined fish, 70.3% were parasitised by at least one parasite species as follows: *Ichthyophthirius multifiliis* (Protozoa), *Chilodonella* sp. (Protozoa), *Cosmetocleithrum gussevi*, *C. confusus*, *C. parvum* and *Cosmetocleithrum* sp. (Monogenoidea), *Paracavisona impudica* (Acanthocephala), *Cucullanus grandistomis* (Nematoda), *Proteocephalus kuyukuyu* (Cestoda) and *Dadaytrema* sp. (Digenea). Monogenoidea helminthes were the most prevalent parasite when compared to protozoan and intestinal helminthes. This study showed that *O. niger* has a great parasite diversity composed mainly of monogenoideans followed by acanthocephalan and digenean. This is the first record of *Dadaytrema* in *O. niger* from the Brazilian Amazon. There was a positive correlation between the number of monogenoideans and the condition factor (Kn) of fish, and with this mean intensity of infection, fish welfare was not affected.

Keywords: Amazon, freshwater fish, infection, Monogenoidea, condition factor.

Diversidade de parasitos em *Oxydoras niger* (Osteichthyes: Doradidae) da bacia do rio Solimões, estado do Amazonas, Brasil, e relação entre Monogenoidea e fator de condição

Resumo

Este estudo descreve a fauna parasitária de *Oxydoras niger* do lago Coari, tributário do médio rio Solimões, estado do Amazonas, Brasil, e a relação entre o número de Monogenoidea e o fator de condição. De um total de 27 peixes examinados, 70,3% estavam parasitados por pelo menos uma espécie de parasito como segue: *Ichthyophthirius multifiliis* (Protozoa), *Chilodonella* sp. (Protozoa), *Cosmetocleithrum gussevi*, *C. confusus*, *C. parvum* and *Cosmetocleithrum* sp. (Monogenoidea), *Paracavisona impudica* (Acanthocephala), *Cucullanus grandistomis* (Nematoda), *Proteocephalus kuyukuyu* (Cestoda) and *Dadaytrema* sp. (Digenea). Helmintos monogenóideos foram os mais prevalentes quando comparados com protozoários e helmintos intestinais. Este estudo mostrou que *O. niger* apresenta grande diversidade de parasitos composta principalmente de monogenóideos seguidos de acantocéfalos e digenéticos. Este foi o primeiro relato de *Dadaytrema* em *O. niger* na Amazônia brasileira. Foi observada correlação positiva entre o número de monogenóideos e o fator de condição (Kn) e nessa intensidade média de infecção o bem-estar do peixe não foi afetado.

Palavras-chave: Amazônia, peixe de água doce, infecção, Monogenoidea, fator de condição.

1. Introduction

Fish are important for the human population in trade and economy, and constitute the main source of food in different countries, and especially in the Amazon. As the human population inevitably increases, so too has the demand for fish as a source of protein increased.

Among Amazon fish, *Oxydoras niger* Valenciennes, 1821 (Siluriformes: Doradidae) commonly called "cuiu-cuiu", is known for its good meat that looks like salmon in colour, and its importance in public markets. Distributed in the Basins of Amazonas River, Araguaia-Tocantins and Prata, considered the largest Doradidae in Amazon, is sought after for its large size, reaching up to 1.2 m long and 20 kg in weight. Its food consists of debris from the river bottom and aquatic invertebrates, mainly insect larvae, and it reproduces at the beginning of the rainy season (Santos et al., 2006).

Despite the importance of this fish for the population in some regions of the Amazon, little is known of its parasitic fauna. Parasitic fauna of this fish is composed of Monogenoidea *Cosmetocleithrum confusus* Kritsky, Thatcher and Boeger, 1986, *Cosmetocleithrum gussevi* Kritsky, Thatcher and Boeger, 1986, *Cosmetocleithrum parvum* Kritsky, Thatcher and Boeger, 1986, *Cosmetocleithrum rarum* Kritsky, Thatcher and Boeger, 1986 and *Cosmetocleithrum sobrinus* Kritsky, Thatcher and Boeger, 1986 (Kritisky et al., 1986); Branchiura *Dolops longicauda* Heller, 1857; Cestoda *Proteocephalus kuyukuyu* Woodland, 1934; Acanthocephala *Paracavisoma impudica* Diesing, 1851, Kritcher, 1957 (Thatcher, 2006) and Nematoda *Cucullanus grandistomis* Ferraz and Thatcher, 1988 (Ferraz and Thatcher, 1988; Thatcher, 2006). Though some reports on its parasitic fauna exist, nothing is known either of the parasitological indexes, nor of the condition factor in *O. niger*.

Fish may present a great diversity of parasites which depend on the fish species, food habit, temperature, climate and rainfall (Martins et al., 2009; Takemoto et al., 2009). They act as a host for a large number of parasites with varied strategies in their life-cycle. Among the factors that contribute to disease dissemination in fish are host susceptibility, fish stocking densities, the duration of the infectious process and introductions, as mentioned by Reno (1998).

Consequently, studies on fish parasitology are needed to improve the knowledge of the relationships between host and parasites (Pavanelli et al., 2004; Takemoto et al., 2004, 2009; Martins et al., 2009). These studies can indicate the fish food habit, as has been reported by Machado et al. (1996), Takemoto et al. (2004, 2009) and Martins et al. (2009). Piscivorous fish occupy the top of the food web and may present more chance of infection (Machado et al., 1996; Martins et al., 2009), while omnivorous fish present lower risks of infection by the fact that they are primary consumers in the food web (Feltran et al., 2004; Takemoto et al. (2009).

This study describes the parasitic fauna in *O. niger* from the Coari Lake, in the medium Solimões River basin, Amazonas state, Brazil. The prevalence, mean intensity of infection and condition factor relative to monogenoideans helminthes are also discussed.

2. Material and Methods

Twenty-seven *Oxydoras niger* (350 to 1,540 g and 30.5 to 49.5 cm) were collected from September to November 2009 with a net (Authorized by Ibama 11884-1) from the Coari lake, municipality of Coari (04° 00' 582" S and 063° 19' 225" W), in the medium Solimões River basin, in the state of Amazonas, Brazil, and transported to the Health and Biotechnology Institute of the Federal University of Amazonas, Coari, AM, for parasitological examination. During the period, the water temperature varied from 27.7 to 28.9 ºC and dissolved oxygen from 4.2 to 5.3 mg/L.

All fish were measured and weighed, and necropsied when observation of the internal organs was carried out. The gills and the viscera were removed and kept in saline solution 0.65% for examination under the microscope. Parasites found were isolated and fixed according to Eiras et al. (2006) for quantification (Tavares-Dias et al., 2001a,b) and identified according to Thatcher (1979, 2006), Kritsky et al. (1986), Rego et al. (1999), Ferraz and Thatcher (1988). Ecological terms followed Bush et al. (1997) and Rohde et al. (1995).

The length and weight of the hosts were used to calculate the relative condition factor (Kn) of those parasitised and non-parasitised according to Le Cren (1951). Spearman's rank correlation coefficient rs was used to determine the possible correlations between the total length of the host and the number of monogenoidean parasites, and to verify correlations between the number of monogenoideans and the relative condition factor (Zar, 1999).

3. Results

From a total of 27 examined fish, 70.3% (n = 19) were parasitised by at least one parasite species as follows: *Ichthyophthirius multifiliis* Fouquet, 1876 (Protozoa: Ciliophora), *Chilodonella* Strand, 1926 (Protozoa: Ciliophora); *Cosmetocleithrum gussevi* Kritsky, Thatcher and Boeger, 1986, *Cosmetocleithrum confusus* Kritsky, Thatcher and Boeger, 1986, *Cosmetocleithrum parvum* Kritsky, Thatcher and Boeger, 1986 and *Cosmetocleithrum* sp. (Monogenoidea: Dactylogyridae) possibly *Cosmetocleithrum bulbocirrus* Kritsky, Thatcher and Boeger, 1986. Intestinal infection represented 18.5% of the total fish examined composed of *Paracavisona impudica* (Diesing, 1851) Kritcher, 1957 (Acanthocephala: Echinorhynchidae), 3.7% by *Cucullanus grandistomis* Ferraz and Thatcher, 1988 (Nematoda: Cucullanidae), 14.8% by *Dadaytrema* (Travassos, 1931) Thatcher, 1979 (Digenea: Cladorchiniidae) and 3% by *Proteocephalus kuyukuyu* Woodland, 1935 (Cestoda: Proteocephalidae). Monogenoidean helminthes were the most abundant parasites with 70.3% of prevalence and mean intensity of 702.1 parasites, varying from 137 to 1,488 (Table 1).

Table 1. Parasitological indexes in *Oxydoras niger* from the Solimões River basin, Amazonas state, Brazil.

Parasites	EF/PF	P (%)	TNP	MI ± SD	Range	MRD
Ichthyophthirius multifiliis	27/1	3.7	50	50.0 ± 0.0	-	0.0036
Chilodonella sp.	27/1	3.7	60	60.0 ± 0.0	-	0.0043
Cosmetocleithrum spp.	27/19	70.3	13,341	702.1 ± 387.8	137-1,488	0.9775
Cucullanus grandistomis	27/1	3.7	9	9.0 ± 0.0	-	0.0006
Paracavisona impudica	27/5	18.5	161	32.2 ± 46.8	3-115	0.0118
Dadaytrema sp.	27/4	14.8	25	6.0 ± 3.2	3-10	0.0018
Proteocephalus kuyukuyu	27/1	3.7	1	1.0 ± 0.0	-	0.000

EF: examined fish; PF: parasitised fish; SD: Standard Deviation; P: Prevalence; TNP: total number of parasites; MI: mean intensity of infection; and MRD: Mean relative dominance.

There was no significant difference in the relative condition factor (Kn) of parasitised (Kn = 1.00) and non-parasitised fish (Kn = 1.00), as well as no correlation between the number of monogenoidean number and total length (rs = –0.0820, p = 0.732) of the hosts. However, a significant positive correlation was observed between the number of monogenoidean and the relative condition factor (Kn) of the hosts (Figure 1).

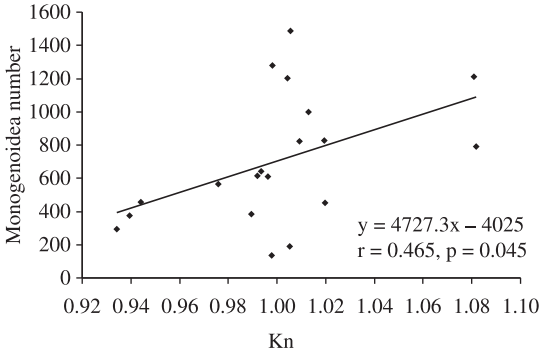

Figure 1. Correlation between Kn and Monogenoidea helminthes in the gills of *Oxydoras niger* from the Solimões River basin, Amazonas state, Brazil.

4. Discussion

In *O. niger* from the Solimões River, Monogenoideans were the most prevalent (70.3%), followed by Acanthocephala (18.5%), Digenea (14.8%), Protozoa (6.6%), Nematoda (3.7%) and Cestoda (3.7%). Nevertheless, Luque and Poulin (2007) related Digenea (33.5%) as the most abundant parasite in the Brazilian freshwater native fish followed by Nematoda (26.0%), Monogenoidea (15.2%), Crustacea (12.5%), Cestoda (11.0%) and Acanthocephala (5.0%). *Oxydoras niger* showed low prevalence and intensity of infection by *I. multifiliis* and *Chilodonella*. However, elevated intensities of these protozoan parasites are common in cultured fish (Tavares Dias et al., 2001a; Martins et al., 2002; Tavares-Dias et al., 2010), where the inadequate handling of water can facilitate their reproduction.

An important characteristic of the monogenoideans is that of their host specificity (Takemoto et al., 2004, 2009; Thatcher, 2006), also serving as a taxonomic indicator. Parasites of the genus *Cosmetocleithrum* are mostly found in Siluriformes fish (Krytisky et al., 1986), mainly Doradidae and Pimelodidae (Suriano and Incorvaia, 1995; Thatcher, 2006). Five species of monogenoideans belonging to the genus *Cosmetocleithrum* were recorded for the first time in *O. niger* and *Pterodoras granulosus* Valenciennes, 1821 in Janauacá Lake, Amazonas state, Brazil (Kritsky et al., 1986). Until now, there have been no studies of parasitic fauna of *O. niger* from the medium Solimões River, in the state of Amazonas, Brazil.

Knowledge of the condition factor is an important tool for the study of fish welfare reflecting directly on its physiology (Le Cren, 1951; Dias et al., 2004). Thus, the condition factor is a tool used to evaluate the relationship between host and parasite (Lizama et al., 2007). No correlation between the number of monogenoidean and total length of the host was found in *O. niger* in the present study, and the relative condition factor (Kn) of parasitised and non-parasitised fish was also similar. In contrast, the number of monogenoidean showed a positive correlation with Kn. Therefore, these results indicate that these parasites did not affect the health of fish. Similarly, Azevedo et al. (2007) did not find correlation between the abundance of the monogenoideans and acanthocephalans in *Astronotus ocellatus* Agassiz, 1831 from the Guandu River, RJ. However, abundance of *Cichidogyrus* presented a negative correlation with the standard length and also with the Kn in cultured *Oreochomis niloticus* Linnaeus, 1757 (Lizama et al., 2007).

Four species of monogenoideans (*C. gussevi*, *C. confusus*, *C. parvum* and *C. bulbocirrus*) were found and presented the greatest intensities in *O. niger* in the present study. They showed a positive correlation with Kn. This elevated mean intensity was similar to that related in cultured *Piaractus mesopotamicus* Holmberg, 1884 (Tavares-Dias et al., 2001b) and larger than that related in *A. ocellatus* in Guandu River, RJ (Azevedo et al., 2007) and ornamental fish from the Negro River, AM (Tavares-Dias et al., 2010). Our results confirm that monogenoideans are among the most common fish parasite that occurs in several environments. High infection levels observed in this study show that they can be present sometimes in a quantity greater than that observed in cultured fish. Its reproduction can be favoured

by the lentic habitat since these parasites have a direct life-cycle (Pavanelli et al., 2004). Graça and Machado (2007) suggested that the fish habitat feeding on the bottom facilitate the suspension of monogenoidean eggs. In fact, this occurred in cichlid fish from the Ingá Park, Maringá (PR). This may explain the elevated number of monogenoidean in *O. niger* in this work. The food habit on predating debris and invertebrates from the bottom of the River is likely responsible for ressuspension of monogenoidean eggs.

On the other hand, Nematoda are the most frequent endohelminthes in populations of wild fish, constituting a significant part of parasite fauna of the hosts in several environments. In *O. niger*, low infection levels were observed by *C. grandistomis* as also reported by Machado et al. (1996) in fish from the high Paraná River parasitised by *C. pinnai*, *Procamallanus inopinatus* Travassos, Artigas and Pereira, 1928, *P. iheringi* Travassos, Artigas and Pereira, 1928, *Piavussunema schubarti* Kohn, Gomes and Motta, 1968, by Santos et al. (2003) in fish from the Paraguai River, MS parasitised by *Cucullanus* sp. and by Bachmann et al. (2007) in *Pimelodus maculatus* Lacépède, 1803 parasitised by *P. pimelodus* Pinto, Fabio, Noronha and Tayt-Son Rolas, 1974. However, high parasitological indexes by *Cucullanus pinnai* Travassos, Artigas and Pereira, 1928 in *P. maculatus* from the Guandu River, RJ (Santos et al., 2007) and by *P. inopinatus* in *Leporinus friderici* Bloch, 1794 and *Leporinus obtusidens* Valenciennes, 1837 (Feltran et al., 2004) were observed. As expected the high intensity of infection by these helminthes are related to the food habit of the host. Carnivorous fish may present more possibility of infection because they occupy the top of the food web as compared to that observed for omnivorous fish like *O. niger*, which eats debris, aquatic invertebrates and insect larvae (Santos et al., 2006). In this case, they present lower risk of infection (Machado et al., 1996; Pavanelli et al., 2004) or other factors could be involved in this process.

In general, in fish, the acanthocephalan life-cycle involves a definitive host and an intermediate host which could be an arthropod amphipod, ostracod or copepod (Tantaleán et al., 2005; Thatcher, 2006). However, some species present in their life-cycle the paratenic hosts (Takemoto et al., 2004; Thatcher, 2006; Azevedo et al., 2007). Azevedo et al. (2007) argued that the principal factor regulating the prevalence and intensity of infection of acanthocephalan is the predation of the intermediate hosts. In the present study, low prevalence and mean intensity were found similar to *Polymorphus* sp. in *A. ocellatus* from the Guandu River, RJ (Azevedo et al., 2007). Sometimes, depending on the environment, acanthocephalans can reach high levels of infection in fish as commented by Martins et al. (2001). *Paracavisona impudica* was also reported in *O. kneri* from the Pantanal Mogrossense (Rego and Vicente, 1988; Eiras et al., 1995) and in *O. niger* from Pucallpa, Peru (Tantaleán et al., 2005). Hence, it can be inferred by these observations that this acanthocephalan species is specific to the Doradidae and *Oxydoras* genus.

From the intestine of only one specimen of *O. niger* from the Solimões River, 115 worms were collected, adhered to the intestinal wall that caused granuloma on their site of attachment. In *O. kneri*, an elevated parasitism by *P. impudica* caused fibrosis surrounding the attachment site of the proboscis (Eiras et al., 1995; Takemoto et al., 2004). Histopathological studies showed little effects of these parasites on the host, but in severe infections, can cause intestinal obstruction, malnutrition, low muscle development (Takemoto et al., 2004), as well as complete desquamation of the intestinal epithelium with severe hyperplasia and hypertrofia of the goblet cells, severe inflammatory reaction at the submucosa, oedema and mononuclear and eosinophilic infiltration (Martins et al., 2001).

Digenea are trematode endoparasites that have a complex life-cycle and are always heteroxenic generally involving two hosts. They can be found in the organs of the definitive hosts (Thatcher, 2006; Takemoto et al., 2009) or as metacercariae encysted (Bachmann et al., 2007). In the present study low parasite load by *Dadaytrema* sp. were observed when compared to *Dadaytrema oxycephala* Diesing, 1836 from *P. mesopotamicus* in rivers of the Pantanal Sul-Matogrossense (Santos et al., 2003). *Dadaytrema oxycephala* has been listed for several freshwater fish species since it is widely distributed in Brazil (Thatcher, 2006; Kohn et al., 2007). In the Amazon, it is a common parasite of the *Piaractus brachypomus* Cuvier, 1818 and *P. granulosus* (Thatcher, 2006). Nevertheless, no species has been related in *O. niger* up until now.

Martins et al. (2009) noticed that moderate infection rates by proteocephalidean cestodes have been registered in fish from several parts of the world, since this endohelminthes is distributed uniformly in several aquatic habitats (Pavanelli et al., 2004). In that opportunity, Martins et al. (2009) found high parasite load by *Proteocephalus macrophallus* (Diesing, 1850) Scholz, Chambrier, Prouza and Royero 1996 and *P. microscopicus* Woodland, 1935 in *Cichla piquiti* Kullander and Ferreira, 2006 from the Volta Grande Reservoir, MG, Brazil. Those authors explained that the exotic characteristic of the host, its piscivorous habit constituted by small fish of the same species could be facilitating the transmission of the cestodes.

Planktonic crustaceans, diaptomid or cyclopoid copepods serve as intermediate hosts of the *Proteocephalus* species. A metacestode or procercoid develops in the body cavity of these crustaceans and the definitive host, a fish, becomes infected directly after consuming them (Scholz, 1999). Consequently, proteocephalidean infection in small fish by the ingestion of these crustaceans may contribute to improve the prevalence rate and the intensity of infection in the largest hosts as the fish of carnivorous habit (Martins et al., 2009). In the present study, the prevalence (3.7%) and mean intensity (1.0) of *P. kuyukuyu* was lower than that observed for *P. macrophallus* and *P. microscopicus* (83.3 and 110.8, respectively) in *C. piquiti*, a piscivorous fish from the Volta Grande Reservoir, MG (Martins et al., 2009). These low indexes of infection in *O. niger* can be

explained by the detritivorous feeding habit of this fish (Santos et al., 2006). It is likely that *O. niger* is feeding on infected crustacean from the bottom of the river favouring transmission.

Relative condition factor indicates the welfare of fish on the environment. Dias et al. (2004) and Santos and Brasil-Sato (2006) did not observe any negative effect of the infection by *Rondonia rondoni* Travassos, 1920 (Nematoda) on the condition factor of *P. granulosus* and *Franciscodoras marmoratus* Reinhardt, 1874. On the other hand, the monogenoidean *Cichlidogyrus* Paperna, 1960 showed a negative correlation to the prevalence and parasitism in cultured tilapia *Oreochromis niloticus* Linnaeus, 1758 (Lizama et al., 2007). As the parasite load increases, the body condition or welfare of fish can be affected. By contrast, in the present study, the condition factor increased as the parasite number increased together. From this point of view, it appears that the parasite infection by monogenoidean on *O. niger* do not affect negatively the fish condition. A positive correlation between the condition factor and *Dadayus pacupeva* Lacerda, Takemoto and Pavanelli, 2003 (Digenea) and *Spinoxyuris oxydoras* Peter, 1994 (Nematoda) in *Metynnis lippincottianus* Cope, 1870 was also related by Moreira et al. (2010). They attributed this finding to low pathogenic effect of the parasites.

In conclusion, we found in this study that the most prevalent parasite was Monogenoidea, a direct life-cycle parasite, different from the others like nematodes and digeneans endohelninthes. If the water condition favours parasite reproduction, in a few days the number of parasites can increase and cause damage to fish health. It must be also remembered that this fish are living in a natural environment and when they are exposed to stressful conditions, the relationship parasite-host-environment might alter.

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