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Parasitic macrofauna of *Podocnemis unifilis* from the Tocantins and Javaés Rivers, Eastern Amazon, Brazil[1]

Ana Beatriz N. Ribeiro[2]*, Danilo N. Santana[3], Jonatas C. Souza[3], Marcos S.B. Oliveira[4], Marcela S. Magalhães[5], Adriana Malvasio[2] and Kellen L.F. Silva[2]

ABSTRACT.- Ribeiro A.B.N., Santana D.N., Souza J.C., Oliveira M.S.B., Magalhães M.S., Malvasio A. & Silva K.L.F. 2023. **Parasitic macrofauna of *Podocnemis unifilis* from the Tocantins and Javaés Rivers, Eastern Amazonia, Brazil.** *Pesquisa Veterinária Brasileira 43:e07283, 2023*. Laboratório de Anatomia Vegetal e Técnicas Histológicas, Universidade Federal do Tocantins, Av. NS 15, Quadra 109 Norte, ALCNO-14, Prédio Lamadrid, Palmas, TO 77001-090, Brazil. E-mail: ana.ribeiro@ueap.edu.br

The parasitic fauna of Podocnemididae species is of great relevance to understanding the ecological relationships of the organisms in this genus. The parasites can have a symbiotic relationship with their hosts; however, environmental imbalances may change this relationship. Therefore, these parasites may become agents that generate zoonoses, especially in animals used by parasites as a food source. The aim of this study was to investigate the gastrointestinal parasitic fauna of specimens of *Podocnemis unifilis*. The animals were collected from the Tocantins and Javaés Rivers, both of which flow in the State of Tocantins, predominantly in the Cerrado territory. Samples of stomach and intestinal contents were fixed in 10% formalin buffered with sodium phosphate, transferred to 70% alcohol for analysis, and separated after 72 hours. Parasites were isolated and identified according to morphology and identification key. Four species of parasites were observed in 100% of specimens of *P. unifilis*, namely *Nematophila grandis* (Trematoda) and *Paratractis hystrix*, *Paraorientatractis semiannulata*, and *Orientatractis leiperi* (Nematoda). *N. grandis* was the only parasite that was not observed in the intestine; it appeared to adhere to the inner wall of the stomach. All nematodes were observed both in the stomach and intestine. These data expand the knowledge related to the *P. unifilis* parasitic fauna and the geographic distribution of these parasites in *P. unifilis* from the Tocantins and Javaés Rivers.

INDEX TERMS: Endoparasites, parasites, yellow-spotted river turtle, *Podocnemis unifilis*, Amazon.

RESUMO.- [**Macrofauna parasitária de *Podocnemis unifilis* dos rios Tocantins e Javaés, Amazônia Oriental, Brasil.**] A fauna parasitológica das espécies de Podocnemididae é de grande relevância para o conhecimento das relações ecológicas desse grupo de vertebrados. Os parasitos podem ocorrer em simbiose com os seus hospedeiros sem causar danos, mas o desequilíbrio ambiental pode causar um desequilíbrio nessa relação e, assim, serem agentes geradores de zoonoses, especialmente em animais que são utilizados como recurso alimentar. Esta pesquisa fez o levantamento da fauna parasitária gastrointestinal de espécimes de *Podocnemis unifilis*. Os animais foram coletados no rio Tocantins e Javaés, ambos no Estado do Tocantins, em território predominante de Cerrado. As amostras de conteúdo estomacal e intestinal foram fixadas em formol a 10% tamponado em fosfato de sódio, transferidas para álcool 70% para análise e separação após 72 horas. Os parasitos foram separados e identificados de acordo com morfologia e chave de identificação. Foram encontradas quatro espécies de parasitos com prevalência em 100% dos espécimes de *P. unifilis*, sendo elas *Nematophila grandis* (Trematoda) e *Paratractis hystrix*, *Paraorientatractis*

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[2] Graduate Program in Environmental Sciences, Universidade Federal do Tocantins (UFT), Av. NS 15, Quadra 109 Norte, ALCNO-14, Prédio Lamadrid, Palmas, TO 77001-090, Brazil. *Corresponding author: ana.ribeiro@ueap.edu.br

[3] Curso de Ciências Biológicas, Universidade Federal do Tocantins (UFT), Campus Porto Nacional, Rua 03 s/n, Quadra 17 Lote 11, Jardim do Ipês I, Porto Nacional, TO 77500-000, Brazil.

[4] Graduate Program in Tropical Biodiversity, Universidade Federal do Amapá (UNIFAP), Campus Marco Zero do Equador, Rodovia Juscelino Kubitschek Km 02, Bloco T, Bairro Universidade, Macapá, AP 68903-419, Brazil.

[5] Departmento de Morfologia, Universidade Federal do Amazonas (UFAM), Av. General Rodrigo Octavio Jordão Ramos 1200, Coroado I, Manaus, AM 69067-005, Brazil.

semiannulata e *Orientatractis leiperi* (Nematoda). Somente *N. grandis* não foi observado no intestino, sendo encontrado somente aderido à parede interna do estômago. Todos os nematoides foram observados no estômago e intestino. Esses dados ampliam o conhecimento sobre a fauna parasitária de *P. unifilis*, e aumentam o conhecimento sobre a distribuição geográfica desses parasitos em *P. unifilis* dos Rios Tocantins e Javaés.

TERMOS DE INDEXAÇÃO: Endoparasitos, parasitos, tracajá, *Podocnemis unifilis*, Amazônia.

INTRODUCTION

Parasites occur in all types of environments and can establish symbiotic relationships with organisms. The characteristics of the ecological niche of the hosts indicate the presence of certain parasite groups, and the diversity of these groups depends on diet, habits, environmental changes, and overlapping habitats between species. In addition, parasites can organize themselves differently when they use generalist species as hosts (Aho 1990, Monteiro 2017).

Changes and fluctuations in environmental characteristics may cause parasite proliferation and negatively affect the health of animals and their habits, as they modify the quality of life of the hosts. Changes in the environment such as excess organic matter, exposure to chemical residues, and constant degradation have been hypothesized to be important factors that contribute to changes in animal health (Machado et al. 2007).

Symbiosis occurs naturally among organisms; however, imbalances that lead to the degradation of animal health may have implications for human health, e.g., in cases when the hosts are a source of food (Nunes et al. 2010). Although studies on parasitism are more focused on human health risks, Schuller (2004) reported the importance of knowledge about ecological relationships and interactions between wild animals, especially those used as food. This knowledge can provide useful information related to the prevention of zoonosis transmission and about relationships in the food chain.

Parasites infect the gastrointestinal tract of vertebrates through food, and in some cases, they may enter the host accidentally. Several parasites reportedly infect reptiles (Monteiro 2017), of which the following three main groups have been identified for chelonians: Platyhelminths (flatworms), Nematelminths (cylindrical worms), and Acanthocephala (Cagno 2006). In the yellow-spotted river turtle ("tracajá" in Brazilian portuguese) (*Podocnemis unifilis*), 17 species of parasitic helminths (Nematoda, Trematoda, Cestoda, Monogenoidea, and Acanthocephala) listed in the literature have been identified (Mascarenhas & Müller 2021).

Podocnemis unifilis, a chelonian, is widely distributed in the Amazon and is intensively consumed by residents of riverside and traditional communities. *P. unifilis* has the plasticity to adapt to different environments and its carapace can reach a length of 50cm (Ferrara et al. 2017). It predominantly feeds on plant material – including leaves, stems, fruits, seeds, stalks, and aquatic plants – and, to a lesser extent, on small mollusks and insects, as well as sediments (Portal et al. 2002, Balensiefer & Vogt 2006, Garcez 2012). Mollusks are intermediate hosts of parasites in the phylum Platyhelminthes (Martins 2019), and these parasites are commonly observed in chelonians of the genus *Podocnemis* (Cagno 2006, Picelli et al. 2015, Mascarenhas & Müller 2021).

The diet of these animals is closely linked to the diversity of parasites found throughout their digestive tract, which ensures the maintenance of the host and parasite species' life cycles, i.e., survival, nutrition, and perpetuation. Understanding the gastrointestinal parasitism of these animals is crucial to achieving the favorable management of the species; this is because cases of inharmonious parasitism may become have applications in controlling the population of a species in an ecosystem (Menegaldo 2016). In addition, *P. unifilis* is widely consumed by certain groups of people, so the risks of exposure to unknown pathogens through the consumption of these wild animals must be considered.

The field of chelonian parasitology is progressing slowly, with few published studies. The most common parasites in the *Podocnemis* genus are *Nematophila grandis*, and *Telorchis aculeatus*. *Loefgrenia loefgrenii, Sauroplasma* sp., and *Haemogregarina* sp. (Armond 2008, Picelli et al. 2015, Carvalho 2016, Menegaldo 2016, Carvalho et al. 2017, Carvalho & Malvasio 2018). However, these groups of parasites may show intraspecies variations. The aim of this study was to investigate the parasitic macrofauna in the gastrointestinal tract of *P. unifilis* collected in two rivers of the state of Tocantins.

MATERIALS AND METHODS

Animal Ethics. This study was approved by the "Sistema de Autorização e Informação em Biodiversidade" (SISBIO) with license No. 69837, under "Authorization for activities with a scientific purpose", and by the Ethics Committee on the Use of Animals (CEUA) of the "Universidade Federal de Tocantins" (UFT), Araguaína Campus, under Process No. 23101.002389/20-31.

Study area. Eighteen specimens of *Podocnemis unifilis* (Testudines, Podocnemididae) were collected from the following two locations: nine specimens from the middle Tocantins River and nine from the Javaés River. The first location was present downstream of the Luiz Eduardo Magalhães Hydroelectric Power Plant reservoir, near the municipality of Tupiratins, between coordinates 8°23'11.2" S 48°06'50.1" W and 8°14'16.4" S 48°08'35.5" W. The second location was present in the Araguaia River basin, bordered by the indigenous lands of the Javaé and Karajá ethnic groups, the Araguaia National Park, the Cantão State Park, the Canguçu Private Natural Heritage Reserve (RPPN), and the Ilha do Bananal/Cantão Environmental Protection Area (APA), between coordinates 10°08'45.3" S 49°59'49.8" W and 9°54'47.9" S 50°06'48.5" W.

The areas were selected while accounting for the different characteristics of anthropogenic influence and protection of the banks of each river. The dynamics of the Tocantins River are specifically related to the changes in its banks as a consequence of human occupation and expansion of agricultural areas dating back to the Brazilian colonial period (Oliveira & Rocha 2014, Bayer et al. 2020). Several protected areas line the banks of the Javaés River, and the chemicals and sediments from the Araguaia River flow into these areas and directly influence them.

Capture, euthanasia, and sampling. The specimens were captured according to the methods described by Malvasio et al. (2019) using a fishing line with attractive baits such as corn and soybeans, chasing the animal in the water after seeing it on the riverbed, as well as capturing females performing reproductive activity on the beach at night. After collection, each animal was biometrically measured according to Ribeiro (2012), i.e., they were weighed on a digital scale

and the maximum curvilinear length of the carapace (CL) was measured using a millimeter tape measure. All animals were transported to the Plant Anatomy and Histological Techniques laboratory of the UFT for euthanasia and to remove their stomach and intestines.

Euthanasia was performed according to the protocol of the "Conselho Federal de Medicina Veterinária" (Federal Council of Veterinary Medicine – CFMV) Resolution 1000/2012 (CFMV 2012) and Malvasio et al. (2021). The stomach and intestines were weighed separately and the stomach fullness index was classified into the following four levels: I) Completely full stomach; II) Partially full stomach; III) Partially empty stomach; and IV) Empty stomach, which respectively corresponded to the stomach content percentages of 68% to 100%, 34% to 67%, 1% to 33%, and 0% (Namora 2003, Dolphine 2014) (Table 1).

Longitudinal sections of the organs were prepared to remove the food contents and locate and separate the parasites. The stomach contents were fixed in 10% formaldehyde buffered in sodium phosphate for 72 hours and immersed in 70% alcohol for storage using a protocol adapted from that reported by Caputo et al. (2010) and Tamiasso et al. (2018). They were subsequently homogenized and separated into three parts of similar weight for separation and identification based on Gibson et al. (2002), Monteiro (2017), and Martins (2019) using identification keys for morphological characters.

The collected parasites were identified using morphological characters according to Sarmiento (1959), Buckley (1969), Gibbons et al. (1997), Fernandes & Kohn (2014), and Jesus et al. (2020).

Table 1. Fullness indices for assessing stomach contents

Stomach contents	Indice	Corresponding
Full stomach	1	68 to 100%
Partially full stomach	2	34 to 67%
Partially empty stomach	3	1 to 33%
Empty stomach	4	0

Described in Namora (2003) and Dolphine (2014).

RESULTS

The stomach contents of 18 *Podocnemis unifilis* specimens were analyzed. The mean size and weight of the nine specimens from the Tocantins River were 18.5cm and 676g and those of the nine specimens from the Javaés River were 17.9cm and 753.4g, respectively. All *P. unifilis* specimens had a high number of parasites in the stomach, which was classified as index I (completely full). Considering that the aim of this study was to identify the parasite fauna, only the mean number of identified and counted parasites was recorded (Table 2).

The collected parasites were *Nematophila grandis* (Diesing, 1839) (Digenea) – which occurred only in the stomach – and *Paratractis hystrix* (Diesing, 1851), *Paraorientatractis semiannulata* (Gibbons, Khalil, & Marinkelle, 1997), and *Orientatractis leiperi* (Buckley, 1969) (Nematoda) – which occurred in the stomach and intestines. All specimens of *P. unifilis* were parasitized by all four parasite species. In the stomach, *N. grandis* was observed to adhere to the stomach wall and *P. hystrix*, *P. semiannulata*, and *O. leiperi* were in the food content (Fig.1 and 2). In the intestine, the parasites were found in the digested or fecal material, with no adhesions to the intestinal walls. Their number in the intestines was small, which leads us to believe that they occurred accidentally during the digestive process.

Approximately 40% of the stomach contents comprised *P. semiannulata* and *O. leiperi* parasites. Plant, animal, and sediment content was detected in addition to parasites.

Considering that a large amount of *P. semiannulata* and *O. leiperi* were found in the stomach, it was only possible to count the *N. grandis* and *P. hystrix* parasites.

Analyses of the stomachs of animals from the Tocantins and Javaés Rivers had a mean number of 6.6 and 7.4 specimens of *N. grandis* and 1,014 and 1,773 specimens of *P. hystrix* respectively.

Table 2. Biometric data and parasite counts *Paratractis hystrix* and *Nematophila grandis*

Specimen	Gender	Local (River)	Length (cm)	Specimen weight (g)	Fullness indices	*P. hystrix*	*N. grandis*
04	Male	Tocantins	16	761	I	830	5
06	Female	Tocantins	26.5	1621	I	180	7
07	Female	Tocantins	17.9	536	I	1520	7
08	Male	Tocantins	21	801	I	900	11
09	Female	Javaés	25.2	1370	I	3010	4
11	Female	Javaés	15	332	I	640	8
12	Female	Javaés	13.2	252.4	I	300	9
13	Male	Javaés	18.9	222.1	I	1360	6
14	Female	Javaés	18,6	525	I	2260	5
15	Male	Javaés	18	472	I	2160	9
16	Male	Javaés	20	707	I	2910	9
17	Male	Javaés	20.2	744	I	350	10
19	Male	Javaés	23.3	1124	I	2970	7
21	Male	Tocantins	16.0	384	I	1640	7
22	Female	Tocantins	15.2	372	I	890	4
23	Male	Tocantins	15.9	353	I	1140	5
24	Male	Tocantins	13.6	718	I	1140	5
25	Female	Tocantins	16.5	538	I	890	8
Mean (Tocantins River)			18.5	676	I	1014	6.6
Mean (Javaés River)			17.9	753.4	I	1773	7.4

***Nematophila grandis* (Diesing, 1839)**

Kingdom Animalia, phylum Platyhelminthes, class Trematoda, family Cladorchiidae, subfamily Schizamphistominae, genus *Nematophila*.

Description: Species belonging to the subclass Digenea, and its two phylogenetically distinct hosts throughout its life cycle – three hosts in rare exceptions – primarily include a mollusk and then a vertebrate, and in most cases fish and reptiles (Gibson et al. 2002, Hickman Jr. et al. 2002). It is a ventrally flattened animal – as described by Armond (2008) – with an oral sucker with basal diverticula, a basal cirrus pouch, a short pharynx and esophagus, a bifurcated genital pore, and a dorsally positioned uterus, with extracecal lateral vitelline follicles. (Fig.3 and 4)

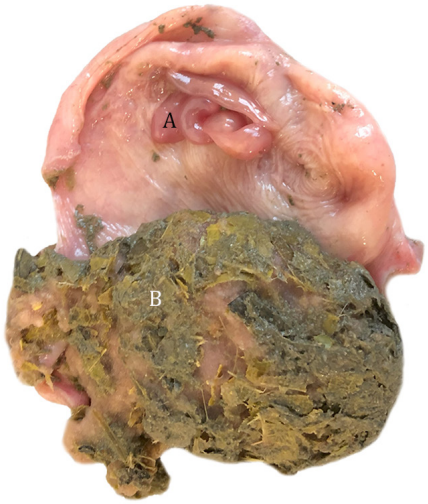


Fig.1. Nematophila grandis adhered to the stomach wall (A) after sectioning and removal of the stomach contents (B) (parasites in situ).

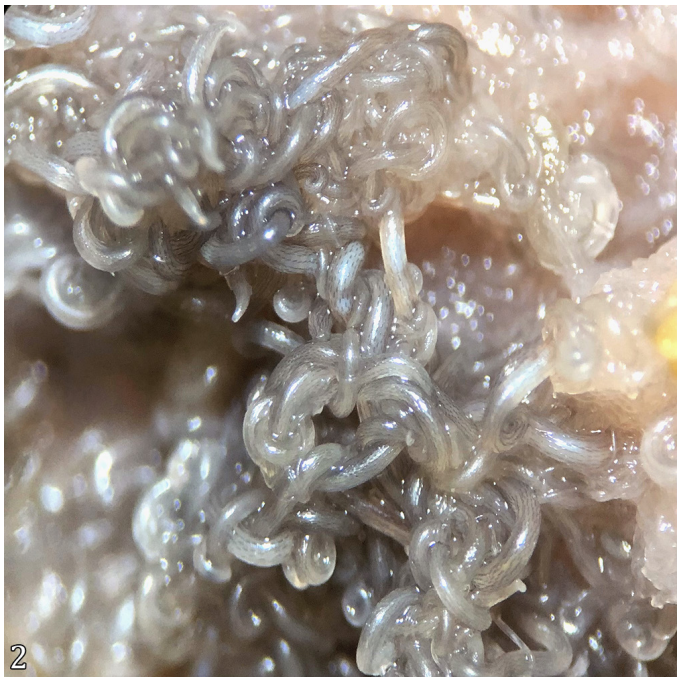


Fig.2. Food bolus viewed through a Leica M165C electronic magnifying glass with an attached camera for separating and counting parasites (parasites *in situ*).

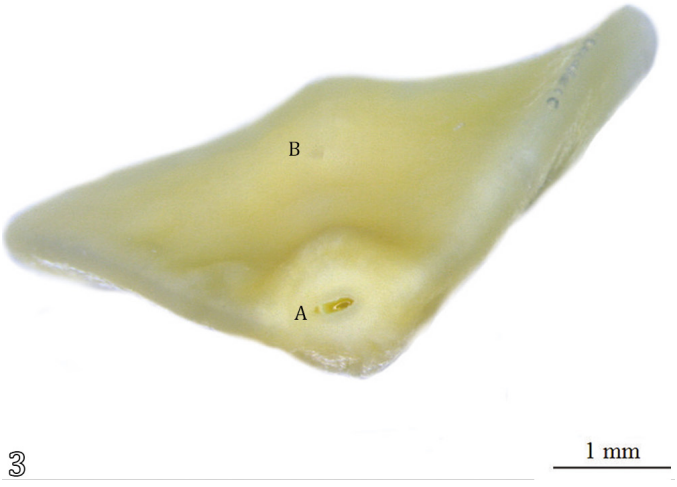


Fig.3. Nematophila grandis. View of the acetabulum (A) and genital pore (B). Image in Leica M165C electronic magnifier with attached camera.

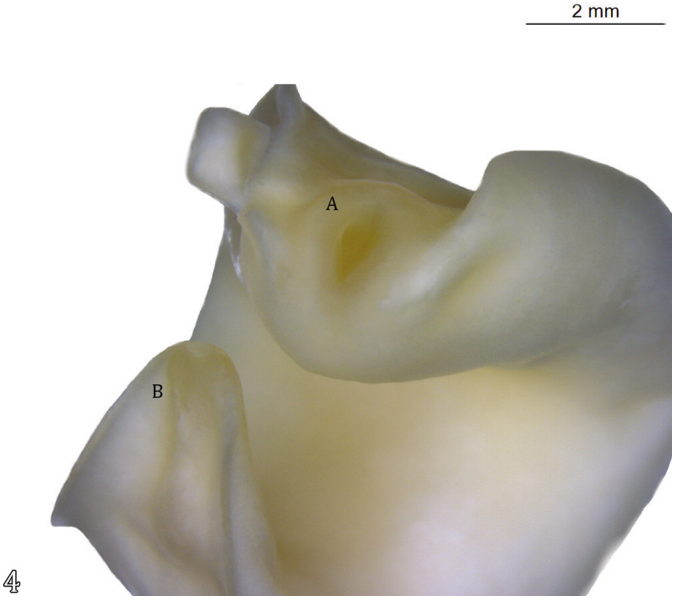


Fig.4. Nematophila grandis. View of the acetabulum (A) and mouth (B). Image in Leica M165C electronic magnifier with attached camera.

Host: *Podocnemis unifilis.* Habitat: Stomach.

Location: Javaés River, near the Araguaia National Park and Cantão State Park (9°58'53.4" S, 50°03'04.1" W); and Tocantins River, in the municipalities of Tupiratins and Itapiratins (8°19'59.9" S, 48°07'58.2" W).

***Paratractis hystrix* (Diesing, 1851)**

Kingdom Animalia, phylum Nematoda, class Secernentea, order Ascaridida, family Atractidae, genus *Paratractis.*

Description: It has a cylindrical body and transverse striae visible mainly on the anterior portion; the cuticle has pointed and conical projections. The specimens of this family are usually small compared to other families, with three or six lips (indistinct or prominent, respectively), an esophagus divided into two parts, with a bulb separated from the rest of the organ in the posterior portion of the esophagus, and no diverticula in the intestine. Males lack preanal suckers, they may have proportional or non-proportional gubernacula and spicules, whereas females have a tapered tail (sexual dimorphism), a simple ovary, and a vulva located in the posterior region, and are viviparous (the embryonic development occurs inside the female's body). This family has the characteristic of parasitizing vertebrates (Vicente et al. 1993). (Fig.5 and 6)

Host: *Podocnemis unifilis.* Habitat: Stomach and intestines.

Location: Javaés River, near the Araguaia National Park and Cantão State Park (9°58'53.4" S, 50°03'04.1" W); and Tocantins River, in the municipalities of Tupiratins and Itapiratins (8°19'59.9" S, 48°07'58.2" W).

***Paraorientatractis semiannulata* (Gibbons, Khalil & Marinkelle, 1997)**

Kingdom Animalia, phylum Nematoda, class Secernentea, order Ascaridida, family Atractidae, genus *Paratractis.*

Description: Parasite described by Cagno (2006) for *Podocnemis cayennensis*. They have an elongated, dorsoventrally flattened, and striated body, with rings on the back, which give the species its name. The entire dorsal surface is covered by semi-rings, like ridges, and the anterior region is widened at the lips and thinned in the posterior region (Gibbons et al. 1997). (Fig.7)

Host: *Podocnemis unifilis.* Habitat: Stomach and intestines.

Location: Javaés River, near the Araguaia National Park and Cantão State Park (9°58'53.4" S, 50°03'04.1" W); and Tocantins River, in the municipalities of Tupiratins and Itapiratins (8°19'59.9" S, 48°07'58.2" W).

***Orientatractis leiperi* (Buckley, 1969)**

Kingdom Animalia, phylum Nematoda, class Secernentea, order Ascaridida, family Atractidae, genus *Orientatractis.*

Description: This parasite was first observed in *Podocnemis vogli* in the Amazon by Buckley (1969). The parasite was analyzed in *P. unililis* in the Brazilian Amazon, as described by Jesus et al. (2020). They are thin parasites with a transversely striated cuticle and have the anterior end more rounded by the lips, which are positioned dorsally, ventrally, and laterally in pairs. It is viviparous and therefore the abundance of individuals is related to the reproductive process that takes place within the host. (Fig.8)

Host: *Podocnemis unifilis.* Habitat: Stomach and intestines.

Location: Javaés River, near the Araguaia National Park and Cantão State Park (9°58'53.4" S, 50°03'04.1" W); and Tocantins River, in the municipalities of Tupiratins and Itapiratins (8°19'59.9" S, 48°07'58.2" W).

DISCUSSION

Changes in the environment may cause changes in the interaction between hosts and parasites with an indirect life cycle. These changes induce transformations in the host's metabolism, either immunological or physiological, which lead to parasite proliferation or death and consequent variation in the ecological balance (Morley et al. 2006, Blanar et al. 2009). In a situation wherein the host is harmed, the parasite promotes mechanical, destructive, and inflammatory events that are harmful to the host, causing gastrointestinal

Fig.5. Paratractis hystrix. Anterior portion: mouth (A) and esophagus (B) visible. Light microscopy image. Leica DM500 microscope with Leica ICC50 HD camera attached. 10x lens.

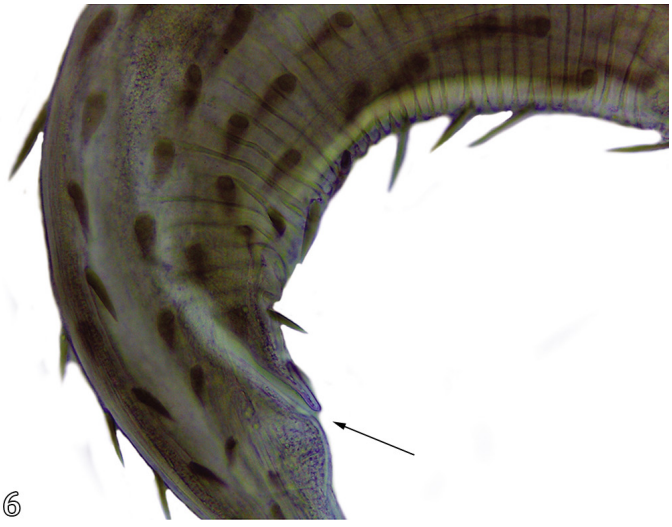


Fig.6. Paratractis hystrix. Posterior lateral portion: gubernaculum evident in males. Light microscopy image. Leica DM500 microscope with Leica ICC50 HD camera attached. 40x lens.

obstruction, retention of nutrients and fluids, and lesions in the parasitized organs that allow the parasites to transmit pathogens and weaken the hosts (Monteiro 2017, Martins 2019).

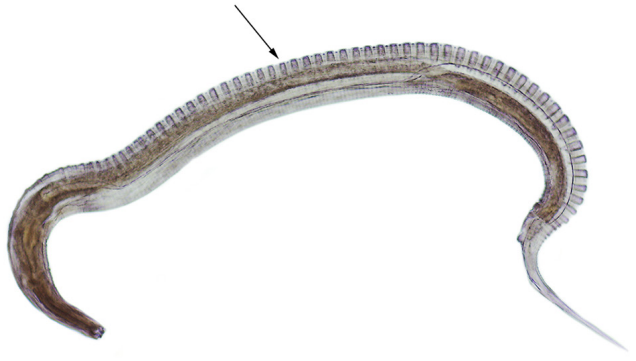
The Digenea *Nematophila grandis* collected from the stomach of *Podocnemis unifilis* is commonly observed as a parasite in chelonians of the genus *Podocnemis* (Salizar & Sanchez 2004, Sanchez et al. 2006, Tantaleán et al. 2011) (Podocnemididae). However, this parasite has been observed in other families of chelonians such as Kinosternidae, Geoemydidae, Testudinidae, and Chelidae (Mascarenhas & Müller 2021). Digenetic flatworms have an indirect life cycle (Monteiro 2017) and, although they are common parasites of chelonians, they depend on intermediate hosts. The occurrence of *N. grandis* adults in *P. unifilis* characterizes these animals as definitive hosts for this parasite, and the life cycle of these digenetic flatworms is mainly associated with the host's food, i.e., *P. unifilis* becomes infected by consuming previously parasitized organisms, such as mollusks and other invertebrates (Carvalho 2018). Therefore, it is a host that depends on favorable environmental conditions for its maintenance and consequent guarantee of symbiosis with its final hosts.

The nematodes in chelonians are considered commensal organisms, i.e., they act directly on their hosts' digestion of plant material, taking advantage of the nutrients, but when they occur in large numbers they can cause gastrointestinal obstruction and malnutrition in the host (Carvalho 2018). Although *P. unifilis* prefers to feed on plant material, it is an opportunistic species (Garcez 2012), and parasites contribute to the species' metabolic maintenance. Although the animals had a large number of parasites in their stomach contents, this is a common phenomenon in wild animals and is usually related to the environment and food interactions (Taylor et al. 2016). A stomach with a prevalence of parasites of approximately 40% and a completely full stomach (index of I) (Namora 2003, Dolphine 2014) is associated with the preference of *P. unifilis* for plant material (Garcez 2012). In ectothermic animals, Pryor & Bjordnal (2005) and Noblet & Yabsley (2000) correlate a high number of parasites in the gastrointestinal tract, especially nematodes, and protozoa, with the ability to digest cellulose, as they act as beneficial agents in food utilization and host nutrition. Notably, the analyzed *P. unifilis* individuals showed no obvious disease associated with the presence of these parasites.

Paratractis hystrix is a nematode species reported in several species of chelonians, including *Peltocephalus dumerilianus*, *Podocnemis cayennensis*, *Podocnemis erythrocephala*, *Podocnemis expansa*, and *Podocnemis vogli* (Cagno 2006, Menegaldo 2016). Although it is common in the *Podocnemis* genus, few studies have reported its occurrence, and its distribution is restricted to the Colombian Amazon (Khalil & Gibbons 1988), the Peruvian Amazon (Sarmiento et al. 1999), and, in Brazil, the region of the Trombetas River, state of Pará (Gibbons et al. 1997). Therefore, little is known about *P. hystrix*, its life cycle, and the species it uses as hosts; therefore, this study expands the area of occurrence of this parasite in Brazil. The specimens of *P. hystrix* found in this study were adult and juvenile individuals, so this nematode uses *P. unifilis* as a definitive host; however, the life cycle of this nematode species remains unknown.

Currently, the genus *Paraorentatractis* has only one species, *Paraorientatractis semiannulata*, described as inhabiting the intestines of *P. unifilis* collected in the Trombetas River, Pará State, Brazil (Gibbons et al. 1997). It was only a decade later that this parasite was reported to occur in the stomach and intestines of *P. unifilis* in the Peruvian Amazon (Salizar & Sanchez 2007). Therefore, the geographical distribution of this parasite was restricted to South America. This parasite is viviparous (Gibbons et al. 1997) and was found in both adult and juvenile stages, which suggested that specimens of *P. unifilis* were definitive hosts for this parasite. This study extended the geographical distribution of *P. semiannulata* to the Tocantins River and Javaés River in the Brazilian Amazon.

The *Orientatractis* genus is a group of endoparasites of Testudines, with seven known species distributed in Asia, Africa, and South America (Buckley 1969, Bursey et al. 2014, Moravec et al. 2015, Cavalcante et al. 2016, González-Solís & Mariaux 2017, Liu et al. 2018, Jesus et al. 2020). *Orientatractis leiperi* reportedly occurs as a parasite in the stomach of *Podocnemis vogli*, in Colombia, and was later reported parasitizing the stomach of *P. unifilis* from the Tocantins River, Pará State, in the area of the Tucuruí Hydroelectric Power Plant (Jesus et al. 2020). The specimens of *O. leiperi* were observed in adult and juvenile stages, which indicates that *P. unifilis* is a definitive



7

Fig.7. Paraorientatractis semiannulata. Side view. Back covered with rings. Light microscopy image. Leica DM500 microscope with Leica ICC50 HD camera attached. 10x lens.

8

Fig.8. Orientatractis leiperi. Side view. Light microscopy image. Leica DM500 microscope with Leica ICC50 HD camera attached. 4x lens.

host of this nematode. However, the life cycle of this parasite remains unknown. Our results extended the geographical distribution of *O. leiperi* to the Tocantins and Javaés River basins in the Brazilian Amazon.

Leão et al. (2019) stated that the fact that *P. semiannulata* and *O. leiperi* share the same ecological niche, with overlapping areas of living, feeding, and reproduction, which explains the fact that the same parasites are abundant in all the collected specimens of *P. unifilis*, even from different areas. Because they are viviparous parasites (Jesus et al. 2020), their reproduction is facilitated within the host, leading to reinfection. Therefore, the presence of a countless number of individuals of these parasite species in the stomach of *P. unifilis* was facilitated by the life cycle within the host.

The knowledge of the ecological relationships between hosts, parasites, and the ecosystem supported management strategies for the species because once the ideal conditions for survival are lost, changes in the parasite fauna indicate how the organisms are being influenced by the environment (Machado et al. 2007). In the present study, we were unable to determine the environmental factors that contributed to the characteristics of the parasitic infections. However, considering that more than 40% of the stomach contents of the specimens of *P. unifilis* consisted of parasites, studies that indicate the importance of the ecosystem and its effects on populations of this species should be encouraged, especially because it is an important food resource for humans.

CONCLUSIONS

The *Podocnemis unifilis* specimens collected from the Javaés River and the Tocantins River showed similar parasite fauna, i.e., parasites belonging to the groups Digenea and Nematoda, with a predominance of Nematoda. Four species were identified, the digenean *Nematophila grandis* and the following three nematodes: *Paratractis hystrix, Paraorientatractis semiannulata,* and *Orientatractis leiperi*. A 100% prevalence of parasitism was observed, i.e., all the parasite species were identified in all the collected *P. unifilis* specimens.

Based on the results of the study and the reviewed literature, we concluded that chelonian species of the same genus harbor a similar parasite fauna, as expected for phylogenetically similar hosts.

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