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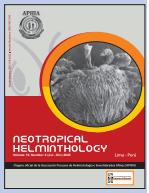

ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

NEW SPECIES OF *ANACANTHORUS* (DACTYLOGYRIDAE) AND NEW DATA FOR *ANACANTHORUS SIMPLICIPHALLUS* PARASITIZING CHARACIFORM FISHES FROM TOCANTINS RIVER, MARANHÃO STATE, BRAZIL

NUEVA ESPECIE DE *ANACANTHORUS* (DACTYLOGYRIDAE) Y NUEVOS DATOS PARA *ANACANTHORUS SIMPLICIPHALLUS* PARASITANDO PECES CARACIFORMES DEL RÍO TOCANTINS, ESTADO DE MARANHÃO, BRASIL

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ABSTRACT

Anacanthorus Mizelle & Price, 1965 is the most diverse genus of Dactylogyridae and is characterized by the absence of anchors and bars in the haptor. Members of *Anacanthorus* are found parasitizing until now only fishes belonging to order Characiformes. Specimens of *Brycon pesu* Müller & Troschel, 1845 and *Caenotropus labyrinthicus* (Kner, 1858) were collected from Tocantins River, Brazil and had their gills removed and individualized in bottles containing water heated to (~65ºC), to relax and release the parasites, and ethanol absolute was increased to reach the concentration of 70%. The parasites found were collected and mounted in Hoyer´s medium. A new species of *Anacanthorus*, *A. itaueirasensis* sp. nov., is described from *Brycon pesu*, presenting the characteristics of *Anacanthorus* species parasitic on bryconids, as morphology of the copulatory complex, composed of a tubular MCO and membranous accessory piece, hooks with a bulbous proximal part of the hook and a poorly developed thumb. A new record for *Anacanthorus simpliciphallus* Silva,

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Cohen, Costa & Justo, 2024 and the comparative measurements are presented, increasing the knowledge of parasite fauna from fishes of Tocantins-Araguaia Basin.

Keywords: Bryconidae – Monopisthocotyla – Neotropical Region – Platyhelminthes – Taxonomy – Tocantins River

RESUMEN

Anacanthorus Mizelle & Price, 1965, es el género más diverso de Dactylogyridae y se caracteriza por la ausencia de anclas y barras en el haptor. Hasta ahora, los miembros de *Anacanthorus* parasitan únicamente a peces del orden Characiformes. Se recolectaron especímenes de *Brycon pesu* Müller & Troschel, 1845 y *Caenotropus labyrinthicus* (Kner, 1858), a los que se les extrajeron las branquias y se individualizaron en botellas con agua calentada a (~65 °C) para relajar y liberar los parásitos. Se aumentó la concentración de etanol absoluto al 70 %. Los parásitos encontrados se recolectaron y montaron en medio de Hoyer. Se describe una nueva especie de *Anacanthorus*, *A. itaueirasensis* sp. nov., de *Brycon pesu*, presentando características de las especies de *Anacanthorus* parásitas de bricónidos, como morfología del complejo copulatorio, compuesto por un MCO tubular y pieza accesoria membranosa, ganchos con parte proximal bulbosa y un pulgar poco desarrollado. Se presenta un nuevo registro de *Anacanthorus simpiciphallus* Silva, Cohen, Costa & Justo, 2024 y las mediciones comparativas, lo que amplía el conocimiento de la fauna parasitaria de los peces de la cuenca del Tocantins-Araguaia.

Palabras clave: Bryconidae – Monopisthocotyla – Región Neotropical – Platelmintos – Taxonomía – Río Tocantins

INTRODUCTION

Anacanthorus Mizelle & Price, 1965 is the most diverse genus of Dactylogyridae parasites of freshwater fishes in South America. Species of the genus were reported parasitizing exclusively fishes belonging to order Characiformes, associated with different families within the order (Santos-Neto *et al.*, 2019; Pereira *et al.*, 2020; Morey *et al.*, 2021, Freitas *et al.*, 2025). Up to date, 96 species are reported from different countries in the Neotropical Region (Cohen *et al.*, 2013; Braga *et al.*, 2014; Morey *et al.*, 2019; 2021; 2024). The main characteristic of the species of *Anacanthorus* is the absence of anchors and bars (Mizelle & Price, 1965; Kritsky *et al.*, 1992). *Anacanthorus* spp. were described and reported from fishes of Bolivia (5 species of Serrasalmidae), Brazil (39 species in Serrasalmidae, 21 in Triportheidae, 8 in Erythrinidae, 12 in Bryconidae, 4 in Characidae), Colombia (2 species of Bryconidae) and in one member of the order Cichliformes, which was considered apparently accidental [see Kritsky, 1974], Peru (5 species of Serrasalmidae and 4 of Bryconidae), and Venezuela (2 in Serrasalmidae). The majority of species of *Anacanthorus* were described from Brazilian freshwaters, with 87 original descriptions of species (Kritsky *et al.*, 1992; Van Every & Kritsky, 1992; Cohen *et al.*, 2012; Brandão *et al.*, 2013; Cohen *et al.*, 2013; Leão *et al.*, 2015; Monteiro *et al.*, 2015; Moreira *et al.*, 2019 a,b; Santos-Neto *et al.*, 2019; Morey *et al.*, 2019; Pereira *et al.*, 2020; Morey *et al.*, 2021; Silva *et al.* 2024).

Fishes of the genus *Brycon* Müller & Troschel are a broadly distributed group of Neotropical characids. It holds considerable economic value, both for commercial and recreational fishing in relatively undisturbed river ecosystems, as well as for their sought-after flesh. These fish are predominantly omnivores, although fruits and seeds being the main components of their diet and playing a significant role in seed dispersal. Additionally, these fish are migratory and act as bioindicators of environmental health (Lima, 2017; Arruda *et al.*, 2019). Until now, *Brycon pesu* Müller & Troschel, 1845 has not been reported parasitized by Monopisthocotyla.

The characiform genus *Caenotropus* Günther, 1864 (Chilodontidae) comprises four species, *Caenotropus moculosus* (Eigenmann, 1912), *Caenotropus mestomorgmatos* Vari, Castro & Raredon, 1995 *Caenotropus labyrinthicus* (Kner, 1858) and *Caenotropus schizodon* Scharcansky & Lucena, 2007. *Caenotropus labyrinthicus* is the largest species, reported in several Brazilian basins (Amazonas, Tocantins, Orinoco), Guyana and Suriname (Froese & Pauly, 2025). The reports of Monopisthocotyla in this host species are restricted to species of *Urocleidoides* Mizelle & Price 1964: *Urocleidoides paratriangulus* Freitas, Bezerra, Meneses,

Justo, Viana & Cohen, 2021, *Urocleidoides tocantinensis* Freitas, Bezerra, Meneses, Justo, Viana & Cohen, 2021 and *Urocleidoides psectrogasteri* Bezerra, Freitas, Cohen & Justo, 2023 (Freitas *et al.*, 2021; Bezerra *et al.*, 2023a) from Tocantins River, Maranhão State, Brazil.

Continuing studies on the helminth fauna of fishes in the Tocantins River, Maranhão state, specimens of *B. pesu* and *C. labyrinthicus* were examined, Monopisthocotyla were collected and a new species of *Anacanthorus* is described herein, in addition to a new host record for a known species, *A. simpliciphallus.*

MATERIAL AND METHODS

In expeditions carried out by ichthyologists from the National Museum (Federal University of Rio de Janeiro - UFRJ) and researchers from the "Laboratório de Helmintos Parasitos de Peixes (LHPP - Fiocruz)", thirteen specimens of *B. pesu* were collected in Itaueiras River, in the municipality of Estreito, State of Maranhão (06º 33' 38" S, 47º 27' 04" W) in the year of 2010. Seventy-two specimens of *C. labyrinthicus* obtained under environmental licensing through the Biodiversity Authorization and Information System (SISBIO 69275-1), were obtained between 2022 and 2023 from Tocantins River in the municipality of Imperatriz, State of Maranhão, Brazil (05°27'50'S; 47°33'48'W) (Fig. 1). These fishes had their gills removed and individualized in bottles containing water heated to (~65ºC), to relax and release the parasites, and ethanol absolute was increased to reach the concentration of 70%, and the material was sent to the Laborátorio de Helmintos Parasitos de Peixes, LHPP, State of Rio de Janeiro for parasitological analysis. In the laboratory, the parasites were collected and mounted between a slide and coverslip, in Hoyer´s medium, to study the sclerotized structures. Measurements were made through the software ImageJ (Wayne, 2010), distributed by Institute National of health (available at https://imagej.nih.gov/ij/download.html).Measurements are presented in micrometers, means are followed by minimum measurements to maximum measurements values and number of structures measured in parentheses. Photomicrographs and drawings were taken using a Zeiss® Axioskop microscope micrographic system with a differential interference contrast (DIC) apparatus and an Olympus BX 41 microscope with phase contrast, equipped with a camera lucida. Holotype, paratypes and vouchers were deposited in the "Coleção Helmintológica do Instituto Oswaldo Cruz - CHIOC" in Brazil.

The authorship of the taxa followed the recommendation of Article 50.1 of the International Code of Zoological Nomenclature (ICZN), which deals with the identity of the authors.

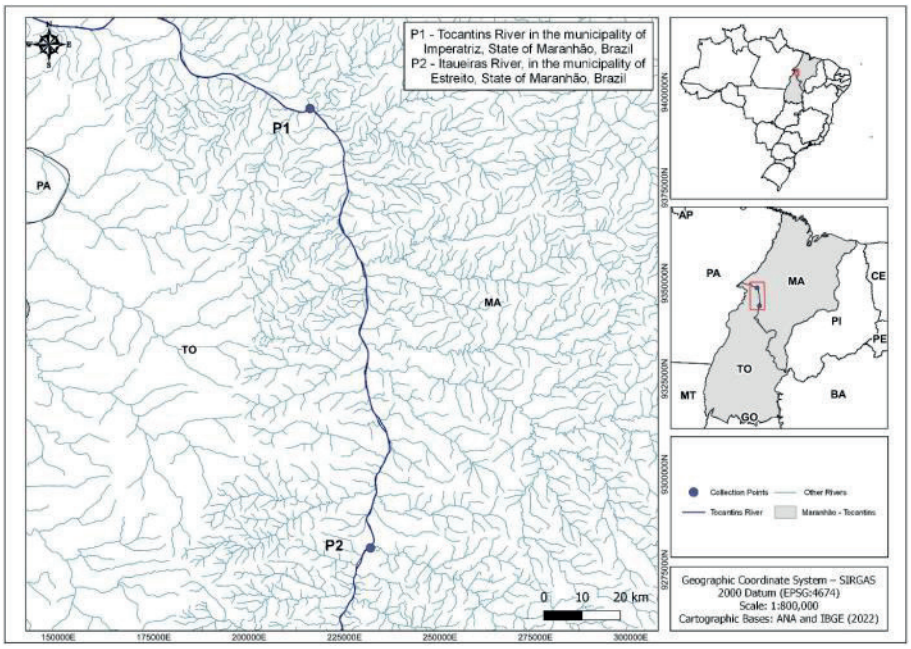

Figure 1. Map of the middle Tocantins River region indicating host collection sites located in the municipality of Imperatriz and the Itaueiras River in the municipality of Estreito, State of Maranhão, Brazil.

Ethic aspects: The fish collecting protocol and laboratory procedures was granted by the Research Committee of "Universidade Estadual do Maranhão (UEMA) under protocol number 21/2017.

RESULTS

Class Monopisthocotyla Brabec, Salomaki, Kolıs̆ko, Scholz & Kuchta, 2023

Order Dactylogyridea Bychowsky, 1937

Dactylogyridae Bychowsky, 1933

Anacanthorus Mizelle & Price, 1965

***Anacanthorus itaueirasensis* sp. nov. Freitas, Justo, Reyes & Cohen** (Fig. 2).

Type host. *Brycon pesu* Muller & Troschel (Bryconidae)

Type Locality. Itaueiras River, Estreito, Maranhão, Brazil (06º 33' 38" S, 47º 27' 04" W)

Parasitological indexes. Total number of hosts: 11; number of infected hosts: 6; total number of parasites: 16; range of intensity: 1–9

Type-material: Holotype CHIOC 40823a, Paratypes CHIOC 40823b, 40824, 40825, 40826a–e.

Etymology: The specific name refers to the river where the fish hosts were collected.

Description (based on 16 specimens mounted in Hoyer's medium): Body fusiform 399 (238–470; n=16) in length, 122 (75–150; n=16) in width. Tegument smooth. Cephalic lobes well developed, with two pairs of lateral lobes. Cephalic organs slightly developed. Eyes 4, equidistant, anterior pair smaller than posterior one. Pharynx subspherical and muscular, 36 (25–50; n=4) in width; esophagus short; intestinal caeca confluent posteriorly to gonads, lacking diverticula. Peduncle short. Haptor 65 (45–90; n=10) in width, slightly bilobed, presenting 7 pairs of hooks, consisting of 4 ventral pairs and 3 dorsal pairs and 4A's, one dorsal pair and one ventral. Hooks similar in shape and size, measuring 29 (28–30; n=14), needle-shaped, reduced thumb, slightly curved tip, slightly recurved shaft, with terminal bulbous; filamentous hook (FH) about ¼ of total length. 4A's with fine tip and slight proximal shaft expansion. Anchors and bars absent. Copulatory complex composed of male copulatory organ (MCO) and accessory piece. MCO 117 (100–135; n=15), tubular, rod-shaped with enlarged base, projecting outside the body. Accessory piece membranous 49 (40–69; n=8), surrounding the MCO, occupying ⅓ of its total length. Testis located posterior to germarium. Vas deferens looping the left intestinal cecum. Germarium suboval. Vitellaria dispersed in bilateral fields of the trunk, from the pharynx to the posterior region of the testis, coextensive with the intestinal ceca. Eggs, oviduct, and oötype not observed.

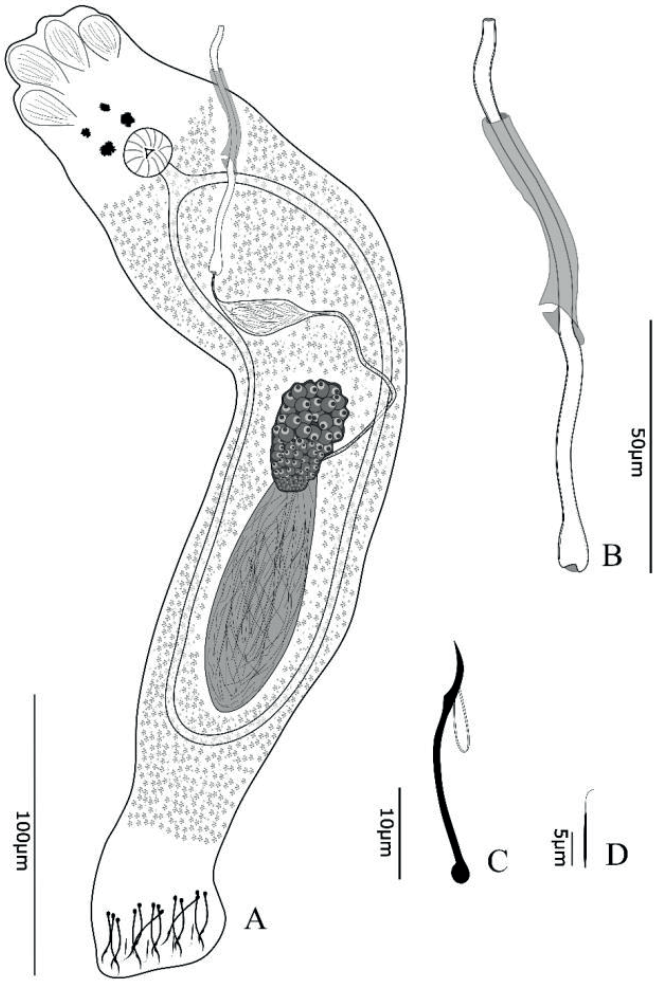

Figure 2. *Anacanthorus itaueirasensis* sp. nov. from *Brycon pesu*. A. Total, ventral view (composite); B. Copulatory complex; C. Hook; D. Hook 4A.

Remarks: The characteristics observed in the *Anacanthorus* specimens collected from *B. pesu* are in accordance with the characteristics pointed out by Santos-Neto *et al.* (2019) of *Anacanthorus* species parasitic on bryconids: morphology of the copulatory complex, composed of a tubular MCO and membranous accessory piece, hooks with a bulbous proximal part of the hook and a poorly developed thumb. The species found in the present study in *B. pesu* resembles *A. elegans* Kritsky, Thatcher & Kayton,

1979 parasite of *Brycon melanopterus* (Cope, 1872), *A. franciscanus* Monteiro, Kritsky & Brasil-Sato, 2010 of *B. orthotaenia* Gunther, 1864, *A. sabaloi* Morey, Sol & Cachique, 2021, from *B. amazonicus* (Spix & Agassiz, 1829) and *A. femoris* Morey, Sol & Cachique, 2021 due to the morphology of the copulatory complex, but can be distinguished by the characteristic of recurved MCO, observed in the latter four species. The accessory piece as membranous sheath present in all these species and in the present new species differs only in morphometric analysis. *Anacanthorus itaueirasensis* sp. n. also differs from these species in the absence of the foramen of the hook, while in congeneric species, the foramen is large or double.

***Anacanthorus simpliciphallus* Silva, Cohen, Costa & Justo, 2024 (Fig. 3)**

Type host: Hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus* (Characiformes, Serrasalmidae)

Type locality: Marketplace on São Luis Island, Maranhão state, host specimen obtained from a fish farm established in the municipality of Matinha (3º05'13.5"S, 45º02'56" W).

Other host: *Caenotropus labyrinthicus* Kner (Chilodontidae) **(New host record)**

Other locality: Tocantins River in the municipality of Imperatriz, State of Maranhão, Brazil (05°27'50'S; 47°33'48'W) **(New geographical distribution)**

Deposited material: Voucher CHIOC: 40827, 40828a–c, 40829, 40830.

Figure 3. Light photomicrographs of *Anacanthorus simpliciphallus* Silva, Cohen, Costa & Justo, 2024. A. Total view, ventral; B. Anterior region with a copulatory complex. C. Haptor.

Infestation parameters: Total number of hosts 60, Infected: 16; total number of parasites: 65; range of intensity: 2–10

New data from specimens collected in *Caenotropus labyrinthicus* [original measurements from the hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus*, according to Silva *et al.* (2024) are presented in brackets]. Body 435 (320-550; n= 9) [422 (262-550; n= 5)] long, 117 (85-150; n=11) [123 (88-145; n=5)] wide. Haptor 82 (75-103; n= 9) [93 (60-135; n= 5)]. Pharynx 27 (15-30; n= 8) [20 and 27; n= 2]. Hooks similar in size and shape, 22 (19-24; n= 9) [21 (20-24; n= 10)]long. Male copulatory organ 75 (65-88; n= 9) [76 (65-83; n= 7)] long. Accessory piece 34 (30-36; n= 11) [41 (37-45; n= 7)] long. Germarium 30 and 50; n= 2 [86 (60-100; n= 4)]; Testis dorsal to germarium 80 (n=2) long [86 (60-100; n= 4)] long.

Remarks: Holotype and paratypes of *A. simpliciphallus* deposited in the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC: Holotype 40263 a; Paratypes 40263 b; 40264; 40265; 40266 a,b; 40267 a, b.) were examined for comparative purposes. The specimens found in the present study are in agreement with morphological characteristics of the type material, being herein referred in a new host record and locality.

DISCUSSION

The vast diversity of fish species found in Brazilian River basins mirrors the rich and varied fauna of Monopisthocotyla (Tavares-Dias *et al.*, 2022). With the aim of increasing knowledge of the Monopisthocotyla fauna from the rivers of the Tocantins-Araguaia basin, studies have been carried out proposing new species and biogeographical records (Boeger & Vianna, 2006; Kritsky *et al.*, 2007; 2013; Cohen *et al.*, 2020; Freitas *et al.*, 2021; Bezerra *et al.*, 2023 b,c; Silva *et al.*, 2023 a,b; 2024; Meneses *et al.*, 2024; Silva *et al.*, 2024). The distribution of Monopisthocotyla and their hosts is strongly influenced by the evolutionary history of fish. These parasites are commonly restricted to specific lineages of hosts and may have more generalist or more specialist species (Braga *et al.*, 2014; Graça *et al.*, 2018). The increase of new species proposed from different basins contributed to knowledge of parasitism fauna and highlighted the association of host-parasite within the high or low specific correlation.

Studies in the Neotropical Region have shown that the composition of gill Monopisthocotyla communities is influenced not only by the phylogenetic relationships of their hosts but also by geographic distribution and environmental factors. Studies on host parasite associations of Monopisthocotyla and their fish hosts in the Neotropical Region have revealed a restricted Monopisthocotyla fauna, shaped by the phylogenetic relationships of their hosts and their geographic distribution (Braga *et al.*, 2014; Graça *et al.*, 2018). Exceptions are scarse, as the findings of *Anacanthorus spathulatus* Kritsky, Thatcher & Kayton, 1979 and *Anacanthorus thatcheri* Boeger & Kritsky, 1988, species originally described and reported from hosts of the family Serrasalmidae from differents basins, in Curimatidae fishes from Acre, amazon region (Kritsky *et al.*, 1979; Negreiros *et al.*, 2024). The description and reports on *Anacanthorus* spp. are consistent with this pattern, as each fish species harbored a distinct composition of *Anacanthorus* spp., with phylogenetically related hosts sharing some parasite species (Graça *et al.*, 2018). Besides, the morphological characteristics of *Anacanthorus* species, particularly the structures of the copulatory complex and hooks, allow for the grouping of species according to the different families of characiform fishes (Santos-Neto *et al.*, 2019).

Anacanthorus simpliciphallus was originally described from a host from the family Serrasalmidae and in the present study, the species is reported parasitizing *C. labirinthicus*, a member of family Chilodontidae. The species of *Anacanthorus* are mostly restricted to a single host family within the order Characiformes. The record of *Anacanthorus simpliciphallus* in *C. labirinthicus* expands the occurrence of *Anacanthorus* species to different host families (see Freitas *et al.*, 2025). In conclusion, species of *Anacanthorus* presents high specificity in relation to their characiform hosts, being considered exclusive to these neotropical fishes.

A database of the valid species of *Anacanthorus* from Neotropical Region encompassing details such as host species, geographical distribution, habitat type, references, DOIs was created by aggregating information from various scientific literature sources, aiming to provide data to each species within *Anacanthorus*. This database has been made for open access and will be updated as new information becomes available and had shown that 96 valid species of *Anacanthorus* are recognized until now, all parasitizing characiform fishes, especially from the families Serrasalmidae, Triportheidae, Bryconidae, Erythrinidae and Characidae (Freitas *et al.*, 2025).

The present paper contributes to the knowledge of the biodiversity of one of the most comprehensive genera of Dactylogyridae, increasing to 97 the number of valid

species of *Anacanthorus*. The finding of a new species of *Anacanthorus* parasitizing a member of Bryconidae and a known species in a member of Chilodontidae increases the diversity of host fish families for this genus of Dactylogyridae.

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Software: AJBF, ARPR, CAMB, DCV, MCNJ, SCC
Supervision: MCNJ, SCC
Validation: MCNJ, SCC
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