



Trematodes and acanthocephalans associated with the yellow mojarra (*Caquetaia kraussii*) in a coastal lagoon system, San Onofre, Colombia

Tremátodos y acantocéfalos asociados a mojarra amarilla (*Caquetaia kraussii*) en un sistema de laguna costera, San Onofre, Colombia

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ABSTRACT

In Colombia, ichthyozoonoses caused by helminths are little studied and remain neglected by the public health sector, representing an interaction to be explored regarding biodiversity and health. *Caquetaia kraussii* is a native fish of Colombia and Venezuela that is economically important due to its high consumption by local communities. This research records the fauna of parasitic helminths associated with *C. kraussii* in a coastal lagoon system in the Colombian Caribbean. Thirty-two specimens of *C. kraussii* were captured and inspected in February and December 2020, resulting in the collection of 242 helminths at the metacercariae stage and adults. Parasites included metacercaria of the trematodes *Clinostomum* sp., *Austrodiplostomum* sp., two forms of *Posthodiplostomum* and adults of *Oligogonotylus andinus*, and adults of the acanthocephalan *Neoechinorhynchus* sp. These results indicate that *C. kraussii* acts as a definitive host for *O. andinus* and *Neoechinorhynchus* sp., and as an intermediate host for *Clinostomum* sp., *Posthodiplostomum* spp. and *Austrodiplostomum* sp. This research reports for the second time a population of *O. andinus* in Colombia and the occurrence of a morpho-species of the genus *Neoechinorhynchus* that could constitute a new record for Colombia. In addition to contributing to the knowledge of the diversity of fish-associated helminths, the results of this research will make it possible to generate recommendations for the management and control of helminthiasis in artificial fish farming systems that are supplied by natural tributaries, and favor the establishment of hosts and parasites.

Keywords: Cichlid parasites; Eoacanthocephala, Freshwater fishes; Helminths; Trematoda.

RESUMEN

En Colombia, las ictiozoonosis causadas por helmintos son poco estudiadas y permanecen desatendidas desde el sector de la salud pública, representando una interacción por explorar en términos de biodiversidad y salud. *Caquetaia kraussii* es un pez nativo de Colombia y Venezuela de importancia económica, debido a su alto consumo por parte de comunidades locales. Esta investigación registra la fauna de helmintos parásitos asociados a *C. kraussii* en un sistema de laguna costera en el Caribe colombiano. En febrero y diciembre de 2020 se examinaron 32 especímenes de *C. kraussii*, de los que se recolectaron 242 helmintos en los estadios de metacercaria y adulto. Los parásitos incluyeron metacercarias de los tremátodos *Clinostomum* sp., *Austrodiplostomum* sp., dos morfoespecies de *Posthodiplostomum* spp. y adultos de *Oligogonotylus andinus* además de adultos del acantocéfalo (Eoacanthocephala) *Neoechinorhynchus* sp. Estos resultados indican que *C. kraussii* actúa como hospedador definitivo de *O. andinus* y *Neoechinorhynchus* sp., y como hospedador intermediario de *Clinostomum* sp., *Posthodiplostomum* spp. y *Austrodiplostomum* sp. Se reporta por segunda vez una población de *O. andinus* en Colombia y la ocurrencia de una morfoespecie del género *Neoechinorhynchus* que podría ser un reporte nuevo para Colombia. Además del aporte al conocimiento de la diversidad de helmintos asociados a peces, los resultados de esta investigación podrían ser aprovechados para generar recomendaciones para el manejo y control de helmintiasis en sistemas piscícolas artificiales que se surten de afluentes naturales y favorecen el establecimiento de hospederos y parásitos.

Palabras claves: Eoacanthocephala; Helmintos; Parásitos de cíclidos; Peces de agua dulce; Trematoda.

INTRODUCTION

Fishery resources are an important source of macro- and micronutrients for human populations, representing more than 17% of animal protein of the global consumption, and up to 50% in some countries (Thilsted *et al.* 2014). In Latin America, fisheries and aquaculture production are fundamental milestones in social, economic, and nutritional development, with about 85% of production resulting from artisanal fisheries (FAO & ECLAC, 2020).

This nutritional dependence on fish resources also leads to a potential exposure of human communities to health risks, considering that many of the parasitic infections that affect fish species for consumption are zoonotic (Chai *et al.* 2005). These parasitic zoonoses transmitted through food consumption, including fish, are of high relevance to public health and socio-economic problematics in some countries, particularly in Asia (Lima dos Santos & Howgate, 2011), in addition to being a key contributor to the transmission of diseases through food webs.

Zoonotic helminthiasis related to the consumption of fish or fish products have been associated with populations in low- and middle-income countries (Chai *et al.* 2005). In the context of countries such as Colombia, Mexico and Peru, the acquisition of fish in local markets or through subsistence fishing can expose people to parasites at different stages of development (Rojas Sánchez *et al.* 2014; Castellanos-Garzón *et al.* 2019; Murrieta Morey *et al.* 2022). However, the geographic distribution of these diseases and the populations at risk have been constantly growing as a consequence of the expansion of international markets and demographic changes, increasing the risk of contagion even in developed countries (Chai *et al.* 2005).

Considering the above, the identification of parasites in fish not only allows us to know their diversity and ecology (Bautista-Hernández *et al.* 2015) but also to understand their role as keystone species in shaping communities and their importance in various ecological processes (Frainer *et al.* 2018). In addition, this understanding may be crucial for suggesting animal health guidelines aimed at controlling and preventing parasitic infections with health implications for both fish and humans (Quijada *et al.* 2005; Soler-Jiménez *et al.* 2017).

The yellow mojarra *Caquetaia kraussii* (Steindachner, 1878) (Pisces: Cichlidae) is a fish native from Colombia and Venezuela. In Colombia it is distributed in the basins of the Magdalena, Cauca, and Caribbean (Do Nascimento *et al.* 2017) and Pacifica regions (Rivas-Lara & Gómez-Vanega, 2017). This fish is an important food source, being regularly consumed and traded by local communities. The research related to the mojarra amarilla includes biological and fishing aspects (Solano-Peña *et al.* 2013; Durán *et al.* 2014; Rivas-Lara & Gómez-Vanega, 2017; Zapata-Londoño *et al.* 2020), as well as parasitological studies (Olivero-Verbel *et al.* 2012; Castellanos-Garzón *et al.* 2020). However, these works focus on nematodes, overlooking the diversity of trematodes and associated acanthocephalans.

Therefore, the purpose of this paper is to provide an initial record of the diversity of helminths associated with yellow mojarra in a nature reserve in the Colombian Caribbean.

MATERIALS AND METHODS

Area of study. The study was conducted in the Sanguaré Natural Reserve, located north of the Gulf of Morrosquillo 99°43'13.61" N, 75°40'33.31" W, municipality of San Onofre, Sucre, Colombia (Figure 1). The area corresponds to a civil society reserve and has an area of 898 ha and covers an altitudinal range between 0 and 50 m. The ecosystem is categorized as a tropical dry forest, exhibits a bimodal rainfall regime (April-May and October-November), an annual rainfall of 1100 mm, relative humidity close to 86% and an average temperature of 27 °C (Pizano & García 2014). Sanguaré offers a variety of vegetation cover, including 80ha of flood zones with abundant bulrushes and coastal lagoons, 110 ha of secondary forest, and 708 ha of grasslands, shrubs, and mangroves.

Sample collection and identification. The *C. kraussii* specimens were caught in the main inlet of the reserve by artisanal hook-and-line fishing in February and December 2020 (Figure 2a). After capture, the specimens were placed in containers with water and vegetation and transferred alive to the field laboratory, where they remained in a cool place with a constant supply of oxygen (aquarium air motor) (Figures 2b and c). For helminthological examination each fish was sacrificed by overdosing with Isoeugenol (Erikson, 2011), subsequently their total length (TL) was measured. External inspection of the eyes, oral cavity, gills, surface, and fins was carried out, as well as internal evaluation of the vitreous humor, retina, mesentery, digestive system, and body fin muscles, all by observation through a stereomicroscope.

The procedure for handling and treatment of helminths depended on their stage of development and body location. The parasite forms found were separated, cleaned with a Pasteur pipette and a fine brush, counted, and preserved in 96% ethyl alcohol for molecular analysis or AFA solution (pre-warmed in a water bath) for morphological identification. Metacercariae extracted from the buccal cavity and fins were manually dehisced, washed, counted, and fixed. Metacercariae not encysted in the vitreous humor were immediately transferred to fixatives (96% ethyl alcohol or AFA) and cleaned 24 hours after fixation. Helminths in the digestive system were transferred to a Petri dish with saline solution (0.7%), cleaned, counted, and fixed. Finally, large trematodes found in the buccal cavity and selected for morphological analysis were flattened between two slides with saline solution and then fixed. All collected specimens were transferred to the Helminthology Laboratory of PECET (Universidad de Antioquia) for taxonomic identification.

Representative specimens of each morphotype were processed (staining and mounting on permanent plates) for morphological studies following standardized protocols for helminths (Vélez, 1987; Lenis & Vélez, 2011). Specimens were identified to family or genus level (according to their developmental stage (larva or adult) following the specialized documentation (Yamaguti, 1975; Amin, 2002; Gibson *et al.* 2002; Pinacho-Pinacho *et al.* 2018; Vélez-

Sampedro *et al.* 2022) and deposited in the Colombian Helminth Collection of the Universidad de Antioquia (CCH.116 Batch 179-185). For each of the identified taxa, prevalence ($P = \text{number of parasitized hosts} / \text{number of hosts examined} \times 100$) and average

abundance (total number of parasites recovered from the host divided by the number of hosts inspected) were estimated as infection parameters (Bush *et al.* 1997; Bautista-Hernández *et al.* 2015).

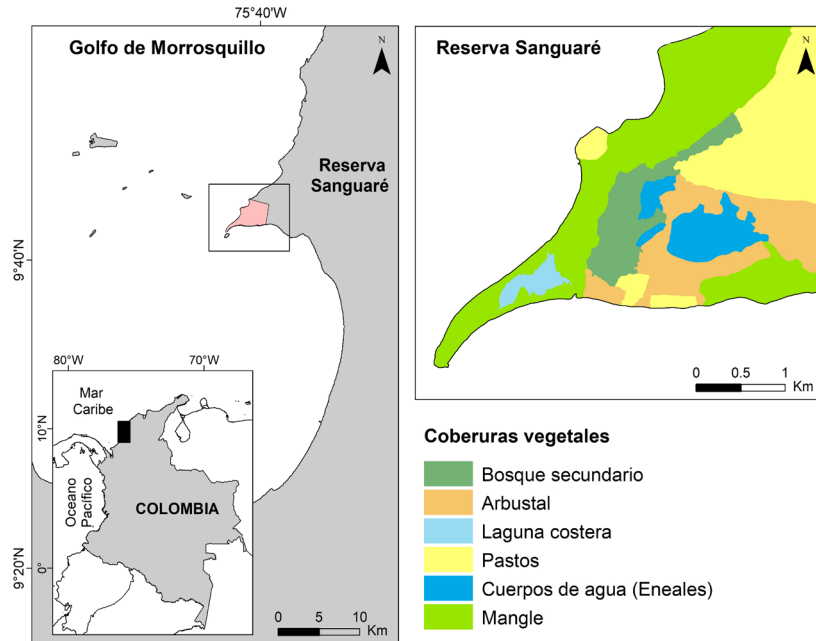


Figure 1. Yellow mojarra *Caquetaia kraussii* sampling site in the Sanguaré Natural Reserve, San Onofre, Sucre.

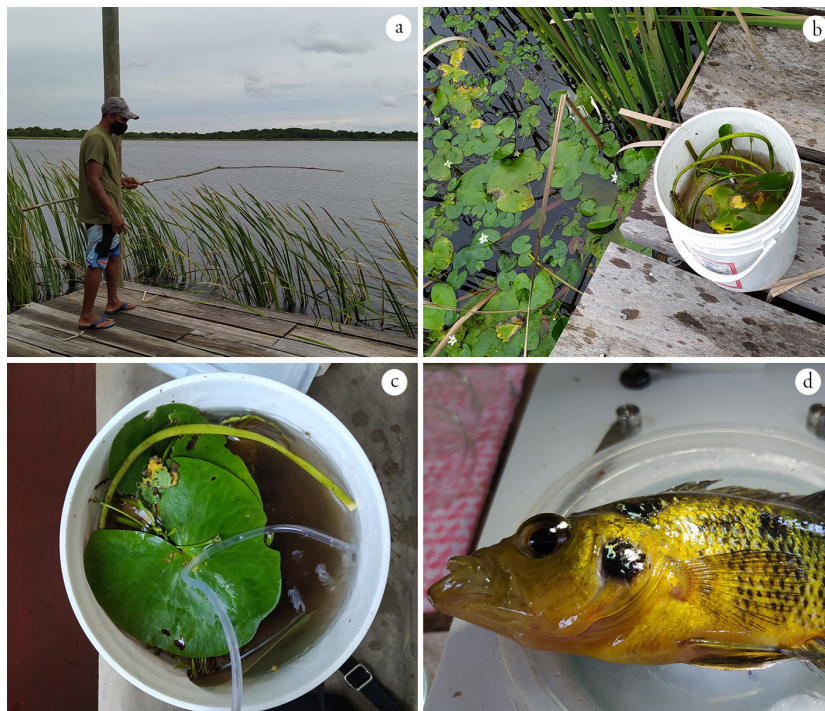


Figure 2. Photographic summary of the collection and processing of yellow mojarra *Caquetaia kraussii* to search for helminths. a) Artisanal fishing with hooks, b) Containers with water and vegetation for the transfer of live fish, c) Installation of an oxygen net for host survival, d) Slaughter and immediate analysis for the recovery of live parasites.

RESULTS AND DISCUSSION

Thirty-two yellow mojarra with a body size range of 15-18 cm were analyzed. The average processing time spent on each host was 2.5 h. From the inspection of the hosts, a total of 242 parasites assigned to six types of helminths were collected, five belonging to the class Trematoda (Platyhelminthes) including *Austradiplostomum* sp., *Clinostomum* sp., *Oligogonytylus andinus* (Vélez-Sampedro et al. 2022), and two morphospecies of the genus *Posthodiplostomum*

in addition to an Acanthocephala of the class Eoacanthocephala (Acanthocephala): *Neoechinorhynchus* sp. (Table 1). Parasites were collected as metacercariae around the eyes, outer part, and muscles of the pectoral fins, in the oral cavity and in the vitreous humor, while adult forms were found exclusively in the intestine (Figure 3 and Table 1). A total of 78.4 % of the fish examined were infected by at least one of the above taxa. The taxa *Austradiplostomum* sp., *Clinostomum* sp. and *Neoechinorhynchus* sp. recorded the highest prevalences and average abundances (Table 1).

Table 1. Helminths registered in yellow mojarra *Caquetaia kraussii* in a coastal lagoon ecosystem, Sanguaré Natural Reserve, Sucre, Colombia.

| Helminth taxon | Site of infection | Prevalence (average abundance) | Figure |
|--|--|--------------------------------|----------|
| Platyhelminthes | | | |
| Trematoda | | | |
| <i>Austradiplostomum</i> sp.* | Vitreous humor | 43.8% (1.59) | 3a and d |
| <i>Posthodiplostomum</i> morphospecies I* | Pectoral fin muscle | 15.6% (1.06) | 3b and e |
| <i>Posthodiplostomum</i> morphospecies II* | Pectoral fin muscle | 6.3% (5) | 3b and f |
| <i>Clinostomum</i> sp.* | Around eyes, pectoral fins, and buccal cavity | 50.0% (0.16) | 3g |
| <i>Oligogonytylus</i> sp. | Middle portion of the large intestine | 18.8% (0.19) | 3h |
| Acanthocephala | | | |
| Eoacanthocephala | | | |
| <i>Neoechinorhynchus</i> sp. | Middle and distal portion of the small intestine | 46.9% (2.72) | 3i |

*Genus for which only metacercariae were recovered

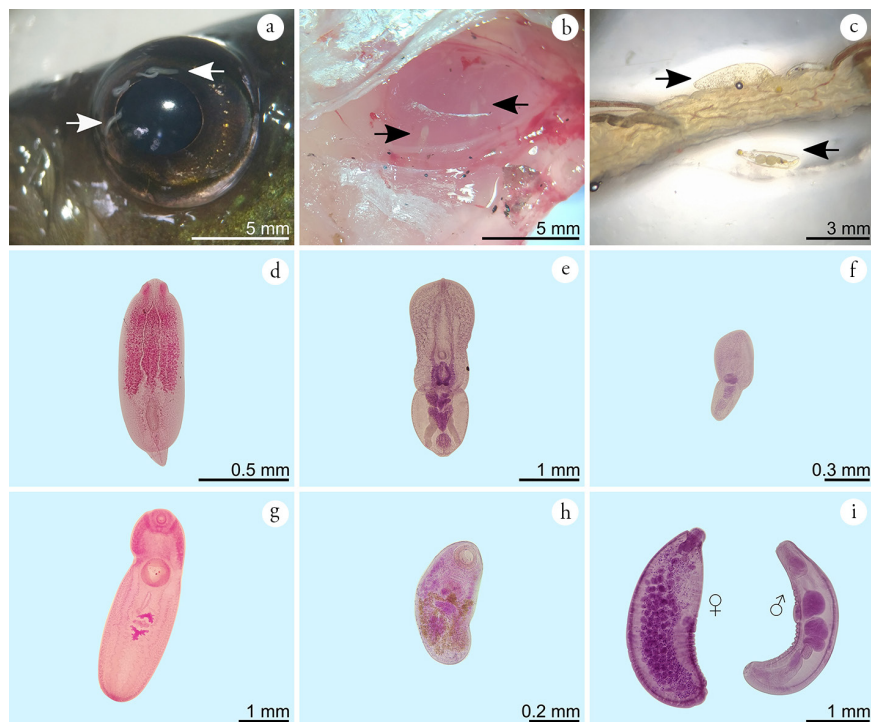


Figure 3. Helminths associated with yellow mojarra *Caquetaia kraussii* in the main redbed of the Sanguaré Natural Reserve, Sucre. a) Free metacercariae in vitreous humor, b) Encysting metacercariae in pectoral fin muscle, c) Acanthocephalans in the middle portion of the small intestine, d) Metacercariae of *Austradiplostomum* sp. e) Metacercaria of *Posthodiplostomum* morphospecies I, f) Metacercaria of *Posthodiplostomum* morphospecies II, g) Metacercaria of *Clinostomum* sp., h) *Oligogonytylus andinus*, i) *Neoechinorhynchus* sp. adults.

The identification of four types of metacercariae and two species in the adult stage suggests that yellow mojarra simultaneously serve as intermediate and definitive hosts for helminths. The life cycles recorded in the literature for the parasites identified here provide information on the trophic position occupied by the yellow mojarra in the ecosystem. As an intermediate host, it harbors trematodes of the genera *Clinostomum*, *Posthodiplostomum* and *Austrodiplostomum*, which complete their life cycle in other piscivorous species present in the reedbed. As a definitive host it harbors the trematode *Oligogonotylus andinus* and the acanthocephalan *Neoechinorhynchus* sp. which use other fish and arthropods as intermediate hosts, respectively (Razo-Mendivil *et al.* 2008; Lourenço *et al.* 2018; Vélez-Sampedro *et al.* 2022).

The infection parameters obtained indicate that *Clinostomum*, *Neoechinorhynchus* and *Austrodiplostomum* are the most prevalent forms in the system studied and provide data on the parasite load for the host in the wild. In the context of local production and consumption, this information is important as a reference to make comparisons with artificial fish farming systems, especially in low-tech fish farms that are supplied by natural tributaries and favor the establishment of hosts and helminths (Lima dos Santos & Howgate, 2011).

The parasite with the highest prevalence was *Clinostomum* (Figure 3g), which was present in 50% of the hosts analyzed. Adults of this genus generally invade the oral cavity, pharynx, or esophagus of piscivorous birds, while several species of fish and amphibians act as second intermediate hosts (Montes *et al.* 2021).

The genus *Clinostomum* comprises 23 validated species of which 11 are found in the New World, four of which are distributed in South America: *C. detruncatum* (Braun, 1899), *C. heluans* (Braun, 1899), *C. marginatum* (Rudolphi, 1819) Braun, 1901), and *C. fergalliarii* (Montes, Barneche, Pagano, Ferrari, Martorelli, & Pérez-Ponce de León, 2021); five in Central America: *C. tataxumui* (Serenio-Uribe, Pinacho-Pinacho, García-Varela & Pérez-Ponce de León, 2013), *C. arquus* (Serenio-Uribe, García-Varela, Pinacho-Pinacho & Pérez-Ponce de León, 2018), *C. caffarae* (Serenio-Uribe, García-Varela, Pinacho-Pinacho & Pérez-Ponce de León, 2018), *C. cichlidorum* (Serenio-Uribe, García-Varela, Pinacho-Pinacho & Pérez-Ponce de León, 2018), and *C. heluans* (Braun, 1899), and four in North America: *C. attenuatum* (Cort, 1913), *C. album* (Rosser, Alberson, Woodyard, Cunningham, Pote & Griffin, 2017), *C. poteae* (Rosser, Baumgartner, Alberson, Noto, Woodyard, King, Wise & Griffin, 2018), and *C. marginatum* (Montes, Barneche, Pagano, Ferrari, Martorelli, & Pérez-Ponce de León, 2021).

The species *C. marginatum* and *C. complanatum* (Rudolphi, 1814) Braun, 1899) were reported from piscivorous birds in the Colombian Caribbean (Rietschel & Werding, 1978; Fernandes *et al.* 2015). However, Caffara *et al.* (2011) indicate that *C. complanatum* has a distribution restricted to the European continent, suggesting the need for a taxonomic revision of the populations of *Clinostomum* reported in Colombia.

Clinostomiasis is a disease of minimal importance at the fish farming level, but Rosser *et al.* (2018) reported serious infections that can affect the health and subsequent marketability of fish. Metacercariae give fish a bad appearance, so people involved in sport, artisanal and commercial fishing discard parasitized individuals (Rodríguez *et al.* 2001). *Clinostomum* infections have been reported in humans, with localization in the mucosa of the throat and eyes. In cases in which a human consumes raw fish, the parasite accidentally attaches to the mucosal surface of the throat, resulting in a clinical syndrome known as halzoun, which manifests with symptoms of laryngopharyngitis (Park *et al.* 2009). This zoonosis has been reported mainly in countries such as Japan and Korea (Hara *et al.* 2014). When the infection is located in the lacrimal opening it manifests with discomfort and pain in the frontal sinus area (Tiewchaloern *et al.* 1999).

Neoechinorhynchus sp. was the form with the highest average abundance and the second most prevalent with 46.9% in *C. kraussii* (Figures 3c and 3i). This genus represents a diverse group of endoparasites of freshwater fish and turtles, with approximately 116 described species (Pinacho-Pinacho *et al.* 2018). The study of different populations of *Neoechinorhynchus* in Central America has allowed the validation of eight species in fish (Pinacho-Pinacho *et al.* 2020): *N. golvani* (Salgado-Maldonado, 1978), *N. chimalapasensis* (Salgado-Maldonado, 2010), *N. roseum* (Salgado-Maldonado, 1978), *N. brentnickoli* (Monks, Pulido-Flores & Violante-Gonzalez, 2011), *N. mamesi* (Pinacho-Pinacho, Pérez-Ponce de León & García-Varela, 2012), *N. panucensis* (Salgado-Maldonado, 2013), *N. mexicoensis* (Pinacho-Pinacho, Serenio-Uribe & García-Varela, 2014), and *N. costarricense* (Pinacho-Pinacho, Serenio-Uribe, García-Varela, & Pérez-Ponce de León, 2020). In South America, 12 species of *Neoechinorhynchus* have been described in fish (Arredondo & Gil de Pertierra, 2012; Melo *et al.* 2013; Brito-Porto *et al.* 2017; De Souza & De O. Malta, 2019): *N. macronucleatus* (Machado, 1954), *N. buttnerae* (Golvan, 1956), *N. paraguayensis* (Machado, 1959), *N. prochilodorum* (Nickol & Thatcher, 1971), *N. curemai* (Noronha, 1973), *N. pterodoridis* (Thatcher, 1981), *N. villoldoi* (Vizcaino, 1992), *N. pimelodi* (Brasil-Sato & Pavanelli, 1998), *N. veropesoi* (Melo, Costa, Giese, Gardner & Santos, 2013), *N. inermis* (Brito-Porto *et al.* 2017), *N. pellonis* (De Souza & De O. Malta, 2019), and *N. colastinense* (Arredondo & Gil de Pertierra, 2012).

In Colombia, the study of acanthocephalans is still in its early stages, and only five species are reported in fish (Nickol & Thatcher, 1971; Schmidt & Huggins, 1973). Two of these belong to the genus *Neoechinorhynchus*: *N. prochilodorum* (Nickol & Thatcher, 1971) reported on *Prochilodus reticulatus* (Valenciennes, 1850) in Laguna del Sonso, Valle del Cauca (Nickol & Thatcher, 1971), and *N. buttnerae* (Golvan, 1956) reported on *Colossoma nigripinnis* (Cope, 1878) in Leticia, Amazonas (Schmidt & Huggins, 1973). Considering the high levels of cryptic diversity that this group presents in other regions of the Neotropics (Pinacho-Pinacho *et al.* 2018), *Neoechinorhynchus* species richness may be underestimated for the country. Based on this scenario, the morphospecies reported

here could represent the record of a species previously unreported for Colombia. Taxonomic studies will allow us to know the specific identity of this morphospecies and its relationship with other species of the genus.

Acanthocephalosis, including that caused by forms of *Neoechinorhynchus*, has negative impacts on fish production. *Neoechinorhynchus buttnerae* is considered one of the species with the greatest impact on aquaculture production (Ramos Valladão *et al.* 2020). It is considered a silent disease, which goes unnoticed by the fish farmer, if adequate sanitary control is not carried out (Ramos Valladão *et al.* 2020). Acanthocephalans affect the mucosal, submucosal, and muscular layers, causing laceration and intense inflammatory reactions. The main clinical manifestation in fish parasitized by acanthocephalans is progressive weight loss. Once in the intestine of the fish, the parasite alters the integrity of the intestinal mucosa and then begins to compete for the nutrients ingested by the fish (Jerônimo *et al.* 2017).

In the present study, three morphospecies of the family Diplostomidae were also found parasitizing *C. kraussii*, these were *Austrodiplostomum* sp. in vitreous humor (prevalence 43.8%; Figures. 3a and 3d) and two morphospecies of *Posthodiplostomum* encysted in pectoral fin muscles (prevalences of 15.6% and 6.3%; Figures. 3b, 3e and 3f). Adult forms of *Austrodiplostomum* are intestinal parasites of cormorants, while metacercariae are parasites of the eyeball and brain of freshwater and brackish water fish (García-Varela *et al.* 2016; Sereno-Urbe *et al.* 2019). This genus includes only two species: *A. mordax* (Szidat & Nani, 1951), described in South America and *A. compactum* (Lutz, 1928) reported from the United States, Mexico, El Salvador, Honduras, Costa Rica, Venezuela, Peru, and Brazil (De Fátima Cracco *et al.* 2022). In the Colombian Caribbean, adults of *A. compactum* and *A. ostrowskiae* have been reported in piscivorous birds (Rietschel & Werding, 1978) and as metacercariae in *C. kraussii* (Olivero-Verbel *et al.* 2012) in *Oreochromis mossambicus* (Peters, 1852) and *O. niloticus* (Linnaeus, 1758) (Soler-Jiménez *et al.* 2017). It is important to note that recent molecular analyses propose synonymy between *A. compactum* and *A. ostrowskiae* (García-Varela *et al.* 2016; Ostrowski de Núñez, 2017; De Fátima Cracco *et al.* 2022). *Austrodiplostomum* metacercariae cause verminous cataracts in fish and can affect other organs such as gills, muscle, swim bladder and brain (Amin, 2002). High infections in cultures associated with this genus are attributed to high fish densities and abundance of mollusk hosts in artificial ponds (Violante-González *et al.* 2009).

Posthodiplostomum are intestinal parasites of piscivorous birds with a worldwide distribution. The metacercariae of *Posthodiplostomum* found in the present study correspond to two morphospecies (Figures 3e and 3f), which differ from each other in body size and organ distribution. Eight species are reported from South America: *Posthodiplostomum grande* (Diesing, 1850), *P. macrocotyle* (Dubois, 1937), *P. microsicya* (Dubois, 1937), *P. nanum* (Dubois, 1937), *P. obesum* (Lutz, 1928), *P. giganteum* (Dubois, 1988), *P. mignum* (Boero, Led & Brandetti, 1972), and *P. euryppygae* (Achatz, Chermak, Bell, Fecchio & Tkach, 2021) (Fernandes *et al.*

2015; López-Hernández *et al.* 2018). In Colombia, the presence of *P. nanum* is recognized in *Butorides virescens maculata* (Drago & Lunaschi, 2011), and although previous work considered the occurrence of *P. minimum* (Rietschel & Werding, 1978), this has not been validated in recent listings for South America (Fernandes *et al.* 2015). The high morphological and molecular variation reported in metacercariae of some species of the genus in Central America (Perez-Ponce de León *et al.* 2021; Díaz Pernet *et al.* 2022) highlights the importance of carrying out taxonomic studies of the morphospecies found here, in order to establish their relationship with previously described lineages.

Metacercariae parasitize the surface of the body, fins, scales or in the musculature and body cavity of fish (Ritossa *et al.* 2013; Cech *et al.* 2020). When the parasites are located in the skin, melanophores agglomerate around them, giving rise to dark pigmented spots, which is known in fish farming as black spot disease (Rodríguez *et al.* 2001). Other liver-hosting *Posthodiplostomum* species are associated with liver damage that can cause digestion dysfunction and consequently, malnutrition in infected fish (Osorio-Sarabia *et al.* 1986; López-Hernández *et al.* 2018). Although at the fish farming level, it is known that black spot disease is produced by diplostomids (Alvarez-León, 2007; Horák *et al.* 2014), taxonomic studies are required to determine the species existing in Colombia.

Adult forms of *Oligogonotylus andinus* (Figure 3h) recorded a prevalence of 18.8 % and the lowest average abundance in the study. This is a genus exclusive to cichlids and contains three species, *O. manteri* (Watson, 1976) and *O. mayae* (Razo-Mendivil *et al.* 2008) in Central America (Razo-Mendivil *et al.* 2008) and *O. andinus* (Vélez-Sampedro *et al.* 2022) described in the blue mojarra (*Andinoacara latifrons*) in a fish farm of peasant economy in the Antioquia department. The life cycle of *O. andinus* is complex and involves cochliopid, poeciliid and cichlid micromollusks (Vélez-Sampedro *et al.* 2022). This research reports for the second time a population of *O. andinus* in Colombia, extending its distribution range from the Cauca River basin in the Andean region to the coastal region of the Colombian Caribbean.

The infection parameters in this study for *O. andinus* in yellow mojarra contrast with those found in blue mojarra, where the abundance and prevalence values reach values of 100% and 39.3% (Vélez-Sampedro *et al.* 2022). Focus studies on small fish farming systems provide important data on the dynamics of parasite transmission, useful for the design of control programs. The study of the life cycle of *Oligogonotylus* in blue mojarra revealed that the presence and high densities of intermediate hosts in fishponds favor high parasite loads (re-infection) in definitive hosts.

Therefore, given the importance of the mojarra amarilla in the food security of local communities, it is recommended to continue with efforts to identify the associated helminths and their transmission routes, which will not only strengthen programs for the management and control of diseases caused by helminths, but also public health strategies at the local level, as well as promote new studies to define the impact of parasites at the fish farming level.

At the taxonomic level, an integrative approach is required that includes obtaining adult specimens for morphological characterization of each species, as well as molecular validation of the parasite species found here and reported from metacercariae. In addition, the molecular approach will allow the identification of cryptic species such as the genus *Neoechinorhynchus*.

At the ecological level, the identification of other hosts involved in the life cycle of the parasites and their mode of transmission to fish is necessary.

Finally, from a veterinary perspective, treatment and control schemes should be developed. It is hoped that this study will serve as the foundation for future research, enabling diagnosis for other species of fish consumed in the region.

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REFERENCES

- ACHATZ, T.J.; CHERMAK, T.P.; MARTENS, J.R.; PULIS, E.E.; FECCHIO, A.; BELL, J.A.; GREIMAN, S.E.; CROMWELL, K.J.; BRANT, S.V.; KENT, M.L.; TKACH, V.V. 2021. Unravelling the diversity of the Crassiphialinae (Digenea: Diplostomidae) with molecular phylogeny and descriptions of five new species. *Current Research in Parasitology & Vector-Borne Diseases*. 1:100051. <https://doi.org/10.1016/j.crpvbd.2021.100051>
- ALVAREZ-LEÓN, R. 2007. Asociaciones y patologías en los peces dulceacuícolas, estuarinos y marinos de Colombia: aguas libres y controladas. *Boletín Científico Centro de Museos Museo de Historia Natural*. 11(1):81-129.
- AMIN, O.M. 2002. Revision of *Neoechinorhynchus* Stiles & Hassall, 1905 (Acanthocephala: Neoechinorhynchidae) with keys to 88 species in two subgenera. *Systematic Parasitology*. 53:1-18. <https://doi.org/10.1023/A:1019953421835>
- ARREDONDO, N.J.; GIL DE PERTIERRA, A.A. 2012. A new species of *Neoechinorhynchus* (Eoacanthocephala: Neoechinorhynchidae) from *Pachyurus bonariensis* (Perciformes: Sciaenidae) from the Paraná River basin in Argentina, with comments on two other species of the genus. *Revue Suisse de Zoologie*. 119(4):425-439. <http://dx.doi.org/10.5962/bhl.part.150202>
- BAUTISTA-HERNÁNDEZ, C.E.; MONKS, S.; PULIDO-FLORES, G.; RODRÍGUEZ-IBARRA, A. 2015. Revisión bibliográfica de algunos términos ecológicos usados en parasitología, y su aplicación en estudios de caso. En: Pulido-Flores, G.; Monks, S.; Lopez-Herrera, M. (eds). *Estudios en biodiversidad*. I. Zea Books, Estados Unidos. p.11-19.
- BRITO-PORTO, D.; SILVA-DE SOUZA, A.K.; DE OLIVEIRA-MALTA, J.C. 2017. A new species of *Neoechinorhynchus* (Eoacanthocephala: Neoechinorhynchidae) from the freshwater fish *Ageneiosus inermis* (Siluriformes) in the Brazilian Amazon. *Revista Mexicana de Biodiversidad*. 88(4):798-800. <https://doi.org/10.1016/j.rmb.2017.10.023>
- BUSH, A.O.; LAFFERTY, K.D.; LOTZ, J.M.; SHOSTAK, W. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. *The Journal of Parasitology*. 83(4):575-583. <https://doi.org/10.2307/3284227>
- CAFFARA, M.; LOCKE, S.A.; GUSTINELLI, A.; MARCOGLIESE, D.J.; FIORAVANTI, M.L. 2011. Morphological and molecular differentiation of *Clinostomum complanatum* and *Clinostomum marginatum* (Digenea: Clinostomidae) metacercariae and adults. *Journal of Parasitology*. 97:884-891. <https://doi.org/10.1645/GE-2781.1>
- CASTELLANOS-GARZÓN, J.A.; DASCHNER, A.; PUSTOVRH, M.C.; CUELLAR, C. 2019. Characteristics related to fish consumption and the risk of ichthyozoonosis in a Colombian population. *Revista de Salud Pública*. 21(6):1-8. <https://doi.org/10.15446/rsap.V21n6.69898>
- CASTELLANOS-GARZÓN, J.A.; FALLA-ZÚÑIGA, L.F.; SALAZAR, L.; PUSTOVRH-RAMOS, M.C. 2020. Anisákidos y anisakidosis: generalidades y su actualidad en Colombia. *Revisión Bibliográfica. Latreia*. 33(2):143-154. <https://doi.org/10.17533/udea.iatreia.47>
- CECH, G.; SANDOR, D.; MOLNAR, K.; PAULUS, P.; PAPP, M.; PREISZNER, B.; VITAL, Z.; VARGA, A.; SZEKEL, Y.C. 2020. New record of metacercariae of the North American *Posthodiplostomum centrarchi* (Digenea, Diplostomidae) in pumpkinseed (*Lepomis gibbosus*) in Hungary. *Acta Veterinaria Hungarica*. 68(1):20-29. <https://doi.org/10.1556/004.2020.00001>
- CHAI, J.Y.; MURRELL, K.D.; LYMBERY, A.J. 2005. Fish-borne parasitic zoonoses: status and issues. *International Journal of Parasitology*. 35(11-12):1233-1254. <https://doi.org/10.1016/j.ijpara.2005.07.013>

- DE FÁTIMA CRACCO, A.; SCORSIM, B.; DE OLIVEIRA, A.V.; TAKEMOTO, R.M. 2022. Morphological and molecular characterization of *Austrodiplostomum compactum* metacercariae in the eyes and brains of fishes from the Ivaí River, Brazil. *Revista Brasileira de Parasitologia Veterinária*. 31(2):e021421. <https://doi.org/10.1590/S1984-29612022021>
- DE SOUZA, A.K.S.; DE O. MALTA, J.C. 2019. A new species of *Neoechinorhynchus* Stiles & Hassall, 1905 (Eoacanthocephala: Neoechinorhynchidae) parasite *Pellona castelnaeana* Valenciennes, 1847 (Clupeiformes: Pristigasteridae) of the Brazilian Amazon. *Neotropical Helminthology*. 13(2):227-233.
- DÍAZ PERNETT, S.C.; BRANT, S.V.; LOCKE, S.A. 2022. First integrative study of the diversity and specificity of metacercariae of *Posthodiplostomum* Dubois, 1936 from native and introduced fishes in the Caribbean. *Parasitology*. 149(14):1894-1909. <https://doi.org/10.1017/S0031182022001214>
- DO NASCIMENTO, C.; HERRERA-COLLAZOS, E.E.; HERRERA-R, G.A.; ORTEGA-LARA, A.; VILLANAVARRO, F.A.; OVIEDO, J.S.U.; MALDONADO-OCAMPO, J.A. 2017. Checklist of the freshwater fishes of Colombia: A Darwin Core alternative to the updating problem. *Zookeys*. 708:25-138. <https://doi.org/10.3897/zookeys.708.13897>
- DURÁN, E.; ROSADO, R.; BALLESTEROS, O.D.; LERMA, D.E. 2014. Comercialización de pescado en las principales plazas de mercado de Montería, Colombia. *Temas Agrarios*. 19(1):50-64. <https://doi.org/10.21897/rta.v19i1.724>
- ERIKSON, U. 2011. Assessment of different stunning methods and recovery of farmed Atlantic salmon (*Salmo salar*): Isoeugenol, nitrogen and three levels of carbon dioxide. *The UFAW Journal-Animal Welfare*. 20(3):365-375. <https://doi.org/10.1017/S096272860000292X>
- FERNANDES, B.M.M.; JUSTO, C.N.M.; CÁRDENAS, M.Q.; COHEN, C.S. 2015. South American trematode parasites of birds and mammals. *Oficina de Livros Brasil*. p.549
- FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS-FAO; ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN-ECLAC. 2020. Food systems and COVID-19 in Latin America and the Caribbean: Towards inclusive, responsible and sustainable fisheries and aquaculture. *Bulletin 15*. FAO. Santiago. p.21 Disponible desde Internet en: https://repositorio.cepal.org/bitstream/handle/11362/46107/1/cb1197_en.pdf
- FRAINER, A.; MCKIE, B.G.; AMUNDSEN, P.A.; KNUDSEN, R.; LAFFERTY, K.D. 2018. Parasitism and the biodiversity-functioning relationship. *Trends in Ecology & Evolution*. 33(4):260-268. <https://doi.org/10.1016/j.tree.2018.01.011>
- GARCÍA-VARELA, M.; SERENO-URIBE, A.L.; PINACHO-PINACHO, C.D.; DOMÍNGUEZ-DOMÍNGUEZ, O.; PÉREZ-PONCE DE LEÓN, G. 2016. Molecular and morphological characterization of *Austrodiplostomum ostrouskiae* Dronen, 2009 (Digenea: Diplostomatidae), a parasite of cormorants in the Americas. *Journal of Helminthology*. 90(2):174-185. <https://doi.org/10.1017/S0022149X1500005X>
- GIBSON, D.I.; JONES, A.; BRAY, R.A. 2002. Keys to the Trematoda: Volume 1. CAB International and Natural History Museum London. p.521
- HARA, H.; MIYAUCHI, Y.; TAHARA, S.; YAMASHITA, H. 2014. Human laryngitis caused by *Clinostomum complanatum*. *Nagoya Journal of Medical Science*. 76(1-2):181.
- HORÁK, P.; KOLÁŘOVÁ, L.; MIKEŠ, L. 2014. Schistosomatoidea and Diplostomoidea. En: Toledo, R.; Fried, B. (eds). *Digenetic Trematodes. Advances in Experimental Medicine and Biology*. Ed. Springer New York. p.331-364.
- JERÔNIMO, G.T.; PÁDUA, S.B. DE; BELO, M.A. DE A.; CHAGAS, E.C.; TABOGA, S.R.; MACIEL, P.O.; MARTINS, M.L. 2017. *Neoechinorhynchus buttnerae* (Acanthocephala) infection in farmed *Colossoma macropomum*: A pathological approach. *Aquaculture*. 469:124-127. <https://doi.org/10.1016/j.aquaculture.2016.11.027>
- LENIS, C.; VÉLEZ, I. 2011. Digeneans in *Trachemys callirostris* and *Podocnemis lewyana* (Testudinata) from the Magdalena River, Colombia: description of *Pseudonematophila* n. gen. and amendment of *Nematophila* Travassos, 1934 (Cladorchiidae: Schizamphistominae). *Zootaxa*. 3095:49-62. <https://doi.org/10.11646/zootaxa.3095.1.5>
- LIMA DOS SANTOS, C.A.; HOWGATE, P. 2011. Fishborne zoonotic parasites and aquaculture: A review. *Aquaculture*. 318(3-4):253-261. <https://doi.org/10.1016/j.aquaculture.2011.05.046>
- LÓPEZ-HERNÁNDEZ, D.; LOCKE, S.A.; MELO, A.L. DE; RABELO, É.M.L.; PINTO, H.A. 2018. Molecular, morphological and experimental assessment of the life cycle of *Posthodiplostomum nanum* Dubois, 1937 (Trematoda: Diplostomidae) from Brazil, with phylogenetic evidence of the paraphyly of the genus *Posthodiplostomum* Dubois, 1936. *Infection, Genetics and Evolution*. 63:95-103. <https://doi.org/10.1016/j.meegid.2018.05.010>
- LOURENÇO, F.; MOREY, G.; MALTA, J. 2018. The development of *Neoechinorhynchus buttnerae* (Eoacanthocephala:

- Neoechinorhynchidae) in its intermediate host *Cypridopsis vidua* in Brazil. *Acta Parasitologica*. 63(2):354-359. <https://doi.org/10.1515/ap-2018-0040>
- MELO, F.T.D.V.; COSTA, P.A.F.B.; GIESE, E.G.; GARDNER, S.L.; SANTOS, J.N. 2013. A description of *Neoechinorhynchus* (*Neoechinorhynchus*) *veropesoi* n. sp. (Acanthocephala: Neoechinorhynchidae) from the intestine of the silver croaker fish *Plagioscion squamosissimus* (Heckel, 1840) (Osteichthyes: Sciaenidae) off the east coast of Brazil. *Journal of Helminthology*. 89(1):34-41. <https://doi.org/10.1017/S0022149X13000564>
- MONTES, M.M.; BARNECHE, J.; PAGANO, L.; FERRARI, W.; MARTORELLI, S.R.; PÉREZ-PONCE DE LEÓN, G. 2021. Molecular data reveal hidden diversity of the genus *Clinostomum* (Digenea, Clinostomidae) in Argentina, with the description of a new species from *Ardea cocoi* (Ardeidae). *Parasitology Research*. 120:2779-2791. <https://doi.org/10.1007/s00436-021-07234-4>
- MURRIETA MOREY, G.A.; TUESTA ROJAS, C.A.; DE OLIVEIRA MALTA, J.C. 2022. Endoparásitos zoonóticos en peces de consumo comercializados en los mercados de la ciudad de Iquitos, Loreto, Perú. *Folia Amazónica*. 31(1):121-133. <https://doi.org/10.24841/fa.v31i1.604>
- NICKOL, B.B.; THATCHER, V.E. 1971. Two New Acanthocephalans from Neotropical Fishes: *Neoechinorhynchus prochilodorum* sp. n. and *Gorytocephalus plecostomorum* gen. et sp. n. *The Journal of Parasitology*. 57(3):576-581.
- OLIVERO-VERBEL, J.; GUERRA-HERNÁNDEZ, M.; GARCÍA-ESPINEIRA, M.C. 2012. *Diplostomum compactum metacercariae* in the eyes of *Caquetaia kraussii* from Totumo Marsh, north of Colombia. *Bulletin of The European Association of Fish Pathologists*. 36(2):203-211.
- OSORIO-SARABIA, D.; PÉREZ-PONCE DE LEÓN, G.; GARCÍA-MÁRQUEZ, L.J. 1986. Helminths of fishes in Pátzcuaro, Michoacán II: Estudio histopatológico de la lesión causada por metacercarias de *Posthodiplostomum minimum* (Trematoda: Diplostomatidae) en el hígado de *Chirostoma estor*. *Anales del Instituto de Biología de la Universidad Nacional Autónoma de México*. 57:247-260.
- OSTROWSKI DE NÚÑEZ, M. 2017. Redescription of *Austrodiplostomum compactum* (Trematoda: Diplostomatidae) from its type host and locality in Venezuela, and of *Austrodiplostomum mordax* from Argentina. *Journal of Parasitology*. 103(5):497-505. <https://doi.org/10.1645/16-128>
- PARK, C.W.; KIM, J.S.; JOO, H.S.; KIM, J. 2009. A Human Case of *Clinostomum complanatum* Infection in Korea. *Korean Journal of Parasitology*. 47(4):401-404. <https://doi.org/10.3347/kjp.2009.47.4.401>
- PEREZ-PONCE DE LEÓN, G.; SERENO-URIBE, A.L.; PINACHO-PINACHO, C.D.; GARCÍA-VARELA, M. 2022. Assessing the genetic diversity of the metacercariae of *Posthodiplostomum minimum* (Trematoda: Diplostomidae) in Middle American freshwater fishes: one species or more? *Parasitology*. 149(2):239-252. <https://doi.org/10.1017/S0031182021001748>
- PINACHO-PINACHO, C.D.; GARCÍA-VARELA, M.; SERENO-URIBE, A.L.; PÉREZ-PONCE DE LEÓN, G. 2018. A hyper-diverse genus of acanthocephalans revealed by tree-based and non-tree-based species delimitation methods: Ten cryptic species of *Neoechinorhynchus* in Middle American freshwater fishes. *Molecular Phylogenetics and Evolution*. 127:30-45. <https://doi.org/10.1016/j.ympev.2018.05.023>
- PINACHO-PINACHO, C.D.; SERENO-URIBE, A.L.; GARCÍA-VARELA, M.; PÉREZ-PONCE DE LEÓN, G. 2020. A closer look at the morphological and molecular diversity of *Neoechinorhynchus* (Acanthocephala) in Middle American cichlids (Osteichthyes: Cichlidae), with the description of a new species from Costa Rica. *Journal of Helminthology*. 94:e23. <https://doi.org/10.1017/S0022149X18001141>
- PIZANO, C.M.; GARCÍA, H. 2014. El Bosque seco tropical en Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH). Bogota. p.349
- QUIJADA, J.; LIMA DOS SANTOS, C.A.; AVDALOV, N. 2005. Enfermedades parasitarias por consumo de pescado. Incidencia en América Latina. *Infopesca internacional*. 24:16-23.
- RAMOS VALLADÁO, G.M.; GALLANI, S.U.; JERÔNIMO, G.T.; TAVARES DE SEIXAS, A.T. 2020. Challenges in the control of acanthocephalosis in aquaculture: special emphasis on *Neoechinorhynchus buttnerae*. *Reviews in Aquaculture*. 12(3):1360-1372. <https://doi.org/10.1111/raq.12386>
- RAZO-MENDIVIL, U.; ROSAS-VALDEZ, R.; PÉREZ-PONCE DE LEÓN, G. 2008. A new cryptogonimid (Digenea) from the Mayan cichlid, *Cichlasoma urophthalmus* (Osteichthyes: Cichlidae), in several localities of the Yucatan Peninsula, Mexico. *Journal of Parasitology*. 94(6):1371-1378. <https://doi.org/10.1645/GE-1546.1>
- RIETSCHER, G.; WERDING, B. 1978. Trematodes of birds from Northern Columbia. *Zeitschrift Für Parasitenkunde Parasitology Research*. 57(1):57-82. <https://doi.org/10.1007/BF00927629>
- RITOSSA, L.; FLORES, V.; VIOZZI, G. 2013. Life-cycle stages of a *Posthodiplostomum* species (Digenea: Diplostomatidae)

- from Patagonia, Argentina. *Journal of Parasitology*. 99(5):777-780. <https://doi.org/10.1645/12-170.1>
- RIVAS-LARA, T.S.; GÓMEZ-VANEGA, H.D. 2017. Algunos aspectos biológicos y pesqueros de *Caquetaia kraussii* (Steindachner, 1878) en la cuenca media y baja del río Atrato, Chocó. *Revista Biodiversidad Neotropical*. 7(1):14-21. <http://dx.doi.org/10.18636/bioneotropical.v7i1.551>
- RODRÍGUEZ, G.M.; RODRÍGUEZ, C.D.G.D.; MONROY, G.Y.; MATA, S.J.A. 2001. Manual de enfermedades de peces. Boletín Del Programa Nacional de Sanidad Acuicola y La Red de Diagnóstico CONAPESCA. 4(3):1-14.
- ROJAS SÁNCHEZ, A.; LAMOTHE ARGUMEDO, M.R.; GARCÍA-PRIETO, L. 2014. Parasitosis transmitidas por el consumo de peces en México. *Ciencia*. 65(2):83-87.
- ROSSER, T.G.; BAUMGARTNER, W.A.; ALBERSON, N.R.; NOTO, T.W.; WOODYARD, E.T.; TOMMY KING, D.; WISE, D.J.; GRIFFIN, M.J. 2018. *Clinostomum poteae* n. sp. (Digenea: Clinostomidae), in the trachea of a double-crested cormorant *Phalacrocorax auritus* Lesson, 1831 and molecular data linking the life-cycle stages of *Clinostomum album* Rosser, Alberson, Woodyard, Cunningham, Pote & Griffi. *Systematic Parasitology*. 95(6):543-566. <https://doi.org/10.1007/s11230-018-9801-5>
- SCHMIDT, G.D.; HUGGHINS, E.J. 1973. Acanthocephala of South American Fishes. Part I, Eoacanthocephala. *Journal of Parasitology*. 59(5):829. <https://doi.org/10.2307/3278417>
- SERENO-URIBE, A.L.; GÓMEZ, L.A.; OSTROWSK, N.M.; PÉREZ-PONCE, D.E.; LEÓN G.; GARCÍA-VARELA M. 2019. Assessing the taxonomic validity of *Austrodiplostomum* spp. (Digenea: Diplostomidae) through nuclear and mitochondrial data. *Journal of Parasitology*. 105(1):102-112. <https://doi.org/10.1645/18-51>
- SOLANO-PEÑA, D.; SEGURA-GUEVARA, F.; OLAYA-NIETO, C. 2013. Crecimiento y reproducción de la mojarra amarilla (*Caquetaia kraussii* Steindachner, 1878) en el embalse de Urrá, Colombia. *Revista MVZ Córdoba*. 18(2):3525-3533. <https://doi.org/10.21897/rmvz.177>
- SOLER-JIMÉNEZ, L.C.; PAREDES-TRUJILLO, A.I.; VIDAL-MARTÍNEZ, V.M. 2017. Helminth parasites of finfish commercial aquaculture in Latin America. *Journal of Helminthology*. 91(2):110-136. <https://doi.org/10.1017/S0022149X16000833>
- THILSTED, S.H.; JAMES, D.; TOPPE, J.; SUBASINGHE, R.; KARUNASAGAR, I. 2014. Maximizing the contribution of fish to human nutrition [Background paper]. ICN2 Second international conference on nutrition better nutrition better lives. Rome, Italy. p.16 Disponible desde Internet en <https://digitalarchive.worldfishcenter.org/handle/20.500.12348/126>
- TIEWCHALOERN, S.; UDOMKIJDECHA, S.; SUVOUTTHO, S.; CHUNCHAMSRI, K.; WAIKAGUL, J. 1999. *Clinostomum* trematode from human eye. *Southeast Asian Journal of Tropical Medicine and Public Health*. 30(2):382-384.
- VÉLEZ, E.I. 1987. Sobre la fauna de tremátodos en peces marinos de la familia Lutjanidae en el mar Caribe. *Actualidades Biológicas*. 16(61):70-84.
- VÉLEZ-SAMPEDRO, V.; URUBURU, M.; LENIS, C. 2022. Morphological, molecular, and life cycle study of a new species of *Oligogonotylus* Watson, 1976 (Digenea, Cryptogonimidae) from Colombia. *ZooKeys*. 1115:169-186. <https://doi.org/10.3897/zookeys.1115.75538>
- VIOLANTE-GONZÁLEZ, J.; GARCÍA-VARELA, M.; ROJAS-HERRERA, A.; GUERRERO, S.G. 2009. Diplostomiasis in cultured and wild tilapia *Oreochromis niloticus* in Guerrero State, Mexico. *Parasitology Research*. 105(3):803-807. <https://doi.org/10.1007/s00436-009-1458-1>
- YAMAGUTI, S. 1975. A synoptical review of the life histories of digenetic trematodes of vertebrates, with special reference to the morphology of their larval forms. Keigaku Publishing Co. Tokyo. p.575
- ZAPATA-LONDOÑO, M.N.; MÁRQUEZ, E.J.; RESTREPO-ESCOBAR, N.; RÍOS-PULGARÍN, M.I. 2020. Population structure and reproduction of five fish species in a Neotropical reservoir. *Revista de La Academia Colombiana de Ciencias Exactas, Físicas y Naturales*. 44(171):622-638. <https://doi.org/10.18257/raccefyn.1049>