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Original Article

Nematode capilaridae in the tongue of *Cerdocyon thous* of free life in Brazil

Nematoide capilaridae na língua de *Cerdocyon thous* de vida livre no Brasil

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Abstract

Studies of helminths in road-killed wild animals are still uncommon but may provide promising results since they can identify the parasites in juvenile and adult hosts and meet the recommendations of current discussions on bioethics that prioritize alternative methods for the use of animals. This study evaluated three *Cerdocyon thous* individuals that were donated after dying from being run over. Two of them had small nematode adults in the epithelial and connective tissues of the tongue. The diagnosis was based on the presence of eggs, observed in histological sections, and morphological characteristics of the nematodes in the tongue. Morphologically, this nematode has a body with transverse grooves, simple mouth opening and no lips, esophagus and stichosome with stichocytes and bacillary bands along the body, which is characteristic morphology of the family Capilariidae and genus *Capillaria*. The presence of this nematode in the tongue of *C. thous* is an extremely important fact that contributes to what is known about the biodiversity of zoonotic parasites in wild canid populations. However, an explanation for these findings remains unclear because, until now, this has not been observed in the biological cycle of the species.

Keywords: Nematoda, *Capillaria*, mammal, Amazon.

Resumo

O estudo de helmintos de animais selvagens vitimados por atropelamento, ainda é uma prática pouco comum, porém pode ser promissor, uma vez que permite a identificação de helmintos a partir de hospedeiros juvenis e adultos, e atendem às atuais discussões em bioética, as quais priorizam métodos alternativos para o uso de animais. Foram avaliados 3 exemplares de *Cerdocyon thous* provenientes de doação pós-óbito por atropelamento. Dois deles apresentaram pequenos nematoides adultos inseridos nos tecidos epitelial e conjuntivo da língua. O diagnóstico foi baseado na análise de cortes histológicos que evidenciaram a presença de ovos no interior do nematoide e nas características morfológicas gerais do mesmo. Morfologicamente estes nematoides apresentavam corpo com estrias transversais, abertura bucal simples e lábios ausentes, esôfago trichuroiude com a presença de esticócitos e bandas bacilares ao longo do corpo, característica morfologicamente sugestiva da família Capillariidae e do gênero *Capillaria*. A presença de nematoides inseridos na língua de *C. thous* é um fato de extrema importância para o conhecimento da biodiversidade de parasitos zoonóticos circulantes presentes em populações selvagens de canídeos. Porém, permanece obscura a explicação para tais achados, uma vez que tal evento não foi observado no ciclo biológico das espécies até o momento.

Palavras-chave: Nematoda, *Capillaria*, mamífero, Amazônia.

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Introduction

Studies involving the helminthofauna of wild animals are of great importance for the conservation of species and for public health, since some of these parasites can injure wild populations and have zoonotic potential (LAFFERTY, 1997).

Some helminths that parasitize wild mammals belong to the family Capillaridae. The taxonomy of this family is still being revised and the group contains many species in the genus *Capillaria* (GUARDONE et al., 2013; FUEHRER, 2014), of which *Capillaria hepatica* Bancroft, 1893 is the most commonly cited in the literature as a parasite of various domestic and wild animals (FREITAS & LENT, 1936; ARAÚJO, 1967; SILVEIRA et al., 1975; GALVÃO, 1981; CHIEFFI et al., 1981; MANDORINO & REBOUÇAS, 1991; VICENTE et al., 1997; RUAS et al., 2003). *Capillaria* comprises a complex group of parasites, which has resulted in the proposal of the genera *Calodium*, *Eucoleus*, *Paracapillaria*, *Pearsonema* and *Aonchotheca* (GUARDONE et al., 2013; FUEHRER, 2014). Within this complex, three species are of zoonotic importance: *Paracapillaria philippinensis* (Syn. *Capillaria philippinensis*), *Eucoleus aerophila* (Syn. *Capillaria aerophila*) and *Calodium hepaticum* (Syn. *Capillaria hepatica*, *Trichocephalus hepaticus* Bancroft, 1893 and *Hepaticola hepatica* Hall 1916.

Due to anthropic impacts, wild animals frequently come out of natural habitats in search of food and suffer injuries. Roads, starting at the construction phase, impact native fauna in several ways, producing direct and indirect effects on populations, such as mortality from being run over, loss of habitat, dispersion of exotic species and intensification of the presence of humans (ASCENSÃO & MIRA, 2006). The study of helminths in road-killed animals is still uncommon; however, studies that use this methodology are promising since they can identify these parasites in adults and young individuals and meet the recommendations of current discussions on bioethics that prioritize alternative methods for the use of animals (RICHINI-PEREIRA et al., 2006). In Brazil, among the wild carnivores, *Cerdocyon thous* is one of the most commonly road-killed species (MALHEIROS, 2004; PRADA, 2004; PINOWSKI, 2005).

Based on the few studies about the presence of capillariids in wild animals, this study describes the first record in Brazil of a Capillariidae nematode parasitizing the tongue of *C. thous*, in the municipality of Paragominas in Pará State, in addition to collecting and analyzing retrospective data on the fauna of helminths of *C. thous* in Brazil.

Materials and Methods

We evaluated the tongues of three animals (*C. thous*) that were donated, after being run over by the company HYDRO Paragominas - bauxite mine, to the Laboratório de Pesquisa Morfológica Animal (LaPMA) - Instituto da Saúde e Produção Animal at the Universidade Federal Rural da Amazônia (UFRA), campus Belém (under authorization of SEMA-PA Nº 455/2009 and 522/2009), animals used for morphological studies.

To extract the tongues, used in morphological studies by LaPMA, an incision in the skin and muscles of the mentonian region was made. The tongue was folded ventrally after cutting the lingual frenulum and then cut caudally at the root to harvest the material. The material was fixed in a 10% formaldehyde solution for the histological analysis and in an AFA solution (93 parts 70% ethyl alcohol, 5 parts formaldehyde, and 2 parts glacial acetic acid) for the morphological analysis. Samples of the nematodes were separated from the lingual tissue, dehydrated in an ethanol series, clarified with lactophenol, placed on a microscope slide under a coverslip as a temporary mount, observed using a light microscope, and photographed with a LEICA DM2500 microscope with an image capturing system. This work was conducted in the Laboratório de Histologia e Embriologia Animal - Instituto da Saúde e Produção Animal. For scanning electron microscopy, fragments of the tongue with nematodes were fixed in 10% formaldehyde, post-fixed in 1% osmium tetroxide, critical point dried with CO_2, coated with gold-palladium and analyzed with a VEGA 3 LMU/TESCAN scanning electron microscope. This was done in the Laboratório de Microscopia Eletrônica de Varredura - Instituto da Saúde e Produção Animal at the Universidade Federal Rural da Amazônia (UFRA), campus Belém. To avoid confusion, only names of genera of helminths are abbreviated and not those of hosts.

Results

Of the three animals evaluated, two had six small adult nematodes in the epithelial and conjunctive tissues of the tongue (Figure 1A and 2A-C). The six nematodes formed galleries within the epithelium (Figure 1D- E and 2B) and their dispersal had a multifocal character. The diagnosis was based on the presence of eggs (FERRER & CASTELLÀ, 1996), observed in histological sections, and morphological characteristics of the nematodes in the tongues, which were analyzed using scanning electron microscopy (body surface) and light microscopy

During the histological analysis of the *C. thous* tongues, adult female nematodes were observed in transverse sections. These were inserted in the basal layers of stratified epithelial tissue, with eggs both inside the parasite as well as egg isolates and clusters within galleries developed by the nematodes (Figure 1D-E). The eggs were barrel shaped with two polar opercula with plugs on the ends, which are diagnostic characteristics of the genus *Capillaria* (Figure 1B-C). The size and the number of nematodes inserted in the tegument of the coating of the tongue did not cause inflammatory reactions and did not affect the morphology of the lingual papillae (Figure 1D).

A light microscopy analysis of a fragment of a nematode, clarified with Amman's lactophenol, was conducted on the anterior region of the helminth because the rest of the body was strongly inserted in the tissue and it was not possible to completely remove the parasite (Figure 3A-B). Morphologically, the nematodes have a body with transverse grooves, a simple mouth opening and no lips, stichosome esophagus formed by stichocytes and bacillary bands (Figure 2D) on the surface of the cuticle along the body, which are also morphological characteristics of *Capillaria* (Figure 3A-B).

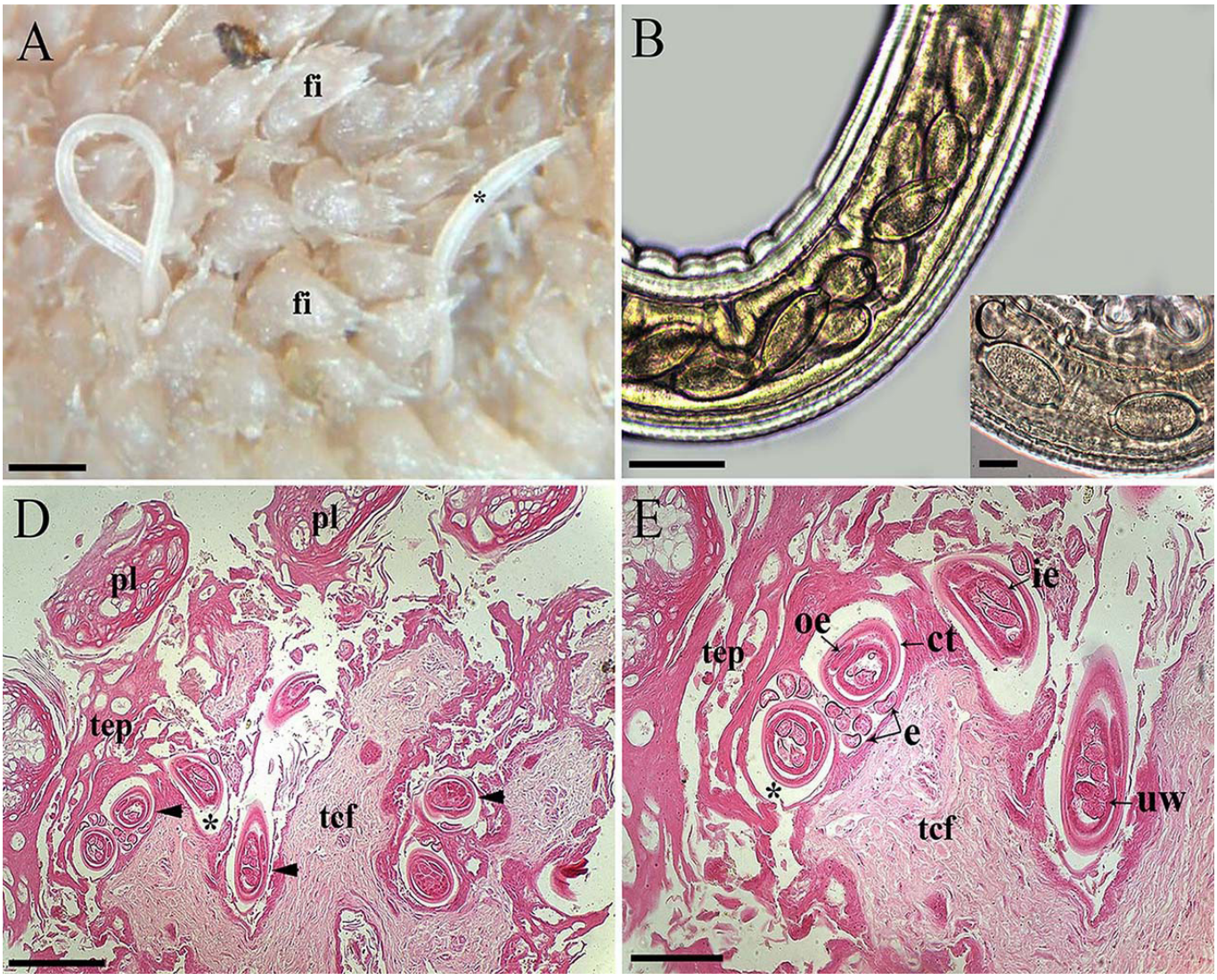

Figure 1. (A) Mesoscopic view of *Capillaria* sp. (*) inserted among the lingual filiform papillae (fi) of *Cerdocyon thous* in Pará State. (B) Lateral view of the *Capillaria* sp. female showing numerous intrauterine eggs. (C) Detail of eggs morphology with barrel shaped and two polar opercula with plugs on the ends. (D-E) Tongue photomicrographs of *C. thous* parasitized by *Capillaria* sp., in Pará State, stained with hematoxilin and eosin. (D) Lingual papillae (pl), sustained to loose connective tissue (tcf) and covered by keratinized stratified flat epithelial tissue (tep), where the *Capillaria* sp. (arrowhead) are inserted in interstitial space (*). (E) Cut of *Capillaria* sp. in keratinized stratified flat epithelial tissue (tep), sustained to loose connective tissue (tcf). Detail of cut of the nematode evidencing the cuticle (ct), uterine wall (uw), intrauterine eggs (ie), oesophagus (oe) and eggs (e) in the intertitial space (*). Scale bars: A= 1.5 cm, B=50 µm, C=20 µm, D= 200 µm, E=100 µm.

Discussion

In studies of the nematofauna of *C. thous*, published between 1915 and 2017, adult and juvenile nematodes in 13 superfamilies (Ancylostomatoidea, Ascaridoidea, Dioctophymatoidea, Filarioidea, Metastrongyloidea, Oxyuroidea, Physalopteroidea, Rictularoidea, Rhabditoidea, Strongyloidea, Spiruroidea, Thichinelloidea, Trichostrongloidea) were recorded in 13 localities in Brazil (Table 1). Of these, 15 families, 18 genera and 24 species of nematodes were identified. Some taxa were not identified to the specific level because the authors only conducted coprological exams. In the cases described as morphotypes, the authors provided morphological characteristics of the eggs (when possible) and/or measurements of the parasite; due to the lack of data, these were classified only as phylum Nematoda (Table 2).

The nematodes found in the tongue of *Cerdocyon thous*, collected in the municipality of Paragominas, Pará State, in eastern Amazon, have similar characteristics to those of other species of the family Capillaridae Railliet, 1915, and genus *Capillaria* Zeder, 1800. The diagnosis of infection by *Capillaria* in this study is based on the presence of eggs with bipolar plugs, as well as the morphological characteristics of the nematodes found in the tongue. Capillariidae, one of the five families belonging to the superfamily Trichinellidea, comprise more than 300 known species

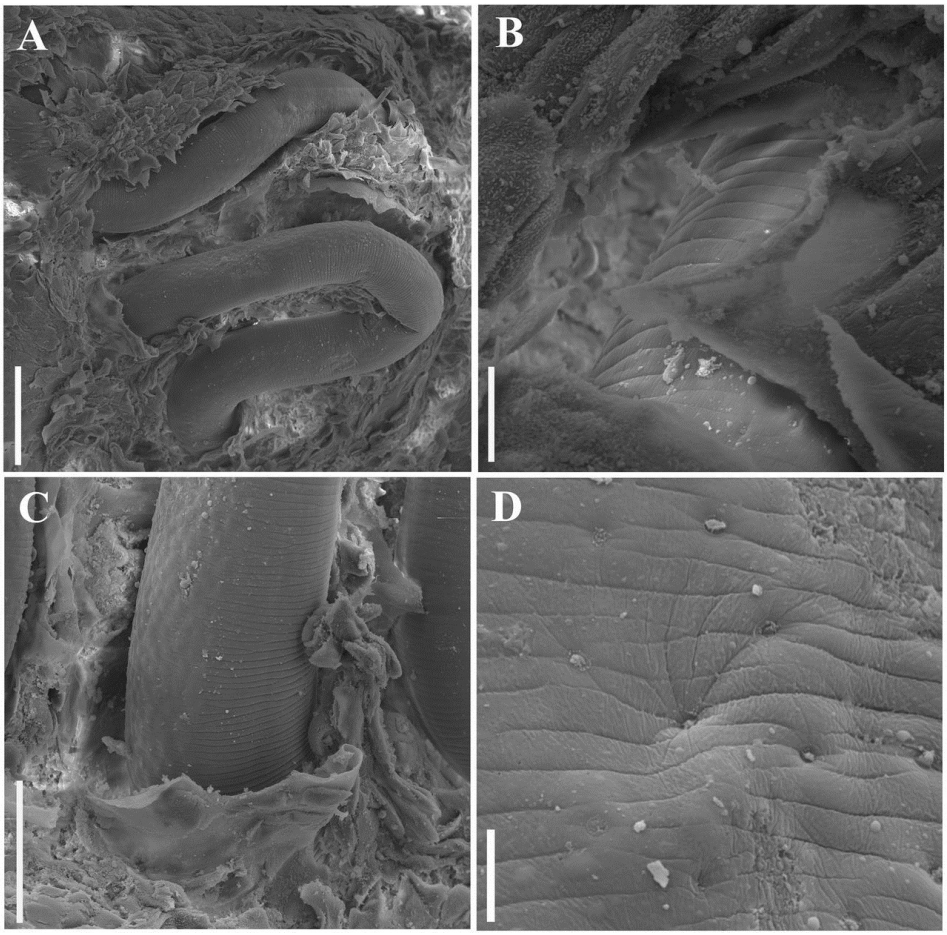

Figure 2. Scanning electron microscopy of *Capillaria* sp. parasitizing the tongue of *C. thous* in Pará State. (A) Overview of the parasite inserted between the lingual papillae. (B) Detail of *Capillaria* sp. inserted in the interstitial space formed by keratinized, stratified, flat epithelial tissue. (C) Detail of the posterior region of the nematode strongly inserted in the keratinized, stratified, flat epithelial tissue of the tongue. (D) Detail of the bacillary bands present along the body of the nematode. Scale bars: A= 100 µm, B= 10 µm, C= 50 µm, D= 5 µm.

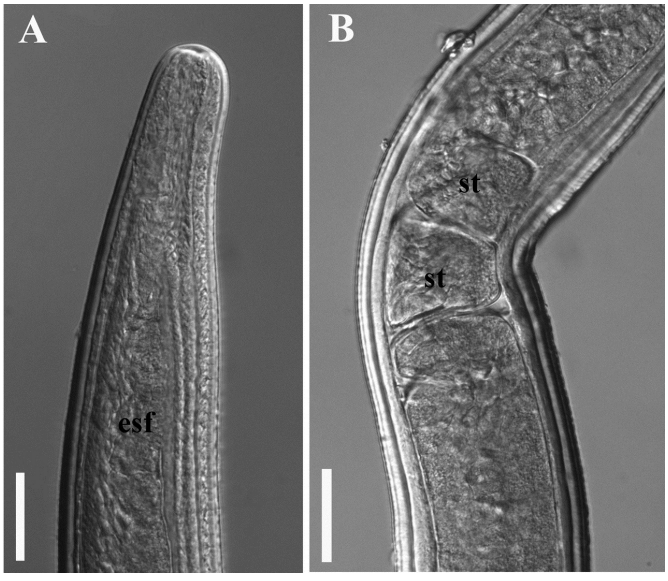

Figure 3. Photomicrographs of *Capillaria* sp. parasitizing the tongue of *C. thous* in Pará State. (A) Overview off anterior region in lateral position, simple oral opening with no lips and initial portion of stichosome esophagus (esf); (B) Lateral view of the middle region of *Capillaria* sp. showing the presence of stichocytes (st). Scale bars: A= 50 µm, B= 50 µm.

Table 1. Nematodes parasites of *Cerdocyon thous* distribuition in Brazilian territory according to register made for diferentes researchers between 1915 and 2017.

Family / Parasite species	Site in host	Location	References
Superfamily Ancylostomatoidea Chabaud, 1965			
Family Ancylostomatidae (Looss, 1905)			
Uncinaria carinii Travassos, 1915	Instestine	SP[a]	Travassos (1915), Vicente et al. (1997)[e], Vieira et al. (2008)[e], Pinto et al. (2011)[e] , Moraes (2016)[c]
Ancylostoma buckleyi Le Roux & Biocca, 1957 [d]	Small intestine, intestine, lung, heart and stomach	PE, SP, MG, MS, PB	Santos et al. (2003), Santos et al. (2004), Griese (2007)[c], Duarte (2007)[c], Vieira et al. (2008)[e], Lima (2009)[c], Pinto et al. (2011)[e], Lima et al. (2013), Gomes et al. (2015), Moraes (2016)[c]
Ancylostoma caninum (Ercolani, 1859) [d]	Small intestine and stomach	SP, RJ, MS, PA, ES, RS	Noronha et al. (2004), Ruas (2005)[c], Ruas et al. (2008), Vieira et al. (2008)[e], Moraes (2016)[c]
Ancylostoma braziliense Faria, 1910 [d]	Small intestine	SP	Griese (2007)[c], Moraes (2016)[c]
Ancylostoma sp.[d]	-	PB	Curi et al. (2010)[b], Santos et al. (2015)[b]
Morphotype 1	-	PR, MG, PI	Brandão (2007)[b,c], Brandão et al. (2009)[b]
Morphotype 2			
Indeterminate	Heart, lung, pulmonary artery	MS, RJ, PE, PB, RN, CE, PI, MG	Travassos & Freitas (1943), Santos (2008b)[b,c], Santos et al. (2012)[b], Santos (2013)[b,c]
Superfamily Ascaridoidea Railliet & Henry, 1915			
Family Ascarididae Baird, 1853			
Ascaridia galli (Schrank, 1788)	Small intestine	PR, MS, PB	Gomes et al. (2015), Santos et al. (2015)
Toxocara canis (Werner, 1782) [d]	Intestine, small intestine	RJ, PE, PB, RN, CE, PI	Noronha et al. (2002), Vieira et al. (2008)[e], Lima (2009)[c], Pinto et al. (2011)[e], Lima et al. (2013), Santos (2013)[b,c], Santos et al. (2015)[b]
Toxocara sp. [d]	-	PR, MG	Curi (2005)[a,b], Curi et al. (2010)[b], Santos et al. (2012)[b], Santos (2013)[b,c]
Morphotype 1	-	PE, PB, RN, CE, PI	Brandão (2007)[b], Santos (2008a), Brandão et al. (2009)[b], Santos (2013)[a,b]
Morphotype 2			
Morphotype 3			
Morphotype 4			
Indeterminate			
Superfamily Dioctophymatoidea Railliet, 1916			
Family Dioctophymatidae (Railliet, 1915)			
Dioctophma renale (Goeze, 1782)	Kidney	RJ	Ribeiro et al. (2009), Pinto et al. (2011)[e]
Superfamily Filarioidea (Weinland, 1858)			
Indeterminate	Heart, lung, pulmonary artery	MS, RJ	Travassos & Freitas (1943)
Family Onchocercidae (Leiper, 1911)			
Dirofilaria sp. [d]	Kidney	MS	Noronha et al. (2002), Vieira et al. (2008)[e], Pinto et al. (2011)[e]
Dirofilaria repens Railliet & Henry, 1911 [d]	Under the skin	MS	Vieira et al. (2008)[e], Pinto et al. (2011)[e]

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Table 1. Continued...

Family	Parasite species	Site in host	Location	References
Superfamily Metastrongyloidea Lane, 1917				
Family Angiostrongylidae (Boerhm & Gebauer, 1934)				
Indeterminate		Small intestine	PR	Moraes (2016)[c]
	Angiostrongylus railliet (Travassos, 1927) Grisi, 1971	Lung, right ventricle, pulmonary arteries, heart	RJ, GO	Travassos et al. (1927), Grisi (1971) Vicente et al. (1997)[e], Vieira et al. (2008)[e], Vieira (2011)[c]
	Angiostrongylus vasorum (Railliet, 1866)	Lung, heart, small intestine, and stomach	MG, SP, DF	Duarte (2007)[c], Duarte et al. (2007), Griese (2007)[c], Pinto et al. (2011)[e], Moraes (2016)[c], Ferreira et al. (2017)
	Angiostrongylus sp.	Heart, lung, pulmonary artery	MS, RJ	Travassos & Freitas (1943), Vicente et al. (1997)[e], Vieira et al. (2008)[e], Vieira (2011)[c]
Family Protostrongylidae Leiper, 1926				
	Aelurostrongylus sp.	Heart	MS	Vieira et al. (2008)[e], Pinto et al. (2011)[e]
Superfamily Oxyuroidea Cobbold, 1864				
Family Oxyuridae Cobbold, 1864				
	Enterobius vermicularis Linnaeus, 1758 [d]	-	PE, PB, RN, CE, PI	Santos (2013)[b,c]
	Morphotype 1			
	Morphotype 2			
	Morphotype 3			
	Morphotype 4			
	Morphotype 5			
Superfamily Physalopteroidea Sobolev, 1949				
Family Physalopteridae (Railliet, 1893)				
	Physaloptera praeputialis Linstow, 1889	Stomach	PR, PB	Vieira et al. (2008)[e], Lima (2009)[c], Pinto et al. (2011)[e], Lima et al. (2013), Moraes (2016)[c]
	Physaloptera terdentata Molin, 1860			
	Physaloptera digitata Scheneider, 1866			
	Physaloptera sp.	Stomach	MG, MS, PI	Santos (2008b)[b,c], Vieira et al. (2008)[e], Brandão (2007)[b], Brandão et al. (2009)[b], Pinto et al. (2011)[e], Santos et al. (2012)[b]
	Indeterminate	Heart, lung, pulmonary artery, stomach,	MS, RJ, RS, PE, PB, RN, CE, PI	Travassos & Freitas (1943), Ruas (2005)[c], Ruas et al. (2008), Santos (2013)[b,c]
Superfamily Trichinelloidea Railliet, 1916				
Family Trichuridae (Ransom, 1911)				
	Trichuris vulpis (Froelich, 1789)	Cecum, large intestine	MS, PB	Vieira et al. (2008)[e], Lima (2009)[c], Pinto et al. (2011)[e], Curi et al. (2010), Lima et al. (2013)
	Trichuris sp. [d]	Large intestine	PI, RS, PR	Chame (1988)[b,c], Ruas (2005)[c], Ruas et al. (2008), Pinto et al. (2011)[e], Santos et al. (2012)[b], Snak et al. (2017)[b]

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Table 1. Continued...

Family	Parasite species	Site in host	Location	References
	Morphotype 1	-	PE, PB,	Santos (2013)[b,c]
	Morphotype 2		RN, CE, PI	
	Morphotype 3			
	Morphotype 4			
	Indeterminate	Heart, lung, pulmonary artery	MS, RJ, PI, MG	Travassos & Freitas (1943), Santos (2008a)
Family Capillariidae				
	Capillaria hepatica (Bancroft 1893) [d]	Liver	RS	Ruas et al. (2003), Ruas (2005)[c], Ruas et al. (2008) , Vieira et al. (2008)[e], Pinto et al. (2011)[e]
	Capillaria sp. [d]	Urinary bladder	RS, PR, MG	Ruas (2005)[c], Ruas et al. (2008), Curi et al. (2010), Snak et al. (2017)[b]
	Pearsonema linsi (Freitas & Lent, 1935)	Urinary bladder	RJ	Vieira et al. (2008)[e], Pinto et al. (2011)[e]
	Pearsonema feliscati (Diesing, 1851)			
Superfamily Rhabditoidea Travasso, 1920				
Family Strongyloididae Chitwood & McIntosh, 1934				
	Strongyloides stercoralis (Bavay, 1876) [d]	Small intestine	PB	Lima (2009)[c], Lima et al. (2013)
	Strongyloides sp.	Small intestine, large intestine	MG, RS, RJ	Ruas (2005)[c], Ruas et al. (2008), Vieira et al. (2008)[e], Pinto et al. (2011)[e], Vieira (2011)[c], Santos et al. (2012)[b]
	Indeterminate		PE, PB, RN, CE, PI	Santos (2013)[b,c]
Superfamily Rictularoidea Railliet, 1916				
Family Rictulariidae Railliet, 1916				
	Rictularia sp.	Small Intestine	MG, SP	Griese (2007)[c], Curi et al. (2010)
	Pterygodermatites (*Multipectines*) *affinis* (Jagerskiöld, 1904) Quentin, 1969	Small Intestine	PB	Duarte (2007)[c], Lima (2009)[c], Lima et al. (2013)
	Pterygodermatites (*Multipectines*) *pluripectinata* Hoppe, Lima, Tebaldi & Nascimento, 2010	Small intestine	PB, MS	Lima (2009)[c], Hoppe et al. (2010), Pinto et al. (2011)[e], Lima et al. (2013), Gomes et al. (2015)
	Indeterminate	-	PE, PB, RN, CE, PI	Santos (2013)[b,c]
Superfamily Strongyloidea Weinland, 1858				
Family Strongylidae Baird, 1853				
	Indeterminate	-	PR	Snak et al. (2017)[b]
Superfamily Spiruroidea Oerley, 1885				
Family Spirocercidae Chitwood & Wehr, 1932				
	Spirocerca lupi (Rudolphi, 1809)	-	MG, PE, PB, RN, CE, PI	Santos et al. (2012)[b], Santos (2013)[b,c]
	Spirocerca sp.		MG	Curi et al. (2010)

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Table 1. Continued...

Family	Parasite species	Site in host	Location	References
Superfamily Trichostrongyloidea Cram, 1927				
	Indeterminate	-	PI	Santos (2008a)
	Morphotype 1		PE, PB,	Santos (2013)[b,c]
	Morphotype 2		RN, CE, PI	
Family Molineidae Skrjabin & Schulz, 1937				
	Molineus felineus Cameron. 1923	-	RS	Ruas (2005)[c], Ruas et al. (2008), Pinto et al. (2011)[f]
	Molineus elegans (Travassos, 1921)	Small Intestine	PB	Lima (2009)[c]
	Molineus sp.	Small Intestine		Lima et al. (2013)
	Indeterminate	Small Intestine, Stomach		
Phylum Nematoda (Rudolphi, 1808)		-	PE, PB,	Brandão et al. (2009)[b], Santos (2013)[b,c]
	Morphotype 1		RN, CE, PI	
	Morphotype 2			
	Morphotype 3			
	Morphotype 4			
	Morphotype 5			
	Morphotype 6			
	Morphotype 7			
	Morphotype 8			
	Ideterminado			

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Table 2. Morphological description of egg morphotypes found in *Cerdocyon thous*, in Brazil, according to different studies conducted between 1915 and 2017.

Parasite species	Morphological characteristics	Measurement (µm)	References
Superfamily Ancylostomatoidea Chabaud, 1965			
Family Ancylostomatidae (Looss, 1905)			
Ancylostoma buckleyi	Not reported	108 × 83	Santos et al. (2003)
Morphotype 1	Oval shape, shell double, thin and smooth, poles big and round	56.5 × 38.5	Brandão (2007), Brandão et al. (2009)
Morphotype 2	Elliptical shape, shell smooth, poles uneven	59 × 39	
Morphotype 3	Elliptical or round shape, shell single, thin, smooth and transparent, embryo morulate or larvae well developed	58.5 × 40	Santos (2013)
Indeterminate	Not reported	54 ×33	Santos (2008b)
Ascaridoidea Railliet & Henry, 1915			
Ascarididae Baird, 1853			
Toxocara sp.	Not reported	71 × 42.5	Santos (2008b)
	Round shape, shell thick and covered by a rugged and ornate outer shell, embryonic mass in development or larvae well developed	85 × 76	Santos (2013)
Morphotype 1	Not reported	31 × 20	Santos (2008a)
Morphotype 2	Not reported	46 × 28	
Morphotype 3	Elliptical shape, shell rough	61 × 36	Brandão (2007),
Morphotype 4	Oval or round shape, shell double and irregularly thick	65 × 7	Brandão et al. (2009)
Morphotype 5	Elliptical shape, shell thick and smooth, embryonic mass in development	67 × 46	Santos (2013)
Superfamily Trichinelloidea Railliet, 1916			
Family Trichuridae (Ransom, 1911)			
Trichuris sp.	Not reported	57 × 27	Chame (1988)
	Not reported	57 × 25	Santos (2008a)
Indeterminate	Not reported	59 × 31	
Indeterminate	Not reported	64 ×28.6	Santos (2008b)
Morphotype 1	Barrel shape, two polar opercula slightly flattened, shell thin, smooth and brown, embryonic mass in development	55 × 25	Santos (2013)
Morphotype 2	Barrel shape, two opercula unequal and little prominent, shell thin and clear, embryonic mass, large compared to the rest of this family	82.5 × 37.5	
Morphotype 3	Barrel shape, two polar opercula symmetric, shell thick, dark brown, embryonic mass or larvae well developed	80 × 38	
Morphotype 4	Barrel shape, two polar opercula symmetric and prominent, light brown, shell thick and smooth, embryonic mass in development	58 × 28	
Family Capillariidae			
Capillaria hepatica	-	59 × 31	Ruas et al. (2003)
Superfamily Physalopteroidea Sobolev, 1949			
Family Physalopteridae (Railliet, 1893)			
Physaloptera tendernata	Ellipsoidal shape, shell thin	27 × 16	Lima (2009)
Physaloptera praeputialis	Ellipsoidal shape, shell thin - *In utero*	27 × 23	
Physaloptera sp.	Not reported	36 × 28	Santos (2008b)
	Elliptical to round shape, shell thick and smooth, containing larvae	43 × 25	Brandão et al. (2009)
Indeterminate	Not reported	51 × 30	Santos (2008a)
Indeterminate	Elliptical shape, shell single, thick and smooth, larvae well formed	57 × 35	Santos (2013)
Superfamily Rhabditoidea Travassos, 1920			
Family Strongyloididae Chitwood & McIntosh, 1934			
Indeterminate	Elliptical or rounded shape, shell single, smooth, thin and transparent, larvae formed	54 × 28	Santos (2013)

Table 2. Continued...

Parasite species	Morphological characteristics	Measurement (µm)	References
Superfamily Strongyloidea Weinland, 1858			
Family Strongylidae Baird, 1853			
Indeterminate	Not reported		Snak et al. (2017)
Superfamily Spiruroidea Oerley, 1885			
Family Spirocercidae Chitwood & Wehr, 1932			
Spirocerca lupi	Not reported	25.5 × 8.5	Santos (2008b)
	Elliptical shape and small size, shell thick and smooth, larvae well developed	36 × 14	Santos (2013)
Superfamily Trichostrongyloidea Cram, 1927			
Indeterminate		40 × 18	Santos (2008a)
Morfotipo 1	Elliptical shape, long and thin, shell thin and smooth, one side slightly convex and the other concave, larvae well developed	54 × 19	Santos (2013)
Morfotipo 2	Elliptical shape and larger, shell thin, transparent and smooth, larvae well developed	65 × 29	
Family Molineidae Skrjabin & Schulz, 1937			
Molineus sp.	Elliptical shape	42 × 16	Lima (2009)
Indeterminate	Not reported	60 ×25	
Superfamily Rictularoidea Railliet, 1916			
Family Rictulariidae Railliet, 1916			
Pterygodermatites pluripectinata	Dairy eggs - *In utero*	39 × 28.5	Lima (2009)
Pterygodermatites affinis	Dairy eggs - *In utero*	25 × 17	
Indeterminate	Round shape, shell smooth, simple and thick, larvae well formed	40 × 31	Santos (2013)
Superfamily Oxyuroidea Cobbold, 1864			
Family Oxyuridae Cobbold, 1864			
Enterobius vermicularis	Asymmetric shape, shell smooth, simple and transparent, larvae developed, poles unequal, one sharper and one more rounded	60 × 32	Santos (2013)
Morphotype 1	Asymmetric shape, dark brown, simple and fluted membrane, embryonic mass, sometimes with developed larvae	87 × 48	
Morphotype 2	Asymmetric shape, light brown or coppery, larvae robust and well formed, apparently with two thin membranes in the shell	132 × 63	
Morphotype 3	Asymmetric shape, light brown or coppery, larvae robust, very similar to morphotype 2, but slightly larger in size	185 × 83	
Morphotype 4	Asymmetric shape, light brown or yellowish, shell simple and thin, larvae well developed	212 × 93	
Morphotype 5	Asymmetric shape, shell double and thin, colorless, larvae in formation	99 × 43	
Phylum Nematoda (Rudolphi, 1808)			Santos (2008a), Brandão et al. (2009), Santos (2013)
Morphotype 1	Not reported	44 × 22.5	
Morphotype 2	Not reported	27 × 14	
Morphotype 3	Shell double and thick, larvae usually present, with protrusion at one end similar to an operculum	34 × 19	
Morphotype 4	Shell oval and thick, with rounded structure slightly protruding at one end, may also be an operculum	60 × 47	
Morphotype 5	Elliptical shape, shell thick, simple and smooth, larvae well formed	45.5 × 26	
Morphotype 6	Elliptical shape, shell transparent, thin and smooth, larvae well formed	58.5 × 28	
Morphotype 7	Barrel shape, shell smooth and relatively thick, dark brown, different polar regions, only one operculum, embryonic mass or larvae well developed	35 × 20	
Morphotype 8	Round shape, medium size, shell smooth, thin, transparent, embryonic mass present	72 × 51	

of nematodes that parasitize all classes of vertebrates around the world (ANDERSON, 2000; GIBSON, 2012; STAPF et al., 2013).

In the last 100 years, three taxonomic inventories of parasites in mammals were conducted, resulting in 13 superfamilies reported for the nematofauna of *C. thous* in Brazil (VICENTE et al., 1997; VIEIRA et al., 2008; PINTO et al., 2011). Among the nematodes that comprise the nematofauna of *C. thous*, the members of the superfamily Ancylostomatoidea were the most representative in terms of number of species, such as *Uncinaria carinii* Travassos, 1915, *Ancylostoma buckleyi* Le Roux & Biocca, 1957, *Ancylostoma caninum* Ercolani, 1859, *Ancylostoma braziliense* Faria, 1910, and *Ancylostoma* sp. In addition to nematode adults, two egg morphotypes were found, as well as individuals that were not identified to the specific taxonomic level; although, they had features of this superfamily.

In Brazil, superfamily Trichinelloidea is represented by two families, (Trichuridae and Capillariidae), three genera (*Trichuris, Capillaria, Pearsonema*) and the following four species: *Trichuris vulpis* Froelich, 1789, a parasite of the cecum of the large intestine in host from Mato Grosso do Sul and Paraíba sates (VIEIRA et al., 2008; LIMA 2009; PINTO et al., 2011; CURI et al., 2010; LIMA et al., 2013); *Pearsonema linsi* Freitas & Lent, 1935 and *Pearsonema feliscati* Diesing, 1851, parasites of the urinary bladder in host from Rio de Janeiro state (VIEIRA et al., 2008); and *C. hepatica*, a parasite of the liver in host from Rio Grande do Sul state (RUAS et al., 2003). In addition, *Capillaria* sp. occurs in different states of Brazil: Rio Grande do Sul (RUAS, 2005; RUAS et al., 2008), Paraná (SNAK et al., 2017) and Minas Gerais (CURI et al., 2010).

This is the first report of a *Capillaria* infection in the tongue of *C. thous* in Brazil, but the occurrence of capillariids in the tongue of mammals has already been reported for other countries. Copland (1975) reports that *C. papuensis* parasitizes the tongue of *Sus scrofa papuensis* in Papua New Guinea. Scapino & Murphy (1978) describe the infection of the mucous membranes of the oral cavity of *Procyon lotor*, and suggests that the parasite is possibly *Capillaria procyonis*. Snyder (1988, 1989) reports the occurrence of eggs of *C. procyonis* in the tongue of *Procyon lotor*; both accounts were for Illinois, in the United States. *Capillaria garfiai* is reported to parasitize the tongue of wild *Sus scrofa* in Spain (FERRER & CASTELLÀ, 1996).

Löwenstein & Kutzer (1989) reported *C. garfiai* in wild boar in Austria, found a prevalence of 69% based on histopathological studies, and demonstrated that parasitism by *C. garfiai* in the tongue of this animal produces small pathological changes in the lingual tissue, which is different from what is reported in this article, since the nematodes did not cause injury.

In Brazil, parasitism by capillariids includes different species of parasites and hosts, and *C. hepatica* is the most commonly cited in the literature as a parasite of wild animals, such as those found in *Sciurus aestuans* (FREITAS & LENT, 1936), *Rattus norvegicus* (ARAUJO, 1967; GALVÃO, 1981). *Rattus rattus* (CHIEFFI et al., 1981), dogs and cats (SILVEIRA et al., 1975), *Tayassu tajacu* (MANDORINO & REBOUÇAS, 1991), *Chrysocyon brachyurus* (VICENTE et al., 1997) and *Lycalopex gymnocercus* (RUAS et al., 2003). Eggs of *C. hepatica* were found in insects (SOLOMON & HANDLEY, 1971; FARHANG-AZAD, 1977). Lima et al. (2008) reported the occurrence of eggs of *Capillaria* spp. in the filet of *Pseudupeneus maculatus* Bloch, 1793, a fish sold in the metropolitan region of Recife, Pernambuco state, and noted the zoonotic potential of the genus and the need for more hygienic and sanitary control of the quality of the product offered to the consumer.

For *C. thous*, Ruas et al. (2003) reported the first case of parasitism of *C. hepatica* in the state of Rio Grande do Sul. In the state of Pará, Moreira et al. (2013) describes parasitism by *C. hepaticum* in synanthropic rodents *R. norvegicus* and *R. rattus*. Although Moravec (1982) included *C. hepatica* in the genus *Calodium* (*Calodium hepaticum*), this name is rarely used, and many authors place it in *Capillaria*.

The site of infection of the capillariids reported in this study is possibly an erratic occurrence in the cycle of this parasite, and the hosts acquired the infection due to certain habits, such as licking the genitals and anus of other animals in the same pack. The life cycle of capillariids is monoxenic and the infection occurs by ingestion of infective eggs after death (e.g., due to cannibalism or predation) and decomposition of the host (FARHANG-AZAD & SCHLITTER, 1978; KATARANOVSKI et al., 2010).

The presence of capillariids in *C. thous* and other wild canids is possibly related to their diet, which includes wild and urban rodents, and is often influenced by habitat loss and the ease of obtaining food close to urban centers. Ruas et al. (2003) describes capillariids as parasites of the hepatic parenchyma and urinary bladder of multiple hosts, which are most commonly found in rodents, especially rats. Pedó et al. (2006) describe *C. thous* as a versatile predator and that small rodent species are the most important food item in its diet, with a 52.8% relative frequency, including at least seven species from distinct habits, such as open areas (*Cavia aperea* Erxleben, 1777), semi-aquatic (*Holochilus brasiliensis* Desmarest, 1819), cursorial in forest and open areas (*Akodon* sp.), semi-arboreal (*Oligoryzomys* sp.), arboreal (*Phyllomys dasythrix* Hensel, 1872), semi-fossorial in forest and open areas (*Oxymycterus* sp.) and peridomiciliary (*Mus musculus* Linnaeus, 1758). Birds, insects and fruits, as well as consuming the most abundant food resources in each season, have also been reported (BISBAL & OJASTI, 1980; BERTA 1987; MOTTA-JUNIOR et al., 1994).

Conclusions

The presence of eggs and nematodes of *Capillaria* sp. in the tongue of *C. thous* is extremely important, not only as a public health issue, but to the knowledge of the biodiversity of zoonotic parasites present in wild populations of canids. However, an explanation of why the eggs and nematodes were in the epithelial and connective tissues of the tongue remains unclear since, until now, this has not been observed in the biological cycle of the species. Parasitism of *C. thous* by capillariids in Pará state requires a more detailed investigation into the circumstances of this finding, in order to obtain adults for morphological and molecular analyses that can elucidate the epidemiological implication of this parasitism and the potential zoonotic factor of this species, as well as to determine the wild rodents that can serve as reservoirs for the parasite.

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