

Toxocara cati (Schrank, 1788) (Nematoda, Ascarididae) in different wild feline species in Brazil: new host records

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Resumo

***Toxocara cati* (Schrank, 1788) (Nematoda, Ascarididae) em diferentes espécies de felinos silvestres no Brasil: novos registros de hospedeiros.** Esta é a primeira descrição detalhada de *Toxocara cati* parasitando felinos na América do Sul. Dezesete felinos silvestres (*Leopardus colocolo*, *Leopardus geoffroyi*, *Leopardus tigrinus* e *Puma yagouaroundi*) atropelados foram coletados em diferentes municípios do Estado do Rio Grande do Sul, Brasil. A morfometria de machos e fêmeas permitiu a identificação de espécimes como *T. cati*. Os helmintos foram encontrados no estômago e intestino dos hospedeiros com prevalência de 66,6% em *L. colocolo*, *L. geoffroyi* e *L. tigrinus*; e 60% em *P. yagouaroundi*. Foram calculados os parâmetros ecológicos para cada hospedeiro e, *L. colocolo* teve a maior intensidade de infecção (22,5 helmintos/hospedeiro). Este é o primeiro registro de *T. cati* parasitando quatro espécies de felinos silvestres no Sul do Brasil e, dois novos registros de hospedeiros para esse parasito.

Palavras-chave: Felinos; *Leopardus*; *Puma*; Sul do Brasil; *Toxocara*

Abstract

This is the first detailed description of *Toxocara cati* parasitizing felines in South America. Seventeen run over wild felines (*Leopardus colocolo*, *Leopardus geoffroyi*, *Leopardus tigrinus*, and *Puma yagouaroundi*) were collected from different towns in the State of Rio Grande do Sul, Brazil. The morphometry of males and females allowed the identification of specimens as being *T. cati*. The helminths were found in the stomach and intestine of hosts with prevalences of 66.6% in *L. colocolo*, *L. geoffroyi*, and *L. tigrinus*; and 60% in *P. yagouaroundi*. The ecological parameters were calculated for each host and *L. colocolo* had the highest infection intensity (22.5 helminths/host). This is the first report of *T. cati* parasitizing four wild felines species in southern Brazil, besides a new record of this parasite for two host species.

Key words: Felines; *Leopardus*; *Puma*; southern Brazil; *Toxocara*

Introduction

Historically, the genera *Dujardinascaris* Baylis, 1927; *Neoascaris* Travassos, 1927; *Paradujardinia* Travassos, 1933; *Porrocaecum* Railliet & Henry, 1912 and *Toxocara* Stiles, 1905 belonged to the family Toxocaridae Hartwich, 1954 (SPRENT, 1962; WARREN, 1971). Different systematic arrangements were proposed to accommodate these genera to new families and subfamilies. However, the current systematic place the genera *Paradujardinia*, *Porrocaecum* and *Toxocara* into the subfamily Toxocarinae Osche, 1958, family Ascarididae Baird, 1853 (HARTWICH, 2009).

The genus *Toxocara* was proposed by Stiles in 1905, with the type species *Lumbricus canis* Werner, 1782 (= *Toxocara canis* Werner, 1782) (SPRENT, 1956). A wide species review of the genera *Toxocara* and *Neoascaris* was conducted by Warren (1971). In this study, the author extended the diagnosis of the genus *Toxocara* and made new combinations, eliminating the genus *Neoascaris* and transferring all species of *Neoascaris* to the genus *Toxocara*.

Currently, 23 species are known to belong to the genus *Toxocara* (GIBBONS et al., 2001). Among them, the species *Toxocara cati* (Schrank, 1788) Sprent, 1956 is a parasite of carnivores from different geographic areas in the world. According to Sprent (1982), the species was introduced to the Neotropical Region by domestic animals brought by Europeans. Sprent (1956) studied the taxonomy and development of *T. cati*, but morphometric data on the species has not been sufficiently developed, yet.

Toxocara cati was reported at different regions in the world: Asia (SADIGHIAN, 1970; YASUDA et al., 1993, 1994; ESFANDIARI et al., 2010; GHAEMI et al., 2011); Europe (TORRES et al., 1998; BAGRADE et al., 2003; VALDMANN et al., 2004; MILLÁN; CASANOVA, 2007); and, recently, in Africa (RADWAN et al., 2009). Most studies were carried out in the Americas, especially in North America (ROLLINGS, 1945; VAN ZYLL DE JONG, 1966; MILLER; HARKEMA, 1968; STONE; PENCE, 1978; PENCE; EASON, 1980; SCHITOSKEY; LINDER, 1981; WATSON et al., 1981; RAUSCH et al., 1983; FORRESTER et al., 1985; TIEKOTTER, 1985; SMITH et al., 1986; WAID; PENCE, 1988; RICKARD; FOREYT, 1992).

In South America, *T. cati* was reported by Beldomenico et al. (2005) in Argentina and Fiorello et al. (2006) in Bolivia. In Brazil, the species was reported parasitizing *Felis catus domesticus* (= *Felis catus* Linnaeus, 1758); *Leopardus pardalis* Linnaeus, 1758; *Panthera onca* Linnaeus, 1758; *Puma concolor* Linnaeus, 1771; and *Puma (Herpailurus) yagouaroundi* (= *Puma yagouaroundi* É. Geoffroy Saint-Hilaire, 1803) (VICENTE et al., 1997; VIEIRA et al., 2008). Recently, Gallas and Silveira (2011) published data on the morphologic structures and their relationship to the body of *T. cati*.

This is the first report of *T. cati* in wild felines of the species *Leopardus colocolo* Molina, 1782 and *Leopardus tigrinus* Schreber, 1775, as new hosts in South America. The feline species *Leopardus geoffroyi* d'Orbigny & Gervais, 1844, is reported as a new host in Brazil and *P. yagouaroundi* É. Geoffroy Saint-Hilaire, 1803, as a new host in the State of Rio Grande do Sul, Brazil.

Material and Methods

A total of 17 wild feline specimens of *L. colocolo* (n = 3), *L. geoffroyi* (n = 6), *L. tigrinus* (n = 3), and *P. yagouaroundi* (n = 5) were collected between 2007 and 2009. The specimens died due to running over in municipalities of Bagé, Caçapava do Sul, Dom Pedrito, Viamão, Osório, São José das Missões, São Sepé, Soledade and Tabaiá, in the State of Rio Grande do Sul, Brazil. The felines were stored in dry ice and taken to the “Laboratório de Zoologia dos Invertebrados” of the “Museu de Ciências Naturais da ULBRA”, for necropsy. Nematodes were fixed at 65°C A.F.A., and cleared with lactophenol (HUMASON, 1972; AMATO; AMATO, 2010). Nematodes were identified according to Yamaguti (1961) and Warren (1971).

All measurements were expressed in micrometers (µm), unless otherwise indicated. Mean, standard deviation and number of specimens measured for a determined character appear in parentheses. The ecological terms were used according to Bush et al. (1997). Drawings were made using a microscope with a drawing tube. The carcasses were deposited in the “Coleção de Vertebrados” do “Museu de Ciências Naturais da Ulbra” (MCNU)

Canoas, Rio Grande do Sul, Brazil, and the helminths were deposited in the “Coleção Helmintológica do Instituto Oswaldo Cruz” (CHIOC) Rio de Janeiro, Brazil, and in the “deposited in the “Coleção Helmintológica do Museu de Ciências Naturais da ULBRA (CHMU)”. The parasite systematic used in this study was proposed by Hartwich (2009). Host species’ names followed the nomenclature proposed by Wozencraft (2005).

Results

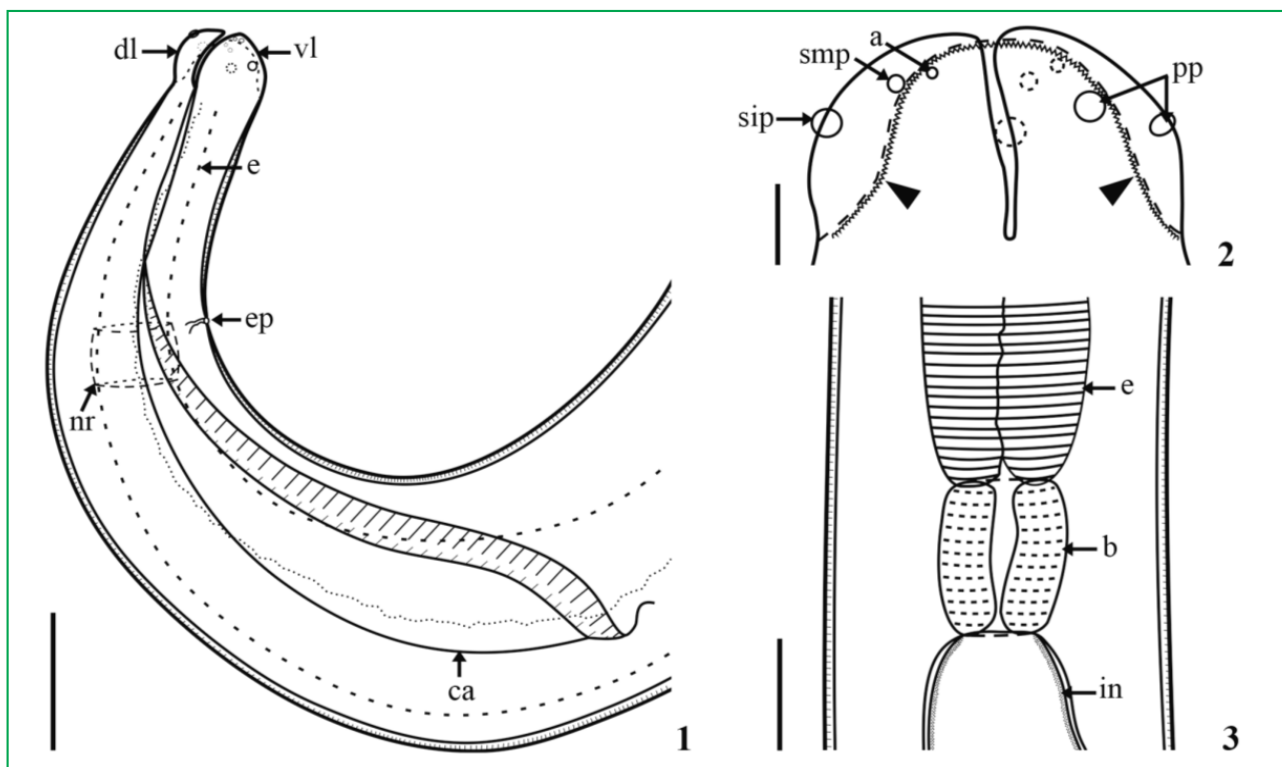
Toxocara cati (Schrank, 1788) Sprent, 1956

Description based on 25 specimens cleared with lactophenol, all measured. Ascarididae, Toxocarinae. Body with the anterior region dorsally curved and the cuticle transversely striated (Figure 1). Strias range from

7.08 to 36.88 (16.94; 6.98; n = 25) long. The buccal capsule had three lips (Figures 1 and 2): one dorsal, with two large papillae situated on the sides (Figure 2) and two subventral lips, both with a single large papilla, in the middle of the lip and another small papilla close to the amphidial pore (Figure 2). In the margin of each lip, there are several denticles ranging from 112 to 136 (124; 7.8; n = 8) (Figure 2), with a large shape on the bottom which progressively change to a triangular shape on the top of the lip. Interlabia absent. A pair of cervical alae, slightly striated (Figure 1), representing 11.5% of total body length (TBL). Nerve ring localized near the excretory pore, of difficult visualization (Figure 1). The esophagus is simple, opening to the intestine with a posterior bulb (Figure 3).

Males (n = 10). Body 19-73mm (33mm; 16.78mm; n = 10) long and 0.42-0.83mm (0.58mm; 0.14mm; n = 10) wide at the end of the esophagus. Dorsal lip 119.86-193.62 (147.52; 26.48; n = 9) long, 110.64-221.28

FIGURES 1-3: Incomplete diagrams of *Toxocara cati*.

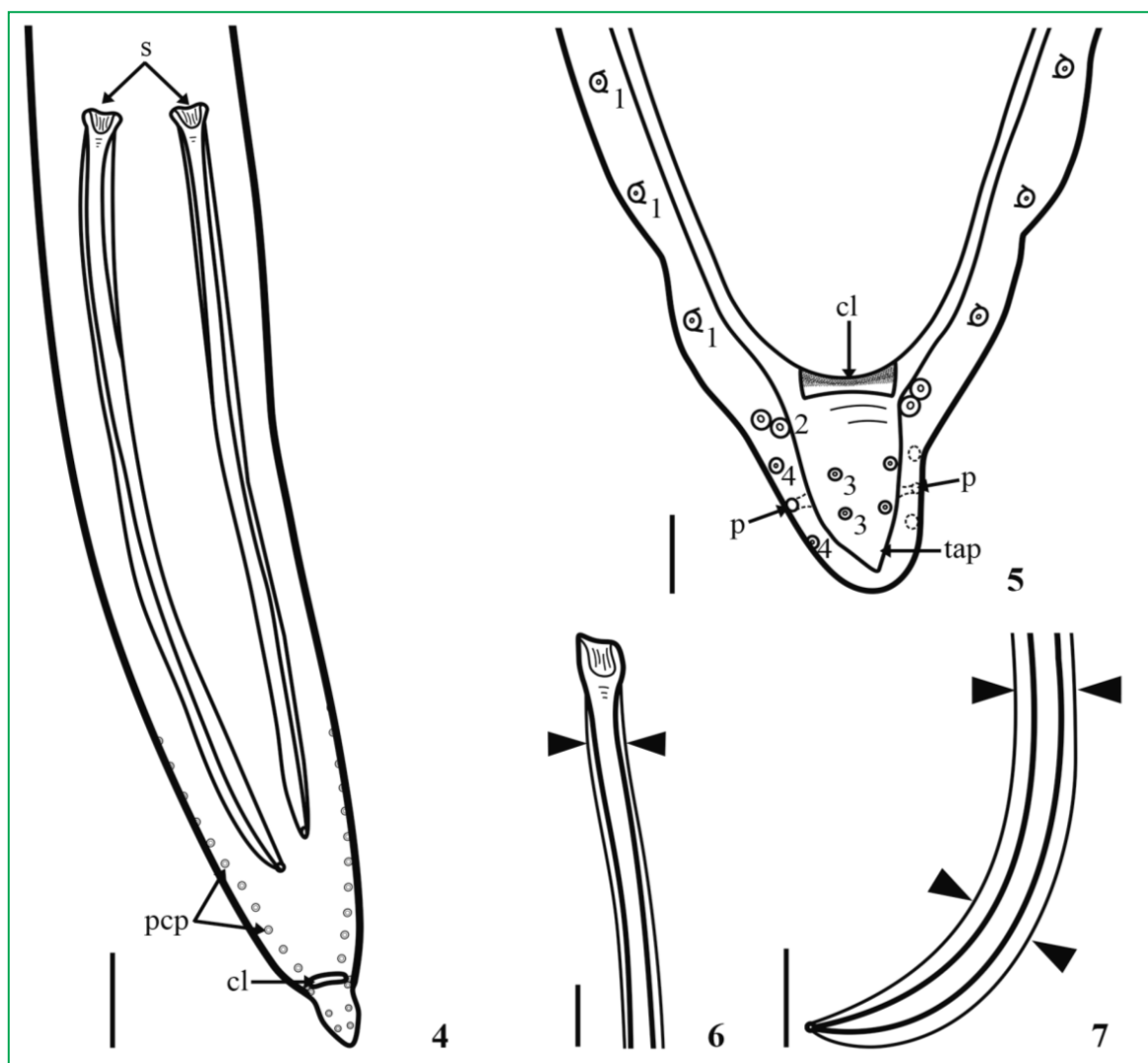


(1) Anterior region showing buccal capsule with dorsal lip (dl) and subventral lip (vl), esophagus (e), nerve ring (nr), excretory pore (ep), and cervical alae (ca). Scale bar = 200µm. (2) Detail of the buccal capsule showing the dorsal lip with a pair of papillae (pp), subventral lip with a single papilla (sip), and a small papilla (smp) close to the amphidial pore (a) and lip denticles (head arrows). Scale bar = 50µm. (3) Posterior end of the esophagus (e) with bulb (b) and the intestine (in). Scale bar = 300µm.

(129.08; 40.04; n = 9) wide (Figures 1 and 2). Subventral lips 82.98-221.28 (142.91; 38.34; n = 18) long, 101.42-221.28 (133.69; 41.30; n = 18) wide (Figures 1 and 2). Esophagus 2.54-4.86mm (3.44mm; 0.83mm; n = 8) long, 0.06-0.18mm (0.09mm; 0.04mm; n = 9) wide at the anterior end and 0.14-0.28mm (0.21mm; 0.04mm; n = 10) wide at the posterior end, representing 20.5% of TBL. Bulb 230.5-690 (350.05; 155.12; n = 8) long, 92.2-368 (206.12; 89.24; n = 8) wide (Figure 3). Nerve ring measuring 0.44-0.92mm (0.74mm; 0.18mm; n = 6) from the anterior end. Excretory pore 0.41-1.24mm (0.73mm;

0.33mm; n = 5) from the anterior end. Cervical alae 1.36-3.82mm (2.31mm; 0.75mm; n = 14) long, representing 13.8% of TBL. Unequal spicules, alate, with the smallest measuring 1.30-1.89mm (1.46mm; 0.23mm; n = 9) and the largest presenting 1.31-2.14mm (1.57mm; 0.25mm; n = 9) long (Figures 4, 6 and 7). Phasmids between the ventrolateral pair of papillae, with 61.36-92.04 (70.80; 13.12; n = 4) to tip of the tail (Figure 5). The tail had a terminal appendage, with 20-25 precloacal papillae in two rows and 12 poscloacal papillae: one double large pair just behind the cloaca, two ventral pairs and two ventrolateral

FIGURES 4-7: Incomplete diagrams of males.



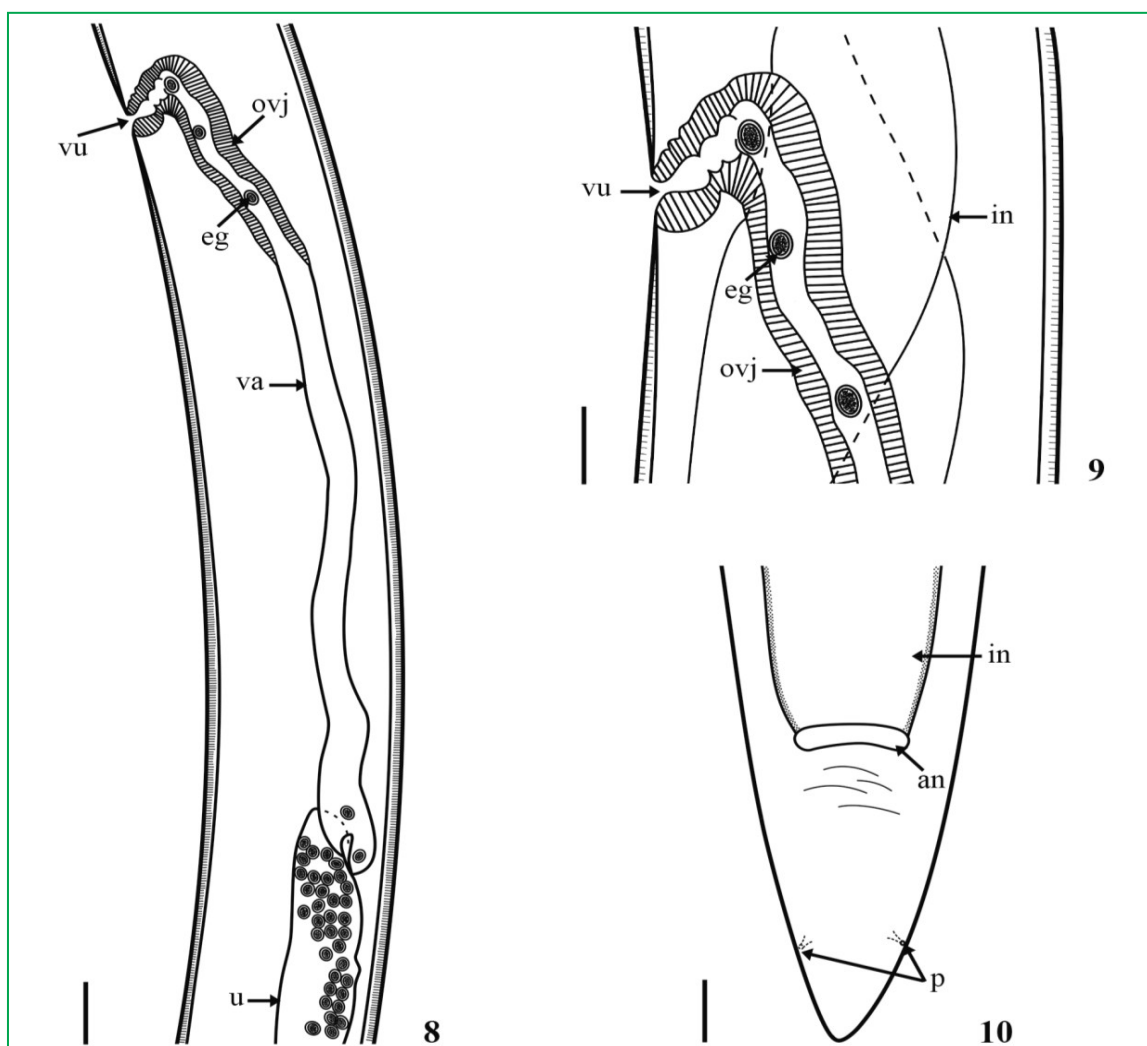
(4) Posterior end with spicules (s), the precloacal papillae (pcp) and cloaca (cl). Scale bar = 150 μ m. (5) Detail of posterior end showing the papillae: 1 (pairs of precloacal papillae), 2 (pair of double poscloacal papillae), 3 (pairs of ventral papillae) and 4 (pairs of ventrolateral papillae), phasmids (p), cloaca (cl) and terminal appendage (tap). Scale bar = 100 μ m. (6) Detail of proximal extremity of spicule, head arrows showing the beginning of ala. Scale bar = 50 μ m. (7) Detail of distal extremity of spicule, head arrows showing the ala. Scale bar = 50 μ m.

pairs (Figure 5). Cloaca measuring 119.86-230.5 (165.96; 38.45; n = 10) to tip of the tail (Figures 4 and 5).

Females (n = 15). Body longer than males, 33-115mm (63mm; 28.15mm; n = 15) long and 0.55-1.33mm (0.85mm; 0.28mm; n = 12) wide at the end of the esophagus. Dorsal lip 156.74-368 (208.49; 62.16; n = 12) long, 147.52-345 (218.48; 55.82; n = 12) wide. Subventral lips 129.08-253 (177.25; 35.78; n = 24) long, 129.08-276.6 (187.05; 36.98; n = 24) wide. Esophagus 1.32-5.18mm (3.70mm; 1.26mm; n = 12) long, 0.10-0.24mm (0.15mm; 0.04mm; n = 14) wide at the anterior end and 0.18-0.56mm (0.34mm; 0.11mm; n = 15) wide at the posterior end, representing 13.1%

of TBL. Bulb 276-829.8 (504.92; 192.6; n = 12) long, 202.84-483 (317.66; 105.16; n = 12) wide. Nerve ring measuring 0.57-1.31mm (0.84mm; 0.24mm; n = 7) from the anterior end. Excretory pore measuring 0.60-1.35mm (0.88mm; 0.26mm; n = 7) from the anterior end. Cervical alae 1.65-4.32mm (2.60mm; 0.73 mm; n = 22) long, representing 9.2% of TBL. Females opisthodelphic, with vulva located at the body's anterior half, measuring 7.36-21.74mm (11.70mm; 4.57mm; n = 13) from the anterior end (Figures 8 and 9), representing 41.5% of TBL. Eggs globular to subglobular in shape, 55.32-73.76 (62.56; 5.52; n = 33) long, 36.88-73.76 (56.28; 9.46; n = 33) wide (Figures

FIGURES 8-10: Incomplete diagrams of females.



(8) Vulvar region with vulva (vu), egg (eg), ovojector (ovj), vagina (va) and uterus (u), Scale bar = 500µm; (9) Detail of the vulvar region showing vulva (vu), ovojector (ovj), intestine (in) and egg (eg), Scale bar = 300µm; (10) Posterior region showing the intestine (in), anus (an) and phasmids (p), Scale bar = 100µm.

8 and 9). Phasmids 138.30-276 (220.05; 45.98; n = 8) to tip of the tail (Figure 10). Anus 295.04-690 (521.04; 119.09; n = 14) to tip of the tail (Figure 10).

Taxonomic summary

Synonyms: *Ascaris alata* Bellingham, 1839; *Ascaris cati* Schrank, 1788; *Ascaris circumflexa* Molin, 1858; *Ascaris crenulata* Bremser, 1824; *Ascaris felis* Gmelin, 1790; *Ascaris globulus* Linstow, 1899; *Ascaris mystax* (Zeder, 1800) Rudolphi, 1802; *Ascaris teres* Goeze, 1782; *Belascaris cati* (Schrank, 1788) Brumpt, 1922; *Belascaris cati* Railliet & Henry, 1911; *Belascaris crenulata* (Bremser, 1824) Railliet & Henry, 1911; *Belascaris mystax* (Zeder, 1800) Leiper, 1907; *Fusaria mystax* Zeder, 1800; *Toxocara cati* Baylis & Daubney, 1923; *Toxocara crenulata* (Bremser, 1824) Yorke & Maplestone, 1926; *Toxocara felis* (Goeze, 1782) Brumpt, 1936; *Toxocara mystax* (Zeder, 1800) Stiles & Brown, 1924.

Hosts: *Leopardus colocolo* Molina, 1782 and *Leopardus tigrinus* Schreber, 1775 – new host records; *Leopardus geoffroyi* d'Orbigny & Gervais, 1844 – new host record for Brazil; *Puma yagouaroundi* É. Geoffroy Saint-Hilaire, 1803 – new host record for the State of Rio Grande do Sul, Brazil.

Hosts specimens deposited: MCNU 2207.

Localities: State of Rio Grande do Sul, Brazil – new locality records.

Sites of infection: Stomach, small and large intestines.

Prevalence: 66.6% in *L. colocolo*, *L. geoffroyi* and *L. tigrinus*; 60% in *P. yagouaroundi*.

Mean intensity of infection: 22.5 helminths/host in *L. colocolo*; 6.7 helminths/host in *L. geoffroyi*; 4.5 helminths/host in *L. tigrinus* and 7.6 helminths/host in *P. yagouaroundi*.

Mean abundance of infection: 15 helminths/host in *L. colocolo*; 4.5 helminths/host in *L. geoffroyi*; 3 helminths/host in *L. tigrinus* and 4.6 helminths/host in *P. yagouaroundi*.

Amplitude of intensity of infection: 1 to 36 helminths in *L. colocolo*; 1 to 9 helminths in *L. geoffroyi*;

1 to 6 helminths in *L. tigrinus* and 1 to 19 helminths in *P. yagouaroundi*.

Voucher specimens deposited: CHMU 43-2-2-9 male; 43-2-3-9 female.

Discussion

The nematodes found in four wild feline species were identified as *T. cati* due to the presence of cervical alae, esophagus with a bulb at the posterior end, males with a terminal appendage and, females with a vulva in the body's anterior third.

Our measurements of *T. cati* were similar to those presented by Warren (1971), Vicente et al. (1997), Beldomenico et al. (2005), Radwan et al. (2009), Esfandiari et al. (2010) and Gallas and Silveira (2011). Males and females' width was smaller than that obtained by Warren (1971). The esophagus length was within the range obtained by Radwan et al. (2009). The measurements of the present work are higher than those given by Esfandiari et al. (2010). Gallas and Silveira (2011) found a positive correlation for all associations of the analyzed characters of *T. cati*. The authors suggest that cervical alae, esophagus length, and spicules in males, and distance of vulva from anterior end in females could be characters enabling strategies of this species in different environments.

According to Baruš et al. (1979) the average number of the denticles per lip of *T. cati* was 126, ranging from 115 to 129. In this study, the average number of the denticles was 124, ranging from 112 to 136. This character, according to the authors, could be used to differ *T. cati* from other species of Ascarididae.

Vicente et al. (1997) presented morphometric data of *T. cati* based on measurements by Stiles. Vieira et al. (2008) did not present morphometric data and ecologic parameters of infections, limiting their work to the record of species deposited in the "Coleção Helmintológica do Instituto Oswaldo Cruz" (CHIOC). The present study provides, for the first time, morphometric data and ecological parameters of *T. cati* in wild felines from Brazil.

The ecological parameters differed between the data found in the literature (Table 1) and that of this study. Beldomenico et al. (2005) found in Argentina a higher prevalence than that observed in the present study, taking into account the similar sample size. However, Fiorello et al. (2006), in Bolivia, reported a smaller prevalence. In studies carried out with *T. cati* from North America, the feline species examined through a high sample size were *Felis canadensis* (= *Lynx canadensis* Kerr, 1792) (n = 274; 22%), *Felis rufus* (= *Lynx rufus* Schreber,

1777) (n = 143; 89%), and *Felis (Lynx) canadensis* (= *Ly. canadensis*) (n = 113, 4%) (Table 1). Among these, the highest intensity of infection was reported for *F. rufus* (= *Ly. rufus*) (44) by Watson et al. (1981).

The mean intensity of infection for *L. colocolo* (22.5) was higher with regard to the other examined hosts. According to Sunquist and Sunquist (2002), the ecology of this species is insufficiently known, however, the host presents a generalist diet, eating any small vertebrate, a characteristic that may be associated to

TABLE 1: Comparison of *T. cati* ecological parameters in different hosts.

Host	Host (n)	Prevalence (%)	Mean Intensity	Mean Abundance	Reference
<i>Lynx r. rufus</i> (= <i>Lynx rufus</i>)	50	36	–	–	Rollings (1945)
<i>Felis (Lynx) canadensis</i> (= <i>Lynx canadensis</i>)	113	4	–	–	van Zyll de Jong (1966)
<i>Ly. rufus</i>	16	75	–	–	Miller and Harkema (1968)
<i>Felis chaus</i>	8	62.5	15.4	–	Sadighian (1970)
<i>Felis rufus</i> (= <i>Ly. rufus</i>)	66	16.6	5	–	Stone and Pence (1978)
<i>F. rufus</i> (= <i>Ly. rufus</i>)	–	16.5	5.8	–	Pence and Eason (1980)
<i>Ly. rufus</i>	51	4	–	–	Schitoskey and Linder (1981)
<i>F. rufus</i> (= <i>Ly. rufus</i>)	143	89 (West Virginia)	44	–	Watson et al. (1981)
<i>F. rufus</i> (= <i>Ly. rufus</i>)	10	80 (Georgia)	13	–	Watson et al. (1981)
<i>Felis concolor</i> (= <i>Puma concolor</i>)	39	15	27	–	Rausch et al. (1983)
<i>Felis concolor coryi</i> (= <i>Puma concolor cougar</i>)	7	14	2	2	Forrester et al. (1985)
<i>Ly. rufus</i>	75	39	3	–	Tiekotter (1985)
<i>F. canadensis</i> (= <i>Ly. canadensis</i>)	274	22	3.9	–	Smith et al. (1986)
<i>F. concolor</i> (= <i>P. concolor</i>)	53	3.8	9.0	0.3	Waid and Pence (1988)
<i>F. concolor</i> (= <i>P. concolor</i>)	2	100	–	–	Rickard and Foreyt (1992)
<i>Felis bengalensis euptilura</i> (= <i>Prionailurus bengalensis euptilurus</i>)	3	66.6	36.5	24.3	Yasuda et al. (1993)
<i>Felis iriomotensis</i> (= <i>Prionailurus iriomotensis</i>)	2	100	–	–	Yasuda et al. (1994)
<i>F. bengalensis euptilura</i> (= <i>Pr. bengalensis euptilurus</i>)	2	50	–	–	Yasuda et al. (1994)
<i>Ly. pardinus</i>	8	37.5	5.3	–	Torres et al. (1998)
<i>Ly. lynx</i>	42	76.9	12.8	–	Bagrade et al. (2003)
<i>Ly. lynx</i>	37	68	17.1	–	Valdmann et al. (2004)
<i>Oncifelis geoffroyi</i> (= <i>Leopardus geoffroyi</i>)	7	85	–	–	Beldomenico et al. (2005)
<i>Leopardus pardalis</i>	10	10	–	–	Fiorello et al. (2006)
<i>Ly. pardinus</i>	5	20	–	0.2	Millán and Casanova (2007)
<i>Felis sylvestris</i>	46	58.7	7.2	4.8	Radwan et al. (2009)
<i>Panthera pardus saxicolor</i> (= <i>Panthera pardus nimr</i>)	1	100	3	3	Esfandiari et al. (2010)
<i>Pa. pardus saxicolor</i> (= <i>Pa. pardus nimr</i>)	2	100	12	12	Ghaemi et al. (2011)
<i>Leopardus colocolo</i>	3	66.6	22.5	15	Present work
<i>L. geoffroyi</i>	6	66.6	6.7	4.5	Present work
<i>Leopardus tigrinus</i>	3	66.6	4.5	3	Present work
<i>Puma yagouaroundi</i>	5	60	7.6	4.6	Present work

the high number of nematodes found when compared to other hosts. The differences found may be associated to the life cycle of the helminth and the availability of hosts infected with *T. cati* larva in the different environments.

In the life cycle of different species of the genus *Toxocara* the definitive host may be infected in two ways: through the ingestion of paratenic hosts (invertebrates and vertebrates) or during the prenatal period, through transmammary transmission, constituting an important pathway (ANDERSON, 2000). The analysis of infected hosts from different geographic areas in the State of Rio Grande do Sul allows one to conclude that the helminth's life cycle is occurring in whole State.

This helminth species is reported for the first time for *L. colocolo* and *L. tigrinus*; it's the first report for *L. geoffroyi* in Brazil, as well as for *P. yagouaroundi* in the State of Rio Grande do Sul.

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