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A new species of Trichuris from *Thrichomys apereoides* (Rodentia: Echimyidae) in Brazil: Morphological and histological studies

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This work is dedicated to the memory of Prof. Reinalda Marisa Lanfredi.

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ABSTRACT

Trichuris thrichomysi n. sp., recovered from the cecum of the wild rodent *Thrichomys apereoides* from a transition zone between the Atlantic Forest and Cerrado morfoclimatic domains, and its life cycle observed under experimental conditions are described. This new species is closely related to *Trichuris travassosi*, *Trichuris chiliensis* and *Trichuris fulvi*, but can be distinguished from them mainly by differences in the posterior end of males. Details of the surface such as the bacillary gland, cuticular inflations and several morphological details obtained by scanning electron microscopy and field emission scanning electron microscopy confirmed the characteristics that differentiate the new species. The histopathology of the intestinal wall of naturally infected rodents is also reported. The present study extends the geographical distribution of *T. thrichomysi* n. sp to the Pantanal ecosystem and reports a new host, *Thrichomys pachiurus*.

1. Introduction

Species of *Trichuris* Roederer, 1791 (Nematoda: Trichuridae) have worldwide distribution (Cafrune et al., 1999). The genus *Trichuris* comprises parasites of medical and veterinary importance (Bundy and Cooper, 1989; Grencis et al., 1993) because it can parasitize different species, among them humans, primates, pigs, dogs, sheep, goats, cattle and rodents. The genus includes 14 South America species that infect rodents, of which four are parasites of Cricetidae: *Trichuris travassosi* Gomes, Lanfredi Pinto and De Souza, 1992 in *Oligoryzomys nigripes*; *Trichuris laevitestis* Suriano and Navone, 1994 in *Akodon azarae* and *Scapteromys aquaticus*; *Trichuris pardinasi* Robles, Navone and Notarnicola, 2006 in *Phyllotis xanthopygus*; *Trichuris chiliensis* Babero, Cattan and Cabello, 1976 in *Akodon longipilis* and eight are parasites of hystricognath: *Trichuris gracilis* Rud., 1819 Hall, 1916 in *Dasyprocta agouti*; *Trichuris myocastoris* Heidegger, 1931 Enigk, 1933 in *Myocastor*

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coypus; *Trichuris pampeana* Suriano and Navone, 1994 in *Ctenomys azarae* and *Ctenomys talarum*; *Trichuris bradleyi* Babero, Cattan and Cabello, 1975 in *Octodon degus*; *Trichuris robusti* Babero and Murua, 1990 in *Ctenomys robustus*; *Trichuris bursacaudata* Suriano and Navone, 1994 in *C. talarum*; *Trichuris dolichotis* Morini, Boero and Rodriguez, 1955 in *Dolochotis patagonum*; *Trichuris fulvi* Babero and Murua, 1987 in *Ctenomys fulvus* and one of Muridae: *Trichuris muris* Schrank, 1788 Hall, 1916 in *Mus musculus* (Morini et al., 1955; Vicente et al., 1997; Rossin and Malizia, 2005; Robles et al., 2006). It has a unique life-cycle strategy and the ability to inhabit an intra-tissue niche in the intestinal epithelial cells of mammalian hosts (Tilney et al., 2005). The Pantanal and Atlantic Forest biomes have great biodiversity. The richness of the fauna and flora is still not fully understood. Because of the encroachment of human activities in these ecosystems, there is a need for studies to promote their preservation and sustainable use of their natural resources (Lopes Torres et al., 2007, 2009).

Species of the genus *Thrichomys* (Rodentia: Caviomorpha) are present in several ecosystems in South America. *Thrichomys apereoides* occurs from North to Central part of Brazil, located in the Cerrado and Caatinga biomes (Bonvicino et al., 2002; Braggio and Bonvicino, 2004). Studies of *T. apereoides* in the wild have shown its involvement in the transmission cycles of *Trypanosoma cruzi* (H.M. Herrera et al., 2005; L. Herrera et al., 2005; Xavier et al., 2007) and have induced helminthological research (Simões et al., 2009) in the Pantanal biome. In this area *Thrichomys pachiurus* is often infected with *Trypanosoma evansi*, responsible for causing severe diseases in horses and dogs (L. Herrera et al., 2005; Herrera et al., 2007).

This paper reports the taxonomic and histological results of a new species found in *T. apereoides* in a transitional space between the Atlantic Forest and Cerrado biomes in Brazil, where numerous nematode specimens collected were found to be new species. Morphological analysis by light and scanning electron microscopy (SEM) revealed novel structural characteristics that in combination with the experimental infection showed new aspects of the infection process, leading to the identification of a new species.

2. Materials and methods

2.1. Host collection

Ten *T. apereoides* were trapped during two expeditions in July 2003 and April 2008 to the municipality of Capitão Andrade (19°02′ 14″S and 41°49′59″W), Minas Gerais state, Brazil (Atlantic Forest zone) and five *Thrichomys pachyurus* were caught during an expedition in August 2007 to the Nhumirim Experimental Farm of EMBRAPA (19°15′01″S and 57°01′29″W) in the municipality of Nhecolândia, Mato Grosso do Sul state (Pantanal zone). The animals were euthanatized according to Cardoso (2002). The survey was associated with the project entitled "Description of the Biodiversity of the Helminth Community of Small Mammals in the Pantanal of Mato Grosso do Sul", sponsored by the Instituto Oswaldo Cruz and the Earthwatch Institute.

The capture and necropsy of the rodents were authorized by the Brazilian Institute of Renewable Natural Resources (IBAMA), the federal environmental agency, and were performed according to biosecurity procedures (license numbers CGFAU 009/2002, 197/2002 and 091/2004). Biosecurity techniques and individual safety equipment were used during all procedures.

2.2. Experimental infection

The collection of parasites from *T. apereoides* captured from the field did not retrieve any males. We, therefore, proceeded with an experimental infection, where both females and males could be obtained.

Fourteen gravid females of *Trichuris thrichomysi* n. sp. recovered from naturally infected *T. apereoides* specimens captured in Capitão Andrade municipality were cut open with a scalpel and the contents of uterus were emptied into Petri dishes. The eggs were washed twice in dechlorinated water and incubated at $28 \pm 2\,^{\circ}C$ for 60 days. Development of cultures was observed under a Zeiss ID 02 inverted microscope. After that, 50-μL aliquots were mounted between slides and coverslips to quantify the percentage of embryonated eggs. One thousand embryonated eggs, in 0.5 mL dechlorinated water, were administered orally to laboratory-bred *T. apereoides* specimens aged 8–12 weeks. The rodents' were necropsied after euthanasia in a CO_2 chamber and their stools were examined and worms recovered. The rodents were bred and the parasite life cycle was maintained throughout the identification period in the Laboratorio de Biologia e Parasitologia de Mamíferos Silvestres e Reservatórios – IOC-FIOCRUZ.

2.3. Helminth examination

The whipworms were collected from the cecum of *T. apereoides* and *T. pachyurus*, washed in saline solution and fixed by immersion in hot AFA (2% glacial acetic acid, 3% formaldehyde and 95% ethanol). For light microscopy (LM), scanning electron microscopy (SEM) and field emission scanning electron microscopy (FESEM) specimens were prepared following Mafra and Lanfredi (1998), with 10 sec of gold coating for FESEM. Drawings were made with the aid of a camera lucida attached to a Zeiss Standard 20 light microscope. SEM micrographs were taken with a Jeol JSM 5310 and FESEM was performed with a Jeol JSM 6340F. All measurements (mean ± standard deviation) are given in micrometers, except measurements indicated in millimeters (mm). For the identification of specific characteristics of the *Trichuris* genus, Chandler (1930) and Robles et al. (2006) were used. For parasitological analysis, the prevalence, intensity and abundance of infection for each species were calculated according to Bush et al. (1997).

The type-species of *T. thrichomysi* n. sp. were deposited in the helminth collection of Instituto Oswaldo Cruz – Fundação Oswaldo Cruz, numbers CHIOC 35709a, 35709b, 35710a, 35710b, 35710c, 37364, 37365a, 37365b and 37365c.

2.4. Histopathological analysis

Large intestine fragments taken from the cecum of naturally infected *T. apereoides* were fixed in 8% formaldehyde at pH 7.4 for 24 h and transferred to 4% formalin. The tissue was then dehydrated in a graded ethanol series, submitted to diafanization with xylene and embedded in paraffin. Tissue sections (5 μm) were stained with hematoxylin and eosin (H&E) and examined under an Olympus BX 51 light microscope equipped with an Olympus DP 12 digital camera.

3. Results and discussion

3.1. Trichuris thrichomysi n. sp.

3.1.1. General

Cuticle with fine transversal striations, body divided into two parts, characteristic of the *Trichuris* genus: thin anterior portion and thicker posterior portion, the transition of the thin to thick portion of the body occurs at the esophagus–intestinal junction. There is a stichosome with one row of stichocytes, observed internally by LM and externally by SEM in the bacillary band (Bb), with cuticular inflations (Ci) and bacillary glands (Bg) in thinner portion on the ventrolateral face.

3.1.2. Male holotype

Total body length 14.5 mm; total esophagus length 7.00 mm; posterior portion of body 8.70 mm long. Width of esophageal region at tip 89; in midregion 155; at esophagus–intestinal junction 177. Maximum posterior body width 333. Length of spicule 2.30 mm; width 18 at tip, 33 at midregion; 66 at proximal end. Proximal cloacal tube, distal cloacal tube and spicular tube length 719, 1.49 mm and 1.87 mm long, respectively. The distance from the junction of proximal cloacal tube and spicular tube to the posterior end of the body is 1.36 mm. Ratios between total length/posterior portion length, total length/spicular length and posterior portion length/spicular length are 1.66, 6.3 and 3.8, respectively (Figs. 1, 7 and 8).

3.1.3. Male paratypes

Based on 5 specimens. Body length 15.9 ± 1.37 mm (14.5–17.8 mm); total length of esophagus 7.7 ± 0.75 mm (7.0–8.5 mm); length of posterior portion of body 9.1 ± 0.38 mm (8.7–9.3 mm). Width of esophageal region at tip 61 ± 24.09 (45–89); in midregion 126 ± 25.32 (107–155); at esophagus–intestinal junction 188 ± 11.53 (177–187). Maximum posterior body width 363 ± 35.24 (333–402). Single testis with 33–38 lobules (Fig. 7). Spicule length 2.26 ± 0.80 mm (1.86–2.78 mm); width 17 ± 6.02 (15–20) at tip, 30 ± 14.99 (19–39) at midregion; 57 ± 19.79 (45–67) at proximal end. The genital apparatus is formed by the junction of the intestine and the ejaculatory tube (Fig. 1, x^2), originates the proximal cloacal tube. The junction of the proximal cloacal tube with the spicular tube (Fig. 1, x^1) originates the distal cloacal tube. The spicule is located within the spicular tube. The length of the proximal cloacal tube, the distal cloacal tube and the spicular tube, was 752 ± 57.87 (719–771), 1.36 ± 0.34 mm (858–1616 mm) and 1.09 ± 0.44 mm (1.73–2.02 mm), respectively. The distance from the junction of proximal cloacal tube and spicular tube to the posterior end of the body is 1.28 ± 0.08 mm (1.17–1.36 mm). Ratios between total length/posterior portion length, total length/spicular length and posterior portion length/spicular length are 1.74 ± 0.14 (1.66–1.91), 7.2 ± 1.30 (6.3–8.7) and 4.2 ± 0.90 (3.5–5.2), respectively.

3.1.4. Female allotype

Total body length 30.3 mm; total length of esophagus 14.6 mm; length of posterior portion of body 16.6 mm. Width of esophageal region at tip 62; in midregion 108; at esophagus–intestinal junction 243. Maximum posterior body width 526. Vulva located 15.2 mm from anterior end. Eggs are oval, with 2 slightly protruding polar plugs measuring 71 × 37. Rectum 437 long (Figs. 2–6).

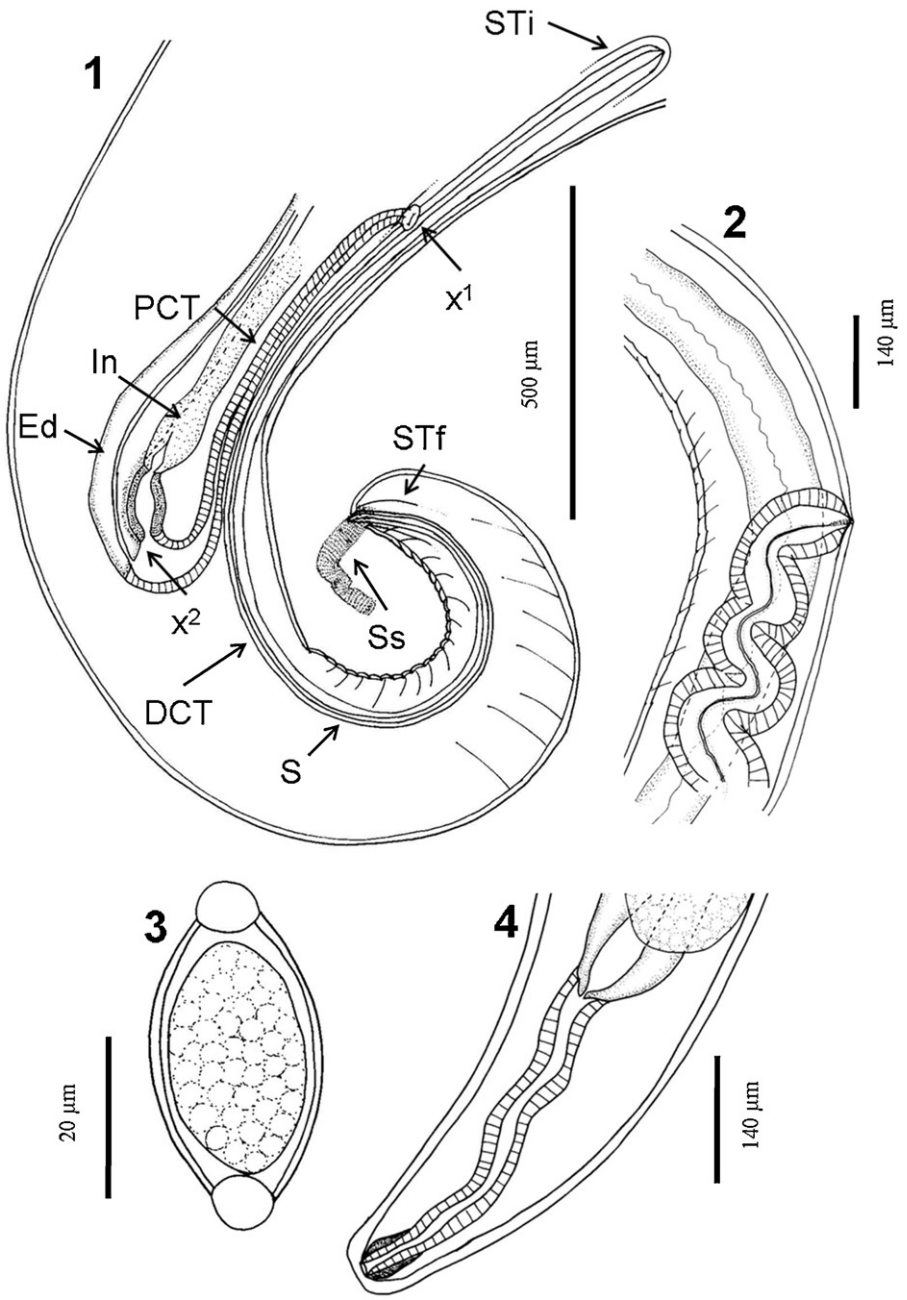
3.1.5. Female paratypes

Based on 8 specimens. Body length 30.0 ± 1.6 mm (27.5–32.3 mm); total length of esophagus 14.4 ± 0.99 mm (12.7–15.8 mm); length of posterior portion of body 16.6 ± 0.68 mm (15.7–17.3 mm). Width of esophageal region at tip 61 ± 11.12 (45–83); at midregion 116 ± 22.96 (89–139); at esophagus–intestinal junction 245 ± 27.67 (196–281). Maximum posterior body width 520 ± 50.96 (454–632). Vulva located 14.8 ± 1.10 mm (12.8–15.9 mm) from anterior end. Egg length 71 ± 0.74 (70–72) and width 37 ± 2.26 (32–39) (Fig. 3). Rectum length 448 ± 33.71 (405–512) (Figs. 4 and 6).

3.1.6. Bacillary band

The cuticular inflations (Ci) appear bordering the bacillary band (Bb) and between the Ci the cuticle is interrupted by openings over each bacillary gland (Bg) (Figs. 9–16). The cuticular inflations located at the anterior end are less numerous (Fig. 9) and continuously increase in number until they reach the middle of the bacillary band (Figs. 10 and 11). The density of Ci continuously decreases from the middle of the Bg towards the posterior end of the Bb (Figs. 12 and 13), where they are not seen (Fig. 14). The density of Ci is also lower in this region and the space between individual inflations is also higher (Fig. 12), when compared to the anterior end (Fig. 10). At the initial portion of the Bb, few Bg can be seen, in contrast to the posterior region of the worm where several Bg are observed, being more numerous in the middle than in the rest of the Bb. This forms a density gradient of bacillary glands along the bacillary band. Bacillary glands of different sizes are also seen in different regions of the worm. High magnification images obtained in a FESEM showed that the bacillary glands have two distinct morphological patterns, presenting or not a number of inner spherical structures organized in clusters (Figs. 17 and 18). The pores measured approx. 1.4 ± 0.6 μm in diameter and pores filled with vesicle-like structures were more frequently seen than pores that do not contain or contain few vesicles (Fig. 18).

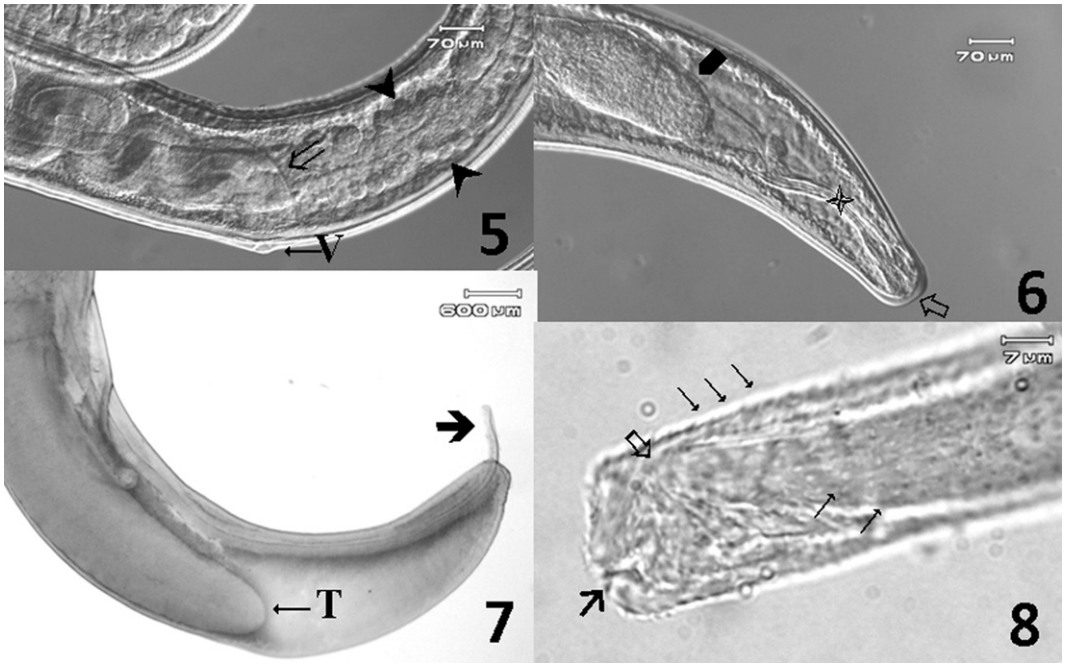
By SEM it was possible to observe in the anterior region of the females the initiation of the bacillary band, showing the first cuticular inflations (Fig. 19). In the esophagus–intestinal junction, the vulva opening is a



Figs. 1–4. Adult specimens of *Trichuris thrichomysi* n. sp. (1) Posterior end of male, showing ejaculatory duct (Ed), intestine (In), junction of intestine and ejaculatory duct to form proximal cloacal tube (x^2), proximal cloacal tube (PCT), junction of proximal cloacal tube and spicular tube (x^1), distal cloacal tube (DCT), initial region of spicular tube (STi), spicule (S), terminal region of spicular tube (STf) and spicular sheath (Ss). Scale bar: 500 µm. (2) Female, showing terminal esophagus, vulva and ovojector. Scale bar: 140 µm. (3) Egg, showing polar plugs and germinate cells in interior. Scale bar: 20 µm. (4) Posterior end of female showing terminal intestine, rectum and anus. Scale bar: 140 µm.

transversal slit formed by cuticular folds covered by spineless and non-everted cuticle (Figs. 20 and 21). The eggs have two polar plugs (Figs. 22 and 23) and in the posterior end the rounded tail with terminal anus opens in a transversal fissure (Fig. 24). At the posterior end of males, the genital apparatuses (Fig. 25) have two adcloacal papillae (Fig. 26). The spicular sheath is ornamented by spines, which are more numerous and larger at the base (Fig. 27) and decrease in number and size in the direction of the spicule tip (Fig. 28). No spines were observed in distal region of the spicular sheath closer to the tip of the spicule (Figs. 29 and 30).

Type host. *T. apereoides*.
Site of infection. Cecum.



Figs. 5–8. Light microscopy (DIC) of *Trichuris thrichomysi* n. sp. (5) Transition of thin to thick region in female showing vulva (V), ovojector (⇒) and stichocytes ( ). Scale bar: 70 μm. (6) Posterior end of female showing terminal intestine ( ), rectum ( ) and anus ( ). Scale bar: 70 μm. (7) Posterior end of male, showing testes (T), spicule covered with spicular sheath ( ). Scale bar: 600 μm. (8) Detail of spicular tip ( ), spicular sheath (→) and spine ornamentation (⟶). Scale bar: 7 μm.

Type locality. Capitão Andrade municipality (19°02′14″S and 41°49′59″W), Minas Gerais state, Brazil.
Prevalence. 40% (4 positive of 10 collected).
Infection intensity. 5.25 ± 5.05.
Mean abundance. 2.1 ± 3.98.
Other host. *T. pachyurus*.
Prevalence. 40% (2 positive of 5 collected).
Infection intensity. 1.5 ± 0.71.
Mean abundance. 0.6 ± 0.89.
Other localities. Nhumirim Farm (18°59′00″S and 56°39′00″W), Pantanal region, Mato Grosso do Sul state, Brazil.
Type specimens. Holotype: 1 male (CHIOC: 35710a); allotype: 1 female (CHIOC: 35710b); paratypes: 3 males (CHIOC: 35710c, 37365a, 37365b), 1 female (CHIOC: 37365c); voucher: 3 females (CHIOC: 35709a, 35709b, 37364).
Etymology. This species was named according to the host genus in which the nematodes were found.

3.2. Histopathology

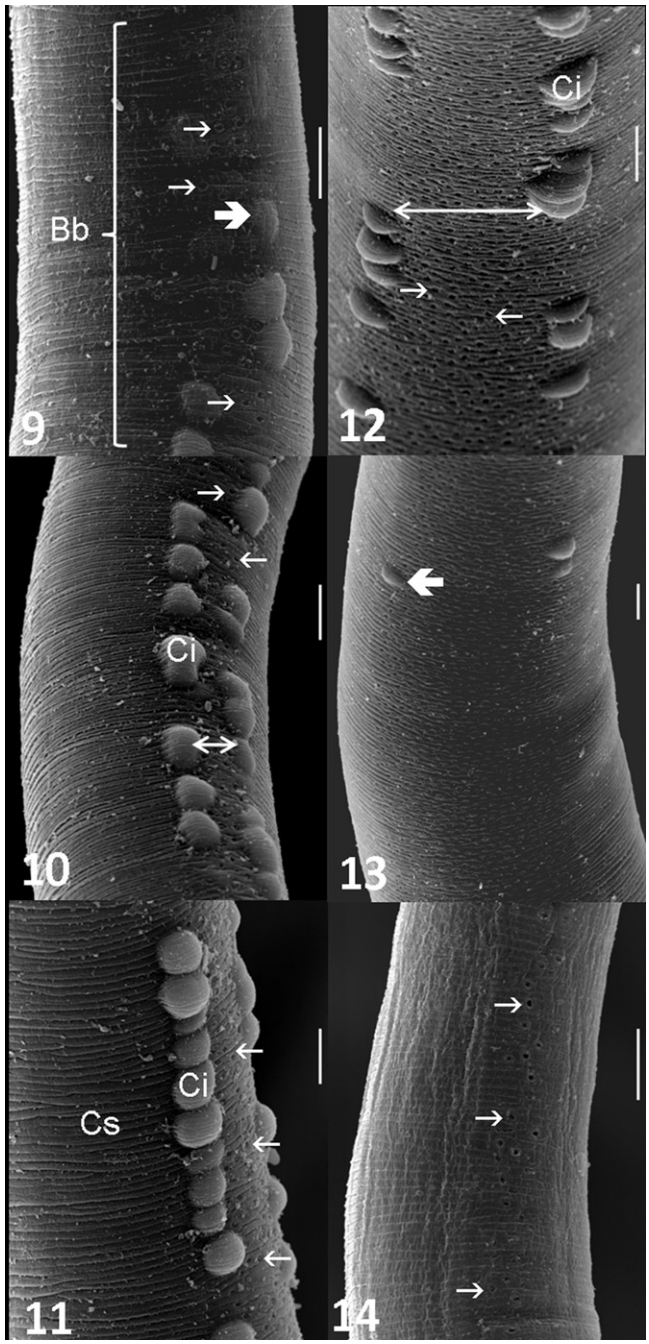
Examination of histological sections of the attached anterior region of *T. thrichomysi* n. sp. revealed a nematode inserted in the lining of the large intestine (cecum) of the host, where it was possible to identify the crypt of Lieberkühn, mucosa, muscularis mucosae, submucosa and muscularis external (Fig. 31). The nematode was found exclusively in the mucosal surface and not in deeper layers, covered by the apical surface of mucosal epithelium, forming a tunnel (parasite niche). In addition, thin sections showed hyperplasia of lymphoid follicles in the submucosa and lymphocytic infiltration in the submucosa and mucosa of the large intestine infected with *T. thrichomysi* n. sp. (Figs. 31 and 32).

4. Remarks

The *Trichuris* genus is well described by light microscopy. Four species of this genus have been recorded in rodents in Brazil: *T. muris* Schrank, 1788; *T. myocastoris* Heidegger, 1931; *T. travassosi* Correa Gomes et al., 1992 and *T. gracilis* Rud., 1819 (Vicente et al., 1997). Of these four species, only *T. travassosi* is closely related to *T. thrichomysi* n. sp., mainly by the spicule size, but differs in the male body length, length of the spicular tube and number of testes lobations, which are all smaller in *T. thrichomysi* n. sp. In addition, the body length/spicule length and posterior length/spicule ratios differ.

Trichuris leporis Froelich, 1789 and *T. chiliensis* Babero et al., 1976 are found in Canada and Chile, respectively. The males of *T. leporis* have a similar spicule size to *T. thrichomysi* n. sp., but differ in the pear-shaped spicular sheath terminal swelling, the greater total length, esophagus length, total length/posterior length and total length/spicule ratios. The females of *T. leporis* are smaller in total length and total length/posterior length ratio than *T. thrichomysi* n. sp.

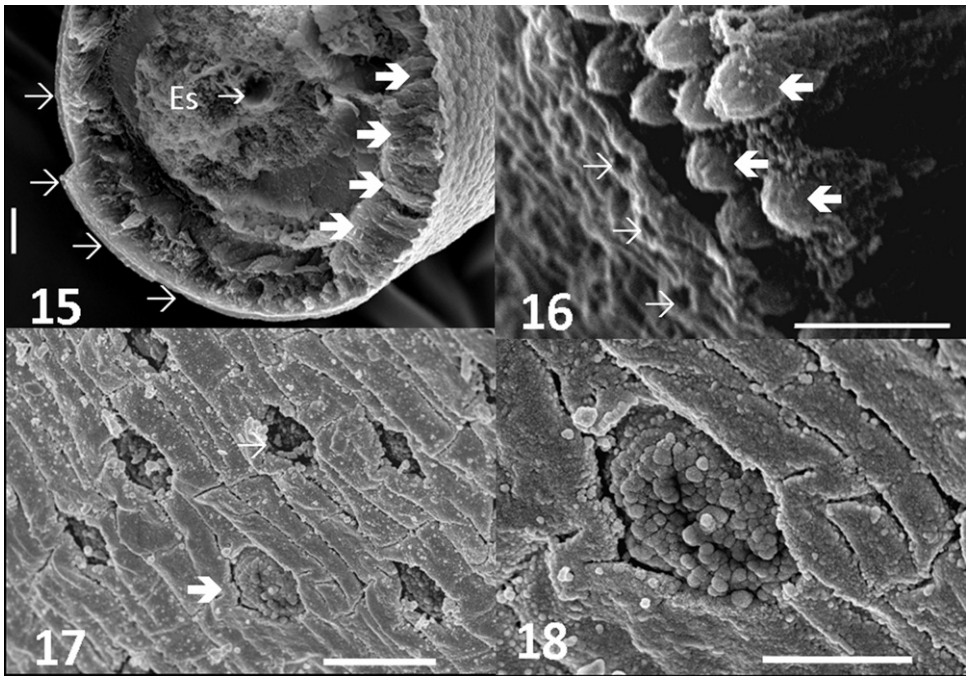
T. chiliensis has similar spicular size and total length to *T. thrichomysi* n. sp., but *T. chiliensis* is absent spicular tube and in females a vulva with prominent downward-projecting cuticular flap.



Figs. 9–14. Scanning electron microscopy of bacillary band of *Trichuris thrichomysi* n. sp. (9) Initial region of bacillary band (Bb), showing first cuticular inflations (➔) and bacillary glands (→). (10) 2/3 of initial region of bacillary band, showing cuticular inflations (Ci), bacillary glands (→) and space between cuticular inflation (↔). (11) First half of bacillary band region, showing cuticular inflations (Ci), bacillary glands (→), and cuticular striations (Cs). (12) Second half of bacillary band region, showing cuticular inflations (Ci), bacillary glands (→) and space between the cuticular inflations (↔). (13) Terminal region of bacillary band, showing the last cuticular inflation (➔). (14) Final part of bacillary band, showing only bacillary glands (→). Scale bar: 10 μm.

Males and females of *T. fulvi* occurring in Chile are larger than *T. thrichomysi* n. sp., but in males the total length/spicular length ratio is similar. The differences are the total length/posterior length, total length/cloacal tube ratios and the distance of the junction of cloacal tube and spicular tube from the posterior end of the body. In females, the differences appear in the rectum length and egg size.

SEM has been used as a complementary tool for identification of different nematode species, mainly to detect cuticular spines in the vulvar region and the spicu-



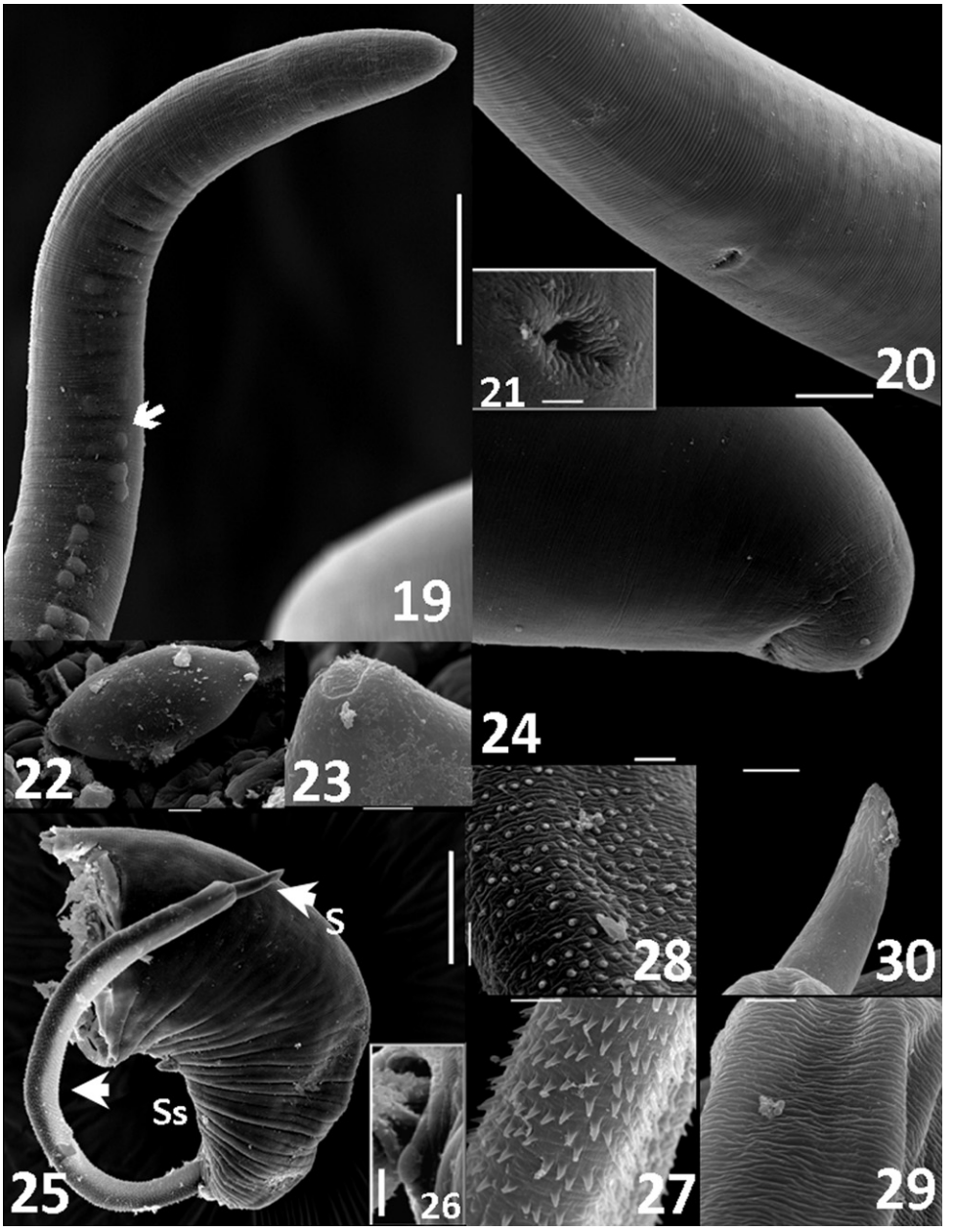
Figs. 15–18. (15, 16) Scanning electron microscopy of bacillary glands of *Trichuris thrichomysi* n. sp. (15) Transversal section showing 2/3 of initial region of bacillary band, showing cuticular inflations (Ci), cuticle (→), base of bacillary glands (➔) and the esophagus (Es). Scale bar: 10 μm. (16) Detail of bacillary glands exposed by opening pores in cuticle (→) and bacillary glands without cuticular covering (➔). Scale bar: 5 μm. (17, 18) Field emission scanning electron microscopy of bacillary glands of *T. thrichomysi* n. sp. (17) Two patterns of bacillary glands, containing few vesicles (→) and filled with vesicle-like (➔). Scale bar: 2 μm. (18) Detail of pore filled with vesicle-like, showing numerous vesicles inside organized in clusters. Scale bar: 1 μm.

lar sheath, and to morphologically characterize bacillary bands. The bacillary band has been studied by scanning electron microscopy in 6 of the 12 *Trichuris* species that parasitize rodents (Pfaffenberger and Best, 1989; Correa et al., 1992; Lanfredi et al., 1995; Robles et al., 2006; Robles and Navone, 2006). The spineless vulvar opening is observed in all females of *Trichuris* in rodents studied by SEM, and only *T. laevitestis* has a protrusive vulva. The study of Barus et al. (1977), using SEM to compare the morphology and topography of spines on the spicular sheath, might help to solve some taxonomic problems regarding the *Trichuris* genus. For instance, it presents in detail how to compare spine morphology. But it does not show species of parasites that infect rodents. *T. thrichomysi* n. sp. has similar morphology, size and spine distribution as *T. travassosi*, but the spicular sheath is shorter. A pointed spine projection is observed in *T. thrichomysi* n. sp., *T. travassosi*, *T. pardinasi*, *Trichuris leavitestis* and *Trichuris elatoris*, but in *Trichuris dipodomys* the spines have a saccule-like projection. Adcloacal papillae are observed in *T. thrichomysi* n. sp., *T. travassosi*, *T. pardinasi* and *T. leavitestis*.

The results here show the contribution of scanning electron microscopy to reveal morphological details of copulatory organs and the bacillary band of Trichurids, contributing to the understanding of the functional role in parasite habits.

Species of *Trichuris* have been described, but few pathogenicity studies have been reported (Beck and Beverley-Burton, 1968). Chandler (1930) and Batte et al. (1977) reported, respectively, that camels and pigs infected with *Trichuris* spp. suffered from chronic diarrhea and dysentery for several weeks and the intestine contained much blood and mucus. Jenkins (1970) reported that damage to the intestinal host cells was restricted only to slight cellular disruption and compression on the surface of mucosal cells in close proximity to the parasite niche, although the mucous membrane retained its normal appearance, and concluded that *Trichuris suis* is not a severe pathogen under natural conditions. In a histological and histochemical study of *Trichuris vulpis* in dogs, Fernandes and Saliba (1974) observed that the helminth does not cause great changes in the cecal wall, although they do cause intense congestion in the mucosa and submucosa. Tilney et al. (2005), using light, scanning and transmission electron microscopy in models of experimental infection of BALB/cDyJ and AKR mice by *T. muris*, observed the worms inserted in the mucosal epithelium, destroying lateral membranes, while leaving the apical and basal cell surfaces intact. In addition, they reported rupture of the mucosal cells, allowing the entrance of cecal bacteria and occasional white blood cells.

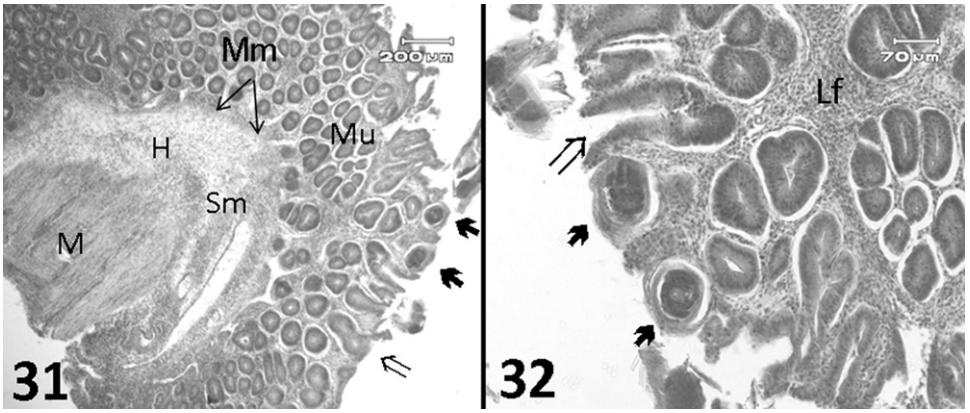
Although minor changes were observed in the tissue, the general preservation of the histological characteristics of the tissue, showing the mucosa, submucosa and muscle layers was recognizable in the cecum of infected *T. apereoides*. These results confirm what was described by Jenkins (1970), Fernandes and Saliba (1974), Batte et al. (1977) and Tilney et al. (2005). However, Fernandes and Saliba (1974) and Tilney et al. (2005), noted the presence of lymphocytes in the submucosa, while Fernandes and



Figs. 19–30. Scanning electron microscopy of adult *Trichuris thrichomysi* n. sp. (19) Anterior end of female, showing initial region of bacillary band in ventrolateral face (➔). Scale bar: 50 μm. (20) Ventral face of female showing the vulva. Scale bar: 50 μm. (21) Detail of vulva, absent spines. Scale bar: 10 μm. (22) Posterior end of female showing anus. Scale bar: 10 μm. (23) Egg. Scale bar: 10 μm. (24) Detail of egg polar extremity showing the operculum-plug. Scale bar: 5 μm. (25) Posterior end of male, showing the spicule (S) covered by spicular sheath (Ss) ornamented by spines. Scale bar: 100 μm. (26) Detail of adcloacal papillae. Scale bar: 10 μm. (27) Base of the spicular sheath. (28) Middle of the spicular sheath. (29) Spicular sheath terminal; scale bar: 5 μm. (30) Spicule tip, without spicular sheath; scale bar: 10 μm.

Saliba (1974) indicated hyperplasia of lymphoid follicles, all of which are in agreement with our results.

Batte et al. (1977), in a study of pathophysiology using SEM, concluded that damage caused by trichuriasis facilitated penetration of the mucosal cells by potentially pathogenic bacteria, causing an inflammatory reaction with the presence of lymphocytic infiltrate. This invasion, associated with the weakened host resistance, may have explained the high mortality of pigs infected with *T. suis* under field conditions. Although in our results were not observed bacteria in the cecum of *T. apereoides*, the inflammatory reactions suggested an associated bacterial infection could have occurred. On the other hand, the invasion of whipworms into the mucosa of the cecum in natural infection may present clinical manifestation for the hosts, resulting from the invasion of the mucosal tissue by the worms. These signs may increase in captive bred animals. The morphological characteristics and pathogenic aspects



Figs. 31 and 32. Light microscopy of histological sections of *Trichuris thrichomysi* n. sp. attached in cecum of *Thrichomys apereoides*. (31) Anterior region of *T. thrichomysi* n. sp. insert into cecum (➔), crypt of Lieberkühn (⇒), showing mucosa (Mu), muscularis mucosae (Mm), submucosa (Sm), hyperplasia of lymphoid follicles (H) and muscularis external (M). Scale bar: 200 μm. (32) Detail of mucosa region, showing *T. thrichomysi* n. sp. (➔), crypt of Lieberkühn (⇒) and lymphocytic infiltration (Li). Scale bar: 70 μm.

of the parasite–host relationship are currently under investigation in our laboratory.

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