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Taxonomy and systematics

Checklist of helminth parasites of wild primates from Brazil

Lista de los helmintos parásitos de primates silvestres de Brasil

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Abstract

The current study is the first attempt to include the many records from wild primate host species from the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC), Rio de Janeiro, Brazil, along with updated information based on literature. We list a total of 50 species of helminth parasites associated with 46 species of wild primates in Brazil. A total of 814 records of helminths in wild primates from Brazil were listed, including 406 samples of helminths stored in the CHIOC. Of these samples, 16 are new host records (NHR). The majority of these helminth species are nematodes with 30 species reported, which corresponds to 60% of the total number of helminths. The helminth species with more host reports of helminths in Brazil is *Saimiri sciureus* (Cebidae), with 16 species (13 nematodes, 3 acanthocephalans). In the current study, 46 species of primates have at least 1 species of helminth recorded, which represents approximately 39% of species of this host in Brazil. Therefore, we can conclude that the helminths documented in wild primates from Brazil are obviously underestimated, since the helminth fauna in the majority of Brazilian primates remains unknown.

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Keywords: Nematoda; Trematoda; Cestoda; Acanthocephala; Biodiversity; Neotropical

Resumen

El presente estudio es la primera publicación que incluye todos los registros de especies de helmintos parásitos de primates silvestres de la Coleção Helmintológica do Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brasil, junto con la información actualizada de los helmintos con base en la literatura. Un total de 50 especies de helmintos están asociadas con 46 especies de primates silvestres en Brasil. Se enumeran un total de 814 registros de helmintos en primates silvestres de Brasil, incluyendo 406 muestras de especies de helmintos depositados en la CHIOC. De estas muestras de la CHIOC, 16 son nuevos registros de hospedadores (NHR). La mayoría de estas especies de helmintos son nematodos con 30 especies registradas, correspondiendo al 60% del número total de helmintos. La especie de helminto con más registros es el nematodo *Dipetalonema gracilis* (Filarioidea, Onchocercidae), asociada a 13 especies de primates. La especie de primate con más registros de helmintos en Brasil es *Saimiri sciureus* (Cebidae) con 16 especies (13 nematodos, 3 acantocéfalos). En el presente estudio se observó que un total de 46 especies de primates silvestres en el país tiene al menos una especie de helmintos registrada, lo que representa aproximadamente el 39% de las especies de este grupo de hospedadores en Brasil. Por lo tanto, podemos concluir que la fauna de helmintos en primates silvestres en Brasil es obviamente subestimada, ya que la helmintofauna en la mayoría de las especies de primates brasileños sigue siendo desconocida.

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Palabras clave: Nematoda; Trematoda; Cestoda; Acanthocephala; Biodiversidad; Neotropical

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Introduction

The order Primates in Brazil comprises 118 species, divided into 19 genera and 5 families (Paglia et al., 2012; Reis, Peracchi, Pedro, & Lima, 2011). Brazil is the country with the highest diversity of primates in the world, with 71.5% of the species that occur in the Neotropical region, and 23.8% of the 496 species of primates worldwide (IUCN, 2014).

Primates are proportionally one of the most threatened mammalian groups in Brazil, due to the fact that Brazilian primates inhabit exclusively forests and therefore are not tolerant to forest destruction (Chiarello et al., 2008). These threats to primates in Brazil refer mainly to anthropic pressure, which causes habitat loss and fragmentation, and illegal hunting (Reis et al., 2011). Another factor which threatens primates in Brazil is the illegal traffic and trade of wild animals. According to Renctas (2001) despite the reduction of illegal trade in wild primates in Brazil, they are still extracted from their natural habitats in significant numbers compared to their natural populations, and even with the decrease of trade for these primates, populations of rare species are still vulnerable or threatened by these illegal activities.

Until this study, some previous publications (Pinto, Knoff, Gomes, & Noronha, 2011; Schmidt, 1986; Travassos, Freitas, & Kohn, 1969; Travassos, 1965; Vicente, Pinto, & Faria, 1992; Vicente, Rodrigues, Gomes, & Pinto, 1997) included records of helminth parasites of wild primates on generalized compilations, or by specific groups of helminths. A study by Vicente et al. (1992) which focuses exclusively on nematodes is the most recent on the biodiversity of helminth parasites of Brazilian primates, but only includes data on nematode biodiversity until 1970. Another relevant contribution on the helminth biodiversity in Brazilian primates is the study by Muniz-Pereira, Vieira, and Luque (2009), which includes data on helminth fauna for 14 species of wild primates included in threatened categories of IUCN until 2008. Therefore, an update on the biodiversity of the helminth fauna in Brazilian wild primates is necessary.

This is also the first attempt to include the many records from wild primates as host species from the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC), Rio de Janeiro, Brazil, along with updated information based on literature, adding data to the previous scattered publications.

Materials and methods

Using published records and information retrieved from the CHIOC, a checklist of the helminth parasites of wild primates from Brazil was generated. The parasites are arranged according to the classification of Gibson, Jones, and Bray (2002) and Jones, Bray, and Gibson (2005) for Trematoda, Khalil, Jones, and Bray (1994) for Cestoda, Anderson, Chabaud, and Willmott (2009) and Gibbons (2010) for Nematoda, Amin (1987, 2013) for Acanthocephala.

The species of helminths are presented in alphabetical order, followed by hosts (specific name), site of infection, localities and references (between parentheses, in chronological sequence). In addition, the checklist includes helminth species recorded only

to genus level (undetermined species). Mention of the helminths and host species in this list does not imply that the authors agree with their validity or taxonomy.

Higher-level classification of primate species follows Wilson and Reeder (2005). Species of hosts are arranged in taxonomic and systematic sequence. The following conventions in relation to the parasite records are observed: NHR refers to a new host record in Brazil. Voucher specimens of the new parasitological records are deposited in the CHIOC. The CHIOC catalogue number was included for all species with type specimens and voucher specimens deposited in the collection.

Results

In the current study we list a total of 50 species of helminth parasites associated with 46 species of wild primates in Brazil. Eleven undetermined helminth species are also included. A total of 814 records of helminths from wild primates from Brazil are listed, including 406 samples of determined and undetermined species of helminths stored in the CHIOC, of these, 16 are new host records (NHR).

The majority of these helminth species are nematodes with 30 species reported, which represent 60% of the total number. Acanthocephala corresponds to 20% (10 species), Trematoda 12% (6 species), and Cestoda 8% (4 species). The helminth species documented with more host species is the nematode *Dipetalonema gracilis* (Rudolphi, 1819) (Filarioidea, Onchocercidae), associated with 13 species of primates.

The primate species with the most reports of helminths in Brazil is the common Squirrel Monkey *Saimiri sciureus* (Linnaeus) (Cebidae), with 11 species (8 nematodes, 3 acanthocephalans), and 4 undetermined helminth species.

Parasite host list

Phylum Acanthocephala Rudolphi, 1802.
Class Archiacanthocephala Meyer, 1931.
Order Oligacanthorhynchida Petrochenko, 1956.
Family Oligacanthorhynchidae Southwell and Macfie, 1925.

Oncicola confusa (Machado-Filho, 1950)

Cebus sp., intestine, Minas Gerais (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 431–432 – paratypes, 4406–4411 – paratypes, 17813 – paratype, 17855 – holotype and allotype).

Oncicola freitasi (Machado-Filho, 1950)

Cebus sp., large intestine, Espírito Santo (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 15869 – paratypes, 17817 a–b – holotype and allotype, 17818 a–c – paratypes).

Oncicola juxtatesticularis (Machado-Filho, 1950)

Callithrix geoffroyi, intestine, Espírito Santo (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 17821 a–b – holotype

and allotype, 17822 a-l – paratypes, 17843 – paratype, 17849 – paratype).

Oncicola machadoi Schmidt, 1972

Cebus apella, rectum, Espírito Santo (Yamaguti, 1963) (CHIOC no. 17814, 17815 a–c, 17816, 17853, 17858).

Oncicola sigmoides (Meyer, 1932)

Callithrix jacchus, small intestine, Rio de Janeiro (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 417–422, 998, 8279, 16145–16146, 17807 a–e, 17808 a–b).

Leontopithecus sp., unspecified site of infection, unspecified locality (Yamaguti, 1963).

Saguinus niger, large intestine, Pará (NHR) (CHIOC no. 17834 a–b, 17835 a–d, 17842).

Saguinus sp., unspecified site of infection, unspecified locality (Yamaguti, 1963).

Saimiri sciureus, large intestine, Pará, Rio de Janeiro (NHR) (CHIOC no. 7661, 8864, 16147, 17809 a–d, 17810 a–c).

Saimiri sp., unspecified site of infection, unspecified locality (Yamaguti, 1963).

Oncicola spirula (Olfers in Rudolphi, 1819)

Cebus apella, intestine, unspecified locality (Petrochenko, 1971).

Cebus sp., intestine, Minas Gerais (NHR) (CHIOC no. 8281).

Leontopithecus rosalia, intestine, Rio de Janeiro (Diesing, 1851; Machado-Filho, 1950; Muniz-Pereira et al., 2009; Petrochenko, 1971; Rudolphi, 1819; Travassos, 1917; Yamaguti, 1963) (CHIOC no. 17811 a–e, 17845).

Leontopithecus sp., intestine, unspecified locality (Petrochenko, 1971).

Saimiri sciureus, large intestine, rectum, Pará, Rio de Janeiro (NHR) (CHIOC no. 3197, 3199, 3205–3206, 3210–3211, 3214, 3220, 3224, 3226, 3323–3329, 4520, 4523, 4524, 4526, 4527, 7660, 9968, 10572 a–d).

Pachysentis lenti (Machado-Filho, 1950)

Callithrix geoffroyi, small intestine, Espírito Santo (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 14830 – paratype, 17819 a–b – paratype, holotype and allotype, 17820 a–c – paratype).

Pachysentis rugosus (Machado-Filho, 1950)

Cebus apella, large intestine, Rio de Janeiro (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 17827 – allotype, 17828 a–c – paratype, 17844 – holotype, 17848 – paratype, 7328 – paratype).

Cebus cay, large intestine, Rio de Janeiro (Machado-Filho, 1950; Yamaguti, 1963).

Pachysentis septemserialis (Machado-Filho, 1950)

Saguinus niger, large intestine, Pará (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 10593 – paratype, 17812 a–c – paratype and holotype).

Prosthenorchis elegans (Diesing, 1851)

Mico chrysoleucus, large intestine, Rio de Janeiro (Machado-Filho, 1950; Yamaguti, 1963).

Leontopithecus chrysomelas, intestine, Rio de Janeiro (Muniz-Pereira et al., 2009; Pissinatti, Pissinatti, Burity, Mattos, & Tortelly, 2007).

Leontopithecus chrysopygus, intestine, Rio de Janeiro (Muniz-Pereira et al., 2009; Pissinatti et al., 2007).

Leontopithecus rosalia, intestine, Rio de Janeiro (Diesing, 1851; Muniz-Pereira et al., 2009; Pissinatti et al., 2007; Travassos, 1917; Yamaguti, 1963).

Saguinus niger, large intestine, Pará (Machado-Filho, 1950; Yamaguti, 1963) (CHIOC no. 10122, 10124, 10126).

Saimiri sciureus, large intestine, Rio de Janeiro (Machado-Filho, 1950; Yamaguti, 1963).

Prosthenorchis sp.

Cebus apella, large intestine, Pará (Petrochenko, 1971) (CHIOC no. 9031, 17840 a–f).

Phylum Nematoda (Rudolphi, 1808).

Superfamily Ancylostomatoidea Chabaud, 1965.

Family Ancylostomatidae Looss, 1905.

Ancylostoma braziliense Faria, 1910

Cacajao calvus, small intestine, Amazonas (NHR) (CHIOC no. 5842, 34006 a–b).

Monodontus sp.

Cacajao calvus, intestine, Amazonas (Gonçalves, Vicente, & Pinto, 2002; Muniz-Pereira et al., 2009) (CHIOC no. 5842, 34006a–b).

Necator sp.

Cacajao calvus, small intestine, Amazonas (Muniz-Pereira et al., 2009; Vicente et al., 1992).

Lagothrix lagotricha, unspecified site of infection, unspecified locality (Muniz-Pereira et al., 2009; Vicente et al., 1997).

Superfamily Ascaridoidea Railliet and Henry, 1915.

Family Ascarididae Baird, 1853.

Ascaris elongata Rudolphi, 1819

Alouatta belzebul, intestine, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009; Pinto et al., 2011; Rudolphi, 1819; Stiles, Hassall, & Nolan, 1929; Stuart et al., 1998).

Superfamily Filarioidea Weinland, 1858.
Family Onchocercidae (Leiper, 1911).

Dipetalonema caudispina (Molin, 1858)

Alouatta guariba, unspecified site of infection, Amazonas, São Paulo (Molin, 1858).

Ateles paniscus, abdominal cavity, Pará (Freitas, 1943, 1964; Molin, 1858; Muniz-Pereira et al., 2009; Vicente et al., 1997) (CHIOC no. 9027, 15438).

Brachyteles arachnoides, abdominal cavity, Rio de Janeiro, São Paulo (Freitas, 1943; Molin, 1858; Muniz-Pereira et al., 2009; Pinto et al., 2011).

Callicebus personatus, musculature, unspecified locality (Molin, 1858).

Cebus apella, unspecified site of infection, Mato Grosso, Minas Gerais (Molin, 1858).

Cebus capucinus, peritoneal cavity, São Paulo (NHR) (CHIOC no. 8267).

Cebus sp., abdominal cavity, Amazonas (Pinto & Gomes, 1980).

Leontopithecus rosalia, unspecified site of infection, Pará (Freitas, 1943; Molin, 1858; Muniz-Pereira et al., 2009; Notarnicola et al., 2008; Pinto et al., 2011).

Leontopithecus chrysopygus, abdominal cavity, unspecified locality (Pinto et al., 2011).

Saguinus bicolor, abdominal cavity, unspecified locality (Pinto et al., 2011).

Saimiri sciureus, unspecified site of infection, Amazonas (Molin, 1858).

Dipetalonema graciliformis Freitas, 1964

Saguinus midas, abdominal cavity, Pará (Freitas, 1964; Vicente et al., 1997) (CHIOC no. 9013, 15441 a–k – paratypes).

Saguinus mystax, abdominal cavity, Amazonas (Gonçalves et al., 2002; Pinto et al., 2011) (CHIOC no. 9965, 34010).

Saguinus niger, abdominal cavity, Pará (Freitas, 1964) (CHIOC no. 9098, 9725, 9726, 29861–29866, 15439 a–b – holotype and allotype, 15440 a–g – paratypes, 15442 – paratype).

Dipetalonema gracilis (Rudolphi, 1819)

Ateles paniscus, peritoneum, abdominal cavity, Amazonas, Minas Gerais, Goiás, Pará, São Paulo (Freitas, 1964; Muniz-Pereira et al., 2009; Vicente et al., 1997) (CHIOC no. 7089).

Brachyteles arachnoides, abdominal cavity, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009).

Callithrix jacchus, abdominal cavity, Pará (Vicente et al., 1992, 1997) (CHIOC no. 27231).

Cebus apella, abdominal cavity, Mato Grosso do Sul, Pará (Noronha, Vicente, & Pinto, 2002; Pinto et al., 2011) (CHIOC no. 9032, 29843, 29847).

Cebus capucinus, abdominal cavity, Amazonas, Goiás Mato Grosso, Mato Grosso do Sul, Minas Gerais, Pará, São Paulo (Freitas, 1964; Vicente et al., 1992, 1997) (CHIOC no. 8703, 9546, 9569).

Cebus cay, abdominal cavity, Amazonas, Pará, Goiás, Minas Gerais, São Paulo (Freitas, 1964).

Cebus libidinosus, abdominal cavity, peritoneum, Mato Grosso (Vicente et al., 1997) (CHIOC no. 11206, 11454, 11610, 15444–15445, 29843, 29845, 29847, 29849, 29856–29859).

Cebus sp., abdominal cavity, Amazonas, Goiás, Mato Grosso do Sul, Minas Gerais, Pará, Rio de Janeiro (Vicente et al., 1992, 1997) (CHIOC no. 9498, 29840–29842, 29846, 29848, 29851, 29852, 29854, 31311).

Lagothrix lagotricha, abdominal cavity, Amazonas, Goiás, Minas Gerais, Pará, São Paulo (Freitas, 1964; Muniz-Pereira et al., 2009; Vicente et al., 1997).

Leontopithecus chrysopygus, abdominal cavity, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009).

Leontopithecus rosalia, abdominal cavity, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009).

Saguinus bicolor, abdominal cavity, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009).

Saimiri sciureus, abdominal cavity, pleura, Amazonas, Goiás, Minas Gerais, Pará, Rio de Janeiro, São Paulo (Freitas, 1964; Vicente et al., 1997) (CHIOC no. 3333, 29860).

Dipetalonema sp.

Alouatta caraya, unspecified site of infection, Espírito Santo (Noronha et al., 2002; Pinto et al., 2011).

Aotus azarae, abdominal cavity, Pará (Vicente et al., 1997).

Cebus apella, unspecified site of infection, Pará, Paraná (Vicente et al., 1992, 1997).

Cebus libidinosus, unspecified site of infection, Pará, Mato Grosso do Sul (Travassos & Freitas, 1941; Vicente et al., 1992, 1997).

Saimiri sciureus, abdominal cavity, Pará (Vicente et al., 1997).

Mansonella (Tetrapetalonema) mystaxi Eberhard, 1978

Saguinus mystax, subscapularis tissue, Amazonas (Vicente et al., 1997).

Mansonella (Tetrapetalonema) zakii Nagaty, 1935

Leontopithecus rosalia, unspecified site of infection, unspecified locality (Muniz-Pereira et al., 2009; Vicente et al., 1997).

Superfamily Habronematoidea Ivaschkin, 1961.

Family Habronematidae Chitwood and Wehr, 1932.

Parabronema bonnei (van Thiel, 1925)

Alouatta caraya, stomach, Minas Gerais (Vicente et al., 1992, 1997) (CHIOC no. 21481, 27227).

Superfamily Heligmosomoidea Skrjabin and Schikobalova, 1952.

Family Viannaiidae Durette-Desset and Chabaud, 1981.

Viannella dubia (Travassos, 1921)

Alouatta caraya, small intestine, Mato Grosso, Pará (Durette-Desset, Gonçalves, & Pinto, 2006; Stuart et al., 1998; Vicente et al., 1997) (CHIOC no. 8512 a–b, 8535).

Cebus libidinosus, small intestine, Mato Grosso (Travassos, 1921) (CHIOC no. 14172).

Saimiri sciureus, small intestine, Rio de Janeiro (Travassos, 1921) (CHIOC no. 3095 – holotype and allotype, 3096–3097 – paratype, 3098–3112b, 3196, 7683).

Family Heterakidae Railliet and Henry, 1912.

Heterakis spumosa Schneider, 1866

Cebus sp., unspecified site of infection, unspecified locality (NHR) (CHIOC no. 529).

Superfamily Metastrongyloidea Lane, 1917.

Family Filaroididae Schulz, 1951.

Filariopsis barretoii (Travassos, 1921)

Callithrix jacchus, lung, Rio de Janeiro, Bahia (Rego & Schaëffer, 1988; Travassos, 1921; Vicente et al., 1992, 1997) (CHIOC no. 3143 – type series, holotype – 31038a, allotype – 31038b).

Cebus apella, lung, Espírito Santo, Mato Grosso (Noronha et al., 2002; Pinto et al., 2011) (CHIOC no. 11453, 16909).

Cebus capucinus, lung, Mato Grosso, Mato Grosso do Sul, Rio de Janeiro (Vicente et al., 1992, 1997) (CHIOC no. 6158, 8583, 10307, 32415 a–c, 32416).

Cebus libidinosus, lung, small intestine, Mato Grosso, Mato Grosso do Sul, Rio de Janeiro (Vicente et al., 1992, 1997) (CHIOC no. 6169, 11199, 11456, 13023, 15260).

Saimiri sciureus, lung, Rio de Janeiro (Rego & Schaëffer, 1988; Vicente et al., 1992, 1997) (CHIOC no. 3292, 3293, 9370).

Filariopsis gordius (Travassos, 1921)

Saimiri sciureus, lung, Pará, Rio de Janeiro (Rego & Schaëffer, 1988; Travassos, 1921; Vicente et al., 1997) (CHIOC no. 3144 – holotype and allotype, 3145–3147, 3391, 3392, 3404–3410).

Filariopsis sp.

Cebus libidinosus, unspecified site of infection, Matos Grosso do Sul (Travassos & Freitas, 1941).

Superfamily Oxyuroidea Railliet, 1916.

Family Oxyuridae Cobbold, 1864.

Trypanoxyuris (Hapaloxymuris) callithricis (Solomon, 1933)

Callithrix jacchus, intestine, Minas Gerais (Hugot, 1984; Vicente et al., 1992, 1997).

Trypanoxyuris (Hapaloxymuris) oedipi Inglis and Cosgrove, 1965

Alouatta belzebul, intestine, Piauí (NHR) (CHIOC no. 4445, 6689).

Alouatta caraya, large intestine, Mato Grosso (NHR) (CHIOC no. 4083–4088).

Alouatta guariba, unspecified site of infection, São Paulo (NHR) (CHIOC no. 1869).

Callimico goeldii, intestine, unspecified locality (Vicente et al., 1997).

Saguinus oedipus, intestine, unspecified locality (Hugot, 1984; Inglis & Cosgrove, 1965; Vicente et al., 1997).

Trypanoxyuris (Hapaloxymuris) goeldi Inglis and Cosgrove, 1965

Callimico goeldii, intestine, unspecified locality (Muniz-Pereira et al., 2009; Vicente et al., 1997).

Trypanoxyuris (Paraoxyuronema) lagothricis (Buckley, 1931)

Lagothrix cana, intestine, Amazonas (Pinto, Ferreira, Mati, & Melo, 2013).

Trypanoxyuris (Paraoxyuronema) brachytelesi (Artigas, 1936)

Brachyteles arachnoides, large intestine, São Paulo (Artigas, 1936; Hugot, Gardner, & Morand, 1996; Muniz-Pereira et al., 2009; Pinto et al., 2013; Vicente et al., 1997).

Trypanoxyuris (Trypanoxyuris) clementinae Hugot, 1985

Cebus apella, large intestine, unspecified locality (Hugot, 1985; Vicente et al., 1997).

Trypanoxyuris (Trypanoxyuris) microon (Linstow, 1907)

Aotus trivirgatus, intestine, unspecified locality (Travassos, 1925; Vicente et al., 1997)

Trypanoxyuris (Trypanoxyuris) minutus (Schneider, 1866)

Alouatta belzebul, cecum, large intestine, Pará (Muniz-Pereira et al., 2009; Vicente et al., 1992, 1997) (CHIOC no. 102, 4445, 6689, 10093).

Alouatta caraya, large intestine, Amapá, Espírito Santo, Mato Grosso, Mato Grosso do Sul (Pinto & Gomes, 1980; Stuart et al., 1998; Vicente et al., 1992, 1997) (CHIOC no. 11407, 13436, 13449, 13617–13619, 13766, 33489).

Alouatta guariba, cecum, large intestine, Espírito Santo, Rio Grande do Sul, São Paulo (Amato, Amato, Calegario-Marques, & Bicca-Marques, 2002; Muniz-Pereira et al., 2009; Noronha, Bragança, Vicente, & Muniz-Pereira, 2004; Pinto et al., 2011;

Souza, Magalhães, Vieira, & Souza-Lima, 2010; Vicente et al., 1992, 1997) (CHIOC no. 572, 29503, 35647–35649).

Alouatta seniculus, large intestine, Amapá, Espírito Santo (Stiles et al., 1929; Vicente et al., 1997).

Alouatta sp., cecum, small intestine, Minas Gerais, Rio de Janeiro (Vicente et al., 1992) (CHIOC no. 1982).

Ateles paniscus, large intestine, Amapá (Vicente et al., 1997).

Saimiri sciureus, large and small intestine, Amapá, Espírito Santo, Pará (Stuart et al., 1998; Vicente et al., 1992, 1997) (CHIOC no. 13511, 21330, 26453).

Trypanoxyuris (Trypanoxyuris) scleratus (Travassos, 1925)

Saimiri sciureus, large intestine, Rio de Janeiro (Travassos, 1925; Vicente et al., 1997) (CHIOC no. 3151, 3153, 3195, 3198, 3201, 3204, 3213, 3223, 3304, 3337, 4560, 6093. Type material not assigned).

Trypanoxyuris (Trypanoxyuris) sp.

Alouatta caraya, intestine, Mato Grosso do Sul (Vicente et al., 1992, 1997).

Saimiri sciureus, large intestine, Pará (Vicente et al., 1992, 1997).

Trypanoxyuris sp.

Saimiri sciureus, caecum, Rio de Janeiro (NHR) (CHIOC no. 8863).

Enterobius sp.

Alouatta caraya, cecum, Mato Grosso, Mato Grosso do Sul (Travassos, 1941; Vicente et al., 1997) (CHIOC no. 12889).

Ateles paniscus, large intestine, Pará (NHR) (CHIOC no. 9025–9026, 9035).

Saimiri sciureus, small intestine, Rio de Janeiro (Vicente et al., 1997) (CHIOC no. 7664).

Superfamily Physalopteroidea Leiper, 1908.

Family Physalopteridae Leiper, 1908.

Physaloptera dilatata Rudolphi, 1819

Callithrix penicillata, unspecified site of infection, Rio de Janeiro (NHR) (CHIOC no. 8321).

Chiropotes satanas, intestine, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009; Pinto et al., 2011).

Lagothrix lagotricha, stomach, unspecified locality (Muniz-Pereira et al., 2009; Vicente et al., 1997).

Leontopithecus rosalia, intestine, unspecified locality (Diesing, 1851; Muniz-Pereira et al., 2009; Pinto et al., 2011; Rudolphi, 1819).

Physaloptera sp.

Cacajao calvus, stomach, Amazonas (Muniz-Pereira et al., 2009; Vicente et al., 1992, 1997).

Cebus apella, stomach, Mato Grosso, Mato Grosso do Sul, Pará (Vicente et al., 1992, 1997) (CHIOC no. 9033, 11455, 13024, 13030, 14997, 18062, 18078).

Cebus capucinus, stomach, Mato Grosso, Mato Grosso do Sul (Vicente et al., 1992, 1997) (CHIOC no. 9437, 9438, 9440, 9441, 9495).

Cebus libidinosus, stomach, Mato Grosso, Mato Grosso do Sul (Travassos & Freitas, 1941; Vicente et al., 1992, 1997) (CHIOC no. 11198).

Cebus sp., stomach, Amazonas (Pinto & Gomes, 1980; Vicente et al., 1992, 1997) (CHIOC no. 9402, 31432).

Lagothrix lagotricha, unspecified site of infection, Pará (Muniz-Pereira et al., 2009; Vicente et al., 1992, 1997).

Leontopithecus rosalia, stomach, Rio de Janeiro (Muniz-Pereira et al., 2009; Vicente et al., 1992, 1997) (CHIOC no. 13600).

Saguinus mystax, unspecified site of infection, unspecified locality (Vicente et al., 1997).

Superfamily Rhabditoidea Travassos, 1920.

Family Strongyloididae Chitwood and McIntosh, 1934.

Strongyloides cebus Darling, 1911

Lagothrix cana, small intestine, Amazonas (Mati, Junior, Pinto, & Melo, 2013).

Superfamily Spiruroidea Railliet and Henry, 1915.

Family Spiruridae Oerley, 1885.

Spirura delicata Vicente, Pinto and Faria, 1992

Saguinus mystax, mucosa of oesophagus, Amazonas (Vicente et al., 1992, 1997) (CHIOC no. 34289).

Spirura tamarini Coosgrove, Nelson and Jones, 1963.

Saguinus nigricollis, esophageal mucosa, Amazonas (Vicente et al., 1997).

Superfamily Subuluroidea Yorke and Maplestone, 1926.

Family Subuluridae (Travassos, 1914).

Primasubulura distans (Rudolphi, 1819)

Saguinus bicolor, intestine, Amazonas (Diesing, 1851; Muniz-Pereira et al., 2009; Vicente et al., 1997).

Callicebus caligatus, intestine, unspecified locality (Vicente et al., 1997).

Mico chrysoleucus, intestine, unspecified locality (Vicente et al., 1997).

Callithrix jacchus, large intestine, Minas Gerais, Rio de Janeiro (Vicente et al., 1992, 1997) (CHIOC no. 337, 342).

Mico melanurus, unspecified site of infection, unspecified locality (Vicente et al., 1997).

Saguinus bicolor, intestine, unspecified locality (Vicente et al., 1997).

Saguinus mystax, intestine, unspecified locality (Vicente et al., 1997).

Primasubulura jacchi (Marcel, 1857)

Callithrix aurita, small intestine, Minas Gerais (Muniz-Pereira et al., 2009; Pinto, 1970; Pinto & Noronha, 1972; Vicente et al., 1992, 1997) (CHIOC no. 30520 a–m).

Callithrix jacchus, large intestine, Bahia, Minas Gerais, Rio de Janeiro (Vicente et al., 1992, 1997) (CHIOC no. 530–533, 758, 1099–1108, 6758, 9165, 18030, 18077, 19827).

Mico melanurus, large and small intestine, Mato Grosso, Mato Grosso do Sul, Minas Gerais (Pinto & Noronha, 1972; Vicente et al., 1992, 1997) (CHIOC no. 20559, 20560).

Callithrix penicillata, large and small intestine, Minas Gerais, Rio de Janeiro (Vicente et al., 1992, 1997; Resende et al., 1994) (CHIOC no. 5666, 7129, 30521).

Callithrix sp., intestine, Minas Gerais (NHR) (CHIOC no. 757).

Subulura sp.

Callithrix jacchus, intestine, Rio de Janeiro (NHR) (CHIOC no. 13663).

Cebus libidinosus, intestine, unspecified locality (Vicente et al., 1992, 1997).

Cebus apella, intestine, unspecified locality (Vicente et al., 1992, 1997).

Superfamily Thelazioidea Railliet, 1910.

Family Thelaziidae Skrjabin.

Trichospirura leptostoma Smith and Chitwood, 1967

Callithrix jacchus, pancreatic ducts, Rio de Janeiro (Vicente et al., 1997).

Callithrix penicillata, pancreatic ducts, Minas Gerais (Resende et al., 1994; Vicente et al., 1997).

Superfamily Trichostrongyloidea Cram, 1927.

Family Molineidae Skrjabin and Schulz, 1937.

Molineus elegans Travassos, 1921

Saimiri sciureus, small intestine, Pará, Rio de Janeiro (Travassos, 1921, 1937; Vicente et al., 1997) (CHIOC no. 3083 – holotype and allotype, 3084–3094, 3112, 3289–3291, 7659, 7682, 9850).

Molineus sp.

Cebus libidinosus, unspecified site of infection, Matos Grosso do Sul (Vicente et al., 1997).

Molineus torulosus (Molin, 1861)

Cebus apella, nodules in the small intestine, Amazonas, Espírito Santo, Mato Grosso (Travassos, 1937; Vicente et al., 1992, 1997) (CHIOC no. 17688, 32414, 33491).

Cebus capucinus, small intestine, Mato Grosso, Mato Grosso do Sul, Rio de Janeiro (Molin, 1861; Rego & Schaeffer, 1987;

Travassos, 1937; Vicente et al., 1992, 1997) (CHIOC no. 7895–7906, 8005, 8015, 8037, 9755).

Cebus libidinosus, nodules in the small intestine, Espírito Santo, Mato Grosso, Mato Grosso do Sul, Rio de Janeiro (Travassos & Freitas, 1941; Vicente et al., 1992, 1997) (CHIOC no. 5980, 11205, 11449, 11452, 11457, 14136–14138, 14158–14160, 14176, 14388, 15177–15180, 15903, 15196, 17670).

Saimiri sciureus, small intestine, Pará, Rio de Janeiro (Vicente et al., 1992) (CHIOC no. 3207, 3209, 3212, 3218, 3225, 3330, 3332, 3336, 3338, 3393, 3394).

Cebus sp., small intestine, Amazonas (Pinto & Gomes, 1980; Vicente et al., 1992, 1997).

Phylum Platyhelminthes Gegenbaur, 1859.

Class Cestoda Van Beneden, 1849.

Order Cyclophyllidea Van Beneden in Braun, 1900.

Family Anoplocephalidae Choldkovsky, 1902.

Mathevotaenia megastoma (Diesing, 1850)

Alouatta belzebul, small intestine, Paraná (Diesing, 1850, 1856; Muniz-Pereira et al., 2009; Stiles et al., 1929; Stuart et al., 1998; Travassos, 1965).

Alouatta caraya, small intestine, unspecified locality (Diesing, 1850, 1856; Dunn, 1963; Stiles et al., 1929; Stuart et al., 1998; Travassos, 1965).

Brachyteles arachnoides, small intestine, Rio de Janeiro (Diesing, 1850, 1856; Muniz-Pereira et al., 2009; Travassos, 1965).

Callicebus caligatus, small intestine, unspecified locality (Diesing, 1856; Travassos, 1965).

Callicebus torquatus, unspecified site of infection, unspecified locality (Travassos, 1965).

Callicebus personatus, small intestine, unspecified locality (Diesing, 1850, 1856).

Cebus apella, small intestine, unspecified locality (Diesing, 1850, 1856).

Cebus capucinus, unspecified site of infection, unspecified locality (Travassos, 1965).

Cebus nigritus, unspecified site of infection, unspecified locality (Travassos, 1965).

Mico melanurus, small intestine, unspecified locality (Diesing, 1850, 1856; Travassos, 1965).

Saguinus bicolor, small intestine, Amazonas (Diesing, 1850, 1856; Muniz-Pereira et al., 2009; Travassos, 1965).

Saguinus midas, unspecified site of infection, unspecified locality (Travassos, 1965).

Moniezia rugosa (Diesing, 1850)

Alouatta caraya, unspecified site of infection, unspecified locality (Travassos, 1965).

Brachyteles arachnoides, unspecified site of infection, unspecified locality (Muniz-Pereira et al., 2009; Travassos, 1965).

Brachyteles hypoxanthus, small intestine, unspecified locality (Diesing, 1850; Muniz-Pereira et al., 2009).

Cebus capucinus, unspecified site of infection, unspecified locality (Travassos, 1965).

Family Davaineidae Braun, 1900.

Raillietina (Raillietina) alouattae Baylis, 1947

Alouatta caraya, small intestine, Amapá, Amazonas (Pinto & Gomes, 1976) (CHIOC no. 30781 a–e).

Alouatta seniculus, unspecified site of infection, unspecified locality (Travassos, 1965).

Family Hymenolepididae Ariola, 1899.

Hymenolepis cebidarum Baer, 1927

Callicebus nigrifrons, unspecified site of infection, unspecified locality (Schmidt, 1986; Travassos, 1965).

Class Trematoda Rudolphi, 1808.

Order Digenea Van Beneden, 1858.

Family Dicrocoeliidae Odhner, 1911.

Athesmia heterolecithodes (Braun, 1899)

Cebus apella, bile duct, unspecified locality (Travassos et al., 1969).

Cebus capucinus, bile duct, unspecified locality (Travassos et al., 1969).

Chiropotes albinasus, bile duct, liver, Pará (Travassos et al., 1969) (CHIOC no. 21015, 21019, 26968 a–d).

Conspicuum conspicuum (Faria, 1912)

Callimico goeldii, bile vesicle, unspecified locality (Muniz-Pereira et al., 2009; Travassos et al., 1969).

Saguinus nigricollis, bile vesicle, unspecified locality (Travassos et al., 1969).

Controrchis biliophilus Price, 1928

Alouatta caraya, bile vesicle, Amapá (NHR) (CHIOC no. 30811 a–h).

Alouatta seniculus, unspecified site of infection, unspecified locality (Gomes & Pinto, 1978; Stuart et al., 1998).

Family Diplostomidae Poirier, 1886.

Neodiplostomum tamarini Dubois, 1966

Saguinus nigricollis, small intestine, unspecified locality (Travassos et al., 1969).

Family Phanerosolidae Mehra, 1935.

Phaneropsolus orbicularis (Diesing, 1850)

Aotus trivirgatus, small intestine, unspecified locality (Diesing, 1850; Travassos et al., 1969).

Incertae sedis

Amphistoma emarginatum Diesing, 1839

Aotus trivirgatus, intestine, unspecified locality (Diesing, 1850; Travassos et al., 1969).

Host–parasite list

Order Primates Linnaeus, 1758.

Family Aotidae Elliot, 1913.

Aotus azarae (Humboldt, 1811): *Dipetalonema* sp.

Aotus trivirgatus (Humboldt, 1811): *Amphistoma emarginatum*, *Phaneropsolus orbicularis*, *Trypanoxyuris* (*Trypanoxyuris*) *microon*.

Family Atelidae Grey, 1825

Alouatta belzebul (Linnaeus, 1766): *Ascaris elongata*, *Mathevotaenia megastoma*, *Trypanoxyuris* (*Hapaloxyuris*) *oedipi* (NHR), *T. (Trypanoxyuris) minutus*.

Alouatta caraya (Humboldt, 1812): *Controrchis biliophilus* (NHR), *Dipetalonema* sp., *Enterobius* sp., *Mathevotaenia megastoma*, *Moniezia rugosa*, *Parabronema bonnei*, *Raillietina (Raillietina) alouattae*, *Trypanoxyuris* (*Hapaloxyuris*) *oedipi* (NHR), *T. (Trypanoxyuris) minutus*, *T. (Trypanoxyuris)* sp., *Viannella dubia*.

Alouatta guariba (Humboldt, 1812): *Dipetalonema caudispina*, *Dipetalonema* sp., *Trypanoxyuris* (*Hapaloxyuris*) *oedipi* (NHR), *T. (Trypanoxyuris) minutus*.

Alouatta seniculus (Linnaeus): *Controrchis biliophilus*, *Raillietina (Raillietina) multitesticulata*, *Trypanoxyuris* (*Trypanoxyuris*) *minutus*, *Viannella dubia*.

Alouatta sp.: *Trypanoxyuris* (*Trypanoxyuris*) *minutus*.

Ateles paniscus (Linnaeus, 1766): *Dipetalonema caudispina*, *D. gracilis*, *Enterobius* sp. (NHR), *Trypanoxyuris* (*Trypanoxyuris*) *minutus*.

Brachyteles arachnoides (É. Geoffroy, 1806): *Dipetalonema caudispina*, *D. gracilis*, *Mathevotaenia megastoma*, *Moniezia rugosa*, *Trypanoxyuris* (*Paraoxyuronema*) *brachytelesi*.

Brachyteles hypoxanthus (Kuhl, 1820): *Moniezia rugosa*.

Lagothrix cana (É. Geoffroy, 1812): *Strongyloides cebus*, *Trypanoxyuris* (*Paraoxyuronema*) *lagothricis*.

Lagothrix lagothricha (Humboldt, 1812): *Dipetalonema gracilis*, *Necator* sp., *Physaloptera* sp.

Family Callithricidae Thomas, 1903.

Callimico goeldii (Thomas, 1904): *Conspicuum conspicuum*, *Trypanoxyuris* (*Hapaloxyuris*) *oedipi*.

Callithrix aurita (É. Geoffroy, 1812): *Primasubulura jacchi*.

Callithrix geoffroyi (Humboldt, 1812): *Oncicola juxtatesticularis*, *Pachysentis lenti*.

Callithrix jacchus (Linnaeus, 1758): *Dipetalonema gracilis*, *Filariopsis barreto*, *Oncicola sigmoides*, *Primasubulura distans*, *P. jacchi*, *Subulura* sp. (NHR), *Trichospirura leptostoma*, *Trypanoxyuris* (*Hapaloxyuris*) *callithricis*, *T. (Hapaloxyuris)* sp.

Callithrix penicillata (É. Geoffroy, 1812): *Conspicuum conspicuum*, *Physaloptera dilatata* (NHR), *Primasubulura jacchi*, *Trichospirura leptostoma*.

Callithrix sp.: *Primasubulura jacchi* (NHR).

Leontopithecus chrysomelas (Kuhl, 1820): *Prosthenorchis elegans*.

Leontopithecus chrysopygus (Mikan, 1823): *Dipetalonema caudispina*, *D. gracilis*, *Prosthenorchis elegans*.

Leontopithecus rosalia (Linnaeus, 1766): *Dipetalonema caudispina*, *D. gracilis*, *Mansonella* (*Tetrapetalonema*) *zakii*, *Oncicola spirula*, *Physaloptera dilatata*, *Physaloptera* sp., *Prosthenorchis elegans*.

Leontopithecus sp.: *Oncicola sigmoides*, *O. spirula*.

Mico chrysoleucus (Wagner, 1842): *Primasubulura distans*, *Prosthenorchis elegans*.

Mico melanurus (É. Geoffroy in Humboldt, 1812): *Mathevotaenia megastoma*, *Primasubulura distans*, *P. jacchi*.

Saguinus bicolor (Spix, 1823): *Dipetalonema caudispina*, *D. gracilis*, *Mathevotaenia megastoma*, *Primasubulura distans*.

Saguinus midas (Linnaeus, 1758): *Dipetalonema graciliformis*, *Mathevotaenia megastoma*.

Saguinus mystax (Spix): *Dipetalonema graciliformis*, *Mansonella* (*Tetrapetalonema*) *mystaxi*, *Physaloptera* sp., *Primasubulura distans*, *Spirura delicata*.

Saguinus niger (É. Geoffroy): *Dipetalonema graciliformis*, *Oncicola sigmoides* (NHR), *Pachysentis septemserialis*, *Prosthenorchis elegans*.

Saguinus nigricollis (Spix, 1823): *Conspicuum conspicuum*, *Neodiplostomum tamarini*, *Spirura tamarini*.

Saguinus oedipus (Linnaeus, 1758): *Trypanoxyuris* (*Hapaloxuris*) *oedipi*.

Saguinus sp.: *Oncicola sigmoides*.

Family Cebidae Bonaparte, 1831.

Cebus apella (Linnaeus, 1758): *Athesmia heterolecithodes*, *Dipetalonema gracilis*, *D. caudispina*, *Dipetalonema* sp., *Filariopsis barreto*, *Mathevotaenia megastoma*, *Molineus torulosus*, *Oncicola machadoi*, *Pachysentis rugosus*, *Physaloptera* sp., *Prosthenorchis* sp., *Trypanoxyuris* (*Trypanoxyuris*) *clementinae*.

Cebus capucinus (Linnaeus, 1758): *Athesmia heterolecithodes*, *Dipetalonema caudispina* (NHR), *D. gracilis*, *Filariopsis barreto*, *Mathevotaenia megastoma*, *Molineus torulosus*, *Moniezia rugosa*, *Physaloptera* sp.

Cebus cay Illiger, 1815: *Dipetalonema gracilis*, *Pachysentis rugosus*.

Cebus libidinosus Spix, 1823: *Dipetalonema gracilis*, *Dipetalonema* sp., *Filariopsis barreto*, *Filariopsis* sp., *Molineus* sp., *Molineus torulosus*, *Physaloptera* sp., *Subulura* sp., *Viannella dubia*.

Cebus nigritus (Goldfuss, 1809): *Mathevotaenia megastoma*.

Cebus sp.: *Dipetalonema caudispina*, *D. gracilis*, *Heterakis spumosa* (NHR), *Molineus torulosus*, *Oncicola confusus*, *O. freitasi*, *O. spirula* (NHR), *Physaloptera* sp.

Saimiri sciureus (Linnaeus, 1758): *Dipetalonema gracilis*, *D. caudispina*, *Dipetalonema* sp., *Enterobius* sp., *Filariopsis barreto*, *F. gordius*, *Molineus elegans*, *Molineus torulosus*, *Oncicola sigmoides* (NHR), *O. spirula* (NHR), *Prosthenorchis elegans*, *Trypanoxyuris* (*Trypanoxyuris*) *minutus*, *T. (T.) scleratus*, *Trypanoxyuris* (*Trypanoxyuris*) sp., *Trypanoxyuris* sp. (NHR), *Viannella dubia*.

Saimiri sp.: *Oncicola sigmoides*, *Trypanoxyuris* (*Trypanoxyuris*) *minutus*.

Family Pitheciidae Mivart, 1865.

Cacajao calvus (I. Geoffroy, 1847): *Ancylostoma braziliense* (NHR), *Monodontus* sp., *Necator* sp., *Physaloptera* sp.

Callicebus caligatus (Wagner, 1842): *Mathevotaenia megastoma*, *Primasubulura distans*.

Callicebus nigrifrons (Spix, 1823): *Hymenolepis semidarum*.

Callicebus personatus (É. Geoffroy, 1812): *Dipetalonema caudispina*, *Mathevotaenia megastoma*.

Callicebus torquatus (Hoffmannsegg, 1807): *Mathevotaenia megastoma*.

Chiropotes albinus (I. Geoffroy and Deville, 1848): *Athesmia heterolecithodes*.

Chiropotes satanas (Hoffmannsegg, 1807): *Physaloptera dilatata*.

Discussion

The first descriptions of helminth parasites of Brazilian primates are from the study by Rudolphi (1819), with helminth samples collected by the German naturalist Ignaz von Olfers and the Austrian naturalist Johann Natterer. Rudolphi (1819) described 3 species of helminths for this host group. The acantocephalan *Oncicola spirula* (Olfers in Rudolphi, 1819) (*Oligacanthorhynchida*, *Oligacanthorhynchidae*) (= *Echinorhynchus spirula* Olfers in Rudolphi, 1819) was described as a parasite of small intestine of the Golden Lion Tamarin *Leontopithecus rosalia* (Linnaeus) (*Callitrichidae*) (= *Simia rosalia* Linnaeus) by Olfers (in Rudolphi, 1819); and the nematodes *Ascaris elongata* Rudolphi (1819) (*Ascaridoidea*, *Ascarididae*) that have as type host the Red-handed Howling Monkey *Alouatta belzebul* (Linnaeus) (*Atelidae*) (= *Simia belzebul* Linnaeus), collected by Olfers, and *Physaloptera dilatata* Rudolphi, 1819 collected in *L. rosalia* by J. Natterer (Rudolphi, 1819).

The literature on helminth parasites of Brazilian primates is fragmented, since many studies are only of a regional scope, or restricted to a particular host species, or pertain to studies with outdated data (Diesing, 1850, 1851; Molin, 1858; Muniz-Pereira et al., 2009; Pinto et al., 2011; Rudolphi, 1819; Stuart et al., 1998; Travassos, 1965; Travassos et al., 1969; Vicente et al., 1992, 1997). Until this current study, the most recent compilation with unique data for Brazilian primates was the study of Vicente et al. (1992), which recorded 9 determined and 4 undetermined species of nematodes, parasitizing 20 species of primates, distributed in 121 helminth samples deposited in CHIOC, between 1910 and 1970. The data on nematodes from wild primates from Brazil included herein, documents 29 determined species of nematodes, distributed among 32 host species, which demonstrates an increase of 3 times the number of nematodes for this host group in Brazil during the last 45 years.

Currently 118 species of wild primates were reported in Brazil (Paglia et al., 2012; Reis et al., 2011), of these 39 are included in the IUCN Red List (2016). In this study, a total of 46 species of primates has at least 1 species of helminth

recorded, which represents approximately 39% of species of primates present in Brazil. Additionally, we verified that 16 species of these primates (*Alouatta belzebul*, *Ateles paniscus*, *Brachyteles arachnoides*, *B. hypoxanthus*, *Cacajao calvus*, *Callimico goeldii*, *Callithrix aurita*, *Chiropotes albinasus*, *C. satanas*, *Lagothrix cana*, *L. lagotricha*, *Leontopithecus chrysomelas*, *L. chrysopygus*, *L. rosalia*, *Saguinus bicolor*, *S. niger*) which represent approximately 34.8% of Brazilian species are included in the IUCN Red List (2016), and all with reports of helminth parasites in this current study.

Due to the fact that most of the species of Brazilian primates (61%) do not have records of any helminth species, we can conclude that the helminth fauna of wild primates in Brazil is obviously underestimated, and requires additional efforts in order to fill this gap on helminthological biodiversity, as well as a better estimation of parasite infection.

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