

## SURVEY OF HELMINTHS IN SMALL MAMMALS ALONG THE AQUEDUCT OF THE SÃO FRANCISCO RIVER IN THE CAATINGA BIOME

Raquel de Oliveira Simões<sup>1\*</sup>, Juberlan Silva Garcia<sup>1</sup>, Sócrates Fraga da Costa-Neto<sup>1,2</sup>,  
Michele Maria dos Santos<sup>1</sup>, Marta Júlia Faro<sup>1</sup> & Arnaldo Maldonado Júnior<sup>1</sup>

<sup>1</sup> Fundação Oswaldo Cruz (FIOCRUZ), Instituto Oswaldo Cruz, Laboratório de Biologia e Parasitologia de Mamíferos Silvestres Reservatórios, Avenida Brasil, 4365, Mangueiras, RJ, Brazil. CEP: 21045-900

<sup>2</sup> Programa de Pós-Graduação em Biodiversidade e Saúde, Instituto Oswaldo Cruz, Fundação Oswaldo Cruz, Av. Brasil 4265, Rio de Janeiro, RJ, Brazil. CEP: 21040-360

E-mails: raquel83vet@gmail.com, garciajsg@gmail.com, socratesfneto@yahoo.com.br, mms.ioc.fiocruz@gmail.com, mlfaro@ioc.fiocruz.br, maldonad@gmail.com

### ABSTRACT

The impact of the São Francisco River Transposition on the helminth community of small mammals is unknown so far, particularly the existence of helminths of zoonotic origin. Therefore, the aim of the present study was to report the helminth fauna of small mammals in areas along the aqueduct of the São Francisco River in the Caatinga biome. Twenty-one small mammals were collected among seven species: *Thrichomys laurentius* (10), *Necromys lasiurus* (5), *Cerradomys langguthi* (1), *Galea spixii* (1), *Rattus rattus* (1), *Oligoryzomys stramineus* (1) and *Didelphis albiventris* (2). Five helminth species were identified: *Heligmostrongylus tcheprakovae*, *Heligmostrongylus interrogans*, *Stilestrongylus freitasi*, *Syphacia alata* and *Viannaia viannai*. Among these, four species had their geographical distribution map expanded with this study. There was no evidence of zoonotic helminths in any of the animals examined. Thus, the present study contributes to increase the knowledge of the helminth fauna in small mammals in the Caatinga biome.

**Keywords:** helminth fauna; marsupials; rodents.

Small mammals can be considered good indicators of environmental change (Olifiers *et al.* 2005) and can be reservoirs of some parasites that are important to public health such as *Trypanosoma cruzi* and *Schistosoma mansoni* (D'Andrea *et al.* 2000, Vaz *et al.* 2007). Nevertheless, ecological studies of helminths and their small mammal hosts are scarce in Brazilian biomes. Simões *et al.* (2010) evaluated the effects of land use and seasonal events on the helminth community structure of the caviomorph *Thrichomys fosteri* in the Pantanal biome. Furthermore, Simões *et al.* (2011, 2012) and Cardoso *et al.* (2016) characterized the helminth community structure, the biomass, as well as the influence of habitat fragmentation on three Sigmodontinae rodents (*Akodon cursor*, *A. montensis* and *Oligoryzomys nigripes*) in the Atlantic Forest of Rio de Janeiro State. However, there is no survey evaluating the characteristics of the helminth communities in small mammals from the Caatinga biome, only taxonomic records are reported (Vicente *et al.* 1997).

Twenty-five millions of Brazilians reside in the

Caatinga biome, where the climate is semiarid and only 3% of surface water is available for domestic use and irrigation. The São Francisco River contains 70% of the water resources available in this region, but it covers only part of the Brazilian semi-arid in the northeast region (Ministério da Integração Nacional 2014). The impact of the São Francisco River transposition on the helminth community of small mammals is unknown so far, particularly the existence of helminths of zoonotic origin, such as *Schistosoma mansoni*, which is the etiological agent of the mansonic schistosomiasis. For further information concerning São Francisco River transposition, see Ministério da Integração Nacional (2014).

Therefore, the aim of the present study was to report the helminth fauna of small mammals in areas along the aqueduct of the São Francisco River in the Caatinga biome, investigating the occurrence of potential zoonotic species.

The study was conducted in the municipalities of Terra Nova (8°14'43"S, 39°22'21"W) and Cabrobó (8°32'44"S, 39°27'22"W) in the State of Pernambuco

(PE), Brejo Santo (7°36'33"S, 38°53'12"W) and Jati (7°41'34"S, 38°59'44"W) in the State of Ceará (CE), Sousa (6°50'22"S, 38°17'39"W) in the State of Paraíba (PB), and Caicó (6°27'50"S, 37°8'32"W) in the State of Rio Grande do Norte (RN) (Figure 1). A small mammal capture session was conducted in January 2011 in PE, and CE and in September 2011 in PB and RN. Each capture session lasted four consecutive nights. We established three transects spaced approximately 500m apart with 15 trapping stations in native vegetation located approximately 200m from the São Francisco aqueduct. A trapping station was established every 5m and included both a Tomahawk trap (Model 201, 16 in x 5 in x 5 in, Wisconsin, USA) and a Sherman trap (Model XLK, 3 in x 3.75 in x 12 in, Florida, USA). The capture effort was of 180 traps on each capture night, totalizing 720 traps-nights during



**Figure 1.** Map showing the studied areas. ⊙ Capital of Brazilian States, ● Municipalities sampled.

The captured animals were transported to a field laboratory where they were sexed, weighed and necropsied. All animal procedures followed the guidelines for capture, handling and care of mammals of the American Society of Mammalogists (Sikes *et al.* 2011). The collection license was obtained from the Chico Mendes Institute for Biodiversity and Conservation (License Number: 24353-1). Biosafety techniques were used during all procedures involving

biological samples (Lemos & D'Andrea 2014).

The stomach as well as the small and large intestines of each animal were examined under a stereomicroscope for the presence of helminths. Animals were submitted to portal perfusion with the aim of recovering any helminths from the circulatory system. All helminths recovered were washed twice in saline to remove tissue debris and fixed in AFA (2% acetic acid, 3% formaldehyde and 95% ethanol). Nematodes were cleared in lactophenol (40% lactophenol, 20% lactic acid and 20% phenol in 100mL of q.s.p water) (Amato *et al.*, 1991). Helminths were identified according to Vicente *et al.* (1997) and Anderson *et al.* (1978). Prevalence, mean intensity of infection and mean abundance of each helminth species were calculated according to Bush *et al.* (1997).

Nineteen rodents were captured along the aqueduct of the São Francisco River. Two individuals of *Thrichomys laurentius* Thomas, 1904 (Rodentia, Echimyidae) were captured in PB, three in RN, four in PE, and one in CE. Five individuals of *Necomys lasiurus* (Lund, 1840) (Rodentia, Cricetidae) and one of *Cerradomys langguthi* Percequillo, Hingst-Zaher & Bonvicino, 2008 (Rodentia, Cricetidae) were captured in PB. One individual of *Galea spixii* (Wagler, 1831) (Rodentia, Caviidae) was captured in RN, and one of *Rattus rattus* Linnaeus, 1758 (Rodentia, Muridae) and one of *Oligoryzomys stramineus* Bonvicino & Weksler, 1998 (Rodentia, Cricetidae) in PE. Two individuals of the marsupial *Didelphis albiventris* Lund, 1840 (Didelphimorpha, Didelphidae) were captured, one in PE and one CE.

Two hundred and twenty-one helminths were recovered from the small mammals. The rodent *T. laurentius* was infected with *Heligmostrongylus tcheprakovae* (Durette-Desset & Tcheprakoff, 1969) Durette-Desset, 1971 (Nematoda, Heligmonellidae), *Heligmostrongylus interrogans* (Lent & Freitas, 1938) Durette-Desset & Chabaud, 1981 (Nematoda, Heligmonellidae) and *Stilestrongylus freitasi* Durette-Desset, 1968 (Nematoda, Trichostrongylidae) in the small intestine, and with *Helminthoxyx freitasi* Quentin, 1969 (Nematoda, Oxyuridae) in the large intestine, totalizing 148 helminths (Table 1). *Necomys lasiurus*, in turn, was parasitized with *S. freitasi* in the small intestine and *Syphacia alata* Quentin, 1968 (Nematoda:

Oxyuridae) in the large intestine, amounting 66 nematodes (Table 1). The marsupial *D. albiventris* was infected with seven specimens of *Viannaia viannai* Travassos, 1914 (Nematoda, Viannaiidae) in the small intestine (Table 1). There was no evidence of zoonotic helminths in any animal examined.

The nematode *Heligmostrongylus interrogans* have been described infecting the small intestine of *Trichomys laurentius* in PE and *T. inermis* in Bahia, both States in the Caatinga biome. More recently, this nematode have been reported infecting *T. pachyurus* from the Pantanal biome in Mato Grosso do Sul State (Simões et al. 2010). In the present study, *H. interrogans* was found in *T. laurentius* in PB, expanding its geographical distribution. Likewise, *H. tcheprakovae* (Durrete-Desset & Tcheprakoff, 1969) Durrete-Desset, 1971 (Nematoda: Heligmonellidae) was previously reported parasitizing *T. laurentius* in PE (Vicente et al. 1997), and now in PB.

The species *Stilestrongylus freitasi* have been previously reported parasitizing *Euryoryzomys lamia* in Rio de Janeiro State, *N. lasiurus* in PE and *Cerradomys subflavus* in Cerrado areas in Goiás State (Vicente et al. 1997). In the present study, the occurrence of *S. freitasi* in the hosts *T. laurentius* and *N. lasiurus* in PB also represents an expansion on the geographic distribution of this species, and it is

the first record of this nematode in a rodent of the family Echimyidae.

Oxyurids of the genus *Syphacia* are known to infect rodents of the Cricetidae family (Hugot & Quentin 1985). For instance, *Syphacia alata* has been described in Brazil infecting *N. lasiurus* and *Oligoryzomys nigripes* in PE. Here we report, for the first time, the presence of this nematode species parasitizing *N. lasiurus* in PB, thereby expanding its geographical distribution.

The nematode *Viannaia viannai* was already reported infecting *D. aurita* and *D. albiventris* in Rio de Janeiro and Pernambuco States in Brazil, respectively (Vicente et al. 1997). In addition, this helminth has been found in the marsupials *D. marsupialis*, *D. virginiana* and *Philander opossum* in Mexico (Acosta-Virgen et al. 2015) and in French Guiana (Jiménez et al. 2011), showing a large geographical distribution of this parasite.

The rodents *C. langguthi*, *G. spixii*, *O. stramineus* and *R. rattus* were negative for helminths (Table 1). The diversity of small mammals is relatively low in the Caatinga biome when compared with other biomes (Carmignotto et al. 2012). In general, a low abundance and richness of small mammals was observed, and the same was verified for the helminths.

**Table 1.** Prevalence (95% confidence intervals), mean intensity (MI), and mean abundance (MA) ( $\pm$ standard deviation) of intestinal helminths in small mammals captured along the aqueduct of the São Francisco River in the Caatinga biome. N= sample size

Helminth species	Host								
	<i>Trichomys laurentius</i> (N=10)			<i>Necromys lasiurus</i> (N=5)			<i>Didelphis albiventris</i> (N=2)		
	P (%)	MI	MA	P (%)	MI	MA	P (%)	MI	MA
<i>Heligmostrongylus tcheprakovae</i>	50 (0.23-0.76)	24.8 $\pm$ 33.4	12.4 $\pm$ 25.7	0	0	0	0	0	0
<i>Heligmostrongylus interrogans</i>	10 (0.0001-0.43)	14	1.4 $\pm$ 4.4	0	0	0	0	0	0
<i>Stilestrongylus freitasi</i>	10 (0.0001-0.43)	1	0.1 $\pm$ 0.3	80 (0.35-0.97)	5.5 $\pm$ 7.7	4.4 $\pm$ 7.1	0	0	0
<i>Helminthoxys freitasi</i>	30 (0.05-0.52)	4 $\pm$ 3.5	1.2 $\pm$ 2.2	0	0	0	0	0	0
<i>Syphacia alata</i>	0	0	0	80 (0.35-0.97)	11 $\pm$ 14.2	8.8 $\pm$ 13.3	0	0	0
<i>Viannaia viannai</i>	0	0	0	0	0	0	50 (0.09-0.91)	7	7 $\pm$ 4.9

The rodent *T. laurentius* presented the highest helminth richness, with four species (Table 1). Similarly to what was observed by Simões *et al.* (2010) for *T. fosteri* in two Brazilian Pantanal locations, the nematode *H. tcheprakovae* was more prevalent than *H. interrogans*. In contrast, in the present study we did not observe trematodes or cestodes. Several beetles belonging to the order Coleoptera can act as intermediate hosts for cestodes (Rego 1972), and the occurrence of these parasites may be related to the abundance of their intermediate hosts (Abu-Madi *et al.* 2000). In a study of a beetle community in the Caatinga biome, Liberal *et al.* (2011) pointed out that the seasonal variation in this biome affects the abundance of the dung beetles. Thus, we suggest that the abundance of the intermediate hosts of this group of parasites in the studied areas may be scarce during the study period, resulting in the absence of cestodes recovered.

There was no evidence of zoonotic helminths in any of the animals examined. Nevertheless, because of the low number of small mammals captured, this finding does not allow discarding the potential occurrence of helminths of medical importance in rodents in the Caatinga biome.

The present study contributed to the expansion of the geographical distribution map of four nematode species (*H. interrogans*, *H. tcheprakovae*, *S. freitasi* and *S. alata*), to the increase of the host spectrum of *S. freitasi* and to the knowledge of the helminth fauna in small mammals in the Caatinga biome. Although a small number of helminth species was recovered from a relatively low number of small mammals, this report highlights the lack of information regarding helminth species in the Caatinga biome and the need for additional studies in this region.

## ACKNOWLEDGMENTS

We would like to thank the secretaries of Health of the municipalities of Terra Nova and Cabrobó in Pernambuco, Sousa in Paraíba, Caicó in Rio Grande do Norte and Brejo Santo and Jati in Ceará for making providing local facilities for the field laboratory and for helping in the field work. We are also grateful to Oswaldo Cruz Institute/Fiocruz and to the Ministry of National Integration. This project received financial support from the National Health Fund - Ministry of Health (grant 3371.0550001/09-073).

## REFERENCES

- Abu-Madi, M. A., Behnke, J. M., Lewis, J. W., & Gilbert, F. S. 2000. Seasonal and site specific variation in the component community structure of intestinal helminths in *Apodemus sylvaticus* from three contrasting habitats in south-east England. *Journal of Helminthology*, 74(1), 7-15. DOI: 10.1017/S0022149X00000020
- Acosta-Virgen, K., López-Caballero, J., García-Prieto, L., & Mata-López, R. 2015. Helminths of three species of opossums (Mammalia, Didelphidae) from Mexico. *ZooKeys*, 511, 131-152. DOI: 10.3897/zookeys.511.9571
- Amato, J. F. R., Boeger, W. A., & Amato, S. B. (Eds.). 1991. *Protocolo para Laboratório -Coleta e Processamento de Parasitas do Pescado*. Rio de Janeiro: Imprensa Universitária, UFRJ: p. 81.
- Anderson, R. C., Chabaud, A. G., & Willmott, S. (Eds.). 1978. *CIH Keys to nematode parasites of vertebrates*. Farnham Royal: Commonwealth Agricultural Bureaux: p. 463.
- Bush, A. O., Lafferty, K. D., Lotz, J. M., & Shostak, A. W. 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *Journal of Parasitology*, 83(4), 575-583. DOI: 10.2307/3284227
- Cardoso, T. S., Simões, R. O., Luque, J. L., Maldonado A. Jr., & Gentile, R. 2016. The influence of habitat fragmentation on helminth communities in rodent populations from a Brazilian Mountain Atlantic Forest. *Journal of Helminthology*, 90(4), 460-468. DOI: 10.1017/S0022149X15000589
- Carmignotto, A. P., Vivo, M., & Langguth, A. 2012. Mammals of the Cerrado and Caatinga: distribution patterns of the Tropical open biomes of Central South America. In: B. D. Patterson & L. P. Costa (Eds.), *Bones, clones and Biomes: The history and geography of recent Neotropical mammals*. pp. 307-341. Chicago: The University of Chicago Press.
- D'Andrea, P. S., Maroja, L. S., Gentile, R., Cerqueira, R., Maldonado Júnior, A., & Rey, L. 2000. The parasitism of *Schistosoma mansoni* (Digenea-Trematoda) in a naturally infected population of water rats, *Nectomys squamipes* (Rodentia-Sigmodontinae) in Brazil. *Parasitology*, 120(6), 573-582. DOI: 10.1017/S0031182099005892
- Hugot, J. P., & Quentin, J. C. 1985. Etude morphologique de six espèces nouvelles ou peu connues appartenant au genre *Syphacia* (Oxyuridae, Nematoda), parasites de Rongeurs Cricétidés et Muridés. *Bulletin du Muséum National D'Histoire Naturelle*, 4(2), 383-400.
- Jiménez, F. A., Catzefflis, F., & Gardner, S. L. 2011. Structure of parasite component communities of didelphid marsupials: Insights from a comparative study. *Journal of Parasitology*, 97(5), 779-787. DOI: 10.1645/GE-2711.1
- Sikes, R. S., Gannon, W. L., & The Animal Care and Use Committee of the American Society of Mammalogists 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammalogy*, 92(1), 235-253. DOI: 10.1644/10-MAMM-F-355.1
- Lemos, E. R. S., & D'Andrea, P. S. 2014. *Trabalho de campo com animais: procedimentos, riscos e biossegurança*. 1st ed. Rio de Janeiro, RJ: Fiocruz: p. 180.

- Liberal, C. N., Farias, A. M. I., Meiado, M. V., Bruno, K. C., Filgueiras, B. K. C., & Iannuzzi, L. 2011. How habitat change and rainfall affect dung beetle diversity in Caatinga, a Brazilian semi-arid ecosystem. *Journal of Insect Science*, 11, 114-125. DOI: 10.1673/031.011.11401
- Ministério da Integração Nacional. 2014. Projeto de integração do Rio São Francisco. Retirado em 31 de Agosto, 2014, de <http://www.mi.gov.br/web/projeto-sao-francisco>
- Olifiers, N., Gentile, R., & Fiszon, J. T. 2005. Relation between small mammal species composition and anthropic variables in Brazilian Atlantic Forest. *Brazilian Journal of Biology*, 65(3), 495-501. DOI: 10.1590/S1519-69842005000300015
- Rego, A. A. 1972. *Strongylopsalis mathurini* (Dermaptera) e *Alphitobius piceus* (Coleoptera) novos hospedeiros intermediários para *Hymenolepis diminuta*. *Memórias do Instituto Oswaldo Cruz*, 70(3), 433-441.
- Simões, R., Gentile, R., Rademaker, V., D'Andrea, P., Herrera, H., Freitas, T., Lanfredi, R., & Maldonado Jr., A. 2010. Variation in the helminth community structure of *Thrichomys pachyurus* (Rodentia: Echimyidae) in two sub-regions of the Brazilian Pantanal: the effects of land use and seasonality. *Journal of Helminthology*, 84(3), 266-275. DOI: 10.1017/S0022149X09990629
- Simões, R. O., Souza, J. G., Maldonado, A., & Luque, J. L. 2011. Variation in the helminth community structure of three sympatric sigmodontine rodents from the coastal Atlantic Forest of Rio de Janeiro, Brazil. *Journal of Helminthology*, 85(2), 171-178. DOI: 10.1017/S0022149X10000398
- Simões, R., Maldonado, A., & Luque, J. L. 2012. Helminth communities in three sympatric rodents from the Brazilian Atlantic forest: contrasting biomass and numerical abundance. *Brazilian Journal of Biology*, 72(4), 909-914. DOI: 10.1590/S1519-69842012000500018
- Vaz, V. C., D'Andrea, P. S., Jansen, A. M. 2007. Effects of habitat fragmentation on wild mammal infection by *Trypanosoma cruzi*. *Parasitology*, 34(12), 1785-1793. DOI: 10.1017/S003118200700323X
- Vicente, J. J., Rodrigues, H. O., Gomes, D. C., & Pinto, R. M. 1997. Nematoides do Brasil. Parte V: nematóides de mamíferos. *Revista Brasileira de Zoologia*, 14(1), 1-452. DOI: 10.1590/S0101-81751997000500001

Submitted: May 15, 2016

Accepted: September 02, 2016