International Journal for Parasitology: Parasites and Wildlife 5 (2016) 254–257

Contents lists available at ScienceDirect

International Journal for Parasitology: Parasites and Wildlife

journal homepage: www.elsevier.com/locate/ijppaw

Current opinion

Intestinal parasites of *Tolypeutes matacus*, the most frequently consumed armadillo in the Chaco region

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ARTICLE INFO

Article history:
Received 23 June 2016
Received in revised form
1 August 2016
Accepted 3 August 2016

Keywords:
Argentinean Chaco
Zoonosis
Xenarthra
Helminths

ABSTRACT

The southern three-banded armadillo *Tolypeutes matacus* (Desmarest, 1804) is distributed from eastern Bolivia, south-west Brazil, the Gran Chaco of Paraguay and Argentina, and lives in areas with dry vegetation. This armadillo is one of the most frequently consumed species by people in this area. The objective of this work was test for zoonotic species among helminths in 12 intestinal tracts of *T. matacus* in a locality from the Argentinean Chaco (Chamical, La Rioja province). The parasites were studied with conventional parasite morphology and morphometrics, and prevalence, mean intensity and mean abundance were calculated for each species encountered. In the small intestine, seven species of nematodes and two species of cestodes were identified. In the large intestine, two species of nematodes were recorded. We did not find zoonotic species but have added new host records. This study in the Chaco region thus contributes to growing knowledge of the parasite fauna associated with armadillo species in this region.

1. Introduction

Some zoonotic infections cause disease in wildlife hosts, while many others exist “silently” in wildlife species as infections which are not apparent (Schwabe, 1969). This reflects a long evolutionary history of adaptation and the development of a balanced host-parasite relationship (Thompson, 2013). When such zoonoses infect humans it is usually as a consequence of human influence or activity (anthropogenic); this may be passive, as a result of poverty and other socioeconomic factors (e.g. Chagas disease), or may stem from activities such as recreational or subsistence hunting, which increase the risk of zoonotic transmission (Thompson, 2013).

The southern three banded armadillo *Tolypeutes matacus* (Desmarest, 1804) is distributed from Eastern Bolivia, south-western Brazil, south through the Gran Chaco of Paraguay, to central Argentina (Noss et al., 2014). In addition to its regional significance, this species is also of global interest because it is held in at least 113 zoos in Asia, Europe, North America and South America (International Species Information System, 2016). In contrast to other armadillos it does not have subterranean habits, using burrows abandoned by other species or hiding in dense vegetation (Redford and Eisenberg, 1992; Cuéllar, 2002; Noss, 2013). When individuals of this species are threatened, they can roll their body into a ball, an exclusive feature of the genus *Tolypeutes* (Meritt, 2008). *Tolypeutes matacus* is omnivorous, feeding mainly on invertebrates and to a lesser extent plant material, mainly fruits; the prevalence of each diet item is seasonal, so it is considered an insectivorous opportunist (Bolkovic et al., 1995; Cuéllar, 2008).

The IUCN lists *T. matacus* as Near Threatened because widespread habitat loss through much of its range and exploitation for food have caused significant decline (Noss et al., 2014). Furthermore, *T. matacus* has a slow reproduction rate; females give birth annually to a single young per litter (Noss et al., 2014).

The relationship between humans and xenarthrans dates back to ancient times, as indicated in early records of consumption and use by Native Americans and colonizers (Martinez and Gutierrez, 2004). Currently, *T. matacus* is consumed daily by people in all regions of South America (Cuéllar, 2000; Ojeda et al., 2002; Altrichter, 2006; Richard and Contreras Zapata, 2010). In the Argentinean Chaco, this armadillo is one of the most frequently consumed wild species (Altrichter, 2006). It is also used for other purposes, including as a pet, and its carapace, tail and skull are used as ornaments, knife handles, key chains, trophies (Altrichter, 2006; Richard and Contreras Zapata, 2010). In Bolivia it is the second-most hunted armadillo species by the Izoceño indigenous group

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http://dx.doi.org/10.1016/j.ijppaw.2016.08.001

(Cuéllar, 2000). Alves and Rosa (2007a) mention the use of the tail of *Tolypeutes* sp. to treat earache in the northeast Brazilian, and, according to street traders, the fat of the animal is consumed as a tea for diarrhea, headaches and asthma, or is rubbed onto inflamed areas as an ointment (Alves and Rosa, 2007b).

Studies in some localities from Paraguay, Bolivia and Argentina have reported the presence of several species of endoparasites in *T. matacus*, including nematodes, cestodes and acanthocephalans, some of them with known zoonotic importance (Table 1).

In view of the risks of parasites transmission associated with consumption and other uses of armadillos, the aim of this work was to test for zoonotic species by analyzing the composition and distribution of helminths in the intestinal tract of *T. matacus* in the department of Chamical, province of La Rioja, Argentina.

2. Materials and methods

This work was conducted in the department of Chamical, province of La Rioja, Argentina (30°21′ S, 66°18′ W). This area belongs to the Arid Chaco and it is characterized by an average temperature of 19.7 °C, total annual rainfall of 448.8 mm (Servicio Meteorológico Nacional, 2015), saline soils and forests of quebracho (*Schinopsis* sp.) and algarrobo (*Prosopis* sp.) (Morello et al., 2009).

The intestinal tracts of 12 individuals of *T. matacus* were examined. Five males, three females and four unsexed individuals were collected in 2006 and 2009 as part of a project of the Universidad Nacional de La Rioja (Sede Chamical) and donated to us by T. Rogel and A. Agüero (Transit guide No 000057–000058, 10 July 2009, see also Rogel et al., 2005). The intestines were fixed in a 10% formaldehyde solution and measured and dissected in the laboratory. Each was divided into two parts: the small intestine, which was further divided into ten segments of equal length, and the cecum and large intestine, which were examined in a single section. Intestinal contents were analyzed under stereoscopic binocular microscope (Olympus SZ61). Nematodes were preserved in 70% ethanol, cleared in lactophenol and mounted on a slide under a cover slip. Cestodes were stained with hydrochloric carmine, dehydrated in a series of ethanol solutions of increasing concentration, cleared with eugenol and mounted with Canada balsam on a slide under a cover slip. Both types of helminths were examined using an Olympus BX51 compound microscope (Olympus Corporation, Tokyo, Japan) equipped with camera lucida. CellSens v1.11 (Olympus) image analyzer software was used to take corresponding morphometric measurements for identification (X40-X600). Helminths were identified using the keys, descriptions and accounts of Navone and Lombardero (1980), Navone (1986, 1987, 1998), Anderson et al. (2009), Hoppe et al. (2009), Navone et al. (2010), and Ezquiaga and Navone (2013). Prevalence (P), mean intensity (MI) and mean abundance (MA) were calculated based on Bush et al. (1997).

Table 1
Previous records, descriptors and new records of parasites of *Tolypeutes matacus* from Chamical, La Rioja, Argentina.

Helminth species	P-MI – MA	Reference
Nematoda		
[b]Ascarids		Deem et al., 2009
Aspidodera fasciata (Aspidoderidae)	92%; 30(3–78); 27.5(0–78)	This study
Aspidodera scoleciformis (Aspidoderidae)	92%; 136(20–441); 125(0–441)	Navone, 1990; Suare et al., 1997; Suare et al., 1998, Monferrán and Silverio Reyes, 2014; This study
Aspidodera sp. (Aspidoderidae)		Deem et al., 2009
[a]*Cyclobulura superinae* (Subuluridae)	8%; 1(1); 0.1(0–1)	This study
[a]*Delicata ransomi* (Molineidae)	33%; 28(2–96); 9(0–96)	This study
Delicata sp. (Molineidae)		Suare et al., 1997
[b]*Dirofilaria immitis* (Onchocercidae)		Deem et al., 2009
Heterakidae		Deem et al., 2009
Leipernema sp. (Strongyloididae)		Suare et al., 1997
Macielia elongata (Molineidae)	8%; 16(16); 1(0–16)	Navone, 1990; Suare et al., 1997; Suare et al., 1998; Monferrán and Silverio Reyes, 2014; This study
Macielia sp. (Molineidae)		Suare et al., 1997
Mazzia bialata (Spirocercidae)		Navone, 1990
Moennigia virilis (Molineidae)	100%; 388(1–3592); 388(1–3592)	Navone, 1990; Suare et al., 1997; Suare et al., 1998; This study
Orihelia anticlava (Onchocercidae)		Notarnicola and Navone, 2003
[b]Oxyurids		Suare et al., 1998, Deem et al., 2009
Pterygodermatites chaetophracti (Rictulariidae)	92%; 4.5(1–11); 4.2(0–11)	Navone, 1990; Suare et al., 1997; Suare et al., 1998; This study
Pterygodermatites sp. (Rictulariidae)	75%; 5.2(1–15); 3.9(0–15)	Monferrán and Silverio Reyes, 2014; This study
Rhabditoidea		Suare et al., 1998
[b]*Strongyloides* sp. (Strongyloididae)		Deem et al., 2009
[b]*Strongylus* sp.(Strongylidae)		Deem et al., 2009
Trichohelix sp. (Molineidae)		Deem et al., 2009; Monferrán and Silverio Reyes, 2014
[a]*Trichohelix tuberculata* (Molineidae)	17%; 9(1–17); 1.5(0–17)	This study
Trichostrongylidae		Deem et al., 2009
[b]*Trichuris* sp. (Trichuridae)		Deem et al., 2009
Cestoda		
[a]*Mathevotaenia* cf. *argentinensis* (Anoplocephalidae)	25%; 11(1–32); 3(0–32)	This study
Mathevotaenia matacus (Anoplocephalidae)		Navone, 1990; Suare et al., 1997
Mathevotaenia sp. (Anoplocephalidae)	25%; 2(1–4); 0.5(0–4)	Suare et al., 1998; This study
Acanthocephala		
Oligacanthorhynchus carinii (Oligacanthorhynchidae)		Smales, 2007
Travassosia sp. (Oligacanthorhynchidae)		Navone, 1990; Suare et al., 1997

P: Prevalence; MI: Mean Intensity (Range); MA: Mean Abundance (Range).
[a] New host records.
[b] Parasites with known zoonotic importance.

3. Results

All individuals sampled were parasitized. Seven species of nematodes and two cestodes were identified in the small intestine; in the cecum and large intestine two species of nematodes were recorded (Table 1). None of the species observed had known zoonotic importance.

Helminths were found in all portions of the intestinal tract. (Fig. 1); *Moennigia virilis* was abundant throughout the small intestine. Two species of *Aspidodera* were recorded in the last two segments of the small intestine and in the cecum and large intestine. The remaining helminth species had lower abundance. *Pterygodermatites* spp. were located in the first five segments of the small intestine with higher abundance in the first and second segments.

Trichohelix tuberculata was located only in segments 3 to 5; *Delicata ransomi* was located in segments 1 and 2 and then from 6 to 10, being more abundant in the first segment; *Cyclobulura superinae* was found only in segment 8. *Macielia elongata* was observed but is not considered for this analysis because it inhabits the stomach; its presence in different locations of the intestine is attributed to post-mortem migration.

4. Discussion

The results obtained here provided new information on parasite-host associations, including the first records of *C. superinae*, *T. tuberculata* and *D. ransomi* in *T. matacus*. These parasite species had been reported in other armadillos in several regions of Argentina (Navone et al., 2010; Ezquiaga and Navone, 2013; Ezquiaga et al., 2015), which confirms their association with order Cingulata.

We studied several specimens of *Pterygodermatites* and observed that some individuals belonged to *P. (P.) chaetophracti*, and others to a yet undescribed species (Ezquiaga et al., unpublished results).

We distinguished two different cestode morphotypes, and identified two species belonging to the genus *Mathevotaenia*. One of the species, *Mathevotaenia* cf. *argentinensis* (Campbell et al., 2003), is a parasite of marsupials from the Chacoan region of Argentina (Campbell et al., 2003). The existence of parasites shared by xenarthrans and marsupials is plausible in light of their shared distribution and physiological and trophic similarities.

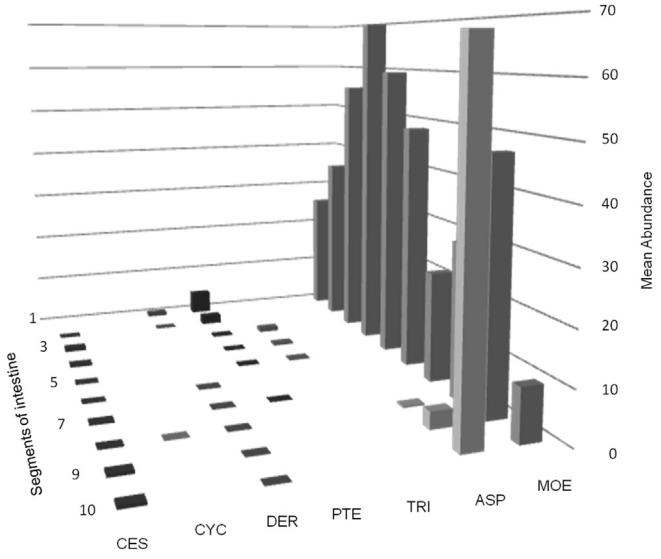

Fig. 1. Distribution of helminths in the small intestine of *Tolypeutes matacus* from Chamical, La Rioja, Argentina. MOE: *Moennigia virilis*, ASP: *Aspidodera* spp., TRI: *Trichohelix tuberculata*, PTE: *Pterygodermatites* spp., DER: *Delicata ransomi*, CYC: *Cyclobulura superinae*, CES: Cestoda.

The omnivorous diet of *T. matacus* (Bolkovic et al., 1995) leads to an expectation of a parasite fauna with a variety of life cycles, and this was observed in our samples. For example, *Macielia elongata*, *Aspidodera* spp., *Moennigia virilis*, *Trichohelix tuberculata* and *Delicata ransomi* have direct life cycles and infect their host when it ingests the eggs on the ground (Navone, 1990). On the other hand, armadillos acquire *Pterygodermatites* spp., *Cyclobulura superinae* and Cestoda by ingesting infected arthropods like coleopterans and dermapterans (Navone, 1990; Navone et al., 2010). The parasite species richness found in this study (11 species) is greater than that recorded by Navone (1990) and Monferrán and Silverio Reyes (2014), and similar to that of Suare et al. (1997) and Deem et al. (2009).

The spatial distribution of parasites in the mammalian intestinal tract is poorly known (Durette-Desset et al., 1977) and our results should be considered preliminary. The patterns observed could be related to variation in the feeding guilds of parasites, their adaptations, and inter- and intra-specific competition.

Although zoonotic helminths were not observed, several have been recorded in *T. matacus* in North Chaco (Deem et al., 2009). It may be relevant that our work was conducted in the southern limit of the distribution *T. matacus*, and by necropsy.

Our work provided new parasite-host records, supporting the concept of hidden biodiversity (Luque, 2008). We also extended the geographic range of parasite species known in *T. matacus* and provide new data on their location in the intestinal tract. This report also has regional relevance, because *T. matacus* is the most frequently consumed armadillo in the entire Chaco (Argentina, Paraguay and Bolivia); it has global significance due to the large number of specimens living in zoos around the world.

To achieve complete knowledge of the parasitological fauna of *T. matacus* in the Argentinean Chaco, we propose that other organs (e.g., skeletal muscles, body cavity, blood samples) should be examined in animals collected in other parts of the region, and future studies should also employ coproparasitological analysis.

Conflicts of interest

This manuscript has not conflict of interest.

Acknowledgements

We thank Tania Rogel for providing the study material and Sean Locke for English review. This research was not supported by any specific funding agencies in public, commercial, or not-for-profit sectors.

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