PARASITIC NEMATODES OF REPTILES (LIZARDS AND SNAKES) IN THE MONTE DESERT OF ARGENTINA

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Nematodes are little known in the Argentine herpetofauna. In order to increase and contribute to the knowledge of parasitism in reptiles, we studied nematodes found in three species of lizards (Aurivela longicauda, Liolaemus darwinii, and L. riojanus) and one species of snake (Philodryas trilineata) from the Monte desert of center-west Argentina. We registered generalist nematodes commonly found in reptiles, belonging to three taxa: Physaloptera sp. (larvae), Physaloptera retusa (adults) (Physalopteridae) and Parapharyngodon riojensis (Pharyngodonidae) (adults). Liolaemus darwinii had the lowest prevalence of Physaloptera sp. (larvae) (30%) and a mean intensity of 1.3±0.4 (1–2). The lizard A. longicauda had the highest parasitic diversity (2 taxa) with prevalence (50%) and mean intensity (4±3.5) of Physaloptera retusa (adults), also with prevalence (12.5%) and mean intensity (20±0) of Parapharyngodon riojensis (adults). Due to the low number of studied specimens, precise conclusions cannot be drawn for Liolaemus riojanus (n = 2) and P. trilineata (n = 1). However, because the hosts were previously fixed, the results probably may do not represent real infection patterns. The four reptile species correspond to new host records from Argentina, and the information provided contributes to the knowledge of endoparasitism in reptiles of the Argentine Monte region.

Key words: parasitic nematodes, Parapharyngodon riojensis, Physaloptera retusa, Liolaemus, Aurivela, Philodryas, lizard, snake.

INTRODUCTION

Until 2004, information about endoparasite metazoans in Argentine lizards has been scarce (Goldberg et al. 2004). However, in the last years an increase in the knowledge about parasitism in reptile species has occurred. Such increases are mainly due to the contributions about nematodes in reptiles from Monte and Puna regions in Argentina (Castillo et al. 2019a, b). Although the Monte region covers an extensive area of Argentina (Karlin et al. 2017), to date, parasites were only studied in a reduced number of
reptile species; namely *Salvator rufescens*, *Teius teyou* (Teiidae), *Homonota underwoodi* (Phyllodactylidae) and *Liolaemus olongasta* (Liolaemidae) (Castillo et al. 2019a, b).

Information about parasite biodiversity is essential, since parasites may play an important role in the ecology of reptiles. It is well-known in the literature that nematode communities are influenced by attributes of the host, such as phylogenetic historical factors (Brito et al. 2014), diet (Ribas et al. 1995, O’Grady & Dearing 2006, Pereira et al. 2012, 2014, Brito et al. 2014), foraging strategy (active and passive search) (Aho 1990, Brito et al. 2014), microhabitat use (Brito et al. 2014); reproduction (Brito et al. 2014, Galdino et al. 2014), sexes (Ribas et al. 1995, Vrcibradic et al. 1999, Brito et al. 2014), age (Pereira et al. 2012), body size (Van Sluy et al. 1994, Ribas et al. 1995, Vrcibradic et al. 1999, Anjos et al. 2005, 2012, Pereira et al. 2012) and environmental characteristics such as humidity or type of habitat (Castillo et al. 2018).

In order to contribute to the knowledge of the parasitic nematodes of reptiles in the Monte region of Argentina, we analyzed the gastrointestinal content of four species of reptiles (*A. longicauda*, *L. darwinii*, *L. riojanus* and *P. trilineata*) captured in the previously mentioned area.

**MATERIAL AND METHODS**

The Monte phytogeographic region encompasses large arid areas, with an average annual precipitation lower than 100 mm/year, including absence of annual precipitation. Xerophyte plants adapted to dry and warm weather predominate. The sector is characterized by scrublands dominated by Zigophylaceae, Malpigiaceae and Fabaceae (Cabrera 1976, Márquez et al. 2016).

Sampling was carried out in different periods and sectors of the Monte desert of San Juan province, Argentina (Figs 1 & 2). During December 2017 and January 2018, pitfall traps and manual capture were used, and the following species were collected and examined: the lizards *Liolaemus darwinii* (Liolaemidae), *Liolaemus riojanus* (Liolaemidae) (Liolaemidae) and *Aurivela longicauda* (Teiidae), and the snake *Philodryas trilineata* (Dipsadidae) (Table 1). Two lizards and the snake species (i.e., *L. darwinii*, *A. longicauda* and *Philodryas trilineata*) have wide distribution in the Monte region and or other provinces from Argentina, and are not under any conservation threat (Giraudo et al. 2012). While *L. riojanus* is categorized as vulnerable and has more restricted distribution (Abdala et al. 2012).

All host specimens were deposited in the Herpetological Collection, Biology Department, School of Exact, Physical, and Natural Sciences, National University of San Juan (*Philodryas trilineata*: UNSJ 4010; *L. riojanus*: UNSJ 4011, 4012; *A. longicauda*: UNSJ 4013–4032; *L. darwinii*: 4033–4052).

Captured specimens were euthanized with an intraperitoneal administration of sodium thiopental, fixed in 10% formalin, and preserved in 70% ethanol. In the laboratory, the dissection and analysis of the digestive tract was carried out. The lizards were dissected through a ventral incision from mouth to anus, digestive tract was extracted and revised using a binocular stereomicroscope. Nematodes found were conserved in 70% ethanol.
For identification of parasites, specimens were cleared in lactophenol, observed using an Arcano light microscope, following specific literature (Anderson et al. 2009, Pereira et al. 2012, 2014). Prevalence, mean intensity and mean abundance of parasites were according to Bush et al. (1997). All nematodes were deposited in the Colección Parasitológica, Department of Biology, Fac. of Exact, Physical and Natural Sciences, National University of San Juan, Argentina, (Physaloptera retusa (Adults): UNSJPar260; Physaloptera sp. (Larvae): UNSJPar 261, 262, 263; Parapharyngodon riojensis: UNSJPar 264).

### Table 1. Reptiles studied from the Monte desert, central-western Argentina.

| Host            | Specimens | Locality               | Geographical coordinates       |
|-----------------|-----------|------------------------|--------------------------------|
| Teiidae         |           |                        |                                |
| *Aurivela longicauda* | ♂ = 4; ♀ = 4 | Encón, Dept. 25 de Mayo | 32.182839°S, 67.824371°W       |
| Liolaemidae     |           |                        |                                |
| *Liolaemus darwinii* | ♂ = 16; ♀ = 24 | Encón, Dept. 25 de Mayo | 32.182839°S, 67.824371°W       |
| *Liolaemus riojanus* | ♀ = 2 | Encón, Dept. 25 de Mayo | 32.182839°S, 67.824371°W       |
| Dipsadidae      |           |                        |                                |
| *Philodryas trilineata* | juvenile | Urban Sector, Dept. Rivadavia | 31°31′00″S, 68°36′00″W       |

**Fig. 1.** Province of San Juan, Argentina, showing the location of the present study
Fig. 2. Environments where the samplings were performed. Capture locations of *L. darwinii*, *L. riojanus* and *A. longicauda*. Town of the Encón, Department of 25 de Mayo (A, B, C).

Fig. 3. Studied hosts. A = *Philodryas trilineata*, B = *Aurivela longicauda* (photo: Ignacio Hernandez), C = *Liolaemus darwinii* (photo: Claudio Mendez), D = *Liolaemus riojanus*
RESULTS

Three taxa of nematode parasites were identified: *Physaloptera* sp. (larvae), *Physaloptera retusa* (adults) (Physalopteridae) and *Parapharyngodon riojensis* (adults) (Pharyngodonidae). Eight specimens of *A. longicauda* (4 males, 4 females) were examined, and 36 nematodes corresponding to two taxa were isolated in their stomachs: *Physaloptera retusa* (14 females, 2 males) and *Parapharyngodon riojensis* (15 females, 5 males). Forty specimens of *L. darwinii* were examined (24 females, 16 males), and 16 nematodes were registered, corresponding to larval stages of *Physaloptera* sp. Only two specimens of *L. riojanus* and one of *P. trilineata* were analyzed, finding larvae of *Physaloptera* sp. (Table 2).

DISCUSSION

In the present study, *Physaloptera* (larvae and adults) infecting *L. riojanus, L. darwinii, P. trilineata* and *A. longicauda* from the Monte desert, represent new host records.

Currently in Argentina, 14 reptile species infected by *Physaloptera* spp. have been reported: *L. quilmes, L. ornatus, L. alticolor, L. koslowskyi, L. neuquensis, L. olongasta, Salvator rufescens, A. tergolaevigata, H. underwoodi, T. etheridgei, L. catamarcensis, L. belli, P. scapulatus* and *X. merremi* (Ramallo & Díaz 1998, O’Grady & Dearing 2006, Goldberg et al. 2004, Cruz et al. 1998, Lamas et al. 2016, Castillo et al. 2019a,b,c,d, Gallardo et al. 2019). *Physaloptera* sp. parasitizing the present hosts raises to 18 the number of reptile species infected by this genera of nematode in Argentina.

Table 2. Quantitative descriptors of nematodes infection in a sector from the Monte region, central-western Argentina. P = Prevalence, MI = Mean intensity; MA = Mean abundance; N = examined host; np = total number of parasite. Mean values are followed by ±1 standard deviation (range).

| Host                  | N  | Nematode               | np  | P %     | MI       | MA       | Site of infection |
|-----------------------|----|------------------------|-----|---------|----------|----------|------------------|
| *Aurivela longicauda* | 4  | *Physaloptera retusa*  | 16  | 50      | 4±3.5 (1–8) | 2±3.16   | Stomach          |
|                       |    | (adults)               |     |         |          |          |                  |
|                       |    | *Parapharyngodon riojensis* (adult) | 20 | 12.5    | 20±0     | 2.5±7.07 | Stomach*         |
| *Liolaemus darwinii*  | 40 | *Physaloptera* sp. (larvae) | 16 | 30      | 1.3±0.4 (1–2) | 0.4±0.6 | Stomach          |
| *Liolaemus riojanus*  | 2  | *Physaloptera* sp. (larvae) | 1  | 50      | 1        | 0.5±0.7 (0–1) | Intestine        |
| *Philodryas trilineata* | 1 | *Physaloptera* sp. (larvae) | 1  | 100     | 1        | 1        | Stomach          |

* These nematodes migrate to the stomach due to the fixation method. Probable location = large intestine

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**Physaloptera** has heteroxenous life cycle and its intermediate hosts are mainly from the Orders Orthoptera and Coleoptera (Anderson et al. 2000). This genus currently includes 105 species which are parasites in reptiles, amphibians, birds and mammals (Pereira et al. 2012, 2014). In the Neotropics, eight species that parasitize the stomach of reptiles are known: P. bonnei Ortlepp, 1922, P. liophis Vicente et Santos, 1974, P. lutzi Cristofaro, Guimaraes et Rodrigues, 1976, P. monodens Molin, 1860, P. obtusissima Molin, 1860, P. retusa Rudolphi, 1819, P. tupinambae Pereira, Alves, Rocha, Lima et Luque, 2012 and P. bainae Pereira, Alves, Rocha, Lima et Luque, 2014 (Castillo et al. 2019c).

Reptiles have been mentioned as paratenic hosts (Widmer 1970). Liolaemus darwinii would have a role as a paratenic host in the life cycle of Physaloptera sp. A possible definitive host, Salvator rufescens, in which adult stages of Physaloptera were recorded (Castillo et al. 2019b). This was captured in the same place as L. darwinii. Aurivela longicauda would have a definitive host role, probably by feeding on other lizards. We have records that A. longicauda has a tendency to feed on other lizards (Blanco et al. 2012).

Parapharyngodon riojensis as a parasite of A. longicauda from the Monte desert, also represents a new host record. It is a generalist nematode, and in Argentina it parasitizes Liolaemus spp., Phymaturus spp. and Tropidurus spp. (Ramallo et al. 2002, Goldberg et al. 2004, Castillo et al. 2017, Ramallo et al. 2017, Castillo et al. 2018, Castillo et al. 2019d). Parapharyngodon riojensis is very common in reptiles of the San Juan province (Castillo & Acosta 2019, Castillo et al. 2019d).

According to our bibliographic review, in Argentina there are currently 15 lizard species parasitized by Parapharyngodon spp. (Cruz et al. 1998, Ramallo et al. 2002b, Goldberg et al. 2004, Lamas & Zaracho 2006, Ramallo et al. 2016, Ramallo et al. 2017, Castillo et al. 2017, Castillo et al. 2018, Castillo et al. 2019e, Castillo et al. 2019c, Castillo & Acosta 2019).

The probability that an uninfected host will become infected would depend on the frequency of movement (Getz & Pickering 1993). Aurivela longicauda is a more agile, faster and more moving species than L. darwinii. Infection is more likely in A. longicauda. In addition, the relationship between lizard SVL (snout vent length) and the intensity of nematode infection suggest that body size is an important determinant of the infection rate (Ribas et al. 1995, Anjos et al. 2012). The larger digestive tract of the larger lizards (A. longicauda), provides more microhabitats suitable for nematode settlement compared to the relatively smaller one of L. darwinii.

Considering the large number of lizard species registered in Argentina, current knowledge on their parasitic nematodes is incomplete and fragmented. The present report expands the number of host species and the geographi-
The distribution of *P. riojensis* and *Physaloptera* spp. represents a valuable contribution to parasitological knowledge and adding to knowledge of this species in the Monte desert of Argentina.

We emphasize that the results obtained with respect to the parasites of *A. longicauda* are similar to those of other phylogenetically related species. *Parapharyngodon* spp. and *Physaloptera* spp. was reported in lizards of the family Teiidae (Ávila & Silva 2010, Gallardo et al. 2019, Vieira et al. 2019).

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The authors declare no competing interests.

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Amphistomes of the World
A check-list of the amphistomes of vertebrates

O. Sey

The amphistomes are one of the rare groups of digenetic trematodes which have a broad spectra of the definitive hosts together with a wide geographical distribution, forming a continuous evolutionary lineage from fishes to mammals. At the same time, some species of them are causative agents of devastating disease of domestic and wild animals, mainly ruminants. Therefore, amphistomes may have professional and practical interests for research and thus a great number of information has been accumulated on their classification and biology. The intention of this check-list is to bring together a comprehensive list of the amphistomes, presently known and sources of references of their hosts and geographic distribution (87 pages). This list consists of three main parts. In the first “Parasite/host check-list” (137 pages), parasites were listed under their scientific names, followed by the synonyms, then the name of the authorship as well as the name of the countries from which they were reported. In the second “General host/parasites check-list” (31 pages), host were listed systematically under their scientific names from fishes to mammals, followed by amphistomes described in them in alphabetical order. In the third “Host/parasites check-list by countries” (63 pages), countries were listed alphabetically, hosts systematically and their parasites alphabetically. When it seemed to be necessary some comments were given and they are found in Chapter 7 “Notes” (5 pages). Three indexes (parasite, host and countries) are added to the list (29 pages).

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