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A NEW GENUS AND SPECIES OF LUNGWORM (NEMATA: METASTRONGYLOIDEA) FROM *AKODON MOLLIS* THOMAS, 1894 (RODENTIA: CRICETIDAE) IN PERU

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ABSTRACT: *Akodonema luzsarmientae* n.g., n.sp. (Nemata: Metastrongyloidea) is described from the pulmonary arteries and heart from several individuals of “soft grass mouse,” *Akodon mollis* (Rodentia: Cricetidae), collected in the region of Ancash, Peru. The new genus and species is distinguished by a reduction of the dorsal ray to 2 small widely separated papillae.

During a study of the helminth parasites of the “soft grass mouse,” *Akodon mollis* Thomas, 1894, from mountain shrub habitat on the western flank of the Andes of Peru, an undescribed species of an angiostrongylid type of nematode representing a new genus was found in the pulmonary arteries and heart. The new species shows some similarity to species of *Galegostrongylus* (Mas-Coma, 1977) and *Thaistrongylus* (Ohbayashi, Kamiya, and Bhaibulaya, 1979) in the reduction, loss, or ancestral absence, of the dorsal ray.

Species of *Akodon* Meyen, 1833, have a strictly Neotropical distribution, with a northern-most species, *Akodon affinis* Allen, 1912, occurring in the western part of the Andes in Colombia (Eisenberg, 1989), and many other species distributed over the South American continent to Tierra del Fuego, where the closely related *Abothrrix hershkovitzi* can be found (Patterson et al., 1984). More than 40 species of *Akodon* have been described (Wilson and Reeder, 2005), and because of cryptic species in the genus, there are probably many more that are currently unrecognized.

Akodon mollis is a small rodent (mean total length = 169.8 mm) that inhabits the montane region and Pacific lowlands of northern Peru northward through the central highlands of Ecuador (Patton and Smith, 1992) (Fig. 1). As is typical of species included in *Akodon*, their diet appears to consist mostly of insects, seeds, and other vegetable material. There are no previous reports of parasites from *A. mollis*.

MATERIAL AND METHODS

Between February 1988 and October 1989, 125 specimens of *A. mollis* were captured using Sherman™ live traps, from the District of Huayllacayán (lat 10°14'56" S, long. 77°26'00" W), Province of Bolognesi, Department of Ancash, in the high-altitude puna habitat of the central Andes of Peru (2,100–3,256 m) (Fig. 2).

Specimens of *Akodon* in this study were captured during a survey of the potential reservoirs of *Leishmania* spp. by a research group of the Institute of Tropical Medicine “Alexander Von Humboldt” of Cayetano Heredia University in Lima, Peru, from 19 different localities (*caseríos*). After individual mice were sampled for *Leishmania* spp., they were killed, and the carcasses frozen at –20 °C and deposited in the Department of Mammalogy of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (MUSM), in Lima, Peru. Subsequently, individual rodents were thawed and examined for parasites using a binocular dissecting microscope in the Laboratory of Helminthology at MUSM.

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Nematodes recovered were fixed and stored in 70% ethanol and later cleared with lactophenol for study.

All nematodes used in this study were deposited in the Colección Helminológica y de Invertebrados Relacionados del Museo de Historia Natural, MUSM, and in the Parasite Collection of the Harold W. Manter Laboratory of Parasitology, University of Nebraska–Lincoln, Lincoln, Nebraska. Measurements were made with the aid of an ocular micrometer and digital measuring software (Sigma Scan Pro, Systat Software, Inc., Chicago, Illinois). All measurements are given in micrometers except where noted, with the range followed by the mean in parentheses. Drawings were made with the aid of drawing tube attached to a Carl Zeiss light microscope.

DESCRIPTIONS

Akodonema n. gen.

Diagnosis: Elongate, delicate nematodes with body of both sexes filiform and tapering to smaller diameter at anterior end. Cuticular sheath absent, cuticle with numerous fine, longitudinal striations. Cephalic region with 3, minute lips, each bearing 2 small papillae. Esophagus claviform in outline, excretory pore well anterior to esophageal-intestinal junction. Intestine filled with blood from host. Both intestine and milky-white uterine tubules spirally arranged within the pseudocoelom.

Male: Tail curved ventrally. Bursa small, incomplete, 2 lateral sides not joined anteriorly or posteriorly. Ventral and lateral rays of bursa long, narrow. Ventral rays fused for most of length, lateral rays equal, arising from common trunk, divided to about 1/2 of length. Dorsal ray absent, but 2 small and delicate papillae present. External dorsal rays present, elongate and narrow. Spicules thin, elongate and well developed. Gubernaculum present.

Female: Oviparous and prodelphic with simple ovejector. Vulva opens at posterior end just anterior to anus, tail short. Eggs elliptical in shape, showing early development of juveniles. Eggs deposited into blood stream, and larvae hatch in lungs of host.

Taxonomic summary

Etymology: The generic name is an arbitrary combination taken from “*Akodo*” in reference to the host rodent (*Akodon*) and the word “nema,” which means “thread” in Greek. Gender feminine.

Akodonema luzsarmientae n. sp.

(Figs. 1–7)

General: Body of both sexes filiform and tapering at anterior end. Cuticle lightly transversely striated. Head smoothly rounded. Mouth with 3 tiny lips. Esophagus club shaped. Excretory pore close to nerve ring. Nerve ring in anterior third of esophagus.

Male (holotype and 9 specimens): Body length 7.8 to 10.6 mm; width at base of esophagus 74 to 87, maximum width 110 to 162. Esophagus 150 to 172 long by 35 to 39 in maximum width. Nerve ring 25 to 28 from anterior end. Excretory pore 19 to 22 from anterior end. Anterior end of testes variable in position, not reaching base of esophagus. Spicules slender, conspicuously striated, equal or subequal, 230 to 246 long by 5 wide; cephalic ends of spicules pointed, edges irregular; distal ends smoothly rounded. Gubernaculum present, poorly cuticularized, 24 to 29 long. Bursa symmetrical and well developed forming two lateral lobes. Dorsal ray reduced to 2 small papillae widely separated. Externodorsal rays long, digitiform, arising separately at base. Lateral rays with common trunk, posterolateral, mediolateral, and externolateral arising from common

FIGURE 1. Dorsal view of “soft grass mouse,” *Akodon mollis* Thomas, 1894 (Cricetidae: Sigmodontinae, Akodontini). Scale bar = 5 cm.

trunk, all about equal in size and length. Ventral rays subequal, fused in lower $\frac{3}{4}$, ventral trunk widely separate from lateral trunk (Figs. 5, 6).

Female (allotype and 8 other paratype specimens; 9 total females included in the paratype series): Body length 17.5 to 26.9 (21.6) mm width at base of esophagus 100 to 165 (135), maximum width 240 to 320 (274). Esophagus 132 to 475 long by 114 to 117. Nerve ring 45 to 172 from anterior end. Excretory pore 57 to 170 from anterior end. Anterior end of ovaries variable in position, but not extending anterior to base of esophagus. Uterine tubules white in life, spirally wound around blood-filled intestine presenting a “barber-pole” appearance common in family. Vulva opening near tip of tail 166 to 174. Anus 46 to 54 from tip of tail. Phasmidial pores not observed. Tail bluntly rounded. Eggs thin shelled, 75 to 93 long and 112 to 196 wide, laid in pulmonary artery and developing and hatching in lung tissue (Figs. 1–4).

Taxonomic summary

Type host: *Akodon mollis* Thomas, 1894, “soft grass mouse” (Cricetidae: Sigmodontinae).

Symbiotypes: *Akodon mollis* Thomas, 1894, adult males and females, Catalog numbers: 3608, 3611, 3623, 3624, 3628, 3629, 3642, 3643, 3645, 3649, 3650, 5760, 5778, 5782, 5786, 5787, 5893, all deposited in the Mammals Collection at the Museo de Historia Natural, MUSM.

Type locality: District of Huayllacayán (10°14'56"S, 77°26'00"W), Province of Bolognesi, Department of Ancash, Peru.

Site of infection: Pulmonary artery and branches, heart, and lungs.

Prevalence of infection: Rodents examined, 125 of which 27 were infected (21.6%).

Intensity: One to 9 nematodes. Total nematodes recovered, 78 (34 from heart and 44 from lungs).

Type specimens: Holotype male: Colección Helmintológica y de Invertebrados Relacionados, Museo de Historia Natural, MUSM No. 1699. Allotype female: Colección Helmintológica y de Invertebrados Relacionados, MUSM, No. 1700. Paratypes: Colección Helmintológica y de Invertebrados Relacionados MUSM, Nos. 1701, 1837, 1838, 1839, and Harold W. Manter Laboratory of Parasitology Collection (HWML48041, HWML48042).

Etymology: The specific name honors Dr. Luz Sarmiento, Emeritus Professor of the Universidad Nacional Mayor de San Marcos, Lima, Peru, and founder of the Helminthological Collection at the Natural History Museum, MUSM, in recognition of both her contribution to the knowledge of the Peruvian helminthology and her inspirational teaching for the study of protozoan and other animal parasites.

Remarks

All members of this group of worms dwell in the tissues of their hosts, often in the blood stream (Spratt, 1961). The new genus, *Akodonema*, is characterized by having well-developed ventral and lateral rays and with the dorsal ray reduced to a pair of sub-ventral papillae. The spicules are elongate. The morphology of the bursa allows comparisons with *Aelurostrongylus* Cameron, 1927, *Marsupostrongylus* Mackerras and Sanders, 1953, *Andersonstrongylus* Webster, 1978, *Thaistrongylus* Ohbayashi, Kamiya and Bhaibulaya, 1959, and *Gallegostrongylus* Mas-Coma, 1977, all of which have a reduced dorsal ray, or the dorsal ray is deeply divided or absent and/or papillae are present in its place. The new genus is most closely associated with the latter 2 genera. According to Mas-Coma (1977), in *Gallegostrongylus*, the dorsal ray is deeply divided with each branch of the ray arising separately and distant from each other. The ventral and lateral rays are well developed, and the spicules are short, delicate, and arcuate. As described by Ohbayashi et al. (1979), *Thaistrongylus* is represented by a single species, *Thaistrongylus harinasutai*, collected from a single host (*Rattus berdmorei* Blyth) and described on

FIGURE 2. Map showing the study area in oval (District of Huayllacayán, Province of Bolognesi, Department of Ancash, Peru) and the distribution of *A. mollis* Thomas, 1894, in Peru (shaded).

the basis of fragmented male and female specimens. The description suggests that the genus has a strongly reduced bursa, including the ventral and lateral rays, and the dorsal ray is reduced to papilla-like and short arcuate spicules. Ubelaker (1986) argued that the genus is very similar to *Gallegostrongylus* and should be placed in synonymy. The differences between the genera *Gallegostrongylus* and *Thaistrongylus* are mainly in how strongly the bursa of the latter is reduced and if the lobes of the dorsal ray are papilla-like or consist of very short rays. On the other hand, *Akodonema* has ventral and lateral rays strongly developed, similar to either *Angiostrongylus* or *Parastrongylus* (see Ubelaker, 1986 for review; see also Robles et al., 2008), and the dorsal ray is clearly reduced to widely separated papillae. The spicules are also of the *Angiostrongylus-Parastrongylus* type, being long and thin.

DISCUSSION

Within the Angiostrongylidae as described by Anderson (1978), 2 groups of genera are evident. A first group is characterized by having intact dorsal rays. This group should remain in the Angiostrongylidae.

REDESCRIPTION

Angiostrongylidae Anderson, 1978

Diagnosis: With the characters of the family. Bursa highly developed or reduced, complete, but typical rays always clearly defined. Dorsal ray is present but sometimes divided. Ventral and lateral rays well developed.

FIGURES 3–9. *Akodonema luzsarmientae* n.g. n. sp., (3) anterior end of gravid female from *A. mollis* Thomas, 1894, ventral view. (4) Egg of *A. luzsarmientae* n.g. n. sp. (5) Magnified posterior extremity of *A. luzsarmientae* n.g. n. sp., showing anus and glands associated with rectum. (6) Posterior extremity of gravid female of *A. luzsarmientae* n.g. n. sp. showing the vulva, vagina and eggs in the uterus. (7) Posterior extremity of a male of *A. luzsarmientae* n.g. n. sp., lateral view. (8) Posterior extremity of a male of *A. luzsarmientae* n.g. n. sp., ventral view. (9) Ventral view of spicules of *A. luzsarmientae* n.g. n. sp. Scale bars = 20 μ m (Figs. 3, 5); 100 μ m (Figs. 4, 6); 40 μ m (Figs. 7–9).

Remarks

Included in this family are *Angiostrongylus* Kaminski, 1905, *Didelphostrongylus* Prestwood, 1976, *Filostrongylus* Mackerras, 1955, *Gurtlia* Wolffhugel, 1933, *Heterostrongylus* Travassos, 1925, *Madangiostrongylus* Chabaud and Brygo, 1960, *Parastrongylus* Baylis, 1928, *Pulmostrongylus* Hsu, 1935, *Rodentocaulus* Schulz, Orlov and Kutass, 1939, *Sobolevstrongylus*

Romanov, 1952, *Stefanskostrongylus* Drozd, 1970, and *Tribostrongylus* Anderson, 1963. A key for these genera is provided by Anderson (1978).

A second group of genera split into several species generally displays a dorsal ray modified from a single intact structure to a pair of divided papillae or papillae-like structures. This group of nematodes will need revision, preferably after an adequate phylogenetic analysis is conducted of the group.

FIGURE 10. *Akodonema luzsarmientae* n.g. n.sp. in the heart of its host. Arrow shows a female worm in the heart of *A. mollis* Thomas, 1894, original magnification (25 $\times$).

Genera included in this group include *Akodonema* n. gen., *Aelurostrongylus* Cameron, 1927, *Andersstrongylus* Webster, 1978, *Antechinosstrongylus* Spratt, 1981, *Madafilaroides* Chabaud and Brygoo, 1960, *Gallegstrongylus* Mas-Coma, 1977, *Marsupostrongylus* Mackerras and Sanders, 1953, and *Thaistrongylus* Ohbayashi, Kamiya, and Bhaibulaya, 1979.

This group can be distinguished from the Angiostrongylidae mainly by the characters of the bursa that show a gradual reduction, as discussed by Webster (1978). This group shows relationships to nematodes belonging to the Filarioidea in which the caudal region of the males possesses remnants of ventral and lateral rays.

DISCUSSION

To date, only 2 species of angiostrongylid-types of nematodes have been reported from mammals in Peru. They are *Angiostrongylus costaricensis* Morera and Céspedes, 1971, in the mesenteric vessels of “pichico barba blanca,” *Saguinus mystax* (the tamarin), from Iquitos (Loreto), and *Parastrongylus* sp. in the pulmonary vein of “the painted big-eared mouse,” *Auliscomys pictus*, from Casapalca (Lima) (Sarmiento et al., 1999). Until recently, just 2 previously reports of angiostrongylids in rodents from South America were known: *Angiostrongylus lenzii* in *Akodon montensis* Thomas, 1913, from Rio de Janeiro, Brazil (Souza et al., 2009), and *Angiostrongylus morerae* in *Akodon azarae* (Fischer, 1829) from Buenos Aires, Argentina (Robles et al., 2008); both nematodes were found in the pulmonary arteries of their rodent hosts.

Akodon is one of the most diverse genera of rodents in Peru, with 13 species recognized to date and many others yet to be described (Pacheco et al., 2009). The helminth fauna of *A. mollis* from Peru is apparently diverse, and the finding of *A. luzsarmientae* n.g. n. sp. could be corroborating the fact of the positive coevolutionary correlation between species richness and altitude (M. Morales, pers. obs.); however, further studies are necessary to test this hypothesis.

It is possible that *A. luzsarmientae* may be a cause of mortality in populations of *A. mollis* in the Andes, because this parasite may provoke inflammation of the lung and heart vessels, interfering with the normal function of these vital organs (Figs. 10–11), as

FIGURE 11. *Akodonema luzsarmientae* n.g. n.sp. in the lungs of *A. mollis* Thomas, 1894, original magnification (20 $\times$).

has been shown with *A. morerae* in populations of *A. azarae* from Argentina (Robles et al., 2008). However, further studies are needed to demonstrate if these infections are fatal; some experimental infections with *Angiostrongylus schmidtii* were not fatal to larger hosts such as cotton rats and white rats, but they were fatal to rodents with smaller body size (Kinsella, 1987). The present study constitutes a third report of an angiostrongylid-type parasite of a small mammal in Peru and extends the host and geographical distribution of this nematode to the Peruvian Andes in South America.

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