

Distribution extension of *Aspiculuris americana* parasite of *Peromyscus difficilis* in Hidalgo, México

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As a part of an ongoing project to inventory the helminth parasites of rodents in México, 30 individuals of *Aspiculuris americana* were collected inhabiting the intestine from three specimens of the rock mouse *Peromyscus difficilis*, collected from Cerro Xihuingo, Municipality of Tepeapulco, Hidalgo State, México. This species of nematode parasite different species of the genus *Peromyscus* (*P. gossypinus*, *P. leucopus*, *P. maniculatus*, and *P. floridanus*) distributed from Yukon Territory in Canada to Florida in the United States of America. This is the first report of *Aspiculuris americana* in a Mexican endemic rodent, widening the known distribution of the species to the southern portion of the country.

Como parte de un proyecto para inventariar los parásitos helmintos de roedores en México, se recolectaron 30 individuos de *Aspiculuris americana* que parasitan el intestino de tres especímenes del ratón de las rocas *Peromyscus difficilis*, recolectados en Cerro Xihuingo, Municipio de Tepeapulco, Estado de Hidalgo, México. Esta especie de nematodo parasita diferentes especies del género *Peromyscus* (*P. gossypinus*, *P. leucopus*, *P. maniculatus* y *P. floridanus*) distribuidas desde el territorio de Yukon en Canadá hasta Florida en los Estados Unidos de América. Este es el primer informe de *Aspiculuris americana* en un roedor endémico mexicano, ampliando la distribución conocida de la especie a la parte sur del país.

Key words: Geographic distribution; helminth fauna; rodent; taxonomy.

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Introduction

The Rock Mouse, *Peromyscus difficilis* is a Mexican endemic cricetid rodent, distributed from southwestern Chihuahua and southeastern Coahuila to north-central Oaxaca, including the states of Durango, Zacatecas, San Luis Potosí, Guanajuato, México, Puebla, Hidalgo, Tlaxcala, Veracruz, and Oaxaca (Fernandez *et al.* 2010). This rodent species has been studied for helminths in México since 1990, being his helminthological record two Trematodes (*Brachylaimidae* gen. sp. and *Caballerolecythus ibunami*), five Cestodes (*Catenotaenia peromysci*, *Dilepididae* gen. sp., *Hymenolepis diminuta*, *Rodentolepis* sp., and *Taenia pisiformis*) and eight Nematodes (*Aspiculuris* sp., *Carolinensis huehuetlana*, *Syphacia* sp., *Stilestrongylus peromysci*, *Vexillata vexillata*, *Protospirura mexicana*, *Calodium hepaticum* and *Trichuris fossor*) (see García-Prieto *et al.* 2012; Falcón-Ordaz *et al.* 2015).

In Hidalgo State, the genus *Aspiculuris* Schulz, 1924 has been found parasitizing *Mus musculus* (A. cf. *Iahorica* and *A. huasacahensis*) from Metztlán and Huasca de Ocampo, and *Peromyscus difficilis* (*Aspiculuris* sp.) from Tepeapulco (Falcón-Ordaz *et al.* 2015). *Aspiculuris* are parasites of Murioidea (Rodentia); currently includes 21 nominal species (Arya 1980; Manna *et al.* 1985; Liu *et al.* 2012) distributed worldwide (Goswami *et al.* 2015). In México has been registered in *Neotoma mexicana* (García-Prieto *et al.* 2012). The main goal of this report is to add one nematode species to the helminth fauna of this host species: *Aspiculuris americana* Erickson, 1938 infecting an endemic rodent of central México.

Materials and Methods

On March 2009, three specimens of *P. difficilis* were caught under permit FAUT-0217 (issued to S. Monks) from Cerro Xihuingo (19° 48' 05.9" N, -98° 32' 30.1" W), Municipality of Tepeapulco, Hidalgo, México 2,511 masl. The collecting and processing of rodents follows the guidelines of the American Society of Mammalogists for use of wild animals in research (Kelt *et al.* 2010; Sikes and The Animal Care and Use Committee of the American Society of Mammalogists 2016). The intestine of hosts was examined for helminths under microscope; nematodes recovered were washed in 0.85 % saline solution, and fixed in 4 % hot formalin. For morphologic study, nematodes were cleared with Amman's lactophenol. All measurements are given in micrometers (µm) unless otherwise indicated. Measurements are registered as the range followed by the mean and standard deviation in parentheses. For scanning electron microscopy (SEM) study, nematodes were dehydrated in series of gradual ethyl alcohol and critical point dried with carbon dioxide. Specimens were coated with a gold-palladium mixture and examined in a Hitachi S-2460N scanning electron microscope at 15 kV. Also, we consult specialized literature and available databases of the Harold W. Mantter Laboratory (HWML), Museum of Southwestern Biology (MSB) and United States National Museum (USNM) to know the current distribution of *Aspiculuris* and its hosts. Parasite voucher specimens were deposited at Colección Nacional de Helmintos (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México (IBUNAM), México City.

Results

Aspiculuris americana. Description based on 30 specimens (13 males and 17 females) identified as *A. americana* (CNHE 10945) recovered from the caecum of one specimen of *P. difficilis*. This species is characterized by the following traits: medium size, stout nematodes. Cervical alae abruptly interrupted, forming an acute angle, ending beyond of esophageal bulb (Figure 1b). Mouth surrounded by six lips, one pair of lateral “epaulettes” with two amphids, and four labial papillae (Figure 1a). Male possesses one pairs of caudal alae (Figures 1 c, d).

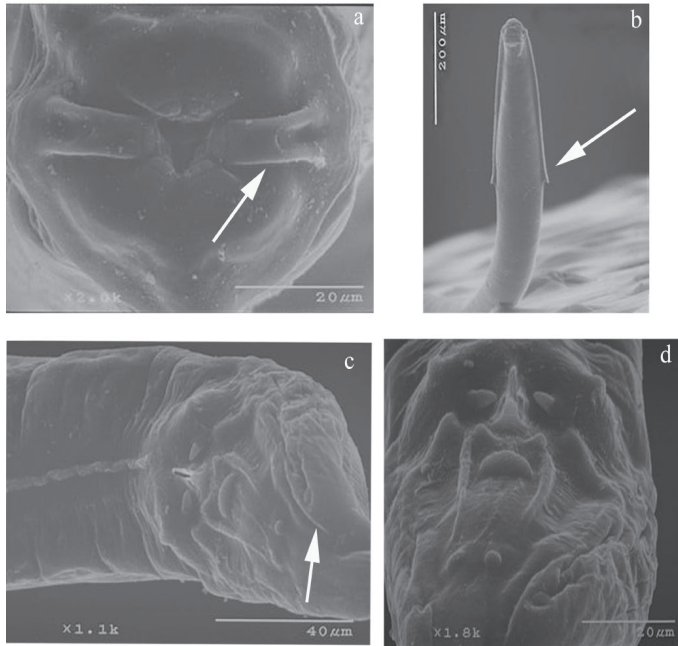


Figure 1: *Aspiculuris americana* male. a). Mouth, apical view showing the “epaulettes”. b). Anterior end, ventral view showing cervical alae. c). Posterior end view showing the caudal alae. d). Detail of caudal papillae.

Male: Cephalic inflation present. Esophagus bulb with form elliptical. Nerve ring anterior to mid-esophagus (Figure 2a). Excretory pore in the anterior third of the body. In a, cross section of the body, the cervical and lateral alae have two crest (Figure 2c) and in the middle of the body they lack alae (Figure 2d). A ventral ala is present in males, beginning at the mid-body region and ending before the cloaca (Figures 1c, 2e). The 12 caudal papillae are arranged in the following manner: one pair precloacal close to margin of cloaca, one pair of adcloacal papilliform formations, a single medial postanal closely associated with cloaca, two pairs postcloacal, followed by one single median (located between two long and straight cuticular thickenings), one subventral pair midway between cloaca and end of tail (Figures 1c, d, 2b). Measurements are given in Table 1.

Female: Cephalic inflation present. Esophagus bulb with form elliptical. Nerve ring anterior to mid-esophagus. Excretory pore in the anterior third of the body. Vulva pre-equatorial. The ovejector is directed towards the anterior region. Eggs with single thin shell without operculum. Posterior end of body terminating in straight, stiff tail. Measurements are given in Table 1.

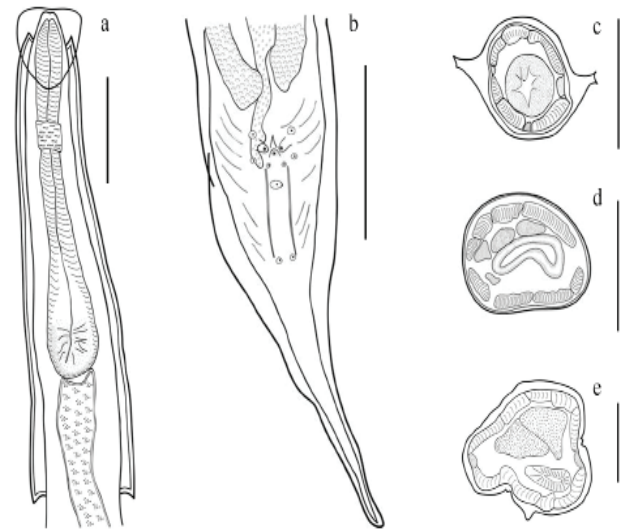


Figure 2: *Aspiculuris americana* male. a). Anterior end of male, lateral view. b). Detail of posterior end of male, arrangement of caudal papillae. Cross sections c). Mid-cervical region. d). Mid-body region. e). Precloacal region. Bar = 100 μ m.

Discussion

The genus *Aspiculuris* was appointed first as *Ascaris* to *A. tetraptera*, later Schulz in 1924 proposed the genus *Aspiculuris* with the type species *A. tetraptera* (Skrjabin et al. 1960). *Aspiculuris* was divided into two groups by Quentin (1975) based on the outline shape of the cervical alae. Members of the first group are characterized by having cervical alae that are abruptly interrupted with the posterior ends pointed and forming an acute angle toward the anterior *A. tetraptera*, *A. dinnicki*, *A. schulzi*, *A. kazakstanica*, *A. americana*, *A. lahoriga*, *A. pakistanica*, *A. tschertkowi*, *A. azerbaijanica*, *A. arianica*, *A. rysavyi*, *A. versterae*, *A. nainitalensis*, *A. bengalensis*, *A. huascaensis*, *A. tiajinensis*. In the second group, cervical alae gradually decrease its width, joining the wall-body or to the lateral alae if there, *A. asiatica*, *A. africana*, *A. ratti*, *A. witenbergi*, and *A. shikoloveta*. These species are distributed in Africa, North America, Asia and Europe, only *A. tetraptera* has a worldwide distribution (Arya 1980; Hugot 1980; Manna et al. 1985; Liu et al. 2012).

Aspiculuris americana was described by Erickson (1938) as a parasite of *Peromyscus maniculatus* and *P. leucopus* in Minnesota. Since then, this taxon has been recorded in several species of *Peromyscus* from the United States of America (Table 2). Erickson (1938), who do not justify the inclusion of the species in the genus *Aspiculuris*, only defined it by the following traits, esophagus club-shaped, thinnest immediately anterior to the elongate bulb, cervical alae terminate in a recurved margin a short distance below the level of esophageal bulb. Based on our examination of the new material from *P. difficilis* from México and the description of Erickson (1938), we determinate the following characteristics: cervical alae continuous with lateral alae, short and abruptly interrupted forming an acute angle, esophageal bulb elongate and male with tail long, slender and pointed. We also confirm that the specimens do not have a lateral alae running throughout the body, as mentioned by Akhtar (1955). When comparing the material of México

with the description of Erickson, we find that he recorded four pairs of papillae in a lateral view, one pair immediately anterior to the anus, three pairs postanal, and one pair away from the anus; we found the same pattern papillary when review our material, however, in ventral view, the specimens collected from *P. difficilis* have 12 papillae, so we consider it a new trait to *A. americana*. On the other hand, [Erickson \(1938\)](#) described the cervical alae recurved, extending below from junction esophagus-intestine 122 µm in males and 120 to 160 µm in females, without considering that cervical alae only refer to the anterior end, there-

Table 1: Measurements of *Aspicularis americana* from three species of *Peromyscus*.

Host	Erickson, 1938		This study	
	<i>P. leucopus</i> and <i>P. maniculatus</i>		<i>P. difficilis</i>	
	Male	Female	Male	Female
Length (mm)	2.25 - 2.46	3.17 - 3.88	2.40 - 3.54 (3.26 ± 0.33; n = 13)	3.55 - 5.52 (4.48 ± 0.57; n = 16)
Maximum diameter			84 - 120 (100 ± 11; n = 13)	138 - 200 (166 ± 21; n = 16)
Cephalic inflation				
Lenght			75 - 100 (86 ± 9; n = 13)	75 - 130 (104 ± 14 n = 17)
Wide			70 - 95 wide (80 ± 7; n = 13)	85 - 105 wide (96 ± 6; n = 17)
Esophagus with bulb				
Length	288	381 - 408	315 - 435 (362 ± 38; n = 13)	400 - 525 (447 ± 43; n = 15)
Esophageal bulb				
Lenght	112.5		115 - 150 (128 ± 10; n = 13)	125 - 160 (141 ± 11; n = 16)
Wide	48.5	64	50 - 70 (57 ± 6; n = 13)	56 - 85 (74 ± 8; n = 14)
Nerve ring		217	94 - 119 (107 ± 9; n = 13)	100 - 175 (132 ± 17 n = 15)
Excretory pore			665 - 728 (693 ± 26; n = 6)	835 - 975 (887 ± 77; n = 3)
Cervical alae and lateral alae				
Beginning			34 - 44 (38 ± 5; n = 6)	31 - 54 (41 ± 8; n = 12)
Lenght			415 - 575 (490 ± 44; n = 11)	470 - 454 (504 ± 20; n = 12)
Lateral alae				
Lenght	122	120 - 160	100 - 228 (145 ± 42; n = 10)	81 - 213 (119 ± 35; n = 11)
Caudal alae				
Lenght			100 - 169 (124 ± 22; n = 11)	
Vulva (mm)		1.25 - 1.45		1.632 - 2.200 (1.859 ± 0.166; n = 9)
Ovejector				106 - 156 (132 ± 21; n = 5)
Anus		656 - 741	210 - 265 (241 ± 17; n = 13)	850 - 950 (892 ± 52; n = 3)
Eggs				
Lenght		76 - 83		69 - 85 (79 ± 5; n = 17)
Wide		27 - 35		25 - 41 (32 ± 3; n = 17)

Table 2: Current distribution of *Aspicularis americana*.

Host	Locality	Reference
<i>Peromyscus gossypinus</i>	12 km south of Lake Placid, Highlands Co., Florida	Kinsella 1991
<i>P. leucopus</i>	Allegany Co., Maryland	Lichtenfels and Haley 1968
	St. Paul, Minnesota	Erickson 1938; HWML:Para: 21838, 21839
	Pennsylvania	Behnke 2015
	Mountain Lake Biological Station, Virginia	Walsh 2013
	Pembroke, Mountain Lake Biological Station, Virginia	USNM 1365217
<i>P. maniculatus</i>	Virginia	USNM 1365205
	Pine Co., Minnesota	Erickson 1938
	Minnesota	HWML: 21851, 21852, 21865, 21866, 21877, 21901, 21902
	Deuel, Co., Nebraska	USNM 1371217
<i>Peromyscus</i> sp.	Nebraska	HWML: 31648, 37276
	Great Basin Desert, Juab County, Utah	USNM 1397713
	Mountain Lake Biological Station, Virginia	Walsh 2013
<i>Peromyscus</i> sp.	¼ mi W Lake LaBerge, Yukon Territory, Canada.	MSB:24831
	Burns Road, Whitehorse, Yukon Territory, Canada	MSB: 24847
<i>Podomys floridanus</i>	12 km south of Lake Placid, Highlands Co., Florida	Kinsella 1991
	7 and 10 mi NW Gainesville	USNM: 1353396, 1353399

HWML: Harold W. Manter Laboratory of Parasitology; MSB: Museum of Southwestern Biology; USNM: United States National Museum.

fore, these measures correspond to the lateral alae; while in the Mexican specimens the lateral alae extending of the junction esophagus-intestine 100 to 228 and 81 to 213 in male and female respectively.

Our research suggests that *A. americana* is an oioxenus and monoxenus parasite of rodents of the genus *Peromyscus* with six species parasitized (Table 2), which would also show that the host-parasite relationship is ancestral, according to host phylogenetic ([Bradley et al. 2007](#)). Finally, the present study provides the first report of *A. americana* in an endemic rodent from México, expanding the known distribution range of the species south of the country.

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Literature cited

AKHTAR, S. A. 1955. On nematode parasites of rats and mice of Lahore, with some remarks on the genus *Aspicularis* Schulz, 1924 and two new species of the genus. Pakistan Journal of Scientific Research 7:104–111.

- ARYA, S. N. 1980. A new species of the genus *Aspiculuris* (Nitzsch, 1821) Schulz, 1924 from the common house rat, *Rattus rattus* of Nainital, India (Nematoda). *Revista Brasileira de Biologia* 4:747–749.
- BEHNKE, J. M., A. STEWART, A. BAJER, M. GRZYBECK, P. D. HARRIS, A. LOWE, A. RIBAS, L. SMALES, AND K. J. VANDERGRIFT. 2015. Bank voles (*Myodes glareolus*) and house mice (*Mus musculus*; *M. m. domesticus*) in Europe are each parasitized by their own distinct species of *Aspiculuris* (Nematoda, Oxyurida). *Parasitology* 142:1493–1505.
- BRADLEY, R. D., N. D. DURISH, D. S. ROGERS, J. R. MILLER, M. D. ENGSTROM, AND W. KILPATRICK. 2007. Toward a molecular phylogeny for *Peromyscus*: evidence from mitochondrial cytochrome-b sequences. *Journal of Mammalogy* 88:1146–1159.
- ERICKSON, A. B. 1938. Parasites of some Minnesota Cricetidae and Zapodidae and a host catalogue of helminth parasites of native American mice. *American Midland Naturalist* 20:575–589.
- FALCÓN-ORDAZ, J., S. MONKS, G. PULIDO-FLORES, L. GARCÍA-PRIETO, AND G. LIRA-GUERRERO. 2015. Riqueza de helmintos parásitos de vertebrados silvestres del estado de Hidalgo, México. Pp. 20–37 in *Estudios en Biodiversidad Volumen I*. (Pulido-Flores, G., S. Monks y M. López-Herrera, eds.). Zea Books. Lincoln, U. S. A.
- FERNÁNDEZ, J. A., F. GARCÍA-CAMPUSANO, AND M. S. HAFNER. 2010. *Peromyscus difficilis* (Rodentia, Cricetidae). *Mammalian Species* 42:220–229.
- GARCÍA-PRIETO, L., J. FALCÓN-ORDAZ, AND C. GUZMÁN-CORNEJO. 2012. Helminth parasites of wild mexican mammals: list of species, hosts and geographical distribution. *Zootaxa* 3290:1–92.
- GOSWAMI, U., A. CHAUDHARY, C. VERMA, AND H. S. SINGH. 2015. First molecular characterization of *Aspiculuris tetraptera* (Nematoda: Heteroxynematidae) from *Mus musculus* (Rodentia: Muridae) in India. *Acta Parasitologica* 60:553–556.
- HUGOT, J. P. 1980. Sur le genre *Aspiculuris* Schulz, 1924 (Nematoda, Heteroxynematidae), Oxyures parasites de Rongeurs Muroidea. *Bulletin du Museum National d'Histoire Naturelle*, Paris 2:723–735.
- KELT, D. A., M. S. HAFNER, AND THE AMERICAN SOCIETY OF MAMMALOGISTS' AD HOC COMMITTEE FOR GUIDELINES ON HANDLING RODENTS IN THE FIELD. 2010. Updated guidelines for protection of mammalogists and wildlife researchers from hantavirus pulmonary syndrome (hps). *Journal of Mammalogy* 91:1524–1527.
- KINSELLA, J. M. 1991. Comparison of helminthes of three species of mice, *Peromyscus floridanus*, *Peromyscus gossypinus*, and *Peromyscus polionotus*, from southern Florida. *Canadian Journal of Zoology* 69:3078–3083.
- LICHTENFELS, J. R., AND A. J. HALEY. 1968. New host records of intestinal nematodes of Maryland rodents and suppression of *Capillaria bonnevilliei* Grundman and Frandsen, 1960 as a synonym of *C. americana* Read, 1949. *Proceedings of the Helminthological Society of Washington* 35:206–211.
- LIU, B., Y. BU, AND L. ZHANG. 2012. A new species of *Aspiculuris* Schulz, 1924 (Nematoda, Heteroxynematidae) from the gray-sided vole, *Clethrionomys rufocanus* (Rodentia, Cricetidae), from Tianjin, China. *Acta Parasitologica* 57:311–315.
- MANNA, B., C. DATE, AND S. DEY. 1985. On a new species of the genus (*Aspicularis paraspicularis*) from white mice *Mus musculus*. *Indian Animal Health* 24:1–3.
- QUENTIN, J. C. 1975. Essai de classification des Oxyures Heteroxynematidae. *Memoires du Museum National d'Histoire Naturelle, Zoologie* 94:51–96.
- SIKES, R. S., AND THE ANIMAL CARE AND USE COMMITTEE OF THE AMERICAN SOCIETY OF MAMMALOGISTS. 2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy* 97:663–688.
- SKRJABIN, K. I., N. P. SCHIKHOBALOVA, AND E. A. LAGODOVSKAJA. 1960. *Oxyurata of Animals and Man. Part one. Oxyuroidea*. Izdatel'stvo Akademii Nauk SSSR, Moskva. Translated from Russian, Israel Program for Scientific Translation, Jerusalem, Israel.
- WALSH, P. T., E. MCCRELESS, AND A. B. PEDERSEN. 2013. Faecal avoidance and selective foraging: do wild mice have the luxury to avoid faeces? *Animal Behaviour* 86:559–566.

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