



New species of *Aspiculuris* (Nematoda: Heteroxynematidae), parasite of *Mus musculus* (Rodentia: Muridae), from Hidalgo, Mexico

Una nueva especie de *Aspiculuris* (Nematoda: Heteroxynematidae), parásito de *Mus musculus* (Rodentia: Muridae), de Hidalgo, México

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Abstract. *Aspiculuris huascaensis* n. sp. was found in the intestine of *Mus musculus* collected from 2 localities in Hidalgo, Mexico, and is described herein. The new species possesses cervical alae abruptly interrupted at mid-length of esophageal bulb form an acute angle, distinguishing it from 5 of the 17 species in the genus. The new species is differentiated from 11 of the remaining species by having cervical alae that form an acute angle and end at mid-length of the esophageal bulb. *Aspiculuris huascaensis* n. sp. most closely resembles *A. tetraptera* in the position of the terminal end of the cervical alae. However, the new species can be distinguished from that species by the number of caudal papillae (12 vs. 14), the presence of a sessile precloacal papilla between 2 cuticular folds, and by having a single pedunculate papilla located slightly posterior to the cloaca.

Key words: *Aspiculuris huascaensis* n. sp., *Mus musculus*, Mexico, Hidalgo.

Resumen. Se describe una especie nueva, *Aspiculuris huascaensis* n. sp., proveniente del intestino de *Mus musculus* de 2 localidades de Hidalgo, México. Esta especie cuenta con 1 ala cervical interrumpida abruptamente formando un ángulo agudo; con base en este carácter, la especie nueva se distingue de 5 de las 17 especies que contiene el género. De 11 especies más, *A. huascaensis* n. sp. se diferencia por el ángulo agudo que forma el ala cervical y porque ésta finaliza a la mitad de la longitud del bulbo esofágico. *Aspiculuris huascaensis* n. sp. se asemeja a *A. tetraptera* por la terminación del ala cervical. Sin embargo, puede distinguirse de dicha especie por el número de papilas caudales (12 vs. 14), por la presencia de una papila precloacal sésil entre 2 pliegues cuticulares y por una papilla sencilla detrás de la cloaca.

Palabras clave: *Aspiculuris huascaensis* n. sp., *Mus musculus*, México, Hidalgo.

Introduction

The diversity of helminths parasitizing rodents of Hidalgo, Mexico, is relatively unknown. To date, 27 helminth species parasitizing 8 hosts species have been recorded (Carmona, 1994; Falcón-Ordaz and Sanabria-Espinoza, 1995, 1996, 1999; Pulido-Flores et al., 2005; García-Prieto et al., 2008) (see Table 1), but specimens of *Mus musculus* Linnaeus, 1758, collected recently from the region of Huasca de Ocampo, Hidalgo, were found to harbor a previously unknown species of *Aspiculuris* Schultz, 1924. That species is described herein.

Materials and methods

Eighteen individuals of *Mus musculus*, 3 of *Rattus rattus* (Linnaeus, 1758), 3 of *R. norvegicus* (Berkenhout, 1769), 1 of *Reithrodontomys fulvescens* Allen, 1894, and 1 of *Peromyscus* sp. were collected from Cerro del Tezontle and 11 individuals of *M. musculus* were collected from San Juan Hueyapan, Huasca de Ocampo, Estado de Hidalgo, México, in July 2003 using small Sherman traps with various types of bait. Animals were transported alive to the laboratory in the traps and killed by an overdose of ether. The digestive tract (from lower esophagus to anus) was removed and examined for helminths. Three individuals of *M. musculus* from Cerro del Tezontle and 1 from San Juan Hueyapan were infected with an undescribed species of *Aspiculuris*. Worms were fixed according to standard practices (Pritchard and Kruse, 1982): nematodes were killed

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Table 1. Helminth parasites of rodents in the Hidalgo State. Parasite-Host list

Helminth species	Host species	Locality (Municipality)	References
Cestoda			
<i>Catenotaenia peromysci</i> Smith, 1954; <i>Hymenolepis diminuta</i> (Rudolphi, 1819); <i>H. horrida</i> (Von Linstow, 1901); <i>Taenia pisiformis</i> (Bloch, 1970) and <i>Vampirolepis</i> sp.; <i>V. nana</i> (Siebold, 1852).	<i>Peromyscus difficilis</i>	Atotonilco el Grande	Carmona (1994)
<i>Railletina</i> (<i>R.</i>) <i>baeri</i> Meggitt and Subramanian, 1927; <i>Vampirolepis</i> sp.	<i>P. difficilis</i>	Huehuetla	Carmona (1994)
<i>Taenia multiceps</i> (Leske, 1780).	<i>P. leucopus</i>	Atotonilco el Grande	Carmona (1994)
<i>Taenia</i> sp. Linnaeus, 1758.	<i>P. maniculatus</i>	Tulancingo	Pulido-Flores et al. (2005)
<i>R.</i> (<i>R.</i>) <i>baeri</i>	<i>Liomys irroratus</i>	Huehuetla	Carmona (1994)
<i>Rodentolepis nana</i> (von Siebold, 1852).	<i>Mus musculus</i>	Metztitlan	Pulido-Flores et al. (2005)
<i>Taenia taeniaeformis</i> Batsch, 1786.	<i>Rattus rattus</i>	Metztitlan	Pulido-Flores et al. (2005)
Nematoda			
<i>Protospirura mexicana</i> Falcon-Ordaz and Sanabria-Espinoza, 1995;	<i>P. difficilis</i>	Huehuetla	Falcon-Ordaz and Sanabria-Espinoza (1995, 1996 and 1999)
<i>Carolinensis huehuetlana</i> Falcon-Ordaz and Sanabria-Espinoza, 1996 and	<i>P. difficilis</i> and <i>Liomys</i>	Huehuetla	Falcon-Ordaz and Sanabria-Espinoza (1997)
<i>Stilestrongylus peromysci</i> Falcon-Ordaz and Sanabria-Espinoza, 1999.	<i>Peromyscus</i> sp.	Atlapexco	Falcon-Ordaz and Sanabria-Espinoza (1999)
<i>Vexillata vexillata</i> (Hall, 1916).	<i>P. maniculatus</i>	Tulancingo	Pulido-Flores et al. (2005)
<i>Stilestrongylus hidalguensis</i> Falcon-Ordaz and Sanabria-Espinoza, 1999.	<i>Mus musculus</i>	Metztitlan	Pulido-Flores et al. (2005)
<i>Capillaria gastrica</i> Baylis, 1926; <i>Carolinensis carolinensis</i> (Dikmans, 1935) and <i>Syphacia peromysci</i> Harkema, 1936.	<i>Rattus rattus</i>	Metztitlan	Pulido-Flores et al. (2005)
<i>Aspiculuris</i> sp. cf. <i>lahorica</i> Akhtar, 1955; <i>Gongylonema</i> sp. Molin, 1957;	<i>Perognathus flavus</i>	Ajacuba	Garcia-Prieto et al. (2008)
<i>Syphacia obvelata</i> (Rudolphi, 1802); <i>Trichinella</i> sp. Railliet, 1895 and			
<i>Trichuris muris</i> Schrank, 1788.			
<i>Nippostrongylus brasiliensis</i> Travassos, 1914 and <i>Syphacia muris</i> (Yamaguti, 1935).			
<i>Heteromyoxuris otomii</i> Garcia-Prieto, Falcon-Ordaz, Lira-Guerreo, Mendoza-Garfias, 2008.			

in Berland's solution, preserved in 70% alcohol, and cleared with glycerol for study in temporary mounts. *En face* preparations and cross sections of the anterior, middle, and posterior regions were made and mounted for examination. For scanning electron microscopy (SEM), nematodes were dehydrated in a graduated series of alcohol, critical-point-dried, coated with a gold-palladium mixture and examined in a Hitachi S-2460N scanning electron microscope at 15 kV. Type and voucher specimens were deposited in the Colección Nacional de Helmintos (CNHE), Universidad Nacional Autónoma de México, Mexico City, the Harold W. Manter Laboratory of Parasitology (HWML), University of Nebraska-Lincoln, Nebraska, and the Colección de Helmintos, Universidad Autónoma del Estado de Hidalgo (CHE). Drawings and measurements were made using a Zeiss microscope equipped with a drawing tube. Measurements are given in micrometers (μm) unless otherwise indicated; range is followed by the mean, standard deviation, and sample size (n) in parentheses. Measurements of holotype and allotype are in brackets.

Description

Aspiculuris huascaensis n. sp. (Figs. 1A-D, 2A-H, 3A-D)

General: Medium size, stout nematodes. Cervical alae abruptly interrupted at mid-length of esophageal bulb, forming an acute angle (Fig. 1, 14). Males possess 3 pairs of caudal ale.

Male: Based on 13 mature specimens. Length 2.16-2.69 mm (2.48 ± 0.172 mm; n = 11) [2.45 mm]; width 78-114 (96 ± 10 ; n = 12) [78] at midbody. Cephalic inflation 39-69 long (58 ± 10 ; n = 11) [60] by 54-75 wide (65 ± 8 ; n = 11) [60]. Esophagus with bulb 291-294 (272 ± 13 ; n = 12) [270] long; esophageal bulb 90-110 (97 ± 6 ; n = 12) [96] long, 40-63 (51 ± 6 ; n = 12) [48] wide. Distance from anterior end to nerve ring 72-93 (80 ± 8 ; n = 9) [66]; to excretory pore 495-579 (545 ± 35 ; n = 4) [492]. Cervical alae begin 12-24 (18 ± 5 ; n = 14) [21] from anterior end, 180-246 (208 ± 20 ; n = 10) [189] long. Cloaca to tip of tail 75-114 (102 ± 13 ; n = 10) [99]. Length to pre-cloacal alae 105-156 (131 ± 20 ; n = 8) [150]; to post-cloacal alae 48-96 (67 ± 20 ; n = 5) [60]; to caudal alae 42-45 (45 ± 10 ; n = 6) [36]. The 12 caudal papillae are arranged as follows: single sessile precloacal papillae between 2 cuticular folds (not observed easily using light microscopy), 1 pair precloacal close to margin of cloaca, 1 pair of adcloacal papilliform formations, 2 pairs pedunculate and postcloacal, a single pedunculate papillae follows immediately, 1 subventral pair midway

between cloaca and end of tail (Fig. 1B, 3C, 3D).

Female: Based on 15 mature specimens. Length 3.024-3.528 mm (3.219 ± 0.150 mm; n = 14) [3.332 mm]; width 99-153 (120 ± 16 ; n = 14) [126] at midbody. Cephalic inflation 60-90 long (74 ± 7 ; n = 14) [72] by 69-84 wide (76 ± 3 ; n = 14) [75]. Esophagus length 312-351 (322 ± 12 ; n = 14) [324]; esophageal bulb 90-111 (103 ± 5 ; n = 14) [108] long, 54-87 (63 ± 8 ; n = 14) [60] wide. Distance from anterior end to nerve ring 81-105 (93 ± 7 n = 11) [105], to excretory pore 555-675 (590 ± 38 ; n = 10) [624]. Cervical alae begin 12-30 (18 ± 5 ; n = 10) [18] from anterior end; with a length of 213-255 (235 ± 10 ; n = 14) [249]. Vulva pre-equatorial, opening 1.204-1.428 mm (1.269 ± 0.066 ; n = 14) [1.302 mm] from anterior end. Ovejector 144-195 (170 ± 15 ; n = 12) [159] long. Distance from caudal extremity to anus 330-372 (358 ± 16 ; n = 14) [372]. Eggs 54-69 (61 ± 3 ; n = 50) long by 18-30 (22 ± 3 ; n = 50) wide; eggs of allotype 60-69 (64 ± 2 ; n = 6) long by 18-21 (20 ± 2 ; n = 6) wide.

Taxonomic summary

Type material: holotype CNHE 6935 (male), Allotype CNHE-6936 (female), Paratypes CNHE-6937 and HWML-64565.

Type-host: *Mus musculus* Linnaeus, 1758.

Site: ceacum.

Prevalence and intensity: 3 of 18 (17%) individuals of *M. musculus* from the type locality (Cerro del Tezontle), infected with 84 nematodes, and 1 of 11 (9%) from San Juan Hueyapan infected with 2 nematodes.

Type-locality: Cerro del Tezontle ($20^{\circ}15'47.40''$ N; $98^{\circ}30'59.71''$ W; elevation = 2 072 m), Huasca de Ocampo, Hidalgo.

Other locality: San Juan Hueyapan ($20^{\circ}14'11.49''$ N; $98^{\circ}32'04.42''$ W; elevation = 2 077 m), municipality of Huasca de Ocampo, Hidalgo.

Etymology: the name of new species is in reference to the municipality of the type locality.

Remarks

The genus *Aspiculuris*, characterized by possessing 3 pairs of alae in the tail of male specimens, currently encompasses 17 species (Hugot, 1980; Inglis et al., 1990). Quentin (1975) separated the members of the genus into 2 groups 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* (Nitzsch, 1821); *A. dinnicki* Schulz, 1927, *A. schulzi* Popov and Nasarova, 1930; *A. kazakstanica* Nasarova and Sweschikova, 1930; *A. americana* Erickson, 1938; *A. lahorica* Akhtar, 1955; *A. pakistanica* Akhtar, 1955; *A. tschertkowi* Tarzhimanova, 1969; *A. azerbaijanica* Tarzhimanova, 1969 *A. arianica* Kotrla and Daniel, 1970; *A. rysavyi* Kotrla and Daniel, 1970; *A.*

versterae Hugot, 1980]. In the second group, the posterior end of the cervical alae is rounded at the level of the esophageal bulb and not pointed, but gradually tapering posteriorly without forming an acute angle; in accordance with Quentin (1975), this group is constituted by *A. ackerti* Kruideneiner and Mehra, 1959, *A. asiatica* Schulz, 1927, *A. africana* Quentin, 1966, *A. ratti* Johnston, 1970, *A. witenbergi* Quentin, 1975, and *A. shikoloveta* Inglis, Harris and Lewis, 1990. However, *A. ackerti* [considered *species*

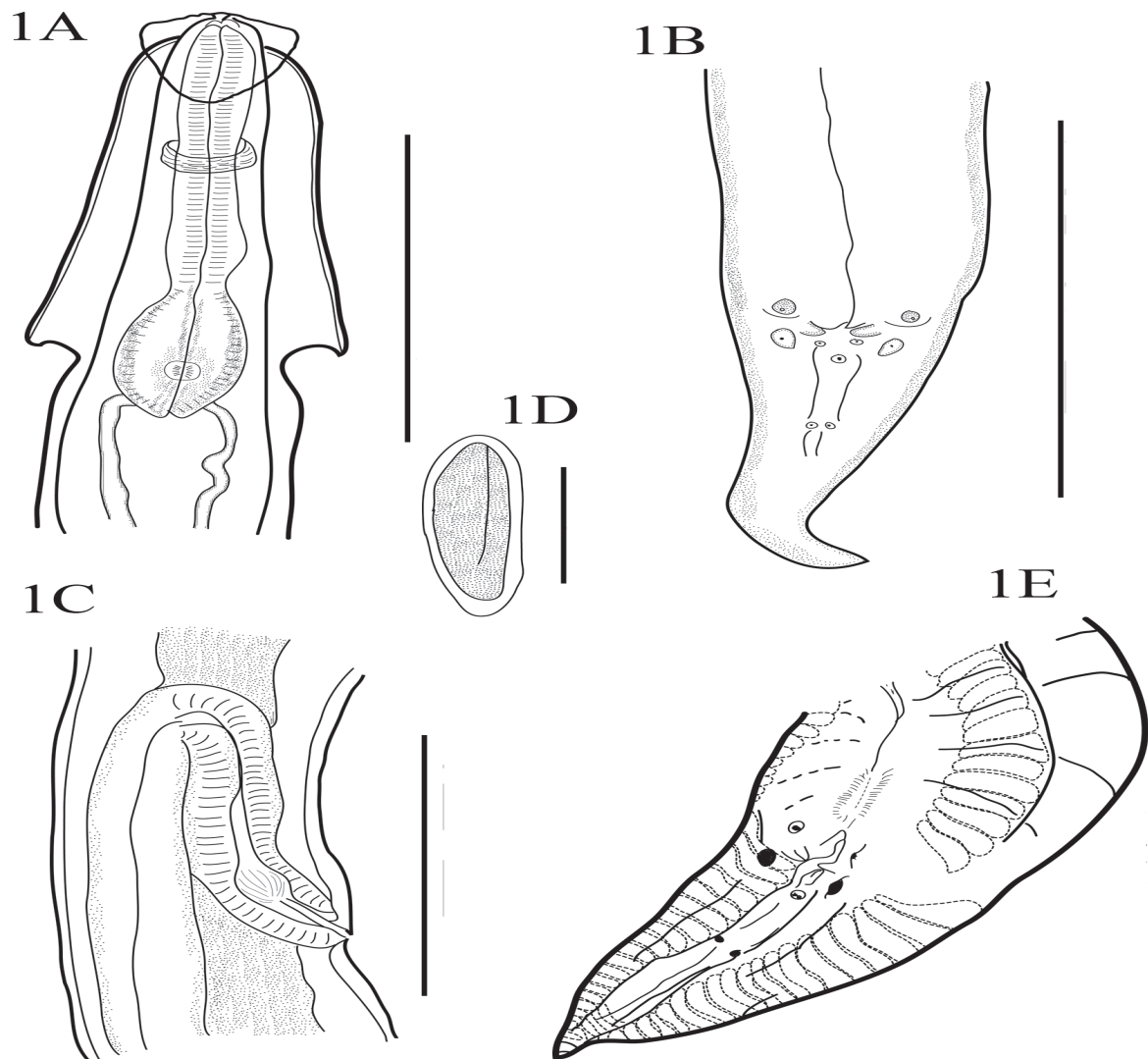


FIGURE 1 A-E. *Aspiculuris huascaensis* n.sp. A. Anterior end of male, lateral view. Bar = 250 μ m. B. Detail of posterior end of male, arrangement of caudal papillae. Bar = 200 μ m. C. Ovejector region. Bar = 200 μ m. D. Egg. Bar = 50 μ m. *Aspiculuris tetraptera* E. Detail of posterior end of male, arrangement of caudal papillae (after Hugot, 1980). Bar = 100 μ m.

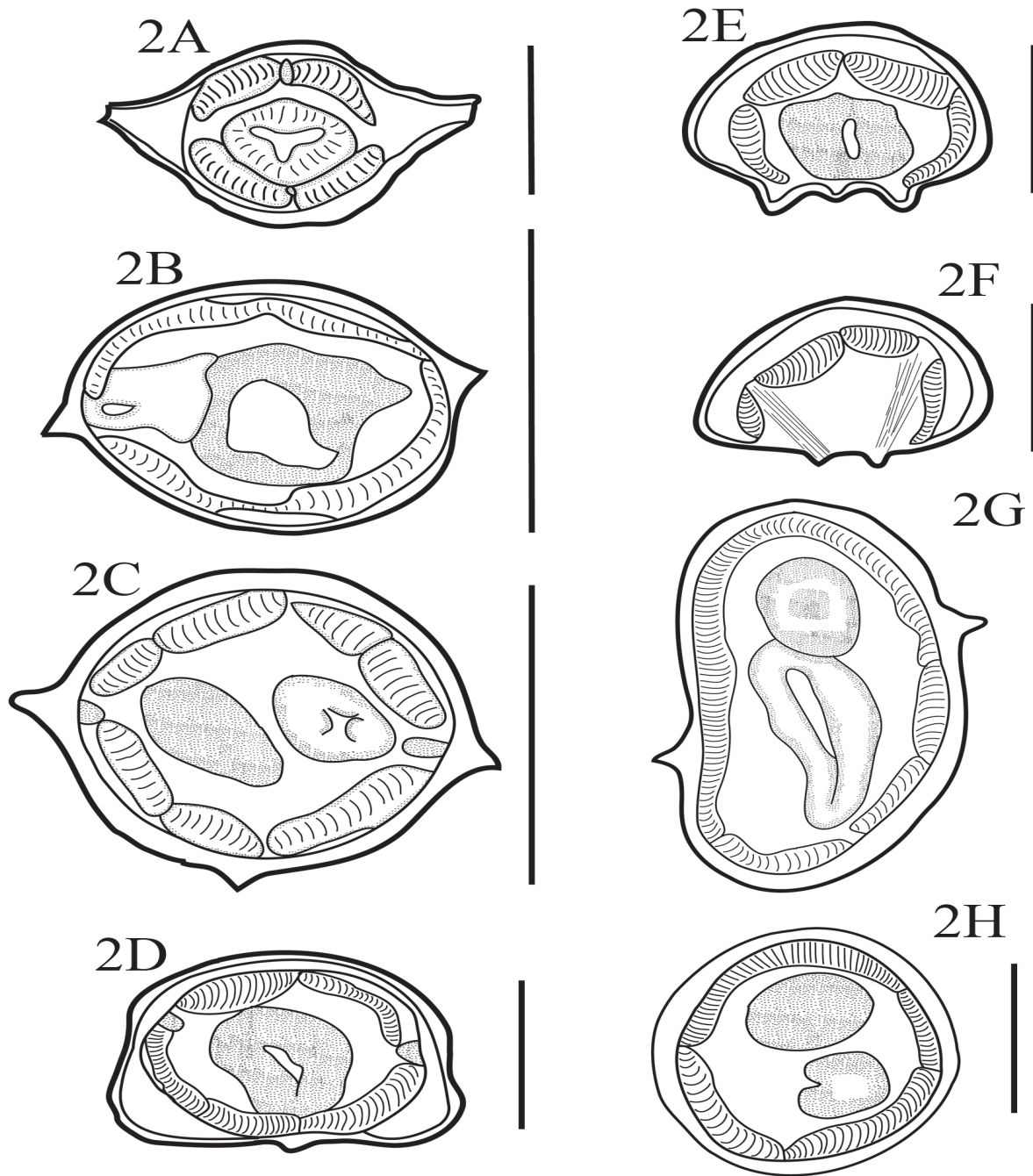


FIGURE 2 A-H. *Aspiculuris huascaensis* n.sp. Male, cross section A. Mid-cervical ale. Bar = 50 µm. B. Junction esophageal bulb-intestine. Bar = 100 µm. C. Mid-body region. Bar = 100 µm. D. Precloacal region. Bar = 50 µm. E. Postcloacal region. Bar = 50 µm. F. Caudal region. Bar = 50 µm. Female, cross section. G. Mid-body region. Bar = 100 µm. H. Caudal region. Bar = 50 µm.

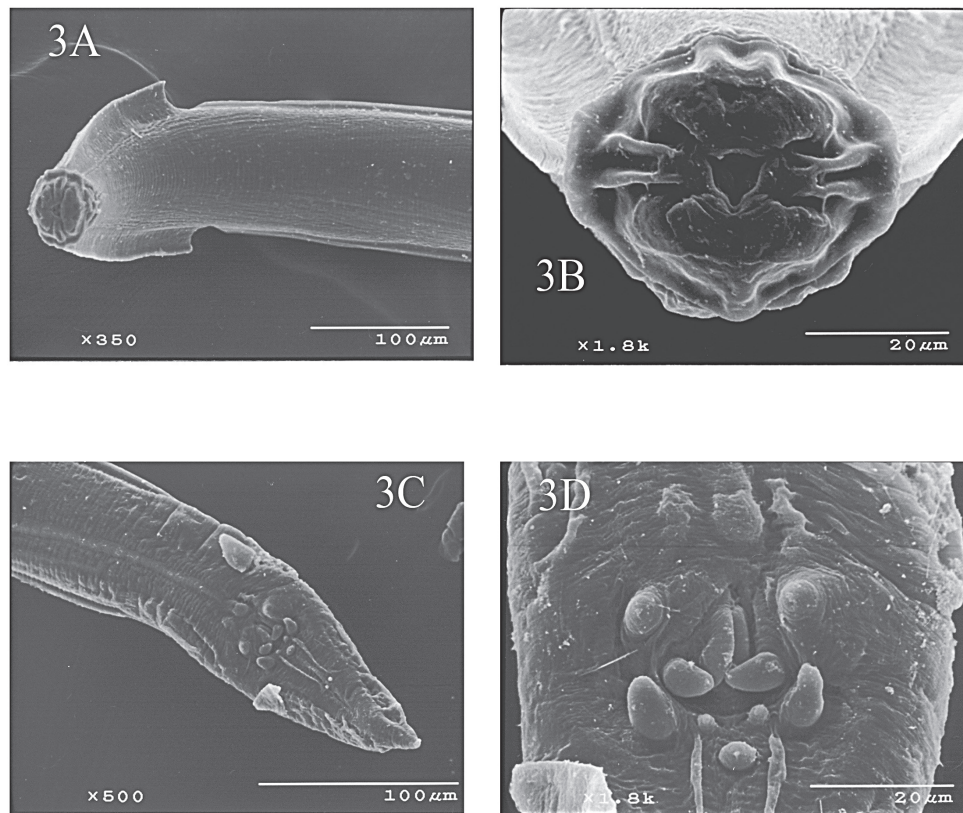


FIGURE 3 A-D. *Aspiculuris huascaensis* n.sp. Male A. Anterior end, ventral view. B. Mouth, apical view. C. Posterior end, ventral view. D. Cloacal papillae.

dubium by Hugot (1980) and Inglis et al., (1990)] recently was transferred to the new genus *Lamotheoxyuris* by Falcón-Ordaz et al. (2010).

The new species most closely resembles to the species included in the first group by having cervical alae abruptly interrupted. However, it differs from *A. americana*, *A. lahorica*, *A. pakistanica*, *A. tschertkowi*, *A. rysavyi*, and *A. versterae* because the posterior end of the cervical alae of those species do not form an acute angle (present in the new species); in addition, with exception of *A. tschertkowi* that have 16 caudal papillae, the remaining 5 species have a smaller number of papillae than *A. huascaensis*, varying from 7 to 10 vs. 12 papillae (Erickson, 1938; Akhtar, 1955; Yamaguti, 1961; Erhadová-Kotrlá and Daniel, 1970; Hugot, 1980; Miller and Schmidt, 1982). *Aspiculuris huascaensis* n. sp. can be distinguished from *A. azerbaijanica*, *A. dinnicki*, and *A. kazakstanica* because the cervical alae in these species extend to the esophagus-intestine junction, while in the new species cervical alae are abruptly interrupted at mid-length of esophageal

bulb level; likewise, the number of caudal papillae of *A. kazakstanica* and *A. dinnicki* is smaller than in *A. huascaensis* (7,10, and 12 papillae, respectively). Males of *A. azerbaijanica* are unknown. Finally, *A. schulzi* and *A. arianica* can be distinguished of the new species by the extent of the cervical alae (ending anterior to the esophageal bulb in those species vs. reaching the middle of the esophageal bulb level in the Mexican specimens) and by having a smaller number of caudal papillae (7, 10 and 12, respectively) (Erhadová-Kotrlá and Daniel, 1970; Skjabin et al. 1960; Miller and Schmidt, 1982).

Aspiculuris huascaensis n. sp. most closely resembles *A. tetraptera* by having cervical alae ending at mid-length of the esophageal bulb. However, the new species can be distinguished from *A. tetraptera* by the number of caudal papillae (12 vs. 14, respectively). In addition, *Aspiculuris huascaensis* n. sp. have a single sessile precloacal papilla located between 2 cuticular folds and slightly anterior to the cloaca, whereas *A. tetraptera* lack both the sessile precloacal papilla and the 2 cuticular folds. In addition,

males of the new species lack a medial papilla (double) associated with the cloaca and those of *A. tetraptera* have a double pedunculate papilla immediately posterior to the cloaca. Finally, in the new species, the anteriormost papilla located between the caudal folds of the tail is simple and that of males of *A. tetraptera* is double (Fig. 1B, 1E, 3C, 3D) (Skjabin et al. 1960; Hugot, 1980).

Discussion

The state of Hidalgo, Mexico, is located at the intersection of the “Eje Neovolcánico” and the “Sierra Madre Oriental”, a region characterized by extreme variation in local ecological systems and a high diversity of flora and fauna that was produced by geographic isolation of local populations. No rigorous biogeographic study has been performed with the helminths of rodents, but several authors have suggested that helminths of rodents could be relatively diverse and contain Neotropic, Nearctic, and Mexican transition zone components (Falcón-Ordaz and Sanabria-Espinoza, 1995, 1996, 1999; Pulido-Flores et al., 2005). The knowledge of helminths of rodents of Hidalgo is still far from complete, but previous studies have failed to report *A. huascaensis* n. sp. from the few other regions of the state that have been studied (Falcón-Ordaz and Sanabria-Espinoza, 1995, 1996, 1999; Pulido-Flores et al., 2005). However, the finding of this new species only in animals collected from a restricted locality lends support to that hypothesis since it appears to be a geographically isolated local population.

It is also noteworthy that this new species has been found only in an introduced species of host and not in any of the other native species present in Hidalgo (Falcón-Ordaz and Sanabria-Espinoza, 1995, 1996, 1999; García-Prieto et al., 2008). It also was not found in other individuals of *M. musculus* that had been collected in previous studies of helminths of rodents from Hidalgo, although, if the hypothesis that helminths of the region occur in isolated populations is correct, more extensive collections from unstudied localities are necessary before this suggested trend could be evaluated and interpreted.

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