Aspidoderidae from North America, with the Description of a New Species of *Aspidodera* (Nematoda: Heterakoidea)

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ASPIDODERIDAE FROM NORTH AMERICA, WITH THE DESCRIPTION OF A NEW SPECIES OF ASPIDODERA (NEMATODA: HETERAKOIDEA)

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ABSTRACT: Aspidodera sogandarensis n. sp. (Heterakoidea: Aspidoderidae) from Dasypus novemcinctus Linnaeus, 1758 is herein described. This nematode occurs in armadillos from as far south as the canal zone of Panama, north through central Mexico, and into the southern United States. Previously identified as Aspidodera fasciata (Schneider, 1866), this new species has blunt projections on the lips and lateral expansions at the distal tips of the spicules, whereas A. fasciata has conspicuous digitiform projections on the lips, and a terminal round expansion at the tips of the spicules. Other species of the family present in North America include Aspidodera binansata Railliet and Henry, 1913; Aspidodera vazi Proença, 1937; and Lauroia trinidadensis Cameron, 1939.

The Aspidoderidae, Skrjabin and Schikhabalova, 1947 (Ascaridida: Heterakoidea) currently includes 16 species divided among 4 genera. The worms occur in the cecum and large intestine of mammals with southern Neartic and general Neotropical distributions. The known host range for species in the family includes xenarthrans, didelphiomorphs, and hystrogonath and sigmodontine rodents.

Five species of the family have been recorded from armadillos north of the Isthmus of Panama, including Mexico and the United States (Chandler, 1946; Caballero, 1955; Flores-Barroeta, 1956); in opossums from Guatemala, Mexico, Panama, and the United States (Chandler, 1932; Foster, 1939; Caballero and Cerecero, 1944; Aldes, 1995); and in hystrogonath and geomyid rodents from the United States, Mexico (Lamothe-Ar-gumedo et al., 1997), and Central America. Species recorded include Aspidodera fasciata (Schneider, 1866) Railliet and Henry, 1913; Aspidodera raillieti Travassos, 1913; Lauroia dasypi Caballero, 1955; Lauroia intermedia Flores-Barroeta, 1956; and Paraspisodera uncinata (Rudolphi, 1819) Travassos, 1914.

Species assignable to Aspidodera Railliet and Henry, 1912 are diagnosed by the distinctive structure of the “hood” on the anterior-most end of the nematode, which has recurrent grooves covered by a cuticle; these structures are known as the cordons (Inglis, 1957). Characters used in combination to identify these nemas to the level of the species include the cordons, the shape and length of the spicules, the shape of the spinneret, and the number of caudal papillae (Santos et al., 1990). Herein, we describe a new species of Aspidodera and present 3 new records of Aspidodera in Central and North America.

MATERIALS AND METHODS

Thirteen nine-handed (or long-nosed) armadillos, Dasypus novem-cinctus Linnaeus, 1758, were collected from 2001 through 2003 in Mexico and the United States (Fig. 1). Armadillos were obtained from local hunters and as road-kills in Morelos, Nayarit, Oaxaca, Veracruz, Florida, and Texas. Some specimens were captured alive and killed with chloroform in the field. Additional specimens collected from armadillos in the United States and Panama were borrowed from the United States National Parasite Collection (USNPC).

For this study, the large intestine was opened, washed in water, and aliquots were examined with a dissecting microscope. Nematodes found were washed in water and immediately placed in 9% physiological saline prior to killing. Separate aliquots or samples of individual parasites were killed either in glacial acetic acid, 70% ethanol, or 10% formalin. Specimens were stored in either 70% ethanol or 10% formalin. Some specimens collected alive were washed in 9% saline solution and preserved in 15% ethanol for later study using molecular methods. Note that these specimens are deposited in the Harold W. Manter Laboratory of Parasitology (HWML) and will be available for DNA sequencing, and can be requested by referencing the HWML number. For examination via light microscopy, specimens fixed as above were cleared in lactophenol, mounted on a slide under a No. 1 coverslip, and studied with a light microscope. Specimens were identified using published descriptions and by direct comparison with type specimens. Specimens prepared for scanning electron microscopy (SEM) were treated with osmium-thiocarbohydrazide-osmium-thiocarbohydrazide-oxide (OTOTO), dehydrated in 100% ethanol, dried to a nonliquid state by critical-point drying using CO2, attached to an SEM stub, and sputter coated with gold palladium.

Specimens examined were borrowed from and deposited into the following collections: Colección Helminthológica del Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil; Colección Nacional de Helminotos (CNHE), Mexico City, Mexico; Collection of Parasitology of the School of Veterinary Medicine of the University of Hokkaido (CP SVM), Sapporo, Japan; and the USNPC, Beltsville, Maryland. Species used for comparisons included Aspidodera vazi Proença, 1937 (CHIOC 9641, 14086, 18354); Aspidodera binansata Railliet & Henry, 1913 (CHIOC 8260, 9637, 9639, 9643, 18351, and USNPC 58363); A. fasciata (CHIOC 4119, 11190; USNPC 8550, 26644, 59968; CP SVM 2950); Aspidodera scolecomorphis (Schneider, 1851) Railliet and Henry, 1912 (CHIOC 10, 5681, 5809, 8387, 9668, 11408, 14551, 15073, 15257, 18355, 19494, 19628, 20046, 34557, 34568); and L. intermedia (CNHE 2460).

Specimens were measured using an ocular micrometer or Sigmascan Pro Image Analyzer (Albring et al., 1995) attached to a Zeiss ultraphot microscope. Measurements are given in micrometers. For each character studied, the range is given first, followed by sample mean, and coefficient of variation (as a percent value; Sokal and Rohlf, 1995) in parentheses. Drawings were made with a Wild microscope equipped with a drawing tube. Specimens imaged with SEM were exposed to a beam of 15 KV on both Hitachi field S-2460N and S-3000 scanning electron microscopes.

RESULTS

From the 11 armadillos infected, we identified 4 species of aspidodid nematodes including 1 of Lauroia Proença, 1938 and 3 of Aspidodera. One of the species of Aspidodera was undescribed. Species found in D. novemcinctus, localities, and museum accession numbers are listed in Table I. This is the first record of a species of Aspidodera from armadillos in Mexico.

Redescription

Lauroia trinidadensis Cameron, 1939

Diagnosis: Nemias with slender bodies, sharp tail, red when alive. Cephalic plates with continuous cordons, velum around
lateral and posterior margins of plate; interlabium developed as a cuticular ridge at base of plates. Lateral longitudinal fields developed into thick and round lateral alae. Precloacal sucker without rim. Gubernaculum absent.

**Taxonomic summary**

**Host:** Dasypus novemcinctus Linnaeus, 1758.

**Localities:** Mexico: Oaxaca, Isla Limón Presa Miguel Alemán, 18°17′07″N, 96°34′55″W, 49 m elevation (22 May 2001; prevalence 50% 2/2). Piscifactoria Temazcal, 18°15′30″N, 96°25′14″W, 62 m elevation (24 May 2001). Yucatán, Mérida, 20°58′52″N, 89°36′36″W (19 November 2001) (Fig. 1).

**Specimens deposited:** Vouchers CMNPA2005-0025, CNHE5363 through CNHE5366, HWML48193 through HWML48195, CHIOC35432, USNPC97135, and USNPC97136.

**Habitat:** Attached to mucosa and in lumen of large intestine.

**Aspidodera vazi Proença, 1937**

**Diagnosis:** Very elongated hood, posterior loops of hood widely separated on each plate. Interlabium arising as projection between plates. Lateral longitudinal fields simple or with lateral alae. Spinneret whip-shaped.

**Taxonomic summary**

**Host:** Dasypus novemcinctus Linnaeus, 1758.

**Localities:** Mexico: Nayarit, Carretera Tepic-Aguamilpa Km 8, 21°32′16″N, 104°52′25″W, 79 m elevation (16 June 2003). Oaxaca, Isla Limón Presa Miguel Alemán, 18°17′07″N, 96°34′55″W, 49 m elevation (22 May 2001; prevalence 50% 2/2). Piscifactoria Temazcal, 18°15′30″N, 96°25′14″W, 62 m elevation (24 May 2001) (Fig. 1).

**Specimens deposited:** Vouchers CNHE5358, HWML48191, HWML48192, and USNPC97134.

**Habitat:** In lumen of large intestine.

**Description**

**Aspidodera sogandaresi n. sp.**

(Figs. 2–6)

(19 November 2001). Panama: Canal Zone, 08°57′41″N, 79°33′54″W (Fig. 1).

**Specimens deposited:** Vouchers CNHE5367 and USNPC58363.

**Habitat:** In lumen of large intestine.
TABLE I. Collection data for aspidoderid nematodes from the nine-banded armadillo (Dasypus novemcinctus Linnaeus, 1758) across Central and North America.

<table>
<thead>
<tr>
<th>Locality</th>
<th>Georeference</th>
<th>Species</th>
<th>Collection number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Km 8, carretera Tepic-Aguamilpa,</td>
<td>21°32’16”N</td>
<td>Aspidodera sogandaresi</td>
<td>HWML48189</td>
</tr>
<tr>
<td>Nayarit</td>
<td>104°52’25”W</td>
<td>Aspidodera vazi</td>
<td>CNHE5358</td>
</tr>
<tr>
<td>Teacalco, Morelos</td>
<td>18°37’12”N</td>
<td>Aspidodera sogandaresi</td>
<td>HWML48184, CHIOC35429, CMNPA2005-0023, CNHE5359</td>
</tr>
<tr>
<td></td>
<td>99°27’20”W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piscifactoría Temazcal, Oaxaca</td>
<td>18°15’30”N</td>
<td>A. sogandaresi</td>
<td>HWML48190, CNHE5362, CHIOC35431</td>
</tr>
<tr>
<td></td>
<td>96°25’14”W</td>
<td>A. vazi</td>
<td>HWML48192</td>
</tr>
<tr>
<td></td>
<td>(62 m)</td>
<td>Laurola trinidadensis</td>
<td>CNHE5365</td>
</tr>
<tr>
<td>Isla Limón, Oaxaca</td>
<td>18°17’07”N</td>
<td>A. sogandaresi</td>
<td>HWML48185-7, CNHE5360, USNPC97133</td>
</tr>
<tr>
<td></td>
<td>96°34’55”W</td>
<td>A. vazi</td>
<td>HWML48191, USNPC97134</td>
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<tr>
<td></td>
<td></td>
<td>L. trinidadensis</td>
<td>HWML48193-5, HWML48244, CHIOC35432, CMNPA2005-0025, CNHE5363-4, USNPC97135-36</td>
</tr>
<tr>
<td>Mérida, Yucatán</td>
<td>20°58’52”N</td>
<td>Aspidodera binansata</td>
<td>CNHE5367</td>
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<tr>
<td></td>
<td>89°36’36”W</td>
<td>L. trinidadensis</td>
<td>CNHE5366</td>
</tr>
<tr>
<td>Panama</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canal Zone</td>
<td>08°57’41”N</td>
<td>A. sogandaresi</td>
<td>USNPC58605</td>
</tr>
<tr>
<td></td>
<td>79°33’54”W</td>
<td>A. binansata</td>
<td>USNPC58363</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El Pedregal, 18 miles north of Lam-</td>
<td>31°19’34”N</td>
<td>A. sogandaresi</td>
<td>HWML48179,* HWML48180,†</td>
</tr>
<tr>
<td>pasas, Texas on U.S. 281</td>
<td>98°09’33”W</td>
<td></td>
<td>HWML48181-3, HWML48243, CHIOC35430, CMNPA2005-0024, CNHE5361, USNPC97132</td>
</tr>
<tr>
<td>College Station, Texas</td>
<td>30°35’59”N</td>
<td>A. sogandaresi</td>
<td>USNPC27135</td>
</tr>
<tr>
<td></td>
<td>96°18’42”W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alachua County, Florida</td>
<td>29°40’N</td>
<td>A. sogandaresi</td>
<td>HWML48188</td>
</tr>
<tr>
<td></td>
<td>82°20”W</td>
<td></td>
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</tr>
</tbody>
</table>

*Holotype.
†Allotype.

USNPC): Nemas with slender bodies, sharp tail, white when alive. Cephalic cap or hood with anastomosing cordons, 6 anterior and 6 posterioria; interlabium well developed (Fig. 2a, b). Lips simple with blunt projections laterally. Interlocking structures between latero-ventrals formed by blunt projection on both sinistro-ventral and dextro-ventral lips (Fig. 2a). Dorsal lip with 1 papilla on each side; latero-ventral lips with 1 papillae and amphid on dorsal side and circular medial papilla (Fig. 2b). Inner face of dorsal lip with 2 pairs of sockets (Fig. 2b). Lateral fields not forming lateral alae (Fig. 3a).

Males (based on measurements of 29 specimens unless otherwise indicated): Body length 4,400–7,009, 5,855 (10.6%); width at midbody 160–337, 268 (14.3%) (Fig. 3a). Cephalic hood 191–264, 221 (9.3%) long; 112–161, 138 (10%) wide. Nerve ring and excretory pore located 390–548, 455 (n = 25, 9.4%) and 552–775, 669 (n = 27, 9.46%), respectively, from anterior end. Stoma length 33–58, 44 (n = 28, 14.8%). Length of esophagus including bulb 1,052–1,502, 1,313 (8.5%). Pharynx length and width 43–88, 64 (n = 28, 13.3%) by 33–56, 44 (n = 28, 13.5%). Corpus of esophagus 891–1,327, 1,086 (10.6%) long. Width of esophagus at level of nerve ring 50–78, 61 (n = 28, 10.1%). Bulb of esophagus pyriform 167–229, 190 (n = 28, 7.3%) long by 148–209, 167 (n = 28, 8%) at maximum width. Length of left spicule 267–372, 331 (n = 25, 7.2%); width at calomus 16–26, 22 (n = 25, 11.1%). Length of right spicule 226–363, 320 (n = 25, 10.2%); width at calomus 16–26, 21 (n = 24, 12.9%). Gerbernum 101–148, 118 (n = 25, 7.8%) long by 14–27, 21 (n = 22, 14.2%) wide (Fig. 3b, c). Rim of sucker 66–95, 75 (9.2%) in diameter.

With 23–29 pairs of caudal sessile papillae distributed in fields anterior, lateral, and posterior to cloaca. Anterior or precloacal papillae consisting of 3 subventral and 1 lateral pairs, 1 single papilla flanked by 2 papillae on posterior part of rim. Lateral or adcloacal papillae consisting of 3–5 pairs, 1 papilla each flanking oclocal opening, 2 or 4 pairs sublateral to cloaca. Papillae distributed posterior to cloaca (postcloacal) consisting of 10–12 subventral and 5–9 lateral pairs (Fig. 3c).

Tail length 268–393, 311 (9.1%) with needle-shaped spinneret 25–46, 36 (n = 28, 14.9%) gradually tapering to a sharp point (Figs. 3b, 5a).

Females (based on measurements of 29 individuals, unless otherwise indicated): Body length 4,711–6,886, 5,601 (10.3%); width at level of vulva 219–385, 297 (19.4%). Nerve ring and excretory pore 361–523, 457 (n = 26, 10.2%) and 549–757, 648 (n = 28, 9.14%), respectively, from anterior end (Fig. 4). Cephalic hood 213–312, 259 (n = 28, 10.9%) long by 114–258, 163 (n = 28, 17.7%) wide. Stoma 31–64, 51 (n = 27, 16.5%). Total length of esophagus including bulb 1,038–1,504,
1,276 (n = 26, 9.0%). Pharynx 50–79, 64 (n = 27, 12.2%) long by 34–62, 49 (n = 27, 14.7%) wide. Corpus length 925–1,310, 1,071 (n = 26, 10.5%) by 41–94, 63 (n = 26, 19.9%) wide. Bulb of esophagus 158–221, 193 (n = 28, 8.4%) long by 123–238, 168 (n = 27, 16.2%) wide (Fig. 4). Vulva located 1,811–2,807, 2,265 (n = 24, 13.0%) from anterior end (Fig. 4). Uteri containing embryonated eggs 60–92, 71 (n = 508, 9.0%) by 40–70, 50 (n = 508, 12.9%). Tail 319–554, 418 (11.9%).

**Taxonomic summary**


_Type locality_: El Pedregal, 18 miles north by road (U.S. 281) from Lampasas, Texas, 31°19′34″N, 98°09′33″W; elevation 311 m (see map in Fig. 1).

**Prevalence in type locality**: 100% (3/3).

_Date of collection of type specimens_: 24 July 2001.

_Other localities_: Mexico: Morelos, Teacalco, 18°37′12″N, 99°27′20″W (22 May 2001; prevalence 100%, 1/2). Oaxaca, Isla Limón Presa Miguel Alemán, 18°17′07″N, 96°34′35″W, 49 m elevation (22 May 2001; prevalence 50% 2/2). Piscifactoria Temazcal, 18°15′30″N, 96°25′14″W, 62 m elevation (24 May 2001). Nayarit, Carretera Tepic-Aguamilpa Km 8, 21°32′16″N, 104°52′25″W, 79 m elevation (16 June 2003). Panama: Canal Zone, 08°57′41″N, 79°33′54″W. United States, Florida, Alachua County, 29°40′N, 82°20′W; Texas, College Station, 30°35′39″N; Texas, Houston, 96°18′42″W (Fig. 1).

**Specimens deposited**: Holotype, male HWML48179. Allotype, female HWML48180; paratypes HWML48181 through HWML48190, HWML48243, HWML48244, CNHE5359 through CNHE5362, CHIOC35429 through CHIOC35431, CMNPA 2005-0023, CMNPA 2005-0024, USNPC97132, and USNPC97133. Vouchers USNPC27135 and USNPC58605.

**Habitat**: Attached to mucosa and in lumen of large intestine.

**Etymology**: The species is named after Dr. Franklin Sogandares-Bernal, our good friend, H. W. Baldwin Ward Medalist, and pioneer in the taxonomy and systematics of parasites from Latin American vertebrates.

**Remarks**

*Aspidodera sogandaresi* is unique in having a wide expansion at the tip of the spicules (Fig. 5a), blunt projections on the lips (Fig. 6a), and lateral fields without conspicuous lateral alae. *Aspidodera sogandaresi* is different from *A. scoleciiformis*, *Aspidodera ansirupta* Proença, 1937, and *A. binansata* in the
structure of the cordons and in the digitiform projections of the lips. Additionally, the cephalic hood in *A. sogandaresi* is larger than that in *A. scoleciformis* and *A. ansirupta*, and has a shorter tail than both *A. scoleciformis* and *A. binansata*. It is also different from *Aspidodera lacombae* Vicente, 1964 in the size of the spicules and shape of the cordons.

*Aspidodera sogandaresi* has a shorter hood and shorter spicules as well as a needle-shaped spinneret in contrast with the
long hood, long spicules, and whip-shaped spinneret of A. vazi. Also, there is a long digitiform projection arising from the dextroventral lip of A. sogandaresi (‘‘g’’ on Fig. 6a) relative to the homologous structures of A. vazi (‘‘g’’ on Fig. 6c). The species most similar to A. sogandaresi is A. fasciata. Similarities include grooves on the hood, shape of spinneret, and size of body. However, A. sogandaresi can be separated from A. fasciata by the more blunt and simpler digitiform projections on the lips (Fig. 6a), a tail tapering gradually to a point of the spinneret, and spicules with an expansion at the tip (Fig. 5a).

**DISCUSSION**

Chandler (1946) reported A. fasciata in armadillos near Houston, Texas, and determined that his material differed from A. fasciata from South America by being smaller; however, he did not consider these differences sufficient to warrant a description of these specimens as a new species. Additional specimens of A. sogandaresi were also collected from a nine-banded armadillo by Emmet Price on 2 April 1926, from the vicinity of College Station, Texas (USNPC27135); later, these specimens were identified by E. A. Chapin as A. fasciata. Comparison of these worms with our samples and with specimens of A. fasciata from South America (USNPC17957 and USNPC59968) allowed us to identify the blunt projections on the lips of A. sogandaresi (Fig. 6a) in contrast to the heavily serrated lips of A. fasciata (Fig. 6b). Figure 6a, b shows that the apparent simple interlocking lip system of A. sogandaresi is also evident on the sockets of the inner part of the dorsal lips. Figure 6a clearly shows 2 pairs of sockets on the inner part of the dorsal lip that complements the simple projections arising from the lateroventral lips. In contrast, the homologous sockets on the dorsal lip of A. fasciata (Fig. 6b) are apparently more complex, matching the heavily serrated projections arising from the latero-ventral lips.

The number of caudal papillae was used by Santos et al. (1990) to distinguish among species in the Aspidoderidae. However, it appears that the number of papillae is highly variable, as there is variation in the number of papillae even among worms found in the same individual host. Because of the high variability of this character within and among species, we do not recommend its use for identification of species of *Aspidodera*.

Finally, lateral alae are absent in A. sogandaresi; nevertheless, some specimens show a flat lateral field associated with the hypodermal cord as shown in cross-section (Fig. 3a). A. vazi may show a similar pattern in the lateral alae, in that Navone (1986) showed that lateral alae were present in some but not all of the individuals she examined in Argentina. It appears that lateral alae may be a polymorphic character in A. vazi.

*Lauroia trinidadensis* Caballero 1955 and *L. dasypi* Flores-
Barroeta 1956 were first described from nine-banded armadillos captured in Guatemala and Mexico, respectively (Caballero, 1955; Flores-Barroeta, 1956). Both species share several similarities with *L. trinidadensis*, including the shape of the lips, overall structure of the hood, and shape and size of spicules. Nevertheless specimens of *L. intermedia* show a spine between the latero-ventral lips, just at the base of the hood, that serves as the diagnostic character for the species. According to the original description, *L. dasypi* has 3 shields with rectangular shapes in the hood (Flores-Barroeta, 1956). The study of the specimens described by Flores-Barroeta (1956) was not possible because the type specimens and apparently the collection in which they were deposited have since disappeared. Because the dorsal lip of *L. dasypi* is described as being narrower and shorter than the latero-ventral lips, it is not possible that the latter can be rectangular. For these reasons, we consider *L. dasypi* to be a species inquirenda.

The discovery of *A. vazi*, *A. binansata*, and *L. trinidadensis* in Mexico represents a substantial extension of the known range of these species. While *L. trinidadensis* now appears to occur in armadillos only around the Caribbean region and in tropical Mexico, both *A. vazi* and *A. binansata* have been collected from armadillos from throughout the subtropical and tropical regions of South and Central America and Mexico. The geographic distribution of both *A. vazi* and *A. binansata* is nearly concordant with the known range of *D. novemcinctus* (see Taulman and Robbins, 1996). *Dasypus novemcinctus* has a wide geographic distribution, occurring from northern Argentina to the south-central United States. This armadillo is capable of surviving in areas with relatively few days of freezing temperatures (Taulman and Robbins, 1996) and has been recently expanding its range to the north. Moreover, some populations of the same species show a continuous range expansion with documented long-distance migration by fertile individuals (Frutos and van den Bussche, 2002).

In a comparable manner, these factors may also explain the presence of *A. sogandaresi* in armadillos over a vast area of Central and North America. Up to the present time, *A. sogandaresi* appears to be the only sylvatic species of *Aspidodera* found in the United States. As summarized by Santos et al. (1990), the known host range for *A. vazi* includes both *D. novemcinctus* and *Tolypeutes matacus* (Desmarest, 1804), whereas *A. binansata* has been recorded in *D. novemcinctus*, *Euphractus sexcinctus* (Linnaeus, 1758), *Cabassous unicinctus* (Linnaeus, 1758), *Chaetophractus villosus* (Desmarest, 1804), and *Dasyprocta leporina* (Linnaeus, 1758).

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LITERATURE CITED


