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TADARIDANEMA DELICATUS (SCHWARTZ, 1927) N. GEN., N. COMB. (TRICHOSTRONGYLINA: MOLINEIDAE) PARASITE OF MOLOSSIDAE BATS

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ABSTRACT: On the basis of the revision of the type material of *Anoplostrongylus delicatus* Schwartz, 1927, and new specimens collected from *Tadarida brasiliensis mexicana* (Saussure, 1860) in 4 arid localities from Mexico, we describe a new genus (*Tadaridanema* n. gen.), to which *A. delicatus* is transferred (as *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb.). This new genus differs from all other genera included in Anoplostrongylinae by having ray 2 larger than ray 3. In addition, *T. delicatus* can be differentiated from the type species of *Anoplostrongylus* (*Anoplostrongylus paradoxus* (Travassos, 1918)) because it possess vestibular branches equal in length, cephalic inflation divided into 2 regions, and synlophe with many small ridges at the midbody level, whereas in *T. delicatus*, vestibular branches are equal in size, cephalic inflation is simple in structure, and the synlophe has only 2 well-developed dorsal cuticular ridges.

Anoplostrongylus delicatus Schwartz, 1927, parasitizes species of bats in *Tadarida Rafinesque*, 1814, and *Molossus Geoffroy*, 1805 (Table I); this species was described by Schwartz (1927) from an unidentified bat in Texas; later, Travassos (1937) transferred it to *Molinostrongylus* Skarbilovitch, 1934. However, Durette-Desset and Chabaud (1975) pointed out that *A. delicatus* does not exhibit the diagnostic features of *Molinostrongylus* sp. and recommended it should be kept in *Anoplostrongylus* Boulenger, 1926. On the basis of the revision of the type material of this nematode species and of new specimens collected from *Tadarida brasiliensis mexicana* (Saussure, 1860) in 4 arid localities from Mexico (Guzmán-Cornejo et al., 2003), we conclude that *A. delicatus* belongs in a new genus, which is described herein.

MATERIAL AND METHODS

Between November 1996 and April 1998, 96 specimens of *T. brasiliensis mexicana* were collected with the use of mist nets from 4 arid regions of Mexico: Cueva de la Boca, Santiago, Nuevo León; Fábrica la Constancia, Nombre de Dios, Durango; Iglesia de Guadalupe Garzarón, Concepción del Oro, Zacatecas; and Río Salado, Zapotitlán de las Salinas, Puebla. Hosts were killed by an overdose of sodium pentobarbital; worms collected were fixed in boiling 70% ethanol. Specimens were cleared with Ammans lactophenol and temporarily mounted for morphological study. Bats were deposited in the Colección de Mamíferos at Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), Mexico City.

For a detailed description of the synlophe, cross sections were made (at the anterior, middle, and posterior regions of the body of *A. delicatus*) following Durette-Desset (1985) and mounted in face view. Specimens were deposited in the Colección Nacional de Helminos (CNHE), UNAM, Mexico City; the Harold W. Manter Laboratory of Parasitology (HWML), Lincoln, Nebraska; and the U.S. National Parasite Collection (USNPC), Beltsville, Maryland. For comparative purposes, the following specimens were examined: *A. delicatus* (USNPC 027138, 05486, 054861) and *Molinostrongylus delicatus* (Schwartz, 1927) Travassos, 1937 (HWML 37516, 37517, 37518).

Measurements were taken with a micrometer ocular and presented as the range, with means, standard deviation, and sample size in brackets, and were expressed in micrometers unless otherwise stated. Figures were drawn with the aid of a drawing tube. Measurements of the holotype and allotype are in parentheses.

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DESCRIPTION

Tadaridanema n. gen.

Diagnosis: Molinoidea, Molineidae, Anoplostrongylinae. Nematodes of medium size coiled loosely, females larger than males. Lips absent. Cephalic inflation almost undivided. Nerve ring located at middle of esophagus; excretory pore opening posterior to nerve ring. Synlophe with 2 great dorsal cuticular ridges in the middle of body. Longitudinal ridges extend posteriorly from border of cephalic inflation to just anterior to caudal extremity. Males with well-developed and symmetrical copulatory bursa; ray 2 larger than ray 3. Rays 4, 5, and 6 separated, straight, and with striated cuticle. Tail of female with an ending tip surrounded by 3 conical cuticular processes; uterine branches unequal.

Taxonomic summary

Type and only known species: *Tadaridanema delicatus* (Schwartz, 1927) n. comb. from the intestine of an unidentified bat from Texas; other records in Molossidae bats from California, Florida, Louisiana, and New Mexico and from the Mexican states of Durango, Nuevo León, Puebla, Sinaloa, and Zacatecas.

Etymology: The generic name refers to the fact that the nematode occurs basically in bats of *Tadarida* spp.

Remarks

Following Durette-Desset (1983), our specimens are included in Molineidae: Anoplostrongylinae by having a caudal spine surrounded by 3 tubercles, a dorsal ray not divided at the base, and synlophe with ridges directed from ventral to dorsal side and for parasitizing New World bats. This subfamily comprises 23 genera distributed worldwide (Durette-Desset, 1983; Vaucher and Durette-Desset, 1986; Durette-Desset and Vaucher, 1996). The new genus differs from all other genera included in Anoplostrongylinae by possessing ray 2 larger than ray 3. In addition, *Tadaridanema* can be distinguished from 13 of the 23 genera by possessing a caudal spine surrounded by 3 tubercles instead of 2 digitiform caudal mucrones (as in *Bidigiticauda* Chitwood, 1938) (Chitwood, 1938); a short tail sharply pointed, without tubercles (as in *Delicata* Travassos, 1935; *Graphidiops* Lent and Teixeira de Freitas, 1938; *Paragraphidium* Teixeira de Freitas and Mendonça, 1959; and *Spinostrongylus* Travassos, 1935) (Travassos, 1935a, 1935b; Lent and Teixeira de Freitas, 1938; Teixeira de Freitas and Mendonça, 1959); a tail lacking a terminal spine (as in *Caenostromylus* Lent and Teixeira de Freitas, 1938, and *Maciela* Travassos, 1935) (Travassos, 1935a, 1935b, and Teixeira de Freitas, 1938); a tail with 2 ventral prominences and a dorsal spine at its truncate extremity (as in *Fontesia* Travassos, 1928) (Travassos, 1928); a tail conical and short (as in *Trichohelix* Ortlepp, 1922; *Trifurcata* Schulz, 1926; and *Filicapitis* Travassos, 1950) (Ortlepp, 1922; Schulz, 1926; Travassos, 1950); a conical and elongated tail (as in *Moennigia* Travassos, 1935) (Travassos, 1935a); or a bluntly rounded tail (as in *Cheiropterionema* Sandground, 1929) (Sandground, 1929). Likewise, the new genus differs from *Delicata*, *Fontesia*, and *Maciela* because they possess vestibular branches of equal size (instead of unequal branches as in *Tadaridanema*). The bilobed bursa present in the new genus distinguishes it from *Cheiropterionema*, *Filicapitis*,

TABLE I. Previous records of *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb.

| Host | Distribution | Reference |
|---------------------------------------|---|-------------------------------|
| Brown bat | College Station, Texas | Schwartz (1927)* |
| <i>Tadarida brasiliensis mexicana</i> | Frio cave, Texas | USNPC† 054860* |
| <i>T. brasiliensis mexicana</i> | Carlsbad caverns, New Mexico | Jameson (1959)*; Cain (1966)‡ |
| <i>T. brasiliensis mexicana</i> | Berkeley, Alameda County, California | Voge (1956)‡ |
| <i>T. brasiliensis</i> | Crosbyton and Frio cave, Texas and Ney cave, New Mexico | Jameson (1959)* |
| <i>T. brasiliensis</i> | Bracken cave, Texas and New Orleans, Louisiana | Martin (1976)‡ |
| <i>T. brasiliensis</i> | Florida | HWML§ 37516–18‡ |
| <i>Molossus ater</i> | Sinaloa, Mexico | Cain and Studier (1974)‡ |

* Recorded as *Anoplostrongylus delicatus*.

† Specimens deposited in the U.S. National Parasite Collection, Beltsville, Maryland.

‡ Recorded as *Moloinstrongylus delicatus*.

§ Specimens deposited in the Harold W. Manter Laboratory of Parasitology, University of Nebraska, Lincoln.

Graphidiops, *Moennigia*, *Paragraphidium*, *Spinostromylus*, and *Trifurcata*, all of which possess trilobed bursa. In addition, *Caenostromylus* and *Trichohelix* can be differentiated from *Tadaridanema* because they possess spicules ending in 2 points, whereas spicules have a pointed tip in the new genus. Finally, species of *Bidigiticauda* are readily distinguishable from species of *Tadaridanema* by the bursal dimensions (smaller than in the new genus) and because species of Chitwood's genus lack gubernaculum.

The new genus is similar to *Anoplostrongylus* Boulenger, 1926; *Biacantha* Wolfgang, 1954; *Bradyostromylus* Price, 1928; *Histiostrongylus* Molin, 1861; *Linustromylus* Vaucher and Durette-Desset, 1986; *Molostromylus* Durette-Desset and Vaucher, 1996; *Parahistiostrongylus* Pérez-Vigueras, 1941; *Torrestrongylus* Pérez-Vigueras, 1935; *Tricholeiperia* Travassos, 1935; and *Websteremema* (Webster, 1971), which also exhibit caudal spine surrounded by 3 tubercles. Notwithstanding, *Histiostrongylus*, *Parahistiostrongylus*, *Biacantha*, *Websteremema*, and *Linustromylus* can be differentiated from *Tadaridanema* by possessing cuticular spines on the cephalic inflation (Travassos, 1937; Pérez-Vigueras, 1941; Wolfgang, 1954; Vaucher and Durette-Desset, 1986), which are absent in the new genus. Likewise, the first 4 genera can be distinguished by having synlophe with many small ridges in the mid-region, instead of 2 dorsal cuticular ridges as in *Tadaridanema*; moreover, species of *Linustromylus* lack synlophe.

From the remaining 5 genera, which also lack cuticular spines in the cephalic region, *Tadaridanema* can be differentiated by the following characters: from *Torrestrongylus* and *Tricholeiperia* because they have spicules divided at the distal end (instead of having distal tip pointed as in the new genus) and ray 2 shorter than ray 3 (whereas in *Tadaridanema*, the length of these rays is inverted). In addition, *Tricholeiperia* lacks a gubernaculum and *Torrestrongylus* possesses a trifurcated dorsal ray (Pérez-Vigueras, 1935; Travassos, 1935b). The presence of spines in the ovejector region and the similar size of the vestibular branches and of rays 2 and 3 of the bursa are diagnostic features of *Molostromylus* (Durette-Desset and Vaucher, 1996), which also distinguishes it from the new genus.

Tadaridanema most closely resembles species in *Bradyostromylus* and *Anoplostrongylus*. Notwithstanding, species of *Bradyostromylus* are distinguished from *T. delicatus* by the following characteristics: (1) synlophe with 2 great and 2 small dorsal cuticular ridges in the middle of the body compared with synlophe with only 2 great dorsal cuticular ridges in the same region in *Tadaridanema* (Figs. 1–3, 6); (2) dorsal ray large (vs. short in the new genus); (3) extremities of ray 8 crossing ray 9 (instead of not overlapping on those rays as in *Tadaridanema*; Figs. 11, 13); (4) vestibular branches equal in length in *Bradyostromylus panamensis* Price, 1928, and *B. inflatus* (Molin, 1861), whereas *T. delicatus* has vestibular branches unequal; (5) spicules twisted with a relatively long twisted median process, instead of spicules simple in structure (Figs. 14, 15); and (6) tail of female ending in a slender filamentous tip, larger than tubercular process, whereas in *Tadaridanema*, both structures have similar size (Figs. 19, 20; Price, 1928; Guerrero, 1982; Durette-Desset, 1985).

Anoplostrongylus share several traits with *Tadaridanema* (i.e., both possess a short bifurcate dorsal ray, with ray 9 always shorter than ray

10 and rays 3 and 4 larger than ray 5). Likewise, the 2 genera have a well-developed gubernaculum and parasitize New World bats (Travassos, 1921; Boulenger, 1926). Notwithstanding, the monotypic *Anoplostrongylus* differs from *Tadaridanema* by possessing rays 2 and 3 almost straight and being similar in size, whereas in the new genus, these rays are curved and ray 2 is larger than ray 3 (Figs. 12, 13). In addition, vestibular branches in *Anoplostrongylus paradoxus* (Travassos, 1918) Boulenger, 1926, are equal in length (vs. vestibular branches unequal in size; see Fig. 16), and the cephalic inflation is divided into 2 regions (vs. cephalic inflation simple in structure; see Figs. 17, 18; Travassos, 1921; Durette-Desset, 1985). Finally, the synlophe at anterior region in *A. paradoxus* possesses 7 cuticular ridges, 2 of them highly developed and located laterally, instead of only 2 well-developed and dorsal cuticular ridges present in *T. delicatus* (Figs. 1, 4). At midbody region, *A. paradoxus* has 19 small ridges (Durette-Desset and Pinto, 1977), whereas in *Tadaridanema* the synlophe maintains the arrangement described for the anterior region (Figs. 2, 3, 5).

DESCRIPTION

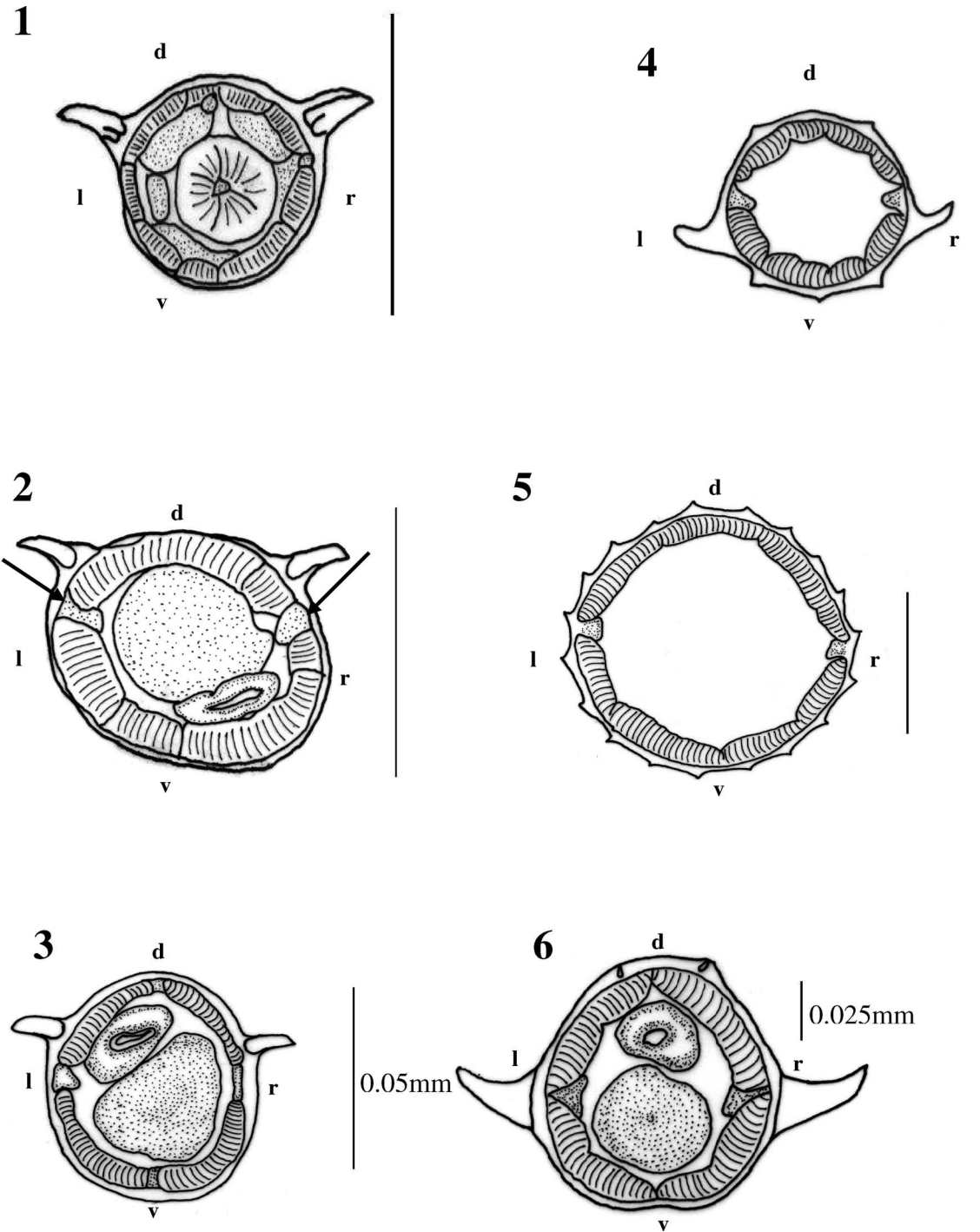
Tadaridanema delicatus (Schwartz, 1927) n. gen., n. comb.

Description: Based in 31 specimens (7 males and 26 females).

Synlophe: Oriented ventral to dorsal; ridges in both sexes arising just posterior to cephalic inflation. Both males and females possess only 2 dorsal cuticular ridges in anterior and midbody regions; posterior region of males also with 2 dorsal ridges, but small in size (Figs. 1, 2, 7–10). Females with 4 ridges of similar size, 2 dorsal and 2 ventral, at prevulvar level. At postvulvar region, synlophe without ventral ridges. Caudal extremity without ridges.

Male: Length 2.7–3.6 mm [3 mm ± 0.4, n = 6] (3.5). Maximum diameter 56–87.5 [71.7 ± 12.6, n = 6] (99.1) at midbody. Cephalic inflation 35–45.5 [43.1 ± 4.7, n = 6] (42.5) long by 24.5–35 [29.1 ± 3.6, n = 6] (28.3) wide. Distance from anterior end to nerve ring 129.5–161 [147.8 ± 14.3, n = 4] and to excretory pore 157.5–203 [184.3 ± 16.5, n = 6]. Esophagus length 283.5–329 [310.9 ± 19.2, n = 6] (255) by 24.5–35 [29.1 ± 3.6, n = 6] (28.3) wide at base. Spicules equal in size, 154–192.5 [167.4 ± 15.8, n = 6] (170) length; alated and simple in structure; distal tip pointed. Gubernaculum well developed and cuticularized, located dorsal to spicules, 38.5–52.5 [46.6 ± 5.7, n = 6] length by 7–10.5 [7.5 ± 1.4, n = 6]. Genital cone present. Bursa with 2 large lateral lobes; prebursal papillae not observed. Arrangement of bursal rays 2 and 3 identical in both lobes; rays 2–6 arising from a common stem. Rays 2 and 3 curved, ray 2 larger than 3. Rays 4, 5, and 6 straight, with striated cuticle, diverging in origin. Rays 4 and 6 shorter than ray 5. Dorsal ray short, splitting into 2 symmetrical rays (9 and 10); ray 9 always shorter than ray 10. Ray 8 long and slender, arising near base of dorsal ray.

Female: Didelphic. Length 4.15–6.3 mm [5.2 mm ± 0.5, n = 25] (5.2). Maximum diameter 77–154 [122.7 ± 19.5, n = 25] (166.4) at medium level. Cephalic inflation 38.5–66.5 [55.5 ± 6, n = 25] long by 42–63 [48.3 ± 4.8, n = 25] wide. Distance from anterior end to nerve ring 175–217 [190.4 ± 16.1, n = 19] and to excretory pore 199.5–



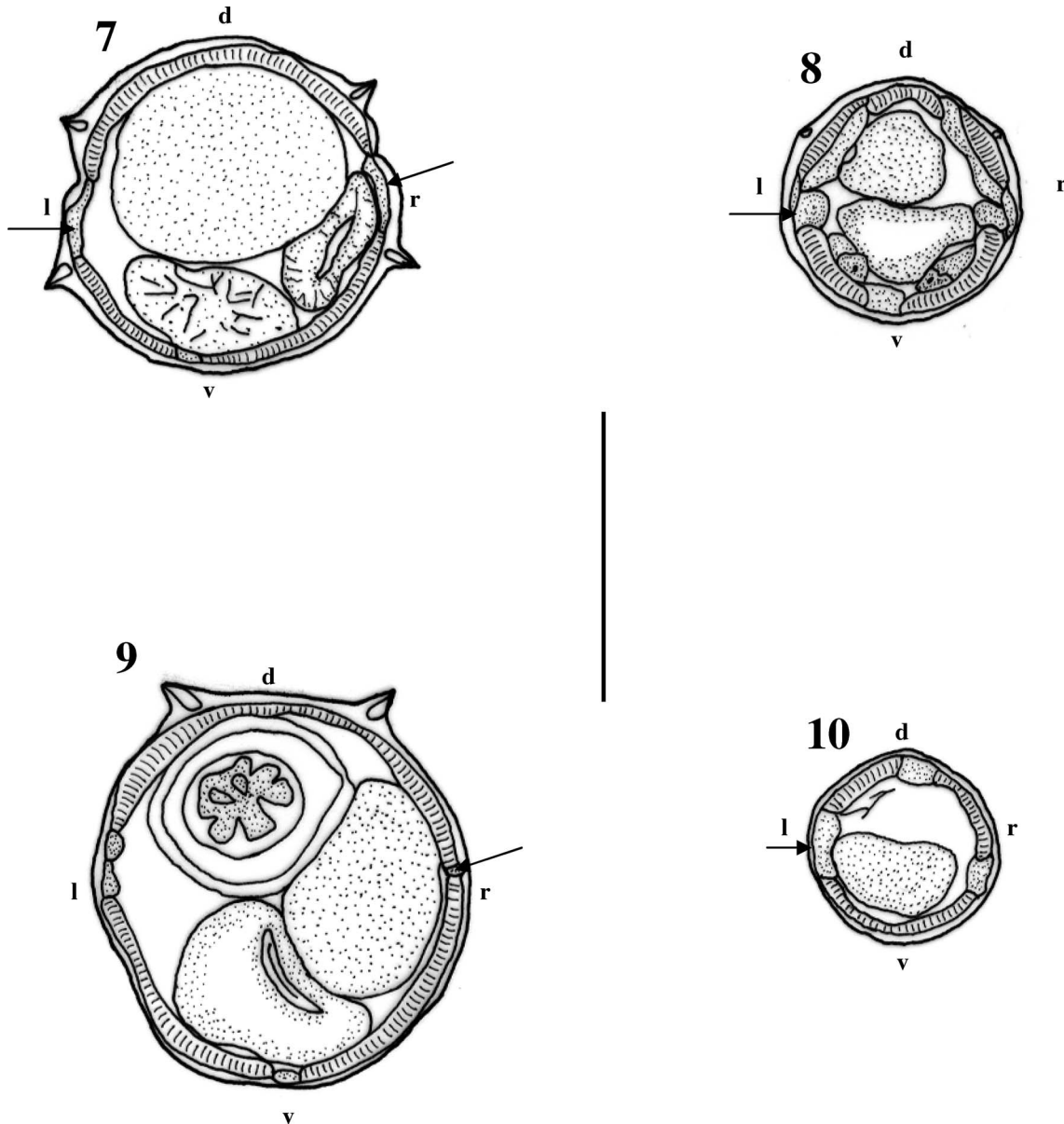
FIGURES 1–6. Synopse of *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb. (1–3); *Anoplostrongylus paradoxus* (4, 5) after Durette-Desset and Pinto, 1977; and *Bradypostrongylus panamensis* (6) after Guerrero, 1982). Cross section at (1, 4) esophageal level and (2, 3, 5, 6) midbody level. Orientation of figures: d, dorsal; v, ventral; r, right; l, left. The arrow indicates the lateral cords. Bar = 0.1 mm.

290.5 [228.4 ± 49.9, n = 23]. Esophagus length 350–406 [383.1 ± 22.5, n = 25] (304.6) by 38.5–56 [43.8 ± 4.4, n = 25] (31.8) wide at base. Postequatorial vulva opening over a knoll; 938–1,701 [1,227.7 ± 189.8, n = 22] from caudal extremity. Vagina vera length 59.5–105 [78.5 ± 14.3, n = 20]; vestibule 178.5–262.5 [206.5 ± 29.5, n = 23] long, with branches unequal in size, anterior longer than posterior; anterior sphincter and infundibulum 45.5–70 [52.9 ± 9.4, n = 25] (49.5) and 63–164.5 [101.1 ± 36.5, n = 10] long, respectively; posterior sphincter and infundibulum 35–87.5 [52.3 ± 9.7, n = 25] (53.1) and

70–87.5 [77 ± 7, n = 5] (77.9) long, respectively. Eleven eggs measured; 70–73.5, [70.9 ± 2.2] (70.8) long by 42–52.5 [47 ± 3.6] (48.5) wide. Anus to tip of tail 63–101.5 [74.7 ± 11.2, n = 21] (99.1).

Taxonomic summary

Type host: Unidentified bat.
Site of infection: Intestine.
Type locality: College Station, Texas.



FIGURES 7–10. *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb., a parasite of *Tadarida brasiliensis mexicana* from Mexico. Cross section of female at (7) anterior branch of ovejector level, (9) posterior branch of ovejector level, and (10) tail level. Cross section of male at (8) spicular level. Orientation of figures: d, dorsal; v, ventral; r, right; l, left. The arrow indicates the lateral cords. Bar = 0.1 mm.

Other hosts: *Molossus ater* Geoffroy, 1805; *Tadarida brasiliensis mexicana* (Sassure, 1860).

Other localities: Mexico: Fábrica la Constancia, Nombre de Dios (ND), Durango State, 23°51'N, 104°51'W; Cueva de la Boca (CB), Santiago, Nuevo León State, 25°26'N, 100°06'W; Río Salado, Zapotitlán de las Salinas (RS), Puebla State, 18°20'N, 97°28'W; Sinaloa; Iglesia de Guadalupe Garzarón, Concepción del Oro (CO), Zacatecas State, 24°37'N, 101°25'W. USA: Berkeley, Alameda County, California; Florida; New Orleans, Louisiana; Carlsbad caverns and Ney cave, New Mexico; Frio and Braken caves and Crosbyton, Texas.

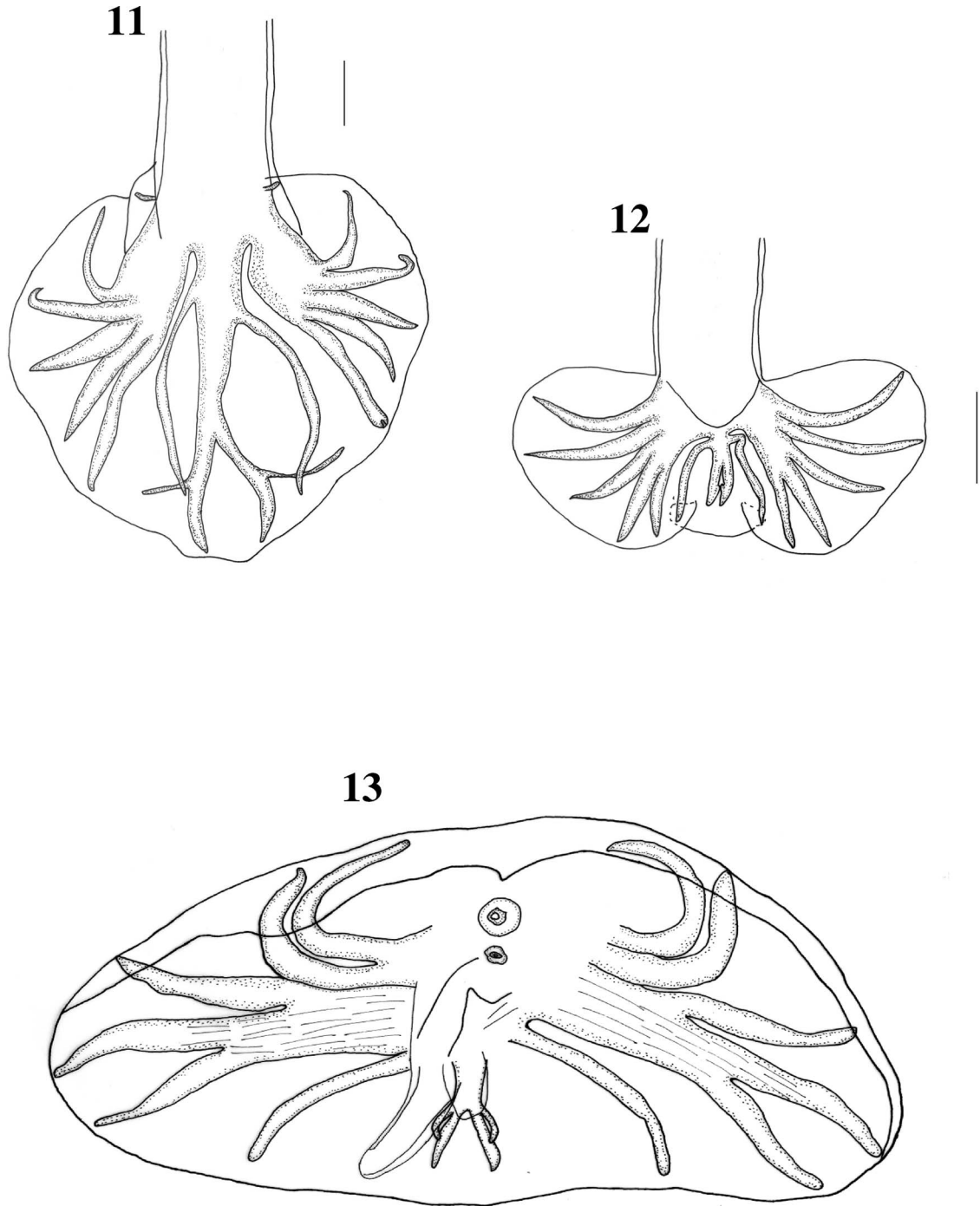
Prevalence: ND = 5 of 31 infected (16.1%); CB = 5 of 27 infected (18.5%); RS = 6 of 12 infected (50%); CO = 10 of 28 infected (35.7%).

Specimens analyzed: Holotype male and allotype USNPC 027138; Vouchers: RS: CNHE 3856–3859; ND: CNHE 3863; CB: CNHE 3861, 3862; CO: CNHE 3860 and 4725; HWML 37516, 37517, and 37518; USNPC 05486 and 054861.

Synonyms: *Anoplostrongylus delicatus* Schwartz, 1927; *Molinostrongylus* (*Anoplostrongylus*) *delicatus* (Schwartz, 1927) Travassos, 1937.

DISCUSSION

Anoplostrongylus delicatus was transferred by Travassos (1937) to *Molinostrongylus* without discussing the reasons for such a decision; Durette-Desset and Chabaud (1975) rejected this proposal and retained it in *Anoplostrongylus* despite the absence of a cephalic inflation characteristic of the type species for this genus. This species cannot be included in *Molinostrongylus* because of the absence of important diagnostic traits (i.e., numerous cuticular spines on inner surface of bursa, rays 3 and 4 close together throughout their length, ray 2 shorter than 3, and synlophes with ridges not oriented from ventral to dorsal side); in addition, species of *Molinostrongylus* parasitize exclusively Old World bats (Durette-Desset, 1983). On the basis of the revision of the type material of *A. delicatus* (USNPC



FIGURES 11–13. Males of *Bradystrongylus inflatus* after Travassos, 1937 (11); *Anoplostrongylus paradoxus* after Travassos, 1921 (12); and *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb. (13) showing caudal bursa. Bar = 0.1 mm.

027138) and in new specimens from *T. b. mexicana* from Mexico, we recommend that this species be transferred to *Tadaridanema*, as *Tadaridanema delicatus* (Schwartz, 1927) n. comb.

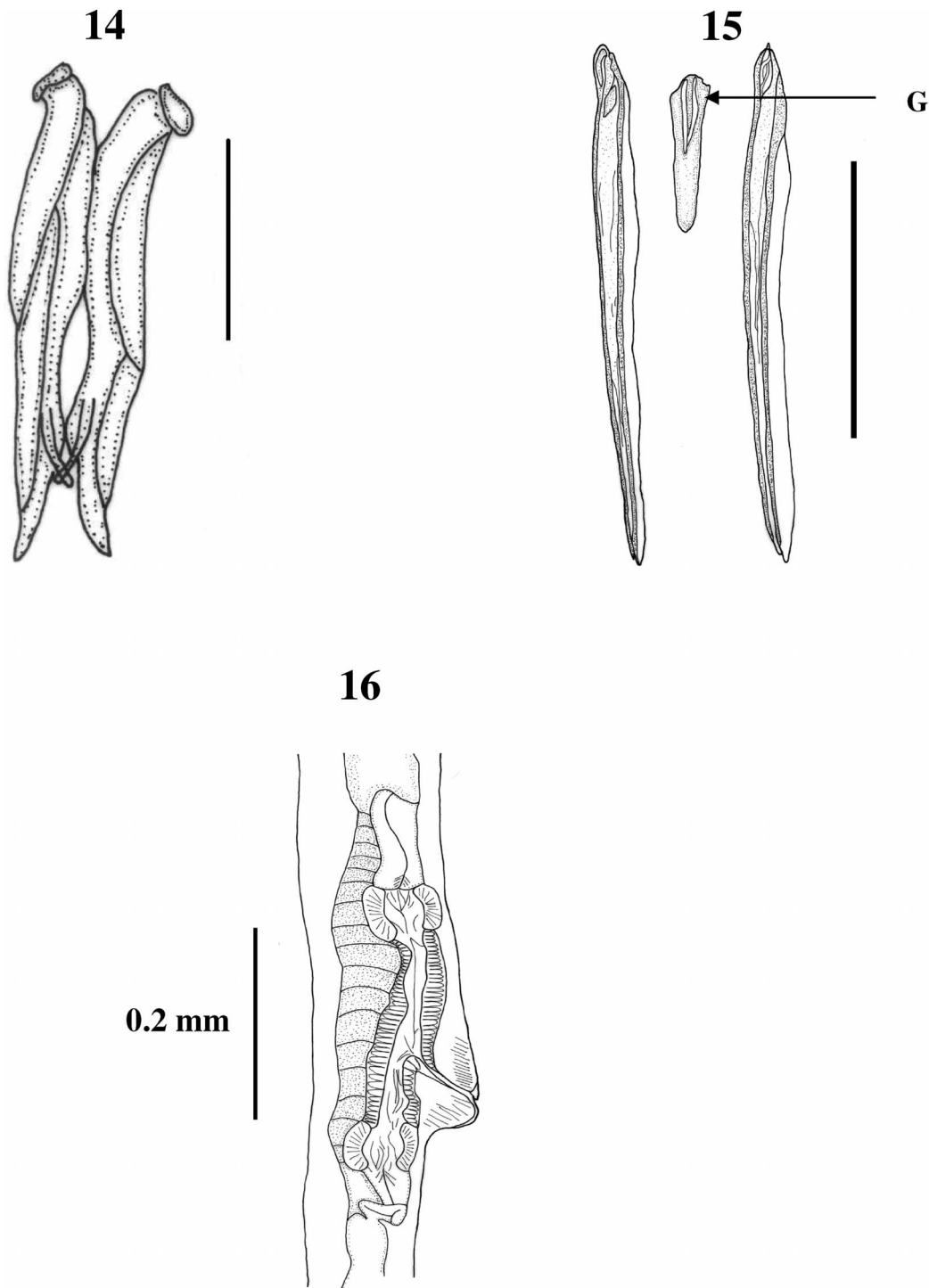
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FIGURES 14–16. Spicules of *Bradypostrongylus inflatus* (14) after Travassos, 1937, and *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb. (15) and ovejector region of *T. delicatus* (16). G = gubernaculum. Bar = 0.1 mm.

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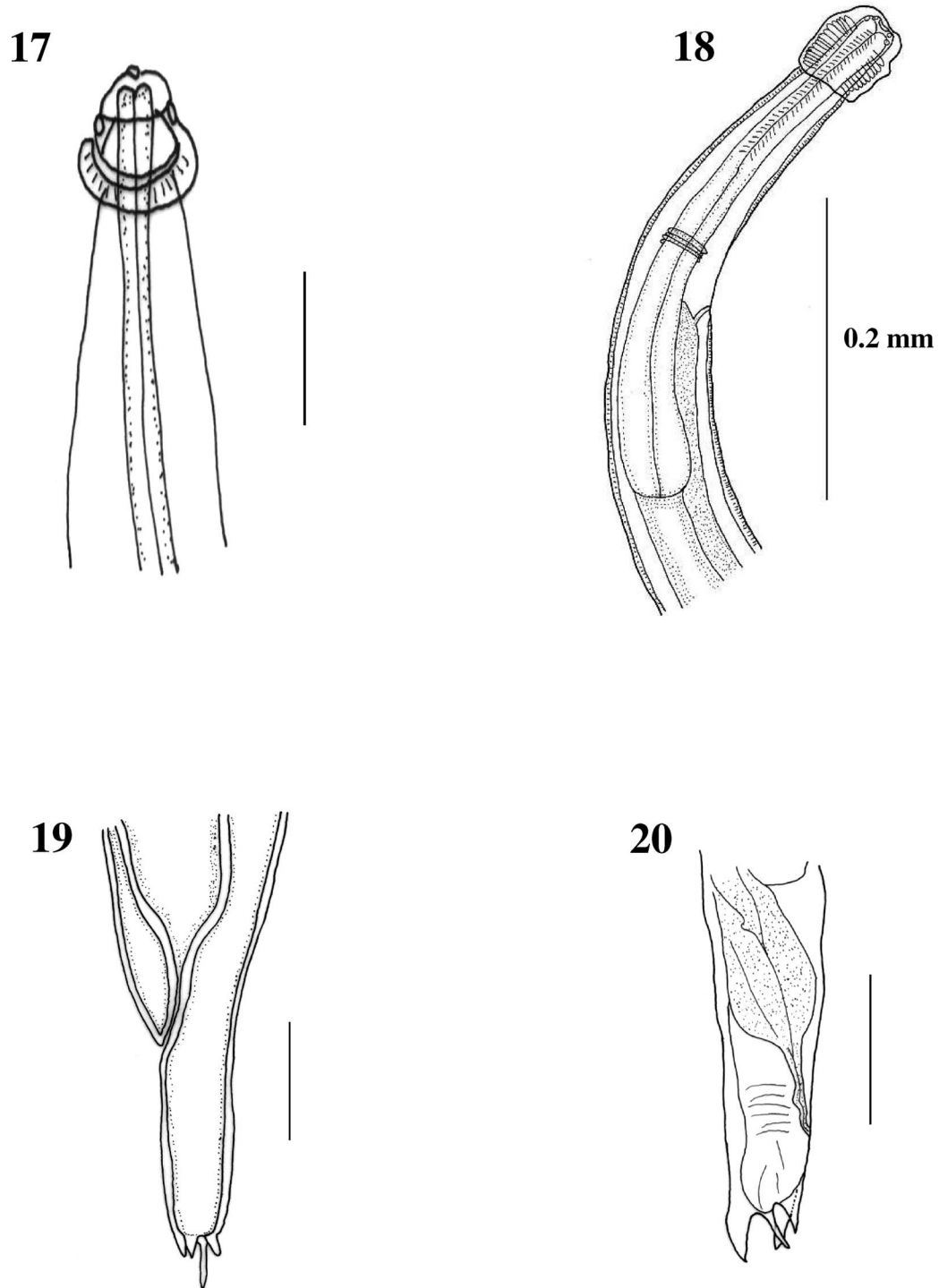
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FIGURES 17–20. Females of *Anoplostrongylus paradoxus* (17) after Travassos, 1921, and *Tadaridanema delicatus* (Schwartz, 1927) n. gen., n. comb. (18) showing cephalic inflation; females of *Bradypostrongylus inflatus* (19) after Travassos, 1937, and *T. delicatus* (20) tail with an ending tip surrounded by 3 conical cuticular processes. Bar = 0.1 mm.

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