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MAZZANEMA N. GEN. AND *MAZZANEMA FORTUITA* N. COMB. FOR *LONGISTRIATA FORTUITA* FREITAS, LENT, AND ALMEIDA, 1937 (NEMATODA: HELIGMONELLIDAE), A PARASITE OF THE MARSH RAT *HOLOCHILUS CHACARIUS* (RODENTIA: CRICETIDAE) FROM NORTHERN ARGENTINA

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ABSTRACT: The species described as *Longistriata fortuita* Freitas, Lent, and Almeida, 1937 is here redescribed from new material collected from the type host, *Holochilus chacarius balnearum* Thomas, and the type locality, San Martín del Tabacal, Salta, Argentina. Neotypes are designed for the species since the type material deposited by the authors is lost. The original description did not include the synlophe or the female and both are here described. Several characters of the synlophe as the number of ridges (14–19), the ridges continuous and all around body, and the presence of a gradient of size of the ridges allow us to place the species within the Heligmonellidae, Nippostrongylinae. The species possesses a unique combination of characters as the synlophe having a carene together with characters of the caudal bursa as the pattern 1-3-1 and the strong development of the dorsal lobe and ray, which precludes its inclusion in any known genus of Nippostrongylinae. A new genus *Mazzanema* n. gen. is proposed for it, resulting in the new combination *Mazzzanema fortuita* n. comb.

In 1928, Dr. Salvador Mazza collected several specimens of the chacoan marsh rat *Holochilus chacarius balnearum* Thomas at Ingenio San Martín del Tabacal, a sugarcane plantation in Salta Province, Argentina. Mazza sent some specimens of the marsh rat to Dr. F. Werneck from the Instituto Oswaldo Cruz, Brazil, who gave the viscera of these hosts to Dr. J. F. T. Freitas. This material allowed the description of the genus *Stilestrongylus* Freitas, Lent, and Almeida, 1937 with its type species *Stilestrongylus stilesi* Freitas, Lent, and Almeida, 1937 (Heligmonellidae), plus 3 other species of Heligmosomoidea, i.e., *Hassalstrongylus argentinus* (Freitas, Lent, and Almeida, 1937) (=*Longistriata argentina*), *Hassalstrongylus mazzai* (Freitas, Lent, and Almeida, 1937) (=*Heligmonoides mazzai*), and *Longistriata fortuita* Freitas, Lent, and Almeida, 1937, all from a single individual host (Freitas et al., 1937).

The descriptions of these species were mostly good and accurate but incomplete, if we take into account that before 1964 they did not include the synlophe; additionally, the females were typically poorly described. The fate of these species was diverse: *L. argentina* was redescribed and, on the basis of the synlophe, transferred to *Hassalstrongylus* Durette-Desset, 1971 (Heligmonellidae); *H. mazzai* was also transferred to *Hassalstrongylus*, although its synlophe remains unknown (Durette-Desset, 1971). Finally, *S. stilesi* was redescribed on new material collected and its position in the genus *Stilestronglus* (as redefined by Durette-Desset, 1971) confirmed (Notarnicola et al., 2010).

The status of *L. fortuita* remained, however, unknown, since the species was never redescribed to precisely determine its taxonomic position. It is worth noting that the definition and composition of *Longistriata* Schulz were subsequently strongly restricted (Durette-Desset, 1971); the present definition of *Longistriata* places this genus in the Heligmosomidae and its component species are strictly parasites of insectivores (Soricidae) (Durette-Desset, 1971, 1983).

We had the opportunity to prospect for parasites numerous specimens of *Holochilus chacarius* from several localities of northern Argentina, among them, the type locality of *L. fortuita*. The finding, in several hosts necropsied, of specimens corresponding to this species as described by Freitas et al. (1937) allowed its redescription and a discussion on its taxonomic position. As a result, the new genus *Mazzanema* n. gen. and the new combination *Mazzanema fortuita* n. comb. are proposed for this species.

MATERIALS AND METHODS

Rodents (n = 21) were deposited in the Colección Mamíferos Lillo (CML), Tucumán, Argentina and their viscera kindly donated for parasite examination. They were captured at Ingenio San Martín del Tabacal, Departamento Orán, Salta Province, Argentina, in March, August, and September 1990. Rodents were fixed in 10% formalin and stored in 70% ethanol. Nematodes recovered were preserved in 70% ethanol. The synlophe is studied following the method of Durette-Desset (1985) and the description of the caudal bursa follows Durette-Desset and Digiani (2012). The ridges of the synlophe, excluding the carene, are considered as dorsal or ventral with respect to the axis of orientation and not to the lateral hypodermal cords. Measurements are given in micrometers, except as otherwise stated, as the range followed by the mean in parentheses. Classification used above the family Heligmonellidae follows Durette-Desset and Chabaud (1993). The nomenclature and synonymy of the host species follows Wilson and Reeder (2005) and Cirignoli et al. (2006). Parasites are deposited in the Helminthological Collection of the Museo de La Plata, La Plata, Argentina (MLP-He).

DESCRIPTION

Mazzanema n. gen.

Diagnosis: Heligmonellidae, Nippostrongylinae. Synlophe with carene made up of 2 hypertrophied ridges of which ventral larger. Ridge in front of the right lateral field largest (carene excluded). Gradient of size of the ridges on dorsal side, lateromedian, from right to left. Caudal bursa subsymmetrical with dorsal lobe and dorsal ray well developed. Characteristic bursal pattern of type 1-3-1. Spicules thin, ending each in a sharp tip. Female posterior extremity invaginated to different degrees. Parasites of Sigmodontine rodents.

Type species: Mazzanema fortuita (Freitas, Lent, and Almeida, 1937).

Etymology: Dedicated to the eminent Argentine physician and epidemiologist Dr. Salvador Mazza.

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***Mazzanema fortuita* (Freitas, Lent, and Almeida, 1937) n. comb.**
= *Longistriata fortuita* Freitas, Lent, and Almeida, 1937
(Figs. 1–18)

General: Medium-sized nematodes, usually tightly coiled sinistrally along ventral side forming up to 7 spirals. Cephalic vesicle present. In apical view, rounded buccal opening surrounded by thin ring. Two amphids, 6 internolabial and 4 externolabial papillae visible, 2 lateral externolabial papillae fused with amphids. Cephalic papillae not observed (Fig. 2). Deirids small, situated at level of excretory pore or slightly posteriorly (Fig. 1).

Synlophe (studied in 4 males and 4 females): In both sexes, cuticle with longitudinal, continuous ridges bearing struts. Ridges appearing just posterior to cephalic vesicle; disappearing at about 400 μm anterior to caudal bursa in males and at level of proximal ovejector in females. Carene present, made up of 2 hypertrophied ridges, of which ventral larger. Slight sexual dimorphism present, especially on ventral side, concerning number and size of ridges. Number of ridges: at level of distal esophagus: 14 (carene, 6 dorsal, 6 ventral) in male, 18 (carene, 7 dorsal, 9 ventral) in female (Figs. 3, 4). At mid-body: 14–15 in male (carene, 6–7 dorsal, 6 ventral), 19 in females (carene, 7 dorsal, 10 ventral) (Figs. 5–7). At mid-body: ridges unequal in size. Carene excluded, ridge adjacent to right lateral field largest. Ridges of ventral right quadrant smallest. On dorsal side, decreasing gradient of size from largest ridge to left, except for left dorsal ridge just contiguous to carene, slightly larger. In females and in larger males, presence of a right ridge just dorsal to axis of orientation, smaller and excluded from gradient (Figs. 6, 7). On ventral side, in males, 3 left ridges larger than 3 right ones (Figs. 5, 6). In females, first left ridge and first right ridge larger, remaining ridges subequal (Fig. 7). Single axis of orientation of ridges, inclined at 67° to sagittal axis in male, 55° in female. Within distal third of body length, number and size of ridges decreasing progressively. In males, carene disappearing at level of the last 2 spirals. At about 600 μm anterior to caudal bursa, 9 ridges subequal in size (Fig. 8). Then ridges disappear abruptly at a level usually corresponding to the arising of the spicules, about 400–450 mm in front of the caudal bursa (Fig. 9). In females, carene developed up to first third of uterus length; then ridges reduce progressively. At mid-length of uterus, 15–16 ridges (carene reduced, 6 dorsal, 7–8 ventral), with similar orientation than at mid-body (Fig. 10). At level of distal uterus, 16 subequal and not salient, oriented mainly perpendicularly to body surface (Fig. 11); at level of mid-infundibulum, 13 thin and not salient (Fig. 12). No ridges at level of distal infundibulum or sphincter (Fig. 13).

Males (on the basis of 14 specimens, neotypes, except otherwise stated): 2.80–4.07 (3.33) mm long and 70–110 (88) wide (carene included) at mid-body. Cephalic vesicle 38–52 (45) long, and 25–33 (29) wide. Nerve ring at 93–160 (126) (n = 13) from apex. Excretory pore and deirids situated respectively at 145–215 (171) (n = 13) and 155–215 (176) (n = 11) from apex. Esophagus 305–365 (330) long (n = 13).

Caudal bursa subsymmetrical, with dorsal lobe well developed, usually closed and difficult to spread out (Fig. 14). Prebursal papillae not observed. Pattern of type 1-3-1. Rays 2 and 3 parallel, arising separately, rays 2 slightly shorter. Rays 4 and 5 diverging at extremity, rays 4 slightly shorter. Rays 8 long, arising symmetrically from base of dorsal ray. Dorsal ray long, divided at its distal third into 2 branches, each one bifurcated distally into 2 subbranches, rays 9 (external) and rays 10 (internal) (Figs. 14, 15). Genital cone triangular, poorly developed, 20–35 long and 18–30 wide at base (n = 4). Papillae on genital cone not observed. Spicules subequal, alate, ending in simple, pointed tips (Fig. 14), 360–480 (429) long and representing 10.8–14.3% of body length. Gubernaculum ovoid, 18–23 (21) long and 10–15 (11) wide.

Females (on the basis of 10 specimens, neotypes, except otherwise stated): 4.50–7.05 (6.10) mm long and 150–200 (169) wide at mid-body. Cephalic vesicle 40–55 (46) long and 30–40 (35) wide. Nerve ring situated at 115–150 (125) (n = 8) from apex. Excretory pore and deirids situated respectively at 135–245 (173) (n = 5) and 135–245 (170) (n = 7) from apex. Esophagus 370–485 (419) long (n = 8). Monodelphic. Vulva situated at 65–95 (79) from caudal extremity. Vagina vera 12–20 (16) long (n = 8), vestibule 110–150 (126) long, sphincter 30–50 (43) long and 32–45 (38) wide, infundibulum 120–180 (156). Uterus 0.98–2.55 (1.72) mm long, taking up 20.5–37.2% (27.5%) of body length, containing 3–100 (55) eggs. Eggs 60–80 long and 30–45 wide. Tail rounded, 32–41 (36) long, with terminal mucron 5–10 (8) long (Fig. 16). Posterior extremity invaginated to different degrees into a broad cuticular dilatation 20–120 long (Figs. 17, 18).

Taxonomic summary

Type host: Holochilus chacarius balnearum Thomas (Rodentia, Cricetidae) deposited at Colección Mamíferos Lillo under CML 5544.

Site of infection: Small intestine.

Locality: Ingenio San Martín del Tabacal (23°16′S, 64°15′W), lote Milagros, Departamento Orán, Salta, Argentina.

Material studied: 15 males and 11 females, neotypes, deposited at MLP-He 3442C.

Other material deposited (host number in parentheses): Same host species and locality: 1 male, 4 females MLP-He 3441C (CML 5546), 16 males, 34 females MLP-He 3443C (CML 5549), 12 males, 81 females MLP-He 3444C (CML 5550), 5 males, 5 females MLP-He 3447C (CML 5553), 2 females MLP-He 3449C (CML 5552); 7 females MLP-He 6664 (CML 5810), 2 males, 2 females MLP-He 6665 (CML 5817), 2 females MLP-He 6666 (CML 5820), 1 female MLP-He 6667 (CML 5821), 1 male, 1 female MLP-He 6668 (CML 5822), 6 males, 25 females MLP-He 6669 (CML 5824), 18 males, 21 females MLP-He 6670 (CML 5825), 1 male MLP-He 6671 (CML 5826).

Prevalence and mean intensity (MI): $P = 66.7\%$ (14/21), MI = 24.7 (1–129) worms per host.

Coparasitism: Coparasitic with *Stilestrongylus stilesi* (14/14), *Hassalstrongylus argentinus* (10/14), and *Hassalstrongylus* sp. (5/14).

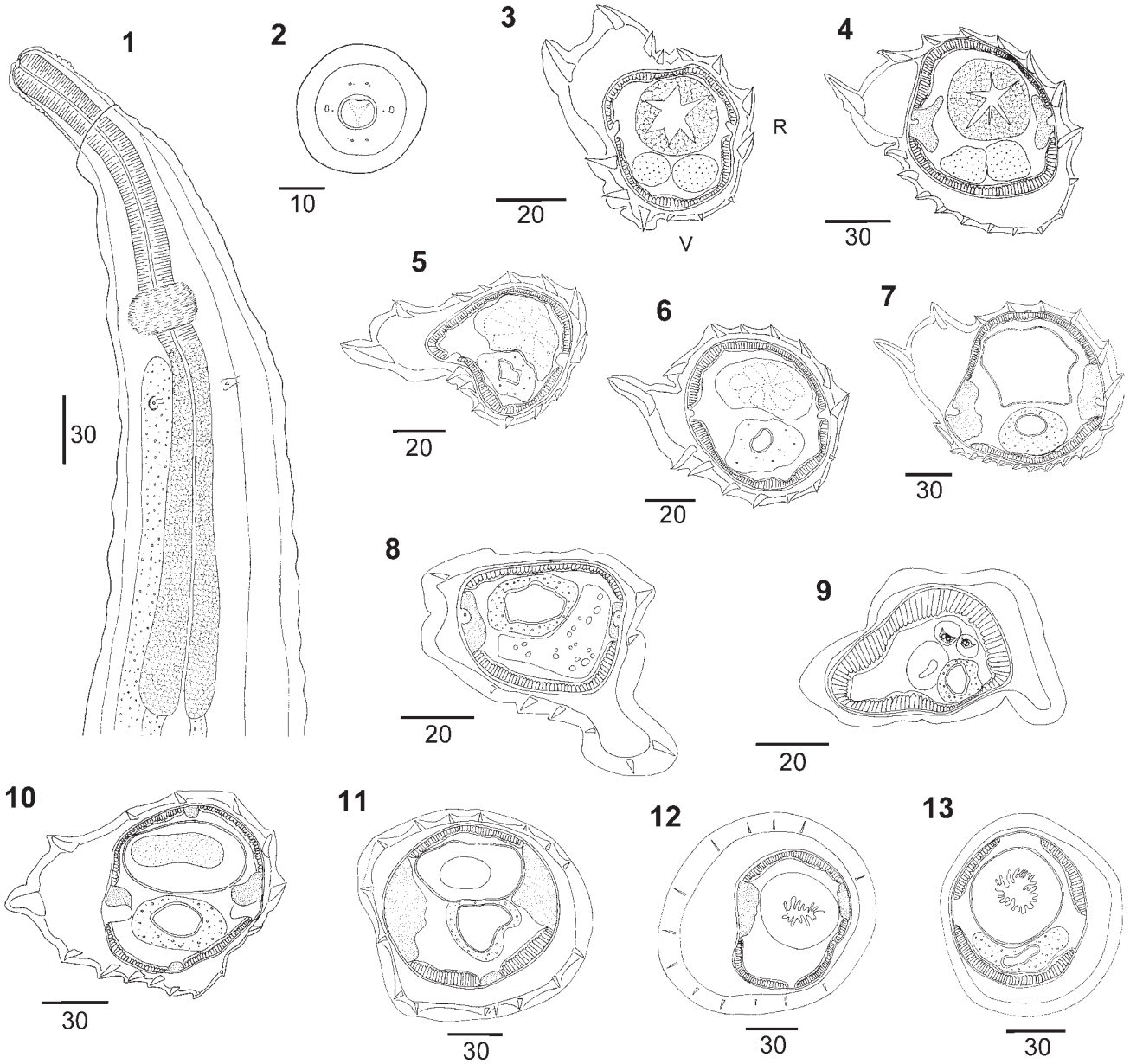
Remarks

Longistriata fortuita was described on a single male. The only material referred as to this species, deposited in the Helminthological Collection of the Instituto Oswaldo Cruz, Rio de Janeiro, Brasil (CHIOC) under No. 9059 is actually lost (M. Knoff, pers. comm.) and no other material of this species is deposited anywhere. However, the description by Freitas et al. (1937) is accurate enough: the presence of longitudinal ridges salient and transversely striated is remarked, and particularly the description and illustration of the caudal bursa, spicules, and gubernaculum are very clear and allow us to easily distinguish the specimens described as *L. fortuita*. Other species described by Freitas et al. (1937) as coparasitic with *L. fortuita*, i.e., *S. stilesi* and *H. argentinus*, were also identified in the hosts examined during this work, but both are easily differentiated from *L. fortuita* by characters of the synlophe, caudal bursa, and spicules in males and by the synlophe and shape of the posterior extremity in females (see redescriptions of *H. argentinus* in Durette-Desset [1968] and of *S. stilesi* in Notarnicola et al. [2010]). Concerning the females of *L. fortuita*, they were not described or identified by Freitas et al. (1937) and the matching of males and females of the species was possible through the study of the synlophe.

As stated in the Introduction, Freitas et al. (1937) described another species, *Heligmonoides mazzai*, then transferred to *Hassalstrongylus* by Durette-Desset (1971), coparasitic with the 3 species mentioned above. However, *H. mazzai* was not found in any the hosts examined. Instead, another species of *Hassalstrongylus* was found in 5 of 21 examined hosts. By the characters of the synlophe this species can be attributed to *Hassalstrongylus*, although several characters of the caudal bursa (subsymmetrical, dorsal lobe short, rays 4 very long and genital cone bulbous) prevent its identification to *H. mazzai*. We consider that such specimens represent an undescribed species of *Hassalstrongylus* that will not be treated in this work. Anyway, the coparasitism with *M. fortuita* n. comb. is remarked (see Taxonomic Summary).

DISCUSSION

Longistriata fortuita was described in 1937, when the importance of the synlophe as a main character in the systematics of this group had not yet been recognized. Numerous species parasitic in different groups of mammals and from different regions were described under *Longistriata*. Only several years later the genus *Longistriata* and the family Heligmosomidae in which it is actually placed were redefined (Durette-Desset, 1971, 1983). Species of *Longistriata* possess a synlophe with axis of orientation subfrontal, 8 ridges (4 dorsal, 4 ventral), and are parasitic in Holarctic Soricoidea (Durette-Desset, 1971, 1983), whereas the family Heligmosomidae is characterized by an axis of orientation



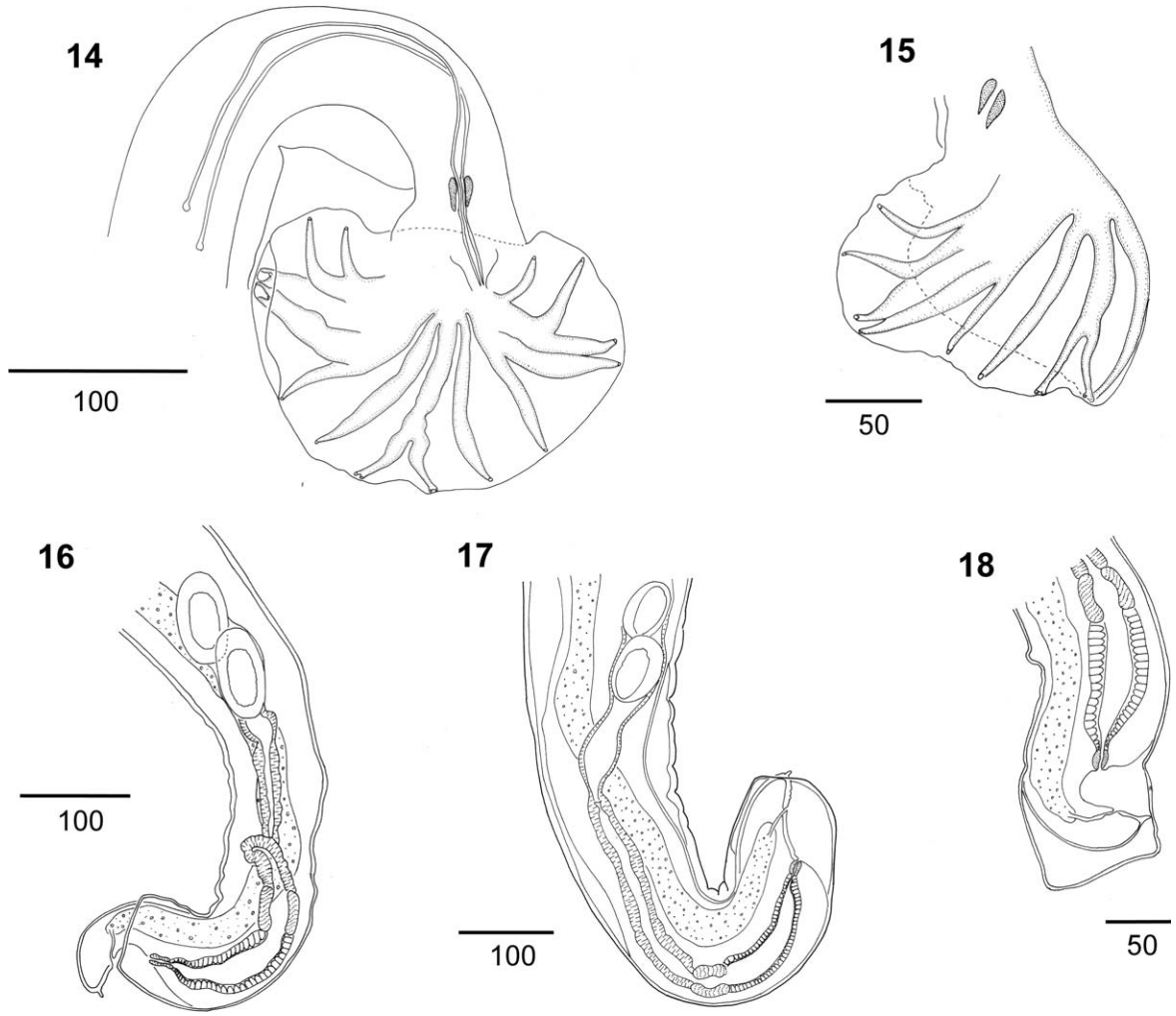
FIGURES 1–13. *Mazzanema fortuita* (Freitas, Lent, and Almeida, 1937) n. comb. (**1**) Male, anterior extremity, ventral-left view. (**2**) Female, head, apical view. (**3–13**) Synlophe in transverse sections of the body. (3, 4) At level of distal esophagus. (3) Male. (4) Female. (5–7) At mid-body. (5, 6) Male. (7) Female. (8–13) Within distal third of body length. (8, 9) Male. (8) 580 μm in front of caudal bursa. (9) 220 μm in front of caudal bursa. (10–13) Female. (10) At level of proximal uterus (1 mm from posterior end). (11) Distal uterus (650 μm from posterior end). (12) Mid-infundibulum (280 μm from posterior end). (13) Vestibule (190 μm from posterior end). Abbreviations: R, right; V, ventral. All sections oriented as in Fig. 3. Scale bars in micrometers.

of ridges subfrontal, female tail with spine, and caudal bursa generally of type 2–3 (Durette-Desset, 1983).

The specimens here redescribed possess the main characters of the superfamily Heligmosomoidea as defined by Durette-Desset and Chabaud (1993), i.e., body strongly coiled, presence of cephalic vesicle, synlophe not bilaterally symmetrical, caudal bursa not of type 2-1-2, and female monodelphic.

The synlophe with oblique axis of orientation, the bursal pattern different from type 2–3, and the lack of caudal spine in the females allow their inclusion into the family Heligmonellidae as redefined by Durette-Desset (1983) and Durette-Desset and Chabaud (1993). Moreover, several characters of the synlophe, i.e., ridges continuous and all around the body, the presence of a gradient of size of the ridges, and the number of ridges (more than 13), with ventral ridges more numerous than dorsal, allow us to place this species within the subfamily Nippostrongylinae (Durette-Desset, 1985).

First of all, the presence of a carene clearly differentiates these specimens from all the 8 known genera of New World Nippostrongylinae: *Carolinensis* (Travassos), *Stilestrongylus*, *Hassalstrongylus*, *Hypocristata* Durette-Desset, *Guerrerostrongylus* Sutton and Durette-Desset, *Trichofreitasia* Sutton and



FIGURES 14–18. *Mazzanema fortuita* (Freitas, Lent, and Almeida, 1937) n. comb. (**14, 15**) Male, caudal bursa. (14) Entire bursa and spicules, ventral view. (15) Right lobe, ventral view (left lobe omitted). (**16–18**) Female, posterior extremity showing different degrees of tail invagination. (16) Showing up to distal uterus, tail slightly invaginated. (17) Tail strongly invaginated, left lateral view. (18) Distal extremity, tail completely invaginated, right lateral view. Scale bars in micrometers.

Durette-Desset, *Malvinema* Digiani, Sutton, and Durette-Desset, and *Suttonema* Digiani and Durette-Desset (Freitas et al., 1937; Travassos, 1937; Durette-Desset, 1971; Sutton and Durette-Desset, 1991; Digiani and Durette-Desset, 2003; Digiani et al., 2003). None of these genera, which are all parasites of cricetids, possesses a carene. The presence of a carene is not very frequent among the Nippostrongylinae; 3 genera include species having a carene formed by 2 large ridges at mid-body, of which the ventral one is usually larger than the dorsal. These genera are: *Neoheligmonella* Durette-Desset, *Odilia* Durette-Desset (both include species with and without carene), and *Nippostrongylus* Lane, 1923 (only species with carene). Members of *Neoheligmonella* have mainly an Ethiopian distribution, whereas *Odilia* and *Nippostrongylus* have mainly an Oriental-Australian distribution (except the cosmopolite species *Nippostrongylus brasiliensis* [Travassos, 1914], parasite of rats and mice). All these species can be primarily differentiated from our specimens by characters of the synlophe or the caudal bursa. In *Neoheligmonella* spp. there is a lower number of ridges at mid-body (never more than 13), and the characteristic bursal pattern is of type 2-3 tending to 2-2-1 (Durette-Desset and Digiani, 2012). In species of *Odilia* with a well-developed carene both ridges of the carene have similar size, there is no sexual dimorphism of the ventral ridges, and the caudal bursae have different types of pattern ranging from 2-2-1 to 1–4, but typically with a short dorsal lobe and the dorsal ray divided proximally. Concerning the species of *Nippostrongylus* they are typically characterized by dissymmetrical or asymmetrical caudal bursae with characteristic patterns of type 1-3-1 tending to 4-1 and 4-1 (Durette-Desset and Digiani, 2012).

The unique combination of characters of the synlophe (carene, dorsal gradient of size, no ventral gradient in females) and the caudal bursa (pattern 1-3-1, dorsal lobe and ray developed, distal fork of dorsal ray) makes these specimens different from all the other genera of Nippostrongylinae and separates them particularly from the rest of the New World representatives of the subfamily. We consider the need of the definition of a new genus for the species *fortuita*, for which the name *Mazzanema* n. gen. is proposed.

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LITERATURE CITED

Cirignoli, S., P. Teta, U. F. J. Pardiñas, and G. D'Elía. 2006. Tribu Oryzomyni Vorontsov, 1959 (sensu Voss and Carleton, 1993). *In* Mamíferos de Argentina. Sistemática y distribución, R. M. Barquez, M. M. Díaz and R. A. Ojeda (eds.). Sociedad Argentina para el Estudio de los Mamíferos SAREM, Mendoza, Argentina, p. 166–175.

Digiani, M. C., and M. C. Durette-Desset. 2003. *Suttonema delta* n. g., n. sp. (Nematoda: Trichostrongylina: Heligmosomoidea) from *Oxymycterus rufus* (Rodentia: Sigmodontinae) in Argentina. Systematic Parasitology **55:** 33–38.

———, C. A. Sutton, and M. C. Durette-Desset. 2003. A new genus of Nippostrongylinae (Nematoda: Heligmonellidae) from the water rat *Scapteromys aquaticus* in Argentina. Journal of Parasitology **89:** 124–132.

Durette-Desset, M. C. 1968. Nématodes Héligmosomes d'Amérique du Sud. III. Nouvelles données morphologiques sur cinq espèces parasites de Rongeurs ou de Primates. Bulletin du Muséum National d'Histoire Naturelle, 2ème série **40:** 1215–1221.

———. 1971. Essai de classification des Nématodes Héligmosomes. Corrélation avec la paléobiogéographie des hôtes. Mémoires du Muséum National d'Histoire Naturelle, Nouvelle série, série A, Zoologie **49:** 1–126.

———. 1983. Keys to genera of the Superfamily Trichostrongyloidea. *In* CIH keys to the nematode parasites of vertebrates, R. C. Anderson and A. G. Chabaud (eds.). Commonwealth Agricultural Bureaux, Fairham Royal, Bucks, U.K., p. 1–68.

———. 1985. Trichostrongyloid nematodes and their vertebrate hosts: Reconstruction of the phylogeny of a parasitic group. Advances in Parasitology **24:** 239–306.

———, and A. G. Chabaud. 1993. Note sur la nomenclature supra-familiale des Strongylida. Annales de Parasitologie Humaine et Comparée **68:** 11–12.

———, and M. C. Digiani. 2012. The caudal bursa in the Heligmonellidae (Nematoda: Trichostrongylina). Characterization and hypothesis on its evolution. Parasite **19:** 3–18.

Freitas, J. F. T., H. Lent, and J. L. Almeida. 1937. Pequena contribuiçao ao estudo da fauna helminthologica da Argentina. Memórias do Instituto Oswaldo Cruz **32:** 195–209.

Notarnicola, J., M. C. Digiani, and P. M. López. 2010. Redescriptions of the nematodes *Litomosoides patersoni* (Mazza, 1928) (Onchocercidae) and *Stilestrongylus stilesi* Freitas, Lent, and Almeida, 1937 (Heligmonellidae) parasites of *Holochilus chacarius* (Rodentia, Cricetidae) from Salta, Argentina. Journal of Parasitology **96:** 993–1001.

Sutton, C. A., and M. C. Durette-Desset. 1991. Nippostrongylinae (Nematoda - Trichostrongyloidea) parasites d'*Oryzomys flavescens* en Argentine et en Uruguay. Revue Suisse de Zoologie **98:** 535–553.

Travassos, L. 1937. Revisão da familia Trichostrongylidae Leiper, 1912. Monografias do Instituto Oswaldo Cruz **1:** 1–512.

Wilson, D. E., and D. A. M. Reeder. 2005. Mammal species of the world. A taxonomic and geographic reference, 3rd ed. Johns Hopkins University Press, Baltimore, Maryland, 2142 p.