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A new species of *Lentiella* (Cestoda: Anoplocephalidae) from *Proechimys simonsi* (Rodentia: Echimyidae) in Bolivia

Una especie nueva de *Lentiella* (Cestoda: Anoplocephalidae) de *Proechimys* (Rodentia: Echimyidae) en Bolivia

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Abstract. During a biodiversity survey of mammals and their parasites in the Beni, Bolivia in the summer of 2000, several spiny rats, *Proechimys simonsi* Thomas, 1900, were collected and examined for parasites. Herein we describe *Lentiella lamothei* n. sp. from one of these hosts. This species is can be distinguished from *L. machadoi* Rêgo, 1964 by having a greater total length but smaller maximum width, a greater number of segments, a smaller cirrus sac, a smaller scolex diameter, and in the eggs, a larger pyriform apparatus. In addition, we formally validate the genus *Lentiella* Rêgo, 1964, that had been placed in synonomy with *Monoecocestus* Beddard, 1914.

Key words: Echimyidae, Departamento del Beni, Bolivia, Anoplocephalidae, *Lentiella lamothei*.

Resumen. Como parte del monitoreo de la biodiversidad de Bolivia, varias ratas espinosas (*Proechimys simonsi* Thomas, 1900) fueron examinadas en busca de parásitos durante el verano boreal del año 2000. En el presente trabajo se describe el céstodo *Lentiella lamothei* n. sp. recolectado en estos hospederos. Esta especie puede distinguirse de *L. machadoi* Rêgo, 1964 por tener una mayor longitud total pero menor ancho máximo, mayor número de proglótidos, bolsa del cirro más pequeña, escólex de menor diámetro, y un mayor aparato piriforme en los huevos. Además, se revalida formalmente al género *Lentiella* Rêgo, 1964, anteriormente sinonimizado con *Monoecocestus* Beddard, 1914.

Palabras clave: Echimyidae, Departamento del Beni, Bolivia, Anoplocephalidae, *Lentiella lamothei*.

Introduction

This contribution is one of the many publications that have resulted from data collected as a result of our collaborative, long-term expeditionary research on the biodiversity of mammals and their parasites from the Republic of Bolivia (Gardner and Campbell, 1992; Anderson, 1997; Dick et al., 2007; Notarincola et al., 2007). In the year 2000, research teams from the Museum of Southwestern Biology and the Harold W. Manter Laboratory of Parasitology traveled through east-central lowland Bolivia and collected small and medium-sized mammals and their parasites from the departments of Beni and Santa Cruz. The work was primarily focused on a survey of potential hosts for Machupo virus, the causative agent of Bolivian hemorrhagic fever. During this survey, many species of mammals were obtained, examined, and deposited in museums. From our work, several specimens of spiny rats (*Proechimys simonsi* Thomas, 1900) were collected and examined for parasites and 2 individuals were found to be infected with an undescribed species of anoplocephalid cestode.

Species of the genus *Proechimys* Allen, 1899 occur throughout lowland tropical evergreen forests of South America from east-central Honduras (*P. semispinosus* (Tomes, 1860)) south through northern Paraguay (*P. longicaudatus* (Rengger, 1830)). *Proechimys simonsi* is known to occur in suitable habitats in Ecuador, Peru, Bolivia, and western Brazil (Eisenberg and Redford, 1992; Wilson and Reeder, 2005). During work carried out in the north eastern part of South America, the anoplocephalid cestode, *Lentiella machadoi* Rêgo ,1964 was described from 8 whole specimens taken from the small intestine of an individual of *Proechimys guyannensis* (Geoffroy, 1803) collected in Abaeté, Estado do Pará, Brazil (Rêgo, 1964). In this paper Rêgo (1964) established the genus *Lentiella* based on morphological characters of the species *L. machadoi*. For clarity we reproduce the original diagnosis of the genus here:

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Lentiella Rêgo (1964)
Diagnose.– Anoplocefalídeos de reduzidas dimensões e siples genitália. Escolex e ventosas grandes. Pescoço inexistente ou reduzido. Proglotes mais largos que longos, com segmentação linear. Póros genitais regular ou irregularmente alternos. Testículos pouco numerosos, dispostos nap arte posterior do segmento, em fila contínua, posteriormente ao ovário e vitelino. Bôlsa do cirro, grande, provida de cirro espinoso. Vagina ventral á bôlsa do cirro. Ovário bastante lobado, ligeiramente anti-poral, Vitelino compacto, de posição mediana nos segmentos, mas poral em relação ao ovário. Receptáculo seminal pequeno. Útero tubular, que se ramitica, mas não ocupa a parte posterior dos segmentos. Ovos con aparéelo piriforme pouco desenvolvido. Sistema excretor? Adultos em roedores.

As noted above, the details of the excretory system were not recorded; however, the general characteristics of the type species appear to be well enough defined that Rêgo (1964) was able to describe the species in a new genus (*Lentiella* n. gen.).

Beveridge (1994) examined the type specimens in the Helminthological Collection of the Instituto do Oswaldo Cruz (IOC 29.770a) and stated:

The testes lie in the posterior part of the medulla and the vagina, which is only clearly visible in 2 proglottids, opens to the genital atrium anterior to the cirrus-sac, in contradistinction to Rêgo's (1964) description. The uterus is prominently lobed and appears to be slightly reticulated; however, in the only specimen available, from the collection… …(IOC 29.779)[sic], the proglottids in which the critical stages of uterine development occur are damaged. More material is required for a detailed study of uterine development, and pending this, the genus is made a synonym of Monoecocestus.

We note here that in his description, Rêgo (1964) did not mention where the vagina enters the genital atrium; however, mediad from the genital atrium, the vagina passes ventrally to the cirrus sac. Therefore, based on our observations of both the description by Rêgo and of specimens that we collected in Bolivia, we verify that the genus *Lentiella* is valid and herein we describe a new species of anoplocephalid cestode collected from *P. simonsi* in the Beni Dept., Bolivia. The description is based on 5 fully developed specimens with gravid segments and sections of additional specimens.

Materials and methods

Captured mammals were processed immediately following standard protocols (Gardner, 1996). The complete gastrointestinal tract, liver, lungs, pleural, and peritoneal cavities were examined separately for helminths using a dissecting microscope. Cestodes found were placed immediately in a large volume of distilled water to relax the strobila for later morphological examination. Specimens were killed and preserved in either 10% formalin or 70% ETOH and were transported in the same solution to the laboratory for staining and subsequent study by light microscopy. Specimens used in the present study were stained in Semichon's acetic carmine or Erlich's acid hematoxylin, dehydrated in an alcohol series, cleared in terpineol and xylene, and mounted in Dammar gum. After staining, superficial tegument and tissues, including either dorsal or ventral longitudinal and transverse muscles, were removed from some specimens to allow observation of internal organs. Eggs were viewed by clearing a gravid proglottid with lactophenol and viewing free eggs with the aid of a microscope. Serial cross sections were prepared from one specimen to allow observation of the relative placement of organs.

All measurements were taken with the aid of an ocular micrometer. Figures were made with the aid of a drawing tube. Scolex length was measured from the anterior extremity to the posterior margin of the suckers. Neck length was measured from the posterior margin of the suckers to the first visible sign of segmentation. Genital pore alternation is presented as the number of times the genital pore switched sides per 100 proglottids. Thus, a higher number corresponds to more regular alternation. The widths of dorsal and ventral osmoregulatory canals were recorded at the midpoint of the proglottid on the antiporal side. Measurements of the cirrus sac were not taken if the cirrus was everted. Dimensions of the pyriform apparatus were measured from digital photographs. Testis distribution was measured as the distance between the 2 distal extreme testes (Haukisalmi et al., 2004). The index of asymmetry was calculated as the ratio of the distance between the midpoint of the vitellarium and the poral extremity/the total width of the proglottid (Sato et al., 1993). All measurements are provided in micrometers unless otherwise specified. Measurements provided include the mean measurement, followed by the range in parentheses, and the number of measurements if different than that given initially.

Description

Lentiella lamothei n. sp. (Figs. 1-7)

Measurements based on 5 whole gravid individuals from a single host. Measurements are summarized in Table I. Scolex 752 (673-840) wide, 368 (341-395) long.

Suckers face laterally or antero-laterally. Width of suckers 293 (248-348 n=20), sucker aperture 179 (132-232 n=20). Neck 615 (360-735) long, 502 (480-540) wide at narrowest point. Specimens have 41 (37-43) proglottids per gravid strobila. Strobila 19.4 (16.1-21.6) mm in total length. Width at widest point 1.37 (0.78-1.62) mm in mature proglottids. Immature proglottids 150 (120-180) long, 894 (780-1110) wide. Mature proglottids 449 (330-660) long, 1323 (1110-1590) wide. Gravid proglottids 876 (780-960) long, 1308 (1200-1500) wide. Genital pores alternate regularly, with an average of 90 (82-96) switches per 100 proglottids.

The following measurements are based on 15 mature proglottids with 3 proglottids measured per strobila. Testes ovoid, 27 (18-37) per proglottid, 47 (32-66 n=75) in diameter. Testis distribution 522 (410-650). Testes dorsal and ventral to transverse excretory canal. Cirrus sac 210 (123-310) long, 120 (76-158) wide. Internal and external seminal vesicle absent. Seminal receptacle 116 (73-163) long, 69 (41-107) wide. Vitelline gland 95 (70-111) long, 96 (70-114) wide. Index of asymmetry 0.61 (0.56-0.65). Ovary 224 (180-284) long, 277 (234-332) wide. Midline of ovary 801 (658-983) from poral extremity, midline of vitelline gland 694 (573-867) from poral extremity. Vagina dilated distally, when dilated, usually overlapping cirrus sac. Vaginal dilation reaching maximum length of 237 long and 114 wide, appearing in immature segments, not seen or absent in mature proglottids. Vagina 422 (316-664) long, entering genital atrium anterior to cirrus sac. Uterus dorsal to seminal receptacle and ovary, ventral to testes, if contacted. Uterus crosses ventral excretory canals rarely, in gravid segments only. Uterus may cross osmoregulatory canals ventrally or dorsally. Gravid uterus with anterior, posterior, and lateral diverticula. Genital organs crossing excretory canals dorsally. Dorsal and ventral excretory canals present. Ventral canals 25 (16-39) in width, dorsal canals 13 (4-21) wide, transverse canals 18 (8-43) wide. Eggs round, 46 (43-51 n=25) in diameter containing an oncosphere 12 (10-14 n=25) wide surrounded by pear-shaped pyriform apparatus. Pyriform apparatus simple, with 2 short horns and no filaments, 31 (25-34 n=12) along its axis.

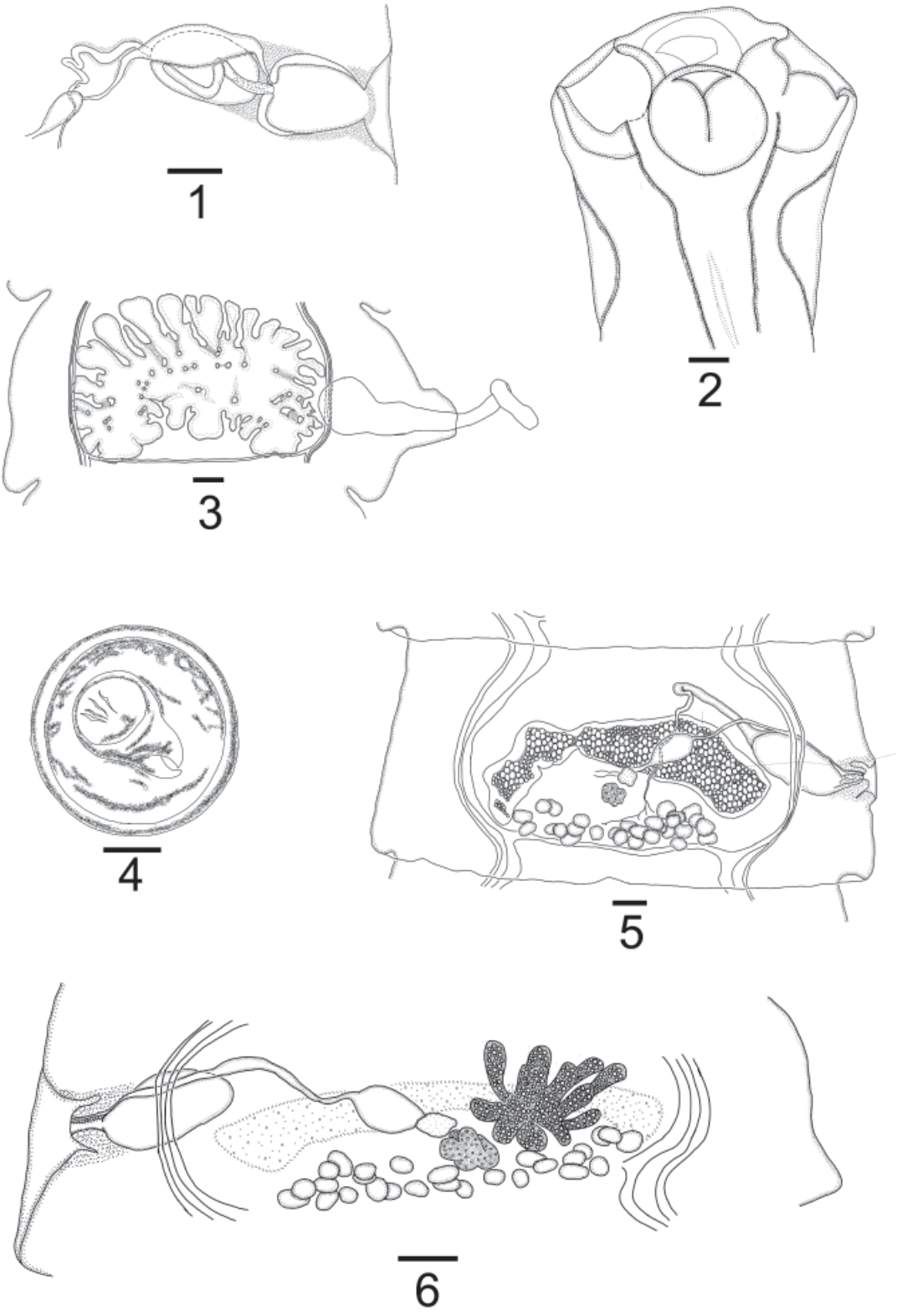
Taxonomic summary

Type-host: *Proechimys simonsi* Thomas 1900, Symbiotype (see Frey, et al., 1992) deposited in the University of New Mexico, Museum of Southwestern Biology Mammal Division (MSB), MSB98787.
Site of infection: small intestine.
Type-locality: Puesto Militar Casarabe, Dept. Beni, Bolivia, 5.5 km South of Casarabe by road, 14° 53' 44" S 64° 25' 59" W, 188 m elevation.
Type-specimen: holotype, mounted on a microscope slide, collected 26 May, 2000, HWML70023, 9 paratypes from same host symbiotype, mounted on slides, HWML70024, preserved in formalin, HWML63382. All specimens deposited in the Harold W. Manter Laboratory of Parasitology, Division of Parasitology, The University of Nebraska State Museum, University of Nebraska, Lincoln, Nebraska.
Prevalence and intensity: 2/6 (33%), average 40 specimens from duodenum.
Etymology: this species is named after Dr. Rafael Lamothe-Argumedo, teacher, taxonomist, and one of the leaders in helminthology at UNAM in Mexico.

Lentiella Rêgo, 1964, emended.
Diagnosis.- Anoplocephalids of small size. Scolex and suckers large. Proglottids wider than long in immature, mature, and gravid segments, posterior penultimate and ultimate segments devoid of eggs, always longer than wide. Genital pores regularly alternating. Small but numerous testes, located in posterior part of segment, in continuous line, posterior to ovary and vitelline gland. Testes overlap transverse, but not ventral or dorsal osmoregulatory canals. Cirrus sac large, cirrus spined. Vagina enters gential atrium anterior to cirrus sac. Lateral genital ducts (vagina and cirrus sac) cross osmoregulatory canals dorsally. Ovary lobed, slightly anti-poral. Vitelline gland compact, posterior and poral to the ovary. Small seminal receptacle present. Vaginal dilation present in immature segments. Internal and external seminal vesicles absent. Tubular uterus arching anteriorly from center, not occupying posterior part of the segments. Uterine development abrupt, filling with eggs before uterine wall fully developed. Uterus crosses ventral excretory canals rarely, in gravid segments only. Uterus may cross osmoregulatory canals ventrally or dorsally. Gravid uterus with anterior, posterior, and lateral diverticula. Anapolytic with eggs generally absent from terminal senescent segments. Eggs with simple pyriform apparatus. Adults in rodents, South America.

Remarks

Compared to the only other species in the genus, *L. lamothei* n. sp. differs from *L. machadoi* by having a greater total length but smaller maximum width, a greater number of segments, a smaller cirrus sac, a smaller scolex diameter, and in the eggs, a larger pyriform apparatus. Other measurements may prove useful in distinguishing the 2 taxa. However, due to the condition of the material from Rêgo (1964), we recommend that new material be collected and measured so a comparison can be made with properly relaxed specimens of *L. machadoi*. Currently, including this report, species of *Lentiella* are known only from hystricognath rodents of the genus *Proechimys* in the



Figures 1-6. *Lentiella lamothei* n. sp. 1, gential atrium of immature proglottid showing vaginal dilation. 2, scolex. 3, gravid uterus. 4, egg showing pyriform apparatus and oncosphere. Scale bar= 0.01 mm. 5, first postmature proglottid. 6, mature proglottid. Scale bars= 0.1 mm for Figs. 1-3, 5-6.

Table 1. Meaurements comparing *L. lamothei* n. sp. and *L. machadoi*

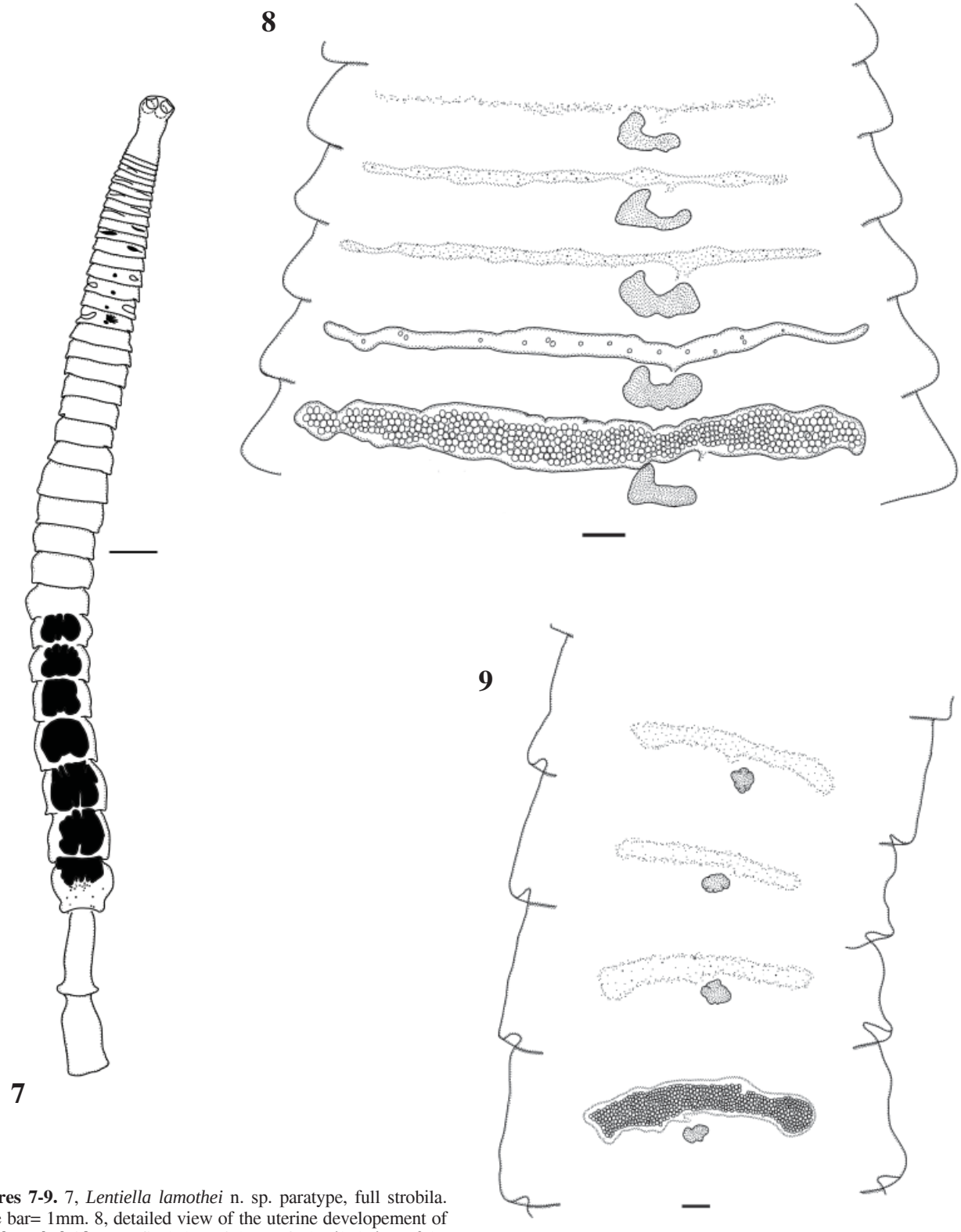
	L. machadoi Rêgo, 1964	*L. lamothei* n. sp. range (mean)
Total length	5.4-10.5	16.1-21.6 (19.3)
Proglottids, number	24-28	37-43(41)
Strobila width, max	2100	780-1620 (1374)
Mature proglottid		
Length	202	330-660 (490)
Width	1830	1140-1620 (1374)
Gravid proglottid		
Length	562	780-960 (876)
Width	1420	1200-1500 (1308)
Scolex diameter	1050	673-840 (752)
Scolex length	1120	341-395 (369)
Sucker diameter	300-330	248-348 (293)
Testes number	20	18-37 (26)
Testes diameter	45	32-66 (47)
Cirrus length	300	123-310 (209)
Cirrus width	112	76-158 (120)
Seminal receptacle		
Length	150	73-163 (116)
Width	60	41-107 (69)
Ovary		
Length	--	180-284 (224)
Width	--	234-332 (277)
Vitelline Gland		
Length	--	70-111 (95)
Width	--	70-114 (96)
Vagina, Length	--	316-664 (422)
Vaginal swelling, max	--	114
Index of asymmetry	--	0.56-0.65 (0.61)
Egg, diameter	45	43-51 (46)
Oncosphere, diameter	23	25-34 (31)
Pyriform apparatus, length	--	25-34 (31)

Neotropics (Brazil and Bolivia).

Species assigned to the genus *Lentiella* appear superficially similar to species of *Monoecocestus* in that the vagina enters the genital atrium anterior to the cirrus sac. However, *Lentiella* has a tubular uterus while the developing uterus of all known species of *Monoecocestus* is reticular in nature. In addition, the vitelline gland in *Lentiella* is posterior to the ovary and on the poral side compared with the vitelline gland in known species of *Monoecocestus* which are central and posterior to the ovary.

The 2 species of *Lentiella* can be readily distinguished from species of *Viscachataenia* Denegri et al., 2003 with the former having only a single set of genital organs per segment and a tubular uterus.

Comparing *L. lamothei* to known forms of the Anoplocephalidae that also have a uterus that is tubular in nature, it is evident that only species of Nearctic *Anoplocephaloides* have this type of uterine development and structure. However, *L. lamothei* can be recognized as distinct from species of *Anoplocephaloides* in having a uterus that remains diffuse until the uterine wall becomes immediately recognizable and the uterus is full of eggs. In species of *Anoplocephaloides*, the tubular uterus develops more slowly, forming a definitive uterine wall and lumen before becoming gravid. Finally, the testes of *Lentiella* are



Figures 7-9. 7, *Lentiella lamothei* n. sp. paratype, full strobila. Scale bar= 1mm. 8, detailed view of the uterine developement of *Anoplocephaloides* spp. Scale bar= 0.1 mm. 9, detailed view of the uterine development of *Lentiella lamothei* n. sp. holotype. Scale bar= 0.1 mm.

always posterior to the ovary and vitelline gland compared to species of *Anoplocephaloides* that have testes that are largely antiporal.

Discussion

Species of *Proechimys* are known to eat seeds, fruits, and fungi (Eisenberg and Redford, 1992), and with the discovery of this cestode, it is clear that they also eat some kind of arthropod. Assuming the close relationship of *Lentiella* spp. to *Monoecocestus* spp., this arthropod is likely an Oribatid mite, since the life cycle of at least one species of *Monoecocestus* has been experimentally verified (Freeman, 1952). We assume the close relationship of *Lentiella* and *Monoecocestus* from the relative position of the vagina to the cirrus sac at the genital atrium, and the posterior position of the testes in the proglottids.

Development of the uterus has been one of the most important taxonomic characters of species included in this family of cestodes, especially in the Anoplocephalinae, where the uterus does not degenerate in gravid proglottids (Rausch, 1976; Spasskii, 1951). It has been established that the development of the early uterus (e.g. reticulate, tubular) is homoplasic (Wickström et al., 2005), but general structure and development of the uterus is still used to discriminate between and among species within a genus. The development of the uterus in *L. lamothei* n. sp. appears to be most similar to *Anoplocephaloides* in that it is not reticulate early in development, but differs from *Anoplocephaloides* species in the nature of the development. The uterus in *L. lamothei* n. sp. appears in the segment less than 5 proglottids before it becomes prominent in the strobila; appearing as an aggregation of cells that spans the proglottid, not unlike most other anoplocephalids. However, in *Anoplocephaloides* the uterus develops a recognizable uterine wall and lumen prior to becoming full of developing eggs (Fig. 8). In *L. lamothei* n. sp., development from a simple aggregation of cells to fully gravid uterus takes place in the span of one proglottid, and in the newly formed uterus undeveloped eggs occupy a majority of the uterine area (Fig. 9). The uterine wall in this fully gravid proglottid is has not completely developed, and still looks like an aggregation of densely packed cells. In the following proglottids the uterus grows rapidly, but the number of eggs does not follow its fast development, leaving the uterus partially filled in subsequent proglottids. Soon the uterus develops the anterior and posterior diverticula common in *Monoecocestus* and other anoplocephalid species until it becomes sac-like, filling with eggs. Many specimens examined followed developmental pathways noted by Rêgo (1964) in that the eggs would sometimes be completely expelled from the last 2 or 3 proglottids. Those senescent segments appear in sharp contrast to those proglottids before them, as they became 2 to 3 times longer than wide.

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