

ORIGINAL ARTICLE

Physaloptera apodemi sp. nov. (Nematoda: Physalopteridae) from *Apodemus sylvaticus* (Linnaeus, 1758) (Rodentia: Muridae) from Tianjin, China

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Abstract A new species, *Physaloptera apodemi* sp. nov., was collected from *Apodemus sylvaticus* (Linnaeus, 1758) (Rodentia: Muridae) from the National Baxianshan Nature Reserve, Tianjin, China. The new species differs from the congeners by having 22 caudal papillae, the number and arrangement of caudal papillae, either the left or the right spicule with striated sheaths at their proximal end, the vulva located in the anterior fifth of body, and the egg size. A key to the species of *Physaloptera* from rodents is also given.

Key words *Physaloptera*, Nematoda, *Apodemus sylvaticus*, rodent, China.

1 Introduction

Nematode species of the genus *Physaloptera* Rudolphi, 1819 are common in rodents and were reported in Muridae, Cricetidae, Sciuridae, Echimyidae and Dasyproctidae (Veciana *et al.*, 2013; Ederli *et al.*, 2018; Maldonado *et al.*, 2020). To date, 14 species of *Physaloptera* have been reported from rodents worldwide (Baylis, 1928; Vaz & Pereira, 1935; Schell, 1950; Yamaguti, 1961; Skrjabin & Sobolev, 1964; Quentin, 1968; Parihar & Nama, 1978; Sutton, 1989; São Luiz *et al.*, 2015; Ederli *et al.*, 2018; Maldonado *et al.*, 2020). However, most of species were reported from America. In Asia, three species of *Physaloptera* have been reported from rodents, namely *P. funambuli* Parihar & Nama, 1978 from *Funambulus pennanti* in India (Parihar & Nama, 1978); *P. massino* Schulz, 1926 from *Mus musculus wagneri* and *Rhombomys opimus* in Kazakhstan (Skrjabin & Sobolev, 1964); and *P. ngoci* Le-Van-Hoa, 1961 from *Rattus norvegicus* in Vietnam (Le-Van-Hoa, 1961, Veciana *et al.*, 2013). However, species of *Physaloptera* have not been reported from rodents in China. In the present study, a new species of *Physaloptera* was collected from *Apodemus sylvaticus* (Linnaeus, 1758) (Rodentia: Muridae) from the National Baxianshan Nature Reserve, Tianjin, China. A key to the species of *Physaloptera* from rodents is also given.

2 Materials and methods

Ten *Apodemus sylvaticus* were captured from the National Baxianshan Nature Reserve, Tianjin, China to examining their parasites. Nematodes were collected from their stomach. After washing in physiological saline, the specimens were fixed in hot 70% ethanol, then preserved in 70% ethanol. For light microscopic examination, nematodes were cleared in

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temporary mounts of lactophenol. Drawings were made with the aid of a Nikon microscope drawing attachment. For scanning electron microscopy (SEM) studies, specimens were fixed in 4% formaldehyde, post-fixed in 1% OsO₄, dehydrated through an ethanol series and acetone, and then subjected to critical point drying. The specimens were coated with gold and examined with a Hitachi S-570 scanning electron microscope at an accelerating voltage of 15 KV. Measurements (minimum, maximum, followed by mean in parentheses) are given in micrometers (μm), unless otherwise stated. Specimens have been deposited in the College of Life Sciences, Hebei Normal University (HBNU), Hebei Province, China.

3 Results

Family Physalopteridae Leiper, 1908

Genus *Physaloptera* Rudolphi, 1819

Physaloptera apodemi sp. nov. (Figs 1–3)

General description. Body large and robust, females larger than males. Cuticle thick with distinct transverse striations, forming a distinct cephalic collarete near anterior end (Fig. 2A). Oral opening surrounded by two semicircular pseudolabia, each pseudolabium provided with two large cephalic papillae, one small amphid, an externolateral tooth and three internolateral teeth (Figs 2A–B). Internal lateral teeth dissimilar in shape, two lateral teeth with rounded tip, central tooth triangular (Fig. 2B). Oesophagus divided into short anterior muscular part and long posterior glandular part. Nerve ring located at posterior end of muscular oesophagus. Cervical papillae located at level of anterior end of glandular oesophagus (Fig. 1A). Excretory pore posterior to cervical papillae.

Description. Male ($n=10$). Body length 13.67–18.29 (15.85) mm. Maximum width 786–1143 (942); body width at level of nerve ring 223–553 (377). Muscular oesophagus 427–563 (475) long; glandular oesophagus 2.21–2.91 (2.54) mm. Total length of oesophagus 2.83–3.38 (3.01) mm, 16.78–21.95% (19.31%) total body length (TBL) from anterior end. Nerve ring 388–466 (436) from anterior end; cervical papillae 689–845 (775) from anterior end; excretory pore 777–922 (843) from anterior end. Posterior end of body ventrally curved in spiral with ornamented caudal alae which unite on ventral surface of body (Figs 3A–B). Ventral surface of cloacal region with prominent longitudinal ridges (Figs 3B–C). Cloacal aperture 619–990 (801) from posterior extremity. Twenty-two total caudal papillae including four pairs of pedunculated papillae organized laterally at caudal alae, three sessile papillae just anterior to cloaca, and five pairs of post-cloacal sessile papillae and one single sessile papilla (Figs 1H, 3B) with following distribution: two pairs of papillae immediately posterior to cloaca; third pair located below, with inclined orientation; fourth and fifth pairs equidistant, parallel; and one single papilla located between fifth pair of papillae (Figs 1H, 3C–F). A pair of phasmids located anterior to fifth pairs of post-cloacal papillae (Fig. 3F). Spicules unequal and dissimilar, left spicule longer and thinner than right one, both left and right spicules with striated sheaths in their proximal end. Left spicule 451–525 (481) long, with a pointed tip. Right spicule 352–397 (375) long, with a blunt tip (Figs 1F, 3D). Gubernaculum absent.

Female ($n=10$). Body length 24.45–32.57 (29.41) mm. Maximum width 1191–1714 (1423); body width at level of nerve ring 379–534 (448). Muscular oesophagus 485–621 (566) long; glandular oesophagus 3.22–4.08 (3.59) mm. Total length of oesophagus 3.78–4.56 (4.09) mm, 12.83–15.45% (14.33%) TBL from anterior end. Nerve ring 466–553 (502) from anterior end; cervical papillae 786–1214 (936) from anterior end; excretory pore 884–1390 (982) from anterior end. Vulva located at anterior fifth of body, 4.52–7.71 (5.68) mm from anterior end, and 16.78–24.11% (19.68%) TBL from anterior end (Fig. 2C). Vagina extending anteriorly for a short distance then bending backward, extending posteriorly and connecting with two uteri (Fig. 1E). Eggs ellipsoidal with thick shell, 39–44 (42) long, 21–27 (24) wide. Tail conical, 505–631 (562) long (Figs 1G, 2D).

Type host. Wood mice, *Apodemus sylvaticus* (Linnaeus, 1758) (Rodentia: Muridae)

Site of infection. Stomach.

Prevalence. 50% (5 of 10 hosts examined)

Mean intensity. 12 (7–20 worms per host)

Material examined. Holotype male (HBNU-M-2001), National Baxianshan Nature Reserve, Ji County, Tianjin, China (40°12'N, 117°32'E), 12 Aug. 1982, coll. Zhaozhi Qiu. Paratypes. 9 males (HBNU-M-2002) and 10 females (HBNU-M-2003), same data as holotype.

Etymology. The specific name derives from the generic name of the host.

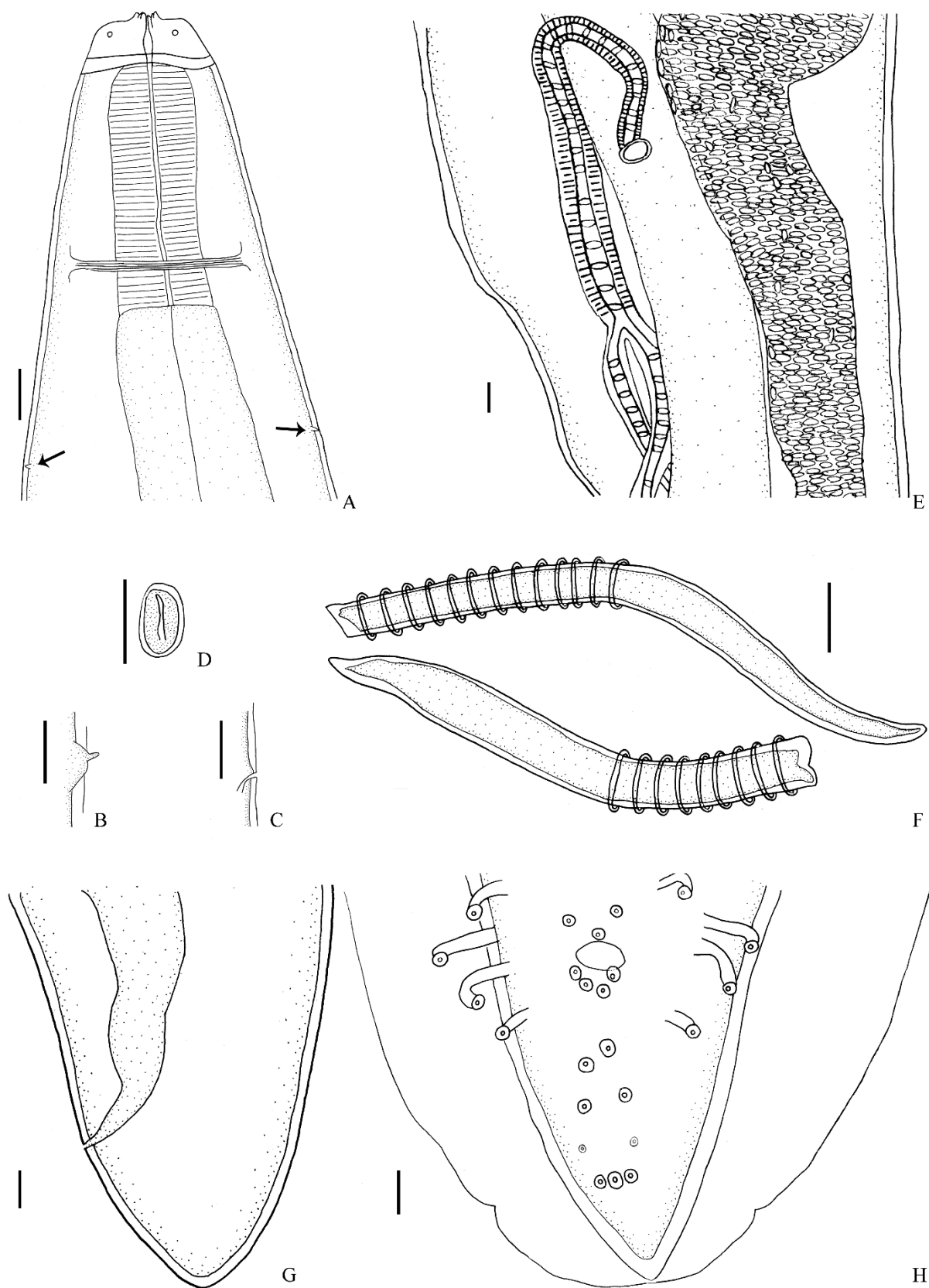


Figure 1. *Physaloptera apodemi* sp. nov. A. Anterior end of female, ventral view, arrow indicating cervical papillae. B. Right cervical papilla of female, ventral view. C. Excretory pore of male, lateral view. D. Egg. E. Vulva region, lateral view. F. Spicules. G. Posterior end of female, lateral view. H. Posterior end of male, ventral view. Scale bars: A, E, G–H=0.10 mm; B–D, F=0.05 mm.

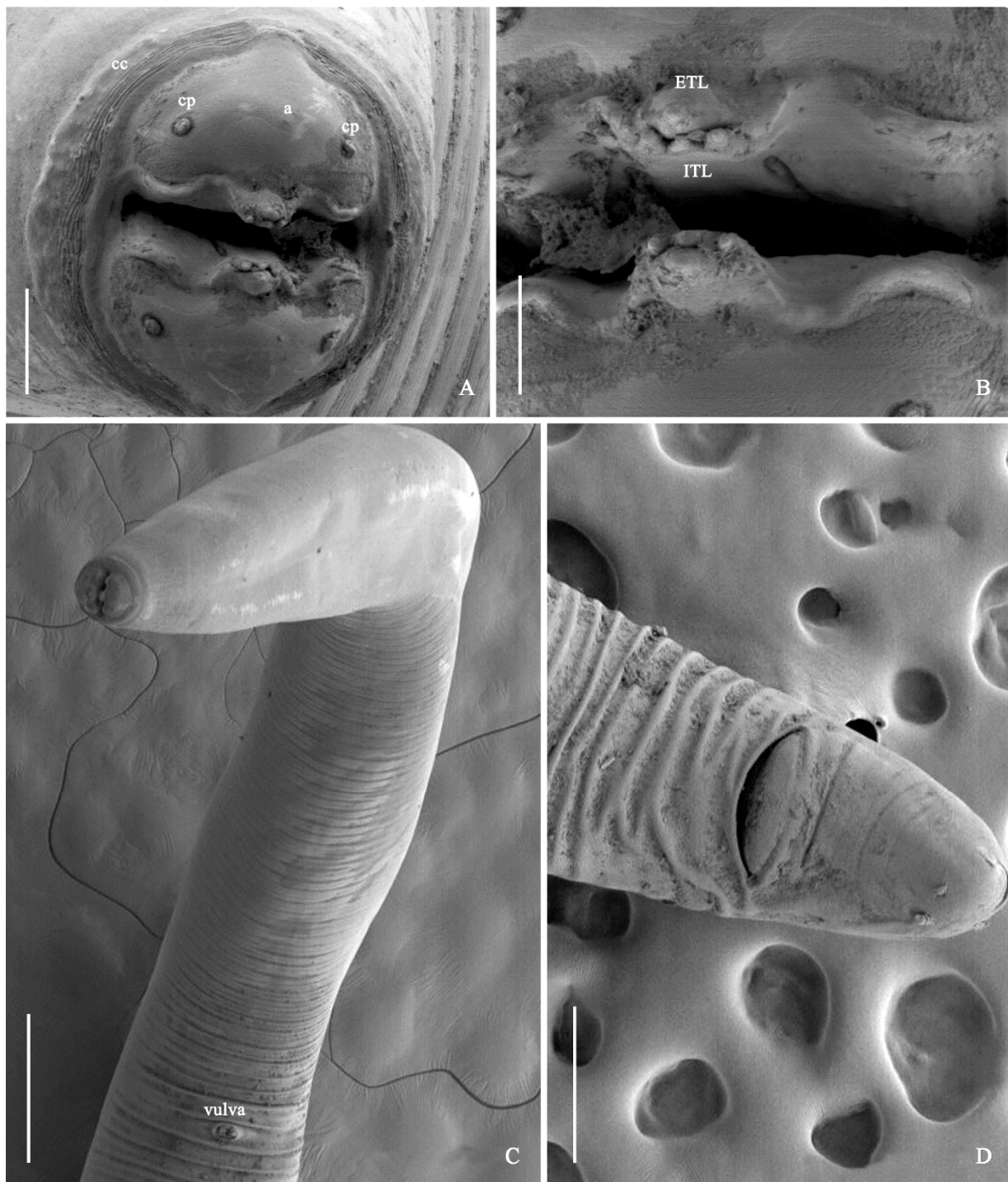


Figure 2. Scanning electron micrographs of *Physaloptera apodemi* sp. nov., female. A. Cephalic end, apical view, showing the cephalic papillae (cp), amphid (a) and cephalic collarette (cc). B. Part of pseudolabia, apical view, showing externolateral tooth (ELT) and internolateral teeth (ILT). C. Anterior part of body, showing vulva. D. Posterior end of body, ventral view. Scale bars: A = 50 μ m; B = 25 μ m; C = 400 μ m; D = 250 μ m.

4 Discussion

The present materials, collected from *Apodemus sylvaticus*, exhibit a robust body with thick cuticle, two well-developed pseudolabia with one externolateral tooth and three internolateral teeth; a cephalic collarette; ornamented caudal alae united

on the ventral surface of body; 22 caudal papillae including four pairs of pedunculated papillae, 6 pairs and 2 single sessile papillae; unequal and dissimilar spicules and the vulva located anterior to the mid-body. Based on these characters, the new species is reported under the genus *Physaloptera*.

Up to now, 14 species of the genus *Physaloptera* Rudolphi, 1819 from rodents have been reported worldwide, namely *P. aduensis* Baylis, 1928 from *Hybomys univittatus* in Nigeria; *P. amazonica* Maldonado, Simões, Luiz, Costa-Neto & Vilela, 2020 from *Proechimys gardneri* in Brazil; *P. banfieldi* Johnston & Mawson, 1941 from *Melomys banfieldi* in Australia; *P.*

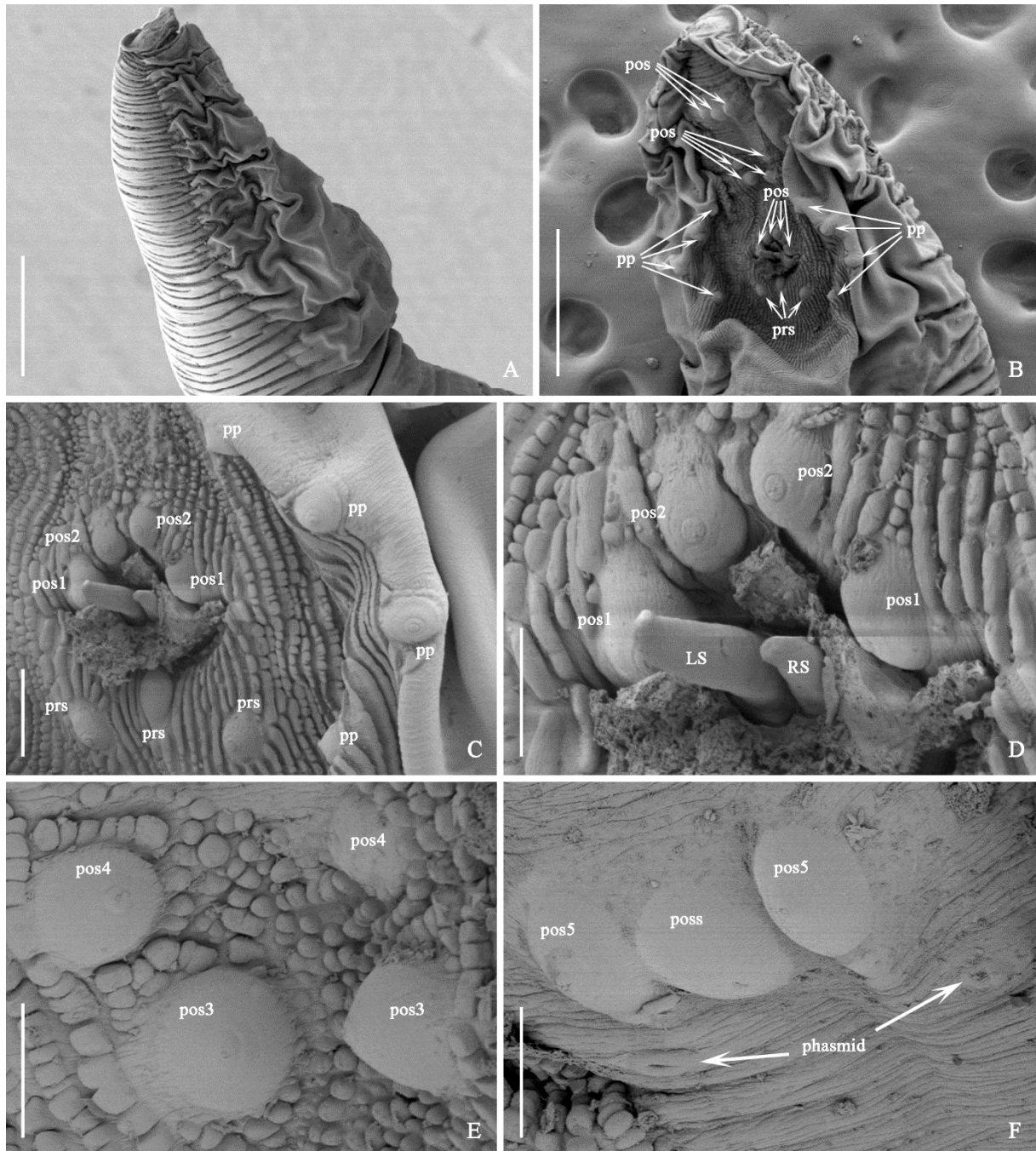


Figure 3. Scanning electron micrographs of *Physaloptera apodemi* sp. nov., male. A. Posterior end of body, lateral view. B. Posterior end of body, ventral view, showing pedunculated papillae (pp) and sessile papillae (pos or prs). C. Cloacal region, showing pedunculated papillae (pp), three pre-cloacal sessile papillae (prs) and first and second post-cloacal sessile papillae (pos1, pos2). D. Enlarged cloacal region, showing first and second post-cloacal sessile papillae (pos1, pos2), left spicule (LS) and right spicule (RS). E. Third pair of post-cloacal sessile papillae (pos3) and fourth pair of post-cloacal sessile papillae (pos4). F. Fifth pair of post-cloacal sessile papillae (pos5), post-cloacal single sessile papilla (poss) and a pair of phasmids. Scale bars: A–B = 300 μ m; C = 50 μ m; D–F = 30 μ m.

bispiculata Vaz & Pereira, 1935 from *Nectomys squamipes* in Brazil; *P. calnuensis* Sutton, 1989 from *Calomys laucha* in Brazil; *P. funambuli* Parihar & Nama, 1978 from *Funambulus pennanti* in India; *P. galvaoi* São Luiz, Simoes, Torres, Barbosa, Santos, Giese, Rocha & Junior, 2015 from *Cerradomys subflavus* in Brazil; *P. goytaca* Ederli, Gallo, Oliveira & Rodrigues de Oliveira, 2018 from *Cerradomys goytaca* in Brazil; *P. hypsida* Schell, 1950 from *Sigmodon hispidus* in U.S.A.; *P. longispicula* Quentin, 1968 from *Cercomys cumocularius* in Brazil; *P. massino* Schulz, 1926 from *Mus musculus wagneri* and *Rhombomys opimus* in Kazakhstan; *P. murisbrasiliensis* Diesing, 1861 from *Mus brasiliensis* in Brazil; *P. ngoci* Le-Van-Hoa, 1961 from *Rattus norvegicus* in Vietnam; *P. troughtoni* Johnston & Mawson, 1941 from *Rattus assimilis* in Australia.

The new species can be easily distinguished from *P. aduensis*, *P. amazonica*, *P. funambuli*, *P. galvaoi*, *P. goytaca*, *P. ngoci* in the numbers of uterine branches (2 uterine branches in the new species vs. 6–7 in *P. aduensis*, 4 in *P. amazonica*, *P. funambuli* and *P. ngoci*, 4–5 in *P. galvaoi*, 5 in *P. goytaca*). *P. apodemi* **sp. nov.** differs from *P. banfieldi* by having 4 instead of 6 pairs of pedunculated caudal papillae. The new species can be distinguished from *P. bispiculata* in numbers of caudal papillae (22 vs. 21), in the left and right spicules with striated sheaths in their proximal end, and in the egg size (42×24 vs. 50×36). *P. apodemi* **sp. nov.** is different from *P. hypsida* in the length of spicules (the left longer than the right vs. the left shorter than the right in the latter) and in the numbers of caudal papillae (22 vs. 21). The new species differs from *P. longispicula* and *P. massino* in the length of the spicules (left spicule 451–525 long and right spicule 352–397 long in the new species vs. left spicule 850 long and right spicule 710 long in *P. longispicula*, left spicule 765 long and right spicule 595 long in *P. massino*). *P. apodemi* **sp. nov.** is different from *P. murisbrasiliensis* and *P. troughtoni* by having unequal instead of equal spicules. The new species is very similar to *P. calnuensis* in the numbers and distribution of caudal papillae. However, it can be distinguished from the latter in the spicules with striated sheaths, in the vulva located at anterior fifth of body instead of the vulva located just anterior to the mid-body. Moreover, the third pair of post-cloacal sessile papillae is arranged in an inclined pattern and the fourth pair has a parallel arrangement in the new species, whereas the third pair has a parallel arrangement and the fourth pair is arranged in an inclined pattern in *P. calnuensis*. Therefore, we considered the present materials as a new species. This is the first species of *Physaloptera* from rodents reported in China.

Key to the species of *Physaloptera* Rudolphi, 1819 from rodents.

| | |
|---|-----------------------------------|
| 1. Uteri with two branches | 2 |
| Uteri with 4–7 branches | 10 |
| 2. Spicules equal | 3 |
| Spicules unequal | 4 |
| 3. Single median post-cloacal papilla present | <i>P. murisbrasiliensis</i> |
| Single median post-cloacal papilla absent..... | <i>P. troughtoni</i> |
| 4. Six pairs of pedunculated caudal papillae | <i>P. banfieldi</i> |
| Four pairs of pedunculated caudal papillae..... | 5 |
| 5. Twenty-two caudal papillae present | 6 |
| Twenty-one caudal papillae present | 7 |
| 6. Both left and right spicules with striated sheaths in their proximal end | <i>P. apodemi</i> sp. nov. |
| Spicules without striated sheaths..... | <i>P. calnuensis</i> |
| 7. Left spicule is longer than right spicule | 8 |
| Left spicule is shorter than right spicule..... | <i>P. hypsida</i> |
| 8. Left spicule 0.46 mm long and right spicule 0.40 mm long | <i>P. bispiculata</i> |
| Spicules longer than 0.50 mm | 9 |
| 9. Left spicule 0.85 mm long and right spicule 0.71 mm long | <i>P. longispicula</i> |
| Left spicule 0.765 mm long and right spicule 0.595 mm long | <i>P. massino</i> |
| 10. Uteri with 4 branches | 11 |
| Uteri with more than 4 branches | 13 |
| 11. Seven pairs of pedunculated caudal papillae present | <i>P. funambuli</i> |
| Four pairs of pedunculated caudal papillae present..... | 12 |
| 12. Left spicule lanceolate at the final third | <i>P. amazonica</i> |
| Left spicule not lanceolate at the final third | <i>P. ngoci</i> |
| 13. Uteri with 6–7 branches | <i>P. aduensis</i> |
| Uteri with 4–5 branches | 14 |
| 14. Uteri with 4–5 branches, two small external lateral teeth on each of the pseudolabia..... | <i>P. galvaoi</i> |
| Uteri with 5 branches, small external lateral teeth absent | <i>P. goytaca</i> |

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