

Mesomermis devii sp. nov. (Nematoda: Mermithidae), a new species of nematode from Devi Cave in Georgia

Oleg GORGADZE*, Shalva BARJADZE

Institute of Zoology, Ilia State University, Tbilisi, Georgia

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Abstract: Adult female individuals of the nematode *Mesomermis devii* sp. nov. (Nematoda: Mermithidae) have been described. The host organism is not determined. The individuals were isolated from moist guano obtained in the dark zone of Devi Cave (West Georgia). The new species is characterized by the following: rounded and symmetrical apical end of the head; mouth aperture is located in the middle of the head terminus; 6 cephalic papillae are arranged in a single row; each papilla is equipped with 2 or 3 sensilla; stoma has uneven width and the pharyngeal tube is of even width along the whole length; small amphids, with large, slightly oval, roundish holes and large, rounded pouches; pear-shaped vagina. Additionally, the radial holes emerging from the gland situated in the cuticle of the terminal part of the tail differentiate it from the species of the genus *Mesomermis*. This is the second record of this genus in Georgia. A list of species in the genus *Mesomermis* distributed in the Palearctic and brief morphological descriptions indicating their hosts and distribution details are provided.

Key words: Mermithid, parasite, Georgia, Caucasus

1. Introduction

Nematodes belonging to the genus *Mesomermis* Daday, 1911 (Nematoda: Mermithidae) are widely spread throughout the world. More than 30 species of this genus have been described from the countries of Asia and the Americas. One of them, *Mesomermis caucasica* Rubzov, is registered in Georgia (Rubzov, 1972). They mainly parasitize larvae of water-dwelling midges belonging to the family Simuliidae (Diptera), mainly the species of the genus *Simulium*, causing the death of the host organisms (Camino, 1994; Wise, 2006, 2007; Vega and Kaya, 2012). Considering this, representatives of the genus *Mesomermis* are regarded as biological control agents (Welch and Rubzov, 1965; Poinar, 1971; Rubzov, 1978; Camino, et al., 2015).

Nematodes of different groups were isolated from moist guano taken from the dark zone of Devi Cave while studying the biodiversity of karst caves of western Georgia. One of these groups was represented by the nematodes of the genus *Mesomermis* from the family Mermithidae. The nematode species of this genus was described on the basis of adult female individuals and was recognized as a new species, *Mesomermis devii* sp. nov.

2. Materials and methods

Nematodes of the genus *Mesomermis* were collected from the samples of moist guano picked from the dark zone of Devi Cave. Devi (Demish-pokva) Cave (42°44'N, 42°5'E, alt. 1121 m a.s.l.) is situated on the left bank of the River Moroja, near the village Chkvaleri, Tsalenjikha district, Samegrelo-Zemo Svaneti region, Kvira karst massif, Georgia. Its length is approximately 100 m. This cave was formed from Lower Cretaceous limestone. At the end of the cave there is a siphon lake, which is a source for a small stream. This stream passes through the entire cave and disappears in the opening near the cave entrance (Tatashidze et al., 2009). All individuals of the investigated nematodes were immature females. None of them had a mucron on the tail. Separation of nematodes from the moist guano was done using a Baermann funnel (Baermann, 1917).

Observations were carried out on both dead and live individuals. In spite of our attempts, male individuals were not found in the moist guano samples taken from the same cave in 2015. The live individuals were killed by means of heating them in distilled water up to 60 °C for 2 min. The dead nematodes were placed in the fixing agent TAF (consisting of 7 mL of formalin, 2 mL of triethanolamine, and 91 mL of distilled water) (Poinar, 1975) and were

* Correspondence: oleg.gorgadze@iliauni.edu.ge

processed using the method of Seinhorst (Seinhorst, 1959). Drawings, pictures, and measurements of nematodes were done from both live and dead individuals. Measurements were done using a light microscope (Motic-DMB1) with 10×, 20×, 40×, and 100× magnification. Some small details of the nematodes significant for diagnosis (stoma, amphids, etc.) were examined using the immersion objective of 100× magnification. Drawings and photos of nematodes mounted on slides were performed using a Genius (G-Shot) DV 1110 digital video camera.

3. Results

Description of the new species is based only on female individuals, which were sampled in moist guano in the dark zone of Devi Cave, West Georgia. This is the second record of this genus in Georgia. The new mermithid species differs morphologically from *M. caucasica*, which was previously recorded in Georgia, and from all other species united in this genus.

3.1. Diagnosis of the genus *Mesomermis* Daday, 1911

Type species: *Mesomermis zschokkei* Daday, 1911

The following are characteristic for the genus: medium and/or small body; comparatively thick cuticle; cuticle of adult individuals without cross fibers, while larvae have cross fibers; presence of 6 cephalic papillae; medium or small oval amphids in female forms; amphidial pouch is located close to the pharyngeal tube or covers it; they are characterized by 6 longitudinal cords; stomal aperture is located in the middle of the terminal part of the head. Collar is absent. Stichosoma is without clearly defined margins between the gomorocytes, epicytes, and stichocytes located around the esophagus. Vagina is short, pear-shaped, with V-shaped curved channel; outer and inner parts of vagina are clearly defined; for the male individuals, 2 long spicules with parallel margins arched like a sickle are characteristic; tail is heavily pointed and rounded at the end; larva has a conic tail, with lacelike appendix at the end; adult forms lose their tails. Nematodes of this genus parasitize water insects. Larvae of representatives of families Simuliidae and Chironomidae serve as hosts for their majority (Rubzov, 1972).

Twenty-six species of the genus are distributed in the Palearctic region. Information about each species is given below.

M. albicans Rubzov, 1972—parasitizes *Simulium argyreatum* Meigen, *S. cryophilum* (Rubzov), *S. galeratum* Edwards, *S. latipes* (Meigen), and *S. morsitans* Edwards. Channel of vagina is completely arcuate; tail is sharply pointed. Width of the head is less than 1/3 of the body diameter. Holes of amphids are round in shape. Stichosomal nuclei are 24–26 µm in size. Distribution: Leningrad region (Russia).

M. ammophila Rubzov, 1972—the host organism and female individuals are not known. The species has small

amphids, the diameter of which are nearly equal to 1/3 of the head diameter. Distribution: Kyrgyz Republic.

M. arctica Rubzov, 1972—parasitizes *Schönbaueria gigantea* (Rubzov). Head is slightly pointed towards the anterior part. Head diameter is 63% of the body diameter. Distribution: Polar Ural (Russia).

M. baicalensis Rubzov, 1972—parasitizes *Prosimulium alpestre* Dorogostaisky et al. Body of female larva is thick and short ($a = 60$). Distribution: Irkutsk region (Russia).

M. biseriata Rubzov, 1966—parasitizes *Simulium morsitans* Edwards. Its amphids are very large in size. Their transverse diameter is not less than half of the head diameter. Stichosoma contains 24 stichocytes. Distribution: Leningrad region (Russia).

M. bistrata Rubzov, 1972—parasitizes *Simulium latipes* (Meigen). Cells of lateral cord are situated in the front of the nerve ring, arranged in 2 rows. Distribution: Leningrad region (Russia).

M. bitruncata (Coman, 1961)—the host organism is not known. Cephalic papillae with 6 sensilla. Ends of head and tail are acuminate. Distribution: Romania.

M. brevis Rubzov, 1972—the host organism is not known. Body is very short; female, $a = 34$ –37. Distribution: Primorsky Krai (Russia).

M. canescens Rubzov, 1972—parasitizes *Simulium argyreatum* Meigen. It has 16–17 cells in a separate row of lateral cords at the front of the nerve ring. The body is slightly widened from the head to the nerve ring. Distribution: Leningrad region (Russia).

M. caucasica Rubzov, 1972—parasitizes *Odagmia variegata* Meigen. Posterior part of the body is sharply conically pointed, and it does not form the thickened cuticular tail appendage. Distribution: Georgia (Chakhura River).

M. formosa Schmassmann, 1914—the host organism and female individuals are not known. Spicules are short. Their length is less than body diameter. Distribution: Romania.

M. japonicus Poinar & Saito, 1979—parasitizes *Simulium japonicum* Matsumura. Male individual is characterized by amphids of large size (length, 32 µm; width, 15 µm) and rounded amphidial pouches. Distribution: Kanagawa Prefecture (Japan).

M. lacustris Daday, 1911—the host organism and female individuals are not known. Length of pharyngeal tube is nearly 1/2 of the body length. Distribution: Switzerland.

M. longicaudata (Coman, 1961)—the host organism and female individuals are not known. Sexual papillae are arranged in a single medial row, which doubles only near the anal aperture. Cephalic papillae with only one sensillum. Distribution: Romania.

M. longicarpus Rubzov, 1972—the host organism and male individuals are not known. Amphidial holes are

situated behind the apical end at a distance of half of the head diameter. Body is long ($a = 150$). Dorsal and ventral papillae with 5 sensilla. Distribution: Leningrad region (Russia).

M. melusinae Rubzov, 1972—parasitizes *Boopthora erythrocephala* de Geer, *Odagmia ornata* (Meigen), *Simulium argyreatum* Meigen, *S. cryophilum* (Rubzov), *S. latipes* (Meigen), *Simulium morsitans* Edwards, and *S. verecundum* Stone & Jamnb. Outer and inner parts of vaginal channel make right angle. Spiculae heavily bent, their length at anus 1.5 times exceeds the body diameter. Stichosoma has the 24 largest stichocytes. Distribution: Leningrad region (Russia).

M. minuta Rubzov, 1972—parasitizes *Simulium morsitans* Edwards. Vulva and vaginal channel are almost perpendicular to the longitudinal axis of the body. Distribution: Leningrad region (Russia).

M. nigra Rubzov, 1972—the host organism is not known. Body has black coloration. The species differs from all of the above-discussed species by a long body and comparatively large amphids. Distribution: Kyrgyz Republic.

M. ornata Rubzov, 1972—parasitizes *Odagmia ornata* (Meigen). Cephalic papillae have 2–3 sensilla. Distribution: Leningrad region (Russia).

M. oxycerca Steiner, 1929—the host organism and female individuals are not known. Amphids are oblong, tubular, with pear-shaped hole. Only male individuals are described. Distribution: from the River Iaiva (basin of the River Kama) (Russia).

M. parallela Rubzov, 1972—parasitizes *Prosimulium alpestre* Dorogostaisky et al. The body is of the same diameter along the whole length; head diameter is 3/4 of the body diameter. In the terminal part of the body, the cuticle is slightly thickened. Stichosome contains 10 large cells. Distribution: Altayskii Krai (Russia).

M. patrushevae Rubzov, 1972—the host organism is not known. The head diameter comprises nearly 2/3 of the mid-body diameter. Stichosoma has large nuclei. Distribution: Western Siberia—Tumen region (Russia).

M. prisjaznoi Rubzov, 1972—parasitizes black flies (Simuliidae). It has 6 pairs of spindle-shaped cells in lateral cords, in the front of the nerve ring. Stichosoma with 10 large cells. Distribution: Khabarovsk region (Russia).

M. sibirica Rubzov, 1972—parasitizes *Gnus relictum* (Rubzov). It has 6–8 cells, arranged in a single row of lateral cord in the front of the nerve ring. The body visibly widens from the head towards the nerve ring. Distribution: East Siberia—Irkutsk region (Russia).

M. vernalis Rubzov, 1972—parasitizes *Simulium cryophilum* (Rubzov), *S. latipes* (Meigen), *S. morsitans* Edwards. Tail is blunt and rounded. Stichosoma has 32 stichocytes. Vulva is situated obliquely and located in the

posterior part of the body. Distribution: Leningrad region (Russia).

M. zshokkei Daday, 1911—the host organism is not known. Spicules oblong, their length exceeds the body diameter. Distribution: Switzerland.

3.2. Taxonomy

Mesomermis devii sp. nov. (Figures 1 and 2)

Type locality: Georgia: Samegrelo–Zemo Svaneti region, Tsalenjikha district, near Chkvaleri village, Kvira karst massif, Devi (Demish–pokva) Cave (42°44'N, 42°5'E, alt. 1121 m a.s.l.).

Type material: holotype (adult female) on slide: dark zone, Devi Cave, 24 October 2012 (code CAU–Devi–20121024–01). Paratypes (same data as holotype): 4 adult females on 3 different slides, the same data as for holotype (CAU–Devi–20121024–02–05); male is not known. Holotype and paratypes are deposited in the collection of the museum of the Institute of Zoology of Ilia State University, Georgia.

Measurements. Holotype (adult female): length = 14.1 mm; head diameter at the level of cephalic papillae = 45 μ m; body diameter at the level of nerve ring = 85 μ m; maximum body diameter = 160 μ m; distance head to nerve ring = 260 μ m; length of amphid = 9 μ m, its width = 8 μ m $V = 52\%$; length of vagina = 115 μ m; diameter of vagina in the frontal part = 40 μ m; in the middle part = 25 μ m; in the terminal part = 22 μ m.

Paratypes (adult females; $n = 4$): length = 13.6 (13.1–14.1) mm; $a = 80$ –86; $b = 5.2$ –5.5; $V = 52\%$ –59%. Head diameter at the level of papillae 41 (38–45) μ m; length of amphids = 9 (9–10) μ m, width = 8 (7–8) μ m; body diameter at the nerve ring = 87 (85–88) μ m; maximum body diameter = 156 (152–160) μ m; body diameter at the level of vulva = 156 (153–160) μ m; distance from the head to nerve ring = 257 (260–254) μ m; $V = 55.9\%$ (52.2%–59.7%); length of vagina = 116 (115–117) μ m; diameter of vagina in the frontal part = 41 (40–42) μ m, in the middle part = 25.5 (25–26) μ m, and in the terminal part = 22.5 (22–23) μ m.

Morphology. Adult female ($n = 5$): the nematode is small in size, with white coloration. Frontal part of the body is significantly narrowed (Figures 1a and 2a). Apical part of the head is rounded and symmetrical (Figures 1b and 2b). Head diameter is four times less than that of the body. Collar not narrowed at the end. Stomal aperture is located in the middle of the apical part of the head, sometimes slightly displaced to the ventral side. Amphids are small in size, with large holes. Papillae are situated close to amphids. Terminal part of the body is conic at the tail and significantly narrowed. Tail is rounded at the end and slightly bent at ventral side (Figures 1e, 2c, and 2d). Terminal part of the tail without mucron.

Cuticle is thick, with smooth surface; cross fibers are not visible. Cuticle thickness varies depending on the fixing

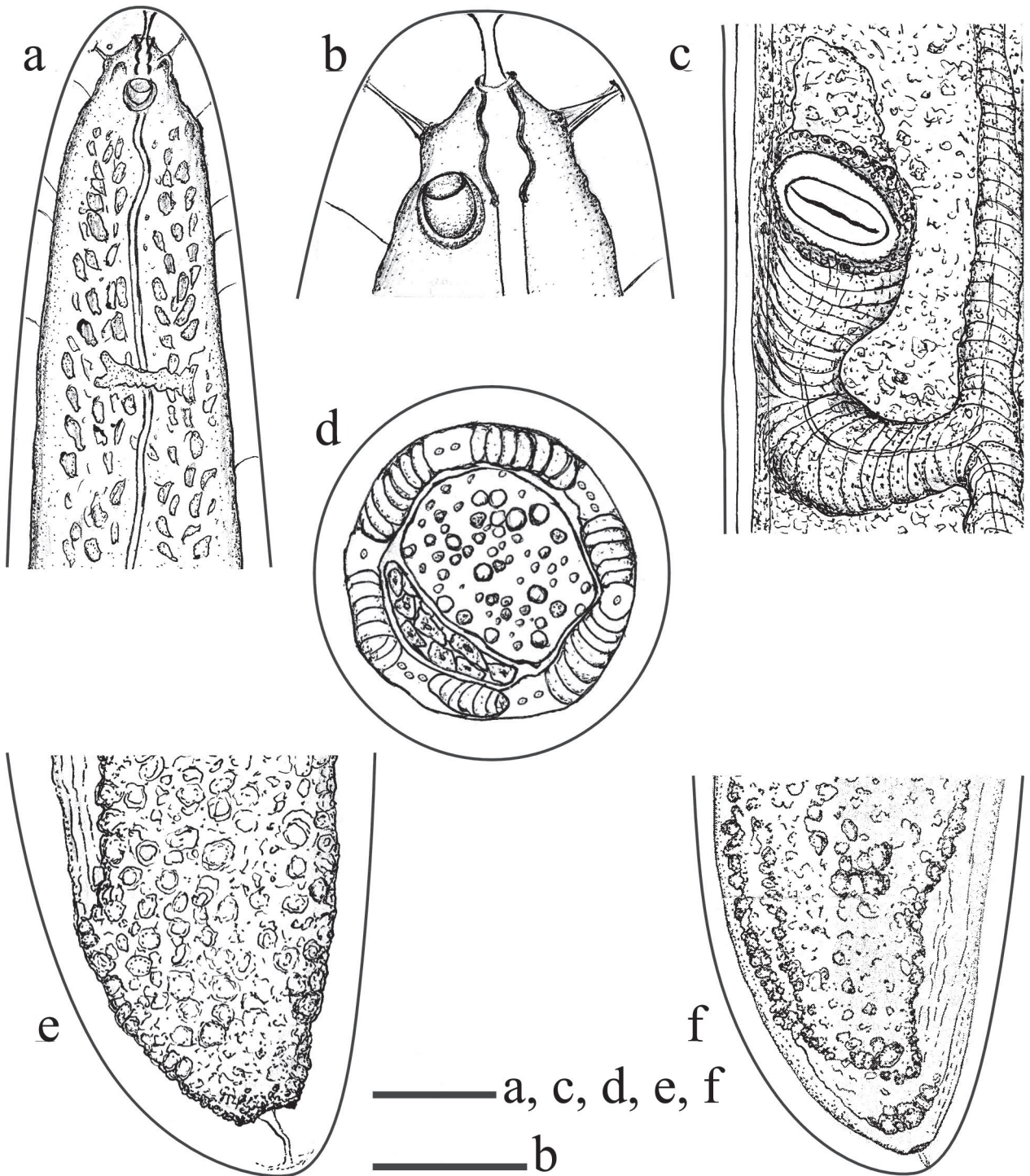


Figure 1. *Mesomermis devii* sp. nov., adult female, holotype: a- anterior region of body, nerve ring, and pharyngeal tube, lateral view; b- head, width of cuticle, lateral view; c- vulva and vagina, ventral view; d- cross-section at middle of body. Paratype: e and f- tails, lateral view. Scales for a, c, d, e, f = 50 μ m; for b = 25 μ m.

agent (TAF and lactophenol). For example, thickness of stomal longitudinal cuticle of the nematode, fixed in TAF, is 12 μ m; near the nerve ring = 10.5 (10–11) μ m; in the middle of the body = 10 (11–12) μ m; near the tail terminus

= 14 μ m. With fixing in lactophenol, the same indices were equal to 15, 13, 15, and 17 μ m, respectively. Dorsal and ventral longitudinal cords are well developed (Figure 1d). Along with the dorsal and ventral cords, nematodes have 2

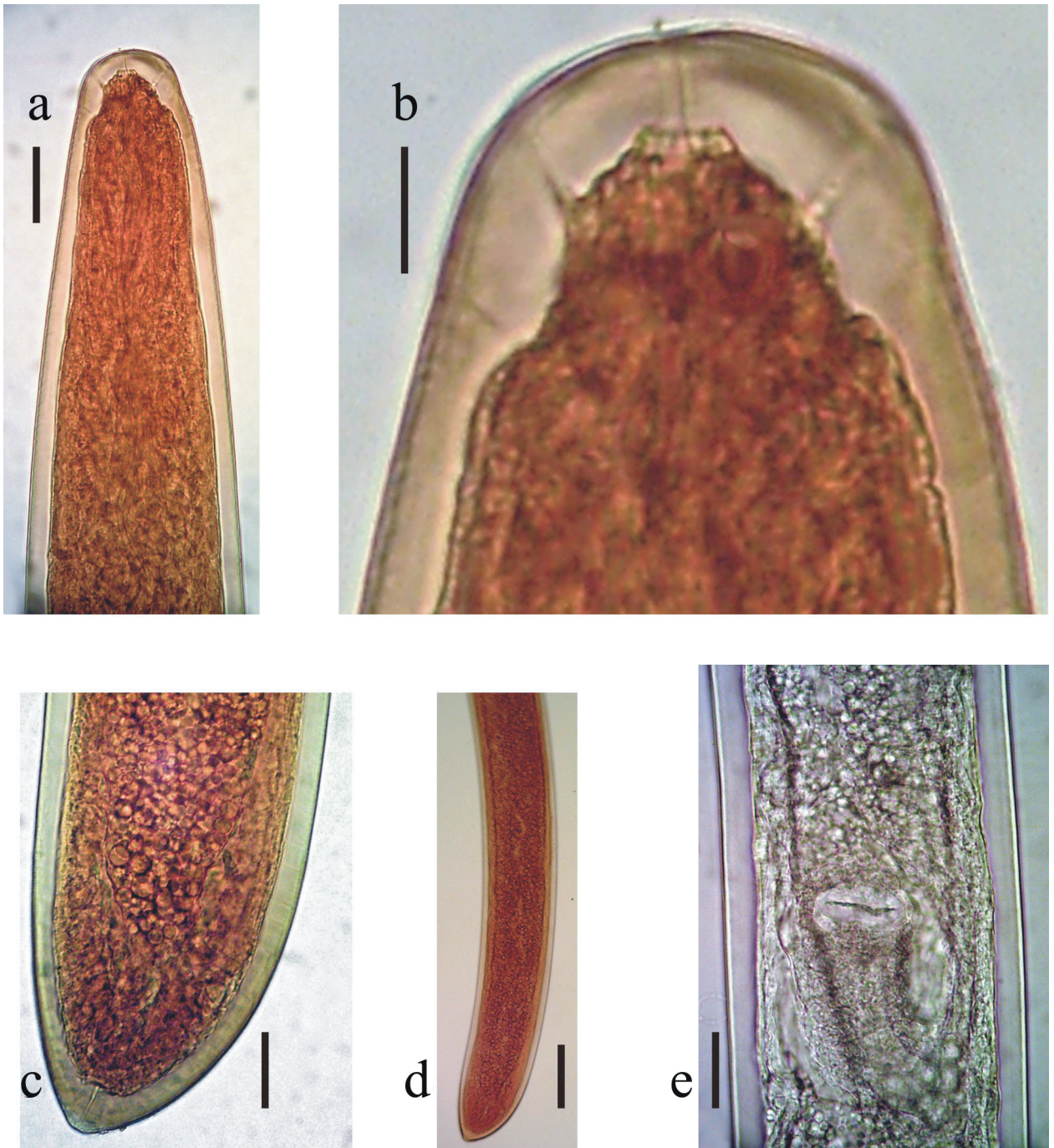


Figure 2. *Mesomerms devii* sp. nov., adult female, holotype: a- anterior region of body, nerve ring, and pharyngeal tube, lateral view; b- head, width of cuticle, lateral view; c- tail, large hole of tail terminal cuticular gland, lateral view; d- posterior region of body, lateral view; e- vagina, ventral view. Scales for a, c, e = 30 μ m; for b = 20 μ m; for d = 100 μ m.

lateral and 2 subdorsal cords. Dorsal and ventral cord cells are located at the front of the nerve ring, arranged in 2 and 3 rows. Behind the nerve, along the entire dorsal side of the body, one row of cells is significantly narrowed; 2 rows are narrowed in the central part as well. Cells of the terminal (caudal) part of the body are larger than in the central part.

Lateral cords are the best developed. Cells in the front of the nerve ring cells are arranged in 3–4 rows; above the nerve ring, in 2–3 rows (Figure 1a); and behind the nerve ring to the end of the stichosoma, in 3 rows. Here they occupy 1/3 of the body length; lateral cords are the widest in the midbody, and in the terminal part of the body, lateral

corde pass to the dorsal side and make up the cells of the 4th row. The 6 papillae are located on the head at a single level; they are remote from each other; each dorsolateral papilla is equipped with 2 sensilla; the rest, with 3 sensilla (papillae have a total of 16 sensilla). Amphids are small in size, roundish-oval in shape (Figures 1b and 2b). They are located behind the lateral papillae, slightly dorsally, 30 μm from the frontal end of the head. The hole of the amphid is large; its diameter (7.5 μm) is nearly equal to the width of the amphid. Amphids have large (12.5 \times 13 μm) pouches (pockets). Excretory hole is located behind the nerve ring. It is located 257 μm from the apical end of the body at the transverse section of 87–88 μm diameter. The 4 dorsal holes of the cervical (neck), postpapillar glands, and 5 ventral openings of the postpapillar glands are presented. The 4 dorsal and 4 ventral openings of the postpapillar glands are arranged parallel to each other in front of the nerve ring, and there is one opening on the ventral side, behind the nerve ring. The first anterior pair of postpapillar glands has its openings behind the capitular papillae (at the level of amphidial hole); the second and third pairs are located close to each other and are 120 and 130 μm respectively from the apical end of the head. The fourth pair is located after the nerve ring, 280–290 μm from the apical end of the head. The pharyngeal tube ends before the middle part of the body. Its total length is 3.5 mm, constituting 15% of the entire body length. The diameter of the pharyngeal tube is different at different parts of the body. For example, the length of the pharyngeal tube in the stoma is 25 μm (Figure 1b), 12 μm of which passes through the head cuticle (its diameter is 2.5 μm), and 13 μm of which extends out of the cuticle to the amphids. Walls of tube channel are thick, wide, chitinized, and uneven in shape. In this section of the stoma, the diameter of the pharyngeal tube is 5 μm ; the diameter of the tube heading to the caudal part of the body is 3 μm along the whole body. A small number of large

(8.7 μm) nuclei and numerous small (2–3 μm) stichocytes are observed in the stichosoma. Trophosoma starts behind the nerve ring, 1.5 mm from the cephalic part, ending 101 μm from the terminal end of the tail. Vulva is pushed back from the middle part of the body. Cross-section of vulva is slightly inclined from the body axis. Length of vulval transverse section is 15 μm and width is 1.5 μm . Around the cross-section of the vulva (view from above) is a clearly defined wide, oval, cuticular ring (Figures 1c and 2e). Length of vulval ring is 36–37 μm , width 23–25 μm . Vulval labia are not prominent from the body surface, and they are not visible. The channel of the vulval cross-section in the vagina is first perpendicular to the body axis, then bent like an arch towards the frontal part of the body; it merges with the vagina in the middle, making a blunt or right angle (Figures 1c and 2e). Vagina is pear-shaped and elongated. Anterior part of vagina is visibly thickened. Middle and terminal parts are cylindrical and arcuate; anterior part of vagina is slightly longer than the posterior part. Anterior part of the ovary ends at the frontal part of trophosome; the posterior part does not reach the terminal part of the trophosome. Oocytes in the ovary are arranged in 3–4 rows. The merged holes, exiting out from the gland, are clearly visible in the cuticle of the terminal part of the tail (Figures 1e, 1f, and 2c).

Etymology. The new species was named according to the place of its discovery: Devi Cave.

Biology. Its host is unknown.

3.3. Diagnosis and relationships

Adult females of the newly described species *M. devii* sp. nov. are similar to the females of *M. melusinae* Rubzov, described in the genus *Mesomermis* (Rubzov, 1966). The structure of stoma is identical for these two species.

The differences between females of *Mesomermis devii* sp. nov. and its morphologically closely related species *M. melusinae* are provided in the Table.

Table. Differences between females of *Mesomermis devii* sp. nov. and the morphologically closely related species *M. melusinae* Rubzov, 1972.

Characters/species	<i>Mesomermis devii</i>	<i>M. melusinae</i>
Body length	13.1–14.1 mm	18 mm
The position of vulva with respect to the body	Vulva is located posteriorly (V % = 52–59)	Vulva is located in the frontal part of the body (V % = 48–49)
The thickness of cuticle	10–14 μm	4–5 μm
The size of amphids and amphid holes	Length 9 μm ; width 8 μm , with 7.8 μm amphid holes	Length 15 μm ; width 13–14 μm , with 5–6 μm amphid holes
The length of vulval cross-section	25 μm	10 μm

4. Discussion

Female forms of *M. devii* sp. nov. are characterized by the following combination of characters: a) small, slightly oval amphids with large holes and large rounded pouches; b) pear-shaped and elongated arcuate vagina; external part of vaginal channel is perpendicular to the body; c) uneven stoma and pharyngeal tube of even width; d) conic tail, rounded end, slightly bent on ventral side; e) merged holes, outgoing from the gland in the cuticle of the terminal part of the tail.

By the morphology of vagina and the cuticular glandular holes of the terminal part of the tail, *M. devii* sp. nov. differs from other Palearctic species in the genus *Mesomermis*, such as *M. albicans*, *M. arctica*, *M. baicalensis*, *M. bistrata*, *M. bitruncata*, *M. brevis*, *M. canescens*, *M. formosa*, *M. japonicus*, *M. longicarpus*, *M. melusinae*, *M. minuta*, *M. ornata*, *M. parallela*, *M. sibirica*, and *M. vernalis*.

Only males are known for the following 10 species distributed in the Palearctic region: *M. ammophila*, *M. biseriata*, *M. caucasica*, *M. lacustris*, *M. longicaudata*, *M. nigra*, *M. oxycerca*, *M. patrushevae*, *M. prisjaznoi*, and *M. zschokkei*.

Due to the fact that thickness of cuticle, shape of apical end of the head, size and shape of amphids, and number of sensilla in the cephalic papillae are similar for males and females belonging to the same *Mesomermis* species, females of the new species were compared with males of the abovementioned 10 Palearctic species described based on males.

The new species differs from *M. ammophila* by: (1) thickness of cuticle: 10–14 μm in the new species; 2.5–3 μm in *M. ammophila*; (2) diameter of amphids: 8 μm in the new species; 12–14 μm in *M. ammophila* (Rubzov, 1972).

The new species differs from *M. biseriata* by: (1) thickness of cuticle: 10–14 μm in the new species; 4–8 μm in *M. biseriata*; (2) diameter of amphids: 8 μm in the new species; 30–31 μm in *M. biseriata* (Rubzov, 1972).

The new species differs from *M. caucasica* by thickness of cuticle: 10–14 μm in the new species; 2–3 μm in *M. caucasica* (Rubzov, 1972).

The new species differs from *M. lacustris* by: (1) shape of apical end of the head: head is rounded in the new

species, while it is convex in *M. lacustris*; (2) diameter of amphids: 8 μm in the new species; 13 μm in *M. lacustris*; (3) number of sensilla in the cephalic papillae: 2–3 in the new species; only 1 in *M. lacustris* (Rubzov, 1972).

The new species differs from *M. longicaudata* by the number of sensilla in the cephalic papillae: 2–3 in the new species, while only 1 in *M. longicaudata* (Rubzov, 1972).

The new species differs from *M. nigra* by: (1) length of body: 13.1–14.1 mm in the new species, while 59 μm in *M. nigra*; (2) diameter of amphids: 8 μm in the new species, while 23 μm in *M. nigra* (Rubzov, 1972).

The new species differs from *M. oxycerca* by: (1) shape of amphids: round or oval in the new species, while tube-shaped in *M. oxycerca*; (2) length of amphids: 9 μm in the new species, while 43 μm in *M. oxycerca* (Rubzov, 1972).

The new species differs from *M. patrushevae* by: (1) by thickness of cuticle: 10–14 μm in the new species; 2.5 μm in *M. patrushevae*; (2) diameter of amphid hole: 7.8 μm in the new species; 12 μm in *M. patrushevae* (Rubzov, 1972).

The new species differs from *M. prisjaznoi* by: (1) thickness of cuticle: 10–14 μm in the new species; 5 μm in *M. prisjaznoi*; (2) diameter of amphids: 8 μm in the new species; 13–20 μm in *M. prisjaznoi* (Rubzov, 1972).

The new species differs from *M. zschokkei* by the shape of the amphid hole: round or oval in the new species, while quadrangular in *M. zschokkei* (Rubzov, 1972).

Nomenclatural acts: This work and the nomenclatural acts it contains have been registered in ZooBank. The ZooBank Life Science Identifier (LSID) for this publication is: <http://zoobank.org/urn:lsid:zoobank.org:pub:9929325F-90CD-4C83-8C7F-9FFF7C78B03>

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