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Description of *Hexamermis serenensis* sp. n. (Nematoda : Mermithidae), a parasite of *Dociostaurus maroccanus* (Thunberg) (Orthoptera : Acrididae) in Spain

Pedro HERNÁNDEZ-CRESPO and Cándido SANTIAGO-ÁLVAREZ

Dpto. Ciencas y Recursos Agrícolas y Forestales, ETSIAM, Universidad de Córdoba, Ap 3048, 14080 Córdoba, Spain.

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Summary – *Hexamermis serenensis* sp. n. (Nematoda : Mermithidae) is described and all stages of development illustrated. The species is differentiated by : *i)* large size (6.5-27 cm); *ii)* six cephalic papillae arranged in two opposed groups surrounding the mouth; *iii)* small thread-like amphids located dorsally and slightly behind the cephalic papillae; *iv)* vulvar cone well muscularized; vagina in equatorial position, horn-shaped, perpendicular to long axis of the body; *v)* vestigial anus present in females; *vi)* paired spicules medium sized, curved, with a sharp tip; *vii)* six-seven broken rows of genital papillae (n = 96 – 134); *viii)* tail conoid in both sexes, with a small blunt protuberance. Natural hosts include the locusts *Dociostaurus maroccanus* (Thunberg) and *Calliptamus italicus* L., and the grasshoppers *Dociostaurus genei* (Ocsk.), *Chorthippus bicolor* (Charp.), *Sphingonotus azurescens* (Rb.) and *Oedipoda charpentieri* Fieb.

Résumé – ***Description de* Hexamermis serenensis *sp. n. (Nematoda : Mermithidae), un parasite de* Dociostaurus maroccanus *(Thunberg) (Orthoptera : Acrididae) in Spain*** – *Hexamermis serenensis* sp. n. (Nematoda : Mermithidae) est décrit et tous les stades de développement illustrés. L'espèce est distincte par : *i)* la grande taille (6,5-27 cm), *ii)* six papilles céphaliques disposées en deux groupes opposés entourant l'ouverture buccale, *iii)* des amphides petites, filiformes, localisées dorsalement, légèrement après les papilles céphaliques, *iv)* le cône vulvaire bien musculariséé, le vagin en position équatoriale, en forme de corne, perpendiculaire à l'axe le plus long du corps, *v)* la présence d'un anus vestigial chez les femelles, *vi)* des spicules pairs, de taille moyenne, incurvés, à extrémité pointue, *vii)* six-sept rangées discontinues de papilles génitales (n = 94 – 134), *viii)* la queue conoïde chez les deux sexes, avec une petite protubérance arrondie. Les hôtes naturels comprennent les criquets *Dociostaurus maroccanus* (Thunberg) et *Calliptamus italicus* L. et les sauterelles *Dociostaurus genei* (Ocsk.), *Chorthippus bicolor* (Charp.), *Sphingonotus azurescens* (Rb.) et *Oedipoda charpentieri* Fieb.

Key-words : *Dociostaurus maroccanus Hexamermis serenensis,* locust, mermithid, nematodes, parasite, taxonomy.

Mermithids are common parasites of orthopterans (Webster & Thong, 1984). Species of *Mermis*, *Agamermis*, *Longimermis*, and *Hexamermis* have been found in association with acridoids. Twelve species of *Hexamermis* have been recorded parasitizing insects (Hagmeier, 1912; Welch, 1963; Kaiser, 1977; Poinar & Chang, 1985; Poinar & Linares, 1985; Camino & Stock, 1989 *b*; Stock & Camino, 1992 *a, b*). Of these twelve, four species have been recorded from acridoids (locusts and grasshoppers) : *Hexamermis truncata* (Rudolphi, 1809), *Hexamermis lineata* Kaiser, 1977, *Hexamermis ovistriata* Stock & Camino, 1992 and *Hexamermis cochlearius* Stock & Camino, 1992.

During spring and summer in 1990, 1991 and 1992, a mermithid parasite of the genus *Hexamermis* (Hernández-Crespo & Santiago-Álvarez, 1991; Hernández-Crespo, 1993) was obtained from the locust *Dociostaurus maroccanus* (Thunberg) (Orthoptera : Acrididae) and other Acridoidea in the province of Badajoz (Spain). Another *Hexamermis* species still not identified has been found in the same area parasitizing *Ocnogyna baetica* (Lepidoptera : Arctiidae) (Lipa *et al.*, 1993). These two records represent the only known cases of *Hexamermis* recorded in Spain parasitizing insects, although *Mermis nigrescens* Dujardin has been found on *D. maroccanus* adults in the province of Jaen (Benlloch, 1949). Adults of *Hexamermis* found in *D. maroccanus* differed in morphology from the species found in *Ocnogyna baetica* and also differed from other species of the genus *Hexamermis* described in the literature. In this paper *Hexamermis serenensis* n. sp., recovered from *D. maroccanus* hosts, is described and all developmental stages are illustrated.

Materials and methods

Post-parasitic juveniles of mermithids leaving *D. maroccanus* hosts collected at La Serena (Badajoz, Spain) were transferred to a Petri dish containing clean moist sand and maintained at room temperature to facilitate the final moult. Both sexes of emerging adults were

maintained together until egg laying. Eggs were incubated in tap water at 26 °C. Adults and juveniles were killed by immersion in distilled water at 60 °C, fixed in TAF and transferred to glycerine (Poinar & Thomas, 1984). Measurements and drawings were made from glycerine mounted specimens using a Leitz DR-NB light microscope equipped with Nomarski optics and an ocular micrometer.

Hexamermis serenensis sp. n.
(Fig. 1)

MEASUREMENTS

See Table 1.

DESCRIPTION

Adults : White nematodes; females two to three times longer than males. Outer cuticle with fine criss-cross fibres clearly visible. Six cephalic papillae arranged in two opposed groups of three surrounding the mouth. Lip papillae absent. Amphids thread-like, small (10-12.5 μm), located slightly posterior to the cephalic papillae; the same in males and females. Lip region rounded, slightly truncate. Mouth terminal and central, making a slight depression on the cuticle. Tail conoid in both sexes, not rounded but with a small blunt protuberance. Vulva a transverse slit; vulval cone well muscularized. Vagina in equatorial position, horn-shaped, perpendicular to long axis of the body but sometimes slightly

Table 1. *Measurements of* Hexamermis serenensis *sp. n.* (all measurement in μm except L.)

	Holotype	Allotype	Preparasitic	Postparasitic	Paratypes	
	Male	Female	larva	larva	Males (n = 18)	Females (n = 6)
L (mm)	95.0	230.0	3.3-4.3	–	102.7 ± 24.5 (65-145)	243.0 ± 33.2 (200.0-270.0)
Max. body diam.	175.0	325.0	32.5-37.5	–	191.4 ± 21.3 (165-242.5)	300.0 ± 30.5 (257.5-340.0)
Diam. at papillae	75.0	77.5	10.5-12.5	–	76.8 ± 4.4 (67.5-85)	80.8 ± 5.8 (75.0-87.5)
Diam. at nerve ring	125.0	160.0	27.5-30.0	–	124.9 ± 7.8 (112.5-142.5)	147.5 ± 9.2 (132.5-160)
Diam. at anus	175.0	237.5	–	–	178.9 ± 15.1 (160-220)	236.5 ± 21.0 (200-250)
Dist. ant. end nerve ring	377.5	412.5	137.5-155.0	–	374.6 ± 20.7 (325.5-412.5)	410.8 ± 15.9 (392.5-435)
Dist. anus tail tip	262.5	350.0	–	–	266.3 ± 40.7 (212.5-350)	356.0 ± 55.9 (295-447.5)
Vagina length	–	187.5	–	–	–	167.5 ± 18.4 (150-192.5)
Vagina width	–	125.0	–	–	–	173.3 ± 30.0 (125-207.5)
Spicules length	187.5	–	–	–	175.9 ± 17.7 (147.5-212.5)	– –
Spicules width at base (dorsal view)	25.0	–	–	–	24.5 ± 2.5 (20-27.5)	–
Onchiostylet length	–	–	8.0-9.5	–	–	–
Onchiostylet width at base	–	–	2.5-3.0	–	–	–
Tail tip appendage length	–	–	–	42.9-54.3	–	–
Tail tip appendage width at base	–	–	–	17.2-25.7		

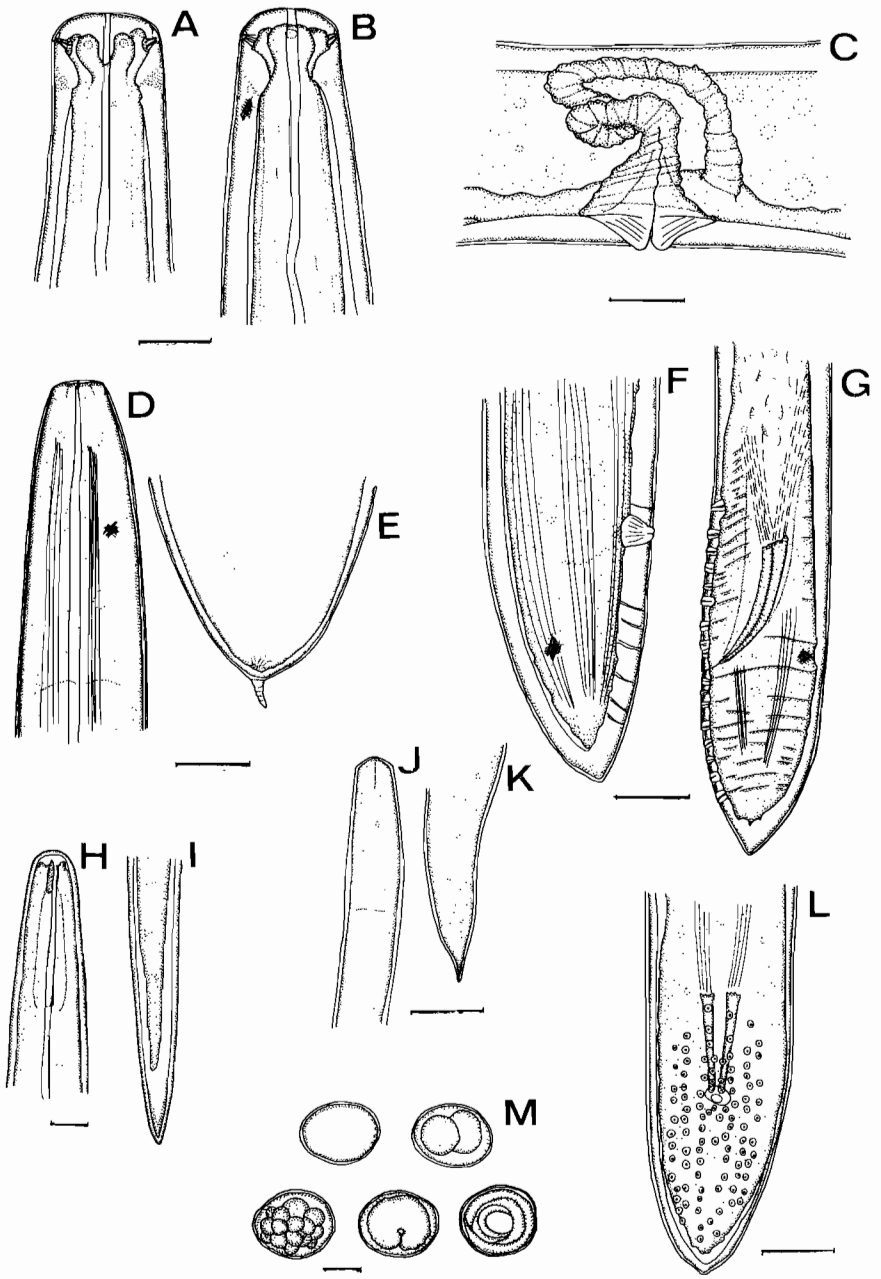

Fig. 1. Hexamermis serenensis *sp. n. A, B : Male head in ventral and lateral view respectively; C : Female, horn-shaped vagina; D, E : Postparasitic larvae, head and tail respectively; F, G : Tail of female and mail in lateral view, respectively; H, I : Preparasite larvae head and tail, respectively; J, K : Parasitic larvae head and tail, respectively; L : Male tail in ventral view showing genital papillae. M : Egg at different stages of development, unicellular, bicellular, multicellular, embryonic and coil.* (Scale bars : A, B = 0.05 mm; C – G, J – M = 0.1 mm; H, I = 0,01 mm.)

oblique, with a wide loop before joining the uteri. Vestigial anus present. Spicules paired, not parallel, separated (27.5-40 μm) at the base, curved; variable in length, sometimes equal or exceeding the width of the body at the anal level; with the musculature well developed; spiculum tips without ornament, sharp. Genital papillae very variable in number (96-134) and position, arranged in six-seven broken rows.

Eggs : Ovoid, flatted, smooth, sticky, white, without any ornaments. Laid singly, not in a matrix. Generally not embryonated in uterus. Maximum diameter (n = 6) : 200-226 (220 μm); minimum diameter : 172-189 (176 μm).

Preparasitic larva : Small relative to the adult. Papillae surrounding the stomal region homologous to the adult head papillae. Tail sharp, sometimes with a very small truncate tip. Onchiostylet widest at its base.

Parasitic larva (5 days old) : Head slightly conoid. Tail tip sharp.

Postparasitic larva : Dimensions similar to that of adults. Tail tip rounded, with a sharp finger-like cuticular appendage always retained after final moult. Lip region truncate. Period of formation of adults after leaving the host : 42-57 (51) days; (n = 21); Interval between leaving host and the beginning of moulting : 13-30 (17.6) days (n = 16).

TYPE HOST AND LOCALITY

Nymphs from second to fifth instar and adults of *Dociostaurus maroccanus* (Thunberg) (Orthoptera; Acrididae). La Serena, Province of Badajoz (Spain).

HOST RANGE

This nematode has been found associated with the locusts *D. maroccanus* and *Calliptamus italicus* L., and the grasshoppers *Dociostaurus genei, Chorthippus bicolor* (Charp.), *Sphingonotus azurescens* (Rb.) and *Oedipoda charpentieri* Fieb.

TYPE MATERIAL

Male holotype and female allotype in Muséum National d'Histoire Naturelle, Paris (France), eighteen male paratypes and six female paratypes in Departamento de Ciencas y Recursos Agrícolas y Forestales, Universidad de Córdoba, Spain.

DIFFERENTIAL DIAGNOSIS

All the characteristics of *H. serenensis* sp. n. place it in the family Mermithidae Braun, 1883 and genus *Hexamermis* Steiner, 1924 (Poinar, 1975). It differs from species of other genera that have been found associated with Orthoptera, such as *Mermis, Agamermis, Amphimermis* and *Longimermis*. It possesses shorter and different shaped spicules than *Amphimermis;* it can be differentiated from the genus *Mermis* by the smooth eggs, without any ornament, and by the absence of lip papillae (Nickle, 1972; Poinar, 1975); from *Agamermis* by the preparasitic larvae not possessing a visible node and the postparasitic larvae preserving the tail appendage (Cobb *et al.,* 1923); from *Longimermis* by the arrangement of head papillae (Camino & Stock, 1989 *a*); and from *Amphibiomermis* by straight vagina (Artyukhovsky, 1969).

Hexamermis serenensis sp. n. is characterized by : *i)* large size (65-270 mm); *ii)* six cephalic papillae arranged in two groups on opposite sides of the mouth; *iii)* small thread-like amphids located slightly posterior to the cephalic papillae; *iv)* vulval cone well muscularized; vagina in equatorial position, horn-shaped, perpendicular to longitudinal axis of the body; *v)* vestigial anus present in females; *vi)* paired spicules medium sized, curved, with a sharp distal tip; *vii)* six to seven broken rows of genital papillae (n = 96 – 134); *viii)* tail conoid in both sexes, not round.

H. serenensis sp. n. differs from other species in the genus *Hexamermis* by *i)* its long size, *ii)* the high number of genital papillae (96-134) in the male distributed in six-seven broken rows, and *iii)* the morphology of the tail which is conical in shape. Only two species of the genus, *H. incisura* (Kaiser, 1977) and *H. dactylocercus* (Poinar & Linares, 1985) have a tail morphology similar to *H. serenensis* sp. n.

H. serenensis sp. n. is close to *H. truncata* in the morphology of the head, but it differs in the distribution pattern of genital papillae (six rows) and in the length of the spicules (150 μm) (Kaiser, 1977). *H. cavicola* (Welch, 1963) and *H. lineata* (Kaiser, 1977) are smaller but wider, with a maximum body diameter of 650 μm and 438 μm in females, respectively; their spicules are longer (490 μm and 224 μm, respectively); the genital papillae of *H. lineata* are distributed in six rows. *H. incisura* and *H. elongata* genital papillae are arranged in four rows; the morphology of preparasitic larvae of *H. incisura* is clearly different from that of *H. serenensis* sp. n. *H. cochlearius* has a characteristic spoon-like concavity in the tip of the spicules that are shorter (116 μm), and has a reduced number of genital papillae (Stock & Camino, 1992 *b*). *H. arsenoidea* is smaller and thinner (Pologentsev & Artyukhovsky, 1958, 1959). *H. brevis* (Hagmeier, 1912) and *H. hortensis* (Camino & Stock, 1989 *b*) differ greatly in the morphology of the head. The spicules of *H. ovistriata* (127-240 μm) are very variable in length and do not differentiate it from *H. serenensis* sp. n., but the arrangement and length of amphids differ greatly; eggs of *H. serenensis* sp. n. do not possess the three longitudinal lines characteristic of the species named (Stock & Camino, 1992 *a*). *H. cathetospiculae* has larger spicules (289-334 μm) (Poinar & Chang, 1985). *H. dactylocercus* differs in the morphology of the cephalic papillae and amphids (Poinar & Linares, 1985).

Hexamermis spp. parasitizing acridoids

H. truncata is known as a parasite of insects and other arthropods, having a wide host range and a worldwide distribution (Nickle, 1972). *Hexamermis albicans* (von

Siebold, 1848), *Hexamermis pussardi* Baylis, 1933 and *Hexamermis acuminata* Leidy, 1875 are synonyms of *H. truncata* (Kaiser, 1977; Wouts, 1981). Due to difficulties in rearing these mermithids in the laboratory, and the ambiguous description of the taxonomic characteristics of this species (before Kaiser, 1977), *Hexamermis* species found in insects may have been misidentified as *H. truncata*. In fact, some or all the past records referring to *H. truncata* parasiting acridoids could correspond to *H. lineata* (Kaiser, 1977). Thus, the association of *H. truncata* with acridoids (Uvarov, 1928) may be considered doubtful and the real host range and distribution of *H. truncata* remains unclear.

Other species of the genus *Hexamermis*

Hexamermis meridionalis Steiner, 1924, *H. microamphidis* Steiner, 1925, *H. alascensis* Steiner, 1932, *H. polyina* Steiner (Vandel 1934), and *H. cornuta* Gleiss, 1955 have been considered to be "*nomina dubia*" (Poinar & Gyrisco, 1962; Kaiser, 1977). The descriptions of *H. abrevis* Rubtzov, 1971, *H. angusta* Rubtzov, 1971, *H. obtusa* Rubtzov, 1971, *H. paralbicans* Rubtzov, 1971 and *H. tamalensis* Baylis, 1933 are based on few individuals (Baylis, 1933; Rubtzov, 1971). *H. arvalis* Poinar & Gyrisco, 1962 and *H. kirjanovae* Pologentsev & Artyukhovsky, 1958 have been transferred to the genus *Amphibiomermis* (Artyukhovsky, 1969).

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