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First report of *Hexamermis* sp. (Nematoda: Mermithidae) parasitizing *Eurygaster maura* (Heteroptera: Scutelleridae) in an overwintering area

Gülcan Tarla, Şener Tarla, and Mahmut İslamoğlu*

Wheat, *Triticum aestivum* L. (Poales: Poaceae), is the most important food crop in the world in terms of the total harvested weight and the amount used in both human and animal nutrition. Harmful insects are one of the factors affecting the quality and cost of wheat production.

Sunn pests, *Eurygaster integriceps* Puton, *E. maura* (L.), and *E. austriaca* Schrank (Heteroptera: Scutelleridae), are serious pests of wheat in Turkey and in neighboring countries in the Middle and Near East (Kınacı & Kınacı 2004). Among them, *E. maura* is distributed predominantly in western and northern Europe, whereas *E. integriceps* is distributed predominantly in southern and eastern Europe (Critchley 1998). Among the *Eurygaster* species, *E. maura* is the most common and important pest species of cereals. The proportion of *E. maura* in Central Anatolia, relative to other sunn pests, was 98.4% when studied by Koçak et al. (2014) and 99.3% when assessed by Memişoğlu (1985). Nymphs and adults of this species have been linked to plant damage, as they feed on leaves, stems, and grains of cereals (Critchley 1998). The sunn pests inject chemicals into the grain that can destroy the gluten and reduce the baking quality of flour (Hariri et al. 2000).

The European sunn pest, *E. maura*, is a major pest of grain crops and can cause crop losses up to 100% in the absence of control measures (Bandani et al. 2005; Kıvan & Kılıç 2006). In Central Anatolia, *E. maura* is clearly migratory and often reoccupies the same overwintering and invasion areas (Brown 1965). This univoltine species spends about 9 mo in an obligatory adult diapause under dry leaves, usually in *Quercus* (Fagales: Fagaceae) scrub or weed stubble on the mountains and hills near wheat fields. Soon after the wheat crop begins to grow in the spring, the European sunn pest enters crop fields and feeds and completes its development on wheat. Then, the adults of the new generation move to the mountains before the wheat and barley are harvested. During this period, climatic conditions, adult parasitoids, nematodes, and entomopathogenic fungi could play an important role in reducing this pest's populations.

Reports of mermithids attacking *E. maura* were made by Memişoğlu & Özer (1992; 1994) in Turkey; however, the mermithids were not identified to the species level. Many mermithids have been reported from species of closely related hemipterans. Examples include *Mermis* sp. (Nematoda: Mermithidae) and *Hexamermis* sp. (Nematoda: Mermithidae) parasitizing *Aelia rostrata* Boheman (Hemiptera: Pentatomidae) and *E. integriceps* in Turkey (Dikyar 1981; Memişoğlu & Özer 1994; Memişoğlu et al. 1994; Tarla et al. 2010; 2012a; 2012b) and *Hexamermis* sp. parasitizing *Rhaphigaster nebulosa* Poda (Heteroptera: Pentatomidae) in Italy (Manachini & Landi 2003). *Pentatomimermis pentatomiae* (Rubtzov) (Nematoda: Mermithidae) was reported from *Elasmostethus interstinctus* (L.) (Heteroptera: Acanthosomatidae) at Novosibirsk, Russia (Rubstov 1978). Also, nematodes of the genus *Hexamermis* were observed infesting *Piezodorus guildinii* (Westwood) and *Acrosternum hilare* (Say) (Heteroptera: Pentatomidae) in the United States (Kamminga et al. 2012). Recently, *Hexamermis eurygasteri* Tarla, Poinar & Tarla (Nematoda: Mermithidae) was first described from *E. integriceps* in Turkey (Tarla et al. 2011). In addition, mermithids were reported on some other insect species in Turkey (Demirbağ & Yaman 1999; Yaman et al. 2002, 2009; Mennan & Ertürk 2006).

The objective of this study was to determine the infection rates of *E. maura* with the recently recorded parasitic nematode *Hexamermis* sp. under natural conditions in the overwintering area and to assess the nematode's potential for natural suppression of the European sunn pest.

The parasitic nematode *Hexamermis* sp. was obtained from the body cavity of *E. maura* (Fig. 1A) for the first time at Ankara, Turkey, in 2013 (39°40'20"N, 32°55'15"W, 1,485 m). In the second year, before *E. maura* migrated to cereal fields, overwintering adults were collected by hand in dead leaves of *Quercus* from Beynam (39°40'18"N, 32°55'12"W, 1,483 m), an overwintering area in Ankara Province on 2 and 3 May 2014. The insects were brought to the laboratory in transparent plastic bags, where they were sexed (120 females and 114 males) in 2014. After being killed in ethyl alcohol (70%), the bugs were dissected in distilled water under a stereomicroscope (Leica Mz 75) to determine the presence or absence of mermithids. The rate of parasitism was calculated individually for female and male sunn pests. The adult parasitic nematodes were obtained according to the method described by Tarla et al. (2011). After emerging from infected insect (Fig. 1B), the postparasitic juvenile nematodes migrated into the moist soil, where they matured to the adult stage. The adult nematodes were removed carefully from the soil, killed in distillated hot water (65 °C), fixed in 5% formalin, and processed to glycerine. The study was carried out in a laboratory at Uşak University.

Eurygaster maura and *E. integriceps* are very difficult to separate taxonomically without dissection or examination of genitalia (Gaffour-Bensebbane 1991; Critchley 1998). Therefore, taxonomic distinction of *E. maura* species was completed according to characteristics of the male aedeagus, which has 2 internal spines (Fig. 2).

The *E. maura* adults collected from the overwintering area were found to be parasitized by mermithid nematodes in 2013. In the second year of this study, infection rates in the bodies of dissected *E. maura* were calculated separately for females and males. In 2014, the

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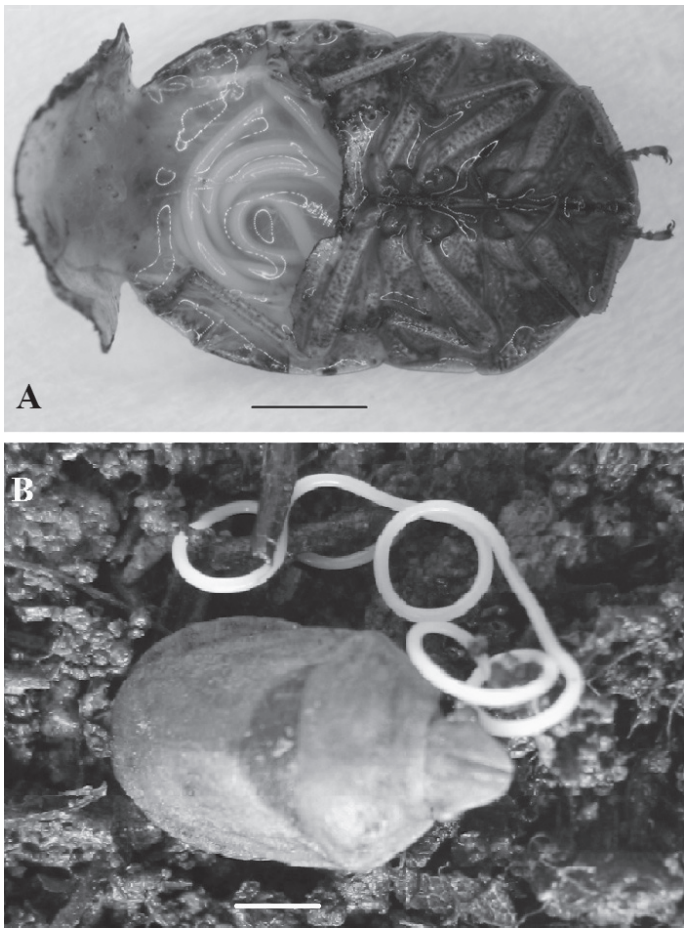


Fig. 1. Post-parasitic juvenile *Hexamermis* sp. in the body cavity (A) and emerging from the cervix of *Eurygaster maura* (B) (scale bar: 2.1 mm).

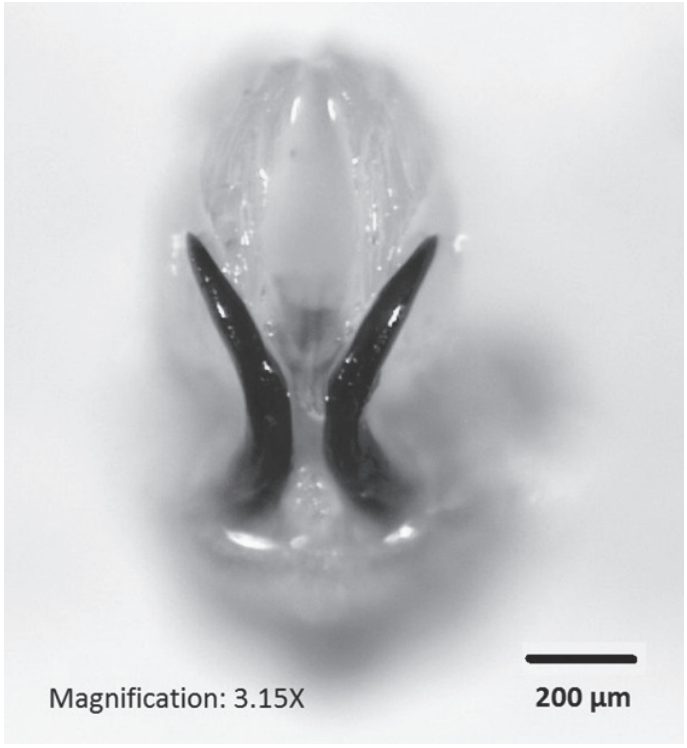


Fig. 2. Internal spines of *Eurygaster maura* male's aedeagus.

parasitism rate for females (*n* = 120) was 20.0% and that for males (*n* = 114) was 31.6%.

The mean body lengths of adults (*n* = 5) and post-parasitic (*n* = 5) stages of the nematodes were measured as 76.8 ± 12.91 (63.9–93.7) mm and 103.3 ± 11.17 (89.7–120.2) mm, respectively. Description: Bodies are medium-large, slender, color white, and cuticle containing prominent crisscross fibers visible with the light microscope. Mouth terminal and head containing 6 cephalic papillae, no lip papillae, amphids reduced, and 6 hypodermal cords at mid-body. Post-parasitic juvenile tail tip has a finger-like appendage (Fig. 3A). But, after molting (Fig. 3C), posterior end of female has bluntly rounded tail (Fig. 4A). Head of female is pointed (Fig. 4B). Vulva has short lips and distinctive cuticular cone (Fig. 4C). Juvenile has cephalic papillae and amphids reduced in size (Fig. 3B). Male is unknown. Due to presence of those characters described above, the nematode species was placed in the genus *Hexamermis* Steiner, 1924. The taxonomic distinction of the genus of this nematode was completed according to published literature (Nickle 1972; Rubstov 1978; Artyukhovsky 1990; Kaiser 1991). The post-parasitic juveniles of *Hexamermis* differ from *Agamermis* Cobb, Steiner & Christie, 1923 by the tail tip appendage always being preserved after the final molt (Hernández-Crespo & Santiago-Alvarez 1997; Achinelly & Camino 2008*).*

The mermithid nematode parasite of the genus *Hexamermis* discovered in Turkey was found to parasitize more than 25% of the total *E. maura* population in the overwintering area in 2014. Naturally occurring entomophagous nematodes are important regulatory factors for some insect populations (Smart 1995; Rahaman et al. 2000). In some cases, mermithids are the major determinant of grasshopper abundance (Baker & Capinera 1997); thus, they may similarly be key factors governing population dynamics of European sunn pest.

Our morphological observations on juveniles and adult females of the *Hexamermis* sp. obtained from *E. maura* revealed that it may not be *H. eurygasteri*. For this reason, our future studies will include efforts to obtain the males of this species and will involve determining DNA sequences of the parasite. Although *Hexamermis* species have not previously been reported from *E. maura*, there are earlier reports of unidentified mermithids attacking *E. maura* (Memişoğlu & Özer 1992, 1994) in Turkey. Memişoğlu & Özer (1992, 1994) reported that the mortality caused by parasitic nematodes was 15.5 and 7.2% in 1983 and 1984, respectively. Later, Tarla et al. (2011) described *H. eurygasteri* parasitizing *E. integriceps*, a major pest of wheat in Turkey, and this was the first description of a mermithid parasitizing a species of *Eurygaster* (Tarla et al. 2011). Also, Tarla et al. (2012a) reported parasitism rates of 13.8 and 16.0% for females, and 7.5 and 7.1% for males, in 2008 and 2009, respectively. Thus, this report of parasitism of *Eurygaster* by *Hexamermis* sp. is consistent with previous research.

In conclusion, natural parasitism of *E. maura* by *Hexamermis* sp. is reported for the first time. The findings suggest that this nematode species may be an important natural mortality factor for regulation of populations of *E. maura* under field conditions because it showed high rates of parasitism. Thus, additional research should be conducted to further assess the potential of *Hexamermis* sp. for suppression of *E. maura*.

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Summary

The European sunn pest, *Eurygaster maura* (L.) (Heteroptera: Scutelleridae), is an insect of great importance to wheat (*Triticum* spp.; Poales: Poaceae), and other small grains in the Central Anatolia Re-

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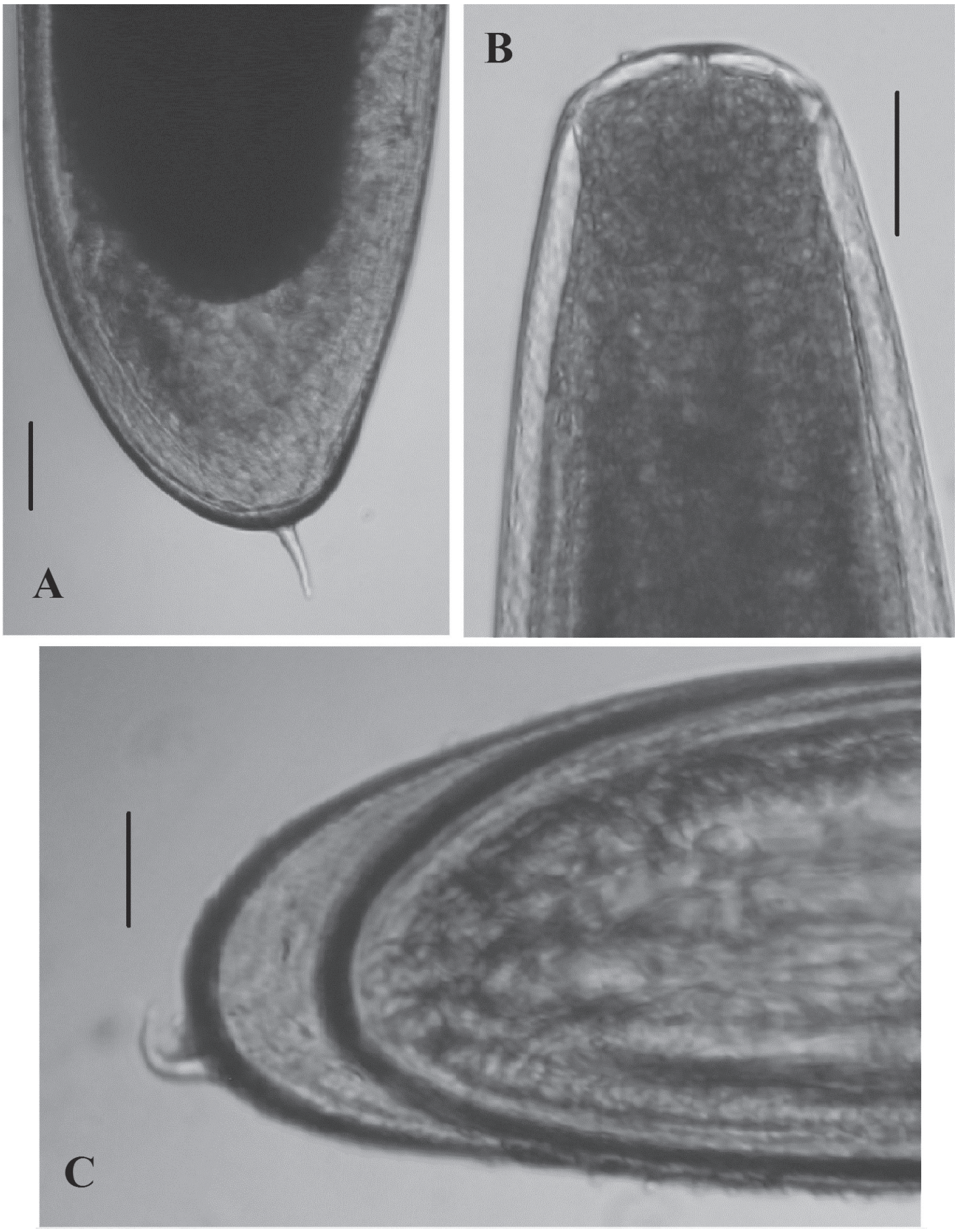


Fig. 3. Tail appendage (A), anterior portion of female (B), and posterior end of molting female of post-parasitic juvenile *Hexamermis* sp. (C) (scale bar: A, 42 µm; B, 43 µm; C, 58 µm).

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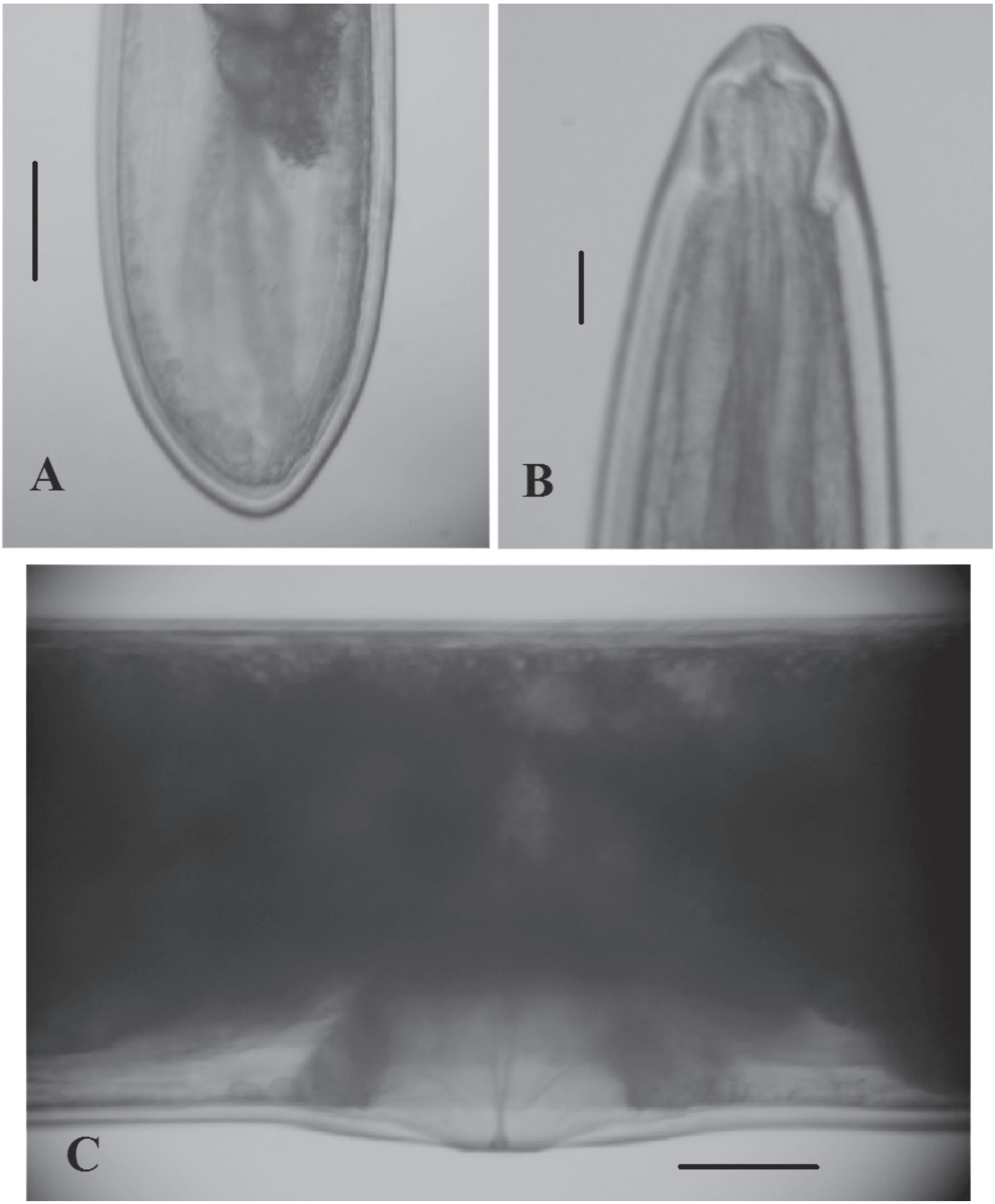


Fig. 4. Tail of female (A), anterior portion of female (B), and vulva of *Hexamermis* sp. (C) (scale bar: A, 78 µm; B, 32 µm; C, 89 µm).

gion of Turkey. Natural parasitism of this pest by a parasitic nematode, *Hexamermis* sp. (Nematoda: Mermithidae), was reported for the first time in Ankara, Turkey, in 2013. During the next year, adults of *E. maura* were collected from an overwintering area under plant leaf litter and brought to the laboratory and sexed. After killing, they were dissected to determine the presence or absence of mermithids. Natural parasit-

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ism rates caused by the parasitic nematode were calculated individually for females and males of the sunn pest. The parasitism rates in the overwintering area were 20.0% for females and 31.6% for males during 2014. These findings suggest that *Hexamermis* sp. has potential as a biological control agent of *E. maura*.

Key Words: cereal crop; European sunn pest; parasitic nematode; wheat

Sumario

El chinche plaga Europea de sunn, *Eurygaster maura* (L.) (Heteroptera: Scutelleridae), es un insecto de gran importancia en el trigo (*Triticum* spp .; Poales: Poaceae) y otros cultivos de cereales en la Región Central de Anatolia, Turquía. El parasitismo natural de esta plaga por un nematodo parásito, *Hexamermis* sp. (Nematoda: Mermithidae), se reportó para su primer registro en Ankara, Turquía, en el 2013. En el año siguiente, los adultos de *E. maura* fueron recolectados de áreas de hibernación debajo de escombros de plantas llevados al laboratorio y su sexo determinado. Después de matarlos, fueron diseccionados con el fin de determinar la presencia o ausencia de mermithids. Por lo tanto, las tasas de parasitismo naturales causados por el nematodo parásito se calcularon por separado para hembras y machos del chinche plaga de sunn. Las tasas de parasitismo en las áreas de hibernación fueron 20.0% para las hembras y 31.6% para los machos en 2014. Estos hallazgos sugieren que *Hexamermis* sp. tiene potencial como agente de control biológico de *E. maura* en un programa de control integrado.

Palabras Clave: cultivos de cereales; chinche plaga Europea de sunn; nematodo parásito; trigo

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