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First record of *Filenchus annulatus* and the genus *Malenchus* (Nematoda: Tylenchidae) from Iraq

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Abstract:

In the present study, 12 species from 10 genera within the infraorder Tylenchomorpha were recovered from soil samples collected in Misan province, southeastern Iraq, and identified using morphological and morphometric characteristics. Among these, *Pratylenchus thornei* was the most frequent species (15.7%), followed by *Tylenchorhynchus zeae* (12.3%). The family Tylenchidae is one of the most abundant and diverse nematode families, with a global distribution and diverse feeding habits. Two species of the family were identified. The species *Filenchus annulatus* was recovered from the rhizosphere of maize. Females of this population had a body length of 393-457 µm, a lateral field with four incisures, a slender stylet measuring 7.3-8.7 µm long, V = 58.8-64.2, and a tail 89-96 µm long, tapering to a pointed or filiform terminus. The second species, *Malenchus labiatus* was recovered from the rhizosphere of alfalfa. Females of this population had a body length of 399-456 µm, annuli 1.2-1.5 µm wide at mid-body, a lateral field with two crenate incisures, a stylet measuring 8.3-9.8 µm, and a tail 97-111 µm long with a pointed terminus. The morphological and morphometric characters of both populations are consistent with those of the type populations and other reported populations. This study represents the first record of *F. annulatus* and the genus *Malenchus* in Iraq.

Keywords: Misan province, Morphometry, New record, Taxonomy

Introduction

The family Tylenchidae Örley, 1880, is one of the most abundant and diverse families of nematodes, comprising up to 30% of nematode communities in soil samples (Yeates & Bird, 1994; Ferris & Bongers, 2006). Despite their high diversity and ecological significance, the feeding behavior of many tylenchid species remains poorly documented. Some genera feed on freshwater algae, others are associated with lichens and mosses, while certain species feed on plant epidermal cells and root hairs (Yeates et al., 1993; Siddiqi, 2000). Additionally, several species are fungivores, feeding on saprophytic and plant-pathogenic fungi (Okada et al., 2005).

Within the family, *Filenchus* is the most species-rich genus (Munawar et al., 2022), followed by the genus *Malenchus* (Qing et al., 2018). In Iraq, nematode diversity within Tylenchidae is largely unexplored; only a single report of an unidentified *Filenchus* species associated with olive trees in northern Iraq has been documented (Albazazz & Aljuboori, 2024).

Recent surveys of plant-parasitic nematodes in Misan province, southeastern Iraq, have revealed several species, including *Tylenchorhynchus clarus* Allen, 1955, *T. zeae* Sethi & Swarup, 1968 (Jumaah & Azimi, 2022a), *Pratylenchus thornei* Sher & Allen, 1953 (Jumaah & Azimi, 2022b), *Psilenchus hilarulus* de Man, 1921 (Jumaah & Azimi, 2024a), and *Hoplolaimus columbus* Sher, 1963 (Jumaah & Azimi, 2024b). The present study provides the first detailed morphological and morphometric characterization of two Tylenchidae species from Iraq.

Materials and Methods

Soil samples were collected from the rhizosphere of various crops in the Misan province, Iraq. Nematodes were extracted from the soil using either the centrifugal flotation technique (Jenkins, 1964) or the tray method (Whitehead & Hemming, 1965). The extracted nematodes were heat-killed in 4% formaldehyde solution and processed into anhydrous glycerin following the method of De Grisse (1969). Permanent microscopic slides were prepared from the preserved specimens for detailed morphological examination. Observations and morphometric measurements were conducted using a Leitz SM-LUX light microscope equipped with a drawing tube. Photomicrographs were taken using a Tucsen Michrome 20 digital camera mounted on an Olympus BX51 light microscope. Final image plates were compiled and refined using Adobe Photoshop (version 2019). Species identification was performed using standard nematological literature and reliable identification keys, including Geraert (2008). The relative frequency of each identified species was calculated.

Results

Based on morphological and morphometric characteristics, 12 species from 10 genera within the infraorder Tylenchomorpha De Ley & Blaxter, 2002, were identified (Table 1). Among these, *Pratylenchus thornei* was the most frequent species (15.7%), followed by *Tylenchorhynchus zeae* (12.3%). Detailed morphological and morphometric descriptions of two species of Tylenchidae newly recorded from Iraq, *Filenchus annulatus* (Siddiqui & Khan, 1983) Siddiqi, 1986, and *Malenchus labiatus* Maqbool & Shahina, 1985, are presented below.

Table 1. Nematode species recovered from different crops in Misan province, with their locality, GPS coordinates, and relative frequency (%).

Species	Associated plant	Locality	GPS coordinates	Relative frequency (%)
Aphelenchus avenae Bastian, 1865	Barley	Ali-Al Sharqi	32°08'34.18"N 46°43'11.69"E	8.5
Criconemoides sp.	Pomegranate	Al-Kahla	31°40'53.29"N 47°16'44.14"E	7.5
Filenchus annulatus Siddiqui & Khan, 1983 Siddiqi, 1986	Maize	Al-Maymouna	31°38'54.65"N 46°56'41.61"E	8.2
Helicotylenchus abunaamai Siddiqi, 1972	Watermelon	Al-Kamit	32°00'58.48"N 46°57'20.03"E	5.5
Helicotylenchus egyptiensis Tarjan, 1964	Date palm	Qala Saleh	31°30'57.46"N 47°18'59.19"E	9.3
Heterodera avenae Wollenweber, 1924	Wheat	Al-Kamit	32°01'37.35"N 46°48'40.83"E	5.4
Hoplolaimus columbus Sher, 1963	Oleander	Al-Amarah	31°47'14.14"N 47°11'34.02"E	6.8
Malenchus labiatus Maqbool & Shahina, 1985	Alfalfa	Al-Amarah	31°47'45.67"N 47°09'15.43"E	8.9
Pratylenchus thornei Sher & Allen, 1953	Faba bean	Alkahla, Ali-Al Gharbi	31°41'02.46"N 47°16'50.05"E 32°28'57.13"N 46°37'48.78"E	15.7
Psilenchus hilarulus de Man, 1921	Okra	Al-Uzair	31°18'51.69"N 47°23'59.42"E	8.3
Tylenchorhynchus clarus Allen, 1955	Sugarcane	Majar Al-Kabir	31°35'22.48"N 47°12'31.98"E	9.6
Tylenchorhynchus zeae Sethi & Swarup, 1968	Pumpkin	Ali-Al Gharbi	32°07'56.81"N 46°43'05.75"E	12.3

Table 2. Morphometric characteristics of *Filenchus annulatus* from Misan province, Iraq, and compared with a population from Iran (Atighi *et al*. 2013). All measurements are in µm and presented as mean ± SD (range).

characters	Present study		Atighi *et al*. 2013	
	Female	Male	Female	Male
n	8	4	20	15
L	438.4 ± 15.7 (393-457)	347.0 ± 27.8 (315-360)	402.0 ± 24.5 (370-450)	377 ± 38 (306-426)
a	34.5 ± 2.1 (30.0-36.8)	32.6 ± 2.6 (30.9-36.6)	34.0 ± 2.4 (28.7-37.4)	33.2 ± 2.5 (29.7-38.7)
b	5.6 ± 0.3 (5.2-5.9)	4.2 ± 0.4 (4.6-5.2)	-	-
c	4.4 ± 0.8 (3.4-4.7)	3.9 ± 0.9 (3.8-4.7)	4.9 ± 0.3 (4.5-5.6)	5.0 ± 0.2 (4.7-5.3)
c´	10.5 ± 0.2 (9.8-10.7)	8.6 ± 0.9 (7.2-10.8)	10.3 ± 1.6 (6.8-13.1)	9.4 ± 1.2 (7.5-11.3)
V	62.2 ± 1.3 (58.8-64.2)	-	63.0 ± 2.1 (60.8-67.8)	-
V´	82.6 ± 2.3 (79.5-85.0)	-	78.0 ± 1.3 (75.6-80.1)	-
Stylet length	8.4 ± 0.2 (7.3-8.7)	7.9 ± 0.4 (7.2-8.2)	8.2 ± 0.7 (7.0-10.0)	7.7 ± 0.7 (7.0-9.0)
MB	43.4 ± 2.2 (40.5-46.5)	40.7 ± 4.2 (39.2-42.2)	47.1 ± 2.4 (42.5-51.1)	47.4 ± 2.8 (38.6-50.7)
Anterior end to secretory-excretory pore	64.7 ± 2.3 (60-68)	62.2 ± 1.8 (61-65)	58.3 ± 2.5 (54-63)	56.3 ± 3.7 (51-65)
Pharynx	79.5 ± 2.6 (74-83)	75.8 ± 3.9 (73.2-77.7)	82.0 ± 4.6 (75-94)	79.9 ± 5.6 (71-91)
Lip region-vulva	288.7 ± 19.5 (269-314)	-	253.0 ± 13.6 (233-285)	-
Vulva-anus	83.6 ± 5.3 (79.2-88.5)	-	71.3 ± 6.9 (62-85)	-
PUS	9.6 ± 0.4 (9.3-10.2)	-	6.6 ± 1.7 (4.0-11.0)	-
T/VA	1.7 ± 0.1 (1.3-1.9)	-	1.1 ± 0.2 (0.9-1.5)	-
Body width	12.4 ± 0.8 (11.5-13.8)	11.9 ± 0.5 (10.6-12.7)	12.2 ± 0.7 (11-14)	11.4 ± 1.0 (10-13)
Vulval body width	11.4 ± 0.8 (10.2-12.8)	-	-	-
Anal body width	7.2 ± 1.0 (6.8-8.3)	7.8 ± 0.7 (6.7-9.5)	7.6 ± 0.7 (6.5-9.0)	8.1 ± 0.8 (7-10)
Tail length	94.2 ± 2.8 (89-96)	73.8 ± 2.2 (67-76)	77.5 ± 10.9 (58-93)	75.9 ± 9.1 (60-91)
Spicules	-	12.6 ± 0.9 (12.0-14.8)	-	12.8 ± 0.8 (11.5-14.0)
Gubernaculum	-	3.9 ± 0.2 (3.6-4.5)	-	4.6 ± 0.7 (3.5-6.0)

***Filenchus annulatus* (Siddiqui & Khan, 1983) Siddiqi, 1986**

(Fig. 1, Table 2)

Female

Body slightly ventrally arcuate after fixation. Cuticle finely striated, annuli about 0.7-1.0 µm wide at mid-body. Lateral field with four incisures; outer lines faintly areolated. Lip region continuous with the body contour, nearly quadrangular, 2.3-2.8 µm high and 4.5-6.0 µm wide. Cephalic framework delicate. Stylet with rounded, slightly posteriorly directed basal knobs, 1.0-1.4 µm wide. Dorsal gland orifice located 1.2-1.5 µm from stylet base. Pharynx composed of a cylindrical procorpus, and oval median bulb with a small valve; isthmus slender, basal bulb pyriform, not overlapping the intestine. Nerve ring surrounds the isthmus. Secretory-excretory pore located at the level of the anterior part of the pharyngeal bulb, posterior to the hemizonid. Reproductive system mono-prodelphic, with a single outstretched ovary; oocytes arranged in a single row, spermatheca nearly spherical, filled with rounded sperm, vagina occupying approximately 40-50% of the corresponding body diameter, vulva a transverse slit lacking flaps or epiptygmata, post-vulval uterine sac shorter than the body diameter. Tail elongate-conoid, tapering to a pointed or filiform terminus.

Male

Slightly shorter than female, with general morphology similar except for sexual characters. Testis single, and outstretched; spermatocytes arranged in a single row. Spicules are tylenchoid and ventrally arcuate. Gubernaculum simple, rod-shaped. Bursa adanal, 21-25 µm long. Tail similar in shape to that of the female.

Remarks

The general morphology of the Iraqi population of *F. annulatus* closely resembles the type population originally

described from India (Siddiqui & Khan, 1983). However, several minor morphometric differences were observed: the distance from the anterior end to the secretory-excretory pore is slightly greater (60-68 *vs* 58 µm), pharynx is longer (74-83 *vs* 72 µm), and tail is slightly shorter (89-96 *vs* 100 µm). These differences likely represent intraspecies variations due to geographic or environmental factors. Compared with the Iranian population recovered from the rhizosphere of *Prunus* sp. (Atighi et al., 2013), no notable differences were observed. The Iraqi population examined in the present study was collected from the rhizosphere of maize (*Zea mays* L.) in the Al-Maymouna region (GPS coordinates: 31°38'54.65"N 46°56'41.61"E), Misan province, southeastern Iraq. This is the first report of *F. annulatus* from Iraq.

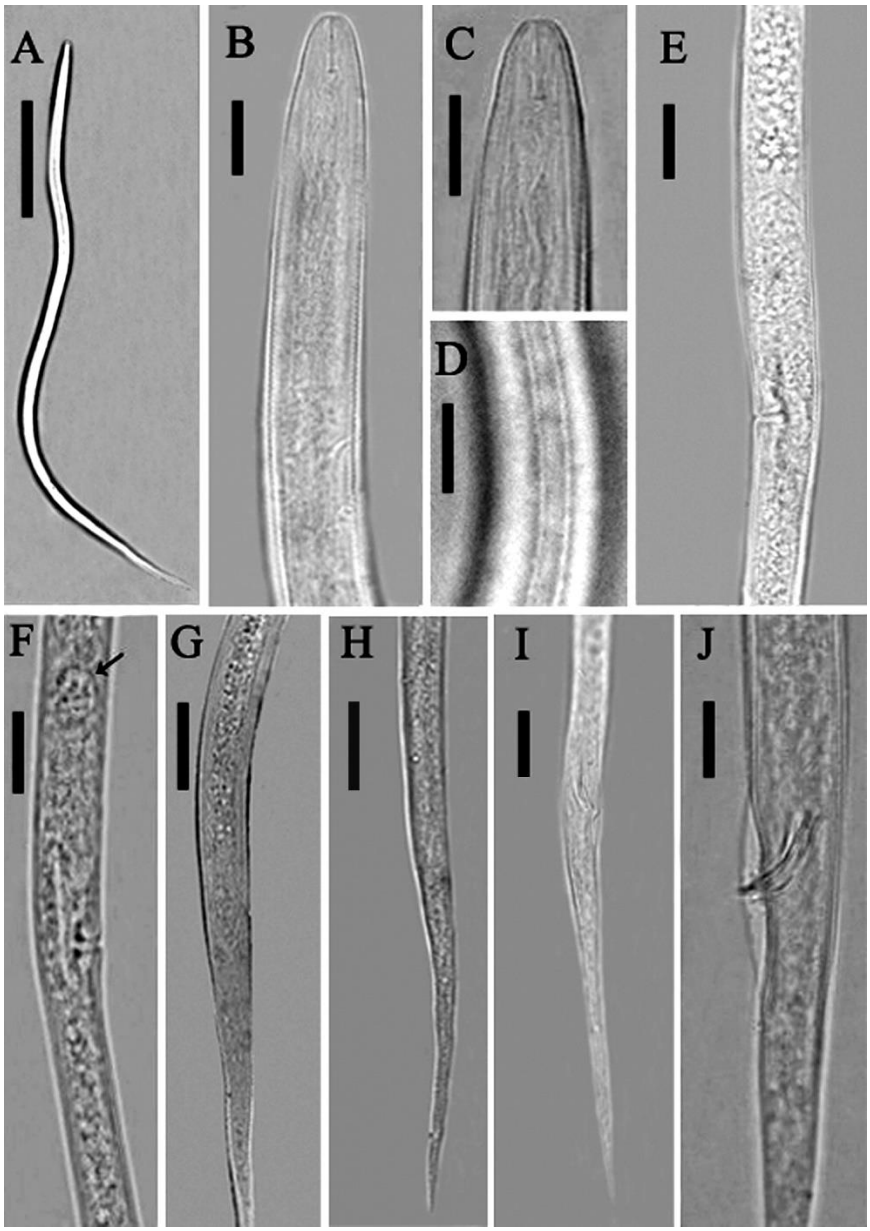

Figure 1. Light photomicrographs of *Filenchus annulatus* from Iraq. A-H: Female. I, J: Male. A: Entire body; B, C: Anterior body region; D: Lateral field at mid-body; E, F: Part of reproductive system (the arrow indicates the spermatheca); G-J: Posterior body region. Scale bars: A = 90 µm, B-J = 10 µm.

Table 3. Morphometric characteristics of *Malenchus labiatus* from Misan province, Iraq, compared with the type population (Maqbool & Shahina, 1985). All measurements are in µm and presented as mean ± SD (range).

Characters	Present study		Maqbool & Shahina, 1985	
	Female	Male	Female	Male
n	9	4	13	6
L	426.2 ± 19.7 (399-456)	436.0 ± 21.8 (421-458)	420 (400-450)	420 (410-440)
a	33.5 ± 3.4 (29.0-35.8)	37.4 ± 3.2 (35.9-41.8)	27 (24-31)	33 (30-38)
b	5.2 ± 0.3 (4.9-5.7)	4.9 ± 0.7 (4.2-5.6)	5.0 (4.1-5.4)	4.9 (4.7-5.1)
c	4.4 ± 0.5 (3.9-4.8)	4.1 ± 0.3 (4.0-4.5)	4.3 (3.8-5.0)	3.7 (3.6-4.0)
c´	12.6 ± 0.8 (11.6-13.3)	12.9 ± 0.9 (11.2-13.8)	11 (10.0-13.5)	11.4 (10.4-13.0)
V	61.2 ± 1.8 (59.3-64.0)	-	60 (59-63)	-
V´	79.3 ± 1.7 (78.5-81.2)	-	-	-
Stylet length	9.2 ± 0.4 (8.3-9.8)	8.4 ± 0.9 (7.8-9.5)	8.4 (8.0-8.8)	8.4 (8.0-8.8)
MB	43.5 ± 2.8 (39.8-46.7)	42.7 ± 1.5 (41.2-44.2)	43 (41-46)	44 (43-45)
Anterior end to secretory-excretory pore	63.4 ± 2.8 (61-67)	64.2 ± 2.8 (62-67)	70 (65-76)	70 (65-78)
Pharynx	79.4 ± 3.8 (76-87)	81.8 ± 2.9 (79-85)	83 (80-90)	86 (83-89)
Lip region-Vulva	273.2 ± 12.5 (259-292)	-	-	-
Vulva-Anus	71.6 ± 3.8 (64-77)	-	64 (54-72)	-
PUS	9.3 ± 0.8 (8.4-10.4)	-		-
T/VA	1.5 ± 0.2 (1.2-1.8)	-	1.3-1.9	-
Body width	14.1 ± 0.6 (13.4-14.8)	-	15 (13-18)	
Vulval body width	12.4 ± 1.2 (11.5-13.4)	-	-	-
Anal body width	7.9 ± 0.5 (7.5-9.0)	8.1 ± 0.4 (7.8-9.6)	-	-
Tail length	104.0 ± 6.8 (97-111)	102.8 ± 3.2 (95-106)	103 (98-112)	112 (102-115)
Spicules	-	14.9 ± 0.3 (14.5-16.0)	-	14.4 (14.4-15.0)
Gubernaculum	-	3.7 ± 0.2 (3.2-4.5)	-	3.2 (3.2-4.0)

***Malenchus labiatus* Maqbool & Shahina, 1985**

(Fig. 2, Table 3)

Female

Body slender, ventrally arcuate after fixation. Cuticle with distinct annuli, 1.2-1.5 µm wide at mid-body. Lateral field with two crenate incisures, extending from the middle of the procorpus to the middle of the tail, occupying one-quarter to one-fifth of the body width. Lip region continuous with body contour, annulated, 2.2-3.9 µm high and 4.6-5.1 µm wide, with a prominent terminal disc. Stylet delicate, with rounded, posteriorly directed basal knobs, 1.0-1.2 µm across. Dorsal pharyngeal gland orifice located 0.5-1.0 µm posterior to stylet base. Pharynx consisting of a slender procorpus, an oval median bulb, and a small, nearly pyriform basal bulb. Secretory-excretory pore located at the level of the anterior part of the pharyngeal bulb. Nerve ring encircling the midpoint of the isthmus. Reproductive system mono-prodelphic, with a single outstretched ovary; oocytes arranged in a single row; spermatheca elongate, bilobed, filled with sperms; vulva with distinct vulval flaps; post-vulval uterine sac measuring about 0.5-0.7 times the body width. Tail long, tapering to a finely pointed terminus.

Male

Morphologically similar to the female, except for sexually dimorphic features. Testis single, outstretched; spermatocytes arranged in a single row. Spicules tylenchoid, small, and ventrally arcuate. Gubernaculum simple, rod-shaped. Bursa adanal, 18.5-25.0 µm long. Tail similar in shape to that of the female.

Remarks

The general morphology of *M. labiatus* from Iraq closely resembles the type population originally described from the

rhizosphere of sugarcane (*Saccharum officinarum* L.) in Pakistan (Maqbool & Shahina, 1985). No significant differences were observed when compared with the Iranian population collected from the rhizosphere of sugarcane (Yaghoubi et al., 2015) and a population from maize in Pakistan (Sikandar et al., 2017). The Iraqi population examined in the present study was collected from the rhizosphere of alfalfa (*Medicago sativa* L.) in the Al-Amarah region (GPS coordinates: 31°47'45.67"N 47°09'15.43"E), Misan province, southeastern Iraq. This is the first record of the genus *Malenchus* from Iraq.

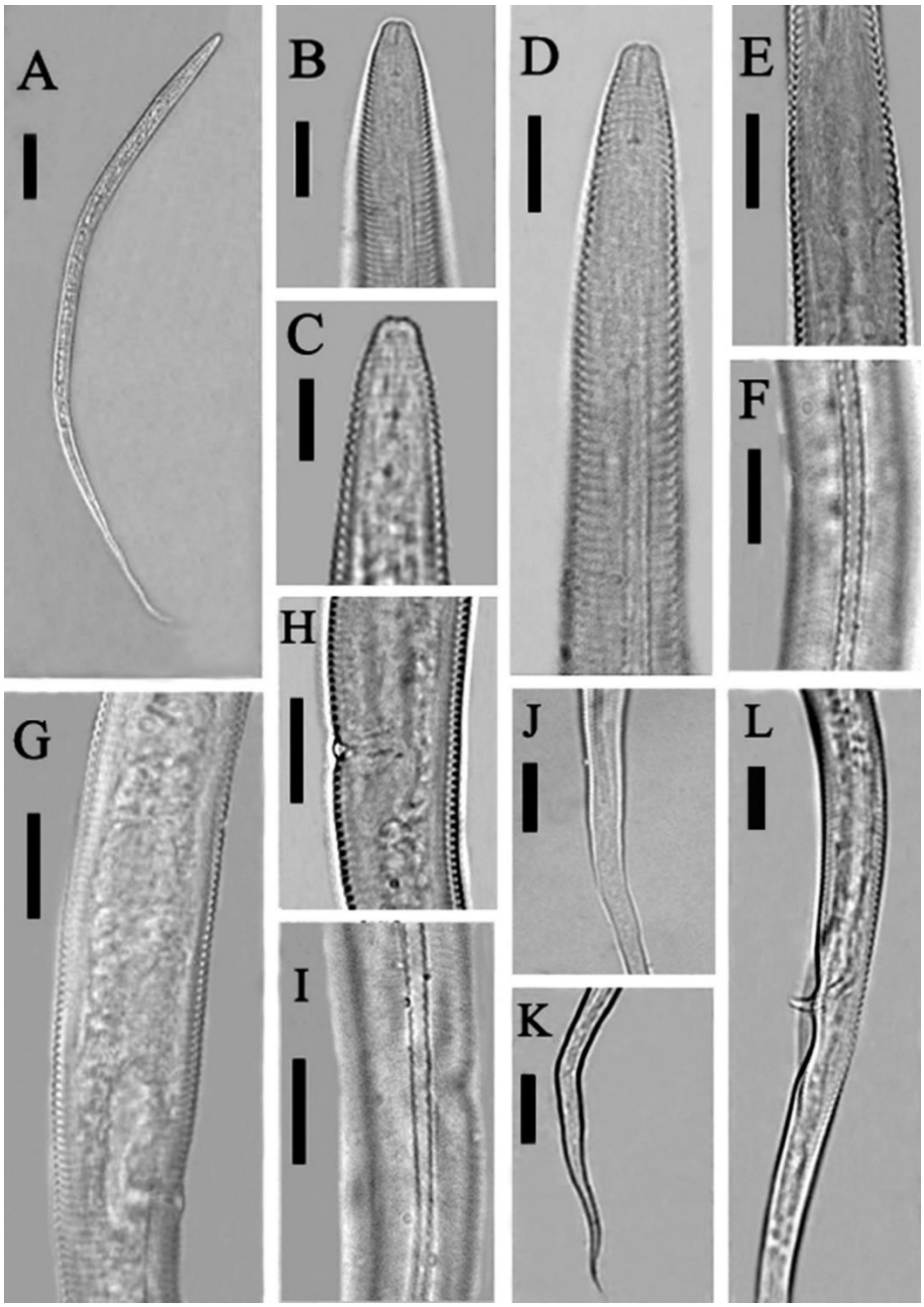

Figure 2. Light photomicrographs of *Malenchus labiatus* from Iraq. A-K: Female. L: Male. A: Entire body; B-D: Anterior body region; E: Secretory-excretory pore region; F: Lateral field at mid-body; G, H: Part of reproductive system; I: Lateral field at vulval region; J-L: Posterior body region. Scale bars: A = 50 µm, B-J = 10 µm.

Discussion

This study presents the first morphological characterization of *Filenchus annulatus* and the first record of the genus *Malenchus* from Iraq based on populations recovered from Misan province. These findings contribute valuable data to the limited knowledge of Tylenchidae diversity in the country. Misan province is one of Iraq's most agriculturally and industrially important regions, with diverse crop production, livestock resources, and oil reserves (Murtadha, 2021). Its agricultural landscape includes major crops such as sugarcane, wheat, barley, maize, faba bean, watermelon, okra, cucumber, and tomato, as well as fruit trees like date palm and a variety of ornamental plants (Shahla & Salam, 2020).

Given this agroecological diversity, and the previous reports of economically important plant-parasitic nematodes, such as *Pratylenchus thornei* and *Hoplolaimus columbus* from this province (Jumaah & Azimi, 2022b, 2024b), there is a clear need for expanded nematological surveys. *P. thornei* was the most widely distributed species, recovered from faba bean. It has also been reported as the most common nematode parasite on faba bean and other legumes in Italy, North Africa, and the Middle East, where it significantly reduces faba bean growth (Di Vito et al., 2000). The second most frequent species, *Tylenchorhynchus zeae*, has a host range that includes several economically important crops such as cabbage, cauliflower, grapevine, and olive. Its pathogenicity on maize has been confirmed, producing symptoms including stunted roots, root swellings, and dwarf, chlorotic shoots under greenhouse conditions (Kang et al., 2023).

Future research in Iraq is needed to conduct comprehensive surveys of nematode biodiversity and distribution, incorporating both morphological and molecular approaches. Moreover, pathogenicity studies on local crops are essential to assess their economic impact and to guide the development of sustainable pest management strategies.

Conflict of Interest

The authors declare no conflicts of interest.

Ethical Considerations

All ethical principles and standards were fully observed in the conduct of this research.

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بیماری‌های گیاهی، جلد ۶۰، شماره ۲، صفحات ۲۰۲-۱۹۳

اولین گزارش از *Filenchus annulatus* و جنس *Malenchus* (Nematoda: Tylenchidae) از عراق

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چکیده

در این مطالعه، ۱۲ گونه از ۱۰ جنس متعلق به فوق بالاخانواده Tylenchomorpha از نمونه‌های خاک جمع‌آوری شده از استان میسان در جنوب شرقی عراق جداسازی و با استفاده از ویژگی‌های ریخت‌شناختی و ریخت‌سنجی شناسایی شدند. ازمیان آن‌ها، گونه *Pratylenchus thornei* دارای بیشترین فراوانی نسبی (۱۵/۷ درصد) بود و پس از آن *Tylenchorhynchus zeae* قرار داشت (۱۲/۳ درصد). خانواده Tylenchidae یکی از فراوان‌ترین و متنوع‌ترین خانواده‌های نماتدها است که اعضای آن پراکنش جهانی داشته و رفتارهای تغذیه‌ای بسیار متنوعی دارند. دو گونه از این خانواده شناسایی شدند. گونه *Filenchus annulatus* از فراریشه ذرت جدا شد. ماده‌های این جمعیت دارای بدن به طول ۳۹۳ تا ۴۵۷ میکرومتر، سطوح جانبی با چهار شیار طولی، استایلت ظریف به طول ۷/۳ تا ۸/۷ میکرومتر، شکاف تناسلی واقع در ۵۸/۸ تا ۶۴/۲ درصدی طول بدن، و دم به طول ۸۹ تا ۹۶ میکرومتر با انتهای نوک‌تیز تا نخی‌شکل بودند. گونه دوم، *Malenchus labiatus* از فراریشه یونجه جمع‌آوری شد. ماده‌های این جمعیت دارای بدن به طول ۳۹۹ تا ۴۵۶ میکرومتر، عرض حلقه‌ها در میانه بدن ۱/۲ تا ۱/۵ میکرومتر، سطوح جانبی با دو شیار طولی کنگره‌دار، استایلت به طول ۸/۳ تا ۹/۸ میکرومتر و دم به طول ۹۷ تا ۱۱۱ میکرومتر با انتهای نوک‌تیز است. ویژگی‌های ریخت‌سنجی و ریخت‌شناختی هر دو جمعیت با جمعیت‌های تیپ و سایر جمعیت‌های گزارش‌شده مطابقت دارد. این مطالعه، نخستین گزارش از حضور *F. annulatus* و جنس *Malenchus* در عراق به شمار می‌رود.

کلیدواژگان: *استان میسان، تاکسونومی، ریخت‌سنجی، گزارش جدید*

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