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Original article

First report of *Quinisulcius capitatus* (Allen, 1955) Siddiqi, 1971 infesting pepper (*Capsicum annuum* L.) crops in Poland

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Abstract

Among the plant-parasitic nematodes feeding on peppers (*Capsicum annuum* L.), the most frequently mentioned genera are root-knot nematodes (*Meloidogyne*), root-lesion nematodes (*Pratylenchus*), spiral nematodes (*Helicotylenchus*), and pearl nematodes (*Naccobbus aberrans*). These nematodes negatively impact pepper plant growth, manifesting as root damage and wilting of the above-ground parts. A study conducted in the intensive pepper cultivation area of Potworów, Poland identified the plant-parasitic nematode genera and species associated with wilting. Soil samples were collected from 26 sites, and 11 genera of plant-parasitic nematodes were found. The most prevalent were *Meloidogyne* (present in 81% of samples), *Pratylenchus* (73% of samples), along with *Paratylenchus* and *Quinisulcius* (both found in 50% of samples). An average of 55 *Quinisulcius capitatus* nematodes were found per 100 ml of soil, with the statistical significance of this value being 62.71 for the specific comparison being made in the study. This pilot study confirmed the species *Q. capitatus* through morphometric, morphological, and genetic analyses (sequencing of the 28S rDNA gene). Subsequently, the abundance of *Q. capitatus* in pepper crops was assessed under controlled conditions (16/8 hours day/night) by growing peppers in pots inoculated with the nematode. The study revealed an average 23-fold increase in nematode abundance. The observations of wilting symptoms in the pepper plants, concurrent with the rapid increase in *Q. capitatus* abundance, suggests this nematode is a potential pest for this crop. To our knowledge, this is the first report of *Q. capitatus* infesting peppers in Poland. These results provide a strong basis for further research into the specific impacts of *Q. capitatus* on pepper production in Poland.

Key words: 28S rDNA, occurrence, peppers, Poland, potential pest, stunt nematodes

Introduction

Capsicum annuum L., is a species of the nightshade family (Solanaceae Juss.), and the most common and diverse species of pepper, followed by *Capsicum chinense* Jacq, *Capsicum frutescens* L., *Capsicum baccatum* L., and *Capsicum pubescens* (Ruiz and Pav). As the most economically important species of the *Capsicum* genus, *C. annuum* is widely cultivated for the hot or mild peppers of its myriad varieties and cultivars (Allonso-Villegas *et al.* 2023). *C. annuum* is native to the Americas, specifically Mexico and parts of South America. Christopher Columbus brought peppers to Europe during his transatlantic voyages in the late 15th century, and from there, through the Columbian Exchange, they spread to Africa, India, and China (da Veiga *et al.* 2022; Silvar *et al.* 2022; Hancock 2023). Currently, peppers represent a global commodity (Bridgemohan *et al.* 2018), with Asia accounting for approximately 66% of worldwide production (FAO 2025). In 2023, the leading European producers were Spain (1,389,830 tons), the Netherlands (42,000 tons), and Poland (28,600 tons) (FAO 2025). Within Poland, cultivation covered roughly 3,000 hectares in 2023 (FAO 2025), concentrated primarily in the Potworów area of the Mazowieckie Voivodeship. Production methods included both open-field cultivation and protected plastic tunnels.

During the growing season, pepper plants are exposed to harmful bacterial pathogens, including bacterial canker, bacterial wilt, and bacterial spot. They are also susceptible to numerous fungi, such as those causing *Verticillium* wilt, powdery mildew, southern blight, *Phytophthora* blight, gray mold, *Fusarium* wilt, *Fusarium* stem rot, damping-off and root rot, *Choanephora* blight, *Cercospora* leaf blight, and anthracnose. Additionally, viruses and viroids pose a threat, as do insects like thrips species (*Frankliniella occidentalis* and *Thrips tabaci*), green peach aphid (*Myzus persicae* Sulz.), and cotton bollworm (*Helicoverpa armigera*; Lepidoptera: Noctuidae) (Roberts *et al.* 2024; Todorova *et al.* 2024).

Phytophagous nematodes frequently accompany pepper vegetation (Bafokuzara 1996; Baimey *et al.* 2009; Qing *et al.* 2019; Qing *et al.* 2020; Garba and Rizvi 2021; Feyisa *et al.* 2023; Long *et al.* 2023). The most commonly mentioned include root-knot nematode *Meloidogyne* (Di Vito *et al.* 1992; Moosavi 2015; Gomez-Rodriquez *et al.* 2017; Silva-Soares *et al.* 2018; Pinheiro *et al.* 2018; Carillo-Fasio *et al.* 2021; Kvvs *et al.* 2023; Sandrine *et al.* 2024), root lesion nematodes of the genus *Pratylenchus* (Garba and Rizvi 2021; Tola *et al.* 2022; Apalowo *et al.* 2024; Ekine and Ezenawka 2024; Sandrine *et al.* 2024), the false root-knot nematode *Naccobbus aberrans* (Bernardo *et al.* 2020; Lax *et al.* 2022), and spiral nematodes like *Helicotylenchus* (Lugo *et al.* 2010; Tola *et al.* 2022; Apalowo *et al.* 2024; Ekine and Ezenawka 2024). Stunt nematodes, specifically those from the genera *Tylenchorhynchus* and species *Bitylenchus capsicumi*, were also identified in the pepper root zone (Akhter and Zarina 2014; Kvvs *et al.* 2023). Wilting symptoms in pepper plants have been experimentally linked to the species *Neodolichorhynchus sulcatus*, which increased significantly in soil abundance over a 40-day growing season (Qing *et al.* 2020). Additionally, the stunt nematode, *Quinisulcius capitatus* (Allen, 1955) Siddiqi, 1971, was isolated from the rhizosphere of cultivated peppers (Lugo *et al.* 2010).

Q. capitatus is an ectoparasitic, polyphagous nematode found in the rhizosphere of various cultivated vegetable crops, such as: beans (*Phaseolus vulgaris*), cucumbers (*Cucumis sativus*), onions (*Allium cepa*), parsley (*Petroselinum crispum*), potatoes (*Solanum tuberosum*) and tomatoes (*Solanum lycopersicum*) (Brzeski 1986; Kasapoğlu Uludamar *et al.* 2018; Mbatyoti *et al.* 2020; Iqbal *et al.* 2021; Munawar *et al.* 2021; Peraza-Padilla *et al.* 2024). Despite numerous reports of its occurrence, information on its harmfulness remains limited. It is assumed that *Q. capitatus* can cause damage to melons, maize, wheat, and sorghum (Hussain *et al.* 2019; Gu *et al.* 2021). In Poland, the genus *Quinisulcius* is represented exclusively by *Q. capitatus* and this nematode is considered a rare species (Brzeski 1998). It was found in parsley-grown soil at a density of five individuals per 100 ml, occurring in 1% of 110 samples collected (Brzeski 1986). It was also found in samples from potato and tomato crops in central and southeastern Poland (unpublished data). Furthermore, *Q. capitatus* was detected in over 60% of samples collected as part of a study of soils intended for pepper cultivation and soil from the root zone of pepper plants showing symptoms of growth inhibition, all originating from an intensive pepper-growing area of Potworów (Mazowieckie Voivodeship). These observations prompted research aimed at assessing the suitability of pepper as a host plant for *Q. capitatus*. A morphological characterization was also performed, and genetic confirmation of the nematode's affiliation to the *Q. capitatus* species was obtained.

Materials and Methods

Field studies of *Q. capitatus* occurrence

Between 2017 and 2024, samples were collected from an intensively cultivated pepper plantation (*C. annuum*) in the Potworów area (Mazowieckie Voivodeship, Poland). Soil samples were collected for analysis from locations where pepper plants with wilting symptoms were observed. After thoroughly mixing the soil, 200 ml was separated and nematodes were collected using the centrifugal flotation method (Van Bezooijen 2006). Nematodes present in the samples were counted, and genera and species were identified using an OLYMPUS BX60 biological microscope. For each collected sample, the number of individuals of each genus of plant parasitic nematode present in a 100 ml soil sample was counted. The frequency of occurrence (FO%) of each genus was calculated using the formula: FO = (number of fields where a genus was detected/total number of fields sampled) × 100, and the prominence value (PV) was calculated using the formula: PV = population density × √absolute frequency of occurrence/10 (Kefelegn *et al.* 2024).

Morphological and Molecular Characterization of *Q. capitatus*

Nematodes were extracted from soil samples and were observed under a stereomicroscope for initial segregation. For genetic studies, ten female nematodes from each of the two populations were preserved in DESS (Yoder *et al.* 2006). For morphological and morphometric species identification, 30 female nematodes from each population were heat-killed at 60°C and fixed in TAF (Courtney *et al.* 1955). Fixed nematodes were transferred from TAF to glycerol using the Seinhorst method (Seinhorst 1959), and permanent microscopic slides were prepared using the paraffin-ring method. Morphological observations, morphometric measurements, and photographs were obtained using a Leica DM 5000 B biological microscope equipped with Nomarski differential interference contrast (DIC) optics (Leica Microsystems, Wetzlar, Germany). Images were processed with Leica Application Suite Version 3.7 software. Species identification was performed using the taxonomic key provided by Brzeski (1998).

For genetic species identification, female nematodes were removed from the DESS and washed successively in phosphate-buffered saline (PBS) and sterilized Milli-Q water to remove residual DESS. DNA was then isolated from individual specimens using lysis buffer (Holterman *et al.* 2006). The resulting lysate was immediately used for PCR or stored at -20°C. PCR reactions were performed in a Bio-Rad PTC Tempo Deepwell thermal cycler. Both PCR and sequencing were performed using primers D2A and D3B (Nunn 1992). Analysis and visualization of the PCR product (amplicon) were performed by agarose gel electrophoresis. Amplicons were visualized under UV light after staining the gel with SimplySafe reagent (EURx, Gdansk, Poland). Subsequently, 28S rDNA regions were sequenced using the Sanger method on an ABI 3500L genetic analyzer (Applied Biosystems, Foster City, CA, USA). The obtained 28S rDNA sequences were analyzed using BioEdit (Hall 1999). The obtained sequences were compared with sequences deposited in the National Center for Biotechnology Information (NCBI) using the Basic Local Alignment Search Tool (BLAST).

Changes in the abundance of *Q. capitatus* in soil with *C. annuum* cultivation - pilot experiment

Two morphologically and genetically characterized nematode populations were selected for the test, which aimed to assess the development of *Q. capitatus* on *C. annuum* plants. The study was conducted under controlled conditions (19 ± 1°C and a 16/8-hour day/night cycle). Pots (2.3 l) were filled with soil in which *Q. capitatus* naturally occurred at an initial density of 15 individuals (adults + juveniles) per 100 ml. Each pot was planted with one *C. annuum* pepper plant, cv. Ożarowska, at the 5–6 leaf stage (BBCH 15–16). The experiment utilized six replicates (six containers). Plants were watered and fertilized with a commercially available fertilizer intended for pepper cultivation, following the manufacturer's recommendations. After 90 days, plants were removed from each pot, the soil was mixed, and a 100 ml sample was collected from each replicate. Nematodes were isolated using the sugar flotation method (Hooper and Evans 1993) and counted using an OLYMPUS SZ-6045 stereoscopic microscope (Olympus, Japan) at 40× magnification. The roots of the pepper plants were assessed for nematode damage using the same OLYMPUS SZ-6045 microscope. Six pepper plants grown in pots in soil without nematodes served as controls. The effect of pepper plants on the development of the *Q. capitatus* population was determined by measuring the nematode population density in the soil before planting (initial population, Pi) and after the experiment (final population, Pf). RF factor was calculated.

Results

Field studies of *Q. capitatus* occurrence

Plant-parasitic nematodes belonging to 11 genera were isolated from all 26 samples collected from soil or from the root zone of pepper plants. The most abundant nematode encountered was the root-knot nematode *Meloidogyne hapla*, which was present in nearly 81% of the samples. Its average population density was 177 J2 (juveniles, second stage) per 100 ml of soil, with a PV of 256.50. Root-lesion nematodes of the genus *Pratylenchus* were present in 73% of the samples, with an average density of 12 individuals per 100 ml of soil (PV 16.54). Pin nematodes (*Paratylenchus*) and nematodes of the genus *Quinisulcius* were isolated from half of the analyzed samples, with average population densities of 12 and 55 individuals per 100 ml of soil, respectively, and PV values of 14.82 and 62.71, respectively. Spiral nematodes (*Helicotylenchus*) (19.23%), ring nematodes (*Mesocriconema*) (15.38%), *Tylenchorhynchus* and *Geocenamus* (11.54% combined) were also detected. Individuals of the genera *Bitylenchus*, *Ditylenchus*, and *Trichodorus* were isolated from a few samples (Table 1). Among the stunt nematodes, the most common species identified was *Q. capitatus*, which occurred in 62% of the samples. Less abundant were *Bitylenchus dubius*, *Geocenamus nothus*, *Tylenchus microphasmis*, *Tylenchorhynchus* spp., and *Geocenamus* / *Merlinius* spp., which were found in less than 10% of the samples (Table 2). The collected populations of *Quinisulcius capitatus* accounted for 2 to 91% of the total number of plant parasitic nematodes and 81 to 100% of the total number of stunt nematodes. Samples ranged from one to 263 individuals per 100 ml of soil. In the two samples where *Q. capitatus* was present, *B. dubius* also occurred, and its share in the total number of stunt nematodes was 9–10%. From two to six individuals of *B. dubius* were counted per 100 ml of soil. Individuals representing the remaining genera and species occurred alone in the samples. From a 100 ml soil sample, two individuals of *G. nothus*, 41 individuals of *T. microphasmis*, an average of five individuals of *Geocenamus*, and from 31 to 53 individuals of *Tylenchorhynchus* spp. were isolated.

Morphological and Molecular Characterization of *Q. capitatus*

Morphological and morphometric studies revealed that the nematode developing on pepper plants was *Q. capitatus*. Analysis of the morphometric characteristics of *Q. capitatus* females showed no significant difference from the original species description (Allen 1955) or from other studied populations of this nematode (Hopper 1959; Loof 1959; Knobloch and Laughlin 1973; Maqbool 1982; Vovlas 1983; Mekete *et al.* 2008; Iqbal *et al.* 2021; Munawar *et al.* 2021; Peraza-Padilla *et al.* 2024) (Table 3). Photographs of the body parts characteristic of *Q. capitatus* females were also taken (Fig. 1). Using BLAST, the obtained 28S rDNA sequences of *Q. capitatus* were compared with sequences deposited in the NCBI database. The analysis confirmed that the obtained sequences were identical to those from the NCBI database, thus verifying their identity as the species *Q. capitatus*.

Changes in the abundance of *Q. capitatus* in soil with *C. annuum* cultivation - pilot experiment

The experiment demonstrated that in the soil of 90-day-old *Capsicum annuum* plants, the population of *Q. capitatus* increased 23-fold relative initial pre-plant levels (Table 4). Both juveniles and adult females were isolated from the soil. Pepper plants grown in nematode-infected soil exhibited wilting symptoms, although no damage or root rot was detected. In contrast, control plants showed neither wilting nor growth inhibition.

Discussion

Field studies on the occurrence of nematodes in the rhizosphere of *C. annuum* revealed the presence of *Q. capitatus* in 50% of the collected samples. Despite its widespread distribution globally (Peraza-Padilla *et al.* 2024) and abundance in pepper crops in Uganda (Bafokuzara 1996), *Q. capitatus* has not yet been detected in pepper crops in Poland. Greco *et al.* (1992) demonstrated that *Q. capitatus* is a polyphagous ectoparasite of plant roots, with a host range including horticultural plants, grasses, and forest trees.

Examination of changes in the abundance of *Q. capitatus* in soil cultivated with *C. annuum* revealed a significant increase in nematode populations. Simultaneously, this nematode was observed to cause wilting of pepper plants, even though expected tissue damage was not visible on the plant roots. Studies by Singh *et al.* (2013) and Kefelegn *et al.* (2023) have shown that plant damage caused by this nematode is often difficult to detect, making it challenging to assess its impact on yields. Furthermore, by feeding directly on the plant root system, these nematodes damage root tissues, potentially facilitating the entry of other plant pathogens. Therefore, belowground interactions between nematodes and the rhizosphere microbiome must be considered as a possible variable in plant health.

These preliminary studies on the abundance of *Q. capitatus* were conducted using a sweet pepper cultivar widely available to commercial and amateur growers. The results, including the frequency of *Q. capitatus* in pepper-cultivated soil and its proportion within the total nematode count, provide a basis for further research into the impact of this species on pepper crops in Poland.

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Caption to Tables and Figures

Table 1. Prominence value (PV), mean population density in 100 ml of soil (MPD/100 ml soil) and frequency of occurrence (FO%) of plant parasitic nematodes in samples from soil with *Capsicum annuum* L. cultivation collected from 26 locations

Nematode genus	PV	MPD/100 ml soil	FO%
Bitylenchus	2.01	5	7.69
Ditylenchus	0.67	2	7.69
Geocenamus	2.19	5	11.54
Helicotylenchus	10.61	15	19.23
Meloidogyne hapla	256.50	177	80.77
Mesocriconema	6.01	10	15.38
Paratylenchus	14.82	13	50.00
Pratylenchus	16.54	12	73.08
Quinisulcius	62.71	55	50.00

Trichodorus	0.95	3	3.85
Tylenchorhynchus	23.00	42	11.54

Table 2. Prominence value (PV), mean population density in 100 ml of soil (MPD/100 ml soil) and frequency of occurrence of phytophagous nematodes (FO%), referred to as stunt nematodes in samples from soil with *Capsicum annuum* L. cultivation collected from 21 locations

Nematode genus/species	PV	MPD/100 ml soil	FO%
Bitylenchus dubius	2.01	5	9.5
Geocenamus nothus	0.63	2	4.8
Geocenamus spp.	2.24	5	9.5
Quinisulcius capitatus	62.71	55	62.0
T. microphasmis	12.97	41	4.8

Table 3. Morphometrics of females of *Quinisulcius capitatus*. Data are in a form mean ± SD (range). All abbreviations are used according to Brzeski (1998)

Characters	Present study	Allen 1955[a]	Hopper 1959	Loof 1959	Siddiqi 1961	Knobloch and Laughlin 1973	Maqbool 1982	Vovlas 1983	Mekete *et al.* 2008	Munawar *et al.* 2021	Peraza-Padilla *et al.* 2024	Peraza-Padilla *et al.* 2024	Peraza-Padilla *et al.* 2024
Origin	Poland	USA	USA	Italy	India	Mexico	Pakistan	Italy	Ethiopia	Canada	Costa Rica Santa Bárbara	Costa Rica Barva,	Costa Rica Vázquez de Coronado,
Host	Pepper	Pear	Okra	Date palm	Grass, lily	Grass, wild poppy, barrel cactus, cotton	Potato	Maize	Coffee	Grass	Tomato	Tomato	Bean
n	30	13	5	14	8	–	5	25	10	20	11	11	11
Body length	817.9 ± 33.6 (748.5–881.4)	630–850	650–710	631–830	700–810	520–630	610–730	641–730	630–790	810.3 ±44.6 (744.0–911.0)	722.0 ± 54.7 (664.6–818.5)	768.6 ± 55.8 (649.5–875.7)	733.2 ± 55.6 (661.7–808.5)
a	33.2 ± 1.0 (31.4–35.0)	30–38	30.2–36.2	31–37.6	30–35	29–33	30–33	31–35	30.9–38.6	41.4±1.8 (38.6–43.7)	28.9 ± 1.4 (26.5–31.3)	30.5 ± 1.6 (27.6–33.0)	28.8 ± 0.9 (27.7–30.1)
b	5.6 ± 0.2 (5.2–5.9)	5.0–5.8	4.6–4.9	4.7–5.5	4.5–5.5	4.4–5.3	6.8–7.4	4.1–5.3	–	5.5 ± 0.3 (5.0–6.3)	5.1 ± 0.3 (4.8–5.7)	5.0 ± 0.2 (4.6–5.3)	4.9 ± 0.2 (4.7–5.4)
c	15.7 ± 0.7 (14.4-17.0)	12–17	14.5–16.1	14.3–17.4	15–17	15–17	3.8–4.9	13–16	15.3–17.6	22.4±1.1 (19.9-23.8)	15.0 ± 1.0 (13.9–16.7)	14.6 ± 1.3 (13.2–17.3)	15.5 ± 0.6 (14.6–16.6)
c′	2.9 ± 0.2 (2.6–3.3)	–	–	–	–	–	–	2.8–3.2		2.6 ±0.2 (2.2–3.2)	2.8 ± 0.1 (2.6–2.9)	3.0 ± 0.3 (2.4–3.3)	2.8 ± 0.1 (2.5–3.0)
V	55.2 ± 0.7 (53.9–56.6)	51–58	55.2–56.9	53.5–58	54–56.5	52–59	53–56	54–57	54.7–63.6	57.4±1.5 (53.4–59.8)	56.4 ± 0.8 (55.0–57.6)	56.0 ± 1.7 (52.7–58.6)	56.4 ± 1.5 (54.6–59.9)
MB	54.8 ± 1.6 (51.5–57.8)	–	–	–	–	–	–	57–60	–	52.3 ± 1.7 (47.4–56.1)	–	–	–
Lip height	5.2 ± 0.5 (4.2–6.0)	–	–	–	–	–	–	–	–	4.0 ± 0.2 (3.7–4.4)	4.7 ± 0.5 (3.9–5.6)	8.2 ± 0.5 (7.1–8.8)	3.4 ± 0.3 (2.9–4.1)
Lip width	8.2 ± 0.3 (7.7–8.9)	–	–	–	–	–	–	–	–	7.6 ±0.4 (6.9–8.3)	8.4 ± 0.5 (7.3–9.3)	8.2 ± 0.5 (7.1–8.8)	8.5 ± 0.4 (8.0–9.4)
Stylet length	17.5 ± 0.4 (16.8–18.4)	16–18	16.5–17.3	16–18	16–17	16–17	18.4–19.5	15–17	15–18	18.3 ±1.0 (15.5–20.4)	15.8 ± 0.8 (14.8–17.0)	15.8 ± 0.9 (14.2–16.9)	15.0 ± 0.8 (13.7–16.2)
Median bulb length	16.2 ± 0.6 (15.1–17.5)	–	–	–	–	–	–	–	–	14.0 ± 1.6 (11.3-16.9)	15.9 ± 1.2 (14.4–18.1)	16.7 ± 1.1 (15.0–18.5)	16.3 ± 1.0 (14.5–18.3)
Median bulb width	11.5 ± 0.5 (9.5–12.3)	–	–	–	–	–	–	–	–	10.4 ± 1.4 (8.4–14.2)	12.7 ± 1.0 (11.3–14.1)	12.8 ± 0.9 (11.0–13.9)	12.2 ± 0.9 (11.4–14.2)
Anterior end to excretory pore	130.7 ± 4.3 (121.9–142.8)	–	–	–	–	–	–	119–128	121	128.6±5.3 (121.0–139.0)	116.4 ± 10.7 (97.8–131.1)	122.8 ± 6.9 (107.9–133.2)	120.6 ± 5.7 (112.6–129.9)
Pharynx length	145.6 ± 4.7 (138.9–160.1)	–	–	–	–	–	–	–	–	147.8±5.8 (140.2–159.0)	143.3 ± 15.3 (120.2–169.4)	155.0 ± 10.1 (134.3–65.7)	149.2 ± 7.2 (141.1–163.0)
Maxim body width	24.6 ± 0.8 (23.1-25.9)	–	–	–	–	–	–	–	–	19.0 ± 1.5 (16.9–21.3)	25.0 ± 1.9 (22.1–27.4)	25.2 ± 1.3 (23.5–27.8)	25.4 ± 2.0 (22.5–28.4)
Vulva body width	23.5 ± 1.0 (21.2–25.1)	–	–	–	–	–	–	–	–	18.4 ±1.3 (15.7–20.8)	24.2 ± 1.8 (21.5–26.8)	25.1 ± 1.4 (22.4–27.1)	23.9 ± 1.3 (21.7–25.7)
Anal body width	17.7 ± 0.7 (15.9–18.9)	–	–	–	–	–	–	–	–	13.8 ±1.1 (11.2–15.2)	17.1 ± 1.1 (15.9–19.4)	17.4 ± 0.8 (16.4–18.8)	16.9 ± 1.2 (14.6–18.9)
Tail length	52.2 ± 2.7 (46.9–57.2)	–	–	–	–	–	–	40–48	–	35.8 ± 2.4 (31.3–40.4)	48.3 ± 3.0 (45.7–56.5)	53.1 ± 6.0 (42.4–60.1)	47.3 ± 2.9 (42.9–51.3)
Phasmid position	Middle of tail	Middle of tail	Middle of tail	Anterior to middle of tail	Anterior to middle of tail	Anterior to middle of tail	Anterior to middle of tail	Anterior to middle of tail	–	Middle of tail	Anterior to middle of tail	Anterior to middle of tail	Anterior to middle of tail

Table 4. Effect of pepper (*Capsicum annuum*) cultivation on population density of *Quinisulcius capitatus*

Replicate	Pi (Initial population density per pot)	Pf (Final population density per pot)	RF Reproduction factor
1	299	8899	25.8
2	401	7198	20.9
3	345	5987	17.4
4	499	7321	21.2
5	345	9844	28.5
6	299	8211	23.8
Mean	299	7910	22.9
Control*	0	0	0

*Mean of six replicates

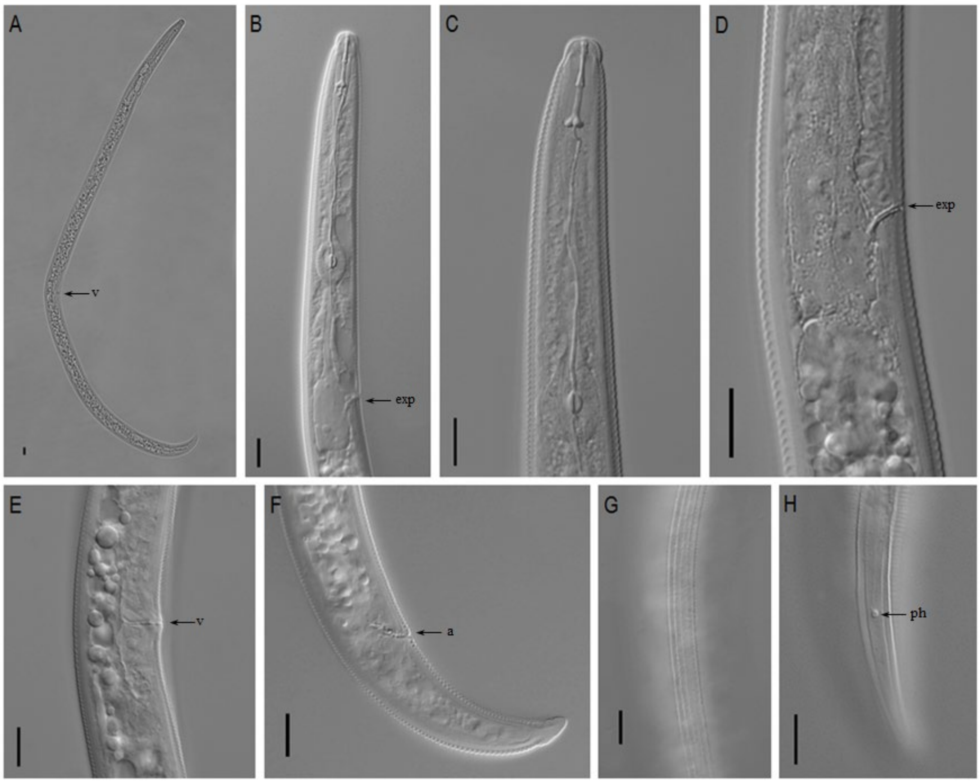

Fig 1. Light photomicrographs *Quinisulcius capitatus.* (A) Entire female, (B) Esophageal region, (C) Lip region, (D) Basal esophageal bulb, (E) Vulval region, (F, H) Female tail, (G) Lateral lines. Scale bars for all photomicrographs: 10 μm. Arrows point to (a) anus, (exp) excretory pore, (ph) phasmid, and (v) vulva