Meloidogyne artiellia

Scientific Name
Meloidogyne artiellia Franklin

Synonyms:
None

Common Name(s)
British root-knot nematode, cereal and legume root-knot nematode

Type of Pest
Nematode

Taxonomic Position
Class: Secernentea, **Order:** Tylenchida, **Family:** Heteroderidae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2009 & 2010

Pest Description (see Figure 1)

From Franklin (1961, 1978):
Eggs: (n=20), length 75-111 µm; breadth 34-43 µm.

Juveniles: (n=10-20), body length 301-370 µm; body breadth 10-16 µm; tail length 18-26 µm; stylet length 14-16 µm. The most striking feature of the larvae is the short tail with rounded tip. It is about 24.5 µm long, and two and one half times as long as the body diameter at the anus.

Females: (n=8-10 specimens), length 650-760 µm; width 340-460 µm; stylet 12-16 µm; vulva 15-22 µm.

Body swollen, pear- or flask-shaped, tapering gradually anteriorly to a small head; smooth, rounded posteriorly, with terminal vulva. Annules visible in neck region and around tail. The broad “neck” narrows abruptly at the head which is 4-5 µm across. In face view, there appear to be six almost equal lips, and a small labial cap around the mouth aperture. The amphids open as short slits on the inner edge of the lateral lips. Each of the four sub-lateral lips has a small papilla, but none was visible on the lateral lips. Optical sections show a delicate, six-radiate skeletal structure around the anterior end of the stylet, but it disappears below the level of the lips. Dorsal views of the head show a constriction on the lateral lips about one-third behind the anterior edge. These lips could, therefore, be described as consisting of two unequal annules. The excretory pore lies ventrally one or two stylet lengths behind the head. The cuticular (perineal) pattern around the vulva and anus is characteristic. It is formed of striae and ridges of

the cuticle, the latter being more pronounced nearer the vulva an anus. In general outline, the pattern is roughly that of a figure eight, the upper, smaller area enclosing the phasmids which are usually quite distinct, the anus situated at the center and the vulva occupying the diameter of the lower, larger part of the pattern. At the top of the arch, which is morphologically the dorsal part of the tail, the pattern is usually angular. Cuticular folds curve towards the anus from each side but leave a smooth unpatterned area around the vulva. The vulva is further from the anus in relation to the tail length than in most other species of the genus. The distance from the anus to vulva is about three times that from the anus to a line joining the phasmids. The exact position of the tail tip is difficult to determine because the lateral lines are marked only by the position of the phasmids and by slight irregularities in the striae.

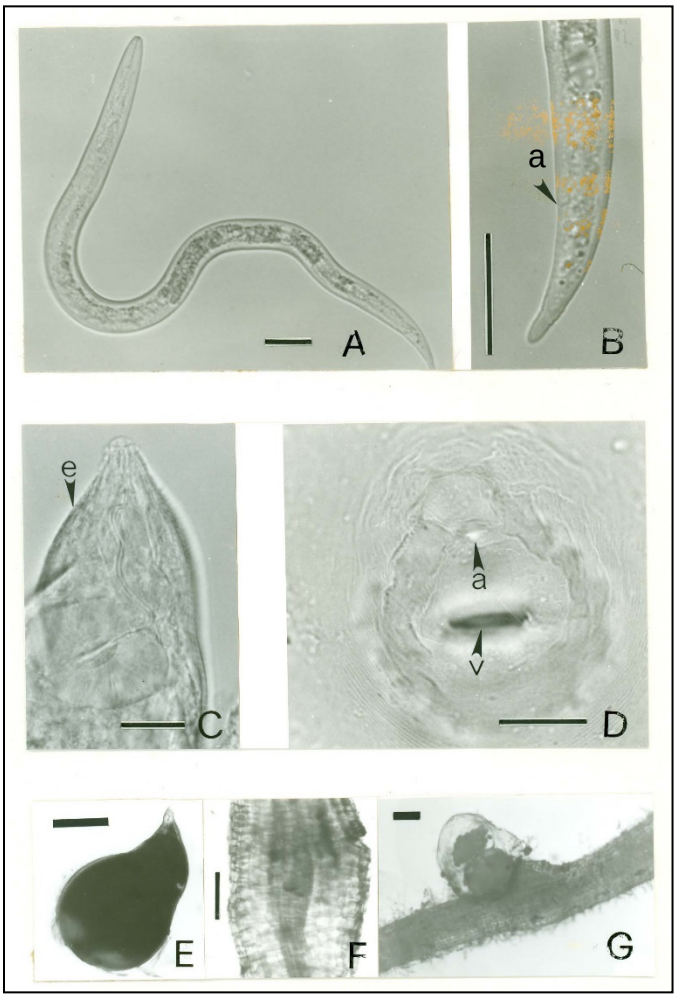

Figure 1. Photomicrograph of *M. artiellia* life stages. Scale bars = 20 µm in A-D and 200 µm in E-G. A) entire body of second-stage juvenile (J2); B) posterior body portion of J2, a=anus; C) anterior body portion of swollen female, e=excretory pore; D) perineal pattern showing the eight-shaped inner area marked by coarse lines and containing vulva (v) and anus (a), Note the fine striae and continuous striae surrounding the inner area; E) entire body of swollen female; F) slight swelling induced by J2 on chickpea root; G) large egg mass covering a swollen female, which protrudes with its posterior portion of the body from the surface of a chickpea root. All photos courtesy of R.N. Inserra.

Males: (n=7-15), length 0.82-1.37 µm; width 23-36 µm; stylet 17-27 µm; a=31-40; *b=10-15; c=60-100, where a=length/greater diameter; b=length/distance from head end to end of oesophagus; c=length/length of tail (anus to tip)] *Measurements for b were made from the anterior end to the posterior edge of the oesophageal bulb, as the end of the glandular region overlaps the intestine and is difficult to define.

Body annulated, annules about 1.5 µm wide. Lateral fields with four incisures at the tail, but along the greater part of their length a fifth incisure is present in the center of

each field. The lateral fields continue round the tail which is twisted through about 90º. Phasmids small, approximately adanal. Head with labial cap and six nearly equal lips. Face views show the slit-like amphid openings on the lateral lips; papillae not seen, nor was the stellate skeletal structure, such as that in the female. In dorso-ventral view a constriction is seen on the lateral lips about one-third from the front. A tubular guide surrounds the anterior end of the stylet which has well-developed, rounded, basal knobs. Pro-corpus narrow, two to three body-widths long, followed by a spindle-shaped muscular corpus about twice as long as wide. The oesophageal glands stretch for about three body-widths ventro-laterally along the intestine. Nerve ring one bulb-length behind muscular bulb. Two body-widths behind the oesophageal bulb is a conspicuous hemizonid and immediately behind it is the excretory pore with its duct running back for a short distance. Spicules typical for the genus, curved with anterior thicker part and tapering posteriorly to a point. A small gubernaculum, about one-third the length of the spicules, lies dorsally in the cloaca wall. Tail very slightly longer than the anal body diameter.

Biology and Ecology

Di Vito and Greco (1988a) have investigated the biology of *M. artiellia* on chickpea under Mediterranean climate conditions using growth chamber and microplot studies. Like several nematodes, *M. artiellia* is adapted to cool and dry conditions and has the ability to enter into an inactive, quiescent state to survive environmental stresses (Jensen, 1972). In climates with cool, wet winters and warm, dry summers, *M. artiellia* is active during spring and winter months and inactive from late spring through summer. Typically one generation is completed under non-irrigated conditions.

Development time depends on temperature. Temperatures of 10ºC and 30ºC have been reported as unfavorable for root penetration, development and egg production, while temperatures in the 15-25ºC range are considered optimal. *M. artiellia* has a reported threshold temperature of 10ºC.

This species reproduces asexually, but has the ability to produce sexually when conditions are appropriate (DeGiorgi et al., 2002). Adults have reportedly occurred 14-18 days following root penetration at optimal temperatures between 15-25ºC. Females develop after 230-240 degree days over 10ºC. Females swell, producing large gelatinous egg masses or sacs, containing between 500-1000 eggs. The egg sac is deposited on either galled root surfaces or inside root galls (Hussey, 1985).

Egg hatch may or may not involve stimulation from the host root (Hussey, 1985). Hatching can occur for an extended period at temperatures between 5-10ºC. Hatch is most rapid at temperatures between 15-25ºC. Eggs will not hatch under extended dry periods but may persist in soil or dry roots awaiting more favorable moist soil conditions. Emergence occurs under moist soil conditions; juveniles may become inactive under dry conditions.

Meloidogyne larvae and eggs can be easily distributed by irrigation ditches, and in areas of saturated soil, larvae may survive under water for up to three weeks (Milne,

1972). *M. artiellia* can also reportedly survive in “fallow” fields for 1-2 years (Jensen, 1972).

There are four juvenile stages. The first stage occurs inside the egg. Following a molt and emergence, second stage juveniles move out of the egg and invade the host plant roots (Hussey, 1985). The second is the only stage when juveniles are mobile and are thought to be attracted to host plant roots (Hussey, 1985). They may feed singly or in a group.

If a larva cannot find a suitable feeding site on a host, it will continue searching until its energy is depleted. When a suitable site is selected, the larva will penetrate the root, usually near or behind the root cap, at lateral root initials or in galled root tissue near an embedded adult female. The site where one juvenile enters the root may attract others (Hussey, 1985). The juvenile moves through the root to the region of cell differentiation, settles, and becomes inactive while feeding.

Feeding induces cells in the primary phloem or parenchyma to swell and form “giant” or “nurse” cells on which juveniles feed until development is complete (Hussey, 1985) (Fig. 2). If the plant does not form giant cells as the nematode attempts to establish a feeding site, the larva may not complete its development and leave in search of another root, or die of starvation in the process (Jensen, 1972; Hussey 1985). When giant cell formation occurs, tissues surrounding the feeding nematode begin transforming at approximately the same time, producing a gall within 1-2 days following root penetration (Hussey, 1985).

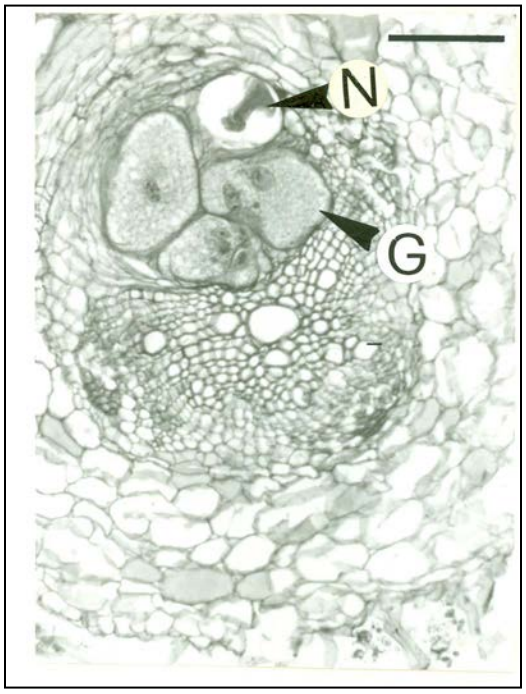

Figure 2. Cross section of a chickpea root infected by *M. artiellia*. Scale bar = 70 µm. Note: the specialized giant cells (G) which provide nutrients to the nematode (N).

A female larva will swell as it feeds until development is completed. Total development time varies from approximately 20 days at 25ºC to 55 days at 10ºC. Following chickpea root penetration, third and fourth stage juveniles have been observed 3-5 and 10-12 days, respectively, at 15-25ºC (Di Vito and Greco, 1988a).

Symptoms/Signs

Damage to host plants caused by root-knot nematodes involves impaired root growth (e.g., small gall formation (Fig. 3), proliferation of lateral roots, or stimulation of giant cell growth at feeding sites in parenchyma and phloem) and impaired root function (contributing to chlorosis, stunted growth (Fig. 3), nutrient deficiencies, and/or necrosis of above-ground plant parts). Symptoms of nematode damage may be similar to those caused by nutrient or water deficiency.

Nematode infestation of plant roots limits water uptake. Infested plants may appear wilted under hot and sunny conditions, even with ample soil moisture. Symptoms may not be apparent until plants reach later stages of growth.

Injured root tissue is susceptible to other disease-causing pathogens. Much of the visible damage to plant hosts is likely caused by a combination of biotic and abiotic factors (Davis and Venette, 2004).

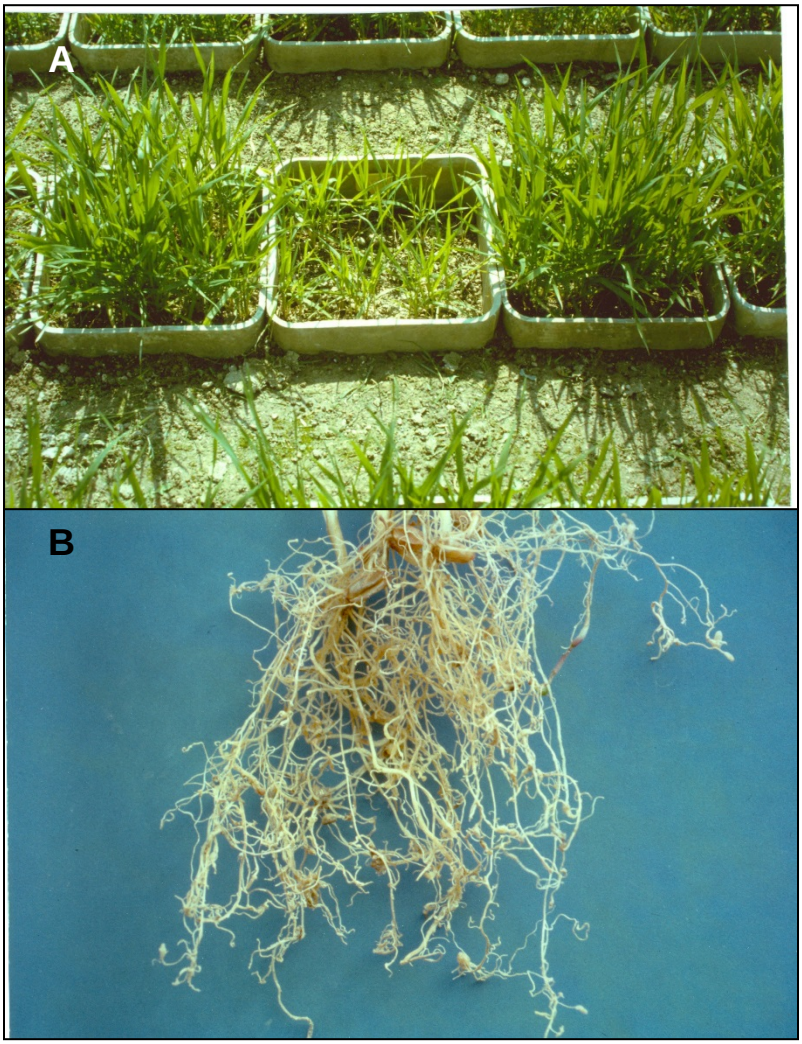

Figure 3. A) Stunted hard wheat plants in a microplot heavily infested by *M. artiellia* (center) compared to healthy plants in a non-infested control plot (right) and a plot slightly infested with the nematode (left). B) Hard wheat roots infected by *M. artiellia*. Note: the small galls and root proliferation induced by the nematode infection. All photos courtesy of R.N. Inserra.

In wheat, spikes are sparse and reduced in size. Root galls induced by *M. artiellia* are very small and often are covered by large egg masses that represent the only visible signs of the nematode infection (Greco et al., 1992).

Pest Importance

M. artiellia has been reported as a damaging pest of cereals and leguminous crops in European and Middle Eastern countries. Consistent damage on chickpea has been observed in fields after rotation with wheat. Damage to wheat has been reported in Mediterranean countries where wheat is continuously grown (Di Vito and Greco, 1988a). Microplot studies indicate that this nematode may reduce yields by 80% in chickpea and wheat (Di Vito and Greco, 1988b).

Known Hosts

Investigations on the host range of this root-knot nematode indicated that *M. artiellia* reproduces well on cereals, cruciferae, and leguminosae.

Apium graveolens (celery), *Artemisia* spp. (sagebrush), *Avena sativa* (oat), *Beta vulgaris* ssp. *vulgaris* (mangel), *Brassica napus* var. *napobrassica* (rutabaga), *Brassica oleracea* (cabbage, broccoli, kale), *Brassica rapa* (turnip), *Brassica* spp., *Cicer arientinum* (chickpea), *Hedysarum coronarium* (sulla), *Hordeum vulgare* (barley), *Lathyrus cicera* (lesser pea), *Lathyrus sativus* (grass pea), *Lens* spp. (lentils), *Medicago sativ*a (alfalfa), *Medicago* spp. (medic), *Nasturtium fontanum* (rashad), *Phaseolus vulgaris* (bean), *Pisum sativum* (pea), *Raphanus sativus* (radish), *Sorghum vulgare* (sorghum), *Trifolium incarnatum* (crimsom clover), *Trifolium pretense* (red clover), *Trifolium repens* (white clover), *Triticum aestivum* (wheat), *Triticum durum* (durum wheat), *Triticum* spp. (wheat), *Triticum vulgare* (common wheat), *Vicia faba* (broad bean), *Vicia monantha* (garden vetch), *Vicia sativa* (vetch), and *Vicia* spp. (vetch) (CABI, 2007; Davis and Venette, 2004).

Known Vectors (or associated organisms)

In two genotypes of chickpea with complete resistance to *Fusarium* wilt, infection by *M. artiellia* overcame the resistance to *Fusarium oxysporum* f. sp. *ciceri* race 5 (Castillo et al., 2003).

Known Distribution

The British root-knot nematode occurs in northern Europe, the Mediterranean, North Africa, the Middle East, Russia, and China.

Africa: Algeria, Morocco, and Tunisia. **Asia:** China, Israel, Russia, Syria, and Turkey. **Europe:** United Kingdom, France, Greece, Italy, and Spain.

Potential Distribution Within the United States

As with other plant pests occurring in the Middle East, there is risk of introducing *M. artiellia* into the United States because of the intensification in the movement of machinery and personnel between the United States and Middle Eastern (Greco et al., 1992).

Little information is currently available on the potential distribution within the United States, but areas that plant mustard crops, legumes, and small grains are at risk from introductions. A recent risk analysis by USDA-APHIS-PPQ-CPHST, portions of Arkansas, California, Colorado, Idaho, Illinois, Kansas, Maryland, Michigan, Missouri Montana, Nebraska, North Dakota, Oklahoma, Ohio, Oregon, South Dakota, Texas, and Washington where small grains are grown are at a moderate risk of nematode establishment based on host availability.

Survey

CAPS-Approved Method: Use either soil sampling or collection of host roots or of a combination of both methods.

Soil sample: send sample to nematology diagnostic lab where nematodes will be extracted from the soil and identified.

Collect host roots: collect abnormally swollen roots and send to a nematology diagnostic lab where damage and galled roots will be assessed.

Literature-Based Methods:

Leguminous crops (clover and vetch) and crucifers (cabbage, cauliflower, radish, and turnip) are checked during cool months for patches of stunted plants with chlorotic leaves or other nutrient deficiency symptoms. Soil and roots from these plants are collected and the roots examined with the aid of a stereomicroscope for the presence of galls and nematode egg masses adhering to the small galls. Note: The standard procedure of egg mass staining with ploxine B cannot be used for *M. artiellia* detection because the egg masses of this nematode do not retain the stain (Greco et al., 1992).

Vovlas and Inserra (1996) outline general considerations for conducting a survey for a new *Meloidogyne* spp. in citrus orchards. In general, they recommend sampling root tissues to inspect for the presence of galled roots. They also note that soil samples may detect *Meloidogyne* spp., but these individuals may not be of particular concern. Many native or naturalized *Meloidogyne* spp. parasitize a number of weed hosts. Thus, careful examination of individuals will be necessary to confirm species identity. Samples of soil or host roots must be collected with the purpose of obtaining males, juveniles, or nematodes within root tissues. Samples must then be processed to separate nematodes from soil and debris. Finally, nematodes must be prepared either for identification using morphological (e.g., perineal patterns) or molecular techniques.

Root-knot nematodes are extracted from soil using a variety of techniques. Six methods (and subtle variations thereof) are particularly common: Baermann trays; Baermann trays with elutriation or sieving; centrifugal flotation; flotation-sieving; semiautomatic elutriation; and Cobb's decanting and sieving. These methods are described in detail by Barker (1985). The efficiency of the nematode extraction is influenced by the amount of soil that is processed at one time. Extraction efficiencies are greatest when 100 g to 450 g of soil are processed. Extraction efficiencies for *Meloidogyne* spp. are frequently low and can vary between 13 and 45% (Davis and Venette, 2004).

Key Diagnostics

CAPS-Approved Method:

1. Assessment of root galls will indicate a possible root knot nematode infection.

2. Morphological: The length of at least 20 second-stage juveniles, the head and stylet morphology of males, and the nature perineal patterns of females from samples.

Literature-Based Method:

M. artiellia may occur in mixed populations with closely related or other easily confused species. Swollen females and egg masses of *M. artiellia* are distinctly large but can be easily confused with other root-knot nematodes without close examination using magnification. Due to technological advances in identification techniques, differentiating among morphologically similar root-knot nematodes can be accomplished by restriction fragment length polymorphism (PCR-RFLP) of ribosomal DNA (DeGiorgi et al, 1991, 1994, 2002; Davis and Venette, 2004).

Easily Confused Pests

Meloidogyne artiellia can be confused with other root-knot nematodes. *Meloidogyne artiellia* can be easily distinguished morphologically from other root-knot nematodes reported in the United States as follows: *M. artiellia* second-stage juveniles (J2s) have tail 18-26 µm long, whereas the J2 of *M. acrita*, *M. arenaria, M. christiei*, *M. cruciana*, *M. megatyla*, *M. hapla*, *M. incognita*, *M. graminis*, *M. javanica*, *M. querciana*, and *M. thamesi* have tail length of >30 µm. Body length parameters of *M. artiellia* J3 range 300-370 µm and overlap with those of *M. acrita* (345-396 µm), *M. incognita* (360-393 µm), and *M. javanica* (340-400 µm), but they are smaller than those (>370 µm) of other root knot nematodes reported in the United States (Greco et al., 1999). Female *M. artiellia* also have a cuticular perineal pattern with a very distinct inner area containing the vulva and anus. This area is marked by a few coarse striae in an eight-shaped figure with a large base and a small top.

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