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A British Root-knot Nematode, *Meloidogyne artiellia* n.sp.

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Roots of oats grown on sandy loam in Norfolk were observed by E. B. Brown of the National Agricultural Advisory Service, Cambridge, to have small galls associated with proliferation of the lateral roots. Close examination showed the presence of female *Meloidogyne* in the galls. The nematodes differed in some respects from the generally-known species and specimens were sent to the author for study.

Tests by Brown showed the following plants to be hosts : Kale (*Brassica oleracea* v. *acephala*), swede (*B. napus* v. *napobrassica*), pea (*Pisum sativum*), bean (*Vicia faba*), clover (*Trifolium pratense*), lucerne (*Medicago sativa*) : oats, wheat and barley were lightly infested. I have found cabbage (*Brassica oleracea* v. *capitata*), Brussels sprouts (*B. oleracea* v. *gemmifera*) and *Medicago lupulina* to be infested. In the last plant mature females were seen in the bacterial nodules. Brown found no infestation on grasses, carrots, sugar beet, tomato, onion, strawberry, lettuce, potato, sainfoin and rye. Dwarf bean (*Phaseolus vulgaris*) was immune when tested by me.

In January, 1958, kale growing in a different field on the same farm was found by Brown with the same *Meloidogyne* in the roots. The very small galls each had a single flask-shaped female partly embedded in the tissue and enveloped in a gelatinous egg sac (Fig. 1A).

From the roots of cabbages grown in soil from the infested area specimens of all stages of the nematode were obtained. The differences in the posterior cuticular pattern of the females, as well as in other characters, appear sufficient to separate this population from all the previously described species and it is here described as *Meloidogyne artiellia* n.sp.

The nematodes were fixed in the roots by immersion in hot cotton blue lactophenol and measurements were made on specimens mounted in the same medium and drawn under the camera lucida, unless otherwise stated.

MATURE FEMALE

Length : 0·7 mm. (0·76—0·65 mm.) (n=8)
Breadth : 0·4 mm. (0·46—0·34 mm.) (n=8)
Stylet : 14μ (12—16μ) (n=10)

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.

As seen in Fig. 1A, the females that develop in brassica roots are usually only partly embedded in the small galls. The exposed part of the body is completely enveloped by the gelatinous material into which the eggs are laid ; this condition, which occurs in young females even before eggs are produced, is useful in distinguishing this *Meloidogyne* from young females of *Heterodera cruciferae*, which may be found side by side on the same roots. Young *Heterodera* females have a small gelatinous egg sack which enlarges as the eggs are laid and is therefore always well filled with eggs. *Heterodera* can also be distinguished by its small vulval cone, while in *Meloidogyne* the vulva is not prominent. Brown has found specimens of the two genera on the same oat plant, the cyst-forming species in this case being *H. major* (=*avenae*).

The broad "neck" narrows abruptly at the head which is 4–5μ 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 (Fig. 1C). 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 (Fig. 1D). 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 (Fig. 1E). The excretory pore lies ventrally one or two stylet lengths behind the head.

The stylet is very slender and may be slightly curved ; it has well developed rounded knobs, somewhat triangular in side view. The duct of the dorsal oesophageal gland opens into the lumen of the oesophagus 4–7μ behind the stylet base. The swollen pro-corpus is constricted at its junction with the large, muscular corpus (Fig.1F). The lobes of the oesophageal gland overlie the intestine latero-ventrally. The two ovaries are coiled around the swollen intestine, often extending into the neck, and the oocytes are in several rows. The six rectal glands described by Maggenti and Allen (1960) are visible in young females viewed from the caudal end.

The cuticular pattern round the vulva and anus is characteristic

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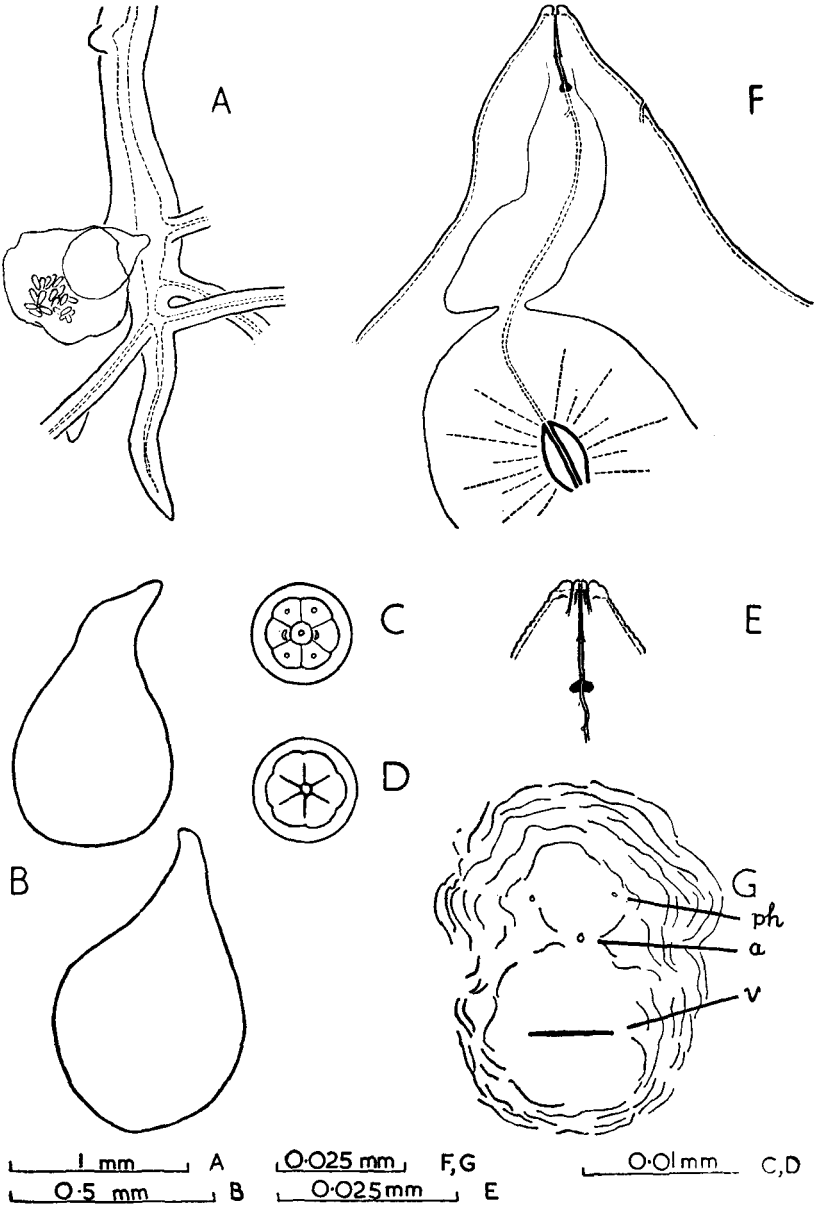

Fig. 1.—*Meloidogyne artiellia* n.sp. female

A.—Cabbage root with mature female. B.—Shape of females. C.—Head in face view. D.—Head skeleton. E.—Dorsoventral view of head. F.—Oesophageal region. G.—Posterior cuticular pattern.

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(Fig. 1G and Plate I). It is formed of striae and ridges of the cuticle, the latter being more pronounced nearer the vulva and 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 centre 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 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. The vulva is 15–22μ wide, with a mean for ten specimens of 17·5μ. In all but two of the specimens measured, the vulva is slightly wider than the distance apart of the phasmids.

EGGS

95μ × 37μ (75–111μ × 34–43μ) (n=20)

MALE

Length 1·07 mm. (0·82–1·37) (n=15)
Breadth 29μ (23–36μ) (n=15)
a=35 (31–40)
*b 12·8 (10–15) (n=14)
c=83 (60–100) (n=10)
Testis 60% (45–76%) (n=15), occasionally reflexed
Spicules 27μ (25–30μ) (n=12)
Gubernaculum 8μ (6–9μ) (n=10)
Stylet 19μ (17–27μ) (n=7)

Body annulated, annules about 1·5μ wide. Lateral fields with four incisures at the tail, but along the greater part of their length a fifth incisure is present in the centre of each field (Fig. 2B). The lateral fields continue round the tail which is twisted through about 90° (Fig. 2C). Phasmids small, approximately adanal.

Head with labial cap and six nearly equal lips. Face view shows the slit-like amphid openings on the lateral lips; papillae not seen, nor was a 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 (Figs. 2D & E). A tubular guide surrounds

* Measurements for the ratio b (total length divided by length of the oesophagus) 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.

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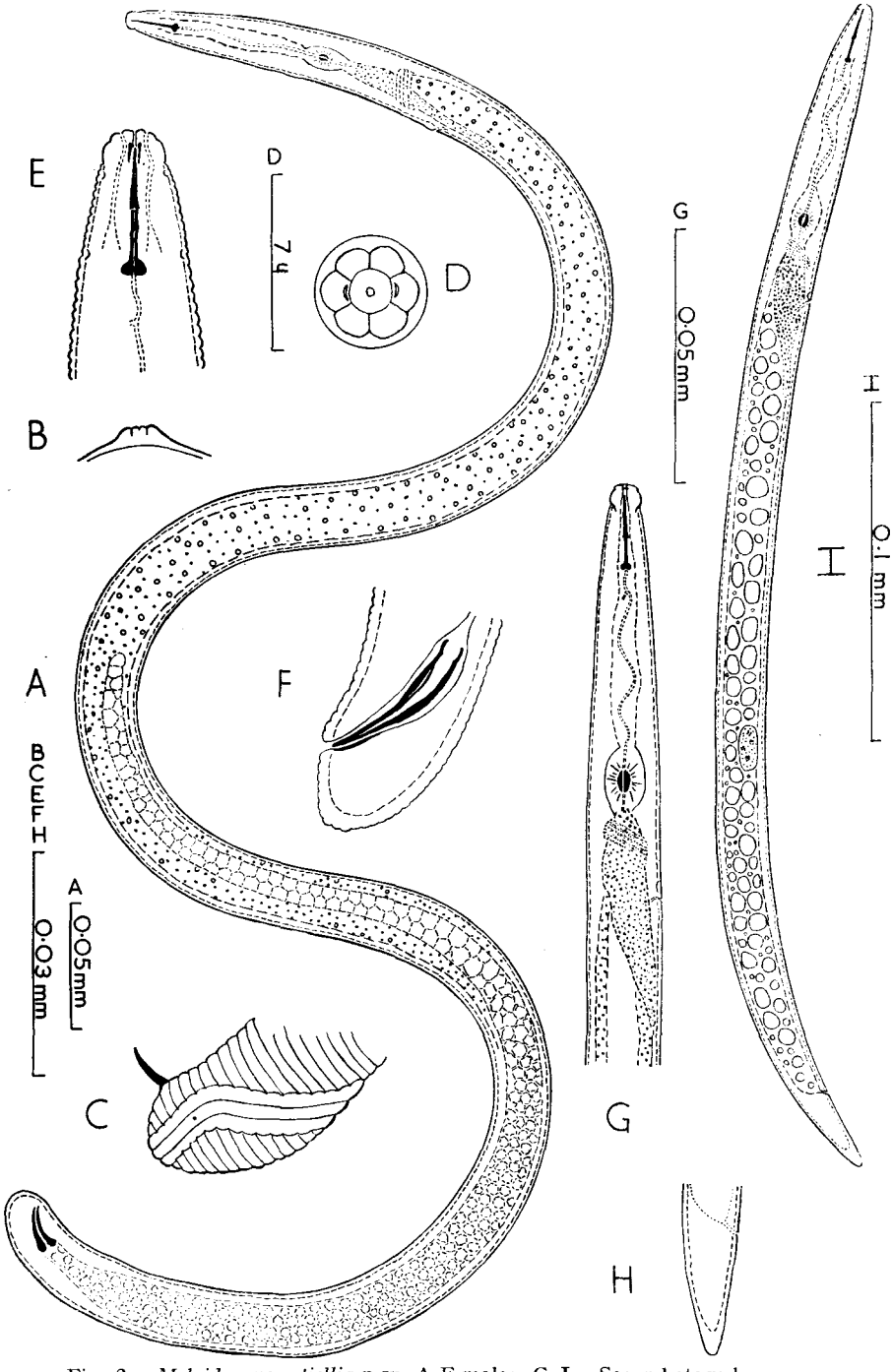

Fig. 2.—*Meloidogyne artiellia* n.sp. A-F male: G–I.—Second stage larva.
A.—Whole male. B.—Transverse section of lateral field. C.—Tail surface.
D.—Face view of head. E.—Dorsoventral view of head. F.—Spicules.
G.—Oesophageal region. H.—Tail. I.—Whole larva.

the anterior end of the stylet which has well-developed, rounded, basal knobs. The duct of the dorsal oesophageal gland opens into the lumen of the oesophagus 5–7μ behind the stylet. Posterior cephalids (Hirschmann, 1959) are situated at about the level of the anterior edge of the stylet knobs ; at this point the body narrows perceptibly forming a neck-like region. Anterior cephalids are just discernible immediately behind the head constriction (Fig. 2E).

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 (Fig. 2A).

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 (Fig. 2F).

Testis about two thirds of the body length and sometimes reflexed anteriorly. Of about twenty specimens only one had two testes. There was nothing to indicate whether any correlation existed between number of testes and nutrition of the nematode during development, as shown by Triantaphyllou (1959) to be the case in *M. incognita.*

LARVA

Length 354μ (334–370μ) ($n=20$)
Breadth 15·4μ (10–16μ) ($n=20$)
a 23·5 (22–25·5) ($n=20$)
**b* 5·9 (5·4–7) ($n=20$)
c 14·3 (13–16) ($n=11$)
Stylet 14·7μ (14–16μ) ($n=10$)

The above measurements were made on larvae (presumed to be second-stage) hatched from egg masses in water, fixed in T.A.F. and transferred to warm cotton blue lactophenol, in which they were mounted. The most striking feature of the larvae is the short tail with rounded tip. It is about 24·5μ long, and two and one half times as long as the body diameter at the anus (Fig. 2H). Body finely annulated with lateral fields about one third of the body width wide and marked by four longitudinal incisures for most of their length. At the level of the oesophageal bulb the two inner incisures merge and

* Measurements for the ratio *b* (total length divided by length of the oesophagus) 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.

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disappear leaving the outer two which coincide and disappear close behind the stylet. On the tail the lateral fields narrow gradually behind the anus and disappear close to the tip. Phasmids small, situated at about one third of the distance between anus and tail tip. No deirids observed.

The head has a shallow cap and in lateral view no annules are visible on the lips.

Stylet unusually long and very slender. Duct of dorsal oesophageal gland opening 3·7μ (2·5–4·5μ, $n=10$) behind stylet knobs, which are rounded, triangular as in the female.

Procorpus narrow, leading to well-developed muscular bulb with the usual three valve plates in the centre. Bulb followed by a narrow isthmus about one body-width long which broadens into the intestine. Nerve ring encircles isthmus about one bulb-length behind muscular bulb and just in front of the hemizonid. The glandular lobes lie along the intestine latero-ventrally for about two body-widths. The hemizonid, with the excretory pore and duct very close behind it, is nearly two body-widths behind the muscular bulb (Fig. 2G).

Head offset by a slight constriction; labial annule appears smooth and labial cap very shallow. Immediately behind the head constriction an anterior cephalid is just visible and a posterior one is present close in front of the level of the stylet knobs. There is no marked head skeleton.

DIAGNOSIS. *Meloidogyne artiellia* has most of the characters of the genus but differs from all other described species in the posterior cuticular pattern of the female and in the tail and stylet of the newly hatched (i.e. second stage) larva. Cuticular pattern marked by coarse, angular ridges round anus and vulva, squarish dorsally and bending towards anus from either side. Lateral fields not readily traceable; phasmids close together (about vulval-width apart); anus nearer to tail tip than to vulva. Outer part of pattern formed from fine, fairly smooth striae.

Larval stylet longer (14·7μ) than that of any species except *M. africana* (12–18μ) and *M. brevicauda* (14·3–14·5μ). Larval tail short and blunt: the only other blunt-tailed species, *M. brevicauda*, has a very different posterior cuticular pattern, and in the male the two subventral and two subdorsal lips are fused. *M. brevicauda* also has a short-tailed larva, as does *M. africana*; all except one other species, apart from the new one, have longer tails ($c=10$). The exception, *M. inornata*, has $c=11·6–12·7$, but the tail is sharply pointed.

In view of the characters shown by this species and by *M. africana* (Whitehead, 1959) and *M. brevicauda* (Loos, 1953), three slight amendments should be made to the generic diagnosis given by Allen (1952):

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(a) Six lips, but sub-dorsals and sub-ventrals may be fused (*M. brevicauda*).
(b) Lateral lips not always markedly larger than sub-medians (*M. artiellia*).
(c) Anus and vulva sometimes on an eminence (*M. africana*).

Holotype Female, slide number 77/8/1
Length 0·7 mm.
Breadth 0·4 mm.
Stylet 14μ

Allotype Male, slide number 77/8/2
Length 0·952 mm.
Breadth 41μ
Stylet 17μ
Spicules 28μ
$a=32$; $b=13$; $c=92$; T=65%

Type Host—Roots of Cabbage, *Brassica oleracea capitata*
Type Locality—Wells, Norfolk, England.
Allotypes on slides nos. 77/8/3–7 Nematology Collection, Rothamsted Experimental Station.

This is the first species of *Meloidogyne* to be described initially from Britain. *M. hapla* has been found on field crops on several occasions (Brown, 1955) and I have seen it on *Succisa pratensis* Moench and *Ajuga reptans* L. from Northumberland. It seems highly probable that it also is an indigenous species. The widely-held view that root-knot eelworms are found in the field exclusively in tropical and sub-tropical regions, and occur in northern Europe only in glasshouses, must therefore be modified. It may well be that root-knot disease occurs more often in the field in temperate climates than has hitherto been realised.

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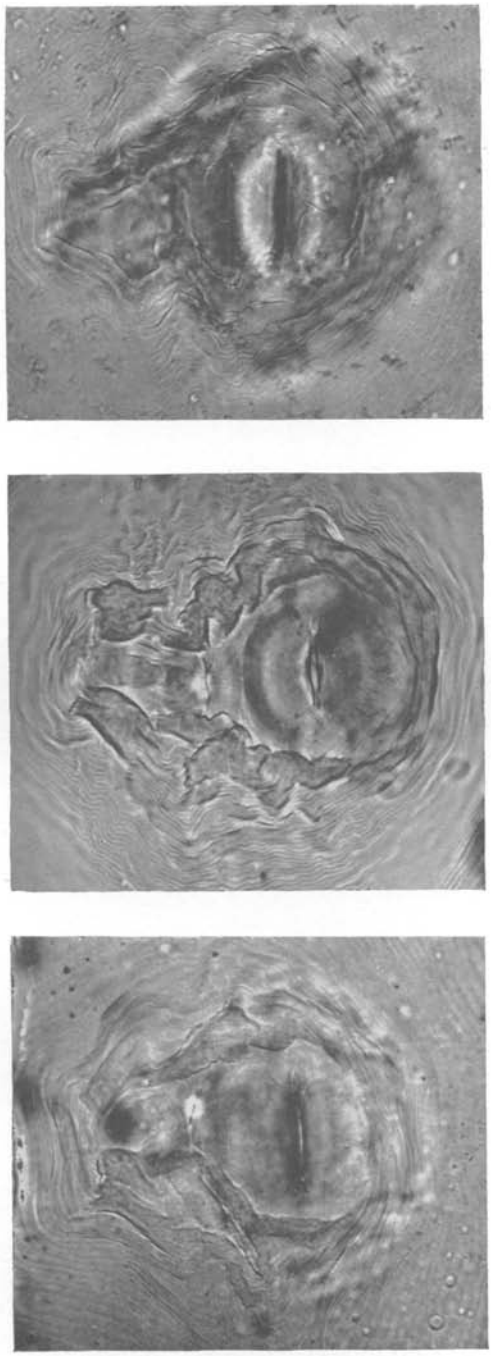

—Posterior cuticular patterns of three female *Meloidogyne* ***artiellia*** n.sp.

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