Franklin, M. T. 1965. A root-knot nematode, Meloidogyne naasi n. sp., on field crops in England and Wales. *Nematologica.* 11 (1), pp. 79-86.

Nematologica 11 (1965): 79-86. E. J. Brill, Leiden

A ROOT-KNOT NEMATODE, *MELOIDOGYNE NAASI* N. SP., ON FIELD CROPS IN ENGLAND AND WALES

BY

MARY T. FRANKLIN
Rothamsted Experimental Station, Harpenden, Herts., England

Meloidogyne naasi n. sp. is described from cereals, grasses and sugar beet in west and south-west England and Wales. It is distinguished by the perineal pattern and the forward position of the excretory pore in the female, by the long, slender tail of the larva and by the protruding first head annule in the male. In both larva and male there is a curious structure resembling a group of small vesicles in the anterior part of the median oesophageal bulb.

During the past 12 years samples of grass and cereal roots bearing small galls containing females of a *Meloidogyne* sp. have been received from several places in Wales and western England. Galls were found from May to August and, although mostly small, many contained 5-10 female nematodes with large, coalescent egg masses. The nematodes could not be assigned to any known species and are here described as *M. naasi* n. sp. in recognition of the discovery of the infestations by members of the National Agricultural Advisory Service (NAAS).

Mature Females: (measurements of 25 specimens mounted fresh in agar).

Length (including neck): 455-705 μ (mean 557 μ). Length of neck: 91-205 μ (148 μ). Greatest breadth: 227-398 μ (330 μ). Head to base of median oesophageal bulb: 73-111 μ (91 μ). Median bulb: 28-46 μ (34 μ) long $\times$ 20-40 μ (28 μ) broad. Stylet: 11-15 μ (13 μ). Dorsal gland opening 2-4 μ (3 μ) from stylet base. o = 16-33 (25, n = 18).

The female body is approximately spherical with sharply offset neck and a slight prominence at the tail end. The neck varies in length and curvature (Fig. 1, D) and the cuticle is coarsely ridged round the vulva and anus. The females are completely embedded in the root tissue and eggs are laid within the root and seldom exposed on the surface (Fig. 3, B). The gelatinous matrix is soft and easily disintegrates in water.

In the mature female, the cuticle is 7-18 μ thick on the spherical part of the body and is clearly annulated on the neck and tail. The excretory pore lies ventrally on the 9th (7th-11th) annule behind the head, slightly in front of the base of the stylet. The anterior part of the stylet is a little longer than the posterior; it is very slender and curved dorsally. The basal part bears well-developed knobs that tend to slope backwards (Fig. 1, B). There are probably two head annules behind the head cap but the whole structure is very small and hard to distinguish. In dorsoventral view, the amphid openings can be seen between the cap and the first annule

(Fig. 1, C). Immediately behind the head the neck widens rapidly to its maximum and then continues roughly the same width until it joins the spherical body. The

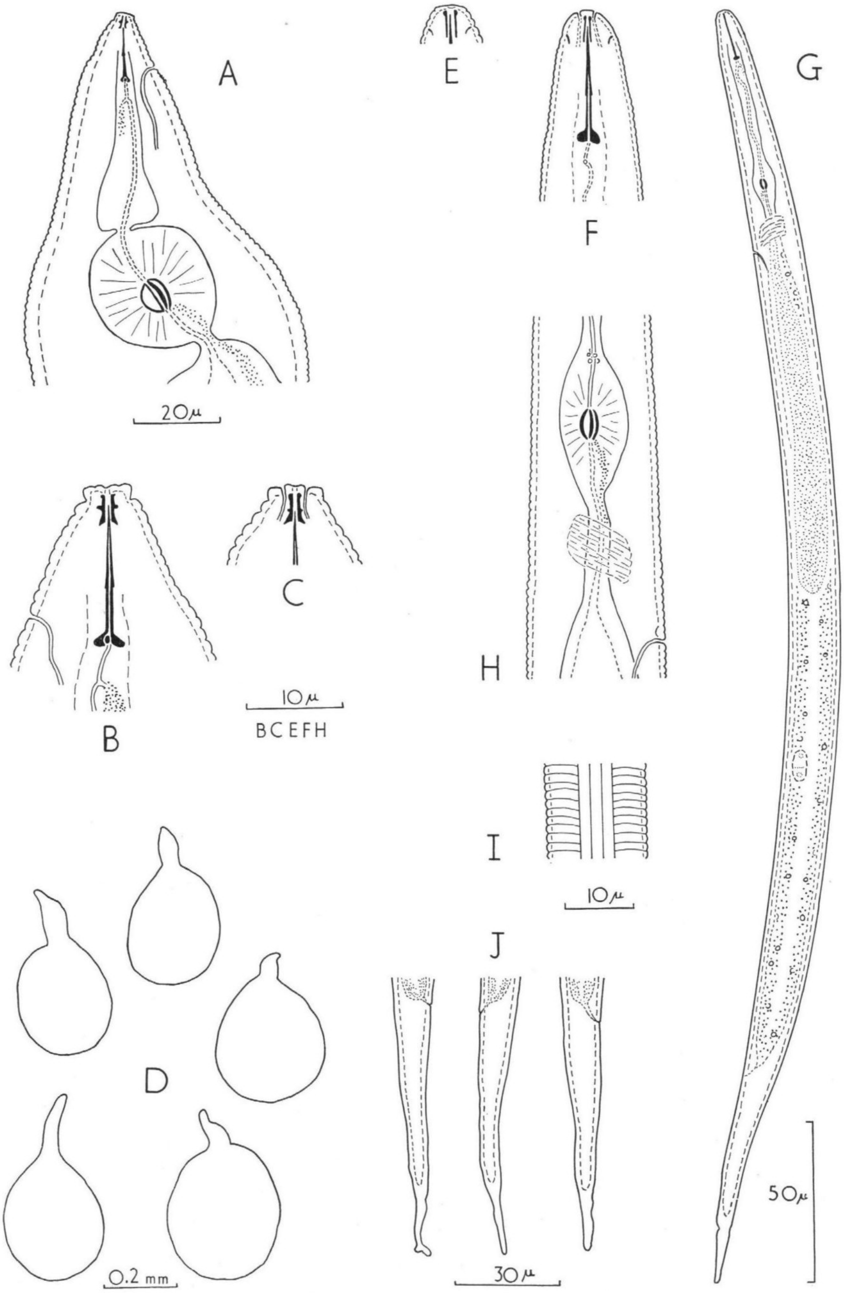


Fig. 1. *Meloidogyne naasi* n. sp. A-D: female. A — oesophageal region; B — head, lateral; C — head, dorso-ventral; D — mature females; E-I: second-stage larva. E — head, lateral; F — head, dorso-ventral; G — whole larva; H — hind part of oesophagus; I — lateral field; — J. tails.

head skeleton comprises a cylindrical spear guide slightly expanded at the base where it extends into the neck and with short "arms" protruding at the level of the base of the head (Fig. 1, B & C).

A constriction at the base of the procorpus separates it from the large muscular oesophageal bulb which lies in the neck about two bulb lengths behind the head. There are conspicuous central valve plates measuring 7 μ across. The gland lobe overlies the anterior part of the intestine which, together with the ovaries, fills the swollen part of the body. As in other species of *Meloidogyne,* there are six large matrix-producing cells associated with the rectum. The posterior cuticular pattern is characterised by having large phasmids, usually a little closer together than the width of the vulva, and coarse ridges on the cuticle in the dorsal region forming broken, irregular lines around and between the phasmids (Fig. 2, A, B, C & Fig. 4). A prominent fold covers the anus and shows as a curved line between vulva and phasmids. The area around the vulva has few or no striae except for a few lines radiating from the ends of the vulval slit. The vulva is 17-25 μ (22 μ) wide, the phasmids are 12-25 μ (18 μ) apart and the distance of the vulva from an imaginary line joining the phasmids is 18-26 μ (22 μ). (All means of 25 specimens mounted in lactophenol).

Males: (measurements of 25 specimens mounted in TAF).

Length: 860-1316 μ (mean 1148 μ). Breadth: 23-34 μ (30 μ). *a*: 32-48 (40). *b*: 11-17 (15) (total divided by distance from front end to valve plates in median oesophageal bulb). Stylet: 16-19 μ (18 μ). Dorsal gland duct opens 2-4 μ (3 μ) behind stylet base. Spicules (mean of 19): 25-30 μ (28 μ). Gubernaculum (mean of 17): 4-8 μ (6 μ).

As in all species of *Meloidogyne* the males vary greatly in length. The specimens studied were recovered from barley roots, grown in soil from the type locality and incubated in the laboratory. In specimens killed by heat the posterior tenth of the body twists through about 180°.

The general structure is typical of the genus, the tail blunt and very short (Fig. 2, D). The lateral field occupies about one-third of the body width and is formed of three bands (four incisures), the outer ones irregularly crossed by the body annules. The field is continuous round the tail; anteriorly it narrows to two, then one, band and disappears at the level of the stylet. The phasmids are close behind the anus and the tail length is about $^2/_3$ of the anal-body-diameter. The excretory pore is two body-widths behind the median oesophageal bulb and one to two annules behind the hemizonid.

The head (Fig. 2E, F) is approximately 9 μ wide and 4 μ high and is scarcely offset from the body; in lateral view three annules can be seen behind the head cap on the dorsal and ventral profiles. In dorsal or ventral view there appear to be three annules on the lateral lips, the anterior more prominent than the others; the amphid openings and ducts enter at each side of the head cap. The stylet is well-developed with rounded knobs; the anterior pointed part is a little shorter than the posterior part and the aperture lies on the ventral side close behind the solid, sharply pointed tip. There are anterior cephalids on the second neck annule and posterior cephalids about two annules in front of the stylet knobs. The oesophageal lumen is clearly visible and the duct from the dorsal oesophageal gland joins it 2-4 μ (mean 3 μ) behind the stylet knobs, the value for *o* being 11-20 (mean of 11, 14). The fusiform median bulb is 11 μ wide with central valve plates in front of which are four or five small vesicle-like structures grouped irregularly round the lumen of the bulb. The gland lobe lies ventro-laterally along the intestine for a distance of 3-4 body widths. All specimens examined showed only one testis, which was reflexed in some. The spicules are slightly curved ventrally, the distal part tapering to a point, the proximal part broader with thickened margins as illustrated (Fig. 2G). The gubernaculum is small and saucer-shaped.

Second stage larvae: (measurements of 25 specimens in lactophenol).

Length: 418-465 μ (435 μ). Breadth: 14-18 μ (15 μ). *a*: 25-32 (28). *b*: 7-8 (7.7) (length divided by distance from front end to centre of median bulb). Stylet: 13-15 μ (14 μ).

In a close examination of several hundred eggs, three or four were found containing moulting first-stage larvae. It was not possible to examine the larvae in detail but they were obviously shorter and broader than the hatching larvae which, it was clear, must be second-stage larvae as has been shown in other species of *Meloidogyne.* The second-stage larvae were folded four, five or occasionally six times in the egg.

The body is slender and clearly annulated. The lateral field consists of three bands (four incisures) that are not crossed by transverse striae (Fig. 1 I). Anteriorly it starts as a narrow band behind the stylet, broadens and gets three incisures at the level of the median bulb and reaches its full width at the level of the excretory pore. Behind the anus it narrows gradually to finish about half-way along the tail. The excretory pore and hemizonid are close to the posterior edge of the nerve ring (Fig. 1, G, H).

The tail is sharply pointed with a clear terminal region about one quarter the tail-length (Fig. 1, J). It is difficult to distinguish the anus except under the high-power oil immersion objective and, for calculations of *c,* the total lengths of specimens could not be measured at the same magnification as the tail length. Tails of 25 specimens averaged 70 μ long (52-78 μ) and 11 μ wide (9-13 μ) at the anus, and had a length/width ratio of 6.4. The approximate value for *c,* based on means for total length and tail length measured at different magnifications, is 6.2. This is smaller (hence a relatively longer tail) than for other species except *arenaria,* for which Chitwood gives $c = 6\text{-}7.5$. The extreme tip of the tail may be irregular and is occasionally forked, as illustrated. Phasmids were not seen. The rectum is not swollen.

The head is rounded and not offset, with a small head cap and probably two annules on the sub-dorsal and sub-ventral lips but none was seen on the laterals (Fig. 1, E, F). The head skeleton comprises a delicate guide tube for the stylet, the anterior edge being expanded and appearing knob-like in optical section. In face view the skeleton is six-rayed and on the head surface slit-like amphid openings can be seen.

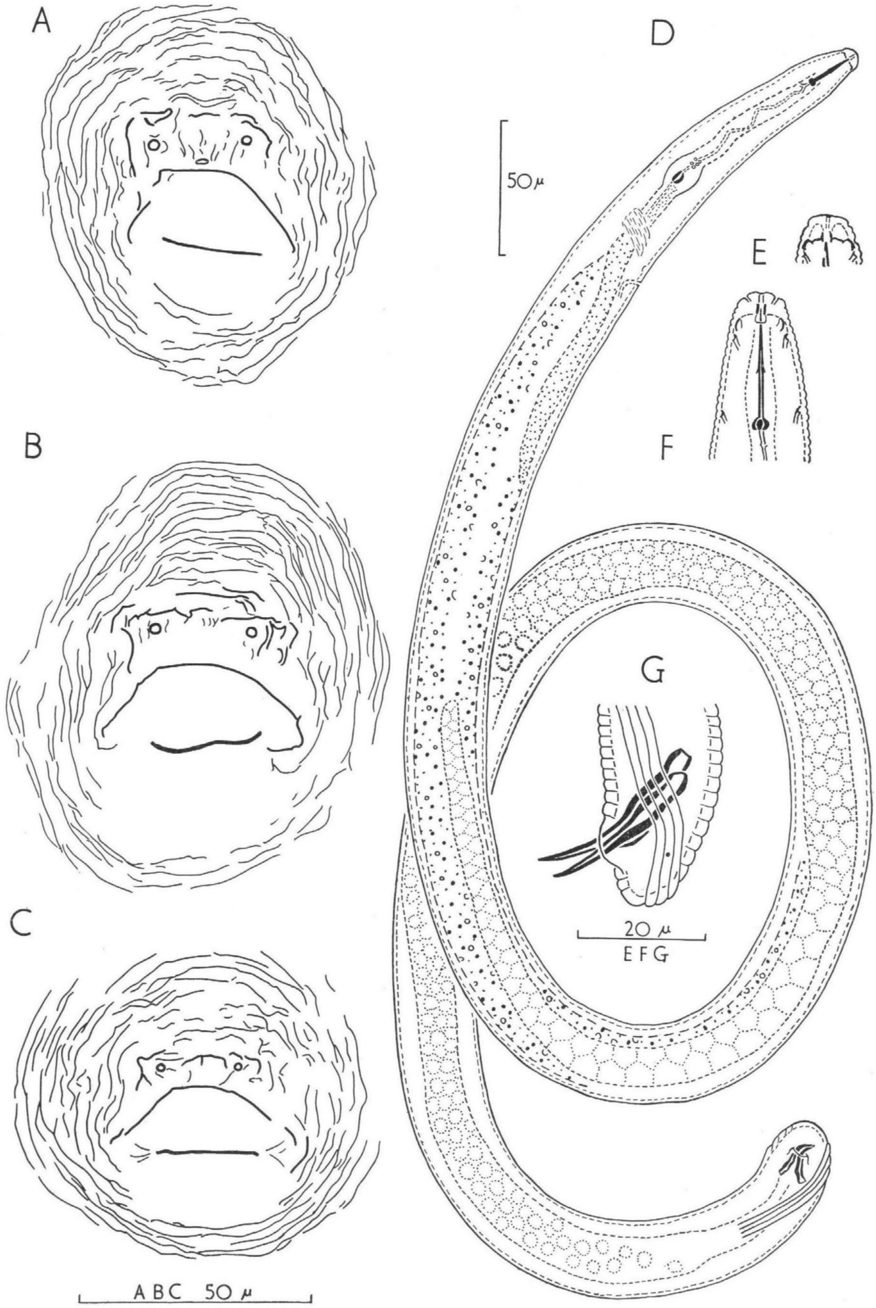


Fig. 2. *Meloidogyne naasi* n. sp. A, B, C — female posterior cuticular patterns; D-G: male. D — whole; E — head, lateral; F — head, dorso-ventral; G — tail.

The stylet is very slender, the anterior part being somewhat longer than the posterior which has backwardly sloping basal knobs. The dorsal gland duct opens into the oesophageal lumen about 2-3 μ (mean of 25.3 μ) behind the stylet knobs. The median oesophageal bulb is oval with large valve plates in the centre and, as in the male, there is a curious structure associated with the lumen anterior to the valve. This structure is always present in larvae of this species and is most easily seen in specimens mounted in water or fixative. It is irregular and looks like a group of four or five minute diverticula or vesicles, mostly in contact with the oesophageal lumen (Fig. 1, H). A search for similar structures in other species of the genus has been unsuccessful.

The oesophageal gland lobe lies ventrally over the intestine and ends 164-208 μ (mean of 25, 189 μ) behind the anterior end of the body: this is just over 2/5 of the total body length. The genital primordium, consisting of a small group of cells, is in the hind third of the body.

Eggs

Embryonated eggs average 89 μ (71-99 μ) long by 41 μ (36-48 μ) wide, with a ratio of length to breadth of 2.2.

Holotype female: length, including neck, 548 μ; neck 121 μ; width 305 μ; stylet 15 μ; dorsal gland opening 3 μ behind stylet; median bulb 34 μ long, 27 μ wide. Slide no. 77/9/1, R.E.S. Nematology Collection.

Allotype male: length 1153 μ; width 30 μ; stylet 18 μ; dorsal gland opening 4 μ behind stylet; excretory pore 60 μ from head end; spicules 26 μ. Slide no. 77/9/2.

Paedotype larva: length 433 μ; width 15 μ; excretory pore 74 μ from head end; stylet 14 μ; dorsal gland opening 2 μ from stylet; tail 74 μ long, 10 μ wide at anus. Slide no. 77/9/3.

Paratypes on slides 77/9/4-77/9/15.

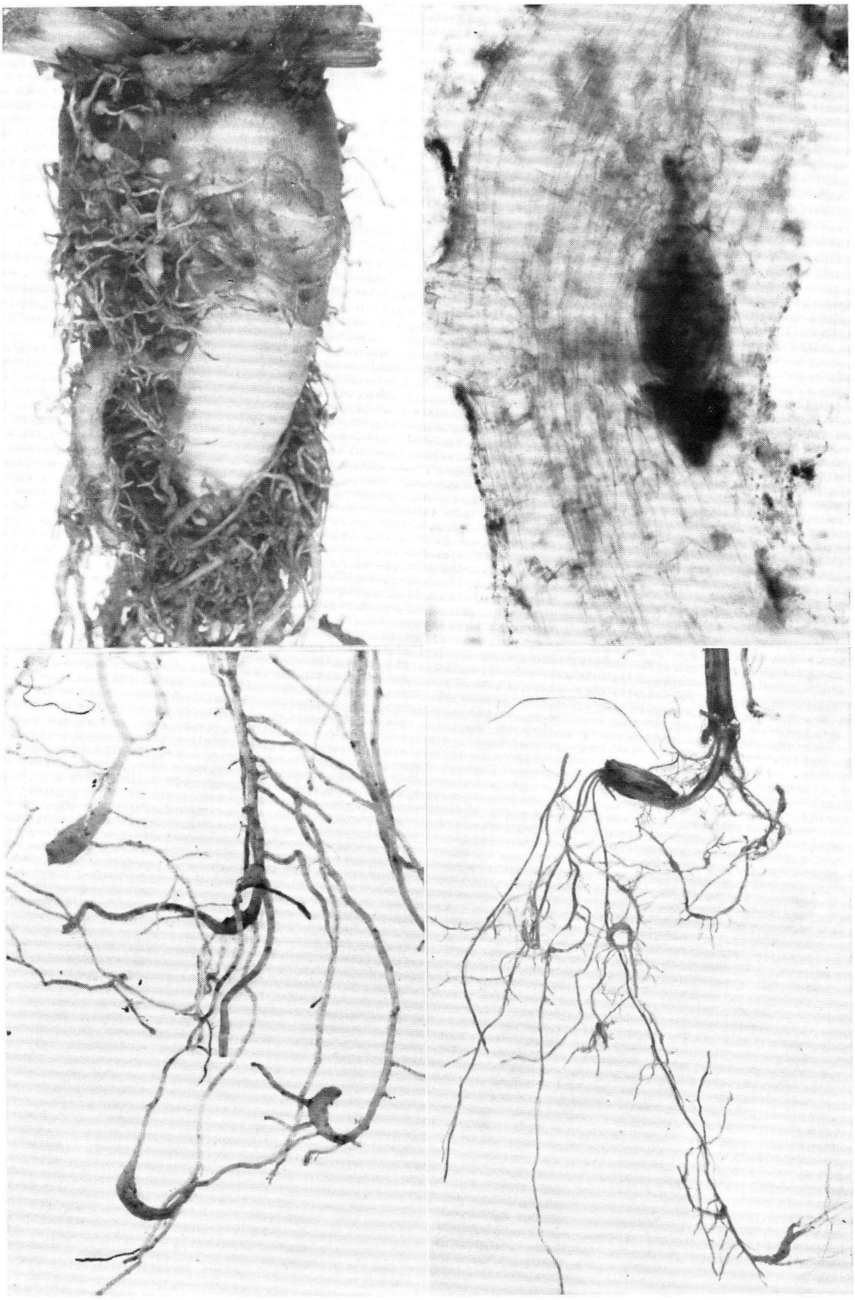
Type host: *Hordeum vulgare* L. spring-sown barley var. Proctor.

Type locality: Pendeck Farm, Tytherington, Gloucestershire, England.

Diffential diagnosis: *Meloidogyne naasi* differs from other described species in the form of the posterior cuticular pattern in the female which has a distinct fold over the anus, large phasmids below the surface, a little closer together than the vulval length, and broken striae between the phasmids at right angles to the dorsal arch. The pattern is on a slight prominence on the spherical body. The excretory pore in the female is on the 7th to 11th neck annule as compared with 12th to 25th annule in other species in which it has been noted. The male stylet is shorter than in most other species but is similar to that in *M. exigua, M. hapla, M. kikuyensis, M. acronea* and *M. artiellia.* As seen in dorso-ventral view the first head annule in the male is characteristically larger than the two posterior ones. This has not been recorded in other species.

The larva is distinguished by the structure of the median oesophageal bulb and

A B



C D

Fig. 3. *Meloidogyne naasi* n. sp. A — sugar beet with galls on lateral roots; B — mature female and egg-sac within root, showing giant cells around head; C & D — roots of spring barley var. Proctor showing terminal club-shaped, hook-shaped and spiral galls.

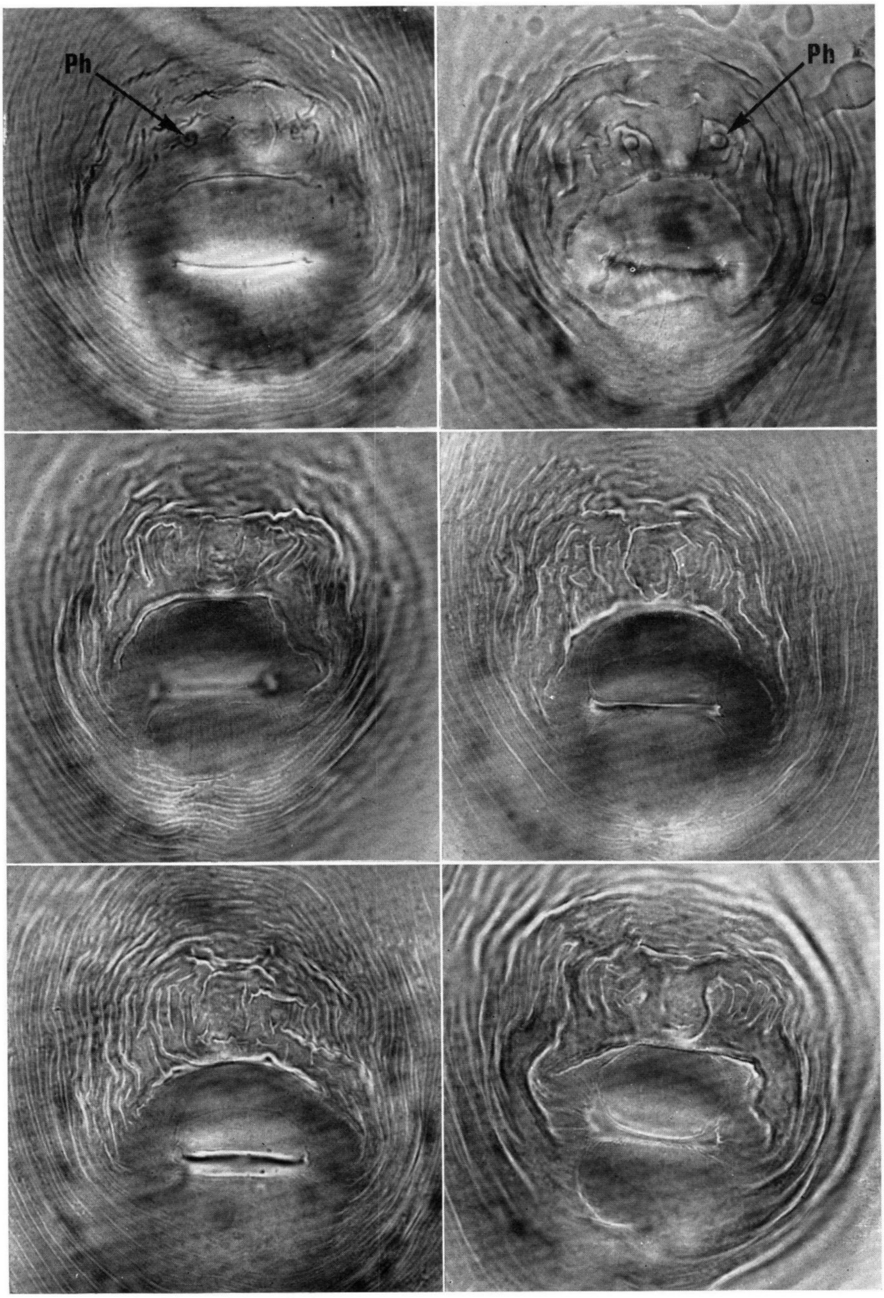


Fig. 4. *Meloidogyne naasi* n. sp. Posterior cuticular patterns. Phasmids can be seen in top two specimens.

by the long, tapered and sharply pointed tail. The tail most closely resembles that of *M. arenaria* but in the latter, according to Chitwood, the larvae are 450-490 μ long compared with 418-465 μ in the new species.

The galls formed on the roots of the type host are of a shape unusual for *Meloidogyne* infestations (Fig. 3, C & D), the root often curving into the shape of a horseshoe or a complete spiral. There is no excessive production of secondary roots as in infestations by *M. hapla*.

Distribution

M. naasi was found in July 1952 by Miss S. Lewis (National Agricultural Advisory Service, Cardiff) on the roots of Italian ryegrass (*Lolium multiflorum* Lam.) from near Swansea, South Wales. The infested field carried oats and peas for silage and was undersown with ryegrass; for the 3 preceding years it had been in grass and in 1948 there had been a cereal crop following pasture. In 1952 the infestation was distributed all over the field on the grass roots but was not found on oats. In addition to ryegrass, *Poa trivialis* and *P. annua* were infested in the field and wheat (*Triticum vulgare*), *Agropyron repens* and *Plantago* sp. in pot tests.

In 1956 Miss Lewis found the nematode on barley, but not oats, in a mixed corn crop at Rhossili, on the Gower Peninsula about 15 miles west of Swansea. In the same field *Stellaria* sp. and four species of grass were infested: 5 years later infestations were still present in several fields of the same farm. Galls on the roots of *Dactylis glomerata* contained both *Meloidogyne naasi* and *Ditylenchus radicicola* (Lewis, 1962).

Infestations on spring barley were found by NAAS officers in four different localities in Gloucestershire in 1961, 1962 and 1963. North of Bristol, fields were infested at Thornbury and Tytherington, west of Gloucester at Churcham and on the west of the Severn at a height of 700 ft. (213 m) at S. Briavel's. Further to the south-west, spring barley has been found infested in Somerset, Devonshire and Cornwall as well as wheat in the last two counties. At one place in Devon wheat was infested by both *M. naasi* and *M. arenaria.*

Only once has a crop other than a cereal or grass been found affected; this was sugar beet growing at Church Stretton, Shropshire, 60-70 miles north of Gloucester. The galls were small and mainly on the lateral roots close to the tap root (Fig. 3, A). The field had carried cereals and a ley for the 3 years preceding the sugar beet crop.

In 1964 fresh infestations on cereals were found by members of the NAAS in Gloucestershire, Devon and in a new area near Preston, Lancashire, 150 miles north of Gloucester. This suggests that the parasite is widely distributed. In the same year meadow fescue was found infested on the Gower Peninsula 3 miles distant from the site of the original infestation on ryegrass.

Fields of infested barley frequently show patches of stunted and yellowing plants and observations indicate that crops are damaged but this has not been proved experimentally.

Hosts

Gramineae

Hordeum vulgare L. barley, var. Proctor, Rika
Triticum aestivum L. wheat, var. Capelle, Jufy
Lolium multiflorum Lam. Italian ryegrass
L. perenne L. perennial ryegrass
Agropyron repens (L.) Beauv. couch grass, twitch
Arrhenatherum elatius (L.) J. & C. Presl. onion twitch
Dactylis glomerata L. cocksfoot
Festuca pratensis Huds. meadow fescue
Poa annua L.
P. trivialis L.

Chenopodiaceae

Beta vulgaris L. sugarbeet
Chenopodium polyspermum L. all-seed

Polygonaceae

Polygonum persicaria L. persicaria
Rumex sp. dock

Plantaginaceae

Plantago sp. plantain

Caryophyllaceae

Stellaria media (L.) Vill. chickweed

ACKNOWLEDGEMENTS

Galled cereal and grass roots containing the new nematode were sent by the following National Agricultural Advisory Service Officers: Miss S. Lewis, C. A. Collingwood, E. B. Dennis, G. M. Dixon, R. Gair and H. G. Morgan. R. A. Dunning sent galled sugar beet roots. I thank F. D. Cowland and Mrs. S. A. Clark for photographing Figs. 3 & 4 respectively.

RÉSUMÉ

Un nématode des racines, Meloidogyne naasi *n. sp. associé à des plantes cultivées en Angleterre et au Pays de Galles*

M. naasi n. sp. occasionne des galles sur les racines d'orge, blé, *Lolium perenne* et betterave dans l'ouest de l'Angleterre et le Pays de Galles. Les femelles et les oeufs sont presque toujours encastrés dans les galles. Le perinée et la position avancée du pore excréteur sont caractéristiques pour la femelle. Les mâles se caractérisent par un premier anneau de la tête plus grand que les deux suivants. Les juvéniles au deuxième stade mesurent 418-465 μ (moyenne 435 μ) et ont l'extrémité effilée ($c = 6.2$). Il y a dans le bulbe médian oesophagien du mâle et du juvénile une structure qui ressemble à un groupe de petites vésicules associées avec le lumen oesophagien.

REFERENCE

LEWIS, S. (1962). A root-knot eelworm attacking grasses. *Plant Path.* **11**, 92.

Received for publication: 28 September 1964.