On the Morphology of the Coffee Root-Knot Nematode, *Meloidogyne exigua* Goeldi, 1887*

LUIZ GONZAGA E. LORDELLO AND ADIEL PAES LEME ZAMITH
Escola Superior de Agricultura "Luiz de Queiroz," University of S. Paulo, Piracicaba, Brazil

The first record on nematodes attacking roots of coffee trees in Brazil was published by Jobert in 1879. Some years later, Goeldi (1887) stated that the primary cause of a disease affecting coffee plantations at the so-called Province of Rio de Janeiro was the nematode referred to by Jobert. At that time, Goeldi erected the new genus *Meloidogyne,* and described *Meloidogyne exigua* as the type species. Since then, authors have made references to root-knot nematodes found infecting coffee trees in several South American countries, and in the U. S. A., at the New York Botanical Garden (Chitwood, 1949; Lordello, 1953; Taylor, Dropkin & Martin, 1955; etc.). In 1949, Chitwood published his well-known paper on the root-knot nematodes, proposing the revalidation of the genus *Meloidogyne,* which had been synonymized with *Heterodera* Schmidt, 1871 by previous authors.

Recently, the writers examined roots of coffee trees grown in the Ribeirão Prêto area, in the State of S. Paulo, Brazil, and found *M. exigua* attacking all the decaying plants. Experiments for recuperating old coffee orchards have been conducted at one of the plantations infected by *M. exigua,* but the trees did not respond as expected. Actually, preliminary surveys suggest that *M. exigua* is an important detriment to coffee production in the Ribeirão Prêto region. *M. exigua* produces somewhat small galls on the roots of coffee trees. These galls may be easily overlooked, particularly if the material collected is not protected against desiccation. Necrotic areas are also to be seen on the roots. The trees found infected belong to the following varieties of *Coffea arabica* L.: red Bourbon, yellow Bourbon and "Mundo Novo."

M. exigua is a little known root-knot nematode species. The description by Goeldi is adequate to place the genus, but is erroneous in many respects. In addition, Chitwood could not give an entirely satisfactory redescription because the material he had for study was in poor condition. For those reasons, the observations carried out with the abundant material collected at Ribeirão Prêto are here presented as a contribution to the knowledge of *M. exigua,* the coffee root-knot nematode.

Meloidogyne exigua Goeldi, 1887

EGGS: The eggs are ellipsoidal, 73.4-88.7 microns long and 38.3-44.4 microns wide (fig. 1, J). Observation made on eggs containing larvae did not offer any indication that the first larval moult takes place inside the egg.

PREPARASITIC LARVAE: The worm shaped body tapers to both extremities, more sharply posteriorly, ending in an elongated tail. Head bearing one post labial annule; stylet bulbs weakly developed and rather compressed longitudinally. Cuticle annulated, the annulation being much less evident than in adults. Middle bulb of oesophagus ovoid. Oesophageal glands rather long (fig. 1, H, and I). The nerve ring encircles the oesophageal isthmus just below the middle bulb. Intestinal cells filled with coagulated substances, forming

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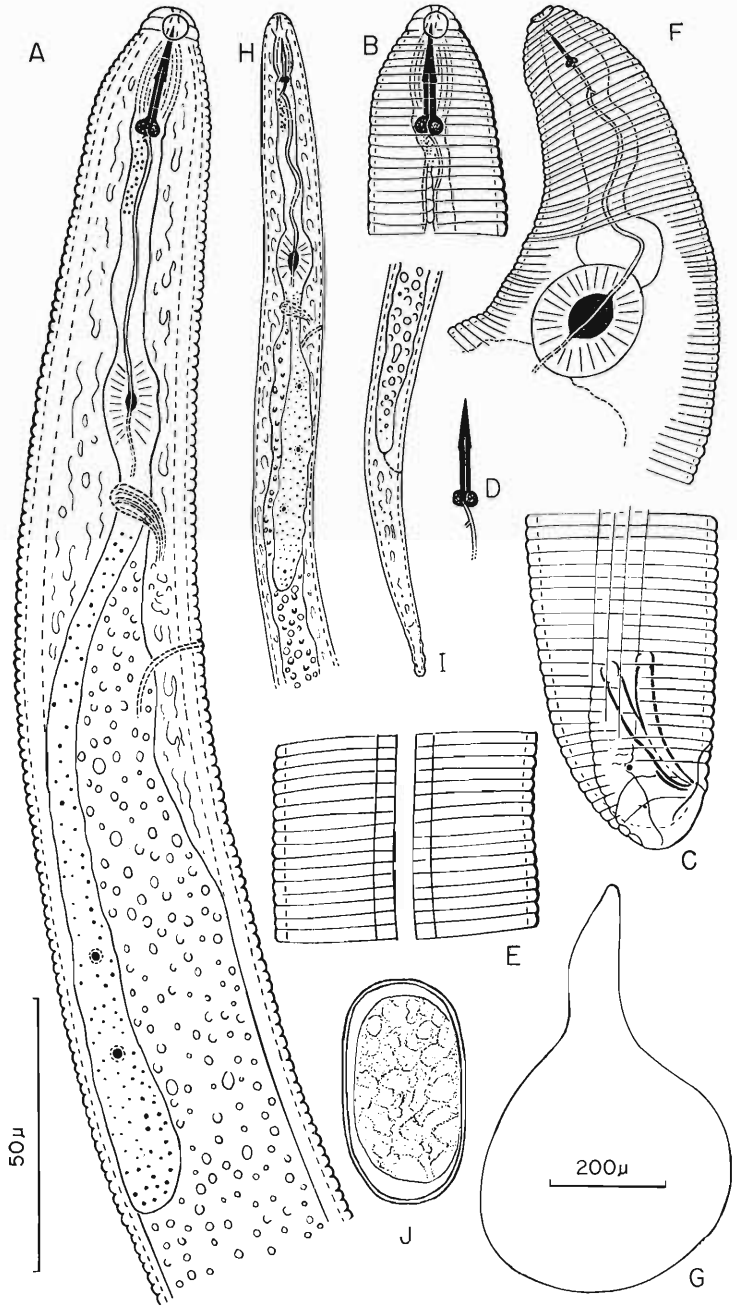

Fig. 1.—*Meloidogyne exigua* Goeldi, 1887: A. Oesophageal region of the male; B. Head of the male; C. Posterior end of male; D. Stylet of male; E. Lateral field of male; F. Oesophageal region of the female; G. Form of the female body; H. Oesophageal region of preparasitic larva; I. Posterior end of preparasitic larva; J. Egg.

more or less round and characteristic bodies. Anal opening sometimes hard to locate. Phasmids not seen. Lateral fields 3.1 microns wide, made up of four incisures.

Measurements (in microns). Length: 333.5-358.0; width: 13.7-15.3; tail: 44.4-46.0; stylet: 9.2; middle bulb of oesophagus: 10.7 x 7.7; length of oesophagus: 78.0-82.6; anal diameter: 7.7-9.2; a = 22.2-26.0; b = 4.2-4.4; c = 7.3-7.8.

FEMALE: The whitish females have well defined neck and were obtained from the smooth-walled cavities of the root tissues (fig. 1, G). A number of dead females was also obtained during dissection of the galls. These females were violaceous in color and had rather resistant cuticle, looking like wall of cysts of the *Heterodera* species.

Head pointed, stylet straight or slightly curved, provided with small knobs. Canal of the oesophagus strongly walled from the beginning of the organ until it enters the valves of the middle bulb, where it becomes rather weak. A constriction of the surrounding tissues is seen at the point of union of the oesophageal canal with the middle bulb, the latter being ovoid to spherical and quite strong (fig. 1, F). Lateral fields and excretory pore not

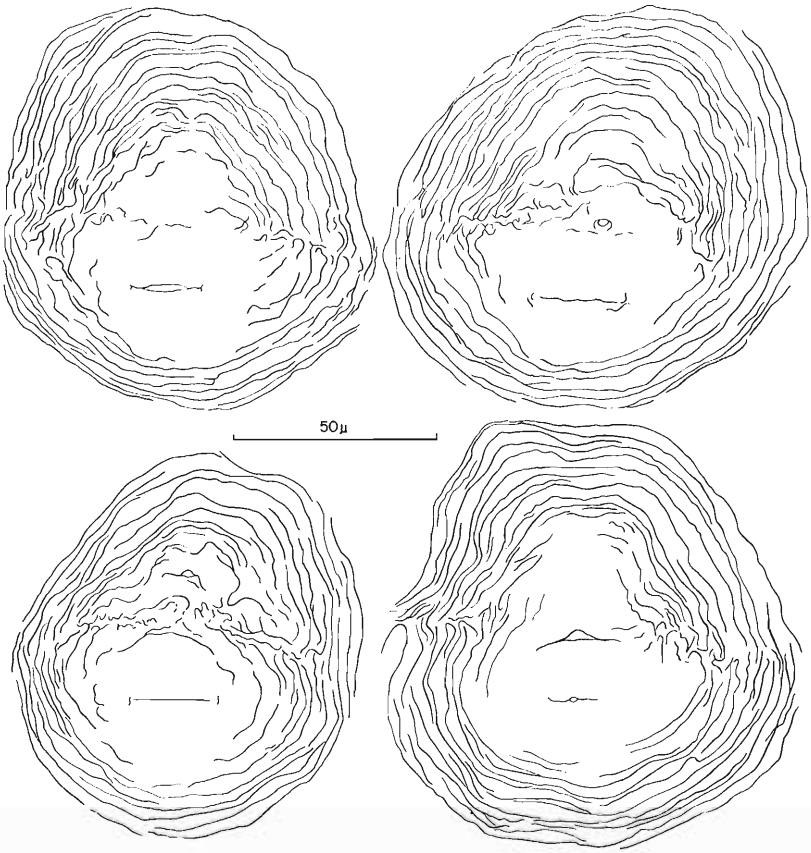

Fig. 2.—*Meloidogyne exigua* Goeldi, 1887: Perineal patterns of adult females.

seen. Ovaries convoluted, usually filled with oocytes. The perineal pattern agreed with that figured by Chitwood (1949) and Taylor, Dropkin & Martin (1955) for the species. The arch is low and slightly flattened and the lateral lines poorly defined and bordered by folded and broken striae (fig. 2).

Measurements (in microns). Length: 387.5-496.0; width: 279.0-372.0; stylet: 10.7; distance from the orifice of the dorsal gland to base of stylet: 4.6-7.7; oesophagus middle bulb: 30.6-33.6 x 24.5-26.0.

MALE: Body worm-like in shape, tapering more abruptly toward anterior end. The head, more frequently obtained in lateral or sublateral view, is slightly set off from neck. Labial annule wide and rather flat in lateral view; post labial annule without any striation in dorso-ventral, as well as in lateral view. Cuticle strongly annulated. Lateral fields beginning a little back of the level of the stylet knobs and extending to tail end. They are usually made up of four incisures, but in several males additional incisures were counted. The transverse striae of cuticle may cut the outer bands of the fields, as illustrated (fig. 1, E). At about the middle of the body, the fields are 7.6-9.2 microns wide.

Meloidogyne males usually have a twisted body. *M. exigua* males, however, are not twisted, thus constituting an exception among the root-knot nematodes already studied by the writers. Actually, other species previously investigated have males to which the twist of the body was calculated to be 90 degrees (Lordello, 1956, and 1956a). Twisting may be considered as being adaptative in character, since it is supposed that the males have to roll their body around the female body when copulation takes place.

Stylet strong, the knobs being ovoid and very pronounced. The nerve ring encircles the isthmus just below the middle bulb (fig. 1, A). Intestinal cells filled with coagulated bodies of different forms. Excretory pore well defined, located at 96.0-130.0 microns from the head end. All the males studied have two well developed testes, which may be reflexed or completely outstretched, usually reaching the oesophageal region. Spicules arcuated ventrally; gubernaculum well defined. Phasmids very small (fig. 1, C).

In the population handled, two types of males were found, which differed in the distance between the opening of the dorsal oesophagal gland and the stylet knobs. In one type, that distance is around 3.0 microns, while in the other the orifice is too close to the knobs to measure. Since no differences were observed in the other stages of the parasite, the two male types were considered as individual variations within the same species (fig. 1, B, and D).

In lateral and sublateral views, the *ampulla* of the amphids may be more or less easily located, due to its circular outline. The writers prefer to use the term *ampulla* for such amphidial structure in the genus *Meloidogyne,* instead of the word "cheek" introduced by Chitwood (1949) which, according to the writers' opinion, is quite inadequate. As already shown by Allen (1952), Cobb (1924) did not use the word "cheek" to designate the organ mentioned above, but stated that "the amphids are protected by cheeks." As Allen (1952) does, the writers understand that Cobb referred to the well developed lateral lips of the *Meloidogyne* species.

Measurements (in microns). Length: 832.3-1,092.4; width: 26.0-46.0; stylet: 18.4-19.9; distance from the opening of the dorsal gland to base of stylet: 0.0-3.0; stylet knobs: 4.0-6.1 x 3.0; middle bulb of oesophagus: 15.3 x 9.2; tail: 6.1-10.0; spicules (measured on chord of their arc): 20.0-26.0; gubernaculum: 7.7; height of head: 3.1-4.6; a = 23.8-32.0; b = 8.1-8.9; c = 95.8-110.0.

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Alkaline Phosphatase in the Trematode Excretory System*

WILLIAM H. COIL

The function of the excretory system among the platyhelminth worms is yet to be understood; however, both Beaver (1929) and Willey (1934) have published notes on the morphology of the flame cells in trematodes. There are good reasons to believe that this system functions in both osmoregulation and excretion. Kromhout (1943) showed that, in the case of the turbellarians, the excretory system is most highly developed in the fresh water forms and least in the marine species. On the other hand, Buchanan (1931) found that turbellarians gain weight by imbibition in distilled water and lose weight in salt water, thus showing that this system can be overworked under extreme conditions. In contrast to this, many trematodes can pass from fresh water to solutions with various osmotic pressures during the various stages of their life cycles. The motion of the flame cells can be stimulated by saline (Beaver 1929) or urine. This could be either a response to the ions of different inorganic salts or a response to an osmotic change. The presence of concretions in the excretory bladders of some trematodes would lead one to believe these are the result of excretory action.

Several years ago when I was attempting to work out the complex excretory system of some gorgoderid trematodes, it occurred to me that there must be an easier way than the study of living material. This led to the speculation that alkaline phosphatase, present in the excretory systems of many other animals, might be present in the excretory system of trematodes. At that time this postulate was tested, but for some reason, unknown to me, no evidence was found to support it. Recently, while studying a gorgoderid cercaria (close to *Cercaria sphaerocerca* Miller, 1936) from the gills of a sphaeriid bivalve, it was noted that the daughter sporocysts possessed unusually large flame cells and associated capillaries. It was thought that this large material might work better than previous specimens.

The living material was fixed in chilled acetone (below 0°C) and then placed, in acetone, in a refrigerator for 24 hours. Imbedding was carried out

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