



*Helicotylenchus pseudorobustus* A-K: Topotype females. L, M: California, *Philodendron*. N, O: Maryland, bluegrass, P, Q: paratypes *H. microlobus*. R: paratype *H. bradys*. S: paratype, *H. phalerus*. (From Fortuner, Maggenti & Whittaker, 1984, courtesy of *Revue de Nématologie*) A. Female, in relaxed habitus. B, C. anterior end. D. oesophageal region. E-S. Tails.

***Helicotylenchus pseudorobustus* (Steiner, 1914) Golden, 1956.**

Syn. *Tylenchus pseudorobustus* Steiner, 1914; *Tylenchorhynchus robustus* var. *pseudorobustus* (Steiner, 1914) Micoletzky, 1922; *Tylenchus* (*Tylenchorhynchus*) *pseudorobustus* Steiner, 1914; *Helicotylenchus microlobus* Perry in Perry, Darling & Thorne, 1959; *H. bradys* Thorne & Malek, 1968; *H. phalerus* Anderson, 1974.

**MEASUREMENTS** 20 ♀♀ topotypes, in Fortuner, Maggenti & Whittaker, 1984). Mean ( $\pm$  standard deviation) L = 764 ( $\pm$  58)  $\mu$ m; stylet = 27.1 ( $\pm$  0.6)  $\mu$ m; oesophagus = 116 ( $\pm$  6)  $\mu$ m; oesophageal glands = 142 ( $\pm$  9)  $\mu$ m; dorsal gland opening = 8.8 ( $\pm$  1.1)  $\mu$ m; excretory pore = 114 ( $\pm$  5)  $\mu$ m; body diameter = 27.8 ( $\pm$  3.8)  $\mu$ m; tail length = 15.9 ( $\pm$  1.7)  $\mu$ m; tail diameter = 15.6 ( $\pm$  1.8)  $\mu$ m; a = 28 ( $\pm$  3.8); c = 48.4 ( $\pm$  4.4); c' = 12 ( $\pm$  3.4); m = 46.7 ( $\pm$  1.4); V = 61.6% ( $\pm$  1.8). Mean values from 12 samples in Fortuner, Maggenti & Whittaker, 1984: L = 715 ( $\pm$  38.5)  $\mu$ m; stylet = 26.9 ( $\pm$  0.73)  $\mu$ m; oesophagus = 116 ( $\pm$  6)  $\mu$ m; oesophageal glands = 146 ( $\pm$  8)  $\mu$ m; dorsal gland opening = 10.4 ( $\pm$  1.3)  $\mu$ m; excretory pore = 111 ( $\pm$  5)  $\mu$ m; body diameter = 26.4 ( $\pm$  1.9)  $\mu$ m; tail length = 17.5 ( $\pm$  1.1)  $\mu$ m; tail diameter = 15.2 ( $\pm$  0.8)  $\mu$ m; a = 27.4 ( $\pm$  2.1); c = 41.5 ( $\pm$  3.7); c' = 1.2 ( $\pm$  0.1); m = 48 ( $\pm$  1.1); V = 61.1% ( $\pm$  0.8).

**DESCRIPTION** Female (topotypes plus variability observed by Fortuner, Maggenti & Whittaker, 1984): **Body spiral**, tightness of spiral variable; distinctly annulated, annules 1–2.5  $\mu\text{m}$  wide. **Lip region hemispherical**, with 4–5 annules (sometimes indistinct); first annule and labial ring slightly elevated above the general lip outline and visible in transverse view in a few North American specimens. Outer margins of labial framework extending posteriorly for 1–3  $\mu\text{m}$ . Anterior cephalids mostly indistinct; posterior cephalids also difficult to see, 15–16  $\mu\text{m}$  from anterior end. Lateral fields 5–7  $\mu\text{m}$  wide, always anteriorly scalariform, with irregularly scattered transverse lines seen in the tail region of some specimens in topotype and a few other populations. **Spear** well developed, mean length from 25.5–28  $\mu\text{m}$ , cone 12.5–14  $\mu\text{m}$  long, **knobs often flattened, rarely rounded or indented anteriorly**. Excretory pore at level of oesophageo-intestinal junction, or slightly anterior or posterior to it; level to 2 annules behind the hemizonid. Hemizonion not seen. Oesophageal glands overlapping the anterior end of the intestine, subventrals slightly longer or equal in length to the dorsal gland. Intestinal fasciculi absent. Vulva rather anterior for the genus, mean V value 59–62%. Spermatheca empty, offset. **Tail dorsally convex-conoid, terminus forms a definite rounded projection of variable length, annulated or non-annulated**, with a mucro in some specimens of a few populations; **9.1 ( $\pm$  1.2) ventral tail annules in topotypes, an average of 7–12 annules in other samples**; relative size of dorsal terminal tail annules very variable; ventral non-annulated section present or absent. **Phasmids always anterior to anus level, 7.8 ( $\pm$  1.9) annules anterior in topotypes, averaging 2–8 annules anterior in other samples** and in the centre of the lateral field or closer to the ventral incisure; **junction of the inner incisure on tail very variable**, often u, j or m-shaped in topotypes and European sample, y or v-shaped in North American samples.

**Male:** unknown.

**TYPE HABITAT AND LOCALITY** Soil under “bear’s bed” (mossy cushion) in Switzerland. Topotypes collected under moss near Altmatt, Switzerland.

**SYSTEMATIC POSITION** Tylenchida: Tylenchoida: Hoplolaimidae: Rotylenchoidinae: *Helicotylenchus* Steiner, 1945.

**DISTRIBUTION AND HOSTS** *H. pseudorobustus* (= *H. microlobus*, *H. bradys*, *H. phalerus*) has a worldwide distribution in both temperate and tropical countries. Some reported identifications have been questioned by Fortuner *et al.*, 1981 (from Thailand, Canada, Malaysia and Fiji Islands), and by Fortuner *et al.*, 1984 (from Nigeria and South Africa). It is often found associated with wild graminaceous plants: uncultivated prairie in Kansas (Orr & Dickerson, 1966) and Iowa (Schmitt & Norton, 1973), grasses and lawns in Wisconsin, Rhode Island, Tennessee, Austria, France (Sher, 1966), Maryland and New York (Feldmesser & Golden, 1972, 1974), California (Siddiqui *et al.*, 1973), North Dakota (Donald & Hosford, 1980) Fiji Islands (Van den Berg & Kirby, 1979), pastures in Illinois (Ferris & Bernard, 1971a), Canada (Anderson, 1974), France (Berge *et al.*, 1973), Holland (Sher, 1966), Belgium (Geraert, 1967), Germany (Weischer, 1975), New Zealand (Yeates, 1973), weeds in Brazil (Zem & Lordello, 1976), veld grasses, shrubs and ferns in South Africa (Van den Berg & Heyns, 1975), and bear’s bed (= mossy cushion) in Switzerland, type host and locality (Steiner, 1914). Taylor (1960) tested 127 plant varieties and found that 94 supported a population increase. Hosts included maize, oats, barley, rye, common and durum wheat and also sugarbeet, red clover, soybean and potato (but potato was reported as non-host by Overman *et al.*, 1971 and wheat as non-host by Dickerson *et al.*, 1978). *H. pseudorobustus* is known on maize in Iowa (Castaner, 1966), Illinois (Ferris & Bernard, 1971a), Indiana (McSorley, 1978), Kansas (Dickerson *et al.*, 1978), Nigeria (Caveness, 1973), Korea (Choi, 1975) and India (Swarup & Sethi, 1968), on sorghum in Florida (Overman *et al.*, 1971). Sorghum is a poor host in Kansas (Dickerson *et al.*, 1978) and England (Jones, 1979). Other hosts are: sugarcane in Cuba (Decker *et al.*, 1970), Venezuela (Siddiqui, 1974) and Fiji Islands (Van den Berg & Kirby, 1979); rice in Nigeria (Bridge, 1972), California (Siddiqui *et al.*, 1973) and Dominican Republic (Kermarrec & Belliard, 1977). Also reported on non-graminaceous plants, particularly soybean, in Illinois (Ferris & Bernard, 1971a), South Dakota & Iowa (*H. bradys*; Thorne & Malek, 1968), Iowa (Nyhan *et al.*, 1972), Kansas (Dickerson *et al.*, 1978), Mississippi and Louisiana (Rebois & Golden, 1978) and Indiana (Alby *et al.*, 1980); tomato, potato, eggplant, bell pepper in Spain (Romero & Arias, 1969); potato, tomato, garlic, carrot in Argentina (Vega & Galmarini, 1970); tomato, carrot, eggplant, bean, onion, potato, lettuce, melon, strawberry, parsnip and linseed in Nigeria (Bridge, 1972); tomato and carrot in Portugal (Abrantes *et al.*, 1978); bean, mulberry and potato in Korea (Choi, 1975), *Capsicum* spp. in Thailand (Pholcharoen & Boonduang, 1972); tobacco in Tennessee (Ponchillia, 1975) and Zaire (Ali *et al.*, 1973); bamboo, grape, sugarbeet, *Camellia*, *Philodendron*, banana in California (Siddiqui *et al.*, 1973); strawberry, lily, white clover and *Aeschynanthus* in Canada (Anderson, 1974); red clover in North Dakota (Donald & Hosford, 1980); grape in South Africa (Van den Berg & Heyns, 1975); cotton in USSR (Sumenkova, 1971); *Piper aduncum* in Fiji Islands (Van den Berg & Kirby, 1979); cowpea in Nigeria (Caveness, 1973); *Dioscorea* tubers in Nigeria (Bridge, 1973a); sweet potato in Malaysia (Sauer & Winoto, 1975); arrowroot in St. Vincent (Edmunds, 1969); rose in Texas (Sher, 1966) and Canada (Anderson, 1974); rose, gladiolus and carnation in Turkey (Geraert *et al.*, 1975); banana in Dominica (Edmunds, 1969); banana and plantain in Florida (McSorley, 1979). Cabbage is a poor host in Poland (Brzeski, 1971) and pea, flax and lucerne are reported as non-hosts by Taylor (1960) but lucerne is a host in Iran (Kheiri, 1972). Also observed associated with a number of trees, *Pinus virginiana* in Maryland and avocado in Israel (Sher, 1966), sycamore in Georgia (Churchill & Ruehle, 1971), oak and hickory in Iowa, boreal forest and tundra in New York, Vermont, New Hampshire and Maine, white pine in Minnesota and Wisconsin (Norton & Hoffmann, 1974), cottonwood in Canada (Anderson, 1974), *Castanea mollissima* in Italy (Mancini & Moretti, 1977), peach in South Africa (Van den Berg & Heyns, 1975), tea and orange in Iran (Kheiri, 1972), citrus in Nigeria (Bridge, 1972) and California (Siddiqui *et al.*, 1973), acacia, pine, poplar, persimmon, ginkgo, keaki in Korea (Choi, 1975), oil palm in Fiji Islands (Van den Berg & Kirby, 1979) and unnamed trees in South Dakota (*H. bradys*: Thorne & Malek, 1968) and Iowa (Norton & Hoffmann, 1974).

**BIOLOGY AND LIFE-HISTORY** Feeds semi-endoparasitically with its body half to two-thirds embedded in root tissues. Rarely females are found entirely inside cortical parenchymatous tissues of sycamore roots (Churchill & Ruehle, 1971), tomato (Bridge, 1972) and grape (Pinochet *et al.*, 1976). Eggs and newly hatched larvae occur around the females, slightly swelling cereal roots (Jones, 1978). Populations generally increase during the growing season of soybean in Illinois (Ferris & Bernard, 1971b) and maize in Iowa (Thomas, 1978). On sugarcane in Cuba, populations peak in August with active root development and decrease when the roots age (Razjivin *et al.*, 1974). In France, populations peak in October/November on pastures. The number of adults decreases in winter, over-wintering larvae maturing in April and reproducing in spring and early summer. One population peak occurs per year but all stages can be found in soil at all times (Berge *et al.*, 1973). In Iowa, it probably overwinters as eggs (Schmitt & Norton, 1972). The average population growth is 3.7 on maize and soybean in Iowa (Norton, 1977). Populations are very unevenly distributed on soybean in Indiana (Alby *et al.*, 1980). *H. pseudorobustus* prefers fine-textured soils with high percentages of silt and clay (Norton *et al.*, 1971; Ferris & Bernard, 1971b; Schield, 1972; McSorley, 1978). It is common in well drained areas in Iowa prairie (Schmitt & Norton, 1972). The largest populations occur at the summit of each toposequence studied (Nyhan *et al.*, 1972). Population level is correlated with soil moisture (McSorley, 1978), nematodes surviving better in moist than in dry soils (Rossner, 1972). It is less common in soils with low pH (4.5–6.9) (Norton & Hoffmann, 1974). Populations increase with the percentage of muck in pot experiments (Elmiligy & Norton, 1973) and decrease under high nitrogen levels (Castaner, 1966; Van Bezooijen, 1979).

**HOST-PARASITE RELATIONSHIPS** *H. pseudorobustus* feeds on pericycle, endoderm and cortex cells, but not on root tips. Cells physically disrupted during penetration become necrotic. Feeding occurs from one of a small group of cells around the head of the nematode. Slight swelling of the root around the females occurs due to the presence of eggs and newly hatched larvae (Jones, 1978). It is not considered to be a dangerous pathogen of tobacco in Tennessee (Ponchillia, 1975), of yams and cowpea in Nigeria (Bridge, 1973a, b),

of maize in Iowa (Norton *et al.*, 1978), nor of wheat in England (Jones, 1979). Pot inoculations failed to reduce root weight of soybean (McGawley & Chapman, 1976) and only the highest inoculum level (20,000) reduced root weight but not top weight of grape (Pinochet *et al.*, 1976). Other authors found it associated with, and partly responsible for, damage to crops: maize in India (Swarup & Sethy, 1968), grass and lawns in Maryland (Feldmesser & Golden, 1972; 1974) and Holland (Van Bezooijen, 1979), banana and plantain in southern Florida (McSorley, 1979). Pot experiments proved its pathogenicity to sycamore (Churchill & Ruehle, 1971), soybean (Elmiligy & Norton, 1973), cowpea (Amosu, 1976), maize (Norton, 1977) and grass (Van Bezooijen, 1979). It is generally considered a weak pathogen but may contribute to root necrosis and, along with other nematodes or pathogens, to yield reduction or crop failure.

**ASSOCIATIONS WITH OTHER PATHOGENS** Suspected of interacting with *Rosellinia* sp. to cause "burning disease" of arrowroot rhizomes in St. Vincent (Chaudhuri in Edmunds, 1969). It may also interact with *Fusarium nivale* on grass in Holland (De Leeuw & Vos in Van Bezooijen, 1979) but does not play a significant role in *Verticillium* wilt of cotton in USSR (Sumenkova, 1971).

**CONTROL** Controlled by 224.5 kg/ha of 10G prophos on lawns in Maryland (Feldmesser & Golden, 1972) and by 224.5 kg/ha of 10G ethoprop on lawns in New York (Feldmesser & Golden, 1974). Temik 15G and Counter 15G applied together in band treatments at 1 to 1.5 lb a.i./acre each reduced numbers on maize (Dickerson, 1978). Standak 75W was ineffective (Averre & Barker, 1980). Acetic, butyric, formic, lactic and propionic acids were nematocidal; fulvic and humic acids reduced reproduction in pots (Elmiligy & Norton, 1973). Populations are significantly lower under high levels of nitrogen in Iowa maize fields (Castaner, 1966), in pastures in Holland (Van Bezooijen, 1979) and in mulching experiments in Nigeria (IITA, 1976). Taylor (1960) showed no varietal resistance in most crops to *H. microlobus* (= *H. pseudorobustus*) but listed a few non-host plants. There are some differences in susceptibility but no significant resistance in maize and soybean cultivars tested in pot experiments (Norton, 1977). Control by cultural rotation is possible in Kansas under sorghum and wheat (Dickerson *et al.*, 1978), in England under wheat (Jones, 1979) and in Florida under potato (Overman *et al.*, 1971). However, in the last two instances, populations built up under post-culture fallow. Populations were significantly reduced under several Fabaceae, including peanut in Nigeria (Wilson & Caveness, 1980). Ploughing, compared to chisel-plough, offset disc, till-plant and no-tillage, lowers the populations of *H. pseudorobustus* (Thomas, 1978). The nematode is six times more abundant in non-tillage soils than in tillage soils in Nigerian maizefields (Caveness, 1974).

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R. FORTUNER  
California Department of Food and Agriculture  
Sacramento, California  
U.S.A.

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