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Morphological Variations in a Malaysian Population of *Tylenchorhynchus annulatus annulatus* n. Rank (Nemata: Belonolaimidae)[1]

Takayuki MIZUKUBO[2] and Yukio TOIDA[3]

[2]*Laboratory of Nematology and Soil Zoology, Department of Environmental Biology, National Institute of Agro-Environmental Sciences, Kannondai 3–1–1, Tsukuba, Ibaraki 305, Japan*

[3]*Eco-Physiology Research Division, Tropical Agriculture Research Center, Ohwashi 1–2, Tsukuba, Ibaraki 305, Japan*

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During a survey of the plant-parasitic nematodes associated with rice disease in Malaysia, Y. TOIDA collected a *Tylenchorhynchus* species from soil around paddy-field rice (*Oryza sativa* L.) with evident yellowing and dwarf symptoms. The specimens were first identified as *T. sacchari* SIVAKUMAR and MUTHUKRISHNAN, 1983, but after observation of more than 40 specimens, it became clear that some characters had variable states implying close affinity to *T. annulatus* (CASSIDY, 1930) GOLDEN, 1971. This threw doubt on the validity of the *T. sacchari* description, which was made on the basis of 12 specimens. In this paper, we will describe the Malaysian specimens and discuss the taxonomic status of *T. sacchari* and related species from observational evidence. Specimens examined were killed by gentle heat, fixed in TAF and mounted in dehydrated glycerin by the quick method of SEINHORST (1959).

Tylenchorhynchus annulatus annulatus n. rank (Figs. 1–28)

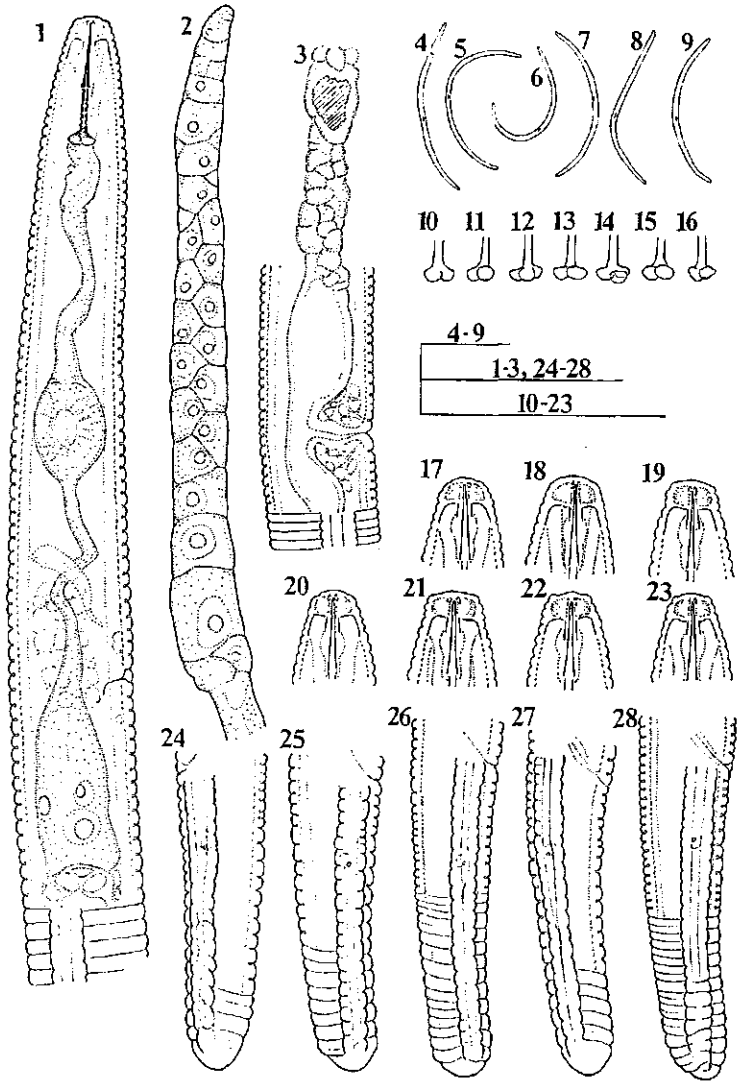
Measurements

Females (n=40): L=515–741 μm (mean 637 μm, SD 39); max body width=15.8–22.4 μm (19.6 μm, 1.07); a=26.9–36.8 (32.5, 2.22); b= 4.0–6.1 (5.0, 0.34); c=12.5–15.5 (13.8, 0.57); c′=2.9–4.5 (3.4, 0.26); V=51.2–57.2% (54.9%, 0.86); V′=55.1–61.7% (59.2%, 0.94); spear=16.2–18.5 μm (17.4 μm, 0.45: n=50); conus=8.6–9.9 μm (9.2 μm, 0.31: n=50); m=49.1–55.8% (52.8%, 1.49); MB=42.9–50.8% (47.0%, 1.55); E.P.=12.5–17.0% (14.8%, 0.77); tail/V–a=16.7–22.0% (19.2%, 1.09); G_1=19.8–31.7% (23.7%, 2.66); G_2=17.9–30.1% (22.8%, 2.50); esophagus=116–154 μm 127 μm, 5.9); anterior body end to median bulb=53–70 μm (60 μm, 3.6); excretory pore=82–106 μm (93 μm, 4.6); anterior body end to vulva=286–405 μm (349 μm, 22.7); vulva to anus=189–295 μm (242 μm, 19.2); tail=40–52 μm (46 μm, 3.0); phasmids to anus=6.6–17.2 μm (13.0 μm, 2.13); anterior gonad=120–196 μm (151 μm, 16.7); posterior gonad=106–188 μm (145 μm, 16.5); R_{ex}=51–60 (56, 3.0: n=10); RV_{an}=132–171 (145, 6.0: n=10); tail annules=18–35 (24.3, 2.66); annule width at esophagus=1.4–2.3 μm (1.9 μm, 0.21); annule width at mid-body=1.2–2.0 μm (1.6 μm, 0.19).

Description

Females (n=40): Body arcuate to open C when heat-relaxed (Figs. 4–9). Annules coarse and deeply expressed, often irregular in width. Lip region medium height, with 3 or 4 annules (2 specimens out of 40 show 2 lip annules), variable in shape Figs. 17–23), i.e. rounded (50%) or truncate (50%) anteriorly, continuous (78%) to or very slightly offset (22%) from body contour, 3.3 μm±0.34 (2.9–3.8) high, 7.2 μm±0.27 (6.6–7.6) wide. Labial framework lightly sclerotized extending down into body by 2 to 3 annules. Cephalids not seen. Spear moderately long, 2.4 times±0.11 (2.2–2.6) of head diameter; knobs of spear with variations

[1] Appl. Ent. Zool. **26** (3): 406–409 (1991)



Figs. 1–28. *Tylenchorhynchus annulatus annulatus* n. rank from Malaysia. Female. 1: Anterior body end; 2: Gonad showing double row of oocytes; 3: Vulval region showing empty spermatheca; 4–9: Body habitus; 10–16: Variation of spear knobs; 17–23: Variation of lip region; 24–28: Variation of tail. Scale bars: 4–9: 300 μm, 1–3, 24–28: 30 μm, 10–23: 30 μm.

(Figs. 10–16), sloping posteriorly (40%), flattened anteriorly (28%), broadly rounded (13%) or laterally directed (17%), slightly indented (2%), 4.0 μm±0.24 (3.3–4.5: n=30) wide, 1.7 μm±0.14 (1.5–2.0: n=30) high. Dorsal esophageal gland orifice at 2.4 μm±0.58 (1.7–3.4: n=8) from spear base. Metacorpus oval or offset posteriorly, 13.9 μm±1.31 (11.9–15.8: n=10) long, 10.1 μm±0.63 (8.9–11.3: n=10) across, occupying more than half of the corresponding body diameter; valve conspicuous. Isthmus slightly narrower than procorpus; basal bulb pyriform, lobed over intestine by short distances (3.7 μm±1.66 (1.3–7.3: n=26)). Excretory pore near isthmus, 73.7%±4.03 (65.1–

83.8) of esophageal length. Hemizonid lenticular, 2 annules long, immediately to 1 annule anterior to excretory pore; hemizonion 1 annule long, 6.0± 1.25 (2–8: n=10) annules posterior to excretory pore.

Gonad paired and symmetrically outstretched, with oocytes in single row (65%: n=43) or partially double row (35%) (Fig. 2). One female out of 43 with reflection of anterior gonad. Spermatheca empty, rarely observed (Fig. 3). Egg 39 μm long, 15 μm across (n=1). Vulva plane to or sunken in body; vagina tubular, perpendicular to body axis, 10.3 μm±1.03 (7.9–11.9: n=19) long or 53.5%±3.39 (47.5–60.0: n=17) of vaginal body diameter. Post anal intestinal sac absent.

Tail fairly uniform (Figs. 24–28), subcylindrical with smooth termini of hemispherical (71%: n=49) or subhemispherical (29%) shape; terminal hyaline part 5.7 μm±0.90 (4.6–7.9) thick. Phasmids large circular pouches beneath lateral fields with small aperture, which centered in lateral field at the anterior thirds of tail, i.e. 28.1%±3.86 (16.4–35.1) of tail length.

Lateral fields begin at the position of spear knobs, with 4 incisures from the median bulb; 6.0 μm± 0.63 (4.6–7.9) wide, i.e. 30.8%±2.22 (26.4–35.7) of the widest body diameter; inner 2 incisures on tails separated until the very end (61%: n=41) (Figs. 24, 25) or approaching behind phasmids and fused at posterior thirds of tail (32%) (Figs. 26, 27) or suddenly interrupted by aerolation at the posterior thirds of tail (7%) (Fig. 28); margins crenate throughout and partially incompletely areolated, ending shortly before tip.

Males: Unknown.

Specimens examined

Collected on 22, June, 1990 by Y. TOIDA from soil around paddy-field rice (*Oryza sativa* L.) at Seberang Perai, Penang, Malaysia. Specimens are deposited at the Herbarium and Insect Museum of the National Institute of Agro-Environmental Sciences, Tsukuba, Ibaraki, Japan.

DISCUSSION

The 4 incisures of lateral fields, smooth tail tip, broader tail tip of hemispherical or subhemispherical shapes, tail with at least 18 annules, spear at least 16 μm and at most 20 μm long and lip with 2 to 4 annules separates our specimens from all other *Tylenchorhynchus* species except *T. annulatus* (CASSIDY, 1930); *T. coffeae* SIDDIQI and BASIR, 1959; *T. crassicaudatus* WILLIAMS, 1960; *T. dactylurus* DAS, 1960; *T. digitatus* DAS, 1960; *T. elegans* SIDDIQI, 1961; *T. ewinigi* HOPPER, 1959; *T. goldeni* RASHID and SINGH, 1982; *T. punensis* KHAN and DAREKAR, 1979; *T. sacchari* SIVAKUMAR and MUTHUKRISHNAN, 1983; and *T. vadliensis* SAHA and KHAN, 1982. Some of these are further distinguished from our specimens by the following unique characters: *T. vadliensis*: conoid tail and plane margin of lateral fields; *T. coffeae*: only two lip annules; *T. crassicaudatus*, *T. dactylurus* and *T. digitatus*: longer spear of 20–21 μm long; *T. ewinigi* and *T. punensis*: presence of post anal intestinal sac.

The 2 bisexual species, *T. elegans* and *T. goldeni* (synonym of *T. elegans* according to FORTUNER and LUC, 1987) and the 2 parthenogenetic species, *T. annulatus* and *T. sacchari*, come close to our specimens. Except for *T. goldeni*, they may be diagnosed by the following characters: (A) lip apex shape; (B) contour between lip and body region; (C) number of lateral incisures below the middle of tail; (D) aerolation of lateral fields; (E) size of egg; (F) presence or absence of males. The states of these characters were coded as follows for categorization: A: 1=rounded (Figs. 17, 18, 20), 2= truncate (Figs. 19, 21–23); B: 1= continuous (Figs. 17, 18, 20–23), 2=slightly offset (Fig. 19); C: 1=four (Figs. 24, 25), 2=three (Figs. 26, 27), 3=disappearing (Fig. 28); D: 1=non (Fig. 26), 2=incomplete (Figs. 24, 25, 27, 28); E: 0=unknown, 1=about 40 μm long, 2=about 50 μm long, 3=about 70 μm long); F: 1=present, 2= absent. The distribution of character-states are indicated for *T. annulatus* as A(1), B(2), C(1), D(2), E(2), F(2); for *T. elegans* as A(1), B(1), C(1–2), D(1), E(3), F(1); for *T. goldeni* as A(1), B(1), C(1), D(2), E(0), F(1); for *T. sacchari* as A(2), B(1), C(2), D(2), E(0), F(2) and for our Malaysian specimens as A(1–2), B(1–2), C(1–2–3), D(1–2), E(1), F(2).

The highly variable character-states in Malaysian specimens show that this population can relate to both *T. annulatus* and *T. sacchari*. The latter was diagnosed by the 3 lateral tail lines which are often observed in Malaysian specimens and were also reported for *T. elegans* from India, although the authors took this species for *T. mashhoodi* (GUPTA and UMA, 1985). The offset lip of *T. annulatus*, which has been weighted as a diagnostic character-state (HOOPER, 1978: TARJAN, 1973), is often difficult to distinguish from the continuous

state (SIDDIQI, 1976). The shape of the lip region was also variable in the comparative study of *T. claytoni* populations (GOLDEN et al., 1987). These facts indicate that Malaysian specimens and *T. sacchari* are identical with *T. annulatus* even at the subspecies level. Unless lip shape is critical as noted above, *T. elegans* is not fully independent of *T. annulatus* except in its larger eggs, difference in body habitus and absence of males, which may not be critical between very similar species. *T. goldeni* has been synonymized with *T. elegans*, an acceptable action taking character variations into account. *T. goldeni*, however, is unique among the 4 species discussed here because of its somewhat larger V-value (55–59%) and smaller number of lip annules (2–3). All 4 species should be combined into a single species, *T. annulatus*, and placed under the following subspecific ranks:

Tylenchorhynchus annulatus annulatus n. rank
Syn. *Tylenchorhynchus annulatus* (CASSIDY, 1930) GOLDEN, 1971; *Tylenchorhynchus martini* FIELDING, 1956; *Tylenchorhynchus sacchari* SIVAKUMAR and MUTHUKRISHNAN, 1983, new synonym.

Tylenchorhynchus annulatus elegans n. rank
Syn. *Tylenchorhynchus elegans* SIDDIQI, 1961

Tylenchorhynchus annulatus goldeni n. rank
Syn. *Tylenchorhynchus goldeni* RASHID and SINGH, 1982

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Antennal Single Sensillum Responses to Sex Pheromone in Male Beet Armyworm, *Spodoptera exigua*, HÜBNER (Lepidoptera: Noctuidae)[1,2]

Fumiaki MOCHIZUKI[3] and Tatsuaki SHIBUYA[4]

[3]*Speciality Chemicals Research Center, Shin-Etsu Chemical Co. Ltd., Niigata 942, Japan*
[4]*Institute of Biological Sciences, University of Tsukuba, Tsukuba, Ibaraki 305, Japan*

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The beet armyworm, *Spodoptera exigua*, HÜBNER, is a severe pest of vegetable and ornamental crops in Japan. It has been reported that a mixture of (*Z,E*)-9,12-tetradecadienyl acetate (Z9,E12-14:Ac) and (*Z*)-9-tetradecen-1-ol (Z9-14:OH) is attractive to male beet armyworms of a Japanese population (WAKAMURA, 1987). Neurophysiological methods recording an electroantennogram and a single sensillum response are usually used to examine antennal reception of pheromones (KRAMER and HEMBERGER, 1987). In particular, the single sensillum recording method gives an insight into how males accept pheromone components.

The male antenna of the beet armyworm is equipped with specific olfactory sensilla (about 100 μm long with spiral ridges on their surface), which are named Type I trichodea and are thought to be responsible for pheromone reception (MOCHI-

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