

Four New Species of the Genus Hemicriconemoides (Nematoda: Criconematidae)¹

J. PINOCHET and D. J. RASKI²

Abstract: Four new species of the genus *Hemicriconemoides* (*H. californianus* n.sp., *H. taiwanensis* n.sp., *H. annulatus* n. sp., and *H. nitida* n.sp.) are described. The range of total length of *H. mangiferae* is increased on the basis of specimens collected in Israel. Observations on *H. mangiferae* and *H. litchi* support the validity of *H. litchi* as distinct from *H. mangiferae*. *Key Word:* taxonomy.

The genus *Hemicriconemoides* was proposed by Chitwood and Birchfield in 1957 (2) with *H. wessoni* Esser, 1960 (7), designated

as the genotype. Many new species were added to the genus before a major taxonomic work was done by Dasgupta et al. in 1969 (4). In the revision of the genus five new species (*H. parvus*, *H. intermedius*, *H. microdoratus*, *H. insignis* and *H. brevicaudatus*) were added, bringing the total number of species to 16. In 1970, Germani and Luc (8) made another study of the genus, and described one more species, *H. affinis*. They also removed *H. communis* Edward and Misra, 1965, and *H. litchi* Edward and Misra, 1965 (5), from

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²Respectively, Research Assistant and Professor of Nematology, Department of Nematology, University of California, Davis 95616.

synonymy and synonymized *H. microdoratus* with *H. cocophillus* Loos, 1949 (10). Since then, four new species have been added, *H. sacchariae* Heyns, 1970 (9), *H. mehdii* Suryawanshi, 1971 (13), *H. varionodus* Choi and Geraert, 1972 (3), and *H. gabrici* (Yeates, 1972) Raski, 1975 (15 and 11). In this present study the description of four new species are presented, thus bringing the total number of species in this genus to 26.

MATERIALS AND METHODS

Specimens of *Hemicriconemoides* from the University of California, Davis, and the Riverside Nematode Survey Collections (U.C.N.S.C., Davis or Riverside) were assembled for this taxonomic study. Four new species described include representatives from North America, South America, and Asia.

The majority of these specimens were already mounted in dehydrated glycerin, but the exact procedures followed in fixation are not known. The specimens of *H. californianus* were obtained from mass collections stored in 5% formaldehyde solution. These were transferred to FAA, then to 2.5% glycerin in 30% alcohol, and finally to 5% glycerin in 30% alcohol. The last solution was allowed to evaporate in BPI dishes, then later placed in a desiccator for 2 weeks before mounting.

Besides the symbols of the De Manian formula, the following symbols are used: V' = distance from the vulva to terminus expressed in μm ; R = total number of body annules; R_{ex} = annule on which excretory pore is located, counting from the anterior end; R_v = annule on which vulva is located counting from terminus; R_{van} = number of annules between vulva and anus; VL/VB = distance in μm from vulva to terminus divided by body diam at vulva. The first number after symbol represents the average. Measurements in parentheses indicate population range. Lip region: anterior part of nematode to basal ring of cephalic framework and composed of the first 2-3 annules. Oral plate: anterior part of lip region where oral aperture is located. Annule diam: length of a straight line passing through the center of an annule in cross section. Annule width: dimension of an annule measured at right angles to its diam.

Hemicriconemoides californianus n.sp.

Fig. 1(A to H)

Paratypes (10 females): $L = .44$ mm (.41-

.46); $a = 17$ (16-19); $b = 4.1$ (3.4-4.6); $c = 21$ (17-25); $V = 91$ (90-92); $V' = 39$ μm (33-44); $R = 119$ (112-127); $R_{\text{ex}} = 35$ (34-37); $R_v = 11$ (10-12); $R_{\text{an}} = 5$ (4-6); $R_{\text{van}} = 6$ (5-6); stylet = 80 μm (77-83); prorhabdion = 70 μm (67-73); $VL/VB = 1.7$ (1.3-1.8).

Holotypes (female): $L = .45$ mm; $a = 17$; $b = 4.1$; $c = 25$; $V = 92$; $V' = 36$ μm ; $R = 116$; $R_{\text{ex}} = 34$; $R_v = 11$; $R_{\text{an}} = 5$; $R_{\text{van}} = 6$; stylet = 83 μm ; prorhabdion = 73 μm ; $VL/VB = 1.3$.

Cuticular sheath attached to body at anterior end, vulva, and tail. On some paratypes cuticular sheath attached on tail, in others well separated from tail. Body narrows slightly anteriorly. Lip region truncate, with two annules, first annule slightly smaller in diam than second. In some paratypes, first and second annule same diam. Oral plate elevated and rounded. Annules 4-5 μm wide at mid-body. Stylet knobs anchor-shaped, small, 5-6 μm across. Vulvar sheath lacking. Diameter of sperm cell in spermatheca 2-3 μm . Body diam distinctly narrower immediately posterior to vulva. Tail broadly conoid with bluntly rounded terminus.

Paratypes (8 males): $L = .44$ mm (.38-.47); $a = 25$ (22-28); $b = 4.0$ (3.6-4.8); $c = 17$ (14-18); $T = 32$ (30-36); spicule = 24 μm (22-25); gubernaculum = 5 μm (3-6).

Allotype (male): $L = .45$ mm; $a = 27$; $b = 3.7$; $c = 16$; $T = 34$; spicule = 25 μm ; gubernaculum = 5 μm .

Lip region continuous, not set off. Lateral field indistinct. Testis packed with large rounded sperm cells 2-3 μm in diam. Spicules arcuate. Caudal alae rudimentary, almost indistinct, with crenate margin. Tail convex-conoid, with last 5-6 annules narrowing abruptly.

Holotype: Female collected by R. V. Schmitt, April 1973, slide 1389, U.C.N.S.C., Davis, California.

Allotype (male): Same data as holotype, slide 1390, U.C.N.S.C., Davis, California.

Paratypes (108 females, 6 males): Same data as holotype distributed as follows: 79 females, 2 males U.C.N.S.C., Davis; 12 females, 2 males Plantenziektenkundige Dienst, Wageningen, The Netherlands; 12 females, 2 males U.S. Department of Agriculture, Nematode Collection (U.S.D.A.N.C., Beltsville, Maryland) Beltsville, Maryland; 2 females National Nematode Collection, Indian Agricultural Research Institute (I.A.R.I.), New Delhi, India; 3 females Nematology Department,

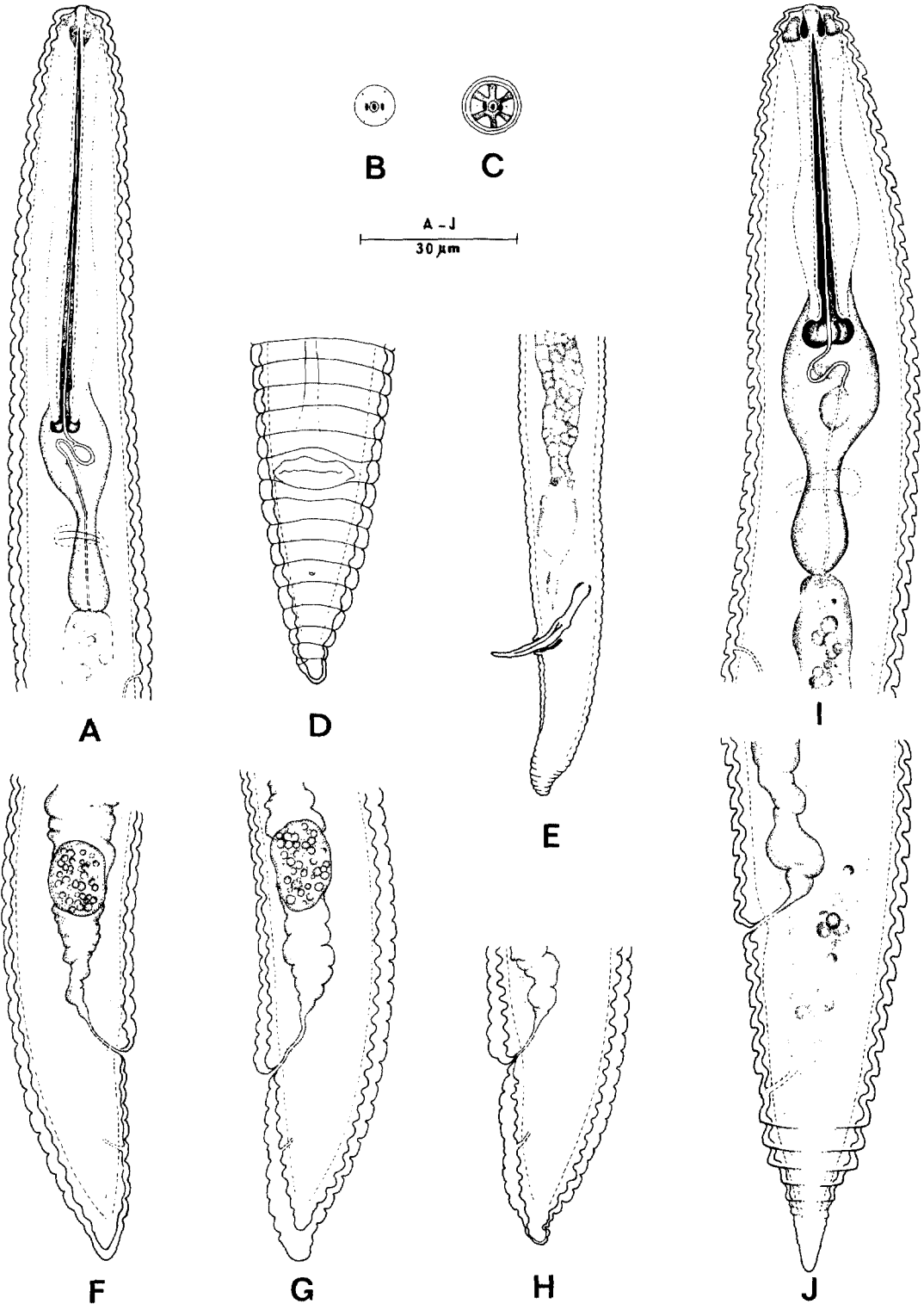


FIG. 1 (A-H). *Hemicriconemoides californianus* n.sp. A) Female, anterior region; B-C) Female, face view; D) Female, tail in ventral view; E) Male, tail region; F-H) Female, posterior region. I-J. *Hemicriconemoides taiwanensis* n.sp. I) Female, anterior region; J) Female, posterior region.

Rothamsted Experimental Station, Harpenden, England.

Type habitat and locality: Soil about roots of grape, *Vitis vinifera* L., 1753, on University of California campus, Davis, California.

Diagnosis: *Hemicriconemoides californianus* is closely related to *H. varionodus* Choi & Geraert, 1972 (3), *H. chitwoodi* Esser, 1965 (7), and *H. gaddi* Loos, 1949 (10). It is differentiated from *H. varionodus* by its smaller stylet, 80 μm (77-83) vs. 84-90 μm for *H. varionodus*; greater number of body annules, 119 (112-127) vs. 102-112; and shape of stylet knobs, anchor-shaped in *H. californianus* and variable, mostly rounded with flattened, posterior sloping knobs in *H. varionodus*.

H. californianus differs from *H. chitwoodi* by lip region having first annule same size or smaller than second annule. In *H. chitwoodi*, first annule is larger than second. Tail shape in *H. californianus* is more broadly conoid with bluntly rounded terminus. *H. chitwoodi* has a conoid tail gradually tapering to slender conoid outline, with finely rounded terminus. *H. californianus* has the anus on the 4-6th annule from the terminus (8-10th in *H. chitwoodi*).

H. gaddi differs from *H. californianus* in having a continuously rounded head shape, first annule always much smaller than second annule.

H. californianus has been identified also from: grass, El Quisco, Provincia de Valparaiso, Chile; from oak soil, Sycamore Canyon Road, Santa Barbara, California, and Bolinas Bay, Marin County, California; from willow, San Diego County, California; from alder, Butte Creek, Butte County, California; from grassy sod beneath black walnut, Cordelia, Solano County, California; from macadamia, Santa Barbara, Santa Barbara County, California; from grape, Lodi, San Joaquin County, California, and Beaulieu Vineyards, Oakville, Napa County, California.

Hemicriconemoides taiwanensis n.sp.

Fig. 1-(I to J)

Paratypes (3 females): L = .60 mm (.59-.61); a = 18 (17-19); b = 5.4 (5.3-5.5); c = 17 (16-20); V = 89 (87-89); V' = 66 μm (64-67); R = 152 (146-158); R_{ex} = 36 (34-37); R_v = 14 (13-16); R_{an} = 6 (5-6); R_{van} = 8 (7-10); stylet = 60 μm (58-62); VL/VB = 2.1 (2.0-2.3).

Holotype (female): L = .61 mm; a = 17; b = 5.3; c = 20; V = 89; V' = 67 μm ; R = 149; R_{ex} = 34; R_v = 13; R_{an} = 5; R_{van} = 8; stylet = 60 μm ; VL/VB = 2.0.

Cuticular sheath attached to body at anterior end, vulva and tail. Body narrows regularly towards anterior end, which has a rounded outline. Oral plate slightly elevated. First labial annule smaller in diam than second. Annules 4-5 μm wide at mid-body and oriented posteriad. Stylet knobs massive, 9-11 μm across, and rounded. Vulvar sheath lacking. Tail shape conoid, diminishes evenly to 4-5th annule from terminus, then narrows abruptly in diam, and again tapers regularly towards terminus. These same body annules (4-5 from terminus) also become less conspicuous, followed by long terminus with roughened edges and rounded tip.

Male: Unknown.

Holotype (female): Collected 1 May 1968, slide 1388, U.C.N.S.C., Davis.

Paratype (3 females): Same data as holotype, deposited as follows: 1 male each at U.C.N.S.C., Davis, California; Plantenziektenkundige Dienst, Wageningen, The Netherlands; and the National Nematode Collection, I.A.R.I., New Delhi, India.

Type habitat and locality: Grass from park soil in Taiwan.

Diagnosis: *Hemicriconemoides taiwanensis* is most closely related to *H. strictathecatus* Esser, 1960 (7), and differs from this species in its shorter stylet, 60 μm (58-62) vs. 79 μm (73-83) for *H. strictathecatus*. *H. taiwanensis* also shows posteriorly orientated body annulation lacking in *H. strictathecatus*.

Hemicriconemoides annulatus n.sp.

Fig. 2-(A to C)

Paratypes (10 females): L = .52 mm (.47-.56); a = 15 (13-17); b = 5.5 (5.0-6.3); c = 17 (15-18); V = 94 (93-95); V' = 32 μm (27-38); R = 91 (85-94); R_{ex} = 23 (19-25); R_v = 8; R_{an} = 8; R_{van} = 0; stylet = 57 μm (54-60); prorhabdion = 46 μm (44-49); VL/VB = 1.2 (1.0-1.4).

Holotype (female): L = .56 μm ; a = 15; b = 5.6; c = 18; V = 94; V' = 38 μm ; R = 94; R_{ex} = 23; R_v = 8; R_{an} = 8; R_{van} = 0; stylet = 59 μm ; prorhabdion = 47 μm ; VL/VB = 1.2.

Cuticular sheath attached to body at anterior end and tail, well separated around vulva. Body narrowing slightly towards anterior end, having rounded, almost

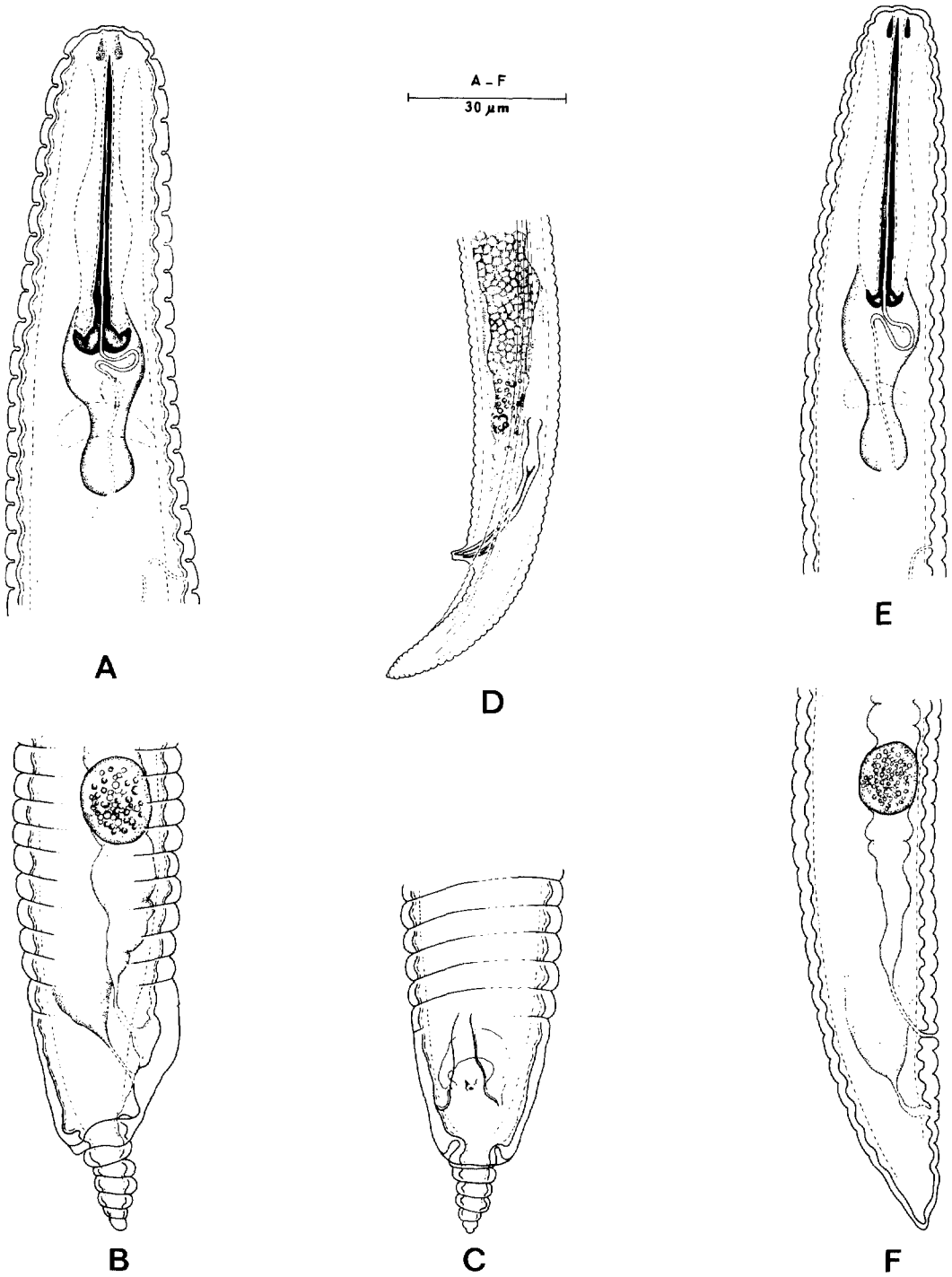


FIG. 2 A-C. *Hemicriconemoides annulatus* n.sp. A) Female, anterior region; B) Female, posterior region; C) Female, tail in ventral view; D-F. *Hemicriconemoides nitida* n.sp. D) Male, tail region; E) Female, anterior region; F) Female, posterior region.

hemispherical, lip region with two rounded annules, the first smaller than the second. Oral plate flat on anterior surface. Deep indentation lacking after first annule, but present after second. Annules 6-8 μm wide at mid-body, always rounded. Stylet knobs anchor-shaped, massive, 10-11 μm across. Large vulvar sheath. Body annules prominent up to eighth annule from terminus which is wide and smooth. On this annule vulva and anus are present. As this broad annule narrows posteriad in funnel shape equivalent to the fusion of 5-6 annules, a unique, very pronounced, annulated tail with cuticular sheath well attached appears; terminus rounded.

Male: Unknown.

Holotype (female): Collected by C. I. Hannon in 1958, Slide 1398, U.C.N.S.C., Davis, California.

Paratypes (26 females): Same data as holotype distributed as follows: 20 females U.C.N.S.C., Davis; 2 females Plantenziektenkundige Dienst, Wageningen, The Netherlands; 2 females U.S.D.A.N.C. Beltsville, Maryland; 1 female National Nematode Collection, I.A.R.I., New Delhi, India; 1 female Nematology Department, Rothamsted Experimental Station, Harpenden, England.

Type habitat and locality: St. Augustine grass, *Stenotaphrum secundatum* (Walt.) Kuntze, 1891, at Crago Sod farm, 8 miles south of South Bay, Florida.

Diagnosis: *Hemicriconemoides annulatus* is most closely related to *H. wessoni*, from which it can be distinguished by its wide, funnel-shaped 8th annule from terminus, posterior to which is a chain-like annulated tail with sheath firmly attached. The tail of *H. wessoni* has a conoid shape tapering abruptly behind anus with sheath well separated. Annules of *H. annulatus* measure 6-8 μm in width and are rounded as compared to those of *H. wessoni* which are 4-5 μm and somewhat flattened.

H. annulatus also has been collected from St. Augustine grass, *S. secundatum*, near Lake Florence, Winter Haven, Florida; Logan 851 S.W. 64th Terr., Fort Lauderdale, Florida; and from soil about roots of tangelo (*Citrus paradisi* \times *C. reticulata*) Fruitland, Sarasota, Florida.

Hemicriconemoides nitida n.sp.

Fig. 2-(D to F)

Paratypes (10 females): L = .42 mm (.40-.44); a = 14 (14-15); b = 4.4 (4.0-4.6); c = 18 (13-22); V = 90 (89-91); V' = 41 μm (38-45); R = 93 (88-98); R_{ex} = 27 (25-32); R_v = 9 (8-11); R_{an} = 4 (3-5); R_{van} = 5 (4-5); stylet = 55 μm (53-58); prorhabdion = 47 μm (44-48); VL/VB = 1.7 (1.7-1.9).

Holotype (female): L = .44; a = 15; b = 4.5; c = 19; V = 90; V' = 45 μm ; R = 93; R_{ex} = 26; R_v = 10; R_{an} = 4; R_{van} = 6; stylet = 58 μm ; prorhabdion = 48 μm ; VL/VB = 1.7.

Cuticular sheath attached to body at anterior end and vulva, slightly separated on tail. On some paratypes cuticular sheath well separated from tail. Body narrowing slightly towards anterior end having rounded-truncate lip region. First annule smaller in diameter than second. Oral plate slightly elevated. Annules 4-5 μm wide at mid-body. Stylet knobs anchor-shaped, 6-8 μm across. Vulvar sheath lacking. Diameter of sperm cell in spermatheca 1 μm across. Tail conoid with annulation becoming indistinct towards terminus.

Paratypes (3 males): L = .41 mm (.39-.42) mm; a = 23 (21-24); b = 5.4 (4.8-6.0); c = 14 (13-14); T = 25 (24-26); spicule = 31 μm (30-32); gubernaculum = 7 μm .

Allotype (male): L = .42; a = 24; b = 5.4; c = 14; T = 26; spicule = 32 μm ; gubernaculum = 7 μm .

Lip region continuous. Lateral field with 4 incisures. Spicules arcuate and finely pointed. Caudal alae rudimentary with crenate margin beginning slightly anterior to cloaca and ending in middle portion of tail.

Holotype (female): Collected by S. A. Sher, September 10, 1973, slide 1396, U.C.N.S.C., Davis.

Allotype (male): Collected same date as holotype, slide 1397. U.C.N.S.C., Davis.

Paratypes (11 females, 2 males): Same data as holotype, deposited as follows: 9 females, 1 male at U.C.N.S.C., Davis; 1 female, 1 male Plantenziektenkundige Dienst, Wageningen, The Netherlands; 1 female U.S.D.A.N.C., Beltsville, Maryland.

Type habitat and locality: Weed soil by elm, west bank of Mississippi River, Brooklyn Park, Minneapolis, Minnesota.

Diagnosis: *Hemicriconemoides nitida* is related to *H. gaddi*, *H. varionodus*, and *H. californianus* n.sp., but differs from all three species by its shorter stylet, 55 μm (53-58), fewer total annules, 93 (88-98) and fewer annules from vulva to terminus, 9 (8-11).

DISCUSSION

H. californianus was studied and identified by Chang and Raski (1) as *H. chitwoodi*. They reported this nematode reproduced on grape seedlings, *Vitis vinifera* 'Thompson Seedless', *Vitis rupestris* Scheele, 1848, and grapevine hybrid 1613 (*Solonis* × *Othello*). It did not reproduce on *Camellia japonica* L., 1753, *Wisteria* or *Cycas* leading to the conclusion it was a biotype different from typical *H. chitwoodi*. The original source of that population was the same as the type host and locality for *H. californianus*. *H. chitwoodi* has also been mistakenly identified as *H. gaddi* from camellia in Louisiana and Georgia (14).

A population of 10 females from St. Helena, California, reported as *H. mangiferae* Siddiqi, 1961 (12) by Dasgupta et al. (4), should be correctly classified as *H. californianus*.

In the course of this work, many collections of *Hemicriconemoides* spp. were observed. *H. mangiferae* was found to be one of the most common species. The specimens conform closely with earlier descriptions of *H. mangiferae* (6, 7, 12), except for six specimens recently collected on date, *Phoenix dactylifera* Linn., 1753, from Hamam Mussa, South Sinai, Israel. These females measured .65 (.63-.67) mm in total length, whereas the total range is .41-.61 mm in various collections from different parts of the world. In all other respects, these specimens fit the description of *H. mangiferae*, thus extending range of its length to .41-.67 mm.

The original description of *H. mangiferae* (12) reports the female tail as conoid, but some paratypes are described and illustrated with bluntly rounded tail. The females of *H. litchi* Edward and Misra, 1963 (5) are described as having bluntly rounded tails, but are distinguished from *H. mangiferae* by the smaller number of body annules, shorter stylet, and position of vulva and anus in the female of *H. litchi* and number of incisures in lateral field of the male (2 for *H. litchi*, 4 for *H. mangiferae*).

Dasgupta et al. (4) considered *H. litchi* to be a synonym of *H. mangiferae*. Afterwards Germani and Luc (8) reported three females from Ghana to have characteristics very similar to *H. litchi*, including blunt rounded tail, 115-128 body annules, stylet = 67-68 μm , and $R_v = 11-13$. They concluded *H. litchi* to be a valid species, distinct from *H. mangiferae*.

Six collections of female specimens from four different countries were examined in this study, and appear to be similar to those studied by Germani and Luc (8). The tail shape is bluntly rounded with incisures around the terminus resulting in a crenate margin. Body annules range from 111-133, $R_v = 10-12$, and stylet = 51-73 μm . These were collected from *Theobroma cacao* L., 1753, at Espirito Santo and at Belmonte, Brazil; Langan soil, Lampang, Thailand; bamboo, Marikina, Luzon, Philippines; and *Theobroma cacao*, Tumero, Aragua, Venezuela.

In addition to the Israel collection reported above, females of *H. mangiferae* were identified from mango in two localities in the Plateau Province of Nigeria, and from banana, Chiangmai, Thailand. These have 131-158 body annules, $R_v = 12-16$, stylet = 71-79 μm , and conoid tail shape.

One collection of females from grass soil near Puerto Vallarta, Mexico, is similar to *H. mangiferae* in having 134-150 body annules, $R_v = 12-13$, and stylet = 75-78 μm . However, these have a bluntly rounded tail shape as in *H. litchi*. Siddiqi (13) described conoid and bluntly rounded tail shapes in the paratypes of *H. mangiferae*. It would seem that tail shape is not as reliable a character to distinguish *H. litchi* and *H. mangiferae* as are body annule count and length of stylet. Unfortunately, males are uncommon, and consequently it is not possible to confirm the number of incisures in the lateral field of males which would be very helpful in distinguishing these species.

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