

Revision of the Genus *Hemicriconemoides* Chitwood & Birchfield, 1957 (Nematoda: Criconematidae)

D. R. DASGUPTA,¹ D. J. RASKI¹ AND S. D. VAN GUNDY²

Abstract: In the present study, evaluations of the nominal species and descriptions (*H. parvus*, *H. intermedius*, *H. insignis*, *H. microdoratus* and *H. brevicaudatus*) are made of five new species. *H. squamosus* is proposed as a *species inquirenda*; *H. mangiferae* is judged a valid species. *H. litchi* and *H. birchfieldi* are synonymized with *H. mangiferae* and *H. ureshinoensis* with *H. kanayaensis*. *H. strictathecatus* is considered a valid species. A key to the species of the genus is given. The limitation of use of male diagnostic characters in a mixture of populations of *Hemicriconemoides* with some other criconematids is discussed. The life cycle of *H. chitwoodi* has four complete molts; one in the egg, three in soil, two of which have spines. The adult female has a sheath cuticle from an incomplete fifth molt.

Chitwood and Birchfield (2) proposed the genus *Hemicriconemoides* to include those species "which fit neither the present concepts of *Criconemoides* Taylor, 1936 nor that of *Hemicycliophora* de Man, 1921." Three species (*Hemicriconemoides wessoni*, *H. biformis* and *H. floridensis*) were described by these authors and *H. wessoni* was made genotype. Three species, identified and described as members of the genus *Criconemoides* by Loos (12), were transferred to the new genus (2). Since then, eleven new species have been described: *H. chitwoodi*, *H. minutus* and *H. strictathecatus* by Esser (9); *H. kanayaensis* by Nakasono & Ichinohe (13); *H. mangiferae* by Siddiqi (15); *H. obtusus* by Colbran (4); *H. communis* and *H. litchi* by Edward & Misra (7); *H. ureshinoensis* by Yokoo (20); *H. pseudobrachyurum* by De Grisse (5) and *H. birchfieldi* by Edward *et al.* (8).

Goodey (11) placed the genus *Hemicriconemoides* in synonymy with *Hemicycliophora*. Siddiqi & Goodey (16) resurrected the genus again. *Iota squamosus* Cobb, 1913 (3) was considered to be a member of *Hemicriconemoides* by Siddiqi & Goodey (16), and they synonymized *H. mangiferae*

and *H. strictathecatus* with *squamosus*. One of the generic characters of *Hemicriconemoides* and *Hemicycliophora* given by Siddiqi & Goodey (16) is: "spear base anchor-shaped" in *Hemicriconemoides* and "basal knobs of spear spheroid" in *Hemicycliophora*. On the basis of this difference in knob shape, *Hemicriconemoides biformis* and *H. floridensis* were proposed to be removed from *Hemicriconemoides* and placed in *Hemicycliophora*.

In the present study, evaluations of the nominal species and descriptions of five new species are presented. A brief description of the developmental stages of *H. chitwoodi* is also included.

The authors wish to extend their thanks to Mr. R. P. Esser for providing some of the paratypes and other collections of *Hemicriconemoides* for this study. We also acknowledge the help of Dr. S. A. Sher for making available the collections of *Hemicriconemoides* in the Department of Nematology at the University of California, Riverside.

MATERIALS AND METHODS

Nematodes in the nematode survey collections at Davis and Riverside were assembled for this generic study. These specimens include representatives from six continents:

Received for publication 8 October 1968.

¹ Department of Nematology, University of California, Davis, California 95616, and ² Department of Nematology, University of California, Riverside, California 92502. Present address of senior author: Division of Nematology, Indian Agricultural Research Institute, New Delhi-12, India.

North America, South America, Asia, Australia, Africa and Europe.

Some of the symbols used by De Grisse (6) are added to the deManian formula. These are: R = total number of sheath annules; R ex = annule on which excretory pore is located, beginning from anterior end; R V = annule on which vulva is located, counting from terminus; R an = annule on which anus is located, counting from terminus; R Van = number of annules between vulva and anus; VL/VB = distance from terminus to vulva divided by body width at vulva; V' = length of body from vulva to terminus in microns. The measurements given within parentheses in the description of each holotype refer to the population range. The annule counts were made on the ventral side of body. No attempt was made to describe males in those populations which contained a mixture of *Hemicriconemoides*, *Criconemoides*, *Paratylenchus* and *Criconema*.

Slides of type specimens are deposited at UCNC (University of California Nematode Collection, Davis, California) and USDANC (United States Department of Agriculture Nematode Collection, Beltsville, Maryland).

MORPHOLOGY

Species in the genus *Hemicriconemoides* vary in length from 0.29–0.63 mm. Fixed specimens are straight or slightly curved ventrally. The adult females of *Hemicriconemoides* have double cuticles; according to Fassuliotis (10) in *H. chitwoodi* the outer or sheath cuticle represents an incomplete fourth molt. However, the present study of developmental stages of this species indicated four complete molts and an incomplete fifth molt. Therefore, the sheath cuticle of *Hemicriconemoides* is an incomplete fifth-molt cuticle. Except for *H. obtusus*, in which the cuticular sheath is closely appressed to the inner cuticle throughout the entire length of

body, the cuticular sheath is closely appressed to the inner cuticle only at the head, the vulva and sometimes at the terminus. A lateral field is lacking. Timm (17) reported longitudinal lines on the cuticle of *H. litchi*. Examination of specimens from Nigeria identified as *H. mangiferae*, specimens from Ceylon identified as *H. gaddi* and specimens from the same locality and habitat from where *H. litchi* was reported by Timm (17), revealed the presence of very faint longitudinal lines which could only be seen with very careful observation. These lines appeared to be subcuticular rather than cuticular. The annules of the sheath and body are 2–8 μ wide in the middle of the body, usually smoothly flattened in the sheath and rounded on the body (not retrorse) and their number varies from 51 to 164.

The adult males lack a cuticular sheath. The lateral field of the males usually has four incisures, although only two lines have been reported in *H. gaddi*. Of the four incisures, the outer two lines are more prominent than the two fine inner lines. Occasionally males are found within larval cuticles bearing twelve rows of lobed, scale-like or conoid spines. The cuticular spines in the larvae of *H. pseudobrachyurum* bear dentations on their edges.

LIP REGION: The lip region of *Hemicriconemoides* is markedly conoid (*H. kana-yaensis*), rounded (*H. gaddi*) or truncate (*H. chitwoodi*). The oral aperture is obscure and appears to be a simple narrow slit. There is wide variation in shape and extent of development of the labial disc between species. In some species the labial disc is conspicuous and elevated, surrounding the oral opening, while in other species it is inconspicuous. In lateral view the labial disc appears more or less circular in form, rounded or flattened at the top. In *en face* view the labial disc appears to be hexagonal or quadrangular in shape. In *H. cocophyllus*,

besides the labial disc, there is a well-developed amphidial disc surrounding the labial disc. The amphid apertures are prominent, appearing as narrow darkened slits on the lateral margin of the labial disc of the amphidial plate. The sclerotization of the lip region is hexaradiate, widening at the base. The papillae are not identifiable, but there is a suggestion of fine internal innervations in the sublateral and lateral sectors.

LABIAL ANNULES: Labial annules are similar to body annules but are not definitely set off. The base of the sclerotized labial framework is used to distinguish the demarcation between the body and labial regions, and the labial annules are counted to that point. The lip region of *H. obtusus* is an exception since the labial annules are definitely set off. Basically there are two labial annules, which vary considerably in shape and size. Within one population of *H. cocophillus*, most of the individuals have two well-developed labial annules, an occasional specimen may have three, while others show almost complete suppression of the first labial annule. Usually the first annule is smaller than the second (e.g., *H. mangiferae*), but the reverse is true for some species (e.g., *H. chitwoodi*). The first annule may be angular or rounded, and is irregularly hexagonal when seen in *en face* view.

STYLET: The prorhabdion is 75 to 90% of the total stylet length. The knobs are massive, 5–11 μ across and anchor-shaped; they bear prominent forward-directed processes, with the exception of *H. strictathecatus*, which has rounded knobs.

ESOPHAGUS: The esophagus of *Hemicriconemoides* is typically criconematoid. The dorsal gland orifice is located about 5–9 μ posterior to the base of the stylet knobs.

REPRODUCTIVE SYSTEM: The adult females of *Hemicriconemoides* have a monodelphic, prodelphic and outstretched reproductive system. Only two specimens were found with a single flexure in the gonad anterior to the spermatheca. The vulva is at 88–96% and a vulvar sheath may be present or absent. The vulvar sheath may be narrow and very fine (e.g., *H. microdoratus*) or broad and formed of two to three annules (e.g., *H. brachyurus*). In some species a vulvar sheath is present both in the sheath cuticle and in the inner body cuticle (e.g., *H. brachyurus*), while another has the vulvar sheath only in the sheath cuticle (*H. microdoratus* n. sp.). In ventral view the sheath appears as a projection with rounded corners. The vulva anteriorly leads to a narrow vagina of variable length (8–14 μ), slightly curved, which opens into the uterus, oviduct and ovary. The anterior end of the uterus is offset, usually ventrally, into a rounded or oblong spermatheca, frequently filled with rounded spermatozoa measuring 2–3 μ . Edward and Misra (7) illustrated spermatozoa as elongated rod-like structures, but we have never observed this type.

Males have a monorchic reproductive system. The spicules are slender and slightly curved ventrally. The gubernaculum is small and trough-like. The caudal alae are narrow and crenate and reach almost to the tip of the tail. Caudal alae are reported lacking in some species (*H. brachyurus*, *H. kana-yaensis*, *H. wessoni* and *H. gaddi*).

TAIL: Most species of *Hemicriconemoides* have a tail shape which is rounded or conoid. Some species have considerable intraspecific variability. For instance *H. brachyurus* has a rounded hemispherical tail, nevertheless females are occasionally found with atypical tail shapes up to and including the conoid. The male tail is conoid, with a pointed or bluntly-rounded terminus.

TABLE 1. Average (minimum-maximum) measurements in microns of ten individuals of each soil stage in the life cycle of *Hemicriconemoides chitwoodi*.

| Developmental stage | Cuticle | Stylet | Esophagus | Length | Width | Fassuliotis (10) | | | |
|----------------------------|-----------------------|---------------|------------------|------------------|---------------|------------------|----------------|------------------|---------------|
| | | | | | | Stylet | Esophagus | Length | Width |
| Second-stage larvae | smooth | 43 (39-48) | 68 (61-73) | 202 (189-219) | 17 (13-18) | 43 (41-46) | | 196 (188-207) | 14 (13-15) |
| Third-stage larvae | spined | 57 (52-61) | 93 (89-95) | 288 (219-365) | 22 (19-24) | 64 (60-68) | 94 (74-101) | 314 (205-402) | 25 (18-28) |
| Fourth-stage male larvae | spined | 66 (63-71) | 101 (98-106) | 284 (219-354) | 22 (18-26) | | | | |
| Fourth-stage female larvae | spined | 78 (73-85) | 116 (110-134) | 365 (317-439) | 29 (27-33) | | | | |
| Adult females | smooth with sheath | 90 (84-98) | 135 (122-143) | 484 (414-536) | 30 (28-35) | 89 (81-100) | | 521 (438-601) | |
| Adult males | smooth without sheath | absent | 106 (100-117) | 406 (329-439) | 17 (15-19) | | | 397-457 | 30-36 |

DEVELOPMENTAL STAGES

Previously *H. chitwoodi* had been described as having only three complete molts, one in the egg and two in the soil (10). The sheath or extra cuticle of the adult female was postulated as an incomplete fourth molt. In a population of *H. chitwoodi* collected and maintained in the greenhouse on camellia, we have been able to detect three molts in the soil stages and an incomplete fifth molt in the adult female. Fassuliotis (10) reported spined cuticles only in third-stage larvae. From our observations (Table 1), it appears likely that his collections of spined stages contained only third-stage larvae and fourth-stage male larvae. The range of measurements reported preclude the presence of any fourth-stage female larvae. Our separation of the stages in the life cycle of *H. chitwoodi* was based primarily on differences in length of stylet and esophagus. Length and width measurements are of secondary importance since these nematodes tend to shrink during fixation. The fourth-stage male larvae were similar, in size and shape, to third-stage larvae and only differed in length of stylet and esophagus. Presumably there was very little feed-

ing and growth during this stage. Further evidence was the resemblance in the esophageal length of fourth-stage larvae and adult



FIG. 1. *Hemicriconemoides chitwoodi*. A nearly completed molt of a spined fourth-stage female within the spined third-stage cuticle.

males. The fourth-stage females, however, continued to feed and grow and were easily distinguished from the others. Spicules and vulva could be distinguished in late fourth-stage male and female larvae, respectively. The molt between the third and fourth spiny stages is shown in Figure 1. This illustrates a nearly completed molt of a spined fourth-stage female within the spined third-stage cuticle. There were six spines or scales on each annule of both the third- and fourth-stage larvae and these were similar to those described on *H. pseudobrachyurum* (5).

In summary, the life cycle of *H. chitwoodi* has four complete molts; one in the egg and three in the soil, two stages of which have six spines or scales per annule, arranged in twelve rows the full length of the body. The adult female has a sheath or additional cuticle resulting from an incomplete fifth molt. This is similar to the life cycle of *Hemicycliophora arenaria* (18) but differs by having spined third- and fourth-stage larvae which may be a valuable character in separating these two genera.

SYSTEMATICS

Genus *Hemicriconemoides* Chitwood & Birchfield, 1957

Syn. *Iota* (Cobb, 1913) Siddiqi & Goodey, 1963. *Hemicriconemoides* Chitwood & Birchfield, 1957, p. 80; Oostenbrink, 1960, pp. 197–198; J. B. Goodey, 1963, p. 95; Siddiqi & Goodey, 1963, p. 366, pp. 369–370.

DIAGNOSIS EMENDED: The following change is made in the diagnosis given by Siddiqi and Goodey (16) for the genus; spear knobs anchor-shaped, with prominent forward-directed processes, rarely rounded, but not sloping backward.

TYPE SPECIES: *Hemicriconemoides wessoni* Chitwood & Birchfield, 1957.

Syn. *Hemicycliophora wessoni* (Chitwood & Birchfield, 1957) Goodey, 1963.

Hemicriconemoides wessoni Chitwood & Birchfield, 1957

(Fig. 2, I–L)

Hemicriconemoides wessoni Chitwood & Birchfield, 1957, pp. 81–82; *Hemicycliophora wessoni* (Chitwood & Birchfield, 1957) Goodey, 1963, p. 98; *Hemicriconemoides wessoni*: Siddiqi & Goodey, 1963, p. 369; *Hemicriconemoides wessoni*: Oostenbrink, 1960, p. 197.

Measurements (2 ♀, Florida): L = 0.39–0.52 mm; a = 13; b = 5.5; c = 16–17; V = 93–94; V' = 28–31; VL/VB = 0.9–1.6; R = 90–91; R V = 8–9; R an = 6–7; R Van = 1; stylet = 54–58 μ ; prorhabdion = 43–48 μ .

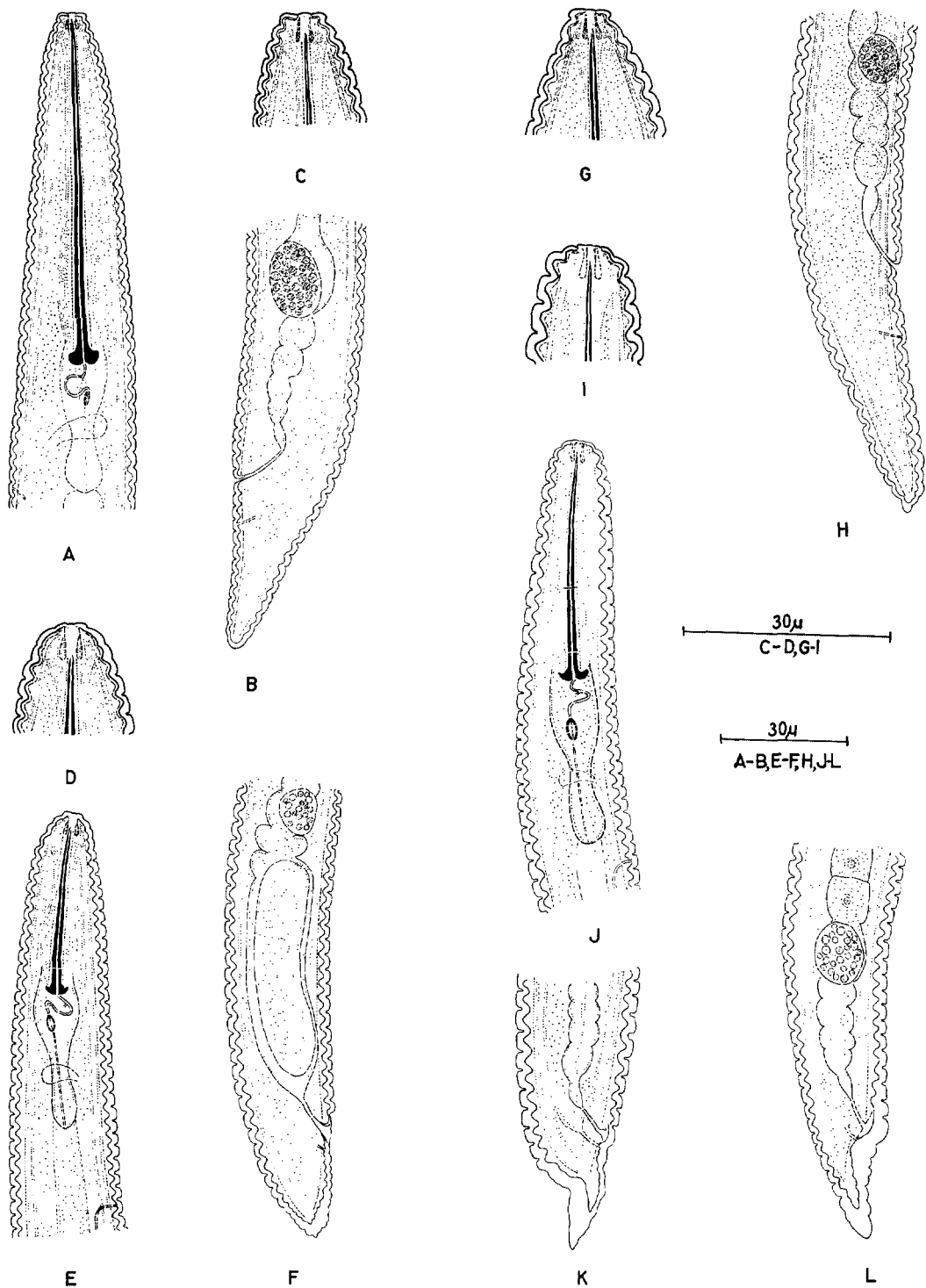
(3 ♀, Georgia, U.S.A.): L = 0.39–0.51 mm; a = 12–13; b = 4.2–4.6; c = 14–16; V = 92–94; V' = 31–32; VL/VB = 1.2–1.3; R = 85–91; R V = 8; R an = 7; R Van = 1–2; stylet = 54–60 μ ; prorhabdion = 45–47 μ .

Females.—Cuticular sheath attached at anterior end, well separated on tail. Head slightly set off, with 2 rounded annules; first annule smaller than second. Labial disc slightly elevated, flat or truncate at top. Annules 4–6 μ wide in middle of body. Dorsal gland orifice 6–9 μ posterior to base of stylet knobs. Stylet knobs massive, 8–12 μ across. Vulvar sheath small, present both on body and sheath cuticle. Tail conoid, tapering abruptly behind anus.

Diagnosis.—*Hemicriconemoides wessoni* can be identified by its conoid tail, abruptly narrowing posterior to the anus, the well-

→

FIG. 2 A–C. *Hemicriconemoides strictathecatus*: A. Female, esophageal region; B. Female, posterior region; C. Female, head; D–F. *Hemicriconemoides microdoratus* n. sp.: D. Female, head; E. Female, esophageal region; F. Female, posterior region; G–H. *Hemicriconemoides kanayaensis*: G. Female, head; H. Female, posterior region; I–L. *Hemicriconemoides wessoni*: I. Female, head; J. Female, esophageal region; K. Female, posterior region; L. Female, posterior region.



separated cuticular sheath at the tail region and the small number of sheath annules (76–91).

H. wessoni has been identified from the following habitats and localities: oak (*Quercus* sp.) soil, Winter Haven, Florida, U.S.A.; pine (*Pinus* sp.) soil, South Nahunta, Georgia, U.S.A.

Hemicriconemoides strictathecatus

Esser, 1960

(Fig. 2, A–C)

H. strictathecatus was placed in synonymy with *H. squamosus* by Siddiqi and Goodey (11). They considered that *H. strictathecatus* has the same anchor-shaped stylet knobs as those of *H. squamosus*. During this generic study three females were found in soil around a coconut tree (a type habitat of *H. strictathecatus*) which have rounded knobs, not anteriorly directed. This shape of knobs is a distinct departure from the usual shape of stylet knobs of all other species. The measurements of these specimens closely fit the original description of *H. strictathecatus* which is considered to be a valid species.

Measurements (3 ♀): L = 0.49–0.51 mm; a = 14–15; b = 4.4–4.9; c = 14–19; V = 90–93; V' = 33–42; VL/VB = 1.5–2.0; R = 136–147; R V = 12–14; R an = 9–11; R Van = 3; stylet = 82–83 μ prorhabdion = 72–73 μ ; R ex = 38.

Females.—Cuticular sheath attached at anterior end and at vulva, not well separated on tail. Lip region with 2 annules, first annule directed outward. Labial disc rounded, slightly or not elevated. Stylet knobs rounded. Vulva without vulvar sheath. Tail gradually tapers posterior to anus, rounded at tip.

Diagnosis.—*H. strictathecatus* can be distinguished from all the species by the rounded shape of the stylet knobs.

H. strictathecatus has been identified from the following habitat and locality: coconut (*Cocos nucifera*) soil, Western Panama.

Hemicriconemoides microdoratus n. sp.

(Fig. 2, D–F)

Measurements (60 ♀, paratypes): L = 0.34–0.43 mm; a = 14–17; b = 4.5–5.3; c = 14–19; V = 90–93; V' = 29–33; VL/VB = 1.2–1.5; R = 105–111; R V = 11–12; R an = 10–11; R Van = 1; stylet = 41–43 μ ; prorhabdion = 32–34 μ ; R ex = 31–32; egg = 12 μ \times 53 μ .

Female (holotype): L = 0.43 mm; a = 17; b = 5.3; c = 19; V = 93; V' = 30; VL/VB = 1.4; R = 107; R V = 11; R an = 10; R Van = 1; stylet = 41 μ ; prorhabdion = 33 μ ; R ex = 0.32. Cuticular sheath attached to body at anterior end. Lip region not set off, rounded, bearing 2 rounded annules. First annule larger than second. Labial disc slightly elevated, rounded at top. Annules 3 μ (3–5) wide in middle of body. Stylet knobs 5 μ (5–6) across. Dorsal gland orifice 3 μ (3–5) posterior to stylet knob base. Excretory pore 98 μ (97–105) from anterior end. Vulva on 11th annule from terminus; vulvar sheath small, formed of 2 annules. Anus on 10th annule from terminus. Tail convex-conoid, tapers slightly, ending in rounded tip.

Holotype.—Female collected March 17, 1962, Slide 1033, University of California Nematode Collection, Davis.

Paratypes.—9 ♀, slides 1034–1039, UCNC, Davis.

Type Habitat and Locality.—Cleared jungle soil (unknown plants), Ambewela Cattle Farm, Ambewela, Ceylon.

Diagnosis.—*H. microdoratus* is most closely related to *H. cocophillus* and can be distinguished by its continuous rounded lip region (partially set off, truncate lip region

in *H. cocophillus*), absence of amphidial plate, shorter stylet (41–43 μ vs. 47–58 μ in *H. cocophillus*) and greater size of first lip annule.

Hemicriconemoides kanayaensis

Nakasono & Ichinohe, 1961

(Fig. 2, G–H)

Hemicriconemoides ureshinoensis Yokoo, 1963, pp. 273–276; new synonymy.

Measurements (8 ♀, topotypes): L = 0.51–0.62 mm; a = 19–23; b = 4.0–4.8; c = 12–16; V = 87–91; V' = 52–63; VL/VB = 2.2–2.8; R = 142–158; R V = 16–21; R an = 11–15; R Van = 4–6; stylet = 70–75 μ ; prorhabdion = 60–64 μ ; R ex = 36–38.

A detailed description of females and males is given by Nakasono and Ichinohe. Examination of topotype specimens showed they fit the original description and *H. kanayaensis* is considered to be a distinct species.

Diagnosis.—*H. kanayaensis* can be separated from all the species by its markedly conoid continuous lip region and by the greater length and cylindrical shape of the body posterior to the vulva.

H. ureshinoensis was described as a new species by Yokoo (20). The description and measurements of this species agree in general with those of *H. kanayaensis*, except for the location of the vulva (12–15 vs. 16–21 in *H. kanayaensis*) and both species are reported from the same habitat (tea soil). This difference (value of R V) is judged insufficient to be enough to constitute a separate species and is considered to be an interpopulation variation. Therefore it is concluded *H. ureshinoensis* is conspecific with *H. kanayaensis*.

Hemicriconemoides brachyurus (Loos, 1949) Chitwood & Birchfield, 1957

(Fig. 3, A–F)

Hemicycliophora brachyurus (Loos, 1949) Goodey,

1963, p. 97; *Criconemoides brachyurus* Loos, 1949, p. 19–21; *Hemicriconemoides brachyurus* Siddiqi & Goodey, 1963, p. 369.

Measurements (30 ♀, Formosa): L = 0.40–0.54 mm; a = 13–17; b = 4.3–5.2; c = 16–25; V = 93–95; V' = 26–37; VL/VB = 1.0–1.4; R = 98–119; R V = 79; R an = 6–7; R Van = 1–2; stylet = 56–64 μ ; prorhabdion = 45–54 μ ; R ex = 29.

Females.—Cuticular sheath attached at anterior end and separated on tail. Annule 3–5 μ wide in middle of body. Lip region slightly set off, with 2 rounded annules; first annule smaller than second. Labial disc elevated, flattened at anterior, hexagonal in face view. Stylet knobs 8–11 μ across. Vulvar sheath present both in sheath and body cuticle. Tail usually rounded, hemispherical, rarely acutely conoid.

Hemicriconemoides brachyurus has been identified from the following habitats and localities: sugarcane soil, Taichung, Formosa; unknown habitat, St. Coombs Estate, Ceylon.

Hemicriconemoides gaddi (Loos, 1949)

Chitwood & Birchfield, 1957

(Fig. 3, G–J)

Hemicriconemoides gaddi Oostenbrink, 1960, p. 203; *Hemicycliophora gaddi* (Loos, 1949) Goodey, 1963, p. 97; *Hemicriconemoides gaddi* Siddiqi & Goodey, 1963, p. 369.

Measurements (3 ♀, Ceylon): L = 0.41–0.49 mm; a = 14–15; b = 4.2–4.5; c = 15–17; V = 91–92; V' = 38–40; VL/VB = 2.1–2.4; R = 110–128; R V = 13–15; R an = 8–9; R Van = 3–5; stylet = 79–85 μ ; prorhabdion = 68–74 μ ; R ex = 36.

(30 ♀, India): L = 0.43–0.63 mm; a = 15–24; b = 3.7–4.9; c = 14–19; V = 91–93; V' = 40–53; VL/VB = 2.4–2.7; R = 120–152; R V = 13–17; R an = 7–11; R Van = 4–6; stylet = 72–86 μ ; prorhabdion = 60–75 μ ; R ex = 36–38.

Females.—Cuticular sheath attached to

body at anterior end and at vulva, well separated on tail. Lip region set off from body, with 2 rounded annules; first annule larger than second. Labial disc slightly elevated or inconspicuous. Annules 2–3 μ wide in middle of body. Stylet knobs 5–7 μ across. Dorsal gland orifice 3–5 μ posterior to stylet knob base. Vulva on 13–17th annule from terminus, vulvar sheath lacking. Tail gradually tapering to a more conoid tip. Anus on 7–11th annule from terminus.

Diagnosis.—*H. gaddi* is closely related to *H. chitwoodi*, from which it can be separated by its continuous rounded lip region (lip region partly set off and truncate in *H. chitwoodi*), in which the first annule is smaller than or about equal to the second annule and the first annule is rounded and not directed outward (first annule much larger than second and directed outward at an angle in *H. chitwoodi*).

H. gaddi has been identified from the following habitats and localities: Jungle (unknown plant) soil, Stony Cliff Estate, Kotaloga, Ceylon; Coffee (*Coffea arabica*) soil, Chikmagalur, Mysore, India.

Hemicriconemoides mangiferae

Siddiqi, 1961

(Fig. 3, K–N)

Hemicriconemoides litchi Edward & Misra, 1963, pp. 409–411, new synonymy.

Hemicriconemoides birchfieldi Edward, Misra & Singh, 1965, pp. 157–161, new synonymy.

Measurements (10 ♀, Malabon-collection no. 2, Philippines): L = 0.49–0.58 mm; a = 16–19; b = 4.2–5.0; c = 16–19; V = 91–92; V' = 35–42; VL/VB = 1.3–1.6; R = 135–147; R V = 14–15; R an = 10–11; R Van = 4; stylet = 78–81 μ ; pro-

rhabdion = 68–70 μ ; R ex = 38.

(8 ♀, Malabon-collection no. 2, Philippines): L = 0.49–0.55 mm; a = 17–20; b = 4.2–5.0; c = 16–20; V = 91–93; V' = 32–38; VL/VB = 1.2–1.5; R = 137–142; R V = 13–15; R an = 9–10; R Van = 4–5; stylet = 72–75 μ ; prorhabdion = 60–64 μ ; R ex = 37.

(10 ♀, Nigeria): L = 0.49–0.60 mm; a = 18–24; b = 3.5–5.0; c = 16–19; V = 90–93; V' = 35–45; VL/VB = 1.4–1.6; R = 138–152; R V = 15–17; R an = 12–14; R Van = 3–5; stylet = 72–86 μ ; prorhabdion = 60–74 μ ; R ex = 36–38.

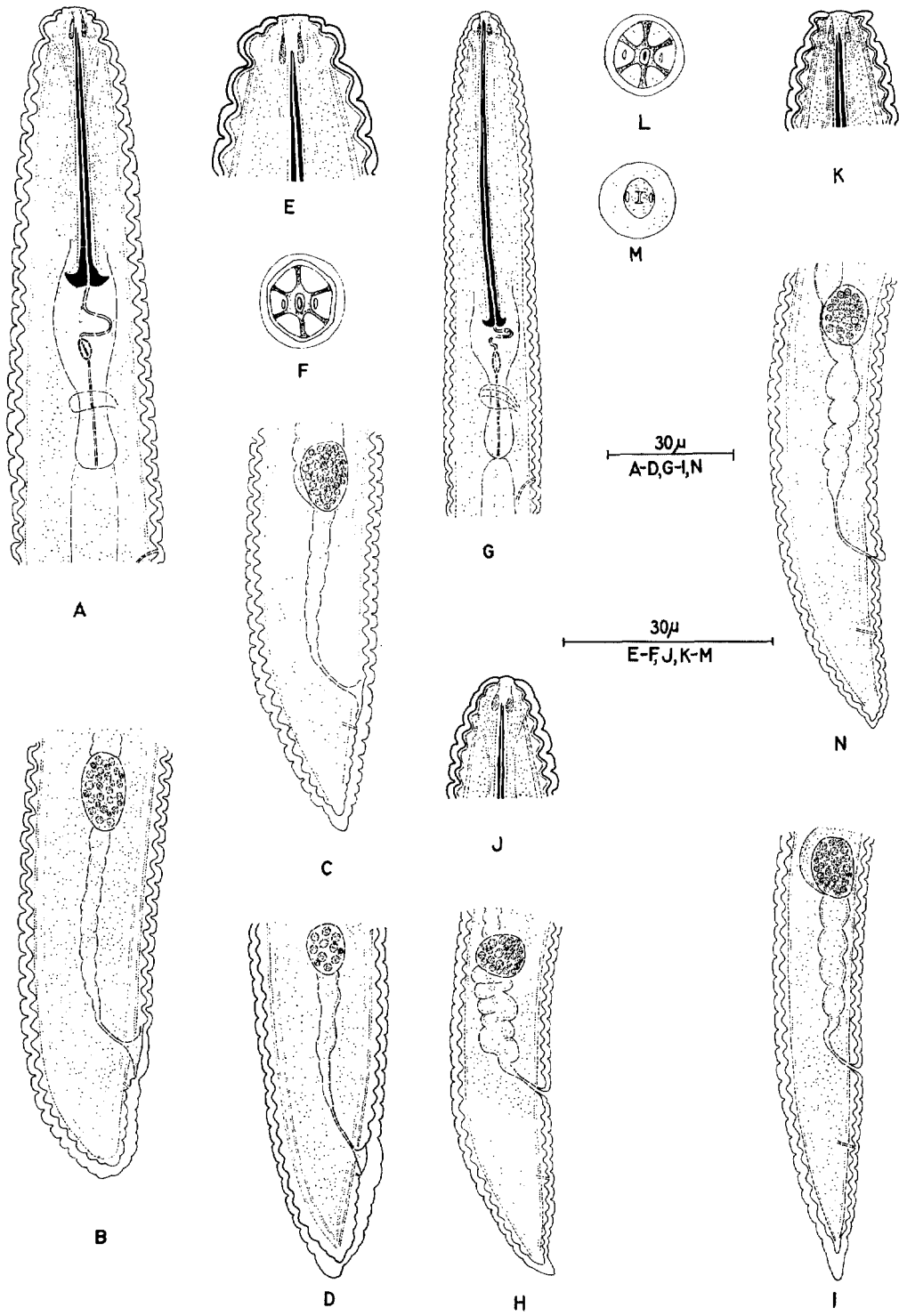
(10 ♀, Venezuela): L = 0.47–0.51 mm; a = 15–20; b = 4.9–7.1; c = 19–24; V = 92–93; V' = 30–35; VL/VB = 1.2–1.5; R = 125–137; R V = 10–13; R an = 7–9; R Van = 3–4; stylet = 65–72 μ ; prorhabdion = 54–61 μ ; R ex = 34.

(10 ♀, St. Helena, California): L = 0.41–0.51 mm; a = 14–19; b = 3.2–3.9; c = 18–22; V = 90–93; V' = 31–42; VL/VB = 1.7–1.9; R = 116–133; R V = 12–14; R an = 9–10; R Van = 3–4; stylet = 70–84 μ ; prorhabdion = 60–67 μ ; R ex = 34–37.

Females.—Cuticular sheath attached to body at anterior end, vulva and sometimes on tail. Lip region slightly set off, with 2 annules; first annule smaller than second or about equal to second, angular, directed outward. Labial disc slightly elevated, rounded at top, inconspicuous in some specimens, roughly hexagonal in *en face* view. Annules 3–4 μ wide in middle of body. Stylet knobs 5–7 μ across. Excretory pore on 34–38th annule from anterior end. Vulvar sheath lacking. Tail convex-conoid or rounded. In

→

FIG. 3 A–F. *Hemicriconemoides brachyurus*: A. Female, esophageal region; B–D. Female, posterior region; E. Female, head; F. Female, *en face* view; G–J. *Hemicriconemoides gaddi*: G. Female, esophageal region; H–J. Female, posterior region; J. Female, head; K–N. *Hemicriconemoides mangiferae*: K. Female, head; L–M. Female, cephalic framework and *en face* view; N. Female, posterior region.



convex-conoid tail the last 3–4 annules narrow abruptly.

Diagnosis.—*H. mangiferae* is most closely related to *H. strictathecatus*, from which it can be separated by its anteriorly directed stylet knobs (stylet knobs rounded in *H. strictathecatus*).

Specimens of *H. mangiferae* have been identified from the following habitats and localities: mango (*Mangifera indica*) soil, Plateau Province, Nigeria; mango soil, Malabon, Luzon, Philippines; pineapple (*Ananas sativus*) soil, Malabon, Luzon, Philippines; bamboo (*Bamboosa vulgaris*) soil, Mirikina, Philippines; grape (*Vitis vinifera*) soil, St. Helena, California; Zinfandel grape soil, Lodi, California; alder, *Alnus* sp., soil, Chico, California; *Arctostaphylos manzanita* soil, California; Bay tree (*Umbellularia californica*) soil, Jenner, California; Bay tree soil, Fairfield, California; willow soil, San Diego, California; oak tree (*Quercus* sp.) soil, Hayward, California; cocoa (*Theobroma cacao*) soil, Venezuela.

H. squamosus, *H. mangiferae*, *H. birchfieldi* and *H. litchi* appear to be very similar if not conspecific. All were described originally from collections made in India, and the first three of these species were reported from soil about the roots of mango. Unfortunately, the status of *H. squamosus* cannot be resolved because type specimens are not available. Siddiqi and Goodey (11) concluded that *H. mangiferae* is a synonym of *H. squamosus* from studies of unpublished notes and sketches of Cobb. The original description of *H. squamosus* by Cobb (3) gave a total length of 0.80 mm, which Siddiqi and Goodey (16) corrected to 0.40 mm. It is not clear if this factor applied to all calculations by Cobb or only to length. No mention was made of the stylet length, which is about 98 μ by calculation from the illustration in Cobb's description. It was further

noted by Siddiqi & Goodey that Cobb reported 8 squamules per annule but his sketches showed about twelve. They further judged that Cobb's female was probably a preadult larva.

Many doubts exist about the true nature of *H. squamosus*. Until specimens can be found from the type locality to re-establish the identity of *H. squamosus*, it should be placed in *species inquirendae* and recognize *H. mangiferae* as a valid species.

Edward & Misra (7) and Edward *et al.* (8) described two new species, *H. litchi* and *H. birchfieldi*, differing from *H. mangiferae* in stylet length, location of vulva, total number of sheath annules, number of incisures in the lateral field of the male and presence or absence of caudal alae. These measurements overlap, as indicated by the populations resembling *H. mangiferae* from different parts of the world. Specimens from Venezuela have a rounded tail shape similar to some of the specimens described as *H. mangiferae* and *H. litchi*. They also have a stylet ranging in length from 65–72 μ , a measurement that links *H. litchi*, *H. birchfieldi* and *H. mangiferae*. The location of the vulva and total number of sheath annules also overlap. The caudal alae of *Hemicriconemoides* are low and rudimentary and can easily be overlooked in lateral view. Because the females of *H. litchi*, *H. birchfieldi* and *H. mangiferae* do not show any difference in general appearance and the morphometric characters mentioned by the authors of *H. litchi* and *H. birchfieldi* overlap, it is judged these two species should be considered as conspecific with *H. mangiferae* pending further study of males.

Hemicriconemoides parvus n. sp.

(Fig. 4, A–C)

Measurements (10 ♀, paratypes): L = 0.29–0.38 mm; a = 11–17; b = 3.1–3.9; c = 22–31; V = 91–95; V' = 16–25; R =

106–116; R V = 8–10; R an = 5–6; R Van = 3–4; stylet = 56–65 μ ; prorhabdion = 45–55 μ ; R ex = 32–36.

Female (holotype): L = 0.38 mm; a = 14; b = 3.9; c = 31; V = 95; V' = 16; R = 111; R V = 8; R an = 5; R Van = 3; stylet = 60 μ ; prorhabdion = 50 μ ; R ex = 36. Cuticular sheath attached to body at anterior end and at vulva, not well separated on tail. Lip region with 2 annules, first annule angular, directed outward, larger than second annule. Labial disc inconspicuous, not elevated. Annules 2 (2–3) μ wide in middle of body. Stylet knobs 5 (5–6) μ across. Vulvar sheath lacking. Tail gradually tapers to rounded tip.

Male.—Unknown.

Holotype.—Female collected by S. A. Sher, March 1966, slide 1040, UCNC, Davis.

Paratypes.—9 ♀, same collection as holotype, distributed as follows: 8 ♀ slides 1041–1048, UCNC, Davis; 1 ♀ slide numbered T-611P, USDANC, Beltsville.

Type Habitat and Locality.—Soil about the roots of *Ceanothus* sp., Badger Canyon, San Bernardino, California.

Diagnosis.—*H. parvus* is closely related to *H. mangiferae* but can be separated from it by its shorter length (L = 0.29–0.38 mm vs. 0.41–0.61 mm in *H. mangiferae*) and by the first annule being larger than the second (first annule smaller or about equal to second annule in *H. mangiferae*).

Hemicriconemoides brevicaudatus n. sp.

(Fig. 4, D–F)

Measurements (8 ♀, paratypes): L = 0.37–0.44 mm; a = 10–14; b = 4.1–4.8; c = 32–37; V = 94–96; V' = 14–17; VL/VB = 0.7–0.9; R = 51–55; R V = 2; R an = 1; R Van = 1; stylet = 52–57 μ ; prorhabdion = 43–46 μ ; R ex = 19–20.

Female (holotype): L = 0.39 mm; a = 11; b = 4.5; c = 35; V = 96; V' = 17; VL/VB = 0.9; R = 55; R V = 2; R an = 1; R Van = 1; R ex = 19. Body tapering abruptly posterior to vulva, appearing malformed. Two cuticles more or less closely appressed to each other; attached at anterior end, vulva and on tail (slightly separated on tail in some paratypes). Sheath annules rounded and not flattened. Annules 7 (7–8) μ wide in middle of body. Lip region slightly set off, high and roughly square in outline. Labial annules two, of about equal size. Labial disc distinct, markedly elevated, flattened at top. Stylet knobs 6 (6–10) μ across. Vulvar opening wide; without vulvar sheath. Tail short, conoid.

Male.—Unknown.

Holotype.—Female collected by F. Caviness, November 10, 1960, slide 1049, UCNC, Davis.

Paratypes.—7 ♀, same collection as holotype distributed as follows: 6 ♀ slides 1050–1055, UCNC, Davis; 1 ♀ slide numbered T-609P, USDANC, Beltsville.

Type Habitat and Locality.—General bush soil, Oyo Province, West Nigeria.

Diagnosis.—*H. brevicaudatus* can be separated from all the other species by the extreme posterior position of the vulva (2nd annule from terminus vs. 5–21st annules in other species), the rounded sheath annules and the smaller number of sheath annules R (51–55 vs. 76–164 in other species).

Hemicriconemoides intermedius n. sp.

(Fig. 4, G–I)

Measurements (12 ♀, paratypes): L = 0.35–0.44 mm; a = 12–18; b = 4.3–5.4; c = 20–32; V = 93–96; V' = 14–25; VL/VB = 0.8–1.1; R = 88–94; R V = 7–8; R an = 6–7; R Van = 1; stylet = 47–52 μ ; prorhabdion = 36–41 μ ; R ex = ?.

Female (holotype): L = 0.41 mm; a = 16; b = 5.4; c = 23; V = 95; V' = 16; VL/VB = 0.9; R = 92; R V = 7; R an = 6; R Van = 1; stylet = 50 μ ; prorhabdion = 41 μ . Cuticular sheath attached at anterior end, separated on tail. Annules 4 (4–5) μ wide in middle of body. Lip region slightly set off, with 2 annules. First annule smaller than second. Labial disc slightly elevated, flattened at top. Stylet knobs 8 (8–10) μ across. Vulvar sheath present both in sheath and body cuticle, formed of 2 (2–3) annules. Tail subacutely conoid (irregularly rounded in 1 paratype).

Holotype.—Female collected by G. Martin, 1955, slide 1061, UCNC, Davis.

Paratypes.—10 ♀, same collection as holotype, distributed as follows: 9 ♀ slides 1062–1070, UCNC, Davis; 1 ♀ slide numbered T-610P, USDANC, Beltsville.

Type Habitat and Locality.—Soil about roots of baobab tree, Victoria Falls, Northern Rhodesia, Africa.

Diagnosis.—*H. intermedius* is closely related to *H. brachyurus* and *H. pseudobrachyurus*. It can be separated from the former species by the lower number of R (88–94 vs. 98–113 in *H. brachyurus*), usually subacute conoid shape of tail (usually hemispherical in *H. brachyurus*) and lower value of V' (14–25 vs. 26–32 in *H. brachyurus*). It can be separated from the latter species by the presence of a vulvar sheath.

Hemicriconemoides insignis n. sp.

(Fig. 4, J–L)

Measurements (5 ♀, paratypes): L = 0.31–0.43 mm; a = 14–18; b = 3.4–4.4;

c = 23–27; V = 93–94; V' = 27–30; VL/VB = 1.2–1.5; R = 113–118; R V = 9–11; R an = 6–8; R Van = 3; R ex = 29–31; stylet = 67–70 μ ; prorhabdion = 60–61 μ .

Female (holotype): L = 0.43 mm; a = 18; b = 4.4; c = 26; V = 93; V' = 27; VL/VB = 1.2; R = 115; R V = 11; R an = 8; R Van = 3; stylet = 68 μ ; prorhabdion = 60 μ ; R ex = 30. Cuticular sheath attached to body at anterior end, vulva and not well separated on tail. Annules 3 (3–4) μ wide in middle of body. Lip region conoid, truncate, apparently bears one large annule. In some specimens another annule (very inconspicuous and difficult to detect) seems to be present between the labial disc and the labial annule. Labial annule much larger than first body annule. Labial disc inconspicuous. Stylet knobs 5 (5–7) μ across; vulvar sheath lacking. Body tapers slightly posterior to anus, tail rounded.

Male.—Unknown.

Holotype.—Female collected January 21, 1958, slide 1056, UCNC, Davis.

Paratypes.—4 ♀, same collection as holotype, slides 1057–1060, UCNC, Davis.

Type Habitat and Locality.—Virgin forest soil, Maroota, New South Wales, Australia.

Diagnosis.—*H. insignis* is most closely related to *H. parvus* and *H. mangiferae*, but is distinguished from both the species by its labial annule being larger than the first body annule and by the very inconspicuous first annule.

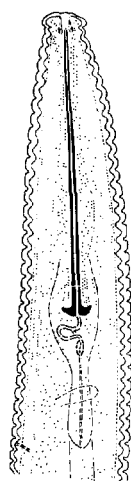
Hemicriconemoides chitwoodi Esser, 1960

(Fig. 5, A–D)

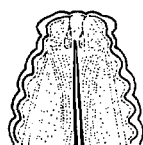
Hemicriconemoides gaddi Whitelock & Steele, 1960,

→

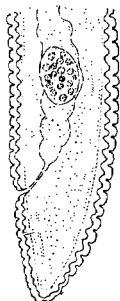
FIG. 4 A–C. *Hemicriconemoides parvus* n. sp.: A. Female, esophageal region; B. Female, head; C. Female, posterior region; D–F. *Hemicriconemoides brevicaudatus* n. sp.: D. Female, esophageal region; E. Female, posterior region; F. Female, head; G–I. *Hemicriconemoides intermedius*: G. Female, esophageal region; H. Female, posterior region; I. Female, head; J–H. *Hemicriconemoides insignis*: J. Female, esophageal region; K. Female, posterior region; L. Female, head.



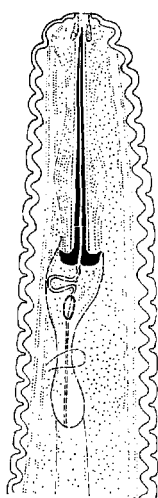
A



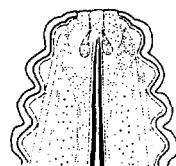
B



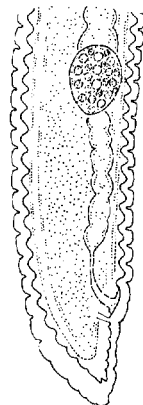
C



G



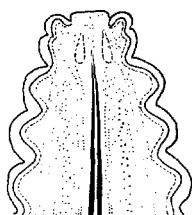
I



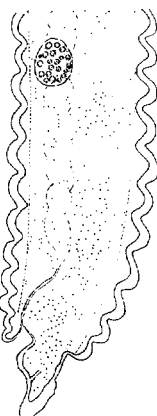
H

30μ
B, F, I, L

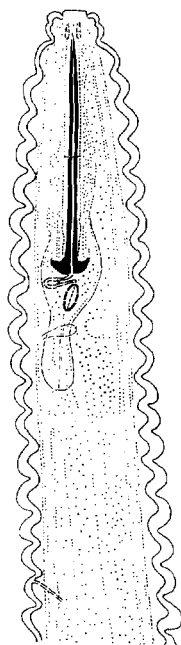
30μ
A, C, E, G, H, J, K



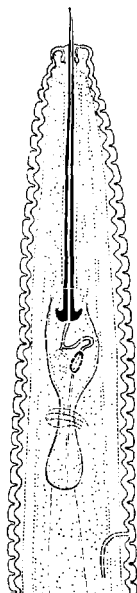
F



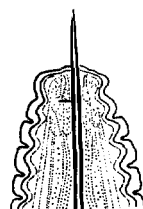
E



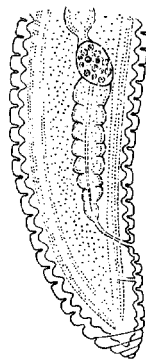
D



J



L



K

pp. 446–447; *Hemicycliophora chitwoodi* (Esser, 1960) Goodey, 1963, p. 97; *Hemicriconemoides chitwoodi* Siddiqi & Goodey, 1963, p. 369.

Measurements (10 ♀, Lake Alfred, Florida): L = 0.46–0.59 mm; a = 15–20; b = 3.6–4.4; c = 13–22; V = 88–92; V' = 32–58; VL/VB = 1.9–2.6; R = 118–133; R V = 12–16; R an = 8–10; R Van = 4–6; stylet = 78–90 μ ; prorhabdion = 68–78 μ ; R ex = 33–36.

(6 ♀, Lake Alfred, Florida): L = 0.37–0.42 mm; a = 24–28; b = ?; c = 12–14; T = 27–35; spicules = 27–31 μ ; gubernaculum = 3–5 μ .

Females.—Cuticular sheath attached at anterior end and at vulva, not well separated on tail. Lip region slightly set off, bearing 2 annules; first annule larger than second, angular, directed outward. Labial disc elevated and rounded at top. Annules 3–5 μ in middle of body. Stylet knobs 6–7 μ across. Vulvar sheath lacking. Tail conoid, gradually tapering into somewhat angular tip. Anus on 8–10th annule from terminus.

Males.—More slender than female. Extra cuticular sheath lacking. Lip region continuous, stylet lacking; esophageal region vestigial. Lateral field with 4 incisures. Caudal alae rudimentary, with crenate margin. Tail pointed.

Diagnosis.—*H. chitwoodi* is closely related to *H. gaddi* and has been diagnosed under that species.

H. chitwoodi has been identified from the following habitat and localities: *Camellia japonica* soil, Lake Alfred, Florida; Elsinore, California; San Diego County, California; Los Angeles County, California; Millburn, New Jersey.

In his description of *H. chitwoodi* Esser (9) stated that males had no caudal alae. Examination of specimens sent by him and specimens from other collections indicate the presence of rudimentary caudal alae.

Hemicriconemoides obtusus Colbran, 1962 (Fig. 5, E)

Criconemoides obtusus (Colbran, 1962) Siddiqi & Goodey, 1963, p. 370.

Measurements (2 ♀, Australia): L = 0.39–0.40 mm; b = 4.0–4.2; V = 88–91; V' = 42–52; VL/VB = 1.0–1.3; R = 110–115; R V = 14–15; stylet = 50–55 μ ; prorhabdion = 40–42 μ .

The specimens examined here were much flattened but they agree with the original description of *H. obtusus* (Colbran, 1962).

Diagnosis.—*H. obtusus* can be distinguished from all the species by its well set off, conoid, truncate lip region; by the very closely pressed double cuticles and by its extremely thin inner cuticle.

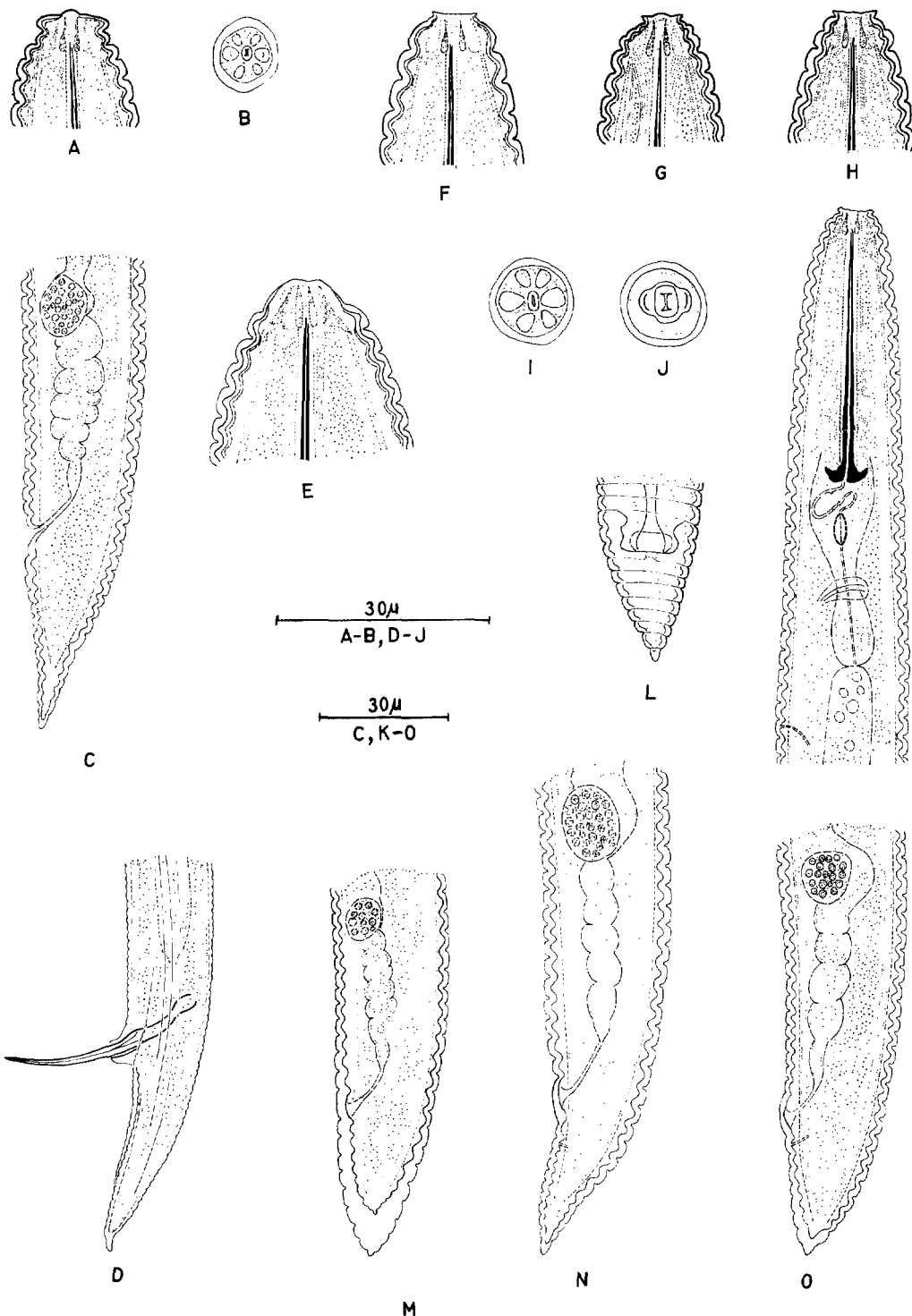
Examination of topotype specimens and a few more specimens sent by Colbran revealed that the annules are not retrorse as mentioned by Siddiqi & Goodey (16); they are instead rather flattened. These animals have a thick outer cuticle and a very thin inner cuticle and one larva was found to have spines similar to those of *Hemicriconemoides*. Although the lip region of *H. obtusus* is not typical of the genus and the body cuticle is very thin and not well separated, yet it shares all other characters of the genus. It is concluded that *H. obtusus* is the most aberrant species of the genus.

Hemicriconemoides cocophillus (Loos, 1949) Chitwood & Birchfield, 1957

(Fig. 5, F–O)

Criconemoides cocophillus Loos, 1949, pp. 21–22;

FIG. 5 A–D. *Hemicriconemoides chitwoodi*: A. Female, head; B. Female, *en face* view; C. Female, posterior region; D. Male, tail; E. *Hemicriconemoides obtusus*: E. Female, head; F–O. *Hemicriconemoides cocophillus*: F–H. Female, head; I. Female, cephalic framework; J. Female, *en face* view; K. Female, esophageal region; L. Female, tail in ventral view; M–O. Female, posterior region.



Hemicriconemoides cocophillus (Loos, 1949) Chitwood & Birchfield, 1957, pp. 81–85; *Hemicycliophora cocophillus* (Loos, 1949) Goodey, 1963, p. 97; *Hemicriconemoides cocophillus* Siddiqi, 1961, pp. 30–32; *Hemicriconemoides cocophillus* Siddiqi & Goodey, 1963, p. 369; *Hemicriconemoides communis* Edward & Misra, 1963, pp. 405–409, new synonymy; *Hemicriconemoides cocophillus* Timm, 1965, pp. 43, 60–61.

Measurements (4 ♀, India): L = 0.46–0.50 mm; a = 14–15; b = 4.0–5.0; c = 16–17; V = 91–92; V' = 36–42; VL/VB = 1.2–1.7; R = 108–113; R V = 9–10; R an = 8–9; R Van = 1; stylet = 50–57 μ ; prorhabdion = 40–47 μ ; R ex = 31–32.

(4 ♀, Oyo Province, Nigeria): L = 0.52–0.54 mm; a = 13–17; b = 4.8–5.4; c = 13–17; V = 92–94; R = 113–120; R V = 10–11; R an = 9; R Van = 1–2; stylet = 57–58 μ ; prorhabdion = 45–47 μ ; R ex = 30–31.

(2 ♀, Abeokuta Province, Nigeria): L = 0.41–0.44 mm; a = 13–14; b = 4.0–4.2; c = 13–14; V = 92–93; V' = 30–37; VL/VB = 1.2–1.4; R = 110–114; R V = 10–11; R an = 8–9; stylet = 52–55 μ ; prorhabdion = 40–45 μ ; R ex = 30.

(6 ♀, Niger Province, Nigeria): L = 0.47–0.51 mm; a = 15–17; b = 4.8–5.2; c = 15–16; V = 93–94; V' = 32–39; VL/VB = 1.1–1.5; R = 100–110; R V = 9–10; R an = 7–9; stylet = 51–55 μ ; prorhabdion = 40–45 μ ; R ex = ?.

(6 ♀, Umuahio Province, Nigeria): L = 0.45–0.50 mm; a = 14–16; b = 5.0–5.1; c = 15–18; V = 92–93; V' = 30–38; VL/VB = 1.1–1.4; R = 106–113; R V = 10–11; R an = 9–10; R Van = 1; stylet = 50–52 μ ; prorhabdion = 40–42 μ ; R ex = 29.

(5 ♀, Venezuela): L = 0.47–0.51 mm; a = 12–16; b = 4.1–5.1; c = 12–14; V = 92–93; V' = 30–34; VL/VB = 1.1–1.5; R = 99–108; V = 9–11; R an = 8–10; R Van = 1; stylet = 47–50 μ ; prorhabdion = 35–40 μ ; R ex = ?.

Females.—Cuticular sheath attached to body at anterior end, may or may not be

well separated on tail. Head slightly set off. Labial annules 2–3, usually 2; first annule smaller than the second. Labial disc slightly elevated or inconspicuous in lateral view. Amphidial plate surrounding labial disc, well developed. Annules 3–5 μ wide in middle of body. Stylet knobs 5–9 μ across. Dorsal gland orifice 5–7 μ posterior to base of stylet knob base. Vulvar sheath well developed, present in both sheath and body cuticle. Tail convex-conoid to attenuated.

Diagnosis.—*H. cocophillus* can be distinguished from *H. wessoni* by the greater number of sheath annules (96–130 vs. 90–91), the well-developed amphidial plate (lacking in *H. wessoni*) and the truncate lip region.

H. cocophillus has been identified from the following habitats and localities: General bush soil, Oyo Province, Nigeria; cocoa (*Theobroma cacao*) soil, Abeokuta Province, Nigeria; rice (*Oryza sativa*) soil, Niger Province, Nigeria; unknown habitat, Umuahio Province, Nigeria; moss and fern soil, Nahan, Himachal Pradesh, India; grass soil, Kotmale, Ceylon; Naranjo (*Citrus* sp.) soil, Venezuela; sugarcane (*Saccharum officinarum*) soil, Java, Indonesia; guava (*Psidium quajava*) soil, Quezon City, Philippines; *Pistacio* sp. soil, Mosul, Iraq.

Both the sympatric and allopatric populations of *H. cocophillus* show variations in the number of labial annules (Fig. 5, F–H) and in tail shape (Fig. 5, M–O). While most of the specimens bear two labial annules, a single specimen was found to have three labial annules, yet a few specimens have a large second labial annule and inconspicuous first labial annule. The tail of some specimens is convex-conoid, while others have a more slender tail closer to the illustration of Loos (12).

There is a discrepancy between the original description and sketches of *H. coco-*

phillus by Loos (12). As pointed out by Siddiqi (15), Loos described *H. cocophillus* as having a convex-conoid tail, but his illustration shows a digitate tail. Edward and Misra (7) and De Grisse (5) considered Siddiqui's (15) description of *H. cocophillus* to refer to an undescribed species, differing from *H. cocophillus* in the shape of the tail. However, Timm (17) remarked that his description of *H. cocophillus* fits with Siddiqi's description of *H. cocophillus* and the description of the male of *H. communis* given by Edward and Misra (7). Edward and Misra (7) proposed a new species, *H. communis*, differing from *H. cocophillus* mainly in tail shape. Since specimens have tails ranging from convex-conoid to a more slender tail (within a single population) and since other differences mentioned by Edward & Misra (7) are overlapping, as indicated by the present study, *H. communis* is proposed as a synonym of *H. cocophillus*.

Hemicriconemoides pseudobrachyurum
De Grisse, 1964

A few specimens from the Netherlands were examined and the measurements and characters of these animals fit well within the range of the description for type specimens of *H. pseudobrachyurum*. This study confirms *H. pseudobrachyurum* is a distinct species.

SPECIES INQUIRENDA

Hemicriconemoides squamosus (Cobb,
1913) Siddiqi & Goodey, 1963

KEY TO THE GENUS *Hemicriconemoides*
CHITWOOD & BIRCHFIELD, 1957

1. Lip region well set off *obtusum*
Lip region not set off or only partly set
off 2
2. Stylet knobs rounded, without forward-
directed processes *strictathecatus*
Stylet knobs anchor-shaped with prom-
inent forward directed processes 3
3. R V = 2, R = less than 56, sheath an-
nules rounded *brevicaudatus* n. sp.

- R V = 7-21; R = more than 75, sheath
annules flattened 4
4. Stylet less than 46 μ *microdoratus* n. sp.
Stylet more than 46 μ 5
5. Vulvar sheath present 6
Vulvar sheath absent 10
6. R = less than 98 7
R = more than 98 9
7. Stylet more than 71 μ *minus*
Stylet less than 60 μ 8
8. Tail narrows abruptly after anus *wessoni*
tail more regularly conoid
..... *intermedius* n. sp.
9. Lip region rounded, amphidial plate ab-
sent, tail usually rounded *brachyurus*
Lip region truncate, amphidial plate pre-
sent, tail convex-conoid or tapering to
more angular tip *cocophillus*
10. Lip region markedly conoid, R V = 16-
21 *kanayaensis*
Lip region rounded-truncate, R V = 7-17
..... 11
11. Lip region with a large annule or first
annule very conspicuous *insignis* n. sp.
Lip region with 2 distinct annules 12
12. L = 0.29-0.38 mm *parvus* n. sp.
L = 0.41-0.61 mm 13
13. R = less than 104, stylet less than 60 μ
..... *pseudobrachyurum*
R = more than 104, stylet usually more
than 60 μ 14
14. Tail rounded or convex-conoid *mangiferae*
Tail conoid, tapers to a more angular tip
..... 15
15. Lip region rounded, not set off, first
annule rounded, not directed outward,
second annule as big or bigger than
first *gaddi*
Lip region truncate, partly set off, first
annule angular, directed outward, sec-
ond annule much smaller than first
..... *chitwoodi*

DISCUSSION

Males are rare in *Hemicriconemoides* but have been reported in a number of species (*H. wessoni*, *H. cocophillus*, *H. gaddi*, *H. brachyurus*, *H. mangiferae*, and *H. chitwoodi*). The total length, presence or absence of caudal alae, number of incisures in lateral field and comparison of spicules and tail length have been used as diagnostic characters. Although these characters have definite merits in separation of species, their reliability is questionable in a case where a population of *Hemicriconemoides* is mixed

with *Criconemoides*, *Bakernema* or *Criconema*. The caudal alae in *Hemicriconemoides* are low and easily overlooked. They were reported lacking in *H. chitwoodi* but actually are found to be present. The same might be true for other species reported to be lacking caudal alae. It was apparent from this study that the number of incisures in the lateral field should be determined not only in totemount but also in cross section at different levels of the body. In mixed collections of *Hemicriconemoides* and *Criconemoides* from California and Venezuela a few males had no visible lateral field. When viewed in cross section near 50%, however, incisures of a lateral field were clearly visible. Our present knowledge of males of these genera is insufficient to permit separation of these genera on the basis of male characters only.

The characters of females useful in distinguishing the species are: number of sheath annules, total length, stylet length, knob shape, length of body posterior to vulva (V'), annules between vulva and anus and shape of lip region. Observations on many individuals within a single population and many populations of different geographical origins indicated the possible occurrence of many variations in female tail shape. Such was the case in *H. brachyurus* and *H. cocophillus*. The usual shape of the tail in *H. brachyurus* is hemispherical; occasionally a few specimens are encountered with a conoid tail. The evidence of great variation in tail shape within a single population was demonstrated in *Hemicyclophora zuckermani* by Brzeski and Zuckerman (1). These facts suggest caution in the use of tail shape alone in diagnosing a species.

H. obtusus is the most aberrant species of the genus because of its peculiar lip region and closely-pressed double cuticles. Two other species are quite unique among the rest of the species: *H. brevicaudatus* due to

its rounded annules of the sheath cuticle and extreme posterior position of the vulva, and *H. strictathecatus* due to its rounded shape of stylet knobs; yet these three species share all the other characters of *Hemicriconemoides*. A greater number of species have the first annule more or less angular, truncate and directed outward (*H. mangiferae*, *H. chitwoodi*, *H. parvus*, *H. strictathecatus*, *T. insignis*, *H. cocophilus*) and the labial disc in these species is rounded at the top in lateral view. *H. wessoni*, *H. brachyurus*, *H. intermedius* and *H. brevicaudatus* have the same kind of lip region but their first annule is rounded and the labial disc is flattened. *H. gaddi* and *H. microdoratus* have a rounded lip region with a rounded labial disc. The relationship between species perhaps will be better understood when the larval stages in all the species are fully described.

LITERATURE CITED

1. BRZESKI, M. W., and B. M. ZUCKERMAN. 1965. Morphological variations, life stages and emended description of *Hemicyclophora zuckermani* Brzeski (Nematoda, Criconematidae). *Nematologica* 11:66-72.
2. CHITWOOD, B. G., and W. BIRCHFIELD. 1957. A new genus, *Hemicriconemoides* (Criconematidae: Tylenchina). *Proc. Helminthol. Soc. Wash.* 24:80-86.
3. COBB, N. A. 1913. New nematode genera found inhabiting fresh water and non-brackish soils. *J. Wash. Acad. Sci.* 3:432-444.
4. COLBRAN, R. C. 1962. Studies on plant and soil nematodes. 5. Four new species of Tylenchoidea from Queensland pineapple fields. *Qd. J. Agr. Sci.* 19:231-239.
5. DE GRISSE, A. 1964. *Hemicriconemoides pseudobrachyurum* n. sp. (Nematoda: Criconematidae). *Nematologica* 10:369-372.
6. DE GRISSE, A. 1964. Morphological observations on *Criconemoides*, with a description of four new species found in Belgium. (Nematoda). *Meded. LandbHoogeschool. OpzoekStns. Gent* 29:734-761.
7. EDWARD, J. C., and S. L. MISRA. 1963. *Hemicriconemoides communis* n. sp. and *H. litchi* n. sp. (Nematoda: Criconematidae), from Uttar Pradesh, India. *Nematologica* 9:405-411.

8. EDWARD, J. C., S. L. MISRA, and G. R. SINGH. 1965. *Hemicriconemoides birchfieldi* n. sp. (Nematoda: Cricematidae) from Allahabad, Uttar Pradesh, India; with a revision of the key to the species of *Hemicriconemoides*. *Nematologica* 11:157-161.
9. ESSER, R. P. 1960. Three additional species in the genus *Hemicriconemoides* Chitwood and Birchfield, 1957 (Nematoda: Tylenchida). *Nematologica* 5:64-71.
10. FASSULIOTIS, G. 1962. Life history of *Hemicriconemoides chitwoodi* Esser. *Nematologica* 8:110-116.
11. GOODEY, T. 1963. Soil and freshwater nematodes. 2nd edition by J. B. Goodey. Methuen, London. 544 pp.
12. LOOS, C. A. 1949. Notes on free-living and plant-parasitic nematodes of Ceylon—No. 4. *J. Zool. Soc. India* 1:17-22.
13. NAKASONO, K., and M. ICHINOHE. 1961. *Hemicriconemoides kanayaensis* n. sp. associated with tea root in Japan (Nematoda: Cricematidae). *Japanese J. Appl. Entom. Zool.* 5:273-276.
14. OOSTENBRINK, M. 1960. The family Cricematidae. In J. N. Sasser and W. R. Jenkins (Eds.). *Nematology, Fundamentals and Recent Advances*. University North Carolina Press, Chapel Hill.
15. SIDDIQI, M. R. 1961. Studies on species of Cricematinae (Nematoda: Tylenchida) from India. *Proc. Helminthol. Soc. Wash.* 28:19-34.
16. SIDDIQI, M. R., and J. B. GOODEY. 1963. The status of the genera and subfamilies of the Cricematidae (Nematoda); with a comment on the position of Fergusobia. *Nematologica* 9:363-377.
17. TIMM, R. W. 1965. A preliminary survey of plant parasitic nematodes of Thailand and the Philippines. SEATO Publication, Bangkok, 71 pp.
18. VAN GUNDY, S. D. 1959. The life history of *Hemicycliophora arenaria* Raski (Nematoda: Cricematidae). *Proc. Helminthol. Soc. Wash.* 26:67-72.
19. WHITLOCK, L. S., and A. E. STEELE. 1960. Notes on *Hemicriconemoides gaddi* from camellias in Louisiana and Georgia. *Pl. Dis. Rep.* 44:446-447.
20. YOKOO, T. 1963. A new ring nematode, *Hemicriconemoides ureshinoensis* n. sp. found in the soil around the root of tea-plant with some notes on its distribution in the soil. *Agr. Bull. Saga (Japan) Univ., Agric. Bull.* No. 16, pp. 31-35.