The Genus *Isolaimium* Cobb, 1920 (Order Isolaimida, Isolaimiidae New Family)

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Abstract: Five species of *Isolaimium* Cobb, 1920 are described and illustrated: *I. nigeriense* n. sp., *I. multipapillatum* n. sp., *I. californicum*, n. sp., *I. papillatum* Cobb, 1920, and *I. stictochroum* Timm, 1961. A unique feature in *Isolaimium*, not found in any other nematode, is the presence of six cuticularized tubes surrounding the stoma and opening on the head. Order Isolaimida Cobb, 1920 is emended to accommodate this genus, which is considered to lie between the mermithoids and the dorylaimoids.

Until 1961 the genus *Isolaimium* was known only from the type species, *I. papillatum* Cobb, 1920, which was only partially illustrated. Since then Timm (8), Andrássy (1) and Hogewind and Heyns (6) have added descriptions of *Isolaimium* species. The peculiar nature of the cephalic papillae has been recognized and Hogewind and Heyns (6) attempted to elucidate their structure. They illustrated six thick-walled tubes with a hollow lumen surrounding the mouth opening and stoma, as seen in *en face* view and in sectional views of the stomatal region. However, they considered that these tubes apparently lead inwardly from the large cephalic papillae, although, in their *en face* view, the papillae and tube apertures are depicted as separate. In lateral views of the head they drew two or three circles of cephalic papillae, apparently all connecting with the six tubes. This discrepancy is resolved in our study of three new species from the USA and Nigeria and specimens of *Isolaimium papillatum* Cobb, 1920 from the USA and of *I. stictochroum* Timm, 1961 from India. There are six hollow cuticularized tubes surrounding the mouth; they run parallel to the stoma and are open at the surface (Fig. 1 F); they are not connected with papillae or sensillae. These tubes are shown by Cobb (3) in his drawing of *I. papillatum* as fine channels opening at a surface depression on the front of the head, but they are labelled "ppl 6."

The circle of six large cephalic papillae, set into a depression and having prominent innervations, was described by Cobb (3), Timm (8), and Andrássy (1). Cobb and Timm showed another circle of four papillae at the base of the head. Timm designated a dorso-lateral structure at the level of this circle as a pore-like amphid. This structure can be seen clearly in many specimens of all the five species studied here and appears to be a papilla of the second circle, although it often lies anterior to it. Its dorso-lateral position (lateral or ventro-lateral, however, in *I. multistriatum* Hogewind and Heyns, 1967) is the typical position of the amphid in the Secernentea and in those Adenophorea which have a pore-like or small amphid, e.g. some mermithids. It is possible that amphids might have evolved from dorso-lateral papillae. In spite of the indirect connection of the amphidial nerves with the nerve ring, there are some indications of how this separation could have occurred. E.g. in *Siphonolaimus*, according to Zur Strassen (9), the amphidial nerves are connected with the lateral ganglia at the nerve ring itself. This view would reconcile the controversial positions of Chitwood and Wehr (2) and De Coninck (4) on the primitive distribution of cephalic sensory structures.

In the three new species described here,

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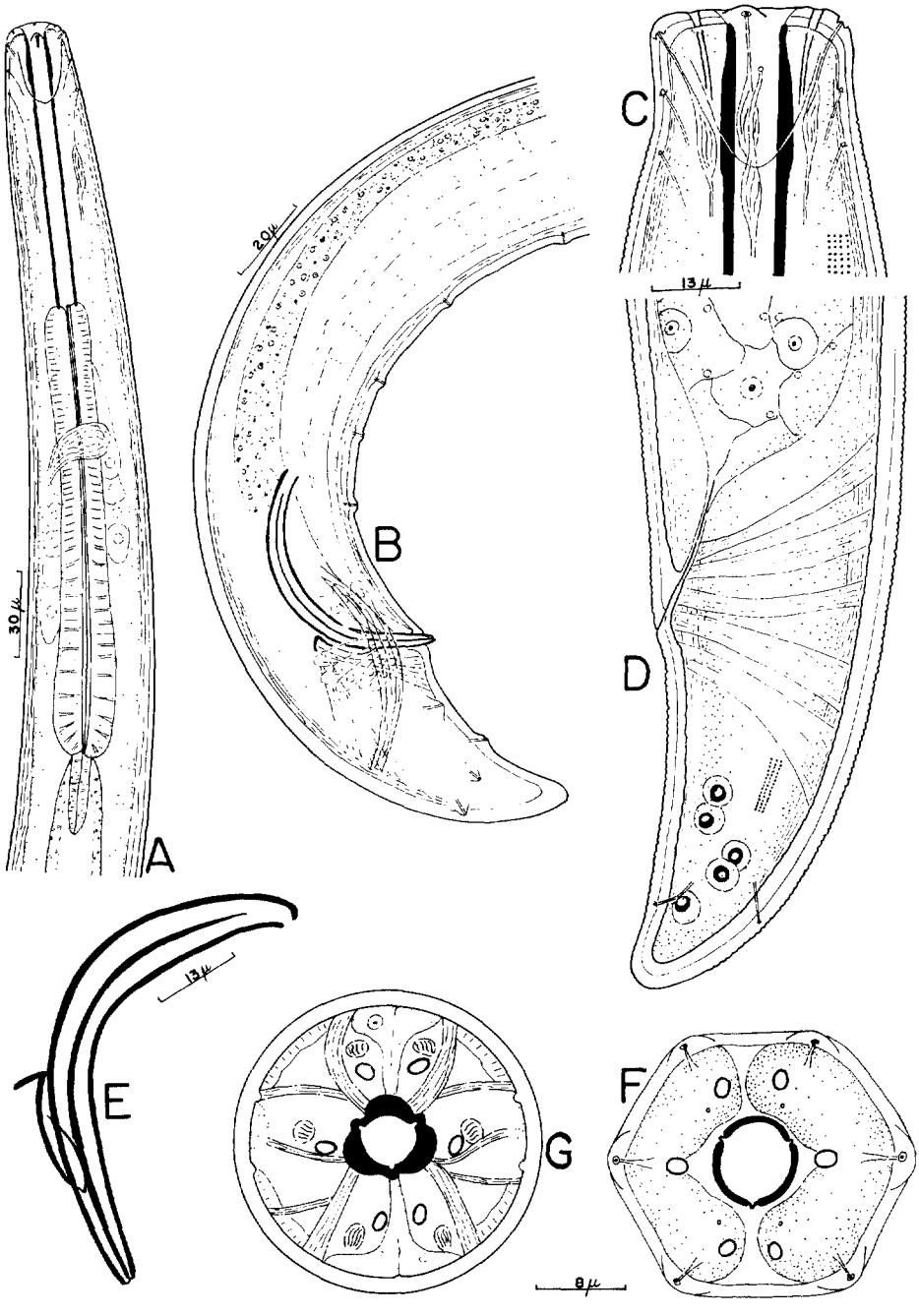

FIG. 1. *Isolaimium nigeriense* n. sp. A. Esophageal region. B. Male tail. C. Male head. D. Female tail. E. Copulatory apparatus. F. *En face* view of male. G. Section through thickened part of stoma.

a somewhat dorylaimoid amphid-like structure is present in the lateral cephalic region beneath the surface of the cuticle, but there is no aperture to the outside of the body. In lateral view it appears somewhat fibrous and in transverse section it seems to be granular (Fig. 1 G).

SYSTEMATIC POSITION

Timm (8) discussed the systematic position of *Isolaimium* and pointed out certain affinities with the Dorylaimoidea. Since 1961 this genus has been placed: questionably in the Cylindrolaiminae of the Axonolaimidae by T. Goodey (5); questionably in the Bathyodontidae by De Coninck (4), who indicated the genus has a strong affinity with the dorylaimids; and questionably in the Mermithidae by Théodoridés (7), who regarded it as insufficiently known.

The present study emphasizes the unique position of *Isolaimium* in the Nematoda. Hollow tubes surrounding the mouth opening are not found in any other nematode. Therefore, Cobb's (3) Order Isolaimia, emended to Isolaimida, is resurrected for this genus alone, excluding all the other genera he placed in it. The Order Isolaimida is considered to lie between the orders Dorylaimida (de Man, 1876) Pearse, 1936 and Trichosyringida (Ward, 1917) J. B. Goodey, 1963. The systematic placement of *Isolaimium* will be:

Order Isolaimida (Cobb, 1920) emended
Superfamily Isolaimioidea new superfamily
Family Isolaimiidae new family
Subfamily Isolaimiinae new subfamily

All the above categories follow the diagnosis of the genus.

Isolaimium Cobb, 1920 (emended)

DIAGNOSIS: Isolaimiidae new family. Body elongate (3–6 mm). Cuticle annulated, at least anteriorly; punctations set in longitudinal and transverse rows (probably always present; sometimes faint or visible only on tail). Lateral chords faint. Six hollow tubes surrounding mouth and stoma. External circle of six large recessed papillae; second circle of six smaller papillae. Amphids apparently absent or represented by dorsolateral papillae of second circle. Esophagus clavate, with thickened lining. Stoma long, triradiate, cuticularized, usually with thicker walls near anterior. Cardia long, cylindrical. Vulva transverse; female gonads amphidelphic, with flexures. Male gonads diorchic, outstretched. Spicules thick, cephalate or non-cephalate, internally divided or not. Short parallel gubernaculum with two short posterior apophyses. Preanal, midventral, papillary supplements in male. Large caudal papillae on male tail and fine papillae on female tail. Tails short, conoid, with bluntly-rounded to pointed tip.

TYPE SPECIES: *Isolaimium papillatum* Cobb, 1920.

KEY TO SPECIES OF ISOLAIMIUM

1. Longitudinal striae very faint ..... *papillatum* Cobb
   Longitudinal striae prominent 2
2. Lip region greatly expanded ..... *incus* Hogewind & Heyns
   Lip region not expanded or slightly expanded 3
3. Longitudinal striae composed of distinct punctations 4
   Longitudinal striae not composed of distinct punctations on most of body 7
4. Longitudinal striae 100–120 ..... *nigeriense* n. sp.
   Longitudinal striae about 60 5
5. Preanal supplements 10–14 ..... *multipapillatum* n. sp.
   Preanal supplements 3–6 6
6. Spicules with single internal division

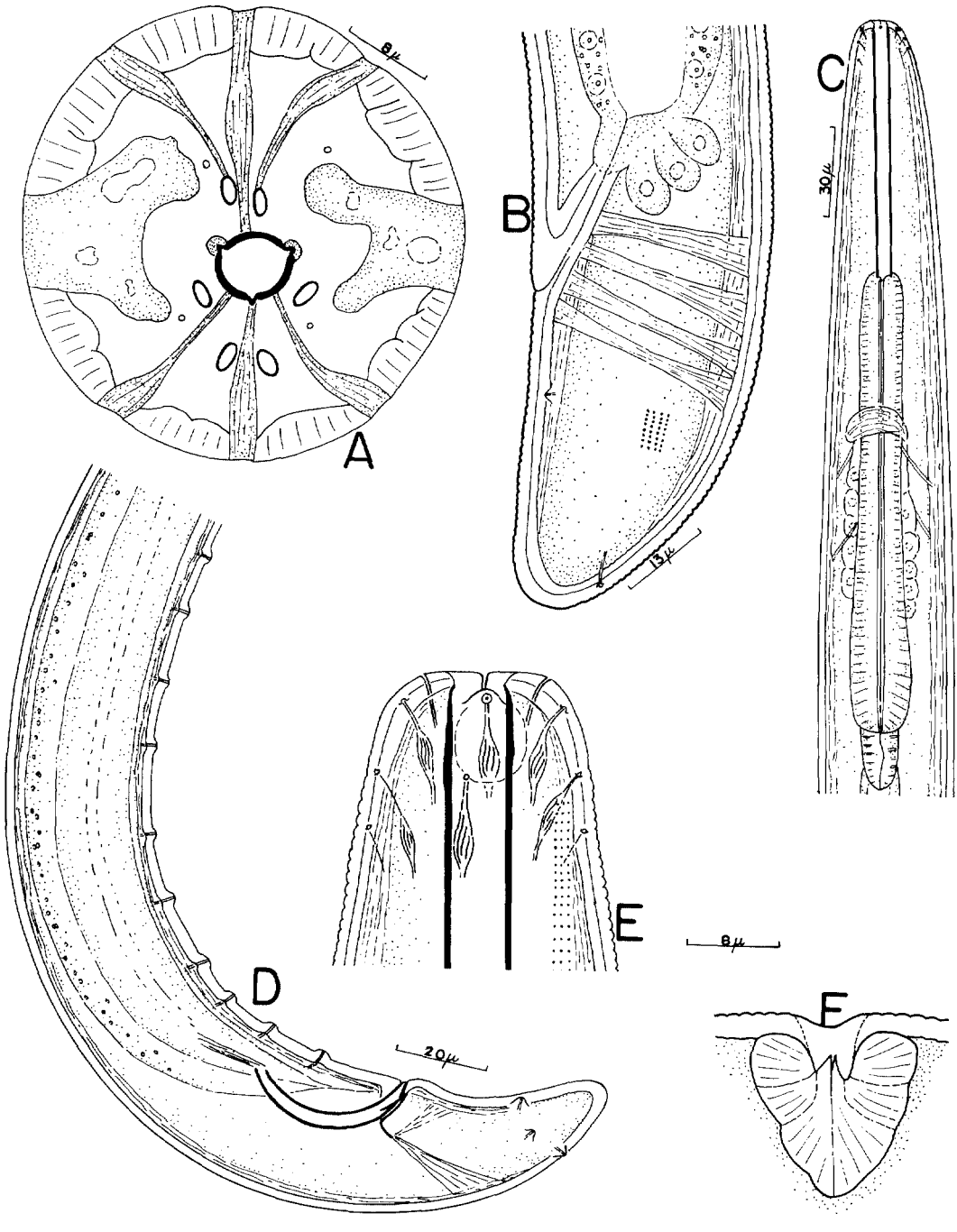

FIG. 2. *Isolaimium nigeriense* n. sp. A. Section near base of stoma (cuticle sloughed off). *Isolaimium multipapillatum* n. sp. B. Female tail. C. Esophageal region. D. Male tail. E. Male head. F. Vulvar region.

..... *californicum* n. sp.
Spicules with doubled internal division
..... *stictochroum* Timm
7. Longitudinal striae about 80 .....
..... *africanum* Hogewind & Heyns
Longitudinal striae more than 120 ....
..... *multistriatum* Hogewind & Heyns

DESCRIPTION OF SPECIES

Isolaimium nigeriense n. sp.

(Figs. 1 A–G, 2 A)

Male (n = 3): L = 3.2 (2.98–3.48) mm; a = 67 (65–70); b = 12.1 (11.8–12.7); c = 53 (44–60).

Female (n = 2): L = 2.73–3.53 mm; a = 55–71; b = 11.9–13.3; c = 46–55; V = 54–55.

Holotype (male): L = 3.1 mm; a = 65; b = 12.7; c = 60; stoma = 92 μ.

Allotype (female): L = 3.53 mm; a = 71; b = 13.3; c = 55; V = 55; stoma = 96 μ.

Description.—Body of male gently curved toward ventral side at posterior end; female body only slightly curved. Annulation more prominent at anterior end and longitudinal lines more apparent at posterior end. Transverse and longitudinal lines (100–120 in number) both composed of fine punctations, distinct on entire body but more so on tail. Lateral field granular, finely vacuolate in esophageal region. Body uniformly tapering to anterior end, but head distinctly expanded in one male specimen; head truncate at anterior, 18–29 μ in diameter. Six large papillae on head, set into depressions, with conspicuous innervations; anterior to these papillae and surrounding the stoma aperture, six prominent open cuticularized tubes extending parallel to stoma for its full length (very broad and conspicuous in 4 males from Abeokuta Province). In addition to the 6 tube apertures there may be a circle of 6 tiny papillae between the tube openings and the stomatal aperture, but only 4 submedian papillae could be detected. Amphid-like lateral structures beneath surface of cuticle, funnel-shaped, distinct at their posterior end but without any distinct aperture at surface. Stoma 88–96 μ long, with walls thickened near anterior end; tooth-like projection sometimes seen at base of stoma represents edge of esophageal radius. Cardia 20–30 μ long. Numerous specimens of a sporozoan, presumably *Duboscquia* sp., in pseudocoelom and intestinal cells of one specimen (Fig. 1 D).

Vulva slit-like; no ova present in uterus. Spicules with internal division up to anterior end, 72–80 μ long. Gubernaculum parallel to spicules, with small side piece; two posterior apophyses, variable in length from almost absent up to 13 μ. Six to seven midventral preanal papillae, not very conspicuous; anteriormost supplement 140–200 μ anterior to anus. Four pairs caudal papillae, variable in position with respect to tail length. Female tail bearing one pair subdorsal and one pair subventral inconspicuous papillae near tail tip. Tail 1.4–1.8 anal body diameters long in male, 1.2–1.3 in female.

Type Habitat and Locality.—Soil from around cocoa, Ibadan Province, Nigeria. Other localities: Abeokuta Province and Oya Province, Nigeria (four males from Abeokuta Province have pointed tails and the stoma is 95–123 μ long; these have been excluded from the type material).

Holotype Male.—Collected by F. E. Caveness, 24 November, 1960; Slide 1071, University of California Nematode Collection, Davis.

Allotype Female.—Collected by F. E. Caveness, 16 November, 1960; Slide 1072, UCNC, Davis.

Paratypes.—1 ♂ each on Slides 1073 and 1074 and 1 ♀ on Slide 1075, UCNC, Davis.

Diagnosis.—This species is close to *Isolaimium multistriatum* Hogewind and Heyns,

1967. Dr. Heyns kindly sent me two paratypes of the latter for comparison. The present species differs in the definite punctation, whereas in *I. multistriatum* the longitudinal lines are resolvable into dots only on the tail and in the stomatal region. The cephalic tubes are broader and more conspicuous in *I. nigeriense*; the second circle of cephalic papillae is more posterior; the intestine is tessellated and there are few small globules, while in *I. multistriatum* the intestine is not tessellated and its cells contain numerous refractive sphaeroids of various sizes. In the latter the cuticular annulation is more prominent and continues around the tail tip; the stoma is thickened near the anterior as in *I. nigeriense*.

Isolaimium multipapillatum n. sp.
(Fig. 2 B–F)

Male (n = 5): L = 3.49 (3.17–4.16) mm; a = 78 (70–87); b = 14 (12.7–15.6); c = 79 (62–95).

Female (n = 3): L = 3.49 (3.32–3.74) mm; a = 64 (57–72); b = 14.1 (13.8–14.4); c = 81 (71–87); V = 53.3 (52–55).

Holotype (male): L = 3.18 mm; a = 71; b = 12.7; c = 62; stoma = 88 μ.

Allotype (female): L = 3.41 mm; a = 62; b = 14.2; c = 71; V = 52; stoma = 90 μ.

Description.—Body of male curved in half-circle at posterior end; female body less curved. Faint annulation, more prominent at anterior and posterior. Longitudinal and transverse striation, composed of large round distinct punctations; about 60 longitudinal lines; transverse striae about 1.3 μ apart. Head slightly offset (head of one male from Georgia definitely offset), 19–25 μ in diameter. Stoma 80–92 μ long. Cardia 16–30 μ long.

Vulva sunken (Fig. 2 F), slit-like; vagina short, surrounded by thick muscles. One female with one egg in each uterus, 40 × 30 μ, without shell. Spicules thick, without internal division, non-cephalate, 54–56 μ long through center. Short parallel gubernaculum with side piece lateral to spicules and two short posterior apophyses, variable in length. Ten to fourteen conspicuous preanal supplements, with distinct innervations; anteriormost supplement 172–220 μ anterior to anus. Three pairs of large caudal papillae on tail, variable in position. Two pairs of subventral papillae anterior to anus. Female tail bearing one pair of subventral papillae on anterior part of tail and one pair of subdorsal papillae near tail tip. Tail 1.2–1.5 anal body diameters long in male, 1–2.6 in female.

Type Habitat and Locality.—Sandy soil, experimental forest of Forestry Department, Auburn University, Auburn, Alabama. Other localities: Alabama Port near Biological Laboratory, Mobile Bay, Alabama; Perry, Tifton and Worth County, Georgia; Florence, South Carolina; and Mt. Rainier, Maryland.

Holotype Male.—Collected by B. E. Hopper in May, 1956; Slide 1076, University of California Nematode Collection, Davis.

Allotype Female.—Collected by M. Waseem in January, 1956 from area affected by tide (17/00); Slide 1077, UCNC, Davis.

Paratypes.—1 ♂ each on Slides 1078 and 1079, UCNC, Davis; 1 ♂ and 1 ♀ each in nematode collections of U.S.D.A., Beltsville, and Central Experiment Farm, Ottawa.

Diagnosis.—Isolaimium multipapillatum n. sp. is distinguished from all other species by the greater number of male supplements. It is further distinguished from the type species, *I. papillatum,* by the conspicuous punctation of the cuticle. A single headless male specimen collected by G. Steiner on 23 June, 1923, at Mt. Rainier, Md., has 10 prominent supplements and internal division of the spicules. The two male specimens collected by G. Thorne in November, 1939, from

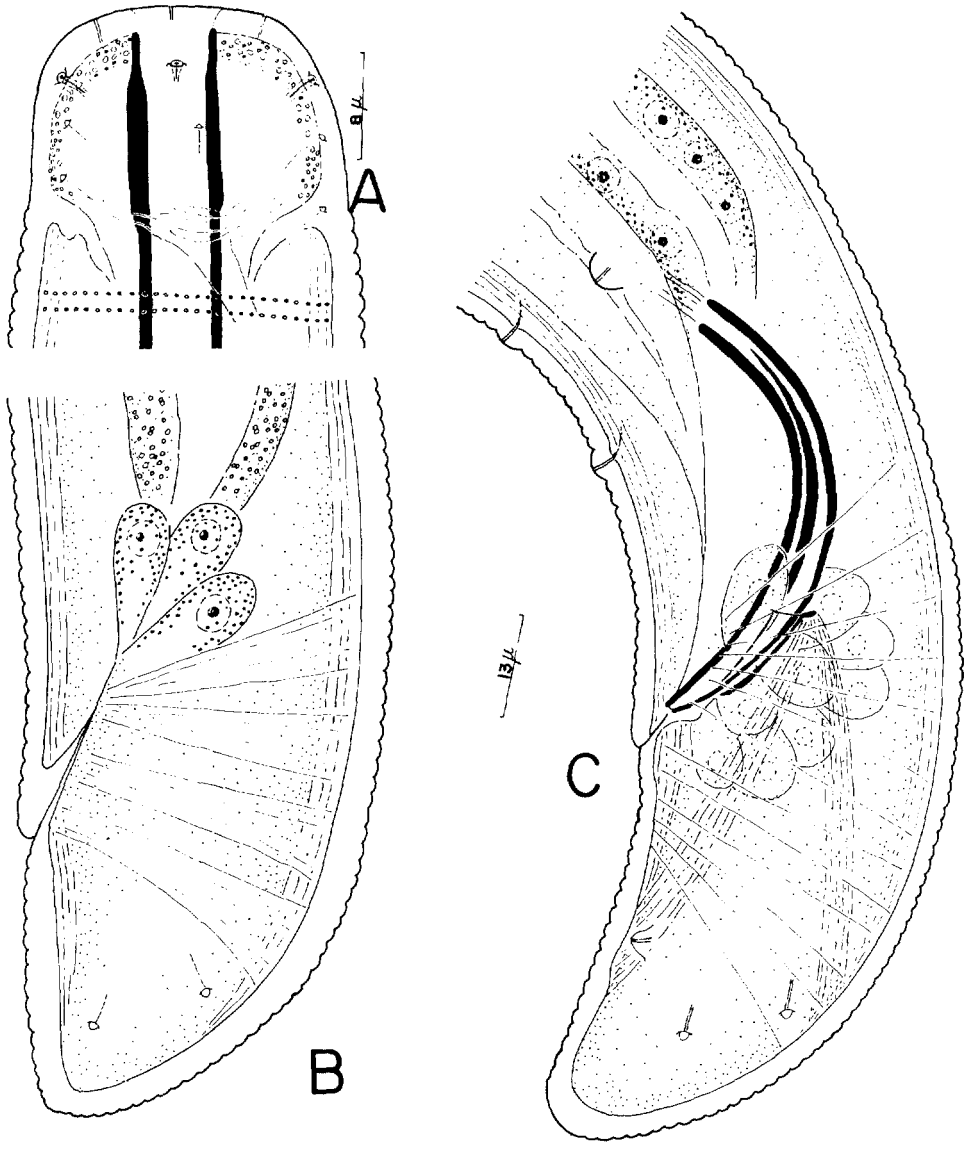

FIG. 3. *Isolaimium californicum* n. sp. A. Female head. B. Female tail. C. Male tail.

Tifton, Ga., have 7 and 10 supplements and no internal division of the spicules.

Isolaimium californicum n. sp.
(Fig. 3 A–C)

Male (4): L = 3.74 (3.29–4.63) mm; a = 96 (82–110); b = 15.7 (13.2–17.8); c = 90 (75–103).

Female (7): L = 4.46 (4.28–4.81) mm; a = 99 (85–113); b = 16.3 (15.3–17.5); c = 105 (97–113); V = 56.3 (53–60).

Holotype Male: L = 3.34 mm; a = 82; b = 13.2; c = 84; stoma = 90 μ.

Allotype Female: L = 4.54 mm; a = 113; b = 16.7; c = 113; V = 54.8; stoma = 90 μ.

Descriptions.—Body of female outstretched; male curved in half-circle at tail end. Cuticle coarsely annulate and punctate; annules 1.4 μ wide; punctation more distinct at anterior and posterior; longitudinal lines about 60. Head end uniformly tapering; head diameter 20–22 μ; head set off as fibrous and granulated area anterior to beginning of annulation. Six cephalic tubes faint. Three circles of cephalic papillae, the third at beginning of annulation. Stoma 87 (71–98) μ long. Cardia 19–28 μ long. Vulva slit-like, depressed; vagina button-like in surface view; one ovum with shell observed, 90 × 36 μ. Spicules non-cephalate, 54–60 μ long through the median line, internally divided. Gubernaculum parallel to spicules, with lateral sleeves around spicules and a short dorsal apophysis. Subdorsal and subventral gubernacular muscles extending to near tip of tail. Four to six midventral preanal supplements; two pairs of blunt preanal submedian papillae; three pairs of caudal papillae. Tail 1–1.3 anal body diameters long in male, 0.9–1.2 in female.

Type Habitat and Locality.—Soil around roots of apple tree, Sebastopol, California. Other locality: six juveniles collected by G. Thorne 17 May, 1939, from around roots of apple, Berkeley, California, probably belong to this species.

Holotype Male.—Collected by G. Thorne 18 December, 1940; U.S.D.A. Collection, Beltsville, Slide T-119t.

Allotype Female.—Same data as holotype; U.S.D.A. Slide T-120t.

Paratypes.—U.S.D.A. Slides T-649p, T-650p and T-651p; 1 ♂ and 1 ♀ in University of California Nematode Collection, Davis, Slide 1086.

Diagnosis.—This species closely resembles *I. multipapillatum* n. sp. but can be distinguished by the following characteristics: 1) the supplements are fewer and less protruding; 2) the spicules are internally divided; 3) the posterior apophysis of the gubernaculum is shorter; 4) the ventral gubernacular muscles are attached much more posteriorly.

Isolaimium papillatum Cobb, 1920
(Fig. 4 B,D,F–H)

Four specimens believed to represent the type species of the genus were collected in Butcher, Kansas, in 1949 and are preserved in the Nematode Collection, Davis.

Male (n = 2): L = 4.71–4.94 mm; a = 84–90; b = 18.1–19.0; c = 87–99.

Female Juvenile (n = 2): L = 3.34–3.54 mm; a = 56–64; b = 14.5–16.4; c = 70–80.

Description.—Prominent annulation; annules about 2 μ apart. Very faint longitudinal lines, at least 100, resolvable into fine dots or punctations on tail; apparently two transverse rows of punctations for each annule, i.e. one row in center of annule and one row at each interannular groove. Head uniformly tapering to anterior or slightly offset. Stoma 78–83 μ long in juveniles, 90–94 μ in males, not noticeably thickened near anterior. Cardia 18–20 μ long. Spicules thick, without internal division, cephalate in one specimen and non-cephalate in the other, 60–65 μ long. Short gubernaculum with two posterior apophyses. Five small mid-ventral preanal supplements. Three pairs of thick subventral papillae anterior to anus and four or five pairs of prominent caudal papillae; one male as figured (Fig. 4 F), the other lacking the second pair of papillae. Female tail bearing two pairs of inconspicuous caudal papillae near tip. Tail 1–1.2 anal body diameters long.

Diagnosis.—The present specimens differ from Cobb's in having a coarser cuticle, which would fall under Cobb's category "rather coarse" (i.e. 500 ± striae per mm).

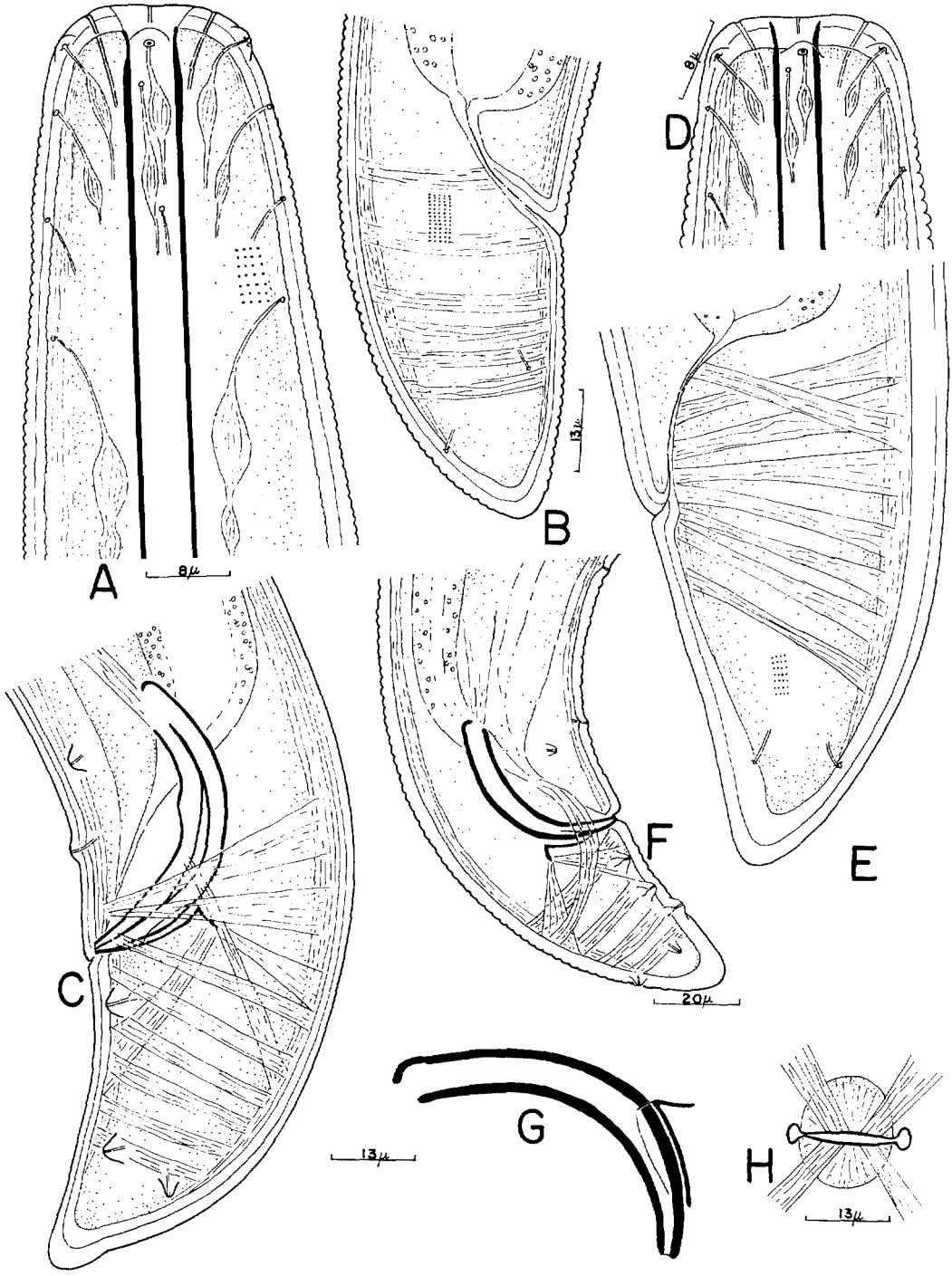

FIG. 4. *Isolaimium stictochroum* Timm, 1961. A. Female head. C. Male tail. E. Female tail. *Isolaimium papillatum* Cobb, 1920. B. Female tail. D. Female head. F. Male tail. G. Copulatory apparatus. H. Vulvar region in ventral view.

The cuticles of his specimens are in the next lower grade, "rather fine" (i.e. 750 ± striae per mm). That Cobb's description of the cuticle is inaccurate can be seen in his statement "cuticle rather thin," since he illustrates it as thick and layered. The supposed difference in width of annulation does not seem great enough to justify establishing a new species, as Hogewind and Heyns (6) have done for the single female of Andrássy (2), which has a finer cuticular striation (0.8 μ). The latter has been renamed *Isolaimium andrassyi* Hogewind and Heyns, 1967, but since it is based on only one female it must be regarded as a *species inquirenda.*

Isolaimium stictochroum Timm, 1961
(Fig. 4 A,C,E)

Five adult specimens from the Horticultural Division nursery, Indian Agricultural Research Institute, New Delhi, India, were collected by D. J. Raski in September, 1962 and are on deposit in the nematode collection, Davis.

Male (n = 3): L = 4.42 (4.24–4.62) mm; a = 83 (71–89); b = 17.2 (15.7–18.9); c = 92 (85–103).

Female (n = 2): L = 5.21–5.27 mm; a = 85; b = 20.3–21.7; c = 97–105; V = 52–53.

Description.—Fine annulation can be seen only at anterior of body; annules about 0.8 μ wide. Transverse striation obscured on rest of body by prominent longitudinal lines, about 60 in number, consisting of fine punctations set about 0.5 μ apart at mid-body. Head not set off, 22–27 μ in diameter. Stoma 80–100 long. Cardia 20–31 long. Spicules 49–62 μ long, slightly cephalate, with internal division which is itself split into two at mid-spicule. One male with three distinct mammillate mid-ventral supplements, another with one prominent supplement at spicule level and seven fine innervations anterior to it, more or less uniformly distributed, but without any protrusion of the body surface. Three pairs subventral papillae anterior to anus. Female with two pairs of fine papillae near tail tip (in one specimen the two are close together and almost fused). Tail length in both sexes 1–1.2 anal body diameters long.

Diagnosis.—The present specimens fit the description of Timm (8) closely except for the shape of the tail tips, which are more bluntly rounded in Timm's specimens. However, in *I. nigeriense* n. sp. there is a similar variation in tail shapes of two populations from different provinces of Nigeria. Timm considered the amphids to be pore-like, but in the present specimens these structures are seen to be papilla-like. The six anterior canals surrounding the mouth were previously overlooked.

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