Taxonomy and Morphology of *Axonchium* (Nematoda: Belondiroidea), and a description of *A. thornei* n. sp.

HELEN CAROL HECHLER[1]

Abstract: Useful diagnostic characters in the nematode genus *Axonchium* include: lip shape, stylet length, shape of the esophageal constriction, presence or absence of spiral musculature in the esophageal sheath, proportion of the esophageal length occupied by the esophageal expansion, length and shape of cardia, shape of the vulva and vaginal cuticularization, development of the anterior gonad, shape of the posterior uterus, subcuticle thickness at mid-body, tail shape, number and arrangement of supplements and caudal pores, and body measurements. *A. thornei* n. sp. is separated from *A. choristum* by its thinner subcuticle at mid-body, number of supplements, and shorter spicules, from *A. solitare* by presence of males, and from both species by the female tail shape and shorter stylet. *A. saccatum* is synonymized with *A. gossypii* and *A. nitidum* is synonymized with *A. bulbosum*. *A. leptocephalum, A. longicollis, A. magnicollis,* and *A. tenuicollis* are made *species inquirendae*. A key to 25 species of *Axonchium* is given.

Species of *Axonchium* Cobb, 1920 have been found in Brazil, the Congo Republic, Hawaii, India, Mauritius, the Netherlands, Puerto Rico, Switzerland, Sumatra, and the continental United States. They have been collected from around the roots of many kinds of plants, including alfalfa, banana, cactus, citrus, coconut, cotton, mahogany, rubber, sugarcane, tea, and turf. Nothing is known of their feeding habits or parasitic effect. Thirty-two species have been described. The type species is *Axonchium amplicolle* Cobb, 1920.

MATERIALS AND METHODS

Most of the specimens used in this investigation are syntypes of species of *Axonchium* described by Thorne (17) and now kept in the Gerald Thorne Collection within the U.S.D.A. Nematode Collection, Beltsville, Maryland. These species are: *A. choristum* Thorne, 1939; *A. crassum* Thorne, 1939; *A. gigas* Thorne, 1939; *A. micans* Thorne, 1939; *A. serpens* Thorne, 1939; and *A. solitare* Thorne, 1939. An additional species, described herein as *A. thornei* n. sp., was found among this material. All these nematodes had been fixed in formalin and mounted in glycerine. Syntypes of *A. amplicolle*, and a single male and a single female of *A. macrophallum* Thorne, 1939, stained with carmine and mounted in balsam, were also in this collection. Paratypes of *A. rotundum* Thorne, 1964 and specimens of *A. amplicolle*, mounted in glycerine, were kindly loaned by Dr. A. J. Ayala. Paratypes of *A. asacculum* Siddiqi, 1958 were from the U.S.D.A. Type Collection. About 70 females of *A. micans* were collected from turf under the bridge at the intersection of Virginia Route 7 and Broad Run. These specimens were studied live, in formalin, and in glycerine.

Details of the stylet and its extensions, lateral and ventral pores, esophageal sheath, and amphid pouches were obscured in many of the carmine stained-balsam mounted specimens. The stylet extensions were nearly invisible in specimens mounted in glycerine, but were easily seen in the Broad Run material of *A. micans*, either live or fixed in formalin.

Many of the older specimens had become flattened after years under a cover slip. Therefore the width and "a" value were omitted in reports of the dimensions of several species. Spicules were measured in a straight line between the anterior and posterior ends.

Received for publication 21 April 1969.

[1] Crops Protection Research Branch, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland 20705.

Lectotypes were selected from among the syntypes of those species for which no holotype had been designated. These type specimens were deposited in the Gerald Thorne Collection within the U.S.D.A. Nematode Collection. The holotype, allotype, and paratypes of *A. thornei* n. sp. were deposited in the Type Collection of the U.S.D.A. Nematode Collection.

Morphology and Diagnostic Characters

Head and Lips: The shape of the head and lips is useful in separating species of *Axonchium*. Four types have been found: *Type 1.* (Fig. 9C) Head smooth, narrower than the neck and widening gradually to the neck diameter. The lips are nearly amalgamated. *Type 2.* (Figs. 2A, 2H1, 2H2, 4A, 4D1, 7A, 8A) Head set off from the neck region with lips separate, smooth and rounded. In focal plane view lateral body walls in amphidial region nearly parallel, forming the feature Thorne (17) called a "collar." *Type 3.* (Fig. 3D, 5A, 6A) Similar to type 2, except the anterior part of each lip, bearing the inner papilla, is set off by a depression. *Type 4.* In only one species, *A. labiatum* Thorne, 1939, the head is similar to type 3, except the anterior part of each lip is comparatively enlarged and conspicuously set off by a deep constriction.

Stylet and Stylet Extension: The stylet (Fig. 3D) is fusiform in lateral view in all the species examined. The stylet orifice extends between one-fifth and one-third of the stylet length, depending on the species, with some variability within a species. The orifice length is very difficult to measure accurately unless the stylet is situated in a perfect lateral view, which is rare because mounted specimens of *Axonchium* tend to twist anteriorly. Thus, although the proportion of the stylet length occupied by the orifice varies between some species, this proportion is seldom useful diagnostically. In dorsoventral view the sides of the stylet are nearly parallel or slightly divergent posteriorly, and closer together than in lateral view (Fig. 9D); therefore the stylet is oval in cross section (Fig. 4D3). A bifurcation is visible at the dorsal posterior end of the stylet in many specimens, particularly in the larger species. It probably is present in all species. The length of the stylet, varying between 8 and 23 microns in the species examined, is occasionally useful as a diagnostic character. The stylet is not shorter than the head width, as stated by several authors (9, 17, 18), but slightly longer in the species examined here.

The stylet extension, best studied in fresh material, comprises two tubes, the shorter one surrounding the longer one (Fig. 3D). The shorter tube is of greater diameter posteriorly and its axis tends to be ventrally displaced. The inner, longer tube is only slightly wider in diameter at the posterior end. Thickenings are present at the posterior end of the extensions where it joins the esophageal lumen.

Amphids: The amphidial apertures in all species are transverse slits located at the base of the lips. The slit may be noticeably shorter than the head width, particularly in those species with amalgamated lips, whereas in most species with separate lips it is almost as wide as the head. In a few species, in which the anterior pouches of the two amphids are separated by a very narrow partition, the amphids seem to surround the head. In all species the pouch is cyathiform with the sensillae near the base of the stylet extension. Thorne (17) observed triangular structures, deeply notched anteriorly, within the base of the amphid pouches in *A. crassum*, which he named "stiffening elements." He figured them also for *A. micans*. These structures were visible in all the species examined here (Figs. 1B, 2A, 2H3, 3D, 4A, 4D3, 5A, 6A, 7A, 8A, 9C) except *A. ampli-*

colle mounted in balsam and may be present in all species of *Axonchium*.

ESOPHAGUS: The esophagus consists of a slender anterior portion with fine musculature, and a wider posterior section with heavier musculature and sourrounded by a sheath. The musculature in the posterior portion, as illustrated by Siddiqi (14), is confined to rays, with non-muscular areas between them. Only the large dorsal esophageal gland nucleus, located in the anterior end of the wide basal portion, is visible. Either the subventral gland nuclei are extremely inconspicuous and obscured by the musculature, or these glands are absent.

In most of the species examined specimens were found in which the esophageal expansion was as long as three-fourths or as short as two-thirds the esophageal length. In *A. asacculum* the constriction was located about two-fifths the distance from the anterior end. Therefore the location of the constriction is of diagnostic value for only a few species.

In some species the anterior end of the basal expansion tapers toward the constriction, and the two parts of the esophagus are separated by a narrow isthmus (Figs. 2B, 3B, 5D, 6B, 7D, 7H, 8D). In other species the anterior end of the expansion is truncate, and the two portions of the esophagus abut (Fig. 1F). In these species, the isthmus is not present.

In all species except *A. gigas* the muscle bands of the sheath are straight. They spiral dextrally around the esophagus in *A. gigas*. These differences have been discussed in detail elsewhere (8).

CARDIA: The cardia differs in length from species to species and its size and shape can sometimes be used as a diagnostic character (Figs. 1C, 1H, 2C, 3C, 5E, 6C, 7F, 7I, 8H).

VULVA AND VAGINA: The vulval orifice may be a transverse slit (Fig. 1J1), a transverse oval (Fig. 3E1, 4E1, 5G1), or circular (Fig. 2G1, 6H1, 7E1, 8F1). Vaginal cuticularization ventral to the sphincter may be very narrow and inconspicuous, becoming gradually thicker than the body cuticle and not offset from it (Fig. 1D, G), or it may be quite thick but not offset from the cuticle (Fig. 1E). This usually occurs in association with the slit-like vulval orifice. In other species the vaginal cuticularization is conspicuous, thickened, and offset from the body cuticle and sometimes from the vaginal sphincter (Fig. 2F, 3F, 4F, 5B, 6E, 7B, 8E). This type of cuticularization is associated with the circular or oval vulval opening. In some species an additional, more heavily striated disc-like cuticularization is present surrounding the vulval opening (Fig. 2F, 6E, 7B, 8E). The variability of the vulva cuticularization between species is a useful diagnostic character.

The walls of the vagina within the sphincter have sigmoid striations. The vaginal lumen assumes various shapes ventrally but becomes cross-shaped dorsally at the sphincter in the species studied (Fig. 1J, 2G, 3E, 4E, 5G, 6H, 7E, 8F).

POSTERIOR GONAD: (Fig. 1D, 1G, 7C, 9A). In all species the posterior gonad consists of an ovary, oviduct, oviduct expansion, sphincter, uterine expansion, and uterus, as described by Coomans (6).

The ovary is reflexed, with a broadly rounded or truncate terminus. In the germinal zone several germ cells appear in a cross section. In the growth zone the younger oocytes are flat discs occupying the full diameter of the ovary. The oldest germ cell distal to the junction of the ovary and oviduct is longer than wide. A blind sac extends beyond the junction of ovary and oviduct. As pointed out by Coomans (6), the epithelium of ovary and blind sac consists of a layer of spindle-shaped cells. A constriction may be present between the ovary and the sac at the junction of the oviduct if no enlarged egg cell is present, and the walls of the sac may be

quite plicated and the epithelial covering finely striated. The wall is elastic and expands considerably to accommodate an enlarging egg. In highly fecund nematodes the ovary is quite large, whereas it is small and shrunken with plicated walls in females in which reproduction has ceased.

The oviduct is a thick-walled narrow tube surrounded by very conspicuous transverse striae. The walls of its lumen do not have the longitudinal striae found in the walls of the uterus (Fig. 9E). Proximally, the oviduct enlarges to a heavily convoluted expansion with thinner walls. This expansion is roughly triangular in shape, but one or two arm-like extensions may be present overlapping the oviduct expansion. A sphincter separates the oviduct expansion from the uterus.

Proximal to the sphincter, a spherical or oval expansion of the uterus is present. Its walls are slightly thicker than those of the oviduct expansion. Both expansions are highly convoluted and capable of stretching to accommodate enlarged eggs.

The uterus is wide adjacent to the vulva, but distally is usually narrow, sinuous, and thick-walled with longitudinal striae lining the lumen, a transversely striated outer wall, and a somewhat convoluted outer covering (Fig. 9B). In most species the long narrow part occupies a very short section of the nematode body and overlaps itself several times in a sinuous manner. The wider section of the uterus, just posterior to the vulva, is sometimes separated from the narrow part by a constriction and is often filled with sperm in species with males. Sperm may also be present throughout the length of the uterus, in the uterus expansion, and occasionally in the oviduct expansion.

The ovary, oviduct, oviduct expansion, and uterus expansion differ little between species. The uterus may vary in the length of the narrow, sinuous portion, or the narrow portion may be almost straight. In most species the differences in proportion of the wide part to the narrow part seem to result from differences in fecundity or sperm content between the individual specimens, and not to differences between species. However, in *A. amplicolle* the uterus is consistently shorter and considerably less sinuous than in most of the other species (Fig. 1G). In *A. asacculum* the uterus is very short. The narrow portion between the proximal wide portion near the vulva and the uterine expansion is very short and straight, and the expansion is hardly set off (Fig. 1D).

ANTERIOR GONAD: The form of the anterior gonad may differ considerably between species. The gonad may be entirely absent (Fig. 1D) or limited to a short, narrow, digitate sac anterior to the vulva (Fig. 1G). In other species it is wider and longer, with a constriction located at one-third to one-half the distance between the vulva and the terminus of the gonad (Fig. 2I, 7C, 8G). It has not been determined whether this constriction is a sphincter. The portion distal to the constriction may be wide and truncated or more narrow and tapering. In a fourth type almost all parts described for the posterior gonad are present in the anterior gonad, although most of them are much smaller. The uterus is often as large and conspicuous as in the posterior gonad, but always straight, never sinuous. The uterus expansion, sphincter, oviduct expansion, oviduct, and ovary are much smaller than those of the posterior gonad (Figs. 3A, 4C, 5C). The oviduct and ovary may be absent, with the gonad terminating in a spherical oviduct expansion (Fig. 1E, 6D). No author has reported a functional anterior gonad in species of *Axonchium*; the structures anterior to the uterus are reduced in size and no egg from the anterior gonad has been seen.

PRERECTUM: The length of the prerectum has been used as a diagnostic character by some authors. Actually it is quite variable

within a species. In *A. serpens* the length varies between 5 and 10 times the anal body diameter, and it varies between 3.5 and 7.5 times the anal body diameter in *A. micans*. In many specimens the stricture was difficult to locate. Therefore, although the prerectum may tend to be longer in some species than in others, its length should not be considered an important diagnostic character for a species.

CUTICLE: Two layers are easily visible in the cuticle in all species. The outer, more hyaline, one is usually about one micron thick over the entire body, sometimes thicker on the tail, and somewhat thicker overall in larger species. The inner one is much thicker at the extremities than at mid-body. The bounding surfaces of the inner layer are marked with transverse striae, very fine in most species, but coarser in a few. In species with coarse transverse striae, the striae may be repeated on the outer surface of the outer layer, particularly in the neck region. Radial striae are present, extending through the entire thickness of the inner layer and visible as punctations in surface view. The punctations are not arranged in rows in association with the transverse striae. The radial striae are most noticeable in profile at the extremities of the body where the inner cuticle is thicker, but are present at mid-body also. In some of the larger species layers of crisscross fibers are visible in the inner layer. At the middle of the body the inner layer of the cuticle is much thicker than the outer layer in some of the species (Fig. 2F, 3F, 4F, 5B, 6E); in others the two layers are of almost the same thickness (Fig. 7B, 8E). This difference is useful as a diagnostic character.

HYPODERMAL CHORDS AND PORES: The hypodermal chords at the anterior end of the body are T-shaped in cross section, quite narrow near the cuticle between the muscle bands and widening gradually toward the center of the body (Fig. 9F). Near the middle of the body the dorsal chord is smaller than the others and often is not T-shaped (Fig. 5F). Posteriorly the chords are quite wide (Fig. 9G). Therefore the distance between the muscle fields is widest in the tail region and becomes progressively more narrow anteriorly until, at two-thirds to three-fourths the esophageal length from the head, they are hardly farther apart than the individual muscle bands.

The hypodermal organs or glands are located in the enlarged part of the chord nearer the center of the body. In some species the organs tend to be large and conspicuous and the chord is wider to accommodate them (Fig. 8B). In other species their presence causes little change in the width of the chord. The conspicuousness of the organs is also somewhat variable within species. Therefore the size of the hypodermal organs is not a very useful diagnostic character.

Associated with the hypodermal organs are pores extending through the cuticle to the surface (Fig. 2B). They occur laterally and ventrally. In all species the lateral pores are fairly evenly distributed in a single row from just anterior to the nerve ring to about two-thirds of the body length from the head in males and to the anus in females. In females of several species the single row of pores continues on the tail. In other species the last two pores on the tail are paired, arising from the same hypodermal gland in both sexes. In still others one pair is found on the female tail and two to four pairs on the male tail. In males the pores may occur in two staggered rows anterior to the anus for a distance of about one-third body length. Thus, the arrangement of lateral pores in the posterior part of the body is of diagnostic significance.

Ventral pores are unevenly distributed. They are concentrated in the neck region in both sexes. Two to four pores anterior to the nerve ring may pass through the cuticle obliquely; the remainder are perpendicular to

the surface of the cuticle. In males the ventral pores tend to be more closely spaced just anterior to the supplements, with fewer between the base of the esophagus and the middle of the body. In females they are more closely spaced near the vulva.

Ventral pores are rare in *A. rotundum* and apparently lacking in *A. asacculum*.

FEMALE TAIL: Female tail shapes range from hemispherical to digitate and can be a useful diagnostic character. Species with very short tails are easily separated from species with very long tails of a similar general type. However, the method used by several authors of separating species on the basis of the tail length being either shorter or longer than the anal body width is not useful to separate species since in some species tails may be either slightly longer or shorter than the anal width.

MALE TAIL: Male tails tend to be asymmetrical in lateral view, less curved ventrally than dorsally; thus the terminus is located ventrally. Shape of the spicules and lateral guiding pieces seems fairly uniform throughout the genus, but the size varies between species. Each spicule forms a single tube anteriorly (Fig. 9H, 9I) and a double tube posteriorly (Fig. 9J). Supplements vary considerably between species in number, location, and arrangement and the total number present may vary slightly within a species. The arrangement of supplements is of great diagnostic value in species in which males occur.

TESTES: No variability between species in the form and shape of the testes was noted in those studied here.

BODY MEASUREMENTS: Species of *Axonchium* range in length from about 1 to 4.5 mm. Variability within many species is about 0.5 mm and over 1 mm in a few. Because many specimens had been flattened when they were mounted, accurate "a" values could not be calculated for them, and body width was not evaluated as a diagnostic character. The esophagus length varies between species from ½ to ¼ the body length in adult females; in most species it is about ⅓ as long as the body. The "c" value for species of *Axonchium* varies from about 50 to over 100, with variability within some species up to 20 "c" units. The vulva is located at a little over half the body length in most species.

In summary, tail length can be useful for separating species. Body length is useful for separating species that differ considerably from each other, but variability within a few species prevents its use to separate species of nearly the same length. Esophagus length may occasionally be useful to separate species. The location of the vulva differs little between species and has no diagnostic value.

Axonchium Cobb, 1920 EMENDED

DEFINITION: Belondiroidea. Body tapering anteriorly to a narrow lip region. Lips separate with head offset, or lips amalgamated, head not offset. Amphids usually very wide, with stiffening elements. Stylet fusiform in lateral view, tapering gradually anteriorly in dorsoventral view. Stylet extensions comprised of two concentric tubes, the outer, shorter one widening posteriorly, the inner, longer one of almost the same diameter throughout, its walls thickened slightly at its junction with the esophageal lumen. Anterior part of esophagus narrow with delicate musculature, separated from the wider, more heavily muscled portion by a constriction or narrow isthmus. Dorsal esophageal gland nucleus large and conspicuous; subventral gland nuclei inconspicuous or absent. Muscle bands of esophageal sheath straight or spiral. Anterior gonad non-functional or absent. If present it may be a short digitate sac, or wider and longer with a single constriction, or similar to the posterior gonad but reduced in size. Vulva circular, oval, or slit-like; vaginal lumen gradually becoming cross-

shaped dorsally. Vagina often surrounded by thickened cuticularization of various shapes. Tails of females hemispherical, rounded conical, or digitate; shape of male tails close to that of females. Ventromedian supplements 5 to 30, usually closely spaced or contiguous, an adanal pair present. Spicules dorylaimoid, lateral guiding pieces present.

DESCRIPTIONS

Axonchium amplicolle Cobb, 1920

(Fig. 1A, B, F, G, H, I)

Lectotype (1 ♀):[2] L = 1.53 mm; w = .042 mm; e = .690 mm; t = .024 mm; a = 36; b = 2.2; c = 64; V = 57%; stylet not visible.

Paralectotypes (6 ♀♀): L = 1.36–1.56 (1.47) mm; w = .037–.045 (.042) mm; e = .550–.690 (.650) mm; t = .018–.024 (.022) mm; a = 33–36 (35); b = 2.2–2.7 (2.3); c = 62–82 (68); V = 55–67 (57)%; stylet = .009 mm (visible on one specimen only), extensions not visible.

Mauritius Specimens (2 ♀♀): L = 1.85, 1.78 mm; w = .057, .057 mm; e = .810, .780 mm; t = .028, .028 mm; a = 33, 31; b = 2.3, 2.3; c = 65, 63; V = 52, 54%; stylet = .011 mm, extensions = .013 mm.

Female.—Head offset, anterior part of lips slightly offset by a depression (Fig. 1A, 1B). Amphids almost as wide as constriction behind head. Narrow anterior part of esophagus occupying 26 to 40% of total esophageal length. Esophageal expansion truncate anteriorly, the two parts of the esophagus abutting, separated by a very narrow constriction (Fig. 1F). Esophageal sheath muscle bands straight, not spiral. Cardia (Fig. 1H) 15 to 21 μ long in paralectotypes, 19 μ long in lectotype, 17 and 25 μ long in specimens from Mauritius, about 1.5 times as long as its diameter. Outer cuticle about 1 μ thick, subcuticle slightly thicker at mid-body. Vulva a crosswise slit, vaginal lumen gradually becoming cross-shaped dorsally within sphincter. Vaginal culticularization inconspicuous, thickening gradually toward sphincter, not offset from sphincter or body cuticle (Fig. 1G). Anterior gonad an undifferentiated digitate pouch less than one body diameter long (Fig. 1G). Posterior uterus short, with no narrow sinuous section, tapering gradually to the constriction proximal to the uterus expansion (Fig. 1G). No sperm cells seen within the female reproductive system. Tail tapering slightly to broadly rounded terminus (Fig. 1I). One or two caudal pores present on each side of tail. They are arranged in the same row with the lateral pores anterior to the anus, not paired side-by-side as illustrated by Cobb (5). Prerectum 7 times as long as the anal body diameter in one paralectotype, stricture difficult to locate in the other specimens.

Males.—Unknown.

Diagnosis.—*A. amplicolle* is similar to *A. mauritiense* and *A. amphidium*. It differs from *A. mauritiense* by having one caudal pore on each side of the tail, or two arranged in the same row with the lateral pores anterior to the anus (five pores on each side in *A. mauritiense*), and from *A. amphidium* by the more narrow amphid.

Type Habitat and Locality.—Soil around roots of Luca de Persia, imported to the United States from Rio de Janiero, Brazil.

Additional Locality.—Mauritius (specimens loaned by A. J. Ayala).

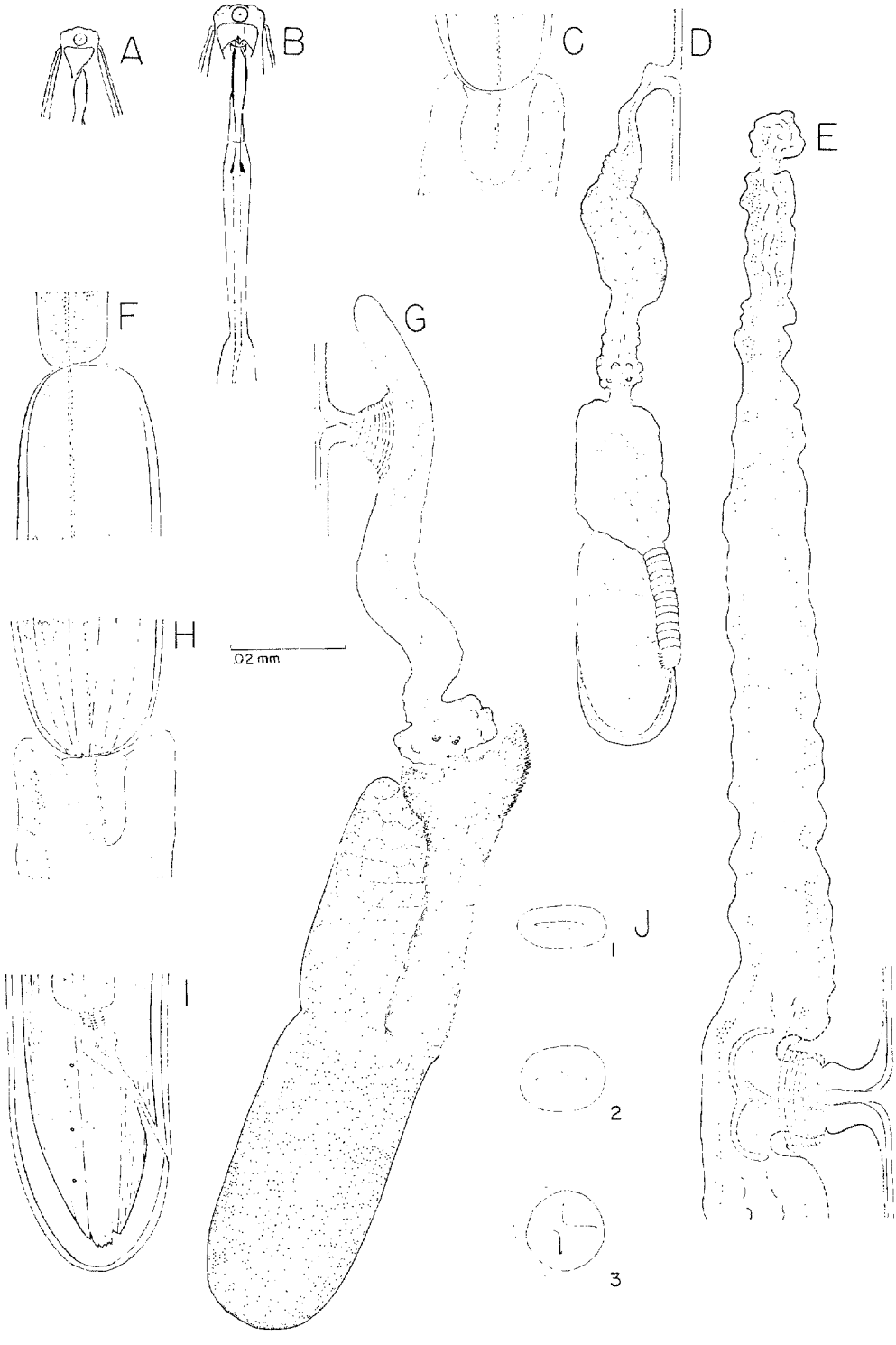
Type Specimens.—Lectotype ♀ on slide *Mononchus* 25a-T; paralectotypes 6 ♀♀ on slides *Belondira* 3 (1)-P, *Dorylaimus* 82-P, *Dorylaimoides* 4b-P, and T-677p.

Axonchium asacculum Siddiqi, 1968

(Fig. 1D)

Paratypes (2 ♀♀): L = 1.07, 1.10 mm; w = .024, .027 mm; e = .465, .442 mm; t =

[2] L = actual length, w = actual width, e = length of esophagus, including cardia, t = length of tail, value in parentheses is the mean.


A
B
C
D
E
F
G
H
.02 mm
I
J
1
2
3

.019, .018 mm; a = 44, 40; b = 2.3, 2.4; c = 55, 61; V = 58, 55%; stylet = .008, .009 mm, extensions = .009 mm.

Female.—Lips amalgamated, head not offset from body. Amphids not as wide as body just behind head. Esophageal expansion truncate anteriorly, the two portions of the esophagus abutting. Esophageal constriction located about 40% of esophageal length from head. Muscle bands of esophageal sheath straight, not spiral. Cardia short, about 8.5 μ long, hardly longer than its diameter. Outer cuticle about 1 μ thick, subcuticle barely visible except on tail. Vulva a transverse slit, vagina a tube flattened dorso-ventrally and extending posteriorly within body. Vaginal cuticularization extremely inconspicuous, not offset from body cuticle or sphincter (Fig. 1D). Anterior gonad absent. Posterior uterus very short, with a wide section near vulva and a short, straight, narrow portion distally (Fig. 1D). Uterine expansion very inconspicuous. Tail terminus hemispherical. A single caudal pore present on each side of tail in one specimen; in the other specimen a single pore was present on one side of the tail and a pair was present on the other. Ventral pores not seen. Prerectum about 5.5 times as long as anal body diameter.

Males.—Unknown.

Specimens.—Paratypes 2 ♀♀ on slides T-669p and T-670p.

Axonchium choristum Thorne, 1939
(Figs. 2; 9F, G)

Lectotype (1 ♀): L = 2.13 mm; w = .060 mm; e = .810 mm; t = .031 mm; a = 35.5; b = 2.6; c = 68; V = 53%; stylet = .012 mm, extensions = .013 mm.

Allolectotype (♂): L = 2.67 mm; w = .064 mm; e = .840 mm; t = .034 mm; a = 41; b = 3.2; c = 77; stylet = .013 mm; spicules = .057 mm.

Paralectotypes (5 ♂♂): L = 2.16–2.67 (2.43) mm; w = .052–.063 (.059) mm; e = .660–.940 (.780) mm; t = .030–.036 (.034) mm; a = 38–46 (42.1); b = 2.6–3.7 (3.1); c = 64–77 (71.8); stylet = .012–.013 mm, extensions = .013–.017 mm; spicules = .051–.057 mm.

Timpanogos Loop Specimens (5 ♀♀): L = 2.19–2.58 (2.41) mm; w = .052–.060 (.055) mm; e = .720–.845 (.808) mm; t = .033–.036 (.034) mm; a = 41–46 (43.2); b = 2.6–3.3 (3.0); c = 66–76 (70.2); V = 47–52 (49.8)%; stylet = .012–.013 mm, extensions = .015–.016 mm. 1 ♂: L = 2.35 mm; w = .054 mm; e = .645 mm; t = .036 mm; a = 44; b = 3.7; c = 65; stylet = .012 mm, extensions not visible; spicules = .055 mm.

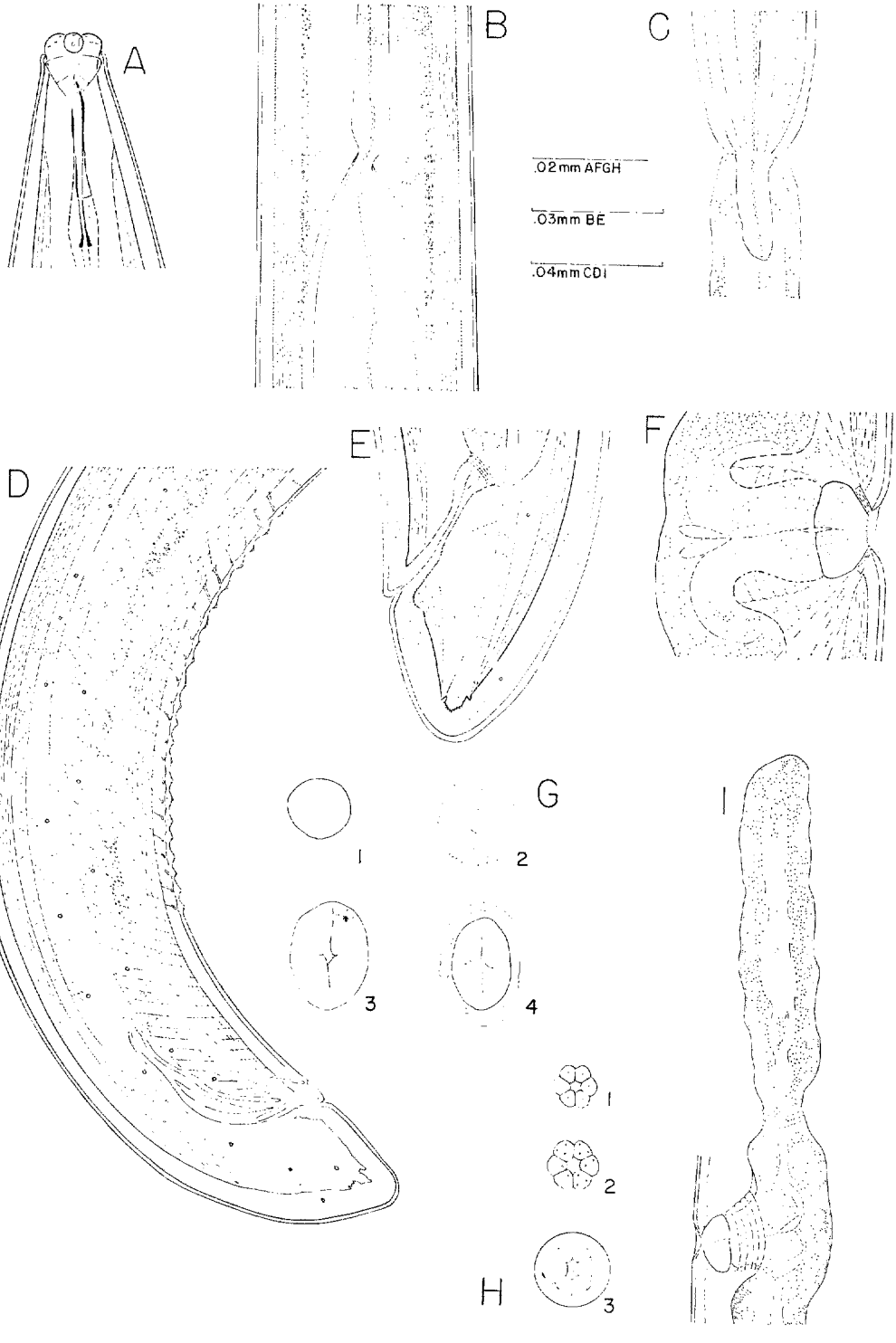
Provo, Utah Specimens: 4 ♀♀: L = 2.31–2.50 (2.39) mm; w = .054–.063 (.060) mm; e = .675–.730 (.707) mm; t = .031–.036 (.033) mm; a = 36–43 (39); b = 3.2–3.7 (3.5); c = 65–79 (71.7); V = 48–50 (48.7)%; stylet = .012 mm, extensions = .015–.016 mm.

Ogden Canyon Specimens: 3 ♀♀: L = 2.13–2.27 (2.17) mm; w = .057–.063 (.061) mm; e = .600–.690 (.640) mm; t = ,030–.036 (.032) mm; a = 34–37 (35.6); b = 3.2–3.5 (3.3); c = 63–71 (68); V = 50–52 (51)%; stylet = .012 mm, extensions = .016 mm.

Female.—Head offset from body, anterior lips not offset, amphids as wide as lip constriction (Fig. 2A). Esophageal constriction located at 28 to 36% of esophageal length

←

FIG. 1. A. *Axonchium amplicolle*, type locality, head; B. *A. amplicolle* from Mauritius, head; C. *A. rotundum*, base of esophagus with cardia; D. *A. asacculum*, female reproductive system; E. *A. rotundum*, anterior female gonad; F. *A. amplicolle*, type locality, esophageal constriction; G. *A. amplicolle*, type locality, female reproductive system; H. *A. amplicolle*, type locality, base of esophagus with cardia; I. *A. amplicolle*, type locality, tail; J. *A. rotundum*, vulva, ventral view. 1. surface, 2. cuticularization, 3. sphincter.


A
B
C
.02mm AFGH
.03mm BE
.04mm CDI
D
E
F
G
1
2
3
4
H
1
2
3
I

from anterior end of body. Anterior part of esophageal expansion tapered, esophageal constriction narrow, the two parts not abutting (Fig. 2B). Muscle bands of esophageal sheath straight, not spiral. Cardia (Fig. 2C) cylindrical, 25 μ long in lectotype, 25 to 27 μ long in paralectotypes, about 3 times as long as its diameter. Outer cuticle about 1 μ thick, subcuticle at mid-body about 3.5 μ thick. Vulva circular (Fig. 2G1, 2G2). Vaginal lumen gradually becoming a lengthwise slit, then cross-shaped within the sphincter (Fig. 2G3, 2G4). Vaginal cuticularization appearing hemispherical in lateral view, with a more heavily striated, disc-like structure just ventral to it surrounding the vulval opening, which may serve as the attachment point for some of the vaginal dilator muscles (Fig. 2F). Anterior gonad with one constriction near vulva, anterior part with a truncate terminus (Fig. 2I). Posterior uterus wide behind vulva, then narrowing abruptly to a short sinuous section proximal to the uterus expansion. Tail conical, slightly curved on ventral side, tapering on dorsal side to a moderately broad, rounded terminus (Fig. 2E) with two caudal pores on each side.

Male.—Anterior part of body similar to that of female. Tail (Fig. 2D) nearly straight ventrally, curved dorsally toward a moderately broad, rounded terminus. Caudal pores 3, or sometimes two pairs, on each side. Lateral pores staggered 200 μ anterior to anus, then in a single row anteriorly to neck region. Supplements 19 to 26, contiguous, beginning opposite anterior end of spicules or slightly more anterior.

Diagnosis.—*A. choristum* is similar to *A. solitare* and *A. thornei*. It differs from *A. solitare* by its female tail shape and presence of males, and from *A. thornei* by a larger number of supplements on the male and longer stylet and spicules. It differs from both these species because the subcuticle is thicker than the outer cuticle at mid-body.

Type Locality and Habitat.—Soil around cactus roots, prickly pear, *Opuntia hystricina*, Emigration Canyon, Utah, near Salt Lake City.

Other Localities.—Timpanogos Loop above Camp Timpanoolie, Utah; soil around sugar beet roots, Provo, Utah; hillside soil, Ogden Canyon, Utah.

Type Specimens.—Lectotype ♀ on slide *Axonchium* 3 (1)-T; allolectotype ♂ on slide *Axonchium* 3 (2)-TT; paralectotypes 3 ♂♂ on slides *Dorylaimus* 17a (1–3)-P, 2 ♂♂ on slide *Axonchium* 3-P.

Additional Specimens.—Timpanogos Loop 1 ♂ on slide *Dorylaimus* 27, 1 ♀ on slide *Axonchium* 1 j, 4 ♀♀ on slide *Axonchium* 1 i; Provo, Utah 4 ♀♀ on slide *Axonchium* 10 c; Ogden Canyon 3 ♀♀ on slide *Axonchium* 1 h.

Axonchium crassum Thorne, 1939

(Figs. 3; 9A, B, E)

Lectotype (♀): L = 3.82 mm; w = .127 mm; e = 1.50 mm; t = .035 mm; a = 30.0; b = 2.5; c = 111; V = 57%; stylet = .021 mm, extensions = .024 mm.

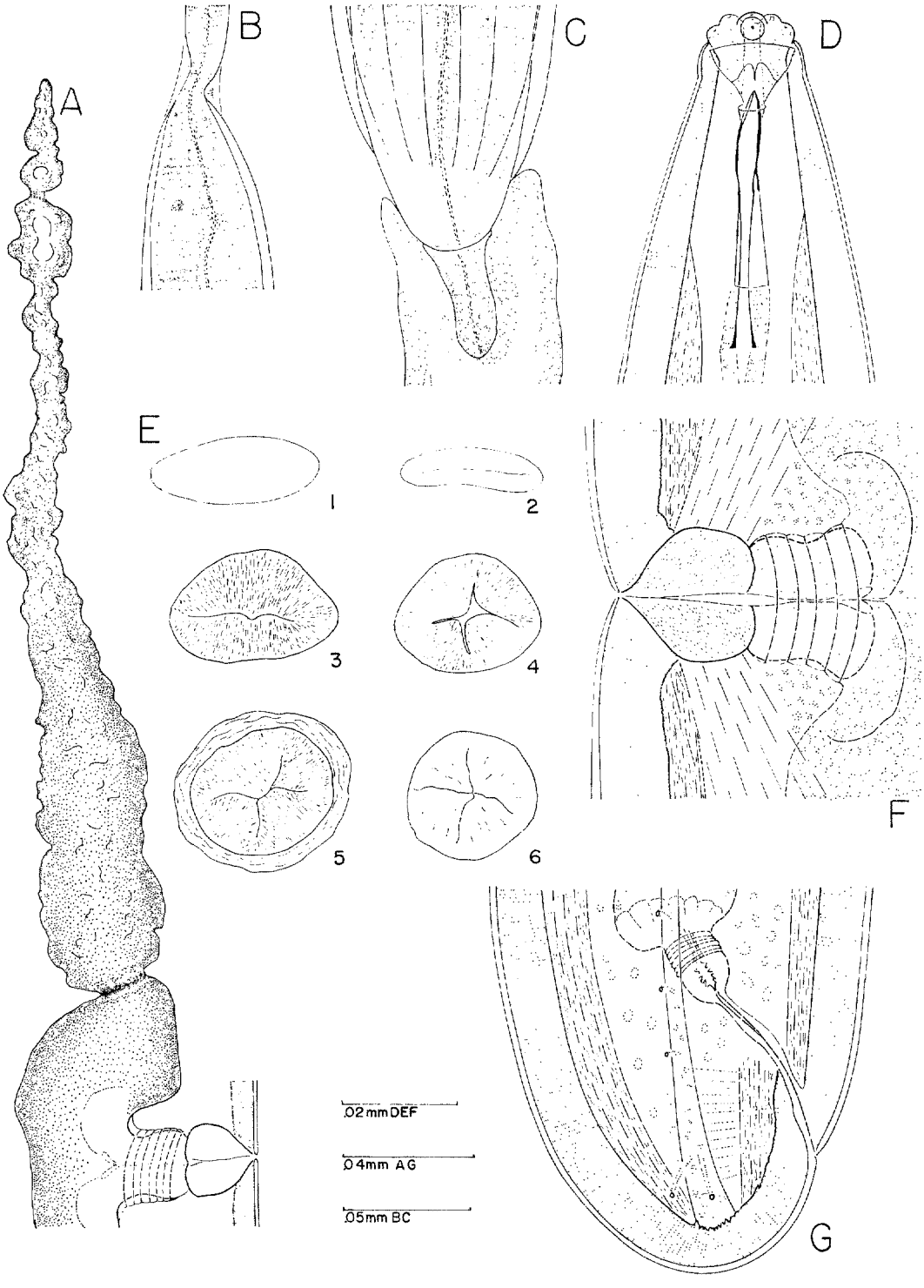
Paralectotype (1 ♀): L = 3.66 mm; w = .120 mm; e = 1.50 mm; t = .038 mm; a = 30.5; b = 2.4; c = 98; V = 58%; stylet = .021 mm, extensions = .024 mm.

Arkansas Specimen (1 ♀): L = 4.17 mm; e = 1.47 mm; t = .045 mm; b = 2.8; c = 93, V = 58%.

Georgia Specimen (1 ♀): L = 3.74 mm; e = 1.59 mm; t = .037; b = 2.4; c = 104;

←

FIG. 2. *Axonchium choristum*. A. female head; B. esophageal constriction and ventral pore; C. base of esophagus with cardia; D. male tail; E. female tail; F. vulva, lateral view; G. vulva, ventral view. 1. surface, 2. disc surrounding vulva, 3. dorsal cuticularization, 4. sphincter; H. *en face* view, female. 1. extreme anterior end, 2. lips, 3. base of amphid pouch; I. female anterior gonad.


A
B
C
D
E
1
2
3
4
5
6
F
G
.02mm DEF
.04mm AG
.05mm BC

V = 56.5%; stylet = .023 mm, extensions = .026 mm.

Female.—Head offset, anterior portion of lips offset by a depression (Fig. 3D). Narrow anterior part of esophagus occupying 21 to 25% of esophageal length. Anterior end of esophageal expansion tapered, esophageal constriction long and narrow, the two portions not abutting (Fig. 3B). Muscle bands of esophageal sheath straight, not spiral. Cardia 46 μ long, cylindrical, its length about 2½ times its diameter (Fig. 3C). Outer cuticle about 1.5 μ thick, subcuticle about 12 μ thick at midbody. Vulva oval on surface, a crosswise slit within cuticle (Fig. 3E1, 3E2). Vaginal lumen gradually becoming cross-shaped dorsally (Fig. 3E). Cuticularization surrounding vagina conspicuous, in lateral view appearing wedge-shaped ventrally, sides nearly parallel dorsally between hypodermis and vaginal sphincter (Fig. 3F). Anterior gonad convoluted, tapering gradually anteriorly to the very small vestigial uterine and oviduct expansions and a small vestigial ovary at its terminus (Fig. 3A). Vestigial ovary reflexed in Arkansas specimen. Posterior uterus wide near vulva, narrowing more or less abruptly to a long, narrow, sinuous portion proximal to the uterus expansion (Fig. 9A). No sperm cells seen within the female reproductive system. Tail short, hemispherical, one pair of caudal pores on each side (Fig. 3G). Lateral pores anterior to anus arranged in a single row. Prerectum about 5 anal body diameters long.

Males.—Unknown.

Diagnosis.—*A. crassum* is similar to *A. gigas* and *A. coronatum* because of its large size. It differs from *A. coronatum* by the smooth cuticle on the neck region and from *A. gigas* by the straight muscle bands in the esophageal sheath. It differs from both these species by its short, hemispherical tail.

Type Habitat and Locality.—Forest soil, Washington, D. C.

Other Localities.—Orchard, Jasper County, Georgia; peach orchard, Pike County, Arkansas.

Type Specimens.—Lectotype ♀ on slide *Axonchium* 7 (1)-T; paratype ♀ on slide *Axonchium* 7-P.

Additional Specimens.—Arkansas ♀ on slide G-1457; Georgia ♀ on slide G-1646.

Axonchium gigas Thorne, 1939
(Figs. 4; 7H, I)

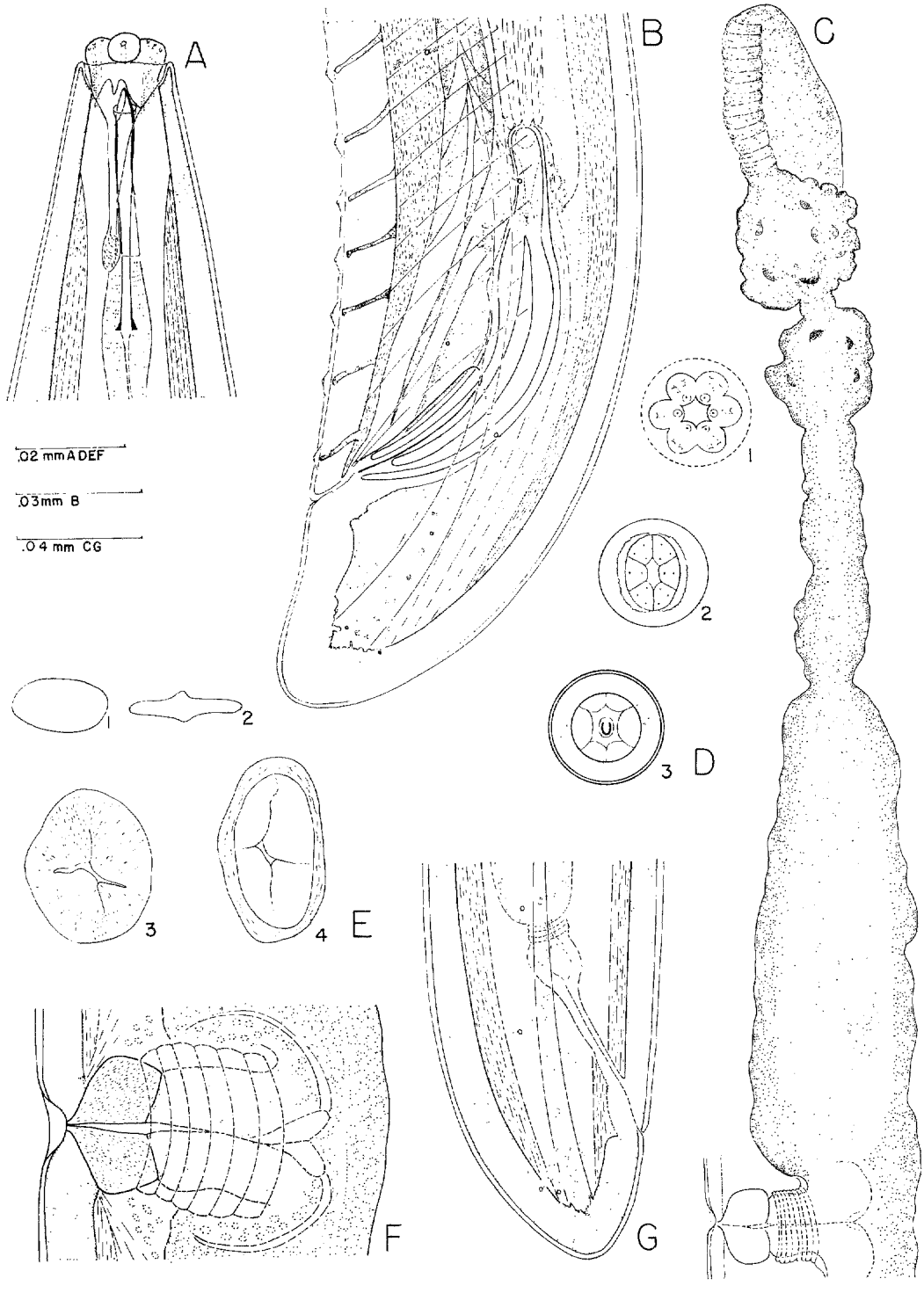
Lectotype (1 ♀): L = 4.25 mm; e = 1.14 mm; t = .044 mm; b = 3.7; c = 98; V = 53%; stylet = .018 mm, extensions = .024 mm.

Allolectotype (1 ♂): L = 3.76 mm; e = 1.03 mm; t = .045 mm; b = 3.8; c = 84; stylet = .018 mm, extensions = .024 mm; spicules = .089 mm.

Female.—Head offset, rounded, anterior part of lips not offset (Fig. 4A). Amphids very wide, nearly encircling lip region, crenate in cross section anteriorly (Fig. 4D2). Esophageal constriction located at 31 to 34% of the esophageal length from the anterior end of the body. Esophageal expansion tapering anteriorly, the two portions of the esophagus separated by a narrow isthmus, not abutting (Fig. 7H). Basal part of esophagus surrounded by muscle bands which spiral dextrally for most of its length, but are straight for a short distance anteriorly. Cardia (Fig. 7I) 42 to 65 μ long, cylindrical posteriorly, slightly constricted at junction with esophagus, its length about 2⅔ its diameter. Outer

←

FIG. 3. *Axonchium crassum*, female. A. anterior gonad; B. esophageal constriction; C. base of esophagus with cardia; D. head; E. vulva, ventral view. 1. surface, 2. just within cuticle, 3. ventral portion of cuticularization, 4. dorsal portion of cuticularization, 5. sphincter, 6. vagina dorsal to sphincter; F. vulva, lateral view; G. tail.


A
B
C
.02 mm A DEF
.03mm B
.04 mm CG
1
2
1
2
3
D
3
4
E
F
G

cuticle about 1 μ thick, subcuticle at midbody about 8 μ thick. Vulva a crosswise oval, vaginal lumen gradually becoming cross-shaped dorsally (Fig. 4E). Vaginal cuticularization quite narrow ventrally, widening within cuticle to diameter of sphincter (Fig. 4F). Anterior gonad (Fig. 4C) with all structures of the posterior gonad but smaller. Anterior uterus packed with sperm cells, particularly near vulva. Posterior uterus wide near vulva, narrowing abruptly to a sinuous portion proximal to uterus expansion, with sperm present in wide part. Tail tapering to a rounded terminus (Fig. 4G). One pair of caudal pores present on each side of tail. Lateral pores in a single row anterior to anus. Prerectum about 5 anal body diameters long.

Male.—Anterior part of body similar to that of female. Tail (Fig. 4B) straight ventrally, curved dorsally to a rounded terminus. One pair of caudal pores on each side of tail, lateral pores staggered in two rows anteriorly between anus and a point a short distance anterior to supplements, then arranged in a single row anteriorly toward the head. A single row of 17 supplements present beginning just anterior to the adanal pair. Supplements closely approximated, the anterior ones separated by one or two smooth mammilate structures on the surface of the cuticle.

Diagnosis.—*A. gigas* is similar to *A. propinquum, A. crassum,* and *A. coronatum.* It differs from *A. coronatum* by lack of conspicuous striae on the neck region, from *A. propinquum* by a larger number of supplements in the male, and from *A. crassum* by a longer, more conical tail in the female.

Type Locality and Habitat.—Soil in aspen grove about roots of *Rudbeckia occidentalis,* City Creek Canyon, Utah.

Type Specimens.—Lectotype ♀ on slide *Nygolaimus* 5 e (1)-T; allolectotype ♂ on slide *Nygolaimus* 5 e (2)-TT.

Axonchium micans Thorne, 1939
(Figs. 5, 9D)

Lectotype (1 ♀): L = 2.52 mm; w = .075 mm; e = .840 mm; t = .024 mm; a = 34; b = 3.0; c = 105; V = 52%; stylet = .013 mm, extensions not visible.

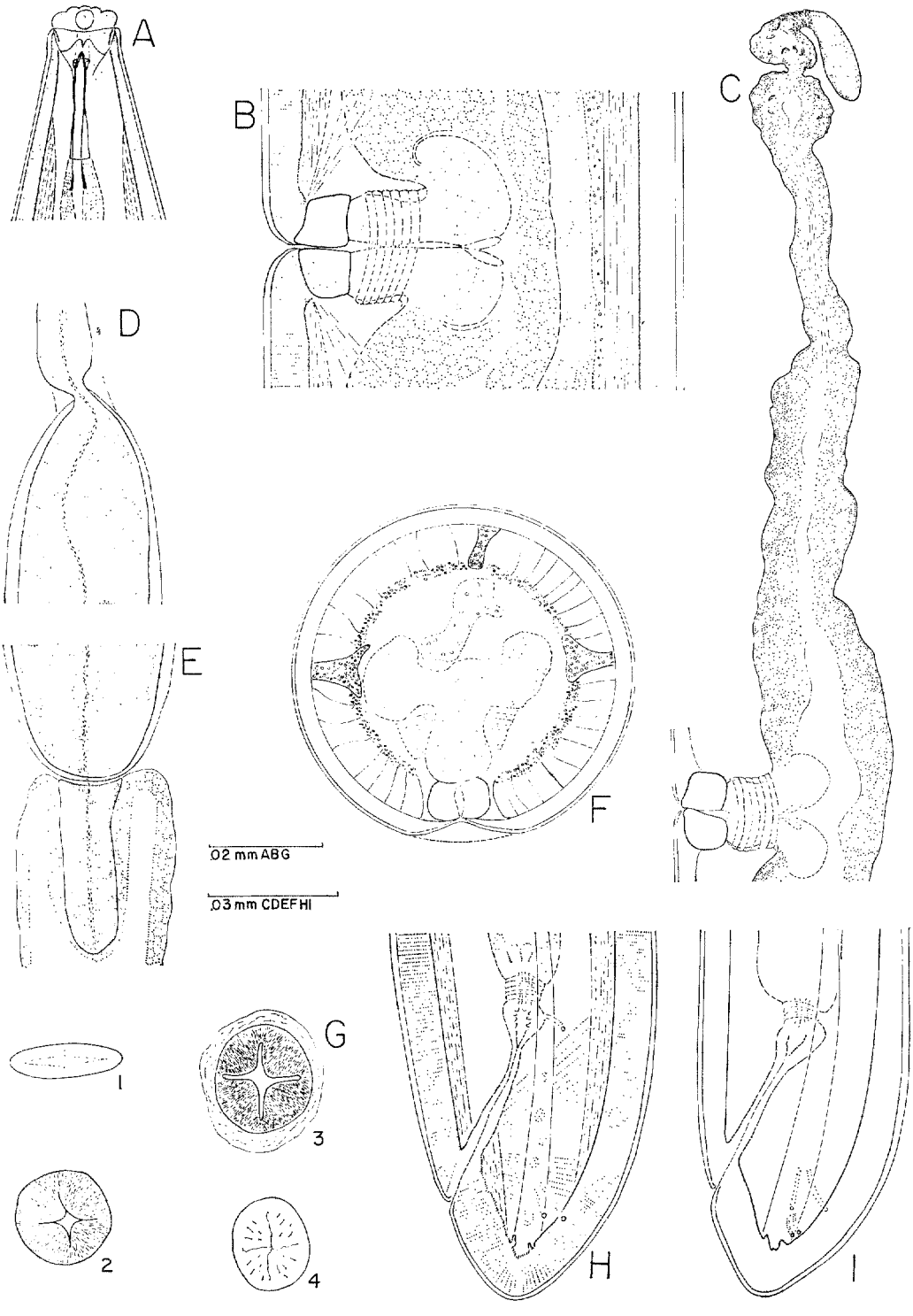
Paralectotype (1 ♀): L = 2.46 mm; w = .069 mm; e = .800 mm; t = .025 mm; a = 36; b = 3.1; c = 96.5; V = 54%; stylet = .012 mm, extensions not visible.

Broad Run, Va. Specimens (25 ♀♀): L = 1.90–2.66 (2.23) mm; w = .051–.077 (.062) mm; e = .660–1.090 (.807) mm; t = .022–.031 (.025) mm; a = 29–42 (35.7); b = 2.1–3.3 (2.8); c = 74–105 (88.4); V = 50–57 (52.5)%; stylet = .009–.011 mm, extensions = .013–.016 mm.

Female.—Head offset, anterior portion of lips offset by a depression (Fig. 5A, 9D). Esophageal expansion tapering anteriorly, junction of the two portions a narrow isthmus, the two portions not abutting (Fig. 5D). Constriction located at 25 to 33% of esophageal length from anterior end of body. Muscle bands of esophageal sheath straight, not spiral. Cardia (Fig. 5E) wider anteriorly, 35 μ long in lectotype, 34 μ in paralectotype, 21 to 27 μ long in Broad Run specimens, its length about 3 times its diameter. Outer cuticle about 1 μ thick, subcuticle at midbody about 6 μ thick. Vulva circular or a crosswise oval on surface, vaginal lumen cross-shaped (Fig. 5G). Vaginal cuticularization a very shallow wedge ventrally within subcuticle, dorsally the same diameter as sphincter (Fig. 5B). Anterior gonad convoluted, tapering gradually to small uterine and oviduct expansions (Fig. 5C). A minute re-

←

FIG. 4. *Axonchium gigas.* A. female head; B. male tail; C. anterior female gonad; D. *en face* view. 1. anterior end, 2. amphid pouch, anterior, 3. base of amphid pouch; E. vulva, ventral view. 1. surface, 2. within cuticle, 3. cuticularization, 4. sphincter; F. vulva, lateral view; G. female tail.


A
B
C
D
E
F
.02 mm ABG
.03 mm CDEFHI
G
1
2
3
4
H
I

flexed ovary present in most of the specimens. Posterior uterus wide at vulva, tapering to a long narrow sinuous section proximal to the uterus expansion. Tail curved dorsally and ventrally to a rounded terminus (Fig. 5H, 5I). A pair of caudal pores present on each side. In a few Broad Run specimens they vary in arrangement, sometimes closer together on one side of the specimen than on the other (Fig. 5I). Lateral pores anterior to anus arranged in a single row. Prerectum 6 times as long as anal body diameter in lectotype, varying between 3.5 and 7.5 times anal body diameter in Broad Run specimens

Males.—Unknown.

Diagnosis.—*A. micans* is similar to *A. serpens*, from which it differs by very wide amphids, nearly surrounding the head, anterior portion of the lips more offset, the shape of the vaginal cuticularization, and absence of males.

Type Locality and Habitat.—Forest soil, Washington, D. C.

Other Locality.—Turf under bridge at junction of Virginia highway 7 and Broad Run.

Type Specimens.—Lectotype ♀ on slide *Axonchium* 8 (1)-T; paralectotype ♀ on slide *Axonchium* 8-P.

Additional Specimens.—Broad Run 5 ♀♀ on slide G-2070, mass collection vial G-836-f.

Axonchium rotundum Thorne, 1964
(Fig. 1C, E, J; 9C K)

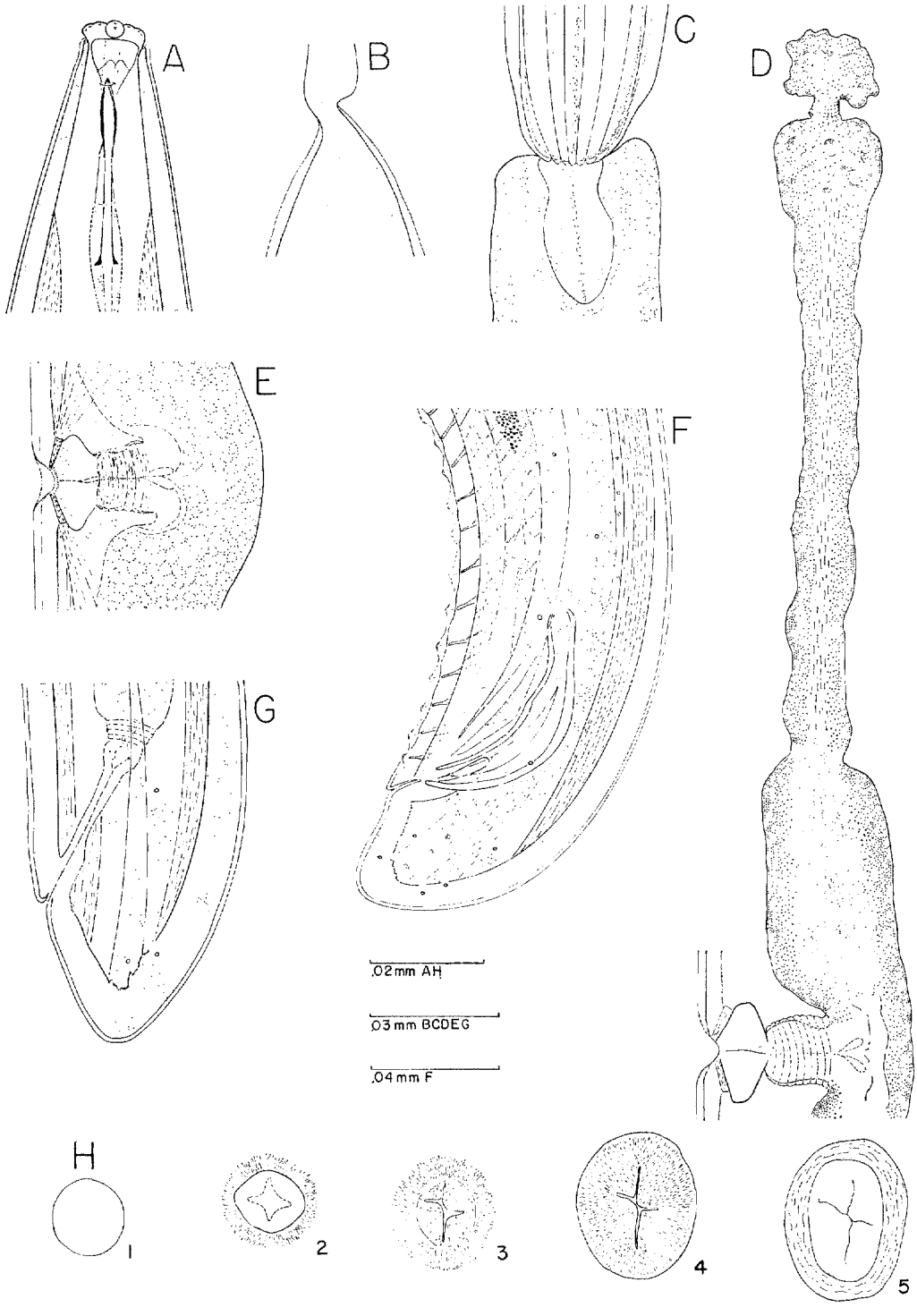
Paratypes (2 ♀♀): L = 2.25, 2.08 mm; w = .037, .039 mm; e = .640, .630 mm; t = .022, .020 mm; a = 60, 53; b = 3.4, 3.3; c = 100, 107; V = 51, 52.5%; stylet = .008–.009 mm, extensions = .013 mm. 2 ♂♂: L = 2.20, 2.05 mm; w = .040, .040 mm; e = .064, .585 mm; t = .021, .021 mm; a = 54, 51; b = 3.4, 3.5; c = 105, 98; stylet = .008, .009 mm, extensions = .013 mm; spicules = .044, .046 mm.

Female.—Head smooth, barely offset (Fig. 9C). Amphids not as wide as head. Esophageal constriction a narrow isthmus, the two portions of the esophagus not abutting. Constriction located at 32 to 35% of esophageal length from anterior end. Muscle bands of esophageal sheath straight, not spiral. Cardia short (Fig. 1C), 12 to 15 μ long, slightly longer than wide. Outer cuticle about 1 μ thick, subcuticle quite thin except at extremities of body. Vulva a crosswise slit (Fig. 1J1), vaginal lumen flattened ventrally, gradually becoming cross-shaped (Fig. 1J2, 1J3). Vaginal cuticularization gradually widening between surface cuticle and sphincter, inconspicuous but wider than in *A. amplicolle* (Fig. 1E). Anterior gonad convoluted, filled with sperm cells, tapering gradually to sphincter proximal to vestigial oviduct expansion (Fig. 1E). Uterine expansion not well defined, no vestigial ovary present. Posterior uterus with short wide portion near vulva, narrowing to a long sinuous portion proximal to uterine expansion. Sinuous portion may have wider section containing sperm. Body diameter less at level of rectal sphincter than at anus, forming a clavate terminus (Fig. 9K). Tail almost hemispherical. A pair of caudal pores present on each side of tail, lateral pores anterior to anus in a single row, ventral pores rare. Prerectum length 4 to 6 times anal body diameter.

Male.—Anterior portion of male body similar to that of female. Terminus of male body not clavate, shaped as illustrated by Thorne (17). Similar to female in arrange-

←

FIG. 5. *Axonchium micans*, female. A. head; B. vulva, lateral view; C. anterior gonad; D. esophageal constriction; E. base of esophagus with cardia; F. cross section through vulva; G. vulva, ventral view. 1. surface, 2. cuticularization, 3. sphincter, 4. dorsal part of vagina and uterus; H. tail, type locality; I. tail, Broad Run specimen, showing variability in arrangement of caudal pores.


A
B
C
D
E
F
G
.02mm AH
.03mm BCDEG
.04mm F
H
1
2
3
4
5

ment of caudal and lateral pores. Ventral supplements widely and evenly spaced, 7 present in each specimen, beginning within range of spicules.

Diagnosis.—*A. rotundum* is similar to *A. amalgans*, from which it differs by larger size, shorter tail and greater "c" value, and presence of males.

Type Locality and Habitat.—El Yunque Rain Forest, Puerto Rico. Specimens loaned by A. J. Ayala.

Axonchium serpens Thorne, 1939
(Figs. 6; 9H, I, J)

Lectotype (1 ♀): L = 3.0 mm; w = .054 mm; e = .870 mm; t = .030 mm; a = 56; b = 3.5; c = 101; V = 52%; stylet = .015 mm, extensions = .018 mm.

Allolectotype (1 ♂): L = 3.10 mm; w = .067 mm; e = 1.14 mm; t = .034 mm; a = 48; b = 2.8; c = 93; stylet = .014 mm, extensions not visible; spicules = .068 mm.

Paralectotypes (6 ♀♀): L = 2.43–3.70 (3.19) mm; e = .720–1.065 (.964) mm; t = .030–.037 (.033) mm; b = 3.0–3.7 (3.3); c = 81–112 (94.5); V = 48–55 (49.9)%; stylet = .012–.015 mm, extensions = .017–.019 mm. 9 ♂♂: L = 2.83–3.60 (3.36) mm; e = .780–1.035 (.919) mm; t = .033–.036 (.034) mm; b = 3.2–4.3 (3.7); c = 82–110 (98); stylet = .013–.015 mm, extensions = .017–.019 mm; spicules = .068–.076 mm.

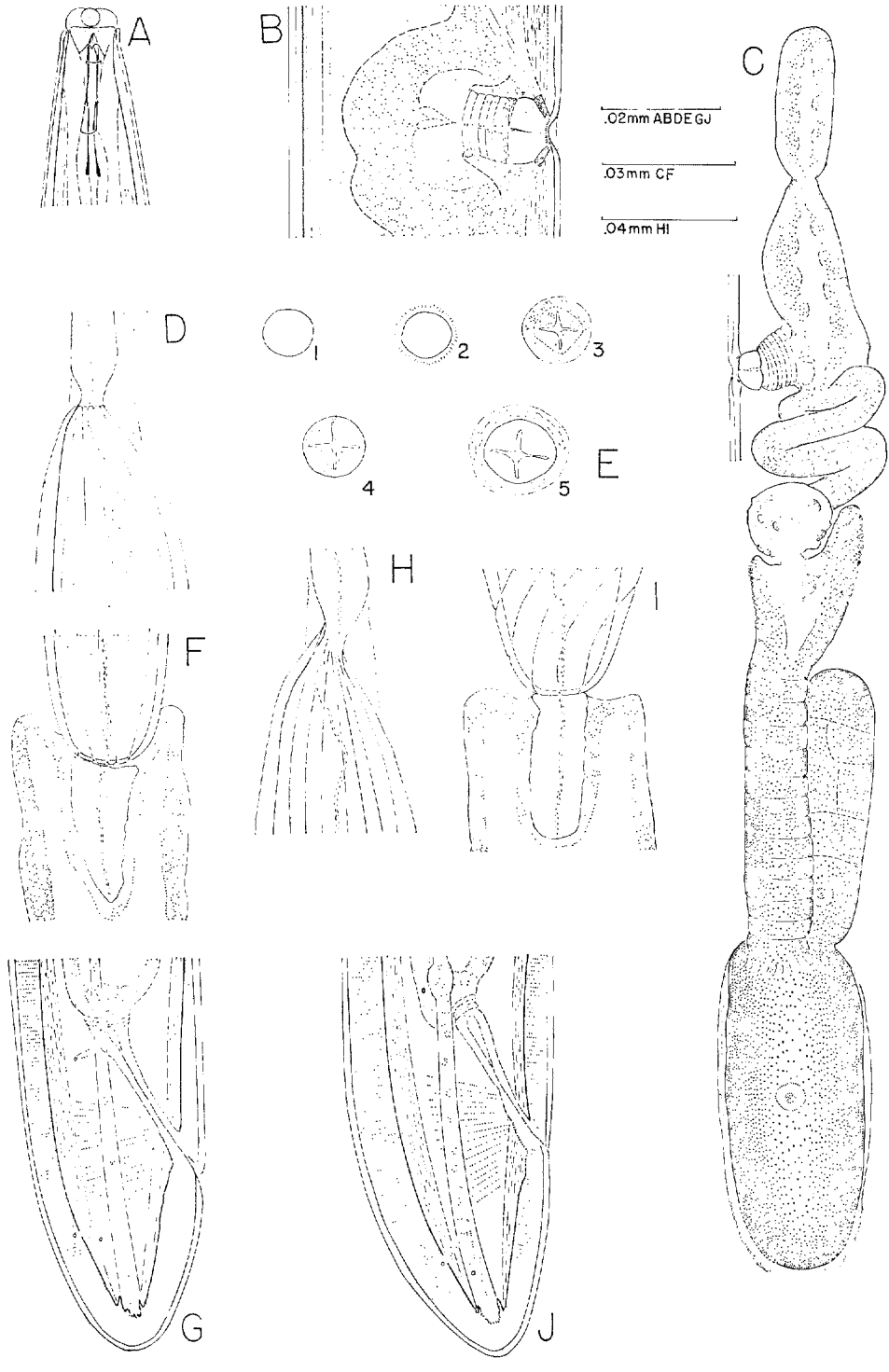
Aspen Creek Specimens (2 ♀♀): L = 3.05, 3.05 mm; w = .052, .055 mm; e = 1.000, .900 mm; t = .030, .034 mm; a = 58, 55; b = 3.0, 3.4; c = 101, 88; V = 50, 50%; stylet = .014 mm, extensions = .019 mm.

Female.—Head offset, lips comparatively low, anterior part of lips barely offset from posterior part (Fig. 6A). Esophageal expansion tapering anteriorly, constriction forming an isthmus, the two portions of the esophagus not abutting (Fig. 6B). Constriction located at 23 to 35% of esophageal length from anterior end of body. Muscle bands of esophageal sheath straight, not spiral. Cardia (Fig. 6C) about twice as long as its diameter, a slight constriction present a short distance behind esophageal expansion, 25 μ long in lectotype, 25 to 49 μ long in female paralectotypes, 25 to 38 μ long in male paralectotypes. Outer cuticle about 1.5 μ thick, subcuticle about twice as wide at mid-body. Vulva circular on surface, vaginal lumen gradually becoming cross-shaped within body (Fig. 6H). Vaginal cuticularization set off from body cuticle, wider than sphincter (Fig. 6E). A more heavily striated, disc shaped cuticularization present just within the vulval opening and surrounding it. Anterior gonad long, with most of the parts of the posterior one (Fig. 6D). Uterine section convoluted, wide near vulva, constricted to a more narrow tube leading to conspicuous uterine expansion, sphincter, and large oviduct expansion. A very small vestigial ovary present in many specimens. Sperm cells present in anterior gonad. Posterior uterus wide near vulva, a constriction present proximal to sinuous narrow portion, enlarging gradually distally to the uterus expansion. Sperm cells often present. Tail (Fig. 6G) conical with rounded terminus. A pair of caudal pores present on either side of tail, lateral pores anterior to anus in a single row. Length of prerectum 4 anal body diameters in lectotype, 5 to 10 in paralectotypes.

Male.—Anterior part of male body similar to that of female. Tail (Fig. 6F) nearly straight on ventral side, curved on dorsal side

←

FIG. 6. *Axonchium serpens*. A. female head; B. esophageal constriction; C. base of esophagus with cardia; D. anterior female gonad; E. vulva, lateral view; F. male tail; G. female tail; H. vulva, ventral view. 1. surface, 2. within cuticle, 3. ventral part of cuticularization, 4. dorsal part of cuticularization, 5. sphincter.


A
B
C
.02mm ABDEGJ
.03mm CF
.04mm HI
D
1
2
3
4
5
E
F
H
I
G
J

to a rounded terminus. Two to four pairs of caudal pores present on each side, lateral pores in two staggered rows for about 700 μ anterior to anus, in a single row more anteriorly. Ventral supplements 25 to 30, contiguous, beginning just anterior to adanal pair.

Diagnosis.—*A. serpens* is similar to *A. micans*, from which it differs by the rounded lips with the anterior portion less offset, more narrow amphids, shape of the vaginal cuticularization, and the presence of males.

Type Locality and Habitat.—Soil from scrub oak, Red Butte Mountain, Utah.

Other Locality.—Aspen Creek, Utah.

Type Specimens.—Lectotype ♀ on slide *Axonchium* 1 b (1)-T; allolectotype ♂ on slide *Axonchium* 1 b (2)-TT; paralectotypes 6 ♀♀, 9 ♂♂ on slides *Axonchium* 1-P, *Axonchium* 1 b (3–6)-P, *Nygolaimus* 5 a-P, *Nygolaimus* 5 e-P.

Other Specimens.—Aspen Creek 2 ♀♀ on slide *Axonchium* 1 m.

Axonchium solitare Thorne, 1939
(Fig. 7A–G)

Lectotype (1 ♀): L = 2.02 mm; w = .046 mm; e = .600 mm; t = .032 mm; a = 42; b = 3.4; c = 64; V = 51%; stylet = .012 mm, extensions not visible.

Paralectotypes (3 ♀♀): L = 2.13–2.43 (2.20) mm; w = .042–.046 (.045) mm; e = .580–.730 (.660) mm; t = .032–.034 (.033) mm; a = 42–52 (48.5); b = 3.1–3.7 (3.4); c = 64–70 (65.8); V = 50–52 (51.3)%; stylet = .012 mm, extensions = .012 mm.

California Specimens (3 ♀♀): L = 2.14–2.20 (2.18) mm; w = .039–.042 (.040) mm; e = .640–.660 (.650) mm; t = .032–.033 (.032) mm; a = 52–55 (53.8); b = 3.3–3.4 (3.3); c = 65–70 (68.3); V = 56–58 (56.5)%; stylet = .011–.012 mm, extensions not visible.

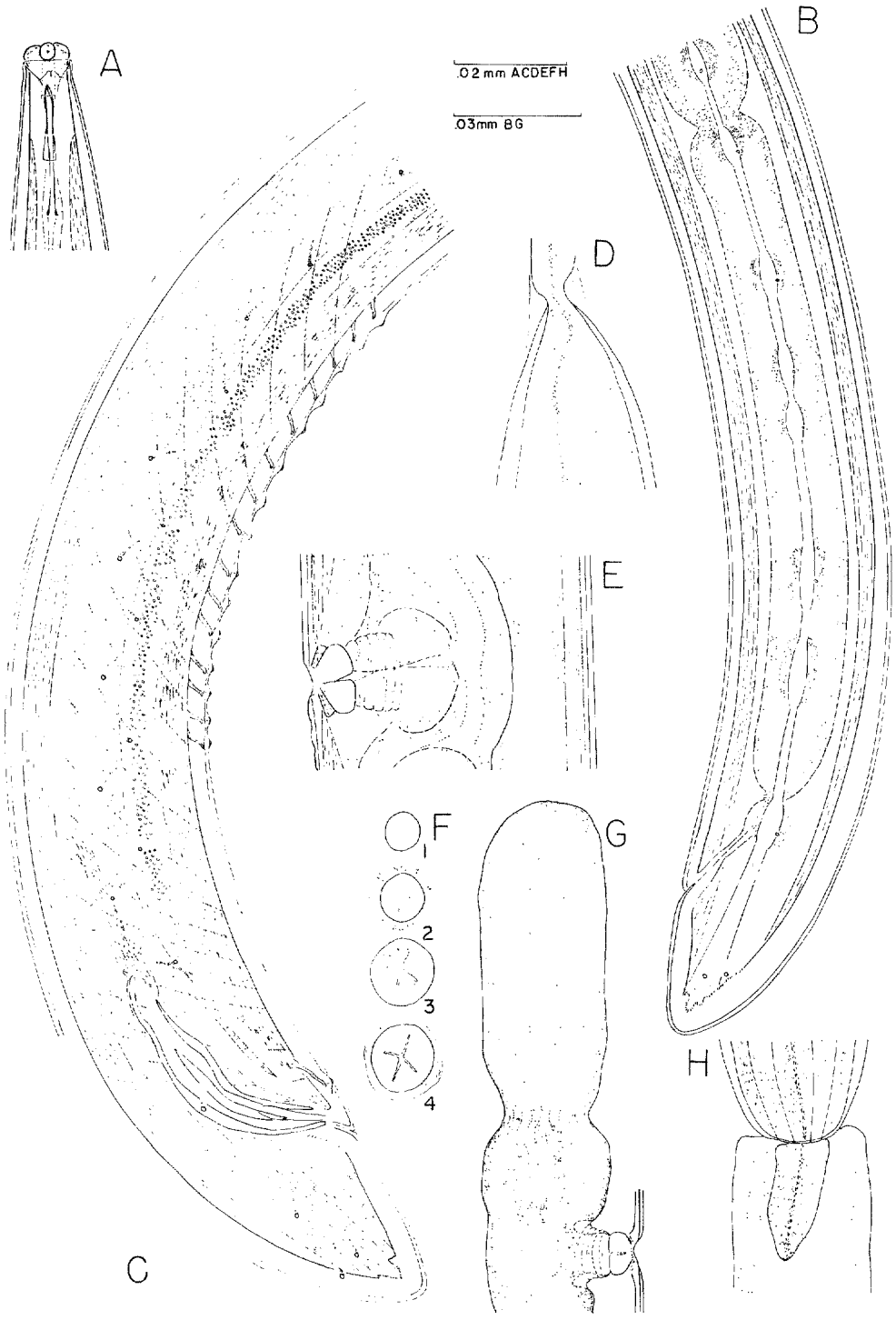
Female.—Head offset slightly, lips low, rounded, anterior portion of lips not offset (Fig. 7A). Esophageal expansion tapered anteriorly, constriction forming an isthmus, the two portions of esophagus not abutting (Fig. 7D). Constriction located at 31 to 37% of esophageal length from anterior end of body. Sheath muscle bands straight, not spiral. Cardia (Fig. 7F) medium in length, 14 μ long in lectotype, 10 to 21 μ long in paralectotypes, 15 to 17 μ long in California specimens, about twice as long as its diameter. Outer cuticle about 1 μ thick, subcuticle about the same thickness at mid-body. Vulva circular on ventral surface, vaginal lumen gradually becoming diamond-shaped, then cross-shaped, within body (Fig. 7E). Vaginal cuticularization hemispherical in lateral view, the same diameter as sphincter, with a more heavily striated, disc-like portion surrounding vulval opening (Fig. 7B). Anterior gonad wide with a truncate or broadly rounded terminus and a constriction near vulva (Fig. 7C). Posterior uterus wide near vulva, constricted to a narrow sinuous portion proximal to uterus expansion (Fig. 7C). Tail curved about equally dorsally and ventrally to a rounded terminus (Fig. 7G). One pair of caudal pores present on each side of tail, lateral pores arranged in a single row anterior to anus. Prerectum 5.5 times as long as the anal body diameter in lectotype, 5 times as long in one paralectotype, stricture not visible in other specimens.

Males.—Unknown.

Diagnosis.—*A. solitare* is similar to *A.*

←

FIG. 7. A. *Axonchium solitare*, female head; B. *A. solitare*, vulva, lateral view; C. *A. solitare*, female reproductive system; D. *A. solitare*, esophageal constriction; E. *A. solitare*, vulva, ventral view, 1. surface, 2. level of subcuticle, 3. ventral part of cuticularization, 4. dorsal part of cuticularization, 5. sphincter. F. *A. solitare*, base of esophagus with cardia; G. *A. solitare*, female tail; H. *A. gigas*, esophageal constriction; I. *A. gigas*, base of esophagus with cardia; J. *A. thornei*, female tail.


A
B
.02 mm ACDEFH
.03mm BG
D
E
F
1
2
3
4
G
H
C

thornei and *A. choristum*. It differs from *A. choristum* by the thinner subcuticle at mid-body and the shape of the tail, from *A. thornei* by longer stylet and the shape of the female tail (compare Fig. 7G and 7J), and from both these species in the absence of males.

Type Locality and Habitat.—Soil from around alfalfa roots, Grand Junction, Colorado.

Other Locality.—Kern County, California.

Type Specimens.—Lectotype ♀ on slide *Axonchium* 12 (1)-T; paralectotypes 3 ♀ ♀ on slides *Axonchium* 12-P and *Dorylaimus* 31 i (1)-P.

Additional Specimens.—3 ♀ ♀ on slide *Axonchium* 12 c.

Axonchium thornei n. sp.
(Figs. 7J, 8)

Holotype (1 ♀): L = 1.96 mm; w = .052 mm; e = .622 mm; t = .031 mm; a = 37.4; b = 3.1; c = 62; V = 52.6%; stylet = .009 mm, extensions = .014 mm.

Allotype (1 ♂): L = 2.13 mm; w = .042 mm; e = .720 mm; c = .030 mm; a = 50; b = 2.9; c = 71; stylet = .010 mm, extensions = .014 mm; spicules = .042 mm.

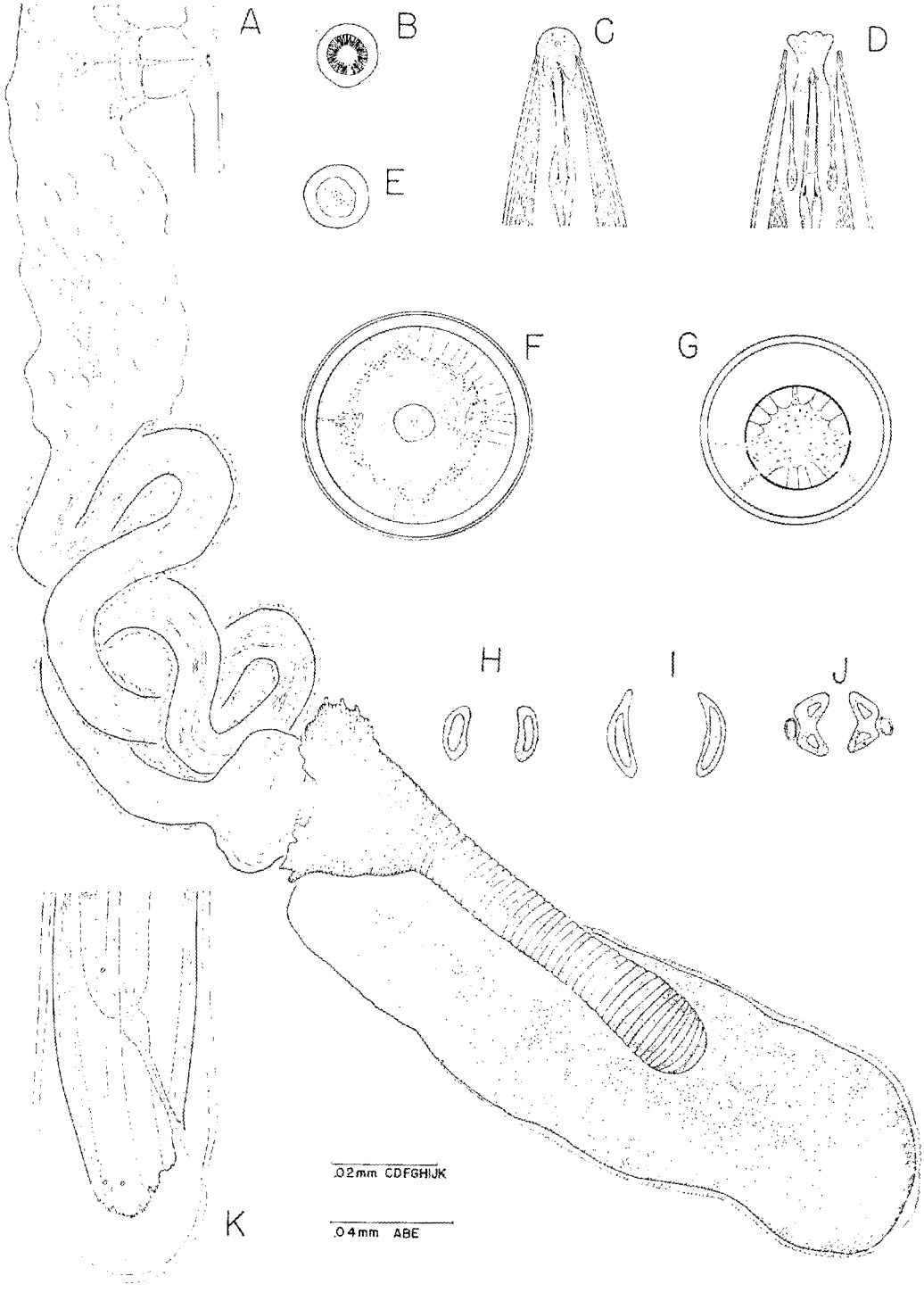
Paratypes (6 ♀ ♀): L = 1.75–1.98 (1.89) mm; w = .045–.054 (.049) mm; e = .570–.675 (.610) mm; t = .030–.036 (.033) mm; a = 33–41 (38.2); b = 2.8–3.3 (3.1); c = 52–66 (58.7); V = 52–57 (54.2)%; stylet = .009–.011, extensions = 0.011–.015 mm. 5 ♂ ♂: L = 1.87–2.13 (1.93) mm; w = .042–.048 (.045) mm; e = .465–.720 (.590) mm; t = .030–.033 (.031) mm; a = 40–44 (42); b = 2.9–4.2 (3.3); c = 57–71 (63); stylet = .009–.011 mm, extensions = .014–.016 mm; spicules = .039–.043 mm.

Female.—Head offset, lips higher than in *A. solitare*, rounded, the anterior portion not offset (Fig. 8A). Anterior end of esophageal expansion tapering toward isthmus, the two portions of the esophagus not abutting (Fig. 8D). Esophageal constriction located at 30 to 38% of esophageal length from anterior end of body. Muscle bands of esophageal sheath straight, not spiral. Cardia (Fig. 8H) 19 μ long in holotype, 21 to 25 μ long in other females, slightly over twice as long as its diameter. Cuticle about 1 μ thick, subcuticle slightly thinner at mid-body. Vulva (Fig. 8F) circular on surface, vaginal lumen gradually becoming diamond-shaped, then cross-shaped, within body. Vaginal cuticularization in two parts, ventral part disc like, dorsal part less heavily striated, hemispherical in lateral view, of the same diameter as sphincter (Fig. 8E). Anterior gonad wide throughout its length except for constriction near vulva, its terminus truncate, containing sperm cells in proximal part or throughout its length (Fig. 8G). Posterior uterus wide proximally, constricted to a narrow sinuous portion distally, sperm present within it. Tail conical, ventral side not curved as much as dorsal side, terminus rounded (Fig. 7J, 8B). A pair of caudal pores present on each side of tail; in one specimen they are paired on one side, nearly in the same row with the anterior lateral pores on the other. Lateral pores anterior to anus in a single row. Organs of the lateral chord associated with the pores large and conspicuous (Fig. 8B). Prerectum about 6 times as long as anal body diameter in holotype, 5 times as long in one paratype, stricture not visible in remaining specimens (Fig. 8B).

Male.—Anterior portion of body similar to that of females. Tail slightly curved ventrally, curved more dorsally to a rounded

←

FIG. 8. *Axonchium thornei* n. sp. A. female head; B. female tail; C. male tail; D. esophageal constriction; E. vulva, lateral view; F. vulva, ventral view. 1. surface, 2. just dorsal to cuticle; 3. cuticularization, 4. sphincter; G. anterior female gonad; H. base of esophagus with cardia.


A
B
C
D
E
F
G
H
I
J
K
.02mm CDFGHIJK
.04mm ABE

terminus (Fig. 8C). Three caudal pores present on each side of tail, lateral pores staggered between anus and anterior supplement, in a single row anterior to supplements. Ventromedian supplements 14 in allotype, 13 to 15 in paratypes, contiguous, beginning anterior to spicule.

Diagnosis.—*A. thornei* is very similar to both *A. choristum* and *A. solitare*. In *A. thornei* the female tail tends to be more tapered and the terminus is not quite as broad as in *A. solitare*. There is more curvature dorsally and less ventrally than in *A. solitare*; thus the terminus has a slightly more ventral location in *A. thornei* (compare Fig. 7G, 7J). The female tail of *A. choristum* is wider in comparison to its length than in *A. thornei*, and the terminus is slightly broader. The subcuticle at mid-body is somewhat thicker than the outer cuticle in *A. choristum*, whereas in the other two species both cuticular layers at mid-body are of nearly the same thickness. There are 12 to 15 ventral supplements on the male of *A. thornei* and 19 to 26 in *A. choristum*. The stylet of *A. thornei* is slightly shorter than the stylet in either *A. choristum* or *A. solitare*, and the spicules are shorter in *A. thornei* than in *A. choristum*.

Type Locality and Habitat.—Soil around roots of *Balsamorrhiza sagitata*, Cache County, Utah.

Type Specimens.—Holotype ♀ on slide T-123t; allotype ♂ on slide T-124t; paratypes 6 ♀♀ and 5 ♂♂ on slides T-674p, T-675p, T-676p.

DISCUSSION

The original description of several species of *Axonchium* for which no specimens were available give so few details that identification by present standards is not possible. Five of these species, listed below, are considered to be *species inquirendae*:

Axonchium dudichi Andrassy, 1952

A. leptocephalum Altherr, 1953

A. longicollis (Cobb, 1893) Thorne & Swanger, 1936

A. magnicollis (Cobb, 1906) Thorne & Swanger, 1936

A. tenuicollis (Steiner, 1914) Thorne & Swanger, 1936

A. parvum Steiner, 1927 was removed from *Axonchium* by Thorne (17), who considered it a species of undetermined position.

A. saccatum was separated from *A. gossypii* because of its longer prerectum, tail longer than anal body diameter, longer body, and longer esophagus. The body and esophageal lengths reported by Jairajpuri (9) were slightly longer for *A. saccatum* but not sufficiently to justify description of a new species. Although the diagnosis of *A. saccatum* (9) specifies a tail longer than one anal body diameter, in the description and illustration it is shorter, similar to the tail of *A. gossypii*. Thus, the tail lengths of *A. saccatum* and *A. gossypii* probably do not differ. The fourth criterion given for separation of the two species is that the prerectum is twice as long in *A. saccatum* as in *A. gossypii*. It has been shown here that the prerectum in paratypes of *A. serpens* varies between 5 and 10 anal body diameters, and it also varies between 3.5 and 7 anal body diameters in specimens of *A. micans*. This raises the possibility that comparable variability could also occur in *A. gossypii*. Therefore the following synonymy is proposed:

←

FIG. 9. A. *Axonchium crassum*, posterior female gonad; B. *A. crassum*, cross section, uterus; C. *A. rotundum*, female head; D. *A. micans*, head, dorso-ventral view; E. *A. crassum*, cross section, oviduct; F. *A. choristum*, cross section, nerve ring; G. *A. choristum* female, cross section, level of caudal pores; H. *A. serpens*, cross section, extreme anterior end spicules; I. *A. serpens*, cross section, ¼ distance from anterior end of spicules; J. *A. serpens*, cross section, posterior part of spicules and guiding pieces; K. *A. rotundum*, female tail.

A. gossypii de Coninck, 1962
syn. *A. saccatum* Jairajpuri, 1964
n. syn.

A. nitidum was separated from *A. bulbosum* by its posture when relaxed, longer prerectum, and tail shape (9). In species of which a large number of specimens were available, *A. serpens* and the Broad Run population of *A. micans*, as much variability was seen within species in prerectum length and tail shape, and in the relaxed posture of *A. micans*, as was reported between *A. nitidum* and *A. bulbosum*. Unfortunately details of many other structures, such as the subcuticle thickness, anterior portion of the lips, anterior gonad, muscle bands of the esophageal sheath, shape of the esophageal constriction, and shape of the vaginal cuticularization, were not given in the descriptions of either *A. nitidum* or *A. bulbosum*, and the caudal pores were not described for *A. nitidum*. If this additional information were to become available the two populations might prove to be different. At this time, however, it seems best to synonymize them as follows:

A. bulbosum Williams, 1958
syn. *A. nitidum* Jairajpuri, 1964
n. syn.

The description of *A. macrophallum* was based on two specimens mounted in balsam, a single male and a single female from two different localities (16). The male clearly differs from males of other species of *Axonchium* because of its long spicule. The muscle bands of the esophageal sheath in the male and the two larvae collected with it do not spiral. The muscle bands in the female are spiral. The female is in poor condition but, except for the sheath, it seems to correspond well with the male in those structures that are visible. It will be necessary to collect specimens of both sexes from both localities before the species of the female can be definitely assigned. Therefore, in the key to the species given below only the male of *A. macrophallum* is considered.

Key to the Species of *Axonchium*

1. Spicule length almost twice anal body diameter ..... *A. macrophallun* Thorne, 1939
   Spicule length definitely less than twice anal body diameter 2
2. Female tail terminus peg-like 3
   Female tail terminus rounded or broadly conical 4
3. Tail 1.5 times as long as anal body diameter, peg portion occupying less than ⅓ tail length ..... *A. arcuatum* Thorne, 1964
   Tail 3 times as long as anal body diameter, peg portion occupying about ½ tail length ..... *A. caudatum* Williams, 1958
4. Lips nearly amalgamated, head hardly set off from body 5
   Lips separate, head set off from body by a definite constriction 9
5. Anterior gonad absent in females ..... *A. asacculum* Siddiqi, 1968
   Anterior gonad present in females 6
6. Posterior portion of female body clavate, tail diameter greater than body diameter immediately anterior to anus 7
   Diameter of female tail equal to or less than pre-anal body diameter 8
7. Females about 1.0 mm long, female tail about as long as anal body diameter, "c" = 50, males unknown ..... *A. amalgans* Thorne, 1939
   Females about 2.0 mm long, female tail length about ⅔ anal body diameter, "c" = 90 to 100, male with 6 to 8 ventromedian supplements spaced about ½ body diameter apart, beginning opposite anterior end of spicules ..... *A. rotundum* Thorne, 1964
8. Two caudal pores present on each side of female tail, a refractive band of tissue present in lip region ..... *A. baldum* Thorne, 1964
   One caudal pore present on each side of female tail, no refractive band of tissue present in lip region ..... *A. indicum* Siddiqi, 1964
9. Anterior portion of lips set off conspicuously by a deep constriction ..... *A. labiatum* Thorne, 1939
   Anterior portion of lips slightly set off by a depression or not set off 10
10. Posterior end of female clavate, tail wider than body immediately anterior to anus 11
    Female tail diameter equal to or less than pre-anal body diameter 12

11. Anterior gonad length less than one body diameter, males not described ..... *A. bulbosum* Williams, 1958
syn. *A. nitidum* Jairajpuri, 1964
Anterior gonad length 3 times body diameter, male tail with 5 ventromedian supplements, one opposite anterior end of spicules, one a body diameter anterior to the first, a group of 3 a little more than one body diameter anterior to the second ..... *A. elegans* Jairajpuri, 1964
12. Surface cuticle on neck very conspicuously striated ..... *A. coronatum* (de Man, 1906) Thorne and Swanger, 1936
Cuticle on neck smooth or with inconspicuous striae 13
13. Length of anterior female gonad less than one body diameter, with no constriction 14
Length of anterior female gonad one body diameter or longer, with at least one constriction 16
14. Caudal pores more than two on each side of tail, paired side by side ..... *A. mauritiense* Williams, 1958
Caudal pores one on each side of tail, or two arranged in the same row with lateral pores anterior to anus, not paired side by side 15
15. Amphids very wide, nearly surrounding lips ..... *A. amphidium* Thorne, 1964
Amphids not quite as wide as lip region ..... *A. amplicolle* Cobb, 1920
16. Anterior female gonad with one constriction between vulva and terminus, portion anterior to constriction undifferentiated, its terminus truncate or broadly rounded 17
Anterior female gonad with most of the structures of the posterior one: uterus, uterine expansion, sphincter, oviduct expansion, and possibly a vestigial ovary 21
17. Female with a single caudal pore on each side, male with 6–9 ventromedian supplements widely spaced, beginning opposite anterior end of spicules ..... *A. gossypii* de Coninck, 1962
syn. *A. saccatum* Jairajpuri, 1964
Female with two caudal pores on each side. Males, if present, with supplements closely spaced, beginning opposite anterior end of spicules 18
18. Esophageal sheath with spiral muscle bands ..... *A. vaginatum* Jairajpuri, 1965
Sheath muscle bands straight 19
19. Female tail curved almost as much ventrally as dorsally, terminus almost centrally located, males unknown ..... *A. solitare* Thorne, 1939
Female tail curved more dorsally than ventrally, ventral side nearly straight, terminus ventrally located, males described 20
20. Subcuticle thicker than outer cuticle at mid-body. Male with 19–26 ventromedian supplements beginning anterior to spicules ..... *A. choristum* Thorne, 1939
Subcuticle at mid-body not thicker than outer cuticle. Males with 12–15 ventromedian supplements beginning anterior to spicules ..... *A. thornei* n. sp.
21. Stylet at least 18 μ long 22
Stylet less than 16 μ long 24
22. Female tail very short, hemispherical, less than ½ anal body diameter long, males not described ..... *A. crassum* Thorne, 1939
Female tail longer, at least ¾ as long as the anal body diameter. Males described 23
23. Male with 11 to 13 ventromedian supplements beginning near adanal pair, closely spaced ..... *A. propinquum* (de Man, 1921) Thorne, 1939
Male with about 20 closely spaced ventromedian supplements, beginning just anterior to adanal pair. Sheath muscle bands spiral ..... *A. gigas* Thorne, 1939
24. Anterior portion of lips offset. Amphids quite wide, nearly surrounding head. Vaginal cuticularization no greater in diameter than sphincter, no disc surrounding vulva. Males unknown ..... *A. micans* Thorne, 1939
Anterior portion of lips very slightly offset. Amphids not quite as wide as head. Vaginal cuticularization with heavily striated disc-like portion surrounding vulva, dorsal portion wider in diameter than sphincter. Males with 25 to 30 contiguous ventromedian supplements beginning just anterior to adanal pair ..... *A. serpens* Thorne, 1939

LITERATURE CITED

1. ALTHERR, E. 1953. Nematodes du sol du Jura vaudois et francais. Bull. Soc. Vaudoise Sci. Nat. 65:429–460.
2. ANDRASSY, I. 1952. Freilebende Nematodes aus dem Bükk-Gebirge. Ann. Hist.-Natur. Mus. Nat. Hung. (Budapest) 2: 13–65.
3. COBB, N. A. 1893. Nematodes, mostly Australian and Fijian. pp. 252–308, figs. 1–10, pls. 36–42. In the Macleay Mem. Vol., Linn. Soc., N.S.W. (Sept.).
4. COBB, N. A. 1906. Free living nematodes inhabiting the soil about the roots of cane and their relation to root diseases. Pp.

163–195. *In* Fungus maladies of the sugar cane, with notes of associated insects and nematodes. (2nd edition) Bull. No. 5, Hawaiian Sugar Planters Assoc., Exper. Sta. Div. Pathol. and Physiol. (Honolulu).

5. COBB, N. A. 1920. One hundred new nemas. IX. pp. 217–343. *In* Contributions to a Science of Nematology, Waverly Press, Baltimore.
6. COOMANS, A. 1964. Structure of the female gonads in members of the Dorylaimina. Nematologica 10:601–622.
7. DE CONINCK, L. 1962. Nematodes associated with wilted cotton IV. Contributions à la connaissance des Nematodes Phytoparasites et Libres du Congo. Instituut voor Dierkunde, Lab. voor Systematiek Rijksuniversitiet, Gent.
8. HECHLER, HELEN CAROL. 1969. Variability of the basal esophageal sheath in belondirid nematodes. J. Nematol. 1:160–165.
9. JAIRAJPURI, M. S. 1964. Studies on Nygellidae n. fam. and Belondiridae Thorne, 1939 (Nematoda: Dorylaimoidea) with description of ten new species from India. Proc. Helminthol. Soc. Wash. 31:173–187.
10. JAIRAJPURI, M. S. 1965. A new species of the nematode genus *Axonchium* Cobb, with notes on the occurrence of *A. caudatum* Williams in India, and the taxonomic status of *Discolaimium pakistanicum* Timm and Bhuiyan. Proc. Zool. Soc. (Calcutta) 18: 155–158.
11. DE MAN, J. G. 1906. Nematodes di l'Ile de Walcheren. Ann. Soc. Roy. Zool. Malacol. Belg., 41:156–174, 19 figs.
12. DE MAN, J. G. 1921. Nouvelles recherches sur les nematodes libres terricoles de la Hollande. Cap. Zool. 1:3–62, pls. 1–14.
13. SIDDIQI, M. R. 1964. Six new nematode species in the Superfamily Dorylaimoidea from India. Labdev; J. Sci. Tech. 2 (2):136–144.
14. SIDDIQI, M. R. 1968. Five new species of Belondiroidea (Nematoda) from Sibsagar, India, with a revised classification of the superfamily. Proc. Helminthol. Soc. Wash. 35:248–258.
15. STEINER, G. 1914. Freilebende Nematoden aus der Schweiz. Arch. Hydrobiol. Planktonk. 9 (2):259–276.
16. STEINER, G. 1927. Tylenchus pratensis and various other nemas attacking plants. J. Agr. Res. 35:961–981.
17. THORNE, G. 1939. A monograph of the superfamily Dorylaimoidea. Cap. Zool. 8:1–261, pls. 1–32.
18. THORNE, G. 1964. Nematodes of Puerto Rico: Belondiroidea new superfamily, Leptonchidae, Thorne, 1935, and Belonenchidae new family (Nemata, Adenophorea, Dorylaimida). Univ. P. R. Agr. Exp. Sta. Tech. Paper 39, 1–51.
19. THORNE, G. and H. H. SWANGER. 1936. A monograph of the nematode genera *Dorylaimus* Dujardin, *Aporcelaimus* n. g., *Dorylaimoides* n. g. and *Pungentus* n. g. Cap. Zool. 6:1–223, pls. 1–31.
20. WILLIAMS, J. R. 1958. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 2. Belondiridae (Dorylaimoidea, Enoplida). Mauritius Sugar Ind. Res. Inst. Occas. Pap. 2:1–9.