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Description, Developmental Biology, and Feeding Habits of *Seinura tenuicaudata* (De Man) J. B. Goodey, 1960 (Nematoda: Aphelenchoididae), a Nematode Predator*

HELEN CAROL HECHLER**

The genus *Seinura,* described by Fuchs (1931), was synonymized with *Pathoaphelenchus* Cobb by Steiner (1931) and later with *Aphelenchoides* Fischer by T. Goodey (1933). J. B. Goodey (1960) reestablished *Seinura* as a valid genus in the Aphelenchoididae and assigned 15 species to it.

The population of *Seinura* used in this study was increased from a single gravid female collected from soil under a rotted manure pile near a greenhouse in Urbana, Illinois. Specimens from this population agreed very well with Christie's (1939) description of *Aphelenchoides tenuicaudatus* (de Man, 1895). J. B. Goodey (1960) elevated Christie's population to species rank as *S. christiei.* However, critical comparisons of the population used in this study with specimens from Christie's population*** and specimens from Goodey*** identified by him as *S. tenuicaudata,* revealed no consistant differences in morphology. Therefore the population used in this study was identified as *Seinura tenuicaudata* (de Man, 1895) J. B. Goodey, 1960 and, because of the law of priority *S. christei* is proposed as a synonym of *S. tenuicaudata.*

Since *S. tenuicaudata* has been neither adequately described nor illustrated by present standards, detailed descriptions of adults and immature stages are included in this paper; in addition, its developmental biology and predaceous feeding habit is reported.

MATERIALS AND METHODS

S. tenuicaudata was increased in cultures of *Aphelenchus avenae* Bastian, 1865, established and maintained according to techniques described by Hechler (1962). *Seinura* were added by placing a block of agar containing several *Seinura* gravid females into 10-day-old cultures of *A. avenae.* Cultures were incubated at 28° C. until they reached the desired stage of development for study.

Studies on larval development, rate of egg production, and generation time were made at 28° C. using 2 percent water agar in Van Tiegham cells. Large numbers of *A. avenae* were concentrated in a small volume of water by centrifugation and then placed on the agar. After the water had evaporated and *A. avenae* had entered the agar, individual specimens of *S. tenuicaudata* were added to the cells using a nylon needle. Under these conditions *A. avenae*

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remained active long enough for a generation of *S. tenuicaudata* to be completed.

Egg development was studied by placing eggs in water in watch glasses. Observations were made with a 40X water immersion objective. Higher magnification needed to study certain phases of development was obtained by placing eggs in water on microslides, covering with a coverslip, and observing under an oil immersion objective. Other eggs were held at 28° C. to determine time of development.

To study feeding, a small drop of water containing a mixture of *A. avenae* and *S. tenuicaudata* was placed on a microslide with several drops of 2 percent water agar cooled almost to solidification. A 20 × 50 mm. coverslip was added before the agar solidified. Nematodes remained active for several hours in these preparations.

Specimens used in the description were fixed in formalin or FAA, mounted in the fixitive or glycerine, or mounted alive in water. Measurements were made on specimens fixed in FAA and mounted in glycerine. For cytological studies, living nematodes were placed in cold Carnoy solution (6 parts absolute ethanol; 3 parts chloroform; 1 part glacial acetic acid) for 15 to 25 minutes, and then mounted in iron aceto-carmine on a microslide. After 12 hours or more in the stain, nematodes were crushed by application of gentle pressure on the coverslip and were then observed.

DESCRIPTION

Seinura tenuicaudata (de Man, 1895) J. B. Goodey, 1960 (Fig. 1)

DIMENSIONS: 50 females: L = 820 microns (500-940); a = 33.7 (30.0-40.5); b = 10.1 (8.2-11.4)*; c = 8.5 (6.6-11.3); V = 71.7% (70.0-78.0).

25 males: L = 685 microns (612-750); a = 34.3 (31.0-40.0); b = 8.7 (8.3-9.5); c = 13 (12-14).

FEMALE: Fig. 1-A, C, E, F). Body moderately slender, tapering at extremities, with six lips offset from body. Cuticle very finely striated, three faint incisures in lateral field. Stylet 17.0-19.5 microns long, knobless, double guiding ring just posterior to conical stylet section, oblique orifice on ventral side.

Precorpus narrow. Metacorpus a large elongate muscular bulb, about 12 × 20 microns long. Crescentic valve located posteriorly at 65-75 percent of bulb length. Radiating muscular tissue surrounding valve; anterior and extreme posterior portions of bulb alveolated and seen to function as a reservoir for glandular products in live specimens. Esophageal glands in an elongate lobe, 125-175 microns long, over-lapping intestine dorsally. Two smaller glands and nuclei within glandular mass most easily seen in starved live specimens. Narrow esophageal duct leads from just posterior to nerve ring anteriorly into base of metacorpal bulb, passes through muscular tissue, then widens into large reservoir in anterior end of bulb. Reservoir opens dorsally into esophageal lumen about one valve length anterior to valve, ventral ducts open about 4 microns behind valve. Walls of esophageal lumen about as thick as those of stylet, blending with posterior end of stylet in many fixed specimens. Thickened walls extend to base of bulb where lumen widens slightly before joining intestine. No esophago-intestinal valve observed.

Position of excretory pore variable, usually opposite posterior end of bulb in relaxed specimens, somewhat posterior to it in live nematodes, occasionally as far forward as valve. In Christie's material pore often opposite valve.

*Esophagus was measured from head to base of median bulb.

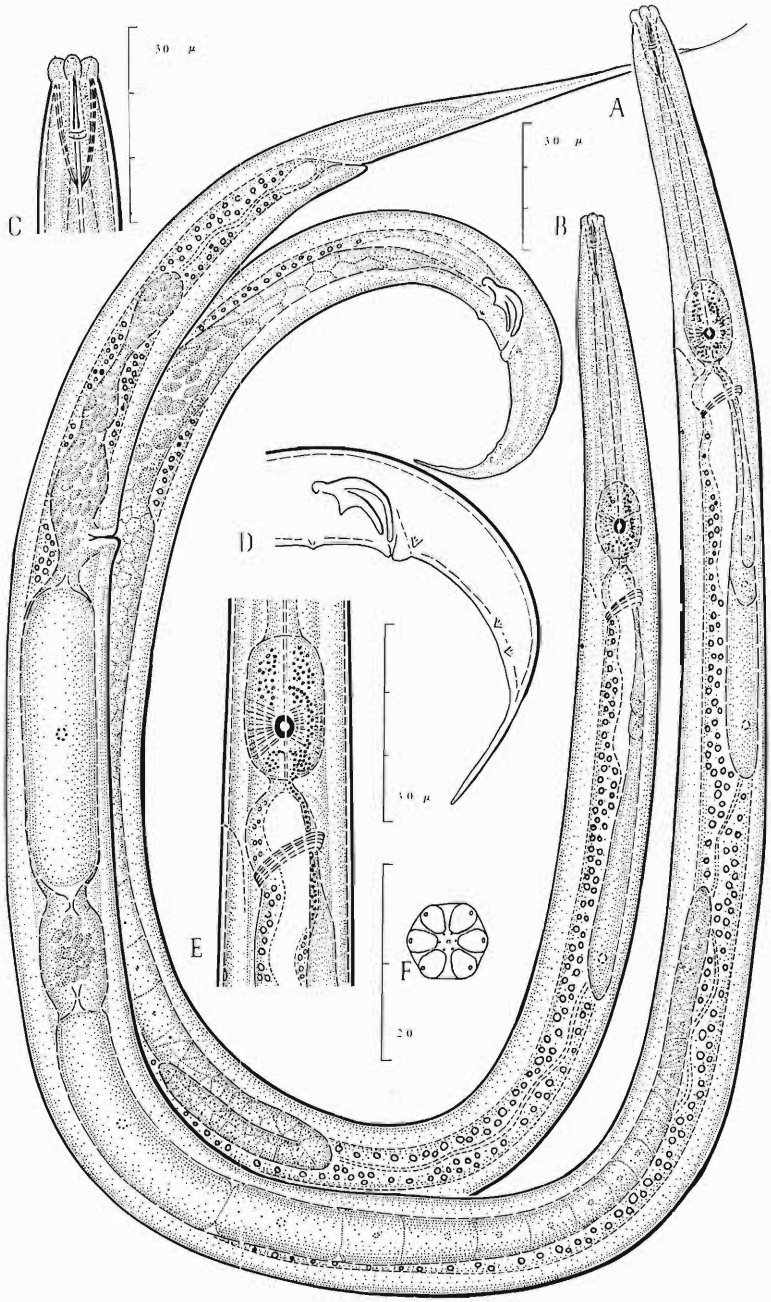

Fig. 1. *Seinura tenuicaudata.* A. female; B. male; C. female head; D. male tail variation; E. median bulb; F. *en face* view, female.

Nerve ring about 10 microns behind bulb. Extremely faint hemizonid about 18 microns behind excretory pore. Hemizonion and cephalids not seen.

Ovary single, outstretched anteriorly. Anterior end location varying from three body widths posterior to esophageal gland to three body widths behind bulb. Oogonia arranged in a single or double row in extreme anterior end, always in a single row as they enlarge. Uterus set off from ovary by constriction. Round to oval spermatheca visible in anterior end of uterus. Vulva a transverse slit, about one-half body width in length. Walls of vagina thickened. Vagina perpendicular to body wall or directed slightly anteriad. Postvulval uterine sac long, reaching 42-64 percent of vulva-anus distance. Sac is wide posterior to vagina, narrows to about one-third vulvar body width, and widens again gradually to clavate terminus. Spherical sperm cells, 4 microns in diameter, densely fill sac, uterus, and spermatheca in inseminated females.

Intestine tesselated. Lumen wide just posterior to bulb, narrowing rapidly behind nerve ring, widening again just anterior to rectum.

Tail slightly shorter than vulva-anus distance, tapering to a filiform terminus.

MALE: (Fig. 1-B, D) Males smaller than females, anterior end of both sexes similar, but esophageal glands of male in somewhat shorter lobe, 105-125 microns long. Testis single, most frequently reflexed. Anterior end of testis located at about 60 to 50 percent of body length from head in young individuals. In older males with spermatogonia depleted, testis very short, vas deferens very wide and packed with mature spermatozoa. Spicules shaped as shown in Figure 1, 15-16 microns long. No gubernaculum present. Posterior cloacal wall and anal lip appear thickened and refractive.

Tail tapers gradually, then more abruptly, ending in a spike-shaped terminus measuring 35 percent (29-37 percent) of tail length. Shape of spike variable, as shown in drawings. In relaxed specimens, tail strongly curved ventrally. Caudal papillae located as follows: a single ventral papilla near anterior end of spicules; a subventral pair just posterior to anus; and two subventral pairs at about one-half tail length.

DEVELOPMENTAL BIOLOGY

OOGENESIS: Oogonia multiply in the anterior part of the ovary. Discrete chromosomes too small to count accurately are formed during mitosis. In enlarging oogonia moving toward the posterior part of the ovary, the chromatin did not stain well.

Sperm penetration occurs at the posterior end of the egg as it passes into the uterus or very soon thereafter. The shell begins to form and meiosis begins. At first metaphase there are 6 tetrads in the center of the egg with the spindle parallel to the long axis (Fig. 4-A). By first anaphase, the nucleus has migrated to the periphery of the egg at a point about equal to one-half the egg length and the spindle is oriented perpendicular to the long axis of the egg with one pole adjacent to the membrane. At first telophase the 6 dyads at the inner pole are clumped together while those near the surface of the egg remain spread apart (Fig. 4-B). At this time the protoplasm appears highly vacuolated as noted by Mulvey (1955). The second division (Fig. 4-C) leaves 6 chromosomes in the egg nucleus. Meanwhile the sperm remains unchanged in the end of the egg (Fig. 4-F). The egg is laid at this point, 1½ to 2 hours after it entered the uterus. The two polar bodies are formed after the egg is laid.

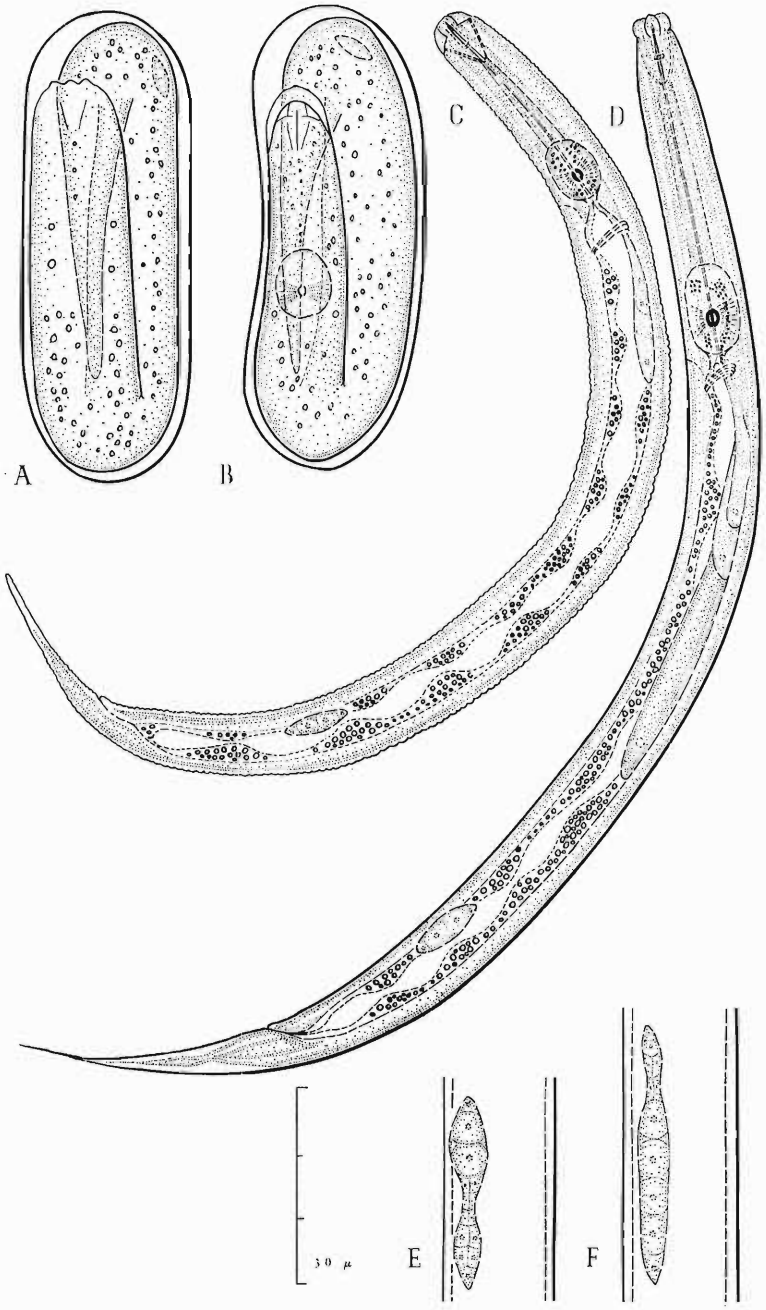

Fig. 2. *Seinura tenuicaudata.* A. first stage; B. first molt; C. hatching stage; D. third stage; E. late third stage female, genital primordium; F. late third stage male, genital primordium.

EMBRYONIC DEVELOPMENT: Eggs measure 69-86 × 21-25 microns, ranging from 3 to 4 times as long as wide, straight to slightly curved, with finely rugose shell. About 45 minutes after the egg is laid the protoplast contracts. The first cleavage occurs in one and one-half to two hours with one of the resultant cells slightly smaller than the other. One to two hours later the larger cell divides perpendicular to the long axis of the egg, then the smaller cell divides, resulting in a row of four cells. After two to three hours they begin to divide parallel to the long axis. Further cell division is difficult to follow. The embryo appears uniformly granular until the egg is 26 to 30 hours old, when the vermiform shape becomes apparent, the anterior part becomes more hyaline, and motion begins.

FIRST STAGE: When motion begins the head is broad and flat but as the body lengthens the head narrows and becomes more rounded (Figure 2-A). When fully grown the first stage is about 135 microns long; two to two and one-half times as long as the egg. It travels its own body length inside the egg many times, moving either head or tail first. It has six small conical lips which develop after motion begins, and the stoma becomes visible as a triangular clear area. No stylet or median bulb is visible. The genital primordium has two germinal cells, it is seven microns long and located at 75% of the body length.

After a period of quiescence lasting about one-half hour, spasmodic twitching of the head and tail begins. As motion becomes more frequent the stylet gradually develops from a row of round refractive globules in the head, and the median bulb and valve plates develop. Twitching and contraction of the head and tail continues until they are freed from the old cuticle. The cast cuticle, bearing only the lips and small oral aperture, is visible for only three to five minutes. (Fig. 2-B).

SECOND STAGE: Prehatching period. The molt is complete when the egg is 30 to 35 hours old. At the time the cuticle is loosened the valve in the bulb begins to pulsate, as it does at each other molt. The body lengthens rapidly to three to three and one-half times as long as the egg, and locomotion resumes. It begins to fill the shell tightly and motion becomes difficult.

The egg shape remains unchanged until about 20 minutes before hatching. At that time pressure of the head causes a bulge to develop in one end of the egg. Locomotion continues with repeated pressure of the head in the end of the egg until the shell ruptures and the head emerges. No protrusion of the stylet at hatching was seen. In all eggs observed emergence always occurred at the end of the egg, never at the side.

Total time of development from laying to hatching at 28° C. for 18 individual eggs varied from 35 to 40 hours and averaged 37 hours.

Posthatching period. (Fig. 2-C) (20) L = 165-220 microns; a = 15.0-18.5; b = 4.6-5.8; c = 5.7-6.6.

Stylet about 10 microns long. Cuticular striations more prominent than in later stages. Head broad, lips weakly developed, not offset. Stylet and bulb weak. Body comparatively wide, the *a* value much smaller than for later stages. Relaxed larvae in ventrally curved posture. Wide intestinal lumen empty. Esophageal gland comparatively short and narrow, 35 to 40 microns long, about half the size of that of the next stage. Genital primordium 8 to 9 microns long, at 55 to 65% of body length, with four cells arranged in a single row, two large germinal cells between two smaller epithelial cells, located to the right of the ventral chord as seen under the compound microscope.

No feeding was seen before the second molt. Locomotion in agar is sluggish, and although many individuals were seen to touch prey with their lips, none attempted to insert the stylet. In water the second molt begins about three hours after hatching, and the third stage emerges from the cast cuticle after another eight hours.

THIRD STAGE: (Fig. 2-D) (20) L = 218-340 microns; a = 22.0-31.5; b = 5.0-6.1; c = 5.3-7.6.

Stylet 11 to 12 microns long. Relaxed specimens in posture of adult. Lips well developed, offset from body, stylet and bulb well developed. Esophageal

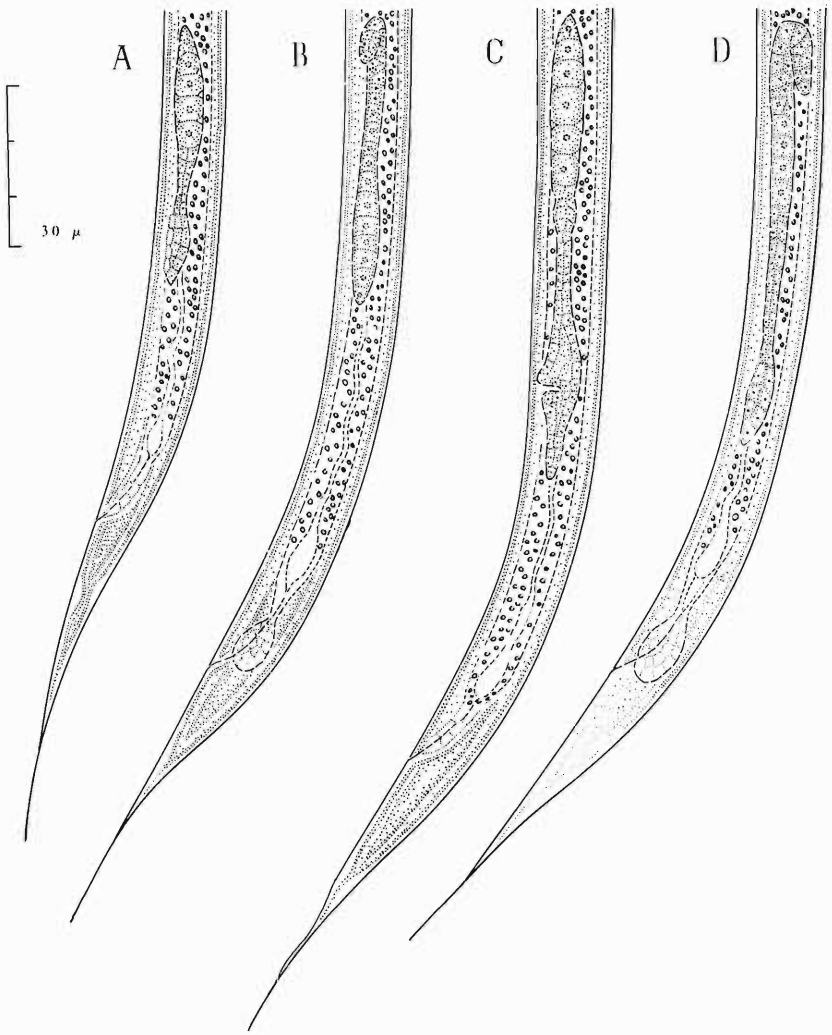

Fig. 3. *Seinura tenuicaudata*, posterior. A. early fourth stage, female; B. early fourth stage, male; C. late fourth stage, female; D. late fourth stage, male.

gland 60 to 80 microns long. Genital primordium located at 65 to 75% of body length, increases during the stage from 10 to 25 microns in length. It is similar in both sexes until late in the stage when the epithelial cells begin to divide. In the female a flat appendage set off from the germ cells by a constriction develops from the posterior epithelial cell (Figure 2-E). In the male the anterior cell divides, forming a pointed extension to the gonad anterior of the germ cells (Fig. 2-F).

During the third molt the number of germ cells increases to four in the female and to 12 or more in the male. The gonoducts also continue to elongate in both sexes.

Specimens kept in water without food after emerging from the second molt died after five days. Others which were transferred to agar with prey began to feed and continued their development. In the presence of ample prey the third stage lasts about 18 hours. One individual was seen to kill three prey, another four, before beginning the third molt.

FOURTH STAGE: (7 males) L = 420-540 microns; a = 25.3-34.4; b = 6.5-7.7; c = 6.5-9.1. (11 females) L = 400-610 microns; a = 29.3-36.8; b = 6.9-8.4; c = 6.1-10.0.

Stylet 14-16 microns long, esophageal gland 80-100 microns long. Gonad in females increases during the stage from 35 to 85 microns in length, with the posterior end at 68-75% of body length. Early in the fourth stage vaginal primordium cells develop from the ventral body wall (Figure 3-A). The uterus and post-vulvar uterine sac continue to develop from the posterior epithelial cells and they are fully formed but flattened during the final molt. The spermatheca is marked by a slight thickening. Shortly before the final molt begins the vagina appears as a hyaline, flattened tube (Fig. 3-C). The oogonia increase in size, but no eggs enter the uterus until after impregnation by the males.

In males the genital primordium increases to about 150 microns. About midway through the stage, growth from the anterior end is directed posteriad, and late in the stage the tip is often reflexed (Fig. 3-B, D). Spermatogonia are arranged in at least two rows near the tip, and increase to 5 or 6 to a cross section near the posterior end of the body. Just before the final molt the cloacal primordium appears dorsad of the rectum as a rounded mass of cells in lateral view, cordate in ventral view. The spicules are formed simultaneously with the stylet during the final molt.

Development of the fourth stage takes about 36 hours.

SPERMATOGENESIS: Mitotic division continues in the testis into adulthood until some certain number of spermatogonia are formed. When these have all matured the vas deferens is short, wide, and filled with spermatozoa. Occasionally the flexure is still present in the anterior end of the testis.

Primary spermatocytes are seen in the posterior part of the testis just before the final molt, with six tetrads at the first metaphase (Fig. 4-D). After the first division the cells separate from the main mass in the testis and enter the vas deferens. The secondary spermatocytes begin to divide about the time the final molt is complete. There are always 6 dark staining bodies at the plate at the second metaphase although dyads cannot always be resolved. The second division is completed in the vas deferens. The chromosomes in the spermatozoa, both in the male and after transfer to the female, remain separated and are arranged in various recurring patterns: including five in a circle and one in the middle in a different plane; straight and crescent shaped rows of six; and two rows of three. In some spermatozoa only five chromo-

somes could be counted, suggesting the X 0 type of sex determination in this species. However the nuclei are so small that this could not be confirmed.

MALES: Immediately after the final molt males begin to feed and attempt to copulate by wrapping their tails around the females. They were also seen wrapping their tails around other *Seinura* males, but never around *A. avenae*.

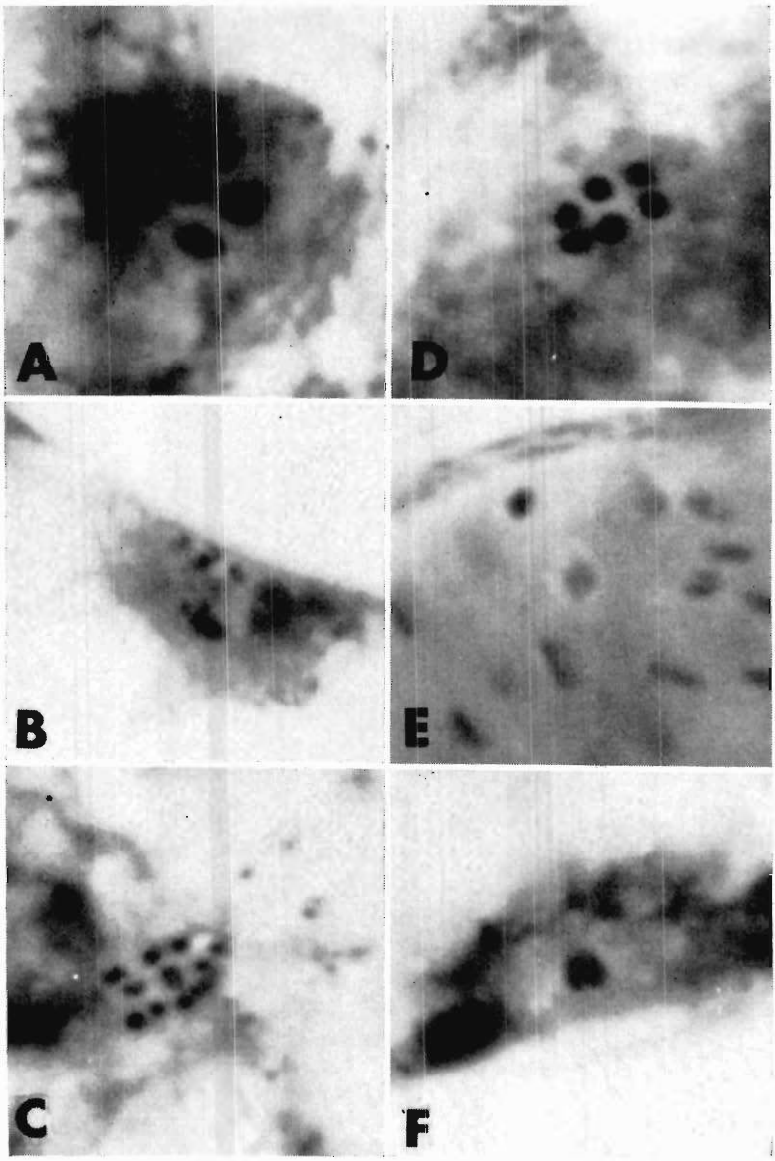

Fig. 4. A. First metaphase, oogenesis; B. First telophase, oogenesis; C. Second metaphase, oogenesis; D. First metaphase, spermatogenesis; E. Sperm cells in female; F. Sperm cell in end of egg.

FEMALES: After impregnation by the males the uterus and postvulvar sac of the females become plump with sperm cells. A female can be impregnated by more than one male. In the presence of males and ample prey egg production begins 18 to 24 hours after the females emerge from the final molt. About 12 eggs are laid in 24 hours. One female laid 5 eggs at precisely two hour intervals. This rate continues for about four days, then slows gradually to only six to eight eggs a day. In these studies nematodes continued to produce eggs for at least seven days, the longest period a single individual was kept under observation. Many observations show that a female *S. tenuicaudata* produces 1 or 2 eggs while feeding on one adult *A. avenae*.

Well fed gravid females removed from a source of food laid two eggs about two hours apart, then only two to five additional eggs at longer and longer intervals until their reserves were exhausted.

Egg laying does not interrupt other activities of *Seinura*. They have been seen laying eggs while feeding without removing the stylet from their prey even at the moment of depositing the egg, and while traveling through agar they lay eggs without interrupting their flowing sinuous movement.

NEED FOR MALES: Eight molting *S. tenuicaudata* females were placed singly in small cells of agar with ample prey and were transferred to cells with fresh prey every second day. After 10 days all but two females had been lost in the agar. No eggs were seen during this period, although the nematodes fed and appeared opaque at all times.

The two remaining females then were put in a cell with eight males. The next day eggs were seen in the agar, and after two more days larvae were seen feeding predaceously. During this three day period the males repeatedly wrapped their tails around the females and around each other.

Other females isolated before adulthood did not contain sperm, while those taken from dishes with males invariably had sperm in the uterus and postvulvar sac.

SEX RATIO: Counts were made of males and females from cultures of various ages to determine the sex ratio. There were usually somewhat more females than males, the ratio of males to females ranging from 1:1 to 1:2.5. No correlation could be found between variability of sex ratio and environmental changes.

GENERATION TIME: The total time for the development of one generation of *Seinura tenuicaudata* at 28° C. is 5½ to 6 days. Males develop at the same rate as females.

FEEDING

Predaceous feeding on other nematodes in the genus *Seinura* was first discovered and studied in detail in Hawaii by Linford (1937), and Linford and Oliveira (1937). This study confirms and elaborates on their findings. The feeding of *Seinura tenuicaudata* was compared with that of other *Seinura* species and no differences were found.

FEEDING ON *A. avenae*: In agar a *Seinura* moves sinuously, often stopping and moving its head in all directions. When the lips touch an *A. avenae* the *Seinura* immediately forces its head tightly against the body wall and jabs repeatedly with the stylet until penetration is achieved. Unless the lips touch the prey, no reaction occurs. The inserted adult stylet reaches about one third of the distance across the body of an adult *A. avenae* (Fig. 5-A).

It is often difficult for a large *Seinura* to pierce a small nematode in soft agar because the prey will fold at the point of contact and be pushed through

the agar instead of being penetrated by the stylet, although a larger prey, or a small one in harder agar, is penetrated more easily. Predators of this genus have not been seen feeding in water.

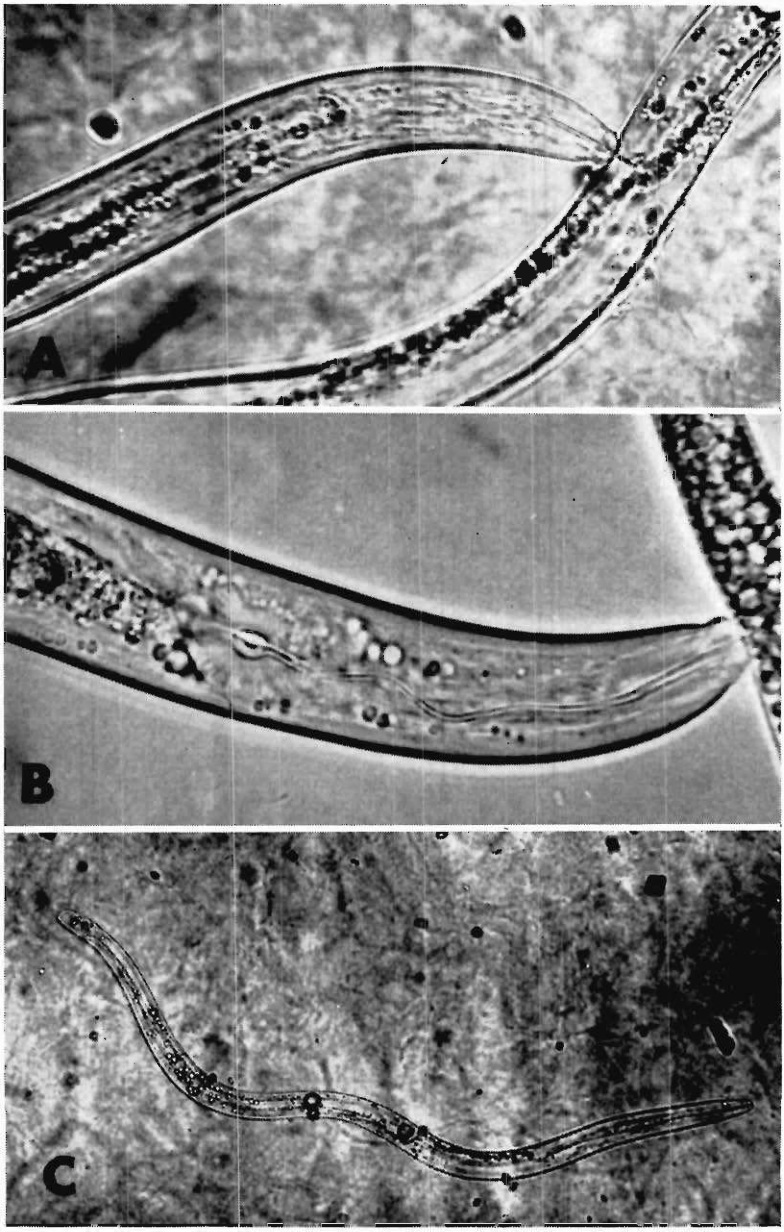

Fig. 5. A. *Seinura tenuicaudata* feeding on *Aphelenchus avenae* showing inserted stylet; B. Median bulb of feeding *Seinura* showing flow of glandular material; C. Body of *Aphelenchus avenae* emptied by *Seinura*.

The prey stops traveling through the agar as soon as the stylet pierces its cuticle. It may move feebly in place for several minutes, but its action is uncoordinated and locomotion is not possible. After 15 to 20 minutes it lies quietly except for occasional twitching of the stylet and median bulb. Immediately after penetration round globules begin to move from the esophageal gland of the predator and accumulate in the alveolated anterior part of the esophageal bulb (Fig. 5-B). During spasmodic twitching of this part of the bulb discrete globules pass through the stylet into the prey, where the soft body contents immediately begin to disintegrate to a consistency easily ingested by the predator.

Periods of twitching alternate with periods of rapid, rhythmic pulsation of the muscular part of the bulb. Each type of motion lasts 30 seconds to 2 minutes. The powerful pulsation of the bulb actuates the flow of food toward the stylet from distant parts of the prey. Food gushes rapidly into the intestine, forcing previously ingested food behind it. When pulsation stops there is a back-flow into the prey from the stylet.

The food appears as large round globules. At 1800× magnification they can be seen elongating when they enter the stylet. Between the stylet orifice and the intestine they seem to be moving forward.

When a predator consumes the modified content of the prey it leaves only the excretory pore lining and the alimentary tract inside the cuticle. The stylet, esophageal tube and valve plates remain joined together, while the intestinal lining shows as only two thin parallel lines between the valve plates and the anus (Figure 5-C). If the predator leaves the prey before completely consuming the body contents, they continue to disintegrate until only a disorganized mass of globules and the cuticularized structures remain inside the body wall.

A single *Seinura* may kill many *A. avenae* in rapid succession. Often in a crowded culture a passing prey will dislodge the stylet of a feeding predator. The predator usually immediately kills this new prey, and often after 12 to 15 hours a group of 20 to 30 *A. avenae* will be arranged in a neat row in the agar, evidently all killed by one predator.

In contrast, more than one predator has been seen feeding on one prey at a time in cultures in which the predator outnumbers the prey. A large *A. avenae* was observed with nine *Seinura*, 3 females and 6 males, feeding on it simultaneously, and another was seen with 18 feeding *Seinura*.

All stages of *Seinura* which feed do so on all stages of *A. avenae*. In Hawaii *S. tenuicaudata* was seen feeding on *A. avenae* eggs, but this was seen only once in the present study.

CANNIBALISM: When a predator in agar containing abundant nematodes of another species suitable as prey touched another nematode of its own species with its lips it made no attempt to feed. However, contrary to the report by Linford (1937), once the other species are consumed cannibalistic feeding begins and continues until only a few widely scattered *Seinura* remain in the dish. Males, females, and larvae feed on all stages indiscriminately. *Seinura* feeding cannibalistically appear starved and translucent and they seldom lay eggs.

OTHER PREY: Linford and Oliveira reported that *Seinura* spp. fed successfully on larvae of *Meloidogyne* sp., all stages of *Pratylenchus pratensis*, *Aphelenchoides parietinus* and various scavengers, as well as *A. avenae*. In the present study they also fed and reproduced on *Ditylenchus dipsaci* (Kuhn, 1857) Filipjev, 1936 from onion, larvae of *Heterodera trifolii* Goffart, 1932

and *Meloidogyne hapla* Chitwood, 1949, and *Neotylenchus linfordi* Hechler, 1962. They did not seem to be able to penetrate the cuticle of adult *Xiphinema sp.* and *Hoplolaimus galeatus* (Cobb, 1913) Thorne, 1935.

Washed clover rootlets with *Heterodera trifolii* cysts and exposed white females were placed in Petri dishes, cooled water agar was poured over them, and *Seinura* were added. The *Seinura* did not attempt to penetrate either the females or the cysts.

In dishes with *Seinura tenuicaudata* and another *Seinura* sp., *S. tenuicaudata* fed on the other *Seinura,* and produced more eggs than it does feeding cannibalistically, although reproduction was extremely slow. The other *Seinura* was not seen feeding on *S. tenuicaudata.*

DISCUSSION

Before each molt and before hatching of the egg pulsation of the median bulb occurs. This may aid proper development of the muscles of the bulb; or, since a tighter fit of the egg shell and a rapid elongation of the body occurs during pulsation, the nematode may be ingesting fluid from around itself.

Evidently insemination by the males is needed to stimulate egg development. The females do not lay infertile eggs which later die. Furthermore, impregnation need not take place immediately after the female reaches adulthood for it to produce viable eggs. The eggs increase in size in the ovary, then development stops. After impregnation they move into the uterus and maturation proceeds.

Seinura have not been seen feeding in water, and penetration of the prey is difficult even in very soft agar. Presumably they need the support of harder agar to insert the stylet in the prey.

The *Seinura* do not attempt to penetrate other nematodes with the stylet unless the lips touch the prey. Evidently the presence of prey is detected only through the cephallic papillae or amphids on the head, while the body cuticle is not sensitive.

Under the conditions of these studies there was no evidence to indicate that *Seinura* are attracted to prey at a distance. However, in densely populated agar cultures any attractive substances would be evenly distributed, without establishment of concentration gradients, and attraction would not be noticed. These observations do not rule out the possibility that under soil conditions a concentration of nematodes around roots might be attractive to *Seinura.*

The apparent forward movement of food globules in the esophageal lumen during ingestion cannot be explained at present.

The food of *Seinura* is probably finely divided for easy ingestion and possibly partially digested before it is sucked into the intestine. However, some waste material is left in the intestine after digestion is complete. The discharge of this material through the anus of live nematodes has been seen.

The starved appearance and low rate of egg production in *Seinura* feeding cannibalistically suggests that the body contents of members of their own species are not nutritionally suitable. Possibly other nematodes supply certain nutrients which the *Seinura* do not synthesize themselves.

SUMMARY

The nematode predator *Seinura tenuicaudata* (de Man) Goodey, 1960 is described and synonymized with *Seinura christiei* Goodey, 1960. The biologi-

cal development was studied at 28° C. in potato dextrose agar cultures of *Aphelenchus avenae* Bastian, 1865 feeding on *Pyrenochaeta terrestris*.

The period of egg development was 35 to 40 hours, with one molt in the egg. The hatching stage, with weakly developed stylet, median bulb, and lip region, did not feed before the second molt. Feeding was necessary for further development through the third and fourth molts. The complete generation time was 5½ to 6 days. Males and females were present in about equal numbers and males were necessary for reproduction. A haploid number of six chromosomes was found.

Feeding studies confirmed the work of Linford and Oliveira except cannibalistic feeding was seen.

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On the Nature of Hatching of *Heterodera schachtii*

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The property of host plant root exudates to stimulate emergence of larvae of the cyst forming nematodes, *Heterodera* spp., (Baunacke, 1922) has been studied extensively abroad (Rensch, 1924; Triffitt, 1930; Fenwick, 1952; den Ouden, 1956; Wallace, 1956; Shepherd, 1962) and in this country (Thorne, 1956 and Neal, 1959). Research into the character of the stimulating agent for *Heterodera rostochiensis* indicates that vitamins, vitamin derivatives and inorganic salts play a role in hatching (Neal, 1959). The hatching response as it occurs in nature is believed to be due to a specific stimulus, though non-specific action such as brought about by sub-lethal and apparently non-toxic solutions of appreciable osmotic pressure are known to reduce or arrest hatching (Dropkin et al, 1958; Steele, 1962). It is also believed to be different from the hatching obtained on simple dissolution or rupture of the egg membrane; in eclosion the larva becomes active, making repeated stylet thrusts at the egg membrane which eventually ruptures, instead of remaining passive as it does if the membrane is dissolved or ruptured. The nature of the material which stimulates the hatching response and its mode of action are still poorly understood. Dropkin et al (1958) have suggested that the stimulant exerts its influence by rendering membranes more permeable to metabolites or by entering directly into metabolic reactions.