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Correspondence may be addressed to the corresponding secretary-treasurer, Edna M. Buhrer, Division of Nematology, Plant Industry Station, Beltsville, Md., or to the editor, Jesse R. Christie, Division of Nematology, Plant Industry Station, Beltsville, Md.

This number issued October 26, 1945.

Ditylenchus destructor, n. sp., the potato rot nematode, and *Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936, the teasel nematode (Nematoda: Tylenchidae). GERALD THORNE, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, Salt Lake City, Utah.

A nematode attacking potatoes, *Solanum tuberosum* L., was discovered by Kühn in 1888 which he identified as the stem or bulb nematode, *Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936 (Syn.: *Anguillula dipsaci* Kühn, 1857). Under these names, various workers have recorded the pest from many points in Europe and the British Isles and investigations have been made concerning its biology and hosts, perhaps the most important being the work by Quanjer (1927).

Infections on potatoes were unknown in the United States until Earle C. Blodgett collected diseased potatoes near Aberdeen, Idaho, on October 26, 1943, when they were called to his attention by John L. Toevs, Superintendent of the Aberdeen Branch Experiment Station. Identification of the causal agent as *Ditylenchus dipsaci* was first made by Glen KenKneight of the University of Idaho and this was later confirmed by members of the Division of Nematology of the U. S. Bureau of Plant Industry, Soils and Agricultural Engineering. The writer compared them with specimens collected from potatoes intercepted by inspectors in ships' stores at the port of Boston in 1932 and found them to be the same. When first examined in 1932, ana 'omical differences had been noted, and with this wealth of fresh material in hand it was possible to determine definitely certain diagnostic characters which are of sufficient importance to justify the establishing of a new species. To make the identificatiɔn more certain, specimens of *D. dipsaci* infecting teasel, the type host, were secured from Oregon for comparative purposes. The species from potatoes is herein described as *Ditylenchus destructor*, n. sp., and potato-rot nematode is suggested as a common name. The diagnosis of *Ditylenchus dipsaci* is emended and it is here referred to as the teasel nematode because preliminary studies indicate that with further research it will be possible definitely to separate certain other forms of the commonly called "bulb or stem nematode." Unfortunately it has been impossible to complete these studies in time for inclusion in this paper but it now appears that we may be able to account, at least in part, for the many puzzling failures to make transfers of "populations" from one well-known host to another. Frequently we have been dealing with forms, perhaps species, which are very definitely different in certain morphological characters and these may be expected to possess a highly developed host preference. These studies have included specimens from alfalfa, *Medicago sativa* L.; red clover, *Trifolium pratense* L.; sweet clover, *melilotus alba* Desr.; field garlic, *Allium vineale* L.; onion, *Allium cepa* L.; daffodil, *Narcissus pseudonarcissus* L.; teasel, *Dipsacus fullonum* L.; and *Crepis capillaris* (L.) Wallr.

Varieties of *Ditylenchus dipsaci* previously established, all under old generic names, are as follows: *Anguillulina dipsaci* var. *allocatus* Steiner, 1934, found living free in the soil; *A. dipsaci dipsaci* Steiner and Scott, 1935, infesting teasel; *A. dipsaci* var. *communis* Steiner and Scott, 1935, attacking narcissus, potato, etc.; *A. dipsaci* var. *amsinckiae* Steiner and Scott, 1935, parasitic in *Amsinckia intermedia* Fisch. & May; and *Tylenchus dipsaci* var. *tobaensis* Schneider, 1937, from

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Potamogeton mucronatus Presl. (Syn.: *P. malainus* Miq.) and *Myriophyllum spicatum* L. The writer has examined the varieties *communis* and *amsinckiae* and believes that both will become valid species when given detailed study. Since narcissus is the first host named under the variety *communis,* there can be no objection to removing the nema attaching potatoes and giving it the specific name *Ditylenchus destructor.*

NATURE OF THE INFECTION

There were no visible symptoms on the plants during the summer of 1944 since the nemas did not attack the stems under the field conditions studied. The year was most favorable for nema activity with precipitation slightly above normal during April and May, while in June there were 3.14 inches of rainfall, an excess over normal of 2.56 inches. Temperatures remained very close to normal during these months so that conditions in general were probably better than average for nema development. Therefore it seems safe to assume that at Aberdeen the pest does not attack buds and stems as it has been reported to do in Europe (Quanjer, 1927). The first nemas attacking tubers were found on volunteer plants on August 9th and by the 31st numerous lesions were present on tubers produced from clean seed planted in infested soil of the experimental plots.

Injury is first characterized by small discolored spots on the tubers in which the nema colonies are developing. These spots consist of decaying gray to brown tissue with a somewhat honeycombed and granular appearance (Fig. 1, A). As the lesions spread through the tubers a drying and shrinking of the skin occurs and frequently cracks appear. Occasionally the entrance to a colony is marked by only a small pit. Nemas are found in the zone between the decaying and uninjured tissues where they reproduce and multiply to enormous numbers, all stages from egg to adult usually being present at the same time. Tubers in the original-discovery field were so severely damaged that most of the crop was left lying in the field, while in other instances the injury at digging time was not conspicuous and in several cases it was not until the potatoes were passed over the grading tables that infections were discovered. Invasion of the tissues continues during storage and by mid-winter many tubers are almost completely destroyed (Fig. 1, B, C). The nemas are most easily found by teasing apart a small piece of infected tissue in a watch glass of water and examining under the binocular microscope.

Ditylenchus destructor n. sp.

♀ : 0.8–1.4 mm.; $\alpha = 30$–35; $\beta = 8$–10; $\gamma = 15$–20; V–$^{65}78$–83^{10}

♂ : 0.8–1.3 mm.; $\alpha = 34$–40; $\beta = 7$–8; $\gamma = 12$–16; T–73–80

Cuticle near head marked by transverse striae which average about 1 μ apart while on the remainder of the body the striae are so obscure as to be almost invisible unless the specimens be killed in cold fixative, when the slightly shrunken cuticle exhibits striae similar to those near the head. Lateral fields composed of 5 elements, marked by 6 incisures[1] which appear as bright longitudinal lines under the oil-immersion objective (Fig. 2, F). On the neck and tail the number of incisures may be decreased to 2. Deirids small but usually visible near the base of the neck. Phasmids probably present but so minute that they have not been observed. From a lateral view the amphid apertures appear as minute refractive dots on the apices of the lateral lips while *en face* they are similar to those figured for *Ditylenchus dipsaci* (Fig. 3, C). The labial framework is well sclerotized and a prominent feature of the lip region. Spear with well-knobbed base and wide muscular

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[1] The term ''incisures'' is here introduced as a definite name for those longitudinal markings of Tylenchidae and related nemas, which formerly have been known as ''wings'' and ''lateral striae.''
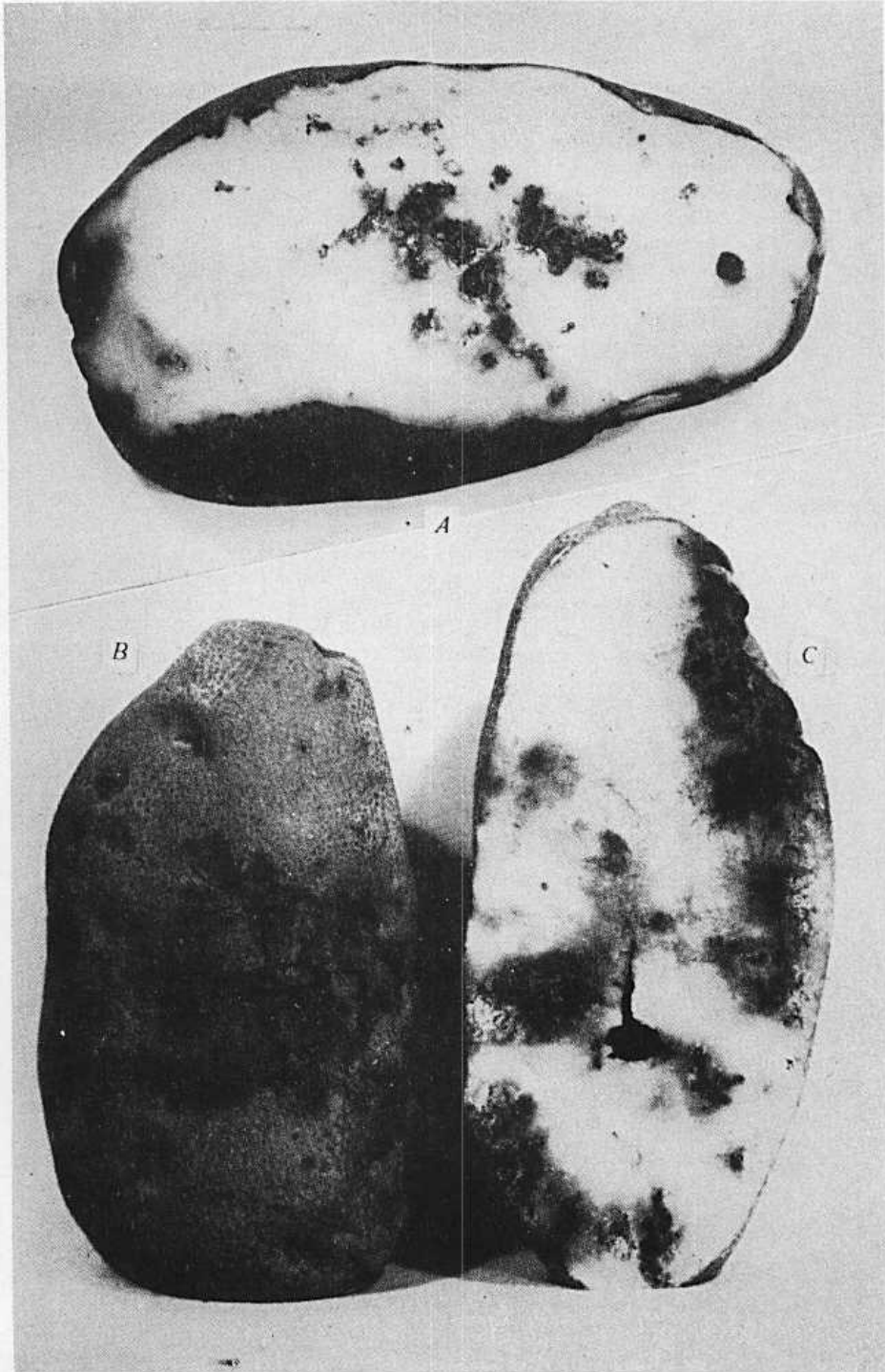
Fig. 1. Potatoes infected with *Ditylenchus destructor*. A—Tuber at digging time showing typical, shrunken, honeycombed tissues as they appear after peeling. B—Tuber after 3-months' storage. Note variations in lesions from pin-hole to large, shrunken, cracked lesions. C—Cross section of tuber after 3-months' storage.

bands attaching it to the labial framework. Esophageal gland outlets as in other *Ditylenchus* species (Fig. 3, B, D). Basal bulb of esophagus elongate, largely enclosing esophageal glands which generally extend a short distance back over the anterior end of the intestine. These glandular lobes may be either longer or shorter than those illustrated (Fig. 2, A, D). Anterior end of intestine extending forward into the base of the esophagus where it makes an obscure junction with the lumen. A very small, valvular apparatus prevents regurgitation of food. Intestine densely granular, ending in a distinct rectum and anus.

Anterior ovary outstretched to near base of esophagus, the developing oöcytes arranged in 2 or more lines, changing to tandem near the middle of the ovary. Eggs average slightly longer than the body diameter and about half as wide as long. A rudimentary posterior uterine branch extends about two-thirds the distance to the anus, ending in a cell which apparently is a remnant of the ovary which existed in some ancestral form. This rudimentary uterine branch has not been observed to function as a spermatheca. Spermatozoa usually are visible well up in the uterus as they await the entrance of the eggs. The thick lips of the broad, transverse vulva are elevated well above the body contour. Vulva-anus distance equal to $1\frac{3}{4}$ to $2\frac{1}{2}$ times the length of the tail.

Testis outstretched to near the base of the esophagus, the spermatogonia mostly arranged in single file until near the middle of the body where they become primary spermatocytes from which develop the spermatozoa. Spicula with certain distinctive characters when observed in lateral view (Fig. 2, C). This pattern changes considerably if viewed from either a slightly dorsad or ventrad angle. The well-developed bursa rises about opposite the proximal ends of the spicula and extends $\frac{3}{5}$ to $\frac{3}{4}$ the length of the tail. Number of lateral incisures near the tail usually decreased to 4, forming a pattern much like that illustrated for *Ditylenchus dipsaci* (Fig. 3, F).

Diagnosis.—Obligate plant-parasitic *Ditylenchus* with the above measurements and general description. Lateral fields marked by 6 incisures; glands of esophagus generally extending in a lobe overlapping anterior end of intestine; ovary with developing oöcytes arranged in 2 or more rows; eggs averaging about as long as body diameter and half as wide as long; spiculum with characteristic pattern as figured; terminus finely rounded.

Type host.—*Solanum tuberosum*, potato.

Type locality.—Fields near Aberdeen, Idaho, U. S. A.

Studies of the common crops and weeds of the Aberdeen section have revealed that the dandelion, *Taraxacum officinale* Weber, serves as the host which carries *Ditylenchus destructor* over in the fields between potato crops. No other plant has been found to be a host.

A population of *Ditylcnchus dipsaci* attacking sweetpotatoes in Maryland and New Jersey, and causing injury very similar to that of *D. destructor*, was studied by Kreis (1937). It is believed by the writer that this probably was *D. destructor* but, unfortunately, it has not been possible to secure specimens for comparative studies.

> *Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936
>> Syns.: *Anguillula dipsaci* Kühn, 1857
>>> *Anguillulina dipsaci* (Kühn, 1857) Gerv. & Ben., 1859
>>> *Tylenchus dipsaci* (Kühn, 1857) Bastian, 1865
>>> *Anguillulina dipsaci dipsaci* Steiner & Scott, 1935

♀ : 1.0–1.3 mm.; $\alpha = 36$–40; $\beta = 6.5$–7.1; $\gamma = 14$–18; V–$^{60-70}80^7$

♂ : 1.0–1.3 mm.; $\alpha = 37$–41; $\beta = 6.5$–7.3; $\gamma = 11.5$–14.5; T–65–72

Body marked by transverse striae about $1\,\mu$ apart which are easily visible under the oil immersion at any point on the body. Lateral field marked by 4

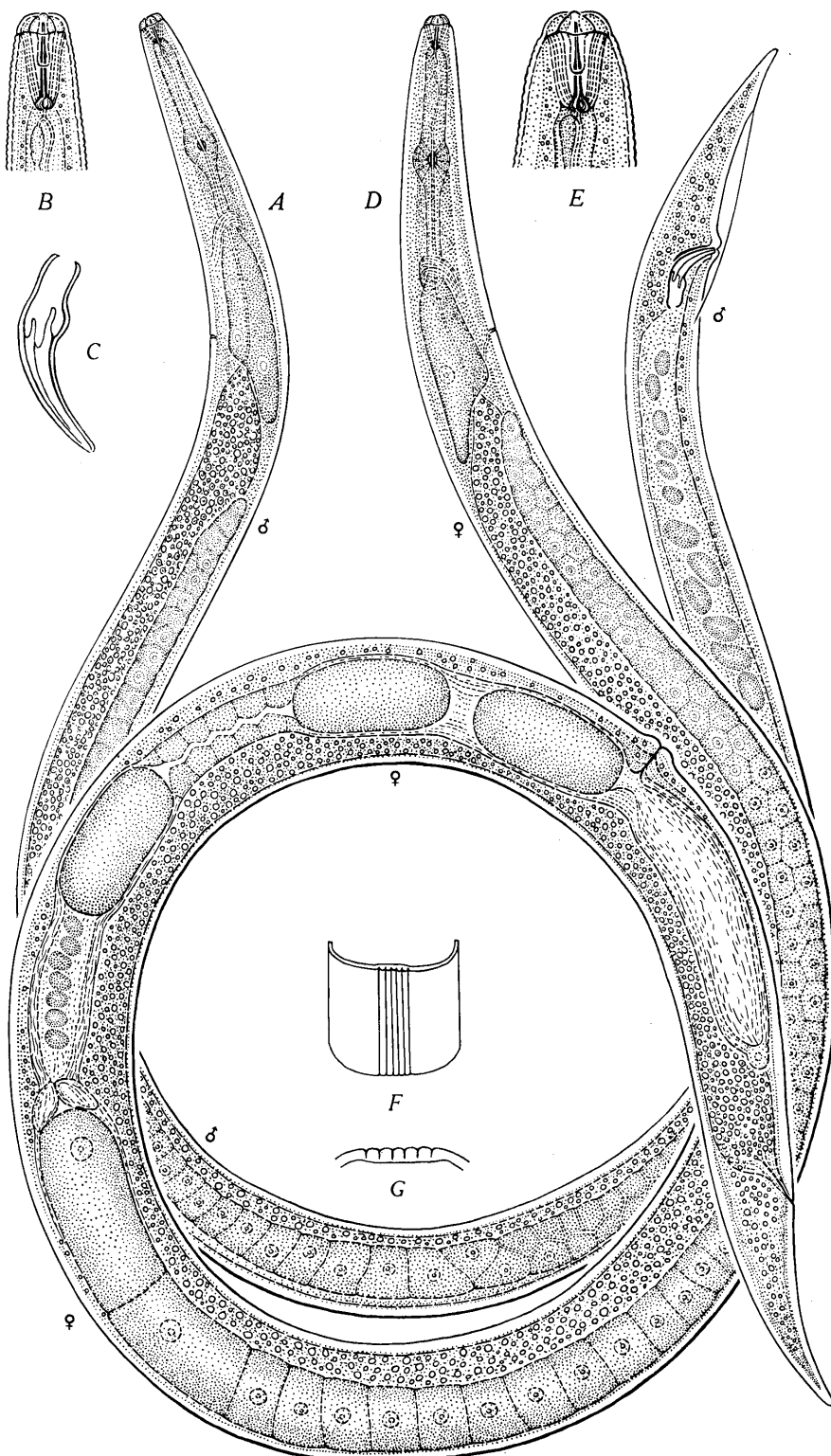FIG. 2. *Ditylenchus destructor.* A—Male; × 330. B—Head of male; × 1000. C—Spiculum; × 1000. D—Female; × 330. E—Head of adult female; × 1000. F— Section of cuticle at mid-body showing 6 incisures of the lateral field; × 330. G—Cross section of lateral field; × 1000.

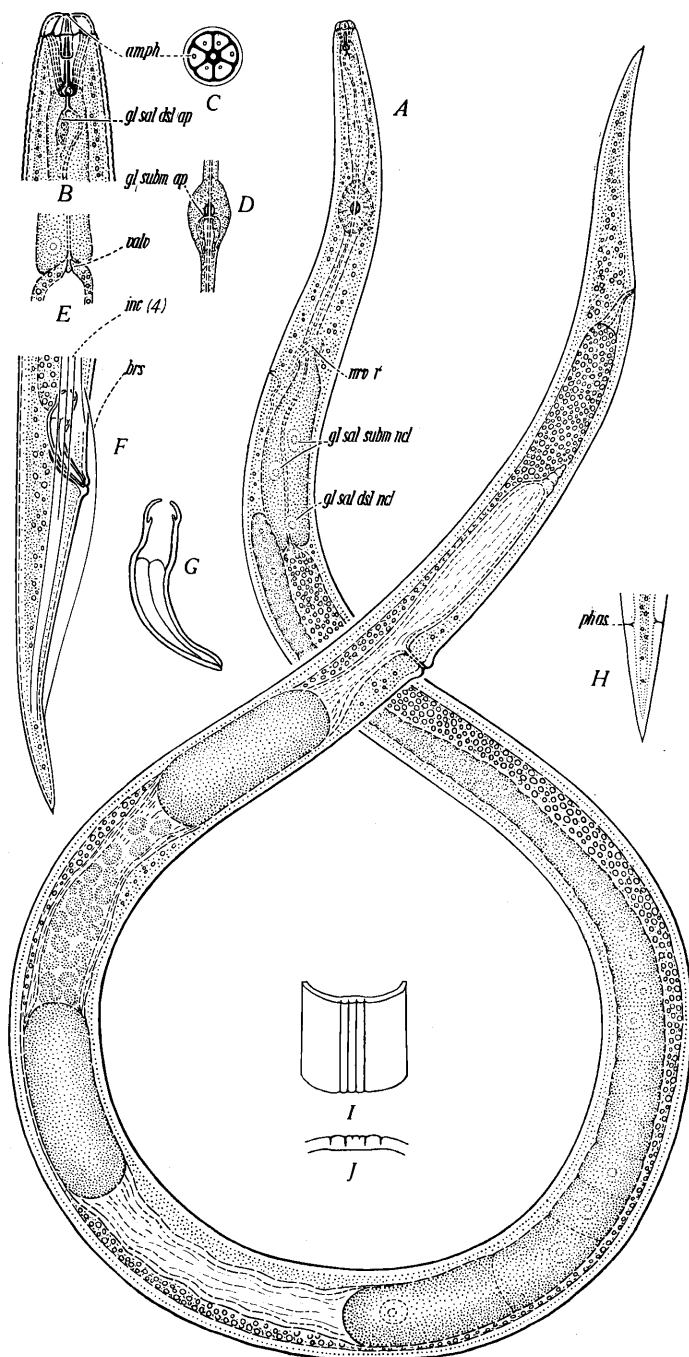FIG. 3. *Ditylenchus dipsaci.* A—Adult female; × 330. B—Head of female; *amph*, amphid; *gl sal dsl ap*, aperture of dorsal salivary gland; × 1000. B—Head *en face* showing arrangement of amphids and 4 labial papillae; *amph*, amphid; × 1000. D—Dorsal view of median esophageal bulb; *gl subm ap*, apertures of submedian esophageal glands; × 500. E—Junction of intestine and esophageal lumen; *valv*, muscular valvular apparatus in anterior end of intestine; × 500. F—Posterior portion of male; *inc*, 4 incisures of lateral field; *brs*, bursa; × 500. G—Spiculum; × 1000. H—Terminus; *phas*, phasmid (much exaggerated); × 500. I—Section of cuticle at mid-body showing 4 incisures; × 330. J—Cross section of lateral field (note the 2 minute incisures in the central element); × 1000.

incisures which divide it into 3 elements. On the neck and tail the number of incisures is decreased to 2. Cross sections of the body from certain favorable specimens show the center element is marked by 2 minute incisures which may indicate that an ancestor once possessed 6 (Fig. 3, J). Deirids usually visible near base of neck. Phasmids exceedingly obscure and visible only from a dorsal or ventral view on favorable specimens. Amphid apertures located on the apices of the lateral lips where they appear as minute refractive dots which are best seen *en face* (Fig. 3, B, C). Spear with strongly developed knobs from which protrudor muscles lead to the well-sclerotized labial framework. Esophageal gland outlets typical of the genus and subfamily (Fig. 3, B, D). Basal bulb of esophagus largely enclosing esophageal glands, with the usual 3 prominent gland nuclei. Anterior end of intestine extending forward into the base of the esophagus where it joins the funnel-shaped base of the lumen with a very small muscular valvular apparatus. Intestine densely granular, ending in a distinct rectum and anus.

The outstretched ovary reaches forward, sometimes as far as the median bulb of the esophagus but more generally near the basal bulb. In rare specimens it is reflexed. The developing oöcytes largely lie in tandem and develop into eggs which are from 2 to 3 times as long as the body width. The rudimentary posterior uterine branch extends about half way back to the anus, ending in a few cells which apparently are remnants of the ovary of an ancestral form. This rudimentary uterine branch has not been observed to function as a spermatheca. In fertilized females the spermatozoa are found well up in the uterine branch where they await the passage of the eggs. Lips of vulva thick and elevated well above the body contour. Vulva-anus distance equal to from 1¾ to 2¼ times the length of the tail. Terminus always acute.

The outstretched testis usually extends forward to within 4 to 6 body-widths of the esophagus base; and in no instance has a flexure been observed. The developing spermatogonia are arranged in single file except in certain short regions of growth. When observed in a perfectly lateral view the spicula exhibit a general pattern that apparently is characteristic of the species but the proper angle of observance is so difficult to obtain on the various specimens that this pattern would be of doutbful taxonomic help. The well-developed bursa rises about opposite the proximal ends of the spicula and extends about three-fourths the length of the tail. The 4 lateral incisures form a pattern similar to that illustrated (Fig. 3, F).

Diagnosis emended.—Obligate plant-parasitic *Ditylenchus* with the above measurements and general description. Lateral field marked by 4 incisures; base of esophagus extending but slightly over the anterior end of the intestine; gonads outstretched, their cells lying in tandem. Eggs 2 to 3 times as long as the body diameter. Spicula with characteristic pattern as figured. Terminus acute.

Type host.—*Dipsacus fullonum*, fullers teasel.

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Helicotylenchus, a new genus of plant-parasitic nematodes and its relationship to *Rotylenchus* Filipjev.

G. STEINER, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering.

In 1934 I. N. Filipjev created the new genus *Rotylenchus* for Tylenchinae which he characterized as having double ovaries, an aphelenchoid oesophagus, a strong stylet, a broadly annulated cuticle and a chitinized head (See also Filipjev, 1936). *Tylenchus robustus* de Man 1880 was made the type of the genus.

The tylenchs thus separated represent a natural group deserving consideration as a valid genus. Filipjev erred, however, in selecting *Tylenchus robustus* de Man 1880 as the type species, since that form is assumed to have a ''tylenchoid,'' not an ''aphelenchoid'' oesophagus. As shown in de Man's (1876) figure 18a, plate VI, also referring to *T. robustus* there is a terminal oesophageal bulb which is set off from the intestine, and in which there are three enclosed oesophageal glands, the nuclei of two of which are shown. While the 1880 paper has no figures and does not mention the oesophagus-intestine junction, an 1884 paper does figure the species, again with a distinct terminal bulb. The term ''aphelenchoid,'' as used by Filipjev, however, means forms with an indistinct separation of oesophagus and intestine, without a sharply defined terminal oesophageal bulb, and with enlarged oesophageal glands which protrude over the intestine proper. These two types of oesophagus-intestine junction were originally thought to be the differentiating characters of the aphelenchs and tylenchs. This is no longer so, since we know today that both types of junction and both types of gland location occur in various groups of both tylenchs and aphelenchs.[1] Thus the terms ''aphelenchoid'' and ''tylen-of feeding and kind of food ingested by these forms, wherein digestion is becoming choid'' oesophagus can no longer be used in Filipjev's sense. ''Aphelenchoid'' and ''tylenchoid'' oesophagi should be differentiated only on the basis of the position of the outlets of the three oesophageal glands; in the case of the aphelenchs these outlets are always in the middle, or metacorpus, bulb or its homologous part; in the case of the tylenchs the outlet of the dorsal gland is just posterior of the buccal stylet, or at least in the procorpus, while the outlets of the two subventral glands open in the middle, or metacorpus, bulb or its homologous part. On the basis of this character the aphelenchs and tylenchs are fundamentally different, and it is this character that separates the two groups, not the mode of junction of oesophagus and intestine. This mode of junction, however, may well be used to separate genera and even subfamilies in the Tylenchidae and the Aphelenchidae, but proper descriptive terms should then be used.

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[1] The loss of a distinct terminal bulb together with an increase in size of oesophageal glands appears to represent an evolutionary process related to the mode of feeding and kind of food ingested by these forms, wherein digestion is becoming partly or wholly extra-oral and is creating a correlated transformation of the intestine into a storage organ with reduced lumen and vestigial rectum.

As mentioned above, Filipjev (1934) diagnosed his genus *Rotylenchus* as having an oesophagus without a clearly defined terminal bulb and with the oesophageal glands overlapping the intestine, but selected a type species (*Tylenchus robustus* de Man 1880) at variance with these very characters. He may have made this decision not on the basis of a study of the original description by de Man, but on the description by T. Goodey (1932) who figured what he thought was this species but which was a form without a terminal oesophageal bulb and with enlarged oesophageal gland cells protruding dorsally over the intestine. Since the generic name of *Rotylenchus* is now attached to *Tylenchus robustus* de Man 1880, a new generic name is to be created for the forms having a modified terminal oesophagus with no distinctly set off bulb and with enlarged, protruding oesophageal glands. The name *Helicotylcnchus* is proposed and a new generic diagnosis formulated below; the description of a new species is furnished which is made the type.

To emphasize the need for more careful future work, particularly in regard to a study of the shape and mode of oesophagus-intestine junction in the tylenchs and the aphelenchs, the following additional remarks are presented.

It is not sure that de Man's *Tylenchus robustus* of 1876 and those of 1880 are the same. A comparison of the figures of the 1876 with those of the 1884 paper reveals a difference not only in the annulation of the female tail end, but also in the shape and annulation of the head. Furthermore the 1876 paper does not mention the male, while that of 1884 shows a male with an extremely short tail and a costate bursa. If the forms of the 1876 and 1884 papers are identical, *Rotylenchus* as a genus might also be differentiated from *Helicotylenchus* by this costate bursa of the male.

It appears that the presence or absence of a bursal rib in these forms is correlated with the position of the phasmid in the female; if the phasmid is located on the tail, the male has a costate bursa, while a phasmid in the rectal or prerectal region of the female indicates a non-costate bursa in the male. Obviously the costa of the bursa in the males of these forms is the homologue of the phasmid. In this connection, it might be well to refer also to *Hoplolaimus* v. Daday where a similar situation exists. Here Filipjev considered the absence of a bursal rib in the male (he calls it ''lateral caudal papilla'') as the differentiating character between *Hoplolaimus* and *Rotylenchus*. In applying this principle also in the case of *Helicotylenchus* and *Rotylcnchus* both genera appear even more fundamentally separated.

It might be proper to present here a few remarks concerning the phasmids in these various genera mentioned. The tylenchs belong to the so-called Phasmidia in contrast to the Aphasmidia, both being the two large groups into which the nematode phylum is subdivided. The lateral caudal papilla in the female tylenchs, as stated above, is a phasmid, although sometimes modified, *e.g.*, in the hoplolaims, where it is transformed into a sclerotized, somewhat enlarged structure which may be called a scutellum or scutellate phasmid in contrast to the punctate phasmid. In the male tylenchs, with few exceptions, the phasmid is represented by the bursal rib; where such a bursal rib is missing, the phasmid of the female has been shifted forward to a preanal position; as exemplified by the hoplolaims, this forward movement was shared by the bursal rib of the male, *i.e.*, in this instance by the scutellum. This process unquestionably is of importance and involves a structure of fundamental significance in nematode morphology. We are therefore inclined to place weight on the modifications and translocations of this organ as observed in the genera here dealt with. Minuteness of this structure does not void its morphological and taxonomic significance. In the past investigators working in nematode morphology and taxonomy paid too little attention to these and other minute structures or considered them negligible. This mistake should be corrected to assure progress and

the solution of various pending problems of economic significance, *e.g.*, that of host specialization and strains, since for plant-parasitic nematodes differences in behavior, particularly in host specialization, are often noticed in forms that are not yet distinguishable on the basis of morphological characters. Thus practical needs demand a better knowledge of nematode morphology and taxonomy.

Referring again to *Tylenchus robustus* and the existing confusion of its status, there should also be mentioned the form described and illustrated by T. Goodey in 1940 under the synonym of *Anguillulina robusta* (de Man). This form has a true terminal oesophageal bulb which is well set off from the intestine and which encloses all three oesophageal glands, in contrast to the form presented by the same author in 1932. As far as the general form of the oesophagus is concerned, these 1940 specimens of Goodey are in accord with de Man's descriptions of 1876, 1880, and 1884, but Goodey remarks that the male of his form has no bursal rib and that it differed in this regard from the male figured by de Man in 1884. In our opinion Goodey's 1940 specimens represent a separate species, not only because of the forward-shifted phasmid (or bursal rib) but also because the tail of the male is of a very different shape, much longer than that of de Man's 1884 specimens. Furthermore, if the absence of a rib in the bursa of the male is to be considered a character of generic value (*e.g.*, in Filipjev's diagnosis of the genus *Hoplolaimus*), then *Tylenchus robustus* (= *Anguillulina robusta*) of Goodey 1940 represents not only a different species but even a different genus. A restudy of these forms should prove very helpful to alleviate the existing confusion.

Helicotylenchus,[1] n. g.

Diagnosis.—Tylenchinae with body usually kept in a spiral shape; cuticle of body and head annulated; on tail annulation following contour of terminus. Lateral fields broad, separated into three longitudinal strips which may or may not be aerolated. Phasmids small dot-like marks, in the adult always located at latitude of anus or in front of it, never on tail proper, usually shifted forward during larval development. Head high, cupolate, buccal stylet of adult 20 μ or longer, quite strong. Outlet of dorsal oesophageal gland ¼ to ½ length of buccal stylet behind latter. Junction of oesophagus and intestine indistinct, not marked by incision, oesophagus therefore without terminal bulb. All three, or at least dorsal oesophageal, glands enlarged, overlapping intestine on dorsal side. Females amphidelphic, both branches of sexual apparatus always on same side of intestine, either to the right or to the left. Males, where known, with a noncostate bursa. Exclusively plant-parasitic nematodes, living ectoparasitic on roots or other subterraneous parts of plants.

Type species.—*Helicotylenchus nannus*, n. g., n. sp.

Helicotylenchus nannus, n. g., n. sp.

Fig. 1

This is a species first observed in 1940 on roots of lima beans, in one of the greenhouses of the Plant Industry Station, U. S. Department of Agriculture, Beltsville, Maryland. Later it was found repeatedly on roots of a number of plants grown in the various greenhouses at this Station as well as outside plantings, and is now known to us to occur through all the Southeastern States. Only females have been observed.

Description.—Body forming a more or less open spiral, cylindrical, tapering cephalad of intestine and caudad from about middle of short tail. Cuticle plainly annulated; annules broad convex. Lateral fields about ⅓ as wide as body diameter;

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[1] ἕλιξ = spiral line.
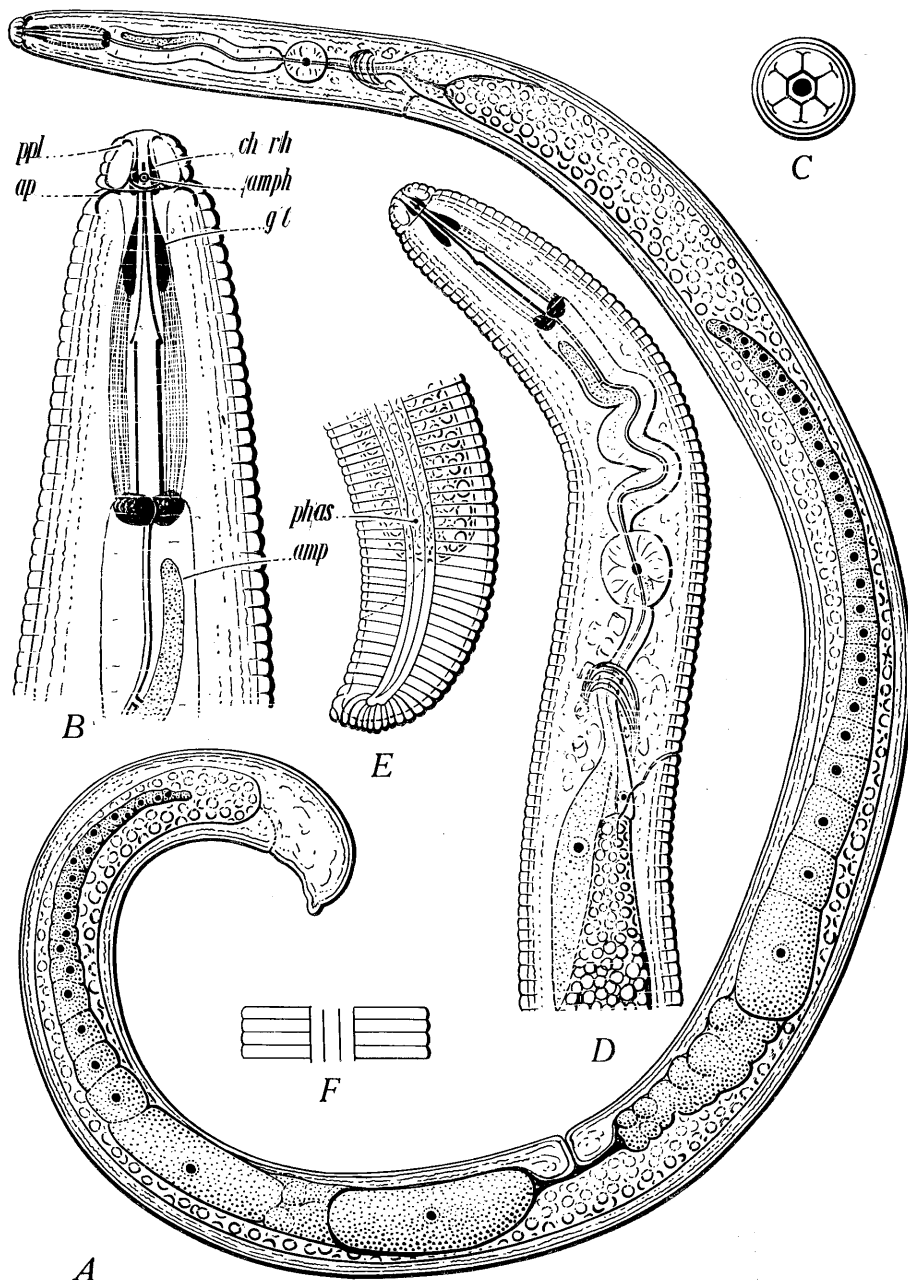
FIG. 1.   *Helicotylenchus nannus*, n. g., n. sp.   A—Female, × 500.   B—Head end; *amph*, amphid; *amp*, ampulla of dorsal oesophageal gland; *a p*, cuticularized apophysis; *ch rh*, cheilorhabdion; *g t*, guiding tube of buccal stylet; *ppl*, cephalic papilla; × 1800.   C—Front view of head; × 1800.   D—Anterior end; × 750.   E—Tail end; *phas*, phasmid; × 750.   F—Lateral field; × 750.

central strip only very slightly wider than edging ones; none of them aerolated; anteriorly the three strips beginning at height of outlet of dorsal oesophageal gland, posteriorly ending in front of tail end. Phasmid (adult ♀) in region of posterior end of intestine (Fig. 1, E). Cervical papillae not seen. Tail end ventrally with about 9 to 10 annules, dorsally with annulation following tail contour as shown in figure 1, E, but variable; terminus always somewhat knoblike. Head cupolate, narrower than body, comprising 5 annules; in front view (Fig. 1, C) exhibiting a subsurface cuticularized framework; cephalic papillae and amphids obscure, possibly arranged as shown in figure 1, B. Buccal stylet of adult 26 to 28 μ long, its basal knobs of somewhat angular contour. Vestibulum wall thickened, forming a cylindrical guiding case for stylet (Fig. 1, B) and an attachment support for protrudor muscles of latter.

Outlet of dorsal oesophagus gland about 13 μ, *i.e.*, about ½ length of buccal stylet behind the latter; a rather long extension of the gland ampulla dorsad in front of minute outlet. Procorpus about 70 μ long, distinctly contracted at its junction with spherical middle bulb of oesophagus. Middle bulb about 14 μ in diameter. Junction of oesophagus with intestine as drawn in figure 1, D, but details often difficult to see. Dorsal oesophageal gland enlarged and overlapping intestine. Intestine granulated, opaque, possibly consisting of only 14 cells. Rectum obscure, vestigial.

Branches of amphidelphic sexual apparatus of female quite long, the posterior one reaching to near the rectum; both branches to right side of intestine but left position also seen; ovaries having single series of oöcytes. Eggs cylindrical, measuring 18 by 56 μ when still in uterus.

Measurements.— ♀: 0.55–0.64 mm.; α = 22–25; β = 5.6–6.4; γ = 37–41; v = 63–65%.

Diagnosis.—*Helicotylenchus* of small size (0.55–0.64 mm.); lateral field about ⅓ body width, its strips of about equal width; phasmid in adult ♀ in region of posterior end of intestine; head with 5 annules; buccal stylet 26 to 28 μ long; outlet of dorsal oesophageal gland about ½ length of buccal stylet behind latter; vulva at 63 to 65%. Male unknown.

Type location.—Beltsville, Md.

Type host.—*Phaseolus lunatus* L. (lima bean).

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Summary of soil fumigant tests made against the golden nematode of potatoes
(*Heterodera rostochiensis* Wollenweber), 1942–1944. B. G. CHITWOOD and
EDNA M. BUHRER, U. S. Bureau of Plant Industry, Soils & Agricultural Engi-
neering, Hicksville, N. Y., and Beltsville, Md.

Since the discovery of an infestation of the golden nematode of potatoes
(*Heterodera rostochiensis* Wollenweber) in this country in 1941, we have been
attempting to control, or even eradicate, this pest by means of soil fumigants.
"Eradication" would denote complete elimination of the pathogenic organism—a
perfection which we constantly seek in disease control studies, but seldom attain.
Were it accomplished, the disease would never again occur in the same location,
barring new inoculations. Cost would be of minor importance in such a case.
"Control" would indicate reduction in the numbers of pathogens—the practical
solution of a problem. It is a realistic term which admits of imperfection. As
applied to agricultural problems, it requires a balance of its cost with the increase
in crop production resulting therefrom. The value of a crop therefore is a major
item for consideration. If a soil treatment will eliminate crop losses for only one
season, it must be quite inexpensive to be justifiable, but if it will eliminate crop
losses for several seasons it can be a much more expensive treatment. As will be
seen, our studies of necessity emphasized "control" of the disease.

The most promising results were obtained with mixtures of methyl bromide
(marketed under the trade names of Dowfume E, Dowfume P, and Dowfume G)
and with Larvacide (chloropicrin), carbon disulphide, and D–D:

Dowfume E: 90% ethylene dichloride, 10% methyl bromide

Dowfume P: 90% propylene dichloride, 10% methyl bromide

Dowfume G: 67.5% ethylene dichloride, 22.5% carbon tetrachloride, 10%
methyl bromide

Chloropicrin (CCl_3NO_2)

Carbon disulphide (CS_2)

D–D: 1,3-dichloropropylene and 1,2-dichloropropane

The following table is a summary of treatments, made between 1942 and 1944
by injecting the chemicals into the soil of experimental plots in the region of infes-
tation which in this country is localized on Long Island, N. Y., and growing indi-
cator potato plants thereafter. Included in the data of the table are such pertinent
figures as would enter into a calculation of the value of any chemical from the
grower's standpoint, as well as the estimation of efficacy of the chemical itself.
In arriving at the figures in the two columns under "Costs of production" there
were taken into consideration the following costs incurred prior to harvesting:
labor, land rent, seed, fertilizer, spray chemicals, and fumigants. It is important
that the two columns be compared with each other and be used for estimating the
value of the chemical treatments only. An effort has been made to concentrate all
necessary information into the table and to label it as completely as possible, rather
than comment extensively in the text. The life history of this nematode under
Long Island conditions is published elsewhere (Chitwood and Buhrer: The life
history of the golden nematode of potatoes, *Heterodera rostochiensis* Wollenweber,
under Long Island, N. Y., conditions. Phytopathology, *in press.*)

Dowfume E was only moderately effective in reducing *H. rostochiensis.* In
increasing potato yield, its expense was justified in only 2 instances as compared
with the controls.

Dowfume P gave 66 to 94 per cent reduction of *H. rostochiensis.* In only 1
instance was its expense counter-balanced by increased production of potatoes on
infested land.

Dowfume G gave 10 to 100 per cent reduction of the nematodes. Again, in
only 1 instance was it cheaper to produce potatoes on treated land than in the
controls.

TABLE 1.—*General summary of soil treatments, 1942–1944*

Chemical	Application rate	Treatment date	Soil temp. (at 6″) when treated	Potato variety grown[a]	Nematode reduction in treated plots	Potato yields		Costs of production	
						Total yield in control plots	Yield increase in treated plots	In control plots	In treated plots
	lbs. per acre		° F.		%	cwt. pcr acre	cwt. per acre	per cwt.	per cwt.
D–D	500[b]	10– 8–43	60	Gr. Mtn.	79	36	41	$4.15	$ 2.85
	863	11– 5–43	48	"	98	31	64	4.85	3.65
	863	11–13–43	43	"	87	33	88	4.55	2.40
	1726[b]	10– 8 43	60	"	97	36	28	4.15	6.70
	3452[b]	10– 8–43	60	"	99	36	7	4.15	16.50
Carbon disulphide	2000	5–16–42	60	Ir. Cob.	67	x	x	x	x
	2000	7–12–42	75	"	19	59	0	2.55	4.25
	2000	6– 5–42	65	"	76	x	x	x	x
	1000	10–31–42	52	Gr. Mtn.	68	67	33	2.25	2.00
	1000	11– 5–43	48	"	90	31	50	4.85	2.45
	1000	11–13–43	43	"	NP[c]	33	29	4.55	3.20
	1000	11–28–43	42	Ir. Cob.	NP[c]	89	14	1.70	1.90
Chloropicrin	2480	5–23–42	60	Ir. Cob.	95	x	x	x	x
	498	7–12–42	75	"	62	59	49	2.55	5.00
	496	11– 6–42	49	Gr. Mtn.	93	84	54	1.80	3.90
	248	10– 8–43	60	"	33	36	15	4.15	6.75
	498	10– 8–43	60	"	42	36	16	4.15	10.40
	496	11– 5–43	48	"	98	31	42	4.85	7.40
	496	11–13–43	43	"	89	33	31	4.55	8.45
Dowfume G	1000	6– 7–42	65	Ir. Cob.	10	x	x	x	x
	2000	6– 7–42	65	"	50	x	x	x	x
	2000	5–23–42	60	"	100	x	x	x	x
	1000	11– 6–42	49	Gr. Mtn.	77	84	45	1.80	2.40
	500	9–14–42	67	"	40	99	0	1.50	2.30
	1000	9–14–42	67	"	10	136	33	1.10	1.85
	1500	9–14–42	67	"	90	141	35	1.10	2.20
	2000	9–14–42	67	"	80	134	54	1.10	2.50
	1000	11– 5–43	48	"	20	31	41	4.85	4.30
	1000	11–13–43	43	"	NP[c]	33	33	4.55	4.70
Dowfume F	1000	6– 7–42	65	Ir. Cob.	66	x	x	x	x
	2000	6– 7–42	65	"	94	x	x	x	x
	1000	9–14–42	67	Gr. Mtn.	70	136	18	1.10	2.00
	1500	9–14–42	67	"	90	141	– 6	1.10	2.90
	2000	9–14–42	67	"	70	134	31	1.10	2.85
	1000	11– 5–43	48	"	87	31	33	4.85	5.00
	1000	11–13–43	43	"	NP[c]	33	40	4.55	4.11
Dowfume E	1000	6– 7–42	65	Ir. Cob	20	x	x	x	x
	2000	6– 7–42	65	"	24	x	x	x	x
	1000	11– 6–42	49	Gr. Mtn.	69	84	29	1.80	2.75
	500	9–14–42	67	"	20	99	34	1.50	1.75
	1000	9–14–42	67	"	40	136	29	1.10	1.90
	2000	9–14–42	67	"	70	134	31	1.10	2.85
	1000	11– 5–43	48	"	79	31	44	4.85	4.10
	1000	11–13–43	43	"	NP[c]	33	39	4.55	4.30

x indicates that data are not available.

[a] Abbreviations in this column are for varieties Irish Cobbler and Green Mountain.

[b] Injury to plants apparent. Dose too heavy at point of application; better spacing of chemical might minimize injury.

[c] None proven. Living plants at harvest in treated plots show proportionately more of the total nematode infection than do dead plants in controls, since there is less root to observe in the latter. Hence a treatment with a true efficacy of 60 to 70% may show no nematode reduction at harvest.

Chloropicrin gave 33 to 98 per cent reduction of nematodes, but the increased crop did not justify the expenditure for soil fumigant in a single instance.

Carbon disulphide gave 19 to 90 per cent reduction in *H. rostochiensis.* In 3 cases it produced sufficient increase to offset the expenditure.

D–D gave 79 to 99 per cent nematode reduction. In 3 out of 5 tests, potatoes were produced more economically in treated plots than in untreated plots.

We conclude that fumigation of land infested with the golden nematode is not economically justifiable from the standpoint of crop production, unless the benefits in nematode control can be shown to extend over a period of several years. This is true despite phenomenal crop increases on treated infested land, which commonly doubled and sometimes tripled the crop on untreated infested land.

Our tests brought out some generalizations which should be helpful in future work with the aforementioned chemicals:

1. D–D and carbon disulphide show the greatest promise when nematode reduction, crop increase, and cost of production are all compared.

2. Temperature during the 1 or 2 weeks immediately following soil treatment undoubtedly affects nematode kill. This is most pronounced when methyl bromide or carbon disulphide is used, less pronounced when chloropicrin or D–D is used. Better methods of treating may improve the results with any of the chemicals tested.

3. Spacing of the injections of the chemicals is very important. A heavy dose of D–D at the point of application, combined with wide spacing, caused injury to some plants the following spring; whereas a lighter dose at the point of application, combined with closer spacing (resulting in the same, or even greater, amount of chemical per acre) gave no injury and better nematode kill. We may be able to obtain greater nematode kill than any yet attained, with smaller quantities of D–D more closely distributed in the soil.

Tests on the susceptibility and resistance of several southern grasses to the root-knot nematode, *Heterodera marioni.* C. W. McBETH.[1]

Many of the common grasses have been reported infected with the root-knot nematode, *Heterodera marioni* (Cornu) Goodey. A critical review of forms reported to be resistant or tolerant has been prepared by Tyler (1941, U. S. Dept. Agr. Pub. 406). There are no reports on injury to any of the grasses by a root-knot-nematode infection although highly susceptible crops following certain grasses have been reported severely damaged, thus indicating that certain grasses may carry over or maintain a heavy root-knot population in the soil perhaps without evident injury to the grass. The Georgia Coastal Plain Experiment Station Report for 1936 states that tobacco following bullgrass, *Paspalum boscianum* Flügge, was a failure due to the root-knot nematode. In the same report crabgrass, *Digitaria sanguinalis* (L.) Scop., is said to be moderately susceptible and not effective in a rotation to control root knot. Bermuda grass, *Cynodon dactylon* (L.) Pers., has been reported anywhere from immune to quite susceptible.

All of the legumes grown in this section of Georgia in association with grasses in permanent pastures are susceptible to root knot. The majority of these legumes are annuals and produce most of their growth in a relatively short period, usually during the winter or spring. Since grasses are the principal pasture constituents during the summer months when the root-knot nematode is most active, it is

reasonable to assume that if the grass is immune and no susceptible weeds are present, the root-knot-nematode population would be kept down so that legumes could be grown without injury. It also appears possible that a root-knot-immune grass might be successfully worked into rotation with root-knot-susceptible crops such as tobacco and cotton. It therefore seemed advisable to test the susceptibility of certain grasses in the Georgia Coastal Plain area to determine their value in any such agricultural scheme as might be practiced here. The grasses selected for this test are either commonly grown in the area or are being experimentally tested for adaptability here.

PROCEDURE

Three tests were made to determine this root-knot susceptibility. The first was conducted in the field in naturally infested soil. To insure a thorough in-
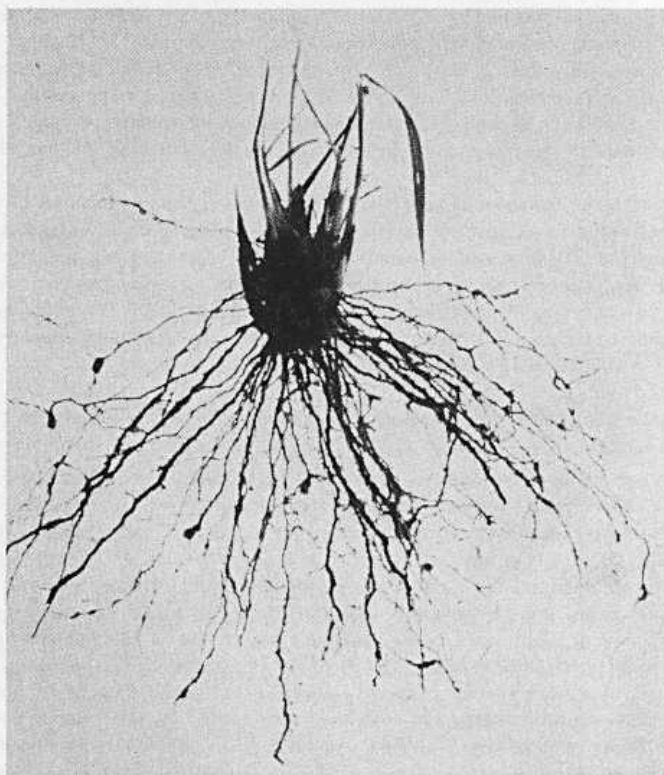

FIG. 1. Root-knot nematode galling on roots of *Paspalum malacophyllum*.

festation, cowpea roots heavily infected with root knot were added to the soil. The following 7 grasses were then planted: common Bahia grass, *Paspalum notatum* Flügge; Paraguay strain of Bahia grass, *P. malacophyllum* Trin.; Vasey grass, *P. urvillei* Steud.; Dallis grass, *P. dilatatum* Poir.; Carpet grass, *Axonopus affinis* Chase; and Woolly fingergrass, *Digitaria eriantha* var. *stolonifera* Stapf. Root samples of these grasses were taken several times during the summer and dissected fresh under the low power of a binocular microscope, for determination of root-knot infection. In this and the following two tests plants were not considered susceptible unless egg-producing *Heterodera marioni* females were found in their roots.

The second test was made in glazed pots in the greenhouse. Tobacco roots, heavily infected with root knot, were mixed in the soil as inoculum. In addition to the 7 grasses tested in experiment 1, common Bermuda grass, *Cynodon dactylon*, was added. Root samples were examined by staining in lactophenol-acid-fuchsin stain. The staining method of examination is much more dependable than the fresh-root examination, since larger samples can be examined in much less time and a light infection is much more easily detected, especially where few or no root swellings are present.

TABLE 1.—*Results of tests for root-knot-nematode susceptibility of eighteen southern grasses*

Grasses tested	Test No. 1			Test No. 2			Test No. 3			Appearance of infection on roots
	Larvae only	Egg masses	Not infected	Larvae only	Egg masses	Not infected	Larvae only	Egg masses	Not infected	
Dallis grass	...	...	x	...	x	...	x	...	...	Slight swelling
Vasey grass	...	x	...	...	x	...	x	...	...	" "
Pensacola Bahia grass	...	...	...	...	...	...	...	x	...	" "
Common Bahia grass	...	...	x	...	x	...	x	...	...	" "
Paraguay Bahia grass	...	...	x	...	x	...	x	...	...	" "
Carpet grass	...	x	...	...	x	...	...	x	...	Small knots
Common Bermuda grass	...	...	...	...	x	...	...	x	...	Well knotted
Bermuda P.I. #105933	...	...	...	...	...	...	...	x	...	Small knots
Coastal Bermuda grass	...	...	...	...	...	...	...	...	x	
Woolly fingergrass	...	...	x	...	...	x	...	x	...	No swelling
Paspalum malacophyllum	...	...	x	...	x	...	...	x	...	Well knotted
Oats	...	...	...	...	...	...	...	x	...	Small knots
Common pearl millet	...	...	...	...	...	...	...	...	x	
Pearl millet selection 48–A3	...	...	...	...	...	...	...	x	...	Small knots
Tift Sudan grass	...	...	...	...	...	...	...	x	...	Well knotted
Common Sudan grass	...	...	...	...	...	...	...	x	...	" "
Corn	...	...	...	...	...	...	...	x	...	" "
Rhodes grass	...	...	...	...	...	...	...	x	...	" "

The third test was made in the greenhouse in a bed where *Paspalum malacophyllum*, heavily infected with root knot, had been growing (Fig. 1). To insure a thorough infestation, the *P. malacophyllum* roots were chopped up and worked into the soil. In addition to the 8 grasses listed above, the following were included in the test: Oats, *Avena sativa* L.; common pearl millet, *Pennisetum glaucum* (L.) R. Br.; Selection 48–A3 of pearl millet; common Sudan grass, *Sorghum vulgare* var. *sudanense* (Piper) Hitchc.; Tift strain of Sudan grass; Pensacola strain of Bahia grass; corn (maize), *Zea mays* L.; Coastal strain of Bermuda grass; P.I. #105933 of Bermuda grass; and Rhodes grass, *Chloris gayana* Kunth. Root samples were examined by staining with lactophenol-acid-fuchsin stain.

RESULTS

The results of the three host tests are given in the following table. The reason that certain grasses were found infected in one test and not in the others may be explained in two ways: Either the grass is so highly resistant that the chances of locating an infection are very small, or some grasses are susceptible to certain races of the root-knot nematode and resistant or immune to others. Staining the roots reduces the danger of missing an infection in highly resistant plants.

Of the 18 grasses examined, all but 2 were found to be infected. Coastal Bermuda grass and common pearl millet failed to show any signs of infection in their single test (#3), in spite of the heavily infested soil in which they were grown.

It is interesting to note that the degree of root-knot susceptibility varies with the strains of certain grass species. For instance, Coastal Bermuda grass proved to be entirely immune in this test, while common and Strain P.I. #105933 of Bermuda grass were quite heavily infected. The same appears to be true in the millet strains: common pearl millet was immune while selection 48–A3 was quite susceptible.

Of the infected grasses tested, the Bahia grasses and Wooly fingergrass appear to be the most highly resistant species. The common and Paraguay strains of Bahia grass appear to be more resistant than the Pensacola strain—a comparison open to some question, however, since the latter was included in only 1 test and the two former in all 3 tests.

In the first 2 tests Woolly fingergrass was not found infected but egg-producing females were found in the third test. As there is considerable variation in seedlings of this grass it may be possible that certain selections are immune to root knot while others are susceptible.

Corn, Carpet grass, common Bermuda grass, *Paspalum malacophyllum*, and the Sudan grasses were most heavily infected. Oats were rather lightly infected and showed very small swellings.

SUMMARY

Eighteen grasses, either commonly grown in, or being experimentally tested for adaptability to, the Coastal Plain Area of Georgia, were tested for resistance to the root-knot nematode. Woolly fingergrass and both common and Paraguay Bahia grass (included in all 3 tests), and Pensacola Bahia grass (included in 1 test), appeared to be highly resistant. Sudan grass, common Bermuda grass, Carpet grass, and corn were most heavily infected. Coastal Bermuda grass and common pearl millet (both of which were included in only 1 test) proved to be entirely free of infection; on the other hand, common Bermuda grass (included in 2 tests) and Pearl millet selection 48–A3 (included in 1 test) were infected, indicating a difference in the resistance of certain strains of grasses to the root-knot nematode.

A review of the genus *Crenosoma* Molin, 1861 (Nematoda: Trichostrongylidae);
    its history, taxonomy, adult morphology, and distribution.[1] ELLSWORTH C.
    DOUGHERTY, Department of Zoölogy, University of California, Berkeley, California.

INTRODUCTION

Specimens which I refer to four species of the genus *Crenosoma* Molin, 1861, have been available to me and form the basis of the present study. Although

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[1] To Dr. Frans C. Goble, Winthrope Chemical Co., Rensselaer, New York, I wish to express sincere appreciation for unfailing assistance and critical appraisal during the course of this work.

Crenosoma has been reviewed as recently as 1939 by Morozov and again in 1941 by Wallace, a comparative study based on actual specimens has not appeared since the work of Skriabin and Petrov (1928), who described and figured the three then known species—*C. vulpis* (Dujardin, 1844) Railliet, 1915, *C. striatum* (Zeder, 1800) Molin, 1861, and *C. taiga* Skriabin and Petrov, 1928. I have been able to study specimens of one of these—*C. vulpis*—and of three others, not known at the time at which Skriabin and Petrov's paper appeared—*C. mephitidis* Hobmaier, 1941 (syn. *C. zederi* Goble, 1942), *C. microbursa* Wallace, 1941, and a form recorded as *Crenosoma* sp. by Goble and Cook (1942) from the Eastern raccoon (*Procyon l. lotor*).[2] The last of these is herein described as a new species, *Crenosoma goblei*, sp. nov., on the basis of specimens from both the California and Eastern raccoon and is named for Dr. Franse Goble.

The four species studied represent all that are known positively to occur in North America. *Crenosoma potos* Buckley, 1930, was described by Buckley (1930) from the kinkajou (*Potos flavus* subsp.?), which occurs in South and Central America; the kinkajou from which type and only known specimens of *C. potos* were taken, however, died at the London Zoölogical Gardens, and Buckley did not give its origin. Probably *C. potos* is to be found in North (*i.e.*, Central) America, although such occurrence has not yet been demonstrated. It has not been possible for me to study specimens of the species peculiar to Eurasia—*C. striatum, C. taiga, C. skrjabini* Pologentsev, 1935, and *C. petrovi* Morozov, 1939.

In the present paper is given a modern account of the history, taxonomy, adult morphology, and distribution of *Crenosoma* and its species. It is not my aim to cover here knowledge on other aspects of its biology, such as embryology and larval development, pathogenesis of crenosomatosis, etc.

I. HISTORICAL SUMMARY

The first form now referred to *Crenosoma* of which there is a record was noted by Redi (1684, p. 22), who observed in the bronchi of the common hedgehog (*Erinaceus e. europaeus*) nematodes which are regarded to-day to have belonged to *C. striatum*. Over one hundred years later this species was designated by Zeder (1800, p. 74) as *Strongylus striatus*. The fox crenosome, *C. vulpis*, was first described as *Liorhynchus vulpis* by Dujardin (1844, p. 283) from imperfect specimens and subsequently appeared under various names—*Strongylus decoratus* of Creplin (1847, p. 289), *S. annulatus* of von Siebold (1848, p. 114), *Crenosoma semiarmatum* of Molin (1861, p. 442), etc.

Van Beneden (1858) in establishing the genus *Filaroides* based his descriptions on lungworms which he identified as *Filaria mustelarum pulmonalis* Rudolphi, 1819. It has been generally overlooked, however, that actually he dealt with a mixture of two different species; some of his specimens obviously belonged to a species of the genus *Crenosoma*, whereas others belonged to Rudolphi's species (1819, p. 216). The specimens belonging to *Crenosoma* had the annulated appearance typical of the genus; these were figured by van Beneden (1858, pl. XXIII, figs. 1, 2, and 6) and regarded as "immature." They were recovered from a location free in the lung parenchyma and were all females. The specimens belonging to Rudolphi's species were found in cysts and were considered "adults"; they

included only fragments—of which a rolled up anterior end (pl. XXIII, fig. 3) and a male posterior end (fig. 5) were figured. These two different forms were united by van Beneden under the name of *Filaroides mustelarum* (= *F. martis* (Werner, 1782) Dougherty, 1943). So completely did he combine the characters of the two species with which he dealt that the genus *Filaroides* as defined by him applied in part to what is now regarded as *Filaroides* and in part to what is now understood to be *Crenosoma*. Beginning with Weyenbergh (1868) *Filaroides* was for almost sixty years used primarily for organisms now placed in the genus *Skrjabingylus* Petrov, 1927. Weyenbergh quite understandably based on van Beneden's description his identification as *Filaroides mustelarum* of a species now recognized to have been *Skrjabingylus nasicola* (Leuckart, 1842) Petrov, 1927; it can be seen that the part of van Beneden's account applying to a species of *Crenosoma* could easily lead to confusion with *S. nasicola*, which is also an annulated form. Railliet (1915), however, apparently recognized that the characters of *Crenosoma* at least were included by van Beneden in the original diagnosis of *Filaroides*, for in forming the combination of the specific name *vulpis* with *Crenosoma* he rendered the species which now should be designated *Crenosoma vulpis* (Dujardin, 1844) Railliet, 1915, as *Crenosoma* (? *Filaroides*) *vulpis*. However, the question mark beside *Filaroides* in this designation renders impossible, I believe, the interpretation that Railliet thereby made *Crenosoma* Molin, 1861, a synonym of *Filaroides* v. Beneden, 1858. Yorke and Maplestone (1926) reproduced certain of van Beneden's drawings to illustrate their diagnosis of the genus *Filaroides*, namely an anterior and a posterior end (fig. 300 A, B), referable to *Crenosoma*, and the posterior end of the male (fig. 300 C) belonging to *Filaroides*. Petrov (1927) was the first worker actually to restrict *Filaroides* to one of the two species originally involved. He apparently did not recognize the fact that a species of *Crenosoma* had been included in van Beneden's description and established a generic diagnosis based on the lungworm now known as *Filaroides martis*, but called by him *F. bronchialis* (syn. *F. mustelarum* (Rudolphi, 1819) v. Beneden, 1858). In my opinion Petrov thus fixed the type of the genus *Filaroides* v. Beneden, 1858, and permanently excluded species of *Crenosoma* from consideration as members of the former genus.

The species of *Crenosoma* originally included in *F. mustelarum* (= *F. martis*) by van Beneden cannot be identified with certainty. His specimens were recovered from the polecat (*Mustela p. putorius*). Three species have been described from European mustelids—*C. taiga* by Skriabin and Petrov (1928), *C. mustelae* by Galli-Valerio (1930), and *C. petrovi* by Morozov (1939), and a fourth, *C. vulpis*, although generally found in the Canidae, has also been reported by Petrov (1940) from Mustelidae. Of the first three *C. petrovi* has been reported only from the Russian pine marten (*Martes martes ruthena*). *C. taiga* has been recorded both in the kolinsky (*Mustela sibirica* subsp.?) by Skriabin and Petrov (1928) and in the polecat by Petrov (1940). *C. mustelae* was described from the polecat by Galli-Valerio (1930) mainly on the basis of egg measurements. Böhm and Gebauer (1934) in a review of the family Metastrongylidae and Wallace (1941) have rejected this species as inadequately described and hence invalid. I cannot entirely concur with this view, for it may be possible by a suitable interpretation of Galli-Valerio's data to recognize his species when more adequate material comes to hand. He pointed out that the egg measurements of his form (83.5×6 [sic] μ) differed from those of *C. taiga* as given by Skriabin and Petrov (max. $68 \times 36 \mu$). Obviously the egg width (6μ) was a typographical error for some larger dimension; but admittedly it is true that 83.5μ would designate a longer egg than any indicated to date for the species of *Crenosoma*—except *C. potos*. There is no evidence, however, that enough measurements have been made for the various species of *Crenosoma* to indicate that those of Galli-Valerio have any special significance. It would not in fact

seem impossible that *C. mustelae* is a synonym of *C. taiga* and also that van Beneden's specimens belonged to the same species as Galli-Valerio's, *i.e.*, to *C. taiga*.

The genus *Crenosoma* was established by Molin (1861) at a time when strongyline nemas with reduced stomata were almost all placed in the genus *Strongylus* Müller, 1780; and it was not for 35 years or more that Molin's genus began to be generally accepted—first with Stossich (1896). Skriabin (1916) reviewed the genus, but his paper is not available in the United States, and I have not therefore seen it. With the work of Skriabin and Petrov (1928) three species were definitely established—one of these, *C. taiga*, new at the time.

Since 1928 five additional, apparently valid species have been described: *C. potos* of Buckley (1930), *C. skrjabini* of Pologentsev (1935), *C. petrovi* of Morozov (1939), *C. mephitidis* of Hobmaier (1941a), and *C. microbursa* of Wallace (1941). Study of specimens of the recently described *C. zederi* of Goble (1942) has convinced me that this species is a synonym of *C. mephitidis*. The present paper adds a ninth apparently valid species—*Crenosoma goblei*, sp. nov.—to the genus.

Wetzel and Müller (1935) were the first to demonstrate that the larval stage of a species of *Crenosoma*—namely *C. vulpis*—employed gasteropod molluscs as intermediate hosts. Hobmaier (1941a) and Petrov (1941) have showed the same to be true for several other species of the genus. Further work by Wetzel (1940) has refined our knowledge of the larval development of *Crenosoma vulpis*.

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II. CRENOSOMA MOLIN, 1861, AND ITS SPECIES

Phylum NEMATODA

Class PHASMIDEA

Order RHABDITIDA   Suborder STRONGYLINA

Family TRICHOSTRONGYLIDAE Leiper, 1912

Subfamily SKRJABINGYLINAE Skriabin, 1933

Genus *Crenosoma* Molin, 1861

Crenosoma vulpis (Dujardin, 1844) Railliet, 1915

Figs. 1, A, and 2, C

</div>

Synonymy.—*Liorhynchus vulpis* Dujardin, 1844; *Strongylus decoratus* Creplin, 1847; *Strongylus annulatus* v. Siebold, 1848; *Crenosoma semiarmatum* Molin, 1861; *Strongylus lupi* Molin, 1861 (*nec* Rudolphi, 1809); *Strongylus Canis Vulpis*, of Catalogue of the Vienna Museum, in Molin, 1861; *Crenosoma decoratum* (Creplin, 1847) Stossich, 1898; *Crenosoma* (*?Filaroides*) *vulpis*, of Railliet, 1915; *?Crenosomum* sp., of Railliet, 1899.

Hosts.—Common Western European fox, *Vulpes vulpes crucigera* (Bechstein) (type host); *V. vulpes* subspp.? [U.S.S.R.]; common red fox, *Vulpes f. fulva* (Desmarest); common gray fox, *Urocyon c. cinereoargenteus* (Schreber); common arctic fox, *Alopex l. lagopus* (Linné); domestic dog, *Canis familiaris* Linné; common wolf, *Canis l. lupus* Linné; Ussurian raccoon dog, *Nyctereutes procyonoides ussuriensis* Matschie; ?common European badger, *Meles m. meles* (Linné); *M. meles* subsp.? [U.S.S.R.]; common wolverine, *Gulo g. gulo* (Linné).

Location.—Bronchi.

Geographical distribution.—Eurasia (type locality: ?France); eastern United States and Canada.

Discussion.—*C. vulpis* is the best known of the crenosomes; yet doubtless much is to be learned of its distribution and general biology.

Dujardin's description (1844) was based on female worms found in an old flask in the Muséum d'Histoire naturelle, Paris; he referred them to the genus *Liorhynchus* Rudolphi, 1801, which is probably to be regarded as a *nomen nudum*

since its type is an apparently unrecognizable species, *L. truncatus* (Rudolphi, 1793) Rudolphi, 1801. The names given by Creplin (1847) and von Siebold (1848)— *Strongylus decoratus* and *S. annulatus*, respectively—were accompanied by reference to the location of the parasite in the host, but by practically no description. Molin (1861) gave the first good description of the species on the basis of specimens in the Vienna Museum—under the name of *Crenosoma semiarmatum*—and
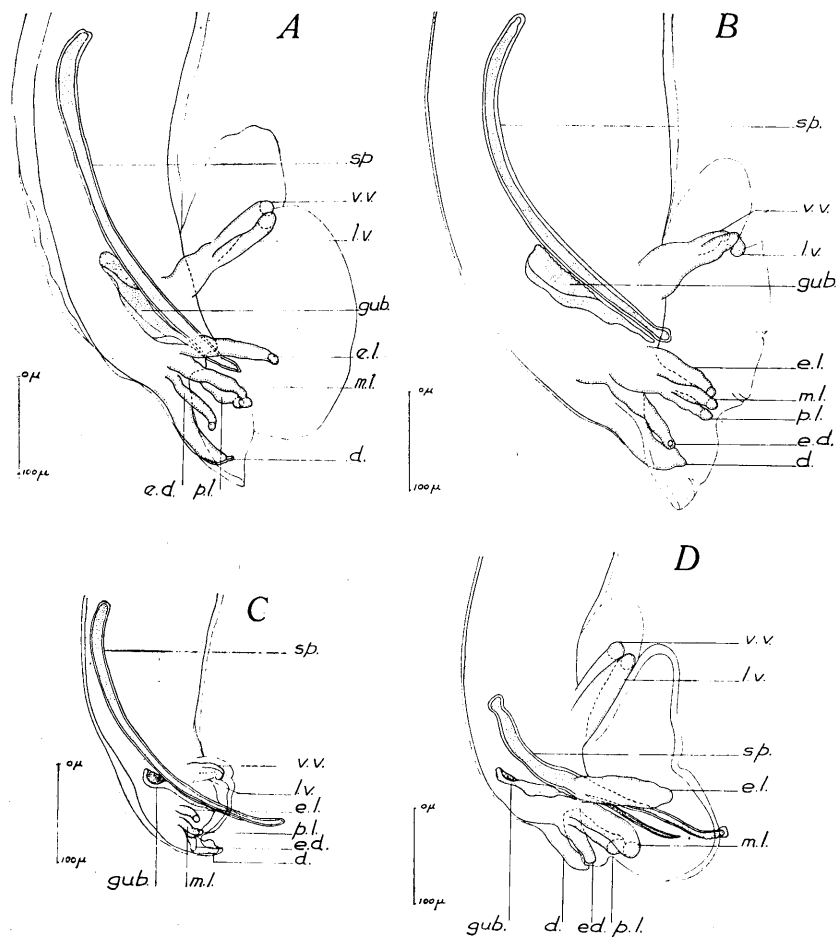

Fig. 1. A—*Crenosoma vulpis;* lateral view of male posterior end. B—*C. mephitidis;* lateral view of male posterior end. C—*C. microbursa;* lateral view of male posterior end. D—*C. goblei*, sp. nov.; lateral view of male posterior end. *d.*, dorsal ray; *e. d.*, externodorsal ray; *e. l.*, externolateral ray; *gub.*, gubernaculum; *l. v.*, lateroventral ray; *m. l.*, mediolateral ray; *p. l.*, posterolateral ray; *sp.*, spicule; *v. v.*, ventroventral ray.

referred to *Liorhynchus vulpis* and *Strongylus decoratus* as synonyms thereof. He did not recognize, however, that *Strongylus annulatus* v. Siebold, 1848, was the same species and accordingly renamed it *Strongylus lupi*, despite the earlier *Strongylus lupi* of Rudolphi (1809) (= *Spirocerca lupi* (Rudolphi, 1809) Chitwood, 1932). Stossich (1896) crudely figured the anterior end and female posterior end of *C. vulpis* under the name *Crenosoma semiarmatum*. Mueller (1897), however,

supplied the first good figures. These were accurate except that he represented the dorsal ray as doubled. This error could never have occurred if he had seen the bursa in a full ventral view; and it is to be assumed that he did not, despite the figure showing this position, which was probably reconstructed from his study of a laterally oriented specimen. Stossich (1898) adopted the name *Crenosoma decoratum* for the fox crenosome and was followed by Yorke and Maplestone (1926). However, Railliet (1915) used the name *Crenosoma vulpis*, and Baylis (1926) and apparently Skriabin (1916) proved that this was correct. Most authors have subsequently followed this name. Skriabin and Petrov (1928) gave further figures, as also did Sprehn (1932), who extensively and well illustrated the species (Abb. 81, 103, 104, 747–750) both with line drawings and photomicrographs.

Although the fox crenosome has been placed in the genus *Strongylus*—as by Creplin (1847), von Siebold (1848), and others—the specific name *vulpis* of Dujardin (1844) has never been combined with *Strongylus*. *Strongylus Canis Vulpis* of Molin (1861), although applied to the fox crenosome, is not available nomenclatorially as it is polynomial and can therefore have no effect on the status of *vulpis* of Dujardin, despite the existence of an earlier *Strongylus vulpis* (v. Frölich, 1789) Zeder, 1800 (= *Uncinaria criniformis* (Goeze, 1782) Railliet, 1899). On the basis of priority therefore, the correct name of the fox crenosome is *Crenosoma vulpis* (Dujardin, 1844) Railliet, 1915.

Railliet (1899) reported a nematode from the lungs of the common European badger (*Meles m. meles*) which he designated *Crenosomum* [sic] sp., but did not describe. In view of the recent report by Petrov (1940) of *C. vulpis* in a badger presumably from the Soviet Union (*Meles meles* subsp.?) it is possible that Railliet observed the latter species.

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Crcnosoma mephitidis Hobmaier, 1941

Figs. 1, B; 2, B; and 3, A & D

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Synonymy.—*Crenosoma mephitidis* Hobmaier, 1940, *nomen nudum; Crenosoma zederi* Goble, 1942.

Hosts.—Western striped skunk, *Mephitis mephitis occidentalis* Baird, and California spotted skunk, *Spilogale gracilis phenax* Merriam (syntype hosts); eastern striped skunk, *Mephitis mephitis nigra* (Peale and Beauvois); commercially bred variety of red (= silver) fox, *Vulpes fulva* (Desmarest) (experimental host); domestic dog, *Canis familiaris* Linné (experimental host).

Location.—Bronchi.

Geographical distribution.—California (type locality: San Francisco County); New York.

Discussion.—This species was first mentioned by Hobmaier (1940), who called it *Crenosoma mephitidis*, but gave no description for it. The following year he (Hobmaier, 1941a) provided a complete description and figures. *Crenosoma mephitidis* must therefore date from 1941 and in its earlier usage be regarded as a *nomen nudum*. Goble (1942) later described from a New York skunk a new species, *Crenosoma zederi*. I have been fortunate in receiving California specimens identified as *C. mephitidis* from Dr. Hobmaier and New York specimens identified as *C. zederi* from Dr. Goble. Careful examination leads me to the conclusion that there is no consistent difference between the two groups of specimens and that they represent a single species. The most important distinguishing criterion given by Goble for *C. zederi* was that the annular folds, which characterize the genus *Crenosoma*, were present throughout the length of the body in the male. Hobmaier recorded these as restricted to the anterior end in *C. mephitidis*. However, Goble has distinguished the fainter folds of the posterior part of the body in his ''*C. zederi*,'' whereas Hobmaier, whose specimens illustrate this same condition, has

recognized only the strongly marked anterior folds in his *"C. mephitidis."* Furthermore there are no significant differences in the measurements of parts in either group of specimens.

The correct name for the species described by Hobmaier and by Goble is therefore *Crenosoma mephitidis* Hobmaier, 1941—*C. zederi* Goble, 1942, falling as a synonym thereof.

C. mephitidis is morphologically very close to *C. vulpis*. The male is, however, distinguishable by its thicker rays, especially the dorsal, and by the fact that its lateral rays on each side are united at their base into one stock, whereas the externo-lateral of *C. vulpis* arises independently of the medio- and posterolateral. The latter difference is quite apparent in figures 1, A (*C. vulpis*) and 1, B (*C. mephitidis*).

Crenosoma microbursa Wallace, 1941

Fig. 1, C

Host.—Hudsonian striped skunk, *Mephitis mephitis hudsonica* Richardson (type host).

Location.—Bronchi.

Geographical distribution.—Minnesota (type locality: Itasca State Park).

Discussion.—This species is remarkable in the very small size of the bursa, as figure 1, C, well illustrates. The fact that both *C. microbursa* and *C. mephitidis* occur in a single host species, *i.e.*, *Mephitis mephitis* (Schreber), might suggest that they are variants of a single nematode species; however, their morphological differences appear greater than those between *C. mephitidis* and *C. vulpis*. I have examined some of the type material, representing both sexes, which Wallace (1941) used in describing *C. microbursa*.

Crenosoma petrovi Morozov, 1939

Synonymy.—*Crenosoma petrowi* Morozov, 1939 (*err. pro C. petrovi*).

Host.—Russian pine marten, *Martes martes ruthena* Ognev (type host).

Location.—"Lungs."

Geographical distribution.—U.S.S.R. (type locality: Gorki region).

Discussion.—In its general appearance, as judged by Morozov's figure, *C. petrovi* is like a very small *C. vulpis*. However, all its measurements fall below those recorded by others or observed by me for the latter species. *C. petrovi* was apparently described by Morozov (1939) on the basis of a single male specimen.

Crenosoma potos Buckley, 1930

Host.—Kinkajou, *Potos flavus* (Schreber) (?subsp.) (type host).

Location.—Bronchi.

Geographical distribution.—Unknown in wild state—host died in London Zoölogical Garden.

Discussion.—*C. potos* has been carefully and completely described by Buckley (1930). Although he expressed the possibility that this species might be different enough to justify erection of a separate genus, I believe, with a perspective over nine instead of four species of the genus, that it is quite characteristic of *Crenosoma*.

Crenosoma skrjabini Pologentsev, 1935

Host.—Common shrew, *Sorex araneus araneus* Linné.

Location.—"Lungs."

Geographical distribution.—U.S.S.R. (type locality: Middle Volga region).

Discussion.—This highly distinctive species vies with *C. petrovi* as the smallest of the genus and has by far the smallest spicules. It was described by Pologentsev (1935) on the basis of one male and three incomplete females.

Crenosoma striatum (Zeder, 1800) Molin, 1861

Synonymy.—*Strongylus striatus* Zeder, 1800; *Filaria erinacei* Rudolphi, 1819; *Strongylus erinacei* (Rudolphi, 1819) Diesing, 1851.

Hosts.—Common hedgehog, *Erinaceus e. europaeus* Linné (type host); central Russian hedgehog, *E. e. centralrossicus* Ognev.

Location.—Bronchi.

Geographical distribution.—Europe (type locality: ?Germany).

Discussion.—*Crenosoma striatum*, oldest known species of *Crenosoma*, was first observed by Redi (1684). It was named *Strongylus striatus* by Zeder (1800), but was not figured until the work of Molin (1861), who transferred it to his new genus *Crenosoma*. Eberth (1863) illustrated various parts of the anatomy of *C. striatum*. More recently Skriabin and Petrov (1928) have figured it and given it a modern diagnosis.

Rudolphi (1819) recorded specimens from the Vienna Museum (now Naturhistorisches Museum), which he called *Filaria erinacei*, but which he had not seen himself. Diesing (1851), who worked on the same collections, transferred this species to *Strongylus* and remarked that it resembled *Strongylus commutatus* Diesing, 1851 (= *Protostrongylus pulmonalis* (v. Frölich, 1803) Goble and Dougherty, 1943). Stossich (1898) placed *Strongylus erinacei* in the synonymy of *Crenosoma striatum*, where it apparently belongs.

Crenosoma taiga Skriabin and Petrov, 1928

Synonymy.—?*Filaroides mustelarum*, of van Beneden, 1858 (*partim*); ?*Crenosoma mustelae* Galli-Valerio, 1930.

Hosts.—Kolinsky, *Mustela sibirica* Pallas (?subsp.) (type host); polecat, *M. p. putorius* (Linné).

Geographical distribution.—U.S.S.R. (type locality: Siberia); ?Europe.

Discussion.—Relatively little is known of this species. Aside from its description by Skriabin and Petrov (1928) the only other records are by Petrov, who has recorded it from the kolinsky (1928) and the polecat (1940). These last-mentioned hosts died in the Moscow Zoölogical Garden. As previously noted in the historical summary, certain specimens from the polecat considered to be *Filaroides mustelarum* (= *F. martis*) by van Beneden (1858) and others named *Crenosoma mustelae* by Galli-Valerio (1930) may represent *C. taiga* occurring in European hosts.

Crenosoma goblei, sp. nov.

Figs. 1, D; 2, A; and 3, B & C

Synonymy.—*Crenosoma* sp., of Goble and Cook, 1942.

Diagnosis.—Male: 3.6 to 5.9 mm. long, 240 μ in maximum width; cuticular folds found in about the anterior 2 mm. of body; parallel longitudinal ridges over entire surface of cuticle; oesophagus, 240 to 280 μ long; excretory pore opening, 120 μ from anterior end; bursa with voluminous lateral lobes, but strongly reduced dorsal lobe; rays stout, progressively shorter from externolateral posteriorly; externolateral longest and stoutest, ventrals next; dorsal shortest or at least no longer than externodorsal; all rays separate almost to their bases; spicules equal, lying closely together, 270 to 320 μ in length and provided each with a strongly sclerotized dorsal appendix about 80 μ long; end of spicule serrated dorsally and tipped with a small, weakly sclerotized cuticular cap; gubernaculum, 80 μ long, roughly divisible into 3 sections: a short, anterior part, shaped like the bowl of a spoon, a longer, slightly thicker midportion, and a short, slender posterior end.

Female: 6.2 to 10.4 mm. long, 480 μ in maximum width; cuticular folds most obvious in anterior 4.5 to 5 mm., but more weakly present in posterior half of body;

oesophagus, 300 to 330 μ long; vulva slightly preëquatorial in position and provided with a moderately large, local swelling of body cuticle, up to 150 μ in thickness; anus about 150 to 160 μ from posterior end; female posterior end morphologically like those in other species of *Crenosoma*.

Larva: 320 μ long.

Hosts.—California raccoon, *Procyon lotor psora* Gray (type host); Eastern raccoon, *Procyon l. lotor* (Linné).

Location.—Bronchi.

Geographical distribution.—California (type locality: Calaveras Dam, Alameda County); New York.

Type specimens.—Type male,[3] U. S. Nat. Mus. Helm. Coll. No. 36909; paratype male, U. S. Nat. Mus. Helm. Coll. No. 36910.

Discussion.—The male of *Crenosoma goblei* differs from those of other species, with the exception of *C. taiga* and *C. striatum*, in having a strongly developed, pigmented dorsal appendage on each spicule. The bursal rays in *C. striatum* are short, stubby, and subequal, whereas those in *C. goblei* are relatively longer and stouter and are of markedly different lengths. The resemblance of *C. goblei* to *C. taiga* is very close. The former differs from the latter, however, in the form of the bursa, which is foreshortened posteriorly, extending only as far as the ends of the dorsal and externodorsal rays, and flares out laterally in *C. goblei*, but which is full and extends well posteriorly to the posteriormost rays in *C. taiga*. The dorsal ray in *C. goblei* is either the shortest or at most no longer than either externodorsal ray, whereas in *C. taiga* it is longer than the other rays except for the ventro- and lateroventral rays. The externolateral ray is sturdy and digitiform in *C. goblei*, but it is somewhat bizarre in shape, being roughly triagular in outline and constricted at the base in *C. taiga*. These two species appear to be twin forms, bearing the same kind of relationship to one another as that between *C. vulpis* and *C. mephitidis*.

Genus *Crenosoma* Molin, 1861

Synonymy.—*Strongylus* Müller, 1780 (*partim*); *Filaroides* v. Beneden, 1858 (*partim*).

Diagnosis.—Skrjabingylinae: small, moderately thin worms; cuticle thrown into folds completely encircling body at least in anterior of both sexes, with posterior edge of one fold overlapping anterior edge of next posterior; bursa of male well developed with slight to moderate fusion of rays into ventral, lateral, and dorsal groups; vulva of female marked by two cuticular plates, which form wall of orifice, and usually provided with a local swelling of body cuticle which sometimes assumes the form of a distinct vulvar appendage.

Genotype.—*Crenosoma striatum* (Zeder, 1800) Molin, 1861, type by subsequent designation (Yorke and Maplestone, 1926).

Discussion.—The nine species of *Crenosoma* can be distinguished and keyed primarily on the basis of spicular and bursal morphology in the male. The bursae and spicules of the four species studied at first hand are shown in lateral view in figure 1, A to D; ventral views of *C. goblei* and *C. mephitidis* appear in figure 2, A and B, and a dorsolateral view of *C. vulpis* in figure 2, C.

Useful characters for formulating a key to the females of the genus are lacking for some of those species not studied in the present work. The absence or presence and extent of cuticular swelling in the region of the vulva may well prove to be the most important character in distinguishing most species, although not all. Unfortunately this structure is not known for *C. petrovi*, *C. skrjabini*, and *C. taiga*. In *C. mephitidis* and *C. microbursa* there is no apparent cuticular swelling at the

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[3] Collected by Mr. Donald S. Longanecker.

vulva. In *C. goblei* there is a moderately large swelling, as figure 3, C, illustrates. *C. vulpis* has a somewhat similar, but larger swelling excellently illustrated by Sprehn with a photomicrograph (1932, Abb. 89); that in *C. striatum* is apparently even bigger—a transparent, conical papilla, as illustrated by Molin (1861, Tab. "XIV" [corr. XXV], fig. 2); and that in *C. potos* is a very large cuticular projection, tubular in form and longer than the body is wide. The nature, number and extent of cuticular annulations in *Crenosoma* females—and in males, too, for that matter—must be reëvaluated before such characters can have diagnostic significance,
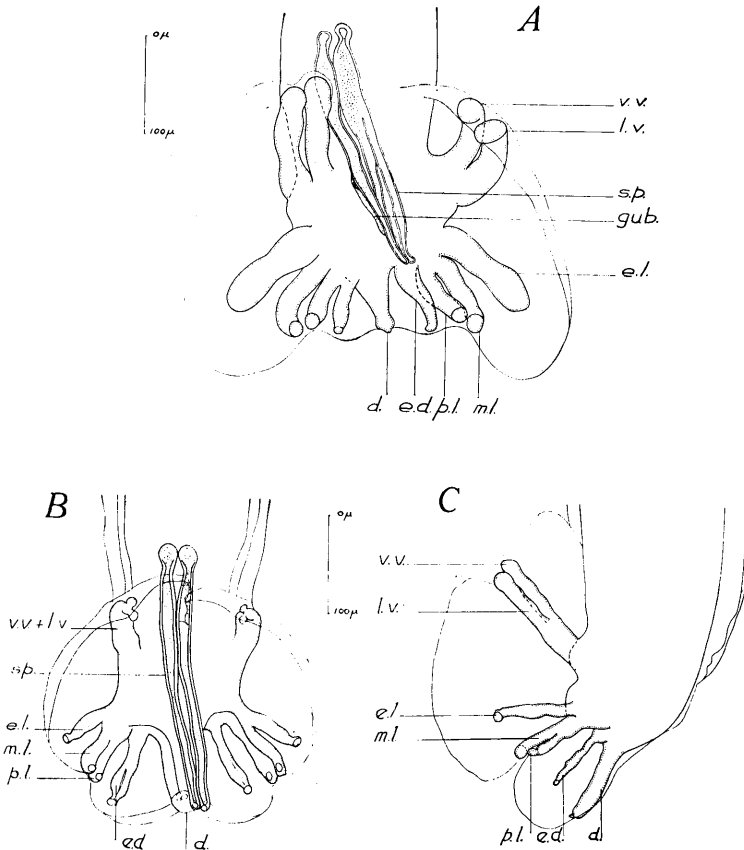

FIG. 2. A—*Crenosoma goblei*, sp. nov.; ventral view of male posterior end. B—*C. mcphitidis*; ventral view of male posterior end. C—*C. vulpis*; dorsolateral view of male posterior end. *d.*, dorsal ray; *e. d.*, externodorsal ray; *e. l.*, externolateral ray; *gub.*, gubernaculum; *l. v.*, lateroventral ray; *m. l.*, mediolateral ray; *p. l.*, posterolateral ray; *sp.*, spicule; *v. v.*, ventroventral ray.

for it is obvious that various workers have described differently these annulations by regarding or ignoring the fainter, more posterior folds. Figure 3, A and B illustrate the anterior ends of *C. mephitidis* and *C. goblei* respectively and show the annular folds and longitudinal striations in the body cuticle. Possibly the structure of the ovejectoral apparatus may prove to show criteria for distinguishing the females of *Crenosoma*, but at present insufficient evidence is at hand, and careful study requires dissection and consequent sacrificing of specimens. The ovejectoral apparatus of *C. mephitidis* is illustrated in figure 3, D.

Wallace (1941) has given a key for the males of the species of *Crenosoma* known to him. It is, however, inaccurate in certain respects. He made use of the gubernaculum as principal key character and stated that in *C. potos* and *C. micro-bursa* it was "thick in front and tapered behind in lateral view," whereas the rest of the species had gubernacula "slender in lateral view." Actually this struc-
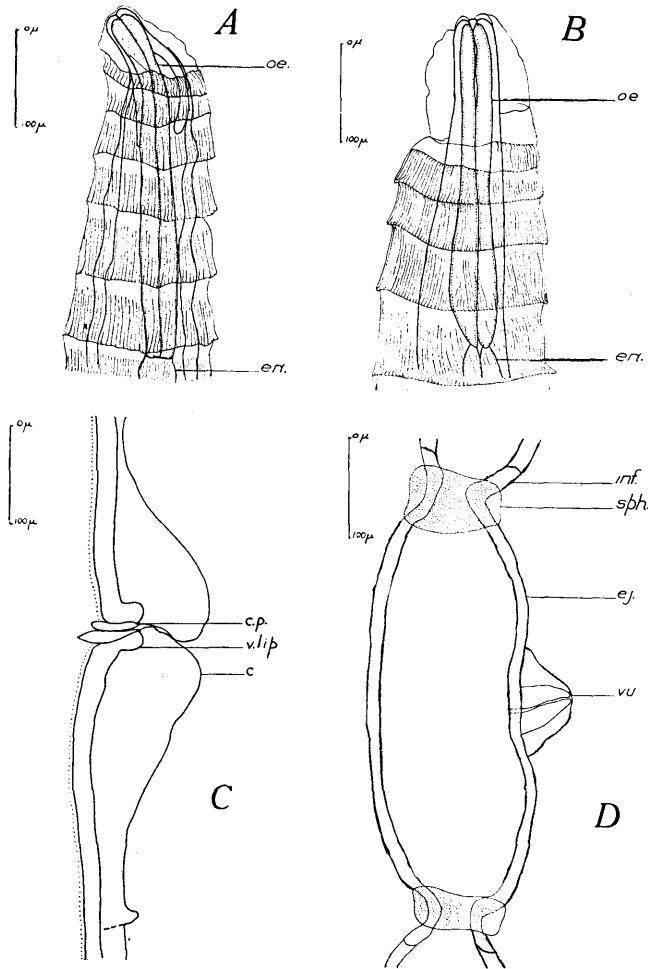

FIG. 3. A—*Crenosoma mephitidis;* anterior end showing striated cuticular folds. B—*C. goblei,* sp. nov.; anterior end. C—*C. goblei;* region of vulva in female. D—*C. mephitidis;* ovejectoral apparatus in female. *c.,* cuticle; *c. p.,* cuticular plate; *ej.,* ejector; *en.,* mesenteron or intestine; *inf.,* infundibulum; *oe.,* oesophagus; *sph.,* sphincter; *v. lip,* vulvar lip; *vu.,* vulva.

ture tends to be slender posteriorly in all species of *Crenosoma* and does not consti-tute a consistent distinguishing criterion. Furthermore, Wallace has separated *C. striatum* from *C. vulpis* on the basis of the presence of longitudinal striations on the cuticle of the former and their lack on that of the latter. But *C. vulpis* in reality also has longitudinal cuticular striations.

The following key is offered for identifying males of the genus *Crenosoma:*

1. Spicule with well developed, pigmented dorsal appendix 2
   Spicule without dorsal appendix, or at most with a poorly developed, non-pig-
      mented appendix 4
2. Rays short and stubby; ventrals about ¼ of length of spicules .... *C. striatum*
   Rays long and massive; ventrals about ½ of length of spicules 3
3. Dorsal ray shortest of rays, or at most no longer than externodorsal.
                                                                                            C. goblei, sp. nov.
   Dorsal ray longer than other rays except for fused ventrals .... *C. taiga*
4. Dorsal and externodorsal rays arising in common trunk .... *C. skrjabini*
   Dorsal and externodorsal rays arising separately 5
5. Rays relatively very long and slender; dorsal ray almost equal to spicule in
      length .... *C. potos*
   Rays relatively short to very short; dorsal ray of less than ½ of length of
      spicule 6
6. Bursa strongly reduced, much shorter than spicule; rays very short and stubby.
                                                                                            C. microbursa
   Bursa large and full, almost as long as spicule; rays well developed and digiti-
      form 7
7. Externolateral ray united at base with medio- and posterolateral rays.
                                                                                            C. mephitidis
   Externolateral ray arising independently of other laterals 8
8. Spicules more than 300 μ long; characteristic of Canidae .... *C. vulpis*
   Spicules less than 250 μ long; found in martens (Mustelidae) .... *C. petrovi*

   The principal measurements of the nine species of *Crenosoma* are tabulated in
table 1. Morozov (1939) has already given a table for the principal measurements
and characters of all but *C. mephitidis*, *C. microbursa*, and *C. goblei*. Through
typographical error, however, there are several inaccuracies—most important: (1)

TABLE 1.—*Dimensions as known at the present time for species of Crenosoma*

	C. vulpis[a]	*C. mephi-tidis*	*C. micro-bursa*	*C. petrovi*	*C. potos*
Male					
Length	3.5–8 mm.	6–9 mm.	9–11 mm.	2.2 mm.	12–14 mm.
Width	280–320 μ	300–350 μ	210–230 μ	170 μ	400–520 μ
Oesophagus	240–360 μ	350–395 μ	300–330 μ	120 μ	350 μ
Spicule	340–400 μ	265–380 μ	290–310 μ	225 μ	970 μ
Gubernaculum	55–130 μ	90 μ	60– 80 μ	110 μ	280 μ
Female					
Length	12–16 mm.	18–26 mm.	18–22 mm.	....	23–26 mm.
Width	300–480 μ	480–700 μ	400–470 μ	....	520–600 μ
Oesophagus	320–400 μ	350–560 μ	300–350 μ	....	400 μ
Tail	85–160 μ	140–170 μ	....	....	300–400 μ

	C. skrjabini	*C. striatum*	*C. taiga*	*C. goblei,* sp. nov.
Male				
Length	2.8 mm.	5–6.8 mm.	6.2–7 mm.	3.2–6.4 mm.
Width	160 μ	240 μ	315 μ	240 μ
Oesophagus	295 μ	340 μ	300 μ	240–280 μ
Spicule	120 μ	240 μ	285–295 μ	270–320 μ
Gubernaculum	20 μ	85 μ	130 μ	80 μ
Female				
Length	....	12–13 mm.	13.7 mm.	8–12.5 mm.
Width	290 μ	340 μ	475 μ	480 μ
Oesophagus	....	300 μ	550 μ	240–280 μ
Tail	115–130 μ	220 μ	160 μ	150 μ

[a] Measurements in micra are here given to the nearest 5 μ even in the cases
where indicated more precisely in earlier works.

omission of the Russian word for "gubernaculum," which leads one to the mistaken impression that the measurements thereof are in the range of those for the dorsal appendix of the spicule; (2) mutual exchange of the words for "long" and "thin," which apply correctly to the rays of *C. potos,* with the words for "short" and "thick," which apply to the rays of *C. vulpis.*

<center>III. TAXONOMIC POSITION OF THE GENUS CRENOSOMA</center>

In the recent classifications of those nematodes of the suborder Strongylina in which greatly reduced stomata are present the genus *Crenosoma* Molin, 1861, has been placed along with other mammalian lungworm genera—with the exception of *Syngamus* v. Siebold, 1836—in a family Metastrongylidae Leiper, 1909, sometimes included with a family Pseudaliidae Railliet, 1916, in a superfamily Metastrongyloidea Lane, 1917. The other genera with reduced stomata, most of which inhabit the gastrointestinal tract, have usually all been placed in families Trichostrongylidae Leiper, 1912, and Heligmosomidae Cram, 1927, sometimes included in turn in a superfamily Trichostrongyloidea Cram, 1927. Thus Skriabin (1933b) has placed *Crenosoma* in a subfamily Crenosomatinae Skriabin, 1933, of the family Metastrongylidae and superfamily Metastrongyloidea. Böhm and Gebauer (1934) erected a subfamily Bronchostrongylinae, which included *Crenosoma,* and placed it in the family Metastrongylidae. Workers such as B. G. and M. B. Chitwood (1937), B. G. Chitwood (1937), and Skriabin (1941) have used superfamilies Metastrongyloidea and Trichostrongyloidea, whereas Travassos (1937) in a monograph on the Trichostrongylidae has not recognized a superfamily for the trichostrongyles, but has placed them as a family in the suborder Strongylata Railliet and Henry, 1933 (= Strongylina Pearse, 1936).

For designating forms which B. G. and M. B. Chitwood (1937) and others have termed "metastrongyloid" and "trichostrongyloid"—those, in other words, in which the stoma, or buccal capsule, is greatly reduced or vestigial—I propose the noun *meiostome,* from μειόω (to make smaller) and στόμα (mouth), and the adjective *meiostomatous;* for those strongylines in which the stoma is relatively well developed, I propose the noun *eustome,* from εὖ (well) and στόμα, and the adjective *eustomatous.* The conditions of *meiostomy* and *eustomy* intergrade to a certain degree in the Strongylina, but almost all strongylines may be easily classified under one or the other category.

When the meiostomatous strongylines were first specifically separated from the eustomatous forms by Railliet (1885), they were placed in a subfamily Strongylinae Railliet, 1885, of the family Strongylidae Baird, 1853; at that time the genus *Strongylus* Müller, 1780, was used for almost all strongylines with reduced stomata. Railliet placed the eustomes in a subfamily Sclerostominae Railliet, 1885. The meiostomes were first subdivided by Kamenskiï (1905), who recognized new subfamilies Protostrongylinae and Blastostrongylinae for those forms regarded by him as the most primitive of the strongylines; he did not concern himself directly with the rest of the meiostomes, but he apparently regarded them as constituting a separate subfamily (?Strongylinae). Railliet and Henry (1909) recognized a subfamily Pseudaliinae for the meiostomatous lungworms of porpoises (suborder Odontoceti) and a subfamily Metastrongylinae for the remaining meiostomes. Leiper (1909) in a work appearing a month after that of Railliet and Henry, but bearing the date 1908, was the first to recommend familial rank for the meiostomes. He proposed the family Metastrongylidae on the basis of meiostomy, with subfamilies Metastrongylinae and Trichostrongylinae (new). The first of these subfamilies he distinguished as follows: "vagina elongate, uteri lie close together and have simple musculature"; the second: "vagina short, uteri divergent, and musculature differentiated into ovejectors." It is true that the genera placed by Leiper

in his subfamily Metastrongylinae were all from the respiratory and circulatory systems, and those in his subfamily Trichostrongylinae all from the gastrointestinal tract. Nevertheless the particular genera listed in each group did correspond in morphology to the characters indicated for that group. However, Railliet and Henry (1912) in recognizing both subfamilies Metastrongylinae and Trichostrongylinae placed in the Metastrongylinae lungworm genera whose female reproductive organs corresponded to the characters given by Leiper for the Trichostrongylinae, *e.g.*, *Crenosoma* Molin, 1861, *Dictyocaulus* Railliet and Henry, 1907, and *Filaroides, scnsu* Weyenbergh, 1868 (= *Skrjabingylus* Petrov, 1927; *nec Filaroides* v. Beneden, 1858).

Subsequently the meiostomatous strongylines have, for the most part, been divided roughly into two groups after the pattern established by Railliet and Henry (1912)—one for those of the respiratory and circulatory systems (Metastrongylidae or Metastrongyloidea) and one for those of the gastrointestinal tract (Trichostrongylidae or Trichostrongyloidea). Leiper himself (1912) abandoned the morphological basis of his meiostomatous subfamilies by accepting *Dictyocaulus* in the Metastrongylidae, from which he separated the subfamily Trichostrongylinae of his earlier classification into a new family Trichostrongylidae. However, as I am prepared to show here, I believe that to divide the meiostomatous strongylines on the basis of habitat is artificial, for there is no necessary correlation here between habitat and basic morphology.

I have been able to study the phylogenetically significant parts of the female reproductive system in almost all of the strongyline groups—eustomatous and meiostomatous. It is not appropriate to deal here with the entire study on this subject. However, certain facts are important to present considerations. In a previous paper (Dougherty, 1944) I have already shown that there exist among the meiostomatous lungworms two types of female reproductive tracts. Interestingly enough these types correspond exactly to those used by Leiper (1909) in separating subfamilies Metastrongylinae and Trichostrongylinae. In my earlier work I recognized three families in the superfamily Metastrongyloidea; two of these—Metastrongylidae and Pseudaliidae—correspond to the metastrongylin type of Leiper, the third—Dictyocaulidae Skriabin, 1941—to the trichostrongylin type of Leiper. At that time I did not wish to alter the construction of the superfamliy Metastrongyloidea. However, I believe that the ''metastrongyloid'' and ''trichostrongyloid'' groups can and should be distinguished on the basis of the female reproductive characters first recognized by Leiper (1909). Accordingly the family Dictyocaulidae is ''trichostrongyloid,'' not, as it is generally understood to be, ''metastrongyloid.''

In my earlier paper I placed *Crenosoma* and its allies with *Dictyocaulus* in the family Dictyocaulidae. As can be seen from figure 3, D, the ovejectoral apparatus in *Crcnosoma mephitidis* has paired ovejectors, each with an infundibulum, sphincter, and ejector typical of the trichostrongyles. This structure is identical with that in *Dictyocaulus* and *Skrjabingylus*, in both of which I have been able to study species. The several species of *Dictyocaulus* occur in artiodactyls with the exception of one species in perissodactyls. The other ''dictyocaulid'' genera are found primarily in carnivores; these are, aside from *Crenosoma*: *Bronchostronglus* Cameron, 1931, in the bronchi of felids; *Otostrongylus* de Bruyn, 1933 (syn. *Kutassicaulus* Skriabin, 1933), in the bronchi and (?) liver ducts of pinnipedes; *Troglostrongylus* Vevers, 1924, in the frontal sinus of felids; *Skrjabingylus* Petrov, 1927, in the frontal sinus of mustelids; and an aberrant genus, *Hcterostrongylus* Travassos, 1925, whose single species occurs in the bronchi of an opposum (order Marsupialia).

Study of the Strongylina in entirety convinces me that division into super-

families is unnecessary and obscures the true degree of relationships within the suborder between the eustomatous and meiostomatous groups. Evidence for this view will be presented in a later work on the classification of the entire suborder. I believe that the superfamilies Metastrongyloidea and Trichostrongyloidea should be reduced to families Metastrongylidae and Trichostrongylidae, respectively. The overall classification of these families is too complex to be considered here. However, it is desirable at this time to reduce the family Dictyocaulidae to the status of a trichostrongylid subfamily (as already designated in the classification introducing section II). Four names have been employed for members of this assemblage—Skrjabingylinae by Skriabin (1933a), Dictyocaulinae and Crenosomatinae by Skriabin (1933b), and Bronchostrongylinae by Böhm and Gebauer (1934). I prefer to make a selection from these on the basis of priority and accordingly take Skrjabingylinae. Although the genus *Skrjabingylus* in its extreme bursal reduction is a somewhat aberrant member of its group, it presents ovejectoral characters as typical as those of any other allied genus; furthermore bursal reduction, which is most extreme in *Skrjabingylus*, but occurs in all skrjabingylins, is the best character for separating members of the subfamily Skrjabingylinae from other subfamilies of the Trichostrongylidae. Travassos (1937) has recognized thirteen subfamilies in the Trichostrongylidae. I am not prepared to analyze this classification here, nor to indicate skrjabingylin affinities more exactly. On the basis of the following diagnosis, however, this subfamily can be distinguished from Travassos's other subfamilies.

Subfamily SKRJABINGYLINAE Skriabin, 1933

Diagnosis.—Trichostrongylidae: Bursal rays fused in part and variously reduced; vulva equatorial or slightly postequatorial; caudal mucrones in female absent; parasitic in the bronchi, trachea, and frontal sinus of mammals.

Type genus.—*Skrjabingylus* Petrov, 1927. *Other genera: Crenosoma* Molin, 1861; *Bronchostrongylus* Cameron, 1931; *Otostrongylus* de Bruyn, 1933 (syn. *Kutassicaulus* Skriabin, 1933); *Dictyocaulus* Railliet and Henry, 1907; and *Troglostrongylus* Travassos, 1925.

IV. THE GEOGRAPHIC AND HOST-DISTRIBUTION OF SPECIES OF CRENOSOMA

Of the nine named species of *Crenosoma*, four are apparently restricted to the Eurasiatic continent—*C. striatum, C. skrjabini, C. taiga,* and *C. petrovi*—and four to the New World—*C. potos, C. goblei, C. mephitidis,* and *C. microbursa.* The ninth and remaining species, *C. vulpis,* has however, been found in both hemispheres; so far in the New World it has been reported only from eastern Canada and eastern United States (see: Law and Secord, 1931; Goble, 1941).

The species of *Crenosoma* occur in two orders of mammals, the Insectivora and the Carnivora. For two reasons I am inclined to regard members of the latter group as ancestral hosts to the genus, despite the fact that the insectivores are more primitive than the carnivores. First of all it may be noted that the several lungworm and sinus-worm genera already discussed as obviously related to *Crenosoma* are composed of species which parasitize carnivores. On the other hand only two species of the Skrjabingylinae, both in the genus *Crenosoma,* have been found in insectivores. The second reason lies in the fact that the greatest number of species of *Crenosoma* has been discovered in carnivore as opposed to insectivore hosts. It would therefore follow that species of *Crenosoma* have become secondarily established as parasites in the latter group.

In the Insectivora the families Erinaceidae and Soricidae are known to contain species serving as hosts to species of *Crenosoma*—to *C. striatum* and *C. skrjabini,* respectively.

In the Carnivora members of three of the ten or so families have proved hosts to species of *Crenosoma*—namely Canidae, Mustelidae, and Procyonidae. So far only *C. vulpis* has been found naturally occurring in the first of these families. *C. potos* and *C. goblei* occur in the last family. It is in the Mustelidae that a radiation of species has occurred: *C. taiga* and *C. petrovi* occur in members of the subfamily Mustelinae, and *C. mephitidis* and *C. microbursa* in members of the subfamily Mephitinae. The last two species are particularly interesting in that they have been found to occur in the same species of striped skunk, *Mephitis mephitis* (Schreber), i.e., *C. mephitidis* in California (in *M. m. occidentalis*[4]) and in New York (in *M. m. nigra*[5]) and *C. microbursa* in Minnesota (in *M. m. hudsonica*[6]). *C. mephitidis* also occurs in the California spotted skunk (*Spilogale gracilis phenax*).

C. vulpis has been reported by Petrov (1941) from European Mustelidae— from the European badger (*Meles meles* subsp.?) and the common wolverine (*Gulo g. gulo*); but these were captive animals in the Moscow Zoölogical Garden, and there is no proof as yet that *C. vulpis* occurs in these hosts under natural conditions. Goble (1942) has noted that in New York *C. vulpis* is found in foxes, and *C. zederi* (= *C. mephitidis*) in skunks, although these animals share the same range. Wetzel (1940) recorded *C. vulpis* as occurring in the raccoon (*Procyon lotor* subsp.?), which is a North American mammal, but he did not give the source of his information, and I have been unable to verify it. Possibly raccoons known to Wetzel in a European zoo have proved to harbor *C. vulpis*. So far I have found only *C. goblei* to occur in raccoons caught in the wild state. It would appear rather likely, however, that *C. vulpis* is less host-specific than other members of the genus. It has been reported from several genera of the Canidae and apparently occurs rarely in the domestic dog (Railliet, 1915). Hobmaier (1940, 1941b) was able to grow *C. mephitidis* in puppies, but met with no success when he tried to infect adult dogs. It seems probable from this result that the dog is a somewhat unnatural host for *C. mephitidis*. Hobmaier (1941b) was also successful in infecting four 6-month-old "Silver" foxes[7] with *C. mephitidis*. These records of *C. vulpis* and *C. mephitidis* indicate that the host-specificity of species of *Crenosoma* may not be perfect, even for families of hosts.

Very likely members of carnivore families other than the three mentioned will also prove to harbor species of *Crenosoma;* such parasites should be sought in the Bassariscidae (ring-tailed cats), Ursidae (bears), Viverridae (mongooses), etc.

SUMMARY

The genus *Crenosoma* is here reviewed on the basis of specimens of four of the nine acceptable species in the genus and of the descriptions of the other five.

An historical review of the genus and its species is given.

The taxonomy and adult morphology of the several species are discussed, and a key and a table of measurements for their identification presented. The four specimens studied include three already known: *C. vulpis* (Dujardin, 1844) Railliet, 1915; *C. mephitidis* Hobmaier, 1941; and *C. microbursa* Wallace, 1941; and a new species, *C. goblei*, sp. nov., from the California raccoon (*Procyon lotor psora;* type host) and the Eastern raccoon (*P. l. lotor*). The five species of which no specimens

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[4] Hobmaier (1941a) gave this form as *Mephitis occidentalis*.

[5] Goble (1942) gave this form as *Mephitis nigra*.

[6] Wallace (1941) gave this form as *Mephitis minnesotae*.

[7] Dr. Edward L. Vail, who supplied the foxes used by Dr. Hobmaier in his experiments, has very kindly informed me (*in litteris*) that they were specimens of the commercially raised variety of the Red (= Silver) fox, *Vulpes fulva* Desmarest, from a fox-farm at Big Bear Lake, San Bernardino Mountains, San Bernardino County, California.

were available are: *C. striatum* (Zeder, 1800) Molin, 1861 (genotype); *C. skrjabini* Pologentsev, 1935; *C. taiga* Skriabin and Petrov, 1928; *C. petrovi* Morozov, 1939; and *C. potos* Buckley, 1930. *C. mustelae* Galli-Valerio, 1930, is considered a possible synonym of *C. taiga*; and *C. zederi* Goble, 1942, is submerged as a synonym of *C. mephitidis*.

Strongylines with well-developed stomata are designated by the new term *eustomatous*, and those with poorly developed or vestigial stomata (such as in *Crenosoma*), by the new term *meiostomatous*. Subdivision of the suborder Strongylina into superfamilies is rejected, and the meiostomatous strongylines are placed into two families based on the morphology of the female ovejectoral apparatus— Metastrongylidae Leiper, 1909, and Trichostrongylidae Leiper, 1912. The family Dictyocaulidae Skriabin, 1941, is reduced to the rank of a subfamily of the Trichostrongylidae, under the name of Skrjabingylinae Skriabin, 1933. Evidence is given for placing *Crenosoma* in the subfamily Skrjabingylinae.

The geographic and host-distribution of species of *Crenosoma* is discussed, and the suggestion made that the Carnivora represent the ancestral host-group of this genus.

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[8] This paper is not available in North America and has not been seen.

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Observations on the ether extract of *Ascaris* males and *Eustrongylides* larvae.

Theodor von Brand and Sister M. Irenaea Winkeljohn, Department of Biology, Catholic University of America, Washington, D. C.

Considerable uncertainty exists as to the nature of the unsaponifiable substances occurring in parasitic nematodes. Bondouy (1910) found in *Strongylus equinus* an unsaponifiable fraction which did not give the usual color reactions of sterols. Flury (1912), Fauré-Fremiet (1913), and Schulz and Becker (1933) state that the unsaponifiable material in *Ascaris* and *Parascaris* consists of ascaryl alcohol instead of cholesterol which is so widely distributed in other animals. The lipoid membrane of the nematode eggs is designated as a sterol (Wottge, 1937; Chitwood, 1938; Jacobs and Jones, 1939). Fauré-Fremiet stated that ascaryl alcohol occurs only in the female reproductive cells, but he does not mention what unsaponifiable substance, if any, is present in the other tissues. Schulz and Becker, on the other hand, imply that ascaryl alcohol occurs in all tissues by stating that this substance has a specific biological role connected with the protection of the worms against the adverse conditions prevailing in the peculiar surroundings of these parasites.

In order to gain further insight into the nature of the unsaponifiable substances present in parasitic nematodes, males of *Ascaris lumbricoides* and larvae of *Eustrongylides ignotus* were studied. The investigation was not confined to the unsaponifiable substances, but included the general chemical composition of the ether-extractable material present in these worms.

ASCARIS LUMBRICOIDES MALES

The worms were obtained from Swift and Company at Chicago. They were washed with saline, dried at 100° C. and stored in a desiccator over sulfuric acid until sufficient material for analysis was available. The dry worms weighed 67.3 gms., corresponding to 450 to 500 gms. of fresh material, or about 450 worms. The dried material was powdered and extracted for 6 hours with ether in a Soxhlet apparatus. Since it is a well-established fact that such an extraction does not yield all the ether-soluble material, the residual ether-extract was gained by Kumagava-Suto's (1908) saponification method.

a. *Soxhlet extraction.*—The ether extract after being dried at 60° C. weighed 1.253 gms. It was redissolved in a minimum of ether and the acetone-insoluble

material was gained by precipitation with 10 cc. of cold acetone. This precipitate weighed 0.367 gm. and gave a strong phosphorous reaction (ammonium molybdate reagent). It consisted, doubtless, of phospholipids.

The acetone-soluble fraction weighed 0.886 gm. It was saponified for 3 hours in a reflux condenser with 10 cc. of 2 N potassium hydroxide. The unsaponifiable material was gained by extraction with ether in a separatory funnel. This fraction weighed 0.348 gm. It was decolorized with animal charcoal. The color reactions of Salkowski, Liebermann, and Neuberg for sterols were slightly positive, but the intensity of the color was less than when the same quantity of pure cholesterol was used. Upon recrystallization from hot 80 per cent alcohol, broad needle-like crystals were formed but amongst them a few rhombic plates typical of cholesterol were observed. The melting point of the dry substance was 88° C. This is only a little higher than that of ascaryl alcohol (84° C.), but much lower than that of cholesterol (148° C.). The remainder of the sample was used to prepare the acetate ester in the customary manner. Its melting point was 53° C. which corresponds well with that found by Schulz and Becker (1933) for ascaryl acetate (52° C.). In view of the similarity of the melting points, both of the original substance and its acetate, with ascaryl alcohol and its acetate respectively, the conclusion seems unavoidable that the main unsaponifiable substance in male *Ascaris* is the same as that in females, that is, ascaryl alcohol. It is not improbable, however, that traces of a true sterol, perhaps cholesterol, were present as an impurity in our material.

The fatty acids were obtained by acidifying the saponified acetone-soluble material with dilute hydrochloric acid (after separation from the unsaponifiable fraction) and extracting the solution with ether. The fatty acids weighed 0.485 gm. and their average molecular weight, as determined by titration with 0.119 N alcoholic potassium hydroxide, was 294.

b. *Kumagava-Suto extraction.*—An additional fat fraction weighing 1.606 gms. was gained by this procedure. It was separated into an unsaponifiable and a saponifiable fraction by the method described above.

The unsaponifiable matter weighed 0.098 gm. It was used for the preparation of a digitonin compound by dissolving it in hot 95 per cent alcohol and adding a hot alcoholic solution of digitonin. The resulting crystalline substance weighed 0.126 gm. It did not give Salkowski's reaction but that of Liebermann was slightly positive; however, the color was much slower in appearing than in the case of cholesterol. The compound was insoluble in ether and acetone, but very soluble in pyridine. Its decomposition point was 207° C. (corr.) while that of cholesterol digitonide is 240° C. It seems very likely that our compound was an ascaryl alcohol digitonide. Since it was prepared from a crude ascaryl alcohol fraction, our observation does not warrant a definite statement as to whether digitonin will be as useful for the quantitative determination of this alcohol as in the case of true sterols. It is, however, an additional proof for the alcohol structure of ascaryl alcohol, supplementing those described by Flury (1912) and Schulz and Becker (1933).

The fatty acids gained by Kumagava-Suto's procedure weighed 0.955 gm. and their average molecular weight was 286.

EUSTRONGYLIDES IGNOTUS LARVAE

The general analytical procedure was the same as in the case of *Ascaris* with the differences noted below. The worms were collected over a period of several years from *Fundulus heteroclitus* caught near Baltimore, Maryland, and stored in the dry condition. The material weighed, after drying, .27.6 gms. corresponding to 120 gms. of fresh substance or approximately 2500 to 3000 worms.

a. *Soxhlet extraction.*—A total of 0.512 gm. of ether extract was obtained. The acetone-insoluble fraction amounted to 0.203 gm. It gave a strong phosphorous reaction, indicating its phospholipid composition.

The acetone-soluble material was separated into an unsaponifiable (0.184 gms.) and a fatty acid fraction (0.190 gm.). We shall return to a consideration of these substances below.

The aqueous fluid remaining after the extraction of the above fractions was made slightly alkaline with potassium carbonate and evaporated at a temperature below 50° C. The resulting syrup was mixed with anhydrous sodium sulfate and extracted with acetone in a Soxhlet apparatus. The material obtained weighed 0.015 gm. Upon heating with potassium bisulfate, it developed a strong odor of acrolein, indicating that it consisted essentially of glycerol.

b. *Kumagava-Suto extraction.*—The additional fat gained by this procedure weighed 0.277 gm. It was separated into an unsaponifiable fraction (0.015 gm.) and a fatty acid fraction (0.238 gm.).

c. *The unsaponifiable matter and the fatty acids.*—In view of the relatively small amounts available, the respective fractions of the two extraction methods were combined for further analysis.

The unsaponifiable material, after decolorization with animal charcoal, was dissolved in hot 80 per cent alcohol. After cooling, centrifuging, and drying, two layers had developed. One was white and crystalline. It gave a pronounced Liebermann reaction and its melting point was 140° C. It appears very probable that it consisted of cholesterol or another related sterol. The other layer was brown and wax-like. Its melting point, 80° C., was near that of ascaryl alcohol. We hesitate, however, to identify it with the latter, because it gave, in contrast to ascaryl alcohol, as strong Liebermann and Salkowski reactions as an identical amount of cholesterol. The scarcity of the material prevented further tests.

The fatty acids were divided into saturated and unsaturated acids by means of the different solubility of their lead salts in benzene. The saturated acids weighed 0.058 gm. and had an average molecular weight of 276. The weight of the unsaturated acids was 0.211 gm. Their molecular weight was determined to be 291. It must be emphasized, however, that this figure is only an approximate value. The alcoholic solution of this fraction was dark brown, and the end point of the titration was therefore difficult to determine.

DISCUSSION AND SUMMARY

The ether extract of male *Ascaris lumbricoides* was composed of the following:

Phospholipids	12.8 per cent
Unsaponifiable material	15.6 per cent
Fatty acids	50.4 per cent
Unidentified	21.2 per cent

The unsaponifiable material consisted of ascaryl alcohol with possibly a small admixture of a true sterol. Our findings, consequently, disprove Fauré-Fremiet's (1913) statement that ascaryl alcohol occurs only in eggs, but whether Schulz and Becker's (1933) assumption of the protective action of this substance is well-founded is as yet not clear.

The molecular weight of the fatty acids (290) can be regarded as an indication that they are identical in males and females. This is evidenced by the work of Flury (1912) who used, probably, a mixed material of males and females and found stearic acid (molecular weight 284), oleic acid (282), and only little palmitic acid (256). We did not search for glycerol, but it should be remembered that

Schulz and Becker (1933) found 8.8 per cent glycerol in the ether extract of this worm. They used, probably, both males and females.

The general chemical composition of the ether extract of the larvae of *Eustrongylides ignotus* was the following:

Phospholipids	25.8 per cent
Unsaponifiable material	16.9 per cent
Unsaturated fatty acids	22.4 per cent
Saturated fatty acids	7.4 per cent
Glycerol	1.9 per cent
Unidentified	25.6 per cent

The unsaponifiable material was a mixture of at least two substances: one was most likely cholesterol or a related sterol; the other had a melting point near that of ascaryl alcohol, but could not be definitely identified as such. The fatty acids were primarily unsaturated acids, and their molecular weight was in the same range as found in most animals. The glycerol content, as given above, appears low. It must be remembered, however, that it can be related only to the fatty acids gained by the Soxhlet extraction. If the latter are calculated as triglycerides, the glycerol found corresponds to 7.9 per cent of the compound. This is a little less than would be expected if all the acids would have been present as triglycerides; tristearin, for example, contains 10.3 per cent glycerol. However, in view of the small amounts of material involved in the present investigation, this discrepancy has no significance. Small amounts of glycerol may well have been lost. It is also possible that some acids may have been present as free acids or in combination with the unsaponifiable matter.

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Variations in the number and arrangement of the caudal papillae of the male of *Onchocerca armillata* Railliet and Henry, 1909, and the validity of the species.[1] EDUARDO CABALLERO Y C., Instituto de Biologia de Mexico.

The specimens that served for this study came from the U. S. National Museum Helminthological Collection and bore the catalogue number 7507. They were collected by Dr. J. Bauche on November 9 and 10, 1911, from the aortic wall of *Bos taurus* in Hué, Annam, Indo-China, and determined by Railliet and Henry in 1912.

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[1] This work was done in the Zoölogical Division, U. S. Bureau of Animal Industry, under a fellowship of the John Simon Guggenheim Memorial Foundation.

The material was in good condition and consisted of 7 males, 2 of which were complete and 5 of which were represented by 5 caudal extremities and 2 cephalic extremities; there were also 2 heads and 1 tail of females, along with some body fragments in which could be seen the prominent annular elevations and the transverse striations of the cuticula, in spite of their broken condition. Accompanying these specimens, in the same bottle, was the caudal extremity of a male of *Elaeophora poeli* (Vryburg, 1879) which undoubtedly came from the same host, since both species may coexist in the aortic wall. A study of this specimen and of the material in the Collection has permitted us to confirm the interpretations of Sandground and the independence of these 2 genera and species of filariae.

Onchocerca armillata has been imperfectly described due to the difficulty of obtaining a sufficient number of male and female specimens in good condition for study. Notwithstanding the importance of this filaria as the cause of atheromas in the aorta of cattle, there are only four descriptions based on actual specimens. The first description was by Lingard in 1905 who found the parasite in the aorta of cattle in India, but did not name it; the second by Tuck in 1908; the third by Railliet and Henry in 1910 and amended by these authors in 1912 and 1917; and the fourth by Bernard and Bauche in 1912 who described not only the adult parasites but also the microfilariae.

In the revision of the genus by Sandground in 1934, this author did not make a morphological study of *O. armillata*, because of a lack of suitable material, and only went so far as to suggest that this may be a distinct species.

As already indicated, this filaria lives in the intima of the aorta and the aortic arches, forming sinuous tunnels therein. It is a parasite of cattle and buffaloes, namely, *Bos taurus, B. indicus, Bubalus bubalis* and *Syncerus caffer* in Madras, U. P. India; Annam, Indo-China; Java, Sumatra, and Borneo; Egypt, Nigeria, the Gold Coast, Belgian Congo, etc., in Africa.

Our morphological observations were made principally on the caudal extremities of the 7 males and the measurements were verified on the 2 complete males and on the cephalic extremity of 1 female.

Males.—Large, filiform, 74.544 to 84.096 mm. in length by 0.200 to 0.232 mm. in diameter; anterior end rounded, with 2 amphids, 4 submedian external papillae and 4 small internal papillae. Cuticula with coarse transverse striations which become less distinct toward the extremities; the transverse cuticular rings are not defined as in the female. Mouth circular; the esophagus is divided into 2 parts: the anterior is muscular, short and measures 0.400 to 0.512 mm. in length by 0.028 to 0.040 mm. in diameter; the posterior portion is long, glandular, terminating in the form of a club and measuring 2.752 to 2.816 mm. in length by 0.080 mm. in diameter; the intestine is more delicate than the esophagus, having narrow walls; the anus is situated 0.144 to 0.152 mm. from the tip of the tail. The nerve ring is located at the middle of the anterior part of the esophagus, about 0.204 to 0.212 mm. from the anterior end. The cervical papillae and the excretory pore were not observed.

The caudal extremity is coiled spirally, with its tip directed ventrally and doubled back under the body; it bears 2 wide lateral alae which increase in size toward the end of the tail and have fine transverse striations. The number, size, and arrangement of the caudal papillae are variable, but in general there are 7 to 8 pairs in symmetrical or asymmetrical positions.

In the first male studied there were 8 pairs of large asymmetrically arranged papillae; these consisted of 3 preanals, 4 adanals, of which the second from the left side was lateral and pedunculated, and 9 postanals of which 2 were lateral and pedunculated and 4 were small and situated at the tip of the tail (Fig. 1, Aa & Ab).
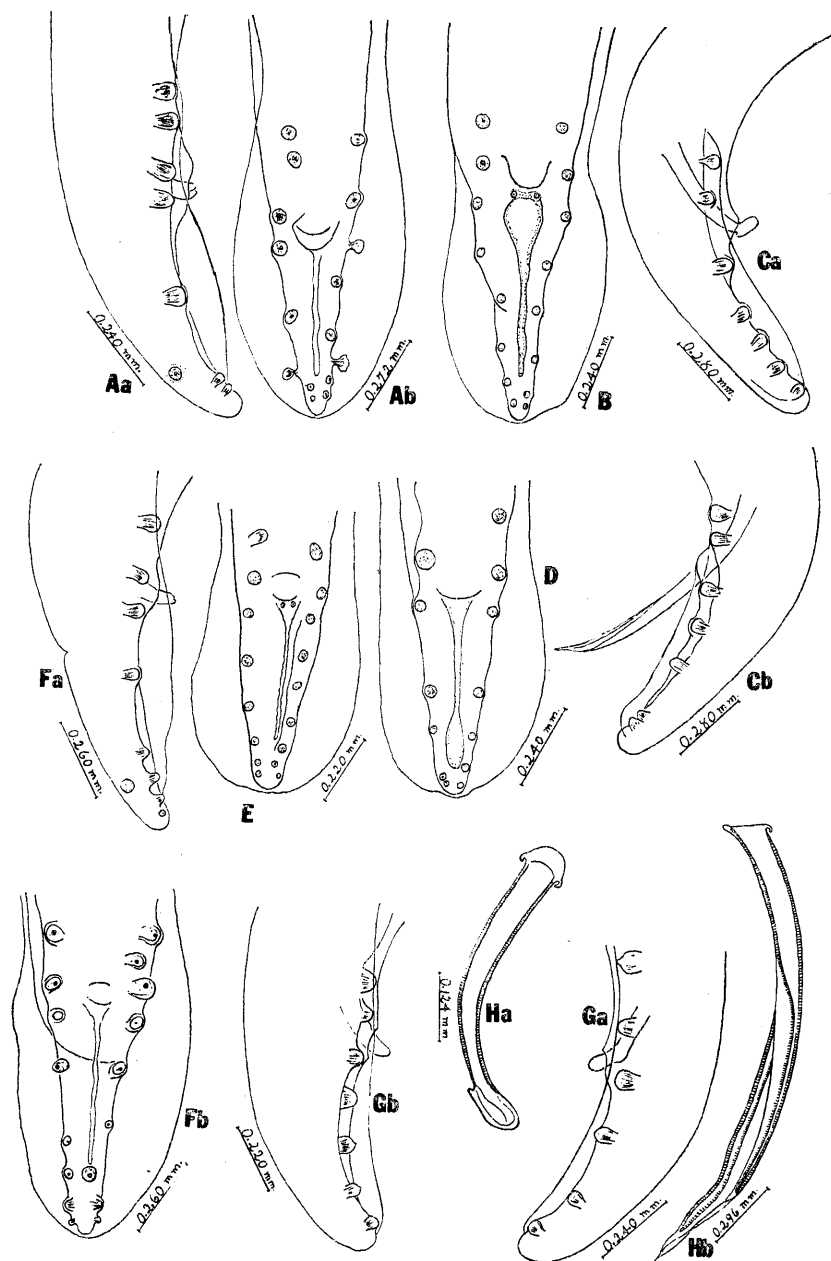
FIG. 1. *Onchocerca armillata.* Aa & Ab—Caudal extremity of first male;
B—Caudal extremity of second male; Ca & Cb—Caudal extremity of third male;
D—Caudal extremity of fourth male; E—Caudal extremity of fifth male; Fa &
Fb—Caudal extremity of sixth male; Ga & Gb—Caudal extremity of seventh male;
Ha—Right spicule; Hb—Left spicule.

In the second male there were 9 pairs of medium-sized papillae with slight asymmetry; these consisted of 2 preanals, 4 external adanals, 2 ventral postcloacal adanals, and 10 postanals of which 4 were small and located at the end of the tail (Fig. 1, B).

In the third male there were 7 pairs of large, slightly asymmetrical papillae, 2 papillae being preanal, 4 adanal, and 8 postanal; the 4 papillae at the end of the tail, corresponding to the small ones of the other specimens, were represented by 4 large papillae, those on the right side discrete and those on the left confluent (Fig. 1, Ca & Cb).

In the fourth male there were 6 pairs of small papillae with slight asymmetry, and 1 large unpaired papilla on the left side. In addition to the single left preanal papilla there were 4 adanals and 8 postanals of which 4 were small and situated at the end of the tail (Fig. 1, D).

In the fifth male there were 9 pairs of small asymmetrical papillae, and one unpaired papilla at the end of the tail. In addition to the unpaired papilla there were 2 preanals, 4 adanals, 2 ventral postcloacal adanals, and 10 postanals of which the last were small and located at the end of the tail (Fig. 1, E).

In the sixth male there were 8 pairs of large papillae, asymmetrical, and a single left preanal papilla, the arrangement being 3 preanals, 4 adanals, and 10 postanals with the last 2 small, lateral, and situated at the end of the tail (Fig. 1, Fa & Fb).

The seventh male had 6 pairs of slightly asymmetrical, large papillae and one unpaired postanal papilla on the right side. These were arranged as 2 preanals, 4 adanals, and 7 postanals, the customary 4 small papillae at the end of the tail being represented by 2 large papillae (Fig. 1, Ga and Gb).

The spicules are unequal and dissimilar, strongly chitinized and having transversely striated walls; the distal extremity of the right spicule is enlarged and bears on the dorsoposterior part a kind of hook; the proximal extremity is rounded (Fig. 1, Ha). The distal extremity of the left spicule ends in the form of a needle encompassed by a delicate membrane, while the proximal extremity is obliquely cut; for half of its length the spicule presents an oblique, undulating and chitinous plate (Fig. 1, Hb). The right spicule measures 0.132 to 0.152 mm. in length by 0.024 to 0.026 mm. in diameter and the left 0.288 to 0.308 mm. in length by 0.024 to 0.028 mm. in diameter; the relation between the size of the two spicules is as 1 : 2.3.

Female.—Diameter 0.336 mm.; anterior extremity rounded and with the same number and arrangement of papillae as in the male; cuticula with transverse striations and coarse annular rings. Anterior part of esophagus 0.560 mm. in length by 0.040 mm. in diameter, posterior part 2.684 mm. in length by 0.072 mm. in diameter. The nerve ring is situated 0.360 mm. from the anterior extremity. The vulva is situated at the level of the anterior third of the posterior part of the esophagus, at a distance of 0.832 mm. from the anterior extremity; ovipositor long, directed from behind forward and parallel to the esophagus. Neither the cervical papillae nor the excretory pore were observed.

Onchocera armillata Railliet and Henry, 1909, presents specific characters sufficient to differentiate it from other species of the genus; these characters are (1) very large caudal papillae, (2) the constant presence of 2 pairs of latero-external adanal papillae, and (3) the possession of wide caudal alae by the male. It is distinguished from *O. reticulata* Diesing, 1841 (Syn. *O. cervicalis* Railliet and Henry, 1910) because in this species the lateral caudal alae of the male are very narrow throughout their entire length, as well as by the other characters mentioned above.

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A note on the identity of Protostrongylus kwongi Wu and Liu, 1943. G. DIKMANS, Bureau of Animal Industry.

Recently two separate lots of helminth parasites that had been collected from sheep and goats in Northwest China, were submitted to the Zoological Division of the Bureau of Animal Industry for examination. Both lots were sent from the Northwest Epidemic Prevention Bureau, Lanchow, China, the first by Dr. P. L. Li and the second by Dr. F. J. Kwong. In the first lot there were 3 vials containing lungworms; one contained the worms recently described by the writer as Protostrongylus gracilis (J. Wash. Acad. Sc. in press) another those described as Varestrongylus sinicus (loc. cit.), and the third contained worms which also appeared to be an undescribed species of Protostrongylus. The males in this vial were characterized by unusually long spicules and the females in this vial were without provaginae.

While preparations were being made to publish the descriptions of these worms, the second lot of parasites, sent by Dr. Kwong, arrived. In this lot there were 2 vials containing lungworms from sheep and goats and in the letter accompanying this material Dr. Kwong stated that the worms were Protostrongylus kwongi, described by Wu, H. W., and Liu, C. K. (Sinensia, 14(1–6); 99–102 (year of publication not given)), and asked that the determination be confirmed. An examination of the contents of the vials showed that they contained 3 different species, one identical with Varestrongylus sinicus, another with the species of Protostrongylus with the long spicules, and a third the specific identity of which remains undetermined. The question now arose as to which of these worms was

P. kwongi. The publication containing Wu and Liu's paper describing *P. kwongi* was not readily available, but a photostatic reproduction of it was eventually obtained. A reading of this article and a comparison of the figures accompanying it with the lungworm material sent by Drs. Li and Kwong show very clearly that so far as the males are concerned the worms with the long spicules are identical with *P. kwongi.* It appears, however, that in their description of the females of *P. kwongi,* Wu and Liu were dealing with different species. On the first page of their article (Sinensia, 14(2) : 99) the authors mention three kinds of females of *P. kwongi,* namely small-sized females, 22.77 to 23.57 mm. long, median-sized females 33.61 to 39.66 mm. long, and large-sized females 46.5 mm.
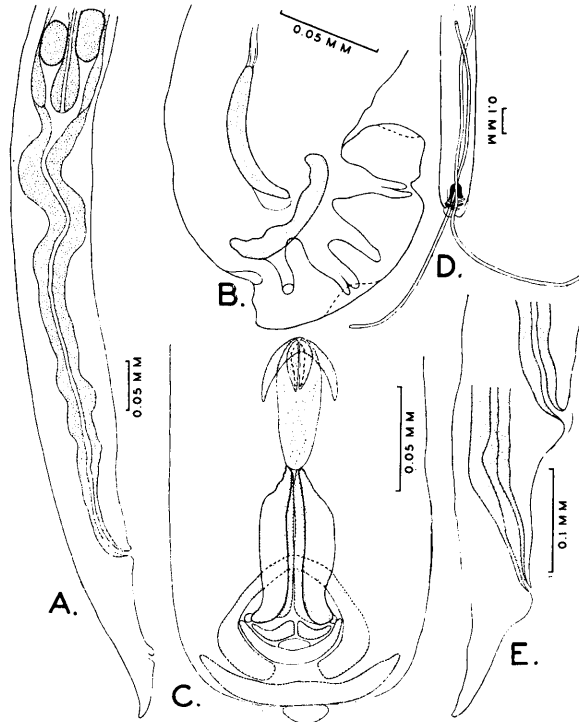
FIG. 1. *Protostrongylus kwongi.* A—Posterior part of female showing length of vagina. B—Bursa, lateral view. C—Gubernaculum, telemon, arcus and dorsal ray. D—Posterior part of male showing length of spicules. E—Posterior part of female showing relative positions of vulva and anus.

long. Vulvular flaps (provaginae?) are stated to be present in all three kinds of females, but on page 100 the authors state that the vulvular flap of the large-sized females has degenerated or disappeared.

Wu and Liu's paper is illustrated by 6 figures. Figure 3 shows the posterior portion of their small-sized female of *P. kwongi* and figure 5 that of the large-sized female. Figure 3 shows a distinct and well-developed provagina and in figure 5 this structure is absent; no figures are present for the median-sized females.

In view of the foregoing and because the publication containing Wu and Liu's description of *P. kwongi* is not generally available in the United States, a brief description of this nematode and a few figures illustrating its salient morphological characters, based on material received from China and deposited in the U. S. N. M. Helm. Coll., is given herewith.

Protostrongylus kwongi Wu and Liu, 1943

Description.—*Male* 30 to 40 mm. long and 0.125 to 0.150 mm. wide. Bursal ray pattern characteristic of genus, namely, ventral rays originating from a common stem, separated in their distal portions, ventro-ventrals somewhat shorter than ventro-laterals. Externo- or antero-laterals separated from both ventral and other lateral rays. Medio- and postero-laterals originating from a common stem, close together and reaching margin of bursa. Externo-dorsals presenting no specially distinguishing features. Dorsal ray mound-like, rounded and presenting some papillae on its ventral surface, their character and number not definitely determined. Spicules 1.6 to 1.8 mm. long, similar in structure and appearance to those of other members of the genus. Gubernaculum 0.140 to 0.160 mm. long, consisting of the usual three parts, namely, capitulum or head, corpus or body and crura or legs. Capitulum and corpus 0.070 to 0.080 mm. long, appearing as light-refracting but completely colorless structures. Crura 0.070 to 0.090 mm. long, heavily sclerotized, dark brown in color and rather massive in structure, distal ends curved ventrally. Chitinous arcs and complicated telamon present.

Female 40 to 45 mm. long and 0.175 to 0.2 mm. wide. Vagina 0.950 to 1.1 mm. long. Vulva 0.220 mm. and anus 0.1 mm. from tip of tail. Eggs in utero 0.1 mm. long by 0.050 mm. wide. Provagina absent.

Hosts.—Sheep and goats.

Location.—Larger bronchioles.

Distribution.—Northwest China.

Specimens.—Hypotype, U. S. N. M. Helm. Coll. No. 45108.

From this description and figures it is clear that the ''large-sized'' female of Wu and Liu is the female of *Protostrongylus kwongi* and that figure 5 of their paper represents the tail end of this female. Their ''small-sized'' female represented by figure 3 of their paper is, in the writer's opinion, the female of *Varestrongylus sinicus*. The identity of the ''median-sized'' female referred to in Wu and Liu's paper remains to be determined.

A new locality record for five species of helminth parasites of the bobwhite quail. J. W. WARD, Mississippi Experiment Station.

During the past four years, 1940–1944, the writer has examined the viscera of 283 bobwhite quail, *Colinus virgianus* and *Colinus virgianus texanus*. The greater part of the birds examined was *Colinus virgianus*. These birds were collected from about 40 of the 82 counties in the state. The study revealed 6 species of worms as infesting quail that have not been reported from Mississippi; 4 of which are nematodes and 2 cestodes. They were *Heterakis gallinae*, *Subulura brumpti*, *Habronema pileata*, *Syngamus trachea*, *Hymenolepis carioca* and *Rhabdometra odiosa*.

Heterakis gallinae was collected from 2 out of 283 quail in the present survey. Venard (1933, Jour. Parasitol. 19: 205) examined 67 Ohio bobwhite quail and reported that 25 of the 67 birds were infested with *Heterakis gallinae*.

Subulura brumpti was collected from 6 out of 283 quail. The maximum number of specimens per bird was 30. All of the birds parasitized by this worm were collected from the same area. At least a part of these were the Mexican variety of quail which had been brought in from Texas. Venard (*loc. cit.*) reports 8 out of 67 Ohio quail as being infested with a related species, *Subulura strongylina*.

Habronema pileata was collected from 2 birds during the present survey.

Syngamus trachea was collected from 1 bird during the present survey.

Hymenolepis carioca was collected from 4 out of 283 birds during the present survey.

Rhabdometra odiosa was collected from 2 of the 283 birds. One bird harbored 3 complete specimens of this parasite and 15 to 20 chains of segments. The other bird harbored four complete specimens and 30 to 40 chains of segments. The 2 birds were collected from the same area.

Leidy (1887, Jour. Compar. Med. and Surg. 8(1): 11) first reported *Rhabdometra odiosa* from *Colinus virgianus*.

Jones (1929, Proc. U. S. Nat. Mus. 75(20:) 1–8) reported this parasite as infesting 7 out of 228 quail examined from Southwestern Georgia and Northern Florida.

A complete list of parasites encountered in the present survey will be published in a subsequent article.

MINUTES

TWO HUNDRED FORTY-FIFTH TO TWO HUNDRED FIFTY-SECOND MEETINGS

The 245th meeting was held October 18, 1944, at the U. S. National Museum. G. F. Otto and Theodor von Brand were elected to the Editorial Committee. Mabelle O. Nolan was elected to membership. Dr. Mollari announced the death of Admiral Butler. Papers were presented by Drs. Yao, Christie, and Bozicevich.

The 246th meeting was held November 22, 1944, at the laboratories of the Zoological Division, Beltsville Research Center, Beltsville, Md. Papers were presented by Dikmans, Doss, McMullen, and Rees.

The 247th meeting was held December 20, 1944, at the U. S. National Museum. The following officers were elected: President, D. A. Shorb; vice president, J. Bozicevich; corresponding secretary-treasurer, Edna M. Buhrer; recording secretary, D. C. Boughton. Mario Mollari was elected the Society's representative in the Washington Academy of Sciences. Papers were presented by Steiner, Price, and Schwartz.

The 248th meeting was held January 17, 1945, at The Catholic University of America. A. O. Foster was elected to a two-year term on the Executive Committee. Papers were presented by Rheinhard, Steiner, Mollari, von Brand, and Rees.

The 249th meeting was held February 20, 1945, at the U. S. National Museum. Glenwood C. Roe, John R. Collins, Minnie S. Trowbridge, and Randall R. Kincaid were elected to membership. Papers were presented by Foster, Enzie, and Chitwood.

The 250th meeting was held March 21, 1945, at the U. S. National Museum. A letter from the Society to Dr. Brumpt was approved. Papers were presented by Andrews, Byrd, and Kemp.

The 251st meeting was held April 18, 1945, at the National Institute of Health, Bethesda, Md. Papers were presented by Kellanby, Brady, Cowie, and Dawton.

The 252nd meeting and annual picnic was held May 19, 1945, at the Bureau of Plant Industry Station, Beltsville, Md. Mildred A. Doss was elected Recording Secretary to fill the unexpired term of D. C. Boughton. Eleanor V. Basson and Daniel S. Jaquette were elected to membership.

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ERRATUM

The running head for Vol. 12, No. 1 was erroneously printed Vol. 12, No. 2.