T H E S I S.

presented in support of the candidature of

THOMAS W. M. CAMERON, M.A.,B.Sc.,

for the degree of

DOCTOR of PHILOSOPHY

of

THE UNIVERSITY OF EDINBURGH.

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1. Studies on the Parasites of Stock in Scotland.

   (a) On the Intestinal Parasites of Sheep and other Ruminants in Scotland.

   (b) The Anatomy of Monodontus trigonocephalus.

   (c) Observations on the Biology of the Infective Larva of Monodontus trigonocephalus.

2, On two new Genera and some new and little known species of the Nematode Family Trichostrongylidae Leiper.

Degree conferred 12th July, 1923

ON THE INTESTINAL PARASITES

OF

SHEEP AND OTHER RUMINANTS IN SCOTLAND.

INTRODUCTION.

Among all the domesticated animals, sheep suffer most from parasitic diseases and authorities are agreed that the steady loss to the country of sheep, mutton and wool is due mainly to animal parasites. The almost complete lack of knowledge of ovine parasites in Scotland prompted this enquiry, as until the species of parasities present and their distribution were known, little could be done to attempt a solution of the many questions of their life histories and the diseases they produce.

During the investigation, occasional opportunities were found to collect helminths from cattle and goats. These are noted under the various parasites. The chief point of outstanding importance was the occurrence of Monodontus trigonocephalus in cattle.

As a basis for comparison, it was decided to investigate and classify only the parasites of apparently healthy sheep slaughtered for food purposes.

Technique.

As the writer had to depend on the courtesy of the officials in charge of the slaughter houses, butchers and others, for his material, a technique had to be adopted which would not only cause them the minimum of inconvenience but would do no harm to the intestines which form a valuable by-product. The small intestine was detached from the large intestine (including the caecum) and cleaned separately. A number of pails were filled with water and the contents of the intestine forced into these by running the viscus between the fingers. This expelled all the parasities with the other material into the pail. A number of intestines treated thus were opened and found to be completely empty and it is assumed accordingly that all were emptied. In case of doubt a stream of water was run through the intestine, and collected. The large intestine was easily everted and the contents washed into a pail. Trichuris ovis could then be picked off the exposed mucous membrane.

The contents of the pails were sedimented and decanted several times, usually about six, but depending largly on the nature of the intestinal contents. The residuum was finally stirred with water and passed through a nest of sieves. This nest was constructed on the lines of that used by Hall (1917) .It contained six sieves, 8" square, constructed of copper sides with copper gauze

bottoms, the meshes being 3,6,10,16,20,and 60 to the inch from the top downwards. The sieves were housed in a square oak framework and any one could be pulled out without disturbing theothers. At the bottom was a solid tray(not used in the present investigations) to collect eggs. The whole apparatus was contained in a wooden box with a handle.

The sieves were assembled and the contents of the pail agitated and poured in at the top. They were allowed to drip and a pail full or two of water was gradually added to wash away debris. The coarse sieve at the top was mainly useful in retaining Cestodes and hard unbroken faeces.

Each tray was removed in turn and emptied into a large photographic dish. The nematodes were picked out on a needle and fixed by dropping into hot alcohol and glycerine. They were examined in glycerine after evaporation of the alcohol.

That the sieves were effective in retaining all the parasites is shewn by the fact that Nematodirus larvae were retained in the bottom tray (60 mesh) while Strongyloids was retained by the last but one (20 mesh)

The parasites of cattle were collected in a similar matter,but owing to the large amount of intestinal contents only a few animals could be dealt with at any one time. Goats were only met with occasionally and were treated individually.

The Endo-parasitic Fauna of Sheep in Scotland.

The following list of parasites was prepared from material collected from sheep slaughtered at the Edinburgh abattoir during the twelve months ending September 1922. During this period some 700 sheep were examined.

TREMATODA.

Fasciola hepatica can be found at all seasons of the year. It was the only fluke found by the author although careful search was made for Dicrocoelium dendriticum. F.hepatica occurs also in goats and cattle in Scotland.

CESTODA.

Moniezia expansa and M. planissima were the only two tape worms occurring at Slateford. Flatterly has recently (1922) reported M.trigonophora and M.alba from sheep in Britain, but although a large number of tape-worms was obtained and examined, only M. expansa and M. planissima were found by the writer. Ripe proglottides of these two species can be obtained throughout the year although the heaviest incidence is in Spring and Summer. The number of specimens in a single host varies, in most cases only one worm is found, but in one healthy lamb killed at Turriff seven complete Monieziaswere found.

NEMATODA.

Ascaris ovis.One specimen of this species, an immature female, was recovered at Slateford in May 1922. It does not differ in any way from A. lumbricoides in man and the pig. It is generally accepted that we are dealing with A.lumbricoides in an unusual host.

Trichuris ovis This is a comparatively common worm in Scotland occurring at all seasons of the year, but seldom are more than three or four specimens found in a single host, It is by no means so common in Scotland as it appears to be in England (Boulenger 1914.)

Capillaria longipes. Six specimens of this parasite were collected in January 1922 and one in May of the same year. It had previously only been recorded by Ransom(1911) in America.

Strongyloides papillosus. This worm appears to be of infrequent occurrence in Scotland and has only been found twice in this series.

Haemonchus contortus has been found on various occasions in the Lowlands, and has also been found in goats on the Pentland Hills.

Ostertagia circumcinta and O.trifurcata were usually found in association with Haemonchus but always in small numbers.

Cooperia curticei. This was only species of Cooperia found. It is a fairly common parasite in Scotland. It has not been reported from England, Boulenger in 1914 recording only C.oncophora. This latter species does not seem to occur in Scotland. C.curticei also occurs in Scottish cattle.

Trichostrongylus vitrinus, T.extenuatus and T.instabilis occasionally occur but always in small numbers.

Nematodirus filicollis and N.spathiger. This is the commonest genus of Trichostrongylidae in Scotland. Large tangled masses of the worm frequently occur in which one can distinguish males of both species. As the females are indistinguishable from each other, it is impossible to give their relative frequency but from a comparison of the males, they seem to be present in about equal numbers. In spite of the large numbers found, they appear to possess but little pathogenicity.

Oesophagostomum venulosum is not uncommon parasite of the large intestine of sheep in which it seems to cause no harm, either local or general. O.colombianum, the cause of "Nodular disease", has not been found in Scotland, although O.radiatum, the cause of bovine Nodular disease, was occasionally found in cattle at Slateford.

Chabertia ovina is an infrequent parasite of the large intestine of the sheep and goat.

Monodontus trigonocephalus, contrary to the view prevailing in the text books, is of constant occurrence in Scotland. On every occasion on which collections were made, this parasite was found.

On four occasions this species was found in Cattle slaughtered at Slateford. The numbers in these cases were 14,26,28,and 37, specimens respectively. This parasite has not been previously reported from cattle. Its occurrence in this host is of special interest as the accepted bovine species is M.phlebotomus.This latter was not found in Scotland M.trigonocephalus is also found in the goat, several examples having been collected from these animals on the Pentland Hills.

SEASONAL DISTRIBUTION.

Collections were made periodically at Slateford from sheep slaughtered for food. At each visit 30 sheep were examined. The collections were made as a rule weekly or fortnightly; but for the sake of convenience the average for each month has been taken. In all about 700 sheep were examined. As these were drawn from all parts of Scotland they may be regarded as giving a fair indication of the seasonal variation for the whole country.

	Monodontus trigonocephalus	*Ch. ovina*	*Oes. venulosum*	*Nematodirus* spp	*Cooperia curticei*	*Trichuris ovis.*
January	130	1	2	66	15	6
February	28	-	-	3	-	-
March	99	2	2	2	3	1
April	92	2	1	31	2	4
May	80	-	9	109	1	1
June	86	4	10	203	16	15
July	155	1	-	91	3	6
August	98	3	-	35	1	3
September	139	3	11	71	-	11
October	81	-	1	-	-	4
November	66	-	-	75	-	1
December	112	-	6	76	2	19
Average per month	97	1	3.5	60	3.5	5
Average per sheep examined	3	-	-	2	-	-

Owing to their infrequent occurrence the other parasites are not included in the table. Although cestodes were continually met with, it was impossible to ascertain their numbers as the heads were usually absent and the remainder of the strobile broken into pieces.

It will be noticed that by far the commonest parasite found is Monodontus trigonocephalus. In this specices copulating forms were practically limited to May and June; during the latter month nearly all the specimens found were in copula.

Nematodirus spp is very common and can usually be found in tangled thread-like masses. Cooperia curticei is also of frequent occurrence but its numbers are never very large. The other nematodes vary greatly, but none were ever found in large numbers.

Geographical Distribution.

The heavy incidence of hookworm recorded from Slateford raised the query as to the source of the parasite. The known pathology of the allied worms in man and the dog suggested that this worm might be of considerable econmic importance in the sheep. Accordingly it was thought desirable to attempt to trace the locus of the infection. For this purpose Scotland may be divided into the following nuteral regions. (Map 1)

I Southern Uplands with

(a) S.W.Costal plain

(b) S.E.Costal plain

II. Lowland belt and Fife.

III. Central Highlands.

IV N.E. Costal plain

V. Northern Highlands.

VI N. Costal plain.

Each district is more or less self contained but within each there is a constant interchange of sheep. Accordingly it was assumed that if a flock in any district could be shewn to harbour the parasite, the whole district could be regarded as infected. In each area a central town was selected (Map2) and visited. Local sheep were examined at the various slaughterhouses. Only sheep which were known to have been born and fed in the district were of use. This increased the

difficulty and lessened the number of sheep available for the enquiry but the willing assistance of the local authorities helped to overcome this.

The following were the towns visited and the result of the examination in each case:-

Northern Highlands	16/8/22	Kyle	S(19M)
	15/8/22	Wick	S(4M)(3 M; 6 Ch.) (21 M; 2 Ch.; 60es.)
N. E. Plain	10/8/22	Turriff	S(4 M)(7 M)(9 M)(9 M s(1 Moniesia)(21 N)(? N)
Central Highlands	14/8/22	Inverness	S(6 M)(8 M)
	8/8/22	Braemar	S(6 M)(None)
	14/1/22	Perth	S(13 M)(16 M; 4 Ch.)
	18/8/22	Fort William	S(7 M)(10 M)
	21/8/22	Inveraray	S(10 M)(10 M)(10 M)(11 M
Fife	5/8/22	St Andrews	S(6 M)(7 M)(15 M)(14 M)
Lowlands	6/2/22	Glasgow (Lanark)	S(15 M)(17 M)(23 M)
	22/8/22	Stirling (Central)	S(31 M)(21 M)
	2/19/22	Edinburgh (Pentlands)	S(7 M; 3 Ch.)(16 M; 1 CH
Southern Uplands	1/9/22	Hawick	S(8 M)(9 M; 4 Ch.)(s(1 HC)
	4/9/22	Selkirk	S(5 M; 1 Ch.)
S.W.Plain	10/7/22	Maybole	S(16 M)
S.S.W "	12/7/22	Stranraer	S(5 M)(6 M)(None)
S.E. "	4/19/22	Berwick	S(4 M)(19 M)

(Each pair of brackets represents one animal and the figures the number of parasites recovered from it .
M.= Monodontus; Ch.= Chabertia; N,= Nematodirus;
H.C. = Haemonchus; S= Adult Sheep; s = Lamb.)

In addition the following places were visited or specimens previously collected at these localities were placed at the writer's disposal by Professor Ashworth.

Arrocher	s(30 HC)(14 HC; 8 Ostertagia)(10 HC; 6 OST.) (14 HC; 20 Ost.)
St Mary's Loch.	s(21 HC; 16 N; 7 Ost.)
Roxburgh	s(3 HC)
Bangour	? M; Ch; Ostertagia.
Kelso	? M; Ch; HC; Ostertagia.

40 sheep were examined in this part of the enquiry; of these 38 harboured hookworms. The maximum number in any one sheep was 31, while the average figure was 10.5. All of these were healthy sheep slaughtered for food purposes. In the 12 lambs examined here and 18 examined at other times no specimens of Monodontus were found.

The results of this examination are plotted on Map 3.

In every district Monodontus trigonocephalus was found, and there can be no doubt that it is not confined to any one spot but occurs all over Scotland.

Conclusions and summary.

1 From an examination of over 700 sheep of Scottish origin, a list of the parasites found in the intestinal tract has been prepared.

2 The commonest parasite found is Monodontus trigonocephalus, a worm which occurs also in goats and cattle. This parasite can be found at any season.

3 Nematodirus spp. also is extremely common during the warmer months.

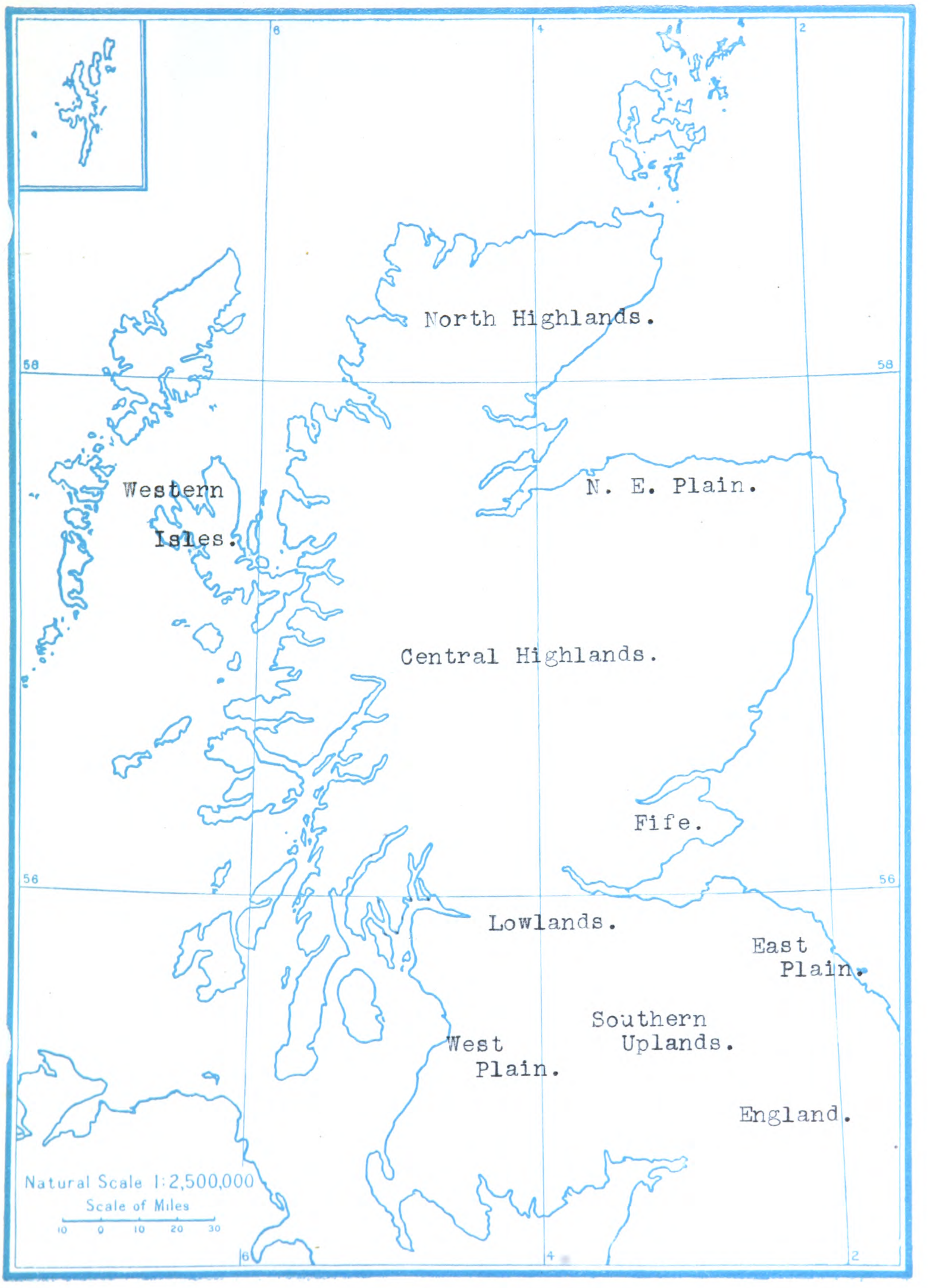
4 From a systematic geographical examination of sheep it has been ascertained that Monodontus trigonocephalus occurs in every district in Scotland; and of 40 sheep examined in this part of the enquiry, 38 were found to be infected. 30 specimens have been recovered from an apparently healthy sheep, but usually the number is much smaller (7-10).

Acknowledgements.

The present investigation was undertaken with the financial assistance of the Moray Trust of the University of Edinburgh.

The writer has to acknowledge his indebtedness to Mr J. Howard Jones, Veterinary Superintendent of the Slateford Abattoir, for permission to use the slaughter house for collecting and the veterinary laboratory for preservation purposes. He has also to thank Dr Hesse for assistance in the actual collecting and Professor J. H. Ashworth for advice and encouragement during the enquiry.

DISTRICTS of SCOTLAND



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TOWNS VISITED

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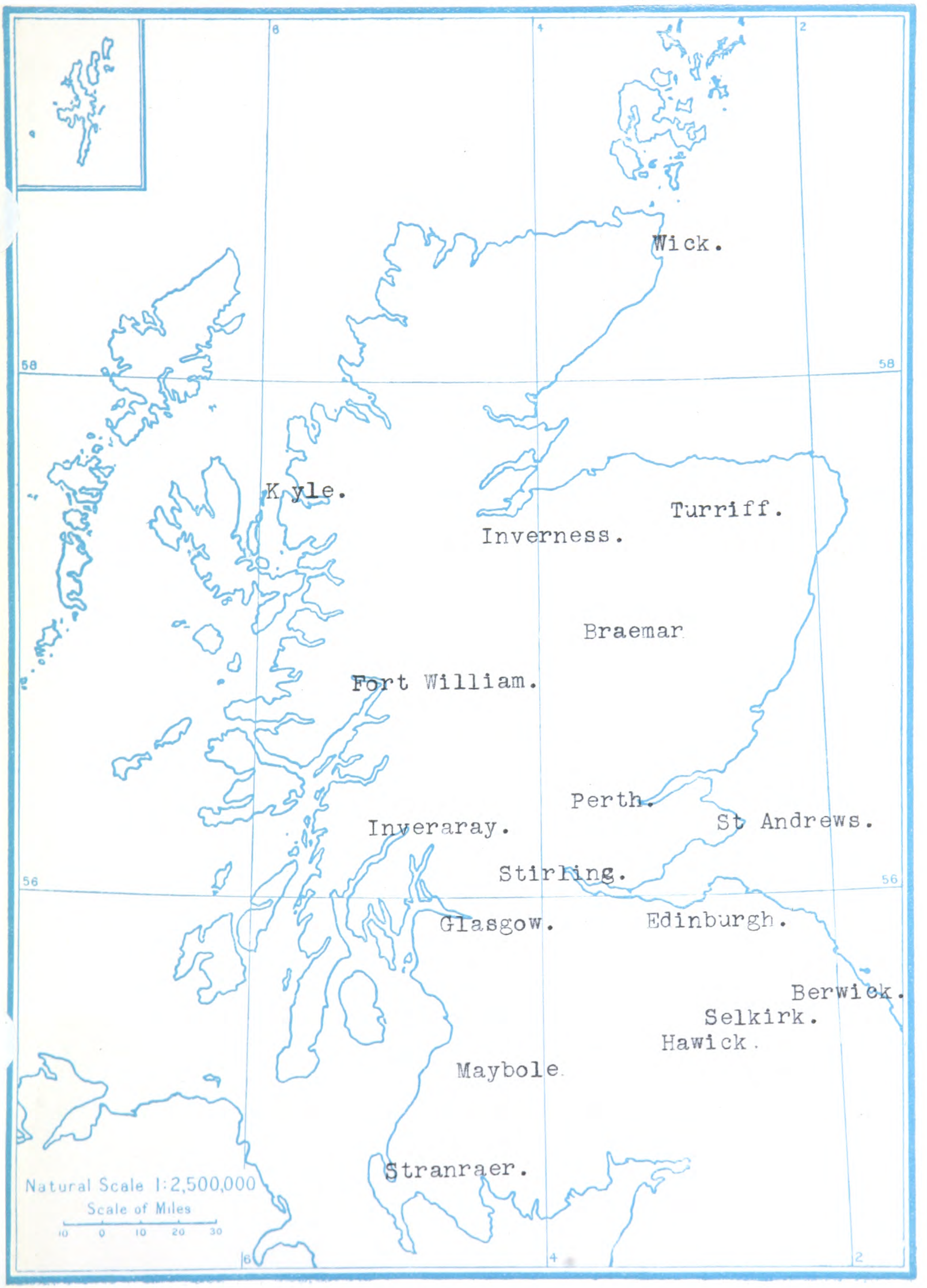

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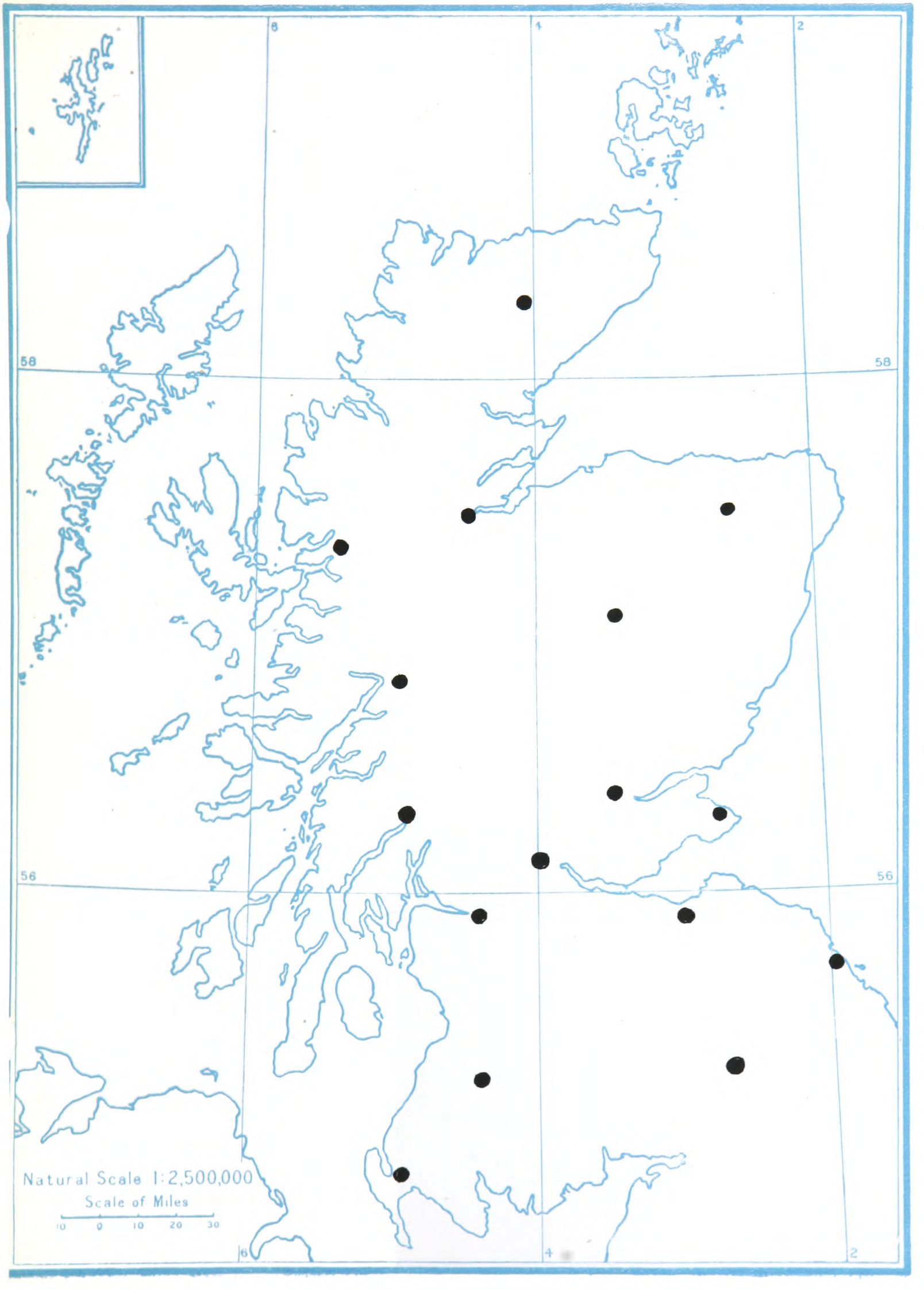
DISTRIBUTION of BUNOSTOMUM TRIGONOCEPHALUM
in
SCOTLAND



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REFERENCES.

BOULENGER, C.L. 1914 A list of Nematode Parasites observed in the Alimentary Canal of Sheep in England.

Parasitology, VII, p200-249

CAMERON, T.W.M. 1922 New Records of Nematodes from Sheep and Cattle in Britain.

Vety. Jl. LXXVIII, p185.

FLATTERLY, F.W. 1922 Considerations on the Life History of Tapeworms of the genus Moniezia.

Parasitology, XIV, p 268-282.

HALL, M.C. 1917 Apparatus for use in examining feces for evidences of parasitism.

Jl. Lab. and Clin. Med., II, No 5.

RANSOM, B.H. 1911 The Nematodes parasitic in the Alimentary Canal of Cattle, Sheep, and other Ruminants.

Bur. An. Ind., Bull. 127.

THE ANATOMY
of
MONODONTUS TRIGONOCEPHALUS.

The Anatomy of MONODONTUS TRIGONOCEPHALUS(Rud.)Railliet.

CONTENTS.

Nomenclature.

On the specific name

In 1802, Rudolphi described Strongylus trigonocephalus from material labelled as coming from the Dog. This worm according to Railliet is identical with the worm found in sheep. It has never since been reported from the dog so that we may assume that the bottle was wrongly labelled. Creplin in 1829 was the first to describe it from the sheep under the name of Strongylus cernuus. In later years it was frequently confused with the worm now known as Chabertia ovina (Syn S. hypostomum Rud). Dujardin and Diesing for example, included both forms in Rudolphi's species. It is now recognised on the authority of Railliet (1900) that S. cernuus and S. trigonocephalus are synonyms and consequently the latter name having priority, becomes the true specific name.

On the generic name

In 1861. Molin created his new genus. Monodontus, with two speices Wedlei and semicircularis. The first named was from the sheep and is obviously a synonym of S. trigonocephalus Rud. No type however was mentioned. In 1895, Railliet speaking of trigonocephalus says "Molin had made of it, not without some reason, the type of a distinct genus (Monodontus)" --------- (Molin en avait fait, non sans quelque raison, le type d'un genre à part (Monodontus)-----)
In 1899= Stiles and Hassell, in speaking of a new species

of Uncinaria, cite as a generic synonym:-"1861 Monodontus Molin-----Type M. semicircularis."In 1905, they explain that this was because Molin had created his genus mainly from his second species. However, under the International rules of Nomenclature, a type species, once designated, even if designated by a subsequent author, is valid. There is no doubt that Railliet had designated Wedlei, now known as trigonocephalus as type of the genus Monodontus, before Stiles and Hassell and accordingly it must stand.

In 1902, Railliet changed the name Monadontus to Bunostomum on the ground that Monodontus ressembled the previously occupied genera Monodononta and Monodon. This change is invalid

In 1905, Railliet split the genus into two new genera Bunostomum(type trigonocephalum) and Eumonodontus (type semicircularis). The genus Bunostomum is a synonym of Monodontus. The species semicircularis however differs from the type of Monodontus in the symmetry of the externo-dorsal rays. This is obvious not only from Molin's figure but from his description of Wedlei,where he points out that the asymmetry of the externo-dorsal ray in that species is characteristic. In his figure of semicircularis he draws this ray symmetrically and makes no mention of any asymmetry in the text. There is no doubt that this asymmetry is a generic characteristic and accordingly we must admit the genus Eumonodontus Railliet (type E. semicircularis) as valid.

Monodontus trigonocephalus.(Rud) Railliet 1900.

Synonyms:-

Strongylus trigonocephalus Rud,1808

Strongylus cernuus Creplin, 1829

Sclerostoma hypostomum (Rud) Duj,1845 (pp)

Dochmius hypostomum (Rud) Dies,1851(pp)

Monodontus Wedlii Molin, 1861.

Dochmius cernuus (Crep) Balliet,1868

Uncinaria cernua (Crep) Railliet, 1885

Strongylus (Monodontus) cernuus (Crep) Railliet,1900

Uncinaria (Monodontus) cernua (Crep) Railliet,1900

Monodontus trigonocephalus(Rud) Railliet,1900

Bunostomum trigonocephalum (Rud) Railliet,1902

Bunostomum kashinathi Lane,1917

Hosts:-

Ovis aries (Sheep)

Capra hircus (Goat)

Bos taurus (Ox)

Habitat:- Small Intestine.

Distribution:- Scotland (Cameron) England (Boulenger)

India (Lane) Europe(Molin and others) Africa (Gedoelst)

Since Looss described in detail the anatomy and histology of the type species of the Family Ancylostomidae no attempt has been made to study comparatively any of the other genera of this group.

From its economic importance as a little known, tho' frequent, parasite of ruminants and its scientific importance as type species of the second sub-family of the Ancylostomidae, Monodontus trigonocephalus has been selected for description.

The lines laid down by Looss in his classical study have been closely followed, Many points in the two species have been found to be identical and as no useful object would be served by re-describing these points, differences only have beeb described in detail while resemblances have been merely noted. In this way it has been possible to greatly shorten the paper without it is hoped reducing its value.It is of course understood that the following description should be read in conjunction with Looss' work on Ancylostoma duodenale.

Technique.

The technique described by Looss on his various works on the Strongylidae was used. The specimens were killed in hot alcohol and glycerine. It was found however that Lacto-phenol was a better clearing agent than glycerine. Some specimens kept it this fluid for t three years were absolutely unchanged and the details could be made out with the greatest ease. In a few cases beechwood creosote was useful- as for spicules, bursal muscles and oesophageal glands, Sections were stained with eosin-haematoxylin. Dissections were made with sharpened needles under the binocular microscope.

MATERIAL.

All the material used for this enquiry was obtained from sheep killed in Scotland. It was mostly collected at Slateford Abattoir and the writer has to thank Mr J. Howard Jones, M.R.C.V.S., for the valuable facilities given him for collecting and preserving the parasites.

The material for M. phlebotomus was obtained partly from Professor Warrington Yorke, through Professor Leiper. The writer would take this opportunity of expressing his great indebtedness to Professor J. H. Ashworth and Professor R. T. Leiper for advice, criticism, and laboratory and library facilities offered him in this study.

External appearance and shape of the Body.

Length.

Ransom (1911) describes the male as 12 to 17 mm long and the female as 19 to 26 mm long. All the specimens examined were within these limits, the maximum observed being 16.5 mm for the male and 26 mm for the female. As the great majority of the parasites were between 14.5 and 15.5 mm. in the male, 22 and 24 mm. in the female, the average sizes of 15mm and 22mm. respectively were taken as standard and all subsequent measurements refer to worms of these lengths.

Thickness.

The thickness of the male is about .45 to .50mm and of the female .48 to .75 mm.

Colour.

The colour of Monodontus trigonocephalus is normally a translucent flesh colour, but occasionally dark-brown specimens are obtained—the pigment coming presumably from ingested blood.

Shape.

Apart from their greater length, these worms are similar in shape to Ancylostoma. Like Ancylostoma also, they shew the same longitudinal torsion and when placed on a slide with the dorsal aspect of the cephalic opening facing upwards the posterior extremity is

displaced laterally.

Cervical Papillae.

Cervical papillae similar in shape to those present in Ancylostoma lie laterally just anterior to the middle of the oesophagus.

Prebursal and Caudal Papillae.

Prebursal papillae in the male and caudal papillae in the female are present but in neither case do they reach the surface of the cuticle.

Posterior end of the Body.

In the female, the slight dorso-ventral compression posterior to the anus observed by Looss in Ancylostoma is also evident. The termination ends in a sharp point, but the body substance never projects through the skin, although occasionally projections into the skin may be observed. The truncated appearance in Ransom's figure is due to shrinkage and is not so obvious in the unfixed specimen. Figure 5A shews the average outline.

In the male there is a tendency, less marked than in Ancylostoma, to become quadrangular. A large genital cone is present.

Shape of Bursa.

The bursa is closed on all sides and the dorsal lobe is only slightly developed. The lateral lobes are continuous ventrally. The dorsal lobe is always asymmetrical and on the right of the middle line. This is shewm in Figure 8

Rays.

In general these rays follow the plan seen in Ancylostoma

The Dorsal Ray.

The Dorsal ray arises in a smallish dorsal trunk. Near its termination (at a varying distance) this ray splits into two diverging branches -both of which are directed towards the right lateral lobe. Each of these branches ends in a double or triple point. These terminal digitations vary both in size and number but there is never found an arrangement similar to that in Ancylostoma. Like that species however, each branch terminates in only one small papilla on the inner surface of the bursa.

Externo-dorsal.

These rays always rise asymmetrically. In several hundreds examined, the right ray has always been given off nearer the base of the dorsal ray. The left externo-dorsal ray is given off at a varying point between the right and the proximal portion of the left diverging branch of the dorsal ray. In some cases it is given off by this branch, in other cases in common with it; in most cases it is given off by the dorsal ray a short distance anterior of the diverging branches, but in a few examples, it arises just posterior of the right externo-dorsal. It is always asymmetrical, but its variable point of origin indicates a degree of plasticity which probably can be associated with recent evolution. Too much stress

should not be put on this point in classification.
Thr two externo-dorsal rays are unequal in length but always terminate about the same level in small papillae on the external surface of the bursa.

Ventral rays.

The ventral rays, are the first to branch off from the main stem of the lateral trunk. They are slender rays divided only in their distal two-thirds but both continuing to run close together and terminating on the internal surface of the bursa.

Lateral rays.

The next ray to be given off is the externo-lateral. This is a stout ray diverging from the other laterals and curving in a ventral direction. It terminates in a small papilla on the exterior of the bursa. The medio-lateral and posterio-lateral rays , diverge slightly from each other but as both are curved in a dorsal direction this divergence is not so evident as their divergence from the externo-lateral. These two rays terminate in small papillae on the internal surface of the bursa.

The Skin.

The skin is very similar ot that of A. duodenale. The average thickness is about .04mm but it becomes very quickly thinner anterior to the cervical papillae. Over the buccal capsule it is about .008mm in thickness. The whole body is finely striated transversely. Unlike Ancylostoma, these striations continue on to the cephalic cuticle - where however they become very faint andcan only be seen under an oil-immersion lens. The post-anal region of the female is striated excent for a very small area at the tip. The bursa is formed as in Ancylostoma and is finely, though irregularly, striated transversly. The skin consists of the same layers as noted by Looss and both layers are striated. The "Chitinous Rod" of Looss is present and terminates posteriorly as in Ancylostoma. Its anterior limits could be found.

The Subcuticle and Lateral Bands.

These are disposed excatly as in Ancylostoma.

The Cephalic Glands.

These are by no means so conspicuous in this species even when alive, as in Ancylostoma but otherwise they are identical. They are best seen in specimens cleared in Lacto-Phenol.

The Musculature

Cephalic muscles.

Dorsal.

Four dorsal pairs of cephalic muscles are seen in cleared specimens. A fifth can be seen in transverse sections. The ventral arrangement is similar.

Cephalo-oesophageal.

A dorsal and a ventral pair of cephalo-oesophageal muscles rise from the oesophagus about the region of the nerve commissure and run anteriorly. Each muscle appears to be double.

Other Muscles.

The other muscles noted as being similar to Ancylostoma duodenale are:-

Intestinal muscles

Anal muscles in female

Vulvar muscles

Spicular muscles

Bursal muscles.

The Body Cavity.

Like Ancylostoma, the body cavity contains an albuminous fluid. It is sometimes pink in colour - presumably from the intestinal contents. Strands of a fibrinous substance of unknown significance are also found.

The Digestive Tract.

The Buccal Capsule.

The buccal Capsule consists of a single ~~chitnous~~ piece of "chitin"(It should be noted that this substance has not the same composition as the "chitin" of the arthropods as when treated with Caustic Potash it disolves) The form of the mouth capsule is slightly variable- the more usual shape being illustrated in fig. 1 but longer or shorter specimens are seen. It is seen to resemble an inverted cone, the base of which is oval with a maximum dorso-ventral diameter. In an average specimen the height of this cone is ·1 mm. but variations are frequent and may give an elongated or a rounded appearance to the capsule when viewed in profile. The chitinous wall is not of a uniform thickness- the maximum thickness being at the base of the capsule. The wall becomes thinner progressively forwards. From the chitin in the mouth opening, two ventral "dental plates" project into the actual opening. These have smooth sharp free cutting edges. Similar but smaller and non-cutting projections are apparent at the dorsal edge of the mouth opening. The dental plates have no ribs and no teeth and are absolutely smooth. They accordingly differ from Ancylostoma duodenale in a number of very important points. They project into the mouth opening with sharp cutting edges, they have no

ridges, and they have no teeth. They must be looked upon as having evolved thro' rather different lines from Ancylostoma. Both may be regarded as descending from a common ancestor possessing teethless non-projecting and non-cutting plates. In the one sub-family these have evolved projecting teeth while remaining themselves non-projecting. In the other sub-family they have become projecting and instead of secondary teeth have become themselves cutting and undivided. The genus Agriostomum, when better known, may represent a third but parallel evolutionary series.

From the inner lateral walls of the capsule, near the opening into the oesophagus, project two small cutting lancets. There are much more pyramidal in shape than in Ancylostoma, but variations are frequent They may be bifid or even square. In some specimens a smaller pair of sub-ventral lancets are found on the lateral walls of the capsule. Their disporitions in two specimens dissected to shew this point are figured. (Pl. 2) These lateral lancets vary in size and the specimens in which they are found are absolutely typical, This shews conclusively that a new species cannot be formed on this point. In M. phlebolomus they are present also but are much larger. In that species however, other more reliable differences are found.

The anterior edge of the buccal capsule is formed not of chitin but of skin and is oval in outline, the dorso-

ventral diam; being larger. The sinuous outline of the chitinous framework can be seen through this skin. As already noted this projects in four places. The cuticle surrounds the mouth and is thickened to form a pad which becomes filled with a granular substance between the two cuticular layers, the inner of which adheres closely to the chitinous framework. A cephalic-oesophageal ligament connects the mouth capsule to the oesophagus.

On the porterio-dorsal aspect of the buccal capsule is the opening of the oesophagal funnel. At the dorsal edge of this the opening of the dorsal oesophageal gland is found. The duct instead of continuing parallel to the buccal wall as in Ancylostoma, projects into the interior on a papilla—the so called "dorsal tooth". The duct opens near the tip of this tooth on its ventral aspect. The significance of this arrangement is not understood. The size of this tooth and the angle at which it rises is subjected to slight varations. Ransom (1911) has noted that the length of its dorsal edge is always less than the distance between its tip and the mouth opening. Although the size of the tooth varied, this relationship was found to remain true.

The oesophagus.

The size and shape of this organ are shewn in Figure 6A. The length is about 1.3mm. and the maximum breadth is .25mm. The oesophageal funnel is a single piece of chitin. Its buccal margin is more or less round (Fig. 3) but is somewhat variable in shape; and projections immediately posterior to the lancets are occasionally found directed into its lumen. The oesophageal margin is triradiate. The chitinous lining (Fig. 3A) differs in shape from A. duodenale. Its lumen is similar but the external chitinous thickenings differ.

Three rudimentary oesophageal valves are found posteriorly. The musculature is, like Ancylostoma, of two kinds - marginal and ordinary.

Three longitudinal nerve fibres are found in the substance of the oesophagus. There are three oesophageal glands - a dorsal and two latero-ventral. The apertures of the latero-ventral glands occur in the chitinous lining of the oesophagus about the level of the nerve ring. That of the dorsal gland is in the dorsal "tooth". Each gland consists of a median and two lateral trunks - the latter giving off numerous internal ramifications. The nuclei lie in the posterior valvular region of the oesophagus.

The Intestine.

Like Ancylostoma, the intestine is a single organ composed of an inner and an outer layer of cells - some of the inner

layer being pigmented.

In both sexes the intestine terminates in a short rectum surrounded by a voluminous rectal ligament.

The intestinal contents are generally of a light pinkish colour, but occasionally are dark brown.

The rectum in the female (Pl. 5A)

The rectum is a chitinous tube about .2 mm. long. This tube has a slight dilation on its dorsal wall similar to that in A.duodenale. In addition in the posterior portion there may be an inconstant small dorsal dilation. The posterior chitinous plate is more posterior than in Ancylostoma and is continued into the postanal cuticle. The ventral portion is also larger, although smaller than the dorsal.

The anterior portion of the rectum, and its remaining structures are as in Ancylostoma.

The Excretory apparatus and the crevical glands.

The excretory pore lies on the ventral side slightly behind the nerve ring. The excretory apparatus and the cervical glands are identical with Ancylostoma.

THE GENITAL ORGANS.

The Male.

The male genital organs follow the same plan as in Ancylostoma and only differ from it in smaller details. The testis is about 1¼ to 1½ times the whole body length. The testicular coils never surround the intestiral tube but zig-zag backwards and forwards. The seminal vesical is about 1 mm long and joins the cement gland by a short tube i.e. as in Ancylostoma, not as in Necator (Fig. 4C) The cement gland is about 3.3 mm long.

The Spicular Apparatus.

The spicules are .65 mm long and are equal in size. They differ considerably from those if A. duodenale. The free end of each terminates in a spatulate point(Fig. 6) This terminal portion consists of almost transparent chitin supported by two -sometimes three - dark chitinous ridges, which under a low power give the point a bifid or even trifid appearance. The point is easily broken by pressure. The spicules are not straight but form a double S in outline. They lie close together at their distal ends, which are both turned to the same side -either left or right; but are usually separated proximally. They normally do not overlap but after the worm has been "rolled" several times, an ovrelap may be found. The proximal end of the spicules is a long open oval into which the spicular pulp passes.

In cross section the spicules are round. Transverse ridges are absent but sculpturings are present.

Each spicule is enclosed in a spicular sheath. This is attached to the rim of the oval referred to above. Near the distal end of the spicules, it unites with the sheath of the other spicule and continues thus, terminating blindly just beyond the free end. This sheath is conspicuously transversely striated. When the spicules are extruded this sheath accompanies them. The gubernaculum, referred to by Looss as being embedded in the dorsal wall of the spicular canal, is absent in Monodontus.

The Genital cone.

The genital cone in Monodontus is a conspicuous structure and projects considerably above the floor of the bursa. Thecloacal opening is subterminal. The apex of the cone is ornimented with cuticular swellings. The remaining portions of the male genital apparatus are shewn in Figs. 7

The Female.

The female genital organs consist of the same elements as in Ancylostoma. Their general arrangements and sizes however differ somewhat. The overies are disposed in a similar manner but have few coils in the region of the vulva.

The uteri both run a similar course and only one will be described. The ovary passes by a very short oviduct- little narrower than itself- into the terminal portion of the

uterus which is modified to form a receptaculum seminalis This lies dorsally and runs in a direction away from the vulva. It passes insensibly into the functional uterus containing fertilised ova. The tube turns through a right angle and running ventrally for some distance passes obliquely to the dorsal surface (Fig.4) It runs in a straight line to about the level of the vulva, turns sharply on itself and, still dorsal, runs parallel to the first portion for some distance. Again passing ventrally it turns through a right angle and continues towards the vulva. The terminal portion is modified to form an ovejector, Like Ancylostma, this ovejector may be divided into two portions -a relatively long pars haustrix and the shorter pars ejectrix. In internal structure also it is similar but externally it is a smooth tube- the bulgings seen in Ancylostoma being absent. The vulva is a broad lateral slit without lips. It leads into a short S-shaped vagina , which is however somewhat larger than in Ancylostoma.A nerve encircles the junction of vagina and ovejectors.

The course of the uterus is best studied in fresh specimens. In these the gap between the two uteri-only crossed by the intestine, ovejector and two strands of ovary ,is very conspicuous.

The nervous system

Like Ancylostoma the "brain " is situated on a fibrous commissure (the"nerve ring ") just anterior to the excretory pore. This ring has a decided dorso-ventral tilt—the dorsal side being the higher. Associated with it may be seen the five ganglia found by Looss- the ventral and the two sets of lateral. A large ventral and two large lateral nerves, and a small dorsal nerve similar to Ancylostoma were seen but the finer nerves seen by Looss could not be made out with certainty. Large anal ganglia are present in both sexes and the nerves running into the bursal rays in the male are similar to those in Ancylostoma.

Bunostomum Kashinathi.Lane 1917.

This species has been described by Lane as occurring in the goat in India. He differentiates it from the type species on a number of very small points as follows.:-

B. trigonocephalum.	B. kashinathi.
a. Mouth cavity longer than broad.	Mouth cavity generally globular.
b. Dorsal edge of Dorsal tooth almost parallel. to cephalad part of dorsal boundry of the oval capsule.	Dorsal edge set at an acute angle.
c. Ventrad edge of dorsal tooth in same line as fundus of oval capsule.	Ventrad edge makes an obtuse anglewith fundus.
d. Spicules lyrate when viewed from dorsad or venter.At a point about .35mm from cephaled end, the right spicule passes ventred of left.Candad of this "daylight" may be seen between the spicules.Striation of cuticular expansions but little evident.	Spicules nearly straight from side but diverge slightly from bases (when viewed from dorsad or venter) and again approach. They cross at a point .6mm from cephalad end and only a small patch of daylight is seen. Striations evident
e. Rays of bursa rather long, slender with smooth outlines.	Rays rather short and stout and tend to have rugged outlines.
f. Female tail .25 to .33mm long and relatively short and wide. Postanal prominence is marked.	Female tail .375 to .4mm long and relatively long and thin.Postanal prominenc e is slight.
g. In Sheep	In Goat.

When a large series of specimens are examined it is found that Lane's points (a) (b) and (c) disappear. There are numerous small variations in the shape of the buccal capsule and in the shape and angle of the Dorsal tooth. These variations grade into each other and are not constant. It is impossible to recognise these small variations as having a specific value.

The spicules of trigonocephalum do not normally cross each other and it is only after manipulation under a coverslip that they can be made to do so. They are generally much less lyrate than figured by Lane. The cuticular expansions of that author are in reality envelopes and in well preserved specimens are conspicuously striated.

The appearance of the rays also is not a specific character as slight variations occur and ruggedness is probably due to unsatisfactory preservation.

Looss (1905 p 33) has shewn that the length of the female tail is useless as a specific character. The post-anal prominence is prominent only in contracted specimens.

The type species occurs in Scotland in both sheep and goats and no differences could be found between specimens from different hosts. It is evedient therefore that on the examination of a large series of well preserved specimens, the differences between kashinathi and trigonocephalus disappear. Accordingly B.kashinathi Lane cannot be accepted as a valid species and must be cited as a synonom of M. trigonocephalus.

Monodontus. phlebotomus Raill, 1900

Syn. Strongylus radiatus Rud, 1803 pp.

Stronglus radiatus Rud. of Schneider, 1866

Dochmius radiatus (Rud) Leuck. 1868

Uncinaria rediata (Rud) Raill. 1885

Monodontus phlebotomus Raill. 1900

Bunostomum phlebotomum Raill. 1902

Bunostomum radiatum (Schneider) Linst. 1906

Bustomum phlebotomum (Raill) Lane, 1917.

Hosts. This parasite has hitherto only been recorded from bovines but among the material examined were three specimens kindly loaned by Professor Yorke and labelled from Sheep.

Distribution. Probably universal. There is no record however of it occuring in Britain. The species found in Scotland from bovines is M. trigonocephalus.

Introduction.

Owing to the shortage of material, it was found impossible to describe this species with the same detail as M. trigonocephalus. Accordingly only the differences from that species are noted

The length of the female var varies from 16 to 21 mm. [illegible] while the male has a maximum of 15mm.

The Dorsal "tooth" is much shorter and blunter than in the type species.

The ventral teeth are as in M.trigonocephalus but the sub-ventral teeth which are only present in some specimens of that species are constant here. They vary in size considerably and those figured were the largest seen. This varibility emphasises the inadvisablity of adopting this as even a specific charater. The nerve ring, excretory pore, and cervical papillae are all about the same level but are more anterior than in the type species.

The male bursa is similar to the type. The right externo-dorsal ray however seems to arise at the base of the dorsal ray. There were not sufficient specimens available to state if this is absolutely constant. The dorsal ray splits into two branches each of which ends in two or three digitations. All the rays are slightly heavier than in the type species. The spicules which are constructed on the same general plan as in trigonocephalus are very much longer and measure from 3.5 to 4mm.

The female tail is longer and more slender than in the type. The genital system is similar to trigonocephalus but slight differences are noted. The coils of the uterus which approach each other in the type, not only touch each other here but in some specimens actually cross; sothat cross scetions might show 4 uterine tubes at the same level. The ovejector instead of being straight in outline is swollen just before the junction of its two parts where there is a decided constriction. The vagina is very long, and forms a small coil leading into

a normal vulva.

In 1917 Lane created a new genus Bustomum (type B.phlebotomum) which differed from trigonocephalum only in the presence of a pair of sub-ventral lancets. In the foregoing description of tri trigonocephalum it has been noted that a pair of sub-ventral lancets are occasionally present in otherwise typical specimens. In phlebotomum also, these lancets while always present, vary somewhat in size. This character cannot accordingly be accepted as even of specific- much less of generic-value, and consequently the genus Bustomum as defined by its author is invalid. The other characters which differ phlebotomum from trigonocephalum-viz.-lenght of spicules, shape of ovejectors and female tail- are of not more than specific value. In our present state of knowledge this species must be regarded as belonging to the same genus as trigonocephalus

Monodontus longecirratus (Linst 1879).Ranstom 1911

This species was recorded once from the Yak by V.Linstow. Its systematic position is uncertain. A single ventral ray is shewn in v Linstows figure: but this may be a mistake on the part of the author for two rays close together and parallel such as occur in Monodontus (S.str). The externo- dorsal rays are unequal in lenght but are shewn as rising symmetrically at the base of the dorsal. (Both externo-dorsals are present in the figure- not one only as surmised by Lane.) This also may be a mistake by v Linstow as the rays are shewn unequal in length. The Dorsal ray however is unpaired;and even admitting the two previous characters as misinterpretations, this character renders it doubtful whether it really is a member of this genus. It is provisionally left here however in the meantime.

REFERENCES.

LANE, C. 1917 Bunostomum kashinathi and the Ancylostomidae.

Ind. Jour. Med. Rec., IV, p414.

LOOSS, A. 1905 Ancylostoma duodenale.
Part 1. The anatomy of the adult worm.

Rec. Sch. Med. ,Cairo.IIIE,

1911 Ibid
Part 2. The development in the free state.

Rec. Sch. Med., Cairo. IV.

MOLIN, R. 1861 Il genere Monodontus.

Acrofalli. p463 - 470.

RANSOM, B.H. 1911 Nematodes parasitic in the alimentary tract of Cattle, Sheep, And other Ruminants.

Bur. An. Ind., Bull.127, p 27.

RAILLIET, A 1895 Traité de Zooligie Medicale et Agricole (2e)

p 474.

1900 Obs. sur les Uncinaires des Canidés.....

Arch. de Paras., III, p84.

1902 Sur quelques Sclerostomiens parasites des Ruminants.

C.R.S.Biol., LIV, p107.

Railliet, A, & Henry, A. 1910 Quelques Helminths nouveaux ou peu connus du groupe des Bunostomiens.

Bull. Soc. Path. Exot., III, p311

STILES, C.W. &HASSALL, A 1899 Internal Parasites of the Fur Seal.

The Fur seal and Fur Seal Islands of the North Pacific Ocean, III, p164.

1905 The determination of Generic Types.

Bur. An. Ind., Bull. 79, p121.

ABBREVIATIONS USED IN THE PLATES.

An	Anus.
C.R.	Cavity of Rectum.
Cl.	Cloaca.
Cem. Gl.	Cement Gland.
Cep. Gl.	Cephalic Gland.
Cer. Gl.	Cervical Gland.
Cer. P.	Cervical Papilla.
Cu.	Cuticle.
Cau. P.	Caudal Papllla.
D.G.	Dorsal Gutter.
D.T.	Dorsal Tooth.
Ex.	Excretory Canal.
Ex.P.	Excretory Pore.
Gg.An.	Gangalion Analis.
Gg.Cep.V.	Ganglion Cephalic Ventral.
L.	Lateral.
P.	Posterio-lateral.
Gg.L	Ganglion Lumbale.
Gg.R.	Ganglion Rectal.
In.	Intestine.
Mar.	Marginal Fibres of Oesophagus.
M.Sp.	Muscle Spincter of Intestine.
M.Som.	Somatic Muscles.
M.Bur	Bursal Muscles.
N.Cep.Gl.	Nucleus of Cephalic Gland.
N.Cep.P.	Nerve to Cervical Papilla.
Oes.	Oesophagus.
Oes.Fun.	Oesophageal Funnel.
Oes.Gl.	Oesophageal Gland.
Ov.	Ovary.
Ovj.	Ovejector.
P.P.A.	Pulvalis Post-analis.
P.H.	Pars Haustrix of Ovejectors.
P.E.	Pars Ejectrix.
Rec.	Rectum.
Rec.Lig.	Rectal Ligament.
Sp.	Spicules.
Str.	Protoplasmic Strands.
S.V.T.	Sub Ventral Tooth.
Ut.	Uterus.
Va.	Vagina.
Vu.	Vulva.
Vu.M.	Vulvular Muscles.
V.T.	Ventral Tooth.

Plate 1.

MONODONTUS TRIGONOCEPHALUS.

Cephalic extremity from one side shewing the Buccal Capsule and the beginning of the Oesophagus.

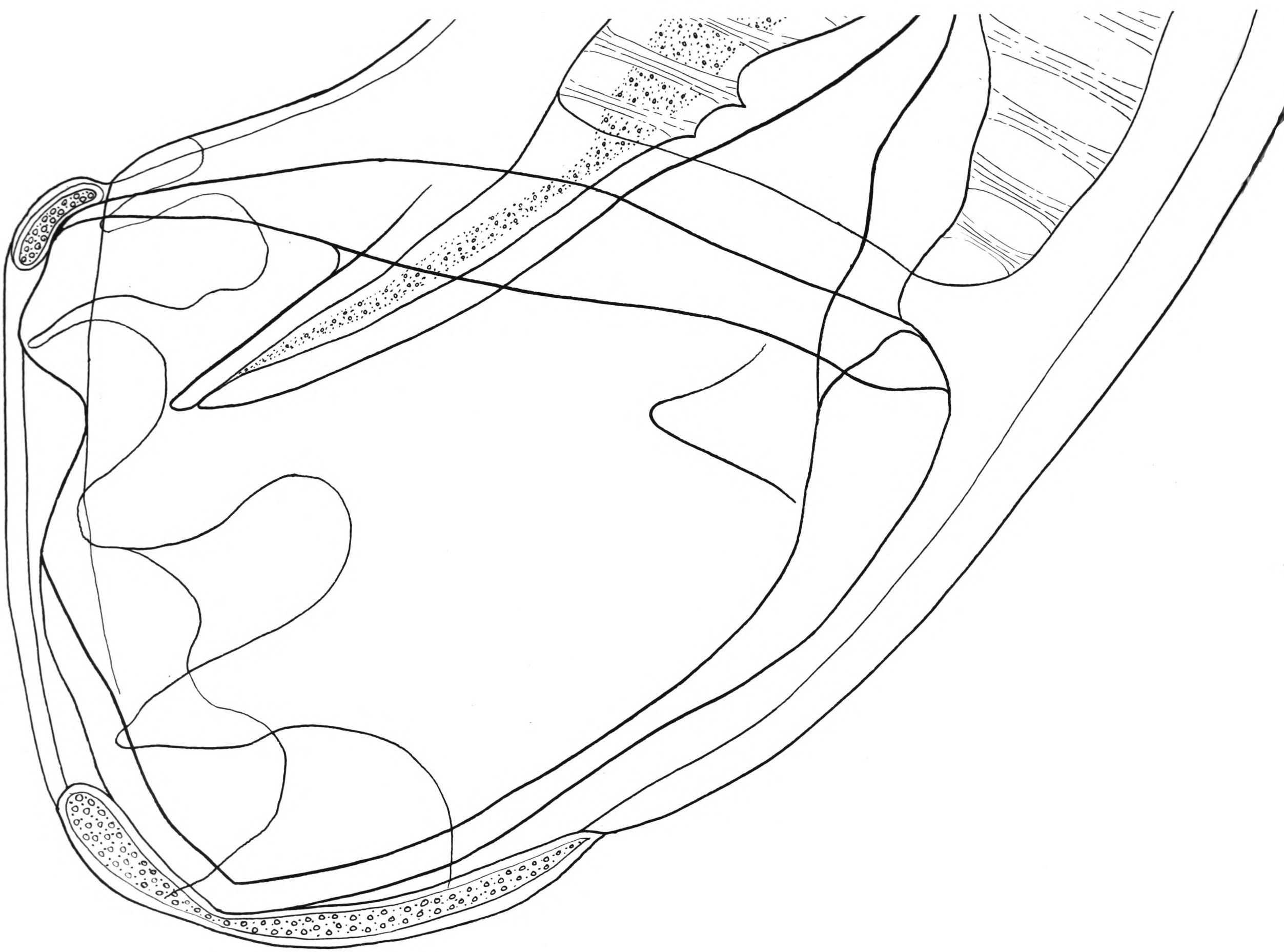


Plate 2.

MONODONTUS TRIGONOCEPHALUS.

(A) Cephalic extremity from Dorsal aspect.
This figure was drawn from the same specimen as Plate 1.

(B) Two dissections of the Buccal Capsule to shew the inconstant Sub-ventral Lancets. The Dissections are viewed from the Dorsal aspect.

A

·02 mm

B

D.T.
D.G.
S.V.T.
V.T.
Oes.Fun.

·1 mm

Plate 3.

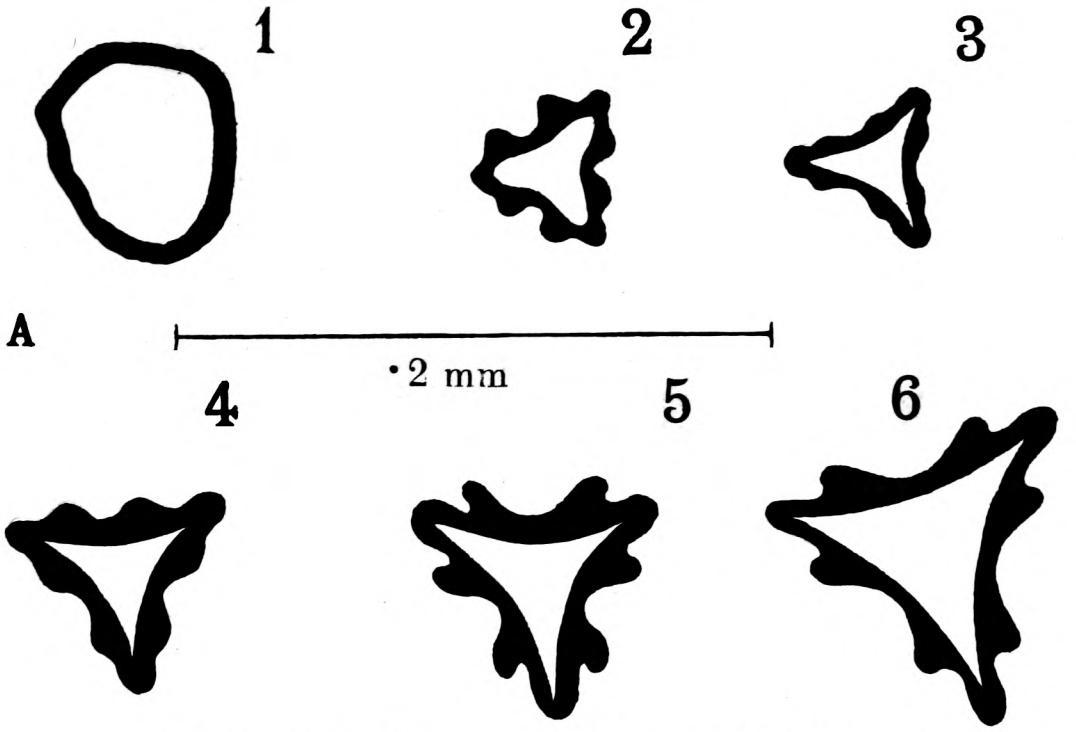
MONODONTUS TRIGONOCEPHALUS.

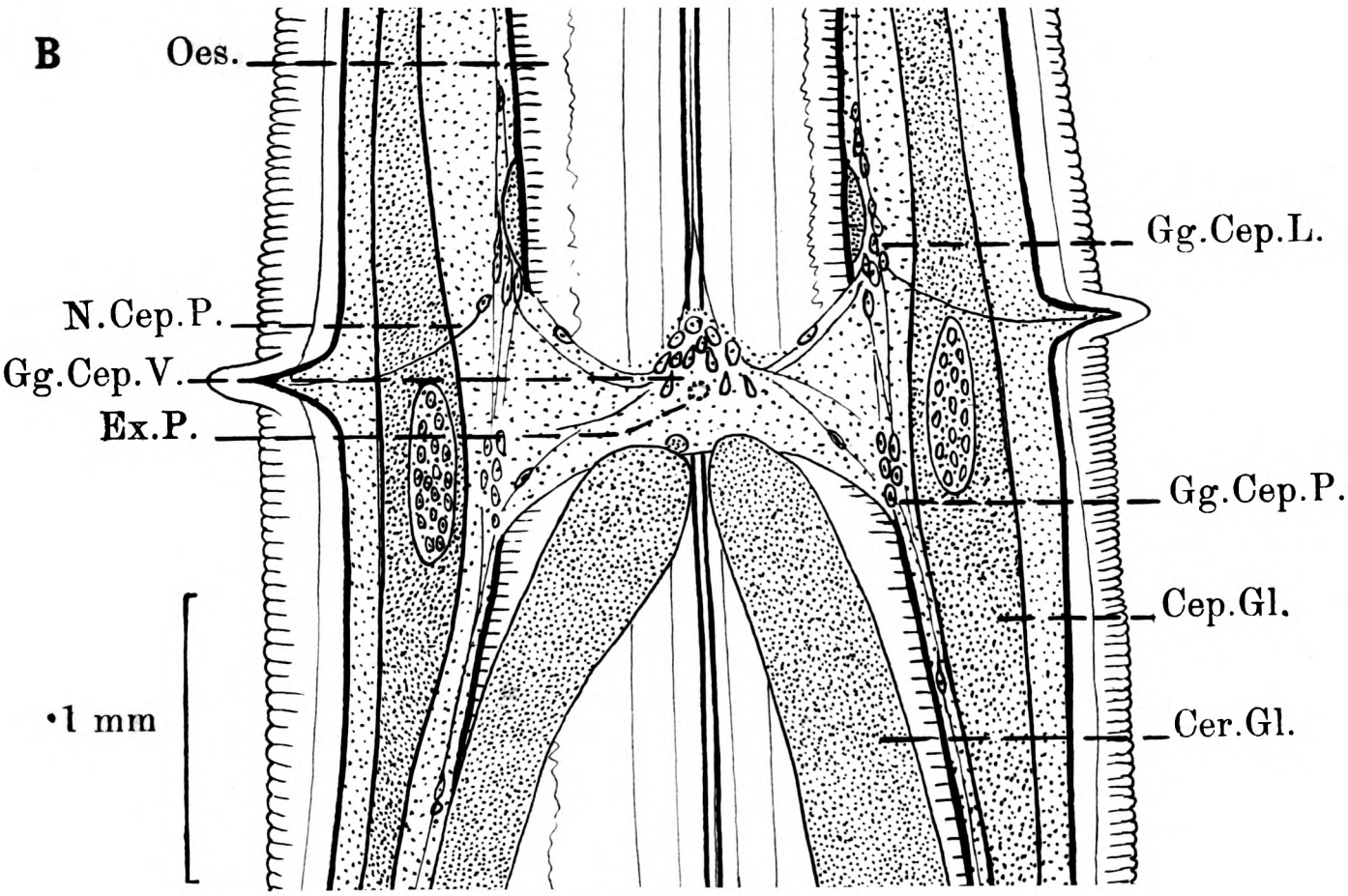
(A) Six sections of the chitenous lining of the Oesophagus.

1. Section at the level of the Oesophageal Funnel.
2. Section just posterior of the Oesophageal Funnel.
3. Section just posterior of 2.
4. Section shortly behind 3.
5. Typical section.
6. Section just anterior to Oesophageal Valves

(B) Longitudinal section of entire worm through the cervical papillae, shewing the Cervical and Cephalic Glands and the Central Nervous System.

(C) Transverse section through the cervical papillae.


1
2
3
A
·2 mm
4
5
6


B
Oes.
Gg.Cep.L.
N.Cep.P.
Gg.Cep.V.
Ex.P.
Gg.Cep.P.
Cep.Gl.
·1 mm
Cer.Gl.

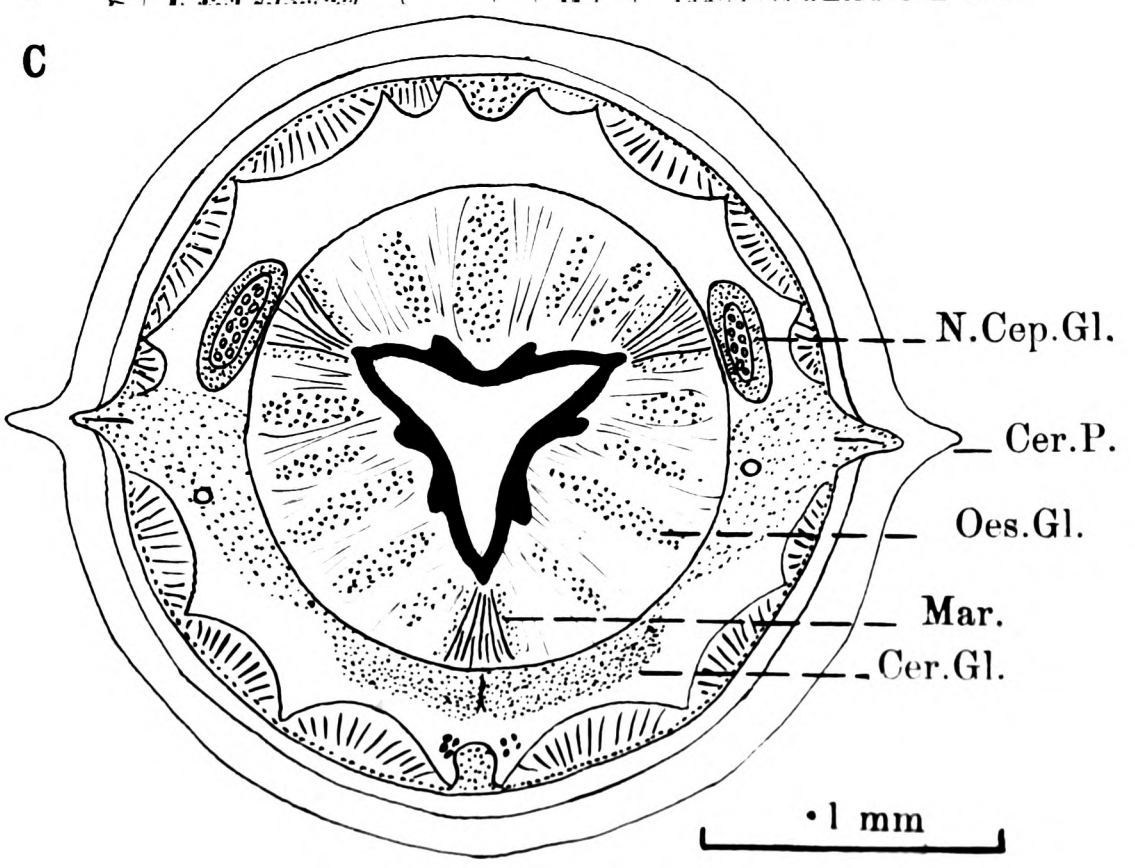

C
N.Cep.Gl.
Cer.P.
Oes.Gl.
Mar.
Cer.Gl.
·1 mm

Plate 4.

MONODONTUS TRIGONOCEPHALUS.

(A) Transverse section of female worm just anterior to vulva.

(B) Diagram to shew the course of the uterus.

(C) Diagram to shew the junction of the seminal vesical and cement gland in the male. From one side.

(D) Diagram to shew junction of ovary and shell gland in the female. From one side.

A

Ut.

Ov.

In.

Ovj.

Ov.

·1 mm

B

D

D.

V.

D.

D.

Ov.

V.

C

SEMINAL VESICAL

CEMENT GLAND

VAS DEFERENS

D

REC. SEM.

OVIDUCT

OVARY

Plate 5.

MONODONTUS TRIGONOCEPHALUS.

(A) Sagittal section of posterior region of female.

(B) Dissection to shew ovejectors, vagina, and vulva.

A

In.
D.L.
M.Sp.
Rec.Lig
Gg.R.
C.R.
P.P.A.
An.
Cu.
Str.
·2 mm
Cau.P.

B

P.H.
P.E.
Cu.
Vu.M.
Va.
Vu.
·2 mm

Plate 6.

MONODONTUS TRIGONOCEPHALUS.

(A) Entire cephalic region, shewing Cephalic and Cervical Glands, Excretory Pore, Cervical Papillae, and Nerve Ring.

(B) Spicules of male from the side.

(C) Dorsal view of same Spicules.

(D) Highly magnified view of distal extremity of one spicule,

A

·2 mm

B

·2 mm

C

D

Plate 7.

MONODONTUS TRIGONOCEPHALUS.

Dissection of Bursa of male to shew the structures in the posterior region of the body. The specimen was cut slightly to one side of the middle line.

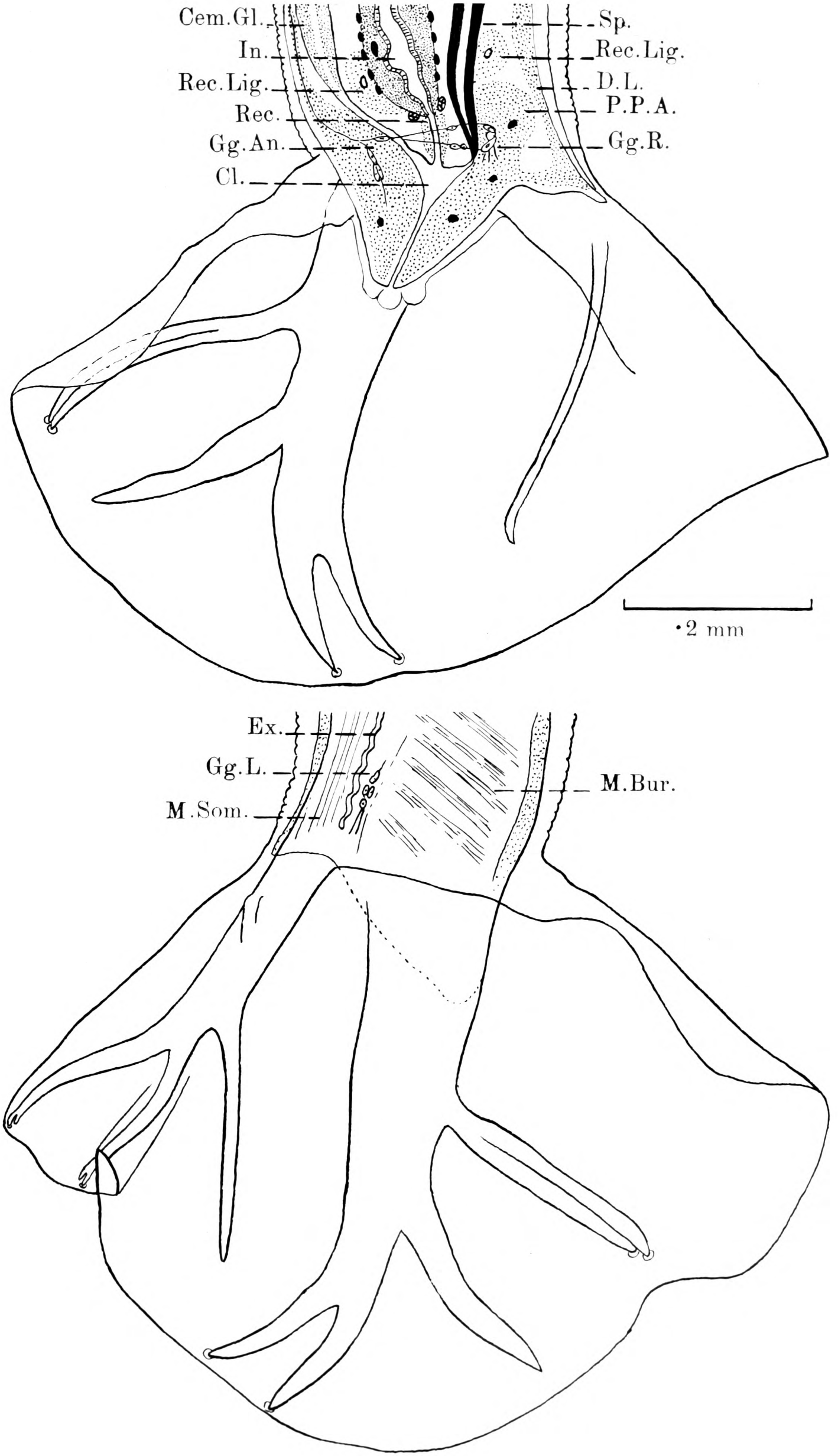

Cem.Gl.
In.
Rec.Lig.
Rec.
Gg.An.
Cl.
Sp.
Rec.Lig.
D.L.
P.P.A.
Gg.R.
Ex.
Gg.L.
M.Som.
M.Bur.
·2 mm

Plate 8.

MONOCONTUS TRIGONOCEPHALUS.

Bursa, detached from body and spread out on a slide.

Viewed from the dorsal aspect.

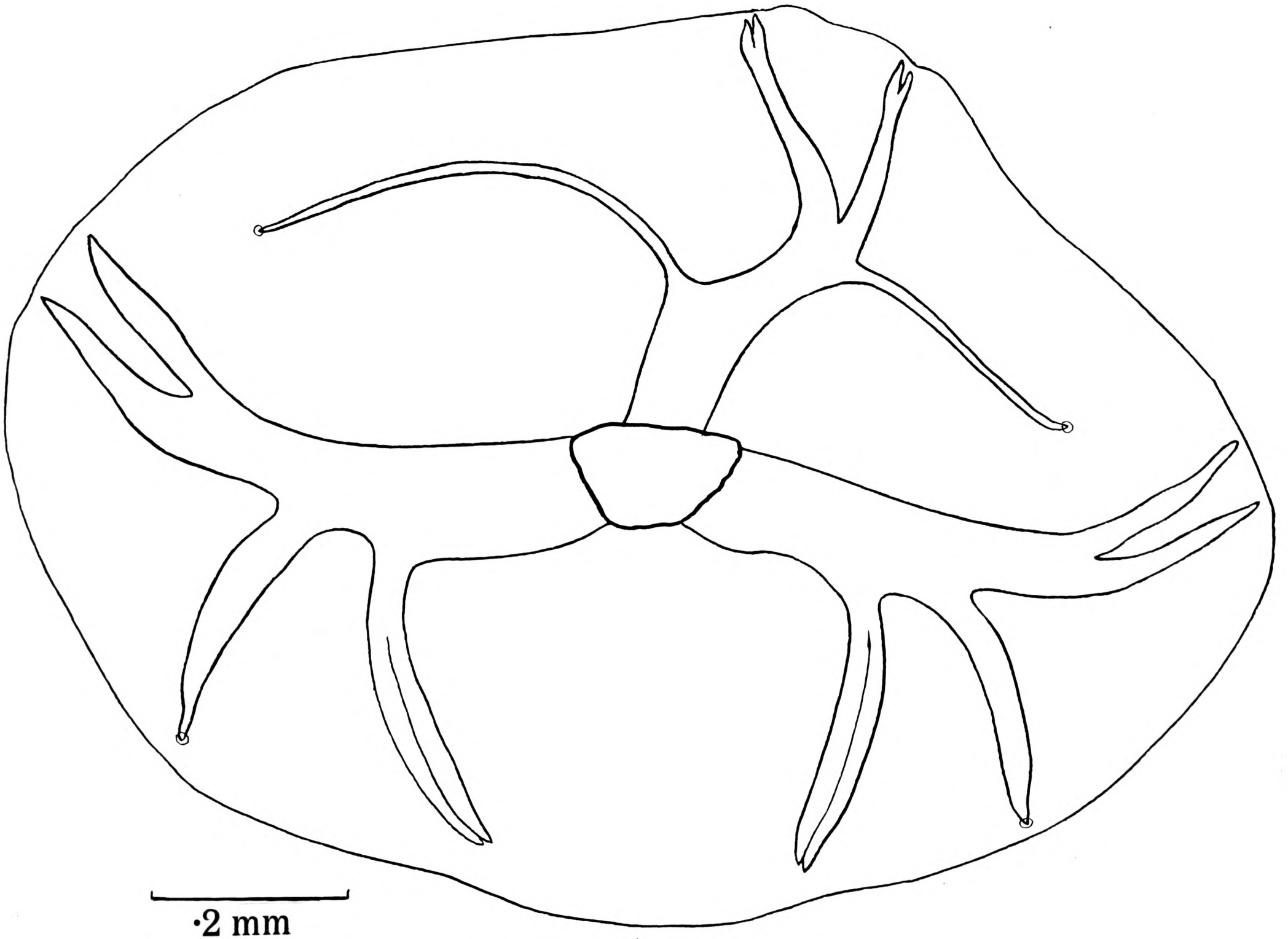

·2 mm

Plate 9.

MONODONTUS TRIGONOCEPHALUS.

The Variation in Position of the Right Externo-dorsal Ray.

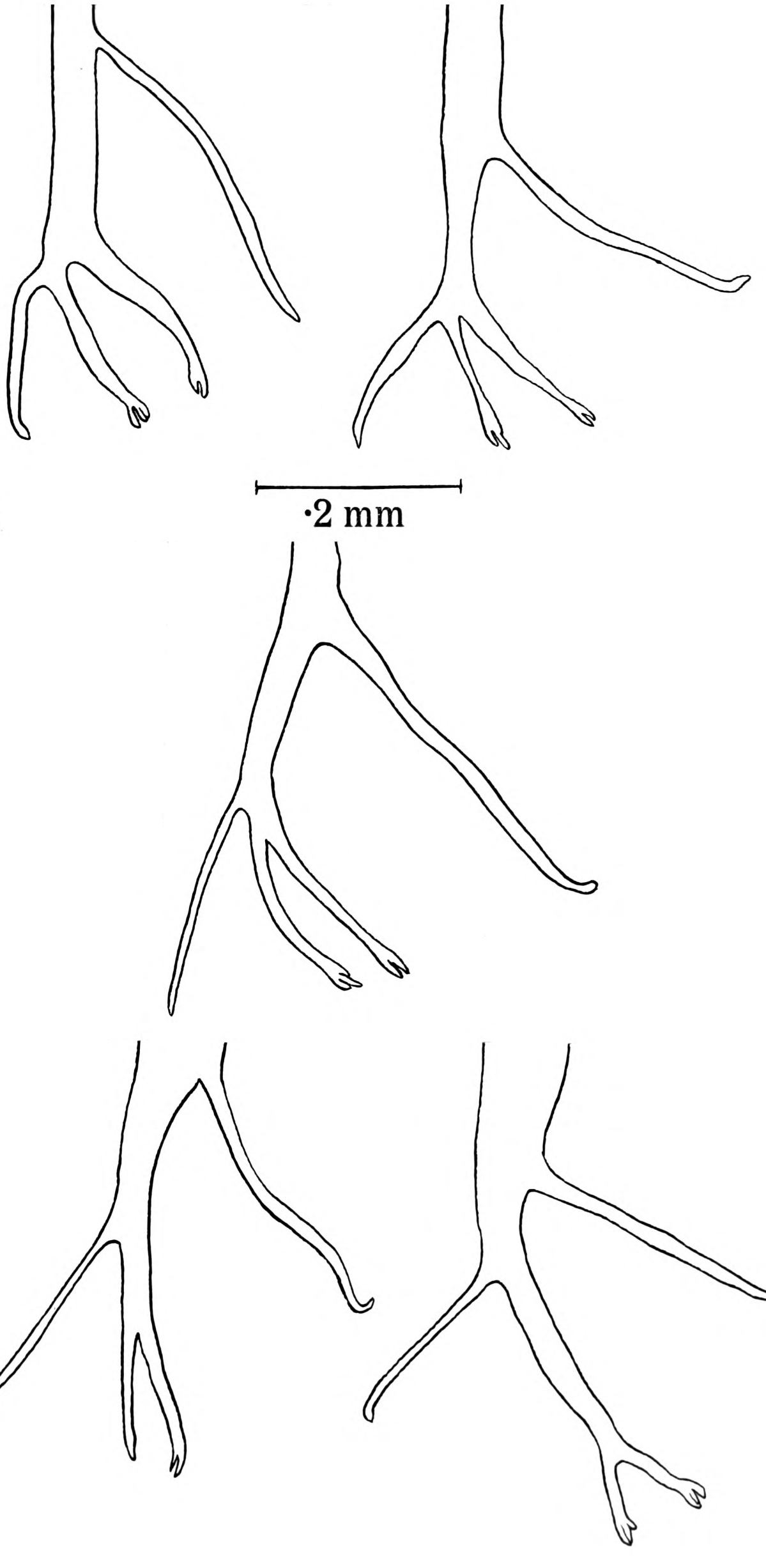
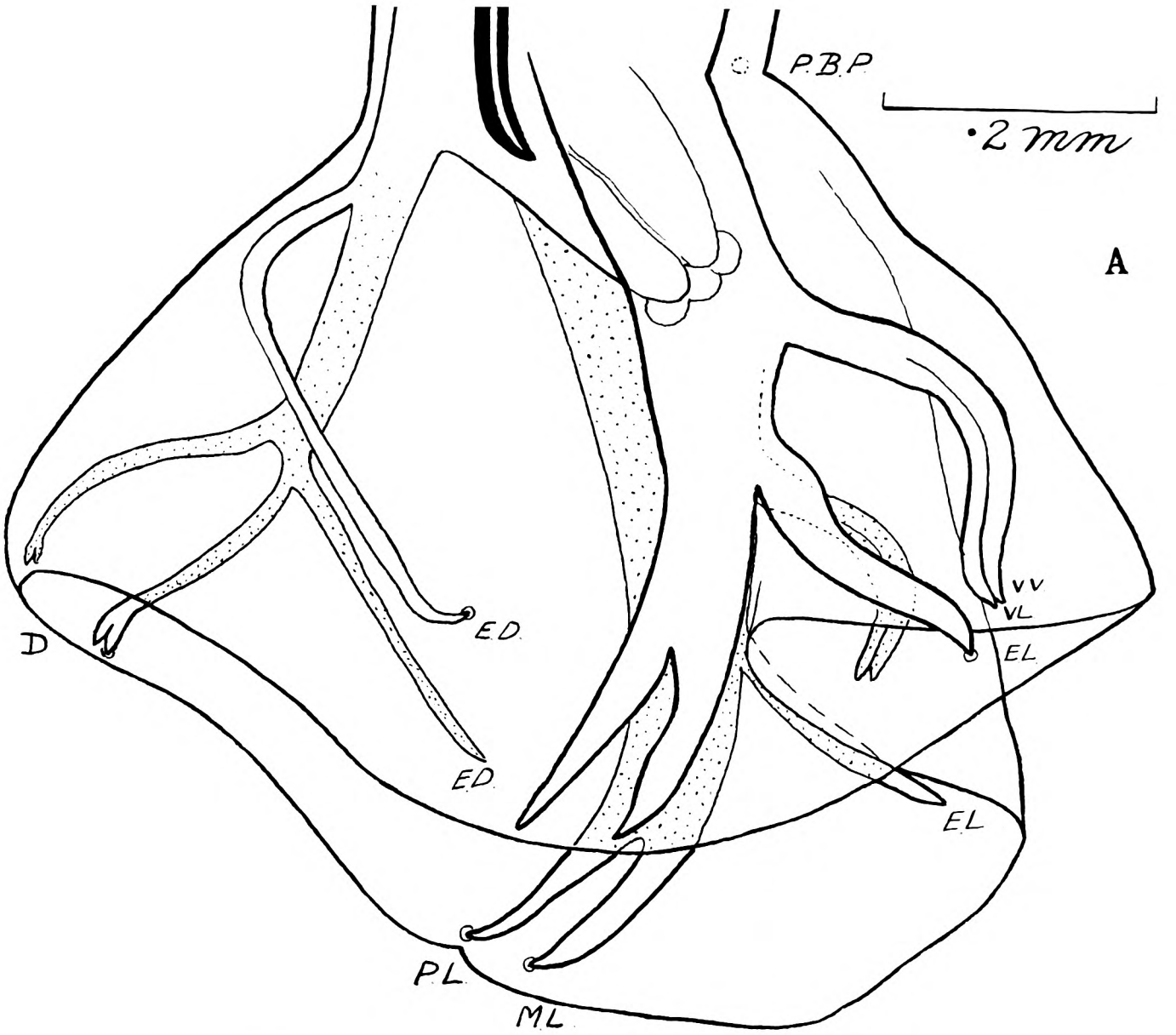

·2 mm

Plate 10.

MONODONTUS TRIGONOCEPHALUS.

(A) Complete Bursa, without pressure.

(B) Arrangement of the muscles and nerves of the bursal rays.


PBP
·2 mm
A
VV
VL
EL
D
ED
ED
EL
PL
ML

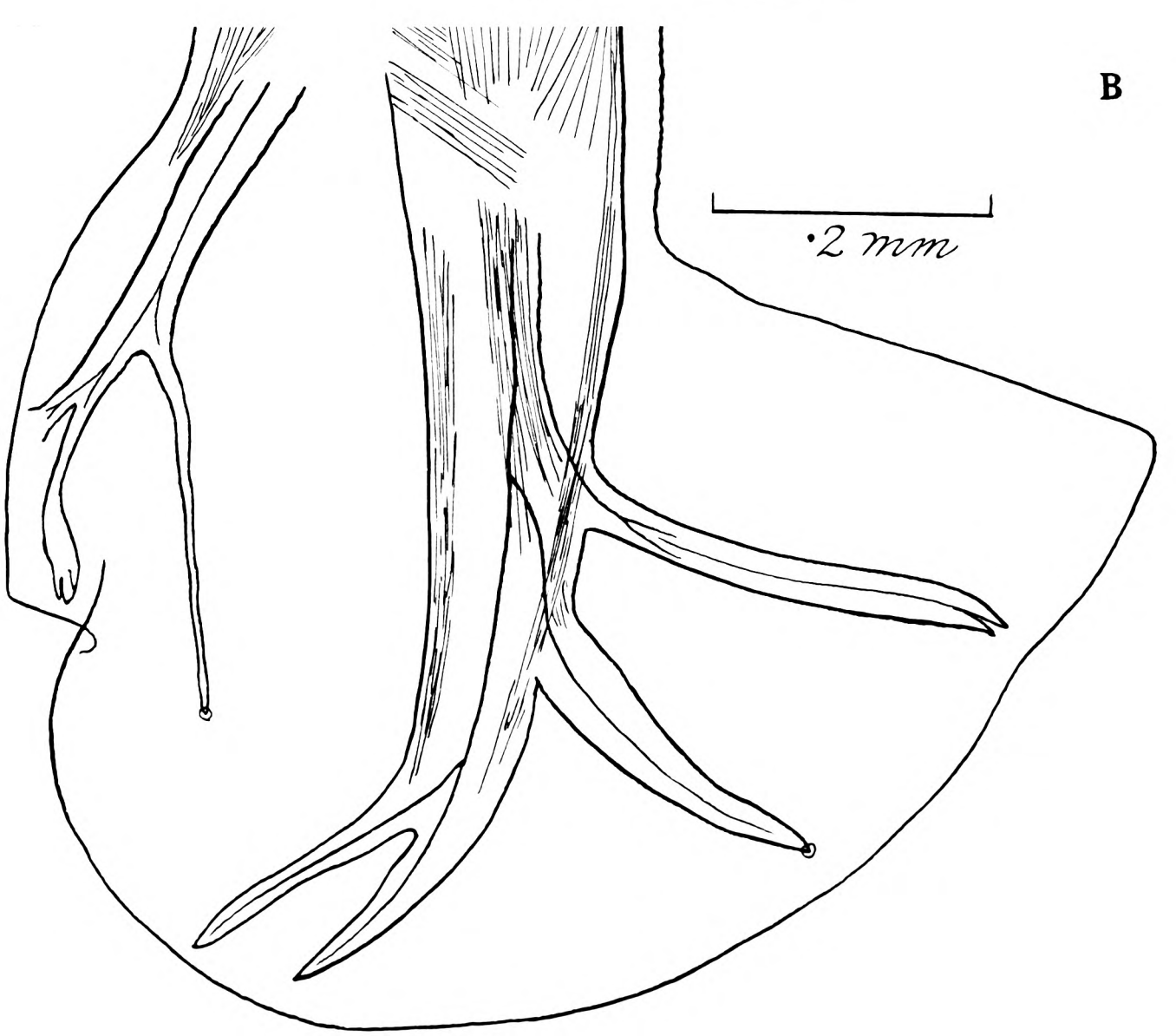

B
·2 mm

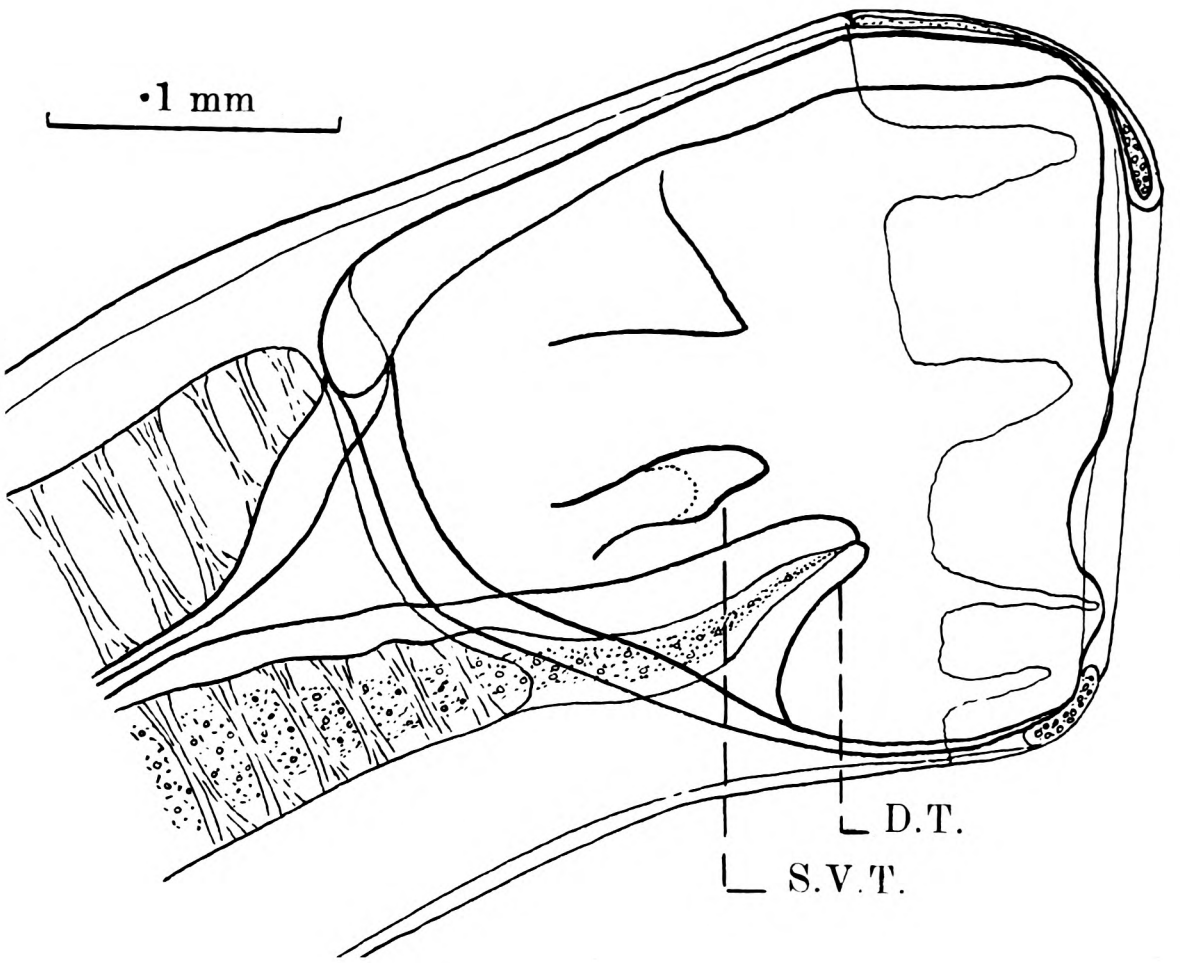
Plate 11.

MONODONTUS PHLEBOTOMUS.

(A) Cephalic extremity, shewing Sub-ventral Teeth.
The dotted outline shews the smallest size observed,
the unbroken outline shews the largest size.

(B) Bursa of male from the Dorsal aspect.

A



B

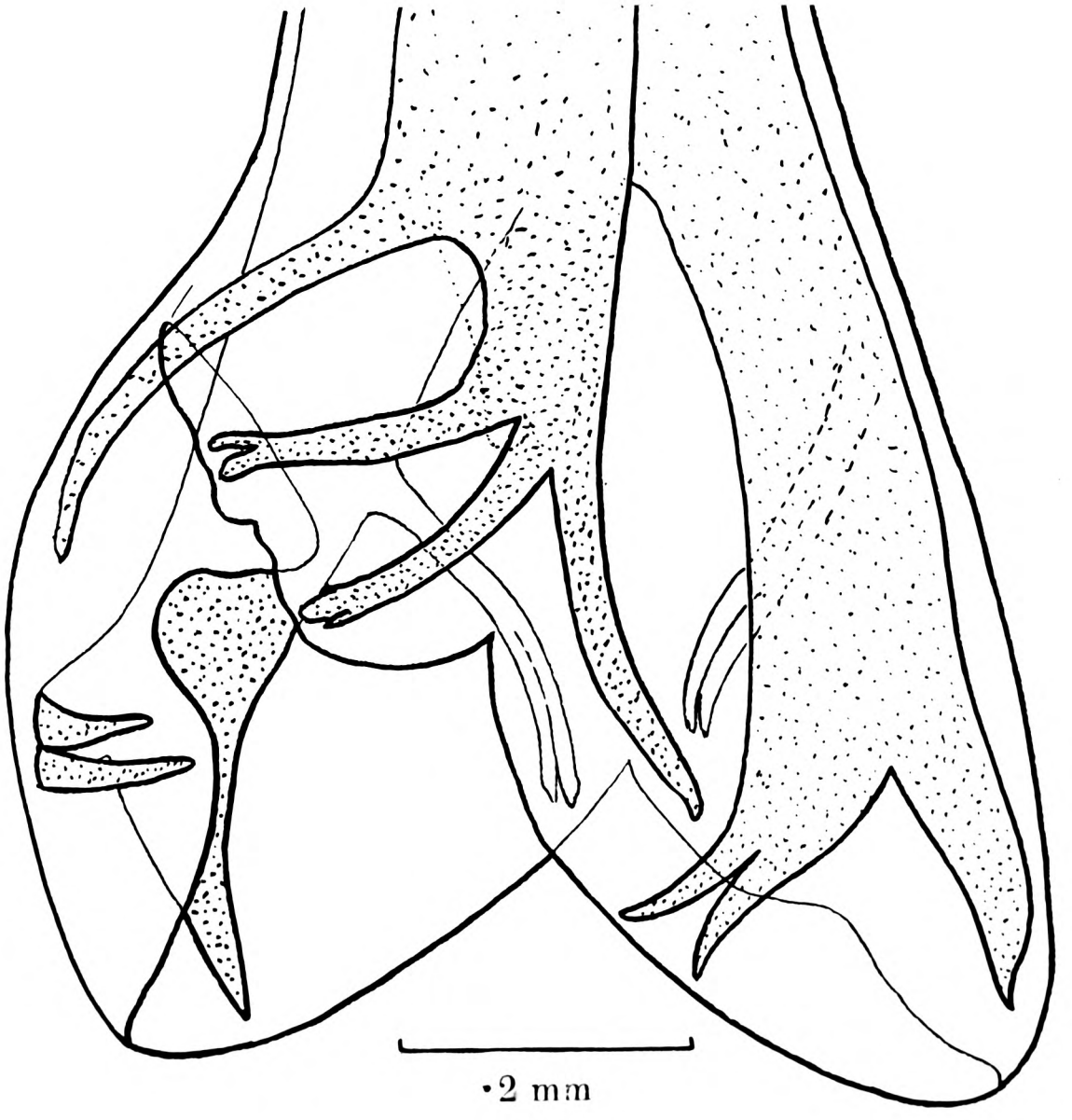


Plate 12.

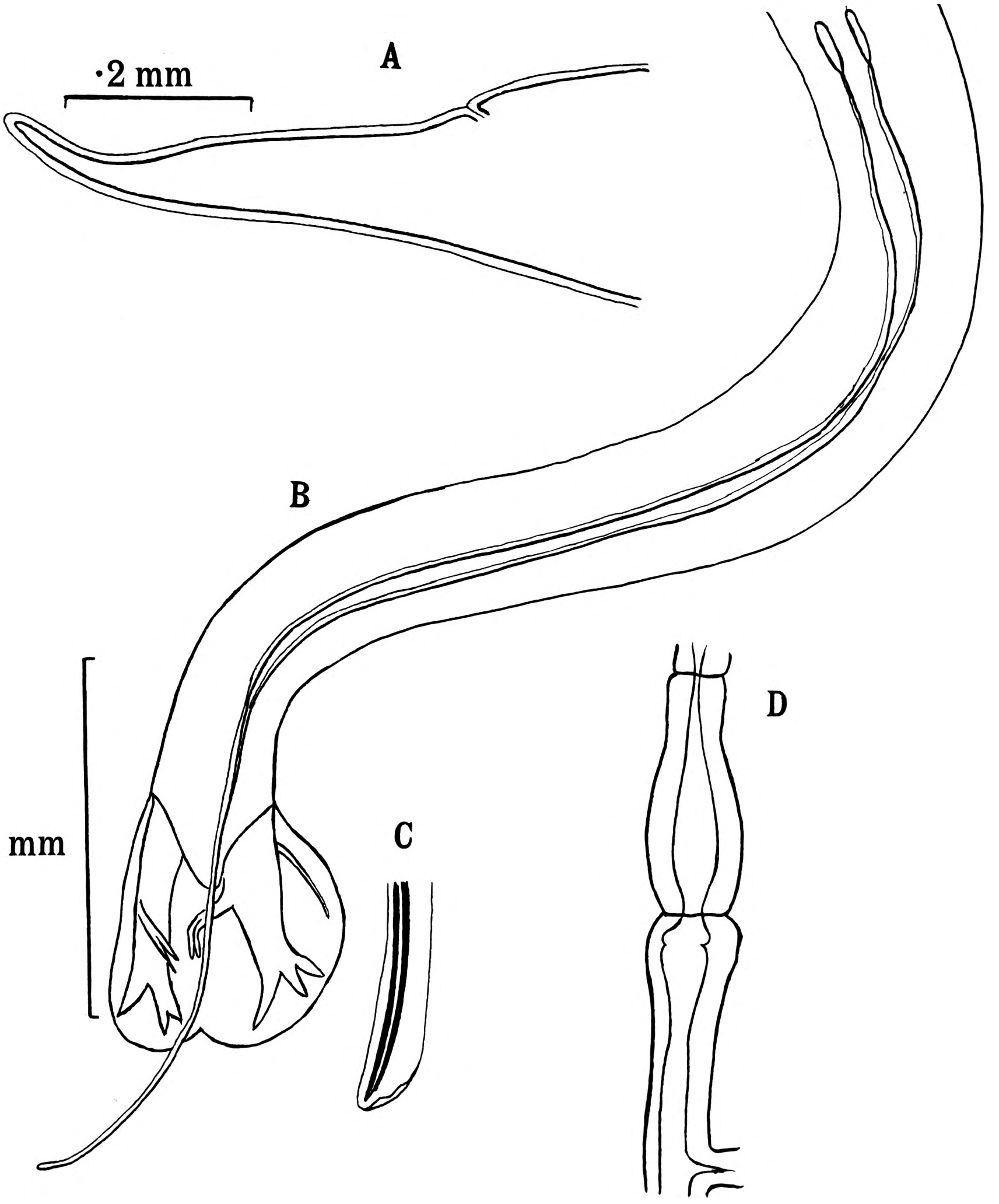
MONODONTUS PHLEBOTOMUS.

(A) Posterior region of female.

(B) Posterior region of male shewing spicules.

(C) Distal extremities of soisules.

(D) Ovejector.


·2 mm
A
B
1 mm
C
D

OBSERVATIONS ON THE BIOLOGY OF THE INFECTIVE LARVA OF *MONODONTUS TRIGONOCEPHALUS*.

TECHNIQUE.

Adult females were dissected as described by Hesse (1923) and incubated at 23°C. The ova hatched within 24 hours and the larvae reached maturity 48 hours later i.e. within three days of oviposition. Larvae were collected from the culture by means of a capillary pipette.

TEMPERATURE REACTION.

A small electrically heated stage was attached to the microscope and a glass slide placed thereon. A drop of water containing a number of larvae was added and the current switched on. The movements of the larvae were observed at all temperatures registered by the apparatus, namely between the limits of 15°C and 47°c.

15° C-22° C The movements of the larvae are very lethargic at 15 C., but slightly increased motility is observed during the rise to 22 C.

22° C-35° C Between these temperatures bursts of activity occur; that is, activity is increased intermittently.

35° C-40° C Larvae are very active, moving from place to place and lashing their tails.

40°C-47°C The larvae become more or less motionless, only spasmodic jerky movements being seen.

On switching off the current the temperature fell, the larvae going through a reverse series of changes and finally returning to their original lethargic state.

EFFECT OF GRAVITY.

Hesse has already noted that the larvae do not attempt to climb blades of grass. This fact was confirmed by the writer. It was also noted that the larvae made no attempt to leave the cultures, and washings of the blotting paper in the Petri-dish cover were always negative.

EFFECT OF ONE PER CENT FUSCINE.

In 1911, Looss shewed that Ancylostome larvae when treated with one per cent Fuscine, did not absorb the stain but , under suitable circumstances, escaped from their sheaths. The sheaths alone became intensely coloured.

In 1922, Goodey shewed that this was also true for Necator larvae; but that those larvae which do not penetrate the skin, such as Haemonchus, and Graphidium, absorbed the stain and died.

Monodontus larvae were placed on a slide and covered with a cover-slip. Only just sufficient water was given to enable the larvae to move. A few drops of one per cent Fuscine was placed at the side of the coverslip, and allowed to run in. The larvae became very active on first contact with the stain, but rapidly absorbed it, coiled on themselves and died. The larvae absorbed the dye to the same extent as the sheathes.

SKIN PENETRATION EXPERIMENTS.

The capability of the larvae to penetrate skin was tested by Goodey's method (1922).

The abdominal skin of a four day's old rat was stretched, hair upwards, on a cork ring and floated on warm saline at a temperature of 37°C-39°C. A drop of water containing about 50 larvae was placed on the skin and the whole observed under a binocular microscope.

The activity of the larvae markedly increased when placed on the skin, but the rapid burrowing motion observed in the case of Necator was absent. As the water evaporated the larvae became much less active, and finally quiescent. A drop of water at 37°C. was added and motility returned. Finally the larvae were allowed to dry completely and were placed in an incubator at 37°C for two hours. A drop of water was added to the spot where the larvae had been and removed in a pipette to a glass slide and examined. All the larvae were found to be present and had not escaped from their sheaths. None of them however recovered their motility. The desiccation at the high temperature had apparently killed them.

A second experiment was undertaken to test the penetrative power of the larvae.

A drop of water containing larvae was placed on the writer's hand on a spot between the fingers where

the skin was thinnest, and allowed to evaporate. Afteraa short time- about half an hour- a drop of water was placed on the same spot and removed to a slide. All the larvae were recovered from this drop in an active condition.

From these two experiments, it is concluded that the larvae of Monodontus trigonocephalus do not penetrate skin.

REFERENCES.

GOODEY, T. 1922 A simple method of experimentation for Skin Infection with Hookworm Larvae.

Proc. Roy. Soc. Med., XV, p19.

GOODEY, T. 1922 Observations on the ensheathed larvae of some Parasitic Nematodes.

Annals of Applied Biology, IX, p33.

HESSE, A.J. 1923 On the free living larval stages of the Nematode Bunostomum trigonocephalum.

Journal of Helminthology, I, p21.

LOOSS, A. 1911 The Anatomy and life history of A. Duodenale Part 2, the development in the free state.

Rec. Sch. Med., Cairo, p431.

ON TWO NEW GENERA

AND

SOME NEW AND LITTLE KNOWN SPECIES

OF

THE NEMATODE FAMILY TRICHOSTRONGYLIDAE.LEIPER.

INTRODUCTION.

Six species of Trichostrongylidae are described in this paper. Four are previously recorded species which were insufficiently known and described.

Graphidium strigosum (Duj., 1845) R. and H. , 1909.

Strongylus affinis Megnin, 1895.

Mecistocirrus digitatus (v.Linstow, 1906) Neveu Lemaire. 1914.

Strongylus torulosus Molin, 1861.

Two species are new to science:- Molineus torulosus from Felis yaguarundi, and Viannaia saimiris from Saimiris sciurea.

The material, on which the description of the first and third species is based, was obtained from the Departmental collection. The remaining material was collected from animals which died at the Gardens of the Zoological Society of London.

The author desires to record the deep obligation he is under to Professor R.T. Leiper, and to thank him, not only for the material placed at his disposal, but also for his assistance and advice.

GRAPHIDIUM. RAILLIET and HENRY, 1909.

The genus Graphidium was created by Railliet and Henry in 1909 to include the species strigosum, affine and rudicaudatum, with the following diagnosis:-
Cuticle with numerous longitudinal striations. Mouth large, supported by a chitinous ring resembling a mouth capsule. Caudal bursa with posterior rays rising in a common trunk, and anterior and posterior rays divided. Vulva in posterior third or quarter of body, covered or not by an appentix. Oviparous." Type by designation. G. strigosum.

The type species occurs in the common rabbit in Europe, but has never been completely described. The presence of well preserved material from British rabbits in Professor Leiper's collection has enabled the following to be prepared.

Graphidium strigosum (Duj. 1845) R.and H 1909. (Plates 1and2).

Syn:-Strongylus retortaeformis. Bremser, 1824 (nec Zeder, 1800.)

Spiroptera leporum Moniez, 1880.

Strongylus blasii v. Linst, 1887.

In the fresh state the worms are blood red in colour, but on fixing in hot alcohol they become brownish or even colourless.
They are long slender forms, which vary considerably in their dimensions. The male is about 8 to 16 mm. long and .18 to .3 mm. broad, while the female is 10 to 20 mm.

long and .19 to .5 mm broad. The cuticle is conspicuously striated longitudinally- there being about 50 equidistant lines distributed around the circumference. There are also numerous fine transverse striations present, which intersecting the longitudinal lines, give these a fine beaded appearance.

Cephalic extremity:- The anterior end is smoothly rounded The cuticle is bent inwards to form a buccal cavity about .015mm. deep. In optical section, this cuticle gives the appearance of two backwardly projecting teeth. The oesophagus is straight, slender and tapers gradually towards its anterior end. It varies in length from .6 to 1mm, and has a maximum diameter of .16mm.

Two inconspicuous, cervial papillae are situated about the junction of the posterior and middle third of the oesophagus.

The nerve ring is inconspicuous, and is situated about the middle of the oesophagus.

The excretory pore lies between the nerve ring and the cervical papillae, The cephalic cuticle is normally not inflated, but occasional inflated specimens are found

The Female. The vulva is a prominent transverse slit, situated on a thickening of the cuticle about 4.5mm. from the posterior end. The body is sharply reduced in thickness posterior to this point. The complete muscular ovejectors are about 1.2mm. long-although

occasional longer forms are found. It is probable that the central portion (•5mm. long) should be looked upon as a part of the vagina, while the two terminal portions (.35mm) which are separated from it by a slight constriction,form the ovejectors proper. The vagina is always directed posteriorly, forming an acute angle with the inferior ovejector, Both ovaries arise in the anterior portion of the body. The superior ovary pursues a convoluted course to join the superior ovejector while the inferior ovary, rising a short distance posteriorly of the other , runs to within 1mm. of the posterior extremity, where it turns and joins the inferior ovejector.

The inconspicuous anus is situated about .28 mm. from the posterior extremity. It joins the intestine by a short rectum.

The posterior extremity is bluntly pointed, and has a band of coarsely striated cuticle (as in Cooperia). It is slightly constricted above this. The ova, embryonated when deposited, are .100 to 110 mm. long and .050 to .060 mm. broad.

The Male. A pair of conspicuous prebursal papillae occur about .04mm. from the commencement of the bursa. The testis and intestine are normal.

The bursa is found rolled on itself, and can only be unrolled with the greatest difficulty. It is laminated (as in Haemonchus), and is very elastic. It is not

divided into distinct lobes, but in the unrolled condition the bursa is folded on either side of the dorsal ray to form a pseudo-dorsal lobe. This disappears on flattening out.

The disposition and relative size of the rays are shewn in Plate 2a. The ventral rays arise in a common stem, and both bend sharply forward. The ventro-ventral ray is smaller than the latero-ventral. The lateral rays also origonate in a common stem. The externo-lateral is about twice the thickness of each of the other laterals, and is directed slightly anteriorly. The medio-and posterio-lateral rays are directed posteriorly. The dorsal ray gives off long stout externo-dorsal rays, which terminate in crooked finger-like processes. The dorsal ray bifurcates near its tip-each bifurcation terminating in two digitations the median of which is the longer and ends in two papilliform processes. All rays are sharply pointed and reach the edge of the busa.

The genital cone is short, with apical ornimentations.

The accessory piece is about .13mm. long by .03mm. broad, and is situated close to the genital cone. It is colourless but well defined.

The spicules are equal, long and filiform, and measure 1.5 to 2.5mm. Each consists of two chitinised rods joined by a membrane. The distal terminations are multiple pointed and very complicated.

Pathogenicity. This worm is a blood sucker-and in addition to causing a gastritis, causes a severe anaemia and emaciation in rabbits.

Hosts. Lepus cuniculus and L.europaeus; Habitat: Stomach and intestine. Locality: Western Europe.

Plate 1.

GRAPHIDIUM STRIGOSUM.

(a) Cephalic extremity.

(b) Ovejectors and vulva .

(c) Caudal extremity of female.

(d) Dorsal ray of male bursa.

(e) Accessory piece.

A

·2 mm

B

·5 mm

C

1 mm

D

·05 mm

E

·05 mm

Plate 2.

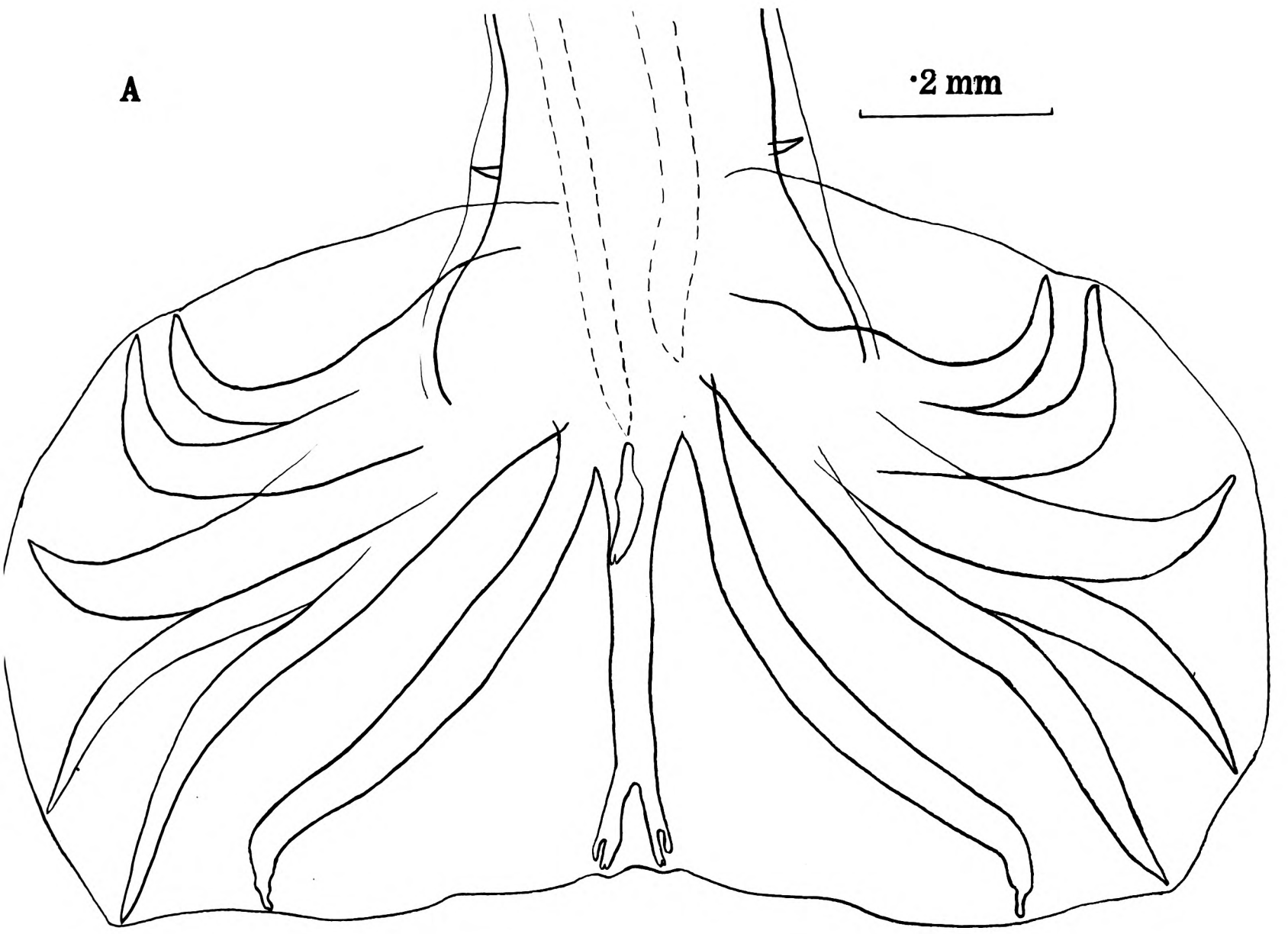
GRAPHIDIUM STRIGOSUM.

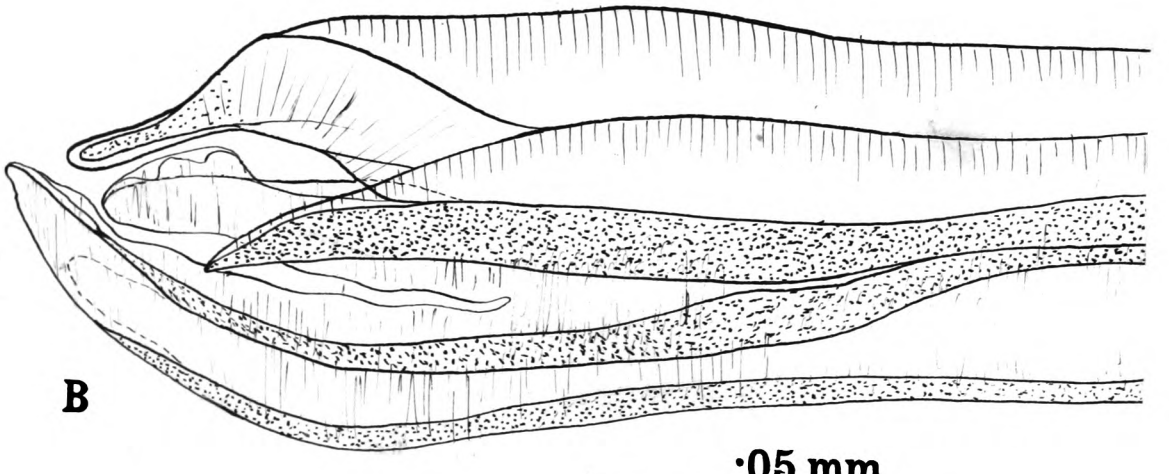
(a) Male bursa.

(b) Extremity of one spicule.

A

·2 mm





B

·05 mm

GRAPHIDIOIDES. Gen. nov.

Graphidioides Affinis (Megin, 1895).(Plates 3and4)

Strongylus affinis was described in 1895 by Megin, and in 1906 by V. Linstow (under the name of Strongylus rectus). In 1909 Railiet and Henry placed it in their new genus, Graphidium. It is proposed in this paper to make it the type of a new genus.

In the fresh state the parasites are blood red in colour, but become brown on fixing in hot alcohol.

They are long slender forms. The male varies in length from 9 to 17mm., with an average breadth of .3mm. The female is 16 to 21mm. long and about .5mm. broad.

The cuticle is similar to that of G.strigosum.

The cephalic extremity. This resembles the anterior extremity of G.strigosum;but the component parts differ. Four small circumoral papillae are present. The oesophagus is more claviform, and is about ·55mm. long, with a maximum diameter of ·1mm.There are no lateral cervical papillae.

The nerve ring is conspicuous, and is situated about the middle of the oesophagus. The excretory pore is situated at the level of the lower border of the nerve ring.

Cervical glands are present. Like G.strigosum, the cephalic cuticle is only occasionally swollen.

The female. The vulva opens transversly, about 6mm. from the posterior extremity. The body does not narrow 1mm

immediately posterior of the vulva. The superior ovejector is very short, while the inferior is very long. Together they measure about 1.2mm. The vagina is short, and always situated at right angles to the ovejectors. Four conspicuous muscle bands originate from the thickened cuticle surrounding the vulva to anastomose with the somatic muscles on the posterior side of the body.
The anus is situated about .5mm. from the posterior extremity. It is conspicuous, and is protected by a small flap of cuticle with a semi-circular margin.
A thickened portion of cuticle projects just posterior of this flap. The body is narrowed abruptly posterior of the anus. The termination is bluntly pointed, but conspicuous transverse striations in this region are absent. The ova are thin shelled, and measure about .14mm. long by .075mm. broad.
The Male. A pair of inconspicuous prebursal papillae are present, about .04mm. from the anterior border of the bursa.
The bursa, which is much smaller than in G.strigosum, is also naturally rolled, but to a less extent than in that species, and is difficult to unroll. It is not laminated but is ornimented with cuticular bosses(as in Nematodirus) It is indistinctly divided into three lobes.
The disposition of the rays is shewn in Plate 4a. The ventro-ventral ray is very small and is directed anteriorly. The latero-ventral ray is much larger and

thicker, and is directed posteriorly with an anteriorly turned tip. The lateral rays are about equal in breadth. The externo-lateral ray terminates in an elongated swollen knob, while the medio-and postrio-lateral rays are sharply pointed.The posterio-lateral ray has a distinct shoulder near its origin. The externo-dorsal rays-given off from the main stem- have spatulate terminations and run parallel to the posterio- lateral rays. The somewhat slender dorsal ray bifurcates near its tip. The short lateral branches are directed outwards, while the longer median branches end in two digitations. All rays- except the externo- lateral and externo - dorsal reach the edge of the bursa. These two terminate a short distance from the edge.

The genital cone is short with concave sides.

The accessory piece is situated some distance anterior to the genital cone, Tt consists of a broad base with raised lateral edges, and a double central keel. The spicules lie between the keel and the raised edges. The shape and size of the accessory piece are somewhat variable. It is about .15mm. long and .8mm. broad.

The spicules are equal, long and filiform, with an average length of 2.8mm. Each spicule consists of two chitinised rods, joined near the tip. The posterior extremity is simple. The anterior extremity is united to two strands. From the median side of each spicule project two membranes which anastomose near the terminations of the spicules. These are,accordingly,

virtually joined together.

Pathogenicity. This worm was the cause of a fatal gastritis in a Patogonian Cavy. It attaches itself to the gastric mucous membrane.

Host: Dolichotes magellineus. Habitat: Stomach. Locality: Angentine.

DISCUSSION.

This parasite differs from G. strigosum in many respects--notably by the absence of cervical papillae, shape of bursa and disposition of ventro-ventral rays, shape of accessory piece and spicules, shape of ovejectors, vagina and posterior extremity of the female. These differences are so striking that it obviously cannot be retained in the same genus. It differs from most of the Trichostrongylinae by the possession of long slender spicules and from Nematodirus and Mecistocirrus by the character of the dorsal and ventral rays. Accordingly it is proposed that this species should be made the type of a new genus, Graphidioides, differing from other Trichostrongylinae genera by the possession of long slender spicules with simple points and widely diverging ventral rays. The type species is Graphidioides affinis (Megnin, 1895).

Graphidium rudicandatus, R. & H., 1909, from Viscacia viscacia, from Argentina, resembles G. affinis very closely. It differs mainly by its smaller size, equal ovejectors, sharply pointed externo-dorsal ray and absence of an accessory piece. Its affinities to the type of Graphidioides are so close, that the latter point requires re-investigation. The other points are only of specific value, and it is proposed to include it in this new genus. Should the absence of an accessory piece be confirmed its position would require re-determination.

Plate 3

GRAPHIDIOIDES AFFINIS.

(a) Cephalic extremity.

(b) Ovejectors and vulva.

(c) Caudal extremity of female.

(d) Dorsal ray of male bursa.

(e) Accessory piece.

A

·2 mm

B

·5 mm

C

·2 mm

D

·02 mm

E

·1 mm

Plate 4

GRAPHIDIOIDES AFFINIS.

(a) Male bursa.

(b) Extremities of spicules.

A

·2 mm

B

·1 mm

MECISTOCIRRUS. NEVEU LEMAIRE, 1914.

In 1006, v. Linstow, described Strongylus digitatus, from India. In 1912, Railliet & Henry created the new sub-genus, Mecistocirrus, of the genus Nematodirus to receive this species. Meanwhile Strongylus fordii was described by Daniels from Malay in 1908, and the following year by Stephens (under the name of S. gibsoni). Leiper, in 1911, had expressed the opinion that this was the same as v. Linstow's species, but Railliet & Henry separated these two forms on the following not very important points:-

	M. digitatus	M. fordii
Length of spicule	...1/6 to 1/5 of body length	...1/4 to 1/2 of body length
Length of bursa	...Twice breadth	...About equal to breadth.
Salient lobule of bursa at level of E. D. rays.	Absent	...Present

In 1912 Neveu Lemaire, from an examination of the female genital system, raised the sub-genus to generic rank. In 1922, Morishita described M. tagumai from Japan. His species differed from the others on the following points: Length of spicules, 1/5 to 1/4 of body length; bursa slightly longer than broad; salient lobule present but small. It will be noticed that this species is exactly intermediate between digitatus and fordii, and forms with them an unbroken series. Examples studied by

me show that the salient lobule of the bursa disappears when the bursa is flattened out, while specimens with spi spicules 1/4 to 1/3 of the body length have a bursal length of twice its breadth. Accordingly there can be no doubt that Leiper's opinion was the correct one, and only one species exists. In 1919, Sheather described the same worm from India as "As a new nematode, causing parasite gastritis in calves," but was apparently unable to identify it.

MECISTOCIRRUS DIGITATUS (v. Linstow, 1906)
Neveu Lemaire, 1914. (Plates 5 & 6).

Syn.:- Strongylus digitatus v. Linst, 1906.

Strongylus fordii Daniels, 1908.

Strongylus gibsoni Stephens, 1909.

Nematodirus digitatus (v. Linst) R. & H. 1909.

Mecistocirrus fordi (Daniels) Neveu Lemaire, 1914.

Mecistocirrus tagumai Morishita, 1922.

Nematode Sp. nov. Sheather, 1918.

The worms, preserved in alcohol, were brownish in colour. The specimens examined varied in length from 16 to 23 mm. in the male, and 19 to 26 mm. in the female. The average maximum diameter of the male was .45 mm., and of the female .5 mm. Morishita (1922) mentions males as long as 31 mm. and females of 43 mm.

The cuticle is finely striated transversely. There are in addition about 30 longitudiual striations.

The anterior extremity is rounded with six inconspicuous papillae. The buccal opening is sub-terminal, and opens slightly towards the dorsal side. It is oval in outline, with its long axis dorso-ventral, and is strengthened by small chitinised strips. There is a large buccal tooth present (as in Haemonchus) with muscles attached posteriorly and ventrally. The sharp point of the tooth is dorsal. A dorsal cephalic gland is visible posterior to the base of the tooth.

The oesophagus is long and very slender. It is only slightly swollen posteriorly. The length is about 1.6 to 1.8 mm.

The cervical papillae are situated at the level of the junction of the anterior and second quarters of the oesophagus, and lie in small depressions in the cuticle.

The nerve ring surrounds the oesophagus about the junction of its anterior and second fifth.

The excretory pore is midway between the nerve ring and cervical papillae.

The cervical cuticle is only slightly thickened. It becomes very thin anteriorly.

The Female.— The vulva is a prominent transverse slit set in a chitinised area close to the anus, about .55 mm. from the posterior extremity. The body is slightly dilated, just anterior to the vulva, but no trace of the crossed lateral lines, seen by Morishita (1922), could be found. This point requires re-investigation, and is probably a mistake.

The vagina is very long— about2.9 mm.—and joins the feebly muscular ovejectors centrally. These are equal in size—about.8 mm. each. The inferior ovejector joins the inferior uterus, which almost immediately turns on itself and runs anteriorly—parallel with the superior uterus. The ovaries are spirally coiled round the intestine, as in Haemonchus, and arise in the anterior

quarter of the body.

The anus is situated about.2 mm. from the posterior extremity, and joins the intestine by a small rectum.

The posterior extremity narrows rapidly from the anus and is bluntly pointed.

The ova measures .095 to .119 mm. long, and .050 mm. broad. They are laid in the morula stage.

The Male.— A pair of inconspicuous prebursal papillae are present just anterior to the commencement of the bursa.

The bursa is completely divided into three lobed. The lateral lobes are spatulate in shape and the tips frequently overlap. It was found to be impossible to completely flatten them out without the aid of dissection needles. The bursa is laminated, and is very elastic. The small lobules noticed by Railliet & Henry (1912) as occuring at the level of the externo-dorsal rays are present only on the folded bursa and disappear on flattening out. The dorsal lobe is small and symmetrical,

The disposition and relative size of the rays are are shown in Plate 6 (a & b). The latero-ventral and externo-lateral are similar in size, and run together posteriorly for almost their entire length. Their tips are directed away from each other. These two rays are by far the largest ~~by far~~ in the whole bursa. The ventro-ventral ray is short and slender, and bends out-

only been recorded from India, Malay, China and Japan, but further invigestigation into cases of Haemonchosis may indicate a wide distribution.

Discussion.- There is no doubt that Neveu Lemaire was justified in making this worm the type of a new genus. It appears to be more closely allied to Haemonchus than to any of the existing genera. In naked eye appearance it shows a very great similarity to this worm, and it has probably been mistaken for it in the past.

Plate 5

MECISTOCIRRUS DIGITATUS.

(a) Cephalic extremity.

(b) Ovejectors and vulva.

(c) Caudal extremity of female.

(d) Buccal cavity shewing tooth.

A

·5 mm

B

·5 mm

C

·2 mm

D

·02 mm

Plate 6.

MECISTOCIRRUS DIGITATUS.

(a) Male bursa.

(b) Male bursa, compressed.

(c) Termination of spicules.

A

B

·5 mm

C

·05 mm

MOLINEUS FELINEUS. Gen. et. Sp. nov.(Plates 7and8)

General.- These are very small slender forms. The male is about 4.75mm. and the female 5.25mm long. Both sexes are about 0.1mm. in diameter.

The cuticle, except for the swollen cephalic extremity is striated longitudinally- there being 12 to 14 eq equidistant lines. Except in the cephalic region only traces of transverse striations can be seen under a high power ($\frac{1}{12}$").

The cephalic cuticle is swollen and conspicuously striated transversely. The swelling completely surrounds the body, but tends to be unilateral. It is about .05mm. in diameter, and is separated from the rest of the body by a distinct line. There is a small mouth cavity, formed by the inflated cuticle, and this communicates directly with the aesophagus. No buccal papillae could be observed.

The oesophagus is straight, slender and tapers anteriorly There is no distinct bulb. It is about .26mm. long and 0.03mm. in maximum diameter.

The nerve ring is situated about midway down the oesophagus.

The excretory pore is just posterior to the nerve ring, and opens on a small protuberance. Cervical papillae are absent.

The Female.- The vulva is a transverse slit, situated about 1.1mm. from the posterior end. The ovejectors, uteri and ovaries are typical.

The anus is situated about .07mm. from the posterior extremity, and joins the intestine by a short rectum.

The posterior extremity is bluntly rounded. From it projects a terminal spine (.03mm. long), formed from the body substance and supported at its base by a cuticular collar.

The ova are oval, thin shelled and about .060mm. long by .040 broad. They are embryonated when laid.

The Male.- Prebursal papillae are absent. The bursa is not distinctly divided into lobes. It is not laminated, but the central portion is covered with small spines. The disposition of the rays is shewn in Figs.11 and 12. The ventral rays are long and parallel, but separated slightly in their distal half. They are directed ventrally and reach the edge of the bursa. The lateral rays, which are also close together and parallel, arise in a common truck. The externo-lateral ray is only half the length of the other lateral rays and does not reach the edge of the bursa. It is in apposition with the medio-lateral for about half its length, but its terminal portion is directed ventrally. The medio-and posterio-lateral rays are long and slender, about equal in size and reach the bursal edge. They are directed slightly dorsally. The dorsal ray gives off the externo-dorsals a short distance down its main stem. The externo-dorsal runs parallel with and close to the posterio-lateral, but terminates about half-way down the latter. Its terminal portion is directed

slightly dorsally. The dorsal ray splits near its termination into two rays, each of which in turn gives off three digitations- the lateral being much the largest.

The spicules are about .12mm. long, and are curved slightly ventrally.The double points are directed posteriorly. The posterior point of each spicule is much the larger, and seems to be formed of two smaller points fused together. The cephalic end of the spicules is broad and cupshaped.

The accessory piece,.06mm. long is an elongated oval in shape, and is flexed ventrally, towards the posterior end.

Pathogenicity is unknown. The present specimens were found in association with numberous examples of Echinococcus, and of Ancylostoma pluridentatum. The intestine was thickened and slightly inflamed, but these symptoms were probably caused by the other parasites.

Host: Felis yaguarundi. Habitat: Small intestine. Distribution: S. America.

DISCUSSION.

This worm shows affinities to a number of the Trichostrongylinae- particularly Oswaldscruzia Travassos, Hyostrongylus Hall, Ostertagia Ransom, and Trichohelix Ortlepp- but shows considerable differences from all of them. It differs from Oswaldocruzia in the presence of an accessory bursal piece, in the shape of the spicules, and in the disposition and length of the externo-lateral ray: from Hyostrongylus in the disposition and length of the externo-lateral rays and absence of lateral branches to the dorsal ray and of prebursal papillae: from Osteriagia in the absence of an accessory bursal membrane: and from Trichohelix in the absence of the cuticular body swelling and in the shape of the spicules and externo-lateral and externo-dorsal rays. These differences seem so considerable that it is proposed to designate this parasite as type of a new genus Molineus- in honour of Molin. This genus differs from all other members of the Trichostrongylinae, especially by the disposition and size of the externo-lateral ray.

As this is the first trichostrongyle worm found in the Fedidae, the specific name felineus is proposed for it. As is the case with many feline parasites, this species is probably not restricted to Felis yaguarundi, and search should be made for it in domestic and other cats in South America.

Plate 7.

MOLINEUS FELINEUS.

(a) Cephalic extremity.

(b) Caudal extremity of female.

(c) Posterior region of female.

(d) Male bursa, lateral view.

A

·05 mm

B

·05 mm

C

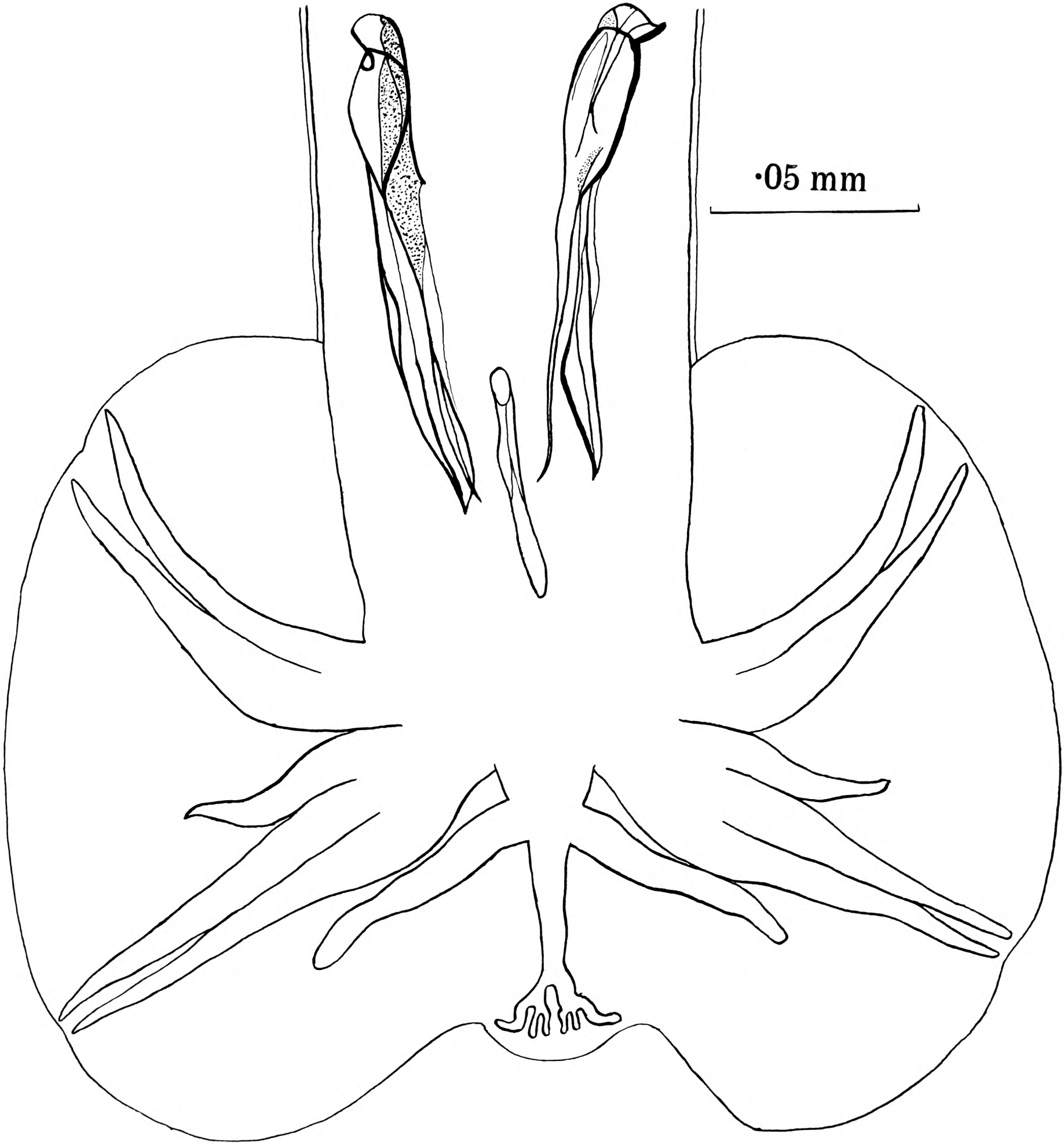
D

·05 mm

Plate 8

MOLINEUS FELINEUS.

Male bursa - Dorsal view.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MOLINEUS TORULOSUS (Molin, 1861). Plates 9and10)

A number of specimens of a genus of Trichostrongyle worms have been recovered from the small intestine of squirrel monkeys (Saimiris sciurea)from Guiana. They show con considerable resemblance to Oswaldocruzia wisei Philpot, but differed from that species in the possession of a distinct accessory piece. At Professor Leiper's suggestion an examination was made of the type specimens of O.wisei, and it was found that under $\frac{1}{12}$" objective an accessory piece was present, though extremely difficult to see. In the later examples found by the writer, the accessory piece is easily seen under a medium power.In the new specimens, also,the externo-lateral ray was shorter than those figured for O.wisei. The reexamination of the type material showed that this was also the case in O.wisei, but that owing to the folded condition of the bursa, this had not been observed. The bursa and cephlic extremity of the parasite are re-figured.(Plates 9and10.) The peculiar contour of the cephlic swelling is constant.

Molin, in 1861, described from Cebus capucinus, from Brazil, a Trichostrongyle worm, which he called Strongylus torulosus. In this species the female was 9mm. long,while the male was 7mm. Body threadlike and extremity gradually attenuated to a trunk-like point. Head constricted at base Mouth terminal, orbiculate and ample with naked borders. Female with vulva in posterior of body far from anus. Uteri

double. Caudal extremity conical and needle-like, Anus near caudal extremity. Male with caudal bursa entire. Dorsal ray bifurcated. Ventral rays separated. Spicules simple, short and curved with proximal extremity large and round, and distal extremity pointed. Accessory piece simple, short; base dilated and rounded, apex sharp."

The similarity of Molin's description and diagrammatic figures with that of O.wisei, together with the relationship of the hosts and their geographical distribution, lead one to the conclusion that O.wisei is a synonym of S.torulosus. But the additional facts put forward above show that this worm should not be placed in the genus Oswaldocruzia.It differs from the type of this genus in the following features:-

Oswaldocruzia subauricularis.	S.torulosus.
(a) Spicules multipointed and complicated.	Spicules with 3 points and comparatively simple.
(b) E.L. ray approx.same size as M.L. and P.L.	E.L. about half-size M.L.and P.L.
(c) E.D.little shorter thanP.L.	E.D.about ½-size P.L.
(d) No accessory piece.	Distinct accessory piec
(e) In reptiles and amphibians.	In mammals.

The name Oswaldocruzia torulosa must accordingly be rejected

Strongylus torulosus shows the greatest affinity to Molineus felineus, described in this paper. It differs from it in the following particulars:-

M. felineus	S. torulosus.
(a) Cervical cuticle with smooth contour.	With notched contour.
(b) E.L. ray separated from M.L. only at tip.	Separated for entire length.
(c) Spicules with sharp points only.	With characteristic hammer-shaped branch.

These points seem to be of specific importance and accordingly, this species should be included in the genus Molineus with the name

Molineus torulosus (Molin, 1861)

Syn:- Strongylus torulosus Molin, 1861.

Oswaldocruzia wisei Philpot, 1922,

Trichostrongylus (s.l.) torulosus Trav., 1922.

Hosts. Cebus capucinus

Saimiris sciurea

This species has also been found by the writer in Cebus fatuellus.

Habitat. Small Intestine.

Distribution. South America.

Plate 9.

MOLINEUS TORULOSUS.

(a) Cephalic extremity.

(b) Male bursa, lateral view - after MOLIN.

(c) Male bursa, ventral view - after MOLIN.

(d) Male bursa, Lateral view

A

·05 mm

B

C

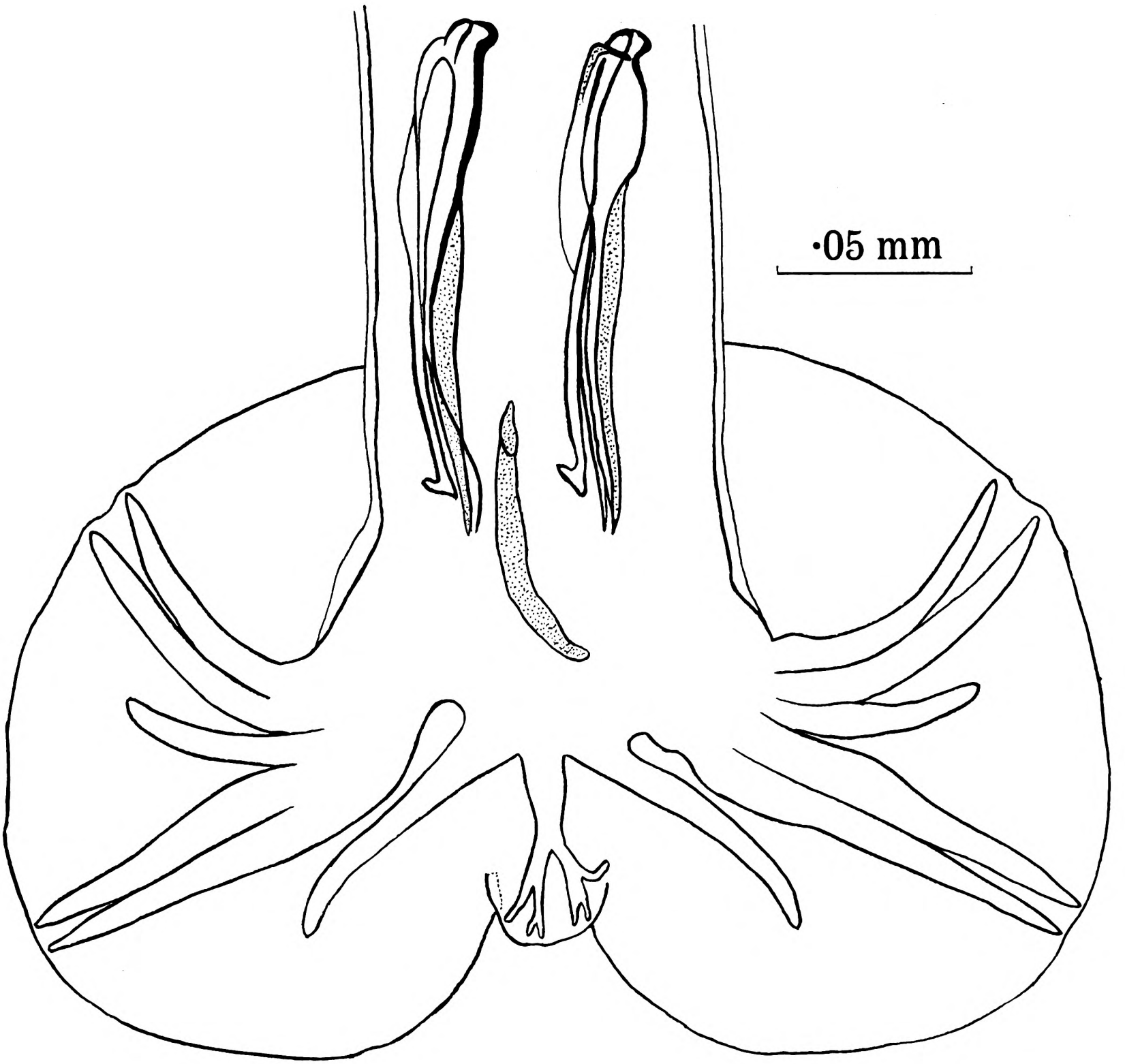
D

·05 mm

Plate 10.

MOLINEUS TORULOSUS.

Male bursa, ventral view.


·05 mm

VIANNAIA SAIMIRIS. SP. NOV. (Plates 11& 12)

The colour, is bright red when alive, becomes brown on fixing in alcohol. The cuticle is transversely striated. The worms are always found coiled in a permanent spiral of two or three turns. They do not uncoil on fixing. The male is 3 to 6mm. long, and the female is 4 to 7mm. Both sexes are about 0.15mm. broad.

The cephalic cuticle is swollen and unstriated. This swelling extends for about .075mm. from the extremity. At this point the body is expanded to meet the in-turning cuticule. This expansion may be homologous with the cervical papillae, which are otherwise absent.

The mouth is simple, and the swollen cuticle forms a cavity into which the oesophagus opens.

The oesophagus is about .325mm.long and .02mm. broad.

The excretory pore is situated about .25mm. from the extremity.

The nerve ring could not be distinguished.

The female.- The vulva is an inconspicuous slit situated about .26mm. from the posterior extremity.

The single ovejector is very muscular, and leads into a single uterus and ovary.

The anus is about .085 mm. distant from the posterior extremity, and joins the intestine by a short rectum about .06mm. long

The posterior extremity is sharply pointed.

The ova are about .060.mm. long and .035mm. broad.

The Male.- The bursa is ample and is indistinctly divided into three lobes. There are no prebursal papillae.

The ventral rays rise together, but proceed at right angles to each other. The ventro-ventral is shorter and thinner than the lateral-ventral, which terminates in a projection on the edge of the bursa. The lateral rays arise on a common stem, but diverge widely. The externo- and medio-lateral diverge about half way down their length but the posterio lateral diverges from its origin. The dorsal trunk gives off the externo-dorsal rays about half way down its length. The externo-dorsal is long, thin and and narrows just before its termination into a finger-like process. The dorsal ray bifurcates in its first quarter. Each bifurcation terminates in two digitations. All the rays approach the edge of the bursa.

The spicules are .25mm. long, simple and in close opposition for most of their length. There is no accessory piece. Pathogenicity unknown.

Host: Saimiris sciurea. Habitat: Embedded in mucus of small intestine and resembling petchial haemorrhages

Distribution: South America.

DISCUSSION.

The presence of only one ovary shows at once that this nematode belongs to the sub-family Heligmosominae Travassos. Although this sub-family is a very compact and obvious one, much confusion still exists among its genera, in spite of the work of Hall and Travassos, mainly on account of the incomplete descriptions in existence. The type species of the type genus is very inadequately described, and has never even been figured. Travassos (1921) considers that the disposition of a body"strongly rolled in a spiral in a definite manner is a very good characteristic." Hall (1916) also places some stress on this point. This feature would divide the Heligmosominae into two groups- Heligmosomum RandH. and Heligmostrongylus Travassos, which are not rollrd in a spiral: and Viannaia Travassos, Viannella Travassos, and Heligmosomoide Hall, which are rolled spirally.

In Heligmosomoides the vulva is anterior, while in Viannella, the ventral rays, and also the M.L. and P.L. rays, are united in their basal two-thirds. Viannaia, as at present accepted, would be the genus for the present species. It would seem, however that the genus requires splitting. This species corresponds to none of the already described species of Viannaia, and the specific name of Viannaia saimiris sp. nov. is proposed for it.

GENERAL REMARKS ON GENERIC DIAGNOSIS.

In this paper it has been found necessary to create two new genera. The omission of a formal generic diagnosis is an intentional one. A genus is simply a collection of species which are considered by an author to resemble closely a type species. The delimitation of certain specified characters as being generic value and others of only specific value, has led to endless confusion- and is after all merely an expression of opinion. At the same time, it is not denied that the drawing of attention to what an author considers are the more salient points in a genus is of considerable value. As, however, the classification of all the parasitic worms is in such a condition of flux in our present state of knowledge, it is considered that the creation of artificial generic diagnosis is not only fruitless, but tends to spoil the the elasticity of a true evolutionary classification. It is not suggested that short descriptions of higher groups should be abolished. On the contrary, they are of considerable value, and have more permanence than the genus- even admitting that many of our families and sub-families are purely artificial and require revision.

KEY TO THE GENERA OF THE FAMILY TRICHOSTRONGYLIDÆ LEIPER.

A. Sub-family *Trichostrongylinæ* Leiper. (Double genital apparatus in female) 1

1. Head with umbrella-shaped membrane ... HISTIOSTRONGYLUS Molin
   Head without umbrella-shaped membrane 2
2. Spicules short with ridges and projections 3
   Spicules long and filiform 12
3. Accessory piece present 4
   Accessory piece absent 10
4. Acc. piece ring-shaped; no prebursal papillæ ORNITHOSTRONGYLUS Trav.
   Acc. piece wedge shaped; prebursal papillæ present or absent ... 5
5. Dorsal lobe of bursa asymmetrical ... ... HÆMONCHUS Cobb.
   Dorsal lobe symmetrical 6
6. V.V. ray separated from and smaller than L.V.; prebursal pap. absent ... ... TRICHOSTRONGYLUS Loass.
   V.V. ray close to and about same size as L.V.; prebursal pap. present or absent 7
7. Acc. bursal membrane present ... ... OSTERTAGIA Ransom
   Acc. bursal membrane absent 8
8. Prebursal papillæ present; no cephalic dilation HYOSTRONGYLUS Hall
   Prebursal papillæ absent; cep. dilation present 9
9. E.L. same size as other lateral rays ... ... TRICHOHELIX Ortlepp
   E.L. half-size of other lateral rays ... ... MOLINEUS Cameron
10. Prebursal papillæ conspicuous ... ... TRAVASSOSIUS Khalil
    Prebursal papillæ absent 11
11. Dorsal ray lyre shaped; spicules with simple points COOPERIA Ransom
    Dorsal ray like "capital of columns"; sp. with multiple points OSWALDOCRUZIA Trav.
12. Spicules with multiple points ... ... GRAPHIDIUM Railliet & Henry
    Spicules with simple points 13
13 Vulva close to anus; Vagina long; uteri parl. MECISTOCIRRUS Nev. Lem.
   Vulva remote from anus; Vagina short; uteri divergent 14
14. Ventral rays same size and parallel ... ... NEMATODIRUS Ransom
    V.V. much shorter than L.V. and divergent ... GRAPHIDIOIDES Cameron

B. Sub-fam. *Heligmosominæ* Travassos. (Single genital apparatus in female) 15

15. Body rolled in a perm. spiral 16
    Body not in a perm. spiral 18
16 Vulva near cephalic extremity ... ... HELIGMOSOMOIDES Hall
   Vulva in posterior half of body 17
17 Ventral rays, and also M.L. & P.L. united in basal two-thirds VIANNELLA Trav.
   Ventral rays, and also M.L. & P.L. not united in basal two-thirds VIANNAIA Trav.
18. Dorsal ray, single ... ... HELIGMOSOMUM R. & H.
    Dorsal ray, double ... ... HELIGMOSTRONGYLUS Trav.

NOTE 1.—Of the two remaining genera, males only are known. Travassos (1921) is of the opinion that the first *Warrenius* Hall is a species of *Heligmosomum*; and the second *Citellinema* a species of *Viannella*.

NOTE 2.—The above table is only intended as a means for identifying the various genera, and not as an attempt to show their relationships.

REFERENCES.

DANIELS, C. W., 1908.—" Animal Parasites in Man and some of the lower Animals in Malaya Studies." *Inst. Med. Rec., Fed. Mal. States*, iii., p. 15.

HALL, M. C., 1916.—" Nematode Parasites of Mammals of the Order Rodentia, etc." *Proc. U.S. Nat. Mus.*, l., pp. 1-258.

HALL, M. C., 1921.—" Two new Genera of Nematodes, etc." *Proc. U.S. Nat. Mus.*, lix., pp. 543-544.

KHALIL, M., 1922.—*Travassosius rufus* gen. et. sp. n. . . . *Ann. Mag. Nat. Hist.*, Ser. 9, x., p. 281.

LEIPER, R. T., 1912.—" Notes of recent and some new records of Helminths in Man . . . " *Jour. London S. Trop. Med.*, i., p. 18.

v. LINSTOW, O., 1906.—" Helminths in the Collection of the Colombo Museum." *Sp. Zeyl*, iii., p. 168.

MEGNIN, P., 1895.—" Sur un gastrité vermineuse du Mara on lièvre de la Patagonée." *Rev. de Sc. Nat. Appliquée*, par. v., xlii., pp. 337-338.

MOLIN, R., 1861.—" Il soltordine degli acrofalli, etc." *Mem. r. Ist. Veneto di sc.*, lett. ed. arti. Venzia, ix., p. 427-633.

MORISHITA, K., 1922.—" On a new Nematode of the genus Mecistocirrus . . . " *Annot. Zool., Japon*, x., pp. 89-99.

NEVEU LEMAIRE, M., 1914.—" Dedoublement du genre *Nematodirus*." *Bull. Soc. Zool., France*, xxxix., pp. 293-296.

NEVEU LEMAIRE, M., 1918.—" Contribution à l'étude des organes reproducteurs . . . chez Metastrongylidæ." *Mem. Soc. Zool., France*, xxvii., pp. 1-121.

ORTLEPP, R. J., 1922.—" On a new Trichostrongyle Genus from an Armadillo." *Ann. Mag. Nat. Hist.*, Ser. 9., ix., p. 413.

PHILPOT, M., 1922.—" On *Oswaldocruzia wisei*." *Ann. Mag. Nat. Hist.*, Ser. 9, x., p. 242.

RAILLIET, A. & HENRY, A., 1909.—" Sur la classification des Metastrongylidæ." C. & S.B., l., p. 87.

RAILLIET, A. & HENRY, A., 1912.—" Os, sur les Strongylidés du genre *Nematodirus*." *Bull. Soc. Path. Erot.*, v., pp. 38-39.

RANSOM, B. H., 1911.—" Nematode parasites in the alimentary canal of . . . ruminants." *Bur. An. Inst., Bull.* 127.

SHEATHER, A. L., 1919.—" A new Nematode causing Parasitic Gastritis in Calves." *Agric. Rec. Inst. Pusa, Bull.* 86.

STEPHENS, J. W. W., 1909.—" A new Human Nematode—*Strongylus gibsoni*." *Ann. Trop. Med. & Pas.*, ii., pp. 315-6.

STILES, C. W. & HASSELL, A., 1920.—" Index Catalogue of Med. and Vet. Zoology—Roundworms." *Bull. No.* 114, *Hys. Lab., Washington.*

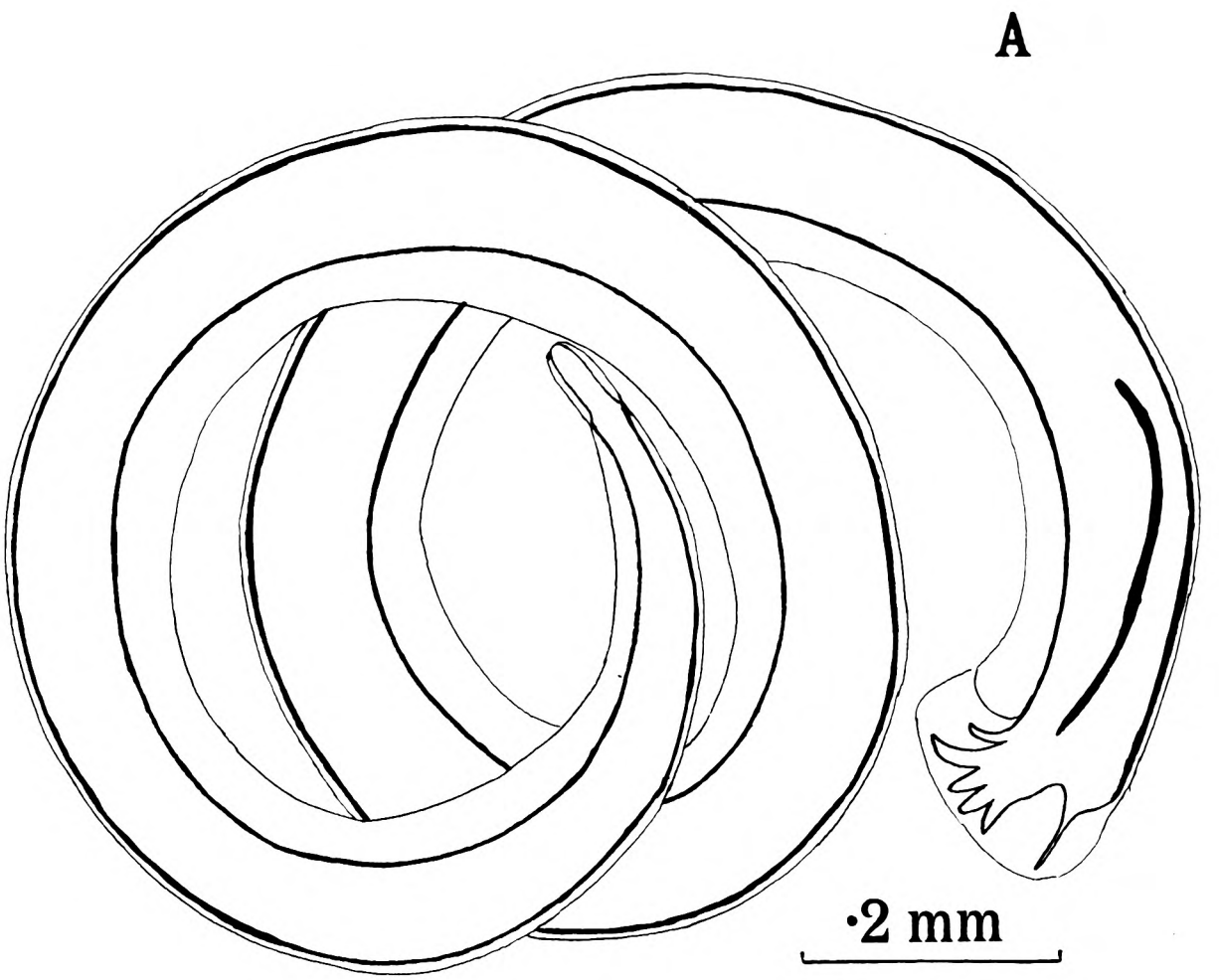
TRAVASSOS, L., 1921.—" Ensaio monografico da fam. *Trichostrongylidæ* Leiper." *Memo. do Inst. Oswaldo Cruz*, xiii., pp. 1-135.

Plate 11.

VIANNAIA SAIMIRIS.

(a) Complete male.

(b) Cephalic extremity.


A
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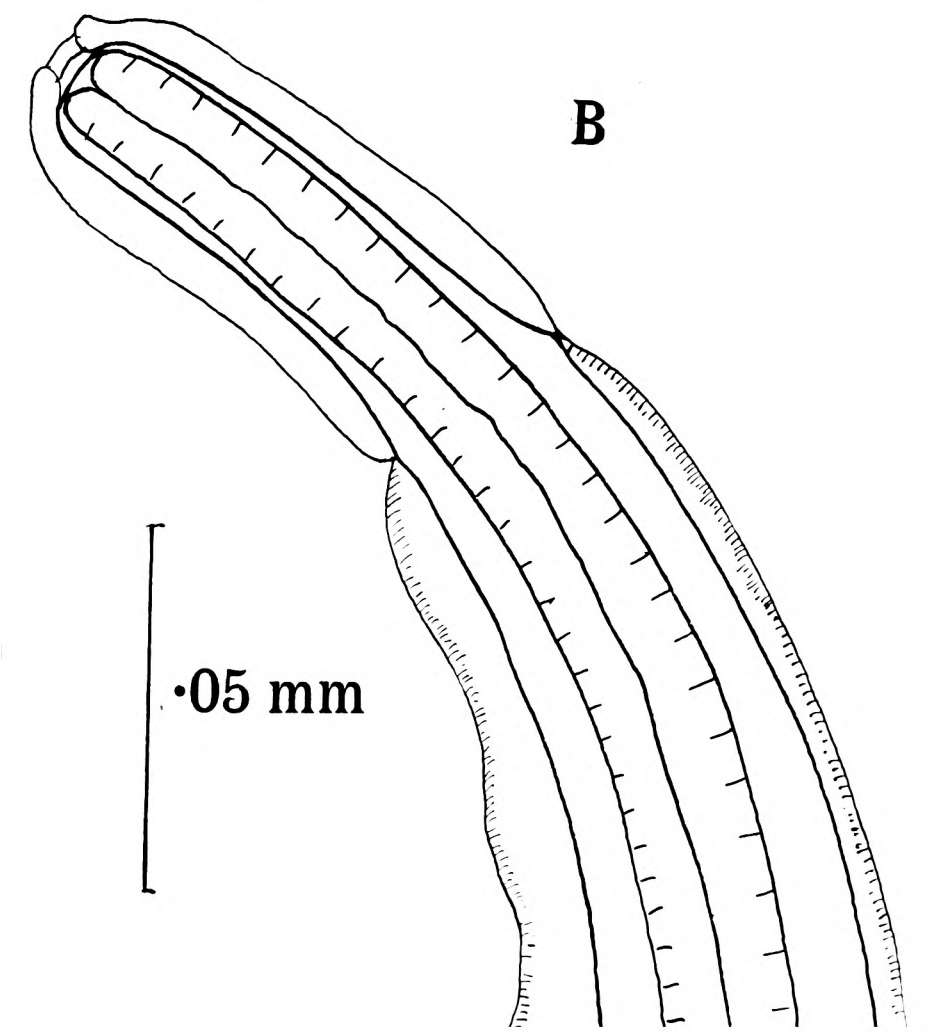
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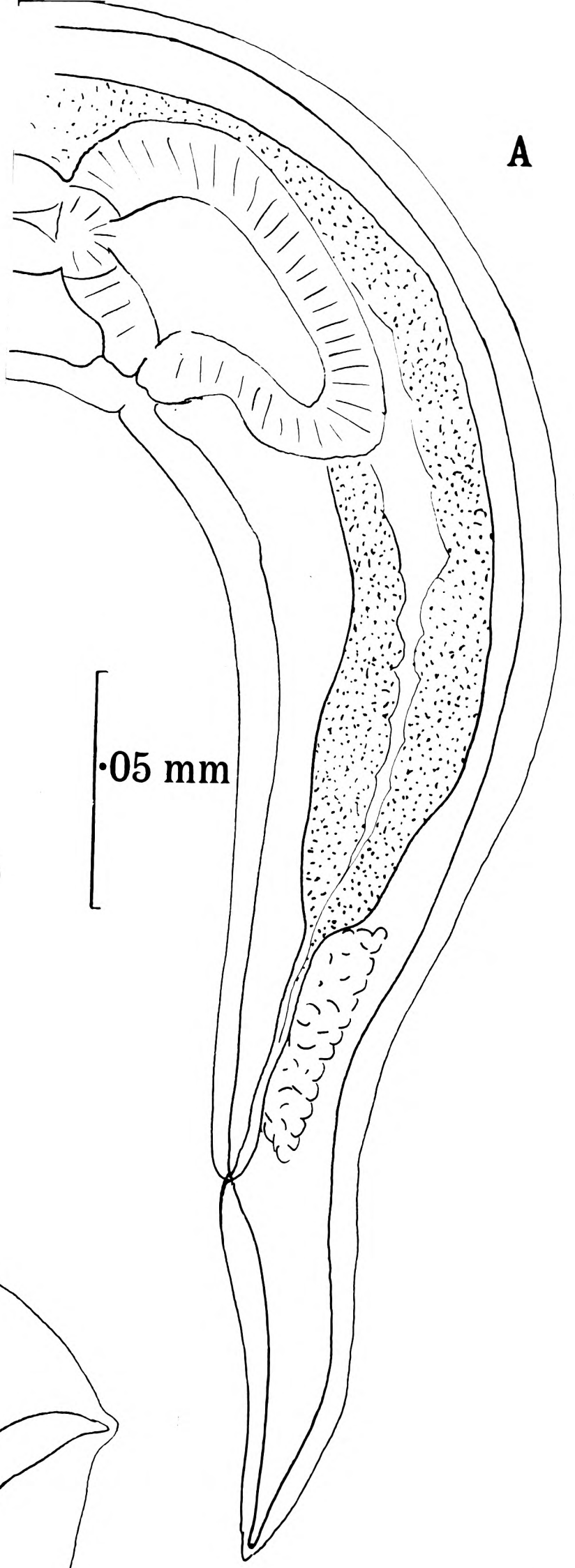
Plate 12.

VIANNAIA SAIMIRIS.

(a) Posterior extremity of female.

(b) Male bursa, dorso-ventral view.


B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