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TREMATODES FROM THE RAT[1]

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Occasional examinations of rats for animal parasites have been carried on for over a hundred years. Later, knowledge of the importance of rats as reservoirs of infection and as agents in the transfer of parasitic diseases has led to the regular and careful examination of large numbers in various parts of the world. Among the more recent publications dealing with the parasites of rats may be mentioned Shipley (1908), Moll (1917), Chandler (1921), Balfour (1922), Baylis (1922), Stevenson (1922), Hegner (1923), and Lavier (1924). Notwithstanding the many investigations, only a single trematode parasite has previously been discovered and concerning it so little is known that its identity is questioned. The first record, that of Dujardin (1845), contains a brief description of the parasite which he named *Distoma spiculator*. Six specimens were found in the small intestine of *Rattus norvegicus* taken at Rennes, France, but they were not sexually mature and the author suggested that they might be identical with *D. trigonocephalum* Rudolphi, a species previously reported from the badger, polecat, hedgehog, weasel, and martin.

The form described by Rudolphi has been studied by several investigators and is a well-established species. Cobbold (1860) transferred both *D. trigonocephalum* and *D. spiculator* to the genus *Echinostoma*. *D. trigonocephalum* had been shown to be synonymous with *P. melis* Schrank, and Lühe (1909) erected the genus *Isthmiophora* to contain it. Referring to the trematode from the rat, Lühe says it has been found only twice and he included it as *Echinostoma spiculator* sp. inq.; very similar if not identical with *Isthmiophora melis*. Odhner (1910) discredited the genus *Isthmiophora* and transferred the species *E. trigonocephalum* to the genus *Euparyphium* Dietz.

During the past year the junior author has been engaged in the parasitological examination of rats from New York City. On November 1, 1923, he discovered in mucosal scrapings from the jejunum of one specimen of *R. norvegicus* a large number of very small trematodes. This rat, together with sixteen others, was caught near the Clason Point dump

[1]Contribution from the Biological Laboratory, New York University.

on the water front. The rat must have harbored several hundred of these worms as hardly a smear could be made from the mucosa without finding from one to six specimens. When the parasites were found there was opportunity to make only a cursory examination of the living worms and they were killed and preserved. It was observed that the oral sucker was surrounded by a crown of spines, about sixteen in number, arranged in a single row. Later study of stained material and of worms cleared in various media without staining failed to disclose the spines which were previously observed and which had been detached in the process of killing and mounting. We were, therefore, particularly anxious to obtain additional specimens and over one hundred rats of the gray and brown varieties collected during the months of November and December from wharves and along the water front of the East Side of New York City were examined without finding another infestation. The first week in April, 1924, a group of twelve rats was received from the Clason Point dump, and one, a specimen of *R. norvegicus*, yielded a second case of parasitism by the trematode previously observed. Again the worms were present in enormous numbers. The discovery of a second infestation by this parasite indicates that it is not an accidental or incidental parasite of the rat, and the large number present in the host appears subversive to such a conclusion. It seems that the species is largely confined to rats of the Clason Point region since examination of almost two hundred rats from other localities failed to disclose a single infestation. It appears also that the infection is not general or extensive but that when the parasites are present they usually occur in large numbers.

The structure of these worms places them at once in the genus *Ascocotyle* Looss. It is interesting to note that Joyeux (1923) found *Ascocotyle minuta* in only two out of forty-three cats examined in Tunis, and a very heavy infection in one of them. Looss (1899) suggested that the cercaria of *A. minuta* encyst in fish and are acquired by the final host through eating uncooked fish. Katsurada has shown that the immature stages of the closely related *Metagonimus* species are encysted in various fresh-water fish. Linton (1915) has shown that the immature stages of *Cryptocotyle* occur encysted in the skin and gills of marine fish. Cort and Yokogawa (1921) report that cercaria of *Heterophyes nocens* are encysted in fresh-water fish and the experimental work of Ciurea (1924) has demonstrated that fresh-water fishes serve as the second intermediate and transfer hosts of *Metagonimus romanicus* and *Apophallus mühlingi*. It appears to be characteristic of this group that its members reach their primary or definitive hosts after encysting in fishes and,

since the rats from which we obtained our specimens had access to considerable refuse from the city and also the water front and docks where fish might easily be obtained, it seems entirely probable that the worms were acquired in that way.

Looss (1899) designated *Ascocotyle coleostoma* as type of the genus and included in it a second species *A. minuta.* Subsequently other species have been added: *A. italica* Alessandrini, 1906; *A. angrense* Travassos, 1916; and *A. longa* and *A. nana,* both described by Ransom 1920. *A. coleostoma* was described from the cecum and large intestine of the pelican in Egypt, whereas *A. minuta* was described from the small intestine of dogs and cats and has been found once in the small intestine of *Ardea cinerea* in Egypt. Ciurea (1924) states that in his opinion the specimens described from the heron in Egypt and those reported by Faria in Brazil do not belong to the species *A. minuta.* Between the species *A. coleostoma* and *A. minuta* there are marked morphological differences so fundamental in character that it appears doubtful whether they can be contained in a natural genus. The more important differences may best be shown by a tabular comparison.

A. coleostoma	*A. minuta*
Double row of oral spines.	Single row of oral spines.
Esophagus absent.	Esophagus present.
Ceca entirely preacetabular.	Ceca extend postacetabular.
Acetabulum some distance posterior to bifurcation of digestive tract.	Acetabulum near the bifurcation of digestive tract.
Coils of uterus extend across the body anterior to the genital pore.	Uterus does not cross the body anterior to the genital pore.
Vitellaria entirely pretesticular, extend forward anterior to the genital pore.	Vitellaria partially post-testicular, entirely postovarian, do not extend forward one-third of the distance to the genital pore.
Habitat: cecum and large intestine of birds.	Habitat: small intestine of mammals and possibly of a bird, *Ardea.*

Although the description of Travassos (1916) is brief and in certain respects indefinite, it seems that *A. angrense* shows substantial agreement with *A. coleostoma* and both are parasitic in birds. The other previously described species are mostly from mammals and are very similar to *A. minuta.* These species appear to constitute a distinct and discrete section of the genus for which we propose the name **Parascocotyle** with *A. minuta* as type.

The specimens from the rat agree more closely with *A. minuta* than any other known form and in certain respects the likeness is striking.

Many of the organs agree in size with those of *A. minuta*, but the worms themselves are much smaller, hardly more than half the size of *A. minuta*, and the suckers, ovary, and testes are relatively much larger. The eggs, on the other hand, are smaller. The discovery of additional material may supply specimens intermediate in these respects and demonstrate the identity of these worms and *A. minuta*, but at the present such identity appears hardly probable and we describe them as a new species.

A. (Parascocotyle) diminuta, new species

These worms were very active when first removed from the intestine of the host. Normally the body is pyriform in outline but in an extended condition the sides may become almost parallel, and the lateral edges, especially in the posterior region, are curved ventrally. In a contracted condition the worm may be almost as wide as long and here also there is a tendency for the lateral edges to turn ventrally. The dorsal lip may be prolonged anteriorly in the form of a triangular process or retracted into a short rounded lobe, so the form of this structure can not be used as a specific feature.

The oral sucker is surrounded by a crown of spines, about sixteen in number, arranged in a single row. The spines are quickly shed when the worms are placed in either normal saline or tap water and while examining a living specimen in the mucosal secretion one observes the spines become detached and frequently several may be seen floating away. The worms lose their spines on killing and we have been unable to secure a fixed specimen with all the spines intact. In fact, it is difficult to be sure of their number in living worms as certain of the spines may have been lost. The spines measure 0.013 mm. in length and 0.0033 mm. in greatest width. In the anterior portion of the body the cuticula bears small spicules but they are reduced in size and disappear posteriorly.

The specimen shown in the figure is one of the largest and as mounted measured 0.35 mm. in length and 0.077 mm. in width. Observed in the living condition this worm extended to a length of 0.46 mm. and it measured then 0.06 mm. in width. Contracted to a length of 0.154 mm. it measured 0.12 mm. in width. The average length of preserved specimens is between 0.25 and 0.3 mm. and the corresponding width is from 0.08 to 0.1 mm. One specimen cut in cross-sections measures 0.084 mm. in greatest width and 0.05 mm. in thickness. Another is 0.092 mm. in width and 0.06 in mm. thickness.

The oral sucker measures from 0.04 to 0.05 mm. in length and from 0.037 to 0.045 mm. in width. The oral cecum arises from the dorsal posterior part of the sucker and extends posteriad about half the distance to the pharynx. It is usually slightly coiled and varies from 0.04 to 0.06 mm. in length. The mouth opening is subterminal. The prepharynx varies in length with the extension of the anterior part of the body and in fixed specimens measures from 0.05 to 0.06 mm. The pharynx is oval, 0.021 to 0.024 mm. in width and 0.024 to 0.032 mm. in length. The esophagus measures 0.02 to 0.025 mm. in length. The intestinal ceca diverge in a wide bend encircling the acetabulum and terminate near its posterior level.

The acetabulum lies in the intercrural area. It measures 0.038 to 0.043 mm. in diameter, is median in position, and situated about two-fifths of the body length from the posterior end. The ventral wall is continuous and the cavity opens anteriorly

through the genital sinus. When the body is extended the acetabulum tends to become elongate in the long axis of the worm. The genital pore is situated immediately in front of the acetabulum and the genital sinus is small, and elongate transversely.

The testes are ventral in position, symmetrically arranged, one on either side of the body near the posterior end. They are oval in shape, longer in the transverse axis of the body, and measure from 0.02 to 0.033 mm. in width by 0.019 to 0.024 mm. in length. Sections show their thickness to be approximately equal to their length. Vasa efferentia pass forward and open into the posterior end of the seminal vesicle. As in other species this structure is U- or V-shaped with the closed end of the loop on the right side of the body. The posterior limb is shorter and smaller. Its caudal end is situated on the left side of the median plane a short distance anterior to the seminal receptacle and near the level of the anterior margin of the ovary. It expands extending dorsally, anteriorly, and toward the right. Near the apex of the loop it contracts slightly and from this point, a short distance behind the end of the right cecum, the anterior limb of the vesicle extends almost transversely across the body approaching the cecum of the left side. The ejaculatory duct arises from the anterior face of the terminal portion of this limb and passes forward and mediad, opening into the genital sinus. It is surrounded by prostate cells but the gland is not large. Cirrus sac and cirrus are absent.

The ovary is almost spherical, 0.022 to 0.032 mm. in diameter, situated on the ventral side of the body, a short distance in front of the right testis. The oviduct arises at the median posterior margin and leads posteriad to the oötype. Here Laurer's canal is given off and passes dorsally, opening to the surface near the midline of the body. A large seminal receptacle, about the size of the ovary, is situated near the median plane slightly posterior to the level of the ovary. It is on the dorsal side of the body. We were unable from our sections to determine whether the seminal receptacle opens into the oötype directly or into the proximal end of Laurer's canal near its origin from the oötype. Shortly after the emergence of Laurer's canal the oötype receives the duct from the vitelline receptacle. Mehlis' gland was not observed. The uterus is arranged in transverse loops, crossing the body four or five times, and the metratermal portion parallels the ejaculatory duct, opening into the genital sinus. The uterus does not cross the body anterior to the acetabulum. Lenticular muscular bodies were not found on either side of the genital sinus. The vitellaria consist of a few large follicles situated near the lateral margins of the body anterior and lateral to the testes. They are almost entirely postovarian. Ducts from the vitellaria pass mediad and unite to form a large vitelline receptacle which discharges into the oötype. The eggs are numerous; they average 0.02 by 0.012 mm. and have thick, yellowish to brownish shells.

The dorsal commissure of the nervous system is situated a short distance anterior to the pharynx but the diminutive size of the specimens makes it impossible to trace the nerves without special technique.

The excretory pore is terminal and opens from a relatively large vesicle. This vesicle extends forward between the testes, and immediately posterior to the oötype it divides to form two lateral collecting ducts which pass forward. When the second infestation was found the attempt was made to work out the pattern of the entire system. The flame cells were observed but the material did not last long enough for a complete analysis and reconstruction of the excretory system and so far no additional specimens have been secured.

Looss (1899) erected the genera *Cœnogonimus*, *Toctotrema*, *Ascocotyle*, and *Centrocestus*, and included them in the subfamily Cœnogoniminæ. *C. heterophyes* was designated as type of the genus *Cœnogonimus*. Lühe (1899) had previously named the species *heterophyes* as type of a new genus *Cotylogonimus*, and placed in a new genus, *Cryptocotyle*, the species included by Looss in the genus *Toctotrema*. *Cœnogonimus* and *Toctotrema* thus disappear as synonyms and the name Cœnogoniminæ is invalidated. Pratt (1902) adopted Cotylogoniminæ for *Cotylogonimus* and *Cryptocotyle*. Looss (1902) showed that *Cotylogonimus* is a synonym of *Heterophyes* Cobbold, 1866, and the name Cotylogoniminæ also disappeared. Lühe (1909) placed *Cryptocotyle* and *Scaphanocephalus* in a new subfamily, Cryptocotylinæ. Odhner (1914) erected the family Heterophyidæ to contain the genera *Heterophyes*, *Toctotrema* (a synonym of *Cryptocotyle*), *Scaphanocephalus*, *Centrocestus*, *Ascocotyle*, *Pygidiopsis*, and *Apophallus*. Ransom (1920) excluded *Scaphanocephalus* from the family and added the genera *Metagonimus* Katsurada, 1913, *Paracœnogonimus* Katsurada, 1914 (possibly a synonym of *Cryptocotyle*), and a new genus, *Cotylophallus*. Nicoll (1923) extended the family Heterophyidæ to contain the subfamilies Microphallinæ Ward, Gymnophallinæ Odhner, and the genera previously included in the family which he placed in the subfamily Cryptocotylinæ Lühe.

The names Cœnogoniminæ and Cotylogoniminæ became invalidated when *Cœnogonimus* and *Cotylogonimus* fell as synonyms of *Heterophyes*. The subfamily Cryptocotylinæ was proposed for the same group of forms, although Looss had previously designated *Heterophyes* as type. Pratt (1902) had accepted that disposal and Odhner (1914) in naming *Heterophyes* as type of the family evidently did the same. *Heterophyes* and *Cryptocotyle* are placed in the same subfamily and *Heterophyes* as type of the family must stand as type of the subfamily. Consequently, if Nicoll's arrangement is accepted, and it appears well founded, the name Cryptocotylinæ should be suppressed in favor of Heterophyinæ. More recently Ciurea (1924) has attempted a further revision of the family Heterophyidæ. His paper had probably gone to press before the appearance of Nicoll's revision and there is no comment on the inclusion of the Microphallinæ and Gymnophallinæ in the family. The remaining genera, after the exclusion of *Paracœnogonimus* and the reinstatement of *Scaphanocephalus*, are arranged in five subfamilies: Heterophinæ, Metagoniminæ, Centrocestinæ, Apophallinæ, and Cryptocotylinæ. These subfamilies are based upon the details of development, the position of the ventral and genital suckers, and the terminal portions of the genital

organs. While Ciurea's arrangement may prove to be valid, further data are necessary before it can be unconditionally accepted. The differences between his subfamilies do not appear at this time to be great enough to separate groups of subfamily rank and certainly do not correspond to the differences between the subfamilies of Nicoll.

The rat in which the second infestation by *Ascocotyle* was found was parasitized also by a second species of trematode. The small intestine was washed in normal salt solution and seventeen echinostomes were recovered from the fluid. Two of the worms were found the day the dissection was made, the others were attached to or embedded in the mucosa and were not washed out until the following morning. Four of the specimens were sexually mature and contained eggs in the uterus, the others were immature and some of them very small. These worms are typical echinostomes and, like *Ascocotyle*, soon lose the spines of the cephalic coronet. In only the first two specimens found, therefore, was it possible to count the spines, in the others all the spines had been lost before the parasites were found. The specimens agree most closely with *Echinostomum mordax* Looss, named by Odhner (1910) as type of a new genus *Heterechinostomum*. A second and unnamed species was reported by Odhner from *Mergus serrator*. The present specimens represent another species of this genus.

Heterechinostomum magnovatum, new species

Sexually mature worms measure from 0.8 to 1 mm. in length and from 0.13 to 0.23 mm. in width. They are widest near the middle of the body or slightly anterior to this level and taper toward either end. The anterior collar is conspicuous, and wider than the body immediately behind it. It is reniform to triangular in shape and bears a single row of large spines, interrupted in the middorsal line. The spines are twenty in number and 0.03 to 0.035 mm. in length. The cuticula is beset with fine dermal spines 0.01 mm. in length which are conspicuous in the anterior ventral region but reduced posteriorly. The body musculature is weak and delicate. The acetabulum is about two-fifths of the body length from the anterior end and measures from 0.07 to 0.1 mm. in diameter.

The mouth opening is subterminal. The oral sucker is spherical to oval, 0.06 to 0.077 mm. in length and 0.05 to 0.07 mm. in width. There is a short prepharynx which measures about one-half the diameter of the oral sucker in length. The pharynx is oval in shape, slightly larger than the oral sucker, but the wall is relatively thin and encloses a large cavity in the organ. It measures 0.06 to 0.1 mm. in length and 0.04 to 0.07 mm. in width. The esophagus is approximately equal to the pharynx in length. The intestinal diverticula have an almost uniform diameter and extend almost to the posterior end of the body.

The excretory system is of the typical echinostome pattern. The pore is terminal, the vesicle is large and bifurcates posterior to the testes.

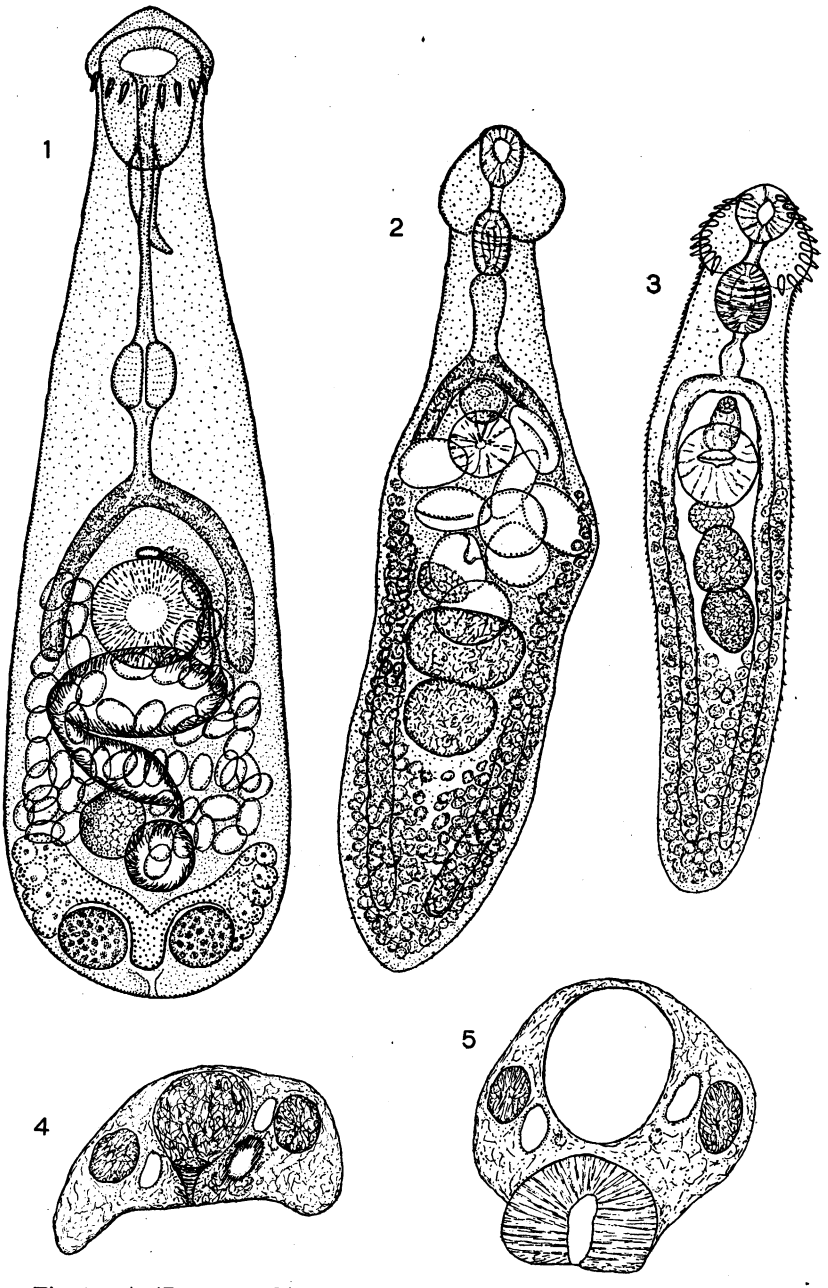

Fig. 1. *A.* (*Parascocotyle*) *diminuta,* ventral view, × 365.
The spines were added from a sketch of the living specimen.

Figs. 2–5. *Heterechinostomum magnovatum.*

2, mature specimen, ventral view, × 136 (spines have been lost); 3, immature specimen, ventral view, × 105 (spines were added from a sketch of the living worm); 4, cross-section through the seminal vesicle just posterior to the genital pore, × 285; 5, cross-section at the acetabular level showing an egg in the uterus, × 285.

The genital pore is situated immediately behind the bifurcation of the alimentary tract. The testes are situated in the anterior portion of the posterior half of the body. They are spherical to oval in shape although so close together that frequently their contiguous edges are considerably flattened. They measure from 0.05 to 0.09 mm. in diameter. The seminal vesicle does not project behind the center of the acetabulum. In one specimen cut in cross-sections it measures 0.05 mm. in diameter. The cirrus sac and prostate are rudimentary. The ovary is situated immediately anterior to the testes and usually on the right side of the body. In only one specimen is it on the left. It is spherical to oval, usually slightly longer in the transverse axis of the body. and measures from 0.03 to 0.04 mm. in diameter. The vitellaria are not arranged in lobes but consist of numerous scattered follicles extending from the acetabular level to the posterior end of the body. The eggs are few, thin shelled, and very large. They measure from 0.07 to 0.08 mm. in length and from 0.06 to 0.065 mm. in width.

This species, like *Echinostoma spiculator* Dujardin, has a conspicuous collar bearing twenty spines but, unlike that form, the present species has the spines arranged in a single instead of a double row. The worms just described are much smaller, not more than one-half the size of the specimens found by Dujardin, the spines are smaller, and the cirrus sac is greatly reduced whereas in *E. spiculator* the cirrus is long and spined. It seems proper to refer *E. spiculator* to the genus *Euparyphium* Dietz, leaving for the present the question of its identity with *E. trigonocephalum*. The echinostome found in New York rats can not be placed in the same genus and is the third trematode species found in the rat.

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