59.51, 22 (67.5)

Article VI.—THE PARASITIC WORMS COLLECTED BY THE AMERICAN MUSEUM OF NATURAL HISTORY EXPEDITION TO THE BELGIAN CONGO 1909–1914[1]

PART I.—TREMATODA

HORACE W. STUNKARD[2]

The specimens which form the basis of this work were collected by Messrs. Herbert Lang and James P. Chapin from various vertebrate hosts in the Congo Valley. Since the greater part of their activity was confined to the upper portions of the river basin, it is but natural that most of the parasitic material should be from that district. The collection of parasitic worms was incidental to the chief purpose of the expedition, which was to make observations of the larger animals in their native habitat and to secure specimens for the American Museum. The parasitic worms, present only in the internal organs and body cavities and relatively small in size, are obviously inconspicuous and would be found only on careful dissection of the host animals. Consequently, the number of helminths secured bears testimony to the thorough and accurate character of the work carried on by the leaders of the expedition. This is especially noteworthy in view of the absence of specific training in this type of collection and the lack of microscopes and accessories usually regarded as essential. Knowledge of the parasitic fauna of this district is very limited and consists of merely a few brief and scattered papers. Initial contributions to the survey and description of the Entozoa have been made by Beauchamp, Gedoelst, and others, but the large parasitic fauna of central Africa remains as yet practically unknown.

The parasitic worms from the Congo were received at the American Museum in December, 1915. On February 23, 1917, they were intrusted to Dr. G. A. MacCallum, for study and identification. The work, however, was never completed and in June, 1920, the specimens were returned to the American Museum. Dr. Roy Waldo Miner, Curator of the Department of Lower Invertebrates, suggested that, during my leave of absence from New York University for the academic year 1924–1925, I undertake a study of this material. I am especially grateful to the authorities of the American Museum for the opportunity to carry on the

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

investigation and wish here to express my deep appreciation of the kindness extended during the course of the study. Since practically all of the previous work on the Entozoa of central Africa has been done in Europe and very few specimens of described species are available in America, permission was sought and cordially granted to carry on the work in the laboratory of the Molteno Institute for Research in Parasitology, Cambridge University, England, and in the Laboratoire de Parasitologie, Université de Paris, France. To Professor George H. F. Nuttall and to Professor E. Brumpt, directors of these laboratories, grateful acknowledgments are hereby made for the courteous and generous manner in which the facilities of these institutions were placed at my disposal. For valued assistance I am also indebted to Dr. D. Keilin of Cambridge University, Dr. H. A. Baylis of the British Museum, London, Dr. E. Roubaud of the Pasteur Institute, Paris, and Drs. M. Langeron and Ch. Joyeux of the Laboratoire de Parasitologie, Paris.

Certain observations and notes made by Dr. MacCallum were submitted with the specimens when they were returned to the American Museum. In the opinion of authorities at the museum, Dr. MacCallum's unfinished report would not be helpful in further study of the material and consequently only the specimens were turned over to me. I have not seen Dr. MacCallum's account and the present descriptions are, therefore, entirely original and based on the specimens alone.

Two of the species have been named by MacCallum in published reports. The amphistome from the elephant he described (1917) as *Cladorchis gigas*, new species. Travassos (1921) showed that the form could not belong in the genus *Cladorchis* and created the new genus *Brumptia* to contain it. Maplestone (1923) redescribed the worm as *Brumptia gigas* and in the present paper evidence is submitted to show that the species is identical with *Amphistomum bicaudatum* Poirier, 1908, and that the correct name is *Brumptia bicaudata*. An announcement of this identity was made in a brief published report (Stunkard, 1926), although the evidence has not previously been presented. After this paper was written, it was learned that in a footnote to his paper, '*Protofasciola* new genus, ein Prototypus des grossen Leberegels,' Odhner, 1926 (Arkiv för Zoologi, XVIII, No. 20, 10 März, 1926), stated "*Amphistomum bicaudatum* ist wie man sofort erkennt, mit *Brumptia* (*Cladorchis*) *gigas* (G. A. MacCallum, 1917) identisch." No data or confirmatory evidence were given.

The other name was published (MacCallum, 1921) in an incidental way under the description of *Cyclocœlum halcyonis* from the kingfisher

Halcyoni coromandus from the Philippine Islands. Referring to the genus *Cyclocœlum* he says: "G. A. MacCallum found it in the Congo collection as the intestinal parasite of a Guinea fowl, *Guttera plumifera schubotzi*, and called it *Cyclocœlum phasidi*, (1913)." As a matter of fact, the specimens, according to the records of Lang and Chapin, were from the liver and not from the intestine, and since the specimens were collected in Africa in November, 1913, and received at the American Museum, December, 1915, they could not have been found by MacCallum as stated. Records of the Museum show that the specimens were loaned to MacCallum, February 23, 1917. The species was not described by MacCallum in 1913 nor at any other time, and the name may, therefore, properly be regarded as a *nomen nudum*. In describing the species, I am, in order to avoid confusion in the literature, adopting the name *Cyclocœlum phasidi*, although up to the present it has been only a manuscript name and I do not concede that it has had any status other than that of a *nomen nudum*.

The general problems regarding the character and distribution of the fauna of central Africa apply as well to the parasitic as to the free-living animals. In any host-parasite association, the parasites in question are dependent upon the particular hosts required to complete their respective life-cycles, and on the environmental conditions essential to their free-living stages. It seems, therefore, that the parasitic fauna of central Africa will be found to be distinct only in so far as the general fauna of that district is peculiar to it. There is, of course, the possibility of complication in that the host specificity is not always precise and certain parasites may develop in more than one host species. Such extension of hosts and of distribution has been repeatedly demonstrated among nematode, flatworm, and protozoan species. This phenomenon might well lead to an overlapping of the parasitic fauna of different districts without corresponding overlapping of the host species, although the existence of any important natural barrier would probably limit the distribution of both host and parasitic species.

The Congo basin, from which these parasites were taken, is not limited by any insurmountable natural barriers. Consequently, the fauna, free-living as well as parasitic, is not peculiar to that region and there is undoubtedly considerable intermingling with the fauna of adjacent districts. Many of the specimens which form the basis of this study came from Faradje, which is near the divide separating the Congo Valley from that of the Nile, and animals probably pass from one region to the other. The extension of the fauna of this district into the Nile and Congo

valleys would be limited only by the conditions necessary for the life-history of any particular form. Temperature, proper food, and topography might conceivably act as limiting factors in dispersal, but it would be natural to expect to find forms radiating from this region into both the Nile and the Congo districts. As a matter of fact, *Gastrodiscus ægyptiacus*, a common parasite of the Equidæ, and many other species occur along the north coast of Africa, extend up the Nile to its headwaters, and down the Congo Valley to the Gulf of Guinea. Similarly, there are no insurmountable barriers between the headwaters of the Congo in Northern Rhodesia and the streams which arise in this region and run southward. There is, undoubtedly, considerable continuity between the fauna of the Congo basin and that of South Africa. *Fasciola gigantea*, parasitic in the interlobular bile ducts of various ruminants, occurs throughout the Congo basin and southward to Cape Colony. In certain respects, then, the fauna of central Africa may be distinct, but in others it certainly is continuous with that of both the northern and southern parts of the continent.

With the completion of the work on the trematodes in the collection, which forms a natural section, it seems desirable and proper to publish the results of that study and to reserve for later reports the description of the cestodes and nematodes.

The trematode material comprises ten species belonging to eight genera and three families. Seven of these species are amphistomes, and since these forms are so thick-bodied that the only certain way to identify material is by the study of serial sections, identification has necessitated a large amount of time-consuming technique. Other difficulties were encountered, sometimes in the small number or immaturity of the specimens belonging to a given species, and sometimes in the character of the material itself. Many of the specimens were broken or decomposed, others were much shriveled, and some were so hard that it was almost impossible to section them. After the structure was worked out, it frequently was difficult to determine whether the specimens should be assigned to a particular species or not, since the descriptions are in many instances inadequate, indefinite, or confused. An analysis, criticism, and summary of the present knowledge concerning the amphistomes was consequently prepared and published elsewhere (Stunkard, 1925).

Trematodes Collected by the American Museum Congo Expedition

Paramphistomidæ[1]
- Paramphistominæ
  - *Paramphistomum cervi* (Schrank, 1790) Fischœder, 1901.
  - *Paramphistomum explanatum* (Creplin, 1847) Fischœder, 1910.
  - *Cotylophoron cotylophorum* (Fischœder, 1901) Stiles and Goldberger, 1910.
  - *Stephanopharynx secundus*, new species.
- Cladorchinæ
  - *Chiorchis fabaceus* (Diesing, 1838) Fischœder, 1901.
- Brumptiinæ
  - *Brumptia bicaudatum* (Poirier 1908) Odhner, 1926.
- Gastrodiscinæ
  - *Gastrodiscus ægyptiacus* (Cobbold, 1876) Railliet, 1893.

Fasciolidæ
- Fasciolinæ
  - *Fasciola hepatica* Linnæus, 1758.
  - *Fasciola gigantea* Cobbold, 1855.

Cyclocœlidæ
- *Cyclocœlum phasidi*, new species (MacCallum, 1921, *nomen nudum*).

Paramphistomidæ Fischœder, 1901

Paramphistominæ Fischœder, 1901

Paramphistomum Fischœder, 1901

Generic Diagnosis.—Body tends to conical form, with convex dorsum and concave venter, rather attenuate cephalad, rather blunt caudad; ventral pouch absent. Acetabulum terminal, tilts ventrad, small to very large, sunken, margin not raised, aperture small to large. Genital sucker absent, pore ventromedian, pretesticular. Excretory vesicle at least partly in acetabular zone. Oral sucker without evagination; esophagus with or without muscular thickening; ceca long, nearly straight to wavy, end postequatorial, posttesticular, usually in acetabular zone.

Male Organs.—Testes two, usually intercecal, small to large, finely lobulate to coarsely lobate, exceptionally nearly smooth, fields coincide to separate, zones coincide to separate; cirrus pouch absent.

Female Organs.—Ovary and Mehlis' gland usually posttesticular, never pretesticular; Laurer's canal may cross excretory vesicle; uterus runs dorsally of testes, under arch of vasa efferentia, then ventrally of vas deferens.

Type Species.—*Paramphistomum cervi* (Schrank, 1790).

Paramphistomum cervi (Schrank, 1790) Fischœder, 1901

Fasciola cervi Schrank, 1790, 'Fortekning, pa nagra hittils obeskrifne intestinalkrak.' K. Vetensk, Acad. n. Handl., Stockholm, (N.S.) XI, pp. 118–126.

[1]The name Paramphistomatidæ was used by Goto and Matsudaira, 1918, but has not been adopted by later authors. If the generic name were *Paramphistoma*, the family name would be Paramphistomatidæ, adding idæ to the root of the genitive, but Fischœder latinized the generic name by changing the ending to *um* and apparently his procedure is accepted with the family name Paramphistomidæ.

Festucaria cervi ZEDER, 1790, 'Beschreibung des Hirsch' splitterwurms *Festucaria cervi*.' Beob. u. Entdeck. a. d. Naturk. v. d. Gesellsch. naturf. Fr. zu Berl., (1) IV, pp. 65–74, Pl. III, figs. 8–11.

Fasciola elephi GMELIN, 1790, 'Systema naturæ per regna tria naturæ, secundum classes ordines, genera, species cum characteribus, differentiis, synonymis, locis.' Edito decima tertia, aucta, reformata, cura Jo. Fred. Gmelin, I, pt. 6 [vermes], pp. 3021–3910.

Monostoma elephi ZEDER, 1800, 'Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer, mit Zufässen und Anmerkungen herausgegeben.' xx+320 pp., 6 Pls. Leipzig.

Monostoma conicum ZEDER, 1803, 'Anleitung zur Naturgeschichte der Eingeweidewürmer.' xvi+432, pp., 4 Pls. Bamberg.

Amphistoma conicum RUDOLPHI, 1809, 'Entozoorum sive vermium intestinalium historia naturalis.' (1) II, p. 457, Pls. VII–XII. Amstelædami.

Paramphistomum gracile FISCHŒDER, 1901, 'Die Paramphistomiden der Säugethiere.' Zool. Anz., XXIV, p. 369.

Paramphistomum bothriophoron (Braun, 1892) FISCHŒDER, 1901, idem.

Paramphistomum microbothrium FISCHŒDER, 1901, idem.

Paramphistomum bathycotyle FISCHŒDER, 1901, idem.

Paramphistomum epiclitum FISCHŒDER, 1904, 'Beschreibung dreier Paramphistomiden-Arten aus Säugethieren.' Zool. Jahrb., Syst., XX, pp. 453–470, 2 Pls.

Paramphistomum papillosum STILES AND GOLDBERGER, 1910, 'A study of the Anatomy of *Watsonius* (n.g.) *watsoni* of Man, and of Nineteen Allied Species of Mammalian Trematode Worms of the Superfamily Paramphistomoidea.' Bull. Hyg. Lab., No. 60, U. S. Pub. Health and Mar. Hosp. Serv., Washington, April, 264 pp., 205 Figs.

Paramphistomum papilligerum STILES AND GOLDBERGER, 1910, idem.

Paramphistomum indicum STILES AND GOLDBERGER, 1910, idem.

This species, long known from the stomach of various cattle in different parts of the world, has recently been the subject of study by Maplestone (1923). In this paper, the morphological features of the parasites described by Fischœder and by Stiles and Goldberger and listed above as synonyms are compared in detail with the result that definite, distinguishing features are shown to be lacking; the forms intergrade and specific differences disappear. The sections A and C of the genus *Paramphistomum*, as outlined by Fischœder (1903), are shown to merge into a common group. It is even possible that the two remaining sections are not distinct. In the closely related species, *Cotylophoron cotylophorum*, I have observed that Laurer's canal may open either in front, at the side, or behind the excretory pore. The position of the opening of Laurer's canal with reference to the excretory pore is not constant enough to be a feature of taxonomic value.

The material of this species in the Congo collection consists of several hundred specimens taken from the stomach of the water-buck

(*Kobus defassa*), at Garamba; two specimens from the stomach of a kob (*Adenota kob aluræ*), at Faradje, Congo Exp. vial No. 355; and fifty specimens from the stomach of a reedbuck (*Redunca bohor*, A. M. N. H. No. 53293), Congo Exp. vial No. 341, at Faradje on Feb. 10, 1912. The specimens from *Adenota kob* taken at Faradje were found together with specimens belonging to the genus *Cotylophoron*. In the stomach of *Redunca bohor*, mentioned above, there were found also five specimens belonging to the genus *Stephanopharynx*.

This series of worms agrees more closely with the description of *Paramphistomum microbothrium* as given by Fischœder (1903) than with any other report. Study of the material, however, supports the conclusion of Maplestone (1923) that *P. microbothrium* is not a valid species and should be suppressed as a synonym of *P. cervi*.

The specimens in the Congo collection are not well extended and the contraction is more pronounced at the anterior end of these worms than of those studied by Fischœder. Consequently, the oral sucker is less elongate, the esophagus is shorter, and the genital pore is relatively farther forward. The region of greatest width is also farther posteriad.

The worms from the stomach of the water-buck (*Kobus defassa*) measure 6 to 10 mm. in length and 3 to 4 mm. in maximum width. They are conical in shape, slightly flattened dorsoventrally, and the region of greatest width is just anterior to the acetabulum. The specimen shown in figure 1 was flattened between two slides and is consequently slightly wider than in the normal condition. In cross-section the body is almost round and the dorsoventral flattening described by Fischœder ("der Querdurchmesser verhält sich zum dorsoventralen wie 4:3.5") is hardly recognizable in alcoholic specimens. Certain specimens cut in cross-section show a circular outline while others are more flattened than noted by Fischœder. The width is about one-third of the body-length. The long axis of the body is curved, with the concavity on the ventral side. There is considerable variation, some specimens are almost straight while others are much bent.

The acetabulum is subterminal and in most specimens the opening is small, due to the contraction of the circular muscles. It varies from 0.35 to 0.6 mm. in diameter. In diameter the sucker measures from 2 to 2.6 mm., slightly larger than reported by Fischœder. Its depth is about 1.5 mm. and the wall measures from 0.33 to 0.52 mm. in thickness.

The cuticula measures from 0.02 to 0.03 mm. in thickness. There are papillæ around the anterior margin of the oral opening and frequently also ridges over the surface of the body when the dermomuscular sac is

much contracted. The anterior sucker was described by Fischœder as a pharynx, although Looss (1902) had presented a strong argument to show that the anterior sucker of the amphistomes is homologous with the oral sucker of the distomes. Subsequently, most writers have accepted the conclusions of Looss and after studies on several different genera I am convinced that the anterior sucker of the amphistomes is to be regarded not as a pharynx but as an oral sucker. In *P. cervi* it usually does not lie at the surface of the body but some distance within it. From the mouth opening, which is not sharply defined but consists of a funnel-like cavity, an oral canal leads inward to the oral sucker. The sucker may lie near the anterior end of the body or be retracted to the level of the genital pore. In the latter condition the oral canal is narrow and longer than the diameter of the sucker; in the former it is wide and forms two sac-like pockets (Fig. 1), one on either side and ventral to the oral sucker. The wall of the oral canal shows no abrupt departure in its histological organization from the body-wall; with the natural reductions and modifications resulting from a change of function the dermomuscular sac is continuous to the oral sucker and consequently the canal is to be regarded merely as the effect of retraction of the oral sucker and the resulting or concomitant cephalic projection of the body parenchyma. The body-wall is rolled in to form the oral canal and the oral sucker agrees in structural detail with the oral sucker of other digenetic trematodes.

The oral sucker is spherical to oval and in most of the specimens wider than long. It measures from 0.88 to 0.98 mm. in length and from 0.95 to 1.12 mm. in width. The wall varies from 0.3 to 0.4 mm. in thickness. The esophagus arises from the ventral posterior margin of the oral sucker. When the sucker is retracted the esophagus makes a ventral loop and after returning to the dorsal side of the body opens into the digestive ceca. The esophagus measures from 0.3 to 0.43 mm. in diameter and is surrounded especially on the dorsal and lateral aspects by clusters of deeply staining secretory cells. Anteriorly the ceca are continuous on the dorsal side (Fig. 5) and they pass posteriad in loops and coils (Fig. 1). Their outline is irregular, they vary much in diameter, becoming narrower near the posterior end of the body where they turn mesiad, dorsad, and anteriad. They end blindly on either side, dorsal to the ovary. The description of the esophagus and ceca agrees with that of Fischœder for *P. microbothrium.*

It is probable that in each paramphistome genus the nervous, excretory and lymph systems are essentially alike in all the species. Consequently, these structures are generic features and do not

properly come in specific descriptions. The lymph system, so far as has been determined, is similar to that of *P. gigantocotyle* as worked out by Looss (1912). The fixation of the present material makes it very difficult to trace lymphatic vessels in the specimens, although portions appear in sections. It is also practically impossible to trace the smaller excretory tubules. The esophageal commissure and larger nerve trunks occupy the usual position and manifest the characteristic features of the genus.

Reproductive Organs.—The genital pore is situated on the mid-ventral surface one-fourth to one-fifth of the body-length from the anterior end. It lies at or near the level of the bifurcation of the alimentary tract if the oral sucker is retracted, but if the sucker is near the anterior end of the body the bifurcation is some distance anterior to the pore. There is a common genital atrium 0.25 to. 0.35 mm. in diameter, enclosed by a rather heavy muscular wall, and usually it forms a conspicuous genital protuberance (Figs. 3, 4). The opening is spherical and varies in size from a minute pore to almost the diameter of the atrial sac. Not infrequently the genital papilla is exserted through the opening and appears as a protruding structure sometimes reaching 1 mm. in length. The opening is surrounded by a strong sphincter (Fig. 3) as described by Fischœder, although its thickness varies inversely with the relaxation of the muscles and increase in size of the pore. The cavity of the atrium is divided into dorsal and ventral chambers when the papilla is retracted (Figs. 3, 4) and frequently both contain eggs.

The description of the testes as given by Fischœder applies to the Congo material, but there are many variations from the condition reported. These organs were described as occupying the middle third of the body but I find that they occupy less than one-third of the body-length and that they are nearer the posterior than the anterior end. This arrangement is shown in Fischœder's figures and the text must be regarded as a rather loose and general statement. The cephalic testis is situated only slightly anterior to the middle of the body and the caudal testis almost immediately behind it. There is a tendency for them to vary from the median line, occupying slightly opposite sides of the body, although either testis may be right or left. They are irregularly oval in form, longer in the transverse than the anteroposterior axis of the body, and longest in the dorsoventral axis. Sections show numerous lobes separated by deep indentations (Fig. 2), but these recesses are narrow and in whole mounts the oval form is conspicuous. They measure 1.2–1.6 mm. in length, 1.8–2.5 mm. in width, and 2–2.7 mm. in thickness.

The vasa efferentia pass forward and unite to form a much-coiled seminal vesicle. The vesicle is separated from the cephalic testis by a loop of the uterus and occupies the dorsal half of the body in this region. The coils of the vesicle measure 0.14 to 0.17 mm. in diameter and, contrary to the statement of Fischœder, are posterior as well as dorsal to the pars musculosa. The vesicular and muscular portions of the duct are connected by a narrow canal, about 0.05 mm. in diameter. The pars muculosa is much coiled and occupies the region anterior and ventral to the seminal vesicle. These coils measure 0.22 to 0.28 mm. in diameter and the wall of the duct is about 0.05 mm. in thickness although the thickness decreases with distention of the canal. After many coils the musculosa opens into the dorsal posterior portion of an enlarged thinner-walled pars prostatica. This structure lies dorsal and anterior to the genital pore; it is usually filled with spermatozoa, and often its walls are partially collapsed. It is oval in shape, longer in the dorsoventral axis, and measures from 0.5 to 0.8 mm. in diameter. Its wall, although continuous with that of the pars musculosa, is thinner, and externally it is covered by a layer of small cells. They may be glandular, but their nature is not certain from the material at hand. This expanded portion of the vas deferens opens ventrally (Fig. 4) by a very short ejaculatory duct into the genital atrium just anterior to the opening of the metraterm.

The female reproductive organs in these specimens agree so completely with the description of Fischœder that little may be added to his account. The ovary is the same size, 0.5 to 0.7 mm. in diameter, although it may lie farther posteriad than reported by Fischœder and, in the specimen shown in figure 1, it is immediately in front of the acetabulum. Mehlis' gland is longer in the lateral than in the anteroposterior axis. It measures 0.2 to 0.25 mm. in length and 0.4 to 0.55 mm. in width, somewhat smaller than in the specimens of Fischœder. Laurer's canal passes dorsally and anteriorly from the oötype and in the specimen shown in Figs. 2 and 7 opens to the dorsal surface posterior and lateral to the excretory pore. It is on the ovarian side of the body. The eggs measure 0.145 to 0.16 in length and 0.075 to 0.099 mm. in width.

The life-history of *P. cervi* was worked out by Looss (1896). He found that in Egypt the parthenogenetic stages develop in snails of the genus *Physa: P. alexandina* Bourguignat and *P. micropleura* Bourguignat.

Paramphistomum explanatum (Creplin, 1847) Fischœder, 1904

Paramphistomum calicophorum FISCHŒDER, 1901, 'Die Paramphistomiden der Säugethiere.' Zool. Anz., XXIV, pp. 367–375.

Paramphistomum crassum STILES AND GOLDBERGER, 1910, 'A study of the anatomy of *Watsonius* (n.g.) *watsoni* of Man, and of Nineteen Allied Species of Mammalian Trematode Worms of the Superfamily Paramphistomoidea.' Bull. Hyg. Lab., No. 60, U. S. Pub. Health and Mar. Hosp. Serv., Washington, April, 259 pp., 205 Figs.

Paramphistomum cauliorchis STILES AND GOLDBERGER, 1910, idem.

Paramphistomum fraternum STILES AND GOLDBERGER, 1910, idem.

Paramphistomum siamense STILES AND GOLDBERGER, 1910, idem.

This species is distinguished from *P. cervi* by Maplestone (1923) because the testes in fully mature worms are always situated diagonally, one overlapping the other both laterally and anteroposteriorly, whereas in adult specimens of *P. cervi*, the testes lie one directly behind the other. This difference is not so precise as at first appears, since in young specimens of *P. cervi* the testes are sometimes diagonally placed (Maplestone, footnote, p. 116). Young stages of the two species are, therefore, practically indistinguishable and even in the adult condition some variation occurs. Grobbelaar (1922) gives a figure of *P. calicophorum* [synonym of *P. explanatum*] in which the testes have a tandem arrangement.

The material of *P. explanatum* consists of six specimens from the stomach of a domestic cow (Congo Exp. vial No. 479, Faradje, Sept. 30, 1912). There were 20 specimens of *Cotylophoron cotylophorum* in the same vial, and presumably from the same host. Only two of the specimens of *P. explanatum* were sexually mature, but in these the testes are definitely diagonal in position. The worms agree in size and internal anatomy with previous descriptions. The essential morphological features of *Paramphistomum* are the same in all species and are illustrated by the figures of *P. cervi*. The excretory pore is considerably anterior to the opening of Laurer's canal in the two specimens of *P. explanatum* which were sectioned.

The life-history of this species has been worked out. Grobbelaar (1922) reported experimental studies on the life-history of *Paramphistomum calicophorum* of sheep in South Africa. He found that the ubiquitous snail, *Isidora tropica* Krauss, serves as the intermediate host of this amphistome in South Africa. Morphological agreement led him to the conclusion that *Cercaria frondosa* of Cawston is the larval stage of *Paramphistomum calicophorum* (synonym of *P. explanatum*).

COTYLOPHORON Stiles and Goldberger, 1910

GENERIC DIAGNOSIS.—Body form as in *Paramphistomum;* esophagus with or without muscular thickening; ceca long, wavy, end in acetabular zone. Acetabulum

of moderate size, terminal, tilts ventrad. Excretory vesicle and canal directed cephalad; excretory pore prevesicular. Genital sucker present, genital papilla present, ventral chamber of genital atrium absent.

MALE ORGANS.—Testes smaller than acetabulum, lobate, immediately preacetabular, zones slightly overlap, fields nearly coincide, crossing median line.

FEMALE ORGANS.—Ovary ventrad of excretory vesicle; Laurer's canal may cross excretory vesicle, it may open either cephalad or caudad of excretory pore.

TYPE SPECIES.—*Cotylophoron cotylophorum* (Fischœder, 1901) Stiles and Goldberger, 1910.

Cotylophoron cotylophorum (Fischœder, 1901) Stiles and Goldberger, 1910

Paramphistomum cotylophorum FISCHŒDER, 1901, 'Die Paramphistomiden der Säugethiere.' Zool. Anz., XXIV, pp. 367–375.

Cotylophoron indicum STILES AND GOLDBERGER, 1910, 'A Study of the Anatomy of *Watsonius* (n.g.) *watsoni* of Man, and of Nineteen Allied Species of Mammalian Trématode Worms of the Superfamily Paramphistomoidea.' Bull. Hyg. Lab., No. 60, U. S. Pub. Health and Mar. Hosp. Serv., Washington, April, 264 pp., 205 Figs.

The material of this species came from four vials. The first was collected from the stomach of a domestic cow (Congo Exp. vial No. 479) dissected at Faradje the 12th of September, 1912. It contained also specimens of *Paramphistomum explanatum*. The contents of the second vial were taken from the stomach of a domestic calf (Congo Exp. vial No. 352). The third contained material from the stomach of an antelope, *Neotragus pygmæus*, A. M. N. H. No. 53176 (Congo Exp. vial No. 102) dissected at Medje, April 2, 1910. The fourth was taken from the stomach of an antelope (*Adenota kob aluræ*, Congo Exp. vial No. 355), March 29, 1912, at Faradje.

The specimens at first appeared very different and it seemed probable that more than one species was represented. The specimens from the calf (Fig. 9) are considerably smaller and less-developed than those from the cow (Fig. 8), but otherwise very similar. Those from the antelopes are usually somewhat more slender, although this is probably due to differences in the manner of fixation. Several worms from each lot were sectioned and the data secured from the study of whole mounts and sections are not easy to correlate. Some of the parasites from the antelopes that measure up to 6 mm. in length are sexually immature. Specimens from the calf, which are very much smaller, and in which the suckers are smaller, are filled with eggs. The explanation for this apparent incongruity is not easy, since no adequate morphological basis was found for their separation into different species. Much variation exists, and there appears to be no clear line of specific demarcation. In the material

at hand, study of any structure shows a continuous series of intergradations and consequently all the specimens are assigned to the same species.

The specimens vary from 3 to 7 mm. in length. In general, the width is from one-third to one-half the length. The acetabulum measures from 1.1 to 1.95 mm. in diameter and its wall is 0.2 to 0.45 mm. thick.

DIGESTIVE TRACT.—The oral sucker is pyriform, with the smaller end anteriad, although the length and width are approximately equal. In specimens from the calf it measures from 0.3 to 0.6 mm. in diameter, in those from the cow 0.4 to 0.7 mm., and in those from *Adenota* and *Neotragus* 0.6 to 0.9 mm. In general, the sucker is relatively larger in the specimens from the antelopes than in those from the cow and calf. The wall of the esophagus becomes thicker and more muscular toward the posterior end and the thickness increases with the contraction of the esophagus. Conversely, in specimens in which the anterior end is much protracted, the esophagus is consequently much longer and the muscular wall proportionately thinner. There is a distinct sphincter in the posterior end of the esophagus (Fig. 8). The ceca conform to the type usual for the subfamily.

The excretory system in this genus, so far as determined, is practically identical with that of *Paramphistomum.* The excretory pore is situated in the median dorsal line at or near the level of the posterior margin of the caudal testis. From it a thick-walled canal passes ventrally and caudally, enlarging to form the vesicle. From the ventral portion of the vesicle collecting ducts pass laterad, caudad and ventrad. They then turn anteriorly to form the lateral collecting ducts of the excretory system. The smaller tubules could not be followed in the material at hand.

The genital sucker measures from 0.4 to 0.75 mm. in diameter. It is larger and stronger in the larger and more mature worms.

The testes show extreme variation in the different sets of material and these variations have been the source of enormous difficulty. The differences involve size, shape, and position. In a general way the size differences may be correlated with sexual development. Most of the specimens from the antelope (*Adenota*) are sexually immature, without eggs in the uterus, and the testes are relatively small (Figs. 11, 13). These organs are distinctly lobed and situated one in front of the other, although sometimes there may be a slight diagonal arrangement. In the specimens from the antelope, the anterior testis and the ovary tend to lie slightly to one side of the median plane, usually left, and the posterior testis tends to lie on the opposite side. In the specimens from

the calf, an example of which is shown in figure 9, the testes usually lie in the median field, one before the other. Similarly in specimens from the cow, one of which is shown in figure 8, the testes may lie directly one before the other. In specimens from the antelope, *Neotragus* (*pygmæus*) they may be diagonal in position, lying on almost opposite sides of the body (Fig. 12). An intermediate condition is shown in figure 10, of a specimen from the cow and it is this arrangement which is used as the critical test for uniting in the same species specimens like those shown in figures 8 and 9 and others like figure 12. The condition shown in figure 10 is essentially intermediate in character between that of figures 9 and 12, and since the three specimens from which these figures were made occurred in the intestine of hosts from the same region there seems to be no doubt but that they represent a single species. Among the specimens from *Neotragus* there were individuals with testes in the same position as those shown in figure 10. The specimen from which figure 12 was made is much contracted and the contraction, in my opinion, explains the position of the testes. The differences in position are thus correlated with the extension and contraction of the worms.

This conclusion is of importance in connection with the characterization of species in the genus *Paramphistomum*. According to Maplestone, *P. cervi* and *P. explanatum* are distinguished because in the former the testes are in a tandem arrangement, and in the latter they are situated diagonally. Grobbelaar (1922) gave a figure of *P. calicophorum* (=*P. explanatum*) in which the testes are tandem. Furthermore, it is interesting to note Maplestone's statement that in the young of the two species of *Paramphistomum* mentioned the testes tend to assume a slightly diagonal position, one before the other, just as they do in the young specimens of *C. cotylophorum*. There seems then a reasonable doubt as to whether *P. cervi* and *P. explanatum* may not be united in a single species.

In organs of lobed form and irregular shape it is not easy to make precise measurements, although greatest width and length may be determined. In the smaller non-gravid specimens from *Adenota* the testes measure from 0.3 to 0.5 mm. in diameter and in larger specimens they may measure up to 1.0 mm. in diameter. Frequently in these larger and more mature specimens the testes are arranged in the diagonal position shown in figure 10, which makes it reasonably certain that two species are not being confused. The origin and course of the vasa efferentia, as well as the relations of the seminal vesicle and the muscular portions of the male reproductive tract, agree with the descriptions of Stiles and Goldberger. In case the genital sucker and genital papilla are retracted,

the male and female ducts open separately at the base of the genital atrium, while, if the genital papilla is protruded, a common hermaphroditic duct is formed.

The ovary is situated at or near the anterior margin of the acetabulum, usually on the left side of the body. It is spherical to oval in form and measures from 0.25 to 0.75 mm. in diameter in gravid specimens. Figure 14 is made from a reconstruction of the ducts which form the female genital complex. The oviduct arises at the dorsal margin and turns posteriad and mediad. At or near the point where it enters Mehlis' gland, Laurer's canal arises and passes to the dorsal surface. In this form as in *Paramphistomum* I have found great variation in the course of Laurer's canal. In some specimens it is entirely prevesicular, in others it opens near and at the level of the excretory pore, while in other worms it crosses the excretory vesicle to open some distance behind it. The oötype is situated on the left side of the body and Laurer's canal passes dorsally in a sinuous course. It may open on the left side of the body, but in most specimens it tends mediad to open at or near the median line. There is no seminal receptacle and the initial portion of the uterus frequently contains spermatozoa. Immediately after the origin of Laurer's canal the oviduct enters Mehlis' gland where it receives the vitelline duct and forms the oötype. Mehlis' gland lies on the dorsal and medial side of the ovary, partially overlapping it. The gland is approximately the same size as the ovary. The uterus emerges from the ventral side of Mehlis' gland and forms several coils behind the posterior testis. It then turns dorsally and passes forward over the testes, turning ventrally along the anterior side of the cephalic testis and below the coils of the seminal vesicle. From this region it passes forward to open into the genital sinus. The vitellaria consist of numerous follicles (Figs. 8 to 13) which in immature individuals are small and scattered in the extracecal area. They increase in size and number with sexual maturity. In the oldest and largest worms they form an almost continuous sheet extending in the cortical area of the body from the esophageal to the acetabular region. In these specimens the vitellaria are not confined to the extracecal zone but extend mediad both dorsally and ventrally, those on the dorsal side almost meeting in the median plane. At the level of the ovary transverse ducts pass mediad, uniting at the ventral pole of Mehlis' gland to form the common duct which opens into the oötype.

The lymph system was regarded by Looss (1912) as one of the most important and characteristic features of the amphistomes. In this paper he gave a detailed description of the lymphatic systems of *Paramphisto-*

mum gigantocotyle and *Schizamphistomum scleroporum.* In *Schizamphistomum,* Looss described three principal longitudinal channels on each side of the body and such an arrangement he believed to be characteristic of the subfamily outlined to contain the genus. According to Looss, the number of longitudinal canals and the form of the lymph system constitute one of the chief diagonstic features of each amphistome subfamily. In the study of other genera belonging to the subfamily Schizamphistominæ, I have found three principal longitudinal channels on each side of the body. Looss described only one such channel on each side in *Paramphistomum,* and in the subfamily Paramphistominæ, so far as known, this arrangement prevails. In the genus *Cotylophoron,* the general features of the system as worked out in the present study are in complete agreement with the condition found in *Paramphistomum.* To this extent, subsequent work has confirmed the opinion of Looss.

Notwithstanding the fact that the lymph system is always present and of undoubted importance among the amphistomes, most writers have largely ignored it because of difficulties in tracing and reconstructing its ramifications. In well-cleared whole mounts it is frequently possible to trace parts of the system, although the specimens are so thick that entire reconstruction is difficult if not impossible. The longitudinal channels previously mentioned give off numerous branches which subdivide and anastomose to form a network permeating the entire body. In younger specimens only the longitudinal channels and the principal vessels which emerge from them are developed. As the worm increases in size, branches from these channels appear, and they in turn subdivide and fuse, establishing finally the complex reticulum found in the adult condition. As the specimens increase in size and sexual maturity it becomes progressively more difficult to trace the ramifications of the system.

The sexually immature specimens of *Cotylophoron* have furnished an opportunity to trace the lymph system in this form. Figure 15 is a camera lucida tracing of the system in one of these specimens. The single pair of longitudinal vessels runs anteroposteriorly on the median side of the digestive ceca. At or slightly in front of the level of the genital sucker they cross on the dorsal side of the ceca to the lateral side of these structures and continue anteriorly. Between the bifurcation of the alimentary tract and the oral sucker the longitudinal canals divide to form numerous branches and flatten to form lymph sinuses which spread out over the sucker. The posterior half of the organ is almost completely surrounded by such lymph sacs. The channels of the lymph

system vary much in size and form. They are not cylindrical tubes of uniform calibre but consist of more or less irregular sinuses. Some of them are very large, especially those which surround the oral and acetabular suckers. The branches which arise from the longitudinal channels and encircle the ceca fuse with each other to form large flattened sinuses. There are from fifteen to twenty of these loops on either side of the body. In the region of the bifurcation of the alimentary tract numerous tubules form a reticulum that encloses not only the proximal ends of the ceca but the esophagus as well. Posteriorly the longitudinal canals converge and subdivide to form a plexus which encloses the excretory vesicle. This is illustrated in figures 15 and 16. Other branches extend posteriorly to supply the region of the acetabulum; one pair passing backward on the dorsal side and another pair extending backward on the lateral aspects of the sucker. The posterior sucker is not so richly supplied with lymph vessels as the oral sucker, at least not at this stage of development. From the longitudinal canals which extend along the median aspect of the ceca, branches pass mediad to supply the genital organs. From either side each testis and the ovary receive their own lymph ducts. In the case of the testes these channels subdivide to form sinuses which encircle each lobe of the organ. The genital sucker, correspondingly, is furnished with its own lymph supply, received from both of the longitudinal ducts.

Examination of the lymph system in many specimens has demonstrated extensive variation in the number and position of the secondary tubules. Even the number of loops which surround the intestinal ceca is subject to considerable variation and may differ on the two sides of the same worm. The primary tubules are characteristic but there certainly is great irregularity in the number and position of their subdivisions. The farther a particular tubule is located from the longitudinal canal the greater variation occurs in it.

This lack of definiteness in form and variation in the manner of branching may be expected from the nature and origin of the lymph system. Arising as a series of confluent intercellular spaces and as outgrowths from these primary centers, the lymph system of the amphistomes presents the same developmental features as the vascular system of higher forms. In the flat worms, however, the channels are not reinforced by the development from the mesenchyme of muscular fibrils. They resemble the lymphatics of higher animals rather than the blood vessels in which the endothelial wall is surrounded by muscular elements. Consequently, the lymph channels assume any form that the intercellular

spaces afford. In the higher animals with definite blood vessels and a circulating medium, there is enormous variation in the position and distribution of the different blood and lymph vessels. The more highly organized the system becomes, the more constant it is in form. Therefore, one would expect to find in the lymph system of the amphistomes extreme variation and little constancy.

These channels, which lack a definite muscular wall and follow the intercellular spaces, constitute the primary or incipient stages in the phylogenetic development of the vascular system. The amphistomes are the lowest animals which have fluid-filled vessels, and these lymph channels are initial stages in a series of advancing complexity, culminating in the circulatory system of the vertebrates. The wall of the lymph channels in these flat worms consists of a thin membranous sheet, and the movement of the contained fluid is occasioned by the contraction of the body-wall and the various internal muscles. As the worm elongates and contracts, changing its shape and proportions, the contents of the lymph vessels are shifted back and forth. Since there are no muscular fibres in the walls of these tubules, there can be no displacement of the fluid except by the contraction of muscles which have no inherent connection with the lymph system.

The lymph channels are filled with a fluid in which coarse granules are suspended. These granules take a plasma stain, which facilitates the recognition of the vessels in sections. Similarly staining but smaller granules are present in the cytoplasm of the entodermal cells and where the lymph channels lie adjacent to the ceca, the granules of the cells are strikingly similar, except for size, to those of the lymph vessels. Scattered at irregular intervals among the coarse granules which fill the lymph channels, there are characteristic mesenchymatous cells, which may be termed lymphocytes. They are very similar to the cells which occur throughout the reticular tissue of the worm. The cytoplasm is scanty, frequently almost indistinguishable, so that the cells seem to consist almost entirely of nucleus. A definite nucleolus is usually present.

The position and distribution of the lymph channels give a clear indication concerning the function of this system. It undoubtedly serves in these thick-bodied animals for the distribution of food and oxygen from the ceca to the various parts of the body. The intimate association of the lymph channels with the digestive ceca throughout their entire length provides for the transfer of soluble nutrient substances from the ceca to the distributing system and it seems probable also that the oxygen necessary for respiration is obtained by the decomposition and reduction

of food substances. There certainly is only a limited supply of free oxygen in the intestine of the host and the respiration of these worms must be to a large extent anaërobic. The position of the principal longitudinal channels, paralleling the digestive ceca, and the presence of the numerous loops which arise from them and surround the ceca forming an almost continuous sheet of sinuses, can be easily explained by the hypothesis just presented. Furthermore, the most active parts of the body receive the richest lymph supply. The oral, caudal, and genital suckers are enclosed in lymph plexuses in direct communication with the longitudinal canals. This provides them the food and oxygen required for the intensity of their muscular activity. Similarly, the rich lymph supply to the testes and the ovary provides for the high metabolic requirement of these organs. As in all parasitic forms, the trematodes have enormously developed reproductive organs and the worm becomes ultimately a highly reproductive machine. The food substances are largely transformed into reproductive products. The intimate lymph association between the digestive ceca and the gonads provides a mechanism for this transfer.

The lymph system is not only associated with the distribution of material for constructive metabolism, but it undoubtedly serves also for the collection of nitrogenous wastes and their transportation to a point of easy elimination. The most active parts of the body, the suckers and the gonads, must produce large quantities of excretory materials. The accumulation of these substances in the organs concerned would produce a condition of unequal osmotic pressure and, consequently, the substances would tend by diffusion to pass into the lymph fluids in the surrounding sinuses. Surcharged with excretory products in the regions of high metabolism, the lymph system provides for the elimination of these substances by its intimate association with the excretory vesicle. Figure 16 is a frontal section and shows the continuity of a principal longitudinal canal and the lymph plexus which encloses the excretory vesicle. The vesicle is practically surrounded by lymph sinuses and this association of the lymph and excretory systems constitutes strong evidence concerning the function of the lymph system.

Stephanopharynx Fischœder, 1901

Generic Diagnosis.—Body compressed, slightly concave ventrad, convex, dorsad, but slightly flattened dorsoventrally, cephalic and caudal ends rounded, sides excurvate longitudinally. Ventral pouch absent. Acetabulum ventro-subterminal, large, not sunken, margin not raised, aperture large. Genital pore with considerable musculature which is not sharply defined in form of a sucker, atrium divided into large ventral and small dorsal chamber, ductus hermaphroditicus present.

Excretory pore prevesicular in acetabular zone. Oral sucker with large posterior evagination; esophagus without muscular thickening; ceca very wavy, end post-equatorial, posttesticular.

MALE ORGANS.—Testes two, smaller than acetabulum, with small lobes, fields nearly coincide, zones abut or separate, preovarial, not widely separated from acetabulum, in equatorial and caudal thirds; musculosa well developed, but not enormous; cirrus pouch absent.

FEMALE ORGANS.—Ovary and shell-gland posttesticular; vitellaria profuse; uterus intercecal; eggs many; Laurer's canal entirely pre-excretory.

TYPE SPECIES.—*Stephanopharynx compactus* Fischœder, 1901.

Only the type species, *S. compactus*, has previously been recorded. It was described by Fischœder (1901) from the stomach of *Bos taurus* taken in Africa. His material consisted of but three specimens, two from one host and one from another. Subsequently Maplestone (1923) added to the description of the form. He had almost a thousand specimens to study, although none of them apparently contained eggs.

Stephanopharynx secundus, new species

The material of this genus present in the Congo collection consists of five specimens, found together with many specimens of *Paramphistomum cervi* in the stomach of the antelope, *Redunca bohor* (Congo Exp. vial No. 961, February 10, 1912, Faradje). These specimens conform in every respect to the diagnosis of the genus as given by Fischœder, but differences in the size of the specimens and in the size of individual structures make it impossible to assign them to the species *S. compactus*. They are at least twice the size of Fischœder's specimens, the internal organs are much larger, and the worms are still sexually immature. Consequently they are regarded as a new species for which the name *Stephanopharynx secundus* is proposed. Fischœder's largest specimens were 5 mm. in length and filled with eggs. Maplestone reports worms up to 7 mm. in length, and adds that "none of the worms were gravid, and prolonged search of the ample material failed to reveal any specimen containing eggs." It seems possible then that Maplestone's material belongs to the new species, *S. secundus*.

Four of the five specimens in this collection were sectioned, and one, the type specimen, preserved in alcohol. The material was so hard that satisfactory sections could not be obtained. Although the gross structure could be determined, it was impossible to follow the smaller tubules or to work out the details of the lymph system.

The worms measure 8 to 11 mm. in length, 5 to 7 mm. in width, and 4 to 6 mm. in thickness. The acetabulum is from 2.3 to 3.0 mm. in diameter. The oral sucker is 1.0 to 1.5 mm. in length, and from 1.6 to 1.7 mm. in diameter. It is probable that the

sucker is spherical in living specimens and capable of much variation in shape as different attitudes are assumed. The oral sucker is not sharply delimited from the large median evagination as may be seen by examination of figure 18. Figures 18, 19, and 20 give a better idea of the oral evagination than a verbal description. The structure is very large, but so irregular in form that measurements are almost useless. It may extend 3.0 mm. in length. The wall varies in thickness, due to contraction or elongation of a particular part, and may be almost as thick as the wall of the oral sucker. In the sectioned worms it measures from 0.4 to 0.5 mm. in thickness. In structure it does not differ essentially from the wall of the oral sucker; the texture is somewhat more loose and open, but the same elements are present. The oral evagination extends almost to the dorsal wall of the body; ventrally it is in close apposition to the genital structures (Fig. 20), and caudally it extends to the level of the cephalic testis. The esophagus arises from the median, anterior, ventral aspect of the oral evagination and passes caudally to about the level of the genital pore. The wall is only slightly thickened. On the ventral side of the body the alimentary tract bifurcates and the two ceca then turn dorsally one on each side of the body. Their course is very sinuous (Fig. 18) and they extend into the zone of the acetabulum.

The excretory system shows no differences from that found in *Paramphistomum*. It seems probable that the system is characteristic and uniform for each subfamily and consequently no differences would be expected. The vesicle is large with much-folded walls (Fig. 19) and communicates with the exterior by means of a short, thick-walled canal. As noted previously, it has not been possible to trace the course and relations of the smaller tubules.

The lymph system also manifests agreement with that found in *Paramphistomum*, type of the subfamily, and with that of *Cotylophoron* described in the preceding section. There are two principal vessels which run longitudinally on the median sides of the digestive ceca. Posteriorly, branches from these vessels form a plexus about the excretory vesicle and others supply the region of the acetabulum. Numerous flattened offshoots from the longitudinal canals merge with each other and form a reticulum which encloses the digestive ceca. Anteriorly the longitudinal canals subdivide to form many sinusoidal tubules supplying the cephalic end of the worm. From the chief longitudinal canals branches pass medially from either side to supply the testes and ovary. The testes are subdivided into many small lobes, each of which is partially enclosed by a lymph sinus.

The testes lie in or near the median plane, one before the other. Maplestone reports that the posterior testis is much nearer the ventral wall than the anterior one and such a condition is shown in his figure. Examination of the figure, however, shows that the specimen is much contracted and this undoubtedly accounts for the position of the testes. These organs are deeply lobed, and the lobes are small and numerous. It is possible that with increasing maturity the separate branches may grow larger, giving the organ a more uniform appearance. The vasa deferentia were not traced, the seminal vesicle was empty and consisted of a small coiled tube. The musculature which surrounds the genital pore, the relations of the genital ducts, and the structure of the copulatory structure is shown in figure 20. In general form the male system is similar to that of *S. compactus* as described by Fischœder. The female system in these specimens is not so well developed as in the male. The ovary and shell-gland are very small, and the vitellaria consist of a few small follicles along the sides of the body. The ovary measures from 0.3 to 0.35 mm. in diameter. The uterus occupies

the usual position; at first it turns backward, then ventrally under the posterior testis in a few loose coils, then dorsally behind the caudal testis and anteriorly over the testes where it turns ventrad and unites with the ejaculatory duct to form a hermaphroditic canal opening through a small papilla. No eggs were present in any of the specimens and no spermatozoa were observed in the female tract. Laurer's canal branches from the oviduct just where it enters the shell gland and passes dorsally, opening to the dorsal surface in the median line anterior to the excretory pore.

The type of this species is deposited in the collections of the Department of Lower Invertebrates, American Museum of Natural History (A. M. N. H. No. 165).

Cladorchinæ Fischœder, 1901

Chiorchis Fischœder, 1901

Generic Diagnosis.—Body flattened, oval to ovate, with convex dorsum and concave venter, rather attenuate cephalad, rather blunt caudad; ventral pouch absent. Acetabulum ventral, near the posterior end of the body; genital sucker reduced, pore ventromedian, at the level of the bifurcation of the alimentary tract. Excretory vesicle anterior to the acetabular zone. Oral sucker with paired evaginations; strong muscular bands pass backward from the sucker on all sides and are inserted on the body wall; contraction of these muscles may retract the oral sucker to the level of the genital pore. Esophagus short, thick-walled; ceca terminate at the middle of the acetabular zone.

Male Organs.—Testes two, one before the other in intercecal area, lobed, forming H-shaped structures; seminal vesicle much coiled, anterior to the testes, cirrus pouch absent.

Female Organs.—Ovary and Mehlis' gland posttesticular near anterior margin of acetabulum. Oviduct arises at the dorsal anterior margin of the ovary and turns dorsad and posteriad to the oötype. Laurer's canal present, prevesicular; uterus passes forward dorsal to the testes and under the seminal vesicle; eggs large.

Type Species.—*Chiorchis fabaceus* (Diesing, 1839) Fischœder, 1901.

Chiorchis fabaceus (Diesing, 1839)

Chiorchis fabaceus, the type and thus far the only known species in this genus, was described by Diesing, 1839, from the South American manatee, *Trichechus exunguis*. His description (1850) is as follows:

A. corpore ovatolanceolato, dorso convexo, abdomine plano, hinc inde (juvenute) convexiusculo ore terminali orbiculari obsolete crenato, acetabuli ventralis limbo parum prominulo.

Natterer fand an 400 Individuen dieser schönen Art in einem Männchen des *Manatus exunguis* Natt., am Ende des Dünndarmes, besonders viele aber im Blinddarme, wo ihr eigentlicher Sitz zu sein scheint, und noch endlich am Anfange des Mastdarmes, frei; zu Borba am 13, Januar 1830, und in denselben Organen eines Weibschens zu Forte do Rio Brancho am 26, April 1832.

Beschreibung. Der lanzet-eiförmige Körper 3-6 Linien lang, und verhaltnissmässig am Kopfende ½-⅓ linie, in der Mitte des Leibes aber 1½-3 Linien breit. Der Rücken gewölbt, die bauchseite platt gedrückt, und nur im jungendlichen Zu-

stande gewölbt. Der cylindrische Hals langgestreckt, doch bei vielen Individuen ganz eingezogen, und dann hat der Wurm die meiste Aehnlichkeit mit einter Kaffeebohne. Der am Grunde der Bauchseite liegende, kreisrunde Saugnapf mit einem schmalen, wenig hervorstehenden Rande umgeben. Die Ruthe nur bei wenigen Individuen in Form eines kleinen Zapfens herausgestreckt. Die im Leben röthlich weisse Haut in Tode gelblich grau, durchscheinend.

Stedman (1889) made additions to the description of this form. His material was from the American manatee. The text is illustrated with twenty-one figures, seventeen of which are done in colors. There is a detailed description of the dermomuscular sac, the parenchyma, and the alimentary tract. The excretory and nervous systems are briefly treated, while the only observation concerning the reproductive systems is that their ducts open by a common pore. The oral sucker was described by Stedman as the pharyngeal bulb. The muscular thickening at the posterior end of the esophagus was regarded as a crop.

Leidy (1890) reported numerous specimens of this worm from the large intestines of a sea-cow, *Trichechus latirostris*, which died in the Zoölogical Garden of Philadelphia, and additional specimens, obtained from another sea-cow, which were presented to the Academy of Natural Sciences of Philadelphia.

Fischœder (1901) created the genus *Chiorchis* to contain the amphistomes from the manatee. Daday (1907) added *Amphistomum oxycephalum* Diesing, *Amphistomum lunatum* Diesing and two new species, *Chiorchis dilatatus* and *Chiorchis papillatus*, to the genus. Stunkard (1917) removed *Amphistoma lunatum* to the genus *Zygocotyle*. In a later paper (Stunkard, 1925) evidence was submitted to show that *Chiorchis papillatus* is a synonym of *Amphistoma oxycephalus* and that the species belongs in the genus *Pseudocladorchis*. Also that the worm described as *Chiorchis dilatatus* cannot be included in the genus *Chiorchis* and should be removed to the genus *Pseudocladorchis*. This leaves *Chiorchis fabaceus* as the only species in the genus.

In the Congo collection there was one vial containing a large number of amphistomes from the African manatee, *Trichechus sengalensis*. They bore the following data: "F. 1063, taken at Banana, August, 1915." Although there are slight differences between these worms and the description of *Chiorchis fabaceus*, I am inclined to assign them to that species. All of the specimens are small and most of them sexually immature. They measure from 4 to 6 mm. in length, 2.5 to 35. mm. in width, and 1.25 to 1.75 mm. in thickness. The proportions agree with those given by Fischœder (1901), although the specimens are considerably smaller. The anterior end is slightly attenuated, but the specimens are much con-

tracted and the oral sucker is retracted, lying about one-half of the distance between the anterior end of the body and the bifurcation of the alimentary tract. This condition has been reported in all previous descriptions, although probably the sucker may be protruded until it lies at the anterior end. If the sucker is so protruded, the body would be considerably elongated. The acetabulum is ventral (Fig. 21), almost one-half of its width intervening between the sucker and the posterior end of the body. It measures from 1.25 to 1.65 mm. in diameter and its wall is 0.26 to 0.33 mm. in thickness. The cuticula and dermomuscular sac are similar to those in all amphistomes and for this species they have been described in detail by Stedman (1889). The oral opening is subterminal (Fig. 22), near the anterior tip of the body and an oral canal leads in to the oral sucker. This oral canal is simply a modified portion of the body-wall and does not differ from it in histological structure. The oral sucker measures from 0.5 to 0.66 mm. in diameter. From its posterior dorsal aspect there is an evagination which divides to form two oral sacs (Fig. 23) that extend backward. From the lateral wall of the oral sucker strong muscle-bands radiate posteriorally. Their size and arrangement are shown in figures 23 and 25. As they pass backward they tend to become ventral in position and most of them are inserted in the body-wall in the posterior region of the body. It is the contraction of these muscles that produces the retraction of the oral sucker in fixed specimens. The esophagus is thick-walled, figure 24, and from the sucker it passes posteriad and ventrad. It then turns dorsally and the posterior portion of the canal is greatly thickened. This region was described by Stedman as the crop, although there is no evidence for such an interpretation. The esophagus is richly supplied with lymph vessels (Fig. 24). The alimentary tract bifurcates at or near the level of the genital pore and the ceca extend to the center of the acetabular zone.

The excretory pore is situated in the mid-dorsal line at the level of the caudal margin of the posterior testis. The vesicle is large, passing posteriad and ventrad to terminate just above Mehlis' gland The collecting ducts arise at the ventrolateral margins of the vesicle, turn outward and backward, and then pass forward. The smaller tubules could not be followed in the material at hand.

The fixation of the specimens is not good enough to trace the lymph system in detail although remnants appear in sections. There is one longitudinal channel on each side of the body. These vessels are dorsad and mediad of the ceca and give off branches which surround them. Anteriorly and posteriorly the longitudinal lymph vessels break up into numerous branches which supply the suckers.

The testes are situated one before the other at or near the center of the body. They are lobed and in whole mounts (Fig. 21) manifest the figure H appearance. Dorsally the organs are single, oval structures. Ventrally each has an anterolateral and a posterolateral lobe on either side of the gland. At the center of the testes they measure from 0.2 to 0.3 mm. in length. The greatest length, i.e., at the lateral margins, is from 0.4 to 0.5 mm. In width they measure from 0.6 to 0.8 mm. The vasa efferentia unite in front of the cephalic testis to form a thin-walled, much coiled seminal vesicle (Fig. 21) which measures from 0.05 to 0.1 mm. in diameter. The vesicle is succeeded by a thick-walled, coiled pars musculosa (Fig. 26) which lies ventral to it. The terminal portion of the musculosa is inclosed in prostatic cells and passes ventrad to form the ejaculatory duct. In all of the sectioned worms the genital papilla is retracted and the ejaculatory duct unites with the metraterm to form a hermaphroditic canal. The terminal portions of the metraterm and of the ejaculatory duct are inclosed in a layer of ill-defined muscular mesh, although a true genital sucker is not present. The arrangement of the copulatory organs is shown in figure 25. The genital pore is situated in the midline at the caudal end of the cephalic third of the body, ventral to the bifurcation of the digestive tract (Fig. 25).

The ovary is spherical to oval, usually longest in the lateral axis and measures from 0.23 to 0.33 mm. in diameter. It is ventral, median, between the posterior testis and the acetabulum. The oviduct arises from its dorsal anterior margin and turns toward the left where Laurer's canal is given off. This canal passes dorsally, turns in front of the excretory vesicle, and opens in the median line near the excretory pore. After the origin of Laurer's canal the oviduct turns dorsally, receives the common vitelline duct and passes mediad and dorsad to enter Mehlis' gland. The latter is about the size of the ovary and immediately dorsal to it. The uterus emerges from the dorsocaudal aspect of Mehlis' gland, passes dorsally a short distance and then turns forward where it expands and is filled with masses of spermatozoa (Fig. 26). It forms loose coils behind the caudal testis and then passes forward, dorsal to the testes. In front of the testes it turns ventrad and unites with the ejaculatory duct as previously described. The vitellaria consist of scattered follicles which extend in the extracecal areas from the oral sucker to the posterior ends of the ceca. Occasionally follicles are found in the intercecal field. The follicles are spherical to oval and measure from 0.09 to 0.15 mm. in diameter. Transverse ducts pass medially at the levels of the oötype and unite just below the excretory vesicle to form a common vitelline

duct. This duct continues ventrad along the anterolateral face of Mehlis' gland to open into the oötype. The relations of the common vitelline duct are shown in figure 26. The eggs are thin-shelled and measure from 0.14 to 0.157 mm. in length, and from 0.082 to 0.086 mm. in diameter.

The life-history of this form is as yet unknown. Certain data, however, throw light on the probable course of development. So far as known all amphistome cercariæ have cystogenous glands, and the amphistomes of mammals encyst on vegetation. In all probability the cercariæ of *Chiorchis fabaceus* encyst on vegetation and are eaten by the final host. The manatees feed on grasses and algæ which grow in the mouths of the rivers which they frequent. Certain morphological features characteristic of the form will probably be distinguishable in the cercariæ. The strong muscular bands which pass backward from the oral sucker and the ventrad position of the acetabulum may prove to be identifying characters.

Brumptinæ Stunkard, 1925

Brumptia Travassos, 1921

Generic Diagnosis.—Body flattened, oval to ovate with convex dorsum and flattened venter, rather attenuate cephalad, rather blunt caudad, ventral pouch absent. Acetabulum ventral, near the posteriad end of the body; genital sucker present, pore ventromedian, a short distance in front of the middle of the body. The most characteristic feature is the presence of two large laterocaudal appendages which contain most of the vitellaria. Excretory vesicle dorsal to the acetabular zone, excretory pore median, dorsal, near the posterior end of the body. Oral sucker with paired evaginations, ceca end in the dorsal part of caudal appendages.

Male Organs.—Testes two, on opposite sides near the middle of the body, lobed; seminal vesicle and cirrus sac large.

Female Organs.—Ovary spherical to oval, lateral, between the testes; Mehlis' gland on mesial aspect of ovary, Laurer's canal runs dorsad and posteriad opening in the midline above the excretory vesicle anterior to the excretory pore. Vitellaria massive, situated in the caudal appendages.

Type Species.—*Brumptia bicaudata* (Poirier, 1908) Odhner, 1926.

Brumptia bicaudata (Poirier, 1908)

Amphistomum bicaudatum Poirier, 1908, 'Trématodes parasites de l'éléphant d'Afrique.' Compte Rendu, de la 37^{me} session de l'Association Française pour l'avancement des sciences, Clermont Ferrand, 1908, p. 580.

Cladorchis gigas MacCallum, 1917, 'A new species of Trematode (*Cladorchis gigas*) parasitic in Elephants.' Bull. Amer. Mus. Nat. Hist., XXXVII, pp. 865–871, Pls. cviii–cx, 1 text figure.

Brumptia gigas (MacCallum, 1917) TRAVASSOS, 1921, 'Contribucio para a systematica dos "Paramphistodæ,"' etc. Braz.-Med., Anno XXV, p. 357. Rio de Janeiro.

Brumptia bicaudatum (Poirier, 1908) STUNKARD, 1926, 'On the specific identity of *Amphistomum bicaudatum* Poirier and *Cladorchis gigas* MacCallum.' Anat. Rec., XXXIV, pp. 165–166.

This species was discovered by Poirier and his description (1908) is here quoted in full since the original account is not readily accessible.

Amphistomum bicaudatum J. Poirier

Cet Amphistome est nettement caractérisé par les deux ailerons caudaux qui terminent son corps.

Le corps, assez épais, a 6 mm. de long, depuis l'extrémité antérieure jusqu' au bord postérieur de la ventouse terminale. Au delà, les ailerons se prolongent sur une longueur de 2 mm.

La largeur, à peu près uniforme sur les deux tiers postérieurs du corps, est 5 mm. Sur le tiers antérieur, la largeur diminue rapidement, cette partie antérieure du corps ayant une forme de cône à large base et tronqué au sommet par la ventouse orale petite.

La ventouse postérieure, a orifice ventral, a 1 mm. de diamètre. L'orifice cloacal, bien net, est situé au milieu de la face ventrale du corps.

Les ailerons caudaux, à bord postérieur circulaire, ont leur face dorsale convexe, continuation de la face dorsale du corps. Leur face ventrale est concave.

Les deux ailerons se séparent dorsalement au niveau du bord postérieur de la ventouse terminale, un peu en arrière de l'orifice de l'appareil excréteur.

Les bords vont se perdre dans la face ventrale du corps, de chaque côté de la ventouse postérieure, au niveau du bord antérieur de cette ventouse.

Ces ailerons contractiles doivent aider l'action de la ventouse qu' ils entourent.

L'appareil excréteur est construit sur le type de celui des Amphistomes; des branches speciales vont se ramifier dans les ailerons.

Les testicules petits, massifs, écartés l'un de l'autre, sont situés latéralement contre les branches intestinales. La poche du cirrhe est presque sphérique.

Les follicules des glandes vitellogènes sont gros et peu nombreux.

L'utérus, peu sineux, ne renferme qu' un petit nombre d'œufs.

L'ovaire et la glande coquillière sont en arrière de la ligne qui joint les deux testicules.

Mais l'appareil le plus charactèristique de cet Amphistome est son tube digestif ou plutôt la forme du pharynx.

La ventouse orale se continue par un pharynx formé d'un petit lobe médian, correspondant au pharynx ordinaire, et de deux lobes latéraux énormes remplissant presque toute la région conique du corps.

Du lobe median part un œsophage étroit qui se continue par deux branches intestinales simples se terminant à l'origine des ailerons.

Cet Amphistome de l'éléphant d'Afrique se distingue ainsi nettement par ses deux ailerons caudaux et par la grosseur des lobes latéraux du pharynx.

The parasites collected by the Congo expedition were intrusted to Dr. G. A. MacCallum for study and identification in February, 1917. In

December, 1917, he published a description of the trematode from the elephant, *Loxodon africanus*, naming the species *Cladorchis gigas*. The report contains a record of collection as supplied by Lang. It gives an adequate survey of the external morphology and compares the form with *Amphistomum bicaudatum* (Baird). MacCallum gives no reference to Baird's description and I have been unable to find it. The measurements given for *Amphistomum bicaudatum* (Baird) agree with those of Poirier. The description of the internal organs is brief and in certain particulars incorrect. The most notable error is the statement that there is an "immense deeply lobulated or branched single testis." On the other hand, certain of the internal structures are admirably described.

Travassos (1921) removed this species from *Cladorchis* and created the genus *Brumptia* to contain it. Maplestone (1923) reported the form from the stomach of a rhinoceros taken at Ngoa, Northeast Rhodesia. He accepted the name *Brumptia gigas* as proposed by Travassos and stated that his "material seems to be identical with MacCallum's in all anatomical details," but that the specimens are somewhat smaller in size. The description of Maplestone makes certain additions and corrections to that of MacCallum. The two testes are correctly described and the paper is illustrated by ten figures.

In the spring of 1925, at Paris, while studying the amphistomes from the elephant collected by the Congo Expedition, I learned that Dr. Roubaud of the Pasteur Institute (a nephew of Dr. Poirier) had the specimens originally collected by Poirier and described by him in 1908. Dr. Roubaud very kindly gave me representative specimens from the Poirier collection for comparison with the material under investigation. One of the Poirier specimens is shown in Fig. 27. Others were sectioned and a detailed study of these worms was made. They are all immature and the lack of development of the sex organs indicates that they are in a very juvenile condition. Aside from the gonads, the arrangement of the respective organs and their relative sizes are in substantial agreement with the sexually mature specimens present in the Congo collection. As a matter of fact, there is no point of morphological difference which is not readily explainable on the basis of age difference. The arrangement of the organs of the reproductive systems is the same in both cases, and the evidence appears conclusive that all the worms belong to one and the same species. Consequently, I announced (1926) the identity of *Amphistomum bicaudatum* Poirier and *Cladorchis gigas* MacCallum.

The nomenclature of the form is not as complicated as at first appears. *Amphistomum* is not a valid generic name; the evidence for its

suppression was given by Fischœder (1901). MacCallum was in error in assigning the form to the genus *Cladorchis* and his specific name *gigas* disappears as a synonym of *bicaudatum*. Recognizing that the species could not be included in any previously known genus, Travassos created the genus *Brumptia* to contain it, including the genus in the subfamily Cladorchinæ. Maplestone (1923) noted the extreme structural differences between *Brumptia* and the Cladorchinæ and expressed doubt whether the genus really belonged in that group. On the basis of extended studies on the amphistomes, the writer (1925) erected the subfamily Brumptinæ in the family Paramphistomidæ for the reception of this form. Its correct name is *Brumptia bicaudata*.

The descriptions of Poirier, MacCallum, and Maplestone give a very good knowledge of the species, and in general my observations confirm their findings. The shape of the worms is characteristic and the size differences have been reported by the authors named. It is interesting to note that specimens from the elephant are larger than those from the rhinoceros. This difference may be due to the greater age and sexual maturity, but probably the worms do not attain so great a size in the rhinoceros. These specimens came from the same locality and presumably the size differences are dependent on host factors. In a smaller host species, parasitic worms ordinarily do not grow as large as they do in a larger host species. This was observed in the case of *Gastrodiscus ægyptiacus*, parasitic in the wart-hog and rhinoceros.

Certain details concerning the anatomy of the species may be added to previous description. The oral sucker is slightly subterminal in position and not sharply marked off from the surrounding parenchyma. Cortically, strong circular fibers are not developed and it is bounded by a limiting membrane. Its form is shown in figures 28 to 33. It is rounded at the anterior end, near the middle it has a ventral muscular prominence or thickening and the posterior portion is enlarged and flattened dorsoventrally until the lumen is narrowed to a slit (Fig. 31). In this region the muscular strands are much reduced and the wall of the sucker consists of loose, vacuolated parenchyma. On either side the lumen of the sucker expands to form two conspicuous grooves, one dorsal, the other ventral in position (Fig. 31), and these grooves extend caudad to the end of the oral evaginations (Figs. 32, 33). Caudally the lumen of the sucker is continuous medially with the esophagus and laterally with the cavities of the oral evaginations. In the anterior portion of these sacs the lumen is triradiate (Fig. 32) and posteriorly the dorsal grooves expand (Fig.

33) to form the cavities of the much enlarged oral evaginations. The wall of the esophagus is not thickened appreciably toward the posterior end and is actually delicate for an amphistome of this size. The ceca extend posteriorly in the lateral areas of the body and pass dorsal to the testes.

The genital organs in the Congo specimens show substantial agreement with the description of Maplestone, although his selection and use of terms is not always precise. The vasa efferentia arise as large thin-walled tubes, continuous with a lobe of either testis as noted by MacCallum, and may be coiled. The initial portion of the common sperm duct, inside the cirrus sac, is also frequently coiled. The vasa efferentia, as well as the initial portion of the common duct, are enlarged and filled with sperm and actually constitute a seminal vesicle, part of which is outside and part inside the cirrus sac. The ovary and female genital complex have been described by both MacCallum and Maplestone. Neither reported the absence of a seminal receptacle and presence of receptaculum seminis uterinum. In the Congo specimens the uterus is much more developed than in those described by Maplestone. In the specimens from the elephant, numerous and massive uterine coils, congested with eggs, fill the body behind, below and above the cirrus sac. Although there is greater development of the organs of both the male and female systems, the size of eggs in the Congo worms falls within the limits reported by Maplestone.

The excretory and lymph ducts may be identified in sections but the fixation of the present specimens is not good enough to permit a complete reconstruction of the systems. The excretory vesicle divides to form the collecting ducts just behind and above the oötype.

It is of interest that the parasite occurs in both the elephant and the rhinoceros and this fact should prove of value in attempts to elucidate its life-history. Some plant, commonly used as food by both, probably bears the encysted cercariæ. Certain morphological features characteristic of the species—the large cirrus sac, the lateral arrangement of the gonad rudiments, and the peculiar caudal alæ—may be sufficiently developed in the cercaria to assist in its recognition.

Gastrodiscinæ Monticelli, 1892

Gastrodiscus Leuckart, 1877

Generic Diagnosis.—Body divided by constriction into small, cephalic, slender, nearly cylindrical portion without sexual glands, and large, caudal, flat, discoidal, ventrally excavate portion containing the genital glands. Ventral pouch absent. Acetabulum small, caudal, ventral, margin raised, aperture relatively large. Genital

pore without sucker. Excretory pore postvesicular, in acetabular zone, caudad of pore of Laurer's canal. Oral sucker with paired evaginations; esophagus with muscular thickening; ceca not wavy, long, end postequatorial, posttesticular.

MALE ORGANS.—Testes two, larger than acetabulum, branched, diagonal, fields and zones overlap, preovarial, widely separated from acetabulum, about in equatorial third; musculosa not enormous; "cirrus pouch not completely closed."

FEMALE ORGANS.—Ovary and shell-gland posttesticular; vitellaria extracecal, extend from bifurcation into postcecal zone; uterus intercecal; Laurer's canal entirely prevesicular.

TYPE.—*Gastrodiscus ægyptiacus* (Cobbold, 1876) Railliet, 1893.

Gastrodiscus ægyptiacus[1] (Cobbold, 1876)

Diplostomum ægyptiacum COBBOLD, 1876, 'The Egyptian horse plague in relation to the question of parasitism.' [Veterinarian, Lond.] (587), XLXIX, 4s.; (263), XXII, Nov., pp. 755–758.

Hemistomum species SONSINO, 1877, 'On the Entozoa of the horse in relation to the late Egyptian equine plague.' [Veterinarian, Lond.] (590), L, 4s.; (266), XXIII, Feb., pp. 49–54; (591) 4s.; (267), Mar., pp. 121–128.

Gastrodiscus sonsinoii COBBOLD, 1877, 'Description of the new equine fluke (*Gastrodiscus sonsinoii*).' [Veterinarian, Lond.] (592), L, 4s.; (268), XXIII, Apr., pp. 233–239, 1 Fig., 1 Pl.

Cotylegaster VON SIEBOLD, 1877, MS. in Cobbold, 1877 (previous reference).

Gastrodiscus polymastos LEUCKART, 1880, 'Die Parasiten des Menschen und die von ihnen herrührenden Krankheiten. Ein Hand-und Lehrbuch für Naturforscher und Aerzte.' 2. Aufl., I, 2. Lief., 1. Abt. Leipzig and Heidelberg.

Gastrodiscus minor LEIPER, 1913, 'Observations on certain Helminths of Man.' Trans. Soc. Trop. Med., VI, p. 265, London.

The material of this species present in the collection consists of three vials containing about five hundred specimens from the intestine of the wart-hog (Congo Exp. vial No. 329, Faradje, January, 1912) and three vials containing about four hundred specimens from the intestine of *Ceratotherium simum cottoni* (Congo Exp. vial No. 984, Faradje, February 3, 1912). The specimens from the wart-hog, *Phacochœrus africanus*, were sexually immature, and consequently specific determination cannot be final. A camera lucida drawing of one of them is shown in figure 34. They measure from 7 to 11 mm. in length, from 5 to 7 mm. in breadth, and about 1.3 mm. in thickness. The anterior prominence is not cone-shaped but narrows at its junction with the body. It is from 2 to 2.5 mm. in length. The acetabulum measures from 1.3 to 1.5 mm. in diameter. The cuticula measures 0.023 mm. in thickness on the dorsal side of the body and 0.003 mm. on the ventral side. The oral sucker has a diameter of 0.5 to 0.6 mm. and the diameter of the esophageal bulb varies from 0.16 to 0.3 mm.

[1]For discussion of the nomenclature of *G. ægyptiacus* see footnote in Looss, 1896, p. 13.

The genital pore is located as in *G. ægyptiacus* on the ventral side of the disc at the base of the cephalic cone. The testes are deeply lobed and dendritic with occasional groups of cells free in the lumen but spermiogenesis had not begun and there are no spermatozoa either in the testes or the efferentia. The vas deferens is a small, slightly coiled tube. The ovary is small and functionless, the vitellaria are not developed, and no eggs are present in any of the specimens. Mehlis' gland and Laurer's canal may be recognized in sections although both are rudimentary. The uterus is a small, coiled tube which passes forward to the genital pore. While the reproductive systems of these worms are not mature, in general features they agree with the description of these systems of *G. ægyptiacus*. In form and internal structure, moreover, they manifest such striking agreement with *Gastrodiscus ægyptiacus* that provisionally I assign them to that species. Maplestone (1923) reported a large number of specimens of *Gastrodiscus* from wart-hogs taken in northeast Rhodesia. Some of these specimens were gravid and Maplestone regarded them as members of the species *G. ægyptiacus*, although they were considerably smaller than other specimens found in the horse from the same locality. The observation of Maplestone increases the likelihood that the specimens from the wart-hog which are present in the Congo collection belong to the species *G. ægyptiacus*. They certainly belong to the genus *Gastrodiscus*, and since *G. ægyptiacus* is endemic in this area, the specimens from the wart-hog probably belong to that species. In general, a parasite which is capable of development in more than one host species will reach a greater size in the larger host. This may then well account for the small size and lack of sexual maturity found among the specimens from the wart-hog.

The specimens from the rhinoceros clearly belong to *G. ægyptiacus* and the present report is apparently the first record of the parasite from that host. This fluke, therefore, is capable of development in different members of the family Equiidæ, in the rhinoceros, and in the wart-hog. Lack of specificity in the definitive host probably accounts for the wide distribution of the species. The structure and life-history of the worm has been known since the classical research of Looss (1896). He there traced the developmental stages of the parasite in the snails *Cleopatra bulimoides* Jicknell and *C. cyclostomoides* Bourguignat. Maplestone (1923) made certain emendations to the description, noting that the anterior testis and the ovary are always on the same side of the body and may be either right or left. Furthermore, he observed great variation in the distribution and extension of the vitellaria. He made many measure-

ments of the distance between the genital pore and the anterior edge of the discal portion of the worm and found that the distance was greater in larger worms and varied as would be expected.

A detailed description of the specimens at hand is unnecessary and would add little to previous accounts. The form of body and character of the organ systems are typical. The oral sucker bears the peculiar anterior papillæ described by Looss, but the origin of the oral evagination and esophagus deserves especial mention. Looss reported the oral evaginations as dorsal in location and the esophagus as arising from the inferior portion of the oral sucker. In the Congo specimens there is a single canal that leads posteriad from the sucker. From this canal the oral evaginations arise as separate sacs that extend dorsally and posteriorly, while the canal passes ventrally and posteriorly to become the esophagus. Each sac is thus in communication with its fellow of the opposite side, with oral sucker, and with the esophagus (Fig. 35). In other respects the digestive, muscular, and nervous system agree with the description of Looss (1896).

In this paper Looss did not clearly distinguish between the excretory and lymph systems, but regarded and described both types of canals as belonging to the excretory system. The granular contents of the lymph canals were noted and other important differences were stated as follows: "En tenant compte de cet aspect variable du contenu des vaisseaux excréteurs, on arrivera à la conclusion qu'il ne doit pas être le même dans les diverses parties du système entier; évidemment, dans les parties périphériques, le contenu—liquide du reste—est plus riche en substances protoplasmiques dissoutes et qui se précipitent sous l'action des réactifs fixateurs, que le contenu des gros canaux terminaux toujours clair et sans granulations." It seems more than probable that the confusion regarding the nature and relations of the lymph system was involved in the conception that food material was absorbed through the ventral body-wall. Looss correctly identified the contents of the lymph vessels as nutrient material, at least as regards those lymph vessels which form the capillary network and sinuses near the body-wall. Since the peripheral canals and lacunæ were filled with this nutrient fluid and since the massive character of the body made it difficult to see how food material could pass from the intestine to distant parts, Looss conceived the idea that food substances were absorbed through the thin cuticula of the ventral side of the body and accumulated in these peripheral channels.

In his later studies on amphistomes, Looss worked out the differences between the lymph and excretory vessels and established the lymph

system as a separate entity. Examination of the intestine of *Gastrodiscus* shows that the ceca are encircled very closely by plexuses of lymph-nets that are in communication with and form a part of an elaborate lymph system which penetrates to all parts of the body. Undoubtedly nourishment passes from the ceca to the lymph vessels and by means of this system is distributed to all parts of the body. Such dispersal is slow and aided only by movement of the various parts of the body since no cilia are present and so far as known none of the vessels are pulsatile. With a knowledge of the true nature of the lymph system, there is no longer the necessity for postulating an absorptive function for the body-wall and I am inclined to believe that such absorption is very slight if it occurs at all. If the parasite were to any appreciable extent nourished like a cestode, one would expect absorption through the dorsal body-wall which is exposed to the intestinal contents rather than through the ventral body-wall which is closely applied to the intestinal mucosa. The thickness of the dorsal cuticula is, however, subversive to such an opinion. Furthermore, *Gastrodiscus* is an inhabitant of the large intestine. It is easy to conceive of a parasite living by absorption in the small intestine where the food supply is varied and abundant but not in the large intestine where the food value of the contents is much reduced. Concerning the ventral prominences which are present on the under side of the disc, it seems very probable that they are not associated with the lymph system but that they are accessory adhesive structures.

Fasciolidæ Railliet, 1895

Fasicolinæ Odhner, 1910

Fasciola Linnæus, 1758

Generic Diagnosis.—Body large, broad, flattened, leaf-shaped, covered with minute spines, the anterior end set off in a cone-like projection. Acetabulum near anterior end. Pharynx present, esophagus short, intestinal crura much branched, extend to posterior end of body. Excretory vesicle much branched.

Male Organs.—Genital pore median, directly before the acetabulum; cirrus sac well developed. Testes median, one before the other, much branched.

Female Organs.—Ovary lateral, anterior to testes, richly branched; receptaculum seminis lacking, Laurer's canal present, vitellaria extensive, in the lateral areas and in the posterior region on both dorsal and ventral sides of the body. Uterus short, in compact coil, preovarian. Eggs large, thin-shelled; parasites of the gall passages of mammals.

Type Species.—*Fasciola hepatica* Linnæus, 1758.

Fasciola hepatica Linnæus

Distomum hepaticum RETZIUS, 1786, 'Lectiones publicæ de vermibus intestinalibus.' Holmia.

Fasciola humana GMELIN, 1790, 'Systema naturæ per regna tria naturæ.' (Part 6.) Lipsiæ.

Fasciola equi GMELIN, 1790. Idem.

Fasciola hepatica apri GMELIN, 1790. Idem.

Fasciola hepatica boum GMELIN, 1790. Idem.

Fasciola hepatica cervi GMELIN, 1790. Idem.

Fasciola hepatica equi GMELIN, 1790. Idem.

Fasciola hepatica porcorum GMELIN, 1790. Idem.

Distomum lanceolatum (in part) RUDOLPHI, 1803, 'Neue Beobachtungen über die Eingeweidewürmer.' Arch. f. Zool., III, pp. 1–32.

Planaria latiuscula GOEZE, 1782, 'Versuch einer Naturgeschichte der Eingeweiderwürmer thierischer Körper.' Blankenburg.

Distoma hominis TAYLOR, 1884, '*Distomata hominis*.' China Imp. Customs. Med. Report, pp. 44–54, Figs. 1–5.

Distomum caviæ SONSINO, 1890, 'Notizie di trematodi della collezione del Museo di Pisa.' Atti Soc. Tosc. di sci. nat. Pisa, VII, pp. 99–144, 137–143.

Cladocœlium hepaticum STOSSICH, 1892, 'I distomi degli uccelli.' Lavoro monografico, Boll. Soc. adriat. sci. nat. Trieste, XIII, pp. 143–196.

This species, found in the bile ducts of mammals all over the world, and named by Linnæus, is too well known both in its adult and larval stages to necessitate further description. It was found in the liver of antelopes *Kobus*, *Adenota*, and *Alcelaphus*, and of native cattle at Faradje in September, 1912. It is present in the wild animals as well as domestic cattle.

Fasciola gigantica Cobbold, 1855

Distomum giganteum DIESING, 1858, 'Revision der Myzhelminthen. Abtheilung: Trematoden.' Sitz. d. k. Akad. Wissensch., Wien, Math.-naturw., Cl. XXXII, pp. 207–390, Pls. I–II.

Fasciola gigantea (Diesing, 1858) COBBOLD, 1858, 'Observations on entozoa, with notices of several new species, including an account of two experiments in regard to the breeding of *Tænia serrata* and *T. cucumerina*.' Trans. Linn. Soc. London, XIII, pp. 155–172, Figs. 1–85.

Distomum hepaticum (in part) GERVAIS AND BENEDEN, 1858, 'Zoologie Medicale.' Paris.

Cladocœlium giganteum (Diesing, 1858) STOSSICH, 1892, 'I distomi degli uccelli.' Lavoro nonografico. Boll. Soc. adriat. sci. nat. Trieste, XIII, pp. 143–196.

Fasciola hepatica angusta RAILLIET, 1895, 'Sur une forme particulière de douve hépatique provenant du Sénégal.' Compt. rend. Soc. Biol., XLVII, pp. 338–340.

Distomum ægyptiacum LOOSS, 1896, 'Recherches sur la faune parasitaire de L' Egypte.' Première partie, Mém. de l'Inst. égypt., Le Caire, III, pp. 1–252, Figs. 1–193.

Fasciola ægyptiaca (Looss, 1896) Sonsino, 1896, 'Varietà di *Fasciola hepatica* e confronti tra le diverse specie del genere *Fasciola, s.st.*' Atti. Soc. tosc. di sci. nat. Pisa, X, pp. 112–116.

Fasciola hepatica ægyptiaca Stiles, 1898, 'The flukes and tapeworms of cattle, sheep, and swine, with special reference to the inspection of meats.' Bur. Anim. Ind. No. 19, U. S. Dept. Agri., Washington.

Fasciola angusta (Railliet, 1895) Looss, 1899, 'Weitere Beiträge zur Kenntniss der Trematoden-fauna Ægyptens, zugleich versuch einer natürlichen Gliederung des Genus *Distomum* Retzius.' Zool. Jahrb., Syst., XII, pp. 521–784, Figs. 1–90.

This species, found first in the liver of the giraffe and subsequently in the liver of various African ruminants, was the second of the three species of *Fasciola* to be described. Although scores of forms have been erroneously assigned to the genus, only three remain: *F. hepatica*, a European species which has been distributed throughout the world with domestic cattle; *F. gigantica*, an African species; and *F. magna* an American form. *Fasciola gigantica* has been found from Egypt to Capetown. Its anatomy has been known since the classical researches of Looss and its life-history was worked out by Porter (1920). Porter speaks of the species as the indigenous cattle fluke of South Africa. *Limnæa natalensis* serves as the intermediate host.

Specimens of this parasite, which appears to be much more common in Africa than *F. hepatica*, were found in the liver of a hartebeest, (*Alcelaphus lelwel lelwel*), Congo Exp. vial No. 453, taken at Garamba, July, 1912; in the liver of *Kobus defassa*, Congo Exp. vial No. 354; in the liver of *Adenota kob aluræ*, Congo Exp. vial No. 321, taken at Faradje, January, 1912; in the liver of a domestic calf, Congo Exp. vial No. 305, dissected at Aba, December, 1911; and in the liver of a domestic cow, Congo Exp. vial No. 481, dissected at Faradje, September 30, 1912.

Cyclocœlidæ Kossack, 1911

Cyclocœlinæ Stossich, 1902

Cyclocœlum Brandes, 1892

Generic Diagnosis.—Large muscular, flattened trematodes. Oral sucker reduced or absent; pharynx spherical, large; intestinal crura tubular, anastomosing at the posterior end of body.

Male Organs.—Genital pore median, ventral to the pharynx. Copulatory organs well developed, seminal vesicle in cirrus sac. Testes diagonally situated, within the ceca near the posterior end.

Female Organs.—Ovary between the testes, on the opposite side from the cephalic testis; oötype median and behind the ovary; receptaculum seminis small; Laurer's canal absent. Vitellaria extracecal, ducts pass mediad just anterior to the

caudal testis. uniting to form a receptacle. Uterine folds fill intercecal area. Eggs numerous, large, thick-shelled, without filaments.

TYPE SPECIES.—*Cyclocœlum mutabile* (Zeder, 1800) Brandes, 1892.

Ward (1918) regarded the anterior sucker of this genus as the oral sucker and stated, p. 382, "Esophagus short, no pharynx." Harrah (1921, 1922) described a weak vestigial oral sucker in the genus *Cyclocœlum*. Morishita (1923) described an oral sucker and also a small but distinct acetabulum in two Japanese species. These observations confirm the contention of Odhner, Stunkard, Harrah and other writers that the monostomes have descended from various distome groups. Witenberg (1923) made a systematic survey of the family and more recently (1926) a revision of his earlier work. In these papers he attempted to establish formulæ for classification and arrange the known species in a definite system. While the work is a valuable contribution, the system in some respects is too arbitrary, too rigid, and ascribes too much importance to minor morphològical features which in many instances can not be more than individual variations. The comment of Looss (1912) on Stiles and Goldberger's classification of the amphistomes might be applied to the system of Witenberg. Looss states: "Die Charakterisierung der Arten, Gattungen u.s.w. baut sich auf, einerseits auf eine pedantisch ins einzelne gehende Analyse und Beschreibung der Körperform und der Topographie von Darm und Genitalapparat, anderseits auf eine konsequente Ignorierung der beiden Tatsachen, dass die Tiere, als Organismen, innerhalb gewisser Grenzen natürlich variieren, und dass Körpform sowohl wie Topographie der Organs mit dem Wachstum gesetzmässige, mit der Kontraktion a priori nicht bestimmbare Veränderungen erleiden."

The value of Witenberg's minor groupings, tribes, subgenera, etc., is doubtful. His division of the genus *Cyclocœlum* into two subgenera is based on arbitrary and artificial groups of characters. The new species, *C. phasidi*, described later would be referred to the first of his subgenera on the basis of size of pharynx, position of mouth, and character of vitellaria. The position of the genital pore, however, would place it in the second subgenus. Consequently the two subgenera merge and disappear.

Cyclocœlum phasidi, new species

This description is based on three specimens from the Guinea fowl, *Guttera plumifera schubotzi*. Two were taken at Niapu, in November, 1913, and the other (Fig. 36) December 14, 1909, at Ngayu. All three obviously belong to the same species. Although the label with the worms states that they are from the liver, I am inclined to suspect, since the

Cyclocœlidæ normally are parasitic in the respiratory passages, that originally they were in the lungs and that the record of their presence in the liver is either an error or an accident. See also the discussion on page 235.

The specimens are elongate oval worms, pointed anteriorly. The surface of the body bears minute pits as described by various authors for other members of the genus. There is no trace of an acetabulum, although diligent search was made for such a structure. The worms measure from 12–13 mm. in length, 3–3.5 mm. in width, and 1–1.5 mm. in thickness. The body-wall consists of the cuticula with its basement membrane and the usual circular, longitudinal, and oblique muscle layers. Below the oblique fibers are the cells which secrete the cuticula and these undoubtedly constitute the so-called epithelial layers of Harrah (1922).

The mouth is slightly subterminal and surrounded by discontinuous muscular strands which may represent traces of an oral sucker. These muscle fibers traverse the parenchyma around the oral funnel but they extend posteriad to the supra-esophageal ganglia and so cannot be said to constitute a clearly delimited oral sucker. The pharynx is spherical, measuring 0.35 to 0.45 mm. in diameter and the esophagus extends approximately the same length, although it is somewhat coiled in two of the specimens and when straightened by the extention of anterior end of worm would be somewhat longer. The oral funnel opens into the anteroventral portion of the pharynx whereas the esophagus arises from its posterodorsal margin and lies on the dorsal side of the body above the terminal portions of the reproductive ducts. In its anterior portion the esophagus is surrounded by a large number of glandular cells. The ceca are unbranched and unite near the posterior end of the body to form a continuous loop.

The excretory and nervous systems are typical for the genus and these specimens show no difference from previous generic descriptions.

The testes are oval; the anterior is slightly longer in the anteroposterior axis and measures from 0.65 to 0.9 mm. in length and 0.57 to 0.82 mm. in breadth. The posterior testis is longer in the lateral axis, measuring from 0.7 to 0.85 mm. in length by 0.85 to 1.0 mm. in breadth. The posterior testis is median, a short distance posterior to the ovarian level and surrounded on the caudal side by the intestinal loop. The anterior testis is on the left side of the body, median and adjacent to the left cecum, a short distance anterior to the level of the ovary. Since Harrah (1922) re-reports the prevalence of sexual amphitypy in this genus it is probable that additional specimens would manifest a reversal in position of the genital glands. The ducts from the testes unite cephalad and mesad of the anterior testis to form a single duct, the vas deferens, which passes forward among the uterine coils to open into the posterior end of the cirrus sac. The genital pore is situated ventral to the pharynx and the cirrus sac extends backward on the ventral side of the body to the level of the intestinal bifurcation. The posterior portion is enlarged and contains the seminal vesicle. From the vesicle a coiled pars prostatica leads to the ejaculatory duct which opens at the genital pore. In none of the specimens was a cirrus extruded. The ovary is situated between the testes on the side opposite from the cephalic testis and adjacent to the cecum of the right side. It is oval in shape and measures from 0.33 mm. to 0.45 mm. in length by 0.27 to 0.36 mm. in breadth. The oviduct arises from the dorsomedian and caudal aspect and passes dorsally and caudally. It receives there a short duct from the seminal receptacle, a spherical sac about the same size as the ovary which lies dorsal and median to it. The duct then turns posteriad and ventrad where it

receives the duct from the vitelline receptacle. It then expands, passing ventrally to form the proximal coils of the uterus. This female genital complex is crowded together (Fig. 36) and enclosed in the large cells of Mehlis' gland. The vitellaria consist of small follicles about 0.1 mm. in diameter, each of which discharges into a central canal or stem (Fig. 37). In one specimen they completely encircle the ceca, in the one shown in figure 36 they are continuous posteriorly but interrupted anteriorly, while in the third specimen they are continuous anteriorly and the stem of one side does not quite reach the posterior end, leaving a short gap. These differences in the vitellaria are noteworthy, illustrating the extent of variation normally present in the species. Just anterior to the caudal testis vitelline ducts pass mediad, uniting on the posteromedian side of the ovary to form the vitelline receptacle. The receptacle curves dorsally and forward; it is then constricted to form a duct which passes forward through the dorsal portion of Mehlis' gland whence it turns ventrad into the gland again to discharge into the oötype. The uterine folds extend backward to the caudal testis and then forward to the genital pore. They occupy all the available space between the intestinal ceca and frequently slightly overlap them. The terminal portion is relatively straight, and provided with muscular walls. In two of the specimens this metratermal portion extends from the genital pore to the bifurcation of the alimentary tract. Eggs, thick-shelled, with cap, average 0.130×0.064 mm.

The type of this species is deposited in the collections of the Department of Lower Invertebrates, American Museum of Natural History (A. M. N. H. No. 166).

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ABBREVIATIONS USED IN FIGURES

AC—acetabulum
CS—cirrus sac
EP—excretory pore
ES—esophagus
EV—excretory vesicle
GA—genital atrium
GP—genital pore
GS—genital sucker
IN—intestinal cecum
LC—Laurer's canal
LV—lymph vessel
MG—Mehlis' gland
NC—nerve commissure
OD—oviduct
OE—oral evagination
OS—oral sucker
OV—ovary
PH—pharynx
PM—pars musculosa
RM—retractor muscles of oral sucker
SP—spermatozoa
SR—seminal receptacle
SV—seminal vesicle
TS—testis
UT—uterus
VD—vitelline duct
VT—vitellaria
WGS—wall of genital sucker
WOE—wall of oral evagination

All figures were drawn with the aid of the camera lucida and were made from permanent mounts. Specimens are deposited in the parasitological collection of the Department of Lower Invertebrates, The American Museum of Natural History.

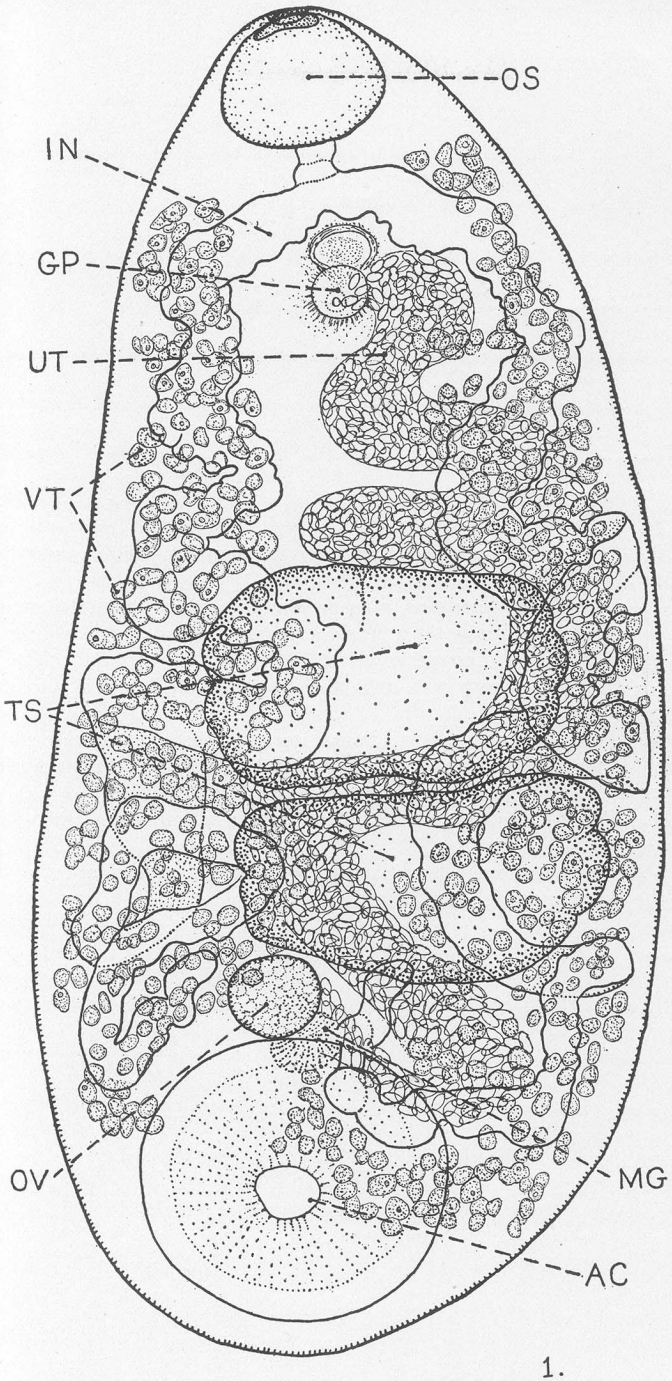


Fig. 1.—*Paramphistomum cervi*, whole mount, from the stomach of *Kobus defassa*. × 20.

Fig. 2.—*Paramphistomum cervi*, frontal section, showing position and relations of the various organs. × 12.

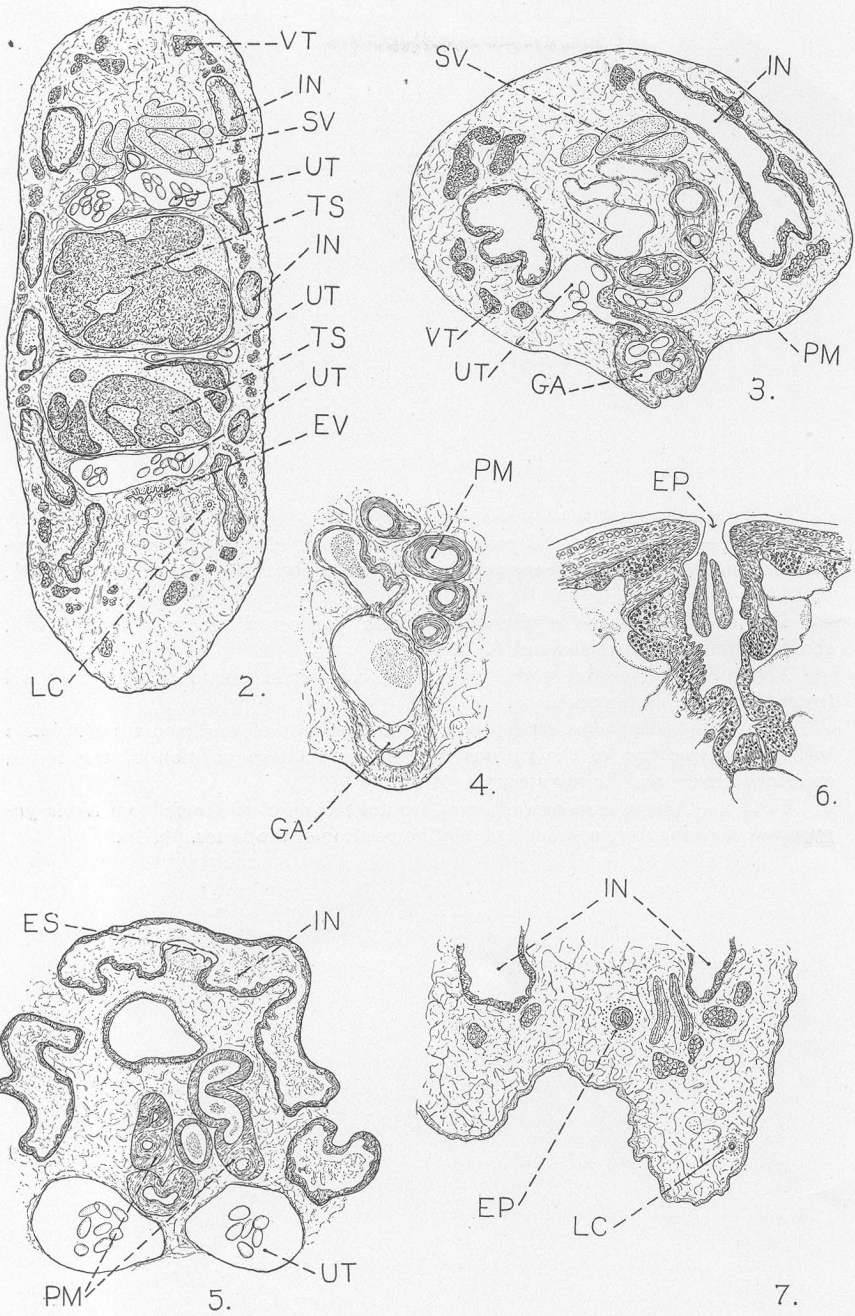
Fig. 3.—*Paramphistomum cervi*, cross-section through the genital pore, showing details of the copulatory organs, the uterus, the pars musculosa, the coils of the seminal vesicle, the vitellaria and intestinal ceca. × 16.

Fig. 4.—*Paramphistomum cervi*, oblique section, showing details of the copulatory organs. × 16.

Fig. 5.—*Paramphistomum cervi*, frontal section through posterior end of the esophagus. It shows the ceca continuous anteriorly, the coils of the pars musculosa, and the position of the uterus at this level. × 16.

Fig. 6.—*Paramphistomum cervi*, sagittal section through the excretory pore. × 400.

Fig. 7.—*Paramphistomum cervi*, frontal section, showing relation of Laurer's canal to the excretory pore. × 20.



Figures 2 to 7

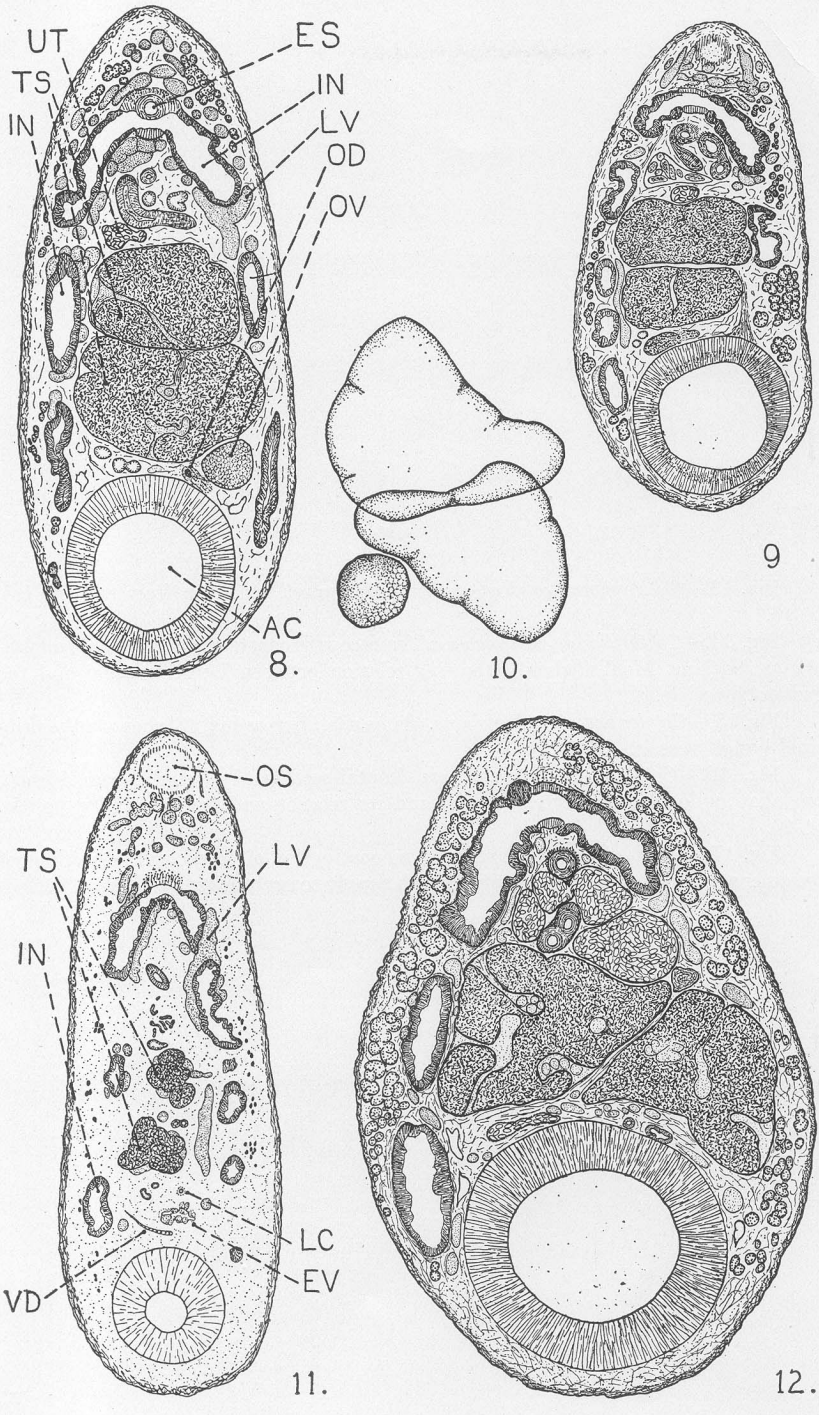
Fig. 8.—*Cotylophoron cotylophorum*, frontal section of specimen from cow, showing position of the various organs and the relations of the testes, one before the other. × 16.

Fig. 9.—*Cotylophoron cotylophorum*, frontal section of specimen from a calf, showing same structures as figure 8. × 16.

Fig. 10.—*Cotylophoron cotylophorum*, from cow, reconstruction of the ovary and testes, showing relative positions. × 16.

Fig. 11.—*Cotylophoron cotylophorum*, frontal section of specimen from *Adenota kob*, showing location of the various organs, the relative position of the testes, excretory vesicle and Laurer's canal. × 16.

Fig. 12.—*Cotylophoron cotylophorum*, frontal section of specimen from *Neotragus pygmæus*, showing development and relative position of the testes. × 16.



Figures 8 to 12

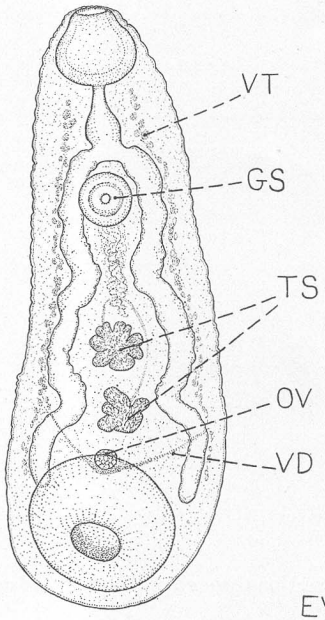
Fig. 13.—*Cotylophoron cotylophorum*, whole mount, specimen from *Adenota kob*. × 16.

Fig. 14.—*Cotylophoron cotylophorum*, from cow, reconstruction of female genital organs (without Mehlis' gland), showing relation between Laurer's canal and the excretory vesicle.

Fig. 15.—*Cotylophoron cotylophorum*. Same specimen as Fig. 13, showing the principal lymph vessels. × 16.

Fig. 16.—*Cotylophoron cotylophorum*, frontal section of specimen from *Adenota kob*, showing longitudinal lymph vessel and its relation with the excretory vesicle. × 20.

Fig. 17.—*Cotylophoron cotylophorum*, reconstruction of three sagittal sections of specimens from *Adenota kob*, showing lymph supply to oral sucker.



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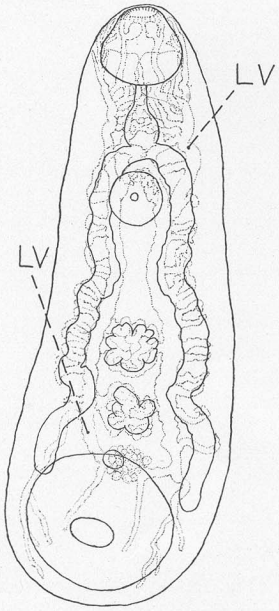

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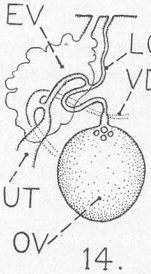

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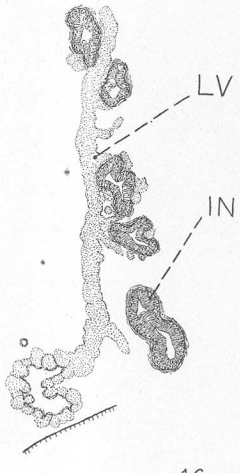

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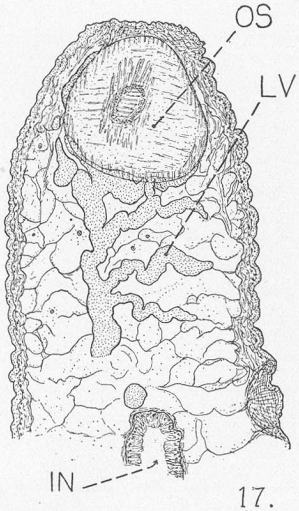

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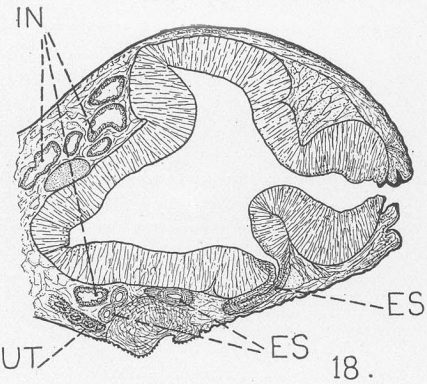
Figures 13 to 17

Fig. 18.—*Stephanopharynx secundus*, sagittal section through oral sucker and oral evagination. × 14.

Fig. 19.—*Stephanopharynx secundus*, sagittal section through posterior region of body, showing position of various organs and sexual immaturity. × 14.

Fig. 20.—*Stephanopharynx secundus*, sagittal section through genital pore, showing copulatory organs. × 26.



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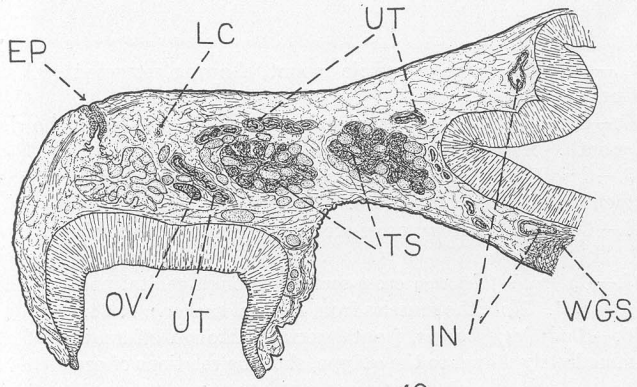

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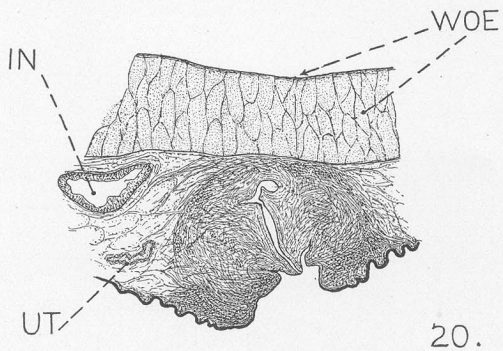

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Figures 18 to 20

Fig. 21.—*Chiorchis fabaceus*, whole mount, showing retracted oral sucker and position of organs. × 12.

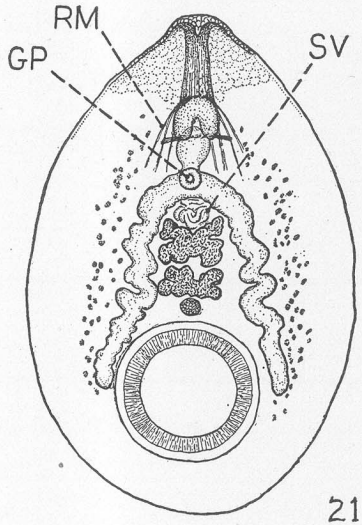
Fig. 22.—*Chiorchis fabaceus*, cross-section through oral canal, showing ventral position of mouth. × 30.

Fig. 23.—*Chiorchis fabaceus*, cross-section through the oral evaginations, showing muscles attached to oral sucker. × 33.

Fig. 24.—*Chiorchis fabaceus*, cross-section of esophagus, showing lymph vessels. × 30.

Fig. 25.—*Chiorchis fabaceus*, cross-section through genital pore and bifurcation of alimentary tract. Note the muscles from the oral sucker. × 24.

Fig. 26.—*Chiorchis fabaceus*, frontal section through bifurcation of alimentary tract and immediately dorsal to the oötype, showing relations of organs. × 24.



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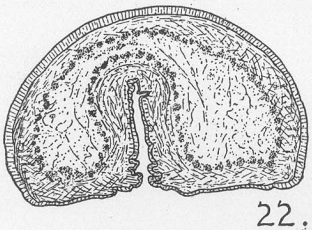

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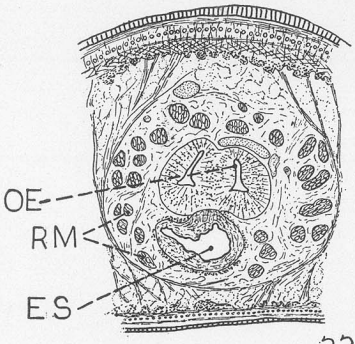

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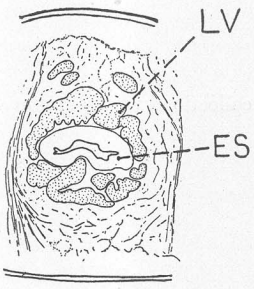

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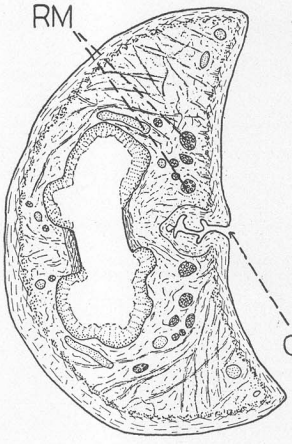

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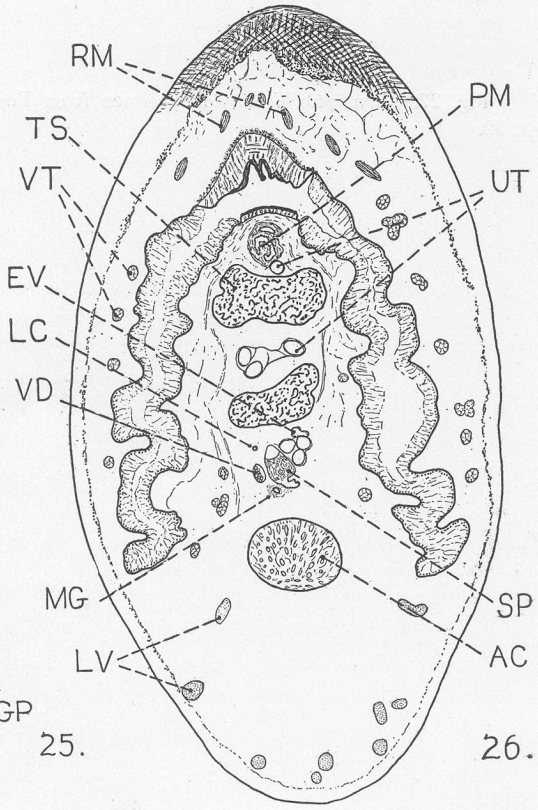

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Figures 21 to 26

Fig. 27.—***Brumptia bicaudata*, specimen from Poirier collection, whole mount. × 22.

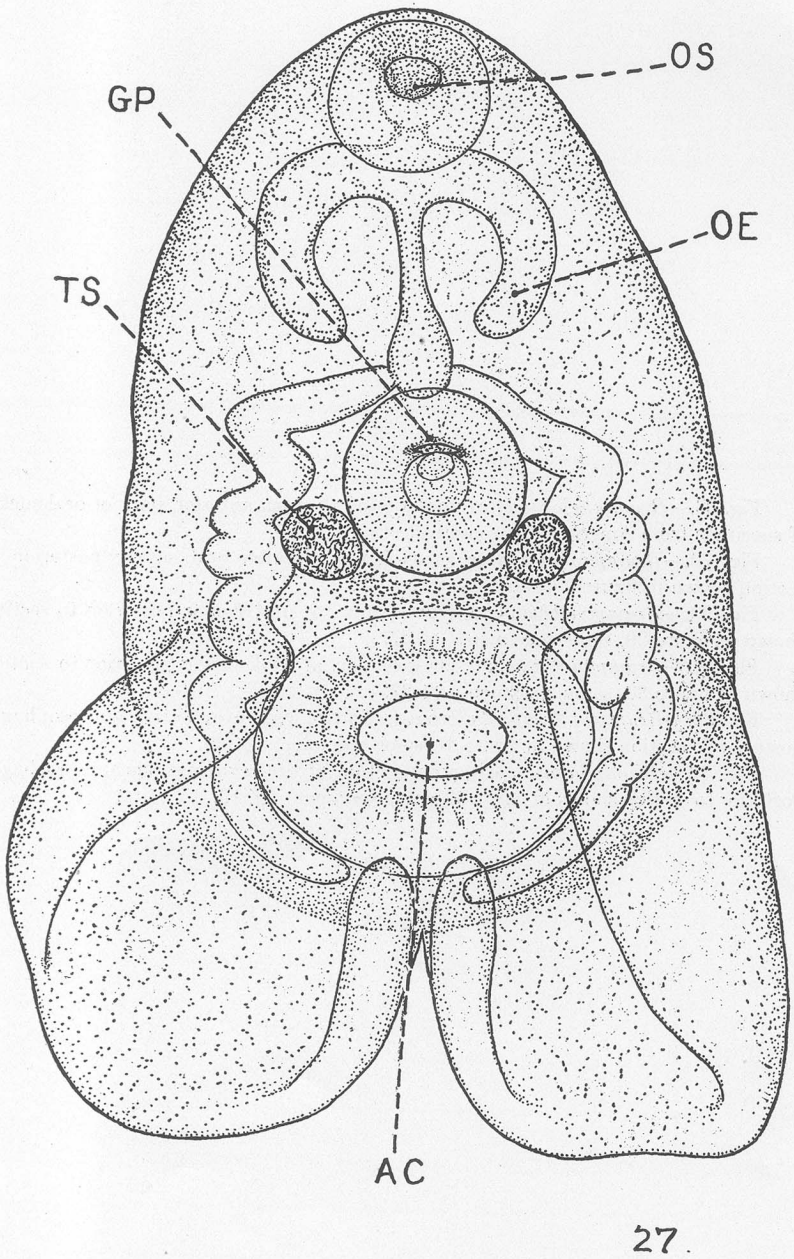


Figure 27

Fig. 28.—*Brumptia bicaudata*, cross-section through anterior part of oral sucker of specimen from American Museum collection. × 27.

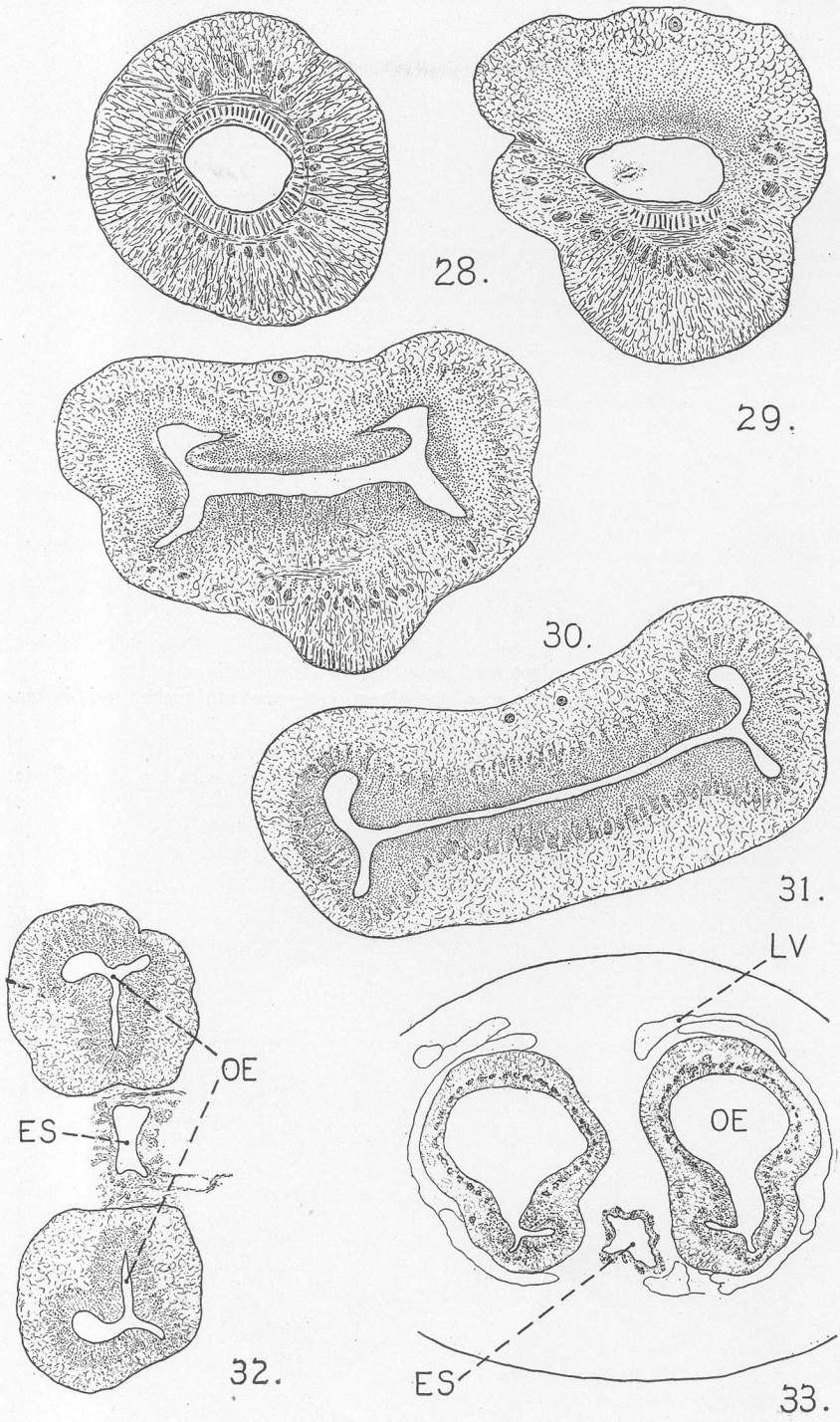
Fig. 29.—*Brumptia bicaudata*, cross-section through oral sucker posterior to section shown in figure 28, same specimen. × 27.

Fig. 30.—*Brumptia bicaudata*, cross-section of oral sucker posterior to section shown in figure 29, same specimen. × 27.

Fig. 31.—*Brumptia bicaudata*, cross-section of oral sucker posterior to section shown in figure 30, same specimen. × 27.

Fig. 32.—*Brumptia bicaudata*, cross-section of oral evagination and esophagus posterior to section shown in figure 31, same specimen. × 20.

Fig. 33.—*Brumptia bicaudata*, cross-section of oral evaginations and esophagus posterior to section shown in figure 32, same specimen. × 15.



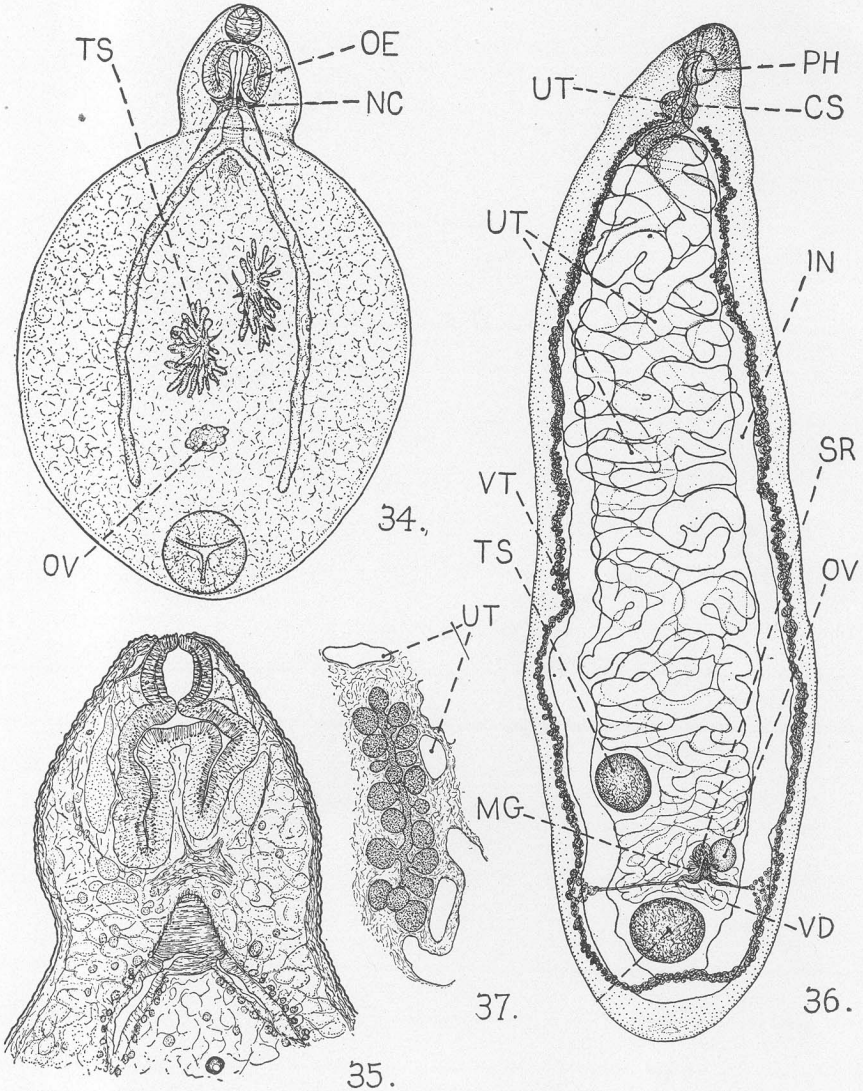
Figures 28 to 33

Fig. 34.—*Gastrodiscus ægyptiacus*, from the wart-hog, whole mount.

Fig. 35.—*Gastrodiscus ægyptiacus*, frontal section through oral sucker and bifurcation of alimentary tract.

Fig. 36.—*Cyclocœlum phasidi*, type specimen, whole mount. × 12.

Fig. 37.—*Cyclocœlum phasidi*, frontal section, showing character of vitellaria. × 40.



Figures 34 to 37