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

[1]Scientific Results of The American Museum of Natural History Congo Expedition. General Invertebrate Zoölogy, No. 12.

[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).

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).

BIBLIOGRAPHY

DIESING, C. M. 1850. 'Systema helminthum.' Vienna, 2 vols, 679 and 588 pp.

FISCHŒDER, F. 1903. 'Die Paramphistomiden der Säugethiere.' Zool. Jahrb., Syst., XVII, pp. 485–660, Figs. 1–104.

GROBBELAAR, C. S. 1922. "On South African Paramphistomidæ (Fisch.).' Trans. R. Soc. S. Africa, Cape Town, X, pp. 181–200, 9 Figs.

HARRAH, E. C. 1921. 'Two New Monostomes from Asia.' Journ. Parasit., VII, pp. 162–165, 2 Figs.

1922. 'Studies on North American Monostomes.' Ill. Biol. Monographs, VII, pp. 225–324, 48 Figs.

LEIDY, J. 1890. 'Notices of Entozoa.' Proc. Acad. Nat. Sci. Phila., XLII, pp. 410–418.

LOOSS, A. 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.

1902. 'Ueber neue und bekannte Trematoden aus Seeschildkröten.' Zool. Jahrb., Syst., XVI, pp. 411–894, Pls. XXI–XXXII.

1912. 'Ueber den Bau einiger auscheinend seltener Trematoden-Arten.' Zool. Jahrb., Suppl., XV, pp. 323–366, 3 Pls.

MACCALLUM, G. A. 1917. 'A New Species of Trematode (*Cladorchis gigas*) Parasitic in Elephants.' Bull. Amer. Mus. Nat. Hist., XXXVIII, pp. 865–871, 3 Pls.

1921. 'Studies in Helminthology.' Zoopathologica, I, No. 6.

MAPLESTONE, P. A. 1923. 'A Revision of the Amphistomata of Mammals.' Ann. Trop. Med. Parasit., XVII, pp. 113–213, 32 Figs. 4 Pls.

MORISHITA, K. 1923. 'Notes on two new monostomes with rudimentary ventral suckers.' Journ. Parasit., X, No. 3, pp. 158–164.

POIRIER, J. 1908. 'Trématodes parasites de l'éléphant d'Afrique.' Compte Rendu de la 37me session de l'Association Française pour l'avancement des sciences, Clermont Ferrand, 1908, p. 580.

PORTER, ANNIE. 1920. 'The life-history of the African sheep and cattle fluke, *Fasciola gigantica*.' S. African Journ. Sci., XVII, pp. 126–130.

STEDMAN, J. M. 1889. 'Researches on the Anatomy of *Amphistomum fabaceum* Diesing.' Proc. of Amer. Soc. of Microscopists, XI, Buffalo, N. Y.

STUNKARD, H. W. 1925. 'The Present Status of the Amphistome Problem.' Parasitology, XVII, pp. 137–148.

1926. 'On the Specific Identity of *Amphistomum bicaudatum* Poirier and *Cladorchis gigas* MacCallum.' Anat. Rec., XXXIV, No. 3, pp. 165–166.

TRAVASSOS, L. 1921. 'Contribucio para a systematica dos "Paramphistomidæ," etc.' Braz. Med., XXV, p. 357. Rio de Janeiro.

WARD, H. B. 1918. 'Fresh-Water Biology.' Wiley and Sons, New York.

WITENBERG, GEO. 1923. 'The Trematodes of the Family Cyclocœlidæ and a New Principle of Their Systematica.' (In Russian, Moscow).

1926. 'Die Trematoden der Familie Cyclocœlidæ Kossack, 1911.' Zool. Jahrb., Syst., LII, pp. 103–186, 15 Figs.

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.