Studies on the Anatomy of a Trematode

by

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Foreword.

I wish to express my sincere appreciation to Mr. J. H. Walker, Jr., under whose supervision this work was done, for the many helpful suggestions, for the loan of material from his collection, and for his unfailing interest in this study. I am indebted to Dr. H. B. Ward of the University of Illinois for the loan of literature from his private library.

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Table of Contents.

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Introduction.

The specimens used in making this study were taken from the small intestine of Graptemys geographicus which was found in the Warrior River in Tuscaloosa County, October 15, 1930. This is the first record of this genus and species to be reported from the State of Alabama.

The genus Telorchis has been reported by Stunkard occurring in Texas, Illinois, Iowa, and North Carolina. The genus has a wide distribution, species having been reported from Sicily, Sardinia, Italy, France, Germany, Austro-Hungary, Turkey, Brazil, United States and Canada. As far as is known it is confined to reptilian hosts, species occurring in lizards, snakes and turtles.

Technique.

These specimens were killed and fixed in Hofer's Fixative, run up through a series of alcohols and preserved in 85% alcohol. Lithium carbonate was added to the 85% alcohol to remove the excess of picric acid.

In the preparation of toto mounts the specimens were passed through a series of alcohols, 70%, 50%, 35%, for a period of 30 to 45 minutes each, then washed in distilled water for 45 minutes. Alum cochineal and alum carmine were found to be the most desirable toto stains. The specimens were left in the stain for at least 22 hours, destained in acid water, placed in alkaline tap water substitute for 30 minutes, dehydrated by passing them through a series of alcohols to 95% alcohol. They were washed several times in absolute alcohol to insure complete dehydration. They were cleared and mounted in damar. Cedar oil and synthetic oil of Wintergreen (methyl salicylate) were used as clearing agents. Oil of Wintergreen was more desirable since it reduced the length of time for clearing and left the organs with greater contrasting shades of color.

Two specimens were mounted in glycerin jelly. There was less shrinkage and more differentiation in these specimens. For these reasons they were better than the damar mounts which had been run through the series of alcohols.

Structures in the glycerin mounts became more highly differentiated after three months time.

In preparing sections the specimens were dehydrated and washed several times in absolute alcohol, placed in a solution of equal parts of absolute alcohol and xylol for 30 minutes. They were cleared in xylol, infiltrated with 56° C. paraffin for two hours in McClung's glass tumbler oven and embedded in fresh 56° C. paraffin. The sections were cut 12 μ and affixed to the slide with Mayer's albumen. After decerating in xylol the sections were dehydrated through a series of alcohols to distilled water and stained in Delafield's hematoxylin. The sections were passed through a series of alcohols to 95% alcohol, counterstained in a 95% alcoholic solution of eosin, placed in absolute alcohol, cleared in xylol and mounted in damar.

Various organs in the specimens, more especially the oral sucker, were altered in shape and size by the technical methods used in the preparation of the trematodes for microscopical study.

External Anatomy.

The trematodes of this species are elongate, tapering at the anterior and posterior ends. The anterior end is rather blunt and the posterior end tapers from the region of the anterior testis posteriorly to the end of the body. The total length of the body measures from 4.84 to 6.56 mm. The greatest width is found anterior to the ovary. The width at this location measures from 0.715 to 0.748 mm. The average width of the body in the region of the esophagus measures 0.364 mm., varying from 0.356 to 0.373 mm. The average width of the body in the region of the posterior testis measures 0.498 mm.

The two suckers are located on the ventral surface of the worm. The oral sucker is subterminal in position and is located at the anterior extremity of the body. The shape of the oral sucker is oval in preserved specimens, the greater diameter of the oval being in the transverse plane. This condition could have been caused by the reagents used in preserving the material or by the shape of the organ at the time of killing. The longitudinal diameter of the oral sucker measures 0.142 mm. and the transverse diameter, 0.107 mm.

The acetabulum is located on the ventral surface of the body between the genital pore and the ovary. The distance from the acetabulum to the oral sucker varies, due to the contraction or extension of the trematode. This dis-

tance measures from 0.462 to 0.818 mm. The shape of the acetabulum is slightly oval to round. The transverse diameter measures 0.142 mm. and the longitudinal diameter, 0.142 mm.

The genital pore is located anteriorly and to the left of the acetabulum on the ventral surface of the worm. The length and width of the external opening measures 0.071 mm. It is the common external opening of the male and female generative systems.

The vitellaria are lobulated groups of follicles located lateral to the intestinal caeca. The vitelline ducts are the usual Trematode type,"H"-shaped, with the cross bar of the"H" located just posterior to the ovary. The distance from the anterior end to the posterior end of the left vitellaria measures 1.86 mm. The vitellaria on the left side lie posterior to a point 1.31 mm. from the anterior end of the body and anterior to a point 1.92 mm. from the posterior end of the body. The right vitellaria lie posterior to a point 1.42 mm. from the anterior end of the body and anterior to a point 1.58 mm. from the posterior end of the worm. The right vitellaria extend a distance measuring 1.60 mm. Anteriorly the vitellaria extend in front of the ovary and posteriorly they extend approximately to a mid-point between the ovary and the anterior testis.

.The ovary is situated in the mid-line between the in-

testinal caeca in the anterior half of the body, 1.73 mm. from the anterior end and 2.63 mm. from the posterior end of the Trematode. The ovary is smoothly ovoid in shape with the greater diameter in the transverse plane.

The testes lie in the posterior region of the body in the intercaecal space, one behind the other along the median line. They are oval in shape and lie close to each other. The anterior testis is located approximately 2.0 mm. from the ovary and 3.7 mm. from the anterior end of the body. The distance which separates the anterior testis from the posterior testis is nearly constant, measuring 0.180 mm. as an average. The posterior end of the posterior testis is found to be 0.50 mm. from the caudal end of the body. The testes are greater in the longitudinal diameter than in the transverse diameter and the posterior testis of these specimens is larger than the anterior testis.

The excretory pore is located at the posterior tip of the body.

The external surface of the body is covered by a cuticula 4.5 μ in thickness, containing many spines in the anterior region. The spines diminish in size and number from the anterior to the posterior end of the worm and are possibly absent at the posterior end. The spines measure 3.96 μ in length and the rows are separated by a distance of 3.37 μ. They are arranged in diagonal rows over the anterior sur-

face except in the region of the oral and ventral suckers where they are arranged in concentric circles.

Lankester (1901) states,

> "recent studies by Blochmann and Kowalevski upon the structure of Cestodes and Trematodes go to show that the investing membrane consists of two parts--the greater part of it represents a true cuticle, while the lower layer is a basement membrane. The epidermis which is more clearly seen in some Cestodes (Ligula) than in Trematodes is represented by deep-lying cells, some of which are glandular, with narrow necks traversing the basement membrane; the cells of the epidermis have, however, become separated from one another by the upward growth of parenchymal tissue and muscles, just as in Hirudo (Lankester) and in some Oligochaeta (Benham) the blood vessels with connective tissue invade the epidermis and, penetrating between the cells, break up the layer; in these Annelids the cells remain attached to the cuticle by a broad external end; but in Trematodes the invasion of tissue has gone so far as to leave only a very narrow part of each cell in connection with the cuticle; and at the same time, the basement membrane has been pushed upwards against the cuticle; the cells have so tp speak slipped down through this membrane. It is worthy of note that Max Braun has observed a definite external layer of cylindrical cells in the lateral suckers of Nitzschia and Epibdella; they are not covered by a cuticle, which stops abruptly against the cells".

The description of the cuticle in these specimens conforms to the explanation given by Lankester (1901). There is a distinct row of round shaped cells with protoplasmic projections lying between the cuticle and the muscle fibers.

The Digestive System.

The digestive system is composed of a subterminal mouth, a thick walled pharynx, a short esophagus and two intestinal caeca which end blindly posterior to the testes in the posterior end of the body. This system occupies a median position halfway between the dorsal and ventral sides of the worm.

The subterminal oral sucker on the ventral side of the worm leads into the mouth. The oral cavity opens into a relatively thick walled pharynx. This structure measures 0.053 mm. in length and 0.075 mm. in width. The esophagus, which is immediately posterior to the pharynx, bifurcates into two intestinal diverticula at a distance of 0.087 mm. from the oral sucker and 0.034 mm. from the pharynx. The width of the esophagus is 0.054 mm. and the diameter of the caeca varies slightly, the average diameter measuring 0.036 mm. In some specimens the diameter of the caeca is greater near the posterior end due to the intestinal content being forced toward the posterior at the time of killing. The intestinal diverticula are located on the sides of the Trematode between the vitellaria and the coils of the uterus. In the region of the testes the diverticula are gently curved outward and are closer to the lateral boundary of the body than in any other region. The blind sac-like ends of the intes-

tinal diverticula are located approximately halfway between the caudal testis and the posterior end of the body. The right diverticulum of the intestine is usually longer than the left diverticulum.

The Excretory System.

The excretory system consists of an excretory pore, a central bladder, two collecting diverticula, smaller tubules connecting the bladder and diverticula with the flame cells.

The excretory pore is located at the posterior tip of the body. The large central bladder extends anteriorly and dorsally and receives small collecting ducts from the organs in the posterior region of the trematode. The bladder divides in the post-ovarial region into two bladder like ducts. These ducts continue anteriorly and mesial to the intestinal diverticula on either side of the median line and end blindly in the post-acetabular region. The smaller ducts and capillaries which terminate in the flame cells could not be definitely traced in these fixed specimens.

Faust (1929) states,

> "The excretory system consists of a median posteriorly disposed bladder, which opens through an excretory pore guarded by a sphincter. On its anterior aspect, usually anterio-laterally, the bladder receives a pair of collecting tubes, which, upon being traced forward, will be found to branch in a precise manner. This branching may occur once or even several times, until the ultimate capillaries are reached, each one ending in a flame cells or solenocyte, which is analogous and possibly homologous to the protonephridium of the vertebrate body".

The flame cells and the capillaries which connect with the larger collecting ducts were studied in other species of trematodes. The size of the flame cells vary in different species. The capillaries that carry the excretion to the

collecting ducts are small convoluted tubes which are capable of extending into a straight tube when the worm extends its full length. Normally the capillaries appear as coiled tubes.

The Male Generative System.

The male generative system is composed of two testes, two vasa efferentia, a vas deferens, a seminal vesicle, prostate glands, a cirrus sac, cirrus, a genital atrium and a genital pore.

The two oval shaped testes, located in the posterior region of the body, one behind the other along the median line, are the most conspicuous organs of the system. The width of the anterior testis measures from 0.107 mm. to 0.205 mm. and the length measures from 0.160 to 0.178 mm. The posterior testis measures from 0.178 to 0.214 mm. in width and from 0.205 to 0.285 mm. in length. The long axis of the testes lies in the antero-posterior plane. At the point of greatest thickness the testes measure 0.155 mm. and extend from the ventral muscular layer to the ventral wall of the excretory system. The excretory tube causes an invagination on the ventral surface of the testes. The distance separating the testes is approximately 0.180 mm.

The vasa efferentia arise from the lateral anterior end of the testes and they pass cephalad just median to the intestinal diverticula. The vasa efferens from the anterior testis passes anteriorly on the left of the body and that of the posterior testis passes anteriorly on the right. They continue cephalad and dorsad to the posterior region of the

cirrus sac where they unite to form the vas deferens; and this duct continues anteriorly to the genital atrium. In the posterior region of the cirrus sac is located the seminal vesicle. Spermatozoa can be noted within the vesicle for a distance of 0.168 mm. The greatest width of the seminal vesicle measures 0.270 mm. and the dorso-ventral diameter measures 0.270 mm. A thick muscular wall surrounds the vesicle. The prostate glands are located at the anterior end of the seminal vesicle. The vas deferens, which measures 0.081 mm. in diameter, runs through the seminal vesicle and prostate glands, continuing anteriorly in a moderately coiled manner, and opening into the genital atrium which is located dorsal to the genital pore.

The cirrus sac extends ten-elevenths of the distance from the genital pore to the ovary, or approximately 1.05 mm. Its greatest width measures 0.607 mm. and the dorso-ventral thickness measures 0.370 mm. The cirrus sac extends obliquely across the median line of the body, coiling slightly at the mid-region of its length. It extends from the anterior right side of the acetabulum to a distance which is anterior and to the right of the ovary.

The Female Generative System.

The female generative system consists of the ovary, oviduct, oötype, Mehlis' gland, seminal receptacle, Laurer's canal, vitelline reservoir, vitelline ducts, vitellaria, uterus, metraterm, genital atrium and genital pore.

The ovary is located on the median line in the anterior half of the body. The length of the ovary measures from 0.088 to 0.115 mm. and the width measures from 0.115 to 0.128 mm. The shape of the ovary is oval, the greater diameter being in the transverse plane. The oviduct arises from the posterior margin of the ovary and extends posteriorly a short distance. The length of the oviduct from the ovary to the oötype measures 0.020 mm. At this point it enlarges to form an oval shaped oötype. The common vitelline duct enters the left posterior side of the oötype from the vitelline reservoir. Laurer's canal is enlarged at the proximal end to form a seminal receptacle which enters the dorsal posterior margin of the oötype. Laurer's canal opens to the exterior surface of the body at a point dorsal to and posterior to the ovary. The unicellular glands of Mehlis' gland surround the oötype.

The uterus arises from the right side of the oötype turning ventrally and posteriorly. Its sinuous and convoluted course extends to the cephalic testis, crosses over

from the right to the left side of the body and returns anteriorly to the slightly curved metraterm which leads to the common genital atrium and opens to the exterior through the genital pore.

The vitellaria are extracaecal in location and consist of a large number of lobulated follicles. The left vitellaria extend a distance of 2.21 mm., and the right vitellaria measure 2.04 mm. in length. The vitelline ducts are of the usual Trematode type, being "H"-shaped with the vitelline reservoir located on the cross-bar of the "H".

Two vitelline ducts, each leading from the vitellaria in the anterior region of the body unite just posterior to the ovary, with two similar ducts, leading from the vitellaria located in the posterior region of the body, and form the vitelline reservoir. These four main ducts are located just mesiad to the vitellaria. A common vitelline duct connects the vitelline reservoir and the oötype.

When insemination takes place the spermatozoa are injected into the genital pore by another trematode of the same species or pass forward into the genital atrium from the vas deferens of the same trematode. They travel posteriorly through the ascending coil of the uterus, move anteriorly toward the ovary through the descending coil of the uterus, pass through the oötype and enter the seminal receptacle. The spermatozoa remain in the seminal receptacle until the ova move from the ovary into the oötype. The ova develop in the ovary and

pass through the oviduct into the oötype. In this organ the unfertilized ovum receives the spermatozoa from the seminal receptacle and the yolk from the vitelline reservoir. The shell is secreted around the egg by Mehlis' gland which surrounds the oötype. When the process is complete the egg is forced into the uterus by a muscular contraction. It traverses the length of the descending coil of the uterus and turns anteriorly toward the genital pore through the ascending coil of the uterus. The egg passes through the metraterm, which is the enlarged anterior end of the ascending coil of the uterus and enters the genital atrium. The genital atrium connects with the genital pore from which the eggs are extruded to the medium in which the trematode is located.

Mature eggs found in the ascending coil of the uterus posterior to the metraterm measure 0.033 to 0.036 mm. in length and 0.0195 to 0.198 mm. in width.

Discussion.

A total of thirty three specimens were used in making a comparison with several species of the genus Telorchis. Only eight of the thirty three specimens can be definitely classified as belonging to Telorchis corti.

The length of my specimens would be included within the measurements as given by Stunkard (1915) in his description of Telorchis corti. There is a variation between my specimens and Telorchis corti as to the location of the greatest width of the body. The region of greatest width of the body in T. corti is at the acetabulum and measures 0.500 mm., while in my specimens the greatest width is at the ovary and measures 0.748 mm. The width at the acetabulum in the specimens studied is 0.070 mm. greater than the width of T. corti at this region. The oral sucker is the same size as the acetabulum in T. corti and in my specimens the acetabulum is larger than the oral sucker. The oral sucker is 0.033 mm. longer and 0.002 mm. wider and the acetabulum is 0.022 longer and 0.029 mm. wider in my specimens than the greatest measurements given for Telorchis corti.

The cuticular spines in the specimens studied are 0.00056 mm. longer than the spines on T. corti. Stunkard (1915) states that the distance between the rows of spines is greater than the length of the spine. In these speci-

mens the spines are 0.00059 mm. longer than the distance which separates the rows.

The esophagus of my specimens is 0.016 mm. longer and 0.029 mm. wider than the esophagus of T. corti. The extent of the cirrus sac in T. corti is three-fourths of the distance from the genital pore to the ovary. The cirrus sac of the specimens studied is one-sixth longer than that measurement. The vas deferens of T. corti is greatly coiled while in my specimens this duct was only moderately coiled. The uterus of T. corti is greatly coiled and is moderately coiled in my specimens. The measurements of eggs found in my specimens are from 0.002 to 0.005 mmm. longer and from 0.0045 to 0.0048 mm. wider than the eggs found in Telorchis corti.

The topographical structural differences between these specimens and Telorchis corti described by Stunkard (1915) do not warrant the creation of a new species. However, the maximum and minimum dimensions of certain structures should be extended to include my additional measurements.

History of Trematodes.

The knowledge of Trematodes began with Gabucinus (1547), who described the occurrence of the liver fluke in sheep. This parasite had been referred to by Jehan de Brie as early as 1379. Leeuwenhoek (1695) added a form found in the herring; Swammerdam (1752), in one of his papers mentions the occurrence of a distome in the lung of a frog. Roesel V. Rosenhof (1758) gave a description and a figure of a trematode found in the frog's bladder. O. F. Müller (1777) described a number of specimens in a series of lectures. The early investigators were unable to interpret the anatomical features correctly and as a result the descriptions given were inaccurate.

Cuvier (1768-1832) divided the Vers intestinaux (which were separated from the Annelids) into two orders: Cavitaries and Parenchymateux. The order Parenchymateux at first included only the family Acanthocephidae (Echenorhynques) but later included the Haeruca. The second family, the Trematode of Rudolphi were included in the Gerofles; which are the Cestodes, Hereterocotylea and the Planaria. The third family designed by Cuvier came under the family Tenoides including principally the Tenias and the Bothrocephalidae. In the fourth family which Cuvier called Cestoide, he placed the single genus Ligule. Cuv-

ier's classification corresponds to a large extent to the present classification, his order Cavitaries including the Nematodes and Echinorynques, the order Parenchymateux including the Trematodes and Cestodes.

The interest in this field of research increased greatly after the time of Müller. Many new species were discovered and several life-histories of the trematodes were worked out. Among the most important men in this period who contributed to the existing knowledge of this form of parasite were: Rudolphi (1808), Von Baer (1827), V. Nordmann (1832), Diesing, Wagener (1858), P. J. Van Beneden, Cobbold, V. Linstow, Willemoes-Suhm, Taschenberg, and more recently, Monticelli, Sonsino, Parona, Perugia, Stossich, Bojanus (1818), Mehlis (1825), Laurer (1830), V. Siebold (1835), Leuckart, Stieda (1867) and Zeller.

Swammerdam worked out certain stages in the life history of the parasitic forms in the eighteenth century. Nitzsch (1807), Carus (1835), Moulinié (1856), La Vallete St. George (1856) and Pagenstecher (1857) were another group of workers interested in the problem of life histories of the Trematodes.

The knowledge of the complicated life histories characteristic of many parasites practically began with Zenker's demonstration of the life cycle of Trichinella in 1860 and Leuckart's (1861) experimental proof of the life cycle of

Taenia saginta. Weinlard (1864) discovered the snail host in which the liver fluke develops, although a previous relation between the fluke and the molluscan host had been suspected. The life cycle of Trichinella spiralis was completely worked out and demonstrated by Graham (1897). Other important discoveries in the life histories and modes of infection quickly followed. Ross (1898) discovered the relation between the mosquito and malaria. Leiper (1914) worked out the life history of blood flukes; and the role of crabs as a second intermediate host of the lung fluke was verified by Nakagawa in 1916.

The first attempt to classify the parasitic worms was made by Zeder (1800). He divided the forms into five families to which he gave the German equivalent of roundworms, hookworms, sucking worms, tape worms and bladder worms. The sucking worms were divided into three genera and an unknown number of species.

Lankester (1901) states,

> "Rudolphi 1808, in an epoch-making work upon intestinal worms invented the term 'Trematoda' for Zeder's 'sucking worms' which he raised to the rank of an Order. Both of these authors laid great and deserved stress on the arrangement of the suckers, a character which, together with the absence of segmentation, is still a sufficient mark of distinction of the Trematodes from the Cestodes".

Blanchard (1847) gives the following classification of the Trematodes:

1. Distomiens - Suckers unarmed; these organs never accompany the mouth; intestine div-

ided into two simple or ramifying branches.

2. Tristomes - Suckers unarmed; two of these organs situated on each side of the mouth. Intestine ramified, of which the two main branches reunite in the form of a circle.

3. Octobethiens - Suckers situated at the posterior part of the body and provided with hooks.

The most attention had been directed toward the endoparasitic forms and as a result all the trematodes were placed into one group. The discovery of the ectoparasitic trematodes and the research of V. Baer, Nordmann, Nitzsch, Diesing and of many others led Leuckart (1856) to propose a division of the Trematodes into two families: Distoma, for endoparasitic forms with a metamorphosis; and Polystomea, for the ectoparasitic forms which have no metamorphosis. During the same year Burmeister suggested the separation of Aspidogaster from the rest and a three-fold division instead of two. His division consists of Malacobothrii (for Distomids), Pectobothrii (for Polystomids) and Aspidobothrii (for Aspidogaster).

The system proposed by Burmeister was overlooked and obscured by P. J. Van Beneden (1858) work on the group. His account of several new species and experimental investigations into the life history of endoparasites brought forth the importance of the two modes of reproduction: the direct or monogenetic and the indirect or digenetic. He

divided the monogenia into two groups, viz., the Tristomes, (one posterior sucker) and Polystomes (several posterior suckers). Burmeister's three fold division of the Trematodes reappeared later in the work of Monticelli (1892).

The class Trematoda was divided by Monticelli (1892) into three orders which are distinguished by the character of the suckers. These orders are Heterocotylea, Monticelli (= Polystoma, Leuckart = Pectobothrii, Burmeister = Monogenea, Van Beneden) includes the trematodes in which there is a large posterior, ventral terminal sucker in addition to two anterior suckers in relation to the mouth (one of which may be lacking). In composition, the posterior sucker may be composed of a single sucker, usually large in size, which is generally divided by radial ridges into a number of compartments or, be more highly developed and contain separate suckers set upon a caudal disc or cotylophore. The cotylophore is usually well provided with chitinous hooks. The excretory system opens to the exterior by means of a pair of pores located laterally and near the anterior end on the dorsal surface. A genital pore is present and is the external opening of the male and female systems. A vagina, independent of the genital pore, is a characteristic of this order. Most of the species are parasitic and monogenetic.

The order Aspidocotylea, Monticelli (Aspidobothrii,

Burmeister) is characterized by an adhesive apparatus that occupies the entire ventral surface of the body, from which it is usually distinctly constricted. It is commonly subdivided into a number of rectangular compartments called suckerlets. An anterior sucker is absent. The intestine is without diverticula and is a simple sac-like structure.

Endoparasitic trematodes of the order Malaccotylea, Monticelli (Distoma, Leuckart = Malacobothrii, Burmeister = Digenea, Van Beneden) are differentiated primarily by the number of suckers. There are never more than two suckers present, an oral sucker, and a second sucker located somewhere on the ventral surface (the latter may be absent). There may be spines present upon the external surface but there are no hooks or chitinous skeletal formations upon the ventral sucker. The two diverticula of the intestine are usually without lateral caeca. The excretory system opens to the exterior by means of a median posterior opening that connects with the central collecting bladder anteriorly. Laurer's canal usually opens upon the dorsal surface and the generative systems open to the exterior by means of a common genital pore.

In recent years research in the field of parasitic trematodes has greatly increased and the morphology as well as life histories of the worms have been worked out. Among the most important Parasitologists of the present day are:

Ward (1865 -) who has worked on the origin of parasitic forms, parasites of man and domestic animals, life history of the Pacific salmon and the morphology and classification of many new species of trematodes. Cort (1887 -) has investigated the larval stages of digenetic trematodes, parasites of the frog, survey of the hookworm disease in the mines of California, and the human blood fluke diseases. Guberlet (1887 -) is an important investigator in the field of classification and morphology of the Class Trematode. Stunkard (1889) has described many new species of trematodes and is a diligent worker in this branch of research. Faust is an important figure in experimenting on the life histories of trematodes and in the field of human helminths.

History of Genus Telorchis (Lühe).

Stunkard (1915) states, "in 1889 Lühe created a new genus, Telorchis, to contain certain reptilian distome parasites, and designated D. clava Diesing (1850) as the type species. In the genus he included D. poirieri Stoss (= D. gelatinosum Poirier nec. Rud.), D. Linstowi Stoss (= Monostomum aculeatum V. Linst.), D. ercolanii Montic. (= D. signatum Ercol. nec. Duj.), D. nematoides Mühl., D. bifurcum Braun, D. plerotieum Braun, and tentatively D. arrectum Mol. nec. Duj."

This same group of reptile distomes was separated by Looss (1899) independently, and also called Telorchis, but his article appeared after that of Lühe. Looss selected D. linstowi as the type species.

Because of the differences existing between T. clava and the other members of the genus, Lühe later (1900) created two sub-genera: Telorchis with T. clava as type, and Cercorchis with T. aculeatus (= T. linstowi Stoss) as the type. The distinguishing features of the sub-genus Telorchis are the absence of an esophagus, and the lateral extension of the folds of the uterus beyond the diverticula of the intestine where they may be coiled over the caeca in the form of a figure "8". An esophagus is present in the sub-genus Cercorchis and the coils of the uterus are con-

fined between the caeca.

Stunkard (1915) states,

> "My examination of almost a hundred mature individuals of six different species affords evidence that the lateral extension of the uterus varies largely as a result of congestion with eggs. In the same species one finds some specimens in which the coils of the uterus are confined between the caeca and others in which the uterine folds overlap the diverticula on one or both sides. Certain species in the genus possess a long esophagus, others a short esophagus, and finally in T. clava an esophagus is absent. Furthermore the absence of an esophagus is not always associated with an extracaecal coiling of the uterus and vice versa, since in T. bifurcus an esophagus is absent and the uterine coils are intracaecal, and in T. corti an esophagus is present and the uterine folds often overlap the caeca. These facts show that the characters designated by Luhe are not adequate to subdivide the genus, and since the apparent morphological differences of his types are merely extreme variations of characters common to several species, the sub-genera disappear".

Goldberger (1911) described as new species T. stossichi, T. attenuatus, and T. robustus, and formulated a key for the identification and separation of the species.

Comparative Description of the Genus Telorchis. (Lühe)

Trematodes in this genus are lanceolate in shape, tapering at the anterior and posterior ends. The region of the grestest width is approximately at the middle of the body. Stunkard (1915) states,

> "they range in length from 1.5 to 13 mm. and in width from 0.25 to 1.6 mm. In T. arrectus the ratio of width is 1 : 4; in T. diminutus it is 1 : 5; in T. clava, T. bifurcus and T. lobosus it is about 1 : 7, while in T. pleroticus it is 1 : 18 and in T. poirieri it is 1 : 22."

The region of the body between the oral sucker and the acetabulum is more motile than the post-acetabular region, which is primarily a sac containing the reproductive organs.

The cuticula is of uniform thickness in any one species. Stunkard (1915) states, "it varies from 2 μ in T. parvus and T. diminutus to 11 μ in T. attenuatus, the thicker cuticle being found in the larger species". Cuticular spines occur on the body arranged in rows and around the external openings in concentric circles. They are deeply embedded in the cuticle, which is raised about the base of each spine in a papilla-like structure. Spines are largest around the oral sucker and gradually diminish in size toward the posterior end of the body where they are indistinct or entirely absent. The rows are usually separated by distances slightly exceeding the length of the spine. In general, the spines may vary in size and in proximity to each

other directly with the size of the trematode. The cuticula which is invaginated at the external openings is not spinous.

The excretory system is composed of an excretory pore, a single median collecting bladder and two collecting ducts lying parallel to each other on either side of the worm. The excretory pore is situated at the posterior tip of the body and opens from a large median collecting duct which extends anteriorly to about the location of the ovary. This duct divides into branches that extend anteriad, one on either side of the median line, just mesiad to the intestinal diverticula. These branches can be traced almost to the region of the acetabulum where they disappear.

The oral sucker is subterminal in position, equal to or slightly exceeding the acetabulum in size. The shape of the oral sucker and acetabulum vary considerably. This can be best observed by watching the movements of a living worm.

Stunkard, (1915) states,

> "a prepharynx is absent in T. aculeatus and T. nematoides and in some species can be noted only when the cephalic extremity of the worm is much extended. All degrees of variation in length occur even to a distinct and elongated pouch in T. bifurcus and T. pleroticus. The pharynx is approximately spherical although either the longitudinal or transverse diameter may be greater. An esophagus is absent in T. clava and in T. pleroticus, short in T. aculeatus and T. parvus, and very long in T. medius and T. solivagus".

The caeca branch anteriorly at an acute angle and extend almost to the posterior end of the body. T. parvus and T. poirieri are the exception to this and the caeca extend only to the intertesticular region. Stunkard (1915) states,

> "anterior to its bifurcation the digestive tract is lined with cuticula continuous with that of the external surface and close to the fibro-muscular wall and cytoplasmic processes extending into the lumen of the canal".

The testes lie in close proximity, one behind the other near the posterior end of the body, in the median line or slightly oblique. The vasa efferentia pass cephalad just median to the caeca and unite posterior to the cirrus sac, where it forms the vas deferens and empties into the seminal vesicle. The cirrus sac is a long cylindrical, muscular pouch extending caudad from the genital pore. It encloses the cirrus, vas deferens, prostate and seminal vesicle. The genital pore is usually located anterior and to the left of the acetabulum.

The ovary lies in or near the median line of the body, posterior to the acetabulum, and usually in the anterior part of the body. The oviduct rises from the dorsal posterior margin of the ovary and after one or two slight irregularities enlarges to form the oötype. The ootype is surrounded by large unicellular glands of the shell gland. Laurer's canal arises from the dorsal surface of the body. The vitelline duct from the vitelline

reservoir enters the oötype just ventral to and to the left of the origin of Laurer's canal. Stunkard (1915) states, "in some species the proximal end of Laurer's canal is enlarged to form a seminal receptacle and in T. aculeatus the enlargement may comprise the entire tube". The uterine tube turns first ventrad and then begins a series of irregular sinuous convolutions, extending posteriorly to the anterior testis and returning anteriorly to the nearly straight metraterm which leads to the common genital atrium. The opening of the metraterm is anterior and to the left of the cirrus sac. Stunkard (1915) states,

> "the descending and ascending coils of the uterus occupy separate distinct fields in T. aculeatus and T. parvus, in T. bifurcus they overlap and in some cases are indistinct, while in T. diminutus and T. nematoides they are so superimposed and confused that only rarely can distinct fields be discerned".

In T. solivagus Odhner (1902) reports that the descending and ascending limbs of the uterus cross each other to form a figure "8". Other authors mention this crossing or absence of crossing as a specific character, but in T. corti both conditions exist.

There is considerable variation in the arrangement and location of the vitellaria. They are extra-caecal and consist of a large number of follicles, usually arranged in lobes. There are usually nine lobes on the right and twelve on the left side of the body, although there is a

tendency for the lobes to fuse, reducing the number. The vitellaria on the left side extend further cephalad and caudad than those on the right. Longitudinal collecting ducts lead from the median line of the vitellaria. These ducts unite in the region of the ovary and turn mesiad to form the vitelline receptacle which is located posterior to the ovary.

In all sexually mature worms the uterus contains numerous eggs. They vary in size from 10 by 20 μ in T. plerotieus to 22.8 by 40 μ in T. parvus, and 21 by 41 μ in T. Diminutus.

Table of Comparison

	Telorchis sp.	T. corti, Stunkard.	T. lobosus, Stunkard.	T. medius, Stunkard	T. diminutus, Stunkard	T. robustus, Goldberger	T. gabonensis, Ruszkowski	T. stenoura, Ingles.
1. Total length of body	3.7 - 6.5 mm.	4.0 - 7.15 mm.	1.67-2.6 mm.	3.0-5.28 mm.	1.2-1.5 mm.	6.0-13.0 mm.	6.0-8.0 mm.	3.7-9.3 mm.
2. Width of body at ovary	.7150-.801"	0.500					0.658	
3. Greatest width of body	at ovary	acetabulum	center of body	0.35-0.48	0.20-0.25	0.80-01.3	at acetabulum	0.86-0.63
4. Length of oral sucker	0.107 mm.	0.140		circular		0.25-0.28	0.154	
5. Width of oral sucker	0.142	0.140		0.115-0.146			0.162	0.19
6. Length of acetabulum	0.134-0.162	0.140	0.117-0.180	0.12-0.146	2 total length / 7 from ant. end	1/5	0.138	
7. Width of acetabulum	0.135-0.169	0.140	circular	0.10-0.110	0.060-0.080	0.20-0.24	0.138	0.13-0.18
8. Length of cuticular spines	0.00396	0.0034		0.0028			0.003	
9. Distance between	0.00337							
10. Thickness of cuticle	0.0045			0.003			0.012-0.027	
11. Length of prepharynx								
12. Length of pharynx	0.053	0.050		0.040		short	0.055	short
13. Width of pharynx	0.075	0.070-0.080	0.055-0.063	0.050-0.060			0.114	
14. Length of esophagus	0.034	0.050	short	0.060-0.070	0.030-0.040	0.14-0.17		0.09
15. Width of esophagus	0.054	0.025		0.20-0.270	0.070-0.10	short		short
16. Diameter of intestine	0.036			0.012-0.015				
17. Length of ovary	0.088-0.115	0.147-0.176	0.040-0.070	spherical	spherical		0.224	0.16-0.21
18. Width of ovary	0.115-0.128	0.117-0.147	0.074-0.085	0.15-0.20	0.060-0.080		0.184	0.15-0.28
19. Length of anterior testis	0.160-0.178	0.200-0.290	0.100-0.05	spherical or oval	0.069-0.092	spherical	0.362	
20. Width of anterior testis	0.170-0.125	0.160-0.240	0.13 - 0.08		0.058-0.072	0.40-0.50	0.274	0.59
21. Length of posterior testis	0.205-0.285	0.200-0.290	lobulated				0.383	0.29-0.44
22. Width of posterior testis	0.178-0.214	0.160-0.240		0.185-0.250			0.274	0.26-0.39
23. Distance between	0.160-0.231	0.50-0.100					0.270	usually in contact
24. Length of cirrus sac	0.980-1.30	1.12-1.18						
25. Extent of cirrus sac	10/11 distance to ovary	3/4 distance to ovary		4/5 distance to ovary	almost to the ovary			beyond level of ovary
26. Vas deferens	moderately coiled	greatly coiled	moderately coiled	coiled				
27. Laurer's canal	present	present	present		0.030	present		not seen
28. Seminal receptacle	present	present	small		present			not seen
29. Metraterm	slightly curved	almost straight						broad, wavy
30. Uterus	coiled moderately	densely coiled		lobes distinguishable	not distinct			moderately coiled
31. Vitellaria	Thick distinct lobes	arranged in lobes	Thick indistinct lobes		poorly developed			not distinctly lobed
32. Width of eggs	0.0195-0.0198	0.015	0.032-0.036	0.021	0.020	0.015	0.013-0.015	0.014
33. Length of eggs	0.033-0.036	0.031	0.018-0.019	0.043	0.041	0.029	0.0276-0.029	0.028
34. Host	Graptemys geographicus	Graptemys Geographicus	Chelydra serpentina	Aromochelys odoratus	Cinosternum pennsylvanicum	Chrysemys elegans	Clemmys leprosa	Clemmys marmorata
35. Organ affected in host	small intestine	small intestine	small intestine	small intestine	small intestine	small intestine	small intestine	small intestine
36. Geographical distribution	Alabama.	Texas and Illinois	Iowa	North Carolina	North Carolina		Tunisia, France	California

Description of the Genus Telorchis. (Lühe)

In 1889 Lühe created a new genus, Telorchis, and in his characterization of the genus, states,

> "the testes lie behind one another at the posterior end of the body; the cirrus sac opens somewhat left of the acetabulum and is very long; the ovary is immediately behind the posterior end of the cirrus sac and is separated from the testes by the coils of the well developed uterus; while the vitellaria consist of numerous follicles occupying the space at the sides of the body and approaching more or less closely the anterior and posterior ends. The diverticula of the intestine reach almost to the posterior end of the body; and with the exception of D. poirieri all species are armed with spines at the cephalic extremity of the worm. The excretory vessel is long and branches anteriorly in the form of a "Y". The oral sucker is usually slightly larger than the acetabulum, though in D. ercolanii of the same size".

A Re-description of Telorchis corti.

The species was described by Stunkard (1915) from fifty specimens, most of which were immature, and were taken from Malacoclemmys leseurii in Texas. I have eight mature specimens collected in 1930 from the intestine of Graptemys geographicus. A study of these worms affords additional information to that given in the description by Stunkard. The body length of Telorchis corti measures from 4.00 to 7.15 mm. The region of the greatest width of the body is at the ovary or at the acetabulum, measuring from 0.500 to 0.748 mm; the width of the body at the acetabulum measures from 0.350 to 0.570 mm. The greatest width of the oral sucker is usually in the transverse plane, measuring from 0.140 to 0.142 mm. and the length measures from 0.107 to 0.140 mm. The acetabulum is larger than the oral sucker and measures from 0.134 to 0.162 mm. in length and from 0.135 to 0.169 mm. in width. Cuticular spines located around the oral sucker measure from 0.0034 to 0.00396 mm. in length. The width of the esophagus varies from 0.025 to 0.054 mm. and the length measures from 0.034 to 0.050 mm. The cirrus sac extends from three-fourths to ten-elevenths of the distance from the genital pore to the ovary. The vas deferens is moderately or greatly coiled and the uterus is medium or densely coiled. The mature

eggs measure from 0.033 to 0.036 mm. in length and from 0.015 to 0.0198 mm. in width.

Summary.

1. A morphological study of Telorchis corti was made.

2. The morphology of the cuticle conforms to the description given by Lankester (1901).

3. Fertilization of ova was observed in live specimens.

4. The topographical location of organs was identical with the description given by Stunkard (1915).

5. Certain differences in size of structures necessitate a redescription of the species.

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Explanation of Plate

Ventral View of Telorchis corti x 43.3