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THE COMPARATIVE PARASITIZATION OF CERTAIN FRESH WATER SNAILS.*

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CONTENTS.

INTRODUCTION.

This problem was begun at the Lake Laboratory in July, 1921, and continued in the Autumn and Winter of the same year at Ohio State University. It is essentially a comparative study of the parasites of certain fresh-water snails. The area from which snails were collected during the month of July was the region of the Bass Islands of Lake Erie. In order to compare conditions there with those of a stream, that part of the Olentangy River which runs through the property of the Ohio State University, was the place of collection in October and November.

While from the nature of the case some systematic work was necessary, the primary purpose of this study was bionomic. To determine the following, have been the aims of this investigation:

**A theisis submited in partial fulfillment of the requirments for the degree of Master of Science at Ohio State University.*

First, the species of fresh-water snails parasitized by larval trematodes;

Second, the identity of the trematode parasites;

Third, the approximate degree of parasitization in each case of infection;

Fourth, the percentage of parasitization within each species;

Fifth, the incidence of larval trematode infection among fresh-water snails.

The work was undertaken at the suggestion of Professor F. H. Krecker. Aside from his helpful suggestions I am indebted to Mr. Bryant Walker, of Detroit, for the identification of the snails; to a fellow student, Mr. James Davis, for a translation from the French of Dollfus' description of Cercaria pachycerca; and to the following for their previous studies on North American larval trematodes: Professors W. W. Cort, Johns-Hopkins University; E. C. Faust, Parasitologist, Union Medical College, Peking; and E. C. O'Roke, South Dakota State College. The literature on trematodes is cited, for no true internal parasites were found other than these.

HISTORICAL ACCOUNT.

"Among the early American Zoologists, Joseph Leidy alone was a student of Cercariæ."*[10]

In 1914, when W. W. Cort wrote his preliminary report: "Larval Trematodes from North American Fresh Water Snails," [4], he found eleven previous references, in North American scientific literature, to larval trematodes. In the last mentioned paper and in the monograph of 1915: "Some North American Larval Trematodes," [5] Cort described fourteen new species of Cercaria. The snails examined by Cort were from different localities throughout the United States, and from various ecological situations. The excretory system was taken as a conservative basis of description. Luhes scheme of classification was used. Not only was preserved material studied, but the reactions of live cercarial were noted. Cort, since then, has made several contributions to our knowledge of Digenetic larval trematodes.

In 1917, Earl C. O'Roke published a short paper on "Larval Trematodes from Kansas Fresh-Water Snails," [13]. This study was less pretentious than that of Cort's but added several new species.

*Numbers in brackets refer to the literature cited.

Also in 1917, Faust, in his preliminary report: "Notes on the Cercariæ of the Bitter Root Valley, Montana," [8] listed 32 larval trematodes which had been previously described. He described fifteen new forms. Faust's completed monograph, "Life History Studies on Montana Trematodes"[9] takes up the biology of a limited region, a detailed embryological and morphological study of the trematodes found there and their systematic relationship. Faust used not only the excretory system of live cercariæ as a basis of classification, but also worked out a method of staining the genital cell masses of the preserved material.

In 1919, Faust presented in "The American Naturalist," (No. 10, pages 85-92), a biological survey of cercariæ described from the United States up to that time. The total number of host records was 72. The net species was 61, as there were eleven species of larval trematodes recorded from two or more hosts. In 1921, the same author [11] described nine new larval distomes out of only two species of snails from the region of Rome, Georgia.

Other papers have appeared describing new species, clearing up developmental problems or group relationships, and some of the various phases in the irregular and complicated set of life histories. Despite the recent advances in parasitology, it is safe to say that only a limited area in the United States has been surveyed for larval trematodes. Also, the life-history and ecology of most of those named are only incompletely known. According to H. B. Ward [17, page 415], even the larva of the common sheep liver fluke, Fasciola hepatica, had not been reported from the United States up to 1918. Two years later, Mark F. Boyd, of the University of Texas, experimented to determine the intermediate host. He states [2]: "Data presented do not enable us to conclude that the larval cycle can be completed in Physa, nor settle the question regarding Linnæa humilis."

APPLICATIONS OF THE PROBLEM.

This last problem is of recognized economic importance in certain sections of the United States in connection with the live stock industry. Beside the fact that Fasciola hepatica is an occasional human parasite there are further reasons for a study of "flukes" and their host relationships. Cort[6] suggests the need of finding out what snails in this country may act as intermediate hosts for the more serious trematodes which have already been introduced into this country by Orientals.

However, the immediate economic application of my study is to the problems of aquiculture—for example, to fish culture in Lake Erie and the streams of the state. At the same time and place that this investigation of the snail parasites was in progress, the fish parasites of Lake Erie were being studied by R. V. Bangham. During his work, my attention was called to his finding, in the digestive tract of the Small Mouth Bass, entire snails. Not only did this show that snails, which serve as food for fish, were a possible source of infection, but Digenetic trematodes were found as parasites of the fish.

F. C. Baker's ecological study [1, pages 153-154, 238-246], "The Realtion of Molluscs to Fish in Oneida Lake," shows the importance of a knowledge of snail parasites.

DEFINITION OF TERMS.

Out of the literature on trematodes certain terms have evolved. At this place it may be well to define some of the terms used throughout this paper.

According to Faust [9, pages 18 and 19], who follows Thomas (314), "the 'sporocyst' is the metamorphosed miracidium. It is merely a sac with endoderm covering and at times a secretory integument. Occasionally one end is partially muscular. From the inner wall of this sac arise the germ balls that grow into the parthenogenetic individuals. In the simplest types the germinal cell mass consists of the entire internal layers lying next to the ectoderm. In the majority of cases, however, the germinal tissue is localized at one end of the sporocyst. (C. dendritica Fig. 87, C. racemosa Fig. 105). In the furcocercariæ, C. gracillima and C. tuberistoma (Fig. 147, 157), there is a rhizoid-like attachment at the germinal end. In these cases there seems to be some evidence for regarding the germinal layer as localized at the end opposite the potential mouth."

Unless the rediac stage is omitted, it normally develops within the sporocyst stage. Faust states [9, page 20]: "Its organization is much more complex than that of the sporocyst. There is a well developed oral aperture, a muscular pharynx and a sac-like gut. There is a birth-pore just behind the collar region, on the left side, slightly ventral. Two projections, usually in the posterior part of the body, readily differentiate the redia externally from the shapeless sporocyst. In the cephalic region around the pharynx there is a nerve complex of highly differentiated nerve cells and nerve fibers. The integument is well developed and thick, and muscular layers within it play an important role in the movement of the redia, whereas the sporocyst depends almost entirely for its movement on the larva within it. In the mature redia the germ tissue is always localized at the posterior extremity of the body."

In another connection Faust states [10, page 92] "Sporocysts and rediæ have not been sufficiently distinguished. The sporocyst is an adult which has lost its digestive tube, while a redia is an adult which possesses both a rhabdocœle gut and a pharyngeal sphincter. In certain sporocysts the sphincter still remains, as in C. dendritica. In other sporocysts, as in furcocercariæ, while no definitely differentiated sphincter is present, the anterior end of the sac is muscular, turning in and out like the finger of a glove. This may be mistaken for a rhabdocœle gut."

According to Faust [9, page 14], Ssinitzin groups the mature sporocysts and redia together under the term "parthenita," or parthenogenetic mother. The term is used throughout this paper to define the mature sporocysts and redia as distinguished from cercaria or other larval trematode of the hermaphroditic generation."

PROCEDURE.

In this study of comparative parasitization, the snail hosts will first be considered. Representatives from all the available fresh-water snails were collected, in July from the Bass Island region, and in October and November from the Olentangy river. The various snails were collected from a number of places in these regions, whenever their range of distribution was not limited to a definite ecological situation. Representative shells from the lots examined were identified by Mr. Bryant Walker, of Detroit. These were the lake snails examined: Limnæa humilis, Goniobasis livescens, Physa ancillaria, Planorbis parva, Planorbis trivolvis and Pleurocera acuta. The river snails were: Limnæa humilis, Ancylus rivularis, Goniobasis livescens, Physa ancillaria and Planorbis trivolvis.

A few snails were collected at a time and examined as soon as possible thereafter. The examination in each case consisted of first crushing the snail or removing the shell piece by piece from the body. Then the snail was placed in a watch glass in a small amount of water. Only enough water was used to allow movement of parasites when freed from the snail tissue. Under a binocular microscope the body of the snail was teased apart with needles. If no parasites were detected in a given snail, the watch-glass in which the examination was made, was washed out before examining another snail. If trematode parasites were present in a given snail, they could be detected both by general appearance and by movements, often characteristic for different trematodes. These peculiarities, as to reactions of live cercaria, as well as the relative number of parasites present were noted. Each lot of parasites from a single snail, were fixed in Hofer's solution and preserved in alcohol for later study. Every lot was kept in a bottle labeled with the serial number of the snail from which it came. In this way the number of snails examined from each species, the number parasitized in each species and the approximate infection of any snail examined was recorded.

The arbitrary terms used for this last item were: "few" for less than ten parasites, "many" for from ten to about one hundred and "very many" for the heaviest infections.

After examining 1043 snails representing the seven species previously named, attention was turned to a study of the trematode parasites obtained from them. From the preserved material, "toto" mounts were made of both parthenitæ and larvæ (cercariæ). These were studied under the compound microscope. Measurements were made of cercariæ and parthenita. The parthenita stage, whether sporocyst or redia, accompanying the various cercariæ was noted. From the literature that is now available, identifications were made. Ward's "Key to North American Trematoda" [17, pages 411–424] was supplemented by one of his shorter papers, the more complete descriptions in the monograph by Cort [5] and Faust [9], and the paper by O'Roke [13].

DATA IN TABLE FORM.

In the tables that follow is presented a comparative study of the parasites found in this investigation. The exact number of snails examined, the ones parasitized and observations as to the parasites are recorded.

SNAILS FROM REGION OF PUT-IN-BAY, OHIO, COLLECTED JULY, 1921.

Host	Location	Number Examined	Parasitized		Serial Number	Name of Parasite	Kind	Parthenita		Cercaria (larva)
			Number	Percent				Sporocyst	Redia	
Limnaea humilis	Squaw									
	Harbor	100	0	0						
Physa	Chicken I.				304		Distome			√
ancillaria	Buckeye I.				338	(Lost)				Few
ancillaria	Hatchery				358		Distome			√
ancillaria	Bay				364	C. urbanensis	Monostome		√	√
ancillaria	Bay				379	C. urbanensis	Monostome		√	√
ancillaria	Chicken I.	100	6	6	397	C. gracillima	Distome			√
Planorbis	Chicken I.				208	(Lost)				
parva	H. Bay				255	C. urbanensis	Monostome			Many
parva	H. Bay				275	C. urbanensis	Monostome		Few	Few
parva					275		Distome			
parva	Sq. Harbor				297	C. urbanensis	Monostome		Few	
	Sq. Harbor	100	5	5	298	C. urbanensis	Monostome		Few	
Planorbis trivolvis	Sq. Harbor	46	1	2.17	640	C. echinocauda	Distome	√		√
Pleurocera	Sq. Harbor				4					√
acuta	Sq. Harbor	100	2	2	7			√		√

SNAILS FROM REGION OF PUT-IN-BAY, OHIO, COLLECTED JULY, 1921—Continued.

Host	Location	Number Examined	Parasitized		Serial Number	Name of Parasite	Kind	Parthenita		Cercaria (larva)
			Number	Percent				Sporocyst	Redia	
Goniobasis	Hatchery				501	C. microcotylae				
livescens	Bay				502	" "	Distome			Many
"	"				509	" "	"			√
"	Hen Island				512	C. anchorcides	"			√
"	Hatchery				514	C. microcotylae	"			√
"	Bay				532	" "	"			√
"	"				545	" "	"			Many
"	"				549	C. urbanensis Cort. 1914	Monostome			√
"	"				"	C. microcotylae	Distome			√
"	"				556	" "	"	Few		Few
"	"				557	" "	"	Few		Few
"	"				559	" "	"			√
"	"				560	" "	"			√
"	"				565	" "	"			Few
"	"				567	" "		Very many		√
"	"				568	" "	"			√
"	"				574	" "	"	Very many		√
"	"				576	" "	"			Very many
"	"				581	" "	"	Many		√
"	"				595	" "	"			Few
"	"	100	19	19	599		"	Few		Few

SNAILS FROM OLENTANGY RIVER, COLUMBUS, OHIO, COLLECTED OCT.-NOV., 1921.

Host	Location	Number Examined	Parasitized		Serial Number	Name of Parasite	Kind	Parthenita		Cercaria (larva)
			Number	Percent				Sporocyst	Redia	
					1432	(Lost)				Few
Limnaea humilis	Olentangy Riv.	100	2	2	1432	(Lost)				Few
Ancylus rivularis	"	100	0	0						
Goniobasis livescens	"				904	C. pachycerca				
" "	"				905	" "	Distome	Few		
" "	"				"	C. microcotylae	"	"		Many
" "	"				910	" "	"			
" "	"				938	C. megalura	"	"		"
" "	"				962	C. gracillima	"		Many	"
" "	"				963.	" "	"	"		"
" "	"	86	7	81	965	C. megalura	"	Many		Very many
Physa ancillaria	Olentangy Riv.				703	Curbanensis	"		Many	Many
" "	"				801		Monostome		Few	Many
" "	"				804				Few	Few
" "	"				812	(Lost)?			√	√
" "	"				815	(Lost in clearing)				Few
" "	"				816	(Lost)?	Distome		Few	Few
" "	"				822					1
" "	"				838		Distome		Few	Very many
" "	"				1302	(Lost)?			Many?	
" "	"	200	10	5	1372	(Lost)?				√
Planorbis trivolvis	Olentangy Riv.	9	0	0						Many

COMPARATIVE PARASITIZATION SUMMARY.

Species of Snail Host	Location of Snail Hosts	Number Examined	Parasitized		Species		Stages	
			Number	Percent	Monostome	Distome	Parthenita	Cercaria
Limnaea humilis	Lake Erie	100	0	0				
Limnaea humilis	Olentangy River	100	2	2		√		√
			(2)	(1)				
Ancylus rivularis	Olentangy River	100	0	0				
		100	20	20	1	√	√	√
Goniobasis livescens	Lake Erie	86	7	8.1		√	√	√
Goniobasis livescens	Olentangy River		(27)	(14.5)				
		100	6	6	1	√	√	√
Physa ancillaria	Lake Erie	200	10	5	1	√	√	√
Physa ancillaria	Olentangy River		(16)	$(5\frac{1}{3})$				
		100	5	5		1	√	√
Planorbis parva	Lake Erie	46	1	2		1		
Planorbis trivolvis	Lake Erie	9	0	0				
Planorbis trivolvis	Olentangy River	100	2	2		√	√	√
Pleurocera acuta	Lake Erie	1043	53	5.03				

DISCUSSION.

The data here presented in table form indicates that seven species of fresh-water snails have been examined for parasites. Of these, six species are shown to be parasitized by Digenetic larval trematodes. The incidence of larval trematode infection of fresh-water snails is shown. From 1043 specimens examined, 53 snails, or more than one in every twenty were parasitized by some stage of Digenetic trematode. Of the 53 host snails, thirty are represented by mounted material, ("toto mounts"). Instead of redescribing the identified parasites, the source of the original description is given. Some variations or additional facts are noted.

Cercaria urbanensis Cort 1914, was the only species of monostome found. Either the parthenita or larva stages of this parasite were found in seven snails. The hosts in which this specie was found were: Physa ancillaria in one snail each from the river and lake; Planorbis parva in four out of 100 Lake Erie snails; and a lake specimen of Goniobasis livescens. The morphological characteristics fit the description for Cercaria urbanensis given by Cort [5, pages 11-17) and in Ward's Key [17, page 412]. Part of Cort's record of infection is quoted [5, page 11): "About five percent of the largest specimens of Physa gyrina from a drainage ditch North of Urbana, Illinois, examined in December, 1913, were infected with the redia and cercaria of a monostome. The infection was in the liver of the snail and there were present both rediæ in different stages of development and free cercariæ."

Of the distome cercaria, there were several kinds. Nineteen percent of the lake specimens of Goniobasis livescens were heavily infected by small distome cercariæ. Both the larva and parthenita stages respectively were very similar in all of these small distomes. They are very closely related to Cercaria leptocantha, a Xiphidiocercaria described by Cort [5, pages 59-62; figures 79-81]. He says of this species (5, page 60-61): "Cercaria leptocantha belongs to a group of very small cercariæ which Luhe [12, 1909, page 106] calls Cercaria Microcotylæ. It is possible that they form a natural group. * * * They are, however, so insufficiently known that no final judgment can be passed on their relationships. At present it seems best to follow Luhe in considering them a provisional group, with Cercaria microcotyla Fillippi as the type and the following characteristics.

1. Developed in gastropods in round or oval sporocysts which are seldom more than twice as long as wide.
2. Cercaria under 0.2 mm. in length.
3. Acetabulum back of the middle of the body and smaller than the oral sucker.
4. Stylet glands not more than four on each side and arranged in rows on each side of the acetabulum.
5. Digestive system undeveloped except for a short prepharynx and a small pharynx."

A much larger distome, a gymnocephalous cercaria closely related to the cercaria of Fasciola hepatica is identified as Cercaria (Gymnocephala) ascoides Leidy 1877. It was found in a specimen of Planorbis parva from Lake Erie. Cercaria urbanensis was found in the same snail. This is a case of double infection, one parasite being a monostome and the other a distome. There were only two of these relatively large distomes. It may be noted in this connection that there seems to be little relation between the size of the snail host and the trematode parasite. The smallest cercaria, as well as the largest, was found in Goniobasis livescens. Goniobasis livescens is one of the largest of the seven snails examined, being many times the size of Planorbis parva, which is the smallest of these snail hosts.

The other species of distome, from a lake specimen of Goniobasis livescens, was Cercaria anchoroides. This peculiar cystocercous cercaria was described by Ward [15] from free-living specimens which he found in Lake St. Clair between July 27 and August 5, 1893. In 1916, he again described this cercaria, [16], but reported no host for it. On July 17, 1921, from snails taken in Lake Erie off the shore of Hen Island, I found not only a cercaria in the characteristic anchor-like stem, or tail which pulls the cercaria along, but also sporocysts. In one of these brown colored sacs, the inverted flukes and anchor stem were protruding at right angles to the sporocyst wall. In another case, the forked tail or wings of the anchor could be seen inside the sporocyst. The reversal of functional activity in the tail of the live cercaria, the wavy outline of the intestine and the proportion of parts indicate that the larval trematode found near Hen Island is of the same species as that described by Ward from

Lake St. Clair. The host of this peculiarly specialized cercaria is for the first time recorded as Goniobasis livescens.

At least three species of the distomes were furocercariæ, if the large cystocercous larva, Cercaria anchoroides, is included. One of these forked-tailed cercariæ was concluded to be Cercaria echinocauda described in 1817 by O'Roke, [13, pages 170-171; figures 39-43). He states, [3, page 170): "Six percent of large numbers of Physa gyrina collected at Lakeview, Kan., August 20 were infected with a form for which I propose the name Cercaria echinocauda. Collections of snails from the same locality made October 12, showed two percent to be infected." In this investigation, the host was Planorbis trivolvis from Lake Erie. Only one snail was infected by this parasite. O'Roke's description of Cercaria echinocauda fits for this parasite, with the exception of his Figure 39 on Plate V. That figure shows the large pigmented eyespots to be set with their long axis at about a forty-five degree angle to the long axis of the body, with the anterior ends of the eyespots farther apart than the smaller posterior ends. A camera lucida drawing with the 4 mm. objective of the parasite from Planorbis trivolvis, which agrees in other respects to the one O'Roke described, shows definitely that the eyespots are set at right angles to the direction which his drawing represents. The anterior ends of these eyespots are directed toward a point which would be midway between the region of the eyespots and the extreme anterior end of the body.

Several specimens of a forked-tailed cercaria, found in a specimen of Physa ancillaria from the Olentangy river, were lost in clearing.

The other species of furcocercariæ was found twice in Goniobasis livescens from the Olentangy river and once in Physa ancillaria from Hatchery Bay, Lake Erie. Faust's description for Cercaria gracillima (9, pages 80-82; figures 142-154), from Montana more nearly fits the parasites from these three specimens than any other description that I have seen. According to Faust [10, page 91]: "None of the species described for the Bitter Root Valley have been recorded east of the Rocky Mountains." This may only indicate the small geographical area that has been covered, for, as he suggests on the same page the same condition is not true in general for other larval trematode parasites. The following is the record of parasitization as given by Faust [9, page 81]: "This species was found in the liver of Physa gyrina Say, collected from the lower reaches of the Bitter Root River near Maclay Bridge, Buckhouse Bridge, and the sloughs at the roadhouse, near Fort Missoula, in the fall of 1916. In addition, it was found in the livers of Limnaea proxima Lea from Rattlesnake Creek, Missoula. The infection in most cases was not exceedingly heavy, except in the collection from the sloughs at the Roadhouse, where thirty-three out of seventy-one individuals were infected, or 46.5 percent.

Out of the 87 specimens of Goniobasis livescens from the Olentangy River, seven were infected. Of these, two infestations were with microcotylous cercariæ similar to those from the lake specimens of Goniobasis.

In two of the 87 snails there were larvæ identified as Cercaria grocillima Faust 1917.

Two other individuals of Goniobasis livescens from the river were infected with Cercaria megalura Cort 1914. [5, pages 31–36; figures 27–36]. Beside the group of gland cells forming an adhesive organ in the tip of the contractile tail, the shape, size and other characteristics make this identification very certain.

Also, different specimens of the mounted parasites showed, as Cort's figures do, a varying amount of the cytogenous material within the body or thrown out around it. As to the classification, Cort removed this trematode from the subdivision of Gymnocephalous cercaria. He calls it a megalurous cercaria, from the characteristic appearance of the tail. As to the parasitization of his material Cort states [5, page 31]: "From 73 specimens of Pleurocera elevatum from Sangamon River near Mahomet, Illinois, examined during November and December, 1913, one was found with the liver packed with redia in which developed a very peculiar kind of cercaria. Comparison showed this form to be the same as the larger cercaria which Cary assigns to Diplodiscus temporatus." Cary's snail host was Goniobasis virginica Say from Princeton, New Jersey (1908). He left no record as to the extent of parasitization.

In two specimens of Goniobasis livescens from the Olentangy River were cercariæ which to my knowledge have not been described from North America. They differ from Cercaria trigonura Cort 1914, [5, pages 49–52; figures 47–54], in their stumpy tails which are truncate, nearly as broad as long and the width about the same at each end. The tail of a representative cercaria measured 0.066 mm. long by 0.055 mm. wide. The cup-like end functions as a sucker rather than the ventral part of the triangular shaped tail of Cercaria trigonura. The bladder is large and entire as contrasted with the bicornuate excretory vesicle of Cercaria trigonura. It extends above the acetabulum occupyihg almost the posterior two-fifths of the body. Aside from the tail and size, the general appearance of the body of this cercaria is similar to that of Cercaria trigonura.

These distome cercariæ from Goniobasis livescens average about 0.4 mm. in length by 0.1 mm. in width. Cercaria trigonura Cort 1914 [5, page 45] is stated to measure 0.24 mm. in length and 0.06 mm. in width. Further, their parthenitæ differ both in size and kind. Cercaria trigonura develop in rediæ measuring 0.43 mm. in length and 0.09 mm. in diameter [5, page 47]. The stumpy-tailed cercaria from Goniobasis livescens develops in sporocysts like the Cotylocercous cercariæ of Dollfus [7]. While the size of the parthenita, as well as the cercariæ varied slightly, the relative size of the two is shown by these measurements taken respectively from an average sized cercaria and a sporocyst mounted together: cercaria 0.4 mm. by 0.1 mm. and sporocyst 2 mm. in length by 0.5 mm. in width.

Robert Dollfus in his preliminary report at the Ninth International Congress of Zoology held at Monaco in 1913 [7, page 684], says:* "The group of Cotylocercous cercaria, with the common type Cercaria pochycerca Diesing, are characterized as follows: a large bladder, not bifurcate, occupying nearly all of the posterior part of the body. Beginning with the ventral sucker its wall is formed of a single layer of very large closely fitted granular cells of glandular appearance. Tail very short, large at least at its base, consisting of a cup with very thick wall and large cells. The bottom of the cup and the sides by their combined movement permit of adhesion to a support after the manner of a sucker. This tail, functioning as a sucker, is well developed."

These stumpy-tailed cercariæ from Gonibasis livescens are identified as belonging in the group of larval trematodes which Dollfus calls Cotylocerous, with Cercaria pachycerca Diesing as the type species.

Some observations as to the ecology of this and other larval trematodes may be in place. Reference has already been

*Translated from the French by James E. Davis, O. S. U.

made to the apparent lack of relation of the size of the snail host to that of the parasite. It will be observed from the tables that Microcotylous cercariæ were the predominant parasites of the lake specimens of Goniobasis. In the individuals of Goniobasis from the Olentangy River, there were no Monostome cercariæ, but there was a wider range in the type of distome larvæ. There was a double infestation at each place.

From the river, two individuals were infested with Cercariæ microcotylæ (very small distomes), two with Cercaria pachycera (a stumpy-tailed larva), two with Cercaria gracillima (a forked-tailed cercaria with eye-spots) and two with Cercaria megalura with the characteristic group of cells for attachment in the end of the long tail. Other particulars might be stated as to the parasites and the environment of the snail hosts. However, the general conclusions of Dollfus as to the ecology of larval trematodes is borne out by this study of their comparative parasitization.

As to the relation of the morphology of the trematode parasites to the environment Dollfus states [7, page 685]: "After comparative examination of the morphology of the cercaria and the condition in which the host lives I have been able to submit that cercariæ with a morphology very similar have hosts very different and lives very different. Cercaria very different inhabit the same environment ("Milieu"). I have been able to establish that it is only arbitrarily that one attributes certain forms to certain places."

Faust [10] states in this connection that, "The mollusks most heavily infected are the ubiquitous species, Planorbis trivolvis and Physa gyrina, and the western species Lymnea proxima.

Beside calling attention to the limited geographical areas that have been covered in the survey for cercaria Faust suggests that [10, page 91]: "the variation of species of flukes in snails from one season to another makes it highly probable that many more species occur in the mollusca of the areas surveyed than the records show."

SUMMARY.

The comparative parasitization of seven species of fresh-water snails, totaling 1,043 specimens, has been studied. The species were Limnæa humilis, Ancylus rivularis, Goniobasis

livescens, Physa ancillaria, Planorbis parva, Planorbis trivolvis and Pleurocara acuta.

Six of these species have been shown to be parasitized by the larval stage of Digenetic trematodes. No parasites were found in the 100 specimens of Ancylus rivularis.

The kinds of cercaria identified were monostomes: (Cercaria urbanensis Cort 1914);
Distomes:

Microcotylous, having as type species (Cercaria leptocantha Cort 1914).

Furcocercous, (Cercaria echinocauda O'Roke 1917),
(Cercaria gracillima Faust 1917).

Cystocercous, (Cercaria anchoroides Ward 1916).

Megalurous, (Cercaria megalura Cort 1914).

Stumpy tailed or Cotylocercous, (Cercaria pachycerca Diesing).

The approximate degree of parasitization of individual snails has ranged from none, (in Ancylus rivularis), to several hundred, (in the case of Goniobasis livescens parasitized by Cercariæ microcotylæ).

There were two cases in which two species of trematodes were found in a single host. In one of these cases, one parasite was a monostome and the other a distome larva.

Little, if any, relation was found between the size of the host and the size, or number of its parasites.

The percentage of parasitization found for the seven species of freshwater snails was as follows:

Goniobasis livescens	14.5 percent
Physa ancillaria	5.33 "
Planorbis parva	5.0 "
Pleurocera acuta	2.0
Planorbis trivalvis	2.0 "
Limnaea humilis	1.0 "
Ancylus rivularis	0.0 "

The incidence of larval trematode infection among certain fresh-water snails has been shown to be over five per cent.

A host, Goniobasis livescens from Hen Island, Lake Erie, was found (July 17, 1921) for Cercaria anchoroides previously only recorded as free-swimming.

A stumpy tailed distome Cercaria pachycerca Diesing, has been reported as a new species from North America.

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