

CONTRIBUTIONS
TO THE
DEVELOPMENT OF THE TREMA-
TODA DIGENEA

PART II
THE BIOLOGY OF THE FRESHWATER CERCARIAE
IN DANISH FRESHWATERS

BY
C. WESENBERG-LUND

WITH 35 PLATES AND 4 PLATES OF MICROPHOTOS

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, NATURV. OG MATH. AFD., 9. RÆKKE, V. 3.

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Introduction.

As is well known, the digenetic Trematoda nearly always pass part of their life in molluscs, mainly in snails. Our knowledge of their development is mainly based upon the study of the phase occurring in fresh-water snails. What we know with regard to their life in marine or land snails is more fragmentary. This is especially true with regard to the land snails. On a close study much would seem to indicate that the trematode life in land snails is a far commoner phenomenon than has hitherto been supposed, and that precisely here will be found many aberrant forms deviating highly from those developing in fresh-water snails. The reader is referred to the recent papers of HARPER (1932, p. 307), NÖLLER und ENIGK (1932, p. 424), MATTES (1933, p. 227). All the Trematoda developing in fresh-water molluscs belong to the fresh-water fauna in their developmental stages.

Curiously enough, recent limnology has never occupied itself with the fresh-water trematodes and this is all the more peculiar since very many live in fresh-water organisms not only as larvae but also as mature animals, and so to speak are true fresh-water organisms during their whole life. Our entire knowledge of the life of digenetic Trematoda has been built up almost exclusively by parasitologists, during recent years mainly in parasitological laboratories from which a series of admirable investigations has been carried out. As far as I know, the fresh-water laboratories and limnologists have devoted their energies to other and more pressing subjects.

During my plancton investigations I have several times obtained Cercariae in the plancton samples. A study of the researches in other countries will show that there too the investigations have revealed Cercariae. In the plancton lists they have always merely been designated as *Cercaria* sp. Once I found a very peculiar *Cercaria* larva which will be mentioned in the following, and during my Furesø-studies (1917) I was able to make some observations which awakened my greatest interest and were of considerable importance for the researches now published. Furthermore, during my studies of various water insects, I often found the larvae affected by cysts and as STEENSTRUP (1842, p. 43) had previously done, observed the milky water caused by crowds of Cercariae round the snails in our ditches and on our moors. During

more than 30 years a more thorough study of the trematode life, especially of the Cercariae, i. e. that developmental stage in which they live side by side with the Rotifera, the Cladocera, insect larvae and many other fresh-water organisms which I have studied for years, was a desideratum which, however, I never thought should be fulfilled. For there could be no doubt that, if these investigations were to be carried out from a fresh-water laboratory, the whole equipment and its organisation must necessarily be of a much higher standard than that of the small rooms in which the investigations have hitherto been made.

Then came a donation from the Carlsberg Foundation in 1931. A house in Hillerød near the Frederiksborg Castle Lake was bought, and equipped throughout as a fresh-water biological laboratory.

As soon as the laboratory had been established, I decided to study the Cercaria fauna of our fresh-waters. — Furnished as the laboratory is with aquaria, air and water supply, a refrigerator and a thermostat for constant temperatures, for acceleration and retardation of development, a chemical balance, centrifuge, open air aquaria in which the organisms can be reared from eggs, the best possible microscopical and microphotographic equipment, it enables me to accomplish an investigation for which through a number of years I had gathered observations that admittedly I thought would never be published. —

The investigations on the trematode fauna of our fresh-waters now appearing are only a link in the chain of publications relating to the biology of fresh-water organisms published by the Danish Fresh-water Laboratory. As such they have their great limitations; they differ very much from the studies from parasitological laboratories; they finish so to speak where the latter begin. The main task has been to obtain a general faunistic view of the Cercaria fauna of our fresh-waters and contribute to the biology of the parasites in the Cercaria stage. The group has not been studied in our country since the appearance of STEENSTRUP's famous work. Almost all the species here treated are therefore new to our fauna. A closer study of all those parasites which attain maturity in birds and mammals does not belong to the main work of a fresh-water laboratory, and would demand an equipment which was neither available nor desirable. With regard to all those forms that attain maturity in fishes and amphibia others are already now occupied with subjects relating to them. That the delimitation of the problem as given here will be felt as a great defect I feel convinced. On the other hand the very circumstance that the researches have been made from a fresh-water laboratory and that the starting point is different from the usual one, may be expected to reveal some facts relating to the biology of the Cercariae, thus to the interplay between life and structure, between host and parasite, which perhaps would not be so much in evidence if the investigations were made from a parasitological laboratory.

As is well known, the Cercariae cannot be collected in the same way as Rotifera, Cladocera and other free-swimming fresh-water organisms. It is necessary to take into the laboratory our fresh-water molluscs, especially the fresh-water snails, keep

them in aquaria, let them throw the Cercariae and then study these in the vessels. Furthermore it is a well-known fact that many more molluscs are affected than those which throw the Cercariae. At the moment of collection many are parasitised in the Sporocyst or Redia stage, many contain only Tetracotyle but no Furcocercariae; hence dissection of the snails is always necessary. The mode of procedure used for the investigations is as follows. The snails are taken into the laboratory, of the larger species (*Limnaea stagnalis*, *Planorbis corneus*) 3 are usually put in a glass containing c. 200 ccm., of the smaller ones (*Bithynia*, small *Planorbis* species and others) 5. If any glass shows Cercariae, the snails in the glass are isolated; the infected snail is then put aside, and in this way a collection of infected snails is obtained. Experience shows that snails can retain the Cercariae for a very long time, furthermore that the ripening of the Cercariae in the parthenitæ can take place for months after the sample has been taken; usually the collection of snails was kept under observation for 4—5 days, whereupon the snails were dissected. The snails in the vessels were not fed; in the course of 1—2 days they had given off most of their excrements whereupon they were given freshwater. Later on the water was not changed. If plants are given to the snails, it is more difficult to see and gather the Cercariae; the water gets dirty owing to the large amount of excrements. If only the water is well aerated, snails can be kept upon inanition for months. This applies especially to *Planorbis corneus*, perhaps not so much to *Limnaea stagnalis*. The temperature must not be too high; during the summer half of the year the snails die faster than in the winter half. There is this drawback about the method that Cercariae in snails kept upon inanition and dying have a tendency to encyst in the snails. This is the case with the *Echinostomata*, *Gymnocephala*, *Xiphidiocercariae* and *Cercariaea*.

The Cercariae were nearly always studied in the living state; and the drawings, which are all camera drawings, have all been executed from living animals. Staining methods were not used very much. The Cercariae were studied in a 0.35 % solution of NaCl. During slow evaporation of the fluid the Cercariae pass into a state of asphyxia in which they keep quiet for 20—30 minutes; in this interval the animals are studied and drawn. In most cases the observer has enough living material to replace the dying ones. Just before death the Cercariae are most suitable for study; this applies especially to the excretory system; other observers, (Loos 1894, p. 3, Cort 1918 b, p. 129, 1918 a, p. 50), have made the same observation.

In most cases it has been necessary to use several animals to obtain a drawing. Simultaneously slides were taken of all animals and preserved in 5 % formaline. The drawings are all made by myself, but all the statements with regard to the dimensions have been obtained from my assistant, Dr. Berg. Most of the material has been measured in the living state as well as in the slides; in the last-named case in five specimens.

Three of the four plates of microphotos show sections of the Gasteropod liver attacked by the Trematoda. Their main object is to show how strongly the liver is attacked. With regard to the pathological changes produced by fluke-infection I refer

the reader to the papers by FAUST (1920d, p. 78), AGGERSBOG (1924, p. 361), and HURST (1927, p. 321).

Before the description of the animals the dimensions are given; in the column to the left those of the living animal, in that to the right those of the preserved specimen. The two figures to the right show the dimensions of the smallest and the biggest animal. It is my impression that all in all the systematic value of the dimensions is but slight; the variations in size are too great. CORT (1916, p. 25) has arrived at a similar result with regard to the size of the eggs.

In a group where in most cases we have not the slightest idea to what mature Trematoda a Cercaria belongs, the rules of nomenclature are of course very difficult. Earlier authors gave the Cercariae names; in recent years other methods have been tried. In his great work on the Indian Cercariae SEWELL has given them numbers and simultaneously stated that they are Indian forms. His Cercariae are determined as Cercariae Indicae I—LX. DUBOIS has adopted the nomenclature of SEWELL and has a list of Cercariae helveticae I—XXXII. SZIDAT gives his species letters (Cercariae A—C. Szidat). HARPER and PETERSEN number them but without stating the country (*Cercaria* F₁, Harper, Echinostome Cercaria No. 1 Petersen). In other words, the nomenclature has brought about a really chaotic situation. As many of the Cercariae are unquestionably cosmopolitan, the worst is that we can find Indian Cercariae in Europe, and vice versa. We shall then be faced by the absurdity of determining a Helvetian Cercaria as e. g. *Cercaria Indica* No. XXX. To this must be added the fact that it is quite impossible to remember clearly the appearance of Cercariae determined by means of numbers or letters. On the other hand, every one who has worked a little with Trematoda knows what *Cercaria monostomi* or *Cercaria ocellata* is. If the nomenclature in recent use is continued we run the risk of getting synonymlists like the following

- Cercaria indicae I. Sewell.
- helvetica II. Dubois.
- 4. Petersen.
- D. Szidat.
- F₁. Harper.

In my view the old manner of giving the Cercaria a name was much better. When later on the ripe stage is found to which the Cercaria belongs, the Cercaria with its name is merely placed under the name of the Trematode. Wherever it has been possible, I have referred the Danish Cercariae to forms which have previously been described. Many of the European forms in particular are very insufficiently described and figured, and I know that many of the species mentioned in this work come under the same category. As far as my experience goes, it is always a dangerous matter to describe and draw Cercariae from specimens taken out of the Sporocysts or from the snails. Many structures, e. g. the collar of the Echinostomes or the caudal pockets of the Monostomes, are not fully developed. On the other hand, in very many

cases in Cercariae which have nearly finished their free-swimming larval stage, the whole cystogeneous apparatus will cover all other organs, so that a close study is impossible. Combined studies of specimens taken from the snail and from the outer medium seem to give the best results. This, however, compels the inquirer to use many specimens for drawing it, and even if the drawings are made with the camera, many camera-sketches must necessarily be combined. When estimating the drawings, this fact should be kept in mind; that the method is dangerous is quite correctly maintained by LANGERON (1924, p. 24).

In several cases the material at my disposal was very small. From my investigations relating to Rotifera, Cladocera, and other plancton organisms I supposed that next year I could find the forms again and supplement the drawings and descriptions. — In the present case, however, I soon learned that this could hardly ever be done. Even in small ponds the Trematode fauna of our Molluscs differs from year to year, and in the many cases in which I have found the developmental stages of a Trematode in one of several hundred snails, experience has taught me that it is almost impossible to find the form again next year. —

I shall not here enter into a detailed account of the vast literature on the subject. I merely wish to point out the remarkable fact that the chief centre for the study of trematode development has been shifted from Europe to other continents, in the first place to North America, Japan and India. Even if science will always be greatly indebted to the excellent investigations of BRUMPT, DOLLFUS, MATHIAS, and SZIDAT, after the death of ODHNER and the cruel fate of LOOS, there can be no doubt, as is clearly shown by the Japanese authors, by CORT, FAUST, WARD, LA RUE and all their pupils and furthermore by SEWELL's great work on the Indian Cercariae, that the fauna of North American, Japan and Indian fresh-waters is much better known, and the species better described and drawn than is the case with the European forms. My knowledge of the ripe stage of Trematodes being very restricted, hardly any remarks with reference to the mature forms will be found. In this respect I refer the reader to LÜHE (1909) and to the more recent papers of LA RUE and SZIDAT a. o. I cannot but recognise that SZIDAT, with his long series relating to the development of the Trematoda and the sure references of the Cercariae to the ripe stages, has inaugurated a new era in German parasitology which after the death of LEUCKART, BRAUN, and LOOS has lost its votaries. With regard to my own paper, I beg to remind the reader that it is written by a limnologist from a limnological laboratory, not by a parasitologist from a parasitological laboratory. In this fact an excuse for the many lacks and deficiencies may be found.

As often mentioned, the excretory system seems to be that of all the organs which is least influenced by the outer medium. Hence it is unquestionably that which appears to be best suited for systematic purposes, and all the more so since it is the organ which has undergone least alteration in the mature form. It is easily understandable, therefore, that enquirers have laid special stress on the study of this system and have used it to clear up the relationship between the different groups of Cercariae. Especially the investigations of FAUST (1919a, p. 315, 1921, p. 205), SEWELL (1930,

p. 357) and JOHNSTON (1920, p. 335) have contributed to our knowledge of the structure of the organ. There is no doubt that in the various groups of the Cercariae the organ has a characteristic structure in each particular group. Nevertheless I am inclined to think, and so are others with me (viz. MILLER 1927, p. 78; STUNKARD 1930, p. 273), that the systematic use of the excretory organ can be exaggerated, and that the natural relationship of the Cercariae can only be established, not upon a single organ, but by a sound, exhaustive consideration of the general anatomical structure of the whole organism. There is no doubt that the excretory bladder, its structure and form and the course of the main trunks of the excretory tubes, as well as in some cases the branches of the second order, are of great systematic value. What I fear is to lay too much stress upon the number of flame cells in the different species, and to use the difference in the number as a means by which the species can be distinguished. The greatest systematic value they may have in the *Furcocercariae*; in the other groups, especially in the *Echinostomata*, the *Gymnocephala* and the *Xiphidiocercariae*, it is a dangerous matter to ascribe to them any great systematic value.

In 1920, p. 348 JOHNSTON states that, for the study of the excretory system of *Echinostomum revolutum* he used over 2000 Cercariae, and that the system was studied for a period of five consecutive weeks; the study was only devoted to an account of the course of the excretory canals, and the number and the position of the flame cells.

An organ concerning which the facts are so difficult to unravel, cannot be used for systematic purposes. Add to this that the cystogeneus apparatus in all the above-named groups as well as in *Monostomata* and *Cercariae* hides the organ, in different degrees in the different specimens, and more in older animals than in those which still lie in the sporocysts, and it will be seen that it is quite unavoidable that different authors arrive at quite different results. Furthermore it must be remembered that, during the life of the Cercariae, the flame cells are subject to division, and our knowledge of the rules of this division is extremely slight. The flame cells of the two sides may occupy different positions and I venture to suppose that their number from the two sides is not always identic. The study of the excretory system of the Rotifera, which in my view have their nearest relations in the Turbellariae, would seem to show that the number of the flame cells is augmented with the size. The greater the species is, the greater also is the number of flame cells. This is especially obvious in the *Asplanchna* species. Only in very few cases has the number of the flame cells been used systematically here. It is from these considerations that I have not, in this paper, considered it so important to state the number and position of the flame cells. In the *Monostomata*, where FAUST, as far as I know, is the only one who has seen them, I have not observed a single one. Only in the *Furcocercariae* have I tried to give the correct number, but I have refrained from using the formula for the number of vibratile tags which, with its strong expression of exactness, passes the bounds for exactitude which I have set myself. I cannot help thinking that several of those authors who have used this formula may be taxed with the very same thing, and that they

have underrated the numerous sources of error which, in my view, it is almost impossible to avoid.

I suppose that more than 10000 snails and mussels have been brought to the laboratory and kept in aquaria. The exact number of the dissected molluscs with information as to localities has been given after the concluding chapter. The localities are almost all situated round Hillerød or in the middle of Seeland around Sorø and Tjustrup lakes. A collection of c. 200 *Limnaea truncatula* derives from the west coast of Slesvig. Most of the snails come from small lakes and ponds. But collections have also been made from our larger lakes, Furesø, Esromsø and Tjustropsø. It really seems as if the Cercaria fauna deriving from snails from 5—15 m., the greatest depths to which our fresh-water snails go down, has a somewhat specific stamp; this is true especially of the Cercariae of *Valvata piscinalis* which, as far as I know, has not hitherto been studied with regard to its Cercaria fauna. —

As is well known, the snails are parasitised by other organisms than the Trematoda. Many of these organisms have been observed, but this is a study apart. The commonest are *Chaetogaster limnaei*. They may often be found as a coating on the surface of the snails. That they live of the Trematoda is beyond doubt. Recently WAGIN (1931, p. 55) found Cercariae in the stomach of the *Chaetogaster* and I can only confirm his finds. See also WILCOX (1901, p. 905). Several times I have found larvae of *Chironomidae*, and curiously enough, in *Bithynia* and *Limnaea* from a depth of c. 4—5 m., a little *Clepsine*. Sometimes the snails have been strongly affected by Infusoria; I should think that a closer study of the Infusoria fauna of our fresh-water snails would yield good scientific results. —

I wish to express my heartiest thanks to the Trustees of the Carlsberg Foundation; without the great gift of the Foundation it would have been impossible to work out the Cercaria fauna of the Danish fresh-waters. Further I have pleasure in thanking to my assistant, Dr. KAJ BERG, whose help has made it possible to carry out the investigations up to the present. I thank him for undertaking the numerous, often tiresome, excursions especially during the past year, and for his work in connection with the calculation of the dimensions of the Cercariae as well as with the microphotos. And last but not least I am under obligation to the many authors who have sent me their papers and given me all the information for which I have applied to them.

I am also indebted to Mr. OLE HAMMER who has found material of *Limnaea truncatula* infected with *Fasciola hepatica*.

Chapter I. Monostomata.

SEWELL (1922, p. 22) refers the monostome Cercariae to six different groups: the *Pleurolophocerca* group, the *Urbanensis* group, the *Ephemera* group, the *Lophocerca* group, the *Lophoides* group, and the *Ubiquita* group.

I cannot follow SEWELL (1922, p. 315—319) who maintains that all the above-named six groups derive from a common ancestral form, and that in the Monostomes we have a series of sub-groups which show varying degrees of interrelationship. I fully agree with ODHNER who maintains the opposite view, namely that the Monostomes form a polyphyletic group which derive partially if not totally from the Distomes, owing to reduction of the ventral sucker. They may be regarded as "reduzierte Distomen" (1907, p. 338). "Ich glaube also, dasz man auf eine gänzliche Zersplitterung der Monostomum-Gruppe gefasst sein musz" (1907, p. 340, 1911k, p. 181). DUBOIS (1929, p. 141) adopts the same view. To me the *Ubiquita* group of SEWELL are true Xiphidiocercariae; it has not been found in Denmark. To the Furcocercariae I refer the *Lophocerca* group and the *Lophoides* group; according to MILLER (1926, p. 69) the first-named belongs to the apharyngeal, brevifurcate, monostome Furcocercariae, the other to the apharyngeal, longifurcate Furcocercariae. I regard the two groups the *Ephemera*-group: i. e. the large monostome Cercariae with three eyes, and the *Urbanensis*-group, i. e. the small monostome Cercariae with two eyes, as very closely related to each other, and as a peculiar type of Cercariae whose relationship to other Cercaria-types is very doubtful. They are characterised by the total absence of a ventral sucker. They possess locomotoric pockets at the base of the tail, an enormous amount of cystogeneus cells, filled with a rod-like or granular matter, a very rich pigmentation most conspicuous in the forepart of the body; three or two eyes; a smooth cuticula without spines, no pharynx, but long intestinal coeca which almost reach the bladder. There are no penetration organs or penetration glands. The excretory bladder is globular, giving off anteriorly two excretory canals uniting in the region of the eyes, and in this way forming a peculiar bow with two long parallel legs. The canals are filled with granules. Posteriorly the bladder has an opening and gives off a canal passing through the whole length of the tail. The rest of the excretory system is almost unknown; it is best described by FAUST (1919a, p. 341) in *C. spatula*, here the canals give off in the middle line one branch anteriorly and one posteriorly, the first carrying four flame cells, the last two.

The Rediae are very variable in form; in the fullgrown stage they have almost no posterior locomotoric appendages, while in the young ones, these are always feebly developed and often seem to be absent. There is an often small pharynx, but a very long often sinuous intestine. Whether normally there follows a series of Redia generations after each other, or only one Redia generation before the Cercaria production, is doubtful, but Rediae producing Rediae have been observed. (Loos 1896, p. 197). Further it is a common feature of all true Monostomes that the development of the Cercariae is not completed in the Rediae but in the tissues of the snail, where they are nourished and magazined at a suitable temperature and high barometer. For *C. pellucida* FAUST (1917a, p. 107) says that the Cercariae usually remain in the Redia till they are ripe. Their life as free-living organisms is extremely short; the Cercariae commonly dart to the lighted side of the vessel and here they encyst, often in the course of a few minutes. The process of encystment has often been observed;

NITZCH (1807, p. 257); LA VALETTE (1855, p. 33 Pl. II, fig. A—G); v. LINSTOW (1896, p. 377); CORT (1915a, p. 12, Pl. I); SEWELL (1922, p. 44); GWENDOLEN REES (1932, p. 9), and others. Encystment in the snail may take place, but it is not the rule. (v. LINSTOW 1896, p. 377; FAUST for *C. conadensis* (1917b, p. 110)).

Of Sewell's six groups there still remains the *Pleurolophocerca* group to which belongs *C. pleurolophocerca* (Sons), *C. lophocerca* Fil. and *C. indica* VII and VIII Sewell. On all essential points these forms differ from true Monostomes. Their cuticula is spinose in front; the excretory system is of quite another type; there is no transversal commissure and the two main excretory tubes form a loop and bend downwards as in the *Gymnocephala*; there is a rudiment of a ventral sucker and an apparatus of large salivary cells which surrounds the rudiment of the ventral sucker and to which no analogue is found in the true Monostomes; further the Rediae all seem to have a very short intestine and may be extremely thread-like or almost filiforme. I refer these forms to the *Gymnocephala*. It is a question whether *C. lophocerca* (Fil.) is not identical with *C. fulvopunctata* Ercolani which LÜHE (1909, p. 186) refers to the *Gymnocephala*. —

***Cercaria ephemera* NITZSCH.** Host: *Planorbis corneus*.

Pl. I, figs. 1—8. Microphotos Pl. XXXVI, fig. 1.

The dimensions are

	<i>Cercariae</i>	
	Living	Preserved
Length of body	1130	344—684
Breadth of body	165	163—209
Length of tail	990	337—419
Breadth of tail	45	53—94
Sucker	45	39—49

<i>Rediae</i>	
Length	688—930
Breadth	161—262

The body is extremely contractile; fully extended it may reach a length of about 1100; when contracted and ready to encyst it is only 200—210 and then isodiametric. It has a characteristic plumbeous colour, is very opaque and highly pigmented, especially in the forepart. In young not quite ripe animals there are two brown irregular spots, where later on the two dark eyespots, surrounded by pigment, appear. The fully ripe larva is trioculate, with a third eyespot between the two just mentioned. In the young *Cercaria* only the part around the future eyespots is irregularly pigmented. During growth the pigment slowly develops more and more round the eyespots and now spreads over the whole body, following in the main two lines to its posterior end.

With regard to the eyespots I refer the reader to FAUST (1918a, p. 117). The body is capable of altering its form enormously. It may be almost as thin as the tail, then contract so as to be alternately broadest at its base, in the middle, and in the forepart; very often it resembles a cobra, with a broad forepart carrying the pigmented areas and a short blunt snout. It is able to roll over itself, to make the dorsal as well as the ventral side concave, and simultaneously dilate the tail to its full extent, while a moment later it may contract it to only $\frac{1}{4}$ of its former length. The whole body is packed with cells with a rod-like substance. Between them, arranged in longitudinal rows, are large irregular vesicular cells, best described for *C. monostomi* v. Linst. by DUBOIS (1929, p. 30). The adhesive pockets at the posterior lateral angles of the body are strengthened by infolds of the outer cuticula. The central cavity is extremely narrow and communicates with the exterior by a pore on the tip of the projection. Cementing glands were not observed. I regret that I have been unable to observe the fine spines mentioned by LÜHE (1909, p. 177). The pockets are locomotoric organs which help the larva to crawl. On a living Cercaria the projections are subject to great form variation; they may be entirely withdrawn and then protuded, whereupon they are evaginated as prominences which are used during the creeping motion over the substratum. It can be directly observed how they seek to catch hold and then loosen their hold, now one now the other. The oral sucker is rather small (40—60) with the mouth at the anterior tip; at its posterior limit the oesophagus begins. The oesophagus is very short and lacks a pharynx. After bifurcation the intestinal coeca almost reach the end of the body. They follow the large excretory vessels; most probably they do not function in the Cercaria stage. The round excretory bladder opens at the base of the tail; two large vessels pass forward from the bladder and unite in the midline, just behind the eyes; their whole lumen is filled with concretions, all small and all of almost the same size; the two vessels form a very conspicuous bow, whose two legs are almost parallel and of the same width. From the excretory pore a single vessel passes backward through the whole tail, but an opening in the tail has not been observed. Neither here nor in any other Monostomes have I been able to find vibratile tags. Inside the thin cuticula of the tail is first a layer of circular muscles followed by a strong layer of longitudinal muscle fibres, and then a space in which many parenchymatous starlike cells are found. The tail has an extraordinary power of contraction and dilatation. The Rediae measure 660—930. They have a considerable ability of altering their form. Pl. I, fig. 8 a—c shows the same Redia drawn in the course of 5 minutes. There is a very strong muscular pharynx followed by a large intestine almost reaching the posterior end. The colour is often red, and the intestine often contains large amounts of food in the shape of fine black granules. Only rarely does the Redia contain more than two to four Cercariae ready to escape. A birth pore and excretory system have not been observed; the former is mentioned by SZIDAT (1930a, p. 108). In the posterior part of the body is stored a great number of germballs increasing in size forwards. There are no lateral projections; nevertheless the power of locomotion is rather considerable. Rediae taken from snails which have been

kept in aquaria from 17/IV to 20/VII, and in which no Cercariae have been developed for two months, are much shorter; they have almost no locomotoric power; they are very dark, they contain only a single Cercaria and very few germballs.

In my area of exploration *C. ephemera* is a very common Cercaria in *Pl. corneus*. It has been found in nine different localities; very often the number of infected snails was very large, about 95 %; double infection with *C. ephemera* and a Xiphidiocercaria is common; in several localities the number was small, only a few per cent. It has also been found in *Planorbis vortex*. For two localities regular observations were made: in one, the moor, Hillerød, in April, May and October 1931, and in April 1932; in the other (Torkeris pond) in May, July, September 1931, and in January, April, May and June 1932. —

Very often the shell of the infected snails is extremely corroded; it is very thin and breaks at the slightest touch; when opened the liver shows a remarkable greyish brown or reddish brown colour. It is often very strongly affected; of the liver substance only very little is left and the surface acquires a peculiar gritted aspect; this is due to the enormous amount of parasites.

When opened, it will almost always be observed that the number of Cercariae is much greater than that of the Rediae; further, as stated above, the number of Cercariae which the Rediae contain is but small, and they are never fully developed. On the other hand, the liver contains enormous amounts of almost fully developed Cercariae. There can be no doubt, as is the rule with the Monostomes, that the Cercariae leave the Rediae before they are fully developed, so that the ripening is completed in the liver itself. Microphoto fig. 1 will show that. — When affected snails are placed in vessels in April—May and brought from the normal temperatures of the ponds (about 4—6° C.) into temperatures of about 15—20° C., they will soon begin to throw out the Cercariae. Regular observations show that only few Cercariae are ejected before 9 o'clock. Then they suddenly appear and often in clouds. They come from the space between the shell and the animal; when the snail has been withdrawn for a short time and then again comes out, a small cloud appears. At 4 or 5 o'clock the ejection ceases. But during the time from 10—4 a vessel containing a single snail may be crowded with Cercariae. The life of the Cercaria as a free-swimming organism is extremely short; a few minutes after the liberation from the snail, they so to speak pounce upon the lighted side of the vessel and fasten themselves there. FAUST (1917 a, p. 35) says that a whole lot of mature Cercariae encyst in two or three minutes after they are freed from the Rediae. If the vessel does not receive light from one side, they dart towards the shell of the snail, and in the course of a few hours the whole shell may be covered with cysts, often to such an extent that they sit side by side, and the shell is thus covered with a homogeneous layer of glossy cysts. Strangely enough, cysts are hardly ever found upon waterplants. In vessels whose inner side was covered with hundreds of cysts, only a few could be found on the leaves of *Elodea* etc.

In ponds and lakes where *C. ephemera* is common the shell of *Planorbis corneus*

is very often covered with cysts. Curiously enough, I have not found them on *L. stagnalis* even if the two snails are lying side by side. As soon as the Cercariae have reached the light side of the vessel, they slide over the glass, using the sucker and the two lateral pockets; the form is incessantly altered, but usually the creeping motion only lasts for a few minutes. It will then be seen that the body acquires a circular form, and immediately after the cystogeneous cells begin to give off a hyaline mass which surrounds the animal. I do not think that it is the cuticula itself which swells and flows out, as WUNDER says (1924a, p. 311) with regard to *C. monostomi*. Only the tail is free. Stretched out perpendicularly from the body and in its full length it moves incessantly with a whipping motion at an enormous speed. During the motion two circles are described, an inner, smaller and closed one, and an outer, much larger and open one behind. The secreta flow out around the body of the Cercaria, leaving a little space behind through which the tail is stretched out. Slowly the tail is constricted at the base, and suddenly it breaks off. The process from the moment of attachment to now has only lasted about 15 minutes. Strangely enough, the tail continues its motion for a long time. Already at two o'clock most of the ejected Cercariae have fastened themselves, but the water is still blackish. A close inspection shows that this is almost entirely due to cast-off tails. During their short lifetime as free-living organisms the Cercariae themselves are more creeping than swimming organisms. The next morning the whole mass of tails is deposited on the bottom of the vessel as a fluffy white mass.

As soon as the tail is cast off, and already a little before, the animal in the cyst begins a rotating movement which lasts rather a long time. During that time the cystogeneous cells uninterruptedly exude matter and so the wall of the cyst is thickened by the deposition of layer after layer. In the completed cyst of *C. monostomi* as well as of *C. ephemera* and of *C. imbricata* the wall consists of three layers: an irregular very hyaline one, which will soon be coloured green or brown by algae, a thicker one of a scale-like structure with the scales extremely small and curved, and an inner one of a hyaline concentric structure (Pl. II, fig. 11). When the wall of the cyst is finished, the animal keeps quiet; it soon acquires a brown colour, but for a long time the eyespots and the sucker are very conspicuous. — The cysts have a glassy appearance and are faintly vaulted like a watch-glass. They are extremely firmly fastened to the substratum. Very often glossy rings occur, but no cysts; they are cysts whose formation has been begun but not completed.

There is no doubt that the ejection of the Cercariae depends partly on the atmospheric pressure. When the barometer is low, in rainy weather and when the sky is overcast, ejection does not take place, whereas it is extremely lively on sunny days with a high barometer.

The temperature and the season have likewise a great influence. —

When *Planorbis corneus* from Torkeris pond and another pond, Donse pond, where *P. corneus* has also been regularly observed, were taken into the laboratory in November—December no Cercariae appeared. On dissection it could nevertheless

be shown that of 75 specimens 5 were heavily infected. In these five specimens there were few Rediae, but the number of Cercariae was enormous; they seemed to be fully developed and appeared in the water exactly as in spring and summer; they encysted in the course of a few hours. In January (29/I, 32) 4 of 10 *Planorbis corneus* were found to be infected. None of them showed any Cercariae, but when they were dissected, enormous amounts of Cercariae appeared. On coming into the water, they lay motionless at the bottom of the vessel for some time; however, when the vessel was placed in the biological thermostat at a temperature of 22° C. they began to swim, and a few hours later they were all encysted on the vessel. The ponds were now frozen, but on 6/IV, when the temperature of the water was only 4° C., 40 *Planorbis corneus* were gathered. On 7/IV, 35 threw out enormous masses of Cercariae. The temperature of the water in the vessels was 19° C.

In other words, this means that during the whole winter the Cercariae hibernate in the snail; most of them are produced in the autumn, whereupon they leave the Rediae and are then found free in the liver. The production of Cercariae almost ceases at a temperature near zero. The Rediae themselves are very dark, almost black; they may contain one or two fully developed Cercariae and 6—8 germballs, all of nearly the same size. I had expected at that period to find Rediae producing Rediae; perhaps I have overlooked them. As mentioned under *C. imbricata*, Rediae producing Rediae may exist also among Monostomes.

It is a very peculiar fact that a liver may be crowded with Cercariae for about 5—6 months and nevertheless, during the whole winter, be used as a functioning organ by the snail. In January, and especially in April, it was very difficult to gather the above-named numbers of snails. Very many empty and much corroded shells were found along the banks of the pond. They showed that numerous snails die during the winter, and it seems highly probable that a large percentage have really been killed by the parasites. — On the other hand, that the snails may actually live for a long time with parasites is clearly shown by the following experiment. —

Three snails from 6/IV 32 which immediately showed Cercariae were placed each in its own vessel; during the time 6/IV to 1/V the water was changed every day; every day the snails ejected a large amount of Cercariae; temperature and air pressure influenced the number. During the latter part of April the number diminished, and in the first half of May the ejection ceased altogether. The snails were under regular observation, but no Cercariae could be observed. On 20/VII the snails were dissected. The liver contained only Rediae; no Cercariae were found there; the Rediae themselves were remarkably short. They contained only 1—2 Cercariae and a few germ-balls, all small, and all of the same size. It seemed to me as if the liver would recover and the active role of the Rediae had ceased.

How long the Cercariae can live in the encysted state I do not know with certainty. Vessels whose lighted sides were covered with a thick layer of cysts were set aside on 15/IV and observed at different times. It was very difficult to see when the Cercariae were really dead. As late as June the Cercariae still moved on pressure.

When the vessels were again examined in October, most of them contained Cercariae with a conspicuous sucker, but no motion could be discovered. Many of the cysts were now empty.

It is a well known fact that in the blind gut of our water-birds there often occur monostome Trematodes belonging to the two genera *Notocotylus* Diesing and *Catatropis* Odhner. LÜHE and LOOS supposed that *C. ephemera* and *C. imbricata* belonged to the developmental cycle of these worms. SZIDAT (1930 a, p. 105) has tried to solve the question and contributed very much to its solution. He found that the cysts occurred partly on shells, but also in great number on water-plants. As mentioned above, I for my part have not observed this in my aquaria. SZIDAT now fed geese and ducks with cyst-infected water-plants and later found the ripe worms in the blind gut. The eggs, furnished with very long threads, were ejected with the excrements into the water, and the eggs or Miracidia again infected the Planorbis. There is no doubt, therefore, that *C. ephemera* are swallowed by ducks and geese as cysts and attain maturity in the coecum.

On 20/VII 31, I found, on a moor (Vixø Moor) near Hillerød, in 3 of 30 *Planorbis vortex*, a little Monostome which I refer with some doubt to *C. ephemera* (Pl. I, figs. 4—7). There were not more than 30—35 Rediae in the snail; these Rediae were not long and thin but short, clumsy, very irregular and often furnished with deep indentations. Often the indentation separated an anterior chamber with large Cercariae from a posterior one only containing germ-balls, diminishing in size from the anterior towards the posterior end (fig. 7). The Cercariae were extremely dark, perhaps not quite ripe, the posterior lateral organs were not always fully developed. The size was only half that of *C. ephemera* but, this apart, I found no differences between the specimens from *Planorbis corneus* and from *P. vortex*. The Rediae never contained more than two or three Cercariae; in the snails, there were not more than 60-70 Cercariae. If we have here to do with *C. ephemera*, it is very interesting to note how the small space in *P. vortex* influences not only the form of the Rediae but also the size of the Cercariae. Arrived in the water, the Cercariae swam around; but they would not encyst, and in the course of the day they all died.

***Cercaria monostomi* v. LINST.** Host: *Limnaea* species.

Pl. II, figs. 1—4.

The dimensions are

	<i>Cercariae</i>	
	Living	Preserved
Length of body	570	390—470
Breadth of body	165	107—174
Length of tail	550	318—405
Breadth of tail	90	76—83
Sucker	70	40—48

Rediae.

	Living	Preserved
Length	2280	1460—1892
Breadth	180	25—314

In the Cercaria stage I have been unable to find any considerable difference between this species and *C. ephemera* Nitzsch; it seems perhaps to be a little smaller; both possess three eyes; the oral sucker, the "triclad" intestine, the excretory system, and the tail seem to be of exactly the same structure in both species. LÜHE (1909, p. 179) supposes there is a small pharynx; but neither DUBOIS (1929, p. 31) nor GWENDOLEN REES (1932, p. 9) nor I have been able to see it. The lateral organs according to DUBOIS (1929, p. 30) possess cementing glands (cellules glandulaires). I regret that I have not found them. The most conspicuous difference in the structure of the two species is that the pigment tends to arrange itself in four parallel longitudinal lines, two dorsal and two ventral ones, which run through the whole body from the pigment-mass around the eyes. However, they are not always conspicuous, and are not developed in young animals. GWENDOLEN REES (1932, p. 9) has seen one flame cell on each side of the oral sucker. The differences between the two species are found in the Rediae and in the biology of the two species. Whereas the Rediae of *C. ephemera* are not more than about 1 mm those of *C. monostomi* attain c. 2—3 mm or more.

The Rediae of *C. ephemera* may often be of a very irregular shape with a rather thick skin, much broader in the middle or behind. Often they show deep indentations. Those of *C. monostomi* are very long sacks with a very thin skin, the breadth is almost the same throughout; indentations do not occur. Whereas the Rediae of *C. ephemera* are often of a vivid red colour, those of *C. monostomi* are hyaline and colourless. This may be due to the fact that *C. ephemera* is found in an animal with red blood, but nevertheless it must be noted that the colour is another, more orange, differing much from the cherry-red blood of a Planorbis. The sucker is very small, much smaller than that of *C. ephemera*, and the intestine a long sack filling almost half the breadth of the Redia, and without indentations. Just as in *C. ephemera*, fully developed Cercariae are found in great numbers outside the Rediae, but here the number of Cercariae occurring in a Redia is much larger. It may be 7—8, and then the Cercariae lie in a long row. In these Cercariae in the Rediae not more than two eyes are visible. The intestine almost reaches the end of the Redia, but there is always a part left which is packed with germ-balls increasing in size from behind towards the front (Pl. II, fig. 4).

C. monostomi is found almost exclusively in *Limnaea* species, mainly *L. stagnalis*, *L. ovata*, *L. peregra*, and *L. palustris*, *C. ephemera* in *Planorbis corneus*. DUBOIS (1929, p. 31) has found *C. monostomi* in *Planorbis carinatus*. In Denmark it has only been found a few times in Tjustrup Lake (on 15/V 32), 1 of 7 specimens in *L. stagnalis*; and on Amager in *L. ovata* (on 27/IV 32) (3 specimens out of 40). None of the snails showed that they were infected. On dissection the whole liver was found to be packed

with brood. Suddenly while I was observing the Cercariae, one of them cast its tail and shortly afterwards another did so too. A few minutes after the snail had been opened, very many of the Cercariae had changed into cysts. LÜHE (1909, p. 179) says: "Encystierung der Cercarien soll nicht im Freien sondern ebenfalls in *Limnaea ovata* und *L. peregra* erfolgen". This seems to be correct, but hitherto I have not had the good fortune to find monostome cysts in a snail. That the Cercariae of *C. monostomi* behave differently from *C. ephemera* which always live as free organisms for several hours is beyond all doubt.

Owing to the presumed difference in the manner of encystment, but especially owing to the great differences in the structure of the Rediae, the monostome Cercaria of the *Planorbis* and that of *Limnaea*, the two species *C. ephemera* and *C. monostomi*, may provisionally be regarded as specifically different forms. The difference in the way in which the pigment is arranged in the two forms, more diffusely in *C. ephemera*, more in four parallel longitudinal lines in *C. monostomi*, a fact which has already been mentioned by LÜHE, would seem to strengthen this view.

Cercaria imbricata Loos. Host: *Bithynia tentaculata*.

Pl. II, figs. 5—11.

The dimensions are

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	215	143—255
Breadth of body	140	112—132
Length of tail	250	246—307
Breadth of tail	20	44—53
Sucker	45	29—37
	<i>Rediae.</i>	
Length	1060	1074—1327
Breadth	380	258—272

The body is smaller than that of *C. ephemera* and *C. monostomi*. It is not leaden-coloured but brown, owing to the rich development of pigment, which is spread over the whole body. But here also it mainly follows the parallel longitudinal lines of which especially the two dorsal ones are rather conspicuous. The cystogeneus cells occupy almost the whole body; sections show that here also, just as in *C. ephemera* they are about half the height of the body. Among them are scattered larger cells ("les cellules géantes" DUBOIS (1929, p. 32)). According to the same author, there are six pairs of irregular cells (cellules glandulaires caudales) in the tail. I have only seen some inconspicuous ones. In the structure of the intestine and the excretory system I have been unable to find any difference from the two above-named species. Whereas all authors allege that they have observed three eyespots, I have never seen

more than the two lateral ones clearly; the median one has always been inconspicuous. I can find no differences in the structure of the lateral organs of *C. imbricata* and *C. monostomi*. — The Cercariae live as free-swimming organisms for a short time; then they fasten themselves upon the lighted side of the vessel.

The Rediae are shorter than those of the two first-named species, especially that of *C. monostomi*. The muscular pharynx is rather large, and the mouth itself capable of extrusion as shown in Pl. II, fig. 10. The borders of the mouth-opening are furnished with short spines. I do not know if this is common to all the Rediae of Monostomes, but with regard to *C. pellucida* Faust (1917 a, p. 59) describes a similar organ, saying "In the prepharynx region is a unique piercing organ, probably of ectodermal origin. It is four-lobed and is covered with spines." Like FAUST I have observed the rhythmic eversion of the organ against the host tissue, and the withdrawal, within the pharynx region. As in all monostome Rediae hitherto observed by me, there are no lateral appendages. LÜHE (1909, p. 178) mentions "Zwei seitlichen, bei älteren Exemplaren sich abstumpfenden Fortsätzen in der Nähe des blinden Darmendes". The intestine is very peculiar. It is very broad, not straight, but almost always strongly curved with several windings; this is most conspicuous in the young Rediae. There is not much room for the Cercariae of which only rarely more than 2—4 simultaneously reach the stage with two well-developed eyes before birth. The intestine may or may not almost reach the posterior end of the Redia. Close to it are always found many germ-balls often arranged in two series (Pl. II, fig. 8). Not only the intestine, but also the spaces between the windings may contain a great amount of yellowish red oil globules which give the Redia a yellow tint. —

During the past two years I have dissected about 150 different snails infected with monostomous Cercariae (of *Planorbis corneus* 104, of *Bithynia tentaculata* about 25). In all cases I have only found Cercariae-producing Rediae. On 20/VII 32, out of 30 *Bithynia tentaculata* originating from a little brook near Arresø, two were found in which the Rediae produced Rediae; in one specimen all the Rediae contained Rediae only, in the other only some of them contained Rediae; some of the Rediae contained Rediae as well as Cercariae. In the literature I have only found a single case mentioned. Of this very species LÜHE (1909, p. 178) says that: "Anscheinend folgen vor der Entstehung der Cercarien mehrere Generationen dieser Redien auf einander". As far as I know, this is the first case in which this observation has been confirmed.

I regard the above-named species as *C. imbricata* Loos. — DUBOIS (1929, p. 32) has described a new species *C. helvetica* I, differing from *C. imbricata* in the following three points: The Rediae are smaller, there are no lateral appendages, and the intestine is very large, reaching the posterior part of the Redia. Since the Redia of *C. imbricata* is large, has small lateral appendages, and a thin intestine only reaching "über die Körpermitte", DUBOIS has made a separate species of it. In the Cercariae of the two species DUBOIS has found no differences. As long as we do not know to which species the Cercaria belongs, and both are found in *Bithynia tentaculata*, I think it better

to refer the form which I have found to *C. imbricata* Loos. I admit that it agrees on all three points with Dubois's specimens. —

In Denmark *C. imbricata* is fairly common. It has been found in 12 localities. Most of them are small ponds, but in one case it was at a depth of 3—4 m. in one of our largest lakes, Esrom Lake. The number of infected snails is never very large. In Esrom Lake (on 29/IX) only two out of 200 were infected, on 14/V only six out of 150. Only rarely did the snails voluntarily give off the Cercariae; in most cases they were only found after dissection. The number of free Cercariae is much larger than that of the Rediae, which rarely surpasses about 30—50; many of the free Cercariae are not wholly ripe and move but slowly; the ripe Cercariae dart towards the lighted side of the vessel and encyst in the course of a few minutes. Encystment on the shells was not observed. —

Double infection with *C. imbricata* and a Xiphidiocercaria was often observed.

After the appearance of SZIDAT's important paper (1932a, p. 205) relating to the development of *Tracheophilus sisowi* Skrj. I have hitherto searched without success for the developmental stages of this very interesting form in *Planorbis corneus* and *Planorbis umbilicatus*. It was SIEBOLD (1835, p. 69) and WAGENER (1858, p. 88) who in Miracidia of *Monostomum mutabile* found "einen bereits völlig-entwickelten Sprössling" (a Redia). LEUCKARDT (1886, p. 75) cites the literature. SZIDAT found juvenile stages of *Tracheophilus sisowi* Skrj. (fam. *Cyclocoelidae*) and discovered the very remarkable fact that *Tracheophilus sisowi* Skrj. did not develop from Monostomes but from distome Cercariae. It was experimentally shown that the *Planorbis* species is the main host for the Miracidium. SIEBOLD's and WAGENER's observations have been corroborated. When it leaves the egg, the Miracidium contains a ripe Redia, a Sporocyst stage being omitted. The Redia introduced into the snail with the Miracidium produces no new Redia generations, but there is a direct production of Cercariae; the number of these is but small. The Cercaria does not leave the snail but encysts near the Redia, and is transferred to the final host (ANAS) when the snails are eaten. — Entering the intestine when the capsule of the cyst is dissolved, the young trematode pierces the wall of the intestine and enters the lungs with the blood or through the body cavity, and sooner or later reaches its destination, the bronchia and trachea. — These very interesting studies finally elucidated the development of the fam. *Cyclocoelidae*, which was hitherto quite unknown. Undoubtedly the whole development of this very interesting form may also be studied in our fresh-waters. —

Biological Remarks.

With regard to the biology of the Monostomes reference is made especially to pp. 13—16.

If the Monostomes are taken in the limitation here indicated there are four points in the biology to which special attention should be paid. —

1. The development of the Cercariae appears always to take place in a Redia. As far as I know, no one has seen monostome Cercariae develop from sporocysts.

On the other hand, the old observation by SIEBOLD (1835, p. 69) and WAGENER (1858, p. 88) with regard to *Monostomum mutabile* and *flavum*, and the recent observations of SZIDAT (1932a, p. 205) with regard to *Tracheophilus sisowi* Skrjabin, corroborate the fact that the Rediae of Monostomes may develop directly from the Miracidium without any Sporocyst stage. Whether this is the general rule is another question.

2. The development of the Cercaria is not completed in the Redia itself but in the snail where the Cercaria is most probably nourished by the blood of the host. A connection between the two facts: no Sporocyst stage and development of the Cercariae outside the Rediae, would seem fairly probable. Omitting the Sporocyst stages the Monostomes have not the same power of enormous germ production as most of the other Trematoda. For this purpose they only possess the Redia stage. Curiously enough, the number of Redia generations seems to be small; only very rarely are daughter Rediae observed; the Rediae almost always contain Cercariae, but very often we find a few half-grown Cercariae ready to be hatched, and then, in the posterior part of the Redia, very many germ-balls all nearly the same size. It may perhaps be allowable to suppose that the Rediae produce sets of Cercariae over a very long period, which mature to the birth stage, one after the other. The enormous amount of Cercariae produced, often greatly surpassing that of the Rediae, would not seem to contradict this view. The immense production of Cercariae in a Trematode without Sporocysts and few generations of Rediae would not be possible if the development of the Cercariae were to be completed in the Rediae.

3. No intermediate hosts occur. Encystment takes place either in the open, on stones, water-plants, etc. or perhaps in the snail in which the Cercariae are hatched. It is a question if this latter form of encystment is normal. The life of the Cercaria as a free swimming organism is very short; normally restricted perhaps to only a few minutes. —

4. All monostome Cercariae hitherto known seem to be strongly phototactic, and the moment when the Cercariae leave the snail appears to be dependent upon the light and a high atmospheric pressure. Whether there is any connection between these facts and the remarkably strong pigmentation, much stronger than in almost all other Cercariae, remains to be shown by further investigations.

Chapter II. Amphistomata.

The amphistome Cercariae are always recognisable from all other Cercariae by the very large ventral sucker bordering the posterior part of their body, and the peculiar course of the main excretory canals which are filled with globular masses of refractive excretory matter. They are among the largest Cercariae known. Owing

to the big body and the relatively feeble tail the power of locomotion is but slight. They live near the bottom; their life as free-swimming organisms is but brief. —

The Rediae have or have not posterior locomotoric appendages (two pairs: *C. inhabilis* Cort 1915a, p. 21), best developed in the younger stages. The intestine is short, often not longer than the well-developed pharynx. There seems to be only one Redia generation. The Cercariae leave the Rediae at a very early stage of development, and are nourished directly by the tissues of the snail. —

The encystment regularly takes place in the open; there is no intermediate host; encystment in the primary host, the snail, has been observed.

Most of our knowledge with regard to the development of the Amphistomes derives from the studies of Loos. In 1892, p. 147, he described the Cercaria of *Amphistomum subclavatum* (= *Cercaria diplocotylea* Pagenst.); in 1896, p. 177 the development of *Gastrodiscus aegyptiacus* (Cobbold) and of *Amphistomum conicum* R. (1896, p. 185), showing that *Cercaria pigmentata* Sonsino really belonged to this species.

CORT (1915a, p. 24) referred these species to two groups. To the one was referred *C. pigmentata* Sonsino, to the other the two other above-named Cercariae. To these CORT added three American forms. The first belonged to the subfam. *Paramphistomidae*, the other to the subfam. *Diplodiscinae*, and SEWELL (1922, p. 66) created two groups, the *Pigmentata* and the *Diplocotylea* group, and added three Indian forms to the *Pigmentata* group and one to the *Diplocotylea* group. The two groups are best distinguished by the absence (*Pigmentata* group) or presence (*Diplocotylea* group) of pharyngeal pouches. Later on FAUST (1919b, p. 173) added an African form and Mc. COY a new form from Missouri (1929, p. 200). BEAVER (1929, p. 13) and KRULL and PRICE (1932, p. 13) each contributed one form. The number of species of the *Diplocotylea* group is now 10, of which only two belong to the European fauna.

Only very few Amphistomes are recorded from Europe. Reference may here be made to the lists of FUKUI (1929, p. 219) and LÜHE (1909, p. 36 and p. 180). *Paramphistoma cervi* and *Diplodiscus subclavatus* are the main forms; the former is found in the mature stage in plant-eating mammals, the latter in amphibia. It is rather peculiar that the Amphistomes are only represented by so very few species in the European fauna and that, as far as I can see, they belong mainly to the tropical or subtropical zone; further that the Amphistomes which are common in the temperate zone mainly develop in aquatic animals such as frogs, salamanders, snakes, turtles. It is a question if this distribution is really normal and if the extinction or ever-increasing scarcity of great mammals in the temperate zone has not caused the extinction also of the parasites, so that we have mainly kept those species which develop in aquatic animals. After the papers of Loos especially CORT (1915a, p. 24), SEWELL (1922), BRUMPT (1929b, p. 262), KRULL and PRICE (1932, p. 1) and CHATTERLEY (1931, p. 177) have added to our knowledge of this noteworthy group. From his own observations of the development of *Paramphistomum cervi*, and drawing on the literature, BRUMPT (1929, p. 262) points out that the Cercariae of the Amphistomes

are born in a very early stage, and that the Cercariae are free parasites in the tissues of the snail, where they attain full development. KRULL and PRICE (1932, p. 18) confirm this observation. BRUMPT gives very instructive photos. I can only corroborate the observation, but I think it may be added that, at any rate as far as my experience goes, this is also the case with all Monostomes. —

Cercaria diplocotylea FIL. Host: *Planorbis umbilicatus*.

Pl. III, figs. 1—4. Microphoto Pl. XXXVIII, fig. 18.

Cercariae.

	Living	Preserved	
Length of body	850	746—955	
Breadth of body	550	337—466	
Length of tail	1760	554—866	
Breadth of tail	170	101—143	
Anterior Sucker	180	103—159	
		Length	Breadth
Posterior Sucker	350	184—200	213—3

Rediae.

Length	2600
Breadth	680

It is very difficult to give a correct description of the form of the Cercaria, because as swimming as also as a creeping organism, it is always changing its form. The figures shown (fig. 2 a—c) are half camera, half freehand drawings of the same animals, drawn in the course of 5 minutes. When the animals alter their shape from that exhibited in fig. 2 a to that seen in fig. 2 c, it is as if a wave passes forward from the tip of the tail, whereupon the animal, when this stage is reached, remains in that form for some time. It is a characteristic feature that three rather sharply defined dilatations are almost always observed in the tail, and that a snoutlike process before the eyes is commonly very conspicuous. This part of the body especially is extremely mobile and variable in form.

The Cercaria is very opaque, owing to the large amounts of pigment, most abundant in the forepart and around the eyes (not drawn in the figure); it consists of blackish brown specks scattered through the whole thickness of the body. The opaqueness is also due to the strongly developed cystogeneus glands, occurring dorsally as well as ventrally, and filling out the whole space between the oral and ventral suckers. The glands appear as small round or pear-shaped bodies, filled with rod-shaped granules (not drawn in the figure). — There are two very conspicuous, highly developed eyes, composed of a large lens and a pigment cone; between them lies the bandlike grey brain. There are no papillae around the mouth. It opens into

the oral cavity; posteriorly the oral sucker is furnished with two pharyngeal pockets. The oesophagus is a long thin tube which, immediately before the bifurcation of the coeca, shows a transversal muscle striation. It looks more like a pseudo-pharynx than like a real one. The two coeca have thick walls and a remarkably long transversal course, and, with the lateral one, almost reach the ventral sucker. The ventral sucker is enormous, filling more than a third of the ventral side. Owing to the opaqueness of the animal, it is very difficult to study the excretory organ. The triangular bladder is rather small, it is placed immediately before the ventral sucker. It gives off two broad transversal excretory canals, which form a loop just above the posterior part of the coeca, whereupon they pass forwards, curving inwards below the transversal parts of the coeca whereupon they form a large bow outwards, and turning forwards they reach the eyes. I have not been able to see the returning canals in the forepart of the body, but in the posterior part they have been seen as two thin ramified canals reaching the sides of the ventral sucker; flame cells were not observed. The broad parts of the excretory tubes are filled with refractive globules. From the bladder there issues posteriorly a large single tube, passing through the whole length of the tail; the lateral canals opening near the tip of the tail have been overlooked (observed by Loos a. o.). In the middle of the body lies a dense circular mass which is the beginning of the reproductive organs. —

The tail is extremely mobile; it may be only one-third of the body length or longer than the body. It may also be as broad as the body or only one-fifth of its breadth. It is attached a little above the acetabulum; it very often breaks off. Circular muscles were not observed, but a layer of longitudinal ones, and inside of them a layer of irregular parenchymatous muscles. — When swimming, the animal presents a peculiar appearance (Pl. III, fig. 3) owing to the fact that the tail is first thrown up along the sides of the body, and then backwards, describing two curves, the first with the opening anteriorly, the other larger, with the opening posteriorly.

The Redia (Pl. III, fig. 4) exhibits some peculiar structures. It is commonly of a long, often cylindric, form; there is no collar, nor are there posterior locomotoric appendages; it often tapers posteriorly. The pharynx is rather large and globular; the stomach is not much larger than the sucker, it is of a regular globular form which I have not hitherto found in Rediae; it is connected with the sucker by a very short oesophagus. It is of a peculiar yellow colour and contains a number of small strongly refractive bodies. The walls are very thick. Strangely enough, in numerous specimens there occurs a dark pigment spot, beginning laterally between the stomach and the body wall; in some cases it is not present, in others only faintly developed. When fully developed, it looks like a pigment eye. The Rediae contained germ-balls and Cercariae in a very early stage of development. Posteriorly they are very small, arranged in two rows; they increase in size anteriorly, and are then only present in a single row. Rediae in Redia production have not been observed. As is always the case with the Amphistomes, the Cercariae leave the Rediae at a very early stage and are found scattered in the tissues of the snail. —

Cercaria diplocotylea was found in *Planorbis umbilicatus* in eight of a hundred specimens and only in a single locality in a small pond at Regnstrup Overdrev near Sorø. It was found on a journey, and I had no opportunity of studying the biology. A brief account of the literature relating to the very interesting process of encystment may be given here. LANG (1892, p. 83) shows that the encystment takes place on frogs. Infection follows when the frog swallows its own skin with the cysts attached. Loos (1892, p. 166) points out that the frogs do not commonly swallow their own skin, and that many cysts may be found at the bottom of the ponds, and are introduced into the alimentary canal, especially during winter, when the frogs hibernate on the bottom of the ponds and feed on the sediments accumulated there. Young Amphistomes together with fragments of cysts have been found in the digestive system and near the parasites. Interesting supplementary notes have been added by KRULL and PRICE (1932, p. 1). The intermediate host of *Diplodiscus temperatus* is *Heliosoma trivolvis* but curiously enough all attempts to infect the snails "ranging in size from newly hatched to mature ones" were without success. Loos (1892, p. 155) successfully infected *Planorbis nitidus* and *vortex* with Miracidia of *Amphistomum subclavatum*. An infected snail kept in an aquarium from 26/X 1929 to 2/VIII, 1930, according to KRULL and PRICE shed Cercariae every day; as in other species there was a special time of the day when most of the Cercariae were shed; in this case the afternoon. Their lifetime is not more than half a day. Encystment begins as soon as the water evaporates and has become so shallow that the Cercariae are exposed to the air of the atmosphere. This does not happen in aquaria with a large amount of water; even if pebbles, lettuce and dry leaves are placed in the container, no encystment takes place. On the other hand, encystation occurs, especially on the pigmented spots, as soon as frogs are placed in the aquarium. According to the authors, the encysted stage sometimes lasts a few days only. KRULL and PRICE further show that frogs become naturally infected by devouring their own stratum corneum on which the Cercariae encyst, tadpoles by eating Metacercariae which they pick up with the pond ooze. The authors further point out the interesting facts that free-swimming Cercariae are drawn into the mouth of the tadpole with the respiratory currents, and that these Cercariae immediately encyst in the mouth cavity and, when carried into the intestine, are infective. — Similar investigations on our European frogs would be of great interest.

Chapter III. Gymnocephala.

At the present stage of our knowledge, the gymnocephalus group of Cercariae is in a state of chaos, and cannot be divided into sub-groups. With SEWELL (1922, p. 89) I dissent from LÜHE'S view that the *Gymnocephala*, *Echinostomata* and *Xiphidiocercaria* must be referred to a special group, the *Leptocercaria*; on the other hand,

I cannot see that the subdivision of SEWELL into four groups: the *Parapleurolophocerca* group, the *Isopori* group, the *Agilis* group, and the *Reflexa* group, is of any value with regard to the European forms. Many of the European species have only been observed once, and described by FILIPPI (1854—1855—1859) from Italy. The American forms described by CORT (1915a, p. 31) and others, and the Indian ones described by SEWELL (1922, p. 94), show structures which we do not find in the European forms. On the other hand, these do not appear to be referable to the American or Indian groups. How doubtful the subdivisions are can best be seen from the fact that CORT (1915a, p. 31) (*C. megalura*), as well as SEWELL (1922, p. 89) (*C. Indica XIV*), have described forms which cannot be placed in any of their groups.

In Denmark we possess:

- Cercaria fasciolae hepaticae* Thomas
- *tuberculata* Fil.
- *papillosa* Fil.
- *helvetica XIX* Dubois
- *grandis* n. sp.
- *obscura* n. sp.
- *lophocerca* (Fil.).

As far as I can see, we have to do with four different types: The *C. tuberculata*, *C. papillosa*, *C. helvetica XIX* and *C. grandis* represent one group. The others represent each one group. Especially according to GWENDOLEN REES's account, *C. fasciolae hepaticae* seems to differ conspicuously in form from all other Gymnocephala; *C. helvetica XVII* and *C. lophocerca* which is most probably identical with *C. fulvopunctata* Ercolani, referred by LÜHE (1909, p. 186) to the *Gymnocephala*, are only with doubt placed here.

As far as I can see, the European gymnocephalous Cercariae have the following characters: Two suckers, which only rarely differ very much in size, the ventral sucker commonly lies behind the middle line of the animal, it has no rows of spines.

No stylet or stylet glands, but often salivary glands. —

A strong development of cystogeneus glands.

A well-developed pharynx, oesophagus and intestinal coeca which commonly do not reach much behind the ventral sucker; the whole organ often very inconspicuous; it may be of the rhabdocoeleous type. The excretory system with the two main excretory tubes which almost reach the oral sucker, here forming a loop, whereupon they pass backwards, almost reaching the bladder; a posterior tube in the tail; most probably it has normally two lateral ducts.

A Sporocyst stage as far as I know has only rarely been observed. The development of the Cercariae takes place in Rediae, with a well-developed collar and posterior locomotoric appendages. Encystment as a rule takes place in the open without any intermediate host, but in many cases and perhaps under bad life conditions in the same snail in which they have been hatched. —

Some of the species which have been regarded as Gymnocephales will only with difficulty be brought under this definition. This applies especially to *C. lophocerca* (Fil.) = *L. fulvopunctata* Ercol. whose place in the system will always be doubtful. —

Of the gymnocephalous Cercariae LÜHE (1909, p. 182) distinguishes 10 different species.

Whereas LÜHE mentions species from *Limnaea* species and from *Paludina vivipara*, curiously enough I have, apart from *Limnaea truncatula*, never found gymnocephalous Cercariae in any of these snails; all the other six species derive from *Bithynia tentaculata*.

***Cercaria Fasciolæ hepaticæ* Thomas.**

Pl. XXXV, fig. 1–8.

The Sporocyst and Redia are described by LEUCKART (1882, p. 80), the Cercaria by THOMAS (1883a, p. 99, 1883b, p. 469) to whose descriptions the reader is referred. See also WRIGHT (1927, p. 47).

The dimensions are:

	<i>Cercariae.</i>	Preserved
Length of body		200—360
Breadth of body		130—240
Oral sucker		60
Ventral sucker		70
Length of tail		400—700

The body is extremely variable in form; fig. 4 shows some of the commonest forms, all drawn from the same individual, and in the course of a few minutes. It may often be heart-shaped, as figured by LEUCKART, THOMAS, and GWENDOLEN REES, but very often it is rectangular or almost quadrangular as is the case with most of the other Gymnocephales; there are no caudal pockets, but the tail is often a little withdrawn into the body; the thin cuticula of the body is covered with very small papillae, which are arranged in transversal rows. The oral sucker is almost terminal and a little smaller than the ventral one, which lies a little behind the middle line of the body; it bears no concentric rows of minute spines; it is strongly protrusile. The whole body is extremely opaque, almost dark, filled as it is with a large amount of cystogeneus cells; in young animals, especially in those which still lie in the Rediae, they are not so strongly developed, lying as two broad dark bands one on each side of the sucker; in specimens which have lived for several hours in water they almost hide all organs, forming a broad transversal ridge around the ventral sucker. With regard to the difference between cystogeneus and parenchymatous cells I refer the reader to GWENDOLEN REES (1932, p. 11) and with regard to the alteration of the tissues preceding the cyst formation, to BOVIEN (1931, p. 223). After a short prepharynx follows a well developed pharynx, whereupon the oesophagus at a short

distance from the ventral sucker divides into the two intestinal coeca which almost reach the posterior edge of the body. The excretory vesicle consists of two parts which are only for a short time filled simultaneously. From the anterior part issue two crescent-formed canals with their broadest part a little above the ventral sucker. Along the outer side of the canals runs another, very thin one, whose junction with the broad canals I have been unable to see. Of vibratile tags WRIGHT (1927, p. 47) saw 7, GWENDOLEN REES (1932, p. 12) 10 on each side. Posteriorly from the bladder issues a tube which at a distance of about one-fifth from the apex of the tail divides into two branches opening on each side of the tail. The tail itself is a strong locomotoric organ with transversal and especially strongly developed longitudinal muscles. The interior is filled with parenchymatous cells fastened to the walls by long threads. The tip of the tail is peculiar. More than in most of the other Cercariae it is always altering its form. In the course of a few minutes it may be blunt, drawn out in a long acute point, or drawn in again, so that the tail seems to end in a cup-shaped sucker-like organ.

Normally the life of the Cercariae seems to be extremely short, never more than 24 hours. I have seen Cercariae come out of the Rediae and in the course of half an hour encyst upon the cover under the microscope. In vessels they always seek the lighted side and encyst there in the course of a few hours. The material forming the cyst wall flows out from the whole surface of the body; first comes a very hyaline mucous substance, which agglutinates the cyst to the substratum, and then the material from the cystogeneous glands, forming the inner cyst wall; in the course of some minutes the cyst is formed and shortly afterwards the tail, which has moved vigorously during the whole process, is thrown off.

The Redia is an oblong body differing very much in form in the various specimens; the older they are, the more aberrant is the form. There is a conspicuous collar; the two posterior locomotoric appendages are best developed in the young stages; in the old ones they may be totally absent; a birth-pore is usually conspicuous. The voluminous pharynx opens in an intestine which in the older stage may be $\frac{1}{7}$ to $\frac{1}{8}$ of the length of the body, but in the younger ones more than half of the body length; a series of muscles run from the collar and the intestine to the body wall. The excretory system is very conspicuous (Pl. XXXV, fig. 5); it consists of two canals, the one passing forwards the other backwards, and uniting above the locomotoric appendages in which a series of branched canals may be observed, both carry at their tips a number of vibratile tags which are difficult to observe, owing to the abundant progeny which generally fills the interior of the Redia. A full grown Redia usually contains about 20—30 germs; daughter Rediae as well as Cercariae may be present simultaneously, but as a rule the Rediae produce either Rediae or Cercariae. The number of full-grown Cercariae rarely seems to surpass 2—3; when pressed, they may often be observed to pass out of the birth pore. In the old stages is often observed an anterior part, with the intestine and the few full-grown Cercariae, and a posterior part containing the germ balls.

The Rediae which, especially in the younger stages, have a considerable power

of locomotion, pass from the lung cavity where they have been developed in Sporocysts (THOMAS) along the alimentary canal till they have reached the liver, where the further development goes on.

Owing to its great economic significance, originally pointed out in Europe but later on realised in all continents and in almost all climates, the life history of the liver flukes and especially that of *Fasciola hepatica* has been very carefully studied. In its broad features it was, as is well known, cleared up simultaneously by LEUCKART (1882, p. 80) and THOMAS (1883a, p. 99). Nevertheless it cannot be denied that there still remained many points in the biology of the animal which required elucidation and especially those of economic interest. Some of these points are enumerated below.

1. Is *Fasciola hepatica* strictly bound to the single snail *Limnæa truncatula*?
2. Investigations in Europe seemed to show that this was practically so; simultaneously foreign explorations showed that the rot had a much greater extension than the snail, and that it occurred over areas where *L. truncatula* was never found. Hundreds of thousands of sheep are killed in North-America, in Africa, and in Australia, and the disease is present in Asia. The question then arises: What was the host in these areas?

3. In Europe *L. truncatula* is the main host. It deviates from other *Limnæa* species by being more terrestrial than these; in arid periods of the year it may almost be regarded as a land snail. It was to be expected that an extermination of the rot would be dependent upon the extermination of the snail, and this again demanded a more extensive knowledge of the biology of the snail.

4. A more elaborate study of the life history of *Fasciola hepatica* was highly desirable on many points. As *Fasciola hepatica* has a larva with a vigorous locomotoric organ, only to be used in water, the question was how the Cercaria would behave if living in a snail which for the greater part of its life was found outside water.

5. THOMAS has shown that encystation takes place, but no knowledge was gained as to where the cysts were found in nature. It could be regarded as highly probable that sheep and cattle were infected by eating the grass containing the cyst. But it was of the greatest economic significance to know how long the encysted Cercariae kept their vitality intact, and to find out if they could endure desiccation and be brought with the hay into the loams and from them during the whole winter be able to infect the animals.

6. Even if it could be regarded as proved that infection of sheep and cattle was established by means of cyst-infested hay, the possibility could not be denied that infection might also take place in other ways: 1) by drinking water infested with swimming cysts detached from the hay; 2) from infested snails found in the grass and swallowed with it; 3) from free Cercariae swimming in the morning dew upon the meadows; these suppositions were worth experimental study.

7. The degree of infestation of the snail, and the main time for the infestation of sheep and cattle.

Owing to a long series of elaborate studies these points may now be regarded as elucidated; this paper cannot bring new facts about them, and mainly for the following rather peculiar reason.

In spite of the fact that the rot is by no means rare in Denmark, even though we have not suffered from large epidemics, I have searched in vain for infested *L. truncatula* material. *L. truncatula* is a rather sporadically occurring snail, and in my area of exploration I have only rarely seen it. It was rather common at the inundated borders of Tuel Lake near Sorø; several hundred snails were dissected, but the parasite was not found in one of them. During two summer sojourns near the great now almost desiccated bay Lammefjord, on whose now rarely inundated or totally dry meadows many sheep and cattle pasture, *L. truncatula* was found and in several localities near the great estate Dragsholm; more than 500 snails were dissected; not a single one was infested. As is well known, the rot is epidemic in the Ditmarsken, and rather dangerous in the western part of Sønderjylland. For this reason my assistant, Dr. K. BERG, at my request gathered about 200 *L. truncatula* and that in localities where the veterinary was sure that there was a strong infestation of sheep and cattle. In this case too no Cercariae were found; at that time (June 1933) I had almost given up the hope of getting the Cercaria. A young student from my classes, Mr. HAMMER, who was studying another subject and traversed a great deal of the country on a motor cycle offered to make enquiries about epidemic foci, and if such were found, to try to find *L. truncatula*. In this way material was brought to the laboratory from Bornholm, Samsø, Møen and from the northwestern part of Seeland a locality where the rot, according to the veterinary, was very wide-spread. The material from this latter locality was rather scarce; it consisted of only about 100 very small individuals and 5 large old snails. One of these snails contained about 50 large Rediae, which harboured several Cercariae, some of them were free in the snail, and lived some hours in the water, whereupon they encysted in the vessel. On all essential points it was in accordance with the figures of THOMAS and GWENDOLEN REES to whose descriptions I have only very little to add.

As a matter of course I am unable to bring new facts which could be used to elucidate the above-named 7 points. Undoubtedly an elaborate study of the rot in Denmark, as compared with the occurrence of *Limnæa truncatula*, must be regarded as a desideratum, which I hope the future will bring.

With such an investigation in mind, I think it allowable to gather from the literature what is now known with regard to the above-named 7 points.

1. Is *Fasciola hepatica* strictly bound to the snail: *Limnæa truncatula*?

With regard to this point the reader may in the first place be referred to MEHL'S excellent work: Die Lebensbedingungen der Leberegelschnecken (1931). It has often been supposed that other *Limnæa*-species, especially *Limnæa pereger* and *L. palustris*, but also *L. stagnalis* were used as hosts by the parasite. It has been shown experimentally (LEUCKART 1882) that the Miracidia attack *L. palustris* and *L. pereger*, but the development does not reach the Cercaria stage. THOMAS (1883a, p. 106) arrived

at the same result. NÖLLER and SPREHN (1924, p. 369; 1925, p. 611), TAYLOR (1922, p. 701), and WALTON (1918, p. 232) have either shown that the development may exceptionally take place in *L. stagnalis*, or have really found Cercariae of *Fasciola hepatica* in *L. pereger*. From all that we know, there can be no doubt that *L. truncatula* is the main host in Central Europe, and that occurrences in other snails may be regarded as exceptions.

2. As stated above, the rot is spread over a great deal of the world where *L. truncatula* does not occur. A series of investigations show that the parasite here mainly uses other *Limnæa* species, but also species of the genus *Physa* and others.

Sandwich Islands: *Limnæa oahuensis*, *L. rubella*: LUTZ 1892, p. 783 and 1893, p. 320. South Africa *Isidora (Limnæa) natalensis* and *tropica*: *Limnæa truncatula*: PORTER 1925, p. 309, CAWSTON 1924, p. 67. Australia: *Physa* species: GILCHRIST 1910, p. 658; Venezuela *Ampullaria luteostoma*: ITURBE and GONZALEZ 1918; North America: *Limnæa humilis*: STILES and HASSAL 1898 and *Physa fontinalis acuta* BOYD 1921, p. 39; Victoria: *Bulinus tenuistriatus* after GWENDOLEN REES 1932, p. 11. East India: *Limnæa minuta javanica*, *Physa*: SMITH.

3. With regard to the life history of *L. truncatula* MEHL (1931), BROCKMEIER (1898, p. 153), WALTON (1918, p. 232), PATZER (1927, p. 321) have given a long series of facts which are of the greatest importance in the fight against the rot. I give the following main points.

The supposition often maintained that *L. truncatula* is only a hunger form of *L. palustris* (BROCKMEIER) is not correct (WALTON, PATZER, MEHL). *L. truncatula* is in the first place limited to small brooks from where in wet summers and during periods of inundation it is carried across the meadows and deposited in great masses in ditches, which later on may dry up. This explains why wet summers and a great downpour is so often followed by a great outbreak of epidemics. It is much more terrestrial than other *Limnæa* species; it does not follow the retreating water in drought periods; the eggs are often found above the waterline, and nevertheless they are able to develop for a long time (PATZER). According to MEHL the egg masses are always deposited in the water, not on dry land.

The length of life differs in the various localities, in some localities it is not a whole year, in others never more than two; the development of the egg masses takes about 1—6 weeks, commonly 2—4.

The snails endure total desiccation of the locality for $4\frac{1}{2}$ months, and during the dry period press the opening of the house against the dry mud; they do not dig themselves down into the mud; as true water animals they seek the cracks in the drying mud or in the root system of grasses etc. Against earlier suppositions (ALSTERBERG 1930, p. 115) MEHL maintains that in nature the snail is extremely little sensitive to temperatures below zero; there is no hope that strong winters with snow will reduce the amount of snails, if only there is a sufficient amount of water. See also PATZER (1927, p. 359—361).

Especially in the young stages cutaneous respiration is of much greater signi-

ficance than lung respiration. It appears that no help is to be expected from the avifauna for the destruction of the snail (MEHL). Whether this also holds good for the small waders, I regard as very problematic.

It may be added that SCHMID (1930, p. 256) has shown that *L. truncatula*, apart from *Fasciola hepatica*, harbours a Cercaria fauna which for its further development requires a permanent sojourn in water. This applies especially to the Furcocercariae of which SCHMID has found three species. Also Echinostomes have been found. KORKHAUS too (1929, p. 268) has found *Tetracotyle* in *L. truncatula* as well as Monostomes.

4. The number of eggs which a single *Fasciola hepatica* may produce is asserted to be very large (2 millions according to WEINLAND and BRANDT (1926, p. 258)); the number of eggs always present in the oviducts is calculated to be 45,000 (LEUCKART 1886—1901, p. 228).

When the eggs are deposited, they are uncleft; it has been experimentally shown that at a temperature at about 25° C. and in clear water the eggs are hatched in about 9 days; below 10° C. no development takes place; temperatures above 25° C. prevent the development. Optimum for pH is for the development 7.5—8; for the hatching of the larva 6.5 (MATTES 1926, p. 145). The eggs do not endure a high degree of desiccation but find a sufficient degree of moisture especially in the excrements to keep alive for a long time (more than a year (MATTES 1926, p. 140)); eggs which are exposed experimentally to temperatures of ÷ 7° C. die, but they endure temperatures of ÷ 3 (MATTES). MEHL (1931, p. 6) shows that the Miracidium must reach a snail in the course of 8 hours. He maintains that in his area of exploration (Franken) the rainwater pools in moist meadows and with a summer temperature of about 20—25° C. are the localities which are best fitted for the development of the eggs, and where the greatest amount of eggs are hatched. MEHL correctly maintains that investigations in nature are still a desideratum. When snails, as MEHL has shown, may be present in such great amounts in localities of this nature, when almost all sheep and a high percentage of cattle are infected in the same locality, and the snails themselves may be infected to the extent of 90 %, there must be periods when the shallow water must be almost milky with Cercariae; the same phenomenon which both STEENSTRUP (1842, p. 43) and I have often seen with regard to other Cercariae (mainly Xiphidiocercariae). WRIGHT (1927, p. 47) has shown that if *L. truncatula* which have been kept dry are put into a drop of water, this will in the course of a few minutes be filled with Cercariae. It may be supposed that the Cercariae during dry periods are kept alive in the snails for a long time, ready to be hatched as soon as water in any form comes in contact with the snail; sudden showers after a period of drought and perhaps only a heavy morning dew, which for some hours wakes the snails, may perhaps be all what is necessary to cover our meadows with a layer of Cercariae which a few hours later are changed into cysts.

As a Cercaria the parasite is extremely sensitive to all influences, as a cyst practically almost insensible. If this is correct, it is a question if a great amount of larvae could not be destroyed in the early summer mornings with dew on the meadows

or often with a heavy downpour. I recall here Thomas' proposal to throw salt on the meadows, and draw attention to Leiper's proposal of irrigation ditches; furthermore to Chandler (1920, p. 193).

THOMAS (1883 a, p. 118) is the only observer who has seen the asexual propagation of the Sporocyst by means of division, and gives a figure of it (1883 a, Pl. II, fig. 9); according to MEHL (1931, p. 8) only 12 Rediae develop in the Sporocyst. The figures of THOMAS seem to indicate a much higher number. The Rediae are very active, using their collar and posterior locomotoric appendages; the short intestine is filled with material from the liver of the snail. Whereas LEUCKART says (1886—1901, p. 275) that daughter Rediae are only produced during the winter, THOMAS (1883 a, p. 126) maintains that daughter Rediae are only produced in warm weather; in the cold months there was always a direct production of Cercariae. If this is correct, this would be in contradistinction from what we find elsewhere where the production of Cercariae almost always belongs mainly to the summer season. The whole development in the snail from Miracidium to Cercaria may at any rate take 7 weeks; hibernation takes place in the snail and mainly as Rediae. The Cercariae are only hatched when water is present, but the amount of water need only be drops (WALTON 1918, p. 264). The snail may retain the fully developed Cercariae for a long time (how long we do not know), whereupon they may be liberated in the course of some days when snails which have lived on dry land are put into water. Of the number of larvae developed in a single snail the suppositions have been extremely exaggerated; some authors speak about millions. All more sound calculations, as those by LEUCKART (1886—1901, p. 276), THOMAS (1883 b, p. 627), MEHL (1931, p. 11) seem to show much smaller numbers; from a single Miracidium most probably only a few hundred Cercariae develop and more than 100 are not found simultaneously in a snail. The number of Miracidia which may develop in a snail is most probably rather restricted, since too great a number during the development of the parthenitae will kill the snail. The development of the Cercariae is said to be greatest in June—July; the first Cysts are found on grass in July, their number is greatest in September—October, the two months when sheep and cattle are said to be most heavily infected.

5. We are indebted to NÖLLER and his collaborators for a series of valuable investigations which have shown the localities for the deposition of the Cysts, their resistance to drought; their form variation during desiccation; and which have clearly pointed out that the infection of sheep and cattle takes places in the encysted stage of the parasites, the Cysts being carried with the hay into the alimentary canals of the animals.

I refer the reader especially to NÖLLER (1925, p. 1); NÖLLER und KONCEK 1928, p. 154; NÖLLER und SCHMID (1927, p. 96); NÖLLER und SPREHN (1924, p. 369, 1925, p. 611); NÖLLER und ULRICH (1927 b, p. 789) further to ORT and SPREHN 1925, p. 1021 and 1051 and MAREK (1927, p. 513) MEHL (1931).

6. It has been maintained (SSINITZIN 1915, p. 280) that infection took place through free-floating Cysts, detached from the grass and carried with the drinking

water into the cattle. Furthermore RAILLET, MOUSSY and HENRY (1913, p. 95) have maintained that they have infected sheep by giving them snails as food. Even if infection may take place in one of these two ways, there cannot be much doubt that infection mainly takes place by means of Cysts deposited on the vegetation; this is also in accordance with the mode of infection of so many other Trematoda which in the cyst stage are well adapted to wait till they are swallowed by the final host together with the vegetation, and also to be liberated from the cyst wall by the chemical influence of the gastric juices.

It is a matter of course that, when it has been proved that infection takes place in the Cyst stage, it is of the greatest importance to know how long the cysts can withstand total desiccation. Practically, this means in other words whether infection takes place not only from fresh hay but also during winter feeding from hay which has been magazined for months in the loans.

Whereas several investigators have maintained this, the more elaborate studies of NÖLLER and SCHMID (1928, p. 96; 1929, p. 327) and NÖLLER and KONCEK (1928, p. 154) seem to show that the danger of infection from even insufficiently dried hay is relatively small, and that hay which has been dry for 5—6 or 7—9 months cannot be a source of infection; MEHL (1931, p. 49) arrives at the same result.

***Cercaria tuberculata* FIL. Host: *Bithynia tentaculata*.**

Pl. III, figs. 5—9.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	185	187—210
Breadth of body	110	141—161
Length of tail	220	212—296
Breadth of tail	30	37—49
Anterior sucker	45	35—52
Ventral sucker	40	44—64
	<i>Rediae.</i>	
Length of body .....	..	289—488
Breadth of body .....	..	201—270
Pharynx .....	..	62—70

The *Cercaria* is very dark, very opaque and peculiarly broad, often almost isodiametric. Apart from the tail, the body is everywhere covered with acute papillae arranged in rows. The tail is somewhat longer than the body. There are no eyespots; no fin membrane on the tail. The oral and the ventral sucker are nearly the same size, the last-named a little smaller. The ventral sucker lies behind the centre of the body with its posterior edge almost touching the bladder. The alimentary

canal has a well-developed pharynx, and an oesophagus which bifurcates near the ventral sucker. The intestinal coeca are very difficult to observe, hidden as they are by the cystogeneus apparatus. The cystogeneus glands, before evacuation, occupy almost the whole part of the body, mainly presenting themselves as two lateral bands running nearest to the lateral edges of the body; they consist of large pear-shaped or elongate cells, filled with rod-like granules; they open dorsally or ventrally everywhere on the body. CORT (1915 a, p. 35) has shown for a related species, *Cercaria megalura*, how the cellules diminish in size after encystation. MATHIAS (1925, p. 92) alleges that he has observed two canals opening at the dorsal border of the oral sucker. These canals I also have observed, but I am in doubt as to whether the whole enormous cystogeneus apparatus pours its material through these ducts; however, I have been unable to see any special glands for these ducts. Exudations from the skin during the formation of the cysts I have observed in echinostome Cercariae; in the gymnocephalous *C. megalura* CORT (1915 a, p. 32, fig. 33, Pl. IV) mentions and figures the openings of the cystogeneus cells through the skin.

The broad excretory vesicle gives off from its two anterior corners two broad excretory vessels packed with granules. Owing to the cystogeneus apparatus I have been unable to see the returning canals and vibratile tags. An excretory pore in the vesicle was not observed, but from its posterior border issues a canal which runs medianly through two-thirds of the length of the tail, branching into two canals opening laterally. Genital organs were observed as a cell-mass behind the ventral sucker.

The Redia is very variable in form, differing with the age. The pharynx is always large. When young (Pl. III, fig. 7), newly born, the Redia has well-developed posterior locomotoric appendages. The tail is short, acute; the gut very long, reaching the appendages. In the anterior part four muscles are very conspicuous. In the older Redia the appendages grow smaller; the length of the intestine is not augmented, and the part behind the appendages is filled with globules with large nuclei, viz. the first developed germballs; before them are found serially globules from which the brood is developed (Pl. III, fig. 6). In still older Rediae (fig. 8) the appendages entirely disappear. Commonly the gut only extends through half the length or an even still smaller part of the body. The body is extremely variable in form and so is the intestine. The mouth may be expanded collar-fashion and again withdrawn. The large Rediae are packed with brood and often contain many Cercariae ready to hatch.

This Cercaria was found in *Bithynia tentaculata*, 42 specimens of which were dissected from Donse Pond near Hillerød on 9/VII, and in Hulsø near Frederiksdal on 27/VI 32, and in Bromme. It was always only found in few specimens. One of them voluntarily gave off the Cercariae; the other only after dissection. The Cercariae swim very little. As MATHIAS (1925, p. 93) has observed, they are negatively phototropic, mostly creeping near the bottom. For *Cercaria megalura* CORT (1915 a, p. 32) mentions that the Cercariae become attached to the substratum by the extremity of the tail, and he figures a peculiar adhesive organ, at the posterior tip of the tail. It has not been observed elsewhere in gymnocephalous Cercariae.

The free-living stage is extremely short, the *Cercaria* often encysts on the object-glass under the microscope, often as soon as the fluids from the snail are mixed with the water. Loos (1896, p. 201—203) has a similar observation with regard to *C. distomatosa*. The cyst is shown in fig. 9; it is very hyaline and has a small indentation in its posterior part. As mentioned by MATHIAS (1925, p. 94), it has two layers. The same author shows that it may endure desiccation for 40 days.

I refer this form to *C. tuberculata* Fil. MATHIAS (1925, p. 95) has shown that it develops in *Psilotrema spiculigerum* Mühl. His description and my own agree very well. Only the spinosity of the body is more strongly developed in his specimens than in mine (Mathias, Pl. IV, fig. 9). MATHIAS has fed white mice as well as *Anas moschata* with the cysts of *C. tuberculata*. Both forms, those of the mammals as well as those of the birds, developed in *Psilotrema spiculigerum*; they were also developed in various other birds. The normal host would appear to be birds, especially *Anatidae*; the structure of the animals is the same in the mammal and in the bird, only specimens from the bird are larger and their spinosity more developed.

MATHIAS arrives at the result that a Trematode may develop in a long series of hosts, but that in this series there will be one or a few which are the main hosts, where the maximum size is attained, and where the development takes the normal time (not interrupted before the normal period has passed).

***Cercaria papillosa* FIL.** Host: *Bithynia tentaculata*.

Pl. IV.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	275	227—472
Breadth of body	185	138—155
Length of tail	340	189—278
Breadth of tail	45	40—53
Anterior sucker	50	44—58
Ventral sucker	60	53—68
	<i>Rediae.</i>	
Length of body	1520	898—1046
Breadth of body	180	222—583
Pharynx	80	74—97

As in *C. tuberculata* there are no eyespots, nor is there any fin membrane on the tail. The ventral sucker is larger than that of *C. tuberculata*. In preserved material its size varies extremely. It may be the same size as the oral sucker, but often it is a little larger. The most characteristic feature is that the whole body is covered with numerous relatively large papillae, which give it a dark, peculiarly dotted aspect.

There is a rather small pharynx; the intestinal coeca branch off immediately before the ventral sucker, and do not reach the posterior border of it. The cystogeneous glands occupy the whole space between the excretory vessels and the lateral borders. The bladder is large, the two anterior excretory vessels are very broad and contain a large amount of big granules. I have seen faintly the returning vessels and two pairs of vibratile tags, one near the anterior sucker, the other pair laterally, on a level with the bladder. — From the posterior part of it a very broad vessel is given off, which does not extend through more than a third or half the length of the tail. It terminates rather acutely (Pl. IV, fig. 2). Lateral canals were not observed.

The Rediae are very variable in shape, with a small pharynx, a well-developed collar, a birth pore, and an intestine of very varying length, in old individuals not extending through more than half the length of the Redia. In the younger stages the posterior locomotoric appendages are well-developed. In one of the specimens parts of the excretory vessel were conspicuous (Pl. IV, fig. 3). The whole interior is packed with immense masses of brood, and the Cercariae are often found crowded together. In May Rediae are found in Redia production. A new-born Redia is drawn in Pl. IV, fig. 10.

As free-living organisms the Cercariae seem to behave exactly like *C. tuberculata*.

The host is *Bithynia tentaculata*. With regard to encystation, it seems to encyst in the snail itself. On 1/X 31, of 70 *Bithynia tentaculata* taken from Furesø 4 contained *C. papillosa*. The peculiar thing was that in one of the four I could find no Rediae. The Cercariae were all creeping about, but possessed no tail. The *Bithynia* was in the same vessel as another one which had thrown off numerous Cercariae. Some of the Cercariae were almost isodiametric, but no real cyst was formed. No doubt the Cercariae had just found their way into the snail and were ready to encyst.

I have found *C. papillosa* in small ponds at Hellebæk and at Fønstrup as well as in material from a depth of 4 to 5 m. in the Furesø. There especially the number of infected snails is rather large, e. g. 5 of 40 or 8 of 50; but in smaller ponds too, as at Hellebæk, the number may be large, e. g. 9 out of 30. The *Bithynia* seem to be infected the whole year round; the Cercaria production is greatest during the summer. —

In Furesø, on 13/V, when the temperature of the water was only 5 degrees, 3 out of 40 *Bithynia* were found with a very peculiar Redia; most of them contained immature brood, but in a few a not quite ripe Cercaria was found, unquestionably a *Gymnocephale*.

The Rediae were extremely irregular (Pl. IV, figs. 4—11). Some of them, presumably the oldest ones, had an anterior stalk-like dark part ending in a flat expansion (fig. 8). Then followed a long part containing the great stomach, filling almost the whole anterior part in which no brood was observed, then a part which often contained nothing, and finally one or two oblong or globular parts packed with brood. The pharynx was extremely small. There was a collar, very differently developed; in the old Rediae the posterior locomotoric appendages were almost absent. Some of the

forms were quite fantastic. As *C. papillosa* is found in the *Bithynia* of Furesø, and the very small pharynx and short intestine is in accordance with the structure of the Redia of *C. papillosa*, I suppose that we are here concerned with very old Rediae of this species, which have hibernated. But I am not sure that this interpretation is correct. Among them there occurred very young, newly born, Rediae with a rather large pharynx and large lateral posterior appendages (Pl. IV, fig. 11).

***Cercaria helvetica* XIX DUBOIS.** Host: *Bithynia tentaculata*.

Pl. V, figs. 1—3.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	240	239—254
Breadth of body	165	149—200
Length of tail	210	152—213
Breadth of tail	50	31—68
Anterior sucker	45	42—53
Ventral sucker	60	57—63
	<i>Rediae.</i>	
Length of body	250	638—1305
Breadth of body	85	236—328
Pharynx	40	74—101

The body is very dark; the skin is neither spinose nor covered with papillae. It is smooth all over. The cystogeneous cells present two very broad bands, rather dark and almost hiding the whole of the internal structure. The cells are filled with rod-like granules; they pour their matter directly through pores into the skin. The ventral sucker is larger than the oral one and is placed almost in the middle of the animal. The prepharynx is very short, the pharynx itself is large and globular, and the oesophagus rather long. The ends of the intestinal coeca have not been observed with certainty. The excretory system consists of a bladder, often broad, triangular, and two strongly developed anterior excretory vessels filled with large globules, not present in a great number. The caudal excretory canal bifurcates almost in the middle line of the tail.

The Redia is very clumsy, the pharynx small, the intestine very broad, often filling the first half of the body (Pl. V, fig. 3); the other part is often separated from it by a constriction and contains a large amount of germ-balls or young Cercariae. There is a rather inconspicuous collar; the posterior locomotoric appendages are only well-developed in the young Rediae and are almost obliterated in the old. —

Host: *Bithynia tentaculata*. In LÜHES descriptions all gymnocephalus Cercariae with the ventral sucker larger than the oral one derive either from *Limnaea* species

or from *Paludina vivipara*; the measurements of that from *Paludina* do not agree with my specimens.

DUBOIS (1929, p. 40) has described a species, *helvetica* XIX, which on all essential points agrees with mine; it seems only to be smaller than his species. Hence I refer it to this species.

The species was only found in one locality, the rivulet Værebroya, near the Roskildefjord. (17/VII 31). The *Bithynia* were strongly infected. Of 20 specimens 11 contained the parasite. Most of them produced free-swimming Cercariae.

Cercaria grandis nov. sp. Host: *Bithynia tentaculata*.

Pl. V, figs. 4—6.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	340	219—270
Breadth of body	210	156—196
Length of tail	380	190—338
Breadth of tail	60	34—59
Anterior sucker	55	42—53
Ventral sucker	85	48—59

Rediae.

Length of body	830—1634
Breadth of body	240—752
Pharynx	69—120

The form is very large, dark, the skin is remarkably thick, but neither spinose nor covered with papillae, smooth. The body is of the common gymnocephalous form, the tail very strong, broad. No eyes. The cystogeneus cells are arranged in two broad bands, smaller anteriorly and broader behind; in the bands they are in the main arranged in two rows; the cells are large, with large nuclei and packed with granules; special ducts have not been observed. The ventral sucker is always much larger than the oral one; the prepharynx is very short, often invisible, followed by a large globular pharynx. Behind it are found about 10—12 oblong pear-shaped cells, arranged in two rows, with the acute points turned inwards and with conspicuous nuclei. They are arranged around the oesophagus. The posterior ends of the intestinal coeca have not been observed with certainty. The excretory system presents some peculiar structures. The excretory bladder is large, almost rectangular, and gives off anteriorly two excretory vessels not very large and containing only about 12—15 rather large granules arranged in a single row. The vessels reach the oral sucker, but I have not been able to see their upper end. Between the cystogeneus cell-clusters and the excretory vessels a hyaline vessel was observed, ending near the excretory

bladder. I suppose that these vessels or recurring canals belong to the excretory system, but neither branches of the second order nor vibratile tags have been observed. From the posterior part of the bladder issues a remarkably broad caudal vessel ending halfway; lateral canals have not been seen. Behind the ventral sucker was found a group of circular cells most probably belonging to the genital organ of the adults. The transversal musculature of the tail is very conspicuous; the interior is filled with parenchymatous cells with conspicuous nuclei.

The young Rediae are elongate with a small pharynx and an inconspicuous collar, and have faintly developed posterior locomotoric appendages. The intestine extends almost halfway (Pl. V, fig. 6); the posterior part is packed with germ-balls. The full-grown Redia is rather clumsy with a conspicuous collar, small appendages and the intestine not extending more than halfway of the length of the body. —

Host: *Bithynia tentaculata*, Ramløse Aa. 13/VII 31.

The snail showed a few Cercariae whose large size immediately struck me. Upon dissection, the snail was seen to be strongly infected. The Cercaria encysted under the microscope and similar cysts were found in the snail.

I cannot see that this peculiar Cercaria has been described hitherto.

Cercaria sp. Host: *Bithynia tentaculata*.

Pl. VI, figs. 9—11.

Rediae.

	Living	Preserved
Length of body	305	430
Breadth of body	180	185
Pharynx	90	85

In a little pond in the royal Park at Frederiksborg, of 9 *Bithynia* which were all infected with *Cercaria virgulae*, one had a double infection, containing also very peculiar Rediae of a *Gymnocephale*. They were only present in a number of 10—15; they were extremely clumsy, very irregular; the pharynx was extremely small; the collar very little developed, and so also were the posterior locomotoric appendages. The intestine is extraordinarily large, often filling almost the whole animal; it is mottled and of a peculiar greyish colour. A birth pore exists. The posterior part contains an enormous mass of small germ-balls, and some Rediae. These small Rediae (Pl. VI, fig. 11) are also found free in the liver; they have a relatively larger pharynx, and it can be shown that the pharynx does not increase in size during life; a collar is rather conspicuous, and sometimes there are faintly developed posterior locomotoric organs. The whole interior is occupied by an enormous intestine as broad as the Redia itself. Posteriorly in the middle line is seen a circular opening, which I suppose belongs to the excretory system.

I do not know to which *Cercaria* this peculiar Redia belongs. Because of the interesting stage (fig. 11) I think it worthy of mention. As I find it quite useless to make new species only upon the Redia stage, it has got no name.

***Cercaria obscura* n. sp.**

***Cercaria helvetica* XVII DUBOIS.** Host: *Bithynia tentaculata*.

Pl. V, figs. 7—8. Pl. VI, figs. 1—5.

The dimensions are:

<i>Cercariae.</i>		Living
Length of body		240
Breadth of body		60
Length of tail		280
Breadth of tail		65
Anterior sucker		45
Ventral sucker		30

<i>Rediae.</i>		
Length of body		410
Breadth of body		225

The *Cercaria* is very dark, the body almost black, and very intransparent. It is extremely variable in form. The tail may be longer than the body, and a few moments later much shorter (Pl. V, figs. 7—8); even when fully extended, it is often broader than the body, and when contracted, of a peculiar broad flattened shape, not tapering at the apex but almost as broad at the apex as where it is fastened to the body. When extended it seems to be dentated along the sides. In reality there is a small fin membrane, most conspicuous when the tail is contracted. The oral sucker is rather small, but a little broader than the ventral one. The latter is placed very near the posterior border of the body, so near that at the first glance it seemed justifiable to refer the *Cercaria* to the Amphistomes with which, however, it would not appear to be related on any point. The structure of the ventral sucker differs also from that of the Amphistomes; this is especially so with regard to size. — Of the alimentary canal only an oesophagus and the very inconspicuous pharynx have been seen. Behind the oral sucker lies a cluster of unicellular pear-shaped glands with distinct nuclei. Of the excretory system only the two broad excretory canals were observed. They were filled with oblong granules. When the body is fully extended (Pl. V, fig. 8) they lie on a line; when the body is contracted, the canals are much broader, and the granules lie side by side. The excretory canals taper in front and behind, and open in the bladder, which is divided into two parts; the one situated in the body being broad and flat, the other, almost heart-shaped, lying in the tail. From this part

there issues a tubule running through the whole length of the tail. Of the rest of the excretory system nothing was seen. Peculiar small circular spots are seen regularly distributed through the tail. The whole body is packed with cystogeneous cells containing rod-like granules, and moreover so strongly pigmented that in the living state it is almost black.

The young Redia (Pl. VI, fig. 1) is of a long band-like form with a well-developed large sucker and a long intestine reaching the posterior locomotoric appendages. Behind them is a tail-shaped part, terminating in an organ which very much resembles a "holdfast" organ. In this stage the Rediae are extremely mobile. When they grow older, they are more clumsy; a collar is in evidence beneath the oral sucker, and the intestine is broader (Pl. VI, fig. 2). Finally, the Redia acquires a very clumsy form, a collar is not conspicuous, and posterior locomotoric appendages are not observed. The intestine is a very broad sack filled with food (Pl. VI, fig. 3). — I have not found Rediae producing Rediae; they have only contained Cercariae in great number. — One rather small Redia contained a large Tetracotyle (Pl. VI, fig. 4) which distended the Redia very much. — The development of the Cercariae takes place in the Redia, not outside in the tissues of the snail as is the case with the Amphistomata. The Cercariae seem to be bottom swimmers; the swimming motion is very peculiar. They always swim sideways; the body is strongly contracted and the broad tail is moved sideways. They do not especially favour the lighted side of the vessel. The sight of these broad flattened Cercariae moving over the bottom in a very characteristic lazy manner, is very peculiar; by the motion alone the Cercariae may be distinguished at the first glance (Pl. VI, fig. 5). — Encystation has not been observed.

This very peculiar form was only found once on 16/IX 31 in a bay of the Furesø. The host is *Bithynia tentaculata*. Of 120 specimens 7 were infected. —

I refer this form with some doubt to *Cercaria helvetica* XVII Dubois; but I find it so characteristic that it must have a normal systematic name; — DUBOIS has found a series of small bristles on "la lèvre dorsale de l'ouverture buccale" (1929, p. 38); they have perhaps been overlooked by me.

In 1931 PETERSEN (p. 24) described a Cercaria which he regards as an Amphistome. The host is *Bithynia tentaculata*. Of all hitherto described species this seems the most nearly related to mine; the form of the tail appears to be the same; the double excretory bladder has the same form and place, and the ventral sucker lies very near the posterior border. There is a cluster of small cells behind the oral sucker. Of the excretory system the two main canals with a series of granules were observed. The alimentary canal seems to be very peculiar. There is an oesophagus which terminates in a well-developed pharynx, but the two long intestinal diverticula which almost reach the posterior margin of the body branch off before and not behind the pharynx. As far as I know, this structure is unique among Cercariae. It develops in Rediae; the tail seems to be much shorter than in my specimen. The Cercaria differs from mine by the absence of pigment. —

In spite of the differences I am inclined to think that it is PETERSEN'S form which I have had before me. The place of the Cercaria is doubtful. The position of the ventral sucker is the same as in the Amphistomes, but on all essential points, especially with regard to the excretory system, it differs from these. I regard it as an aberrant form of the Gymnocephalae; if DUBOIS' form is the same as mine he has arrived at the same conclusion. His form was also found in *Bithynia tentaculata*.

Cercaria lophocerca FIL. Host: *Bithynia tentaculata*.

Pl. VI, figs. 6—8.

The dimensions are:

Cercariae.

	Living	Preserved
Length of body	730	181—242
Breadth of body	180	85—133
Length of tail	1160	315—600
Breadth of tail	170	28—40
Anterior sucker	105	31—42
Ventral sucker .....	..	..

Rediae.

Length of body	2030	..
Breadth of body	80	..
Pharynx	45	..

The body is slenderer than that of the hitherto mentioned species of Gymnocephala from which it differs very much on all essential points.

The Cercaria is of a yellow colour owing to a yellow pigment not arranged in lines, but forming a network over the whole body and giving it a mottled aspect. The forepart of the body is covered with very small spinosities. It is very opaque owing to the large amount of cystogeneous cells filling almost the whole body, and every cell is packed with granules. The oral sucker is well-developed and is followed by a short prepharynx, a pharynx, and a short rod-like gut reaching a little behind the eyes. I have not been able to see the slightest trace of intestinal diverticula. There are two eyes; their structure is in accordance with the description given by DUBOIS (1929, p. 36). A very peculiar feature is the ventral sucker, most conspicuous in young animals, but almost obliterated in older ones. The sucker may be found at all stages of the development. Most probably it has no practical significance for the animal itself, but from a theoretical point of view it is very interesting to find a rudimentary ventral sucker in a gymnocephalous Cercaria, especially when it can be shown that it is best developed in the young animal, and then becomes obliterated during the course of its life. Round the sucker are observed some large cells with a dark content. I suppose that these are the cells which DUBOIS (1929, p. 34. Pl. 15, fig. 95) regards

as penetration glands, and whose ducts have been observed by him near the oral sucker. Of the excretory system the bladder is remarkably large with thick walls. From the anterior corner issue two excretory vessels which bend outward near the region of the eyes. They are difficult to observe, especially because they are not packed with granules. Vibratile tags have not been observed; DUBOIS maintains that he has seen five pairs. From the bladder a posterior duct passes downwards through the tail. The tail is very long and furnished with a finfold, very broad at the posterior end, but also developed along the borders of the whole tail. It is difficult to observe, and either of very varying development in the different species, or differently developed at the different ages of the animal. In young animals it seems to be wholly lacking.

The Cercariae are developed in extremely long, band-like, very irregular Rediae, which are often peculiarly knotty. The pharynx is small and the intestine only about twice or three times the length of the pharynx. The whole sack is filled with brood, but in all observed species only in the shape of germ-balls; Cercariae have never been observed. They seem to leave the Rediae at a very early stage of development.

The host is *Bithynia tentaculata*.

It seems to be a rare form everywhere, being only observed occasionally, the first time by FILIPPI (1859, p. 203), and later on only by DUBOIS (1929, p. 36). In Denmark I have only found it in one locality, a small bay of the Susaa near its outflow into Tjustrup Lake. *Bithynia* is rare here; of four specimens it was found in one. The snail showed no Cercariae when alive; they were only found after dissection. I do not think that the Cercariae were quite ripe; at any rate encystment was not observed. The liver was packed with Cercariae and contained many of the very long Rediae.

It is a question if I have not had before me the insufficiently described species of ERCOLANI: *C. fulvopunctata*. LÜHE (1909, p. 186) refers it to the Gymnocephala, saying that the ventral sucker is "nicht immer deutlich". It is very inadequately described; it agrees with my species in the development of the fin membrane through the whole length of the tail. This is also the case with *C. lophocerca* Fil. though DUBOIS (1929, p. 142) says that *C. fulvopunctata* differs from *C. lophocerca* Fil. "par la présence d'une membrane ondulante sur toute la longueur de la queue". It is furthermore nearly related to *C. Indica* VII (SEWELL 1922, p. 25) which belongs to the *Pleurolophocerca* group and which SEWELL refers to the Monostomes.

Biological Remarks.

In my experience, the following points are characteristic of the biology of the gymnocephalus Cercariae.

1. They are all bad swimmers; they live near the bottom and seem to have no special predilection for light.
2. One of them, at any rate, viz. *C. Fasciolae hepaticae*, seems able to content itself with very little water, perhaps only the morning dew. The life of the Cercaria

is extremely short in its free-swimming stage, normally some hours, often perhaps only some minutes. —

3. Apart from *C. Fasciolae hepaticae* most of the other Gymnocephalae show a peculiar predilection for prosobranchiate snails; their hosts are almost always *Bithynia* and *Paludina*. In Europe few are recorded from *Limnaea* (*C. fallax* Pagenstecker, *C. agilis* Fil. and *C. neglecta* (Fil.); the two last-named have only been found once and only in a single locality).

4. The rule is that encystation takes place in the open. The facts hitherto recorded show that there is no secondary host; the cysts are transferred directly to the final host when the latter feeds on plants etc. on which encystation has taken place.

5. In the encystment stage the cysts are able to withstand desiccation for a long time; according to MATHIAS (1925, p. 94) *Cercaria tuberculata*, the Cercaria of *Psilotrema spiculigerum* Mühling, will endure desiccation for at least 40 days. — NÖLLER (1928, p. 159) has shown that the cysts of *Fasciola hepatica*, upon complete drying of the hay, cannot endure a period of desiccation of 44 days; in nature, where desiccation is not complete, they may preserve their vitality much longer. The first-mentioned result is of great practical significance, because it has been alleged that sheep could get liver flukes by eating old hay which had been stored in barns for winter fodder.

6. In some cases encystation seems to take place in snails. Creeping gymnocephalous Cercariae without a tail have more than once been found in snails which contain no Rediae, and in which it may be supposed that the Cercariae have made their way into the snail to encyst. Several times Cercariae were also observed to encyst almost the moment the fluids of the snail came into contact with water. Further, in some snails I found cysts which contained larvae without collar spines and without xiphidioid stylet, and which I have been inclined to refer to the Gymnocephala. —

Chapter IV.

Echinostomata.

CORT (1915a, p. 36) maintains that it is impossible to subdivide the Echinostomes into smaller natural groups, and DUBOIS (1929, p. 43) adopts the same view; from my own studies I feel inclined to agree with them. SEWELL has tried to divide the echinostome Cercariae into the following four groups.

- | | | |
|-----------------------------------|---|--|
| 1. The <i>echinatoides</i> group. | { | <i>C. echinatoides</i> Fil. = <i>C. echinifera</i> La Val.
<i>C. spinifera</i> La Val.
<i>C. Indicae</i> XLVIII. |
| 2. The <i>coronata</i> group. | { | <i>C. echinata</i> = <i>C. Echinostomi revoluti</i> . Frölich.
<i>C. indicae</i> XX.
<i>C. coronata</i> Fil. |

- | | | |
|-------------------------------|---|--|
| 3. The <i>echinata</i> group. | { | <i>C. trivolvis</i> Cort.
<i>C. indicae</i> XII.
<i>C. indicae</i> XXIII. |
| 4. The <i>megalura</i> group. | { | <i>C. distomatosa</i> Sonsino.
<i>C. megalura</i> Cort.
<i>C. sp.</i> Lutz.
<i>C. indicae</i> IV. |

If I were to subdivide the Danish echinostome Cercariae here studied in accordance with the views of SEWELL, we should arrive at the following results:

- | | | |
|-----------------------------------|---|--|
| 1. The <i>echinatoides</i> group. | { | <i>C. echinatoides</i> Fil., host <i>Paludina vivipara</i> .
<i>C. spinifera</i> La Val., host <i>Planorbis corneus</i> .
<i>C. echinostomi</i> Dubois, host <i>Limnaea palustris</i> .
<i>C. abyssicola</i> n. sp., host <i>Valvata piscinalis</i> . |
| 2. The <i>coronata</i> group. | { | <i>C. Echinoparyphii recurvatae</i> Matth., host <i>Planorbis umbilicatus</i> .
<i>C. affinis</i> n. sp. <i>Limnaea auricularia</i> . |
| 3. The <i>echinata</i> group. | { | <i>C. echinata</i> Sieb. = <i>C. Echinostomi revoluti</i> , host <i>Limnaea stagnalis</i> .
<i>C. hypodereae conoideae</i> Matth., host <i>Limnaea ovata</i> . |
| 4. The <i>megalura</i> group. | { | Not represented. |

The correctness of referring *C. affinis* n. sp. to the *coronata* group is doubtful; the Rediae having a very long and not a very short intestine. —

Cercaria echinatoides Fil. Host: *Paludina vivipara*.

Pl. VII, figs. 1—2.

Rediae.

	Living
Length of body	2510
Breadth of body	710
Oral sucker	180

As stated above, *C. echinatoides* was found in *Paludina vivipara* in a very small shallow pond at Hellebæk near the Sound. Though I have opened more than one hundred specimens from all seasons of the year, apart from a single individual I only found cysts (207—216 μ). On 2/II 32, out of 10 specimens only one contained Rediae with Cercariae which were not quite ripe. —

Paludina vivipara is a rather rare animal in our country, but is not uncommon

in most of the lakes which give water to the Susaa, and in the Susaa itself. Many specimens from these parts have been studied in the summer months, but no Echinostomes were found here.

In spite of the fact that I have seen no ripe *C. echinatoides*, I feel convinced that it is this species with which I have had to do. On opening the cysts, it could clearly be seen that the number of collar spines was more than forty, and that there were four ventral and lateral spines which were much larger than the dorsal ones. Pl. VII fig. 1. The large spines are also very conspicuous through the wall of the unhurt cyst.

As far as I know, none of the other European echinostome Cercariae show such a conspicuous difference between the dorsal and ventral spines. As I have never seen fully ripe Cercariae, the fin round the tail was not fully developed. — In addition, the structure seemed to agree in all respects with *C. echinatoides*. The Redia is colourless, transparent; the pharynx is remarkably small, but the intestine is very well developed; it almost reaches the posterior wall and is conspicuously sinuous. It always contains food of a pale yellowish colour and filled with a number of small grains. There are two rather small posterior locomotoric appendages, often withdrawn. The number of Cercariae contained in the Rediae was not large, rarely more than four to six.

Cercaria Echinostomi DUBOIS. Host: *Limnaea palustris*.

Pl. VII, figs. 3—4.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	840	..
Breadth of body	475	..
Length of tail	670	..
Breadth of tail	155	..
Oral sucker	115	..
Ventral sucker	130	..
	<i>Rediae.</i>	
Length of body	3400	2108—3240
Breadth of body	500	424—498
Oral sucker	160	53—88

This is the largest echinostome Cercaria I have seen. The body is rather broad, with a slight constriction behind the collar. The oral sucker is a little smaller than the ventral one; this is situated a little behind the transversal middle line of the body. The number of collar spines is about 35; they are almost of the same size; the dorsal spines are arranged in two rows. The powerful very muscular tail is provided with a fin membrane broad in the posterior part of the tail, and very narrow anteriorly; the

tail itself is remarkably broad and flat. The digestive system is unusually narrow in all its parts. The pharynx is small; the oesophagus is very long, it almost reaches the ventral sucker. The two diverticula reach the bladder. In their course they form a peculiar elbow, just in the middle line of the ventral sucker. The oesophagus is filled with an uninterrupted line of rectangular refractive bodies, which likewise occur in the first part of the diverticula; the last part is filled with diminutive granules differing in size and irregularly arranged. The whole body is packed with cystogeneus cells. The excretory bladder is rectangular; the narrow ascending tubules, on reaching the ventral sucker, form there a peculiar loop inwards, highly characteristic of the animal; between the ventral and oral suckers the tubules are much broader, and here packed with small granules, not present in the other part of the system. On reaching the collar, they form the normal loop for echinostome Cercariae, and the descending tubules follow the ascending ones on their outer side. Arrived at the ventral sucker, they divide, sending out one anterior and one posterior branch. I think I have seen this with certainty and suppose therefore that SEWELL (1922, p. 112) is correct when he in contradistinction to DUBOIS (1929, p. 42) maintains that the vessels at the level of the acetabulum in the Echinatoides group divide into anterior and posterior collecting tubes. The anterior branch makes a large loop on a level with the ventral sucker; these two branches are provided internally with a long row of ciliated patches presumably flame cells, about 25. The branches carry branches of the second order which again carry the vibratile tags, two of which are seen near the ventral sucker, two or three are seen inconspicuously near the bladder. The others have not been seen with certainty. Posteriorly the bladder gives off a tubule running through the tail, and giving off two lateral branches in the first third of it.

The large Rediae (Pl. VII, fig. 4) are of a regular rod-like form; a collar is faintly developed, and so are the posterior locomotoric appendages. The pharynx is rather small, and the intestine long, commonly reaching the appendages. The Redia contains very many germ-balls, but of ripe Cercariae as a rule not more than 4 to 6.

This very peculiar form is found in *Limnaea palustris*. There can be no doubt that we are here concerned with *C. Echinostomi* sp. de *Fulica atra* described by DUBOIS (1929, p. 45). Originally I had determined the species as *Cercaria limbifera* Seifert (1926, p. 112) and was inclined to suppose that the two species were identical. Seifert's species was redescribed by BROWN (1931, p. 91), and especially after this description I feel convinced that these two species, if not identical, are at all events very closely related to each other.

C. Echinostomi was originally found on 1/VIII, later on 20/X in *L. palustris* on the banks of Bromme Lake near Sorø, in one specimen out of 20. In 10 specimens gathered on 20/X, 31, none were found. Of 10 snails from the banks of Tjustrup Lake, 2 specimens were infected. In small ponds near the borders of Furesø (30/IV, 32) the infection was stronger. Of 25, 6 were infected and of 5 from 14/V, 3. These snails were strongly infected, nevertheless the number of Cercariae thrown out was

but small, only 4 to 6 a day. They were also found in specimens from Bagsværd Lake on 30/VI, 32 (in 1 of 4 specimens), and from Fønstrup Pond on 30/VI, 32 (in 1 of 5 specimens). This species seems, therefore, to be rather common and strictly limited to *Limnaea palustris*. In all the above-named localities *Limnaea stagnalis* and *L. ovata* were lying side by side with *L. palustris*. But nevertheless *C. Echinostomi* was never found in the former two species; on the other hand, these would harbour other echinostome Cercariae which did not occur in *L. palustris*. —

***Cercaria abyssicola* n. sp. Host: *Valvata piscinalis*.**

Pl. VII, figs. 5—7.

The dimensions are:

Cercariae.

	Living
Length of body	360
Breadth of body	170
Length of tail	310
Breadth of tail	55
Oral sucker	55
Ventral sucker	80

The body is elongate with a slight constriction behind the collar; the oral sucker is smaller than the ventral one which is situated in the posterior third of the body. There is a circlet of collar spines which are all nearly the same small size. Their number is about 30. The powerful, very muscular tail is provided with a fin membrane only developed on one side. It is broad at the apex of the tail, but passes as a small membrane to the point of attachment of the tail to the body (Pl. VIII, fig. 6). When the tail is seen laterally, the membrane is seen as an undulating band. I have been unable to see any part of it on the other side of the tail. — The digestive system consists of a rather long prepharynx, a well-developed pharynx and a long oesophagus. The oesophagus almost reaches the ventral sucker, and the two long diverticula extend to the bladder. They are filled with a series of large hyaline globules, numbering about 10 in the oesophagus, and 12—15 in the diverticula. The cystogeneus cells fill almost the whole body cavity; they have a granular structure which makes it very difficult to see the excretory system. The bladder is rather large, almost quadrangular, giving off two anterior canals which pass the ventral sucker as very thin tubules, but are much broader anteriorly to the oral sucker and contain numerous small granules, the biggest of them lying in the broadest part of the tubules. They are tripartite with two lines. Near the pharynx the tubules attenuate again and form the loop characteristic of all echinostome Cercariae. Then the tubules bend downwards again, following the outer side of the tubules. Near the broadest part of the ascending tubules a branch running anteriorly is given off. Flame-cells have been observed along these branches, but I have been unable to give a trustworthy sketch

of their number and position. Posteriorly the bladder gives off a tubule which runs through one-third of the length of the tail; the lateral canals have not been observed.

The Redia has a well-developed pharynx and an intestine which almost reaches the posterior locomotoric appendages. The latter are small and almost invisible in older Cercariae. When old, the Redia is very clumsy; the appendages entirely disappear; the gut is very broad and has a mottled aspect. In one of the Rediae (Pl. VII, fig. 7) I saw the excretory system very clearly. It consisted of a canal running from the pharynx almost to the middle of the body where it divided into two diverging branches almost reaching the posterior end of the body. — In one of the snails there were about 100 cysts round the heart; specimens were found which had thrown off the tail and were in process of encystment; the snail contained 2—6 Cercariae. The cyst has a broad hyaline outer part; then follows a small inner part and then the larva itself. This species has only been found once in three specimens out of 80 taken by dredging at a depth of 7 m. in Tjustrup Lake. —

As far as I know, no echinostome Cercaria has been recorded from *Valvata piscinalis*. Of all hitherto known echinostome Cercariae it seems nearest to *C. echinataoides* from *Paludina vivipara*. It differs from it mainly by the remarkable course of the fin membrane of the tail.

Cercaria Echinoparyphii recurvati. MATHIAS. Host: *Planorbis umbilicatus*.

Pl. VIII, figs. 1—8.

Cercariae.

	Living	Preserved
Length of body	440	197—250
Breadth of body	240	128—132
Length of tail	430	312—377
Breadth of tail	70	47—54
Oral sucker	60	42—47
Ventral sucker	70	39—46

Rediae.

Length of body	2510	1203—2122
Breadth of body	360	221—240
Pharynx medium	80	46—60

The Cercaria is of medium size, ovoid, elongate, and with the normal collar of echinostome Cercariae. The collar spines are all nearly the same size; their number is about 45. The oral sucker is a little smaller than the ventral one; this is situated a little behind the middle line of the body. The tail has no membrane. The cystogeneous cells fill almost the whole body; the internal structure of the Cercaria is therefore very difficult to make out. The oesophagus reaches the ventral sucker and

is provided with a pharynx; the two diverticula reach the bladder. The oesophagus is occupied by a series of large hyaline globules in a number of 10—15. In the diverticula they are only conspicuous in the part nearest the oesophagus. The bladder is rectangular or ovoid; it gives off two anterior tubules which are very thin till they reach the ventral sucker when they bend outward and show a considerable increase in breadth; in this part they are packed with granules. They then form the normal loop of echinostome Cercariae and pass back at the outer side. The rest of their course has not been observed with certainty. Posteriorly the bladder sends off a tubule passing in the middle line of the tail and giving off two lateral branches in the anterior third of the tail. Vibratile tags have not been seen.

The Redia (Pl. VIII, fig. 2) has a rather small pharynx, a well-developed collar, and two faintly developed lateral locomotoric appendages. The intestine is very short, almost always filled with a black content; in very young (newly born) Rediae (Pl. VIII, fig. 4—5) the appendages are much more conspicuous. The number of ripe Cercariae is only rarely more than 4—6; when young, the Redia is very mobile; when old, almost motionless. *Cercaria Echinoparyphii recurvati* Mathias is found in *Planorbis umbilicatus*. It agrees in all essential particulars with those described by MATHIAS, only the spines arranged in transversal rows over the whole body have not been observed, perhaps because I have overlooked them. — It would appear to be related to *C. equispinosa*. BROWN (1926, p. 26).

The species has been found in the following localities.

	Number of specimens examined	Infested specimens
A moor near Hillerød 12/II, 32	30	1
The banks of the Furesø 3/V, 32	40	7
Grønnegade, near Hillerød 2/VI, 32	50	50
30/VII, 32, 75 of 100		
Hørsholm, ponds 8/VII, 32	3	3
Regnstrup, Sorø 11/VIII, 32	100	10

The species seems to be rather common; in one of the ponds, Grønnegade, almost every species was infected and the infection was heavy. The snails produced about 50—100 Cercariae every day. The normal free-living period is very brief. Encystation never takes place in the open. Either the Cercariae die in the course of 24 hours, or they enter another snail if not the same in which they have been developed. In a specimen taken on 12/II from a moor near Hillerød the whole liver consisted almost entirely of cysts, and in addition there were about 100 Rediae, all very old, and only containing one or two Cercariae. These Rediae adhered to the outside of the liver, and were quite motionless. Among the cysts were found several Cercariae, some of them without a tail. Some had only a single, others a double contour. Of 10 snails only one had Cercariae and cysts. From these observations I feel inclined to

suppose that the hibernation takes place in the snail itself. That the Cercariae should leave the snails at temperatures near zero seems to me highly improbable. The cysts are drawn, Pl. VIII, fig. 6—8.

Cercaria spinifera. LA VAL. Host: *Planorbis corneus*.

Pl. VIII, figs. 9—17. Microphoto Pl. XXXVIII, fig. 14 and fig. 17.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	370	173—188
Breadth of body	245	117—176
Length of tail	570	279—358
Breadth of tail	65	24—33
Oral sucker	50	23—50
Ventral sucker	70	31—48

	<i>Rediae.</i>	
Length of body	1190	900—1400
Breadth of body	270	249—297
Pharynx	70	27—63

The form of the body is oblong, ovoid, with a slight constriction behind the collar. The collar spines are 40—45, all approximately of the same size. The oral and the ventral sucker are nearly the same size, the last-named situated a little behind the middle line of the body. The cystogeneus cells are arranged in two large clusters on either side of the middle line; all the cells are packed with short, rod-like bodies. Just in front of the oral sucker, on the anterior edge, are seen six small tips, which might be points for glands, but neither such nor ducts have been observed. The long oesophagus is furnished with a pharynx and reaches the ventral sucker; the two diverticula reach the bladder. The latter is broad and often assumes a rather flat form. The course of the anterior excretory canals is in accordance with that described for *C. Echinoparyphii recurvati*; the part between the ventral sucker and the collar is very broad and filled with small granules, the course of the vessels in the posterior part of the body I have not been able to see with certainty. — The posterior excretory canal through the tail gives off near the base two small lateral branches. —

The tail has a well-developed fin membrane, which seems to be subject to great individual variation. It may reach the body and it may be of differing extension on the two sides of the tail. In some specimens (those from Torkeris Pond) the tail terminates in a long tip without a fin membrane. One of these specimens has been drawn.

The species was chiefly studied in Torkeris Pond, and material was gathered almost at all times of the year. From this locality alone 220 *Planorbis corneus* were opened and the parasite was found in every specimen. In most of them cysts were

found, often forming a great lump in the wall of the lung just above the heart (Pl. VIII, fig. 17).

It is a question whether all these cysts, which may be present by thousands, really belong to this species. They have, in addition, been found in the following localities.

Locality	Number of specimens examined	Infested specimens
Donse 8/VII, 31	100	3
The moor near Hillerød 14/VII and 30/I, 32	190	11
Susaa, Sorø 3/VIII, 31	1	1
Strødam 27/IV, 32	5	5
A pond near Faurholm Kehus. 8/V, 32	6	6
A pond near Steenstrup, Sorø 11/VIII, 32	25	25
The Castle Park, Frederiksborg 1/VIII, 32	5	1

Investigations from Torkeris Pond show that the Rediae are present all the winter, but the production of Cercariae is but small. In the summer the Rediae produce Rediae as well as Cercariae, but mainly Cercariae. A single snail may produce several hundreds on a warm summer day. After 24 hours most of the Cercariae lie as a white layer at the bottom; encystation outside the snail was never observed. They are relatively slow swimmers, and like all echinostome Cercariae they are never found suspended in the water. They mostly swim near the bottom, and are not positively phototactic. Most probably they make their way into the snails again, but their actual entrance into the snail has not been observed. —

The species is generally most easily recognisable in the Redia stage. The Redia is commonly orange-coloured; the pharynx is small, the collar and a birthpore are very conspicuous. In young specimens the posterior locomotoric appendages are very much in evidence, in the older ones they may often be almost obliterated. A highly characteristic feature is the extremely short gut; often it is not more than three times the length of the pharynx; its contents are always black, and when the snail is opened, all the orange-coloured worms with the black spot visible with the naked eye, are observed. The whole interior of the Redia is packed with germ-balls, daughter rediae, Cercariae, Tetracotyle, and now and then echinostome cysts; almost ripe Cercariae may be present in a number of 12. The young Rediae are very mobile, the old ones, almost motionless.

***Cercaria echinata*. SIEB. Host: *Limnaea stagnalis*.**

Pl. IX, figs. 1—13. Pl. X, figs. 1—14. Microphoto Pl. XXXVIII, fig. 15.

The dimensions are:

	<i>Cercariae</i> .	
	Living	Preserved
Length of body	800	664—682
Breadth of body	350	295—332

	Living	Preserved
Length of tail	700	540—614
Breadth of tail	110	101—111
Oral sucker	60	60—88
Ventral sucker	145	106—120

Rediae.

Length of body	4010	1620—2942
Breadth of body	750	318—682
Pharynx	450	189—231

Cysts.

229—268

The Cercaria is large, commonly with a well-defined constriction behind the collar. The number of collar spines is about 40, most probably 37, all almost of the same size, but eight on the inner edge of the lappets a little larger. They are arranged in two alternate rows; as JOHNSON points out for the Cercaria of *Echinostoma revolutum*, they are not fully developed until the Cercariae have left the Redia; and even in free-swimming Cercariae they may seemingly be very little developed. The skin has a peculiar warty aspect. The oral sucker is smaller than the ventral one, and the latter has often a more oblong form; it lies a little behind the middle line. The mouth opening carries a row of small processes at its lower edge. BROWN (1926, p. 123) has found 12 openings round the mouth; they are openings for 12 ducts leading from gland cells distributed throughout the anterior region of the body and obscured by overlying cystogeneus glands. The anterior part of the body is extremely variable in form, rounded, or with a more pointed part set off from the broad collar, behind which a constriction between it and the rest of the body is plainly visible. The whole body from the pharynx to behind the ventral sucker is packed with cystogeneus cells, which make the study of all organs very difficult. In many respects the young Cercariae in the Redia are better suited for study than free-living ones, the latter getting darker and darker every hour. The cells are packed with matter destined for the formation of the cysts, and present in the shape of short rod-like bodies. No ducts were observed. The oesophagus is long and almost reaches the ventral sucker. It is provided with a little pharynx. The two diverticula reach the base of the bladder. The oesophagus is filled with a series of large refractive bodies, very conspicuous and arranged in one or two rows, their number being 22—30. All these bodies make the whole alimentary canal extremely conspicuous, more so, as far as I know, than in any other Cercaria that has been described. The large bodies may also in some specimens occupy the lateral parts of the diverticula. The most posterior parts nearest the bladder are always packed with very small granules. —

The excretory system fully agrees with that carefully described by JOHNSON (1920, p. 348) for the Cercaria of *Echinostoma revolutum*. Like JOHNSON I have seen the bladder divided into an anterior smaller muscular, and a posterior much larger more hyaline part. The anterior part regularly disappears, whereupon the posterior part increases in size. Then the whole bladder disappears again; slowly the posterior part begins to be filled up, and when expansion has reached its highest point, and the bladder has got a quadrangular form, the anterior part is visible. The bladder gives off two anterior tortuous tubules (the muscular descending tubes of Johnson); arrived at the middle of the ventral sucker, they bend outwards. From here to the pharyngeal region they are widely dilated and filled with refractive excretory granules. As always in the echinostome Cercariae, these granules are only formed in this part of the excretory system. They are smallest nearest the pharyngeal region; then they grow larger and then usually smaller again nearer the ventral sucker. They may be formed in this very part of the tubules, but presumably they are again dissolved, for real granules are neither seen in the part of the tubules near the bladder nor in the bladder itself. Near the oral sucker the tubules form the loop characteristic of the excretory system of all echinostome Cercariae, and next turn backwards following the dilated portions on their outer side. Arrived at the bladder, they again run forwards. I have been unable to follow the tubules of the second order which carry the flame cells, nor have I been able to see the manner in which these are connected with the tubules. The flame cells are drawn where I have seen them. The bladder gives off a posterior excretory tubule, running through the tail and giving off two small lateral canals rather near the attachment of the tail to the body. In one of my preparations with a lateral view of the tail, the tubules terminate quite distinctly at the place from which the lateral canals issue. — The tail is almost of the same length as the body or even longer; there is no fin membrane. Beneath the fine cuticula there is a layer of circular muscle fibres, and below this again follows a layer of longitudinal ones. The circular muscle fibres appear in optical section as a linear series of fine refractive dots. The tail further contains parenchymatous cells with numerous round nuclei, scattered everywhere but most numerous nearest the base of the tail. — The young Redia (Pl. X, figs. 1—2) is a very slender, extremely mobile little creature. It is very hyaline. After the pharynx, always well-developed, follows a short intestine. The collar is very conspicuous and the whole part before the collar always in constant motion; the pharynx is incessantly pushed forward and again retracted; simultaneously the collar is now contracted, now expanded. From the collar to the intestine there passes a series of muscle threads; a birth pore is not visible in these newly born individuals. The intestine itself is a thin, rod-like body. The posterior locomotoric appendages are remarkably long, often projecting perpendicularly from the body (Pl. X, fig. 3). In the interior are seen 20—40 germ-balls, globular or oblong, already present before the daughter Rediae leave the mother (Pl. X, fig. 6). The full-grown Redia differs in appearance; it is much broader, and not so mobile; the intestine has not kept pace with the growth of the whole body and is often only $\frac{1}{5}$ to $\frac{1}{6}$ of the total length; the

appendages are not so conspicuous, and a birth pore is always present though not always visible. In many cases the excretory organ is plainly visible, lying round and near the posterior locomotoric appendages. Branches ending in flame cells were often observed (Pl. X, fig. 5); they are even conspicuous in some of my slides. The whole interior is packed with enormous masses of brood, first Rediae and later on Cercariae (Pl. IX, fig. 12). Very often Rediae and Cercariae are present simultaneously. It is difficult to decide how many generations of daughter Rediae are produced, and it is perhaps doubtful whether all Rediae pass through both a Redia and a Cercaria-producing stage, but that they contain Rediae and Cercariae simultaneously is certain. Where this is the case, I have often seen daughter Rediae in the mother Redia devouring either other daughter Rediae or young Cercariae, but I have never seen Cercariae do so; the Cercariae of Echinostomes are only nourished endosmotically. —

The part behind the appendages may be filled with germ-balls; nearer the pharynx are found the fully-developed Cercariae. Their number is rarely more than 12, often only 4—6; a time comes when all the germ-balls are developed into Cercariae, then the Rediae pass into the last stage; no more Cercariae are produced. The colour has changed from hyaline through yellow to brown or almost black. They are now motionless, only the forepart may move a little; the posterior locomotoric appendages are no longer visible, and the form of the whole animal is extremely irregular. Pl. IX, figs. 3—4 and 6—10 shows some of these peculiar forms. They are empty, or contain a few Cercariae, fully developed, motionless, most probably dead. In two cases I found two or three echinostome cysts in the Redia; this has also been found by JOHNSON (1920, p. 362) who has found 58 Rediae with cysts inside. It is not certain whether they belonged to Cercariae developed in the Redia, or to Cercariae which had passed in through the walls of the Redia from without. I regard the first supposition as the most probable, but there is no doubt that we are here concerned with rare exceptions.

In no other Redia have I found so many Tetracotyle as in this species. They occurred in the free, creeping stages as well as in the encysted stage. Snails are found in which almost every full-grown Redia contained Tetracotyle; a number of 10—12 in a single Redia is not uncommon. Pl. X Fig. 4 shows a Redia with six Tetracotyle surrounded by Cercaria brood. When the Rediae grow old and the Cercaria production ceases, they still contain the Tetracotyle. The Redia shrivels between the Tetracotyle, and is changed into a string of "pearls". That these Tetracotyle originate from Furcocercariae which have pierced the skin of the Redia is of course beyond doubt. The highly irregular forms of the old Redia are often due to Tetracotyle stages.

As mentioned above, cysts were often found in the snails and the process of encystation was directly observed. There can be no doubt that encystation may take place in the snail without any free-swimming period, especially under unfavourable life conditions when the snail is almost exhausted, or at low temperatures. —

As is well known, the production of Cercariae is mainly restricted to the summer

months. In so far as the Trematoda use the molluscs for hibernation, it is mainly as Rediae and as cysts that they occur here. —

The rule seems to be that the infection with Miracidia takes place in the summer months; then the production of Rediae sets in; in some cases Cercaria production takes place the same year. If the infection with Miracidia has begun at a relatively late period of the year, the Redia production goes on during the whole winter.

Regular observations relating to Echinostome infection of *Limnaea stagnalis* from Torkeris Pond, based on collections from 29/I, 22/IV, 29/IV, 25/V, 6/VII, 13/IX, 25/XI, show during the autumn, the snails so to speak abound with large yellow Rediae, containing and producing an enormous quantity of young Rediae. The whole intestinal sac of the snail almost seems to contain Rediae only; hardly any part is left of the sexual organs of the snail; the liver tissues are broken down, and the intestine is covered with a thick yellow coating of Rediae. Moreover, if the infection is very heavy, the Rediae are not only found here. Upon dissection it can be shown that the Rediae are lying in nests, spread over the whole mantle (especially observed on snails from Fortun Pond 16/IV, 32). When they are pricked with a needle, yellow masses of Rediae rush out. The snail begins the hibernation period surcharged with the parasite mainly in the Redia stage. Infection of this kind is almost only found in large snails of the oldest age-classes. Their shell is very fragile; the cuticula is broken off on large parts of the shell; the power of reparation with chalk is lowered, and often the shell has open holes through which the yellow Rediae are observed. The spire is almost always lost. During winter very many of these snails die and in that case all the endeavours of the parasites to reach maturity are destroyed at a blow. It is indeed highly remarkable that a good deal of these old heavily infected snails really are able to hibernate. This may, however, be the case, and in the last days of April and May the production of Cercariae in these old snails goes on, and enormous amounts are produced. Again the snails are used by the parasites for their purposes. As Cercariae after a brief period in the open they again enter the snails, but in my opinion not always *Limnaea stagnalis*. The heavy infection with echinostome cysts in *Planorbis corneus* lying side by side with *Limnaea stagnalis* in the same pond, and the absence of Redia infection in *Planorbis*, would seem to show that the Cercariae also encyst in *Planorbis*. Both contain enormous amount of cysts; the old *Limnaea* especially in the mantle, *Planorbis* mainly in the walls of the lung and in the pericardium. In early summer most of these old snails die, and the cysts are spread over the bottom and the margins of the ponds. A comparison with the observations on collections from other ponds during the winter months, especially from Strødam and Donse and from a pond near Clausens brick works would appear to warrant the following view. During autumn and winter the parasites concentrate all their efforts on increasing the Cercaria-producing material, i. e. the Rediae; the increase is greatest at falling temperatures in the autumn; during the winter the young daughter Rediae remain motionless in the mother Redia or support life by cannibalism; hence many of the large Rediae are relatively empty during early spring, containing only a few

well-developed Rediae, while in the autumn they often contain several hundreds in all developmental stages. If the growth of the parasites is too strong, the snail succumbs. If not, when the temperature begins to rise after the period of frost is over, and the snails begin to feed eagerly at the borders of the ponds where the temperatures on the sunny days of early spring may rise to about 20 degrees, the production of Cercariae sets in.

It will be understood that during winter it is commonly impossible to see whether or not a snail is infected. Snails have been kept in aquaria at low temperatures; they have never shown Cercariae, but when dissected, an enormous Redia infection. On 26/IV one *L. stagnalis* was taken from a little pond near Hillerød; it died in the aquarium on 18/V, had never shown Cercariae, but, when dissected, showed enormous masses of Rediae containing Cercariae, not ripe. Another snail from the same pond and the same day was presumed to be infected owing to the yellow colour of the spire. It never showed Cercariae. On 19/V the tip of the spire was broken off, and out came a stream of Rediae. The hole was stopped with paraffin, but three days later the snail died. The Cercariae had left the Rediae; they were lying free in the tissues of the snail, but no encystation had taken place, undoubtedly because the cystogeneous apparatus of the Cercariae had not been fully developed. A third from the same pond and the same date gives the first Cercariae on 23/V. When dissected on 25/V it showed an enormous amount of Cercariae in the Redia, many in the snail itself, and cakes of cysts round the intestine near the lung cavity. Sooner or later in the course of the summer all these heavily infected snails died in the aquaria. They can hibernate in our aquaria, but we have been unable to keep them alive during summer. This is in accordance with the observations in nature. We have always had to do with the largest snails of the last age class, which is destined to die during the summer half of the year.

The development, however, does not always take the course given here. In some rare cases e. g. on 26/I 32 *Limnaea stagnalis* from Strødam showed a heavy infection. During the period 26/I to 24/II twelve snails were dissected. Three of them had shown echinostome Cercariae. These three and two others when dissected exhibited a strong Cercaria production. They had been kept in aquaria at temperatures of 12—17° C. This shows that the development of Cercariae may begin at low temperatures whereupon it stops during the winter and begins again when the temperature rises. The Cercariae are lying dormant in the snails the whole winter. It was in these very same snails that the process of encystation was observed mentioned pag. 64, which shows furthermore that at low temperatures the encystation may take place in the very same snail in which the development has begun.

Whereas I have been unable to find marked differences in the structure of the Cercariae of *Limnaea stagnalis*, the form of the Redia found in *Limnaea stagnalis*, the size of the pharynx, the intestine, and the posterior locomotoric appendages may differ considerably. This is the case too with the development of the collar, the presence or absence of the birth pore and the colour, which may differ from white to

yellow or brown. On 15/VII 32 I found in a pond, Springdam near Hørsholm, *Limnaea stagnalis* heavily infected with echinostome Cercariae. Of 41 specimens 9 showed Cercariae. In the same snails two sorts of Rediae were observed in several specimens. The one was found in the liver, the other covered the lower part of the intestine nearest to the heart. The first-named was red, slender, had a small collar, small pharynx, small posterior locomotoric appendages, and a thin, rod-like intestine; they contained Cercariae in a number of 6—8, all fully developed; the other was extremely hyaline, it had a very large pharynx, a strongly developed collar; it had a very broad, thick gut, longer than in the first-named Redia. It was very clumsy, and contained either young, very slender Rediae or a number of germ-balls. The first-named form was present in enormous numbers, the last-named only in a number of 20—50. In the last-named case especially I have felt inclined to suppose that I have had to do with two different species. On the other hand, I cannot prove that they are not developmental stages of the same species.

I have preferred to refer all specimens found by me in *L. stagnalis* to one and the same form, *Cercaria echinata* Sieb. It must be remembered that many of the characters which we use to distinguish the Rediae from each other are subject to great variations; this is the case e. g. with the intestine. In Rediae producing Rediae it is often long and rod-like, in the Cercaria-producing Rediae broad and short. MATHIAS has made the same observation (1925, p. 77). In *Limnaea stagnalis* two main species, *C. coronata* Fil. and *C. echinata* Sieb., have been observed. *C. Hypodereae conoideae* Bloch may develop in *L. stagnalis* (MATHIAS 1925, p. 74, DUBOIS 1929, p. 53). In the first the ventral sucker is almost in the middle line of the body and the gut of the Redia long and tortuous, in *C. echinata* the ventral sucker is behind the middle line and the Redia has a very short rod-like gut. As I have never in *L. stagnalis* found Rediae with a long tortuous intestine, and the ventral sucker has always been behind the middle line, my species belong to *C. echinata*. DUBOIS (1929, p. 43) has described no less than eight different species from *L. stagnalis*. *Cercaria helvetica* XX, XXI, XXII, XXIII, XXIV, XXXII, *Metacercaria helvetica* III are all new species. I am afraid that all these species cannot be distinguished according to the descriptions and drawings, the last-named belonging only to the Rediae. — *E. echinata* is at all events nearly related to the Cercaria of *Echinostoma revolutum* Froelich so carefully described by JOHNSON (1920, p. 335). Echinostome-infected *Limnaea stagnalis* are found in very many localities; these are small ponds only of a few hundred square metres, moors and small lakes. From some of the localities 40 snails were gathered, in others it was not possible to get more than a single one. To calculate the percentage of infection in material of this kind is absurd in my opinion. Rediae were found in them all. I have seen very small ponds, where 10 out of 41 were infected, and others where the infection was very slight, only 1 out of 18. —

Whereas the *L. stagnalis* from the inundated moors near the borders of Furesø and Esromsø were pretty heavily infected, I have never found a single *L. stagnalis*

from a depth of 3—4 m. in the Furesø infected. *L. stagnalis* is rare here; it is here replaced by *L. auricularia* and *L. ovata* var. *ampla* and in these localities *C. echinata* use these snails for their purpose; both are here heavily infected. 200 specimens have been opened at different times of the year. (10/V, 16/IX, 1/X, 31/X, 20/V and 18/XI 33).

At the time when the temperature of the water was only 7° C. many of the snails threw out numerous Cercariae. —

Cercaria Hypodereae conoideae (BLOCH) MATHIAS. Host: *Limnaea ovata*.

Pl. XI, figs. 3—4—6.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	595	213—272
Breadth of body	190	92—141
Length of tail	480	243—326
Breadth of tail	75	29—46
Oral sucker	65	37—45
Ventral sucker	70	35—50

	<i>Rediae.</i>	
Length of body	1510	720—1535
Breadth of body	320	129—277
Pharynx	110	97—129

Fully extended the body is long, attenuated behind, but also capable of great variation in form. There is a slight constriction behind the collar. This carried about 50 spines, all almost the same size and arranged round the disc in two alternate series; the number of lateral spines are 8 on each side. The oral sucker is a little smaller than the ventral one, and this is situated far behind the middle of the animal. The mouth opening carries on its anterior border six small taps into which most probably salivary glands debouch (they were, however, not observed). The cystogeneus cells fill all spaces between the organs and make it very difficult to get an impression of the fine structures, especially that of the excretory system. The cells are rather small near the sides of the animal, but much larger between the excretory canals. They are packed with cystogeneus material; all of them possess conspicuous nuclei. There is a remarkably long prepharynx, a well developed pharynx, and a long oesophagus which divides near the ventral sucker. The diverticula are difficult to see, but they reach the bladder. In this species the series of hyaline refractive bodies in the oesophagus are not so conspicuous as in *C. echinata*; but they are present. They are not mentioned by MATHIAS. —

As in *C. echinata* the bladder is divided into a posterior larger and an anterior smaller part, both parts are only rarely visible simultaneously, and if so, only for a very short time. Anteriorly the forepart gives off two sinuous tubules, which when they reach the ventral sucker bend posteriorly and then again anteriorly, and here change into two broad tubules containing enormous amounts of grains largest in the middle part and much smaller in the anterior and posterior parts. Arrived a little above the pharynx, they form the normal loop whereupon they pass back again. As far as I have been able to see, they then run directly down to the bladder where another loop is formed whereupon the tubules again bend forward and reach the collar, ending in three vibratile tags. In *C. echinostomi* the descending tubule, having reached the ventral sucker, divided into two branches, one running anteriorly, one posteriorly. It is the last part of the tubule nearest to the sides of the animal which carries the vibratile tags; the branches of the second order and the number of the vibratile tags have not been worked out. A posterior tube gives off two lateral branches in the first seventh of the tail.

The tail has no fin membrane. Beneath the fine cuticula lies a layer of circular muscle fibres, and below them again a layer of longitudinal ones. Scattered in the interior of the tail lie the parenchymatous cells with numerous round nuclei.

The Redia (Pl. XI, figs: 4 and 6) has a rather small pharynx and a short intestine, not more than twice the length of the pharynx. There is a collar and two posterior locomotoric appendages, very conspicuous in the young animals, but faintly developed in the old ones. The Redia is almost colourless, when old with a yellow tint. All my specimens were in the Cercaria-producing stages. Curiously enough, all the fullgrown ones almost always contained a few nearly fullgrown Cercariae and enormous amounts of very small globular germ-balls which filled the whole interior of the Redia, and among which the large Cercariae moved about slowly.

All dissected species of *L. ovata* contained, together with the Rediae, cakes of cysts, arranged round the intestine, often in a number of many hundreds. Often Cercariae were found which had thrown off the tail and were ready to encyst. Whether they come directly from the Rediae or from without I will not venture to decide. — I refer this species with some doubt to *Cercaria Hypoderaeae conoideae* Mathias. It is this very same species which has been very closely studied by MATHIAS (1925, p. 66). He has shown that the miracidia have a predilection for *L. ovata*, but may develop in *L. stagnalis*. On the other hand, *Planorbis* and *L. palustris* were not used as hosts. MATHIAS has furthermore found the Sporocyst in the lung of the *Limnaea*, and the Sporocyst contained Rediae. NÖLLER and WAGNER (1923, p. 463) showed that encystation may also take place in tadpoles, and MATHIAS has shown that ducks fed with infected snails containing cysts, later on harboured *Hypoderaeum conoideum* in their intestine.

On all essential points my specimens agree with *Cercaria Hypoderaeae conoideae*; attention may especially be called to the following features: the oral sucker is a little smaller than the ventral one; the place of the ventral sucker is behind the middle

line of the animal; further, the number of thorns upon the collar is the same. I refer also to VEVERS (1923, p. 134).

The species has only been found a few times at Donse on 9/XI 31, at Amager on 27/IV 32, in the lake of Frederiksborg Castle on 10/V 32, and at Hørsholm on 1/VII 32. The number of infected snails was very small at Amager and in the lake of Frederiksborg Castle; it was only 1 out of 40. On the other hand, it was rather high at Donse (3 out of 10) and at Hørsholm (13 out of 30). — Cakes of cysts were found in all individuals, and most of the infected individuals produced many Cercariae before they were dissected. —

Cercaria affinis n. sp. Host: *L. auricularia*.

Pl. XI, figs. 1—2.

The dimensions are:

Cercariae.

	Living
Length of body	500
Breadth of body	205
Length of tail	475
Breadth of tail	55
Oral sucker	70
Ventral sucker	95

Rediae.

Length of body	490
Breadth of body	95
Pharynx	40

Fully extended the body is long, broader behind, strongly attenuated behind the collar. The number of spines is most probably 47; there are five lateral spines; all the spines are almost the same size. The oral sucker is much smaller than the ventral one, which lies in the last third of the body, long behind the middle line of the animal. The cystogeneus cells fill the whole body, they are packed with cystogeneus material; they possess conspicuous nuclei. There is a prepharynx and a well-developed pharynx; the long oesophagus gives off the diverticula just before the ventral sucker; they reach the bladder. A serial arrangement of large refractive bodies in the alimentary canal was not observed. No division into two parts of the bladder, an anterior muscular and a posterior more hyaline part, was observed. From the anterior corners of the bladder issue two sinuous tubules; when arrived at the ventral sucker they are broadened and contain a large amount of granules. Arrived at the collar they attenuate and form the loop normal to all observed echinostome Cercariae, whereupon they bend back; when they reach the ventral sucker as far as I have been able to see they divide, sending out one branch anteriorly to the

oral sucker and another which reaches the bladder. The last named makes a peculiar loop outwards. These two branches carry the flame cells, which are remarkably conspicuous. Of these I have found 19 on each side, but I do not venture to draw the branches of the second order carrying these flame cells. The posterior branch gives off two lateral canals in the first sixth part of the tail. The tail has the normal equipment of a layer of circular and longitudinal muscles and parenchymateous cells in the interior. There is no finfold. —

The Redia (Pl. XI, fig. 5) is long, rod-like; there is a well-developed pharynx, a collar which is not very conspicuous, and faintly developed posterior locomotoric appendages. The intestine is very long, almost reaching the posterior end of the body.

This form has only been found in one of 10 specimens of *Limnaea auricularia* in the Susaa near its outflow into Tjustrup Lake on 2/VI 31. The Redia contained fully ripe Cercariae to the number of 10—12. Cysts were not observed. It is most probably the same species which I have found in 9 of 20 specimens in Esrom Lake.

I suppose it must be described as a new species. It has the long intestine of the Redia common with *C. coronata* Fil. and the large ventral sucker behind the middle line common with *C. echinata* Sieb.; as far as I know no European echinostome Cercaria has been described with a long Redia intestine and a large ventral sucker behind the middle line.

It will now be seen that so far the following 9 species have been found in Denmark:

<i>Cercaria echinatoides</i> Fil.	<i>Paludina vivipara</i>	Hellebæk.
<i>C. echinostomi</i> Dubois.	<i>Limnaea palustris</i>	Bromme.
<i>C. abyssicola</i> n. sp.	<i>Valvata piscinalis</i>	Tjustrup Lake.
<i>C. Echinoparyphii recurvati</i> Math.	<i>Planorbis umbilicatus</i>	
<i>C. spinifera</i> La Val.	<i>Planorbis corneus</i>	
<i>C. echinata</i> Sieb.	<i>Limnaea stagnalis</i>	
<i>C. Hypodereae conoideae</i> Math.	<i>Limnaea ovata</i>	
<i>C. affinis</i> n. sp.	<i>Limnaea auricularia</i>	Tjustrup Lake.
<i>C.</i>	<i>Planorbis albus</i>	

On 1/VIII 32 I found, in a single specimen of *Planorbis albus* taken in a pond in Frederiksborg Castle Park, an enormous Redia 2 mm. long. It filled a great part of the little snail which contained only this one Redia. It had a peculiar, small pharynx and feebly developed corona. The intestine was almost half as long as the whole body; the posterior locomotoric appendages were feebly developed. The colour was yellow. It is shown in Pl. X, fig. 15. It only occurred in one out of 80 specimens, and has not been found later on. The dimensions are:

Length of body	2280
Breadth of body	200
Pharynx	60

Biological remarks.

1. The Cercariae of the Echinostomes are rather vigorous swimmers. By means of their powerful tail they move quickly through the water; nevertheless they live near the bottom and do not belong to the midmost water layers; in the last part of their life as freely moving organisms they creep on the bottom and are then subject to great variation of the body.

2. Several species are phototatic, but not in any considerable degree.

3. Of the parthenitae the Sporocysts seem to play a very inconspicuous role; propagation, as far as I have seen, takes place the whole year round, mainly by means of Redia-production; many Redia generations may succeed each other. In this way the snails may contain many thousands of Rediae, and the liver presumably contain echinostome Rediae only. (*Hypoderma conoideum*, 8500 in *Limnaea stagnalis* Dufour. 1929, p. 129). Nevertheless, even these highly infected snails do not produce such enormous amounts of Cercariae as is the case with Xiphidio- and Furcocercariae; I have not seen more than several hundred a day. This is presumably due to the fact that the number of Cercariae which a Redia produces in a single batch is but small, rarely more than 10—20. The Redia-producing time of the year is much longer than the Cercaria-producing period which is mainly restricted to the summer months; in that time Rediae with Rediae as well as Cercariae are often found; owing to the strong muscular collar and well-developed posterior locomotoric appendages the Rediae of the Echinostomes possess a great power of locomotion.

4. The very vigorous pharynx is used as a hold-fast organ with which the Redia is fastened to the tissues of the snail and also as an organ by means of which morsels of snail tissues or germ-balls or other Rediae are swallowed (Pl. XXXVIII fig. 14). — On the whole, the Redia of the Echinostomes belong to the most developed and most highly differentiated Rediae hitherto known. —

5. In contradistinction from the Gymnocephala the Echinostomes are almost always found in *Pulmonata* not in *Prosobranchiata*. Though I have dissected about 1800 specimens of *Bithynia tentaculata* I have never found a single specimen of an Echinostome in Bithynia. Most of them are found in *Limnaea* species, not so many in *Planorbis*.

6. With regard to the encystation of the Echinostomes, different views have been advanced. After a brief survey of the literature, I shall give my own observations in the following.

The Encystation of Echinostomes.

As is well known, the echinostome Cercariae hitherto known do not encyst on plants or dead material; after their short life as free-swimming organisms, they make their way into other organisms. According to the literature these seem mainly to be snails; this may be due to the fact that most of the observations are derived from studies in aquaria, which contain snails, Echinostome cysts are, however, also common in *Cyclas* and *Anodonta*; HOLLANDE (1920, p. 543) found numerous cysts

on the stomach and the intestine of *Dytiscus marginalis*; however, it is doubtful whether they were cysts from echinostome Cercariae. I have often, when dissecting larvae of water insects, found cysts of *Echinostomes*, especially in the muscle system; nevertheless, their number has almost always been surpassed by cysts belonging to *Xiphidiocercariae*. NÖLLER and WAGNER (1923, p. 463) found them in the larvae of *Rana esculenta*; they have furthermore fed ducks with these larvae and shown that here they developed into *Hypoderaeum conoideum*. FILIPPI (1854, p. 345) already observed that cysts which he referred to *Cercaria echinatoides* were found in the auricle of a *Paludina*. He maintains that it is almost impossible to find a single *Paludina* in the Lac Varese which had not the auricle so packed with echinostome cysts that it was almost impossible to understand how the organ could function. Of fifty species every single one was infected. Usually neither Cercariae nor Rediae were present. Hence FILIPPI came to the conclusion that the parthenitae had disappeared and that these cysts testified to an earlier occurrence of Rediae and Cercariae.

LEBOUR (1912, p. 442) states that in exceptional cases the echinostome Cercariae may encyst in its first host. —

CORT (1915 a, p. 37) found, with regard to *Planorbis trivolvis*, that it was able to serve both as intermediate and as secondary intermediate host for *Cercaria trivolvis*; he found the Cercariae in the liver and encysted Cercariae in the body cavities of the snail. He found six of thirty-six specimens of *Campeloma subsolidum* with cysts of *Cercaria rubra* (1915 a, p. 40) in the tissues above the gills. The same was the case with *Cercaria reflexae* (1915 a, p. 42), and CORT could here show that the Cercariae were continually making their way out of the snails, whereupon they encysted in others. During the first days after the snails came into the laboratory only a few contained the encysted Cercariae; later all were infected.

FAUST (1917 a, p. 78) seems to be of opinion that *Cercaria trisoleneata* encysts on a substratum, not in another organism, "after it has escaped from the liver tissues of the host" (p. 80). On the other hand, *C. biflexa* is said to encyst in the primary host immediately after breaking through the birth-pore of the Redia. With regard to *Echinostoma revolutum* JOHNSON (1920, p. 361) states that the secondary intermediate host is the same as the intermediate host, he maintains that the cysts "grow". He has observed that the Cercariae often escape from the snail only to reenter the same species to form the cyst; furthermore that the Cercariae need not enter the same snail from which they came. JOHNSON has found more than four hundred cysts in one snail, and contends that it is highly improbable that so many Cercariae should find their way into the same snail. Further, he has found cysts, not only in the snail, but also in the Redia itself. He has found fifty-eight Rediae with cysts inside, two of them harbouring four cysts. He regards it as certain that it is the Cercariae developed in the Rediae which also encyst in them. —

MATHIAS (1925, p. 81) has shown experimentally that the Cercariae of *Hypoderaeum conoideum* encysts in different snails, thus in *L. ovata*, *palustris*, *stagnalis*,

Planorbis corneus and *Planorbis* sp. In *Planorbis* they were not found in the liver, only in the walls of the lung, or in the mantle. In *Limnaea* they occurred almost everywhere, also in the liver. In contradistinction from JOHNSON he supposes that all the cysts, even if present in a number of several hundred, derive from Cercariae which have entered the snail from without and that normally they have a short period as free-swimming organisms. He arrives at this result from his own studies relating to the development of *Strigea tarda*.

MATHIAS (1927, p. 295) shows that *Echinoparyphium recurvatum* encysts in *Planorbis umbilicatus*, *Limnaea ovata*, *L. palustris*, *Cyclas* sp., and that the number of cysts in *Pl. corneus* may be enormous, "plusieurs milliers", "le tortillon véritablement farci de ces cystes". He has also, though only once, found three echinostome cysts in a Redia. He still maintains that in all cases they enter the snail from without. I refer to p. 55—60.

SEWELL (1922, p. 128) found echinostome cysts in sixty out of 67 specimens of *Vivipara bengalensis* deriving from different localities. On examining *Vivipara bengalensis* var. *annandaeli* from a tank at *Baliaghatta*, Calcutta, he found that in 10 individuals no infection was present. On the other hand, when he examined eleven specimens from the experimental tanks, infection was present in ten cases. It seems clear therefore that, in this case, infection had occurred during the sojourn of the snails in the experimental tanks. —

My own observations have given the following results. Echinostome cysts are very often found in dissected snails. A closer examination will reveal these cysts in very many cases. Often their number is small but they may be present by thousands, as stated by MATHIAS. They are not found in the same organ in the different snails. In *Planorbis* and *Paludina* they almost always occur in the auricle, in the *Limnaea* scattered over almost all the organs and mainly in the liver but not in the auricle. Very often molluscs are found which only contain echinostome cysts but neither Rediae nor Cercariae. Furthermore, the snail may very often be infected simultaneously by other Cercariae, especially *Xiphidiocercariae* and *Furcocercariae*. A closer examination often shows that the cysts are not of the same size. Among many hundred cysts of one size several much larger ones are often found; these are yellow and unquestionably do not belong to the same species as the others. From these observations it would seem allowable to suppose with MATHIAS that the cysts originate from Cercariae which have entered the molluscs from without and have not been developed in the host itself. —

In September 1930 I took several *Paludina vivipara* into the laboratory from a pond in Hellebæk; they were used for other purposes and were not studied in regard to an infection with Trematoda. They wintered, and during the days 2/III to 30/III nine were dissected. A feature common to them all was that the auricle were enormously distended and that they contained hundreds of echinostome cysts. When taken out of the cyst, it was seen that the larvae had four lateral spines which were larger than the dorsal ones. It was highly probable therefore that the cysts belonged

to *C. echinatoides* Fil. whose host is *Paludina vivipara* and which is characterised precisely by the larger size of the lateral spines. In none of the specimens could be found Cercariae. I refer to p. 46.

On 3/IV, when the pond was ice-free, 10 *Paludina* were gathered; the auricle contained some cysts but by no means as many as the aquaria specimens. On 26/V 37 *Paludina* were gathered from the same locality. The auricle only rarely contained more than 10–15 cysts; 2 possessed 43 and 72 each. Only one individual had the auricle quite packed with several thousands. On 1/VII, 15 *Paludina* were gathered again, 9 had only 1–5, and only 4 had from 13 to 22. On 18/XI of 13 specimens, only 2 to 3 showed cysts. On 2/II of 10 specimens, again, only 2 to 3 had cysts.

The curious thing was that in none of all these specimens from the above-named dates could I ever find either Rediae or Cercariae. Not until 2/II did a single specimen occur which had several Rediae containing 4–6 Cercariae, not quite ripe. This same *Paludina* contained an enormous amount of cysts; whereas in all the other specimens they were restricted to the auricle, here the cysts were also found in the liver.

It is not easy to interpret these facts. As the enormous amount of cysts in the auricle have mainly been found in the snails which have lived in aquaria, or in February after hibernation in the pond, whereas the number of cysts found in the auricle in Nature during the summer is but small, I presume that, under unfavourable conditions, at low temperatures, encystment may take place in the snail in which the Cercariae are born; at higher temperatures, during the summer, they most probably encyst not only in the *Paludina* but in others hosts as well, and the Cercariae have probably a short free-living period. My observations seem to corroborate FILIPPI's view that the Cercariae may completely disappear in a given locality, while the cysts remain as evidence of their previous occurrence there. —

With regard to *Planorbis corneus* the case is quite different. Here Rediae, Cercariae, and cysts are very often found in the same snail; snails with Rediae and Cercariae alone, and snails which only contain cysts also occur. —

Thus investigations in the Torokeris Pond gave the following results:

Torkeris Pond.	6/V	50 spec. with cysts.	50 spec. with Rediae.	9 spec.
—	29/IX	30 — — —	30 — — —	3 —
—	24/IV	45 — — —	45 — — —	13 —
—	11/VIII	25 — — —	25 — — —	3 —

In other words, this means that all 150 specimens have had cysts and 28 Rediae.

In a few localities snails with echinostome Rediae and Cercariae but without cysts were found, but in 9 localities where investigations were carried on in January, April, May, July and September, and where a total of 98 specimens were opened, cysts were found in every specimen. They were almost always found gathered in a lump on the outer wall of the lung and near the heart. This might be as large as a

large pea, and contain several thousand cysts. In all these 98 specimens not a single Redia or Cercaria was ever observed; on the other hand, they were very often infected either with Furcocercariae or Xiphidiocercariae. It is very curious that we so often find *Planorbis* with hundreds of echinostome cysts gathered in a lump on the same spot, whereas the liver is entirely free from echinostome Rediae and Cercariae. We are here compelled to suppose one of two things. Either the Redia generations in the *Planorbis* have died out and the Cercariae encysted in the same host, or the snail has never been attacked by echinostome Miracidia but the attack began with Cercariae which entered the snail from without to encyst in it. — I regard the latter supposition as the most probable. — And all the more so, since very often e. g. Strødam pond, I found the *Planorbis* lying side by side with *Limnaea stagnalis* which were highly infected with Echinostomata and giving off Cercariae in plenty. As the number of echinostome cysts found in *Limnaea* was always small, I suppose that the Cercariae, having left the *Limnaea*, entered the *Planorbis*, especially because the cysts found in *Planorbis* are of a different size. In other words this means, in localities where both snails are present, a regular change of host takes place, the Miracidia entering the *Limnaea* whenever the Cercariae enter the *Planorbis*. Owing to the very heavy infection of the *Limnaea* and the enormous amount of Cercariae produced by the snail during its life-time on the one hand, and the scarcity of cysts on the other hand, there can be no doubt that the Cercariae normally and most probably at all events during the summer months leave the snails and encyst in other organisms.

On the other hand, some observations show that encystation really may take place in the very same snail in which the Cercariae are born, and precisely in *Limnaea stagnalis*. This seems especially to be the case during hibernation or when the snail dies. On 26/I 30 *Limnaea stagnalis* were taken from a pond in the Strødam reservation. Of these 30 snails 12 were infected with echinostome Rediae; some of these were in Redia-production, most of them in Cercaria-production, but the Cercariae were not quite ripe. There were no Cercariae outside the Rediae. Two specimens were left alive. Temperature in the pond + 2° C., in the aquaria 20° C. On 15/II one of the two died; in the last few days it had thrown out many Cercariae. On 16/II the other snail was dying; it died at 2 o'clock. It contained enormous amounts of Rediae in which fully developed Cercariae were still living. Outside the Rediae most of the Cercariae were dead, many were dying, but very many were in the different stages of encystation. During observation many cysts were formed and there was an extraordinarily good opportunity to follow the process.

Many of these Cercariae are remarkably broad and flat, almost isodiametric; they lie on the dorsal side with the tail bent over the ventral side; many have lost the tail (Pl. X figs. 7—8). When this is the case, a slimy secretion appears round the posterior part of the body (fig. 8); the slime is immediately seen to be of two sorts, an outer hyaline and an inner thicker and darker kind. Then the animals begin to roll themselves into the slime (figs. 9—10) whereupon the rotation takes place during increasing slime secretion. In fig. 14 the finished cyst is seen. —

Figs. 11—13 show animals which are dying or have died during the process.

After this there can be no doubt that Cercariae ready to escape when the snail is dying, encyst in the snail itself.

Pl. umbilicatus were taken on 11/II 32 on the moors near Hillerød (10 specimens); one of them was enormously infected with echinostome brood. On the liver there were about a hundred very old Rediae; they were almost immobile, among them were found a few young more mobile Rediae. Only very few Cercariae were found outside the Rediae, and in them only a few ripe ones were observed. The interesting point was that the whole liver consisted almost entirely of hundreds of cysts, fully developed. This shows that at low temperatures the Cercariae which are ripe do not make their way into the water, but really encyst in the snail in which they are born. —

From my own observations I suppose therefore that MATHIAS is right, when he thinks that the echinostome Cercariae normally leave the host and encyst in a second one; this may often be a snail, but it may also be another organism. On the other hand, I suppose that encystation in the primary host during hibernation is a common thing, and may also take place during the summer under abnormal conditions, when the snail is dying. This may be the case too when snails in aquaria are badly fed. The accumulation of cysts in snails kept for months in aquaria is a phenomenon caused by the fact that the aquaria may not contain organisms in which the Cercariae can encyst in other than the primary host. —

As is well known, most of the Echinostomes mature in birds, especially water birds. Now the singular thing is that in our fauna, and I suppose in the whole of the north European fauna, as far as I know, there are no water birds which directly eat the large *Limnaea stagnalis* and *Planorbis corneus*. I have often in early spring seen the common crow sitting at the borders of our moors, and I know their eating places well. By the ponds at Donse, some few kilometres distant from Hillerød, I have several times observed the peculiar fact that they take the large *Anodonta* in their claws, rise some metres in the air, and then drop them on the stones. An examination of these feeding places brings also to light numerous broken shells of the large *Limnaea* and *Planorbis*; also blackbirds and other thrushes visit these localities. The rich infection of waterbirds with Echinostomata must, in my opinion, take place in another way. —

In early spring many dying or dead snails are to be found which swell during the process of decomposition and protrude from the shells. At the borders of our lakes I have at that season found jelly-balls partly in partly outside the shells of the large *Limnaea auricularia* from Furesø. The snails are stirred up by the breaking ice, they die and at slightly higher temperatures their bodies decompose. The balls form a band half a metre broad and many metres long along the wind-eroded shore. These observations, now more than twenty years old, were made at a time of my life when I had no acquaintance with Trematoda. In my aquaria the decomposing snails also swell and protrude from the shells, and the cysts are found in the decomposing material. Experiments have shown that in my vessels the cysts do not

survive the process of decomposition. In Nature, however, it is probably otherwise. The balls decompose in large quantities of fresh, well aerated water and, in early spring, at low temperatures during incessant motion owing to the washing of the waves. I presume that the living, encysted Trematoda drop out of the snails during their decomposition and are deposited by thousands along the shores in the soft mud which, especially in spring and autumn, shows so many marks of the feet and beaks of wading and swimming birds. Our waders and swimming birds, when looking for smaller snails, worms, and algae, have ample opportunities of getting the cysts from the larger ones, on which, as far as I know, they rarely feed.

Chapter V

Xiphidiocercaria.

General Remarks.

The main characters by which the Xiphidiocercariae may be distinguished from each other are the size of the oral sucker in relation to the ventral one; the position of the ventral sucker; the development of the alimentary canal; the presence or absence of a fin membrane along the borders of the tail; the number and position of penetration glands. —

Some characters may be found in the structure of the stylet, but in my opinion the value of these characters has been somewhat exaggerated. See also FAUST (1917 a, p. 32). As I have seen it used directly as a penetration organ, I regard it as an organ by which the Cercaria forces its way into the secondary host. The excretory system seems always to be of the same main type: an excretory bladder, commonly bilobe, rarely round with two excretory tubes which, near the ventral sucker, divide into an anterior and a posterior tube. Posteriorly the bladder gives off a tube running through the whole length of the tail. A character of systematic value may in some cases be found in the number of flame cells. In many cases the relation between the transversal and the longitudinal diameter of the Sporocysts as well as the number of Cercariae in the Sporocysts furnish good characters. The virgate group is identifiable at a glance by the virgate organ. Cysts may almost always be recognised by means of the stylet which has been thrown off and is lying between the cyst membrane and the animal.

It may as a rule be said that the species from Prosobranchiata are not the same as those from lung snails; and those from *Planorbis* are not identical with those from *Limnaea*. —

If Pl. XVI, fig. 1 and fig. 2 of *C. nodulosa* are compared with each other, it will be seen that the ventral sucker in the contracted individual (fig. 1) lies in the middle of the body, while in the extended individual (fig. 2) it is situated in its posterior part. This is due to a fact which I have often observed and especially in the Xiphidio-

cercariae. It is mainly that part of the body which lies before the ventral sucker which is subject to the great variations in length; the part behind is more stable. Since the position of the ventral sucker is used as a systematic character, this fact should be noted; in this paper the position of the ventral sucker is always given when the animal is contracted to what may be regarded as the normal size in the live state.

With regard to the excretory tube in the tail CORT (1919a, p. 279) says that he has never seen any trace of it in the tail. SEWELL (1922, p. 225) and FAUST (1918a, p. 103) arrive at the opposite result; the explanation may be that what the two last-named authors have recorded as an excretory tube has not been interpreted as such by CORT. For my own part I likewise suppose that the string running through the central part of the tail is an excretory tube, but I confess that in some cases the interpretation is probably doubtful. In all examined species the tail has a transversal muscle layer and longitudinal muscles. They seem to be of the same structure in all species; as a rule they are not shown in the figures.

The tail is commonly inserted in a so-called caudal pocket (FAUST) which in American and Indian forms is said to possess small lappets provided with spines in different numbers. As far as I know, these organs have not been observed in European species. They may perhaps have been overlooked.

The number of penetration glands is often difficult to ascertain. They frequently show variations in the type of granulation of the protoplasm. —

In almost all observed species the body contains great amounts of cystogeneous cells. Commonly they are placed laterally as great bands or they are scattered throughout the body. Their content is not, as in the Echinostomes and the Gymnocephala, of a rod-like structure, it is more hyaline. Scattered throughout the body there also often occur a great number of oil globules. —

Cercariae ornatae.

Cercariae ornatae are characterized by a fin-like projection extending over a greater or smaller part of the tail (LÜHE). Originally they comprised two forms, *C. ornata* La Val. and *C. prima* Ssin. To them CORT (1915a, p. 57) added *C. hemilophura*. SEWELL (1922, p. 217) added two Indian forms *C. Indicae* XXIV and XXVIII, and created a special subgroup for all the species apart from *C. ornata*: the "prima" group, mainly characterised by the ventral sucker being smaller than the oral sucker and lying behind the middle of the body length; the tail is shorter than the body, and a dorsoventral finfold extends only in the distal portion; the intestinal coeca reach a point between the posterior margin of the acetabulum and the posterior end of the body. Salivary glands are present and consist of 4 or 5 cells on each side. The excretory bladder is oval; the excretory canals are dilated in their posterior part; the excretory formula seems to be $2 \times 6 \times 1 = 12$. Development in oval sack-shaped Sporocysts. —

DUBOIS (1929, p. 35) says that SEWELL "complète la définition" for Lühe's

ornata group by the above-named points. This, as far as I can see, is not correct. SEWELL (1922, p. 217) says "I, therefore, propose creating a subgroup of the *Cercariae ornatae* to accomodate *Cercaria prima* Ssin. and *Cercariae Indicae XXIV* and *XXVIII* under the name of the "Prima" group", and it is this subgroup and not the group *ornatae* which he characterises by the above-named points. He expressly points out the fact that *C. ornata* shows considerable differences. —

As far as I know, no one has found *C. ornata* after it was described by LA VALETTE (1855, p. 18). It is mainly characterised by the finfold which extends over the whole length of the tail, and by the size of the ventral sucker which is said to be much larger than the oral one, the former being 0.07 in diameter, the latter 0.01—0.03 i. e. more than twice as large as the oral one. If this is right, *C. ornata* would as far as I know, be unique in this respect among all Xiphidiocercaria. It may be added that in LA VALETTE'S own figure, fig. O, Pl. I the ventral sucker is only very slightly larger than the oral one.

***Cercaria laticauda* n. sp.** Host: *Limnaea stagnalis*.

Pl. XII, figs. 1—2.

The dimensions are:

Cercariae.

	Living
Length of body	500
Breadth of body	170
Length of tail	190
Breadth of tail	85
Diameter of oral sucker	85
Diameter of ventral sucker	75

Sporocysts.

Length	275
Breadth	90

The stylet has rather conspicuous lateral projections. After the large oral sucker follows a short prepharynx and an oblong pharynx; the oesophagus is rather short; the intestinal diverticula branch off immediately before the ventral sucker and embrace it; they do not reach below the posterior border of the ventral sucker. The latter lies almost in the middle of the body and is a little smaller than the oral one. There are two groups of penetration glands with many large pear-shaped cells and ducts which run to the base of the stylet. The excretory bladder is extremely large, with the two horns almost reaching the ventral sucker. The two excretory tubes divide near the middle of the ventral sucker, sending one branch anteriorly and another posteriorly to the base of the tail. Posteriorly the excretory bladder sends off a branch through the whole length of the tail. The structure of the tail is rather peculiar. I have never

seen it extended to more than half the length of the body; it is remarkably broad, when fully stretched out, acute; but when contracted very broad posteriorly; the finfold surrounds the tail in its whole length. There is a conspicuous transversal musculature and a very strong longitudinal muscle band running through the central part of the tail. Hidden in it runs the presumed excretory tube. — The whole animal is dark, mottled, with many dark spots. The interior is filled with cystogeneus cells. The Sporocysts are broad, irregular, oblong bodies containing many Cercariae. —

The form was found in a single specimen of *L. stagnalis* (13/II 32) gathered in Strødam, the pond from which several hundreds have been examined. There was a double infection with this species and *Furcocercaria*. The latter were found in the liver; the Sporocysts of the *Xiphidiocercaria* mainly on the intestine and near the heart. I have been inclined to refer this form to *C. ornata* La Val. but his species was found in *Planorbis corneus* and mine in *Limnaea stagnalis*. Partly owing to this fact, and partly because the ventral sucker is smaller than the oral one, I am provisionally compelled to regard this form as a new one. —

***Cercaria prima* SSIN. Host: *Planorbis albus*.**

Pl. XII, figs. 3—4.

The dimensions are:

Cercariae.

	Living
Length of body	290
Breadth of body	140
Length of tail	120
Breadth of tail	55
Diameter of oral sucker	55
Diameter of ventral sucker	50

Sporocysts.

Length	65
Breadth	50

The stylet is rather short with conspicuous lateral projections. The oral sucker is a little larger than the ventral one; the latter lies behind the middle line of the animal. The prepharynx is long; then follows a rather small pharynx. The oesophagus divides into the two intestinal coeca a little before the ventral sucker; they scarcely reach halfway along the sides of it. There are four penetration glands on each side; and they lie before the ventral sucker. The ducts pass forward to the base of the stylet. The excretory bladder is large, bilobed, with the unpaired part remarkably broad, the paired parts almost reach the posterior border of the ventral sucker. The excretory tubes pass forwards and divide a little above the ventral sucker, sending off one branch anteriorly and one posteriorly. The tube in the tail has only been seen

indistinctly. The tail is broad and short; not more than three-fourths of the length of the body. The finfold is very peculiar. It reaches the base of the tail but is extremely small there; at the rounded end of the tail it is very broad and folded in a peculiar manner, the folds not always reaching through the whole membrane.

The Cercariae develop in small almost globular Sporocysts not containing more than one or two Cercariae.

C. prima was found on 2/VIII 1932 in *Planorbis albus* in one of fifty specimens from a little pond in the park of Frederiksborg Castle. The specimens have not been seen swimming in the water. They came out when the snail was dissected, and were perhaps not quite ripe. This may be the reason why I have not seen the long sensory hairs mentioned by SSINITZIN; why the finfold of the tail has such a peculiar appearance; and the intestinal diverticula are so short. —

Cercariae armatae.

C. armatae were described by LÜHE (1909, p. 191) as Xiphidiocercariae without a finfold, a tail almost of body-length, a ventral sucker a little behind the middle of the body and either of the same size or only a little smaller than the oral one, with an excretory bladder of Y-form and a size of body surpassing 0.25 mm. Later authors divided the group into two: the *Polyadena* group of CORT (1915 a, p. 56) and the *Dawson* group (SEWELL 1922, p. 234). The *Dawson* group is not with certainty found out side India; I do not think it correct (DUBOIS 1929, p. 58) to refer *C. limnaeae ovatae* to it. I will only add that I have never seen the caudal pockets armed with needle-like spines which are mentioned by SEWELL (1922, p. 225) and figured by him in his Indian forms; as far as I know they are not observed by European authors. I regard it as hopeless to refer the European forms to special groups.

Cercaria limnaeae ovatae v. LINST. Host: *L. ovata*.

Pl. XII, figs. 5—6. Pl. XIII, fig. 1.

The body is covered with a fine parallel striation but there are no spines. The dimensions are:

<i>Cercariae.</i>		Living
Length of body		380
Breadth of body		175
Length of tail		125
Breadth of tail		55
Diameter of oral sucker		75
Diameter of ventral sucker		60

Sporocysts.

Length	420
Breadth	65

The stylet has lateral wing-like projections. The ventral sucker is a little smaller than the oral one; it lies behind the middle of the body. After a short prepharynx follows a small pharynx and a long oesophagus which divides before the ventral sucker. The intestinal coeca reach the middle of the excretory bladder. There are at all events five penetration glands situated before the ventral sucker; the ducts debouch at the base of the stylet. The excretory bladder is bicornous with the two horns almost reaching the ventral sucker. The two excretory canals divide near the middle of the ventral sucker into an ascending and a descending branch. Posteriorly from the bladder a branch runs through the whole length of the tail. The tail itself when contracted is only one-third of the length of the body; fully extended it is as long as the body.

The Cercariae develop in Sporocysts (Pl. XII, fig. 6) which are about 6—7 times longer than broad. The host is *Limnaea ovata*. The species is very common, it occurs in many localities; it could best be studied in the ponds of Strødam.

On 7/XII 32 material of *Planorbis corneus*, *Limnaea ovata* and *Limnaea stagnalis* was taken into the laboratory from Strødam. Xiphidiocercariae were thrown out of all the three species. This means, in other words, that Cercariae are produced at temperatures around zero and either retained in the snail during the winter, then perhaps encysting in it, or thrown off when the temperature rises a little.

In the vessels with the three above-named snails which all threw out clouds of Cercariae, *Corethra plumicornis* larvae were introduced. Those from *Pl. corneus* soon came to the *Corethra* larvae; they crept round on them, sooner or later they were found with the oral sucker fastened to the larva, the body strongly contracted and the tail moving. The stylet was held in a slanting position; it looked as if the Cercaria was going to form a furrow; before it was found a depression, but then the whole process ceased, and I never found Cercariae in the larvae.

The Cercariae from *L. stagnalis* showed no affinity at all for the *Corethra* larvae; on the other hand those from *L. ovata* darted at them immediately. In an incredibly short time they had pierced the skin. Pl. XIII, fig. 1 shows the Cercariae in different stages of piercing. The tail is thrown off, and the Cercariae are found creeping round in the *Corethra* larvae. When these larvae are put into the vessel with *C. ovata* at 11 o'clock, all larvae are dead before evening. Their body is packed with cysts often numbering several hundreds. —

The next day the bottom of the vessel containing *Limnaea ovata* was covered with a white layer of dead Cercariae. To my astonishment it could be shown that there were two forms in the material, the one twice as large as the other. The vessel contained three *L. ovata* all from the same locality. These three *L. ovata* were now isolated and *Corethra* larvae put into each of the vessels. One of them showed no Cercariae; the second only the large form, which was *C. limnaeae ovatae*, the third a small form, which was a microcotyleous Cercaria. In the course of 5 hours all the *Corethra* larvae in the vessel with *C. limnaeae ovatae* were dead, whereas those with the Microcotyles were all alive and continued alive long after all Cercariae had been

thrown off and were dead. The larvae from the vessel with *C. limnaeae ovatae* contained hundreds of cysts; those from the vessel with the Microcotyle, not a single one. This little experiment shows how cautious we should be in our experiments and our conjectures.

***Cercaria Haplometrae cylindraceae* ZED. Host: *Limnaea stagnalis*.**

Pl. XIII, figs. 6—10.

The dimensions are:

<i>Cercariae.</i>		Living
Length of body		205
Breadth of body		80
Length of tail		65
Breadth of tail		25
Diameter of oral sucker		45
Diameter of ventral sucker		45
 <i>Sporocysts.</i> 		
Length		80
Breadth		30

The ventral sucker is only a little smaller than the oral one; it lies a little behind the middle of the body. The stylet is long, thin, acute and has no thorn-like lateral extensions. The prepharynx is very short, the pharynx well-developed, the oesophagus long, the intestinal diverticula branch off immediately before the ventral sucker; they seem very short, and embrace only the anterior border of it. It is possible that I have not seen the last part. There are 4 or 5 penetration glands on each side of the sucker; the ducts pass forward to the base of the stylet. The body is filled with cystogeneous cells, which make it very opaque. The bladder is bicornous; the two horns commonly reach only halfway to the ventral sucker. Of the two excretory canals only very little could be seen; posteriorly it gives off a tube through the tail. The tail varies greatly in form; when the animal is swimming, the tail is as long as the body; when creeping only one-third of it.

The species is hatched in Sporocysts, Pl. XIII, fig. 10, 3—4 times longer than broad, covered with a yellow paletot.

The species is common in many localities; the main host is *Limnaea stagnalis*. In a little pond near Gadevang (Clausen's brick factory) the snails were much infected with them. On 19/V 1931 in almost all the snails the liver consisted almost entirely of a yellowish red porridge of Sporocysts; during the winter, at low temperatures, the whole energy of the parasite has been given to the production of Sporocysts by division. The Sporocysts contained enormous amounts of unripe Cercariae; simultaneously the snails contained a similar quantity of Tetracotyle, which as soon as the shell

was broken, poured out in a broad milky stream. On 19/V 31, when 12 snails were taken, every one of them contained Xiphidiocercaria and Tetracotyle, but now the Cercaria production was going on. The shells were extremely dilapidated; the cuticula broken off, the limelayers very thin, and everywhere holes could be found through which the mantle could be seen. Placed in vessels, the snails threw out enormous quantities of Cercariae. The snails were furthermore literally covered with a cap of *Chaetogaster limnaei* which most probably preyed upon the Cercariae. LÜHE maintains (1909, p. 106) that the Cercariae encyst in *Ilybius fuliginosus*. When *Corethra* larvae are placed in the vessels the Cercariae dart at them, and immediately make their way through the skin; several times I found Cercariae with tails, creeping in the larvae. In the course of a few hours the larvae contained several hundred cysts and were all dead (Pl. XIII, fig. 8). In July all the large *Limnaea* with strongly corroded shells were dead.

The same species was found in *L. palustris* in other localities, especially at Bromme Lake near Sorø (20/X 31). Here many cysts were found together with Cercariae; the cysts had the stylet thrown off, often lying between the cyst wall and the animal (Pl. XIII, fig. 9).

***Cercaria gracilis* n. sp.** Host: *Planorbis corneus*.

Pl. XIII, figs. 2—5.

The cuticula is striated with fine parallel oblique lines.

The dimensions are:

Cercariae.

	Living
Length of body	280
Breadth of body	105
Length of tail	165
Breadth of tail	25
Diameter of oral sucker	55
Diameter of ventral sucker	40

Sporocysts.

Length	710
Breadth	85

The ventral sucker is a little smaller than the oral one; the stylet has two sharp lateral points; the ventral sucker lies almost in the middle line of the animal. There are four penetration glands on each side; the two anterior pair have a conspicuous granular content, whereas the content of the two posterior ones is more homogeneous. The ducts pass forward to the base of the stylet. The prepharynx and the oesophagus are almost of the same length; the intestinal coeca branch off before the ventral sucker

and almost reach the posterior border of the animal. The excretory bladder is bicornous, but the unpaired part is commonly very long. The two horns almost reach the ventral sucker. It is extremely variable in form; one moment only the posterior unpaired part is visible, slowly the horns are filled. For a moment the whole bladder is visible, then the posterior part disappears and only the horns are seen. They give off two excretory tubes which divide into an anterior and a posterior branch. From the posterior part of the bladder issues a branch running through the tail in its whole length. Contracted, the latter may be only one-fourth of the length of the body, but extended as long as the whole body. This is packed with cystogeneus cells, which give the body its greyish yellow colour and make it very opaque. The Sporocysts (Pl. XIII, fig. 4) are oblong bodies, often 8 to 10 times longer than broad; their colour is red or yellow; they have a conspicuous paletot and contain enormous amounts of germ-bodies or Cercariae. Once I saw a Cercaria come out; there seemed to be an anterior opening which was only visible when the Cercaria was to be born. —

The host is *Planorbis corneus* which, in my area of exploration, is heavily infected with this form. In the neighbourhood of Hillerød 6 localities are known where the snails are parasitised and commonly to such a degree that 50, 70, or even 100 per cent. are attacked. Where the *Planorbis corneus* is common, incredible amounts of Cercariae may be thrown off. It is especially this very species which may cause the white spots of milky water in our ditches among the leaves of *Potamogeton natans* and other water-plants. Now and then the snails are also infected with Tetracotyle; in a few cases I have seen Tetracotyle in the Sporocysts. In my experience this is a rare case; commonly Tetracotyle are found in Rediae, mainly in those of Echinostomes. Where they are found in conjunction with Sporocysts, they are only rarely found within them.

During the winter the Sporocysts are packed with germ-balls or half-ripe Cercariae. The vessels may then contain highly infected *Planorbis corneus* for weeks without showing Cercariae; then suddenly, when the barometer is high, a vessel may show milky water owing to the immense quantity of Cercariae. It is a characteristic feature that the broods in a Sporocyst are almost all in the same stage of development; in one half-grown, in another ready to be hatched. During the summer the Cercariae are born, ripen, and seem not to remain in the tissues of the snail, but immediately go into the open. —

The free life of the Cercariae lasts about 18—24 hours. After that the whole Cercaria-mass lies dead upon the bottom. On the other hand, there seems to be no doubt that the Cercariae are also able to encyst in the Sporocysts. Old snails which had thrown off plenty of Cercariae and had ceased to produce them often showed numerous cysts in the tissues; the singular thing was that they also occurred in the Sporocysts. Sporocysts were found which simultaneously contained cysts and Cercariae. This was especially the case when the snails were dead and then dissected. Cysts were also found in snails taken from their natural habitat and immediately dissected; this was especially the case with material gathered in January—February.

It would seem that Xiphidiocercariae, when the life conditions are unfavourable, are able to encyst in the primary host and even in the Sporocysts, but the numerous snails found with a Cercaria brood during the winter clearly show that this mode of propagation is not the normal one. —

Owing especially to differences in the size of the Sporocysts and to the different number of penetration glands as a rule, 4 but rarely 5 on each side of the ventral sucker, I have been in doubt as to whether there was not, in my district, more than one species of *Planorbis corneus* infecting Xiphidiocercariae. Furthermore the colour of the Sporocysts, the thickness of the paletot and the size differ from locality to locality. Nevertheless, I have provisionally referred all specimens from *Planorbis corneus* to this species. That there is in my area of exploration, a Xiphidiocercaria peculiar to *Planorbis corneus* is, as far as I have been able to see, beyond all doubt. —

Cercariae microcotyleae.

Cercariae microcotyleae was erected by LÜHE (1909, p. 196) to include very small Distomes with the ventral sucker much smaller than the oral one, and situated behind the middle of the body. There are 2—4 penetration glands; the excretory bladder is small, bicornous. SEWELL has subdivided it into four groups. The *Cellulosa* group, the *Pusilla* group, the *Parapusilla* group and the *Vesiculosa* group. Apart from the *Parapusilla* group, I think that they are represented in Denmark.

The Cellulosa Group.

SEWELL (1922, p. 177) has erected the Cellulosa-group to include Loos' *C. cellulosa* and his *C. Indicae LVII*. It is mainly characterised by its extremely simple excretory system, and the fact that it has only two penetration glands on each side of the ventral sucker. With some doubt I refer a peculiar form found in *Paludina vivipara* to this group.

Cercaria cellulosa Loos. Host: *Paludina vivipara*.

Pl. XIV, figs. 5—8.

The whole body is covered with very small spines most prominent in the anterior part.

The dimensions are:

	Living
Length of body	175
Breadth of body	95
Length of tail	145
Breadth of tail	25
Diameter of oral sucker	30
Diameter of ventral sucker	25

Sporocysts.

Length	1210
Breadth	680

The stylet has a feeble acute lateral enlargement; it differs a little in the dorso-ventral and the lateral aspect. The oral sucker is larger than the ventral one; the latter is situated a little behind the middle line of the body. There are on each side two penetration glands with granular protoplasm and large nuclei; they are placed before the ventral sucker. Their ducts pass forward to the anterior part of the oral sucker. Of the alimentary canal there seems only to exist a very small pharynx lying immediately behind the oral sucker. The excretory bladder is faintly bicornous. The two anterior excretory tubes divide into an anterior and a posterior branch; a posterior canal passes through the tail. The whole interior of the body is filled with greyish round bodies which look like oil globules and make it extremely opaque. The tail may be almost as long as the body but is often carried in a contracted state and is then only half as long.

When swimming, the Cercaria is broad, heart-shaped, but very variable in form. In the lateral aspect it is flat, curved, often so much that the forepart and hind part almost touch each other.

The Cercaria is developed in highly remarkable Sporocysts (Pl. XIV, fig. 7) of an irregular globular form, commonly one and a half times longer than broad; the colour was grey and the grey colour was inherent in small granules which formed a network over the Sporocyst; the paletot was very thick and consisted of flat cells with conspicuous nuclei (Pl. XIV, fig. 8). They gave the whole Sporocyst a scaly appearance. It contained 10—15 germ-balls or Cercariae in different stages of development. Almost always small flat Cercariae were found between the paletot and the very fine membrane which forms the wall of the Sporocyst. The host is *Paludina vivipara*. It was found in a pond at Hellebæk but only in one specimen out of several hundred (26/V 31). The Sporocysts were all found round the kidney, not in it, and they did not occur in the liver.

This very peculiar form seems to be identical with or very nearly related to *C. cellulosa* described by Loos (1900, p. 227, Pl. XIV, figs. 159—161) from Egypt. To this group SEWELL (1922, p. 177) has added another *C. Indicae LVII* (Pl. XVIII, figs. 1—2) which also seems to be related to mine. SEWELL shows that the excretory system in his species is of an extremely simple form, the flame cell formula being $2 \times 4 \times 1 = 8$ flame cells.

The vesiculosa group.

The *vesiculosa* group was erected by SEWELL (1922, p. 195) to comprise small microcotyleous Cercariae with two groups of penetration glands, an anterior one consisting of one pair, and a postero-lateral one containing three pairs.

Cercaria vesiculosa DIES. Host: *Bithynia tentaculata*.

Pl. XIV, figs. 1—4.

The whole body is covered with asperities to such a degree that it has a brownish colour. The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	265	175
Breadth of body	70	110
Length of tail	255	150
Breadth of tail	15	20
Diameter of oral sucker	55	55
Diameter of ventral sucker	30	25

Sporocyst.

Length	335
Breadth	190

The stylet has a wing-like acute projection about one-third from the anterior end. The ventral sucker, which is almost only half as large in diameter as the oral one, is situated a little behind the middle of the body when the animal is contracted. Of the alimentary canal the only parts to be seen are a very small pharynx, the oesophagus and a glimpse of the intestinal coeca. There are two kinds of penetration glands, three pairs laterally to the ventral sucker and one pair before it, or four pairs in all. The three pairs have a very fine granular content and present themselves as rather bright cells; the fourth contains a much more granular protoplasm and is much darker. The ducts from the three pairs pass round the oral sucker and open near the stylet; the fourth at the base of the sucker. The excretory bladder is not round, globular, but when the animal is contracted, almost flat; when the animal is fully extended, it is bicornous. Anteriorly it gives off the two excretory canals which I have not been able to follow in their whole length owing to the opaqueness of the animal. There is a posterior excretory tube which passes through the whole length of the tail. This is subject to great variations in length. The *Cercariae* are hatched in small sausage-shaped *Sporocysts* about 2—3 times longer than broad; they contain 3 to 4 ripe *Cercariae* and several unripe ones. The host is *Bithynia tentaculata*. The species was only seen once in 5 specimens out of 30 from the borders of Tjustrup Lake on 8/VIII 32. The infected snails were twice as large as the uninfected ones. Besides the *Sporocysts* the liver also contained numerous cysts; one specimen had only cysts, another had *Sporocysts* as well as *Cercariae* and cysts. The posterior part of the liver mainly contained *Sporocysts* the anterior part cysts. Many of the *Sporocysts* contained cysts; this is shown in fig. 4.

It is with some doubt that I refer this species to the *vesiculosa* group erected by SEWELL (1922, p. 195). According to him it should include his *Cercaria Indicae* LI

and most probably *C. vesiculosa* Dies. It agrees with these forms on all essential points; only the bladder is not spherical as it should be in this group, but reniform and when the animal is fully extended, bicornous.

The *pusilla* group.

Cercaria pusilla Loos. Host: *Bithynia tentaculata*.

Pl. XIV, figs. 9—12. Pl. XV, figs. 1—4.

The cuticula is covered with very fine asperities. The dimensions are:

Cercariae.

	Living
Length of body	170
Breadth of body	75
Length of tail	150
Breadth of tail	15
Diameter of oral sucker	35
Diameter of ventral sucker	20

Sporocysts.

	Living	Preserved
Length	160	190
Breadth	80	125

The stylet has no conspicuous lateral thickenings; the oral sucker is much larger than the ventral one, which lies in the last third part of the body. There is a small pharynx, but of the rest of the oesophagus only a small tap. There are two large penetration glands on each side situated before the sucker; the anterior pair has a very granular content, both have large nuclei. The ducts pass forward along the edge of the anterior sucker, where they reach it, they have two peculiar appendages on their inner side. They were present in all specimens from three different localities. Their function is unknown; before the mouth is a small projection, not always present, and covered with fine spines. The contractile bladder is reniform; the two anterior excretory tubes pass forward to the ventral sucker and divide there into an anterior and a posterior branch; posteriorly there issues a tube running through the whole length of the tail. When the tail is fully extended, it is almost as long as the body.

The *Cercariae* are hatched in very small *Sporocysts* (Pl. XIV, figs. 9—12, Pl. XV, fig. 4), they are either globular or elliptical; they usually contain only one or not more than two-three ripe *Cercariae* and two to four germ-balls; if the germ-balls are very small, they contain five such. They were present in enormous masses; the whole liver almost only consisted of these small *Sporocysts*. Pl. XV, fig. 3 shows part of the liver filled with them. Some of them were, as in Loos's figures (Pl. XVI,

fig. 178), conspicuously constricted; there can be no doubt that the enormous amount derives from partition. The host is *Bithynia tentaculata*, Hellebæk. It was found on 26/V 31 in three of twenty-five specimens, and occurred again on 3/II 32 in two of ten specimens.

It is only with hesitation that I refer this form to *C. pusilla* Loos. Apart from the peculiar appendage upon the ducts from the penetration glands it is in accordance with Loos's species on all other points.

SEWELL (1922, p. 180) has created a special group of microcotyle Cercariae, the pusilla group. The main character should be three pairs of penetration glands, whereas the cellulosa group only possess two pairs. SEWELL refers *C. pusilla* Loos to his pusilla group. Loos in his description does not mention the number of penetration glands, but his drawing (Pl. XVI, fig. 179) very clearly shows only two pairs.

As far as I understand, Loos pays no special attention to the number of penetration glands. At p. 228 he says with regard to *C. cellulosa* that the number is "le plus souvent trois de chaque coté".

Cercaria cordiformis n. sp. Host: *Bithynia tentaculata*.

Pl. XV, figs. 5—10. Microphoto XXXVIII, fig. 16.

The whole body is covered with fine asperities. The measurements are:

Cercariae.

	Living
Length of body	135
Breadth of body	55
Length of tail	45
Breadth of tail	20
Diameter of oral sucker	25
Diameter of ventral sucker	15

Sporocysts.

Length	400
Breadth	165

The stylet is somewhat broader one third below the tip. The oral sucker much larger than the ventral one, which lies in the last third of the body. No part of the alimentary canal has been seen. There are three penetration glands a little before and laterally to the ventral sucker on each side. The first pair is more coarsely granulated than the two other pair. The ducts pass forward and debouch near the stylet. Round the ventral sucker there are many small cells. The excretory bladder is reniform when the animal is contracted (Pl. XV, fig. 5), when it is stretched out bicornous, giving off the two excretory canals which on a level with the ventral sucker branch

off in an anterior and a posterior branch. The excretory tube in the tail has not been observed with certainty. The tail when contracted is only one-third of the body length, when fully stretched out, longer than the body.

The Cercaria, when swimming, has a peculiar very broad form with a little tap anteriorly and the long thin tail incessantly whipping the water in large curves, Pl. XV, fig. 7. When creeping, the body is stretched out full length and the length of the tail reduced to one-third.

The Cercaria is hatched in very small elliptical, or almost globular Sporocysts containing 6—8 germ-balls and often three to four ripe Cercariae.

The host is *Bithynia tentaculata* and the species was found in different localities at Donse on 10/VII 31, at Hellebæk on 13/IV 31, at Arresø on 14/VII 31, at Vixømoor on 18/VII 31 and at Strødam 10/VII 31. In Hellebæk on 13/IV some snails were found in which the whole content of the liver consisted almost entirely of cysts present to the number of many thousands (Microphoto Pl. XXXVIII, fig. 16). It looks as if the whole mass of Cercariae had suddenly left the Sporocysts and immediately encysted. The same phenomenon was also observed on 10/VII in Donse material; of 42 snails three had cysts only, one had cysts and Cercariae. From Strødam (10/VII) 7 of 25 gave Cercariae. The snails then lived 8 days in the vessels, getting no food at all. 3 of the snails lay upon the bottom with closed shells. When dissected it could be shown that they were still alive, but Sporocysts and Cercariae were not observed. The whole mass of Cercariae had encysted, and the cysts were found as a cake of many thousands which covered the liver.

Cercaria virgulae.

SEWELL (1922, p. 198) has divided this group into *C. virgulae* and *C. paravirgulae*. The former has no oesophagus and intestinal coeca; an oesophagus is present in the latter. Only the first group is found in our country. I do not agree with SEWELL that the virgula group has no oesophagus. Like other rudimentary organs it seems to be developed in a very varying degree. Owing to the peculiar virgula organ the *Cercariae virgulae* are easily distinguishable from all other Xiphidiocercariae. It lies in the region of the oral sucker and consists of two pyriform sacs, fused together in the middle line; the narrow end points forward. The organ is of a refractive substance, it is hollow, with a cavity in the form of a narrow canal. The function of the organ is wholly unknown. It is only in the last part of the ripening process of the Cercariae that the organ is fully developed. In many specimens still lying in the Sporocysts it is not developed.

Common to all *Cercariae virgulae* is further the spinosity of the body and the fact that the ventral sucker, which lies a little behind the middle line, is smaller than the oral one. There is a well developed pharynx, but the rest of the alimentary canal seems to be but feebly developed. All European species develop in *Bithynia tentaculata* or *Paludina vivipara*, not in lung snails. —

Many forms are described, most of them very insufficiently; the two chief European forms are *C. virgula* Fil. and *C. vesiculosa* Dies. (Lühe 1909, p. 199). Dubois has added three helvetica forms: *C. helvetica VIII*, *C. helvetica IX* and *C. helvetica X*.

Cercaria nodulosa v. LINST. Host: *Bithynia tentaculata*.

Pl. XVI, figs. 1—4.

The body is covered with fine spines mainly in the forepart. The dimensions are:

Cercariae.

	Living
Length of body	280
Breadth of body	185
Length of tail	240
Breadth of tail	45
Diameter of oral sucker	65
Diameter of ventral sucker	45

Sporocysts.

Length	270
Breadth	210

As figs. 1—2 show, the body is extremely variable in form. After the large oral sucker follows a small pharynx. I have seen no oesophagus or intestinal coeca. The number of penetration glands is eight; two which lie before the ventral sucker and are always club-shaped; the other six lie laterally, behind the ventral sucker. When the animal is extended, they are also club-shaped, but when it is contracted, they assume a peculiar broad form (Pl. XVI, fig. 1). The excretory bladder is bicornous with the horns rather short. The two excretory canals divide in the middle of the animal, giving off one branch anteriorly and one posteriorly. From the posterior part of the bladder issues a branch which runs through the whole tail. —

The Cercariae develop in small, almost globular Sporocysts, which very often only contain one or two Cercariae, never more than four to six.

C. nodulosa develops in *Bithynia tentaculata* and is a very common form, observed in very many localities and at all seasons of the year. It has been regularly studied upon material gathered in the Hellebæk ponds.

About 100 *Bithynia* were dissected; one-fourth of the material was infected.

Like many of the other Xiphidiocercariae *C. nodulosa* are active swimmers, with some power of staying suspended in the water layers. The motion has been studied under the aquarium microscope. When the Cercariae want to ascend from the bottom, the body is curved to form a large bow with the opening upwards. It is then incessantly suddenly and vigorously turned alternately from one side to the other;

simultaneously the tail is moved with great force. The convex side of the bow is always turned downwards. During this motion the *Cercaria* ascends. When it has reached a certain height the tail is extended to its full length and is now motionless. The body stands still for a moment in the water layers, but then it begins to sink. When the bottom is reached, it rests upon its back; the tail is extended to its full length and the forepart of the body is slowly but regularly shortened and again prolonged. Suddenly the body is strongly bent, the tail moves, and the animal ascends straight as an arrow. The *Cercaria* uses about 30 seconds to ascend one cm. Now and then a *Cercaria* may be seen to ascend slowly in the water layers without any motion; I suppose this is due to variations of temperature in the vessels.

A vessel containing some *Gobio fluviatilis* received water which was rich in *C. nodulosa*. They did not show the slightest affinity for them. The fish swallowed one *Cercaria* after the other; 14 days later the fish were dissected, but no cysts were found. Simultaneously a *L. ovata* was put in a vessel containing several hundred *Cercariae*. The snail immediately began to secrete great quantities of slime, and the *Cercariae* were enclosed in it; several crept about on the skin and many were sitting on the shell, but no boring into the skin could be observed. —

In any case the *Cercariae* regularly leave the snails during the summer months; dissection is, however, always necessary in order to ascertain whether or not a snail is infected. I have had 9 *Bithynia* from a small pond in the Frederiksborg Castle Park (taken on 1/VIII 32) for two weeks in an aquarium; not one of them showed *Cercariae*; when they were dissected every specimen was seen to be heavily infected; the liver consisted almost entirely of small globular Sporocysts, each containing commonly not more than one or two not quite ripe *Cercariae*. —

When *Bithynia* have been kept for several months in aquaria and are then dissected, the liver often contains thousands of small hyaline cysts, with a stylet lying between the body and the wall of the cysts. These cysts come from Xiphidio-cercariae. I suppose that in this case the *Cercariae* have encysted in the snail itself; neither *Cercariae* nor Sporocysts were found. On 4/II 32, at a moment when the pond was just free from ice, 40 *Bithynia* were gathered; eight contained Sporocysts but in one of the snails the liver consisted almost entirely of cysts; no *Cercariae* occurred. The singular thing was that the liver contained some Sporocysts and in them were found globular cysts but always only to the number of one or two. It would seem that the encystation can take place not only in the snail, but also in the Sporocyst itself. This encystation in the snail may go on under unfavourable life conditions, as in the aquaria, or during the winter at low temperatures.

In *Bithynia* from the Hellebæk pond I have only found this species, so I regard it as highly probable that the cysts really belong to *C. nodulosa*. —

Cercaria virgula FIL. Host: *Bithynia tentaculata*.

Pl. XVI, figs. 5—6. Microphoto Pl. XXXVIII, fig. 13.

The *Cercaria* is perhaps not distinguishable from *C. nodulosa*. The dimensions are:

<i>Cercariae.</i>		Living
Length of body		380
Breadth of body		190
Length of tail		190
Breadth of tail		50
Diameter of oral sucker		85
Diameter of ventral sucker		40
 <i>Sporocysts.</i>		
Length		900
Breadth		360

There is a well-developed pharynx; after it a small tip has been seen, but not intestinal coeca. It is difficult to see the number of penetration glands, but there are most probably more than eight, and these are arranged around the ventral sucker. They differ in form from those of *C. nodulosa*. I refer the reader to the two figures. The contractile vesicle has two very long horns.

The Sporocysts of the two species are quite different. They are elliptical (Pl. XVI, fig. 6), much larger than those of *C. virgula*. They contain not one to two but often about 100 *Cercariae* or germ-balls. — It is said to encyst in the larvae of Perlidæ.

With certainty this species has only been found in the ponds of Strødam.

Cercaria helvetica IX DUBOIS 1929. Host: *Bithynia tentaculata*.

Pl. XVI, figs. 7—8.

The body is covered with fine spines. The dimensions are:

<i>Cercaria.</i>		Living
Length of body		200
Breadth of body		90
Length of tail		80
Breadth of tail		30
Diameter of oral sucker		40
Diameter of ventral sucker		30
 <i>Sporocysts.</i>		
Length		250
Breadth		110

The species is very small; almost only half as large as *C. nodulosa* and *virgula*. The ventral sucker is only a little smaller than the oral one. There is a pharynx and an oesophagus; intestinal coeca have not been observed. There are eight penetration glands of an elliptical form, arranged round the sucker. The bladder is highly bicornous and the two horns almost reach the posterior pair of penetration glands.

The Sporocysts (Pl. XVI, fig. 8) resemble those of *C. virgula* but they are shorter and contain only eight to ten Cercariae.

The species was found at Værebroaa in North-Sealand 17/VII 31 5 of 20 *Bithynia* were infected.

Because of its small size it cannot be referred to *C. nodulosa* or *virgula*: DUBOIS (1929, p. 76) has described three new forms and with some doubt I refer this species to his *C. helvetica IX*; it is, however, much smaller.

Biological remarks.

1. As far as has hitherto been ascertained, the Xiphidiocercariae are all swimmers, and commonly bad swimmers. None of them have been observed to be pelagic, but a few of them seem to possess a slight floating power. In the vessels they mainly stand near the bottom; most of them show no special phototaxis and if they do so, they are chiefly negatively phototactic. Their life time as free-swimming organisms does not extend over more than about 24 hours. The swimming motion, during which the body is strongly contracted and the tail whips the water in all directions, is often soon replaced by the creeping motion during which the body is contracted and extended like that of a caterpillar.

2. It is characteristic of most of the Xiphidiocercariae that they are hatched in enormous amounts. The propagation of the Sporocyst by means of bud formation and partition must be immense. Indeed, there also occur Sporocysts which clearly show examples of both. The length of the divided parts differs from species to species. In some they have a length of several mm., in others, and especially among the Microcotyleae, they are almost isodiametric and exceedingly small. In accordance herewith the number of Cercariae in the Sporocysts differs greatly; in the long ones there may be many hundreds, in the globular ones only a few (2—4). Another characteristic feature is that the Cercariae in the long ones are almost all in the same stage of development. With high barometric readings, in bright sunshine, and mainly in the early hours of the morning the snail may throw out incredible numbers of Cercariae; in the course of an hour the water may become milky.

3. The whole development takes place in the Sporocyst; a sojourn in the snail outside the Sporocyst is not the rule.

4. On bright days when the snails lie at the surface among the vegetation, they are seen to be surrounded by white spots and by the leaves of *Potamogeton natans*, *Hydrocharis morsus ranae* and others. I would also refer the reader to the valuable laboratory observations of DUBOIS (1929, p. 113).

5. Encystment in the open has never been observed. In this respect there is the greatest difference between the Monostomes and the Xiphidiocercariae. The former so to speak dart towards the lighted sides of the vessels and encyst immediately; the Xiphidiocercariae are for a short time swimmers, then creepers; if they have not found an intermediate host in the course of 2—4 hours, they die.

6. The Miracidium, at any rate of some of the species, seems to me to show a remarkable affinity for special snails. I have never found *Cercariae virgulae* in other snails than *Bithynia*. *Cercaria vesiculosa* I have only found in *Bithynia*. In very small water ditches, where the surface was covered with leaves of water plants, and where a single sweep of the net gave about 20 old *Planorbis corneus* and as many *Limnaea stagnalis*, every one of the *Pl. corneus* would be infected with Xiphidiocercariae, whereas the *Limnaea stagnalis* did not harbour a single one, but contained immense quantities of Echinostomes (ditch on the moors near Hillerød (15/VII 31)).

7. With regard to the intermediate host the affinity for a distinct species does not seem to be very large. The provisional result that emerges is that encystation is commonly found among insects and snails or at all events invertebrates, more rarely among fishes. According to MAC COY (1928 a, p. 220) a. o. tadpoles occur pretty often as hosts. But in this case too a predilection may be present. Xiphidiocercariae from *L. stagnalis*, *L. ovata* and *Planorbis corneus* were given *Corethra plumicornis* larvae and observed simultaneously, but only those from *L. ovata*. (*Cercaria limnaeae ovatae*) could use the larvae, none of the others. On the other hand, *Cercaria Haplometrae cylindraceae* from *Limnaea stagnalis* encysted immediately in the *Corethra* larvae, but with regard to this very species LÜHE (1909, p. 106) says that the encystation takes place in *Ilybius fuliginosus*. Provisionally it may be assumed that the *Cercariae virgulae* mainly encyst in molluscs, especially in snails. SOPARKAR (1917, p. 512) has shown that a member of SEWELL'S *Polyadena* group (*Xiphidiocercariae Armatae*) *Cercaria Indica XVII*, encysts in *Anopheline* and *Culicide* larvae and that maturity is attained in fishes.

8. It is a well-known fact that the poultry in several localities (e. g. North Germany at the haffs) suffered from a Trematode disease first described by *Hieronymi* and SZIDAT (1921), later on by SEIFRIED (1923), and BITNER (1923). For the literature see SZIDAT (1931 a, p. 293). The Trematoda occur in the oviduct; the eggs are laid without shells (wind-eggs); the infection is spread to the peritoneum and the birds then die from peritonitis. SZIDAT (1926 b, p. 561 and 1931 a, p. 289) has shown that the intermediate carrier of the parasites are odonate larvae (*Libellula quadrimaculata* and *Cordulia aenea* in which cysts were found in 74 p. c.). The number of cysts varied from 1—70. SZIDAT has shown experimentally that the poultry fed with nymphs of *Cordulia aenea* were heavily infected and that the oviduct contained specimens of the Trematode *Prosthogonimus pellucidus* v. Linst. The primary host and the *Cercaria* itself are still unknown.

9. In a very interesting paper WUNDER (1923 a, p. 68) has studied the phototaxis

of a xiphidioid Cercaria which he determines as *C. intermedia* nov. sp.; it is said to be intermediate between *C. armatae* and *C. microcotyleae*; it is stated to be related to *C. secunda* Ssin., the description is insufficient. WUNDER comes to the conclusion that it does not find its host by chemotactic stimuli. At short distances it is unable to distinguish between plants and animals or between different animals; but it leaves plants or mollusc shells and stays on chitinous skeletons and tries to pierce them; there seems to be no special predilection for particular Arthropods. If the chitin is thin, as is the case with a *Corethra* larva or with the skin between the joints of the skeleton in many larvae of water insects, the secretion from the penetration glands is sufficient to pierce the skin; upon chitinous structures of a thicker consistency the stylet is used; the slime from the snails kills them. In the first case the process lasts only five minutes, in the second from $\frac{1}{4}$ to $\frac{1}{2}$ hour. When the parasite has arrived in the interior of the animal, the encystation takes place, and WUNDER shows that the cyst wall may have a different appearance in the different hosts, hyaline in *Corethra*, pigmented in *Ephemeridae* and other insect larvae. The outer layer of the cyst is formed by the host. Even if the Cercariae are able to enter many different forms, the process of encystation is much easier in some hosts than in others; in this case it takes place most rapidly in the *Corethra* larva. — As far as I can see, it is WUNDER's opinion that if the Cercaria has any predilection for a particular host, this is not because of chemotactic affinity but because the two factors have the same phototactic dispositions. In the present case this is so with *C. intermedia* and the *Corethra* larva. Both are negatively phototactic. WUNDER shows this experimentally. At low temperatures ($+ 4^{\circ}$ C.) the *Corethra* larvae are not confined to negative phototaxis, whereas this is the case at higher temperatures ($15-19^{\circ}$ C.). Now if numerous Cercariae are kept in a flat watch glass (temperature 15°) they will move towards the darkened side; the *Corethra* larvae will do so, too, at high but not at low temperatures; at higher temperatures they will again and again mingle with the swarms of the Cercariae and at last be infected to such a degree that death is the result; at low temperatures many will escape this fate. WUNDER further shows that, if the experiment is made in total darkness, the infection is not so great as in the light.

As far as I know, WUNDER's experiments on the phototaxis of *C. intermedia* are the only ones of the kind which we possess, so they are of great interest. Of course they do not warrant any generalisation. —

10. From the observations described above, it will be seen that cysts of Xiphidiorcercariae are a very common phenomenon in snails; the microphotos show that they may occur by hundreds. This has also been observed by CORT (1915a, p. 55), by SEWELL (1922, p. 232) a. o. The question is whether these encysted Cercariae have left the snail, or encystation has taken place in the very snail in which they are born. From my own observations I am inclined to suppose that normally the Cercariae leave the snail and then again enter it. I have directly observed this for a Xiphidiorcercaria hatched from *L. ovata*; it entered an *L. stagnalis* and encysted there. On the other hand, I think that the encystation in the very snail in which the Cercaria is

born is a very common phenomenon which mainly occurs under unfavourable life conditions, when the snail is badly fed, when it dies; it may apply especially to the last Cercariae hatched from the Sporocysts at low temperatures and which now hibernate as cysts in the same snail in which they were developed. Hence I think CORT's supposition (1915 a, p. 55) that the cysts which he found in the liver of *Limnaea reflexa* were really formed after the liver had been removed from the snail, quite correct. —

I am all the more convinced that CORT's observation is correct since I have made a quite similar observation without knowing CORT's paper. A *Planorbis corneus* was dissected; the whole liver consisted almost entirely of Sporocysts containing enormous amounts of Cercariae. The liver was cut off and put into a thermostat at 22° C. Two hours later the water contained enormous amounts of Cercariae. 8 hours later the Sporocysts were filled with cysts. First the tail was thrown off. It lay in the Sporocyst and retained its motion for a remarkably long time. Then a fine membrane around the Cercaria was observed and the stylet was found between the membrane and the Cercaria (observation 19/III 31).

Snails which I have had for months in the aquaria and which are infected with Xiphidiocercariae have very often great quantities of cysts in or on the liver round the intestine and even in the Sporocysts, while in snails taken in directly from Nature this is not often the case. Hence it seems to me to be in some degree an aquarium phenomenon, but under unfavourable life conditions it may also take place in Nature.

Chapter VI.

Macroceraria.

Of all different groups of Cercariae the *Cystocercaria* as defined by LÜHE (1909, p. 201) is perhaps the most interesting, but perhaps also one of the most difficult and most heterogeneous. — It contains forms which, on a number of points, differ from all other Cercariae; the tail especially exhibits a specialisation not hitherto found in any of the other groups of Cercariae. Within the group itself this specialisation follows very different lines. This great variation is combined with very different forms of life either as true plancton organisms, as fixed bottom organisms in our ponds, or as anchored organisms in mountain streams.

The group is extremely heterogeneous and it seems to me questionable whether it is a natural one. SEWELL (1922, p. 146) has withdrawn *C. mirabilis* and allied American forms from the *Cystocercariae* of LÜHE, and divided the others into three groups: 1. The *Gorgodera* group, 2. The *Gorgoderina* group, and 3. The *Appendiculata* group. SZIDAT (1932 b, p. 477) treats the *mirabilis* group in a special paper. He shows that the members, as already surmised by BRAUN (1891, p. 215) and by SEWELL (1922, p. 246), are true Furcocercariae, and refers the name *Cystocercariae* to this

group alone, separating them entirely from all the other Cercariae with a tail of a cystocercous character. The reference of this group to the Furcocercariae seems all the more correct since the excretory system appears to be constructed in accordance with that of the Furcocercariae (WARD 1916, p. 14 for *C. anchoroides* and *C. wrightii*, SZIDAT 1932b, p. 485 for *C. splendens*). SEWELL therefore seems to be right in supposing that the cystocercous character of the tail in the *mirabilis* group may be merely an example of convergence, not of true relationship. The view of the *mirabilis* group as Furcocercariae is strengthened by LUTZ (1931, p. 343) who maintains that the Cercaria of *Hemistomum trilobum* is a true transitional form between the Cystocercariae and the Furcocercariae. In this connection it may perhaps be convenient to note the fact that among the true Furcocercariae e. g. *Bilharziella polonica*, the body is deeply implanted in the basal part of the tail which swells on the sides of the Cercaria. The true cystocercous Cercariae pass a stage in the Sporocysts which seems to correspond with the stage at which these Cercariae of *Bilharziella* have stopped. Since our knowledge of the ultimate fate of the members of the *mirabilis* group is very restricted, I consider it most correct to regard it provisionally as a special group of Furcocercariae. It will be treated here under the name of *Cystocercaria*. —

The rest of the old group of the Cystocercaria may be divided into two groups. For the first group I propose to use LÜHE's name *Macrocercaria*, the other group I propose to use the name of SSINITZIN *Cyrstrophia*. In the Macrocercaria Lühe includes the two groups of SEWELL, the *Gorgodera* and the *Gorgoderina* groups. The tail is not of the furcocercous type. In its anterior end a cavity is formed which may enclose the Cercaria body, but apart from this peculiarity, it is formed as a normal Cercaria tail, broadest anteriorly and tapering behind. The oral sucker is armed with a stylet bearing several spinose points. Penetration glands are present; they are composed of a different number of cells (4—12). The excretory bladder is very narrow, elongate, and almost reaches the posterior margin of the acetabulum. They develop in Sporocysts; host: *Sphaerium*. —

The mature forms are found in the urogenital system of *Amphibia*, mainly in the vesica. The Cercariae are sedentary, attached to a substratum, commonly the edges of the mantle of the *Sphaerium* from which they are hatched or at all events in very close proximity to the mussels. They only swim when obliged to do so; the apex of the tail is used as a sucker.

The European Macrocercaria may be referred to two groups proposed by SEWELL (1922, p. 146). The *Gorgodera* group and the *Gorgoderina* group. The *Gorgodera* group may comprise the three following species:

- C. Gorgoderae cygnoides*. Zed.
- C. Gorgoderae Pagenstecheri*. Ssin.
- C. Gorgoderae Varsoviensis*. Ssin.

The *Gorgoderina* group: *C. vitellilobae* Ssin. The two groups may be distinguished from each other by the following characters: In the *Gorgodera* group the anterior

chamber occupies not more than $\frac{1}{6}$, commonly not more than $\frac{1}{10}$, of the total length of the tail. In the *Gorgoderina* group it occupies about $\frac{1}{3}$. Further, in the *Gorgoderina* group, behind the cavity which is occupied by the body, there is a broad chamber containing numerous spherical cells. In Denmark both groups are represented. The *Gorgoderina* group by *C. Pagenstecheri*, the *Gorgoderina* group by *C. vitellilobae*. —

Cercaria Gorgodereae Pagenstecheri SSIN. Host: *Sphaerium corneum*.

Pl. XVII, figs. 4—12. Pl. XVIII, fig. 3.

The dimensions are:

Cercariae.

	Living
Total length of body	4460
Breadth of "house"	450
Length of tail	3950
Breadth of tail	500
Oral sucker	60
Ventral sucker	70

The Cercaria without tail.

Length	600
Breadth	175
Oral sucker	120
Ventral sucker	100

The *Cercaria* may attain a length of 2—5 mm., the chamber including the *Cercaria* being only about $\frac{1}{10}$ of the total length. The chamber is formed as a duplicate of the cuticula; during the development in the Sporocyst it has grown up over the body and enveloped it. As long as the body is uninjured and undisturbed, it remains in the chamber, and always in a strongly bent position with the forepart almost reaching the bottom of the chamber. It may stretch itself halfway out of the chamber of its own accord, and again withdraw. It is fixed to the bottom by means of a very contractile muscle band. Under pressure the body may be forced out and it may then be seen how the duplicate of the chamber is rolled up and bent outwards (Pl. XVII, figs. 8—10). Then the body cannot re-enter its chamber, but is seen to move freely in the water attached by its muscle band. In Nature the *Cercariae* will be found on *Sphaerium* shells and on stones around them, and among them many with empty chambers, conspicuously showing the walls of the chamber, a fine cuticula bordering the space in which the body lived, and at the bottom of it remains of the muscle band which is now broken off. The chamber is connected with the tail in its whole breadth and there is no constriction between the chamber and the tail. The part of the tail nearest to the chamber is filled with numerous large cells with a hyaline pro-

toplasm and rather small nuclei (Pl. XVII, fig. 9). The tail (Pl. XVII, figs. 4—5) itself shows a very conspicuous transversal muscle layer and two broad bands of longitudinal muscles which pass through the whole length of the tail. The interior is filled with a parenchymatous tissue consisting of rather few cells connected by long threads; the tail tapers towards the apex; it ends in a well-defined little sucker connected with the tail by a thin stalk. These structures are not conspicuous in all the Cercariae; they seem to be obliterated in specimens which have been killed after they have been removed from the substratum. — The tail itself is capable of very powerful motion. Attached to the substratum by the sucker, the 2 mm. long bodies move in large curves. It is a very peculiar sight to see a whole fringe of these hyaline threads always in motion projecting from the slightly open shells of the *Sphaerium* (Pl. XVIII, fig. 3). As soon as the *Sphaerium* is disturbed and shuts the shell, the Cercariae withdraw into the shell and disappear. Usually some of the Cercariae remain outside the shell. They may then be seen at the bottom of the vessel, indicating the *Sphaerium* which are infected. I have never seen a specimen which swam into the water of its own accord. When removed from the bottom, they swim in a lazy manner, but during the motion they sink slowly to the bottom, where they soon fix themselves again. —

THIRY (1860, p. 275) remarks that the locomotoric power of the larva, in spite of the very vigorous motion of the tail, is actually very small. This is correct, but I do not think he is right when he says: "Man würde nicht begreifen, wozu der ungeheure Schwanz vorhanden wäre, wenn seine Bewegungen nicht beim Bohren so vortrefflich verwendet werden könnten". I suppose that these bands and spots of a great number of Cercariae incessantly swinging in all directions are in the first place meant to bring the Cercariae into contact with the new host in which they are to encyst. When this is contrived, the Cercariae, which often sit halfway out the chamber, break off the connection with the tail and jump on to the new host. The many empty chambers would seem to render this supposition reasonable. It is a very characteristic feature that the tails with the empty chambers continue their swinging motion long after the Cercariae have left the chamber. I cannot see how the tail, as assumed by THIRY, can be an apparatus to facilitate a boring action. THIRY refers cysts which he has found in small *Limnaea* to this species. —

With regard to the body only the following points shall be mentioned. The oral sucker is only a little smaller than the ventral one. It is provided with a stylet which in the lateral view shows three teeth. Of the alimentary canal I have only seen a short oesophagus. By the sides of the ventral sucker there are pearshaped penetration glands whose ducts pass through the oral sucker and debouch at the posterior part of the stylet. Their number seems to be six on each side. The bladder presents itself as a long canal almost reaching the ventral sucker. It gives off two canals, which pass forward and, as far as I have been able to see, on the side of the ventral sucker divide into two branches, the one passing anteriorly the other posteriorly, and almost reaching the attachment of the tail. In its posterior part the bladder gives off a canal

which runs through the whole tail but is difficult to see. It is correctly mentioned by THIRY. At the sides of the bladder lie 7 leaf-like cells which diminish in size posteriorly. They have a granular content, but nuclei have not been observed. Their function is unknown to me. —

The Cercariae develop in Sporocysts, which have been thoroughly studied by THIRY. — As WAGNER and later WUNDER (1924, p. 330) have observed, the Sporocysts never contain fully developed Cercariae, the chamber is not developed as long as the parasite is in the Sporocyst or in the mussel; it is not formed until the animal has left the mussel, and is hanging out of the opening between the two shells. With regard to the formation of the chamber I refer the reader to WUNDER (1924, p. 330) whose observations I can only confirm. —

C. pagenstecheri was only found once in *Sphaerium corneum* taken from a little pond (Vejenbrød) on 2/VI 32. The infection was very heavy, 30 of 50 specimens being infected.

***Cercaria vitellilobae* SSIN. Host: *Sphaerium*.**

Pl. XVII, figs. 1—3. Pl. XVIII, figs. 1, 2, 4, 5.

The dimensions are:

<i>Cercariae.</i>	Living
Total length of body	1470
Breadth of "house"	230
Length of tail	920
Breadth of tail	135
Oral sucker	40
Ventral sucker	45

The Cercaria without tail.

Length of body	405
Breadth of body	250
Oral sucker	75
Ventral sucker	85

Sporocysts.

Length	1810
Breadth	210

The Cercaria is 1.75 to 2 mm. long, the chamber occupies only $\frac{1}{3}$ of the total length of the tail. The anterior part in which the body lies is of the same structure as in *C. Pagenstecheri*, but broader; behind this chamber there is in *C. vitellilobae* another, sharply marked off from the rest of the tail. The muscle which fastens the body to the tail passes through the whole length of this chamber, and is fastened to the anterior edge of the remaining part of the tail. This chamber is laterally built

up of very large cells arranged transversally and with large nuclei (Pl. XVIII, fig. 2). The interior is filled with globular cells small in the anterior part and there densely packed. In the posterior part they are more scattered and here they are connected by long protoplasmatic threads. In contrast to *C. Pagenstecheri* the bodies are often stretched out almost at full length from the opening of the first chamber, and they are able to pass out and in at will (Pl. XVII, figs. 2—3). It may then be seen how the muscle band is now dilated, now contracted. When the bodies are stretched out of the chamber, the anterior duplicate is bent outwards; the body itself is commonly much bent and may move from one side to the other. Very often tails are found from which the bodies have disappeared, and in which the first chamber is rolled up and only the second chamber with loose threads of the muscle bands is present. These tails keep their locomotoric power for hours.

Just like *C. Pagenstecheri*, *C. vitellilobae* is a fixed organism attached to or in close proximity to the *Sphaerium* from which it has been hatched. As far as I can see, the tail has no sucker as is found in *C. Pagenstecheri*; its sides commonly present a series of curves whereas the contour in *C. Pagenstecheri* is straighter. The transversal as well as the longitudinal musculature is more powerfully developed, and this is the case, too, with the parenchymatous tissue. The tail therefore is more opaque and compact than in *C. Pagenstecheri* where the tail is very hyaline. It is traversed by the excretory tube the end of which has not been observed. By means of the relatively short but very muscular tail the animals are always in motion, swinging about incessantly and curving the tails and the outstretched bodies in all directions.

The body itself is subject to great variations in form.

The anterior and posterior suckers are almost of the same size. As far as I have been able to see, there is a short oesophagus without a pharynx, intestinal coeca have not been seen. Laterally and before the ventral sucker there are 6—7 cystogeneus cells. With long curved ducts they pass forwards, follow the borders of the anterior sucker, pass into it, and debouch on the posterior margin of the spine. The anterior part of this in the lateral view has three acute points separated from each other by a deep curve; the lateral wings are long. The excretory system is of a structure very similar to that of *C. Pagenstecheri*, a long bladder almost reaching the ventral sucker, and furnished laterally with a series of transversally arranged cells having a granular content with small nuclei. Two excretory canals issue from the anterior part; near the middle of the ventral sucker they seem to divide in an anterior and a posterior branch. There appear to be many vibratile tags, but they were not closely studied. Posteriorly the bladder gives off a tube which passes through the whole end of the tail; the opening has not been observed.

The Cercariae develop in Sporocysts (Pl. XVIII, fig. 4—5) which are attached to the gills of the mussels. They are of a peculiar, clumsy often very irregular form; they contain enormous quantities of Cercariae. In samples taken on 11/IV from Strødam, 16 of 50 *Sphaerium* had Sporocysts which contained immense masses of very unripe Cercariae. The Sporocysts were elongated sacs which were placed with great

regularity side by side along the edge of the gills; a *Cyclas* might contain about 30—40 Sporocysts. On 5/VI, 4 of 20 *Sphaerium* contained Sporocysts and ripe Cercariae and on 20/IX 20 of 50 *Sphaerium* contained ripe Cercariae which soon appeared outside the mussels and sat swinging about at the edges of the mantle, on the shell or in close proximity to the mussels. None were seen to swim voluntarily.

Cercaria vitellilobae was found in *Sphaerium* on a moor near Hillerød on 2/IV 32, at Strødam where it is common the whole year round; and on 29/IX in Esrom Lake in one of 10 specimens. —

The third group for which I propose SSINITZIN'S name *Cercaria cystropha* (1911, p. 20) consists of very aberrant forms; they are among the most marvellous of the freshwater larvae. Almost all the forms of this group have only been observed once or at all events at great intervals. The further evolution of these species is only known for a single form, *C. cystropha* Wagn. which develops in *Halipegus ovocaudatus* found under the tongue of *Rana esculenta*. Some of the forms are marine; one of these, *C. vaullegeardi*, seems to develop in Sporocysts, the others in Rediae; as far as hitherto recorded, they are all parasites on snails. It is the structure of the tail, divided into several parts of very different form and provided with various appendages of which we have no understanding at all, which gives these forms their different aspects.

The following species belong to this group:

- Cercaria cystropha* Wagener 1866. Europe.
- *yoshidae* Cort and Nichols 1921 = C. F. Yoshidae 1917. Japan.
- *capsularis* Sonsino 1892. Italy.
- *appendiculata* Pelseneer 1906, marine.
- *vaullegeardi* Pelseneer 1906, marine.
- *sagittariae* Ssinitzin 1911, marine.
- *laqueator* Ssinitzin 1911, marine.
- *indicae* XXXV Sewell 1922. India.
- *californiensis* Cort and Nichols 1921. California.
- *biflagellata* Faust 1926. South Africa.
- *projecta* Willey 1930. North America.
- *invaginata* Faust 1924.

As I have never seen any of these forms, and they have not been found in Danish freshwaters, they will not be treated here.

Chapter VII. Furcocercaria.

As a result of my studies of Furcocercariae in Danish freshwaters the following remarks may be offered.

18 species have been observed. As far as I have been able to see, they may be referred to the following 7 groups:

1. The *Lophocerca* group.
 - C. cristata*. La Val.
2. The *Ocellata* group.
 - C. ocellata*. La Val.
 - Bilharziella polonica*. Kow.
3. The *Bucephalus* group.
 - C. Bucephalus polymorphus*.
4. The *Cysticercaria* group.
 - C. splendens* Szidat.
5. The *Proalaria* group. Penetration glands behind the ventral sucker (host: Fish).
 - C. I. Petersen*.
 - C. C. Szidat*.
 - C. helvetica* XXXI Dubois.
 - C. longiremis* n. sp.
 - C. F. I. Harper*.
 - C. Frederiksborgensis* n. sp.
6. The *Strigea* group. The penetration glands before the ventral sucker. (host: Snails).
 - C. letifera*. Fuhrmann.
 - C. strigeae tarda*.
 - C. A. Szidat*.
 - C. linearis* n. sp.
7. The *vivax* group.
 - C. vivax*. Sonsini.
 - C. sp.*
 - C. No. 4 Petersen*.

The Lophocerca group.

The genus *Sanguinicola* was erected by M. PLEHN (1908, p. 427; 1915, p. 244) who found the two species *S. inermis* and *S. armata* in the blood of *Cyprinus carpio* and *Tinca vulgaris*. She misinterpreted the systematic position, and it was ODHNER (1911 a, p. 33) who referred the genus to the digenetic Trematoda. See also ODHNER (1924).

Relying on unpublished studies and drawings by LOOS, ODHNER (1911, p. 42) arrived at the result that the *Cercaria cristata* la Val. in capillaries of *Cypridinidae* develops in a species of the genus *Sanguinicola*. SCHEURING (1922) and later on EJSMONT (1925, p. 877) showed that ODHNER's supposition was quite correct.

The systematic position of the Lophocercariae has always been a matter of much controversy.

LÜHE (1909, p. 175) placed them in a separate group. SEWELL (1922, p. 22)

placed them as the *Lophocerca* group under his Monostomata, whereas MILLER (1926, p. 69) placed them under the Furcocercariae as *Apharyngeate brevifurcate monostome Cercariae*. In my opinion there are only two alternatives. Either, if we follow LÜHE, to regard the Lophocercariae as a special group; or if we follow MILLER to regard them as directly related to the Furcocercariae.

To include them in the Monostomata would be a great mistake in my opinion. In that case the Monostomata would include forms with an extremely different mode of life, both blood parasites and parasites of the alimentary canal; forms which pass a stage of encystment and forms without any stage of encystment and which pierce the skin of the final host. In accordance with the entirely different mode of life the anatomical structure of the two types is quite different. The Monostomata have no piercing organ, the oesophagus and diverticula are very well-developed; they have well-developed locomotoric pockets at the posterior angles of the body; the interior is packed with cystogeneous material and the excretory organ differs greatly from that of the Lophocercariae. Furcal rami are not present.

The only character which connects the Lophocercariae with the Monostomata is the absence of an acetabulum. From the Furcocercariae the Lophocercariae differ in the first place by the peculiar compressed body-form and the dorsal finfold, unique in its form and position among freshwater Cercariae, further in the bifurcation of the excretory canal in the tail-stem immediately at its base. As far as I know this trait, too, is unique among freshwater Cercariae. On the other hand, if the penetration apparatus as described by SEWELL for his Indian material is common also in the European material the Lophocercariae agree with the Furcocercariae in that respect as well as with regard to the structure of the digestive tract. Another feature which they have in common is the development in Sporocysts not in Rediae as is the case with the Monostomata s. str.

It would seem, furthermore, that intermediate stages between Lophocercariae and Furcocercariae really exist. SEWELL (1922, p. 57) mentions them; his Lophoides group may be regarded (1922, p. 58) as such, but I cannot find any form which connects the Lophocercariae with the Monostomata sens. str.

It may further be added that, according to MILLER (1926, p. 68), the Lophocercariae is the only one of LÜHE's groups which seems to be restricted to the old world; they have been recorded from Europe by many authors, from Asia especially by SEWELL, and from Africa by WOODLAND (1923).

Hitherto the following Lophocercariae from freshwaters have been described.

- Cercaria cristata*. La Val. 1852.
- *microcristata* Ercol. 1881.
- *Sanguinicolae inermis* Scheur. 1922.
- *indicae IX* Sewell 1922.
- *indicae XIII* Sewell 1922.
- *indicae XXXIX* Sewell 1922.

Cercaria indica LV Sewell 1922.

- *Sanguinicolae* spec. *Bithynia leachii* (Ejsmont) 1926.
- *Sanguinicolae* spec. *Limnaea stagnalis* (Ejsmont) 1926.
- *helvetica* XVI Dubois. 1929.

The Indian forms described by SEWELL differ from the European forms in many essential particulars. *C. indica* XIII may be the form most nearly related to *C. cristata*, but it differs from it by having very small and never filiform Sporocysts and by its smaller size. DUBOIS's species *helvetica* XVI differs from all other species in the reduction of the fin membrane of the body and because the fin membrane of the furca is absent in the first third. It is found in *Limnaea limosa* (= *ovata*).

With regard to the other species I refer the reader to EJSMONT's paper of 1926 (pp. 928—942). The said species all seem to differ very little from each other; well-defined morphological differences have not been found. They occur in different snails *Limnaea stagnalis*, *Limnaea auricularia*, *Valvata piscinalis*, *Bithynia Leachii*, *Paludina impura*, *Planorbis submarginalis*, *Bithynia tentaculata*, *Cleopatra bulimoides*.

It is possible that the two species: *C. cristata*, mainly found in *L. stagnalis* but also in *L. auricularia* (LOOS, SCHEURING) and *C. microcristata*, found in *Bithynia tentaculata* have species range. With regard to the other species, the differences are probably due to the fact that the forms are found in very different snails.

Cercaria cristata LA VAL. Host: *L. stagnalis*.

Pl. XX, figs. 1—10. Microphoto Pl. XXXIX fig. 22.

The dimensions are:

<i>Cercariae.</i>	Living
Length of body	95
Breadth of body without membrane	30
Greatest height of membrane	25
Length of tail	240
Breadth of tail	25
Length of rami	115
Breadth of rami	20
Oral sucker	20
 <i>Sporocysts.</i> 	
Length	19200
Breadth	600

The crest reaches from the penetrating organ to a little before the attachment of the tail, the height differs from specimen to specimen. —

The protrusile penetrating organ is bluntly conical, divided from the body by

a conspicuous constriction. The extreme tip is provided with a pair of conical spines, most probably hollow, and acting as a piercing organ. More than two spines have not been observed. The hairs or papillae which, according to EJSMONT (1926, p. 935, text-fig. 10) are regularly arranged in circles round the cone, I have not seen, perhaps because I have only looked for them in preserved formaline material. His view of the cone as a snout ("Rüssel") capable of great telescopic contraction and extension, I can fully confirm. Figures 2—5 show the same animal drawn in the course of two minutes. The snout is extremely mobile, capable of being withdrawn into a kind of sheath, to be protruded again the next moment at full length. Of the penetration glands I have only observed two fine strings. As far as I know, only SEWELL (1922) has observed the glands in his Indian material of *Lophocercaria*. Only EJSMONT (1926, p. 938) has seen the oesophagus and stomach. He contends that diverticula to the number of four appear "erst später". The digestive tract has been very difficult to observe and I have not ventured to draw the oesophagus. No eyespots have been seen. SEWELL (1922) maintains them for all Indian species. The excretory organ consists in a bladder which is often difficult to see and whose form varies greatly. It sends forward two main trunks which reach the piercing organ. I have been unable to see the flame cells observed by SEWELL in his Indian material. The formula is said to be $2 \times 3 \times 1 = 6$.

With regard to the excretory system in the tail stem, LOOS's drawings in ODHNER's paper (1911, p. 43) show two canals, and EJSMONT arrives at the same result (1926, p. 941 and fig. S, p. 939); the two canals pass into the furcal rami, where they open at the base of a small tip. Curiously enough, SEWELL (1922) draws in all his figures only one caudal excretory canal. As far as I know, two canals in the tail stem are a unique trait in the structure of the Cercariae, though I cannot but think that the drawings of Loos and EJSMONT are correct; my observations are in accordance with the two last authors. Nobody has observed flame cells in the tail stem. The interior of the body, more especially the bent part, is filled with round cells; many of them are remarkably large and furnished with a big nucleus and numerous yellow granules which impart a yellow tinge to the whole body.

The tail stem is in preserved material constricted at its base. Slanting muscles run in two directions, crossing each other. The furcal rami are well-defined at their base, and the rather broad finfold only reaches the place of attachment of the rami to the stem.

The species here described may be referred to *C. cristata* La Val. The measurements agree well with it. It is the only form in which long filiform Sporocysts are found. The only difference from those redescribed by EJSMONT is that they may be much longer, and that the Cercariae are not deposited in a single long row.

Sporocysts. A *L. stagnalis* from 24/III 30, which died on 28/III, was dissected immediately after death. The surface of the liver was covered with numerous small yellow, cushion-formed spots which, when opened, proved to consist almost entirely of Cercariae that appeared in the water in enormous amounts. Below the cushions

were found layers of shorter Sporocysts. The liver was, however, mainly characterised by a great number of long yellowish-white threads with a length of about 1—2 cm. These Sporocysts were chiefly placed on the surface of the liver. When they were loosened, it could be seen that they were fastened by means of a sucking disc provided with strong muscles. Sucking discs have only rarely been observed in Sporocysts.

Among the Sporocysts one was found (Pl. XX, fig. 6) on which the sucking disc was especially well developed (Pl. XX, fig. 10); the skin was remarkably thick and somewhat opaque length 1.90 cm. While watching it, I suddenly saw a long thin Sporocyst make its way through the skin. A few minutes later another arrived in another place, and now everywhere there appeared through the skin, now here, now there, a young Sporocyst which swam away very actively from the mother Sporocyst (fig. 6). The Sporocyst was now studied more thoroughly. Owing to the thick skin and its length I regard it as a mother Sporocyst. It contained brood of three different kinds. 1. The above-mentioned long daughter Sporocysts (600—1000 μ) which were all packed with almost iso-diametrical germ-balls. The number of these daughter Sporocysts was not more than 30—40. 2. An enormous amount of small Sporocysts not more than twice as long as broad (length: 112—150 μ). These Sporocysts contained about 10—12 Cercariae in different stages of development; they are not shown in fig. 6 but in fig. 7, which exhibits part of the same Sporocyst that is figured in 6. 3. Free-lying germ-balls, many of which plainly showed a cleft tail, that is to say Cercaria brood. That a Sporocyst contains simultaneously daughter Sporocysts and Cercariae is nothing remarkable, but the curious thing is that it contains two kinds of Sporocysts, one sort long, packed with very small germs, and leaving the mother Sporocyst everywhere through its walls, and another sort only twice as long as it is broad, and producing Cercariae. As shown in fig. 7, the Cercariae were found lying free in the mother Sporocyst; when it was pressed, they made their way out by piercing the skin. The mother Sporocyst itself was inactive, only the forepart incessantly altered its form. Fig. 8 shows the tip. This forepart, of a greyish tinge, was the only part which did not contain brood.

Sections of the liver show that the whole of it, especially near the edges and in islets corresponding to the cushions on the surface, consists almost entirely of these small bodies.

As far as I can see, the rather complicated development may be interpreted as follows. The 1.9 cm. large Sporocyst is the metamorphosed Miracidium with which the snail was once infected, most probably in 1930. This mother Sporocyst then produced a great number of daughter Sporocysts, 650—1000 μ in length. Most of them fastened themselves to the surface of the liver, imparting to it a floccose appearance. The mother Sporocyst as well as the daughter Sporocysts produced an immense quantity of small oval Sporocysts, not more than 112—150 μ long. The mother Sporocyst therefore produces two kinds of Sporocysts, those 650—1000 μ long, and those only 112—150 μ long. The long daughter Sporocysts, as far as I can see, only produced the latter kind. The long daughter Sporocysts pierce the walls of the

mother Sporocyst, making their way partly through them and partly through the liver of the snail, the small ones are only liberated by rupture of the Sporocyst in which they have been nourished. When the investigation began, the parasite was using all its energy for the production of Sporocysts, and the development of Cercariae had only just started.

Cercaria cristata was found in four different localities. In two of them (Langesø and Sjølsø) they were found in *Limnaea stagnalis*, always in old, very large specimens. In the other two they were found in *Valvata piscinalis* and *Bithynia* (Furesø) and in *L. ovata* (Teglgaardsø). All observations date from the months of June—September. Apart from the specimens from *Bithynia* and *Valvata*, which are derived from Furesø at a depth of 3—5 m, the others all come from ponds and small lakes. The snails were always infected in very small numbers; of *L. stagnalis*, for instance, 1 in 17, of *Valvata* 1 in 50.

One of the *L. stagnalis* was put into the largest of my aquaria in October 1930. I did not know that it was infected, but when it was put into a small vessel on 24/III and placed in a thermostat at 22° C., it immediately threw out an immense quantity of *Lophocercariae*. On 28/III it died. Most of my observations originate from this snail and from those from Langesø where I gathered fresh material during the last ten days of June 1932. The snail proved to be heavily infected. In the course of 24 hours the water in the vessel was filled with numerous Cercariae. These Cercariae were typical plancton organisms, remaining suspended in the water layers. I refer to Chap. VIII. Suspended in the water layers, they are unquestionably apt to come into contact with fishes of the family *Cyprinidae*. In my aquaria the life-time of the Cercariae has never been more than 24—30 hours. Into two of my aquaria, containing two snails heavily infected with *Lophocercariae*, I put two *Carassius*, but curiously enough, no special affinity could be observed. The two *Carassius* lived for half a year and on dissection showed no worms in the heart and no eggs in the gills or in the blood. This has troubled me a good deal because EJSMONT, at Warschau, found the parasite in 55 out of 250 specimens of *Carassius*.

On 21/VI a *Limnaea stagnalis* was found in a pond, Langesø. It immediately produced myriads of *Lophocercariae*. In the course of 24 hours the water was a milky white. It was changed every evening, and every morning it was again milky. This was repeated until 28/VI when the *Limnaea* was dying. The appearance of the liver now differed greatly from that of the specimen in March. It was a yellow mass, containing as it were exclusively Cercariae, which poured out in a broad yellow stream when the liver was ruptured. It was almost impossible to see any Sporocysts; long ones were absent, and the liver itself was in putrefaction in the upper part, nevertheless the snail was still alive when it was dissected.

The Ocellata group.

Only four species belonging to the *ocellata* group (MILLER's apharyngeal-brevifurcate Furcocercaria) have hitherto been recorded from Europe. They are *C. ocellata* La Val. 1855, *Bilharziella polonica* Kow. 1896, *C. macrosoma* Brown 1926, and *C. echinomorpha* Brown 1931. The two last-named species are very nearly related to *C. ocellata*, with which they seem to agree in all essential particulars. Only the two first-named have been found in Denmark. With regard to the difference in the structure of the penetration glands (Acidophile and basidophile glands) I refer the reader to FAUST (1919 b, p. 164; 1920 e, p. 192; 1922 a, p. 11; 1926, p. 101).

Cercaria ocellata LA VALETTE 1855. Host: *Limnaea stagnalis*, *L. ovata*.

Pl. XXI, figs. 1—4. Pl. XXVIII, figs. 7—9.

Cercaria ocellata was first found by LA VALETTE DE ST. GEORGE in *Limnaea stagnalis* in the neighbourhood of Berlin. It was described in 1855 (p. 123). It was not recorded again until 1902, and described by SSINITZIN from Warsaw (1910). It was found again by DUBOIS (1929, p. 96) in Switzerland. It was further recorded by VOGEL from the environs of Hamburg (1930 a, p. 577; 1930 b, p. 1), by BRUMPT from France (1931 a, p. 612, and 1931 b, p. 253), and by TAYLOR and BAYLISS from the neighbourhood of Cardiff (1930, p. 219). It is nearly related to, if not identical with *Cercaria elvae* described by MILLER (1923, p. 35, and later on 1926, p. 30), and later on from Michigan by CORT (1928 a, p. 1027; 1928 b, p. 388). The principal host seems to be *Limnaea stagnalis*, but MATHIAS (1930 b, p. 152) found it in *Limnaea ovata*, and BRUMPT has shown experimentally (1930 a, p. 614) that it may infect 7 different species of molluscs. There was great affinity for *Planorbis corneus*(?), *P. rotundatus*, and *Limnaea palustris*. Only *Bithynia tentaculata* could not be infected. It has been confounded with *Bilharziella polonica*, whose chief host is *Planorbis corneus* (ERCOLANI 1881). —

The dimensions are:

	Living	Preserved
Length of body	350	273—314
Breadth of body	90	51—71
Length of tail	365	292—386
Breadth of tail	45	34—47
Length of furca	260	199—274
Length of anterior organ	85	37—56
Breadth of anterior organ	65	33—46
Length of ventral sucker	35	13—24

Fully extended, the body and tail are almost equally long; when the animal is not fully extended, the tail is longer than the body. The furca is shorter, but has

great power of contraction and expansion. The rami may attain more than two-thirds of the length of the tail, but commonly they are not more than half as long. The breadth of the tail may equal that of the body. The ventral sucker is capable of being protruded much more than in any other Cercariae (Pl. XXI, fig. 3). It is for this reason that slides almost always show lateral views of the animal. When the sucker is extended, a complicated system of muscles running from it to the dorsal side causes the forepart of the body to bend downward and form a sharp angle between the sucker and the anterior organ. The part behind the sucker is almost unaltered. This action of the muscles alters the whole aspect of the animal in a way that I have not hitherto observed in any other Cercaria. The body tapers towards both ends. It is broadest above the sucker, and tapers most anteriorly, where it shows a somewhat rounded snout. The body is divided by a chitinous fold, the forepart containing most of the anterior organ to which several muscles are fastened. The whole body is almost quite smooth, only the part before the chitinous fold shows a fine striation, which may perhaps be interpreted as extremely fine spines arranged in longitudinal lines. Special thorns on the apex were not observed.

The anterior organ is very large and divided into an anterior, more thin-walled, and a posterior very muscular part, which is very conspicuous owing to its transversal muscle threads. A conspicuous sack-like head gland is situated over the organ. In side view the organ is pear-shaped, with a faint curve below and tapering anteriorly. The ventral sucker is situated in the last third part of the animal. It can be entirely withdrawn into the body, and it can be protruded to such an extent and the body bent sideways so far that it becomes twice as broad as usual and is shortened by more than a third. In the ventral view it shows a peculiar chitinous structure (Pl. XXI, fig. 1); the lateral aspect shows concentric circles of very minute spines, and below the cuticula fine circular muscles. The actual sucking part can be withdrawn and extended telescopically, and a system of muscles running through the body is fastened at the point where the cuticula is folded. The muscles consist mainly of two groups of fine threads attached by the other end to the dorsal wall of the body.

Anteriorly, laterally, and posteriorly lie the powerful penetration glands, filling most of the interior with their ducts. There are five pairs of glands, three smaller posterior ones and two much larger ones, of which one mainly occupies the space round the sucker, the other that before. The two groups differ much in appearance. The body of *ocellata* being marvellously transparent with only a faint yellowish tinge, the whole penetration apparatus may be observed very plainly. The two anterior pairs of penetration glands have a coarsely granular protoplasmatic content; the three posterior pairs are of a more greyish colour and have a protoplasmatic content consisting of a much finer granular mass. The two anterior pairs may almost be said to be chromophobic, the three posterior pairs stain very deeply with haematoxyline. The nuclei are always situated in the posterior part of the cells, but are larger in the anterior than in the posterior pairs. The very strong ducts constitute a highly remarkable

feature. With regard to the two anterior pairs it is almost impossible to say where the cells stop and the ducts begin.

Viewed from above, the ducts show a very characteristic course, common to the many hundred specimens observed. It is most distinct in the two anterior pairs. First the ducts bend outward, then inward, so much so that they almost touch each other, then outward again; shortly before they reach the anterior organ, they again bend inward. They then traverse the anterior organ, ending at the apex where there occur six small protuberances, the openings for the ducts. Of their number I am not quite sure; six at all events, are present, but more probably ten. When the body is extended, the course of the ducts is curved, when the body is bent, as shown in Pl. XXI, fig. 3, the curves are much steeper. This is especially the case in the anterior organ where the loops almost reach each other. When the Cercaria has remained in this position for a few seconds, a clear jelly-like mass is seen to pour out from the apex and now remains glued to the forepart of the body (Pl. XXI, fig. 3). TANABE (1923, p. 184) has made the same observation with regard to *Schistosoma pathlocopticum*. It can further be shown that throughout the curves muscle threads run from the ducts either to the skin or to the chitinous list which separates the forepart from the other part of the body.

The alimentary canal is extremely reduced; there is merely a staff-like oesophagus, only reaching a little more than halfway between the anterior organ and the sucker. It divides into two short protuberances all that is left of the intestinal coeca. There is no pharynx. Simultaneously with the reduction of the alimentary canal, the penetrating organs have undergone an enormous development which is unique in this group.

The visible part of the nervous system consists of a somewhat x-shaped greyish mass, situated just in front of the eyes. There are two eyespots, consisting of numerous granules of a brownish-red colour, and before them a well-developed protruding lens.

The bladder is very small. Anteriorly it gives off two excretory canals, posteriorly one, which passes into the tail. On reaching the ventral sucker, the two anterior canals divide into an anterior and a posterior branch. The former carries three flame cells, the latter four, one of which is situated in the tail. The excretory tube in the tail bifurcates before the furca, and the two rami open on their tips. The tail has a layer of circular and longitudinal muscles and, along the excretory tube, a series of globular bodies only observable in living material.

The Cercaria develops in very long Sporocysts (Pl. XXVIII, figs. 7—9), extremely variable in form. Greyish narrow parts alternate with very broad transparent ones, real brood chambers packed with brood. Old Sporocysts consist mainly of narrow greyish parts with a few fully developed Cercariae. A birth pore has not hitherto been observed.

In Denmark *C. ocellata* has so far only been found in one pond in the castle grounds of Hørsholm. It was found in *Limnaea ovata* as well as in *L. stagnalis* but not in the *Planorbis* species. The number of infected specimens was always small,

one in ten. Material was gathered on 8/X 31, when the first infected snail was found. In 1932 material was collected on 23/V, 2/VII, and 16/VII. In May the material consisted almost entirely of Sporocysts, on July 16th almost exclusively of Furcocercariae. Some snails were found which almost exclusively harboured Cercariae, and in incredible amounts. These snails had a peculiar yellow colour. A snail taken on 2/VII every day gave off enormous amounts of *C. ocellata*, which gave the water a greyish colour. It died on 16/VII.

***Cercaria Bilharziellae polonicae* Kow. Host: *Planorbis corneus*.**

Pl. XXI, figs. 5—7. Microphoto, Pl. XXXVI, fig. 5.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	305	185—232
Breadth of body	110	82—87
Length of tail	275	242—266
Breadth of tail	45	25—36
Length of furca	110	77—107
Length of anterior organ	80	44—57
Breadth of anterior organ	65	..
Length of ventral sucker	45	34—46

Bilharziella polonica was found by KOWALEWSKI (1895 p. 1 and 1896, p. 146); later on by SZIDAT (1928 a, p. 331).

So far the *Cercaria* has been found by SZIDAT (1929b, p. 78; 1929c, p. 461) in Kurische Nehrung. It occurred in *Planorbis corneus*, but was extremely rare, only 4 cases in 600 snails, that is, a percentage of only $\frac{3}{4}$ —1. In the above-cited papers SZIDAT has worked out the anatomy and the biology. Further it was found by BRUMPT (1931 b, p. 253) in *Planorbis corneus* originating from small brooks in the Bois de Boulogne. Here, too, it was very rare, occurring only in 6 specimens out of 614. It seems highly probable that the *Cercaria* found by ERCOLANI (1881) in *Planorbis corneus* belongs to this species and not as he supposed to *C. ocellata*.

Fully extended the body and tail are almost equally long; the furca is very short, about one-third of the length of the tail, but when fully extended one-half. It has a conspicuous fin membrane. The body is broader and the tail shorter than in *C. ocellata*. The tail shows a peculiar feature. In its anterior part it is expanded wing-fashion, while the body has a cup-like depression. This feature differs very much from specimen to specimen and may be very pronounced or almost absent in preserved material. The tail breaks off very easily.

In the anterior part the body is covered with fine spines, coarser nearest the apex, inconspicuous in the posterior part. The anterior organ is large and divided into an anterior more thinwalled and a posterior very muscular part. The muscle

threads running transversally are very conspicuous. In side view the organ is somewhat pear-shaped, but the curve below is not so pronounced as in *C. ocellata*. A head gland was not observed. SZIDAT (1929c, p. 465) has "nur geringe Andeutungen erkennen können". The ventral sucker lies behind the middle line; it is not capable of protrusion in so high a degree as in *C. ocellata*. In the ventral aspect it shows a similar chitinous structure surrounding the opening as in *C. ocellata*, and here, seen laterally, it has concentric circles of very minute spines and, below the cuticula, fine circular muscles. The actual sucking part of the sucker can be withdrawn telescopically and again protruded. At the point where the cuticula is folded, is fastened a system which runs transversally through the body. Antero-laterally there are two pairs of penetration glands, posteriorly four; the two first-named pairs have a clear bright protoplasm, the four behind are more greyish and have a granular content. Only the four posterior pairs are chromophilous, the two anterior pairs are not. SZIDAT found three pairs behind and three pairs before the sucker (1929c, p. 463).

The ducts show a course very similar to that in *C. ocellata*, but the ducts from the single cells seem to be separated from each other by rather large crescent-shaped spaces. They are not so broad as in *C. ocellata*, and the ducts from the two sides do not reach each other. In the lateral aspect, as seen in the drawing (Pl. XXI, fig. 6), they approach the ventral side immediately before entering the anterior organ (on the boundary line between the two parts), whereupon they ascend dorsally. In loops they reach the tip of the anterior organ, and open there on a series of small protuberances. The alimentary canal is much reduced; it is rod-like and only reaches halfway from the anterior organ to the ventral sucker; of the intestinal coeca only two small buds are present. The visible part of the nervous system is a greyish mass lying just in front of the eyes. There are two eyespots of the same form and size as in *C. ocellata*. SZIDAT (1929c, p. 464) has seen four pairs of sensory papillae on the body. These papillae I have overlooked. The bladder is small. When the two anterior canals reach the ventral sucker, they divide into an anterior and a posterior branch; at the point of division a transversal branch passes out below the ventral sucker. I do not know whether there is a real transversal commissure. The excretory tube in the tail bifurcates before the furca, opening on the tips.

The animal is not so transparent as *C. ocellata*. Hence it is more difficult to see the flame cells; they are most conveniently studied in the lateral aspect. As far as I can see, the anterior branch drains three flame cells, and the posterior four, with the last pair in the tail.

The tail has a layer of circular and longitudinal muscles. If globular bodies are present, they are only faintly developed. The Cercariae develop in very long Sporocysts very similar to those of *C. ocellata*.

The host is *Planorbis corneus*.

Bilharziella polonica has hitherto only been found in three localities: Torkeris Pond near Hillerød, Hørsholm Pond, and a small pond near Steenstrup (Sorø). It was found in Torkeris Pond on 5/V 31 in one specimen out of 10, and on 4/VII 31

in several specimens; on 23/IX again in several specimens out of 30. Later on it did not occur. In 1932 more than 100 *Planorbis corneus* were observed, but not a single *Furcocercaria* with eyes was found. On 7/VIII it was found in a few specimens at Steenstrup, on 11/VIII 32 in one out of 25. Finally, in Hørsholm Pond 1 specimen of *Planorbis corneus* was found on 5/VII 32 and proved to be infected with *Bilharziella*. Again, on 8/VII, a single specimen was found, which was likewise infected. On 27/VII 32 one of 7 specimens was infected. *Planorbis corneus* is very rare in the pond.

The *Bucephalus* group.

(*Subordo Bucephalata*).

As is well known, ODHNER (1905, p. 291), owing to insufficient evidence with regard to the life history and development, placed the *Gasterostomes* in a separate order. LA RUE gives good reasons for the supposition (1926c, p. 273) that there is a relationship between the *Strigeidae* and the *Gasterostomes*.

SSINITZIN (1910, p. 299), comparing the *Cercaria* of *Bucephalus haimeanus* with that of *C. ocellata*, arrives at the conclusion that the tail of *Bucephalus* is homologous with that of the *Furcocercaria*. At a certain stage in the development of the tail it has almost the same aspect; the whole difference may be referred to inequalities of growth, a strong development of the tail stem in the *Furcocercaria* and a reduced development of it in the *Bucephalus*, combined with a very strong and peculiar development of the furca.

***Bucephalus polymorphus* BAER. Host: *Anodonta*.**

Pl. XXX. Microphoto Pl. XXXIX, fig. 26.

About 50 *Anodonta* from different localities in the neighbourhood of Hillerød were dissected. Most of them came from Furesø, a few from Esromsø, and several from the Hørsholm ponds. In none of them were *Bucephalus* observed. I had hoped to find at the same time the very peculiar *Cercaria duplicata* described by v. BAER (1827 p. 558) and later on by REUSS (1903 p. 458), and WUNDER (1924a, p. 323) but, to my regret, not a single specimen was found. The *Cercaria* is enclosed in a hyaline cyst which is expelled by *Anodonta*, being then found as "Glaskugeln" at the bottom of the water. "Bei der geringsten Strömung sehen wir die leichten Kugeln dahinschweben. Die Verbreitung ist also hier passiv wie bei einem Pflanzensamen" (WUNDER 1924a, p. 329). In one of my aquaria two *Anodonta*, most probably coming from Hørsholm Pond, had hibernated. On 14/V 33, *Bucephalus* larvae suddenly appeared. The aquarium was placed at the window in bright sunshine, and the next day many *Bucephalus* larvae were observed.

I have nothing to add to the numerous descriptions of these very interesting larvae. With regard to the anatomy I refer the reader to ZIEGLER (1883, p. 537), with regard to the biology to WUNDER (1924a, p. 302 and 1924b, p. 289), and with

regard to the Miracidia, encystment and Sporocysts chiefly to WOODHEAD (1927, p. 232; 1929, p. 256; 1930, p. 1; 1931, p. 169).

By means of a cinematographic camera WUNDER has taken a series of moving pictures and in this way elucidated the manner of locomotion hitherto misinterpreted or not understood. I am convinced that WUNDER's explanation is correct, and having now studied the mode of locomotion partly by means of the aquarium microscope and partly by means of an Edinger apparatus, projecting the picture on to a white screen, I presume that I should have arrived at the same result. I refer to table XXX with description. Having worked for years with plancton, studying especially the locomotion and suspension of plancton organisms, it is of especial interest to me that WUNDER, as far as I know without knowledge of the literature on the subject, has arrived at exactly the same result with regard to the floating power of *Bucephalus* as I have with regard to other plancton organisms, especially the Cladocera and the Rotifera. Among all the Cercariae the *Bucephalus* larva is the most pronounced plancton organism hitherto known. Its home seems to be the midmost water layers where, by its peculiar manner of locomotion, it attracts the attention of *Cyprinidae*, especially *Scardinius erythrophthalmus*, in which it encysts. The following is an abstract of WUNDER's paper combined with an account of my own observations.

I regard the *Bucephalus* as a Furcocercaria with reduced tail stem and a strongly developed furca. The power of extension and contraction is common to all Furcocercariae, but here it is developed in a much higher degree than in all hitherto known Cercariae. The position of the animal is the same as in other pelagic Furcocercariae, the furca being turned upwards and the Cercaria body downwards. However, whereas the plancton Furcocercariae hold the furca horizontally and keep it motionless, it is here held almost vertically and capable of great extension and contraction. As pointed out by all other observers, it is in these long rami of the furca that the power of locomotion is seated. The animal is so to speak in incessant motion, though it stands in nearly the same spot in water layers which are almost quite still, whereas, in water agitated by bubbling air, the larva is moved horizontally.

The rami are incessantly contracted and extended. When the extension begins, they become thinner and thinner, the process starting at the base. Shortly before the greatest dilatation is attained, the now very thin rami bend outward, forming two very elegant curves. Almost at the same moment the contraction begins. During the extension of the rami the body of the larva is contracted, during the contraction extended. By means of the aquarium microscope it can now be observed that during the contraction of the arms the body is lifted a little, whereas it sinks down again during extension. Actually the motion may best be described as an uninterrupted treading water almost in the same spot, in some cases combined with a very slight, hardly detectable, ascending motion. The principle applied is that of cross-section resistance. During the extension of the very thin outward-curved arms, the falling motion is retarded, and the animal rests on the horizontally extended tip of the arms. Then, during the contraction of the arms, the body is hauled upwards. On the other

hand, when they are contracted and the horizontal parts drawn in, no part of the body counteracts the fall and so it must sink. As is well known, very many plancton organisms in fresh water make use of the cross-section resistance so as to remain suspended in the water layers, but in all cases merely by means of stiff chitinous thorns, surfaces, etc. All these organs are only able to counteract the fall, not to prevent it entirely; locomotoric organs are always required to prevent the fall. In *Bucephalus* we have an organism which, by means of contraction and extension of the organ intended to counteract the falling motion, is able to remain suspended almost in the same spot of the water layers. All other furcocercous Cercariae have a powerful swimming organ in the unpaired part of their tail, and in the rami which are held horizontally an organ to prevent the fall and keep the body suspended when the motion of the tail ceases. During the pause of immobility the Furcocercaria sinks very slowly; then the motion of the tail stem sets in again, and the larva assumes its old place. However, *Bucephalus* has practically nothing left of the unpaired part of the tail stem; only the two long rami remain. Active motion in a horizontal direction is impossible to it, but by the contraction and extension of the rami, owing to which there is a rhythmic alternation in the cross-section resistance, it is able, during life, to carry out an uninterrupted leaping motion on the spot.

The encystation chiefly takes place in *Cyprinidae*, according to WUNDER (1924 a, p. 319) especially in *Scardinius erythrophthalmus*. The rudimentary tail "die beiden Wülste: die beiden Scheiben" (ZIEGLER 1883, p. 27) secretes a viscous matter by which the Cercaria is fastened to the body of the fish, or drawn into the mouth when the fish snaps at it. The Cysts have been described by WUNDER (1924 a, p. 320). WUNDER says (1924 a, p. 323) that the Cercariae ascend to the surface and "mit ausgebreiteten Schwänzen hängen sie so in ungeheurer Menge stundenlang". This I have never observed. On the other hand, I have seen them, after living pelagically for 24 hours, sink to the bottom, where they assumed the position shown in fig. 1. They adhere to the bottom by means of the rudimentary tail.

The Cysticercaria group.

Cercaria splendens SZIDAT.

Pl. XIX, figs. 1—3.

In July 1910, when fishing with a closing-net at a depth of 4—10 m. over the shell deposits of Furesø, I found in the sample two very remarkable organisms belonging to the same species. They were pear-shaped hyaline organisms, provided posteriorly with a peculiar broad brown flattened band and ending in two broad plates. In the hyaline pear-shaped part there was a Trematode with two suckers. The samples were taken to my laboratory in the live state, and the organisms were found there. They stood suspended in the water, but now and then they suddenly jumped, moving the tail from one side to the other, while simultaneously the broad

plates were clasped together and then again opened. The acute end of the pear-shaped part was turned upwards. A rough sketch was made, but being occupied with other kinds of work, I did not complete the investigation.

In 1913 when gathering the material for my Furesø studies (1917) one specimen of *Limnaea auricularia* threw out many specimens of the same form. Occupied with investigations remote from Trematoda I did not study them more thoroughly. Only some slides were taken.

In 1932 and 1933, while I was studying the Cercaria fauna of our freshwaters, many hundred *L. auricularia*, *L. stagnalis*, *Bithynia*, and *Planorbis* species from the Furesø were brought into my laboratory in spring, summer, and autumn, and several hundreds were dissected. Curiously enough, I never met with one of these Cercariae again. I am thus compelled to give very insufficient drawings from my slides of this highly remarkable organism. In 1932 I received SZIDAT's excellent paper on "Ueber cysticerke Riesencercarien" *C. mirabilis* M. Braun and *C. splendens* Szidat (1932 a, p. 477). However, casual my drawings were, there could be no doubt that it was *C. splendens* which I had found in 1910 and 1913. SZIDAT points out that only seven species of true Cysticercariae are known, five of which are found in North America. These are *C. Wrightii* Ward 1885, *C. anchoroides* Ward 1893, *C. Brookoveri* Faust 1912, *C. macrostoma* 1917, and *C. fusca* Pratt 1919. With regard to these forms I refer the reader to SZIDAT's papers. Only two species are recorded from Europe, the very peculiar *C. mirabilis* Braun 1891, the giant among Cercariae, which measures 7 mm., and the new species *C. splendens* Szidat. *C. mirabilis* was not found again until SZIDAT found it in *Limnaea palustris* var. *corvus*, in the Rossitter Lehmstolle, Kurische Neerung, in 1930. *C. splendens* was found in *Planorbis umbilicatus*. SZIDAT shows experimentally that *C. mirabilis* belongs to *Azygia lucii* common in *Esox lucius*. The further development of *C. splendens* is still unknown, but later on SZIDAT hopes to clear up the development of this species too.

Referring the reader to SZIDAT's paper, and using his observations I complete my drawings by the following description.

The dimensions are:

Length of house	760
Breadth of house	500
Length of tail	770
Breadth of tail	100
Length of rami	450
Breadth of rami	480

The body is divided into three parts: a pear-shaped hyaline part containing the Cercaria; the tail stem; and the furca. The pear-shaped part is extremely hyaline, of a faint bluish tinge. According to SZIDAT it consists interiorly of a parenchyma with very wide meshes. At the apex is the opening into the space in which the Distomum

lies. According to SZIDAT (1932 a, p. 493) "enthält die Spitze um den Kanal der ursprünglichen Öffnung verteilt, zahlreiche feine Stränge oder Fasern, die einem unmittelbar über der Spitze der Kammer gelegenen ganglionähnlichen Körper entsprungen und von hier bis zur Oberfläche ziehen wo sie in winzigen Knöpfchen endigen". SZIDAT assumes that these are sensitive organs. At the sides of the chamber are further distributed peculiar sharply defined buds or knobs of somewhat different size and arranged in 6 to 7 circles. Their function is doubtful, but it seems probable that in this case too, we have to do with sensitive organs. The tail stem is very peculiar, band-shaped, equally broad at both ends, of a brown colour, and containing very powerful muscles. It is always held in a greatly curved position and it seems as if it cannot be held in a straight position. SZIDAT says quite correctly: "In der Bewegung schlägt er vielmehr ähnlich wie eine Stahlfeder heftig über die gestreckte Stellung hinweg, um dann in gleicher Form aus der rechts in die links gerichtete Krümmung überzugehen" (1932 a, p. 494). The two rami are extremely broad, almost circular; they are much more hyaline than the tail. At this point I find the only difference between SZIDAT's specimens and mine. SZIDAT says that the borders of the rami are furnished with a series of very fine spines; here my specimens have a number of papillae, and these papillae are dispersed over the whole surface. Further, the rami have a very conspicuous longitudinal and transversal system of fine muscle threads crossing each other at right angles. The excretory canal runs through the tail. It is rather inconspicuous here. On entering the rami, it divides, and now the two branches are very conspicuous, ending in an opening on a small tip in the middle of the ramus. The distomulum itself is of a yellow colour. A more detailed description is still a desideratum. SZIDAT merely says about it that it "abgesehen von der geringeren Grösse sich kaum von der junge Wurm vom dem der *C. mirabilis* unterscheidet".

With regard to the Redia I refer the reader to SZIDAT's observations. It resembles a Sporocyst, but there is a very small pharynx which, according to SZIDAT, is also used as a genital opening. A gut is absent; the germinal layer lies in the posterior part of the Redia. There is a conspicuous excretory organ. In their first developmental stages the Cercariae are very similar to those of the *Holostomidae* and the *Schistosomatidae*. The Cercariae leave the Redia before maturity and now draw their nourishment directly from the snail. The chamber in which the Cercaria lives in the free-swimming stage is not developed until it has left the snail; in contact with the water the cuticula and the parenchymatous tissues swell. The Cercariae mostly leave the snail between 10 and 12 o'clock. A snail gives off only 6—8 Cercariae a day: *Planorbis umbilicatus* 6, *Limnaea palustris* 3 (1932 a, p. 489).

SZIDAT points out that these organisms are true Furcocercariae and supposes that they belong to a new species of the genus *Azygia*. It seems possible, then, that the *Azygiidae* belong to the large order *Strigeatoidea* La Rue, to which the *Strigeata*, the *Schistosomata*, and the *Bucephalata* belong. This view would seem to be corroborated by A. LUTZ (1931, p. 343), who shows that the Cercaria of *Hemistomum* forms a connecting link with the "Riesencercarien" mentioned here.

*The Proalaria and Strigea group.****Cercaria longiremis*** nov. sp. Host: *Valvata piscinalis*.

Pl. XXII, figs. 1—3.

Fully extended the body and tail are almost of the same length, and the furca only a little shorter than the stem. The dimensions are:

<i>Cercariae.</i>		
	Living	Preserved
Length of body	245	170—256
Breadth of body	115	53—74
Length of tail	255	236—273
Breadth of tail	45	21—33
Length of furca	310	218—288
Breadth of furca	20	..
Length of anterior organ	50	22—46
Breadth of anterior organ	35	19—24
Ventral sucker	35	22—40

The anterior organ is pyriform. The forepart of the body is covered with fine spines, but there are no specially developed spines on its top. Spines on the other part of the body are only feebly developed. The anterior organ is not distinctly divided into a thin-walled anterior and a posterior muscular part. No head gland has been observed. — The small ventral sucker is situated behind the middle line of the body and its circular edges are furnished with two rows of small spines. No eyes. The opening of the alimentary canal is terminal. There is a faintly developed pharynx and a long oesophagus which bifurcates a little before the ventral sucker; the intestinal coeca are broad; they reach only half-way between the ventral sucker and the bladder. In the posterior part they give the impression of being divided by transversal folds. There are eight penetration glands, lying behind the ventral sucker; they contain a granular cytoplasm and vesicular nuclei; they give off the ducts which above the bifurcation of the oesophagus curve into the middle of the body, whereupon they again curve outwards and enter the anterior organ sideways near its posterior end. The bladder lies immediately anterior to the junction of the tail; it consists of a smaller posterior part which is provided with two broad horns from which the two main lateral collecting tubes issue. I have been unable to see any transversal commissure. Near the middle of the ventral sucker is a tangled mass of the main collecting tubes, and from here arise anterior and posterior collecting tubes. I have observed 5 flame cells on each side, two near the anterior organ, two near the tangled mass, and one behind this at the beginning of the tail. I suppose that the number here has been greater. An inlet of CoRT has not been observed; the posterior tube passes through the whole length of the tail and divides to enter the furca, but I have not seen if they reach the tips. — The powerful tail is attached to the posterior end of the body; the union

seems very strong since decaudation only rarely takes place. It has a layer of circular and longitudinal muscles. The most peculiar feature, however, is two series of caudal bodies ending in one to three protuberances fastening themselves on the sides of the tail-stem. There are no finfolds, and the rami of the furca are narrow.

The Cercaria is a typical plancton organism, especially in deep water in large lakes. It stands suspended in the water with the body downwards and the long rami stretched out on a line perpendicular to the long axis of the body. It seems not to have any special predilection for light. For further particulars, I refer to Chapter VIII relating to the biology of the Furcocercariae. — The host is *Valvata piscinalis* whose liver and interior organs may all be covered over by tangled interwoven masses of thin-walled Sporocysts. It is almost impossible to dissect them entire, but pieces of a length of 7—8 mm. are not rare. — They have often a knotted appearance and in the widened parts the Cercariae are developed. A birth pore has not been observed.

The species has only been found in *Valvata piscinalis* from Tjustrup Lake. On 25/VII 1931, 30 were found at a depth of 2 m. On 28/VII, 80 were found at 5—10 m. Of the 30 from 2 m. only one was infected, of the 80 from 5—10 m, 12 were infected.

As no Furcocercaria has been found in a *Valvata* at all events in Europe, and my form presents several peculiarities of structure such as the course of the ducts from the penetration glands, the peculiarly formed bodies in the tail, and its remarkably large size, it seems necessary to regard it as a new form.

Cercaria C. SZIDAT. Host: *Limnaea stagnalis*, *L. auricularia*.

Pl. XXII, figs. 4—5. Pl. XXIII, fig. 1. Microphoto Pl. XXVI, fig. 2.

Fully extended the tail is longer than the body; the breadth may be almost the same; the furca a little shorter. The dimensions are:

<i>Cercariae.</i>		
	Living	Preserved
Length of body	265	173—197
Breadth of body	85	56—65
Length of tail	240	215—222
Breadth of tail	40	23—47
Length of furca	220	195—212
Length of anterior organ	55	35—45
Breadth of anterior organ	35	23—29
Ventral sucker	35	22—39
Mother sporocyst	14300	..

The forepart of the body is covered with fine spines; its tip is protrusile; it carries no thick spines. The anterior organ is large, pyriform, almost twice as long as broad. It is not divided in a thin walled anterior and a posterior muscular part.

Head glands have not been observed. The ventral sucker lies behind the middle line of the body and is furnished with two rows of small spines. No eyes. There is a small prepharynx and an almost globular muscular pharynx. The oesophagus bifurcates immediately before the ventral sucker. The intestinal coeca reach the bladder and diverge a little at their posterior end. There are four penetration glands lying behind the ventral sucker; the two anterior lying above each other, the two posterior ones beside each other. The cytoplasm is granular and the vesicular nuclei are very conspicuous. The course of the ducts is slightly sinuous and they enter the anterior organ near the posterior end. The bladder lies just anterior to the junction of the tail; it is globular or rectangular; it gives off two main lateral collecting tubes and one posterior tube which drains the tail. Near the middle of the ventral sucker is a tangled mass from which an anterior and a posterior collecting tube are given off. A transversal commissure is visible immediately before the ventral sucker. On each side are observed 5 vibratile tags, and one pair at the base of the tail. Perhaps a sixth pair at the posterior corners of the body has been overlooked. An inlet of CORT has not been observed. The posterior tube passes through the whole length of the tail and divides to enter the furca, it opens on the interior side of the rami, midway. The tail possesses one layer of circular and one of longitudinal muscles. There are many caudal bodies arranged serially or in small lumps. There are no finfolds on the furca.

With regard to its biology I refer the reader to chapter VIII. The host is *Limnaea stagnalis* whose liver and interior organs may all be covered by tangled interwoven masses of very long and very thin Sporocysts. They are provided with a subterminal birth pore through which, on 4/XII 1932, I saw Cercariae come out. These Sporocysts have almost straight sides and no alternation of narrower and broader parts. When dissecting a *Limnaea* from Bagsværd Lake whose liver was covered by interwoven Sporocysts, it suddenly gave off a 2 cm. long Sporocyst which, so to speak, shot out of the liver. It was almost 1 mm. thick and had a peculiar proboscis at one end (Pl. XXII, fig. 5). The skin was remarkably thick and showed, especially in the forepart, rings which I suppose to be of muscular consistence. The Sporocyst was opaque and the skin of a peculiar, almost leathery appearance. It contained not a single Cercaria but 5 small daughter Sporocysts packed with small grains. Otherwise the whole interior was empty. A birth-pore could not be observed but when pressed the daughter Sporocysts came out at different points of the skin. All other Sporocysts contained only Cercariae. There can be no doubt that the large Sporocyst was the mother Sporocyst or one of them. Only the proboscidal prolongation showed a slight power of motion; otherwise it was quite motionless. It seems as if these mother sporocysts have no power of division and are only able to produce daughter sporocysts, not Cercariae. It was found at a time when its power of production was almost exhausted. The snail contained only this single mother Sporocyst. As far as I know, these mother sporocysts are only rarely observed.

This species was found in *L. stagnalis* from Bagsværd Lake on 25/VII 1931,

but only in one specimen out of 8; in Furesø on 30/IX 1932 in one very large specimen of *L. stagnalis*; and in *L. auricularia* in 7 out of 70 specimens. On 17/XI it was found in 20 out of 70.

I have determined this species as *Cercaria C. Szidat*; it is nearly related to *C. furcata* Nitsch, *C. fissicauda* la Val., and *C. helvetica XIII* Dubois. They are all found in *L. stagnalis*; at all events they may belong to the same group. This is also the case with *C. flexicauda*, *laruei* and *modicella*, all described by CORT and BROOKS (1928, p. 183). TAYLOR and BAYLIS (1930, p. 232) and GWENDOLEN (1932, p. 25) suppose that the *Cercaria x* of TAYLOR and BAYLIS is identical with *C. helvetica XIII* Dubois. Furthermore it may be nearly related to *C. chromatophora* Brown found in *Limnaea stagnalis* (1931, p. 95). *C. chromatophora* has small areas of pale yellow pigment granules spread over the body and tail. All these species seem to belong to the same group. With regard to their biology I refer the reader to Chap. VIII.

***Cercaria strigeae tardae* MATHIAS.** Host: *Limnaea stagnalis*.

Pl. XXII, fig. 6. Pl. XXIII, fig. 3. Microphoto Pl. XXXVII, figs. 9—12.

Fully extended the tail is shorter than the body, the furca almost of the same length as the tail. The dimensions are:

<i>Cercariae.</i>		
	Living	Preserved
Length of body	370	152—203
Breadth of body	95	62—85
Length of tail	280	170—209
Breadth of tail	45	35—45
Length of furca	285	173—233
Length of anterior organ	75	45—48
Breadth of anterior organ	35	25—33
Ventral sucker	50	22—31

The whole body is covered with fine spines most prominent in the forepart, which has a protrusile part, densely covered with spines. The anterior organ is of an oblong pyriform shape; as the figure shows, it may be almost twice as long as broad but may also be contracted so much that it is almost isodiametric. There is no division into an anterior thin-walled, and a posterior muscular part, but the whole organ has an abundant equipment of muscle threads. No head glands have been observed. The ventral sucker lies in the posterior part of the body, rather distant from the middle line. It is furnished with a single row of short spines. There is a conspicuous prepharynx, a pharynx and a short oesophagus which divides, not near the ventral sucker, but almost in the middle line between it and the anterior organ. The intestinal coeca are broad and, in all the specimens I have seen, have a peculiar sinuous course. The posterior end almost reaches the bladder. There are four penetration glands lying before and laterally to the ventral sucker; the cytoplasm is granular,

and the vesicular nuclei very conspicuous. At the pharynx the ducts bend first outwards and then again inwards, and enter the anterior organ at its base. The bladder is small and often shows anteriorly two horns from which the two main collecting tubes issue. A little above the ventral sucker the tubes form a tangled mass and above it lie two very conspicuous glomeruli connected with each other by a transversal commissure; an anterior and a posterior collecting tube issue from here; the anterior possesses two flame cells, the posterior three lying where they are drawn in the figure. From the posterior part of the bladder issues a tube running through the whole tail and sending a branch into each of the rami of the furca. These branches open on the inner side of the rami a little beneath the middle line. The tube has two pairs of flame cells near the base of the tail. The tail is almost as broad as the fully extended body. It has a layer of circular and longitudinal muscles. A series of small caudal bodies are arranged along the excretory tube. There are no finfolds.

The host is *Limnaea stagnalis*. The Sporocyst is long and filiform, it often attains 10–15 mm. and may reach 2 cm. or even more; the Sporocysts are mainly found in the liver but when the infection is extensive, all organs may be covered over; specimens may be found whose interior seems to consist almost entirely of Sporocysts. The brown colour of the liver is altered into a yellowish white. When immersed in a 3½ % NaCl solution, they move about briskly, especially the young ones. As MATHIAS has observed (1925, p. 48), they, as well as many other Sporocysts, propagate by division, and I suppose that this is the case with all Furcocercaria-sporocysts. MATHIAS (1925, p. 48) saw flame cells in the Sporocyst, not observed by others, as far as I know.

I have referred my species to *Cercaria strigeae tarda*, with which it agrees on all essential points. It differs from it, however, by the sinuous course of the intestinal coeca, and by the presence of glomeruli. The future must decide whether these differences are sufficient to create a new species. *Cercaria strigeae tarda* has been found in *Limnaea stagnalis* from Strødam and studied there in very many specimens from almost all seasons of the year. Either as a Cercaria or as a Tetracotyle it is present the whole year round, as Cercaria only in the summer months; of 127 *Limnaea stagnalis* 103 were infected.

At Donse it has further been found on 7/VII and 10/XI 1932 in 30 and in 8 specimens of *L. stagnalis*, i. e. in all 38 specimens examined. In most of them they were present as Tetracotyle. As a Tetracotyle the species is present in almost all our mollusk species but as a Cercaria I have hitherto only found it in *L. stagnalis*. MATHIAS (1925, p. 61) has shown that it is possible to find in nature or to infect experimentally *Limnaea stagnalis*, *ovata*, *palustris*, *auricularia*; *Planorbis corneus*, *P. umblicatus*, and *Bithynia tentaculata*; and supposes that if *L. ovata* is only rarely infected, this is due to the fact that *L. stagnalis* is more restricted to the surface than *L. ovata* which is mainly limited to the bottom. The Cercariae seek the surface and will therefore more often infect *L. stagnalis* than *ovata*. With regard to the biology I refer the reader to Chapter VIII. It may be nearly related to if not identical with *C. fissicauda* La Val. 1855 redescribed by BROWN (1926, p. 30) and found by him too in *Limnaea stagnalis*.

Cercaria F. I. HARPER. Host: *Planorbis umbilicatus*.

Pl. XXIII, fig. 2.

Fully extended the tail is a little shorter than the body and not so broad; the furca is of the same length as the tail, perhaps a little longer. The dimensions are:

Cercariae.

	Living
Length of body	215
Breadth of body	95
Length of tail	195
Breadth of tail	40
Length of furca	230
Breadth of furca	40
Length of anterior organ	45
Breadth of anterior organ	40
Ventral sucker	35

The body is covered with minute spines, most densely in the anterior third. The anterior organ is almost globular. There is no division in an anterior thin-walled and a posterior muscular part. No head glands have been observed. The ventral sucker lies almost in the middle of the body; it is armed on its margin with an inner row of small tubercles and an outer one consisting of short bristles. There are no eyes. After a short prepharynx follows a pharynx and a short oesophagus which divides immediately before the ventral sucker. The intestinal diverticula reach only a little behind the ventral sucker and have the appearance of being divided by transversal folds. There are two pairs of penetration glands which are placed laterally and behind on either side of the ventral sucker; their cytoplasm is granular, and the large vesicular nuclei are situated in the posterior parts of the cells. The ducts show an incurvation at the level of the pharynx, and enter the anterior organ posteriorly. The rectangular bladder gives off anteriorly two collecting tubes and one posteriorly. The two firstnamed divide at the end of the intestinal diverticula, giving off an anterior and a posterior branch. I have only been able to find five flame cells on each side; three belonging to the anterior branch, and two to the posterior one. The branch in the tail carries two pairs of flame cells; it sends a ramus into each of the furcae, where the rami open on the inner side behind the middle line. The tail has a layer of circular and longitudinal muscles. Along the posterior excretory tube lie 2 × 6 oblong flattened bodies. There are no finfolds on the furca. —

This *Cercaria* is found in *Pl. umbilicatus*.

The Sporocyst, when mature, projects from the surface of the liver and shows conspicuous movements. It is 4—5 mm. long. A birth pore has not been observed. —

I have only found this species once (2/V 1932) in *Planorbis umbilicatus* in a

little moor on the borders of the Furesø near Frederiksdal. Of 40 specimens 8 were infected. —

It is only with some doubt that I refer this species to the *Cercaria F. I* of HARPER. MATHIAS (1925, p. 61) infected *P. umbilicatus* experimentally with *C. strigeae tardae* from which this species differs in size, in the form of the anterior organ, the place of the ventral sucker, the structure of the alimentary canal, and by the absence of a transversal commissure and glomeruli.

It agrees in many essential particulars with HARPER's *Cercaria F. I*. The main difference is that I have seen two pairs of flame cells in the tail, and that HARPER found his species in *Planorbis crista* and *albus*, I mine in *Planorbis umbilicatus*. Experimentally HARPER has shown that his *Cercaria F. I*. passes through a *Tetracotyle*-stage in which he refers it to *T. typica* Dies.

It may perhaps be related to *C. micromorpha* Brown (1926, p. 32) with which it has the number and position of penetration glands in common, but from which it differs by lacking the oesophagus and intestinal coeca (?) and with regard to the flame cells.

Cercaria Frederiksborgensis n. sp. Host: *Planorbis corneus*.

Pl. XXII, Figs. 7—8.

Fully extended the body, tail, and furca are almost equal in length; the body perhaps being the longest. The forepart of the body is covered with short spines; the spinosity of the posterior part is but slight. The dimensions are:

Cercariae.

	Living
Length of body	230
Breadth of body	110
Length of tail	180
Breadth of tail	45
Length of furca	220
Length of anterior organ	50
Breadth of anterior organ	45
Ventral sucker	40

Sporocysts.

Length	180
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The anterior organ is almost globular. No division into an anterior thin-walled and a posterior muscular part. No head glands have been observed. The ventral sucker lies in the posterior part of the body, the anterior edge almost in the middle line; it is a little smaller than the anterior organ. It is furnished with two rows of short spines. There are no eyes. After a pharynx follows a long oesophagus which divides immediately before the ventral sucker. The intestinal coeca, which have

straight contours, reach the bladder. There are six penetration glands placed behind the oral sucker; their cytoplasm is granular; the vesicular nuclei are very conspicuous. The ducts have a sinuous course and enter the anterior organ laterally. The bladder is small, globular or rectangular. The two anterior main collecting tubes divide near the anterior edge of the ventral sucker into an anterior and posterior branch, each of which carries three flame cells. Posteriorly the bladder gives off a tube which passes through the whole tail and bifurcates near the rami. They open on the inner side a little below the middle line. The tail has one layer of circular and one of longitudinal muscles. There are two series of low caudal bodies, of which the first is remarkably large. I have been unable to detect any flame cells in the tail, but suppose that I have overlooked them. There are no finfolds.

The host is *Planorbis corneus*; the Sporocyst is long, filiform, packed either with small germ balls often arranged in two series or with a crowd of Cercariae which move slowly up and down. A birth pore has not been observed. The species was found in one of 45 specimens from Torkeris Pond on 26/IV 1932. The Sporocysts which were in lively motion were mainly found on the intestine, not so much in the liver. The snail had not shown Cercariae; they were not found until the snail was opened; perhaps the Cercariae were not quite ripe. On 29/VI 1932 20 *Planorbis corneus* were opened but none was infected by Furcocercariae.

Cercaria linearis n. sp. Host: *Planorbis corneus*.

Pl. XXVI, figs. 1—2. Microphoto Pl. XXXVI, fig. 6.

Fully extended the tail is shorter than the body and the furca almost as long as the body. The dimensions are:

<i>Cercariae</i> .	
	Living
Length of body	250
Breadth of body	50
Length of tail	170
Breadth of tail	40
Length of furca	210
Length of anterior organ	40
Breadth of anterior organ	25
Ventral sucker	45

The forepart of the body is spinose, the posterior part only in slight degree. The anterior organ is of a relatively small size, pyriform when the body is extended, and almost globular when it is strongly contracted. There is no division into an anterior thin-walled and a posterior muscular part. No head glands have been observed. The ventral sucker is placed almost centrally a little behind the middle line. It has a single row of short spines. After a well-developed pharynx follows an oesophagus

which divides immediately before the ventral sucker. The intestinal branches, which have straight sides, reach halfway between the ventral sucker and the bladder. There are six penetration glands, lying before the sucker. The cytoplasm is granular, and the vesicular nuclei are conspicuous. The ducts take a somewhat sinuous course and reach the anterior organ at its posterior edge. The small bladder often shows two horns from which the two main collecting tubes issue. At the sucker they divide into an anterior and a posterior branch. On the anterior branch I have seen three vibratile tags, on the posterior, two. From the posterior part of the bladder an excretory tube passes through the whole tail, but I have not been able to see it bifurcate and pass out into the furca. There are two pairs of vibratile tags in the tail. When fully extended the tail is as broad as the body. It has a circular and a longitudinal muscle layer. Globular bodies along the excretory tube, if present, are at all events very inconspicuous.

The host is *Planorbis corneus*.

The Sporocyst is 4—6 mm. long, filiform.

The species has only been found once in Hørsholm Pond on 25/V 1932. Of 24 specimens 4 were infected. —

Only very few *Furcocercariae* have been recorded from *Planorbis corneus*; apart from *Bilharziella polonica* Cercaria B has been described by SZIDAT (1923, p. 303). This species is said to possess six cystogeneus cells disposed laterally to the ventral sucker (SZIDAT, however, draws 7). In my two species from *Planorbis corneus* the 6 cells are placed either before or behind the sucker. MATHIAS (1925, p. 61) has infected *Planorbis corneus* experimentally with *Cercaria strigeae tarda* with which my two species cannot be compared. — The two species described here differ in size; in the relation in size between the oral organ and the ventral sucker; in the disposition of the penetration glands before or behind the ventral sucker, and perhaps in the excretory system.

***Cercaria helvetica* XXXI DUBOIS.** Host: *Limnaea palustris*.

Pl. XXVI, figs. 3—7.

Fully extended the body, tail, and furca are all of almost the same length. The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	180	116—122
Breadth of body	45	47—54
Length of tail	180	119—159
Breadth of tail	40	37—42
Length of furca	175	134—173
Length of anterior organ	45	29—37
Breadth of anterior organ	30	17—21
Ventral sucker	30	19—27

Sporocysts.

	Living	Preserved
The mother sporocyst	17400	..
A daughter sporocyst	2140	..

The forepart of the body is covered with fine spines; its tip is protrusile. The anterior organ is larger, pyriform, one and a half times as long as broad. It is not divided into a thin-walled anterior and a thicker posterior muscular part. Head glands have not been observed. The ventral sucker lies almost in the middle line. I have only been able to see two rows of small spines. There is a small prepharynx and an almost globular muscular pharynx. The short oesophagus bifurcates immediately before the ventral sucker. The intestinal diverticula do not reach the bladder, but their posterior end is not visible owing to the abundant equipment of penetration glands. Of these there are eight, commonly disposed in three rows with three cells in the first rows and two in the last all lying behind the ventral sucker. The cytoplasm is granular, the nuclei are large. The ducts have an incurvation just above the ventral sucker. They enter the anterior organ at its posterior edge. — The bladder is broad, anteriorly giving off two collecting tubes, posteriorly one. Near the middle of the ventral sucker is a tangled mass from which an anterior and a posterior collecting tube are given off. A transversal commissure is present before the ventral sucker; another, behind the sucker, I have been unable to observe. The anterior collecting tube is provided with two flame cells, the posterior with four; in the tail one pair is observed. The collecting tube in the tail divides into two branches which pass into the furca, most probably opening halfway on the inner side of the furca. The tail has the normal layer of circular and longitudinal muscles. I have counted eight to ten large globular bodies almost filling out the whole space between the excretory canal and the muscle layer. There are no finfolds. —

The host is *Limnaea palustris*. — The liver and germ gland are packed with enormous amounts of long threadlike Sporocysts containing fully developed Cercariae. These Sporocysts break up, divide, and the parts grow up. Their length is 1—2 mm., they have a conspicuous birth-pore placed near the forepart, which is extremely mobile; the colour is white. They often show irregular broader parts separated from each other by indentations and notches of different kinds. The broader parts seem to be regular broad chambers packed with Cercariae. In the extreme posterior part is the germ chamber in which globular germs are present, and from which the germs are pushed forward into the chambers placed more anteriorly. The wall of these Sporocysts is very thin, hyaline. They produce Cercariae only. Among all these Sporocysts was found a single one not less than c. 1.4 cm. long (Pl. XXVI, fig. 5). This Sporocyst was almost equally broad throughout; it had peculiarly mottled very thick walls wrinkled on the outer side and with peculiar regular undulations on the inner side (Pl. XXVI, fig. 7). The Sporocyst was almost empty. It contained only three daughter Sporocysts packed with germ balls. The mother Sporocyst was

almost motionless; only a slight movement could be observed at the apex. One of the daughter Sporocysts came out through the skin of the mother sporocyst (Pl. XXVI, fig. 6). No birth pore could be observed. There is no doubt that we have here to do with the old mother Sporocyst from which the whole infection of the snail has taken place. Most probably there are only two Sporocyst generations, the first without power of division and a second in which propagation is partly by division and partly by Cercariae. Judging by observations from other Furcocercaria-sporocysts, it seems most probable that the mother Sporocyst only produces Sporocysts, not Cercariae. In the daughter Sporocysts I have never found a new generation of Sporocysts, only Cercariae.

This species was found in the canals in the little park Indelukket near Hillerød 13/IX 1932 and in a little bay of Tjustrup Lake. Of 10 specimens of *L. palustris* only one was infected.

I have referred this species to *C. helvetica* XXXI Dubois (1929, p. 94) but it is also very nearly related to *C. burti* Miller (1923, p. 41). It differs from both in the following points. The ventral sucker is placed almost in the middle line, in the other two posteriorly. Since, however, I have seen how the two parts of the body in the Furcocercariae, that before and that behind the ventral sucker, may dilate and contract independently, I do not regard this difference as very significant. I have only seen one transversal commissure before the ventral sucker. *C. helvetica* XXXI has two, one before and one after the sucker. *C. burti* one, but behind. I fear that one of the commissures has been overlooked, and as the three species agree with regard to number and position of penetration glands, the alimentary canal, and the excretory system, I feel inclined to regard all three as identical; the host is common to *C. helvetica* XXXI and my species.

Cercaria A. SZIDAT. Host: *Limnaea palustris*.

Pl. XXVII, fig. 1.

Fully extended the body is longer than the tail, and tail and furca are of almost the same length. The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	340	146—215
Breadth of body	85	45—79
Length of tail	225	170—226
Breadth of tail	40	27—45
Length of furca	280	162—218
Length of anterior organ	65	28—48
Breadth of anterior organ	40	25—73
Ventral sucker	55	29—34

The whole body is covered with fine spines more prominent in the first-third, the tip is protrusile and covered with stouter spines and four papillae on which the two pairs of canals for the penetration glands are placed. The anterior organ is large, globular or pyriform. It is not divided into a thin-walled anterior and a posterior muscular part. Head glands have not been observed. The ventral sucker lies far behind the middle line; I have only been able to see two concentric circles of small spines. There is a short prepharynx followed by a globular pharynx. There are no eyes. The long oesophagus divides immediately before the ventral sucker into the two intestinal coeca with almost straight sides. Their posterior part reaches the bladder. There are four large penetration glands placed before the ventral sucker, the posterior two to the left and right side of the middle line; the anterior two are more dorsally and ventrally disposed in relation to the two first-named. They are large and have a granular cytoplasm and large vesicular nuclei. The ducts run almost straight forward to the posterior part of the anterior organ through which they pass. They debouch in four small retractile papillae. The bladder is globular or rectangular. There are two anterior excretory ducts and one posterior. Near the anterior edge of the ventral sucker the two anterior ones form a tangled mass from which an anterior and a posterior collecting tube issue. A transversal commissure is present before the ventral sucker. Of vibratile tags I have only observed three pairs in the forepart of the body, and two in the posterior part. In the tail two pairs. The posterior tube passes through the whole length of the tail and bifurcates before the furca. The opening of the two branches I have not seen with certainty. The tail possesses a layer of circular and longitudinal muscles. Caudal bodies have not been observed; there seems to be a layer round the posterior tube connected by threads with the muscle layers and containing scattered nuclei.

The host is *Limnaea palustris*.

The filiform-whitish, very mobile, Sporocysts attain a length of almost one cm.

The species was found on 25/V 1932, Furesø. Of 25 specimens of the snail, 7 were infected. All the 25 specimens simultaneously contained Tetracotyle.

I refer this species to *Cercaria* A. SZIDAT (1923, p. 301) found by him in *Limnaea palustris* and by DUBOIS (1929, p. 88) in *Limnaea stagnalis*. DUBOIS found 20 vibratile tags, I have only seen 12. Some pairs have probably been overlooked by me.

***Cercaria letifera* FUHRMANN. Host: *L. auricularia*.**

Pl. XXVII, figs. 2-8.

Fully extended the tail is shorter than the body but the furca almost as long as the body. The dimensions are:

	<i>Cercariae</i> .	
	Living	Preserved
Length of body	280	188—232
Breadth of body	45	51—54
Length of tail	195	144—167

	Living	Preserved
Breadth of tail	40	29—33
Length of furca	225	146—186
Length of anterior organ	50	44—45
Breadth of anterior organ	35	31—36
Ventral sucker	30	39—46

Sporocysts.

Mother sporocyst	11800	..
Sporocyst	2840	..
Sporocyst	3520	..

The forepart of the body is covered with spines arranged in rows; the apex of the body without thorns; above the mouth opening a series of stouter spines; the anterior organ is oblong or pyriform. It is not distinctly divided into a thin-walled anterior and a posterior muscular part but many transversal muscles cross the posterior part. Head glands have not been observed. There are no eyes. The ventral sucker lies behind the middle line and is remarkably small. It is furnished with a row of short curved spines. The pharynx is globular and the oesophagus bifurcates, not near the ventral sucker, but almost in the middle line between it and the oral organ. The intestinal coeca, which are broader in the posterior part, do not reach the bladder but stop a little past halfway between it and the ventral sucker. There are four penetration glands, placed before the ventral sucker, the posterior two lie on both sides of the middle line, the anterior two one before the other. The cytoplasm is granular, the nuclei large and vesicular. The ducts diverge before the pharynx, and enter the anterior organ at its posterior edge. The small bladder shows two horns to which the two anterior excretory vesicles run. Near the anterior contour of the ventral sucker they divide into an anterior and a posterior branch. The first carries 4 flame cells the last-named 2. The posterior tube running through the tail bifurcates near the furca and opens in the middle line on the interior edge of the rami; there are no finfolds. There are 5 pairs of globular bodies of irregular form and with conspicuous nuclei. The host is *Limnaea auricularia*.

The Sporocysts are threadlike thin-walled hyaline sacks with great power of locomotion. Among those reaching 0.5—0.7 mm., a single one attained more than 1 cm. Most probably it was the mother-sporocyst (Pl. XXVII, fig. 3). As the figures (figs. 4—8) show, the other may be extremely irregular, with broad parts followed by very narrow ones. These last-named are of a greyish colour and look as if they had no lumen. The brood, the Furcocercariae, lie in the broad parts. Some of them at one end show something like a sucker (fig. 8), a broad flat plate furnished with a stalk after which follows one of the brood chambers. The anterior part has often a proboscidal prolongation with a great power of locomotion. In one of the specimens I saw the very conspicuous birth pore through which at the very same moment a Cercaria passed out (fig. 4). The birth pore had dentated edges. — The species has

been found in a single very large specimen of *L. auricularia* gathered at the outflow of Susaa into Tjustrup Lake (30/V 1931). I refer this species to *Cercaria letifera* Fuhrmann (1916, p. 389) with which it has all the essential anatomical details in common. According to FUHRMANN and DUBOIS the coeca "divergent a deux niveaux". This is also the case when the body is contracted; it is, however, not specific for this species but common to all Furcocercaria where the coeca diverge midway between the anterior organ and the sucker. — DUBOIS (1929, p. 81, Tab. V, fig. 19) found 4 flame cells in the middle of the tail. These cells I have been unable to see.

Cercaria I PETERSEN. Host: *Physa fontinalis*, *Limnæa ovata*, *L. auricularia*.

Pl. XXVIII, figs. 1—4.

Fully extended the tail is shorter than the body, but the furca almost as long. The dimensions are:

Cercariae.

	Living
Length of body	200
Breadth of body	45
Length of tail	160
Breadth of tail	40
Length of furca	180
Length of anterior organ	50
Breadth of anterior organ	30
Ventral sucker	35

The forepart of the body is strongly spinose; the spinosity of the rest of the body is but slight. The anterior organ is pyriform, remarkably thick behind, often almost globular. It is not conspicuously divided into a thin-walled anterior and a posterior muscular part, but many transversal muscles cross the posterior part. No head glands have been observed. The ventral sucker lies almost in the middle line of the body, perhaps a little behind it. It is smaller than the anterior organ. It has two concentric circles of small curved spines. The pharynx is globular, the oesophagus is long and divides immediately before the ventral sucker. The diverticula are a little broader in the posterior part; they almost reach the bladder. There are six penetration glands placed two and two behind the ventral sucker, in three series one behind the other. The contents are granular and the vesicular nuclei conspicuous. The ducts take a rather straight course and reach the anterior organ at its posterior border. The bladder is rectangular. To the anterior corners run two excretory vessels, and one posterior through the tail. On reaching the ventral sucker, the vessels form a tangled mass which in specimens from *Physa* form a real glomerulus (Pl. XXVIII, fig. 2); here it divides into an anterior and a posterior branch; the anterior carries at least three flame cells, the posterior three or four. The caudal excretory vessel runs through the whole stem

and divides before the furca, but I have been unable to see the course in the rami with certainty. 2×2 vibratile tags were found in the tail. The posterior branch in the body forms, especially when a little contracted, a peculiar outward curvature. A commissure posterior to the ventral sucker is most probably always present; at all events it is very conspicuous in specimens from *Limnaea ovata* (Pl. XXVIII, fig. 1). The tail has a layer of circular and one of longitudinal muscles. Along the excretory vessel there commonly lie 2×9 caudal bodies; but in some cases the two series are disposed in a single row; the caudal body is then very large, as large as two of the caudal bodies lying before it (Pl. XXVIII, fig. 1). The large nucleus lies immediately above the excretory vessel. There are no finfolds.

The hosts are: *Limnaea ovata*, *L. auricularia*, and *Physa fontinalis*.

The Sporocyst is long, threadlike, greyish in colour; the length is 6—8 mm. and may reach 1 cm. or a little more. It is very mobile; the older ones are very irregular, with inflated parts followed by narrower ones. The brood lies in the former parts. —

I have referred a cercaria which has been found in several localities in different snails to *Furcocercaria I.* Petersen (1931, p. 14). It is a Cercaria with 6 penetration glands behind the sucker. I have not seen the cells mentioned by PETERSEN as "ein quergelagerter Zellhaufen ohne Ausführgänge vor dem Bauchsaugnapf". As far as I know, this is a unique structure among Furcocercariae.

The vivax group.

Cercaria vivax SONSINO. Host: *Bithynia tentaculata*.

Pl. XXIX, fig. 1.

The dimensions are:

	<i>Cercariae.</i>	Living
Length of body		260
Breadth of body		145
Length of tail		230
Breadth of tail		50
Length of furca		220
Length of anterior organ		45
Breadth of anterior organ		45

Fully extended the body and tail are almost of the same length, the furca is shorter. In its broadest part the body is almost three times as broad as the tail. As in all hitherto known members of the *vivax* group the body is broad; it is incapable of being contracted to the breadth of the tail and remarkably flattened. The tail is attached ventrally. The whole surface of body and tail, as far as I have been able to see, is devoid of spines. — Loos (1900, p. 218) says that "la peau est ornée de piquants extrêmement délicats". The anterior organ is rounded, pyriform, very protrusile and on its surface provided with circular rows of spines. It is no sucker, but a real penetrating organ. One pair of head glands lie immediately behind the organ,

but I have been unable to see openings of any kind. The ventral sucker is absent, but in its place is found a circular group of parenchymatous cells. It has been overlooked by SONSINO, but has been seen and figured by LOOS (1900, p. 219) who describes it as a ventral sucker. There is a globular pharynx, and a short oesophagus bifurcating in the first third of the body into the two intestinal coeca which with their white, clear, almost silvery aspect characterise all members of the group at the first glance. They reach the bladder, their contours show slight sinuosities, but no sharp indentations. As in all members of the group, there is no trace of penetration glands. The excretory system is highly characteristic. The bladder is broad and may be trilobate. I have not observed the excretory pore mentioned by SEWELL (1922, p. 282) for *Cercaria Indicae* XV. From the anterior border of the bladder there issue four excretory canals; the two median ones pass forward into the space between the intestinal coeca. Below the place of the ventral sucker they unite, and near the point where the intestinal coeca arise they divide again, giving off two branches issuing almost perpendicularly and uniting with the two outer canals which run outside the intestinal coeca. Where the transversal canal unites with the outer longitudinal canal, a branch runs anteriorly to the anterior organ. From the posterior border of the bladder there issues a caudal excretory vessel which before the furca divides into two branches running through the rami and opening on their tip. The number of vibratile tags in the body is large, most probably 2×10 or 2×12 . I have been unable to see the connecting excretory capillaries. In the tail there are three pairs lying near the base. The tail has an outer circular, and an inner longitudinal row of muscle fibres, which run obliquely from the cuticula to the inconspicuous parenchymatous cells surrounding the excretory vessel. The flattened rami are provided with a finfold.

— The host is *Bithynia tentaculata*.

C. vivax develops in Sporocysts of a length of 3—4 mm.; a birth pore is present, and this, as far as I have been able to see, is terminal. LOOS (1920, p. 213) states that it is subterminal. I have never seen the Sporocysts with the strong and regular constrictions mentioned by LOOS and figured by LANGERON (1906, p. 26). They often show conspicuous constrictions, between which the brood chambers lie; most probably the Sporocysts propagate by division. I have not seen the excretory system observed and mentioned by LOOS. LOOS has furthermore shown that the Sporocysts contain in their body cavity "des germigènes libres" and after reading this, I feel convinced that his observations on this point are quite correct, and that what I originally supposed to be free-lying germ balls were in reality "des germigènes libres" surrounded by a cellular envelope. They lie among the germs. The number of germs may be very large, but in older Sporocysts which contain Cercariae their number is only rarely above 50. In this species mother sporocysts have not been found.

I have seen this species only once in *Bithynia tentaculata* from the moor of Vixö (17/VII 1931). Of 40 specimens it was present in 3. —

I refer this species to the *C. vivax* of SONSINO which it resembles on all essential points. It has been re-described by LOOS (1900, p. 210).

In spite of a very insufficient drawing, it would seem reasonable to suppose that it is a form of the *vivax* group which WUNDER (1924 a, p. 313) has drawn, and in which he studied the tail and its motion. His contention that two excretory canals run through the whole tail cannot be correct. SEWELL (1922, p. 285) has made a highly interesting observation with regard to the Sporocysts of *C. indicæ* XV. He maintains that the Sporocysts are able to produce Miracidia, and describes and figures these Miracidia, comparing them to those of *Schistosomum haematobium*. I agree with LANGERON (1924, p. 28) who asks whether the observer "a senti toute l'importance d'une assertion qui renverse toutes nos connaissances sur la biologie et l'évolution des trematodes". I regret very much that I did not seize the opportunity, when it presented itself, to corroborate or invalidate SEWELL's observation. Curiously enough, I have actually found numerous small cilia-covered organisms swimming among the germ-balls in the Sporocysts of *C. vivax*. Several times I have found Infusoria in the body fluids of snails, but being then unacquainted with SEWELL's observations, I paid no special attention to them. I regarded them as Infusoria, and to this very day I do not think it possible that they can have been anything else. On the other hand, it is a curious thing that these organisms should be found precisely in the Sporocysts of a member of the *vivax* group. Later on I have of course tried to find these forms again, but without success.

Cercaria sp. Host: *Bithynia tentaculata*.

Pl. XXIX, fig. 3. Microphoto Pl. XXXIX, figs. 19, 20.

The dimensions are:

<i>Cercariae.</i>	
	Living
Length of tail	275
Breadth of tail	60
Length of furca	240
Length of anterior organ	50
Breadth of anterior organ	50

On all essential points this species is identical with *C. vivax* Sons. and perhaps cannot be regarded as specific. The dimensions are the same. Referring to the description of *C. vivax*, I shall only mention the differentiating points in the following.

The anterior organ is of a somewhat different form, more pyriform, tapering behind. There is a prepharynx, and the pharynx itself is larger than in *C. vivax*. The two intestinal coeca are about twice as broad as in *C. vivax*, and the borders show deep incisions which give the coeca a very characteristic aspect; whereas the coeca in *C. vivax* are almost equally broad throughout their length, they are here broader anteriorly and much smaller behind. The head glands are strongly developed, and appear as two large clustershaped organs filling most of the space between the

pharynx and the skin. The excretory system is of quite the same type as in *C. vivax*, but I have here seen the posterior branch which is given off at the point where the transversal commissure joins the outer canal. I have not been able to see the flame cells as distinctly as in *C. vivax*; but most probably the number is the same. In the tail I have only seen one pair of flame cells, but most probably there are more.

The host is *Bithynia tentaculata*. The Sporocysts are of quite the same shape and size as in *C. vivax*. — The species was found in *Bithynia tentaculata* at Hellebæk 15/V 1932, but only in one specimen out of 75. — During the time from 15/V to 28/V the snail ejected very many Cercariae daily. The peculiar form of the intestinal coeca was common to all specimens. —

The future must decide whether this Cercaria is identical with *C. vivax*.

Cercaria No. 4 PETERSEN. Host: *Bithynia tentaculata*.

Pl. XXVIII, figs. 4—6. Pl. XXIX, fig. 2.

The dimensions are:

	<i>Cercariae.</i>	
	Living	Preserved
Length of body	275	164—175
Breadth of body	155	89—98
Length of tail	250	236—251
Breadth of tail	55	25—35
Length of furca	285	214—227
Length of anterior organ	75	
Breadth of anterior organ	65	18—19

Fully extended the furca and body are almost of the same length, the tail may be a little longer. In its broadest part the body is three times as broad as the tail. The body is incapable of being contracted to the breadth of the tail, and is remarkably flattened. It has a yellowish opaque colour which prevents a clear view of the internal structure. The tail is not inserted at the posterior end of the body but remarkably high up on the dorsal side (Pl. XXVIII, fig. 5). The anterior organ is almost circular, large, protrusile; a forepart which is almost always carried protruded is spinose and furnished with 6 openings, 3 and 3 in 2 rows; they are without doubt openings for the head glands (Pl. XXVIII, fig. 5). The whole forepart of the anterior organ is spinose. On the sides are seen peculiar strings, three on each side. I am unaware of their function. The head glands appear as two large cluster-shaped organs; as there are 6 openings, they may probably be divided into 2×3 pairs, but I have been unable to see this.

After the anterior organ follows a thick globular pharynx; there is no oesophagus, or at any rate only a very short one. The intestinal diverticula begin immediately after the pharynx; they are very wide, widest in the middle line and tapering slightly

behind; they reach the bladder; the contours show a somewhat sinuous course. In the yellowish animals they shine with an almost silvery sheen. The cell structure is very conspicuous. No trace of a ventral sucker has been observed, and no cystogeneus glands. The bladder is broad, extended transversally. I presume that the excretory organ is built in accordance with the normal type for the *vivax* group, but owing to the opacity of the Cercaria I have only seen the outer excretory canals, not the inner ones, and not the transversal commissures. The posterior excretory tube in the tail reaches the furca and divides there, but I have not with certainty seen if the branches open on the tips. Only a few vibratile tags have been seen, and none in the tail. The tail has a layer of circular muscles and a layer of oblique longitudinal muscles. The excretory tube has an irregular coating of parenchymatous cells. When studying the living Cercariae, I often saw how this string, the excretory tube with its coating of cells, was lifted up towards the anterior part of the tail by means of the oblique longitudinal muscles, and again lowered to the posterior part. When lifted, it could be seen that the whole string was connected with the point where the rami diverge by means of a fine muscle thread; in that position the course of the string was sinuous. The motion was seen in many of the Cercariae. I have never seen this before. — The furca is very long and the rami are remarkably thin and without finfolds but with small spines along the margin of the rami. — One more peculiarity may be mentioned. Along the borders of the body lie a series of 12—15 bright, clear bodies with a dark point. I am quite ignorant of their function. —

The host is *Bithynia tentaculata*. —

In one of the specimens the long, quite empty, mother sporocyst was found. It was greyish dark, thick-walled and almost motionless. The daughter sporocysts were remarkably short, and with power of motion. They contain enormous amounts of Cercaria brood in all stages of development. In one of them was found a creeping Tetracotyle only rarely found in Furcocercaria-sporocysts. —

Owing to the peculiar connection of the tail with the trunk, the structure of the alimentary canal, the absence of a ventral sucker, and the peculiar organs along the lateral edges of the body, there can be no doubt that the Cercaria differs specifically from *C. vivax*. It seems to show great affinities with a Cercaria found by PETERSEN in *Paludina vivipara*. The insertion of the tail is the same, and there is no sucker. Since the figure as well as the description is very inadequate, and since my own, too, lacks important particulars, I consider it most correct to refer my specimens to his form.

It must be admitted, however, that it shows great similarities to the "Tetis" group of SEWELL (1922, p.-291) viz. *Cercaria indicae* XXXIII: Pale yellow colour, rounded refractile cells along the lateral margins of the body, spines along the margins of the rami, but no finfolds, no trace of an acetabulum, an excretory system of a more simple structure than that of *C. vivax*; but only the future can decide whether it belongs to this group. —

Cercaria No. 4. *Petersen* was first observed in unripe stages in *Bithynia tentaculata* from Furesø on 13/V 1931. It was only found in a single snail. It was then found

again on 19/IX 1931 in 2 of 120 specimens from Furesø at 3 m. On 11/V, among 150 specimens of *Bithynia tentaculata* from 4 m, I found one individual which contained Furcocercaria sporocysts with unripe Furcocercaria brood; the broad intestinal diverticula left no doubt that the Furcocercariae belonged to the *vivax* group, and owing to the short Sporocysts I suppose them to be referable to this form.

***Cercaria Apatemon (Strigea) gracilis* RUD.**

This *Cercaria*, which develops in *Bithynia tentaculata* and encysts in fresh — water hirudinea (*Herpobdella atomaria* Car. and *Haemopsis sanguisuga*) has been described and studied in its development by SZIDAT (1929 a, p. 133; 1931 b, p. 160). It is mainly characterised by having four pairs of penetration glands behind the ventral sucker. It seems to be nearly related to *C. burti* Cort, North America. It is a plancton organism but is found near the bottom; it leaves the snail mainly in the afternoon and in diffuse light, phenomena which all seem to be correlated with the life of the secondary host, the *Hirudinea*. —

Apart from the *vivax* group, I have never found Furcocercariae in *Bithynia tentaculata* and never seen *C. Apatemon gracilis*. Nevertheless, I suppose that it will be found in Danish freshwater. For more than once I have found *Tetracotyle* in *Herpobdella*, and these *Tetracotyles* seem to be identical with those shown in fig. 7 of SZIDAT's paper. I therefore regard it as most correct to include this form among the Danish *Cercariae*. Now and then I have supposed that *C. longiremis* n. sp. (mentioned p. 113) also found in a prosobranchiate snail (*Valvata piscinalis*) was perhaps identical with *Cercaria Apatemon gracilis*.

Chapter VIII.

Biology of the Furcocercaria.

The *Lophocerca* group.

Pl. XXXV, fig. 14. Microphoto Pl. XXXIX, fig. 22.

Referring the reader to p. 100—103. I shall here only point out that the *Cercariae* of this group are true plancton organisms which stand suspended in the midmost water-layers ready to jump to fishes, especially Cyprinidae, whose skin they pierce, thereupon making their way into the blood-system where the development is completed. As is the case with the next groups, there is no intermediate host.

The behaviour of the *Cercaria cristata* larva has been studied by means of the aquarium-microscope, but especially with the Edinger-apparatus on a white reflector. Water teeming with *C. cristata* larvae was poured into small glass boxes and studied in the first-named apparatus by means of orthoscopic oculars and a strong microscopical lamp. As soon as the water currents have ceased, the larvae stand still, equally

distributed throughout the fluid. The position is always the same. Suspended in the fluid the whole larva body forms a strongly bent curve, whose ends may touch each other; the rami are turned upwards and spread at an angle which is almost the same in all individuals; the tail is strongly bent and the body held in prolongation of the horizontal part of the tail. In this position (Microphoto Pl. XXXIX, fig. 22) we see hundreds of larvae standing still in the waterlayers; most of them have the rami turned upwards, but if only the tail is curved they seem to be able to keep suspended in all positions. The swarm of larvae remains still. The sinking down of the larvae is so extremely slow that it is very little conspicuous in the aquarium microscope. Now and then a single larva whirls round and ascends but very soon comes to rest again. Of all freshwater plancton organisms which I have studied I know none which seems in a higher degree adapted to a pelagic life.

The peculiar hyaline dorsal crest unique among the Cercariae has often been studied and drawn; its significance has never been understood. To me it was quite natural to regard it as a floating organ which was designed to augment the cross section resistance and in this way counteract the fall. As long as we only study the larva under a common microscope and under cover, we can get no understanding of its significance. We then see the larvae as they almost always are drawn with the body turned upwards, the tail straight and the furca turned downwards; the body and tail lie in prolongation of each other (LA VALETTE a. o.). In this position the larva dies and is preserved. In this position the crest can have no floating significance at all. If, however, the hundreds of suspended larvae are studied under the aquarium microscope the body will appear as a thick rod-like mass and on closer observation we see that behind it has a hyaline, very thin, thornlike process, Pl. XXXV, fig. 14. In other words, this means that we see the body from the edge. The thornlike process is the hyaline membrane as seen anteriorly from the edge. Now its significance as a floating organ is intelligible. When the whole body is strongly curved the forepart with the crest is held horizontally. In this position of the body it augments the plane upon which the larva rests suspended and acts as a pronounced floating organ. —

If now we continue our observation in the Edinger apparatus we shall here simultaneously observe thousands of larvae upon the reflector. They all hang suspended in the above-described position; they form an open circle; in all specimens we see the body from the edge and the hyaline "thorn", i. e. the edge of the dorsal floating membrane, from the edge.

Among the thousands of individuals there are always some which suddenly leave the floating position and whirl upwards. Upon the reflector they ascend about a decimetre, whereupon they again remain suspended. During the whirling ascension it is plainly seen how the Cercaria, which is now rod-like with the tip of the furca turned upwards, rotates round itself, not describing an eight as most of the Furcocercariae, but only a circle; the number of rotations is remarkably small, only four to five. Quite suddenly the rotations cease, the tail is curved, and we see how the body, where the tail is inserted, invariably twists round; at the same moment the

organism floats; very slowly the larva sinks downwards. Upon the reflector the same larva can be followed; it seems as if its life is divided in spells of rest during which the body slowly sinks and which last about one minute and spells of active vertical motion during which it rotates round its own axis; this period only lasts a few seconds. — The factors — external or internal — which release the active motions and the resting periods, bringing the one to an end and causing the other to begin, are unknown; what arouses the interest of the observer is the extreme suddenness with which both periods are introduced. The life of the larva, which does not last more than 24 hours and most probably less, may be described as an uninterrupted jumping during which the periods of suspension are about 20—30 times longer than the jumping period. There can be no doubt with regard to the significance of the motion. Sooner or later the larvae are to be transferred to a fish. Extremely small and quite hyaline as they are it is quite incomprehensible how they can be observed by the fishes; they can only reach them by chance, either when they bump directly against one or when they are caught by the waterstream over the gills. — The latter way seems to me to be the most comprehensible. In November 1933 I again brought *Carassius* and *Leuciscus* species into swarms of *C. cristata*; the fish does not seem to be in any way affected by the larvae. The fishes are not killed in the course of 15—20 minutes as is the case with *Cercaria C. Szidat*. They lived in my aquaria together with *Limnaea stagnalis* throwing out the Cercariae in such quantities that the water may have a milky tint. In the course of 24 hours, however, they got very sluggish; they only moved when touched and when they were then brought into other aquaria they invariably died in the course of 1—2 days; why the fishes from June 1932 (vide p. 103) were not affected I do not know.

According to EJSMONT (1926, p. 944) three species of *Sanguinicola* have been described: *Sanguinicola inermis* Plehn, only found in *Cyprinus carpio*; *S. intermedia*, only found in *Carassius carassius*, and *C. car. auratus* and *S. armata* Plehn, only found in *Tinca tinca*. Since my species affects *Carassius carassius*, it is possible that the larva belongs to that species, but as far as I can see it is very difficult, according to EJSMONT, to distinguish the species in the *Cercaria* stage.

The Ocellata group.

Cercaria ocellata.

During the last forty years Trematodes living as parasites in the blood vessels of mammals and birds have been found in the different parts of Europe. MATHIAS (1930 b, p. 152) enumerates about 12 finds. These Trematodes, belonging to the family *Schistosomatidae* have been described in monographs by PRICE (1929, p. 1). For a long time their development was totally unknown. This was all the more regrettable since, as is well known, it was to the same family that the *Bilharziosis*-producing Trematodes of the East and of the tropics belonged.

Among the many different Cercariae described from Europa a single one, *Cercaria ocellata*, already described by LA VALETTE DE ST. GEORGE from Germany in

1854, deviated very conspicuously from all other European Cercariae, but not until 1931 (a) did BRUMPT show that it belonged to *Trichobilharzia ocellata*. In 1929—30 BRUMPT found the Cercaria of *Schistosoma bovis* Sonsino in Corsica, and in 1929 SZIDAT found the Cercaria of *Bilharziella polonica*. Only these three Cercariae belonging to the family *Schistosomatidae* have hitherto been found in Europe. In America CORT, FAUST and MILLER, in Asia especially SEWELL, have found other forms.

They all belong to the group *brevifurcate apharyngeate distome cercariae* of MILLER (1926, p. 66) to whose paper I refer the reader. The Cercaria of *Schistosoma bovis* whose development has been carefully studied by BRUMPT (1930 b, p. 17; 1930 a, p. 263) is very nearly related to the pathogenic Cercariae of man; the other two differ in essential points, especially in having well developed eyes which are absent in the Cercaria of *S. bovis*.

Since it has now been shown that one of these Cercariae: *C. ocellata* causes the outbreak of dermatitis in bathers and this dermatitis has been hitherto regarded as caused by insects, by specific qualities of the water, or by water plants, and furthermore that both *C. ocellata* and *Bilharziella polonica* have been found in Denmark, I have gathered from the literature all that we know with regard to these interesting Trematode-larvae. This is all the more justifiable since also in Denmark in 1931 there was an outbreak of dermatitis which was most probably caused by *C. ocellata*. At a moment when I had already found *C. ocellata* and expected accounts relating to outbreaks caused by attacks of Cercariae, I had heard nothing about such attacks. Those who were asked regarded water insects as the cause of the outbreak. — With regard to the outbreak of dermatitis caused by Cercariae in Europe it should be remembered that the dermatitis is of very short duration; as far as we know, the Cercariae piercing the skin of man have pierced the skin of a wrong host, their real hosts being birds. In man they are unable from causes unknown to us to penetrate deeper into the veins and be carried with the blood into the mesenteria. They are unable to produce *Bilharziosis* and most probably die beneath the skin without reaching maturity.

Especially with us, who are near the northern limits of the molluscs in which they live, their pathological significance is most probably very small.

For a long time it has been well known that bathers in inland lakes often ran the risk of incurring rather unpleasant attacks of dermatitis. These outbreaks were familiar in almost all parts of the globe. VOGEL (1930 b, p. 6) enumerates a series of observations communicated to him from physicians that bathers in the lake district of Holsten contracted a dermatitis with strong prickling and tingling sensations; the skin became covered with small papules, and a strong itch might last for some weeks. Then the outbreak diminished and later on did not give rise to complications of any kind. For a long time the phenomenon has been well known in Switzerland and was here named "Hundsblattern" or "Aareausschlag". NAEGELI (1923, p. 1121) says that in Switzerland "da und dort wird mit Ausnahme der grossen Städte vor dem Baden während der Hundstagen gewarnt"; the reason given is that "es entstehen Haut-

ausschläge ("Flechten"), schwere Krankheiten oder ganz einfach es sei gefährlich". NÄGELI has gathered a series of observations from the different parts of Switzerland and Germany, and CHRISTENSON and GREEN (1928, p. 573) on the "Swimmer's itch" from Minnesota. MATHESON (1930, p. 421) and later on TAYLOR and BAYLIS (1930, p. 219) have mentioned and thoroughly studied the outbreak of rashes which appeared on the bodies of persons who had bathed in the bathing pool in the Road Park Lane near Cardiff. The bathers had observed that the skin under their bathing costumes was not nearly so much affected as the exposed parts of the body. Similar outbreaks are well known from other parts of the world too. In Japan NARABAYSHI (1917) has shown from his own experience that it was the Cercaria of *Schistosoma Japonicum* which caused the outbreak. A special dermatitis independent of *S. Japonicum* the "Kabure of Japan" is described by MIYAGAWA (1913). According to VOGEL (1930 b, p. 9) the Europeans in Assam when wading are exposed to the so-called "water sores". ASHFORD and GUITIERREZ mention a dermatitis (*Mazamorra*) which mainly attacks the feet and the hands of washerwomen. DARRE mentions a case from Kongo and SMITH cases of ground-itch from the Southern states of North America (VOGEL 1930 b, p. 9).

CORT (1928 a, p. 1027) and (1928 b, p. 388) stated a long series of dermatitis outbreaks after bathing from widely separated places in the United States, the states of Iowa, Washington, Illinois, Florida, Minnesota, Wisconsin, Michigan, "as well as Haiti and France".

It is of course a question if all these outbreaks can be referred to the same cause; many fantastic explanations have been given, but it was CORT (1928 a, p. 1027) who first, in a paper "*Schistosome Dermatitis in the United States*", showed that outbreaks of dermatitis of unknown etiology were caused by a *Cercaria elvæ* hatched from *Limnaea emarginata-angulata* and other snails; the observation was corroborated by CHRISTENSON and GREENE (1928, p. 573) for Minnesota. In the following years almost simultaneously it was shown that outbreaks of dermatitis in different parts of Germany (VOGEL 1930 a, p. 577; 1930 b, p. 883); in England TAYLOR and BAYLIS (1930, p. 219) were caused by the *Cercaria ocellata* La Valette. VOGEL as well as TAYLOR and BAYLIS allowed the Cercariae to penetrate the skin of their forearm. In the course of five minutes a prickling sensation was experienced, and this persisted as long as the water was allowed to remain in contact with the arm. Redness of the skin was then observed; it increased in intensity, whereupon a tingling sensation began to take the place of the prickling. The next day the irritation had increased, small papules appeared and an itching sensation was experienced. The eruption and irritation increased to the fourth day; the lesion only subsided gradually, being still very plain in four weeks' time; it had not altogether disappeared in seven weeks (TAYLOR and BAYLIS). VOGEL did more than that. He had the skin with the dermatitis outbreak cut out of his arm, and cut the skin with a microtome. The series showed eleven Cercariae which had pierced the skin, and in fig. 5 he showed a Cercaria with the canal the animal had produced. BRUMPT (1931 b, p. 253) also let *C. ocel-*

lata attack the arms of himself and his son and arrived at the same result as VOGEL and TAYLOR and BAYLIS. The Cercaria itself was carefully studied by MATHIAS (1930 b, p. 151) and it was shown that if it was not identical with *Cercaria elvae* it was at all events nearly related to it. SSINITZIN (1909 a, p. 299), MATHIAS (1930 b, p. 158), VOGEL (1930 a, b) and TAYLOR and BAYLIS (1930, p. 231) have all tried to find the adult worm belonging to *C. ocellata*. BRUMPT (1931 a, p. 612) succeeded in infecting ducks and refers the Cercaria to *Trichobilharzia kossarewi* described by SKRJABINE and ZAKHAROW (1920). The name of the Cercaria was then altered to *Trichobilharzia ocellata* (LA VALLETTE 1854, BRUMPT 1931 a). BRUMPT says: "Les vers adultes extrêmement grêles vivent dans les vaisseaux superficiels de la muqueuse, où ils s'accouplent et pondent, ainsi que dans quelques vaisseaux mesenteriques." BRUMPT has furthermore hatched the eggs and gives a drawing of the Miracidium. It shows no predilection for special snails, it was only absolutely negative towards *Bithynia tentaculata*. Whereas *L. stagnalis* seems to be its natural host in Nature, in the aquaria the affinity was strongest for *Planorbis corneus*?, *P. rotundatus* and *L. palustris* in which *C. ocellata* is not found in Nature. —

As mentioned above, *C. ocellata* has only been found in a single pond, Hørsholm Pond, about 10 km. from Hillerød. Curiously enough, the main host was here *L. ovata*, but it was also found in *L. stagnalis*, not in *Planorbis corneus* which harboured *Bilharziella polonica*. A large *L. stagnalis* was taken on 2/VII 32 and died on 16/VII. Every day the snail threw out enormous quantities of Cercariae; on dissection it turned out that the whole animal consisted almost entirely of enormous quantities of very long Sporocysts. — The life of the Cercaria was studied; on all essential points I can only corroborate the observation of SSINITZIN (1910 a) and MATHIAS (1930, p. 156). When the Cercaria leaves the snail, it swims about eagerly in the water for a short time; it is strongly phototactic, and seeks the lighted side of the vessel on which it fastens itself. It adheres by the ventral sucker, the forepart is commonly kept free of the substratum and the tail with the furca stretched out perpendicularly in the water. It may move a little, but it almost always remains motionless, attached to the substratum. When the vessel is turned round the Cercaria will go off and again seek the lighted side. They live about $2\frac{1}{2}$ —3 days. Occasionally I have seen a Cercaria turn round when fastened with the ventral sucker; now and then the tail and the furca are moved laterally, but commonly the Cercariae remain motionless. In Pl. XXVIII, fig. 7 I have given some sketches of the most common positions I have observed. In Nature the Cercaria may be attached to the vegetation, and may be present in enormous numbers where snails are strongly affected. As already SSINITZIN (1909 a, p. 315) has observed, the Cercariae do not prefer the surface, as is the case with *Bilharziella polonica*. Most probably they anchor themselves in the neighbourhood of the *Limnaea* from which they are thrown out. Like SSINITZIN I have seen at the bottom of the vessels in which infected *Limnaea* were kept "unterirdische Wälder aus den senkrechtstehenden gabelformigen Schwänzchen der Cercarien". In contact with the human skin they pierce it and cause the now well-known dermatitis. In that case

they have entered a wrong host and die there without attaining maturity. When ducks are lying in infected vegetation, they are infected, and in these hosts they reach maturity. —

At Hørsholm there are very many ducks and some swans. I have enquired whether any sickness had been observed among the birds, but this was denied.

Cercaria Bilharziellae polonicae.

Bilharziella polonica was first found by KOWALEWSKI (1895, p. 1, 1896, p. 146) in the blood of some ducks from Poland; later on he found this very peculiar Trematode in *Anas boschas*, *A. acuta*, *A. querquedula*, *A. crecca*, *Fuligula leucophthalmus* and *Mergus albellus*. He called it *Bilharzia polonica*. LOOS (1899, p. 521) referred it to his new genus *Bilharziella*. TH. ODHNER (1913, p. 54) found it again once in *Fuligula cristata*. SZIDAT (1928 a, p. 331, 1929 b, p. 78) found that the parasite was extremely common in *Anas boschas* and in domesticated ducks. — The development had been entirely unknown till SZIDAT (1929 c, p. 461) showed that the *Cercaria* developed in *Planorbis corneus* and thoroughly studied its biology.

As mentioned above, I have found the *Cercaria* in three different localities, always in *Planorbis corneus*. It was a fact of peculiar interest that the *Limnaea ovata* and *Planorbis corneus* in Hørsholm Pond collected on the very same day and over the same square metres gave: the former *C. ocellata*, the latter *C. Bilharziellae polonicae*.

With regard to the biology of the *Cercaria* I can only corroborate the excellent observations of SZIDAT. As soon as the *Cercariae* come out from the *Planorbis* they so to speak dart to the surface; their feeble tail and very short rami plainly show that they are neither swimmers nor pelagic organisms. Arrived at the surface they fasten themselves by means of the ventral sucker, and in very many cases the tail breaks off; if not, the tail hangs down perpendicularly from the surface. If this is agitated, the tails move forwards and backwards. As SZIDAT has observed, the whole surface is in a very short time covered by a gelatinous matter produced by the *Cercariae* and forming a layer common to all the *Cercariae* (Microphoto Pl. XXXIX, fig. 21). If this matter is produced by the penetration glands or by cystogeneus glands near the anterior organ is doubtful. This strong production of gelatinous matter is unquestionably of the greatest significance in the biology of the animals. Swimming birds which come in contact with this layer with its great number of *Cercariae* will get the membrane with the *Cercariae* on their feathers, from which the *Cercariae* pierce the skin. SZIDAT (1929 a, p. 86) poured water with these *Cercariae* over ducks which were free from parasites; 10–12 days later *B. polonica* was found in the veins of the mesenterium.

Of course *Bilharzia* epidemics have been feared in Europe, but the danger of such is but small. PRÆTORIUS (1929, p. 2055) has shown that *Planorbis corneus* and our *Limnaea* species cannot be attacked by the Miracidia. The chief host, *Bullinus contortus*, does not occur until Corce where BRUMPT (1929 a, p. 879) succeeded in

infecting *B. contortus* with *S. bovis*, the same which is the main host of *Schistosoma haematobium* in Africa.

LUTZ (1921b, p. 119) has shown that the Miracidia of *Schistosoma Mansoni* chiefly attack the antennae of *Planorbis*. They produce a local reaction characterised by swelling and hyperaemia, which is easily observed owing to the red colour of the blood in the larger *Planorbis*. After three or four days, when the Sporocysts begin to develop, a secondary swelling of the antennae takes place, which increases during the first fortnight. "About twenty days after the infection the antennae become pale and shrunken without disappearing altogether; therefore the infected snails may be recognized even after a long time." LUTZ (Pl. 38, figs. 20—38) gives a series of figures of deformed antennae. I have searched without success for specimens of *Planorbis corneus* with deformed antennae. As stated above, my material was very small, but I take the liberty of calling attention to the observation of LUTZ; the attack of *Bilharziella polonica* may possibly produce a similar effect on our *Planorbis* species.

It is a familiar fact that the known blood-infecting Trematoda belong to three families: the *Schistosomatidae*, the *Spirorchidae*, and the *Aporocotylidae* (= *Sanguinicolidae*). The *Spirorchidae* all occur in turtles (N. America), and are very common there (100 p. c.). While the two other families are hermaphroditic, the *Schistosomatidae* are the only known digenetic Trematoda possessing separate sexes. The cause of this dioecia is difficult to understand. In a very interesting paper STUNKARD (1923, p. 165) has put forward the conjecture that the dioecia is connected with the appearance of vertebrates with a complete separation of arterial and venous blood; the blood flukes then leave the arteries and go in search of the venous blood which is richer in nourishment. This circumstance, and the fact that the blood of homoiothermal vertebrates contains more oxygen is surmised to be the cause of the dioecia.

CORT (1921a, p. 226) has shown that all *Schistosomatidae* originating from a single Miracidium are of the same sex. FAUST (1927a, p. 169) points out the epidemical significance of the fact with regard to *Schistosoma japonica* in China. According to SEVERINGHAUS (1928, p. 653) all the Cercariae of a snail may develop into Trematoda of the same sex. If male Trematoda only are brought to development in a host (a marmot), the development will be normal; if female Trematodes alone are brought to development in a host, the females will not be fully developed: the growth will be arrested and the sexual organs remain undeveloped. If after a while the marmot is infected with male Schistosomes, the development will proceed and the females become normal.

These very interesting experiments are mentioned here because it would of course be desirable to ascertain whether our own European *Schistosomatidae* would behave like the pathological ones. The same applies to the interesting investigations of LUTZ (1921, p. 109) with regard to the thickness of the antennae of *Planorbis olivaceus* caused by the development of Sporocysts of *Schistosoma Mansoni*, and to BRUMPT's studies on egg-laying processes in Schistosomes (1930a, p. 263). Investigations on the behaviour of the European *Schistosomatidae* have not, as far as I know, been carried out.

The Strigea group and the Proalalaria group.

The development of the Trematoda with a typical Furcocercaria stage (not a *Bucephalus*, *Cystocercaria* or *Lophocercaria* stage) is among the most complicated of all Trematoda, and in the whole animal kingdom. These Trematoda use at least three different hosts perhaps, and there is some evidence for the supposition that they may use four; however, whether this case is normal or only a result of an individual abnormal line of development is, as far I can see, not fully elucidated. The unusual feature in the normal development for all these forms is, that between the Cercaria stage and the mature stage there is intercalated a new larval stage, differing very much from the normal larva stage, the Furcocercaria, as well as from the mature form, a stage which looks very different in the different forms and which, therefore, has many different names (*Diplostomum*, *Tylodelphys*, *Tetracotyle*, *Codonocephalus*, *Neascus*). It has been experimentally shown that the *Diplostomum* and *Tetracotyle* stage is preceded by a Furcocercaria stage; with regard to the others we merely possess suppositions. —

It is these new larval stages which for their development demand a second host, commonly a snail or a fish; with regard to *Tetracotyle* it is the peculiar occurrence of this stage in very many different animals which allows the supposition of a third one before the last one is reached.

a. The Strigea group.

For almost exactly a hundred years, from the date when NORDMANN in 1832 wrote his *Mikrographische Beiträge* to the most recent investigations (BRAUN 1894a, p. 165; 1894b, p. 680; FAUST 1919c, p. 69; LUTZ 1921a, RUSZKOWSKI 1922, p. 237; MATHIAS 1925, p. 1; SZIDAT 1923—31; LA RUE 1926—32; HAITSMAN 1929, p. 224, 1930, p. 140; 1931, p. 447; HARPER 1931, p. 310) research has tried to solve the question of the development of the Holostomatidae. The course which science has taken has in reality been one of uninterrupted trials and errors, and it almost seems as if the greatest errors are closely associated with the greatest names in parasitology. At all events these eminent parasitologists have with more or less hesitation endorsed different theories which succeeding investigators were forced to abandon. A full historical account of how our knowledge has developed has often been given (HUGES 1928f, p. 502; MATHIAS 1925, p. 22; SZIDAT 1929e, p. 614; of the mature forms by HUNTER 1929, p. 104).

It was the Danish Zoologist ABILDGAARD (1790, p. 24) who first of all created the genus *Strigea*; STEENSTRUP (1842, p. 46, Pl. III, fig. 5—6), as many others after him, found *Tetracotyle* in parthenitae of other Trematoda and gave some figures of echinostome Rediae with enclosed *Tetracotyle*. He regarded them as genetically related to those Trematoda in whose parthenitae they were found. The idea was accepted by FILIPPI who created the name *Tetracotyle* (1854, 1855 and 1859), and this in spite of the fact that SIEBOLD already the next year after the appearance of

STEENSTRUP's famous work (1843 a, p. IXXXIII and 1843 b, p. 325) alleged the incorrectness of STEENSTRUP's view, an opinion later on adopted by MOULINIÉ (1856, p. 150), PAGENSTECHE (1857), and others. MOULINIÉ quite correctly held that the occurrence of Tetracotyle in the Redia was entirely accidental; and that this Tetracotyle "soit une forme plus petite aquatique qui s'introduit dans les Mollusque, comme en plupart des cercaires, en se frayant un chemin a travers les tissus".

At that time no one had any idea to which Trematode these larva stages belonged. It was ERCOLANI (1881, p. 287) who showed that ducks fed with Tetracotyle got adult Holostomes. A great step in our knowledge of the development of the Holostomes was thus taken, since it was now established that the Holostomes pass a Tetracotyle stage. It must, however, be noted that already v. LINSTOW (1877 a, p. 195) supposed that "die Genera Tetracotyle und Diplostomum den Larvenzustand von *Holostomum* darstellen". That it took about 50 years before the main lines in the development of a Holostome were cleared up was, however, due to a wrong theory based upon insufficient observations, but nevertheless, even though with some doubt, accepted by the first authorities on parasitology.

Already in 1877 a v. LINSTOW (p. 195) had studied Miracidia developing from eggs of a Holostome (*H. cornucopia* Molin). A resemblance, which nowadays seems very superficial, led v. LINSTOW to the supposition that the Tetracotyle developed directly from eggs. The development of the Holostomes was supposed to occupy an intermediate position between the other digenetic Trematoda and the Polystomes. On the one hand, there was no development in Sporocysts and Redia, but on the other hand the development was not a direct one because between egg and mature form there was intercalated an encysted stage, the Tetracotyle stage. The hypothetical supposition of v. LINSTOW caused LEUCKART (1886—1901, p. 163) to set forth the theory that the Holostomes had an alternation of hosts, but not of generations, and he called the development of the Holostomes metastatic. The theory was accepted by BRANDES (1890, p. 570) and BRAUN (1892, p. 796) and was universally current till a new significant step was taken by LUTZ (1921, p. 124). He showed that Furcocercariae, developed in threadlike Sporocysts, metamorphose into a Tetracotyle stage, in other words that MOULINIÉ's supposition was correct. The next year RUSZKOWSKI (1922, p. 237) showed for *Hemistomum alatum* that eggs of this worm in fresh water snails developed in Sporocysts in which Furcocercariae later on appeared. The development of all these forms was now cleared up in all its essential points, but hitherto no one had followed the development of a single species from egg to mature worm. This was done by MATHIAS (1922, p. 175 and 1925, p. 14) and by SZIDAT (1924, p. 299; 1929 e, pp. 612 and 686). SZIDAT saw his Cercaria A. penetrate into the skin of *Limnaea palustris* and studied its transformation into *Tetracotyle typica* Filippi, determining the adult form as *Cotylurus cornutus* (Rudolphi) and regarding *Strigea tarda* as a synonym for *Strigea (Cotylurus) cornuta* (Rud.). The cycle of *Cotylurus cornutus* has therefore the following course. From an egg thrown out into the water with the excrements develops a Miracidium which pierces the skin of a *Limnaea palustris*. Here it alters into a mother sporocyst in whose interior daughter sporocysts

are developed; the Sporocysts propagate by division and produce in their interior a series of daughter sporocysts in which sooner or later Furcocercariae develop. These Furcocercariae leave the snail, whereupon they again make their way into another specimen of the same species, and in the genital organs develop into the creeping Tetracotyle stage described by MATHIAS and SZIDAT, which, again, is changed into the immobile stage that, when swallowed by waterbirds, passes into the mature one.

In his excellent monograph of the genus *Strigea* (Abildgaard) SZIDAT (1929c, p. 736) shows that the same Tetracotyle stage, *T. typica*, is also found in leaches (*Haemopsis*, *Herpobdella*).

SZIDAT adds to our knowledge of the development of the free-living Tetracotyle stage from the Furcocercaria onward to the immobile stage. SZIDAT clearly shows — a fact which is of special interest — that the development from Furcocercaria to Tetracotyle must be regarded as a true holometabolic metamorphosis during which the larval organs of the Furcocercaria are broken down and new organs typical of the Tetracotyle are formed. During this time the larva increases in size, that is to say, in breadth and in length but not in thickness. As the whole alimentary canal with the suckers is broken down, the nourishment can only take place endosmotically through the skin, a process which causes the genital organs of the snail to undergo a process of decomposition and change into a slimy mass. The manner in which the old larval organs are broken down and new ones developed must be reserved for future investigations. The new suckers appear in the place of the old ones, and a little later appear the “holdfast” organ and lateral grooves of the resting Tetracotyle stage.

I shall here not enter into details with regard to the extensive literature relating to the anatomy and placing of the different larva stages of the Holostomidae; but restrict myself to refer the reader to the papers of MILLER and FAUST and especially to the long, very valuable, series of papers: Studies on the Trematode Family *Strigeidae* (*Holostomidae*) which under the leadership of Prof. LA RUE have contributed very much to elucidate many points in the anatomy and biology of the highly remarkable development of these Trematoda. I also refer to the papers of BRAUN (1894a, p. 165 and 1894b, p. 680) and CIUREA (1927b, p. 12).

I merely wish to call attention to some points in the natural history of these animals which, as far as I can see, still need further investigation; both belong to domains widely separated from explorations carried out at a freshwater biological laboratory.

SZIDAT has clearly shown that the further development of the Furcocercariae may be regarded as a holometabolic metamorphosis. The question remains, however, why should just these Cercariae pass through this metamorphosis and a Tetracotyle stage be a necessary link in the development of the Holostomata. Why should the whole larva body be broken down and another differing in all essentials from it arise. Just as the cyst of an Echinostome, when introduced into the alimentary canal, gives the adult form, so also does the Tetracotyle. Therefore in the biology of the developmental stages a holometabolic metamorphosis does not seem to be required. Within my knowledge there is no other Trematode family in which we find so great a difference between the larva and adult stage as just in this family. This holds good especially

with regard to the development of the "holdfast" organ. Even if we are unable to see just how, the impression remains that it is the development of this organ which is of chief importance during the passage from the free creeping to the motionless Tetracotyle stage. It is perhaps mainly this organ which, in contradistinction to other organs, demands a special period of nourishment characterised by the enormous growth of the Cercaria body. In my eyes it is not the resting Tetracotyle stage but the free creeping leaflike stage very variable in form and equipped with an enormous power of growth which is the most striking feature in the development of the Holostomes. When a sufficient amount of food is taken in, the development of the most deviating organ of the Holostomes, the great "hold fast"-organ, begins; the cause for the complicated metamorphosis may be found not so much in the biology of the developmental stages as in the biology of the mature stage.

With regard to the Tetracotyle stage there is still the question whether or not it takes food in its resting stage. The last supposition is, as far as I know, tacitly accepted. Surrounded as it is by a thick cuticula and by a much thicker gelatinous envelope this would also seem the most reasonable. SZIDAT (1924, p. 261) says that *Tetracotyle typica* not "feste Nahrung aufnehmen". It must, however, be kept in mind that the oral sucker is well developed that both envelopes have an opening anteriorly and posteriorly, that the excretory bladder functions and from time to time throws out small round or rod-like particles, especially when the organism is subjected to a slight pressure. When in spite of all probability I cannot rid myself of a doubt that the Tetracotyle in some way may influence the tissues of the snail, this is owing to two reasons. In snails which contain many hundreds and even some thousands of encysted Tetracotyle, they are always found in a yellowish-white gelatinous mass, simultaneously containing sperm masses of the snail. It is as if the whole of the genital organs, the hermaphroditic gland, the albumen glands and the duct, are in a process of jelly-like decomposition, which in some way is produced by the Tetracotyle and which may still be continued even after these have been transformed into the resting stage. Furthermore, it has struck me how greatly the resting stages differ in size. When the inner membrane is hardly developed and no sign of the outer jelly-like one is present, the size does not seem to be more than 340 μ , but among the many finished stages we find very many which may reach a length of 510. On Pl. XXV fig. 15—16. I have drawn the smallest and the largest one I have seen. In my opinion there are some reasons which speak in favour of the supposition that even in the resting stage jelly-like matter may in some way be sucked in by the organism.

As is well known, resting Tetracotyle stages are found in very many different animals, belonging to almost all higher groups of land and freshwater organisms. They are furthermore found in almost all organs; in the muscles, in the brain etc. As the mature stages are pronounced parasites in the alimentary canal, there is no doubt that as long as the parasites have not reached it, they have not reached their final hosts. The question therefore arises if there is not, before this final host, in some developmental series intercalated a new intermediate host, or in other words, if

the development does not demand four in all hosts. When for instance a Tetracotyle stage is found in the connective tissue of *Sorex vulgaris* (v. LINSTOW 1877a, p. 191), and we know that many Holostomes are found in the alimentary canal of *Rapaces*, there is the possibility that small Insectivora and Rodentia may be a necessary intermediate stage between snail and bird; it may, however, also be possible that the occurrence of Tetracotyle in the connective tissue of *Sorex* as well as in so many other places outside the alimentary canal is only due to chance. But the question still remains how they arrive in all these organs in which the final development cannot take place. We are almost forced to suppose that the parasite has reached the place in the Cercaria stage; on the other hand, it is difficult to understand how a Cercaria should make its way into the neck musculature of *Mustela putorius* (v. LINSTOW 1876, p. 1), into the subcuticula of *Pelias berus* (v. LINSTOW 1877a, p. 192), and into the connective tissue of *Sorex vulgaris*; into the brain of a minnow (ASHWORTH and BANNERMAN 1927, p. 159), into the brain of *Ammocoetes* (BROWN 1899, p. 489), into the Peritoneum of *Schizothorax intermedius* (PAWLOWSKY and ANITSCHKOW 1923, p. 219). What renders the matter still more obscure is that the authors, especially the earlier ones, used the name *Tetracotyle* for very many organisms and did not even give a drawing of the stage which they found.

I have taken the liberty to call attention to these points because I think that here there are still aims for future investigations.

Cercaria A. Szidat.

It is especially *Cercaria A Szidat* which has been studied in the laboratory at Hillerød.

This species is extremely common in our country; it is perhaps the commonest of all our Furcocercariae. When a large *Limnaea stagnalis* infected with Sporocysts of this species is put into a vessel, it will sooner or later throw out enormous masses of Furcocercariae. These Furcocercariae either sink slowly downwards to the bottom, or they ascend to the surface; they are able to stand still in the waterlayers like pelagic organisms, but they are much more active swimmers, darting away in all directions. If fishes are placed in the aquarium they may live for months together with the infected snails; on the other hand, if the water with the Cercariae is poured into another vessel and a *Limnaea* e. g. *L. stagnalis* or a *L. palustris* is placed in it, the Furcocercariae will be seen to gather round the *Limnaeae*. Shortly after the *Limnaea* will be observed to make small sudden jumps; by means of a lens it can be shown that the whole animal is covered with a layer of Cercariae which are creeping everywhere upon the mantle and shell; the body is pressed against the surface, the tail is very often stretched out vertically to the body; in many specimens the tail is already thrown off. It can further be shown that everywhere the skin is in convulsive motion. The snail reacts to the attack by a heavy slime production, and in this slime very many Cercariae die.

We have here to do with one of those Furcocercariae which use the same species as primary as also as secondary host. In this case the Cercaria stage would seem to be rather superfluous, but it may be important from the fact that the material produced by the single Miracidium which once made its way through a *Limnaea* is not restricted to a single specimen but distributed over many. If a vessel contains only the very same snail which has produced the Cercariae, these attack it, but in Nature where the *Limnaea* often lie side by side and often in great numbers, this will most probably not be the rule. —

It is characteristic of all those localities where the *Limnaea stagnalis* contain *Cercaria A. Szidat* that they often also contain Tetracotyle. Through the studies of SZIDAT (1929 e, p. 612) and others we know that Tetracotyle is a developmental stage in the development of his *Cercaria A.* found by him in *Limnaea palustris*.

I refer the reader to his account which I can only confirm and to which I have only little to add. On Plate XXV, figs. 1—10 I have given the metamorphosis in 10 figures. The figures are all drawn with the same power and show the enormous growth which reaches its climax in fig. 6, whereupon the organism again diminishes in size. In the stage given in fig. 7 the larva is still movable, in fig. 8 the motion has ceased; the thick cuticula is not found until fig. 10. The diminution in size seems to proceed at a great rate. The stages figs. 7—9 are rare. Fig. 2 represents the smallest tailless larva I have seen; the two suckers, the pharynx and blind sacks are still conspicuous. During stages 3—6 all interior organs disappear and a transversal section fig. 13 shows only many vacuoles and numerous nuclei. In all these stages the "riesige Zellen" of SZIDAT are found everywhere. In the stage fig. 7, and till fig. 8 is reached, the new organs of the Tetracotyle are built up again. The "holdfast-organ" begins (Pl. XXIV, fig. 12) as two protuberances which may be twice as large as is seen in the figure; later on they are invaginated in the body. Pl. XXV, fig. 11 shows a longitudinal section of a stage between figs. 7 and 8, and fig. 13 a transversal one through the holdfast organ and ventral sucker. The three figures (3—5) on Pl. XXIV show horizontal cuts of a fully developed Tetracotyle and figs. 6—7 a transversal section in the posterior part of the "holdfast" organ. — On Pl. XXXVII, fig. 12 a microphoto of a snail containing numerous Tetracotyle cut in all directions is seen; they lie in the hermaphroditic gland and it can be observed how the tissues are influenced by the parasite and subject to an intensive destruction. Pl. XXV, fig. 14 shows a Tetracotyle in a Sporocyst of a xiphidioid Trematode; the figure shows how large the parasite is in comparison with the host; furthermore it is seen that it is not nourished by the brood of the Sporocysts, which always seems unhurt; there can be no doubt that in this stage at all events it is nourished endosmotically.

The development has been studied in two localities near Hillerød, at Strødam and in Donse Pond.

In the first part of July it could be shown that the *Limnaea stagnalis* of Strødam were heavily infected with Tetracotyle. Of 10 specimens 9 were infected. The whole visceral sack was covered with yellowish white spots; when pricked with a needle,

the Tetracotyle streamed out. They are often present to the number of many thousands. They occur mainly as the broad flat larvae described and figured by SZIDAT; they are very mobile and may be found of all sizes, from very small specimens to fully developed ones. In the furrow of the visceral sack, imbedded in slime, these larvae are found by hundreds. They seem to be wandering upwards into the liver where these stages also are found; if the Tetracotyle stage is reached at the moment when the snail is killed, most of this stage is found here or in the liver. They lie there in inlets; the colour of the liver is a peculiar bright yellow with a faint reddish tint. This causes the shell also of heavily infected snails to assume a peculiar yellowish red colour, most conspicuous in the upper windings. It is very fragile. To ascertain if these snails have Tetracotyle or not it is only necessary to break off a small piece of the spire and the Tetracotyle will then pour out in a stream. — Of 10 observed specimens only one had Cercariae; in this case the liver was merely an entangled mass of Sporocysts and no Tetracotyle were found.

During the period 9/IX 31 to 29/VI 32 collections were made on 9/IX, 19/IX, 20/I, 24/II, 11/IV and 29/VI. Each time 25—30 snails were collected. In every specimen Tetracotyle were found; not in a single one Sporocysts or Furcocercariae. In most cases only the parasite was found in the Tetracotyle stage; but during the whole period the flat larva stage was present and in a few snails in great numbers. From September to 24/II snails were kept in the aquaria. During the period 14/II—24/II the snails died; all contained Tetracotyle in enormous masses. Many of the snails were simultaneously infected with echinostome Rediae, and many larvae, creeping larvae as well as Tetracotyle, were found in them. Often to the number of 10, the Tetracotyle lie as pearls on a string, and the echinostome Cercariae are arranged in circles round them. I have never seen that these Cercariae produce a sickly appearance. The parasite in the Rediae may be nourished endosmotically. — By 11/IV 32, when the pond thawed, it was difficult to find many old snails; there were many empty shells; unquestionably many snails had died during winter. 10 specimens were found; 9 of these had Tetracotyle in enormous quantities; the free creeping larval stage was not found. Sporocysts and Furcocercariae were not found in a single one.

All the 10 snails observed belonged to the oldest age-class; the shell was much corroded; the spire often broken off. These snails almost all died in May-June; now a younger age-class was found, with fine brown chitine and unbroken spires. In the last part of June some specimens were found which contained Sporocysts and threw out great numbers of Furcocercariae. A few of the oldest age-class which had survived were especially heavily infected. Tetracotyle were not found in the young snails, and the infection with Sporocysts was but slight, presumably only a few per cent. In the autumn of 1932 no Sporocysts were found and the infection with Tetracotyle was by no means so heavy as in 1931. —

I suppose that in 1930—31 there has been a rather heavy infection with Miracidia and that these in June-July have produced an enormous quantity of Furcocercariae which again have produced the extensive infection with Tetracotyle. If

this is right the observations are able to throw some light upon one of the significant functions of the Tetracotyle stage in the development of the *Strigeidae*. A single snail is able to produce Furcocercariae by the hundred or thousand, perhaps by the million, but more than some thousands of the large Tetracotyle a snail cannot harbour. — The parasitic life must be distributed over two specimens; it is only the want of room and the inability to provide nourishment on the part of the host which forces the parasite to seek a new host. And it would seem that a new host of the same species as the first is preferred. At Strødam *Planorbis corneus* occurs very commonly side by side with *Limnaea stagnalis*; *Bithynia tentaculata* is extremely common. Tetracotyle have been found in a few specimens of *Planorbis corneus* but only in small number, and never in *Bithynia tentaculata*.

Recently WINFIELD (1932, p. 130) and NOLF and CORT (1933, p. 38) have shown that individuals of *Limnaea stagnalis appressa* and *L. stagnalis perampla* which were infested with Sporocysts of *Cercaria flabelliformis* were highly resistant to the penetration of its own Cercariae, although these two varieties of snails serve very effectively both naturally and experimentally both as first and second intermediate hosts. The life history of *C. flabelliformis* has been worked out by American authors (FAUST 1917b, p. 105, CORT 1918a, p. 49, CORT and BROOKS 1928c, p. 179, HUGHES 1928f, p. 495 and VAN HAITSMA 1931, p. 447). The Sporocysts develop in the course of six weeks; they give off Cercariae, which enter the same species of snails and in the course of six other weeks are altered into mature Tetracotyle; when this stage is eaten by ducks, it is changed into the mature form *Cotylurus flabelliformis*. The species is very nearly related to the very form with which we are here concerned, namely *Cercaria A. Szidat*.

WINFIELD and NOLF and CORT have now shown that snails which already are infected with Sporocysts of *Cotylurus flabelliformis* are practically immune to the penetration of the Cercariae and to the development of the same species.

WINFIELD (1932, p. 132) maintains that this immunity plays an important part in the survival of snails harbouring this Trematode since it tends to prevent them from being attacked and overwhelmed by the great numbers of Cercariae which escape.

No doubt seems to be possible with regard to the correctness of the fact. On the other hand, there seems to be something lacking in the interpretation; in WINFIELD's presentation, I do not think this interpretation is quite correct I shall return to this point later on.

Wherever *Limnaea* have been strongly infected by larvae of Holostomes the percentage of snails infected by Tetracotyle has always been much larger than of those infected by Sporocysts. Of the first-named often almost 100 per cent. have been infected, of the last-named commonly only a few per cent. The Tetracotyle can be found the whole year round, the Sporocysts occur mainly in the winter months, the Cercariae chiefly in spring and summer. From this I am inclined to suppose that the Miracidia attack mainly takes place in the autumn, the Cercaria attack mostly in spring and summer; in other words, that the Miracidia and the Cercariae attack snails from two

different years; the result of this being that Tetracotyle and Sporocysts of the same Trematode are only rarely found in the same snail. That the snails should be especially protected against two attacks, one by the Miracidium and one by the Cercaria, I think rather doubtful. In this connection attention must be directed towards the results arrived at by RIECH (1927, p. 283) and LUTZ (1924, p. 55) with regard to the Cercariae of Echinostomes. Both arrive at the result that the Cercariae enter the same snail in which they have been developed and I can only confirm their results. I find no indications with regard to the size of the two sets of snails in any of the abovenamed papers. Nevertheless it may be noted that even if the snails are from two different years, the difference in size may really be very slight.

I am inclined to suppose that it is not solely the infestation with other Trematoda but also the age of the snails which determines the invasion of the Cercariae; most probably they only enter young snails.

NOLF and CORT have furthermore tried to find out whether there was a non-specific immunity to the invasion of Cercariae into their normal second intermediate host infested with larval Trematodes belonging to different species. The results were variable; in some cases there was no specific immunity; in snails infected with *Schistosomatium Douthitti* a partial non-specific immunity was present.

There can be no doubt that as a rule there cannot be a non-specific immunity to the invasion of Cercariae of other species, if the snail already harbours parthenitae of other Trematoda.

All investigators agree in having observed the phenomenon which has been called double infection. For my own part I have never opened heavily infected material from a pond without finding a percentage of doubly infected specimens. The double infections consist either of two species of the same group, e. g. two sorts of Sporocysts of Xiphidiocercaria, developing quite different Cercariae or two species belonging to two quite different groups, in most cases Echinostomes together with Xiphidiocercariae or Monostomes. In these cases the Echinostomes preyed upon the Rediae or Sporocysts of the other species. That the Cercariae, belonging to the Strigeidae by no means show any tendency not to attack snails already infested with other Trematoda is shown by the fact known already to STEENSTRUP but incorrectly interpreted by him, that Echinostome Rediae often contain Tetracotyle, as is often shown too in the plates belonging to this work. As I have several times found Tetracotyle in Echinostome Rediae together with Monostomes in the same snail, *Limnaea stagnalis*, we are here concerned with a triple infestation. —

What is the further fate of these Tetracotyle? We know that they are to develop in the alimentary canal of our birds. But which are these birds? Do we find in our fauna any birds which eat these large snails, often of a length of 5 cm.? For South America LUTZ (1929, p. 131 and 1931, p. 352) has shown that the snails are eaten by *Ardeidae* which in this way become infected. There is very little bird life in the ponds at Strødam. Gulls and terns have never been seen; in the autumn *Anas boschas* remains the night over on the pond; *Fulica atra* and *Podiceps* are never seen; *Galli-*

nula chloropus breeds in an adjacent pond; herons visit the ponds regularly and now and then small waders. Frequent visitors at the shores are the common crow and various *Turdus* species. If any birds of our fauna were able to get the *Tetracotyle* directly from the snails I for my part am inclined to suppose that it would mainly be our crow birds and our *Turdus* species. Besides I suppose that the manner of infection is the same as mentioned for the Echinostomes p. 69.

In spite of the many excellent papers which have contributed to the elucidation of the development of the Strigeidae I cannot but think that it is still not fully understood. As mentioned above the *Tetracotyle* stage is found in very many organisms in reptiles and frogs, in fishes, in Mammals (Sorex, Mice) and curiously enough not in the alimentary canal but in the brain, the muscles, the heart, the mesenterium. I cannot see how they arrive here, what they have to do here and if perhaps some of these hosts, especially fishes, Sorex, Mice serve as a third regular intermediate host before they reach the final one (a bird of prey?). I have not tried to contribute to these difficult questions because they are too far away from the main tasks of a freshwater biological laboratory.

b. The *Proalaria* (*Hemistomum*) group.

In 1928c CORT and BROOKS (p. 183) showed that in North-American freshwaters there existed a group of fish-invading holostome Cercariae which "belong to the genus *Proalaria* or to closely related genera, and that their Metacercariae are Diplostomes of the type which develop in the eyes of fish. They have a close structural resemblance; very characteristic is especially the number of penetration glands (4) and their position behind the ventral sucker. For two of them it was shown that they penetrate into certain species of fish and become localized in the lenses of the eyes, and for *C. flexicauda* the development has been traced to a Diplostomum type of larva". The authors refer the *Cercaria* C. of SZIDAT (1923, p. 304) to the same group. It has also four penetration glands behind the ventral sucker and SZIDAT (1925, p. 260) has shown that in the eyes of fishes it develops into a Diplostomum which is identical with *Diplostomum volvens*. These forms were fed to gulls and the adults were identified as *Hemistomum spathaceum* Reed, of which LA RUE (1926b, p. 15) has made the type of the genus *Proalaria*. Characteristic of the *Cercariae* belonging to this group is the fact that they "have the habit of hanging quietly for most of their free life". In other words, this means that they are true plancton-organisms adapted to a pelagic life. This pelagic stage most probably does not last more than one or two days. During this stage the *Cercariae* must come in contact with swimming fishes; the *Cercariae* themselves show no activity at all. —

Combined with the observations of *Cercariae* A. Szidat these facts seem to show that within the holostome Furcocercariae of MILLER's group *pharyngeate longifurcate Cercariae* two types can be distinguished: Forms which use fishes as secondary hosts and forms which use snails as secondary hosts. The former develop into the genus *Proalaria* or related genera, the latter into the genus *Strigea* or related genera. In

both cases the ripe stage may occur in birds; the first group has pelagic larvae in the true sense of the word, the larvae of the second group more frequently seek the bottom and are more active swimmers. In the group whose larvae enter fish the penetration glands lie behind the ventral sucker, in the snail group whose larvae enter snails they lie before the sucker.

In accordance with CORT and BROOKS DUBOIS (1929, p. 149) has given a more schematic view of the matter, separating the Cercariae discussed into two groups, the one developing through a Diplostomum stage into *Proalaria* (*Hemistomum*), the other through Tetracotyle into *Strigea*. To the former group are referred 6 species, to the latter 5 or 6 species.

It is perhaps questionable whether the division holds good; remarks in the literature as well as some of my own observations are well able to augment a doubt. I refer especially to the remarks of SZIDAT (1931 b, p. 167). For my own part I have provisionally preferred to establish the two groups partly upon the anatomical fact that the penetration glands in the one lie before the ventral sucker in the other behind it, partly upon great differences with regard to the biology. To this must be added that the arrangement of the body spines, as pointed out by CORT and BROOKS, may be different. According to these authors the Furcocercariae invading snails have no special spines near the opening of the penetration glands, whereas they are present in the fish-invading group.

So much seems to be certain that the *Cercaria C.* of SZIDAT develops into a Diplostomum, that of *C. strigeae tardae* into a Tetracotyle; what is the life cycle of the other Cercariae, provisionally and only owing to the position of the penetration glands referred to these two groups, we do not know. The life cycle of *Cercaria C.* has been studied in my laboratory for rather a long time.

Cercaria C. Szidat.

Pl. XIX, fig. 4—10. Pl. XXXV, figs. 9—11. Microphotos Pl. XXXVII, fig. 7. fig. 8. Pl. XXXIX, fig. 23.

Since NORDMANN's famous investigations it has been known that a great many Trematodes undergo part of their development in the eyes of fishes; this inquirer alleges that he has found 58 species of Helminths in them. Without going into detail I shall merely call attention to the fact that STEENSTRUP (1842, p. 58) showed the ways or canals through which the animals had found their way to the lens. LA RUE, BUTLER and BERKHOUT have collected all that we know from literature on this point (1926 d, p. 282). Because Trematoda have been found in the human eye also, SALZER (1907, p. 19) has given a very interesting account of the pathological phenomena caused by Diplostomes in the lens of fishes, and his paper is accompanied by very instructive plates. In fishes the presence of the worms causes a protrusion of the lens through the pupil, thus producing telescopic eyes of a milky aspect. In some cases the lens was entirely absent — a phenomenon which I too have observed. The parasites are carried with the blood and lymph through the lumen of the veins. They then pierce the lens capsule and the lens, but most probably they may also enter directly

through the cornea or sclera. In many cases the parasites die; the lens epithelium grows round them, so as to encyst and kill them. But even though the fishes do not always die from the parasitation, they become emaciated.

On 30/IX, 70 *L. auricularia* and one *L. stagnalis* were dredged at 2—4 m. in the Furesø. These 70 *L. auricularia* were dissected and 7 showed Furcocercariae; not a single one of them had Tetracotyle. Four had Echinostomes. The *Limnaea stagnalis* was placed in an aquarium with plants. Upon another excursion on 17/XI, 70 new *L. auricularia* were gathered at 2—4 m. in Furesø. The 70 *L. auricularia* were put into vessels with 5 in each; no plants, no food. On 20/XII, 33 days later, all had died. During the time 30/IX to 20/XII, 20 specimens showed Furcocercariae, 16 Echinostomes, 8 xiphidioid Cercariae, and only in a single specimen were found very few Tetracotyle; the others showed no Cercariae but when dissected proved in several cases to be infested with Sporocysts. Most of the snails infected with Furcocercariae showed these the first days, and were immediately isolated, on 3/XII in bright sunshine and at a high barometer two snails which had never shown Cercariae suddenly threw out enormous masses. After the first days the water was not changed in most of the vessels, but 5 snails which had fresh water every day threw out enormous amounts every day in the course of eight days; then the snails died. The temperature of the Furesø on 17/XI was 7° C. This shows that the Furcocercariae may develop and may be thrown out at rather low temperatures. Of the snails which had never shown Cercariae, four were infected with Sporocysts, containing unripe or very unripe Cercaria brood.

The above-named *L. stagnalis* from 30/IX the next day threw out enormous quantities of a Furcocercariae. This *Limnaea* was placed in an aquarium with plants. For three months till c. 1/I the *Limnaea* still threw out Cercariae; it died on 12/II 33 having lived in the aquarium from about 4½ months. During the last two months no Cercariae had appeared. When dissected, hardly anything was left of the liver but a yellow string consisting of long Sporocysts; most of these were empty; many contained quite unripe Cercaria brood and only a few ripe ones. A regeneration of the liver had not taken place.

The Cercariae from *L. auricularia* and *C. stagnalis* were carefully studied. They are identical in all particulars and there can be no doubt that they belong to the same species; the average measurements taken from 10 specimens from the two snails clearly show that. They both belong to *Cercaria C. Szidat*. It was the same species which I found in 10 of 29 *Limnaea stagnalis* on 11/IX. Its behaviour as a free-living organism has been carefully studied by SZIDAT (1924 a, p. 249). I fully agree with SZIDAT'S observations relating to the swimming motion of the larva, and in this respect I refer the reader to him (pp. 251—252). As SZIDAT correctly infers, the specific weight of the animal must be almost equal to that of the water, merely a little higher. Indeed, like many other Furcocercariae it belongs to the most pronounced plancton organisms of the freshwaters. Like many others, they use the cross-section resistance as a physical principle against the fall. On Pl. XXXIX, fig. 23 shows a

photo of part of a living plancton swarm of *Cercaria C. Szidat*. When the animals are at rest the position in the water is invariably the same. The rami of the furca are spread out, almost all at the same angle. Another highly characteristic fact is that the body is bent laterally and almost always held parallel to one of the rami. It is also peculiar that the bending takes place, not between the body and the tail but in the tail itself, a little below the posterior part of the body. I have tried to find an anatomical structure which would elucidate this but have been unable to do so. When living Cercariae lie under cover, it will almost always be observed that they bend the body in quite the same manner as is shown in the photo. There is no doubt that the rami in the widely spread position act as a suspending organ, and I cannot but think that the body, owing to the curvature, may act in the same way, viz. counteract the fall more than if it was held perpendicularly. It will further be seen that the rami are longer than the tail; in dead material this is not the case; they are almost always shorter. By means of the aquarium-microscope and the Edinger apparatus, and a strong light I have studied the fall. On the white reflector the Cercariae were seen to fall 2 dm. In the Edinger apparatus a swarm of about a thousand suspended Cercariae of which now one now another whirls upwards for a few seconds is a really wonderful sight. To SZIDAT's description I have only one thing to add. I suppose that the rami, during the vertical motion, are held almost perpendicularly on a line with the tail. The tip of the rami turn upwards, the body is contracted. The whole Cercaria, the body, the tail, and the rami, forms a stick; during the motion upwards three points: the oral sucker, the point between body and tail, and the point where the rami are fastened to the tail, are fixed points, whereas the rest is curved from side to side (SZIDAT). Simultaneously the Cercaria is turned in a spiral round its own axis. If this were not the case, I suppose that the Cercaria would not be able to ascend but remain in the same place in the water. During the ascension the rami are pressed together; when the ascension ceases, the rami are spread out and the body elongated. During the vertical motion they are contracted, but in the suspended position extended to their greatest length. Under the aquarium microscope this can easily be observed and is very conspicuous in the Edinger apparatus. The observation is of significance because it shows how the peculiar development of the tail of *Bucephalus* has taken place, and thus it is seen that even small variations in the development of an organism may be of significance. In my eyes the said larva forms a link in the development the final result of which is a *Bucephalus*-larva. As another step and nearer to *Bucephalus* may perhaps be regarded the very peculiar *Dicranocercaria brachycerca* described by Mrs. U. SZIDAT (1932, p. 318).

SZIDAT has made a series of interesting experiments, which all show that the larvae do not seek out the fishes but only come into contact with them by chance. This is quite in accordance with what I have seen. When *Carassius* or *Leuciscus* species are placed in water together with a *Limnaea stagnalis*, the Cercariae do not dart at the fish; it is not covered with a coating of creeping cercariae; I have never seen a

Cercaria fasten itself to the fish; there is no doubt that most of them are drawn in through the mouth or especially enter the fish by piercing the skin.

Three *Carassius vulgaris* were placed in the vessels in which either *L. auricularia* or *L. stagnalis* were throwing out their Furcocercariae. Only a few moments after the fishes had been placed in the vessel they became extremely restless. Some already made sudden high jumps in the water and 15 minutes later some of the fishes were dead. In the meantime they were found either lying upon their side or with the ventral side upwards. They were extremely sluggish and moved only when disturbed. When they were dissected the same afternoon the tailless Cercariae were found everywhere, creeping on the gills, below the scales, in the stomach, in the heart and what was the most interesting, creeping in the lens of the eye. They were found here in a number of four to six. They had still the normal Cercaria-form; only the tail was lacking. Now and then *Carassius* were placed in the vessel in which *L. stagnalis* lived. Until 29/XII the *Carassius* always died in the course of one or two days. In other words this means that till that very day the *Limnaea* threw out its Cercariae. From 29/XII the *Carassius* showed no sign of sickness. They were always brisk and took their food (*Daphnia magna*) eagerly.

On 5/XII two *Carassius* were placed in the vessel; the very same day they were sluggish, lay upon one side and moved only when disturbed. In the evening they were placed in another vessel free from snails but with plenty of food. The first three days they were still extremely sluggish, one of them lay mainly with the belly turned upwards, both were only able to swim with the body held laterally. Equilibration was totally lost. On the fourth day one of them began to recover and on the sixth they both seemed to be quite normal and as brisk as those in the large aquarium from which the other *Carassius* were taken. None of them showed blackish white eyes; nor did the eyes protrude abnormally from the head. On 17/I they were dissected. One showed one *Diplostomum* in the left eye and 5 in the right; the other, 4 in the left eye and one in the right.

The *L. stagnalis* mentioned on p. 152 and which had lived for 4 $\frac{1}{2}$ months in the aquarium and whose Furcocercaria lived as *Diplostomum* in the *Carassius*, was placed on 29/XII 32 with a *Carassius* which lived in company with the snail till its death on 12/II 33. It showed no sign of sickness. It was dissected on 15/IX 33. In the eyes were found 3 and 2 *Distomulum*. They fully agree with those found by SZIDAT in the eye of *Leuciscus rutilus* from which later on *Hemistomum spataceum* is developed in the alimentary canal of gulls.

When looking for the young Cercariae which had just entered *Leuciscus* species, I was especially struck by the great numbers in the veins of the gills and in those to the heart. They were found here already by BLOCKMANN (1910, p. 47). There is of course no doubt that these larvae are carried with the blood into the body, and that their main organ is the lens of the eye where already NORDMANN found *Diplostomum*. Knowing LA RUE's supposition (1926 c, p. 265) that the *Strigeidae* and *Schistosomatidae* are related to each other, I found it of interest that here there was a form which used

the blood channels to reach its definite organ even if the blood-ways themselves are not their final home as is the case with the *Schistosomatidae*. Later on, when I had got the excellent study of SZIDAT on the development of *Apatemon gracilis* (1931 b, p. 170) I saw that he too has had the same thought, and to this last-named form has added a second form which really lives in the blood-system of an organism, viz. *Herpobdella atomaria*.

Between the development of the *Proalaria*- and *Strigea*-group there is the great difference that the Cercariae of the latter, at all events *Cercaria A. Szidat*, return to the snails again and here change into a Tetracotyle as far as I know, Diplostomum stages have never been found in snails. If, therefore, a snail has a double infection of Echinostomes and one of the other two forms mentioned here, in the *Proalaria*-infected snails the Echinostome Rediae have no developmental stages of *Proalaria*, whereas the Rediae in the *Strigea*-infected snails may be heavily infected with *Strigea* brood. — Being a real plancton organism and standing in the midmost water-layers *Cercaria C. Szidat* has no chance of infecting snails. It must pass directly into fishes. Our knowledge of the further development is but small. That the eyes of the fishes must be regarded as one of the organs in which it mainly lives is a well-known fact. Here, near Hillerød, I have found Diplostomes in many fishes from all our lakes; they are mainly found in the outer part of the lens; when not present in too high a number the fishes do not seem to suffer by the parasite. That we have to do with different Diplostomum species in the eyes of fishes is a fact beyond doubt which was already observed by NORDMANN, and here is an untitled field for future investigators. A characteristic of them all seems to be that the development goes on quite gradually; there is no holometabolic metamorphosis as in the *Strigea*-group and no resting stage with a thick cuticula; further, there is no doubt that the Diplostomes in the eyes take food. The development of the eye Diplostomes is therefore different from that of the *Strigea*; SZIDAT (1924 a, p. 260) has arrived at the same result.

In 1931, at the borders of Tuel Lake near Sorø, many *Limnaea stagnalis* were gathered, which among other Cercariae also harboured a Furcocercaria with four penetration glands behind the sucker. They were determined as *Cercaria C. Szidat*. In September 1934 passing over the outlet of Tuel Lake, Dr. BERG found under the stone-bridge five *Gobio fluviatilis* of which the four large ones all possessed blackish eyes, the fifth half-grown one seemed to have normal eyes; in one of the large ones the left eye was merely a bloody mass, the right one very opaque.

In the laboratory it was seen that the lens contained a real layer of Diplostomes; (Microphoto Pl. XXXVII, fig. 1) the interesting point was that they were present in all stages; among the very large ones were found very young ones which still possessed the form of the Furcocercaria, the penetration glands and the strongly protruding ventral sucker with circles of spines. The whole anterior penetration organ with the spines at the top was still present.

Owing to the very dry summer the outlet had stagnant water. In the place where the *Gobio* were taken there were only a few centimetres of water. Here the fishes were

confined and lived there in company with the *Limnaea*. There can be no doubt that the infection was of a very late date and most probably was proceeding on the day of observation.

As already SZIDAT has remarked, *Proalaria* within our present knowledge possess no resting Tetracotyle stage; the development goes on without any resting stage and the animal is transferred as *Diplostomum* into the alimentary canal of waterbirds. The experiment of SZIDAT confirms this for *Diplostomum volvens*, the larva of *Proalaria spataceum* Rud. Originally I was of opinion that nothing could be added to the observations of SZIDAT; a closer examination raised some doubt on this point.

When a lens was opened and the living material studied (Microphoto XXXVII, fig. 7), it was characteristic that there was a conspicuous difference between the creeping leaf-like *Diplostomum* constantly altering its form and the stages which still preserved the cylindrical *Cercaria* form; the latter were always immobile and some of them showed that the body was drawn back from the very thin hyaline cuticula, most conspicuous in the anterior part of the body. This cuticula carries on the forepart the spines of the protrusile organ and ventrally at the top the two circles of spines characteristic of the ventral sucker. This stage which on Pl. XIX, fig. 5 is drawn with the same power as figs. 6—7 is drawn with a higher power in fig. 9. In the next stage, fig. 6 and 8, the body has its leaf-like form, most of the organs of the *Furcocercaria* have disappeared or are undergoing a conspicuous process of decomposition. It is as if part of the process by which the *Furcocercaria* body is altered into a *Diplostomum* takes place during a short resting stage; if the old cuticula of the *Furcocercaria* is left by an out-creeping *Diplostomum* I will not venture to say, but it seems to me that this really is the case. — From this young *Diplostomum* stage the development proceeds gradually. The young specimens show only a very inconspicuous alimentary canal in their interior; the excretory canals are merely faintly seen. The lateral suckers (HUGHES; "Kopfdrüsen" SZIDAT) are not developed, and there is no trace of the "holdfast"-organ. Slowly all the organs of the *Diplostomum* now come to full development; the whole penetration organ of the *Cercaria* is replaced by the small oral sucker; the ventral sucker has no concentric series of spines; the intestinal coeca are filled with a greyish floccose mass, as SZIDAT maintains, unquestionably lens material. That the *Diplostomum* takes in food is beyond doubt, as also SZIDAT has pointed out. The "holdfast"-organ has attained its full development and at a rather early stage of the development we see the tail conspicuously set off from the rest of the body and the clefted bladder opening at its tip; the excretory canals lie wonderfully clear when the animal is pressed. Fully developed the leaf-like larva is an organism subject to incessant change of form, never at rest it may assume all forms from circular to rectangular, the body being now acute anteriorly now posteriorly. It is in this stage, we suppose, that the *Diplostomes* are transferred to birds.

On opening the abdominal cavity of one of the *Gobio* some oval bodies fell out into the fluid (Pl. XXXV, fig. 9, Microphoto Pl. XXXVII, fig. 8). When they were placed under the microscope I could have no doubt that I was here concerned with

a cyst of a form at all events related to the Diplostomes. It was much larger; it was provided with a large "holdfast"-organ of a structure like that of the Diplostomes; the oral and ventral sucker were larger, but of the rest of the organs I could observe nothing, owing to a mass of small globules arranged in strings everywhere and hiding all other organs; when pressed inconspicuous anterior "holdfast"-organs laterally to the sucker could be observed; the whole oval body was surrounded by a thick hyaline cyst wall. On pressure the whole interior ran out between the cyst and the enclosing body. The animal when dissected out of the cyst moved slowly in the fluid. As mentioned above, one of the *Gobio* had only one eye, the other one being merely a bloody mass. When this was placed under the microscope it could be seen that of the lens there was only a thin hyaline mass left. The abdominal cavity of this specimen contained the same bodies but in this case to the number of about a hundred; some lay free, but many were fastened in rows along the alimentary canal. One of these rows is seen in the photo (Pl. XXXVII, fig. 8).

I do not venture to maintain that I had here before me the encysted Diplostomum; on the other hand it seems reasonable to suppose that this was really the case. If Holostomes, as SZIDAT supposed, always have to pass a Tetracotyle stage, the cyst, as far as I know, may belong to a Hemistome. It may perhaps have been another Hemistome but if that were the case, it would be strange that all the 4 *Gobio* with Diplostomes in the eye should have a foreign Hemistome in the body-cavity; that I should here find encysted individuals only and free-living stages in the eye; and that the number should be greatest in the individual where the lens was totally destroyed. Another possibility would be that the Furcocercariae in the lens did not form a cyst where this was not necessary, whereas a cyst was formed by those specimens which did not reach the lens but underwent their development in other organs.

That the lenses of our freshwater fishes harbour other Diplostomes than that now mentioned is beyond doubt. In the lenses of *Abramis blicca* in Frederiksborg Castle Lake on 10/III 1932 were found a few very large Diplostomes which according to the size and structure of the excretory system seem to be very nearly related to *Diplostomulum gigas* HUGES and BERKHOUT (1928g, p. 483). As in that species, the vesicles containing calcareous concretions are not found associated with the tubular portions of the urinary bladder. As shown by FRAYPONT (1880, p. 429), this is the case with *D. spathaceum*. It differs from *Diplostomulum gigas* by having a much smaller number of vesicles with calcareous concretions. In Pl. XIX, fig. 10 I have tried to draw the animal.

Whether all the Cercariae which are mentioned as belonging to the *Proalaria* group really belong to this group, is of course doubtful. On the other hand, the investigations clearly show that in any case other forms also have true pelagic larvae.

Cercaria longiremis.

During my investigations of the fauna of the Furesø the dredge brought up many specimens of *Valvata piscinalis* var. *antiqua*. The snails were placed in small vessels,

in the first place with the intention of studying the food. The next day one of the vessels had milky water and it could be shown that this came from enormous masses of Furcocercariae hanging quietly in the waterlayers. Being occupied with other studies I could not continue the observations. Later, during the years 1930—32, we tried to find infected *Valvata* again. It seems as if the snail is now much rarer than in 1917, and infected specimens have not been found.

On 25/VII 31 *Valvata piscinalis* was found to be of fairly common occurrence in Tjustrup Lake; it lived here at depths of from 3—15 m., somewhat deeper than in the Furesø (3—13 m.) (STEENBERG 1917, p. 93).

Each specimen was placed in a separate glass at 10 o'clock. At 3 o'clock one had thrown out Furcocercariae. The gill of the snail was fully extended. By means of a lens I then saw a long thin thread slowly work its way out of one of the branches of the gill. First arrived the body of the Cercaria, then the tail; then the Cercaria remained a few seconds on the tip of the gill. Then one of the rami was freed; in the fraction of a second the other. The very same moment the Cercaria turned round; the tail described an 8 and the larva ascended in the waterlayers; immediately after it took up its floating position with the rami stretched out perpendicularly to the tailstem. Through the lens I saw the Cercariae incessantly liberate themselves; they pushed forwards now from the tip of one branch now from another. The next day the water in the vessel was milky. Within my knowledge no Furcocercaria has hitherto been described from *Valvata piscinalis*. It was described as *Cercaria longiremis* n. sp. (p. 114). Owing to the position of the penetrating glands behind the ventral sucker and the pelagic larvae it may provisionally be referred to this group together with *Cercaria C. Szidat*.

C. helvetica XXXI Dubois and *Cercaria I. Petersen*.

Two more Cercariae of those possessing penetration glands behind the ventral sucker are true plankton organisms; they are *C. helvetica* 31 Dubois hatched from *L. palustris* (Microphoto Pl. XXXIX, fig. 24) described on p. 122 and *Cerc. I. Petersen* hatched from *L. ovata* and described on p. 127. Both species when hatched hung suspended in the waterlayers; the two rami of the furca are quite motionless. Nevertheless the two species may easily, even when alive, be distinguished from each other at the first glance. Like all pelagic Furcocercariae they sink extremely slowly, whereupon they ascend rapidly some centimetres; then they again stand still, now with the rami stretched out perpendicularly from the tail. Whereas *Cercaria helvetica* XXXI keeps this position of the rami, *Cercaria 1 Petersen* moves the rami nearer to the tail so that the angle between stem and rami is not 90° but about 45° (Microphoto Pl. XXXIX, fig. 25). The difference in the floating position of the two Cercariae is so characteristic that it is easily shown in photos and this is done in Pl. XXXIX, figs. 24 and 25. Another characteristic feature is that the *C. 1 Petersen* in the position given in the photo sink slowly downwards, whereas, when they ascend, they have quite the opposite position and when in that position seem to ascend without moving the tail; with regard to this latter point I am not quite sure of the correctness of my observation.

The *Vivax* group.

Pl. XXXV, fig. 12. Microphoto XXXIX, fig. 19—20.

In 1900 Loos published (p. 210) his admirable description of *C. vivax* Sonsino hatched in Egypt from *Cleopatra bulinoides* Jick. In Tunis it was found by SONSINO (1894, p. 4) in this snail as well as in *Melanopsis praemorsa* L. (p. 223). Loos writes: »Malgré la grande fréquence de notre cercaire dans tous les eaux du Delta, je n'ai pu rencontrer une espèce adulte qui par sa construction interne rappelle celle de la forme larvaire en question si caractéristique« (1900, p. 223).

Within my knowledge the *Vivax* group has not been hitherto observed in Europe; owing to the incomplete provisional description it is doubtful whether *Furcocercaria* No. 4 Petersen belongs to this group; nor has it been observed in America. From India SEWELL (1922, p. 280) describes the peculiar *C. Indicae* XV. It is a regrettable fact that LOOS'S above-cited statement as far as I know is still valid. We have not the slightest idea to what mature forms these highly remarkable forms belong. This is all the more regrettable since just these forms according to SEWELL (1922, p. 286) undergo a unique development, producing Miracidia in the Sporocyst. —

Loos has not in his species observed anything of that. Everywhere in my area of distribution the *Vivax* species seem to be extremely rare; they have only been hatched from *Bithynia tentaculata*; in one case 3 in of 40 specimens, in another in 1 of 75; further in 2 of 120 and in 1 of 150. In three of the cases the specimens were unripe.

Loos (1900, p. 222) says that the free stage lasts more than two days "Elles vont flotter, pendant ce temps, comme des animaux pelagiques à la surface de l'eau et adoptent alors constamment une attitude que j'ai représentée sub no. 175". In this position they may remain for half an hour. As far as I understand Loos, he is of opinion that they are suspended in the water in this position. If they knock against another subject "elles recommencent à monter en haut au moyen de mouvements vifs et très rapides de la queue dont les branches sont alors accolées".

Only in one case have I seen a *Bithynia* throw out *Vivax* Cercariae. They belonged to the material from Hellebæk 25/V. The Cercariae stand near the bottom; when the vessel has been shaken a little, the whole material of Cercariae ascends in the water-layers and now assumes the very position which Loos has described and which is very similar to that of the Lophocercariae. The body is much bent and the tail with the rami extended and turned upwards. In this position they may hang suspended for a long time, whereupon they very slowly sink to the bottom. During the ascension the tail is moved in a figure 8. I have never seen them at the surface. They lived a little more than two days. (Microphoto Pl. XXXIX, figs. 19—20.)

After this has been written ABDEL AZIM (1933, p. 432) has shown, in a series of experiments in Cairo, that *C. vivax* Sonsino encysted in *Gambusia affinis* and *Tilapia nilotica*. Heavily infected, the fish died. The cysts were described. Feeding experiments were made on cats and dogs and on the seventh day Trematode eggs appeared. A dog when dissected contained numerous adult Holostomes. The parasite belonged to the family *Strigeidae* and was determined as *Prohemistomum spinulosum*

Odhner 1913. This parasite is originally described from the common Egyptian kite *Milvus milvus aegypticus* in which it is usually found in large numbers.

“This explains the great frequency of the Cercariae in the *Cleopatra* snails which are found all over the country.”

The Bucephalus and Cystocercaria group.

With regard to these two groups I refer the reader to pp. 98 and 109.

If now we will survey the very different life of the 7 above-named groups of Furcocercariae and the life of their final hosts in which they attain maturity, we shall, as is so often the case, find the most incredible accommodations between the life and structure of the parasites on the one hand and those of the final host on the other. —

Two of the 7 groups: the Lophocerca and the Ocellata groups are blood-suckers, living in the blood system of Vertebrates, while the others live in other organs, mainly the alimentary canal. The first named cannot use intermediate hosts. They must actively make their way into the blood system by piercing the skin. The Lophocercariae using fishes as intermediate hosts are plancton organisms belonging to the midmost waterlayers where these hosts live; the Ocellata group using birds are adapted to life on the underside of the surface; here they fasten themselves on the plumage of waterbirds, whence they make their way to the skin. —

Those who are destined to attain maturity in the alimentary canal have two alternate ways, whether maturity is reached in cold-blooded or in warm-blooded animals. In the first case intermediate hosts are not necessary, they can be eaten directly by their final hosts and in this way reach their destination; what is required is merely that they should in some way attract the attention of their final hosts. In this group we also find the largest and most peculiarly formed Cercariae, the Cystocercariae and the Bucephalidae which are directly snapped up by their final hosts.

The most complicated life cycle occurs in those forms which attain maturity in the alimentary canal of warm-blooded animals. Very much still remains to be elucidated in this field, but at the present stage it seems that two groups may here be distinguished, viz. fish-eating final hosts and snail- and worm-eating final hosts; in both cases an auxiliary host is necessary. The first-named group has planctonic larvae which like the blood-suckers pierce the skin of fishes but do not make their way into the blood but into other organs, especially the eyes, where they wait in a new larval stage till they are devoured by a final host. The latter may be a carnivorous fish, but as a rule it is most probably a fish-eating bird (gull, tern). The last-named group have not planctonic larvae; as intermediate hosts they mainly use snails again, where they are transformed into Tetracotyle stages. As such they arrive in the alimentary canals of waders, ducks etc. either directly when the snail is eaten or when they are deposited in the detritus of the shore and with that enter the alimentary canal. The fact that many of these forms chiefly attain maturity in Rapaces, and that Tetraco-

tle stages are found in many snails eaten by mammals (such as mice etc.) would seem to show that the development is even more complicated than has been supposed, and that these forms require more than one auxiliary host.

Chapter IX. Microcercaria.

Of all Cercaria groups that of the *Microcercaria* is perhaps least known to us. During the last few years many species have been described, a remarkably large number from marine snails, some of them from land snails (*C. limacis* MOULINIÉ 1856, p. 163) and most of the freshwater forms from America and Asia. The original descriptions are usually very poor and the same may be said with regard to the drawings. The only forms known from Europe are *C. micrura* Pagst. which is the larva of *Sphaerostoma brami*; the Cercaria of *Catoptroides macrocotyle* Lühe; and *C. myzura* Pagst. *C. micrura* is found in *Bithynia tentaculata*, *C. Cataphroides macrocotyle* in *Dreissensia polymorpha*, and *C. myzura* in *Neritina fluviatilis* (only found once). I have examined about two hundred specimens of *Neritina* from three of our largest lakes but have never found any infected. Many hundred *Dreissensia* have been kept in our aquaria, and I have looked for *C. catoptroides* whose highly remarkable life history has been studied by SSINITZIN (1901, p. 689). It seems to deviate from all other forms; the Cercaria develops in Sporocysts, the tail is short and is further reduced the Cercaria does not leave the Sporocysts. Finally, the Sporocysts with the encysted Cercariae leave the gills of the mussels, whereupon they, supercompensated owing to fat accumulation, ascend to the surface with the enclosed Cercariae there to be eaten by *Cyprinidae* in whose stomach the ripe stage is reached. In Danish freshwaters only a single species has been found whose host is *Bithynia tentaculata*.

SEWELL (1922, p. 154) has tried to bring some order into the group but comes to the same sad result as others that for the present it is impossible to do so. He proposes two groups: *The Cotylocercous* group of DOLFUS (1913, p. 683) consisting of marine forms and the freshwater form *C. micrura*, and the *Linearis* group, including *C. pachycera* Diesing, *C. linearis* Lespés, *C. buccini* Lebour and *C. Indicae* XXXVIII. There remains a series of forms to which the above-named Cercaria of *Catoptroides macrocotyle* Lühe belongs. They are all forms which are insufficiently known or have only been observed once. Some of them show affinities for the *Cercariaerum-cercaria* and we shall return later to this point.

SSINITZIN (1931, p. 409) describes from *Gonabiasis plicifera silicula* Gld. (locality Oregon) a Microcercaria which encysts in *Potamobius* and attains maturity in freshwater fishes. It is the larva of *Plagioporus siliculus*. Further he mentions a Microcercaria from *Fluminicola virens* which encysts in the same snail and also attains maturity in freshwater fishes.

The main differences between the *Cotylocercous* group and the *Linearis* group

is that in the former the excretory bladder is large and does not bifurcate, it almost reaches the ventral sucker and has the walls formed of a single layer of granular cells which have a glandular appearance; the tail has no pyriform glandular cells. In the *Linearis* group, on the other hand, the bladder is an elongate median cavity, and the tail is occupied by pyriform glandular cells which open distally. Moreover, an oesophagus and intestinal coeca have not been observed, whereas they are present in the main form *C. micrura*. The two species of SSINITZIN (1931) may belong to the *Cotylocercous* group.

The Cercaria of the genus *Paragonimus*, to which the oriental lung fluke *Paragonimus westermanni* (KERBERT 1878) belongs, is a Microcercaria according to KOBAYASHI (1918, p. 97) and FAUST (1930, p. 215), but seems to differ much in almost all essential particulars from other Microcercaria with which it only seems to have the rudimentary tail in common; this tail differs in structure from that of other Microcercariae. The Cercaria develops in snails of the genus *Melania* and encysts in *Astacus* and freshwater crabs (*Potamon*). When the crustaceans containing the cysts are eaten raw, they are transferred to the mammalian intestine, from which the flukes make their way out through the walls of the intestine, traverse the abdominal cavity, whence they migrate upwards through the diaphragm to the thoracic cavity, pierce the pleura and pass into the lungs and the bronchioles (FAUST 1930, p. 220). AMEEL (1932, p. 264) found near Ann Arbor Michigan in *Pomatiopsis lapidaria* Microcercaria resembling those of *Paragonimus westermanni*; it was experimentally shown that they encyst in crayfishes (in the heart tissue, not in the gills and body muscles as is the case with *P. westermanni*). The adult worm is found in the lungs of mink, but it has been experimentally shown that it may also be found in rats and domestic cats.

It is a question whether a closer examination will not reveal the existence of one of these forms in Europe.

C. *Micrura* Fil. Host: *Bithynia tentaculata*.

Pl. XXXI.

The body is extremely variable in form. The dimensions are:

<i>Cercariae.</i>	Living
Length of body	255—450
Breadth	85—135
Length of tail	45— 50
Breadth	30— 45
Oral sucker	50— 55
Ventral sucker	50— 80
 <i>Rediae.</i>	
.....	1380
.....	2930

The ventral sucker lies a little behind the central part of the body, it is larger than the oral one. The oral sucker has a stylet. There is a short prepharynx and an almost globular pharynx. Owing to the opaqueness of the Cercaria the rest of the alimentary canal is difficult to see, but I think I have seen an oesophagus and two intestinal coeca reaching the middle of the bladder. There are on each side four glands with long slightly curved ducts which pass forward; the connection with the stylet I have not observed with certainty. The bladder is very large with thick walls of a glandular appearance. It is of an elliptical or triangular form and almost reaches the ventral sucker; there is a small opening at the base of the tail. Of the excretory canals only two main trunks have been observed. The tail has a posterior part set off from the much larger anterior one.

I have been unable to find any bristles or spines either on the anterior part or in the middle of the animal.

The Cercaria develops in long so-called Sporocysts (Pl. XXI, fig. 2) crowded with Cercariae. It seems questionable to me whether the term Sporocyst is correct. For I have always found a very small and faintly developed structure of pharyngeal form at one end; there is, however, not the slightest trace of a gut, so most probably we have here merely an opening through which the Cercariae come out.

I regret that I have been unable to give a more thorough description. The Cercariae were only found on 18/IX 31 in a large bay of the Furesø (Pl. XXVI, fig. 1—2), in *Bithynia tentaculata*. They were only found when the snails were dissected; they then came out of the Sporocysts and crept round as Hirudineans. Most probably the animals have not been fully ripe. Provisionally I refer my specimens to *Cercaria micrura*.

On 27/IX 31 of 200 *Bithynia tentaculata* from Esrom Lake (Pl. XXXI, figs. 3—4) two were infected with a Microcercaria which agreed in all essential particulars with the specimens from Furesø; in this case too the Cercariae were not quite ripe; no specimens were found free in the snail, and the snail did not, when living, show Cercariae moving about on it or at the bottom of the vessel. Many of the *Bithynia* were simultaneously infected with a Cercariaeum, and the remarkable thing was that the Cercariae were found in the Sporocysts of the Microcercaria (Pl. XXXI, figs. 5, 6, 8, 9) in one Sporocyst five to seven Cercariae could be counted. Some of them crept round among the Microcercariae, but most of them were in an encysted stage surrounded by a hyaline membrane; scattered in the liver of the snail were found many encysted Cercariae. It seems to me that this is a case analogous with the development of some of the Furcocercariae; in both cases the Cercariae pierce the same snail in which they have been developed, and show a predilection for the Sporocysts. The Furcocercaria develops into a Tetracotyle, the Cercariaeum into a hyaline cyst.

I hope the interpretation I have given of the fact is correct. I confess that it has troubled me a good deal. For in the same Sporocysts which also contained the typical Cercariae I have found specimens with a typical microcercous tail. Some of them had a bladder of exactly the same structure as the Cercariaeum. These forms

are very opaque and an oesophagus and intestinal coeca were not observed. Simultaneously with them are found other forms, a little larger, but without a tail; they have a larger ventral sucker and a very conspicuous oesophagus and intestinal coeca. In these forms I have been unable to see any stylet; they seem to be identical with those I have picked out of the cyst. (Pl. XXXI, fig. 10).

Now it is a well-known fact that the Cercariaeum stages when young may possess a short tail (mentioned by HOFMAN for the Cercariaeum stage of *Distomum leptostomum* (1899, p. 189)), it is characteristic of all larvae during their life in the Sporocyst; the tail may be found or may not be found when they have emerged from the Sporocyst; of 4—500 ripe specimens which HOFMANN found in the intestine of *Erinaceus* 5 had still the tail. On the other hand, LOOS (1894, p. 48) has stated that *C. micrura* already in the Sporocyst throws off its tail. As far as I can see, Loos has had a material very similar to mine. Loos says that "soweit ich mich erinnere und meine Aufzeichnungen reichen" *C. micrura* does not leave its Sporocyst but encysts in it; he has found Sporocysts which contained encysted Cercariae only, to the number of about 40. Among many hundreds of Microcercaria in the Sporocysts I have only found 5 to 7 and often some without a tail and in the free creeping stage. Loos has also observed in the encysted stage the "ansehnliche, kugelförmige oder ovale Blase" "die von grossen cubischen und stark mit Körnchen durchsetzten Epitelzellen ausgekleidet wird".

For *Plagioporus virens* too, SINITZIN (1931, p. 417) maintains that the encystation takes place in Sporocysts. In my case there is no doubt that the Microcercariae mostly leave the Sporocysts and encyst in the tissues of the snail, and this is in accordance with the fact that *C. globipora*, in which LOOS (1894, p. 48) has recognised *C. micrura*, has been found as a cyst in the foot of *L. ovata* by v. LINSTOW (1884, p. 141, Pl. X, fig. 26). Just as I myself so WAGENER (1857, p. 103) found the cysts free in the liver, in his case in that of *L. stagnalis*.

I fully agree with SEWELL (1922, p. 160) when he says that further investigations will show that the Microcercariae are related to the "Helicis" group of the *Cercariaea*.

I cannot dismiss the supposition that just this group may pass through a Microcercaria stage in their development, and I am not quite sure whether the observations mentioned here should not be interpreted in this way.

Chapter X.

Cercariaeum.

Our knowledge with regard to the anatomy and biology of the tailless Cercariae is very restricted. Most of them are most probably terrestrial; and precisely the life of the terrestrial Trematoda has been very little investigated. The discovery of four new species (HARPER 1932, p. 307) together with *Cercariaeum helicis* in Scotland and HENKEL (1931, p. 664) and MATTES studies on *Dicrocoelium lanceolatum* (1933, p. 227) show how much there is to do in this branch of science. Owing to our slight know-

ledge of the group it is almost impossible to divide it into smaller groups. Nevertheless SEWELL (1922, p. 160) and DUBOIS (1929, p. 100) have tried to do so. SEWELL proposes three groups: 1. The *Mutabilis* group, 2. The *Helicis* group and 3. The *Leucochloridium* group. The *Mutabilis* group is characterised by the development of the Cercariae in Rediae of a very simple structure. It contains organisms mainly or exclusively developing in freshwater snails.

The *Helicis* group develops in Sporocysts; they are exclusively or mainly land forms. The best known species are *Cercariaeum helicis* Meckel and *C. spinulosum* Hofmann, whose life history has been thoroughly studied by HOFMANN (1899, p. 175). The group also contains freshwater forms (*Cercariaeum Linnaei auricularis* (Filippi), *C. ancylus lacustris* Dies), and marine forms (PELSENEER 1906, p. 161), all very insufficiently known. *C. Linnaei auricularis* will be treated in the following; of *Ancylus lacustris* many specimens have been studied, but I have never found them infected with Cercariae of any kind.

The third group is *Leucochloridium*; the development of members of this group is only known for *L. paradoxum*; I refer the reader to the first part of this work. MCINTOSH (1932, p. 32) has described a series of new species from the Douglas Lake area and shows that now at any rate 18 species are known. Of these only the life history of *Leucochloridium paradoxum* is known. A very aberrant life history is described by SEWELL (1922, p. 171) for *Leucochloridium assamense* from *Lecythoconcha lecythis* and *Vivipara oxytropis* Laktat, Lake Manipur, India. The very peculiar fact that many of the above named species are found in seed-eating birds, or in birds which have not the slightest connection with water, e. g. woodpeckers, shows that the development of *Leucochloridium paradoxum* cannot be the paradigm for the development of the whole group. Most probably it is in some way an exception and perhaps as we know it not a natural one. — DUBOIS (1929, p. 100) refers the *Cercariaeum* species to the five groups: 1. *Mutabile*, 2. *helveticum*, 3. *squamosum*, 4. *helicis* and 5. *Leucochloridium*. Of these 4 and 5 are identical with those of Sewell. The three others result from an attempt to subdivide Sewell's *Mutabile* group. I confess that this attempt does not seem to me a fortunate one. In our country I have found 6 species some of which, as far as I can see, are undescribed. They seem to break DUBOIS's division; as, however, my species are insufficiently known, especially with regard to the excretory system, I have here provisionally followed SEWELL and apart from *Leucochloridium* refer all the species mentioned here to SEWELL's *mutabilis* group. The structure of the excretory bladder needs to be more thoroughly studied.

***Cercaria paludinae impurae* FIL. Host: *Bithynia tentaculata*.**

Pl. XXXII, figs. 1—6, Pl. XXXIII, figs. 1—2.

The body is covered with spines, best developed in the forepart. The dimensions are:

	<i>Cercariae.</i>	Living
Length of body		910
Breadth		375

	Living
Diameter of oral sucker	155
Diameter of ventral sucker	155

Rediae.

Length of body	2530
Breadth	980
Diameter of Pharynx	200
Length of intestine	825

The two suckers have a slight equipment of small spines. I have not seen any stylet at the anterior edge of the oral suckers. After a very short prepharynx follows a very vigorous pharynx, broader than long, a broad rather short oesophagus and two broad intestinal coeca running not much below the posterior edge of the ventral sucker, embracing the two testes. The central sucker which is almost of the same size as the oral one, lies a little behind the ventral part of the body. The whole space bordered by the sides of the body, the oesophagus, the intestinal coeca, and the oral suckers is filled with a great mass of cells with a granular protoplasm and small nuclei. The cells are smallest nearest to the oral sucker; they may in the main be regarded as cystogeneous cells. The excretory system consists of an excretory bladder, tubular of form, often curved posteriorly; it opens with a pore at the apex of the body; anteriorly it may almost reach the ventral sucker. The two main trunks pass forwards along the ventral sucker and reach the oral sucker in large loops; here they make a loop and return. A little below the pharynx they send off a branch which divides into an anterior and a posterior branch, these branches divide again and receive small branches which carry the flame cells. The number of these cells has not been sufficiently studied. In the space between the two intestinal coeca and the ventral sucker lie the two testes, and behind them the ovarium.

The Redia (Pl. XXXII, fig. 4—5) is sack-shaped without a collar or posterior locomotoric appendages. The pharynx is small, the intestine takes up from one-third to about two-thirds of the body; it is nearly always filled with an almost black content which makes the Rediae very conspicuous. They contain 4—6 ripe or almost ripe Cercariae and several unripe ones. —

On 11/XI 31 I found in a *Bithynia tentaculata* from Teglgærdsø near Hillerød Rediae with almost ripe *Cercariaea* stages which were not distinguishable from the above-mentioned. Some of them were remarkably hyaline, and in them I saw the excretory system rather plainly. It consisted of a broader tube in the posterior part of the Redia, in the middle of the animal the tube divided into an anterior and a posterior one; the former was more straight the latter strongly curved, some few flame-cells were seen in the anterior and the posterior part, but I do not venture to give the real number with certainty.

The encystation may take place in the same snail; cysts are often found sur-

rounded by a hyaline very thin membrane, showing in a peculiar manner the different organs. Most characteristic is the strong growth of the ovarium, the uterus and the cirrus, internally equipped with spines (Pl. XXXII, fig. 6).

The *Cercariaea* are rather sluggish and creep around slowly, they are extremely variable in form as shown in Pl. XXXII, figs. 2—3, Pl. XXXIII, fig. 1. They represent the same animal drawn in the course of five minutes.

It has often been alleged that this as well as other tailless Cercariae encyst in the same snail and remain there. This, however, is not correct, as Loos (1894, p. 32) has observed them creeping on the bottom; with regard to this species WUNDER (1924 a, p. 333) has made a series of excellent observations which I can only confirm on all points.

If *Bithynia tentaculata* infected with *Cercariaeum paludina impurae* is kept in vessels, it will be seen that the antennae especially at their tip carry small white fluffs which, observed under a lens, present themselves as *Cercariaea* (Pl. XXXIII, fig. 2). When more closely studied it will be seen that they creep out of the spiracle and pass over the head of the snail whereupon they proceed to the tentacles which in their whole length may be fluffy; more than fifty *Cercariaea* may be found on each tentacle. When the antennae come into contact with other snails, the *Cercariaea* jump on to them and enter the snail, afterwards encysting there. The *Cercariaea* are always fastened by the ventral sucker, the fore- and the hindpart of the body is elevated. The animals stretch out the forepart of the body in all directions. When the snail draws in the antennae, the *Cercariaea* follow, and when they are again extended they are still present and in the same number. I have had snails with infected antennae for weeks in my vessels, but I suppose that the old *Cercariaea* enter the snail to encyst there and that those I have observed during all that time are new arrivals. Like WUNDER, I have never seen *Cercariaea* creeping freely upon the bottom of the vessels. As I have had the macrocercous Cercariae around the mantle borders of *Sphaerium* in one glass, and at the same time the *Cercariaea* on the tentacles of *Bithynia* in another, and observations were made on both simultaneously, it was quite natural to surmise that the constantly moving tails of the *Macrocercariae* played the same role for the body as the *Bithynia*-tentacle which was extended now in one now in another direction for the *Cercariaeum*.

Like WUNDER (1924 a, p. 335) I have seen that the cysts are mainly found around the rectum, the Rediae with the *Cercariaea* in the liver. —

Cercariaeum paludinae impurae is common in our freshwaters. It was first found on 21/VI 31 at Langesø near Hillerød. It was there that I first saw the fluffy antennae at a time when WUNDER's observations were quite unknown to me. It was present here to the number of four out of ten; later on it was found at Donse on 9/VII to the number of 42. At the border of one of our largest lakes, Arresø, 12 *Bithynia* out of 15 had *Cercariaea* on their antennae.

On 17/V 32 new material was taken from Langesø and infected. *Bithynia* isolated. The *Bithynia* moved but slowly, the *Cercariaea* disappeared from the antennae. On

18/VI a *Bithynia* was dissected and cysts were now found, especially round the heart. On 30/V new material was taken from Langesø. Of 35 specimens only one had Rediae; the remaining 34 had no Rediae but cysts were found in 33. The number of cysts was commonly about 30 but might amount to 50. Only exceptionally was the number 3—4. Only one specimen was quite free.

Side by side with the *Bithynia* lived *Physa fontinalis*. Ten were dissected. All contained 10—40 encysted *Cercariaea*, but not a single one Rediae. This would seem to show, as WUNDER too maintains, that the encystation may also take place in other snails.

The place of the cysts was always the same, near the rectum or round the heart, only rarely in the liver and then always in the lower part.

Bithynia tentaculata infected with *Cercariaeum* has also been found in other localities; in Teglgardsø (on 11/IX 31) near Hillerød, at the borders of Tjustrup Lake on 6/VIII 31, and in two specimens out of 200 at a depth of 3—4 m in Esrom Lake on 28/IX 31. In none of these cases were any *Cercariaea* observed on the antennae of the snail; the liver mainly contained not quite ripe *Cercariaea*. The specimens from Esrom Lake were full-grown and of a remarkably large size. It is perhaps questionable whether it is correct to refer all *Cercariaea* from *Bithynia tentaculata* to a single species. PETERSEN (1931, p. 22) has described a form *Cercariaeum* 2 from *Bithynia tentaculata*, but description and drawing are so incomplete that most probably it will not be possible to identify it. Provisionally, it only seems to deviate from *C. paludinae impurae* by having a smooth cuticula without spines.

How the species *Cercariaeum paludinae impurae* (Fil.) is to be interpreted is a matter of doubt. FILIPPI distinguished two, the one with a stylet (*armata*) the other without it (*inermis*). The former according to DUBOIS (1929, p. 100) has 36 flame-cells, a tubular vesicle and two testes, the *inermis* form 64 flame-cells, a small pear-shaped vesicle and only one testis. From this description there can be no doubt that we are here concerned with two species. Loos (1894, p. 32) regards the two forms as identical and calls it *Cercaria Distomi perlati*. All the specimens which I have found in *Bithynia* possess a tubular vesicle but I confess that I have not been able to convince myself that there is a stylet. Nevertheless, I refer them to *C. paludinae impurae*, *forma armata* Fil. What *forma inermis* is, is a matter of doubt. In *L. auricularia* I have found a form which on all other essential points resembles *C. paludinae impura* but like the *inermis* form has only one testicle and a small vesicle. We will return to this form later on.

Cercariaeum No. 1. Petersen. Host: *Paludina vivipara*.

Pl. XXXIV, figs. 2—5.

The body is covered with remarkably stout spines, strongest and most numerous on the forepart of the body; the spines are not acute but have a remarkable bluntly rounded apex. The dimensions are:

Cercariae:

	Living
Length of body	990
Breadth of body	520
Diameter of oral sucker	130
Diameter of ventral sucker	280

Rediae:

Length	145
Breadth	100

The ventral sucker is much larger than the oral one; if concentric circles of spines are present, they are at all events very small. There is a very short prepharynx and a rather small pharynx; the oesophagus is extremely short; the intestinal coeca begin almost directly behind the pharynx; the ventral sucker lies almost in the middle line of the animal and the intestinal coeca divide long before the ventral sucker. They are very broad and reach almost halfway between the posterior border of the ventral sucker and the posterior end of the animal. A stylet at the anterior border of the oral sucker has not been observed. The whole part around the pharynx down to the ventral sucker is filled with two large grapeformed glands consisting of very small cells with granular contents and small nuclei. The excretory system consists of a tripartite excretory bladder, the unpaired part being the largest and opening upon the apex of the animal by a rather large pore. The paired parts are almost globular and give rise to the two main trunks which do not divide before the middle of the ventral sucker; the main trunk passes forward to the oral one; here it makes a loop and passes backward, reaching the central part of the ventral sucker. I have been unable to follow it any farther from the same; point arises another branch which passes forward and sends fine branches around the oral sucker; from the main trunks there issue fine branches ending in vibratile tags, at least three, but their number has not been counted with certainty. Owing to the remarkably thick, wrinkled and spiny consistence of the skin and because of their almost yellow colour the animals are very opaque. The curious thing is that the returning branches of the excretory main trunks in their interior carry about 15 flames which are very conspicuous and localised on quite distinct, and as far as I can see, constant spots. I have never seen this in any of the other *Cercariaeum* species described. Between the ends of the two intestinal coeca lies the relatively small ovarium and behind them the two testes. The *Cercariae* were very sluggish, subject to variation in form, but never found outside the snails (Pl. XXXIV, fig. 3 a—d). The large ventral sucker made the animal always very broad in the central part of the body. — The interesting form was only found in three of about a hundred *Paludina vivipara*; only on 2/II 32 and again on 17/IV; in each snail only 5 to 7 were found, and several very young forms. The strange thing was that they were only found in small halfgrown specimens, not in the large

ones, and furthermore that they were always lying free in the liver. They were extremely sluggish. I saw no Sporocyst or Redia to which this peculiar form could be referred with certainty; the Cercariae were always enveloped in a whole mantle of spermatozoa.

It was remarkable, however, that the liver was covered with small Sporocysts, hyaline but with a very thick paletot (Pl. XXXIV, figs. 4—5). They contained great numbers of very small granules. They were found in two of the snails, and in both very small Cercariae, so small that it might be supposed that they had shortly before left the Sporocysts; in the above-named Sporocysts were never found young Cercariae, and to this very moment I do not know if these presumed bodies belong as Sporocysts to the *Cercariaeum*. Lack of material prevented a more thorough study. The *Cercariaeum* is a highly peculiar form, by the structure of the bladder it belongs to the *squamosum* group of DUBOIS, but by the two testicules to the *mutabile* or *helveticum* group. It seems to break the division of DUBOIS.

PETERSEN (1931, p. 22) describes from male *Paludina*, but only from old animals, a peculiar form with a cuticula covered with "kleinen Höckern", a ventral sucker almost twice as large as the oral one, with the intestinal coeca diverging a long way before the oral sucker, and with a tripartite excretory bladder, just as I have seen it. It seems highly probable that we are here concerned with the same species. The figures seem to show that he too has found vibratile flames in the excretory vessels. His description deviates from mine; he alleges that there is only one common "anlage" for the sexual organs and that this is formed like a clover leaf.

My species has only been found in February and April in small ponds near Hellebæk, North-Sealand.

***Cercariaeum limnaeae obscurae* ERCOLANI.** Host: *Limnaea ovata*.

Pl. XXXIII, fig. 3, Pl. XXXIV, fig. 1.

I think that I have only once seen this species. It was found in one of 10 specimens of *Limnaea ovata* in the Torkeris Pond near Hillerød (15/V 31). The Rediae contained 4—6 perhaps not quite ripe Cercariae which were only spinose in the forepart of the body; the bladder was tripartite with the unpaired part small and globular. The material was not large enough to allow of a more thorough examination.

***Cercariaeum gibba* n. sp.** Host: *Valvata piscinalis*.

Pl. XXXIII, figs. 4—5, Pl. XXXIV, fig. 6.

The body is extremely broad and clumsy; the cuticula is very thick, slightly spinose and the whole animal very opaque.

The dimensions are:

Cercariae:

	Living
Length of body	375
Breadth of body	250
Diameter of oral sucker	60
Diameter of pharynx	50
Diameter of ventral sucker	130

Rediae:

Length	400
Breadth	115
Oral sucker	30

The oral sucker is large; anteriorly are found six small taps; a stylet has not been observed; the ventral sucker, which is extremely large, gives the whole animal its form; the suckers are spineless. There is a very short prepharynx, and a very large globular pharynx; the oesophagus is remarkably slender and often bent in a loop; the two intestinal coeca, when the animal is extended, diverge almost halfway between pharynx and ventral sucker (Pl. XXXIV, fig. 6); they are broad and run downwards beside the bladder. There are 2×3 elongate pear-shaped glands which give off long ducts to the oral sucker (Pl. XXXIV, fig. 6). The excretory bladder is highly peculiar; it has thick walls, is almost triangular of form, and contains numerous globular refracting bodies; behind it is a short tube ending at the apex of the animal. On pressure the refracting bodies pass through the tube and remain in a little heap behind the animal. From the two anterior corners of the bladder issue the excretory tubes which I have not been able to study more thoroughly; as far as I have been able to see, they are constructed in accordance with the tubes in *C. paludinae impurae*.

There is a rather large ovary (Pl. XXXIV, fig. 6). There is at any rate only one testis, but it has not been seen with certainty. This very peculiar form was found in only a single *Valvata piscinalis var. antiqua* out of 50 specimens (Furesø 22/IX 31). Only three individuals were found creeping in the liver. Some few Rediae were found, and these contained tailless Cercariae. The pharynx was very small, the intestine short; there were no locomotoric appendages.

***Cercariaeum crassa* n. sp.** Host: *Pisidium amnicum*.

Pl. XXXIII, fig. 6, Pl. XXXIV, figs. 8—9.

The body is covered with fine spines, best developed in the forepart. The dimensions are:

Cercariae:

	Living
Length of body	840
Breadth of body	290

	Living
Diameter of oral sucker.....	125
Diameter of ventral sucker.....	130
<i>Rediae:</i>	
Length.....	2400
Breadth.....	360
Oral sucker.....	130

The oral and ventral sucker are nearly the same size, the ventral sucker lies almost in the middle line of the animal. No stylet in the frontal border of the oral sucker and no circles of small spines have been observed. The prepharynx is very short; the pharynx globular and the oesophagus long, commonly strongly bent; the intestinal coeca diverge immediately before the ventral sucker; they almost reach the posterior end of the animal. Most of the space between the oral and ventral suckers is filled with clusters of small cells with a granular content and small nuclei. There is a large elliptical contractile bladder containing numerous globular bodies which become displaced, when the animal is pressed. It ends with a short tube which opens posteriorly. From the anterior border of the bladder issue the two main excretory tubes running forwards. Owing to the opacity of the animal only little of the tubes has been observed. As far as I can see, they divide near the posterior edge of the ventral sucker, giving off a branch anteriorly and one posteriorly; just where they divide is seen a ball formed of many loops. The genital organs could not be made out, the specimens not being quite ripe.

When pressed the animals have the normal *Cercariaeum* form but without pressure the animals were of an extremely clumsy form with the ventral sucker placed on a foot-like part of the ventral side (Pl. XXXIV, fig. 9).

The *Cercariaeae* were developed in large *Rediae* (Pl. XXXIV, fig. 8) which had a small pharynx and very small intestine. The *Rediae* contained very many *Cercariaeae*, often 15–20; no posterior locomotoric appendages were present.

The species was found in a *Pisidium amnicum* found on 20/XI 31 in the Furesø. It came from a depth of 4–6 m. Only a single specimen was found, and this contained many *Rediae* on the gills but no free *Cercariaeae*.

PETERSEN (1931, p. 22) has described a *Cercariaeum* No. 3 from a *Sphaerium corneum*. Otherwise *Cercariaeae* have not hitherto been found in freshwater mussels. The description is very insufficient and his and my own observations can only serve to show that our *Sphaerium* and *Pisidium* species really contain *Cercariaeum* stages. A more thorough study of these forms is much needed.

***Cercariaeum limnaeae auriculariae* FIL.** Host: *Limnaea auricularia*.

Pl. XXXIII, fig. 7, Pl. XXXIV, fig. 7. Microphotos XXXVI, figs. 3–4.

The body is covered with fine spines; they are more numerous in the forepart. The measurements are:

Cercariae:

	Living
Length of body	580
Breadth of body	230
Diameter of oral sucker	95
Diameter of ventral sucker	130

Rediae:

Length	4200
Breadth	900

The ventral sucker is larger than the oral one.

I have seen no stylet at the anterior edge of the oral sucker. The prepharynx is short; the pharynx globular, the oesophagus long and commonly twisted. The two intestinal coeca branch off directly round the ventral sucker and reach halfway between it and the posterior end of the animal. The ventral sucker lies almost in the middle. The whole space between the two suckers is filled with clusters of small cells with a granular content and small nuclei. There is a small excretory bladder which opens posteriorly and anteriorly gives off two excretory tubes. These tubes pass forward in many loops, almost reaching the oral sucker. Then they pass backward again, and near the anterior border of the ventral sucker they divide, sending one branch anteriorly and one posteriorly. From these branches issue branches of the third order, and these carry the flame cells. There is a large testis; before it a small ovarium. Behind the ventral sucker and laterally lie the loops of the uterus and cirrus pouch, equipped with internal spines. This peculiar form develops in Rediae (Pl. XXXIV, fig. 7) of a reddish colour, they protrude from the liver which looks as if it was covered with thick spines; the pharynx is extremely small, and so is the intestine. There are no posterior locomotoric appendages. The Redia contains many Cercariae, often 20—30. Most of the Rediae have a blunt forepart and a more attenuated hindpart which may assume the character of a tail or thread; it is commonly by this end that they are fastened to the liver; the forepart protrudes freely into the body cavity.

This peculiar form was found on 25/VI 32 in *Limnaea auricularia* in Hulsø, a little lake lying near Furesø. Of 25 specimens only a single one contained the *Cercariaeum*. On 12/VII, when new material was desired, it was found that all the old large snails to which the above-named 25 belonged had died; only very young snails were present and in them I only once saw some Rediae on the intestine; it could not be decided if these Rediae belonged to this species. In June 1933 40 large specimens of *L. auricularia* were examined but neither Rediae nor Cercariae were found in a single one of them. The above-named snail from 25/VI was immediately after arrival in the laboratory separated from the others as suspect. *Cercariae* were not observed, but round the borders of the mantle were seen yellowish white tumor-like swellings.

When pricked with a needle, the above-named Rediae poured out; curiously enough, *Cercariaea* were never found free in the tumors or in the liver.

SEWELL (1922, p. 171) says that in specimens of *Lecythoconcha lecythis* and *Vivipara oxytropis* he has found gelatinous yellow cysts in the thick edge of the mantle. The cysts measured $1\frac{1}{2}$ —2 mm. in length and about 1 mm. in breadth, and each communicated with the external surface of the mantle, that is, the surface in apposition with the shell, "through a small pore". The cysts contained immature *Leucochloridium* measuring 2—3 mm. in length.

What SEWELL has seen is of course not identical with my observation; the tumors are not cysts, and they have no communication with the surface. They do not contain free *Cercariaea* but Rediae. Nevertheless, with *Leucochloridium* in mind, I was much interested in the observation. The tumors filled with *Cercariaea* carrying Rediae were found at the borders of the mantle, others were found on the head near the antennae. The Rediae with their exceedingly small pharynx and almost no intestine give the impression of being Sporocysts. The place of the Rediae as well as their form like sacks packed with *Cercariaea* stages caused that the thought was directed upon *Leucochloridium*; it was as if this observation showed the way to an understanding of how the development of this incredible organism has taken place.

I refer this species to *Cercariaeum limnaeae auriculariae* Fil. It is said to be closely related to *C. paludinae impurae* but to differ from it in the development in Sporocysts. Only a closer examination will reveal the character of the sacks as Rediae; here as often it is rather problematic whether the parthenitae should be designated as Sporocysts or as Rediae. It differs considerably from it, however, in the structure of the Rediae. The pharynx and intestine are larger and the number of *Cercariae* in the Redia much smaller (5—7) in *C. paludinae impurae* than in *C. limnaeae auriculariae*.

Leucochloridium paradoxum.

Pl. XXXII, figs. 7—8.

With regard to this form it will suffice to refer the reader to Part I of this work.

Chapter XI.

The degree of infection of the Danish Mollusc fauna.

Localities.

- | | |
|------------------------------|--------------------------------|
| 1 Akvarie Pond = Lange Pond. | 6 Bromme Lake. |
| 2 Amager Pond. | 7 Castle Park, Frederiksborg. |
| 3 Ande Pond. | 8 Clausens brick factory Pond. |
| 4 Arresø. | 9 Donse Pond. |
| 5 Bagsværd Lake. | 10 Esrom Lake. |

- | | |
|---------------------------------|------------------------------|
| 11 Emdrup Pond. | 26 Lyngø Pond. |
| 12 Fortun Pond. | 27 The moor. Hillerød. |
| 13 Funke Pond. | 28 Næsbybro Pond. |
| 14 Furesø. | 29 Ramløse Rivulet. |
| 15 Fønstrup Pond. | 30 Regnstrup Pond. |
| 16 Grønholt Ponds. | 31 Steenstrup Pond. |
| 17 Grønnegade Pond. | 32 Strødam Pond. |
| 18 Hellebæk Pond. | 33 The rivulet Susaa. |
| 19 Hørsholm Pond. | 34 Teglgård Pond. |
| 20 Hulsø. | 35 Torkeris Pond. |
| 21 Hørsholm Springpond. | 36 Tjustrup Lake. |
| 22 Indelukket canals, Hillerød. | 37 Tuel Lake. |
| 23 Kehhusbakke Pond. | 38 Vixø Moor. |
| 24 Langesø Pond. | 39 The rivulet of Værebrosø. |
| 25 Lange Pond = Akvarie Pond. | |

In the above named list I have given the names of all localities which have been fairly often or regularly explored. They are given in alphabetical order. All the localities are in Seeland; those with italicized are in the middle of Seeland near Tjustrup and Sorø Lake, where our summerlaboratory is; the others are in the neighbourhood of Hillerød in most cases inside a radius of ca. 30 kilom.

The Strødam ponds have been of special importance for the investigations. They are situated in the Strødam Reservation about 3 km from Hillerød. This was erected by the owner, Mr. AXEL JARL, as a reservation for the Sealandic fauna and flora and as a place where observers could carry on their studies undisturbed. At a time when so many localities, more especially small ponds, are either being destroyed or utilised for other purposes, it is of the utmost importance that there should be a locality whose flora and fauna are protected and accessible to observers who wish to carry on their investigations for a period of more than one year.

The explored lakes are Arresø, Esrom Lake, Tjustrup Lake and Furesø.

Smaller lakes are Bagsværd Lakes, Bromme Lake, Frederiksborg castle Lake, Hulsø and Tuel Lake.

All the other waters are only ponds, in very many cases very small ponds, with a depth of below 1 m. and commonly packed with vegetation.

Molluscs	Locality	Number of snails dissected		Trematoda
<i>Sphaerium corneum</i>	3, 10, 13, 14, 18, 24, 32, 35	411	Macro- —	<i>C. Pagenstecheri</i> Ssin. <i>C. vitellilobae</i> = <i>macrocerca</i> Fil.
<i>Pisidium amnicum</i>	14	1	<i>Cercariaeum</i>	<i>C. crassa</i> .
<i>Anodonta</i>	14, 21	110	<i>Furcoc.</i>	<i>C. Bucephalus polymorphus</i> .
<i>Dreysensia polymorpha</i>	14, 10	100	0	
<i>Neritina fluviatilis</i>	4, 10, 14, 36, 37	190	0	

Molluscs	Locality	Number of snails dissected	Trematoda	
			Furcoc.	C. cristata La Val. C. ocellata La Val. C. 1. Petersen.
			Cercariaeum	C. Limnaeae obscurae Ercol.
Limnaea auricularia	5, 11, 14, 20, 33, 36 . . .	324	Echinost. Furcoc. — — Cercariaeum	C. affinis n. sp. C. letifera Fuhrm. C. C. Szidat. C. 1. Petersen. Limnaeae auriculariea Fil.
Physa fontinalis	4, 10, 14, 24, 27, 28, 29	168	Furcoc.	C. 1. Petersen.
Planorbis corneus	1, 5, 6, 9, 14, 16, 19, 20, 23, 25, 27, 29, 31, 32, 33, 34, 35, 36	850	Monost. Echinost. Xiphidioc. Cystoc. Furcoc. —	C. ephemera Nitzsch. C. spinifera La Val. C. gracilis n. sp. C. splendens Szidat. C. Bilharziellae polonicae Kow. C. Frederiksborgensis n. sp. C. linearis n. sp.
Planorbis umbilicatus	3, 5, 14, 15, 17, 19, 27, 30, 36	341	Amphist. Echinost. Furcoc.	C. diplocotyleae Fil. C. echinoparyphii recurvati Math. C. F ₁ Harper.
Planorbis contortus	16	35	0.	
Planorbis carinatus	27	25	0.	
Planorbis vortex	14, 27, 32, 38	183	Monost.	C. ephemera Nitzsch.
Planorbis albus	7	80	Xiphidioc.	C. prima Ssn.
Planorbis nitidus	17, 35	200	0.	
Acroloxus lacustris		50	0.	

A little more than 7800 molluscs have been dissected.

The number of now described Danish Cercariae are 61. Of these species STEENSTRUP in his famous work found *C. echinata* v. Sieb. and *C. armata* v. Sieb. The other may be regarded as new to our fauna.

It may be added that O. F. MÜLLER was the first to describe and figure two Cercariae *C. inquieta* and *C. lemnae*: 1788—1806, vol. IV, p. 121—122, Pl. 18, figs. 3—12; they cannot be identified.

The above-mentioned list gives material for the estimation of the degree of infection of the Danish Molluscs.

The first column gives the Molluscs which have been dissected; the second the

number of the locality mentioned on p. 174; the third the number of Molluscs dissected; and the last column the name of the Cercaria. Referring the reader especially to p. 186, the list gives no cause for many remarks. It will be seen that only few of the small *Planorbis* species have been dissected; a more elaborate investigation on this point would be desirable. It seems to me rather remarkable that *Anodonta*, *Dreysensia*, and *Neritina* have given almost no Cercariae; the *Bucephalus* was found in a single *Anodonta* specimen which had lived for months in one of our aquaria. The result is surely not in accordance with the real facts, and this is likewise the case with the infectivity of *Limnaea truncatula*. Even if the number of *Bithynia tentaculata* (1785) dissected is much larger than that of all the other snails, I am under the impression that of all our Mollusc species this very snail harbours most species of Trematoda. 19 species have been found in it.

Of *Limnaea stagnalis* and *Planorbis corneus* almost the same number has been dissected; of the former 714, of the latter 850; the former was infected by 8 species, the last-named by 7. The remarkable thing is that they have not two species in common. When it is kept in mind that the two species very often lie side by side and often in enormous numbers, this shows, as has been often pointed out, either that host preference must be a rather indisputable fact with regard to the Miracidia, or that the parthenitae can only develop in quite distinct snails.

Chapter XII.

The Trematode Fauna in 12 Localities in the Years 1931—1932.

In order to study the Trematode fauna in localities differing from each other in my area of exploration I selected 12 localities, viz. 3 lakes, 3 smaller lakes, and 6 ponds, some of which were very small. These latter 6 ponds are covered with vegetation during the summer months. The localities are as follows:

Lakes:	Furesø.
	Esrom Lake.
	Tjustrup Lake.
Smaller lakes:	Bagsværd Lake.
	Bromme Lake.
	Hulsø.
Ponds:	Strødam Pond.
	Donse Pond.
	The moor, Hillerød.
	Hellebæk.
	Torkeris Pond.
	The ditch near the border of Furesø (Frederiksdal).

		Furesø.		Infected snails	Dissected snails
1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	4	20	
2	Gymnoc. <i>C. papillosa</i>	<i>Bithynia tentaculata</i>	20	200	
3	— <i>C. obscura</i>	<i>Bithynia tentaculata</i>	7	120	
4	Echinost. <i>C. affinis</i>	<i>Limnaea auricularia</i>	17	137	
5	— <i>C. echinoparyphii recurvati</i>	<i>Planorbis umbilicatus</i>	7	40	
6	Xiphidioc. <i>C. nodulosa</i>	<i>Bithynia tentaculata</i>	1	290	
7	Cystoc. <i>C. splendens</i>	Planctonic			
8	Furcoc. <i>C. cristata</i>	<i>Valvata piscinalis</i>	1	50	
9	Furcoc. <i>C. Szidat</i>	<i>Limnaea stagnalis</i>	1	1	
9	— <i>C. Szidat</i>	<i>Limnaea auricularia</i>	1	140	
10	— <i>C. 1 Petersen</i>	<i>Limnaea auricularia</i>	1	137	
11	— <i>A. Szidat</i>	<i>Limnaea palustris</i>	7	25	
12	— <i>C. 4 Petersen</i>	<i>Bithynia tentaculata</i>	3	250	
13	— <i>Tetracotyle</i>	<i>Bithynia tentaculata</i>	4	290	
14	Microc. <i>C. micrura</i>	<i>Bithynia tentaculata</i>	5	290	
15	Cercariaeum <i>C. paludinae impurae</i>	<i>Bithynia tentaculata</i>	1	190	
16	— <i>gibba</i>	<i>Valvata piscinalis</i>	1	150	
17	— <i>crassa</i>	<i>Pisidium amnicum</i>	1	1	

Esrom Lake.

1	Monost. <i>C. imbricata</i>	<i>Bithynia tentaculata</i>	8	357
2	Gymnoc. <i>C. papillosa</i>	<i>Bithynia tentaculata</i>	2	357
3	Echinost. <i>C. affinis</i>	<i>Limnaea auricularia</i>	9	20
4	Xiphidioc. <i>C. nodulosa</i>	<i>Bithynia tentaculata</i>	3	357
5	Furcoc. <i>C. 1 Petersen</i>	<i>Limnaea auricularia</i>	9	20
5	— <i>C. 1 Petersen</i>	<i>Physa fontinalis</i>	5	50
6	— <i>Tetracotyle</i>	<i>Limnaea auricularia</i>	2	20
7	Microc. <i>C. micrura</i>	<i>Bithynia tentaculata</i>	5	357
8	Cercariaeum <i>C. paludinae impurae</i>	<i>Bithynia tentaculata</i>	2	357

Tjustrup Lake.

1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	1	7
2	— <i>C. monostomi</i>	<i>Limnaea stagnalis</i>	1	7
3	Gymnoc. <i>C. lophocerca</i>	<i>Bithynia tentaculata</i>	1	4
4	Echinost. <i>C. abyssicola</i>	<i>Valvata piscinalis</i>	3	80
5	— <i>C. echinostomi</i>	<i>Limnaea palustris</i>	2	10
6	— <i>C. affinis</i>	<i>Limnaea auricularia</i>	1	10
7	— <i>C. spinifera</i>	<i>Planorbis corneus</i>	1	1
8	Xiphidioc. <i>C. vesiculosa</i>	<i>Bithynia tentaculata</i>	5	30
9	Furcoc. <i>C. letifera</i>	<i>Limnaea auricularia</i>	1	1
10	— <i>C. 1 Petersen</i>	<i>Limnaea auricularia</i>	1	1
10	— <i>C. 1 Petersen</i>	<i>Limnaea ovata</i>	1	1
11	— <i>Helvetica XXXI</i>	<i>Limnaea palustris</i>	1	10
12	Cercariaeum <i>C. longiremis</i>	<i>Valvata piscinalis</i>	13	110
13	— <i>C. paludinae impurae</i>	<i>Bithynia tentaculata</i>	2	91

		Infected snails	Dissected snails
Bagsværd Lake.			
1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	3 6
2	Gymnoc. <i>C. tuberculata</i>	<i>Bithynia tentaculata</i>	1 8
3	Echinost. <i>C. Hypodereae conoideae</i>	<i>Limnaea ovata</i>	1 1
4	— <i>C. echinostomi</i>	<i>Limnaea palustris</i>	1 4
5	Furcoc. <i>C. C. Szidat</i>	<i>Limnaea stagnalis</i>	1 8
6	— <i>C. strigeae tardae</i>	<i>Limnaea stagnalis</i>	4 23
7	— <i>Tetracotyle</i>	<i>Limnaea stagnalis</i>	15 23
Bromme Lake.			
1	Monost. <i>C. imbricata</i>	<i>Bithynia tentaculata</i>	17 80
2	Gymnoc. <i>C. tuberculata</i>	<i>Bithynia tentaculata</i>	16 80
3	Echinost. <i>C. echinostomi</i>	<i>Limnaea palustris</i>	1 20
4	Xiphidioc. <i>C. Limnaeae ovatae</i>	<i>Limnaea ovata</i>	1 20
5	— <i>C. Haplometrae cylindricae</i>	<i>Limnaea palustris</i>	2 80
5	— <i>C. Haplometrae cylindricae</i>	<i>Limnaea stagnalis</i>	2 13
6	— <i>C. gracilis</i>	<i>Planorbis corneus</i>	8 15
7	— <i>C. nodulosa</i>	<i>Bithynia tentaculata</i>	15 80
8	Furcoc. <i>C. helvetica</i> XXXI Dubois	<i>Limnaea palustris</i>	2 2
Hulsø.			
1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	1 8
2	Gymnoc. <i>C. tuberculata</i>	<i>Bithynia tentaculata</i>	1 15
3	Echinost. <i>C. echinata</i>	<i>Limnaea stagnalis</i>	1 24
4	Xiphidioc. <i>C. nodulosa</i>	<i>Bithynia tentaculata</i>	1 15
5	Furcoc. <i>C. cristata</i>	<i>Limnaea stagnalis</i>	2 24
6	Cercariaeum <i>Limnaeae auriculariae</i> n. sp. ...	<i>Limnaea auricularia</i>	1 190
7	— <i>paludinae impurae</i>	<i>Bithynia tentaculata</i>	1 8
Strødam Pond.			
1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	1 55
2	Gymnoc. <i>C. tuberculata</i>	<i>Bithynia tentaculata</i>	4 120
3	Echinost. <i>C. echinata</i>	<i>Limnaea stagnalis</i>	3 12
4	— <i>C. spinifera</i>	<i>Planorbis corneus</i>	5 5
5	Xiphidioc. <i>C. virgula</i>	<i>Bithynia tentaculata</i>	17 120
6	— <i>C. cordiformis</i>	<i>Bithynia tentaculata</i>	7 25
7	— <i>C. Limnaeae ovatae</i>	<i>Limnaea ovata</i>	33 45
8	— <i>C. laticauda</i>	<i>Limnaea stagnalis</i>	1 220
9	Furcoc. <i>C. strigeae tardae</i>	<i>Limnaea stagnalis</i>	2 127
10	— <i>Tetracotyle</i>	<i>Limnaea stagnalis</i>	103 127
11	— <i>Tetracotyle</i>	<i>Limnaea ovata</i>	5 45
12	— <i>Tetracotyle</i>	<i>Planorbis corneus</i>	2 55
Donse Pond.			
1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	2 100
2	— <i>C. imbricata</i>	<i>Bithynia tentaculata</i>	1 30
3	Gymnoc. <i>C. tuberculata</i>	<i>Bithynia tentaculata</i>	5 42

		Infected snails	Dissected snails
4	Echinost. <i>C. echinata</i>	<i>Limnaea stagnalis</i>	5 38
5	— <i>C. Hypodereae conoideae</i>	<i>Limnaea ovata</i>	3 10
6	— <i>C. spinifera</i>	<i>Planorbis corneus</i>	3 100
7	Xiphidioc. <i>C. Haplometrae cylindrica</i>	<i>Limnaea stagnalis</i>	2 38
8	— <i>C. gracilis</i>	<i>Planorbis corneus</i>	11 100
9	— <i>C. cordiformis</i>	<i>Bithynia tentaculata</i>	4 42
10	Furcoc. <i>C. strigeae tardae</i>	<i>Limnaea stagnalis</i>	3 38
11	— Tetracotyle	<i>Limnaea stagnalis</i>	35 38
12	Cercariaeum <i>C. paludinae impurae</i>	<i>Bithynia tentaculata</i>	1 30

The moor, Hillerød.

1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	18 190
2	— <i>C. imbricata</i>	<i>Bithynia tentaculata</i>	2 25
3	Echinost. <i>C. spinifera</i>	<i>Planorbis cornens</i>	11 190
4	— <i>C. echinoparyphii recurvati</i>	<i>Planorbis umbilicatus</i>	1 30
5	Xiphidioc. <i>C. gracilis</i>	<i>Planorbis corneus</i>	142 190
6	— <i>C. cordiformis</i>	<i>Bithynia tentaculata</i>	4 25
7	Cercariaeum <i>paludinae impurae</i>	<i>Bithynia tentaculata</i>	2 25

Hellebæk Pond.

1	Monost. <i>C. imbricata</i>	<i>Bithynia tentaculata</i>	2 208
2	Gymnoc. <i>C. papillosa</i>	<i>Bithynia tentaculata</i>	2 208
3	Echinost. <i>C. echinatoides</i>	<i>Paludina vivipara</i> . As cysts ..	74 78
4	Xiphidioc. <i>C. pusilla</i>	<i>Bithynia tentaculata</i>	5 35
5	— <i>C. cordiformis</i>	<i>Bithynia tentaculata</i>	5 100
6	— <i>C. nodulosa</i>	<i>Bithynia tentaculata</i>	25 100
7	— <i>C. cellulosa</i>	<i>Paludina vivipara</i>	1 200
8	Furcoc. <i>C. sp.</i>	<i>Bithynia tentaculata</i>	1 75
9	Cercariaeum <i>C. No. 1. Petersen</i>	<i>Paludina vivipara</i>	7 78

Torkeris Pond.

1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	58 220
2	Echinost. <i>C. echinata</i>	<i>Limnaea stagnalis</i>	10 93
3	— <i>C. spinifera</i>	<i>Planorbis corneus</i>	220 220
4	Xiphidioc. <i>C. Haplometrae cylindrica</i>	<i>Limnaea stagnalis</i>	18 93
5	Macro. <i>C. vitellilobae</i>	<i>Sphaerium corneum</i>	1 25
6	Furcoc. <i>C. Bilharziellae polonicae</i>	<i>Planorbis corneus</i>	1 10
7	— <i>C. linearis</i>	<i>Planorbis corneus</i>	1 220
8	— Tetracotyle	<i>Planorbis corneus</i>	4 220
9	— Tetracotyle	<i>Limnaea stagnalis</i>	4 93
10	Cercariaeum <i>C. Limnaeae obscurae</i>	<i>Limnaea ovata</i>	1 55

The ditch near the border of Furesø, Frederiksdal.

1	Monost. <i>C. ephemera</i>	<i>Planorbis corneus</i>	4 30
2	— <i>C. monostomi</i>	<i>Limnaea palustris</i>	1 30
3	Echinost. <i>C. echinata</i>	<i>Limnaea stagnalis</i>	1 10

		Infected snails	Dissected snails
4	Echinost. <i>C. echinostomi</i>	9	30
5	— <i>C. Echinoparyphii recurvati</i>	7	40
6	Xiphidioc. <i>C. sp. Only sporocyst</i>	5	30
7	Furcoc. <i>C. A. Szidat</i>	7	30
8	— <i>C. F₁ Harper</i>	8	40
9	— <i>Tetracotyle</i>	30	30
10	— <i>Tetracotyle</i>	2	30

The first column figures gives the number of infected snails, the last the number of dissected snails. The localities were visited 10—15 times at all seasons of the year in 1931—1932. From every excursion the number of dissected snails and the number of infected ones have been noted. Tables of these have been worked out and it was my intention that this material too should have been printed. However, as I cannot see that the results answer to the efforts, I have not insisted upon the publication of this part of the material.

It would seem that only the following rather meagre results can be extracted from the material:

1. There appears not to be any special Trematode fauna limited to the three above-named categories: lakes, smaller lakes, and ponds, nor any to strongly eutrophic ponds or those of a more dystrophic nature (Hulsø).

As the Prosobranchiata in the lakes preponderate over Pulmonata at depths of more than 5 m. and the two groups of snails have each their special Trematode fauna, the Trematoda parasitising Prosobranchiata are perhaps prevalent in the lakes; since, however, *Bithynia tentaculata* is very common even in smaller ponds, most of this group will also be found there.

2. It would seem that the Furcocercariae preponderate in the lakes. As they are plancton organisms, this is only what might be expected, but those parasitising *Planorbis corneus* and *Limnaea stagnalis* are also or mainly found in ponds. Species which use *Limnaea stagnalis* in ponds use its substitute *L. auricularia* in lakes.

3. With regard to the percentage of infected snails it would seem that it is almost always much larger in ponds than in lakes; more than 3—4 per cent is rare in lakes; in ponds the percentage very often exceeds 50 or may even rise to almost 100. This is due to the enormous aggregation of snails in the vegetation covering the surface of ponds with floating leaves (*Potamogeton*, *Nymphaeaceae*, *Hydrocharis*).

4. As already mentioned in the introduction, I had hoped if the investigations were carried on during two consecutive years that I should find the same Trematode fauna in the same place in the two years and that in this way I should be able to correct and complete my observations from the first year. This, however, was hardly ever the case. Forms from the first year were only rarely present in the second, and new species appeared which I had not found in the first year.

There was, however, one phenomenon which struck me again and again and which was found in many localities.

If a species of snail in a pond or small lake had been strongly infected one year, the snails had almost totally disappeared the next. If we remember the extremely corroded shells, the fact that the hermaphroditic gland was destroyed by the parasites, and that egg masses could not be found in the pond, there can be no doubt that the parasites have killed the whole stock of snails. Combined with this there was another result. In very many cases the strongly corroded snails were also very large specimens. First I supposed that these large specimens were very old most probably several years old. This would be in accordance with the current supposition that e. g. the large *Limnaea* species, *L. ovata*, *L. auricularia* and *L. stagnalis* have a lifetime of two years or perhaps even more.

It may be so in aquaria, and there may be localities also in my country where they attain that age; having now visited several hundred localities, and having gathered the snails at regular intervals and studied them in autumn, winter and early spring, I have received the impression that their age in very many localities is not much more than one year, and that two hibernations are the exception and not the rule.

Of course my thoughts always centred round the Cercaria fauna of the snails, but this by no means prevented me from slowly, through a number of years, gathering a number of impressions with regard to the biology of our snails which were not in accordance with what is universally accepted as correct.

In numerous localities, and especially those where the snails were strongly infected, the same localities which I have of course studied with the greatest care, I found in early spring a large quantity of empty shells and putrefying snails with much corroded shells; simultaneously with these were found another size, only $\frac{2}{3}$ as large; the cuticula was of a fine brown colour; corrosion none, or only detectable at the apex of the shell. These snails grew larger during the summer, and might be present in great quantity during the autumn; they were found in mild winters below the thin ice cover. They were found again in early spring, in some localities in plenty, in others in only a very small number. In three localities, all of them small ponds, where I knew that about 90 or almost 100 per cent of the snails were infected (mainly by Echinostomes and Xiphidiocercariae), the whole stock was now dead, and a border of empty shells was found along the margin of the pond. In another locality (Hulsø) *L. ovata* was present in May-June 1932 in big, very fine specimens; the number was not very large. Three weeks later my assistant and I could not find a single one of the big size, but many small ones. This size was numerous in the autumn; in spring and summer the next year (1933) matters were as in 1932; only the larger size were present. In another small lake, Bagsværd Lake, *L. stagnalis* was numerous in July 1932; in September 1933 it was rare; there were many empty shells, but after two hours' work we had gathered only 50 snails, all infected either with Echinostomes or Furcocercariae. The Trematodes had killed the whole stock. Present were only young snails with a very high spire and not in great number. — I am sure that in very many localities

our *Limnaea* species do not live more than one year, and that they are killed by Trematoda. This is also the reason why a snail may be present in a locality in great numbers one year, and be very rare the next; quite similar observations have been made on *L. palustris* in the canals of Indelukket near Hillerød and at the borders of Bromme Lake near Sorø.

Furthermore I am under the impression that localities with heavily infected snails have remarkably large specimens. This holds good especially of smaller ponds. Infection causes excessive growth and size, not the opposite, as might perhaps have been expected.

It is with these observations in mind I am inclined to suppose that in nature the Miracidia and the Cercariae, as observed by WINFIELD and NOLF and CORT (vide p. 148), only rarely attack the same snail.

5. That the Trematoda have a world-wide influence on molluscs, and perhaps especially on freshwater-molluscs, is beyond all doubt. It would seem that malacologists, in their description of forms and varieties, hardly ever take any notice of this point in their calculations regarding the influence of environmental conditions. In this connection I only wish to point out that the colour of the shell is very often determined by the parasites. The enormous amount of excreta caused by the parasites darken the organs, especially the mantle, but also the shell itself.

In the Furesø heavily infected *Limnaea auricularia* have a perfectly black shell, highly characteristic when laid side by side with a non-parasitised snail whose shell has a very beautiful yellow colour. Infected snails very often have the upper part of the shell black, the lower parts yellow. *Limnaea* strongly infected with *Tetracotyle* have often a peculiar yellowish-red colour of the shell.

As mentioned above, strong parasitism causes excessive growth; this holds good especially in the last part of the life of the snail, and causes the last winding of the shell to be inflated. Some of the many forms of malacologists are most probably nothing but infected species which, during the later part of their lives have been found to eat enormously in order to satisfy the demands of the parasites with regard to food supply.

6. The most interesting group of the Cercariae are those living a true planctonic life.

There can be no doubt that freshwater lakes harbour a peculiar fauna of pelagic Cercariae, most of them belonging to the Furcocercariae, chiefly to the group pharyngeate longifurcate *Cercaria* (Miller), but also to the Lophocercaria, the *Bucephalus* group, and the *Cystocercaria* groups. According to the preliminary report of VOGEL (1932, p. 559) it seems that one of the Cercariae of *Heterophyidae*, the *Cercaria* of *Opisthorchis felinus*, also is pelagic. VOGEL says (p. 561) that it "im Wasser schwebt. Der Schwanz ragt in S-förmigen Krümmung nach oben".

In contrast to the sea, fresh water is remarkably poor in pelagic larva stages. It is a well-known fact that most of the marine groups lose their free-living larva stages, according to most authors owing to the smaller specific gravity of fresh water in comparison with the sea. From a planctological point of view it is therefore of no slight

interest that we possess a whole group of larvae in our freshwaters, which are actually pelagic. Of this phenomenon planctologists have had so to speak no knowledge at all. This is due firstly to the fact these larvae live such an extremely short time and that most of them are so small that they cannot be caught by our nets or so delicate that they do not come under the microscope in a recognisable form; secondly it is because these larvae are mainly suspended in the midmost waterlayers or over the shellbanks with their living molluscs, which are the very places the fishes seek. The structure of the pelagic Cercariae shows conspicuous adaptations to habitat, and these adaptations correspond with those found in other plancton organisms.

From the moment when I found *Cercaria splendens* in plancton samples from the Furesø (1910) and saw *Valvata piscinalis* var. *antiqua* throw out its thousands of Furcocercariae (1913) I have had a clear understanding of the phenomenon. My view was strengthened when I caught the Cercariae with closing nets and in water samples taken with the Brönsted apparatus. Their number was always rather small and they were only found in the autumn. Investigations of other kinds have prevented me from publishing results.

Already WARD (1916, p. 12) writes: "These Cercariae are produced in great abundance and infected molluscs are also abundant and widely distributed. And yet there are almost no records of the occurrence of Cercariae in the voluminous report on freshwater plancton and aquatic life. I am at a loss myself to explain this condition". This is indeed quite right. In 1904, however, I wrote in my Plancton investigations (p. 130): — "There is no doubt that the pelagic region of our lakes may harbour larvæ belonging to those groups of vermes which as parasites are tied to the fishes or belong to the stones and vegetation of the litoral region. To the first named group belong the larva stages of Trematoda and *Botriocephalus*, some of them owing to the peculiar horns seem (*Bucephalus*) to be well adapted to pelagic life." Whereas, during my plancton investigations, I three times got the *Botriocephalus* larva in my nets, the Trematoda larvae were not found until about 10 years later.

Whereas planctologists cannot be said to have any idea of the Cercariae as members of the pelagic society of our lakes, this cannot be said with regard to the parasitologists. SZIDAT has remarks (1924a, p. 251) which show that he has seen his *Cercaria C* and other larvae mentioned by him hanging in the waterlayers. It is, however, especially CORT and BROOKS (1928c, p. 179) who have mentioned the phenomenon and given drawings of the Cercariae in their suspended position. On this subject they say (p. 211) "Definite specific differences were found to exist in these respects which in some cases make easy identification possible". Because all studies of these plancton organisms have been made in laboratories and quite especially in parasitological ones, it is quite natural that particular stress has been laid upon studies of stimuli which are able to carry the Cercaria to its host (MILLER and others). As a supplement to these important studies the planctologist may add the pointing out of the floating power; the life of the Cercaria as a true pelagic organism; the structural

modifications of the body in accordance with demands of augmentation of the cross-section resistance to prevent the fall; and the fact that the pelagic region of our lakes possesses an element of which planctologists have had no idea at all.

Chapter XIII. General remarks.

1. *Adaptation of the Cercaria to the final host and its manner of life.*

On reviewing the plates accompanying this work the first impression of the larva stages is unquestionably surprise at the abundance of forms, and the slight degree of resemblance among the larvae, much slighter than in all the other developmental stages as well as in the mature stage; the great variation manifests itself especially in the larval characters; the form and structure of the tail; the piercing organs with adjacent glands; the equipment of cystogeneous glands, sensitive organs, special larval holdfast organs, planctonic characters. This great variation is all the more remarkable since the freeswimming Cercaria often lives only for a few hours, most probably never for more than about forty-eight hours, Monostomes only for a few minutes (*C. tuberculata* (WUNDER 1923b, p. 226). In the adult stage they may live for years, encysted more than one year, and as parthenitae at all events more than half a year. Combined with these variations in structure go variations in behaviour and general biology. In very many cases it may clearly be shown that both variations, the morphological as well as the biological, are in accordance with the life conditions and structure of the auxiliary secondary host or the final host. It seems as if there is an uninterrupted interplay between the Cercaria and its host, its structure and life, in which either encystation or maturity is to take place and that this interplay stamps the parasite morphologically as well as biologically. There are only a few cases in which the uninterrupted interplay between an organism and its surroundings is more obvious than here, and this is all the more striking since the time in which the outer medium is able to stamp the organism is so extremely short.

1. The most conspicuous larval organ is the tail. In the Monostomes, Amphistomes, Gymnocephala, Echinostomes and Xiphidiocercaria it is a swimming organ. The number of strokes it makes in the lifetime of a Monostome is but few, since the animal often escapes from the snail and a few minutes later, attracted by the light, becomes encysted on the lighted side of the vessel; the same may be the case with the Amphistomes and some of the Xiphidiocercaria. In the Gymnocephala and Echinostomes the tail is a powerful swimming organ equipped with a strong transversal and longitudinal musculature. They are organisms which are in search of a secondary host, commonly a bottom organism, often a snail; they are not particularly attracted by light; they mainly live near the bottom; their power of locomotion in a vertical direction is often small, and several of them, e. g. the Amphistomes, chiefly move horizontally. In some of the Macrocerariae the tail is an organ for fixation and for wavy motions,

which either attract the secondary host or cause easier contact with it when it moves over the bottom. Moreover, in this group and in the Cystocercariae the other end of the tail is provided with a bell-shaped cavity in which the Cercaria lives, only connected with the tail by means of a muscle-thread which is broken off when the Cercaria jumps onto the new host.

In the Cystocercariae, Lophocercariae, and Furcocercariae the tail is in the first place a floating organ which allows a suspended position in the middle layers of the water masses and furnishes possibilities for a pelagic life. A furcation of the tail, the development of a furca, is connected with a pelagic life. According to the life of the host which the Furcocercaria is to enter, different types have been developed, viz. bottom forms which stand pelagically near the bottom but with strong power of motion, and whose intermediate hosts are snails; true pelagic forms with a very slight power of motion and which pass passively over onto fishes; surface forms which together with slime secretions reach the skin of mammalia and birds. — In the pelagic forms the furca is remarkably long, often longer than the tail itself, and it is here used as an outrigger to augment the cross-section resistance; in the surface forms, especially *Bilharziella polonica*, the furca consists of two broad leaves which allow the Cercariae to reach the surface quickly, to which they then adhere by the ventral sucker. In the Microcercariae the tail is only a short blunt rudiment; if they leave the snail at all, the species are slow creeping organisms in search of other snails. Finally, the Cercariae have no tail at all; they either encyst in the snail in which they are hatched, or seek the antennae of the snail, or creep slowly as leaches on the bottom, where they are taken up with the snails by snail-eating bottom organisms. A very peculiar form of adaptation is found in those cases where the reduced tail can be withdrawn into the chamber and the latter be changed into a floating organ which alters the form to a real pelagic organism. This is the case with *C. cystophora* Wagener and *C. mirabilis* Braun, the former developing in small *Planorbis* species, the latter in *Limnaea palustris*.

A still more peculiar adaptation is that of *Cercaria duplicata* (Baer) from *Anodonta*, best studied by WUNDER (1924 a, p. 323). REUSS (1903, p. 458) and WUNDER have shown that the peculiar broad tail is used to form a highly remarkable "Schwanzcyste", which is found at the bottom of the vessels in which infected mussels are kept. According to REUSS the cyst is caused by a floating out of the cuticula, whereas WUNDER shows that it is due to an invagination. The result is a hyaline ball equipped with longitudinal furrows and containing the distome. These balls lie on the bottom and roll over it.

2. A similar variation and the same very conspicuous correlation to the surroundings is also very obvious with regard to the presence or absence of the piercing organ. It is lacking in all those groups which are introduced passively as cysts into the final host. This is the case with the Monostomes, the Amphistomes and the Gymnocephala, and may also be the rule at all event for several of the Cercariae forms. Whether the cysts are eaten together with the water plants, as is the case with

the Monostomes and at any rate with some of the Gymnocephala, or with the grass of inundated meadows (some Gymnocephala) or with the stratum corneum of the Amphibia (some Amphistomes), in all cases the result is the same. This is also the case with the Echinostomes, which, however, in their rows of spines have a powerful holdfast organ which perhaps already functions when the Cercaria, after a short excursion in the open enters a snail and encysts in it. As a rule it is not combined with any secretory system used during the penetration of the skin.

True piercing organs are in the first place the stylet in the Xiphidiocercariae, Macrocercaria and Microcercaria and if present also in the Cercariaea; next the various piercing organs in the Furcocercaria. Combined with the stylet there is always a system of stylet glands which differs in size and place from species to species. It consists of a number of glands with long ducts which debouch near the base of the stylet. Most of all these forms use as secondary hosts Arthropoda, in the first place insects, but also Crustacea, in which they encyst. Direct observations have shown how the stylet is used as a piercing and cutting organ by means of which the Cercaria pierces a hole in the cuticula. It is possible that the penetration glands secrete a fluid which has a destructive effect on the cuticula. That this secretion at the same time is poisonous is highly probable, for the insects, when a large number have passed the cuticula, die or at all events show signs either of great excitement or of great feebleness. Within my knowledge, all stylet Cercariae always encyst in the interior of the host, never exteriorly. As soon as the Cercaria has reached its place of destination and encystation has taken place, the role of the stylet is at an end; it passes over into the encysted stage but lies apart, often between the Cercaria and the interior wall of the cyst. Together with the throwing off of the stylet there also occurs, as far as I have been able to see, a breaking down of the penetration glands. The size and form of the stylet varies from species to species, and in accordance herewith the different species are only able to use such arthropoda as intermediate hosts whose skin the stylet is able to pierce. If two different species of Xiphidiocercariae are placed in a vessel with *Corethra plumicornis* I have observed that both try to pierce the cuticula but only one of them is able to do so, the other not.

True piercing organs of quite another structure are found in all Furcocercariae. The penetration glands are here strongly developed; their number and place vary from species to species; together with the long ducts they fill a great deal of the interior of the snail. In all those forms which pass through a second larva stage (Tetracotyle, Diplostomum, Tylenchus etc.) the oral sucker has still preserved some significance as an organ of attachment; nevertheless its importance as such is but small; it is protrusile in very different degree in the different species; it acts as a penetrating organ and at its top it is equipped with small spines or taps, at the base of which the ducts from the penetration glands debouch. In the Lophocercaria it is provided with two small tips which perhaps may be hollow. In the Furcocercaria of the group *Schistosomatidae*, without an intermediate host or a secondary larva stage, the whole system with its anterior protrusile penetrating organ and the penetration glands has

reached a stage of development not known in any other group of Cercariae. In conjunction the two parts, the penetration organ and the enormously developed ducts and glands, fill the greater part of the interior, only leaving room for the excretory system and the rudimentary alimentary canal. The oral sucker is modified to a powerful penetrating organ with a sharply defined posterior, very muscular, part, and an anterior part, on the tip of which the very broad ducts debouch. The penetration glands are of a complicated structure, the different pairs giving a different chemical reaction.

3. Pronounced larval organs are in the first place also the holdfast organs which are found in different groups of Cercariae. To these belong the peculiar locomotoric pockets situated at the lateral angles of the body of the *Monostomes*, which in some cases are provided with glandulae and in others with spines. In these animals which lack the ventral suckers they act as larval feet with which they fasten themselves, especially immediately before the moment of encystation. Similar caudal pockets armed with needle-like spines are found in some of the Xiphidiocercariae (*Xiphidiocercariae armatae*); they may act in the same manner. Another holdfast organ is the corona of spines in the Echinostomes, but this organ may have its greatest significance in the mature stage. Therefore, in contradistinction to the stylet of the Xiphidiocercariae it is not thrown off in the encysted stage but preserved during and after encystation. As holdfast organs may also be interpreted the abundantly developed small spines and bristles especially on the anterior part of the Furcocercariae. They are simultaneously part of a penetration- and of a holdfast organ used by the animals during the penetration through the skin of the host. The incredible hurry — often only a fraction of a minute — in which the piercing of a host, e. g. a snail, takes place, shows the effectiveness of all the different parts of the piercing and holdfast organs. This is also partly due to the enormous power of contraction and extension of the snout-like forepart of the body, perhaps most conspicuous in the *Lophocercaria* (Pl. XX, figs. 1, 3, 5).

4. Another characteristic larval organ is the whole cystogeneus apparatus whose secretion is used to form the capsule of the cyst. It seems only to be totally lacking in the Furcocercariae. In the Monostomes and Amphistomes it consists of numerous cells spread over the whole body. Apart from the nucleus they commonly contain rhabditiform granules, in other cases the content is granular, homogeneous, often milky, opaque. During the encystation process the cells open everywhere upon the surface of the body; the content is given off and in connection with the surrounding medium altered into a gelatinous capsule. In the Gymnocephala and Echinostomata where we find similar cystogeneus glands, these are often arranged in broad dark bands, lying between the alimentary canal and the body wall. I am of opinion that here also the glands open all over the body. With regard to their function I refer the reader to WUNDER.

As mentioned above, no cystogeneus cells are found in the Furcocercariae; this is in accordance with a mode of life differing from that of all the other Trematoda. Either the Furcocercariae, on having reached an intermediate second host which in

some cases may be the same as the first one, give rise to a new larva stage, or they possess no intermediate host and immediately enter the final one, in whose blood system they live and attain maturity.

5. As free-living organisms the Cercariae are equipped with sensitive organs which have no significance in the parasitic stages of the life of the species. Among them may mainly be mentioned the eyespots, which seem best developed in some of the forms that encyst in the open and not in the interior of other organisms (Monostomes and Amphistomes), and in some of the *Schistosomatidae* which seek the surface in expectation of the host in which they are destined to attain maturity. All forms equipped with eyespots are phototropic, they so to speak dart towards the lighted sides of the vessels, either to encyst (Monostomes) or to fasten themselves there (*Schistosomatidae*).

6. As special larval organs may also be pointed out those organs and structures which may be of significance for all the Cercariae that live a pronounced pelagic life. Among these must in the first place be mentioned the peculiar folded membrane on the dorsum of the Lophocercariae; the very peculiar pear-shaped house of the *Cystocercaria C. splendens*, in reality only the dilated upper part of a tail, further the membranes along the tail or the furca found in the Furcocercariae and the peculiarly formed furca of the *Bucephalidae* (by means of which the animals, according to one author, are said to "fly like eagles through the water" (in every respect a rather peculiar comparison). As mentioned above, the long furca in many of the Furcocercariae may also be regarded as plancton-characters. In this connection may also be mentioned the great hyalinity which characterises so many plancton organisms and which is especially conspicuous in the cystocercous Cercaria *C. splendens* and in many other Furcocercariae.

All the above-named organs, the tail, the piercing organs, the cystogeneus cells, the holdfast organs apart from the suckers, and the sensitive organs, all varying in development and structure from group to group, and often from species to species, are all larval organs many of which are only in use during a few minutes of the life of organisms which, when all their different stages are included, may live for years. The development of the piercing organs, of the tail, of the cystogeneus cells and the sensitive organs, clearly evidence the adaptation to the nature of the surrounding medium in which the next stage of the development is to take place and where the accommodation to the manner of life and structure of body of special hosts is carried out on a more elaborate scale (*Xiphidiocercaria*, *Schistosomatidae*).

Two organs seem very little altered by life in a free-living stage, viz. the alimentary canal and the excretory system. During the short time the species live in the free stage no food is taken, but during the time in which the Cercariae lie free in the tissues of the snail, a time which may be very long for the Monostomes as well as for the Amphistomes, it is a question whether the alimentary canal does not function. In any case the contents of the intestinal coeca seem to show this. Of all the organs the excretory system is that which is least subject to alterations and adaptations,

and so it is that which most resembles the organ in the mature animal. In accordance herewith it is also the organ which has the greatest systematic significance, but according to its structure that which is most difficult and therefore also most dangerous to use for systematic purposes, especially when it is used in an extremely one-sided manner.

2. *Some remarks with regard to the Sporocysts, the Redia and Cyst stages.*

I shall not here undertake a survey of the different hypotheses and theories which from the time of STEENSTRUP down to our day have been set forth to elucidate the highly complicated life history of the Trematoda. For years I have been inclined to suppose that the process of polyembryony should be applied to Trematode life. Later on I learned that DOLLFUS (1919, p. 124) had advanced the same view. I shall restrict myself to refer the reader to the paper of BROOKS (1930, p. 299). As far as I can see, he is nearest to the truth when he interprets the life history of the Trematoda "as one in which the germinal lineage passes through successive larvae stages in which polyembryony features as a mode of multiplication and in which precocious cleavage is an activating factor".

Here I shall merely offer some remarks on the Sporocyst, Redia stage, and Cyst stage.

It is a well known fact that the Cercariae in some cases develop in Sporocysts in others in Rediae. The Xiphidiocercariae, all Furcocercariae including Lophocercariae, Bucephalidae and most of the Macrocercariae develop in Sporocysts; the Monostomata, Amphistomata, Gymnocephala, Echinostomata and Cystocercariae develop in Rediae. From this rule there may be exceptions, but they are few, and some of them rather doubtful. It has often been pointed out that it may be rather difficult to determine whether we have to do with a Redia or a Sporocyst; the posterior locomotoric organs may especially in older Rediae be entirely absent; the gut may be very strongly reduced or totally lacking. Only a pharynx, which also may be very much reduced, shows that we have a Redia before us. In those cases where it serves as a birth-pore, as seems to be the case in the Cystocercariae (*S. splendens* Szidat), the developmental stage may almost equally well be regarded as a Sporocyst and as a Redia. We find these intermediate stages especially among the Microcercariae and in most of the Cercariae; in these cases the pharynx may have its principal significance as a holdfast organ; the rudimentary gut or intestine would seem to have no particular significance as an organ for taking in food or as a magazine for nutritive matter.

We suppose that a Sporocyst stage is always intercalated between the Miracidium and the Redia stage. From this rule we know only a single exception, namely *Tracheophilus sisowi* Skrj. whose Miracidium contains ripe Rediae, a Sporocyst stage being omitted (pag. 20).

In this connection, however, I would point out the fact that we know large groups in which Sporocysts have hardly ever been observed and with regard to which, there-

fore, it has been maintained that Rediae develop directly from the Miracidia. This is especially the case with the Echinostomes (JOHNSON 1920, p. 342). I confess that I have been of the same opinion. In spite of the many hundred snails which I have observed to contain Echinostomes, I have never seen a Sporocyst. This has, however, been observed by MATHIAS (1925, p. 66) in *C. Hypodereae conoideae*. Even if in these forms too a Sporocyst stage is intercalated between the Miracidium and the Redia stage, there is no doubt that in the development of the Echinostomata, and I suppose also in that of the Monostomata and Gymnocephala, the Sporocyst stage plays a very insignificant role as a multiplying factor compared with that of the Redia stage.

At the first glance it seems rather fruitless to speculate as to why the Cercariae in some groups develop directly from a Sporocyst in others from a Redia, but it is of interest to note how much the Sporocyst and the Redia stage differ from each other, especially with regard to propagation, but also with regard to power of motion and manner of nourishment.

1. Between the Sporocyst and the Redia there is, with regard to propagation, a fundamental difference which has not been sufficiently stressed and curiously enough has even been denied (SZINITZIN), namely that the Sporocyst has the power either of division or ramification, which the Redia has not; ramification is only found in a few cases: viz. in *Leuchochloridium*, *Bucephalus* and *Distomum leptostomum*; the power of division is characteristic of the Xiphidiocercariae (p. 82 a. o.) and Furcocercariae; in the latter case in very different degree in the different species. In the long threads constrictions arise, and in the constrictions dark lines appear, whereupon the Sporocyst either breaks up into a series of smaller pieces or only the extreme part is thrown off; the length of the Sporocysts depends on how often the divisions take place; in some species the pieces are almost isodiametric, in others they are very long, threadlike; both cases occur among species of Xiphidiocercariae. — The different stages of division are very conspicuous in many Xiphidiocercariae, MATHIAS (1925, p. 48) has seen them in Furcocercariae, but the Sporocysts of Gymnocephala show the same phenomenon. THOMAS (1883a) has shown them for the Sporocyst of *Fasciola hepatica* (fig. 9, Pl. II). In the very long, extremely thin, thread-like Sporocysts of Lophocercaria they have not been observed.

In these cases, at any rate in the Lophocercariae, the long threads are equipped with a sucker-like formation with which they are fastened.

The smallest pressure on the cover causes the long threads of many Xiphidiocercariae to go to pieces, and form spirals. There can be no doubt that these pieces are carried with the blood-stream through the whole snail and so obtain a hold everywhere, in the intestine, in the mantle etc.

As a rule the power of locomotion of the Sporocyst is but small, especially when it gets older, and the "paletot" prevents the motion, the detached parts are mostly carried away with the blood. Almost always the attack begins from the lower part of the alimentary canal from which they slowly invade the whole liver. In those cases where we have to do with extremely long, very thin, threads, as is the case in many

Furcocercariae, a division of the threads is not so often observed. It is a question, as pointed out also by other authors, if these entangled masses are not in reality ramified Sporocysts.

As far as we know, the Rediae never possess any power of division; in the Monostomata and especially in the Echinostomata the indentations may be very conspicuous and cause the brood-chambers to be marked off from a digestive part containing the pharynx and the gut; but there is no evidence of a separation of the two parts.

2. Another characteristic of most of the forms in which Cercariae develop directly from a Sporocyst is the enormous production of brood. This is especially the case with all Furcocercariae, and with many of the Xiphidiocercariae with long thread-like Sporocysts. The Sporocysts are crowded with brood, as pointed out already by FUHRMANN. DUBOIS (1929, p. 111) shows that in the course of an hour a snail can throw out more than 20,000 Cercariae. In the course of a few hours the water in vessels with infected snails may become quite whitish.

Whereas Sporocysts, where the Redia-stage is lacking, may be regarded as storing magazines often for thousands of Cercariae, all ripening almost simultaneously, the Rediae only rarely contain more than about 20—25 Cercariae and commonly a much smaller amount. Snails infected with Echinostomes and Gymnocephala never give off clouds of Cercariae simultaneously, but only rather a modest amount of about some hundreds at the height of the production.

3. In contradistinction to the Sporocysts there is some evidence for the fact that the Rediae are able to produce sets of Cercariae which ripen successively (Monostomes). In that case, however, the Cercariae leave the Rediae at a very early stage of development and are nourished directly in the tissues of the snail outside the Redia. This is the case with the Monostomes and Amphistomes, where the number of Cercariae is much larger than that of the Rediae. This is e. g. the case with *C. ephemera* in *Planorbis corneus*, from which thousands of Cercariae may come out when it is opened, whereas the number of Rediae is much smaller.

Now and then, lying among the amounts of extremely thin threads packed with brood, we find a single very long, 2—3 mm, remarkably thick Sporocyst, commonly with thick wrinkled walls filled with a greyish substance and only containing a few fully developed Cercariae; it has often a snout-like tip and a birth-pore. This Sporocyst may perhaps be regarded as the mother sporocyst whose power of propagation is now exhausted; if there is any motion, this is only found in the snout-like part. Of these mother sporocysts I have only found a single specimen in each snail (Pl. XX, fig. 6; Pl. XXII, fig. 4; Pl. XXVI, fig. 5; Pl. XXVII, fig. 5). It must be extremely old, most probably it will often hibernate, giving off the daughter sporocysts. As far as I can see, the number of generations of daughter sporocysts is but small. Lying in the mother sporocyst, the daughter sporocyst is packed with germ-balls, all almost isodiametric. In no case have I seen these daughter sporocysts produce a new Sporocyst generation among the Xiphidiocercariae and Furcocercariae. They always develop

Cercariae, but the rate of development is dependent upon the temperature. It is very slow during winter, and extremely rapid during summer.

With regard to the Rediae I have never found specimens which could be designated as mother rediae in the same sense as the above named mother sporocyst.

I am inclined to think that the Trematoda which have no Redia generations conquer the body of the snail mainly by means of their power of partition, those which possess Redia generations by means of series of generations of Rediae. Detached parts of the Sporocysts are spread by means of the blood, the Rediae are active wandering organisms. Especially the young stages of the Redia possess a great power of locomotion; this combined with an enormous power of contraction and extension of the body enables the Redia to make its way through the narrowest sinuosities in the snail. As is well-known, in heavily infected snails, there is no organ which cannot be packed with echinostome Rediae.

Where Rediae do not occur, the parasites hibernate as Sporocysts packed with germ-balls which in spring develop into Cercariae at higher temperatures; where Rediae occur, the hibernation takes place mainly in that stage; these hibernating Rediae mostly contain daughter rediae but also almost fully developed Cercariae which remain in the Rediae for months. As often pointed out, daughter rediae and Cercariae are often found in the same mother redia. We are unable to show with certainty what makes a germ-ball develop into a Cercaria or into a Redia. As already DUBOIS (1929, p. 128) has pointed out, it is most probable that variations in temperature are most effective. The number of Sporocyst and Redia generations differs from species to species and differs at the different seasons of the year. During summer the production of Cercariae is much more pronounced than in winter, and at that season of the year heavily infected snails may often be found in which all Rediae are in Cercaria-production and young Rediae very rare (p. 56—57). It is, however, quite impossible to think of finding rules for the development; as stated above, specific as well as seasonal variations make their influence felt everywhere; to this must be added the time of infection, the age of the snail, its state of health and conditions of nutriment. Especially this latter factor may, as mentioned above, cause great alterations in the life conditions of the parasite and force the Cercariae to encyst even if they are still enclosed in the parthenitae. On p. 15 it has been mentioned that *Cercaria ephemera* may hibernate in the snail; on p. 75 that the Xiphidiocercariae do the same.

I have been unable to find any regular seasonal fluctuation in the parasitization of the snails. As far as I can see other authors have arrived at the same result (MAC CORMICK 1923, p. 163; MAC COY 1928b, p. 121; MILLER and NORTHUP 1926, p. 490).

I possess no more thorough investigations as to the number of Cercariae escaping from the snail host; the time of day when they mainly escape; and their dependence in this respect on temperature, light and the height of the barometer. On these points I refer the reader especially to the investigations of CORT (1922, p. 177) and DUBOIS (1929, p. 109).

Most of the species throw out their Cercariae when the barometer is high. It is

only in bright sunshine that I have seen milky water round the large *Limnaea* and *Planorbis* species in Nature. It has always been due to Xiphidiocercariae. In the laboratory too milky water in the vessels was most pronounced on days with bright sunshine. The escape mostly took place before 12 o'clock but especially many Furcocercariae were thrown out the whole day long. When snails were under observation for weeks, a regular periodicity independent of all outer conditions was quite conspicuous; that this periodicity was caused by a periodicity of the ripening of the Cercariae in the parthenitae could be shown with certainty with regard to the Furcocercariae.

While the biological differences between the Sporocysts and Rediae are being discussed, there is still one point which must be mentioned, namely the different mode of nutrition. In the Sporocyst all nutrition must take place through the body wall. We see how the tissues of the snail are broken down; and how the Sporocyst increases in size, but as far as I know, we have no clear idea of how the parasite gets its nourishment.

With regard to the Rediae with a well-developed pharynx and gut there is no doubt that they directly nip out large portions of the liver by means of the pharynx and take it into gut. If daughter rediae of different ages lie in the mother redia it can also be observed that the oldest one eats the younger Rediae as well as the germ-balls. When very old mother rediae contain only remarkably few daughter rediae and almost no other brood, it seems highly probable that the Rediae have eaten up all the brood and have now become too large to be born in a natural manner through the birth-pore.

The gut itself almost always contains a yellowish fluid in which darker grains of different sizes are observed. This fluid is yellow in species inhabiting *Limnaea*; in those from *Planorbis corneus* it is red. I think it is allowable to suppose that these Rediae, especially those of the Echinostomes, take in the blood of the host as well as portions of the organs in which they lie.

As mentioned above, it is often difficult to distinguish a Sporocyst from a Redia. In those cases where only a pharynx and a very rudimentary gut is present, there can presumably be no doubt that here too the nourishment is taken through the body wall. The gut, often not longer than the pharynx itself, in these cases often contains a black mass of unknown origin. The structure of the alimentary canal seems to show that the Cercariae after they have left the Sporocysts or Rediae as a rule take in no food; in the free-living stage and in the encysted stage this seems also to be the case. There are, however, two exceptions; in the Monostomes and Amphistomes the taking of nourishment goes on long after the Cercariae have left the Rediae, the long intestinal coeca are filled with a yellow fluid containing numerous grains; this seems to show that the Cercariae have taken in food through their mouth during their stay in the mollusc. The other case is the second larva stage of all those Furcocercariae which possess a Tetracotyle stage. The enormous growth of the parasite in this free creeping stage and the great destruction done to the tissues of the host seem to show that we are here concerned with a very vigorous process of nutrition.

The cysts. Apart from the Trematoda which attain maturity in the blood (*Schistosomatidae*) almost all other Trematoda pass through a resting stage in which as a rule no nourishment is taken, in which the sexual organs ripen, and organs which are of significance for the mature forms, for instance organs for fixation (the collar thorns of the Echinostomes, the holdfast organ of the Holostomata) attain their full development. The duration of the encystation stage is subject to great variation in the different species. It is problematic for all species which develop in the eyes of fishes, and it is aberrant from the normal stage in all(?) those forms which possess a true Furcocercaria stage (Tetracotyle). In most cases the cyst is of circular outline, watch-formed and hyaline. In that case the material for the cyst-wall is supplied from the cystogeneous cells. The process of the formation of the cyst-wall has been studied by BOVIEN and WUNDER to whose papers I refer the reader.

The encystation normally takes place either (1) in the open on vegetation, stones and the shells of snails or (2) in an auxiliary host belonging to almost all groups of the animal kingdom. Where encystation takes place in the open, the Cercariae possess no piercing organs of any kind. The first of these groups may be divided into two (1a, 1b) the other into 3 (2a, 2b, 2c).

1a. The Cercariae are strongly phototactic and usually possess eyespots (*Monostomata*, *Amphistomata*). A Redia stage is the rule, but the Cercariae are nourished outside the mother Redia directly from the tissues of the snail. The swarming of the Cercariae takes place in bright sunshine; in cloudy weather they remain in the snails. The Cercariae are all restless swimmers, but their free-living life is very short, not more than about 24 hours, and for many Monostomes normally only a few minutes; the cysts are often found in cakes, especially on shells of snails. There is no auxiliary host, and the cysts are introduced passively with the food.

1b. Of the other group, to which the Cercaria of *Fasciola hepatica* belongs, our knowledge is extremely restricted. Normally encystation seems to take place in the open, in some cases it has been shown that it may take place in snails (perhaps an aquarium phenomenon). A Redia stage is the rule, but the Cercariae do not leave the Rediae until they are to leave the snail. In my vessels *Gymnocephalus* Cercariae are often given off in cloudy weather; they are all bottom forms, some are content with very small water areas (*Fasciola*). Without auxiliary hosts they are transferred with the food to the final host.

2a. In the group which encysts in auxiliary hosts, the Echinostomes have a special place.

At our present stage of knowledge it seems as if the encystation here takes place in the same group of animals in which the parthenitae have developed, namely in Molluscs. It seems as if some species live as parthenitae in one species, as cysts in another, but in very many cases the same species is used, and for some species it has been shown that encystation takes place in the same specimen in which the parthenitae have been developed (aquarium phenomenon?). Whereas the Rediae are found everywhere in the snails, the cysts are found mainly in the auricle, in the lungs,

in the mantle and in the foot tissues. Eyespots are almost always lacking, all piercing organs also; the collar spines most probably cannot be used for that purpose; the Sporocyst generation at any rate plays a very inconspicuous role, and the Cercariae are developed inside the Rediae. It has often been shown that the Cercariae never come out of the Rediae and may encyst in them. Whether or not this is a normal phenomenon, we do not know. They are bottom forms with a very brief free-swimming period. The final hosts are mainly snail-eaters and are transferred either with the snails to the alimentary canal of birds, chiefly waterbirds, or with the mud.

2b. In the second group encystation takes place within a secondary host which as a rule does not belong to the same group of animals in which the parthenitae live, mainly Arthropodes. This renders it necessary that the Cercariae should be able to force their way through the cuticula of their hosts. These forms are all equipped with piercing organs, almost always a stylet at the base of which glands, which may be regarded as poisonous, debouch. By poisonous glands we mean, such as exert a dissolving influence upon the cuticula. As directly observed, the stylet is used as a knife which is moved forwards and backwards and with which the Cercaria cuts a rent in the cuticula. The structure of the stylet varies greatly and it may presumably be supposed that there is some correlation between the structure of the stylet and the material which it is meant to pierce. Most of the Cercariae of this group belong to the Xiphidiocercariae, but also the Macrocercariae, the Microcercariae and the Cercariae may provisionally be referred to it. Much work must be done before this can be proclaimed as established fact. A closer examination will presumably show that a greater or less number of all these forms belonging to the three last-named families have no auxiliary hosts, but that encystation takes place in the snail in which parthenitae have been developed, whereupon the cysts are transferred directly to the alimentary canal of snail-eating animals. Some of them encyst in Arthropoda (viz. *Potamobius*), which in this case is used as intermediate host.

The main group, the Xiphidiocercariae, normally, if not always, use an auxiliary host, often but not always, Arthropoda and, mainly, insect larvae. It is the cysts of this group which are found dispersed in the most different groups of the animal kingdom. Often encystation takes place directly below the skin, but very often the cysts are found deep down in the interior of the animals, and in the most different organs. — Encystation never as far as hitherto known, takes place in the open, but fairly often in the snails in which the parthenitae have been developed. In that case cakes of cysts may be found on the liver, or the whole liver may be filled with cysts. But this phenomenon is most probably not a normal one. It occurs when the snail is dying; in the encysted stage the animals can endure the putrefaction of the snail, but not in the other stages.

Where an auxiliary host is intercalated between the snail and the final host, it is clear that a much smaller amount of the progeny will attain maturity than when the transfer is direct from snail to final host. All Xiphidiocercariae produce enormous amounts of Cercariae.

It would seem that Sporocysts are able to develop a greater amount of progeny than Rediae, in accordance herewith, we find no Redia stage in the Xiphidiocercariae; the whole development of Cercariae takes place in the Sporocyst stage. In the three other groups provisionally referred hereto occur the parthenitae which with almost the same right may be referred to Sporocysts as to Rediae. The Xiphidiocercariae are very active swimmers; as a rule eyespots do not occur; they may live about two days; if an auxiliary host is not found, they sink to the bottom. In vessels with swarms of Xiphidiocercariae these will on the second day dart to the bottom and here form a milky layer often 1 centimetre thick. It is precisely the Xiphidiocercariae which most commonly in Nature form "milky water" round the snails.

It is characteristic of the cysts belonging to this group that they are hyaline, and that the cyst-wall is very thin, not composed of several layers as is the case with that of the Monostomes, and commonly not so thick as that of the Gymnocephala and Echinostomata. It corresponds to this that the cystogeneous apparatus is commonly rather feebly developed and does not fill the body to such a degree as is the case in the Monostomes, Gymnocephala and Echinostomes.

2c. Peculiar forms of cysts are the Tetracotyle stage of the Furcocercariae and the Agamodistome stages in some of the Cercariaea: *Leucochloridium*. Referring the reader to p. 151—157 I shall here merely remark with regard to the Tetracotyle stage that between the free-living Cercaria stage and the Cyst stage there is intercalated a creeping parasitic stage in which the parasite takes food endosmotically, and the size increases enormously. Sooner or later, combined with diminution in size, the Tetracotyle is formed. Just like many Echinostome Cercariae the Furcocercaria enters the same species of snail in which it has been developed and occasionally the same specimen. How the Tetracotyle is transferred to the final host we do not know with certainty. The Cercariae during their short lifetime live an almost pelagic life. They are always produced in Sporocysts and always in enormous numbers. — There is no Redia stage. The Cercariae show adaptations to pelagic life. There are no cystogeneous glands developed in the free-living Cercaria stage and the rather complicated wall of the Tetracotyle must be developed from material worked out by the creeping flattened larva stage.

The encystation processes of the Cercariaea to which many of the Trematoda living in snails with amphibious or terrestrial habits belong, are very little known. They exhibit many very peculiar phenomena; only the Agamodistome stage of *Leucochloridium* is known (HECKERT).

3. Upon Host Preference.

If we try to gain some knowledge from the literature of the behaviour of the Miracidia in their relation to the different mollusc species, it is very difficult to get a clear idea of the real facts. Many authors, especially from older times (CORT 1918d, p. 170), seem to be of opinion that the Miracidia show no specific host preference but that they will be attracted by and use for their further development very different species. My own observations, all based upon studies in Nature, lead to results

which are not in accordance with the old opinion. It cannot be denied that *Fasciola hepatica* in the different parts of the world uses very different hosts. On the other hand, investigations in Europe clearly show that the parasite out of the whole Mollusc fauna of a locality really only uses a single species: viz. *Limnaea truncatula*. As far as I can see the Miracidia show a pronounced predilection for distinct species available in a given locality. Furthermore many observations seem to show that many Trematoda are really strictly tied to a single species or to the members of a single genus. In the following, examples will be given of all these phenomena. Species which develop in the genus *Limnaea* may be able to use the different species of this genus but for my own part I have seen no examples where species which use *Limnaea* also use *Planorbis* species. Those which use *Planorbis corneus* are only rarely found in the small *Planorbis* species, and even these have their own fauna (e. g. the Amphistome *C. diplocotylea*). Those Cercariae which use Pulmonata are only very rarely found in branchiate snails, and vice versa. Especially *Bithynia* has its own Cercaria fauna strictly limited to it, and the same seems to be the case with *Valvata*, whose Trematode fauna hitherto seems to have been unknown. My results seem to accord well with the papers of LÜHE (1909) and DUBOIS (1929) as also with those of other authors.

In his paper on the development of *Strigea tarda* MATHIAS (1925, p. 54) shows that the Miracidium has a pronounced predilection for *Limnaea stagnalis*, but that it may develop in *L. limosa* (= *ovata*) but not in *Planorbis corneus*; this is entirely in accordance with my own results.

Everywhere in Europe the same seems to be the case with *Fasciola hepatica*, whose host is *L. truncatula*; it may penetrate into *L. pereger* but it is alleged that the development cannot be completed there. For *Hypoderaeum conoideum* MATHIAS (1925, p. 76) has shown that "les *Planorbis* et *Limnaea palustris* étaient réfractaires à l'infestation. Les *L. stagnalis* et les *L. limosa* au contraire se contaminaient assez facilement".

The Gorgoderinae are only found in *Sphaerium corneum*. It is very peculiar that all the Danish Gymnocephala are only found in *Bithynia tentaculata*; with regard to Switzerland DUBOIS (1929, pp. 37—43) comes to the same result. Also LÜHE (1909, p. 183) mentions *C. tuberculata* Fil., *C. papillosa* Ercol., *C. crassicauda* Ercol., *C. cucumerina* (Ercol.) *C. fulvopunctata* Ercol. from *B. tentaculata* only; *C. magna* Pagenst. has been found in the related *Paludina vivipara*. Only *C. agilis* Fil. and *C. neglecta* Fil., both, as far as I know, found only once in Italy and never later, are found in *Limnaea* species, and this is also the case with *C. fallax* Pagenst. (*Limnaea stagnalis*). On the other hand, none of my 8 Echinostomes and none of DUBOIS's 13 Echinostomes occur in *Bithynia*; almost all belong to *Limnaea* species. Of the European species, within my knowledge, only the easily recognisable *C. echinatoides* (Fil.) is known, everywhere only from a single snail, *Paludina vivipara*; and *C. Echinoparyphii recurvati* as a Redia only from *Planorbis* species: *P. corneus* (MATHIAS 1927, p. 291) and *P. umbilicatus* (mihi). The group *Virgulae* of the Xiphidiocercariae are strictly

limited to *Bithynia tentaculata* (LÜHE 1909, p. 199; DUBOIS 1929, p. 76; mihi) *C. ocellata* is everywhere found only in *Limnaea stagnalis* as the main form, rarely in *L. ovata*; *Bilharziella polonica* only in *Planorbis corneus*. In the small pond Hørsholm Pond *Limnaea* and *Planorbis* lie side by side, but nevertheless each of the two snails has its own Schistosome; all investigations in other countries corroborate the fact. The whole *vivax* group of the Furcocercariae in Europe is strictly limited to *Bithynia tentaculata*; in Egypt and Tunis it occurs in *Cleopatra bulimoides* and *Melanopsis praemorsae*. The Monostome *C. ephemera* Nitzsch is everywhere found only in *Planorbis corneus*, *C. monostomi* v. Linst. only in *Limnaea* species (DUBOIS 1929, p. 51) or *C. imbricata* Loos in *Bithynia tentaculata* (in Egypt in *Melania tuberculata* (Loos 1900, p. 193)). The Amphistome *C. diplocotylea* Fil. occurs in small *Planorbis* species, perhaps in *P. corneus*.

Especially FAUST has clearly shown in a series of very instructive papers (1924b, p. 199; 1931, p. 373; 1932, p. 350; FAUST and MELENEY 1924) that the three human species of blood-flukes utilise entirely different species of molluscs, and that the Miracidia (1924b, p. 202) may show specialised adaptations to biological peculiarities of special molluscs. Just this point is of course of the greatest significance for all nosogeographical studies, FAUST (1931, p. 373; 1932, p. 351) mentions that Korea which lies midway between Central China and Japan is free from blood flukes because the mollusc host of *S. japonicum*, members of the genus *Oncomelania*, is not found in Korea. Furthermore he states that *S. mansoni* which was introduced into the western world by the African slaves has never gained a footing in U. S. A. but only in South America and portions of the Caribbee Islands which has the genus *Planorbina* in common with the native continent of *S. mansoni*, namely Africa. Attempts to infect the subgenus *Heliosoma* of the genus *Planorbis* common in the vicinity of New Orleans had not been successful. To the absence of the right snails FAUST refers the fact that the United States has been hitherto spared by Bilharziosis.

With regard to Egypt, MANSON (1920, p. 32) maintains that wherever the *Planorbis* (the host of *S. mansoni*) is present, rectal Bilharziosis will be found, and wherever *Bulinus* (the host of *S. Haematobium*) abound, the urinary form of the disease will be the most prevalent. See also CAWSTON (1918, p. 69).

Furthermore, if we study the Cercaria fauna in some of the localities mentioned on p. 178, we shall arrive at exactly the same result.

Near the borders of the Furesø at the coast of Frederiksdal is a small ditch only about 40 m. long and 2 m. broad and in spring not more than 1 dm. deep; in summer it may be almost totally desiccated. It is filled with water-plants. In this very small water area *Planorbis umbilicatus* is abundant, whereas *P. corneus* is very rare. *P. vortex* is almost as common as *P. umbilicatus*. Of the *Limnaea* species *L. ovata* is common, *L. palustris* rather rare. I have only been able to find 30 specimens in the course of about two hours. Of *Limnaea stagnalis* only one old specimen and nine young ones were found. *Bithynia tentaculata* was only present in very few specimens; only 10 could be found.

the *Sanguinolidae* to fishes, and the *Spirorchidae* to turtles. The second group of course shows no predilection at all, and the next host in which they arrive with the food is the final one. The last group uses either one auxiliary host in which it encysts (*Echinostomatidae*, *Xiphidiocercaria*) or two, one in which it encysts and another in which it develops a new larva stage (*Tetracotyle*, *Diplostomum*) not attaining maturity before this second auxiliary host is devoured by a rapacious animal. There is some reason to believe that these species use two auxiliary hosts. In some cases this development may be curtailed, the host in which encystation takes place being the final one, but on that point investigations are greatly needed. In this connection stress need merely be laid on the fact that the first auxiliary host must be one which is eaten by a secondary one; it must belong to its regular diet if the development is to reach its final stage. As most of the animals living upon animal food have a very mixed diet, it is in good accordance with this fact that encystation may take place in animals belonging to very different parts of the main groups, to which the parasites appear to be adapted. Experiments would seem to show that Cercariae which encyst in fishes cannot encyst in molluscs or in Arthropoda etc. but on that point too investigations are highly needed.

During my own investigations in the laboratory, when I have been trying to infect other organisms not with Miracidia but with Cercariae for encystment I have always seen that either the Cercariae show complete apathy towards the organisms or the moment an animal is put into the vessel, they so to speak dart at it and, if it is not removed, cause its death in the course of some hours. Many authors have arrived at the same result.

The more the investigations appear to show that the Miracidia show predilection for species and the Cercariae for special groups of animals: snails, insects, fishes, amphibia, the more difficult it seems to understand by what means the Miracidia and Cercariae in the course of few hours reach the right host. In this connection it must in the first place be remembered that as a rule there is an enormous aggregation of animals on warm sunny days in the littoral zone of our ponds. A series of authors have tried to contribute to the solution of the question with regard to the Cercariae: WUNDER (1923 a, p. 68), FAUST and MELENEY (1924), SZIDAT (1924, p. 249), MILLER and MCCOY (1930, p. 185), MILLER (1929, p. 36), MILLER and MAHAFFY (1930, p. 95). All seem to arrive at the result that the Cercariae are not attracted chemically but by means of peculiarities in the swimming behaviour and by reactions particularly to shadowing. Thus WUNDER has shown with regard to *Cercaria intermedia* and its intermediate host (*Corethra*) that photonegative reactions bring the species in connection with each other (see p. 89). SZIDAT shows with regard to his *Cercaria C.* that it reacts to stimuli of a phototactic and geotactic nature, but not to chemical ones. The Cercaria does not seek out its host, but stands awaiting it in a "Bereitschaftsstellung"; MILLER and MCCOY show that the swimming upwards of the lophocercous *Cercaria floridensis* in response to shadow stimuli is a factor which brings them towards the surface; the

Cercariae are highly sensitive to shadows, and it was supposed that the Cercariae were activated by the shadows cast by fish swimming above them. In this way the Cercariae were brought into the immediate neighbourhood of the fish, and thus the infestation was brought about. MILLER and MAHAFFY arrived at the same result with regard to a Furcocercaria, *C. hamata*, but in addition they show that there is a dual mechanism in the response to shadow and to touch, because the Cercaria may be kept in almost continuous locomotion by touch stimuli whereas a relatively long interval must intervene between shadow stimuli to secure anything like a regular response. Perhaps it may further be permitted to call attention to a highly remarkable fact, which may be common to all organisms that pass through a complicated metamorphosis, viz. that the same species in its different stages of development, e. g. the Trematoda in their Miracidium and Cercaria stages, show very different and often opposite responses to external stimuli. The remodelling of the organism is not only a morphological but also a physiological and psychological one; but in our present stage of knowledge more cannot be said on that point.

As often stated in this work, in many cases a simplification of the development may take place.

It is especially among the *Furcocercariae* which pass a *Tetracotyle* stage and among the *Echinostomes* and *Xiphidiocercariae* that we find examples of Cercariae which encyst in the same molluscs which they entered as a Miracidium. From my own observations I feel inclined to suppose that in that case we often have to do with phenomena which are due to bad life conditions, e. g. in aquaria, or to external conditions which prevent a normal development (desiccation of ponds, low temperatures causing freezing to the bottom of the ponds). A normal development with encystation in the same species in which the Miracidium has developed into a Sporocyst I think I have only seen in the Furcocercaria *Cercaria A. Szidat* but in this case, too, normally not in the same specimen. Especially the Xiphidiocercaria normally encyst in other organisms than snails, and only use snails if they are forced to do so and have no other choice. With regard to *C. echinata* my observations from Torkeris Pond appear to show that, whereas the development of parthenitae takes place in *Limnaea stagnalis*, the encystation takes place in *Planorbis corneus*; if further investigations should show that this is correct, we should here have an example of a species which as Miracidium and as Cercaria showed a predilection for two different snails.

I suppose that it is just this phenomenon, encystation in an abnormal host or an abnormal prolongation of the sojourn in a normal host, which causes the progenesis: the phenomenon that Trematoda produce eggs in the last larva stage. I here refer the reader especially to DOLLFUS (1924, p. 305; 1929, 1932, p. 407) and to WISNIEWSKI (1933, p. 259) who describes cysts with Metacercariae and eggs in the cysts. I confess that I have searched for these phenomena without success in the many thousands of cysts which I have found in many different snails.

4. *The Economic Significance of the Interplay between Trematoda and Molluscs.*

It may be regarded as an established fact that between the mollusc fauna and fish fauna of almost every water-body, a lake, a pond or a stream, and the Trematode fauna of the given locality there is an uninterrupted interplay.

In every pond, lake or stream where molluscs and fish occur, the circulation goes on; each locality has its own; this again differs not only from century to century, but also from year to year, the amount of variation being in inverse proportion to the size of the locality; the smaller the latter is, the greater is the variation. When the continuity of the circle is broken, when a species of snails becomes extinct, when a bird species which is a common visitor disappears from the water-body, the whole circle may run the risk of being broken down.

In very many cases this interplay between molluscs and fishes touches the interests of man. Of course this is chiefly the case when man is used as the final host in which maturity is attained. This is the case for instance with the Chinese liver fluke *Clonorchis sinensis* which in certain districts near Canton and above Swatow has parasitised up to 90 or even a 100 per cent of the population, and where the infection can beyond all doubt be referred to the Chinese habit of eating raw fish; human latrines were found directly over the fish ponds (FAUST 1927 b, p. 35; FAUST and KHAW 1927, p. 147). A similar example is the infection by *Paragonimus Westermanni* in the Japanese population by the eating of crayfish infected with cysts upon the gill filaments and in all soft parts (FAUST 1930, p. 220). It is highly probably that in many cases, especially in the tropics, the native habit of eating raw fish causes infections of different kinds of which hitherto we have known little or nothing at all. See also TUBANGUI and PASCO (1933, p. 581).

In another case the interplay between molluscs and fishes enters into the human sphere of interest as causing a diminution in the production of fish meat either by producing disease or death in the stock of fish or in diminishing its value as marketable goods. —

Perhaps it was first in the aquaria that the death of fish caused by Cercariae thrown out from snails was observed as a common phenomenon (BLOCKMANN 1910, p. 47; ROTH 1904, p. 41). Later on it has often been either presumed or directly observed in nature (SZIDAT 1927 a, p. 83; SZIDAT 1927 c, p. 245; OTTERSTRØM 1915, p. 221 and others).

Without going into detail there is no doubt that in the world-wide economy of freshwater fishes the molluscs play a rôle which can hardly be overrated. I refer here especially to BAKER's very instructive paper on the relation of Molluscs to Fish in Oneida Lake (1916, p. 1). Further it must be remembered that not only may the life of the fish be threatened by Trematode attacks and now and then a general destruction of the fish in the water-body be the consequence, but the Trematoda may also be of economic significance in other respects. It may be regarded as an established fact that strong parasitic infection may produce retardation of early growth, retention of juvenile characters and an increase in the number of scales. I refer the reader

especially to the papers of HUBBS (1928, p. 75) and BAKER (1928, p. 494); the last-named author points out in addition that the fishes may be so strongly infected with cysts that they look pigmented, and as wormy and grubby have no more commercial value.

Now, since it is known that the infection of fish with Trematoda takes place precisely from Molluscs, it is no wonder that proposals have been made for the eradication of Molluscs wherever freshwater fish are subject to intensive economic output. CHANDLER (1920, p. 193).

In my opinion all proposals in this direction are just as onesided as in the long run they will prove extremely uneconomical. All who with regard to lakes and ponds wish to resort to remedies of such a radical nature have no idea of the interrelationships of the inhabitants of water-bodies, the ever-existing interplay between the organisms which, especially in localities of so restricted a nature as a lake, a pond, or a stream often is, is so finely adjusted that one link in the chain cannot be removed without running the risk of rupture and often just where we would not wish it, and where economic losses are the result. Quite apart from the danger of eradicating by means of chemicals a group of animals which enters into the food-economy of fishes, it must be remembered that the Molluscs, owing to the number of species and specimens, almost everywhere play a very great role in the common economy of the water-body; they are one of those factors which to some extent determine the amount of chalk in solution in the water; to a very great extent they determine the amount of lime deposits of the lake, they are among the most important factors with regard to destruction of the living plant material, as well as of decaying material. The bottom of our bays is in the autumn regularly covered with a grey layer of snail excrements. Quite a part from the fact that chemicals, of whatever nature they be, if they will kill the molluscs, will most probably be detrimental to numerous other organisms, especially to the vegetation, an eradication of the Molluscs in water-bodies will totally alter the character of the water. In my opinion the eradication will only be warrantable in the case of artificial fish ponds, and here we may hope to obtain a good result (BAKER 1922, p. 145).

Recent investigations have further shown that our ducks and our poultry are infected by Trematoda which they get during their sojourn in the duck-ponds or when eating insects which carry cysts of Trematoda derived from the lower freshwater fauna.

SZIDAT (1927 b, 1930 a, p. 105) has shown that the monostome *Cercaria ephemera* which develops in *Planorbis corneus* when transferred as cysts into the alimentary canal of our ducks in the appendices of the birds develops into *Catantropis verrucosa*. It lives here in company with species of the nearly related genus *Notocotylus*.

SZIDAT (1927 b, 1929 b, p. 78) has further shown that all the observed specimens of *Anas crecca* and *Anas boschas* from Kurische Nehrung were infected with *Bilharziella polonica* and that the ducks also harboured the parasite in great numbers. In both cases SZIDAT maintains that little harm seems to be done by the parasite.

Of the *Echinostomes* *Hypoderaeum conoideum* seems normally to parasitise our ducks (NØLLER und WAGNER 1923, p. 463), *Echinoparyphium recurvatum* (v. LINST.); ducks and fowls (BITTNER 1925, p. 82).

Another duck parasite is the Holostome *Apatemon gracile* belonging to the subfamily *Strigeinae*, which develops from *Tetracotyle* developing in the intermediate host, the Hirudinea: *Herpobdella atomaria* (SZIDAT 1931b, p. 160). Real damage is caused by the *Prosthogonimus pellucidus* which is found in the oviduct of our poultry and makes the fowls lay wind-eggs. Already WELTNER (1896, p. 199) found cysts in *Libellulidae*. HIERONYMI and SZIDAT (1921); SEIFERT (1923, p. 541; 1924, p. 75); DE BLIECK and HEELSBERGER (1923, p. 13); BITTNER (1923, p. 503 and 1927, p. 213) and OTTE (1926, p. 444) described the disease, but it was SZIDAT (1928c, 1931a, p. 289), who showed that the fowls were affected after eating either the larvae or the newly hatched *Libellulidae* (*Cordulia aenea*). In the pond 74 of 100 larvae contained cysts. There is no doubt that in this parasite we have a foe to our poultry whose influence cannot be overrated.

As far as I know, investigations on the Trematode-infected ducks and poultry have not been carried out in our country; we have only accounts according to which ducks get sick when put into certain ponds; furthermore when some of a flock are brought to the ponds and others kept away from it, the former will be affected, the latter not. A closer examination, in our country also, would undoubtedly be desirable.

LIST OF LITERATURE

Papers marked *) have not been seen.

1790. ABILDGAARD, P. C.: Almindelige Betragtninger over Indvolde-Orme. Skrif. af Naturh. Selskab. **1**, p. 1. København.
1924. AGGERSBORG, H. P. K.: Studies on the Effects of Parasitism upon the Tissues. I. With special reference to certain gastropod molluscs. Quart. Journ. Micr. Sci. **68**, p. 361.
1930. ALSTERBERG, G.: Wichtige Züge in der Biologie der Süßwassergastropoden. Lund.
1932. AMEEL, D. J.: Life History of the North-American Lung Fluke of Mammals. Journ. of Parasitology, p. 264.
1927. ASHWORTH, A. W. and BANNERMAN, I. C. W.: On a Tetracotyle (*T. phoxini*) in the Brain of the Minnow. Trans. Roy. Soc. Edinb. **55**, p. 159.
1827. BAER, K. E. v.: Beiträge zur Kenntniss der niederen Tiere. Nov. acta Acad. Caes. Leopold-Carol **13**, p. 524.
1916. BAKER, F. C.: The Relation of Mollusks to Fish in Oneida Lake. Technical publication No. 4. The New York State College of Forestry at Syracuse University.
1922. — Fluke Infections and the Destruction of the Intermediate Host. Journ. of Parasit. **8**, p. 145.
1928. — The Freshwater Mollusca of Wisconsin. Wisc. Geol. and Nat. Hist. Survey, Bull. 70, pt. I, p. 494.
1929. BEAVER, P. C.: Studies on the Development of *Allosostoma parvum* Stunkard. Journ. Parasit. **16**, p. 13.
1923. BITTNER, H.: Hühnerenzootien durch Trematoden der Gattung *Prosthogonimus*. Berl. tierärztl. Wochenschr. **39**, p. 503.
1925. — Ein Beitrag zur Uebertragung und zur Morphologie von *Echinoparyphium recurvatum*. Berl. tierärztl. Wochenschr. **41**, p. 82.
1927. — Parasitologische Beobachtungen. Zeitschr. f. Infektionskrankh. **30**, p. 213.
1923. DE BLIECK, S. und T. VAN HEELSBERGEN: Trematoden als Ursache einer Entzündung des Eileiters und der Windeier. Deutsche tierärztl. Wochenschr. **31**, p. 13.
1910. BLOCHMANN, F.: Sterben von Aquarienfischen durch Einwanderung von *Cercaria fissicauda* La Val. Centralbl. f. Bakt. und Parasitenk. I. Abth. Orig. **56**, p. 47.
1886. BOAS, J. E. V.: Leveriktens Livshistorie. Tidsskr. f. Landøkonomi.
1931. BOVIEN, P.: Notes on the Cercaria of the Liver fluke. Vidensk. Medd. Nat. For. **92**, p. 223.
1921. BOYD, M.: A possible Intermediate Host of *Fasciola hepatica* L. in North America. Journ. of Parasit. **7**, p. 39.
1890. BRANDES, G.: Die Familie der Holostomiden. Zool. Jahrb. Syst. **5**, p. 1, p. 549.
1891. BRAUN, M.: Ueber die sogenannte "freischwimmende Sporocyste". Centralbl. f. Bakter. **10**, p. 215.
1892. — Trematoda in Bronn: Klassen und Ordnungen des Tierreichs.

- 1894 a. BRAUN, M.: Zur Entwicklungsgeschichte der Holostomiden. Nach den Untersuchungen des Herrn A. und O. Ehrhard mitgeteilt. Zool. Anz. **17**, p. 165.
- 1894 b. — Helminthologische Notizen IV. Zur Entwicklungsgeschichte der Holostomiden. Centralbl. f. Bakt. und Parasitenk. **15**, p. 680.
1898. BROCKMEIER, H.: Die Lebensweise der *Limnaea truncatula*. Forschungsber. Plön. **6**, p. 153.
1930. BROOKS, F. G.: Studies on the Germ Cell Cycle of Trematodes. Amer. Journ. of Hygiene. **12**, p. 299.
1899. BROWN, A. W.: On *Tetracotyle petromyzontis* a parasite of the brain of *Ammocoetes*. Quart. Journ. Micr. Sci. **41**, p. 489.
1926. BROWN, F. J.: Some Freshwater Larval Trematodes with Contributions to their Life-histories. Parasitology **18**, p. 21.
1931. — Some Freshwater Larval Trematodes from Cheshire. Parasitology **23**, p. 88.
1922. BRUMPT, E.: Nouveau traité de Médecine. Fasc. V. Les Bilharzioses, p. 513.
- 1929 a. — Cycle évolutif du *Schistosoma bovis* (= *Bilharzia crassa*) infection spontanée du *Bullinus contortus* en Corse. Compt. rend. **189**, p. 879.
- 1929 b. — Particularités évolutives peu connues des cercaires d'amphistomides. Annales de Parasitologie. **7**, p. 262.
- 1930 a. — La ponte des Schistosomes. Ann. de Parasitologie. **8**, p. 263.
- 1930 b. — Cycle évolutif complet de *Schistosoma bovis*. Infection naturelle en Corse et infection expérimentale de *Bullinus contortus*. Ann. de Parasitologie. **8**, p. 17.
- 1931 a. — *Cercaria ocellata* déterminant la dermatite des nageurs provient d'une bilharzie des Canard. Compt. rend. **193**, p. 612.
- 1931 b. — Prurit et dermatitis produits chez les nageurs par les cercaires de mollusques d'eau douce. Compt. rend. **193**, p. 253.
1920. BUTLER, E. P.: Notes on the Presence of Larval Trematodes in the Eyes of Certain Fishes of Douglas-Lake, Michigan. 21st ann. Rep. Michigan Acad. Sc., p. 116.
1918. CAWSTON, F. G.: The Possible Intermediate Hosts of *Schistosoma* in South Africa. Journ. Trop. Med. Hyg. **21**, p. 69.
1920. — Some Infections due to Freshwater Snails and their Eradication. Journ. Trop. Med and Hyg. **23**, p. 274.
1924. — Distribution of Snails Serving as Intermediate Hosts of Flukes in South Africa. Parasitology **16**, p. 67.
- 1920.*) CHANDLER, ASA C.: Control of Fluke Diseases by Destruction of the Intermediate Host. Journ. Agric. Research. **20**, p. 193.
1931. CHATTERJI, R.: Preliminary Observations on the Life-history of an Amphistome Cercaria *Cercaria Indica* XXVI Sewell 1922. Zool. Anz. **95**, p. 177.
- 1928.*) CHRISTENSON, R. O. and GREEN, W. P.: Studies on Biological and Medical Aspects of Swimmers Itch. Schistosome Dermatitis in Minnesota. Minnesota Med., p. 573.
- 1927 a. CIUREA, J.: Sur une nouvelle *Proalaria* et sa métacercaire. Bull. sci. Acad. Roum. **11**, p. 9.
- 1927 b. — Contributions à l'étude morphologique de *Strigea cornu* (Rud.). Bull. sci. Acad. Roum. **11**, p. 12. Bucarest.
- 1915 a. CORT, W. W.: Some North-American Larval Trematodes. Illinois Biol. Monographs. I, No. 4.
- 1915 b. — Larval Trematodes from North American Freshwater Snails. Journ. of Parasitology. **1**, p. 65.
- 1915 c. — North American Froglung flukes. Transact. Amer. Micr. Soc. **34**, p. 203.
1916. — Egg variation in a Trematode Species. Journ. of Parasit. **2**, p. 25.
- 1918 a. — Homologies of the Excretory System of the Fork-tailed Cercaria. Journ. of Parasit. **4**, p. 49.
- 1918 b. — Methods for Studying Living Trematodes. Transact. Amer. Micr. Soc. **38**, p. 129.

- 1918c. CORT, W. W.: The Excretory System of *Agamodistomum marcianæ* (la Rue); the Agamodistome stage of a forked-tailed Cercaria. Journ. of Parasitology. **4**, p. 130.
- 1918d. — Adaptability of Schistosome Larvæ to New Hosts. Journ. of Parasitology. **4**, p. 170.
- 1919a. — The Excretory System of a Stylet Cercaria. Univ. Calif. Publ. Zool. **19**, p. 275.
- 1919b. — The Cercaria of the Japanese Blood fluke *Schistosoma japonicum* Katsudara. Univ. Calif. Publ. Zool. **18**, p. 485.
- 1921a. — Sex in the Trematode family *Schistosomatidæ*. Science N. S. **53**, p. 226.
- 1921b. — The Development of the Japanese Blood fluke *Schistosoma japonicum* Katsudara. Amer. Journ. Hyg. **1**, p. 1.
1922. — A Study of the Escape of Cercariæ from their Snail hosts. Journ. of Parasit. **8**, p. 177.
- 1928a. — Schistosome Dermatitis in the U. S. (Michigan). Journ. Amer. Med. Ass. **90**, p. 1027.
- 1928b. — Further Observations on Schistosome Dermatitis in the United States. Science. **68**, p. 388.
- 1928c. — and BROOKS, S. P.: Studies on the Holostome Cercariæ from Douglas Lake, Michigan. Transact. Amer. Micr. Soc. **47**, p. 179.
1913. DOLLFUS, R.: *Cercaria pachysera* Dies. et les cercaires à queue dite en moignon. IX. Congrès Intern. de Zool., p. 683.
1919. — Continuité de la ligne des cellules germinales chez les Trématodes Digenea. Compt. rend. **168**, p. 124.
1924. — Polyxénie et Progénèse de la larve métacercaire de *Pleurogenes medians* Olsson. Compt. rend. Acad. Sci. **179**, p. 305.
1929. — Exerte-t-il des cycles évolutifs abrégés chez les Trématodes digénétiqes? Ann. de Parasit. **7**.
1932. — Métacercaire progénétique chez un Planorbe. Ann. de Parasit. **10**, p. 407.
1929. DUBOIS, G.: Les cercaires de la région de Neuchâtel. Bull. de la Soc. Neuchâteloise des Sciences natur. **53**, p. 1. 1928.
1926. EJSMONT, L.: Morphologische, systematische und entwicklungsgeschichtliche Untersuchungen an Arten des Genus *Sanguinicola* Plehn. Bull. de l'Acad. Polonaise. Cracow. Cl. Sc. math. et Nat., p. 877.
1932. ENIGK, K.: *Leucochloridium paradoxum* in *Succinea oblonga*. Sitzungsber. d. Gesellsch. naturf. Freunde, p. 443.
1881. ERCOLANI, G.: Dell adattamento della speciall'ambiente. Nuove ricerche sulla storia genetica dei Trematodi. Mémoires Ac. Bologna. II, p. 239—334.
- 1917a. FAUST, E. C.: Life History studies on Montana Trematodes. Illinois Biol. Monographs. **4**, p. 1—120.
- 1917b. — Notes on the Cercariæ of the Bitter Root Valley Montana. Journ. of Parasit. **3**, p. 105.
- 1918a. — Studies on Illinois Cercariæ. Journ. of Parasit. **4**, p. 93.
- 1918b. — Two New Cystocercous Cercariæ from North America. Journ. of Parasit. **4**, p. 148.
- 1918c. — Eye-spots in Digena. Biological Bulletin. **35**, p. 117.
- 1919a. — The Excretory System in Digenea. Biol. Bulletin **36**, I, p. 315; II, p. 322; III, p. 340.
- 1919b. — Notes on South African Cercariæ. Journ. of Parasit. Urbana **5**, p. 164.
- 1919c. — The Anatomy of *Tetracotyle iturbei* Faust with a Synopsis of Described Tetracotyliform Larva. Journ. of Parasit. **5**, p. 69.
- ? — The Oriental Blood fluke in China. The China Journal of Science and Arts.
- 1920a. — Pathological Changes in the Gasteropod Liver Produced by Fluke Infection. The John Hopkins Hospital Bulletin. **31**, p. 78.
- 1920b. — Criteria for the Differentiation of Schistosome Larvæ. Journ. of Parasit. **6**, p. 192.
1921. — The Excretory System in Digenea. IV. A study of the Structure and Development of the Excretory System in a Cystocercous Larva *Cercaria Pekinensis* n. sp. Parasitology. **13**, p. 205.

- 1922a. FAUST, E. C.: Notes on South African Larval Trematodes. Journ. of Parasit. **8**, p. 11.
- 1922b. — Phases in the Life History of a Holostome *Cyathocotyle orientalis* n. sp. with Notes on the Excretory System of the Larva. Journ. of Parasit. **8**, p. 78.
- 1924a. — What Constitutes a Justifiable Basis for Systematic Grouping of Larval Trematodes. Journ. Parasit. Urbana. **11**, p. 112.
- 1924b. — The Reactions of the Miracidia of *Schistosoma Japonicum* and *haematobium* in the presence of their Intermediate Hosts. Journ. of Parasit. **10**, p. 199.
1926. — Further Observations on South African Larval Trematodes. Parasitology. **18**, p. 101.
- 1927a. — Unisexual Schistosome Infections in Naturally and Experimentally Infected Hosts. Anat. Rev., p. 169.
- 1927b. — Freshwater Fish as a Source of Human Parasitic Infection. The China Journal. **6**, p. 35.
1930. — Human Helminthology. Philadelphia.
1931. — The Nosogeography of Parasites and their Hosts. Porto Rico Journal of Public Health and Tropical Medicine. **6**, p. 373.
1932. — The Role of Aquatic Molluscs in the Spread of Human Trematode Infections. The China Journal. **16**, p. 350.
1924. — and MELENEY: Studies on Schistosomiasis Japonica. II. The Biology, Morphology and Life History of the Causative Organism *Schistosoma japonicum* Katsudara. Amer. Journ. Hyg. Monogr. Ser. 3.
1927. — and OO-KEH KHAW: Studies on *Clonorchis sinensis* (Cobbold). The American Journal of Hygiene. No. 8, p. 1.
- 1916.*) FEHLMANN, J. W.: Eine unangenehme Beobachtung. Schweiz. Fisch. Zeit. **23**, p. 68. (?)
1854. FILIPPI, F. DE: Mémoire pour servir à l'histoire génétique des Trématodes. Mém. Roy. Acc. Sc. Torino. **15**, p. 331.
1855. — Deuxième mémoire pour servir à l'histoire génétique des Trématodes. Mém. R. Acc. Sc. Torino. **16**, p. 419.
1859. — Troisième mémoire pour servir à l'histoire génétique des Trématodes. Mém. R. Acc. Sc. Torino. **18**, p. 201.
1880. FRAYPONT, J.: Recherches sur l'appareil excréteur des trématodes et des cestodes. Archives de Biologie. **1**, p. 415.
1916. FUHRMANN, O.: Notes helminthologiques suisses. Revue Suisse. **24**, p. 390.
1928. — Trematoda. Handbuch der Zoologie.
1929. FUKUI, T.: Studies on Japanese Amphistomatous Parasites with Revision of the Group. Japanese Journal of Zoology. **2**, p. 219.
1922. FÜLLEBORN: Ueber "*Cercaria armata*" und Mückenlarven. Archiv f. Schiffs- und Tropenhygiene. **26**, p. 78.
- 1910.*) GILCHRIST, J. D. F.: The Intermediate Host of the Liver Fluke *Distoma (Fasciola) hepatica* in South Africa. Agric. Journ. Cape Good Hope. **37**, p. 658.
1933. GISLÉN, T.: Om *Leucochloridium* och dess förekomst i Sverige. Fauna och Flora, p. 151.
1932. GWENDOLEN REES, F.: An Investigation into the Occurrence and Life-History of the Trematode-Parasites. Proceed. Zool. Soc. London, p. 1.
1929. HAITSMA, J. P. VAN: Studies on the Trematode-family *Strigeidae (Holostomidae)*. XXI. Life Cycle and Description of the Cercaria of *Cotylurus Michiganensis* (La Rue). Journ. of Parasitology. **16**, p. 224.
1930. — Studies on the Trematode-Family *Strigeidae (Holostomidae)*. 20. *Paradiplostomum ptychocheilus* (Faust). Transact. Amer. Micr. Soc. **49**, p. 140.
1931. — Studies on the Trematode-Family *Strigeidae (Holostomidae)*. XXII. *Cotylurus flabelliformis* (Faust) and its life-history. Pap. Mich. Acad. Sc. **13**, p. 447.

1864. HANNOVER, A.: Iagttagelser over indkapslede Indvoldsorme hos Frøen. Kgl. danske Vidensk. Skr. 5. R. VII, p. 13.
1929. HARPER, W. F.: On the Structure and Life-Histories of British Freshwater-larval Trematodes. *Parasitology*. **21**, p. 189.
1931. — On the Structure and Life-History of British Fresh-water Furcocercariæ. *Parasitology*. **23**, p. 310.
1932. — On some British Larval Trematodes from Terrestrial Hosts. *Parasitology*. **24**, p. 307.
1931. HENKEL, H.: Untersuchungen zur Ermittlung der Zwischenwirte von *Dicrocoelium lanceolatum*. *Zeit. f. Parasitenk.* **3**, p. 664.
1921. HIERONYMI, E. und SZIDAT, L.: Ueber eine neue Hühnerenzootie, bedingt durch *Prosthogonimus intercalandus* n. sp. *Zentralbl. f. Bakter. I Orig.* **86**, p. 236.
1899. HOFFMANN, K.: Beiträge zur Kenntniss der Entwicklung von *Distomum leptostomum* Olsson. *Dissert. Rostock*. **12**, Syst. p. 175.
1920. HOLLANDE, A. CH.: Réactions des tissus du *Dytiscus marginalis* L. au contact des larves de Distome encystées aux parois du tube digestif de l'Insecte. *Arch. Zool. expér.* **19**, p. 543.
1928. HUBBS, C. L.: The related Effects of a parasite on a Fish. *Journ. of Parasit.* **14**, p. 75.
- 1928a. HUGHES, R. C.: Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 7. *Tetracotyle pipiensis* Faust. *Transact. of the Amer. Micr. Soc.* **47**.
- 1928b. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 9. *Neascus van Cleavei* (Agersborg). *Transact. Amer. Micr. Soc.* **47**, p. 320.
- 1928c. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 10. *Neascus bulboglossa* (van Haitsma). *Journ. of Parasit.* **15**, p. 52.
- 1928d. — and PISZCEK, F. R.: Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 11. *Neascus ptychocheilus* (Faust). *Journ. of Parasit.* **15**, p. 58.
- 1928e. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 13. Three species of *Tetracotyle*. *Transact. Amer. Micr. Soc.* **47**, p. 414.
- 1928f. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). *Tetracotyle flabelliformis* Faust. *Michigan Acad. of Sci., Arts and Lettr.* **10**, p. 495.
1928. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 12. *Agamodistomum La Ruei* n. sp. *Parasitology*. **20**, p. 413.
- 1928g. — and BERKHOUT, R.: Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 15. *Diplostomulum gigas* sp. nov. *Michigan Acad. of Sc.* **10**, 1929, p. 483.
- 1929a. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 14. Two New Species of *Diplostomula*. *Occas. Papers of the Museum of Zoology, Michigan, No. 202*, p. 1.
- 1929b. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 18. *Tetracotyle serpentis* sp. nov. *Transact. Amer. Micr. Soc.* **48**, p. 12.
- 1929c. — Studies on the Trematode Family *Strigeidae* (*Holostomidae*). 19. *Diplostomulum scheuringi* sp. nov. and *D. vegrandis* la Rue. *Journ. of Parasit.* **15**, p. 267.
1929. HUNTER, W. S.: A new Strigeid Larva *Neascus Wardi*. *Journ. of Parasit.* **15**, p. 104.
1927. HURST, C.: Structural and Functional Changes Produced in the Gastropod Mollusc *Physa occidentalis* in the Case of Parasitism by the Larvæ of *Echinostoma revolutum*. *Calif. Publ. Zoology*. **29**, p. 321.
- 1918.*) ITURBE, J. et GONZALEZ, E.: Quelques observations sur les cercaires de la vallée de Caracas. 1 Laboratorio Iturbe.
1914. JOHNSON, S. J.: Trematode Parasites and the Relationships and Distribution of their Hosts. *Rep. 14th Meet. Austral. Ass. Adv. Sc.*, p. 272.
1920. JOHNSON, J.: The Life-cycle of *Echinostoma revolutum*. *Univ. of Calif. Publ. Zoology*. **19**, p. 335.
- 1920.*) JOYEUX, C.: Enkystement d'une Cercaire du type *Cercaria armata* chez un Turbellarié d'eau douce. *Bull. de la Soc. de Pathol. Exotique*. **13**, p. 182.

1878. KERBERT, C.: Zur Trematoden-Kenntniss. Zool. Anz. **1**, p. 271.
- 1918—1921. *) KOBAYASHI, H.: Studies on the Lung-fluke in Korea I—III. Mitt. Med. Hochsch. z. Keifo. **5**, p. 97, p. 1, p. 5.
1922. *) — A Review of Japanese Cercariae. Mitteil. mediz. Acad. zu Keifo. **27**.
1930. KORKHAUS, R.: Mitteilung über Befall von Leberegelschnecken mit Tetracotyle-larven und monostomen Cercarien. Sitzungsber. Ges. nat. Fr. Berlin 1929, p. 268.
1893. KOWALEWSKI, M.: Studya helminthologiczne. III. *Bilharzia polonica* n. sp. Rozpraw Wyzd. mat.-przys. Akad. Umiej. Krakowie. (1) **31**, p. 1.
1896. — Etudes helminthologiques. IV. Amendments et suppléments au travail de l'auteur sur le *Bilharzia polonica* sp. n. Bull. acad. sci. Cracovie, p. 146.
1846. KRÖYER, H.: Danmarks Fisk. København.
1931. KRULL, W. H.: Importance of Laboratory-raised Snails in Helminthology with Life history notes on *Gyraulius parvus*. Occasional Papers of the Museum of Zoology. Ann. Arbor. Michigan. N. 226, p. 1.
1932. — and PRICE, H. F.: Studies on the Life History of *Diplodiscus temperatus* Stafford from the Frog. Occasional Papers of the Museum of Zoology. Ann. Arbor. Michigan. N. 237, p. 1.
1892. LANG, A.: Ueber die Cercarie von *Amphistomum subclavatum*. Berichte der Naturf. Gesellsch. Freiburg. **6**, p. 81.
1924. LANGERON: Recherches sur les cercaires des piscines de Gafsa et enquête sur la *Bilharzia tunisienne*. Archives de l'Institut Pasteur. Tunis **13**, p. 19.
1912. LEBOUR, M. V.: A Review of the British Marine Cercariae. Parasitology. **4**, p. 416.
1914. — Some Larval Trematodes from Millport. Parasitology. **7**, p. 1.
1882. LEUCKART, R.: Zur Entwicklungsgeschichte des Leberegels. Archiv f. Naturges. **48**, p. 80.
- 1886—1901. — Die menschlichen Parasiten. Leipzig.
1876. LINSTOW, O. v.: Helminthologische Beobachtungen. Archiv f. Naturg. **42**, p. 1.
- 1877a. — Enthelminthologica. Archiv f. Naturg. **43**, p. 173.
- 1877b. — Helminthologische Untersuchungen. Zoolog. Jahrb. Syst. **3**, p. 97.
1884. — Helminthologisches. Archiv f. Naturg. **50**, I, p. 125.
1896. — Helminthologische Mittheilungen. Archiv f. mikr. Anat. **48**, p. 375.
1885. Loos, A.: Beiträge zur Kenntniss der Trematoden. Zeit. f. wiss. Zool. **41**, p. 390.
1892. — Ueber *Amphistomum subclavatum* Rud. und seine Entwicklung. Festschr. f. Leuckart, p. 147.
1894. — Die Distomen unserer Fische und Frösche. Stuttgart.
1899. — Weitere Beiträge zur Kenntniss der Trematoden-Fauna Egyptens. Zool. Jahrb. Syst. **12**, p. 521.
1900. — Recherches sur la faune parasitaire de l'Égypte. I. Mémoires présentés à l'Institut Égyptien. **3**, p. 1.
1912. — Ueber den Bau einiger anscheinend seltener Trematoden Arten. Zool. Jahrb. Suppl. **15**, p. 323.
1892. LUTZ, A.: Zur Lebensgeschichte des *Distoma hepaticum*. Centralbl. f. Bact. u. Parasitenk. **11**, p. 783. **13**, p. 320.
1893. — Weiteres zur Lebensgeschichte des *Distoma hepaticum*. Zentralbl. f. Bakt. u. Parasitenk. **13**, p. 320.
- 1921a. — Zur Kenntniss des Entwicklungszyclus des Holostomiden. Centralbl. f. Bakt. u. Parasitenk. **86**.
- 1921b. — *Schistosomum Mansoni* and Schistosomatosis observed in Brazil. Memorias do Instituto Oswaldo Cruz. **11**, p. 109.
1924. — Untersuchungen über die Entwicklungsgeschichte brasilianischer Trematoden. Spec. Th. I. Echinostomidæ. Memorias do Instituto Oswaldo Cruz. **17**, p. 55.
1929. — Nova contribuiçã o para o contre cimento do cyclo evolutivo das Holostomideas ou Strigeidas. Instituto Oswaldo Cruz. Suppl. das Memorias No. **8**, p. 131.

1931. LUTZ, A.: Beitrag zur Kenntnis der Ontogenie der Strigeiden. *Memorias do Instituto Oswaldo Cruz.* **25**, p. 343.
1909. LÜHE, M.: Parasitische Plattwürmer in: Die Süßwasserfauna Deutschlands.
1923. McCORMIC, R. N.: The comparative parasitation of certain freshwater snails. *Ohio Journ. Sci.* **23**, p. 163.
- 1926.*) MCCOY, A. C.: A Note on the Intermediate Host or Hosts of *Fasciola hepatica* in New South Wales. *Med. Journ. Australia*, p. 1.
- 1928a. MCCOY, O. R.: Life History Studies on Trematodes from Missouri. *Journ. of Parasit.* **14**, p. 207.
- 1928b. — Seasonal Fluctuation in the Infestation of *Planorbis trivolvis* with Larval Trematodes. *Journ. of Parasit.* **15**, p. 121.
1929. — Notes on Cercariæ from Missouri. *Journ. of Parasit.* **15**, p. 199.
1932. McINTOSH, A.: Some new Species of Trematode Worms of the Genus *Leucochloridium* *Parasitology.* **19**, p. 32.
1920. MANSON, BÄHR PH.: Observations on Bilharziosis amongst the Egyptian Expeditionary force. *Parasitology.* **12**, p. 32.
1927. MAREK, J.: Neuere Beiträge zur Kenntnis der Leberegelkrankheit. *Deutsche tierärztl. Wochenschr.* **35**, p. 513.
1910. MATARÉ, F.: Ueber eine neue Tetracotyle im Hirn von *Phoxinus levis*. *Zeitschr. f. wiss. Zool.* **94**.
1930. MATHESON, C.: Notes on *Cercaria elvæ* Miller as the Probable Cause of an Outbreak of Dermatitis at Cardiff. *Transact. Royal Soc. of Tropical Med. and Hygiene.* **23**, p. 421.
1922. MATHIAS, P.: Cycle évolutif d'un Trématode holostomide (*Strigea tarda* Stp.). *Compt. rend. Acad. Sci. Paris.* **175**.
- 1924a. — Sur le cycle évolutif d'un trématode de la famille des *Psilostomidæ* (*Psilotrema spiculigerum*). *Compt. rend.*, p. 1217.
- 1924b. — Cycle évolutif d'un Trématode echinostome (*Hypoderæum conoideum* Bloch). *Compt. rend. des sciences de la Soc. Biol.* **110**, p. 13.
- 1924c. — Contribution à l'étude du cycle évolutif d'un Trematode de la fam. des *Pleurogenetinae* Sz. (*Pleurogenes medians* Olss.). *Bull. de la Soc. Zool. de France.* **49**, p. 375.
1925. — Recherches expérimentales sur le cycle évolutif de quelques Trématodes. *Bull. Biol. de la France et de la Belgique.* **59**, p. 1.
1926. — Sur le cycle évolutif d'un Trématode de la famille des *Echinostomidæ* (Dietz.) *Echinoparyphium recurvatum* Linstow. *Compt. rend.*
1927. — Cycle évolutif d'un Trématode de la famille des *Echinostomidæ*. (*Echinoparyphium recurvatum* Linstow). *Ann. d. sci. nat. Bot. et Zool. Ser. X. T. 10*, p. 289.
- 1930a. — Sur le cycle évolutif d'un Trématode de la famille des *Notocotylidæ* Lühe (*Notocotylus attenuatus* Rud.). *Compt. rend.*, p. 75.
- 1930b. — Sur *Cercaria ocellata* La Valette. *Ann. de Parasitologie.* **8**, p. 151.
1926. MATTES, O.: Zur Biologie der Larvenentwicklung von *Fasciola hepatica*, besonders über den Einfluss der Wasserstoffionenkonzentration auf das Ausschlüpfen der Miracidien. *Zool. Anz.* **69**, p. 138.
1929. — Bau und Verhalten der Entwicklungsstadien von *Fasciola hepatica* im Zwischenwirt *Limnæa truncatula* an Hand von Präparaten die durch künstliche Infektion gewonnen wurden. *Verh. Deutsche Zool. Ges. Zool. Anz. Supp. 4.* **33**, p. 266.
1933. — Experimentelle Untersuchungen über die Zwischenwirtsfrage von *Dicrocoelium lanceatum*. *Verh. d. Deutschen Zool. Ges.*, p. 227.
1931. MEHL, S.: Die Lebensbedingungen der Leberegelschnecke. *Arbeiten a. d. Bayer.-Landesanstalt für Pflanzenbau und Pflanzenschutz.*
1923. MILLER, H. M.: Notes on some Furcocercous Larval Trematodes. *Journ. Parasit.* **10**, p. 35.

1924. MILLER, H. M.: Studies on Furcocercous Cercariæ. 1. *Cercaria douthitti* Cort and *Cercaria echinocauda* O'Roke. Trans. Amer. Micr. Soc. **43**, p. 145.
1926. — Comparative Studies on Furcocercous Cercariæ. Illinois Biological Monographs. **10**, p. 1.
1927. — Furcocercous Larval Trematodes from San Juan Island. Washington Parasitology. **19**, p. 61.
1928. — Variety of Behavior of Larval Trematodes. Science N. S. **68**, p. 117.
1929. — Behavior and Reactions of a Larval Trematode especially to Changes of Light-Intensity. Anat. Rec. **41**, p. 36.
1926. — and NORTHUP, F.: The Seasonal Infestation of *Nassa obsoleta* (Say) with Larval Trematodes. Biol. Bull. **5**, p. 490.
1930. — and MCCOY, O. R.: An Experimental Study of the Behavior of *Cercaria floridensis* in Relation to its Fish Intermediate Host. Journ. of Parasit. **16**, p. 185.
1930. — and MAHAFFY, E.: Reactions of *Cercaria hamata* to Light and Mechanical Stimuli. Biol. Bull. Woods Hole. **59**, p. 95.
1913. MIYAGAWA, J.: Beziehungen zwischen *Schistosomiasis japonica* und der Dermatitis. Zentralbl. f. Bakter. u. Parasitenk. I. Orig. **69**, p. 132.
1893. MONTICELLI, F. S.: Studii sui Trematodi endoparassiti. Zool. Jahrb. Suppl. III.
1928. MONTGOMERI, R. F.: Observations on Artificial Infestation of Sheep with *Fasciola hepatica* and on a Phase in the Development of the parasite. Journ. of Helminth. **6**, p. 167.
1856. MOULINIÉ, J.: De la reproduction chez les Trématodes endoparasites. Mém. de l'Institut Génévois. **3**, p. 1.
- 1788—1806. MÜLLER, O. F.: Zoologia Danica. Vol. IV.
1923. NAEGELI: Ueber einen beim Baden entstehenden Hautausschlag, die sogenannte Hausblattern. Schweiz. med. Wochenschr., p. 1121—1122.
- 1907.*) NITZSCH, C.: Seltsame Lebens- und Todesart eines bisher unbekanntes Wassertierchens. Kilian, Georgia 257. — Cited after Braun.
1816. NITZSCH, C. L.: Beitrag zur Infusorienkunde der Naturbeschreibung der Zerkarien und Bazillarien. Neue Schr. Nat. Ges. Halle (1) 3.
1933. NOLF, L. and CORT, W.: Our Immunity Reactions of Snails to the Penetration of the Cercariæ of the Strigeid Trematode: *Cotylurus flabelliformis* (Faust). Journ. of Parasit. **20**, p. 38.
1832. NORDMANN, A. v.: Micrographische Beiträge zur Naturges. der wirbellosen Thiere. I.
1924. NÖLLER, W.: Die Entwicklung des Leberegels bis zur Zerkarie in *L. stagnalis*. Berl. tierärztl. Wochenschr. **40**, p. 369.
1925. — Die Leberfaule unserer Haustiere. Jena.
1928. — Über die Leberegelkrankheit unserer Haustiere. Flugblätter d. Deutschen Landwirtschafts-Gesellschaft. No. 97, p. 1.
1923. — und WAGNER, O.: Der Wasserfrosch als zweiter Zwischenwirt einer Trematoden von Ente und Huhn. Berl. tierärztl. Wochenschr. **39**, p. 463.
1924. — und SPREHN, C.: Die Entwicklung des Leberegels bis zur Zerkarie in *Limnaea stagnalis*. Berl. tierärztl. Wochenschr. **40**, p. 369.
1925. — und SPREHN, C.: Das Verhalten von Mirazidien des Leberegels *Fasciola hepatica* in *Limnaea palustris*. Deutsche tierärztl. Wochenschr. **33**, p. 611.
- 1927a. — und ULLRICH, K.: Die Entwicklung einer *Plagiorchis*-Art (Ein Beitrag zur Kenntniss der *Cercariæ armatae*. Sitz. Ber. naturf. Freunde. Berlin 1927, p. 81.
- 1927b. — und ULLRICH, K.: Ueber den Befallsgrad der Leberegelschnecken mit Redien und Cerkarien des gemeinen Leberegels in einem Leberegelschadegebiete. Tierärztl. Rundschau. **33**, p. 789.
1928. — und KONČEK: Die äusseren morphologischen Veränderungen der Leberegelcysten bei der Trocknung. Sitzungsber. naturf. Freunde. Berlin 1927, p. 154.

1928. NÖLLER, W. und SCHMID, F.: Neuere über die Invasionsweise und Invasionszeit bei der Leber-egel Erkrankung. Sitz. Ber. Ges. naturf. Freunde. Berlin 1927, p. 96.
1929. — und SCHMID, F.: Zur Frage der Ansteckungsfähigkeit des Heues von Leberegelweiden. Tierärztl. Rundschau. **35**, p. 327.
1932. — und ENIGK, K.: Weitere Cercarienbefunde bei Landschnecken. Sitzungsber. naturf. Freunde. Berlin, p. 424.
1907. ODHNER, T.: Zur Anatomie der Didymozoen. Zoologiska Studier tillägnade Professor Tullberg. Uppsala.
- 1911a. — *Sanguinicola* M. Plehn — ein digenetischer Trematode. Zool. Anz. **38**, p. 33.
- 1911b. — Zum natürlichen System der digenen Trematoden. I. Zool. Anz. **37**, p. 181.
- 1911c. — Zum natürlichen System der digenen Trematoden. IV. Zool. Anz. **38**, p. 513.
- 1913a. — Zum natürlichen System der digenen Trematoden. V. Zool. Anz. **41**, p. 54.
- 1913b. — Zum natürlichen System der digenen Trematoden. VI. Die Abteilung der Holostomiden und die Homologien ihrer Haftapparate. Zool. Anz. **42**, p. 289.
1924. — Remarks on *Sanguinicola*. Quart. Journ. of Micr. Sci. **5**.
1925. ORTH, O. und SPREHN, C.: Einiges zur Leberegelseuche. Münch. tierärztl. Wochenschr. **76**, p. 1021.
1926. OTTE, W.: Betrachtungen über Geflügeltrematoden in Liv- und Kurland. Berl. tierärztl. Wochenschr. **42**, p. 444.
1915. OTTERSTRØM, C. V.: Ichthyologische Notizer. 1. Horkedøden i Esromsø 1913. Vidensk. Medd. Dansk Nat. For. **66**, p. 221.
1857. PAGENSTECKER, H.: Trematoden und Trematodenlarven. Heidelberg.
1927. PATZER, H.: Beiträge zur Biologie der Leberegelschnecke *Galba* (= *Limnæa*) *truncatula* Müll. Zool. Jahrb. Abth. Syst. Ökol. **53**, p. 321.
1923. PAWLOWSKY, E. N. und ANITSCHKOW, N. M.: *Tetracotyle sogdiana* ein neuer Parasit von *Schizothorax intermedius* und ein Fall der von ihm bei seinem Wirt verursachten Peritonitis. Russ. Hydrob. Zeit. **2**, p. 219.
1906. PELSENER, P.: Trematodes parasites de Mollusques marins. Bull. Sci. de la France et de la Belgique. **40**, p. 161.
1931. PETERSEN, H.: Cercarien der Niederelbe. Zool. Anz. **97**, p. 13.
1908. PLEHN, M.: Ein monozoischer Cestode als Blutparasit (*S. armata* und *inermis* Pl.). Zool. Anz. **33**, p. 427.
1915. — *Sanguinicola armata* und *inermis* (n. g. n. sp.) n. f. Rhynchostomatidæ. Zool. Anz. **29**, p. 244.
1925. PORTER, A.: *Limnæa truncatula* as an Intermediate Host of *Fasciola hepatica* in South Africa. South Afric. Journ. Sc. **22**, p. 309.
1929. PRICE, E. W.: A Synopsis of the Trematode Family *Schistosomidae* with Descriptions of new Genera and Species. Proc. U. S. Nat. Mus. Washington. **75**, part 18, p. 1.
1929. PRÆTORIUS, G.: Besteht eine Bilharziagefahr für Deutschland. Münch. medic. Wochenschr. **76**, p. 2055.
1913. RAILLIET, A. G. MOUSSU et HENRY, A.: Recherches expérimentales sur le développement de la Douve hépatique. C. R. Acad. Sc. **156**, p. 95, et Rec. Méd. vétér. **90**, p. 1.
1929. RAJCEVIC, M.: Wie lange bleiben die Cercarien der Leberegel (*Distomum hepaticum*) an getrockneten alten Heu lebend und infectionsfähig? Deutsch. tierärztl. Wochenschr. **37**, p. 535.
1903. REUSS, H.: Die Cercarie und Sporocyste des *Distomum duplicatum*. Zeit. f. wiss. Zool. **74**, p. 458.
- 1902—1904. — *Cercaria duplicata*. Abhandl. zool. Institut. München. **2**.
1927. RIECH, F.: Beiträge zur Kenntnis der Echinostomiden. 1. Der Lebenszyklus von *Echinoparyphium aconiatum* Dtz. 2. *Cercaria laticaudata* n. sp. Centralbl. Bakt. Parasitk. Abt. 1. Orig. **103**, p. 279.

1904. ROTH, W.: Beiträge zur Kenntniss der parasitären Fischkrankheiten. 5. Über der grauen Star bei Aquariumfische. Natur und Haus. **13**, p. 41.
- 1926a. LA RUE, G. R.: Studies on the Trematode Family *Strigeidae* (*Holostomidae*). *Pharyngostomum cordatum* (Diesing) Ciurea. I. Transact. Amer. Micr. Soc. **45**, p. 1.
- 1926b. — Studies on the Trematode family *Strigeidae* (*Holostomidae*). II. Taxonomy. Trans. Amer. Micr. Soc. **45**, p. 11.
- 1926c. — Studies on the Trematode family *Strigeidae* (*Holostomidae*). III. Relationships. Trans. Amer. Micr. Soc. **45**, p. 265.
- 1926d. — , BUTLER, E. P. and BERKHOUT, P. G.: Studies on the Trematode family *Strigeidae* (*Holostomidae*). IV. The eye of fishes, an important habitat for larval *Strigeidae*. Trans. Amer. Micr. Soc. **45**, p. 282.
- 1926e. — A Trematode with two Ani. Journ. of Parasit. **12**, p. 207.
1927. — Studies on the Trematode family *Strigeidae* (*Holostomidae*). 5. *Proalaria huronensis*. Trans. Amer. Micr. Soc. **46**, p. 26.
- 1932a. — and BARONE, G. H.: *Alaria orogonensis* from the Coyote (Trematoda: *Alariidae*). Trans. Amer. Micr. Soc. **51**, p. 199.
- 1932b. — and TOWNSEND, E.: A Morphological Study of *Alaria nasuae* La Rue and Townsend. Trans. Amer. Micr. Soc. **51**, p. 252.
1903. RUGE, R.: Der *Anopheles maculipennis* Meig. als Wirt eines *Distomum* Centralbl. f. Bakt. u. Parasitenk. **35**, p. 258.
1922. RUSZKOWSKI, J.: Die postembryonale Entwicklung von *Hemistomum alatum*. Bull. Acad. Sci. et Lettres. Krakau. Cl. math. nat., p. 237.
1907. SALZER, F.: Anatomische Untersuchungen über den Wurmstar der Fische. Arch. f. Augenheilk. **58**, p. 19.
1922. SCHEURING, L.: Der Lebenszyklus *Sanguinicola inermis* Plehn. Zool. Jahrb. Abt. Aant. **44**, p. 265.
1926. — und EVERSBUCH: Beiträge zur Entwicklungsgeschichte von *Strigea* (*Holostomum*) *cornu* Rud. Zool. Anz. **66**, p. 41.
1930. SCHMID, F.: Beitrag zur Kenntnis der Trematodenlarven aus der Leberegelnschnecke *Limnaea* (*Galba*) *truncatula* und aus *Limnaea ovata*. Sitz. Ber. Ges. naturf. Freunde. Berlin. 1929, p. 256.
1931. SCHUURMANS STEKHOVEN, J. H.: Der zweite Zwischenwirt von *Pseudamphistomum truncatum* nebst Bemerkungen über Trematodenlarven. Zeitschr. f. Parasitenk. **3**, p. 747.
- 1923—24. SEIFERT, O.: Durch Invasion von Trematoden (*Prostogonimus*-Arten) verursachte seuchenhaft auftretende und tödlich verlaufende Eileiter-Erkrankungen bei Hühnern in Mecklenburg. Deutsche tierärztl. Wochenschr. **31**, p. 541, 551. **32**, p. 75.
1926. SEIFERT, R.: *Cercaria limbifera*, eine neue echinostome Cercaria. Zool. Anz. **67**, p. 112.
1922. SEWELL, R. S.: Cercariæ Indicæ. Indian Journal Medical Research. **10**. Supplm. number.
1930. — The Evolution of the Excretory System in certain groups of the Furcocercous Cercariæ. Rec. Indian Mus. **32**, p. 357.
1928. SEVERINGHAUS, A. E.: Sex studies on *Schistosoma japonicum*. Quart. Journ. Micr. Sci. **71**, p. 653.
1835. v. SIEBOLD, C. TH.: Helminthologische Beiträge. Archiv f. Naturg. **1**, p. 69.
- 1843a. — Bericht über die Leistungen im Gebiete der Anatomie und Physiologie wirbelloser Tiere Archiv. f. Anat. i—lxxxvii.
- 1843b. — Bericht über die Leistungen in Helminthologie. Arch. f. Naturg. **9**, p. 289.
- ? SMITH, H. J.: Die *Fasciola hepatica* (ontwikkeling pathologisch-anatomische en economische beteeknis). Nederl. Ind. Blad. Diergeneesk. **41**, p. 313.
1892. SONSINO, P.: Studi sui parassiti di molluschi di acqua dolce nei dintorni di Cairo in Egitto. Festschr. f. Leuckart, p. 134.

1894. SONSINO, P.: Sviluppo ciclo vitale e ospite intermedio della *Bilharzia hæmatobia*. Processi verb. della Soc. Toscana di Scient. nat., p. 4.
- 1917.*) SOPARKAR, M. B.: A Trematode parasite of Anopheline Mosquitos. Ind. Journ. Med. Research. **5**, p. 512.
1901. SSINITZIN, D.: Einige Beobachtungen über die Entwicklungsgeschichte von *Distomum folium* Oif. Zool. Anz. **24**, p. 689.
1907. — Observations sur les métamorphoses des Trématodes. Arch. Zool. expér. et génér. **37** not. et rev., p. 21.
- 1909 a. — Studien über die Phylogenie der Trematoden. II. *Bucephalus* v. Baer und *Cercaria ocellata* de la Val. Zeitschr. f. wiss. Zool. **94**, p. 299.
- 1909 b. — Studien über die Phylogenie der Trematoden. Können die digenetischen Trematoden sich auf ungeschlechtlichem Wege fortpflanzen? Biol. Zentralbl. **29**, p. 664.
- 1911.*) — The Parthenogenetic generation of Trematodes and its progeny in molluscs of the Black Sea. Rec. Imper. Acad. Sci. 8. ser. Phys. Math. Dep. **5**, 30 (English translation by La Rue, 1925).
1915. — Neue Tatsachen über die Biologie der *Fasciola hepatica* L. Centralbl. f. Bakt. u. Parasitenk. **74**, 1. Abh., p. 280.
- 1931 a. — Studien über die Phylogenie der Trematoden. IV. The life histories of *Plagioporus siliculus* and *Plagioporus virens* with special reference to the origin of *Digenea*. Zeit. f. wiss. Zool. **138**, p. 409.
- 1931 b. — Studien über die Phylogenie der Trematoden. V. Revision of Harmostomidæ. Zeit. f. Parasitenk. **3**, p. 713.
1917. STEENBERG, C.: See Wesenberg-Lund: Furesøstudier.
1842. STEENSTRUP, J.: Om Forplantning og Udvikling gennem vexlende Generationsrækker, København.
1894. STILES, C. W. and HASSAL, A.: A preliminary Catalogue of the Parasites contained in the Collections of the U. S. Bureau of Animal Industry. U. St. Army medical Mus. Biol. Departm. of the Univ. of Pennsylvania.
- 1898.*) — The Inspection of Meats for Animal Parasites. U. S. Departm. of agriculture. Bureau of animal industry. Bulletin **19**.
1923. STUNKARD, H. W.: Studies on North American Blood flukes. Bull. Am. Mus. Nat. Hist. **48**, p. 165.
1929. — The Excretory System of *Cryptocotyle (Heterophyidæ)*. Journ. of Parasit. **15**, p. 259.
1930. — An Analysis of the Methods used in the Study of Larval Trematodes. Parasitology. **22**, p. 268.
1923. SZIDAT, L.: Beiträge zur Entwicklungsgeschichte der Holostomiden. I. Zool. Anz. **58**, p. 299.
1924. — Beiträge zur Entwicklungsgeschichte der Holostomiden. II. Zool. Anz. **61**, p. 249.
- 1926 a. — Studien an Trematoden. Zool. Anz. **66**, p. 270.
- 1926 b. — Vorl. Mitteilung. Centralbl. f. Bakt. u. Parasitenkunde. I. Orig. **99**, p. 561.
- 1926 c. — Beiträge zur Faunistik und Biologie des Kurischen Haffs. Schriften d. Phys. ökon. Gesellsch. Königsberg. **55**, p. 1.
- 1927 a. — Ueber ein Fischsterben im Kurischen Haff und seine Ursachen. Zeitschr. f. Fisherei u. d. Hilfsw. **25**, p. 83.
- 1927 b. — Die Parasiten des Hausgeflügels. Die Holostomiden des Entendarms und ihre Entwicklung. Archiv f. Geflügelkunde. **1**, Heft 11.
- 1927 c. Ueber ein Massenfischsterben im Kurischen Haff. Schriften d. Physic. ökon. Gesellsch. Königsberg. **65**, p. 245.
- 1928 a. — Studien an einigen seltenen Parasiten der Kurischen Nehrung. Zeit. f. Paras. **1**, p. 331.

- 1928b. SZIDAT, L.: Zur Revision der Trematodengattung *Strigea*. Centralbl. f. Bakt. u. Parasitenk. Orig. **105**, p. 204.
- 1928c. — Warum Libellen fressende Haushühner Windeier legen, die wissenschaftliche Ergänzung eines alten Rätsels. Schriften d. Physic. ökon. Gesellsch. Königsberg. **65**, p. 243.
- 1929a. — Beiträge zur Entwicklungsgeschichte der Holostomiden. III. Ueber zwei Tetracotylen aus Hirudineen und ihre Weiterentwicklung in Enten zu *Cotylurus cornutus* Rud. und *Apatemon gracilis* Rud. Zool. Anz. **86**, p. 133.
- 1929b. — Die Parasiten des Hausgeflügels. 3. *Bilharziella polonica* Kow. ein im Blut schmarotzender Trematoden unserer Enten, seine Entwicklung und Uebertragung. Archiv f. Geflügelkunde. **3**, p. 78.
- 1929c. — Zur Entwicklungsgeschichte der Bluttrematoden der Enten. *Bilharziella polonica* Kow. 1. Morphologie und Biologie der Cercarie von *Bilharziella polonica* Kow. Centralbl. f. Bakt. und Parasitenk. **1**, **111**, p. 461.
- 1929d. — Hauptinfektion bei Parasiten, insbesondere bei *Bilharziella polonica*. Vortrag auf d. deutschen Dermatologen-Kongres. Königsberg 1929.
- 1929e. — Beiträge zur Kenntnis der Gattung *Strigea*. I—II. Zeitschr. f. Parasitenkunde. **1**, p. 612, p. 688.
- 1930a. — Die Parasiten des Hausgeflügels. Archiv f. Geflügelkunde. **4**, p. 105.
- 1930b. — Ueber die Zoologische Station für Schädlingsforschung Rossitten und einige wichtige Parasiten der Kurischen Nehrung. Pharmakol. Gesellsch., p. 138.
- 1930c. — *Gigantobilharzia monocotylea* n. sp. ein neuer Blutparasit aus ostpreussischen Wasservögeln. Zeitschr. f. Parasitenk. **2**, p. 583.
- 1931a. — *Cordulia anea* S., ein neuer Hilfswirth für *Prosthogonimus pellucidus* v. Linstow, den Erreger der Trematodenkrankheit der Legehühner. Zentralbl. f. Bakt. u. Parasitenk. **1**. Abt. **119**, p. 289.
- 1931b. — Beiträge zur Entwicklungsgeschichte der Holostomiden. IV. Die Cercarie des Entenparasiten *Apatemon (Strigea) gracilis* Rud. und ihre Entwicklung im Blutgefäßsystem des Zwischenwirthes (*Herpobdella atomaria* Car.). Zeitschr. f. Parasitenk. **3**, p. 160.
- 1932a. — Zur Entwicklungsgeschichte der Cyclocoeliden. Der Lebenszyklus von *Tracheophilus sisowi* Skrj. 1923. Zool. Anz. **100**, p. 205.
- 1932b. — Ueber cysticerke Riesencercarien, insbesondere *Cercaria mirabilis* M. Braun und *Cercaria splendens* n. sp. und ihre Entwicklung im Magen von Raubfischen zu Trematoden der Gattung *Azygia* Loos. Zeitschr. f. Parasitenk. **4**, p. 477.
1932. SZIDAT, U.: *Dicranocercaria brachycerca* n. sp. der Typ. einer neuen Gruppe gabelschwänziger Cercarien. Zool. Anz. **98**, p. 318.
1923. TANABE, B.: The Life History of a new Schistosome *Schistosomatium pathlopticum* found in Experimentally Infected Mice. Journ. of Parasit. **9**, p. 183.
1922. TAYLOR, M.: Watersnails and Liver flukes. Nature. **110**, p. 701.
1930. TAYLOR, E. S. and BAYLIS, H. A.: Observations and Experiments on a Dermatitis-producing Cercaria and on another Cercaria from *Limnaea stagnalis* in Great Britain. Transact. Royal Soc. of Tropical Medicine and Hygiene. **24**, p. 219.
1925. THIEL, P. H. VAN: Beiträge zur Kenntniss der Trematoden aus *Anopheles maculipennis*. Archiv f. Schiffs- u. Tropenhygiene. **29**, p. 396.
1860. THIRY, L.: Beiträge zur Kenntniss der *Cercaria macrocera* Filippi. Zeit. f. wiss. Zool. **10**, p. 271.
- 1883a. THOMAS, A. P.: Life History of the Liver fluke. Quart. Journ. Micr. Sci. **23**, p. 99.
- 1883b. — The natural History of the Liver Fluke and the Prevention of Rot. Journ. of the Royal Agric. Soc. of England. **56**, p. 469.
1933. TUBANGUI, M. and PASCO, A.: The Life History of the Human Intestinal Fluke *Euparyphium ilocarium* (Garrison 1908). The Philippine Journal of Science. **51**, p. 583.

1857. WAGENER, G. R.: Beiträge zur Entwicklungsgeschichte der Eingeweidewürmer. Naturkundige Verhandlungen. **13**, p. 1.
1858. — Helminthologische Bemerkungen. Zeitschr. f. wiss. Zool. **9**, p. 88.
1866. — Ueber Redien und Sporocysten Filippi. Archiv Anat. Physiol., p. 145.
1931. WAGIN, W. L.: *Chætogaster limnæi* Kv. Baer als Cercarienvertilger. Zool. Anz., **95**, p. 55.
1855. DE LA VALETTE, ST. GEORGE: Symbolæ ad Trematodum Evolutionis Historiam.
1918. WALTON, C. L.: Liver Rot of Sheep and Bionomics of *Limnæa truncatula* in Aberystwyth Area. Parasitology. **10**, p. 232.
1923. — Soil reaction, Water snails and Liver flukes. Nature. **111**, p. 117.
1907. WARD, H. B.: The Influence of Parasitism on the Host. Proceed. American Ass. f. Adv. Sci. **56**, p. 1.
1916. — Notes on Two Free-living Larval Trematodes from North-America. Journ. of Parasit. **3**, p. 10.
1929. WEINLAND, E. and BRAND, TH. V.: Beobachtungen an *Fasciola hepatica* (Stoffwechsel und Lebensweise). Zeit. f. vergl. Physiologie. **4**, p. 212.
1896. WELTNER, W.: Ueber Saugwürmer in Wasserjungfern. Blätter f. Aquarien- und Terrarienkunde. **7**, p. 199.
- 1904—1908. WESENBERG-LUND, C.: Planctoninvestigations in the Danish Lakes. Gyldendals Bogh. København.
1917. — Furesøstudier. Kgl. Danske Vidensk. Selsk. Nat. Math. Afd. 8. R. III, 1.
- 1923.*) VEVERS, G. M.: Observation of the life history of *Hypoderæum conoideum* (Bloch) and *Echinostomum revolutum* (Froel). Trematode Parasites of the domestic Duck. Ann. appl. Biol. **10**, p. 134.
1901. WILCOX: *Chætogaster limnæi* Parasite or Commensalist. *Physa heterostropha*. Americ. Natur. **35**, p. 905.
1932. WINFIELD, G.: On the Immunity of Snails Infested with the Sporocysts of the Strigeid *Cotylurus flabelliformis* to the Penetration of its Cercaria. Journ. of Parasit. **19**, p. 130.
1933. WISNIEWSKI, W.: Ueber zwei neue progenetische Trematoden aus den balkanischen Gammariden. Bull. intern. de l'Académie Polonaise des Sci. et des lettres. No. 7. B. II, p. 259.
- 1930 a. VOGEL, H.: Hautveränderungen durch *Cercaria ocellata*. Dermat. Wochenschr. **90**, p. 577.
- 1930 b. — Zerkarien-Dermatitis in Deutschl. Klinische Wochenschr. **9**, p. 883.
1932. — Ueber den ersten Zwischenwirth und die Zerkarie von *Opistorchis felinus* Rue. Archiv f. Schiffs- u. Tropen-Hygiene. **36**, p. 559.
1927. WOODHEAD, A. E.: Concerning the Encystment of *Bucephalus cercariæ*. Science. **65**, p. 232.
1929. — Life history Studies on the Trematode Family *Bucephalidæ*. Trans. Amer. Micr. Soc. **48**, p. 256.
1930. — Life History Studies on the Trematode Family *Bucephalidæ*. No. 2. Trans. Amer. Micr. Soc. **49**, p. 1.
1931. — The Germcell Cycle in the Trematode Family *Bucephalidæ*. Trans. Amer. Micr. Soc. **50**, p. 169.
1885. WRIGHT, R. R.: A Free-swimming Sporocyst. Amer. Nat. **19**, p. 310.
1927. WRIGHT, REES W.: Studies on Larval Trematodes from North Wales. Ann. of trop. Med. and Parasitology. **21**, p. 47.
- 1923 a. WUNDER, W.: Wie erkennt und findet *Cercaria intermedia* n. sp. ihren Wirt? Zool. Anz. **57**, p. 68.
- 1923 b. — Die Encystierung von *Cercaria tuberculata* Fil. Zool. Anz. **56**, p. 224.
- 1924 a. — Bau, Entwicklung und Funktion des Cercarienschwanzes. Zool. Jahrb. Abt. Anat. **46**, p. 303.

- 1924b. WUNDER, W.: Die Schwimmbewegung von *Bucephalus polymorphus* v. Baer. Zeit. f. wiss. Biologie u. Physiologie. **1**, p. 289.
1926. — Mütmassige Schädigung der Karpfenbrut durch Gabelschwanzcercarien. Fischerei-Zeitung. **29**, p. 429.
1927. — Die Bedeutung der Wasserschnecken für die Entstehung von Fischkrankheiten. Fischereizeitung. **30**, p. 753.
1932. — Untersuchungen über Pigmentierung und Encystierung von Cercarien. Zeitschr. f. Morphologie und Ökologie der Tiere. **25**, p. 336.
1883. ZIEGLER, H. E.: *Bucephalus* und *Gasterostomum*. Zeit. f. wiss. Zool. **39**, p. 537.

1933.

1933. SZIDAT, L.: Weitere Beobachtungen über das Vorkommen und die Biologie von *Prosthogonimus pellucidus* v. Linst., den Erreger der Trematodenkrankheit der Legehühner, bei Enten und Gänsen in Ostpreussen. Zentralbl. f. Bakt. u. Parasitenk. 1. Abth. **127**, p. 392.
1933. — Ueber drei neue monostome Gabelschwanzcercarien der ostpreussischen Fauna. Zeitschr. f. Parasitenk. **5**, p. 443.
1933. — und SZIDAT, U.: Beiträge zur Kenntnis der Trematoden der Monostomidengattung *Notocotylus* Dies. Zentralbl. f. Bakt. u. Parasitenk. 1. Abth. **129**, p. 411.
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EXPLANATION OF THE PLATES

Plates 1—35 are all drawn by myself. The drawings are nearly all camera-drawings. Microscope: Zeiss. They are worked out and drawn from living animals, and very often the final drawings are combined from several special drawings. The plates are reduced to $\frac{2}{3}$; only figures Pl. XI, fig. 3, Pl. XXI, fig. 1, Pl. XXIII, fig. 3, Pl. XXVII, fig. 1 are reduced to $\frac{1}{2}$.

The microphotos shown in Plates XXXVI—XXXIX have been taken by Dr. Berg.

Plate I.
Monostomata.

Fig. 1.	<i>Cercaria ephemera</i> Nitzsch.....	<i>Planorbis corneus</i>	Furesø.....	28/IV 32	Oc. 2	Obj. 4
- 2.	—	—	The moor Hillerød	17/IV 31	- 4	- 16
- 3.	—	—	—	17/IV 31	- 4	- 16
- 4.	—	<i>Planorbis vortex</i> ..	Vixømoor	20/VII 31	- 2	- 4
- 5.	—	—	—	20/VII 31	- 4	- 16
- 6.	—	Redia.....	—	20/VII 31	- 4	- 16
- 7.	—	—	—	20/VII 31	Sucheroc.	- 16
- 8.	—	— ; the same specimen drawn in the course of five minutes	— .. The moor Hillerød	17/IV 31	Oc. 4	- 16

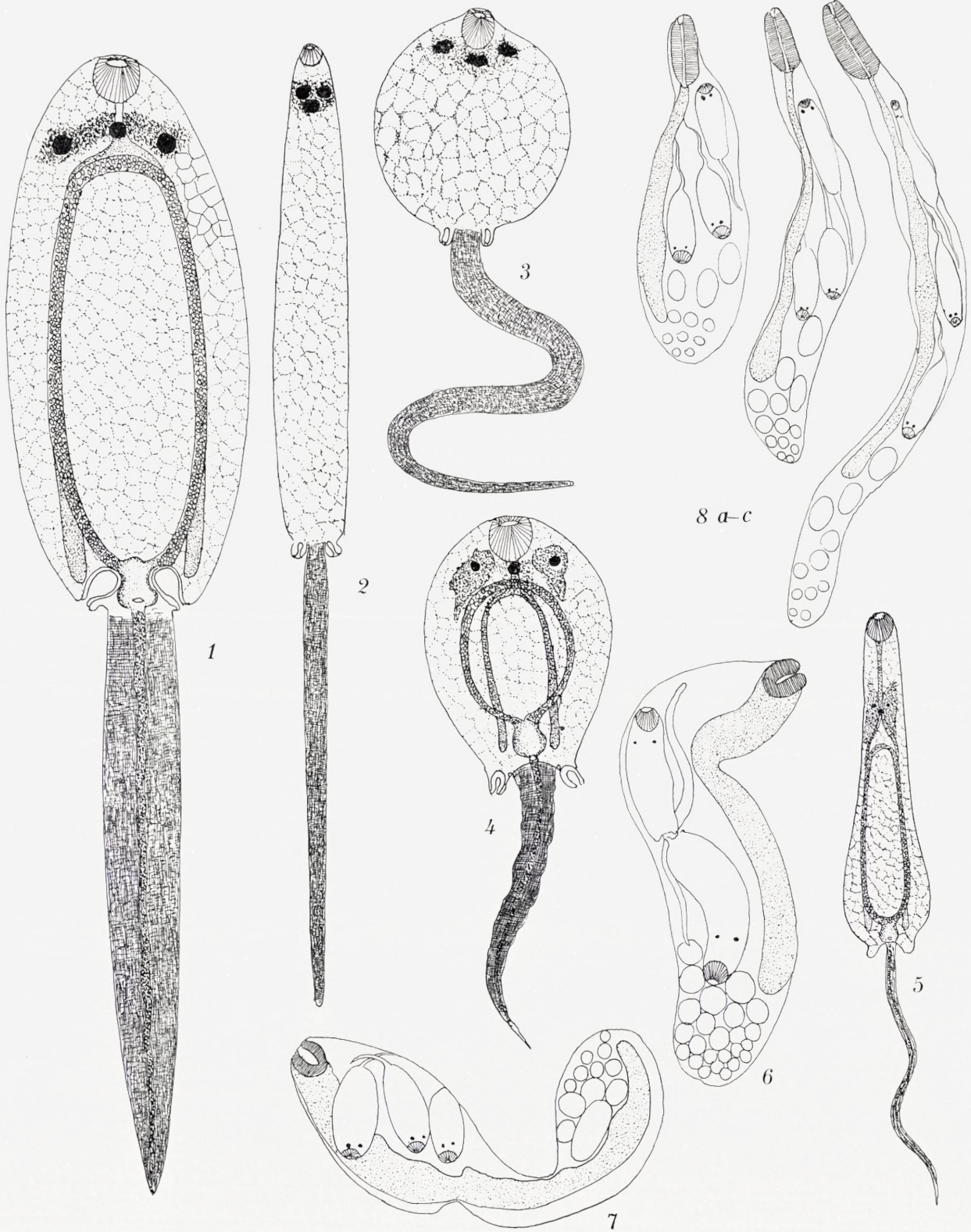


Plate II.
Monostomata.

Fig. 1.	<i>Cercaria monostomi</i>	<i>Limnaea stagnalis</i> . .	Tjustrup Lake	15/V	31	Oc. 2	Obj.	4
- 2.	-- Redia	—	—	15/V	31	- 4	-	16
- 3.	-- Redia: The hold fast organ	<i>Limnaea ovata</i>	—	25/V	31	- 4	-	16
- 4.	— Redia. Posterior part	<i>Limnaea stagnalis</i> . .	—	25/V	31	- 2	-	4
- 5.	<i>Cercaria imbricata</i>	<i>Bithynia tentaculata</i>	Hellebæk	29/V	31	- 4	-	4
- 6.	— Redia	—	Værebroaa, Hillerød	17/VII	31	- 4	-	4
- 7.	— Redia	—	Næsbybro, Sorø	10/VIII	31	- 2	-	4
- 8.	— Redia	--	Værebroaa, Hillerød	17/VII	31	- 6	-	a*
- 9.	— Redia	—	Bromme Lake, Sorø	27/X	32	- 4	-	16
- 10.	--- Redia, gut turned inside out	—	Hellebæk	29/V	31	- 4	-	4
- 11.	— Cyst: part of the wall	—	—	29/V	31	- 4	-	4

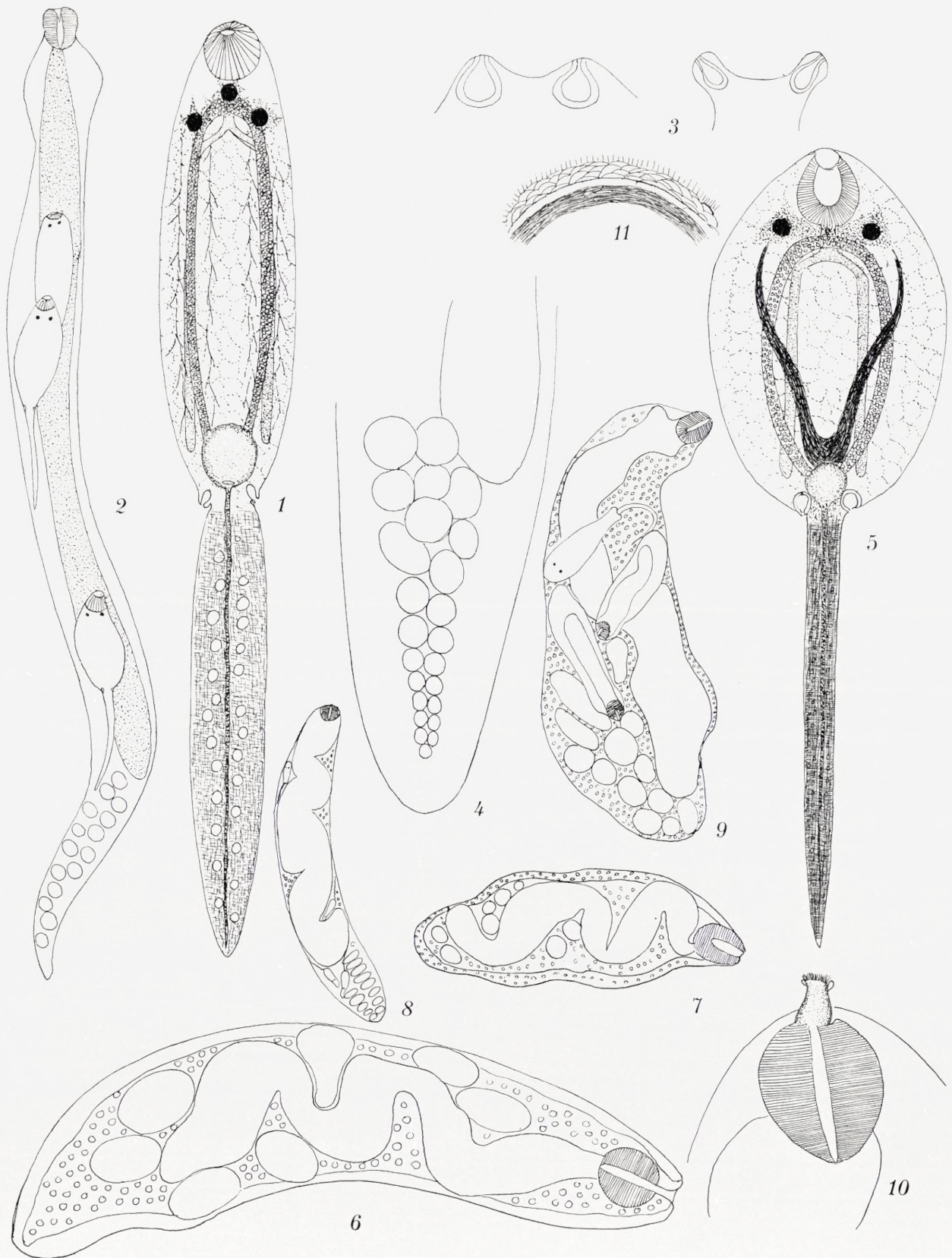


Plate III.
Amphistomata.

Fig. 1.	<i>Cercaria diplocotylea</i>	<i>Planorbis umbilicatus</i>	Regnstrup, Sorø	14/VIII 32	Obj. 4	Oc. 16
- 2.	— The same animal drawn in the course of 5 min.	—	—	14/VIII 32		
- 3.	<i>Cercaria diplocotylea</i> . The peculiar picture of a swimming Cercaria. With incredible speed the tail is lashed laterally from the left to the right and then forward in the same manner. The ob- server receives the impression of two bows, of which the post- erior one is always the most conspicuous; the anterior one less marked	—	—	14/VIII 32		
- 4.	<i>Cercaria diplocotylea</i> . Redia	—	—	14/VIII 32	- 2	- 16

Gymnocephala.

Fig. 5.	<i>Cercaria tuberculata</i>	<i>Bithynia tentaculata</i>	Donse, Hillerød	9/VII 31	Obj. 4	Oc. 4
- 6.	— Young Redia	—	—	9/VII 31	- 4	- 4
- 7.	— Newly hatched Redia	—	—	9/VII 31	- 4	- 4
- 8 a—c.	— The same Redia, drawn in the course of 5 min.	—	—	9/VII 31		
- 9.	— Cyst	—	—	9/VII 31	- 2	- 4

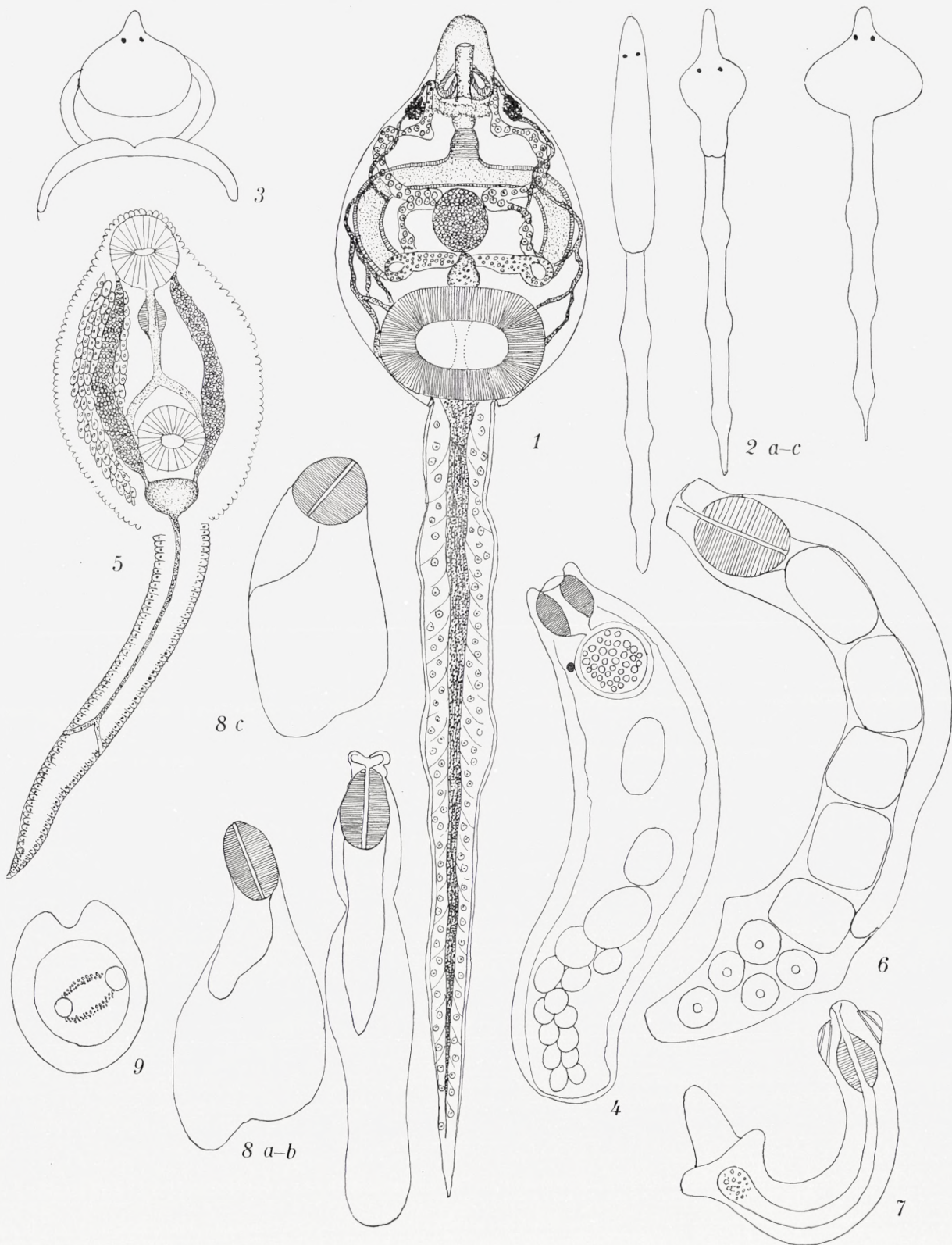


Plate IV.
Gymnocephala.

Oc. 4 Obj. 16.

Fig. 1.	<i>Cercaria papillosa</i>	<i>Bithynia tentaculata</i>	Hellebæk.....	23/V 31
- 2.	— lateral view	—	—	23/V 31
- 3.	— Redia.....	—	—	23/V 31
- 4.	— Redia.....	—	Furesø	13/V 32
- 5.	— Redia.....	—	—	13/V 32
- 6.	— Redia.....	—	—	13/V 32
- 7.	— Redia.....	—	—	13/V 32
- 8.	— Redia.....	—	—	13/V 32
- 9.	— A very old Redia	—	—	13/V 32
Figs. 5—9 illustrate how the Redia contains the nutritive organ in an anterior part while a posterior part contains the brood.				
- 10.	<i>Cercaria papillosa</i> . Very young Redia.....	—	—	13/V 32
- 11.	— Very young Redia.....	—	—	13/V 32

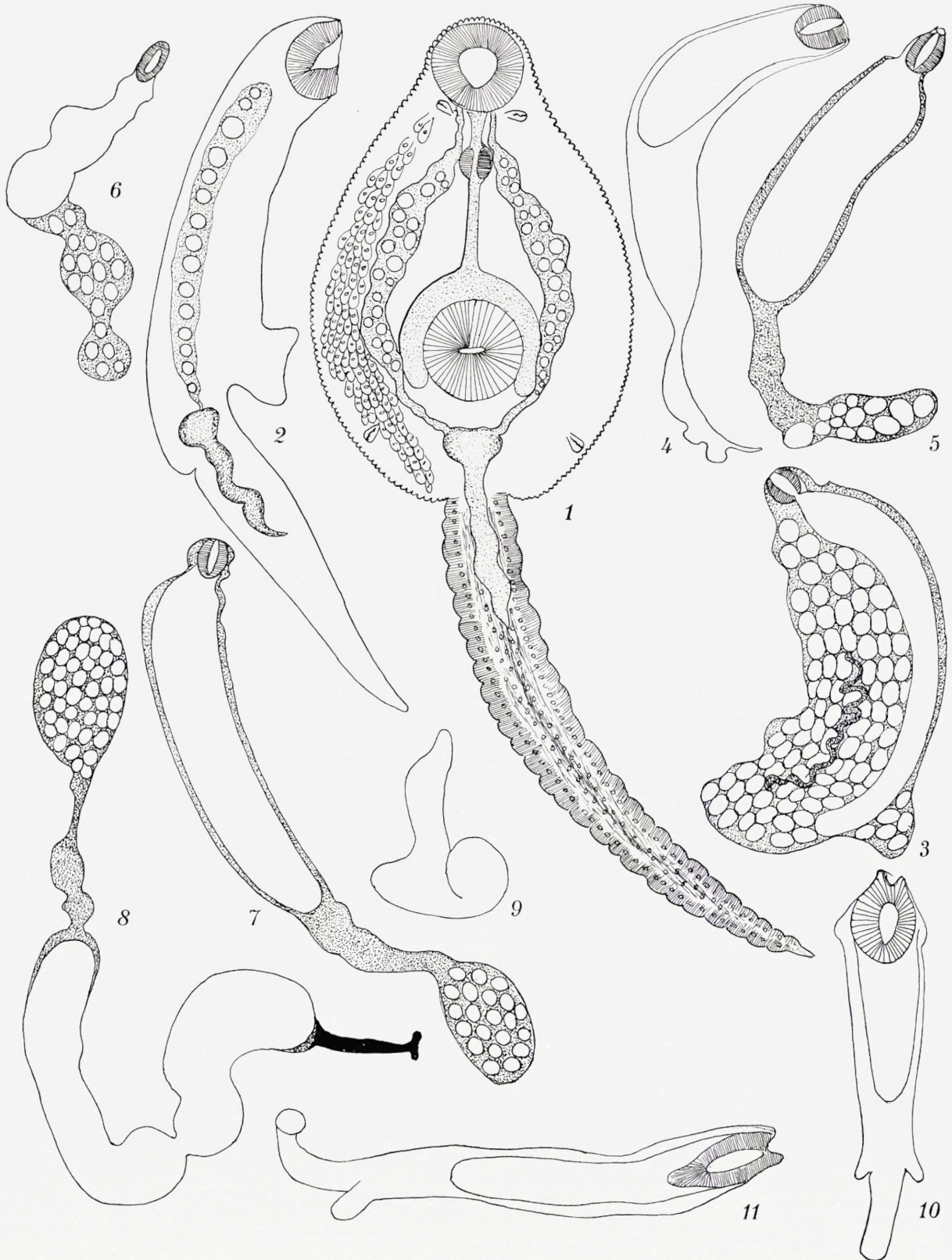


Plate V.
Gymnocephala.

Fig. 1.	<i>Cercaria helvetica</i> XIX	Dubois . . .	<i>Bithynia tentaculata</i>	Værebroaa, Hillerød	19/VII 31	Oc. 4	Obj. 4
- 2.	—	Redia	—	—	19/VII 31	- 4	- 4
- 3.	—	Redia	—	—	19/VII 31	- 4	- 4
- 4.	<i>Cercaria grandis</i> n. sp.	. . . . .	—	Ramløseaa, Hillerød	13/VII 31	- 4	- 4
- 5.	—	Redia	—	—	13/VII 31	- 4	- 16
- 6.	—	Redia	—	—	13/VII 31	- 2	- 16
- 7.	<i>Cercaria obscura</i> n. sp.,	contracted	—	Furesø	16/IX 31	- 4	- 4
- 8.	—	extended .	—	—	16/IX 31	- 4	- 4

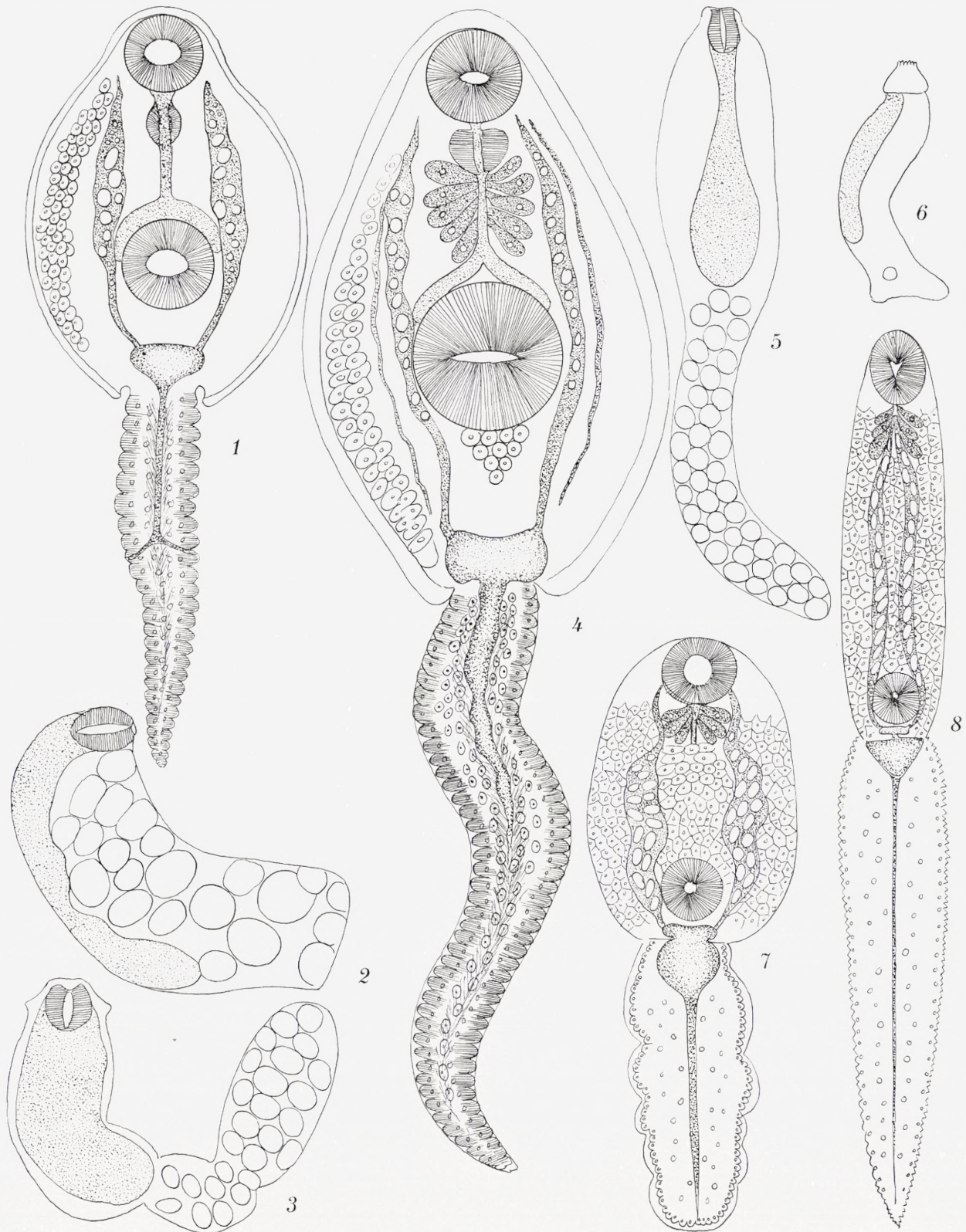


Plate VI.
Gymnocephala.

Fig. 1.	<i>Cercaria obscura</i> n. sp.	.....	<i>Bithynia tentaculata</i>	Furesø	.....	16/IX	31	Oc. 4	Obj. 4
- 2.	—	Redia newly born	.....	—	.....	16/IX	31	- 4	- 4
- 3.	—	Redia very old	.....	—	.....	16/IX	31	- 2	- 4
- 4.	—	Redia with Tetracotyle	.....	—	.....	16/IX	31	- 2	- 4
- 5.	—	Redia, the same specimen drawn in the course of 5 minutes	.....	—	.....	16/IX	31		
- 6.	<i>Cercaria lophocerca</i>	.....	—	Susaa, Sorø	.....	3/VIII	31	- 6	- 16
- 7.	—	Redia	.....	—	.....	3/VIII	31	- 6	- 16
- 8.	—	Redia	.....	—	.....	3/VIII	32	- 6	- 16
- 9.	Redia sp.	.....	—	Castle Park, Hillerød	.....	1/VIII	32	- 2	- 4
- 10.	—	.....	—	—	.....	1/VIII	32	- 2	- 16
- 11.	—	very young	.....	—	.....	1/VIII	32	- 2	- 4

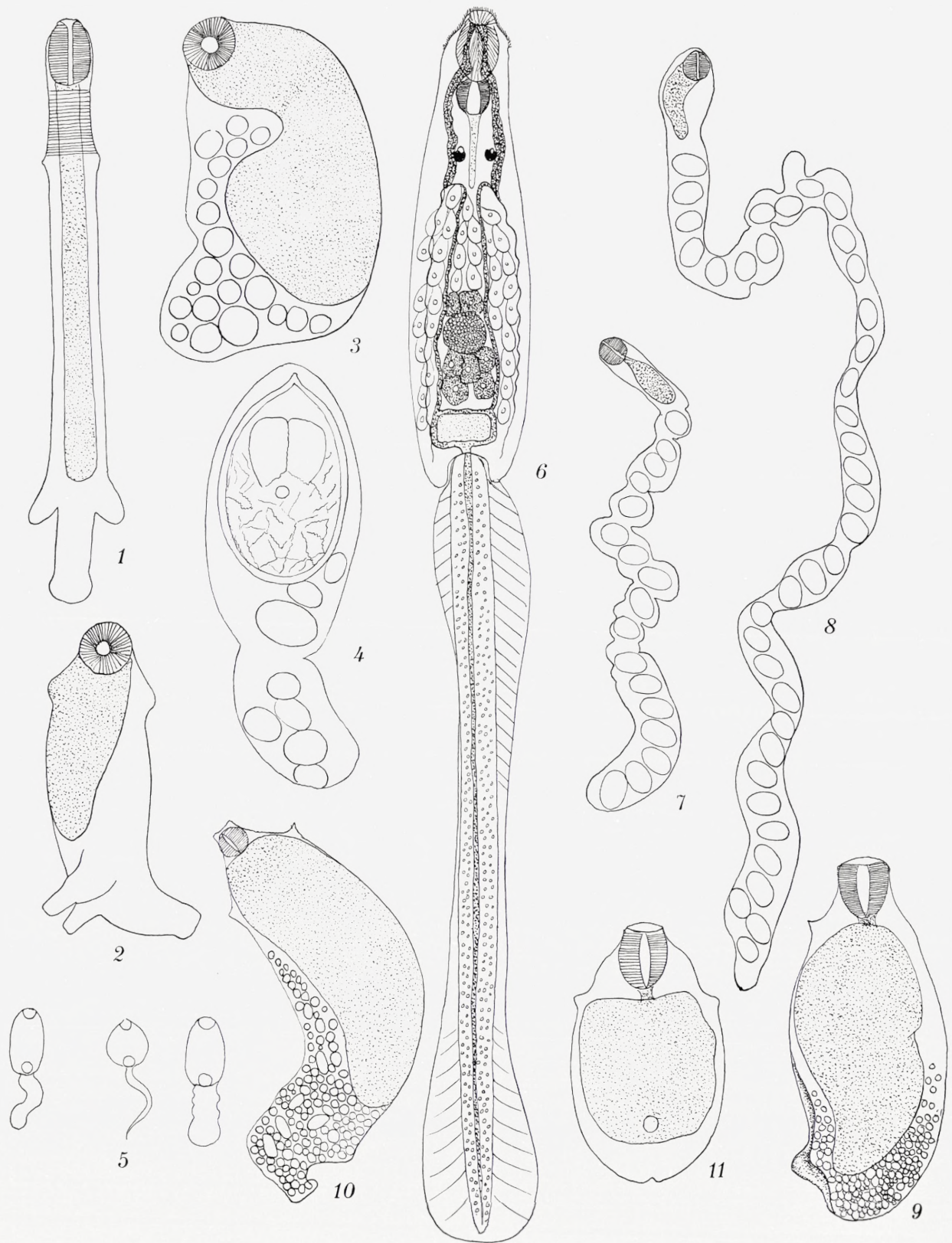


Plate VII.
Echinostomata.

Fig. 1.	<i>Cercaria echinatoides</i>	Corona.....	<i>Paludina vivipara</i>	Hellebæk....	2/III	32	Oc. 6	Obj. a*
- 2.	—	Redia.....	—	—	2/III	32	- 2	- 16
- 3.	<i>Cercaria echinostomi</i>	.....	<i>Limnaea palustris</i>	Bromme....	1/VIII	31	- 2	- 4
- 4.	—	Redia.....	—	—	1/VIII	31	- 6	- a*
- 5.	<i>Cercaria abyssicola</i>	n. sp.	<i>Valvata piscinalis</i>	Tjustrup Lake	30/VII	31	- 4	- 4
- 6.	—	Lateral view of the tail showing the fin fold	—	—	30/VII	31	- 4	- 4
- 7.	—	Redia very young	—	—	30/VII	31	- 4	- 4

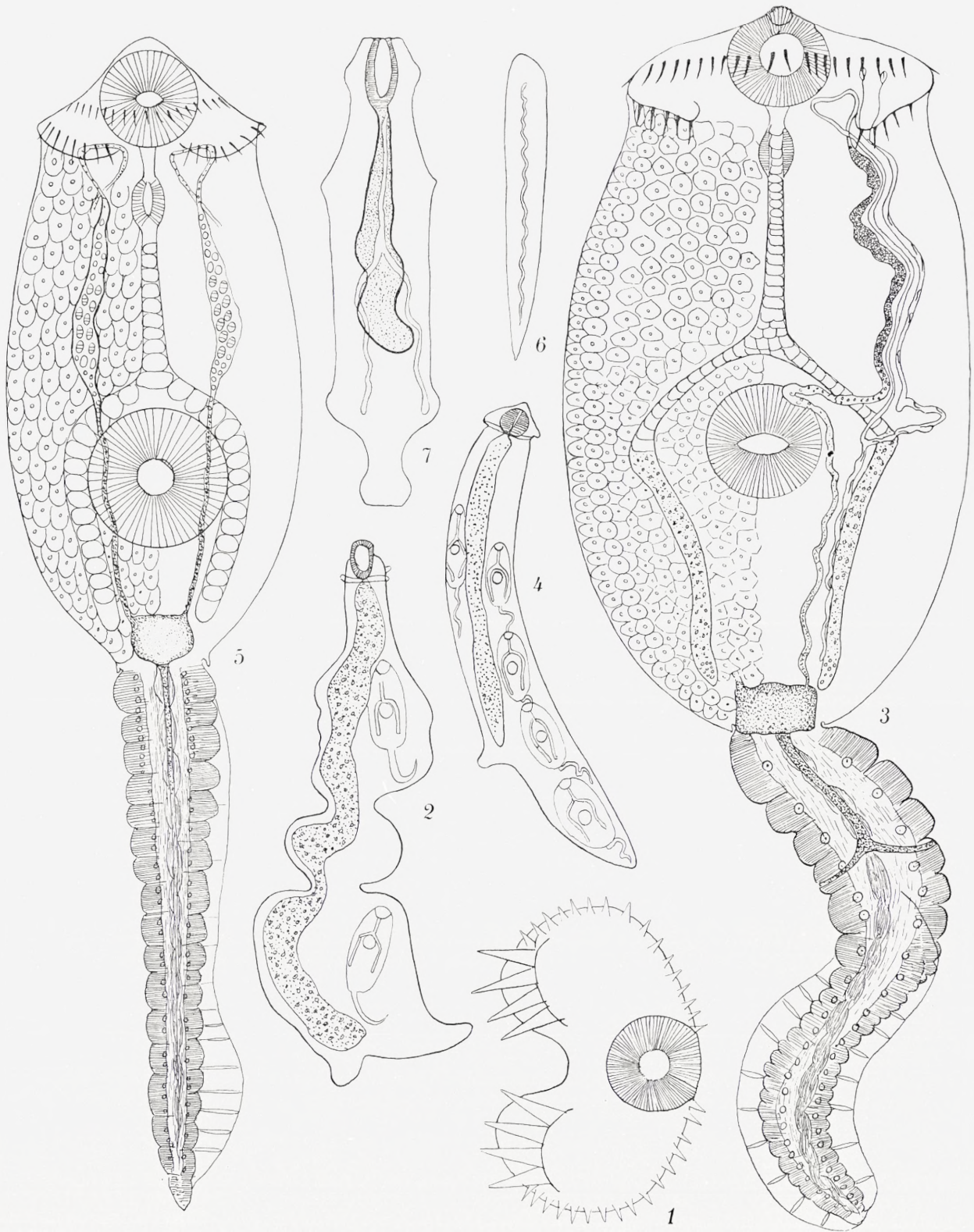


Plate VIII.
Echinostomata.

Fig. 1.	<i>Cercaria echinoparyphii recurvatum</i>	<i>Planorbis umbilicatus</i>	Furesø	25/IV 32	Oc. 2	Obj. 4		
- 2.	— Redia	—	—	25/IV 32	- 2	- 16		
- 3.	— Forepart of the Redia	—	The moor, Hillerød	12/III 32	- 2	- 16		
- 4.	— } Very young Redia .	—	—	12/III 32	- 4	- 16		
- 5.	— } Fig. 5, still in the	—	—	12/III 32	- 4	- 16		
	— } mother Redia . . .	—	—	12/III 32	- 4	- 16		
- 6. }								
- 7. }	— Cysts	—	—	12/III 32	- 4	- 4		
- 8. }								
- 9.	<i>Cercaria spinifera</i>	<i>Planorbis corneus</i>	Torkeris Pond, Hillerød	6/V 31	- 2	- 4		
- 10.	— Redia	—	—	6/V 31	- 4	- 16		
- 11.	— Redia	—	—	6/V 31	- 2	- 16		
- 12.	— Forepart of a Redia	—	—	6/V 31	- 6	- 16		
- 13.	— Redia	—	The moor, Hillerød	6/V 31	- 2	- 16		
- 14.	— Redia	—	—	6/V 31	- 2	- 16		
- 15.	— Redia	—	—	6/V 31	- 2	- 16		
- 16.	— Redia	—	Torkeris Pond, Hillerød	7/V 31	- 6	- a*		
- 17.	— Liver of the <i>Planorbis</i>							
	with a great mass of							
	cysts at the base . . .	—	—	7/V 31				

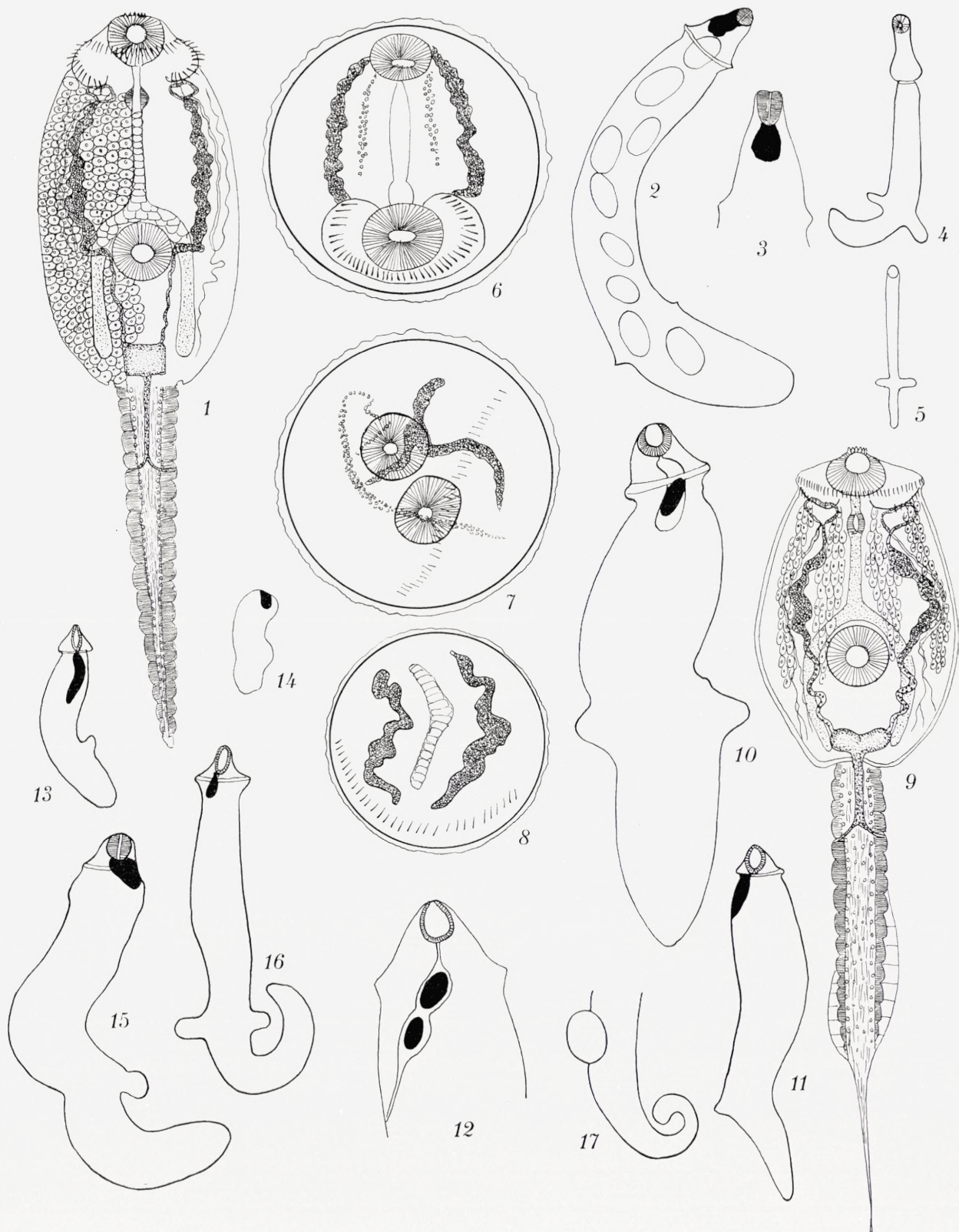


Plate IX.
Echinostomata.

Fig. 1.	<i>Cercaria echinata</i>	<i>Limnaea stagnalis</i>	Torkeris Pond, Hillerød	23/IV 31	Oc. 2	Obj. 4
- 2.	— Redia with Cercariae....	—	—	25/V 31	- 4	- 16
- 3.	— Redia of peculiar form...	—	—	25/V 31	- 6	- a*
- 4.	— Redia of peculiar form...	—	—	8/V 31	- 6	- a*
- 5.	— Redia with daughter rediae	—	—	3/V 31	- 6	- a*
- 6.	} — Old Rediae of peculiar form	—	—	6/VII 31	- 8	- a*
- 7.		—	—	30/IV 31	- 4	- a*
- 8.		—	—	30/IV 31	- 4	- a*
- 9.		—	—	30/IV 31	- 4	- a*
- 10.		—	—	30/IV 31	- 4	- a*
- 11.	—	—	—	30/IV 31	- 2	- 16
- 12.	Redia with daughter redia, Cercaria and Tetracotyle	—	Spring pond.....	15/VII 32	- 6	- a*
- 13.	Redia with Cercariae; the excretory system very conspicuous	—	—	15/VII 32	- 2	- 16

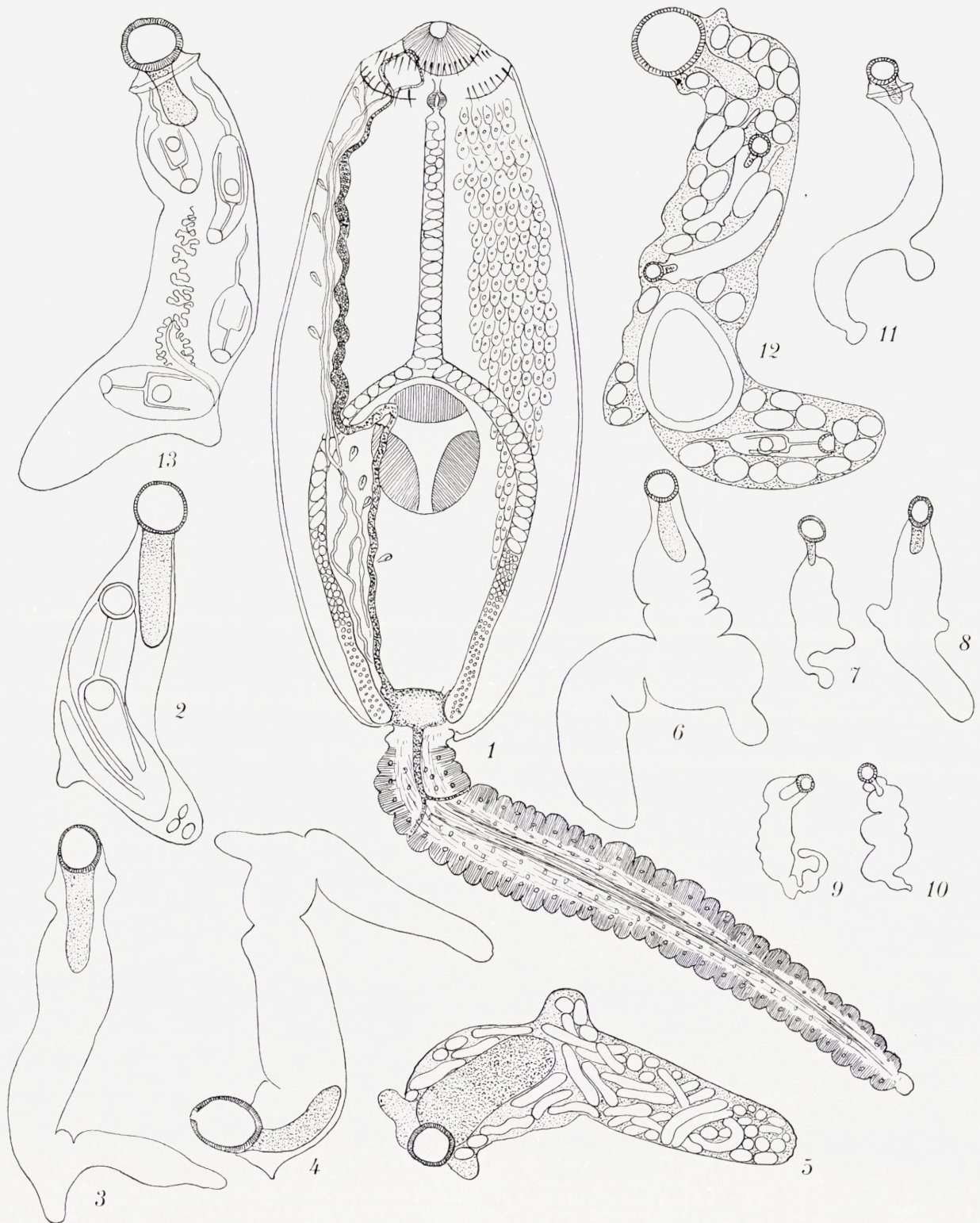


Plate X.
Echinostomata.

Fig. 1.	<i>Cercaria echinata</i> . Redia	<i>Limnaea stagnalis</i>	Torkeris Pond, Hillerød	26/IV	32	Oc. 6	Obj. a*
- 2.	— Forepart of the Redia	—	—	26/IV	32	- 6	- a*
- 3.	— Redia	—	—	30/IV	32	- 2	- a*
- 4.	— Redia with daughter rediae, Cercariae and Tetracotyle	—	—	26/IV	32	- 6	- a*
- 5.	— Excretory system, Redia	—	—	20/IV	32	- 6	- IV
- 6.	— Redia which has just begun propagation . . .	—	—	30/IV	32	- 4	- 16
- 7.	} Figs. 7—14 illustrate the encystation, vide the text . . .	—	Strodam, Hillerød . . .	15/II	33		
- 8.							
- 9.							
- 10.							
- 11.							
- 12.	} Redia sp.	<i>Planorbis albus</i> . .	Castle Park, Hillerød . .	1/VIII	32	- 4	- 16
- 13.							
- 14.							
- 15.							

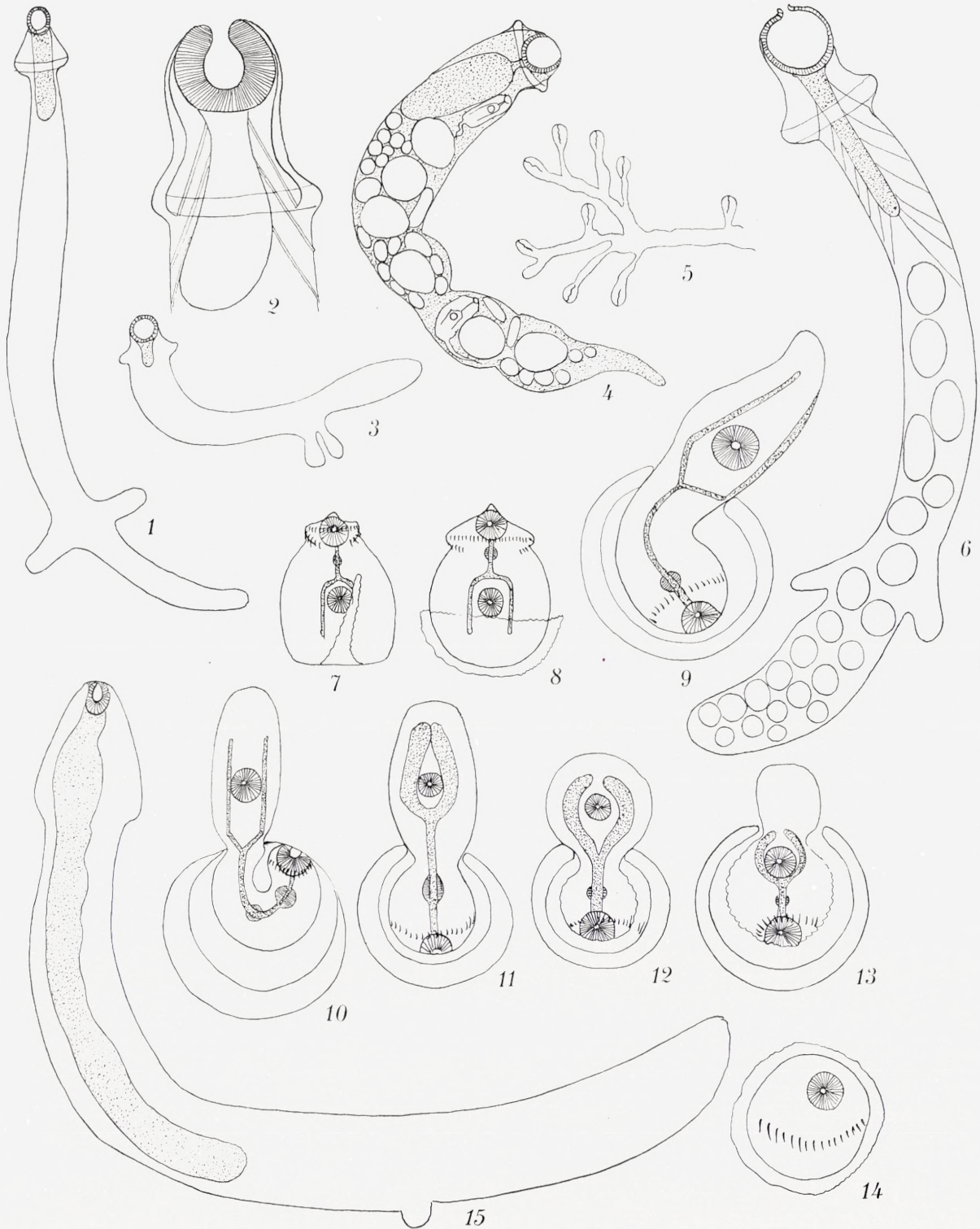


Plate XI.
Echinostomata.

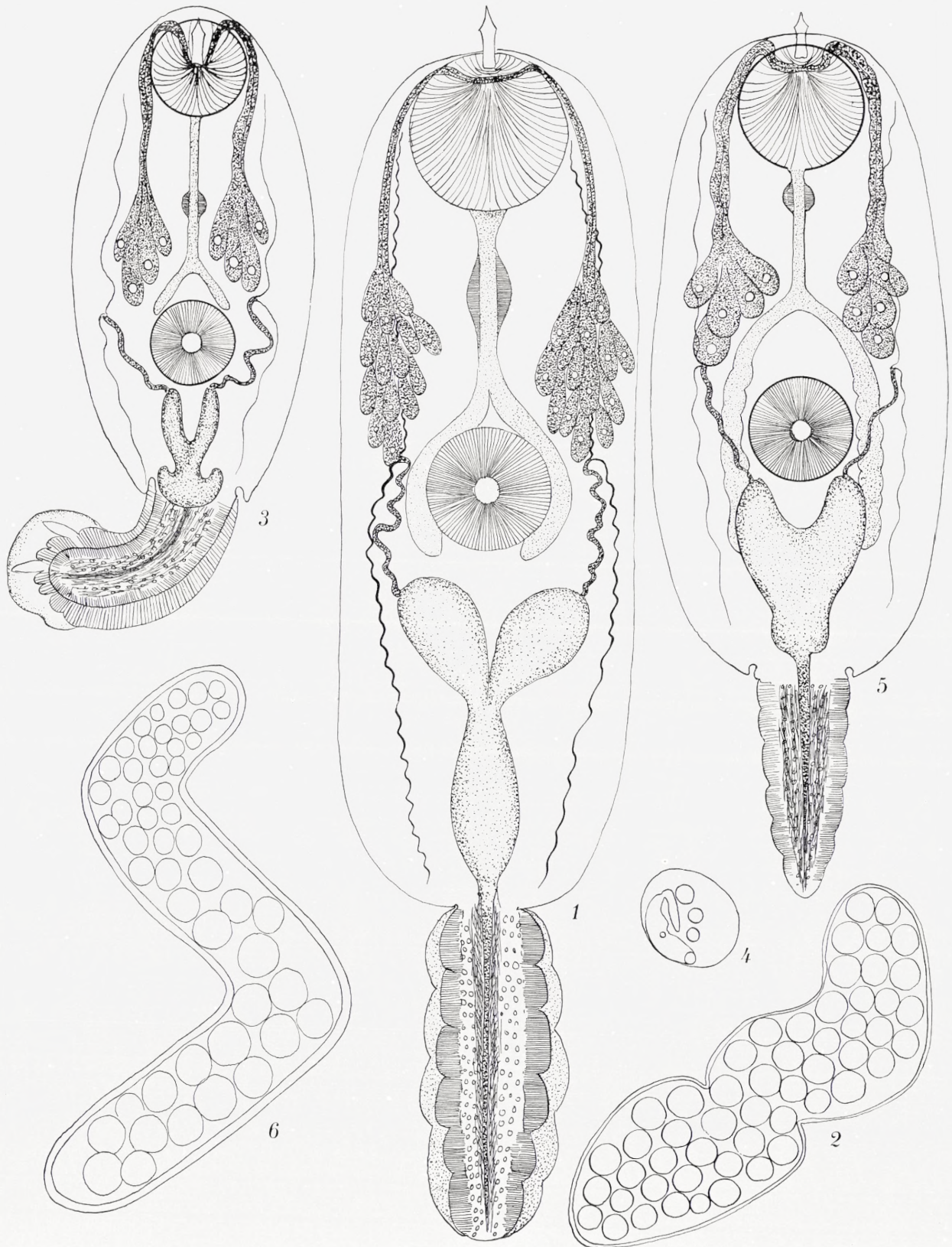
Fig. 1.	<i>Cercaria affinis</i> n. sp.	<i>Limnaea auricularia</i>	Susaa	2/VI 31	Oc. 2	Obj. 4
- 2.	— lateral view	—	—	2/VI 31	- 2	- 16
- 3.	<i>Cercaria Hypodereae conoideae</i>	<i>Limnaea ovata</i>	Donse, Hillerød	9/XI 31	- 4	- 4
- 4.	— Redia	—	—	9/XI 31	- 4	- 16
- 5.	<i>Cercaria coronata</i> . Redia	<i>Limnaea auricularia</i>	Susaa	9/VI 31	- 4	- a*
- 6.	<i>Cercaria Hypodereae conoideae</i> . Redia .	<i>Limnaea ovata</i>	Donse, Hillerød	9/XI 31	- 4	- 16



Plate XII.
Xiphidiocercaria.

Oc. 4 Obj. 4.

Fig 1.	<i>Cercaria laticauda</i>	<i>Limnaea stagnalis</i>	Strødam	13/II	32
- 2.	— Sporocyst	—	—	13/II	32
- 3.	<i>Cercaria prima</i>	<i>Planorbis albus</i> ..	The Castle Pond, Hillerød	2/VIII	32
- 4.	— Sporocyst.....	—	.. —	2/VIII	32
- 5.	<i>Cercaria Limnaeae ovatae</i>	<i>Limnaea ovata</i> ..	Strødam		
- 6.	— Sporocyst.....	—	.. —		



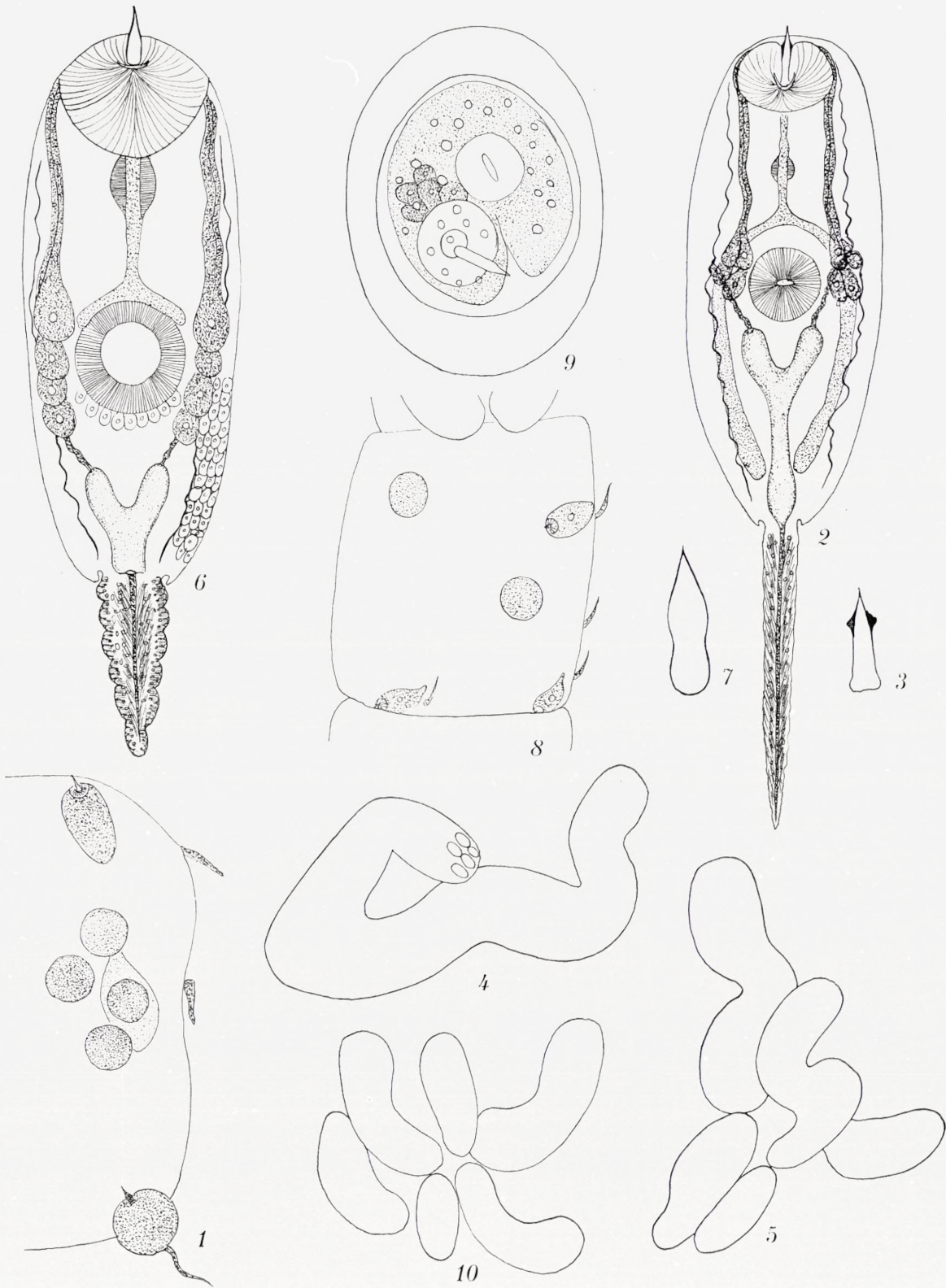


Plate XIV.
Xiphidiocercaria.

Fig. 1.	<i>Cercaria vesiculosa</i> , contracted	<i>Bithynia tentaculata</i>	Tjustrup Lake	8/VIII 32	Oc. 4	Obj. 4
- 2.	— extended	—	—	8/VIII 32	- 4	- 4
- 3.	— Sporocyst	—	—	8/VIII 32	- 2	- 4
- 4.	— Sporocyst with cysts and cercaria germs	—	—	8/VIII 32	- 4	- 4
- 5.	<i>Cercaria cellulosa</i>	<i>Paludina vivipara</i> ..	Hellebæk	26/V	31	- 4 - 4
- 6.	— Sporocyst	—	.. —	26/V	31	- 4 - 16
- 7.	— Sporocyst with Cercariae between it and the paletot...	—	.. —	26/V	31	- 2 - 4
- 8.	— The cells of the paletot ...	—	.. —	26/V	31	- 6 - 4
- 9.	<i>Cercaria pusilla</i> Sporocyst.....	—	.. —	26/V	31	- 2 - 4
- 10.	— Sporocyst.....	—	.. —	26/V	31	- 2 - 4
- 11.	— Sporocyst.....	—	.. —	26/V	31	- 2 - 4
- 12.	— Sporocyst.....	—	.. —	26/V	31	- 2 - 4

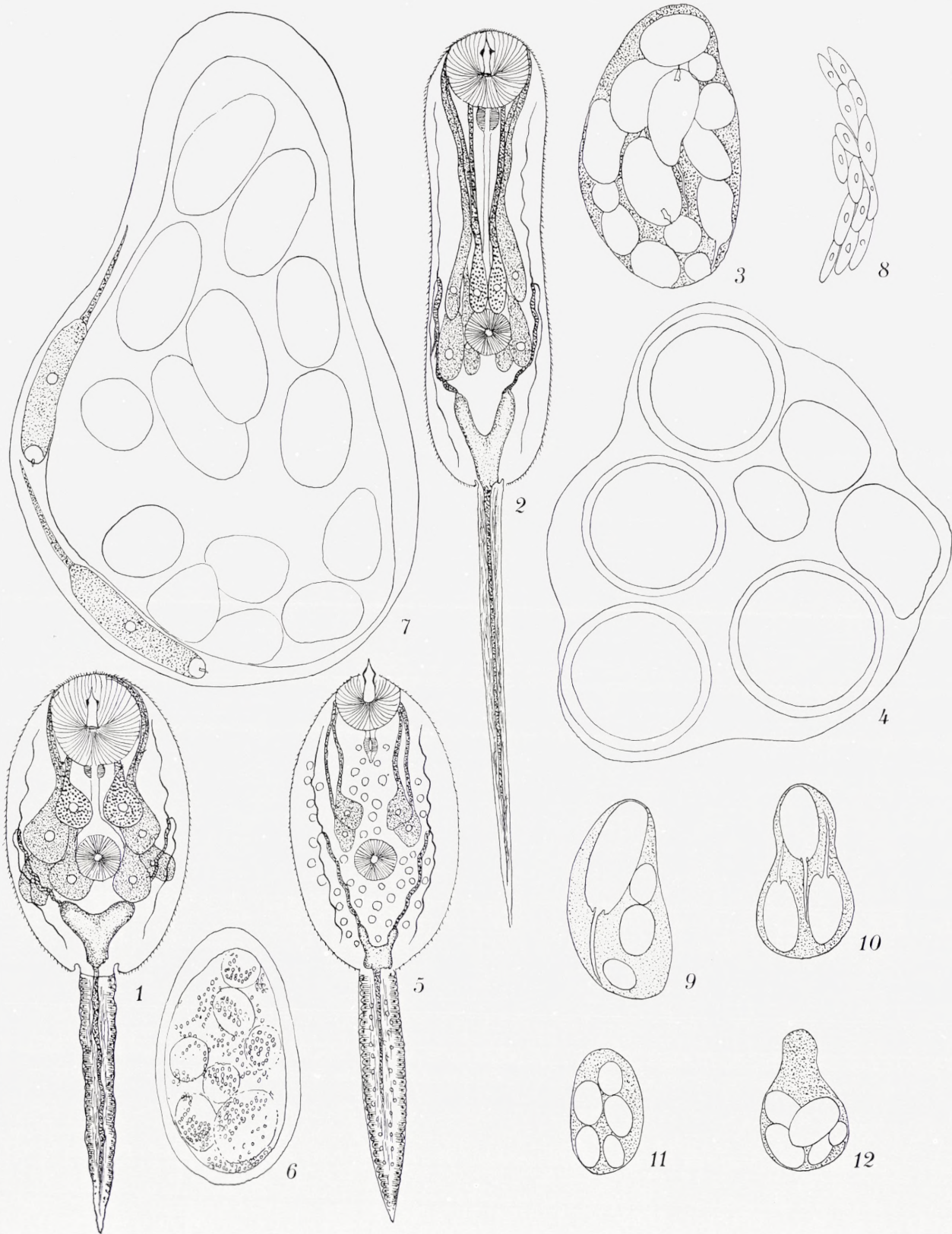


Plate XV.
Xiphidiocercaria.

Fig. 1.	<i>Cercaria pusilla</i>	<i>Bithynia tentaculata</i>	Hellebæk	25/V	31	Oc. 6	Obj. 4
- 2.	— contracted	—	—	25/V	31	- 4	- 4
- 3.	— Part of the liver of the snail containing enormous numbers of sporocysts.....	—	—	25/V	31	- 4	- a*
- 4.	— Sporocyst.....	—	—	13/IV	31	- 4	- 4
- 5.	<i>Cercaria cordiformis</i> n. sp., contracted .	—	—	13/IV	31	- 6	- 4
- 6.	— fully extended.....	—	—	13/IV	31	- 6	- 4
- 7.	— The common form when swimming.....	—	—	13/IV	31	- 6	- 4
- 8.	— Sporocyst	—	Donse ..	10/VII	31	- 6	- 16
- 9.	— Sporocyst	—	Hellebæk	13/IV	31	- 6	- 16
- 10.	— Cyst.....	—	—	13/IV	31	- 4	- a*

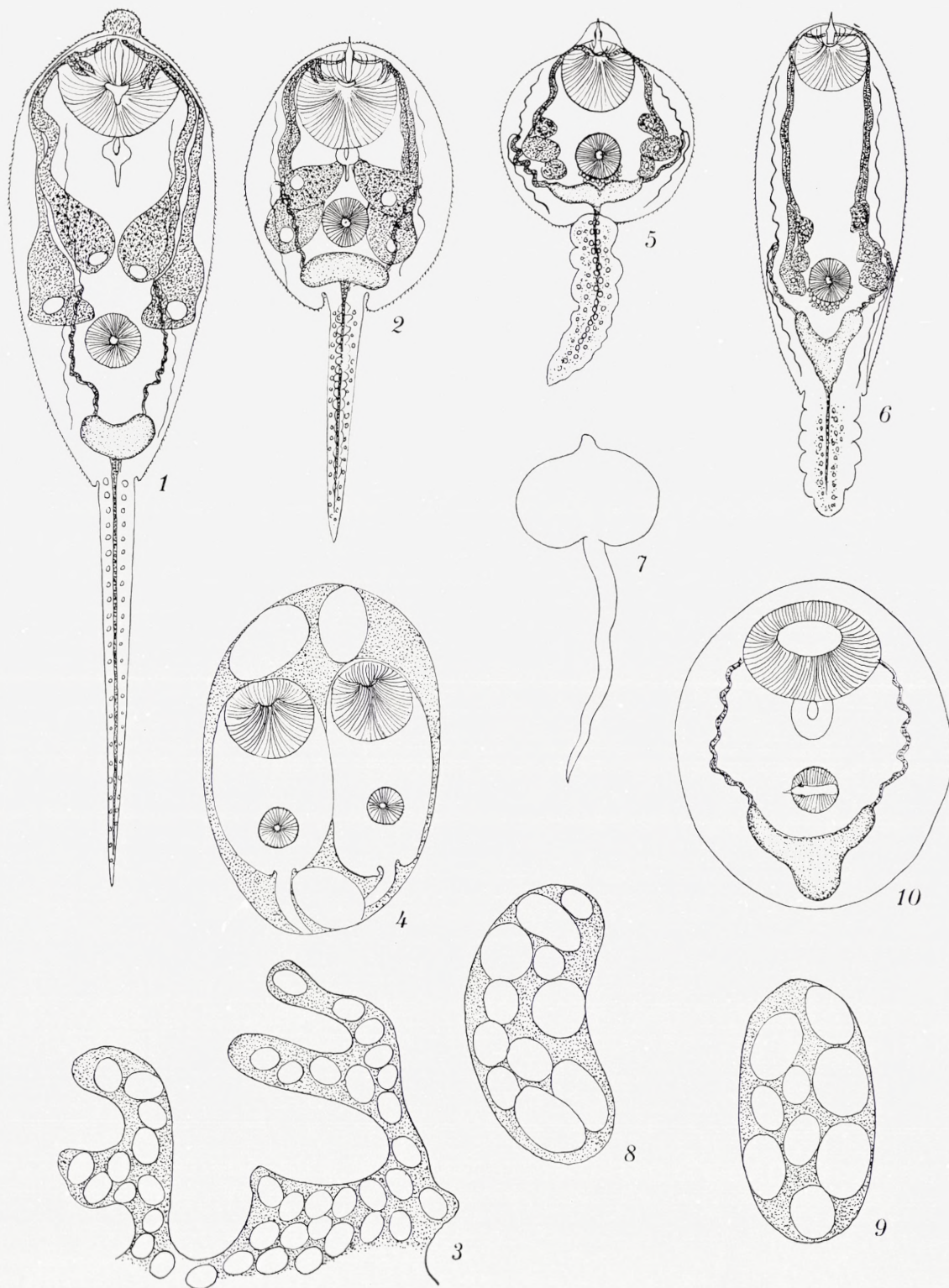


Plate XVI.
Xiphidiocercaria.

Fig. 1.	<i>Cercaria nodulosa</i>	<i>Bithynia tentaculata</i>	Hellebæk.....	2/IV 31	Oc. 4	Obj.	Waterim.
- 2.	— expanded	—	—	2/IV 31	- 4	-	Waterim.
- 3.	— Sporocyst	—	—	2/IV 31	- 6	-	16
- 4.	— Sporocyst	—	—	2/IV 31	- 4	-	4
- 5.	<i>Cercaria virgula</i>	—	Strødam, Hillerød	24/X 31	- 4	-	4
- 6.	— Sporocyst	—	—	24/X 31	- 4	-	16
- 7.	<i>Cercaria helvetica</i> IX Dubois	—	Værebros, Hillerød	17/VII 31	- 4	-	4
- 8.	— Sporocyst	—	—	17/VII 31	- 6	-	16

Plate XVII.
Macroceraria.

Fig. 1.	<i>Cercaria vitellilobae</i> in its house....	<i>Sphaerium corneum</i>	Strødam, Hillerød..	5/VI 31	Oc. 4	Obj. 16		
- 2.	— halfway extended	—	—	.. 5/VI 31	- 4	- 16		
- 3.	— fully extended	—	—	.. 5/VI 31	- 4	- 16		
- 4.	<i>Cercaria Pagenstecheri</i> . Part of the tail; the musculature only drawn in the left part....	—	—	.. 5/VI 31	- 4	- 16		
- 5.	— The posterior part of the tail with its longitudinal and transversal musculature	—	—	.. 5/VI 31	- 4	- 4		
- 6.	— In its house	—	Vejenbrød, Hillerød	2/VI 31	- 2	- 16		
- 7.	— The <i>Cercaria</i> without tail	—	—	2/VI 31	- 4	- 4		
- 8.	— The <i>Cercaria</i> stretched out of its house.....	—	—	2/VI 31	- 4	- 16		
- 9.	— The <i>Cercaria</i> has left its house	—	—	2/VI 31	- 4	- 16		
- 10.	— The <i>Cercaria</i> partly extended	—	—	2/VI 31	- 4	- 16		
- 11.	— Part of the tail with longitudinal and transversal musculature	—	—	2/VI 31	- 4	- 4		
- 12.	— The stylet.....	—	—	2/VI 31	- 6	- 4		

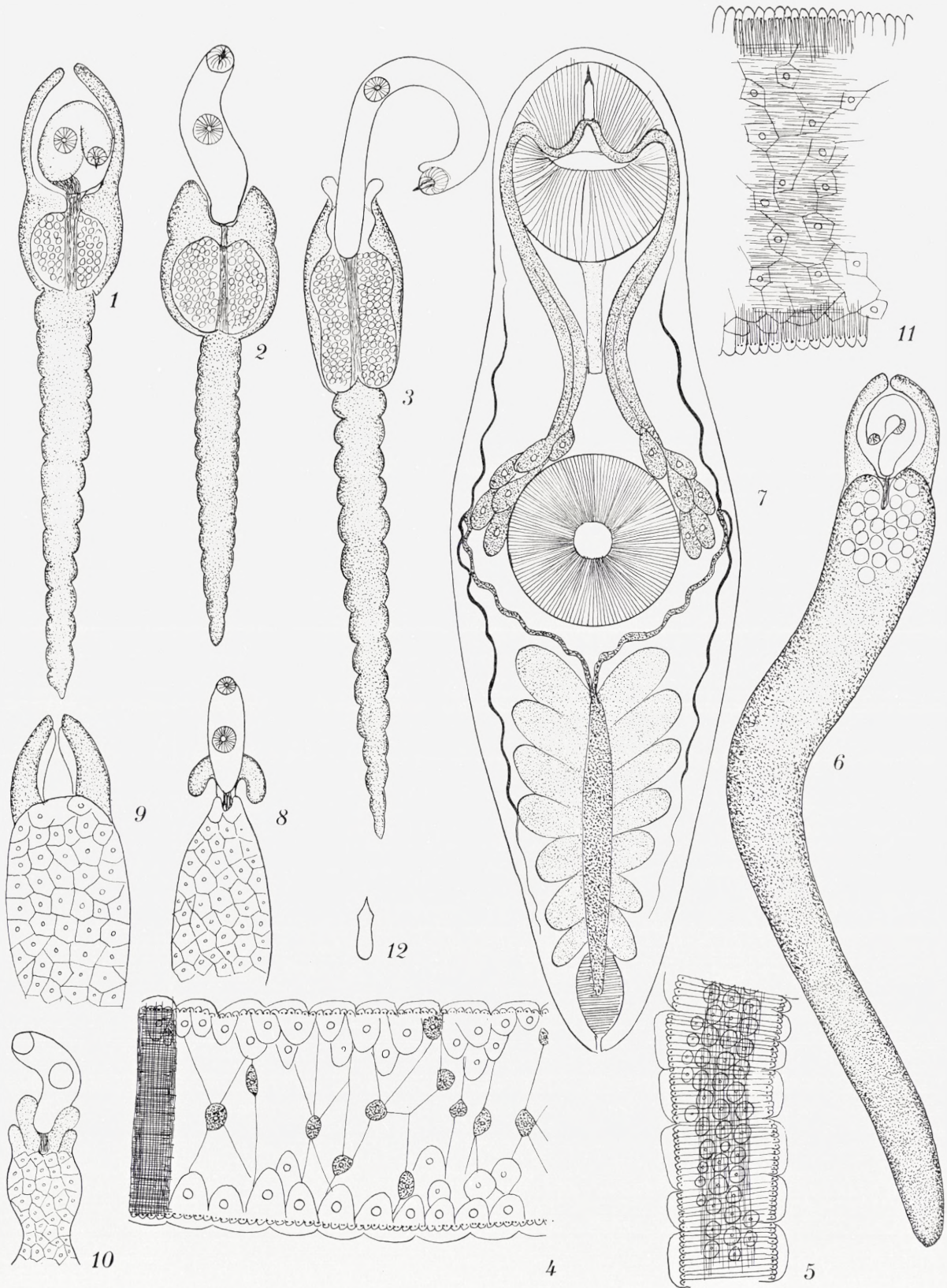


Plate XVIII.
Macroceraria.

Fig. 1.	<i>Cercaria vitellilobae</i> Ssin.	<i>Sphaerium corneum</i> Strødam, Hillerød	5/VI 31	Oc 4	Obj. 4
- 2.	— The anterior part of the tail with the muscle in the middle line	—	—	5/VI 32	- 4 - 4
- 3.	<i>Cercaria Pagenstecheri</i> . A Sphaerium with the vibrating Cerca- riae round the borders of the shell	—	—	2/VI 31	
- 4.	<i>Cercaria vitellilobae</i> . Sporocyst.....	—	—	5/VI 31	- 2 - 16
- 5.	— A very old Sporocyst ...	—	—	17/III 31	- 6 - 16

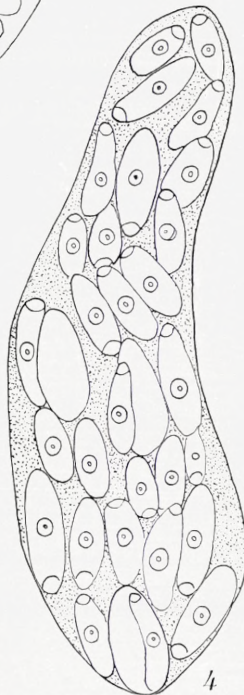
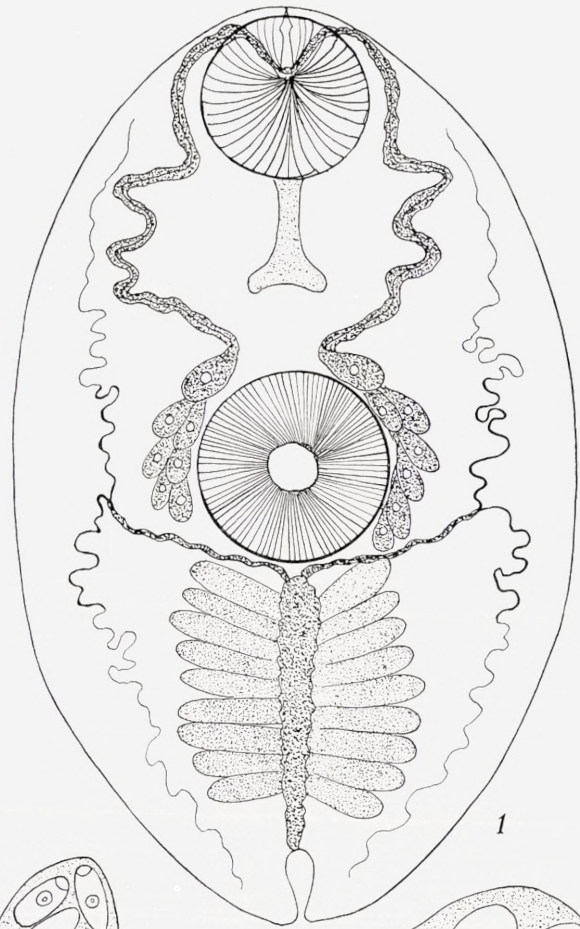
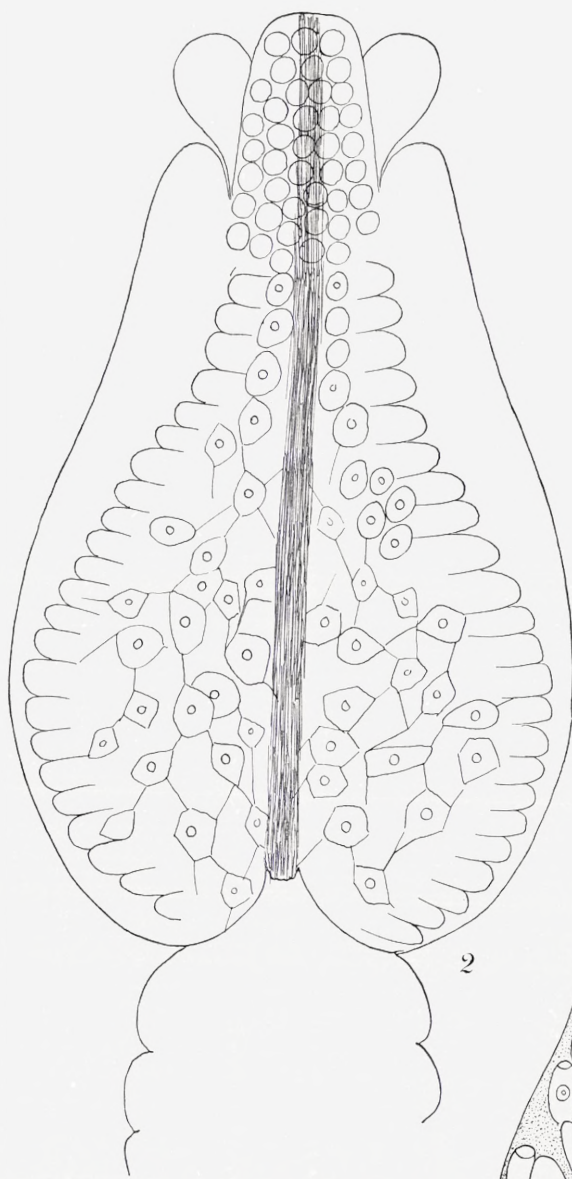


Plate XIX.
Cystocercaria.

Fig. 1.	<i>Cercaria splendens</i>	Taken in Plancton, Furesø	/VII 10	Oc. 4	Obj. 16
- 2.	—	—	/VII 10	- 4	- 16
- 3.	—	—	/VII 10	- 4	- 16
- 4.	<i>Cercaria C. Szidal</i>	Tuelso, Sorø	/IX 33	- 6	- 16
- 5.	— from the lens of <i>Gobio fluviatilis</i>	—			
- 6.	— The young Diplostomum	—		- 6	- 16
- 7.	— The fully developed Diplostomum	—		- 6	- 16
- 8.	— The young Cercaria which has just entered the lens. Almost the same stage as fig. 6	—		- 2	- 4
- 9.	— The same specimen as fig. 5; the larva has withdrawn from the cuticula; larval organs are not observed and the oral sucker of the Diplostomum is to be formed	—		- 2	- 4
- 10.	A Diplostomum found in the lens of <i>Abramis blicca</i>	The Castle Lake, Hillerød	10/III 32	- 2	- 4

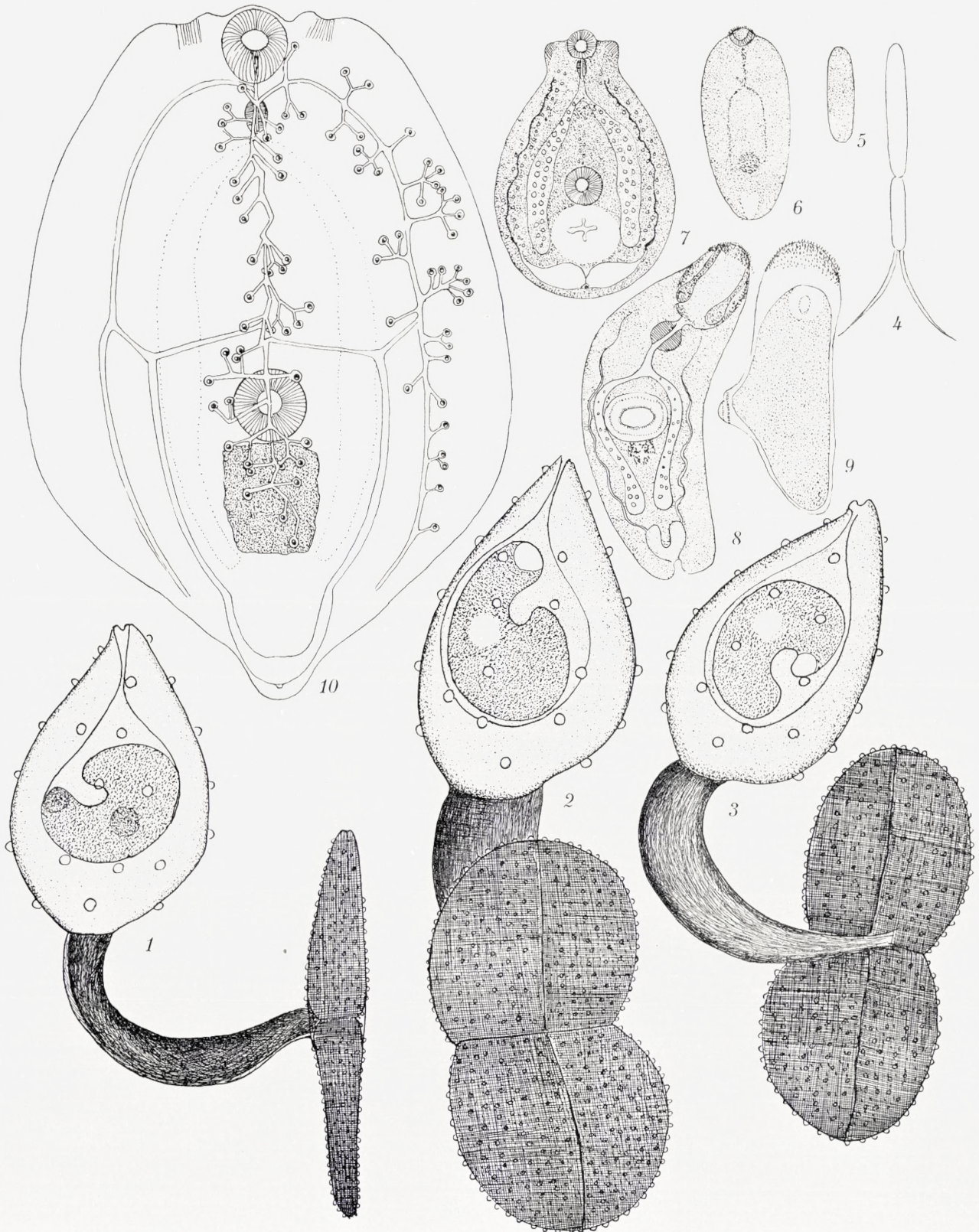


Plate XX.
Furcocercaria.

Fig. 1.	<i>Cercaria cristata</i> . The musculature of the tail only drawn in the upper part of the tail	<i>Limnaea stagnalis</i>	28/V 32	Oc. 6	Obj. 4
- 2—5.	The body of the same specimen drawn in the course of two minutes	—	28/V 32	- 4	- 4
- 6.	The mother sporocyst, very old, containing daughter sporocysts; some of them force their way through the skin	—	28/V 32	- 4	- a*
- 7.	Another Sporocyst containing daughter sporocysts; one large, packed with germs, many small and a few ripe Cercariae which are fully hatched	—	28/V 32	- 6	- 16
- 8.	The tip of the mother sporocyst	—	28/V 32	- 8	- 4
- 9.	A sporocyst bursting, liberating its enormous amount of Cercaria germs	—	28/V 32	- 6	- a*
- 10.	The posterior end of a mother sporocyst with its sucker	—	28/V 32	- 6	- 16

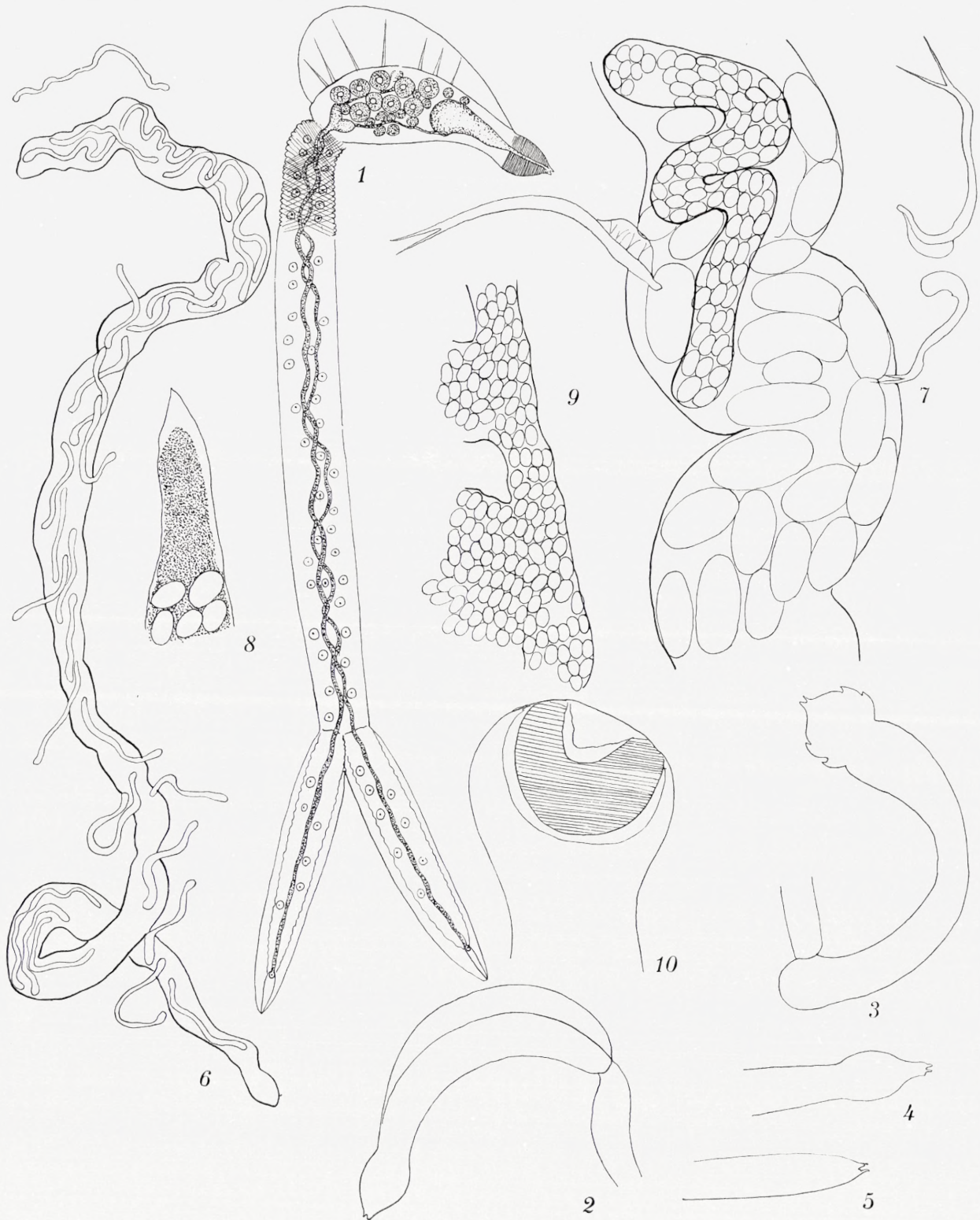


Plate XXI.
Furcocercaria.

Fig. 1.	<i>Cercaria ocellata</i>	<i>Limnaea stagnalis</i>	Horsholm	2/VII 32	Oc. 4	Obj. 4
- 2.	— The body seen laterally, slightly compressed	—	—	2/VII 32	- 4	- 4
- 3.	— The body in the piercing position giving off secreta from the penetration glands	—	—	2/VII 32	- 4	- 4
- 4.	— The body fully extended	—	—	2/VII 32	- 4	- 4
- 5.	<i>Cercaria Bilharziellae polonicae</i>	<i>Planorbis corneus</i>	—	5/VII 31	- 4	- 4
- 6.	— The body, lateral view	—	—	5/VII 31	- 4	- 4
- 7.	— Sporocysts	—	—	5/VII 31	- 4	- 16

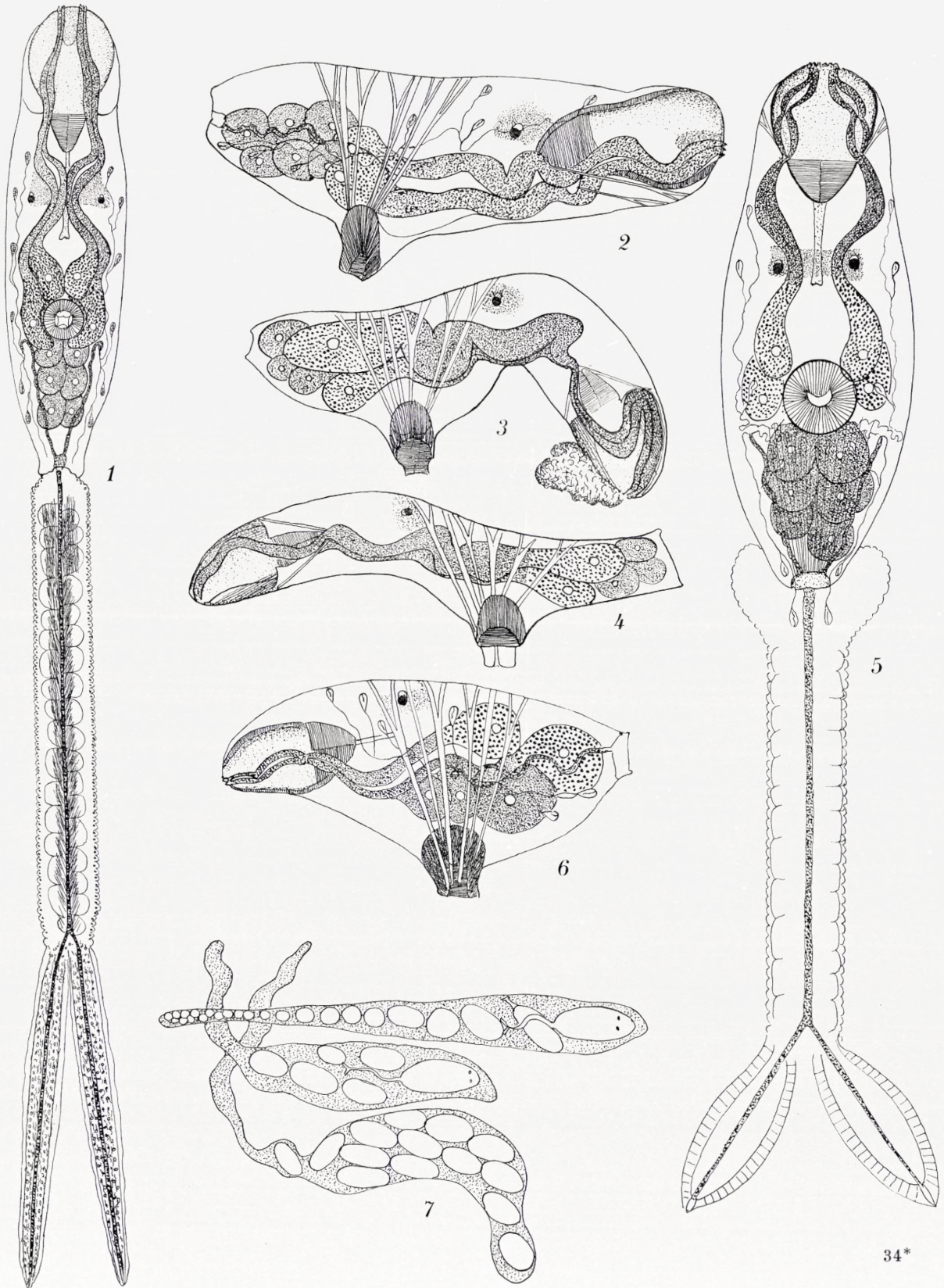


Plate XXII.
Furcocercaria.

Fig. 1.	<i>Furcocercaria longiremis</i>	<i>Valvata piscinalis</i>	Tjustrup Lake.	25/VII 31	Oc. 4	Obj. 4
- 2.	— Sporocyst	—	—	25/VII 31	- 4	- 16
- 3.	<i>Valvata</i> throwing out the Cercariae from the branches of the gill		—	25/VII 31	- 2	- a*
- 4.	<i>Furcocercaria C. Szidat.</i> Mother sporo- cyst	<i>Limnaea stagnalis</i>	Bagsværd Lake	2/VII 31	- 2	- a*
- 5.	— The tip of the mother sporocyst throwing out the daughter sporocysts; the tip is very mobile	—	—			
- 6.	<i>Furcocercaria strigeae tarda</i> . The mother sporocyst	—	Strødam	1/VII 31	- 6	- a*
- 7.	<i>Furcocercaria Frederiksborgensis</i> n. sp.	<i>Planorbis corneus</i>	Torkeris Pond.	26/IV 32	- 4	- 4
- 8.	— Sporocyst	—	—	26/IV 32	- 4	- 4

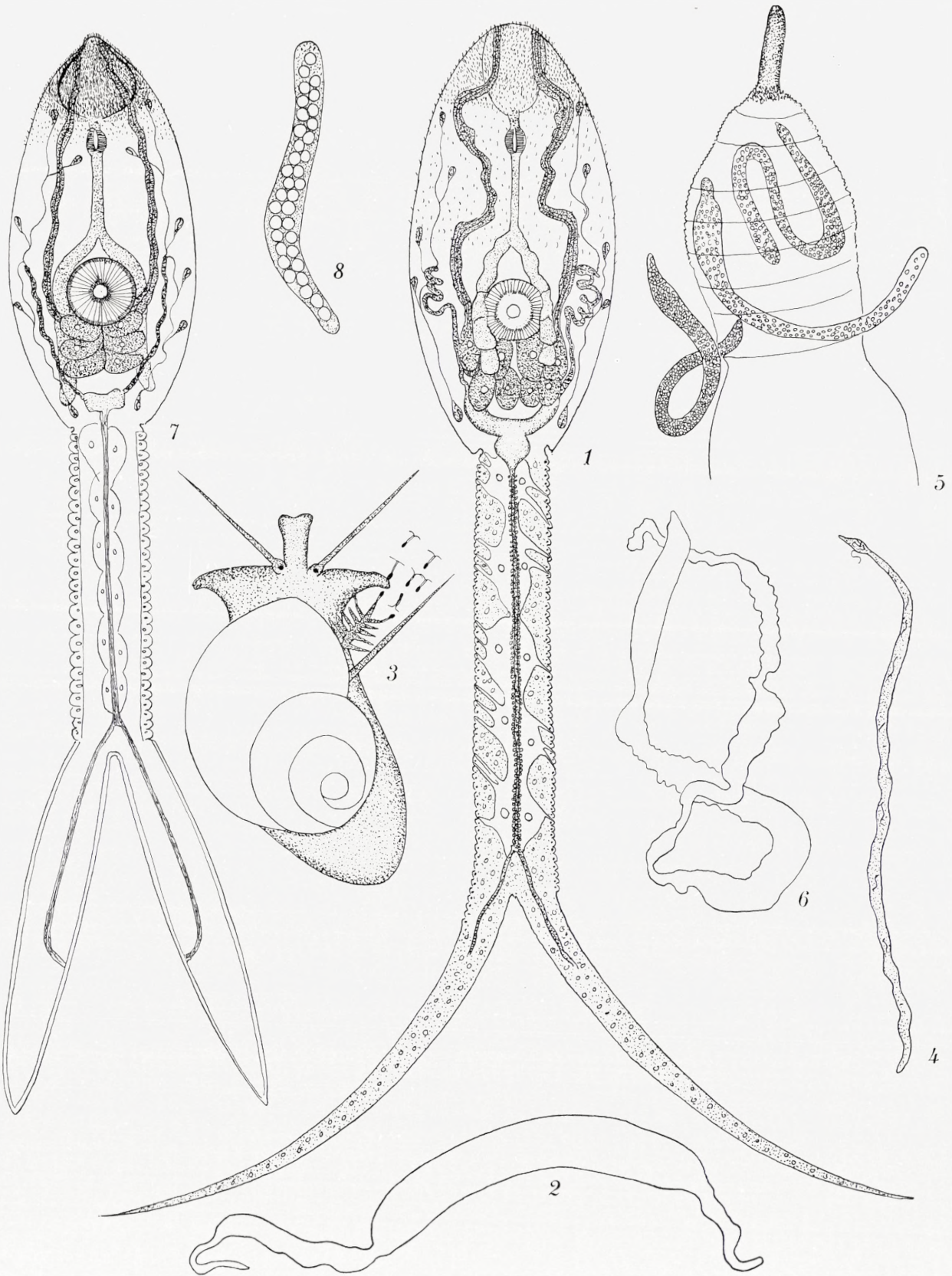


Plate XXIII.

Furcocercaria.

Fig. 1.	<i>Furcocercaria C. Szidal</i>	<i>Limnaea stagnalis</i>	Bagsværd Lake	2/VII 32	Oc. 4	Obj. 4
- 2.	<i>Furcocercaria F₁</i> Harper	<i>Planorbis umbilicatus</i> . .	Furesø	2/V 32	- 4	- 4
- 3.	<i>Furcocercaria strigae tardae</i> . . .	<i>Limnaea stagnalis</i>	Strødam Pond	11/VII 31	- 4	- 4

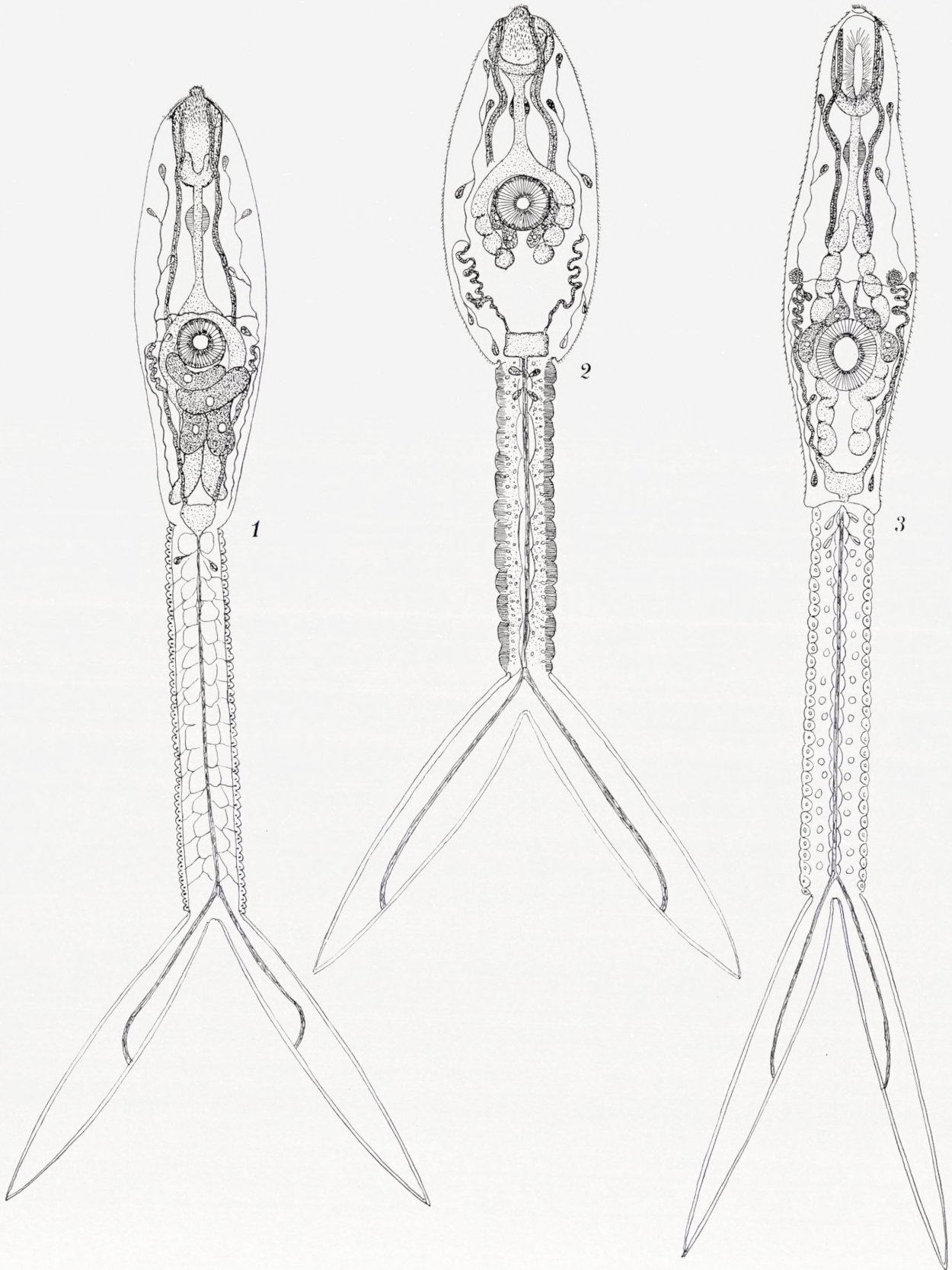


Plate XXIV.

Cercaria A Szidat *Cotylurus cornutus*.

- Fig. 1. The Tetracotyle stage from *Limnaea stagnalis*. Strödam 15/IX 33. Oc. 6 Obj. 16
Fig. 2. A Tetracotyle found in *Limnaea palustris*. Furesø 3/V 32. The gelatinous cover is
not drawn. Oc. 6 Obj. 16
Figs. 3—8. Sections of Tetracotyle *Cotylurus cornutus*. *Cercaria* A. Szidat.
Figs. 3—5 horizontal sections, figs. 6—7 transversal sections, fig. 8 sagittal section.
Figs. 3—7 through the resting Tetracotyle stage; fig. 8 through the creeping stage near
the metamorphosis into the resting stage. Thionine-Acid Fuchsine Aurantia . Oc. 4 Obj. 4

Abbreviations on Pl. XXIV and XXV.

- O.S.* = Oral sucker.
V.S. = Ventral sucker.
H.G. = Holdfast grooves.
H.O. = Holdfast organ.
Ph. = Pharynx.
I.C. = Intestinal coeca.
Ex.p. = Excretory pore.
Ex. = Excretory organ.
G.O. = Genital organ.



Plate XXV.

The metamorphosis of *Cercaria* A. Szidat. *Cotylurus cornutus*.

Figs. 1—10 drawn with the same power (Oc. 4 Obj. 16).

- 1 The *Cercaria*.
- 2 The earliest found specimen shortly after it has entered the snail.
- 3—6 shows the enormous growth, during which all larval organs disappear. The flat organism has free power of motion; it is a creeping organism.
- 7 The parasite is almost quite transformed into the Tetracotyle; it has a slight power of motion. The size has diminished; the body is much darker; the organs characteristic of the Tetracotyle stage are in preparation.
- 8 The stage in which motion has ceased.
- 9—10 The figures show how the size diminishes; Fig. 10 is the typical Tetracotyle without the gelatinous layers.
- 11—12 Two longitudinal sections through the creeping stage. Fig. 11 shows a specimen younger than fig. 12. The two figures show that the holdfast organ begins as protuberances which later on are invaginated. Oc. 4 Obj. 4. Haematoxyline, Azure Eosin.
- 13 A transversal section of the same stage. Oc. 4 Obj. 4, Haematoxyline, Azure Eosin.
- 14 A creeping larva found in a Sporocyst of a xiphidioid Trematode in *Limnaea stagnalis* (Hillerød 22/IV 31). The figure shows the enormous size of the larva in comparison with the host; it is further seen that the germ balls are intact and the larva must be nourished endosmotically.
- 15—16 Two different Tetracotyle from the same snail, to show the great difference in size. Oc. 4 Obj. 16.

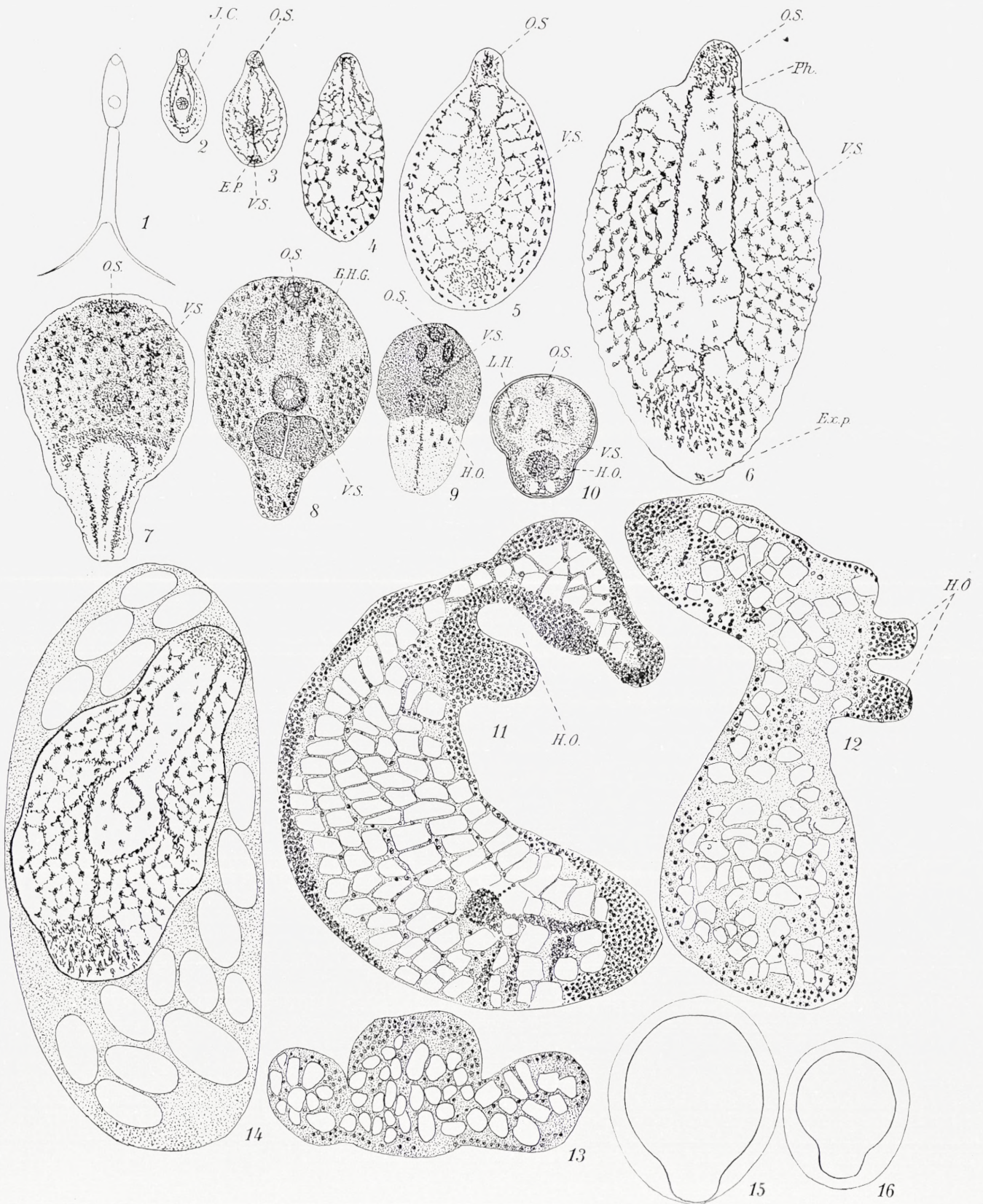


Plate XXVI.
Furcocercaria.

Fig. 1.	<i>Furcocercaria linearis</i> n. sp.	<i>Planorbis corneus</i>	Hørsholm	25/V 32	Oc. 4	Obj. 4
- 2.	— contracted	—	—	25/V 32	- 4	- 4
- 3.	<i>Furcocercaria helvetica</i> XXXI Dubois	<i>Limnaea palustris</i>	Indelukket, Hillerød	13/IX 32	- 4	- 4
- 4.	— contracted	—	—	13/IX 32	- 4	- 4
- 5.	— The mother Sporocyst empty, only contain- ing one single daughter Sporocyst	—	—	13/IX 32	- 2	- 16
- 6.	— A daughter Sporocyst packed with germs	—	—	13/IX 32	- 4	- 16
- 7.	— Part of the mother Sporocyst to show the very thick walls and the cell network	—	—	13/IX 32	- 4	- 4

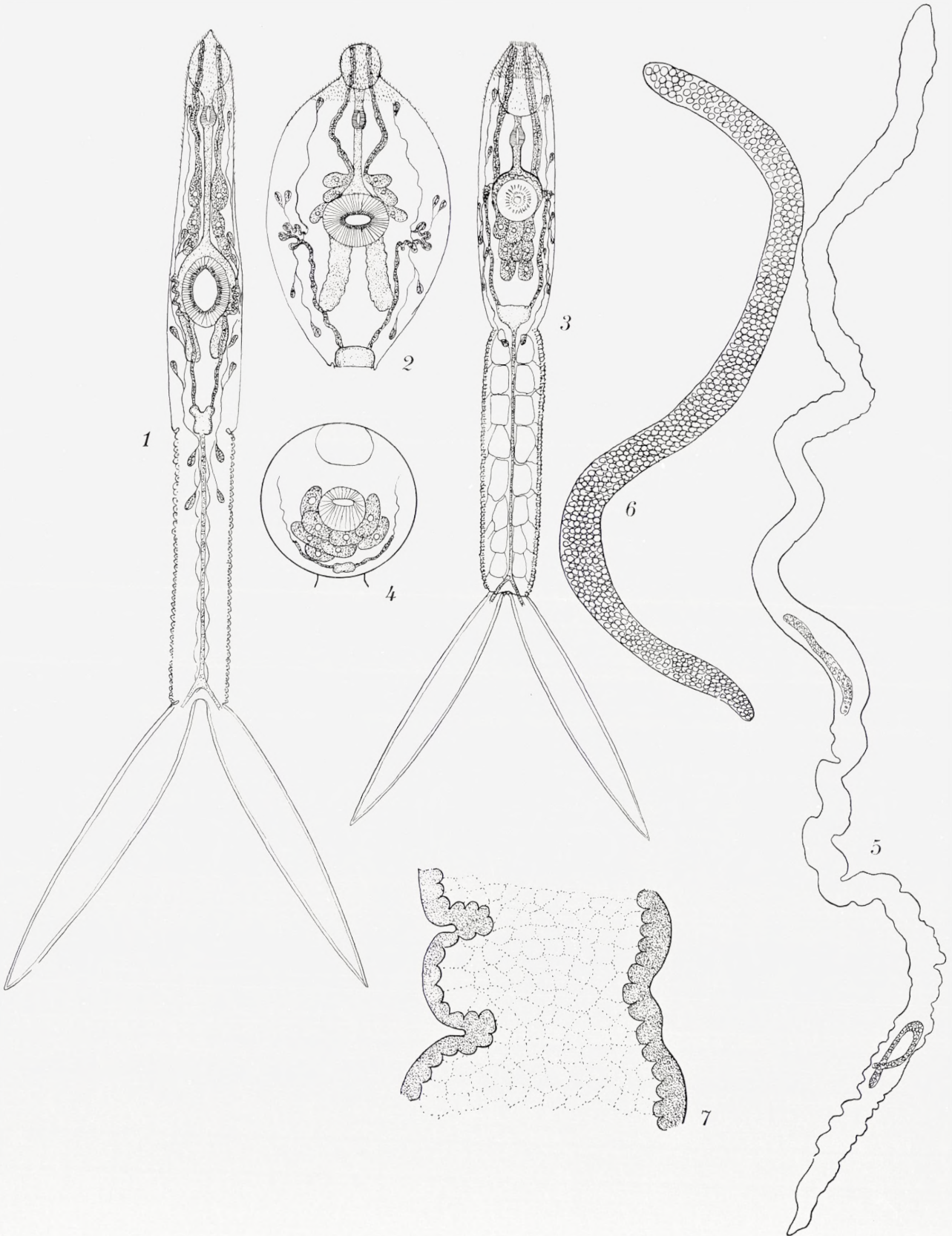


Plate XXVII.

Fig. 1.	<i>Furcocercaria</i>	A. Szidal	.....	<i>Limnaea palustris</i>	..	Furesø	....	25/V	32	Oc. 4	Obj. 4
- 2.	<i>Furcocercaria</i>	<i>letifera</i>	.....	<i>Limnaea auricularia</i>		Susaa, Sorø		2/VI	31	- 4	- 4
- 3.		— mother Sporocyst	.....	—		—		2/VI	31	- 4	- a*
- 4.		— Sporocyst	.....	—		—		2/VI	31	- 4	- 16
· 5—8.		— Sporocysts	.....	—		—		2/VI	31	- 4	- 16

The figures illustrate the extremely variable forms.

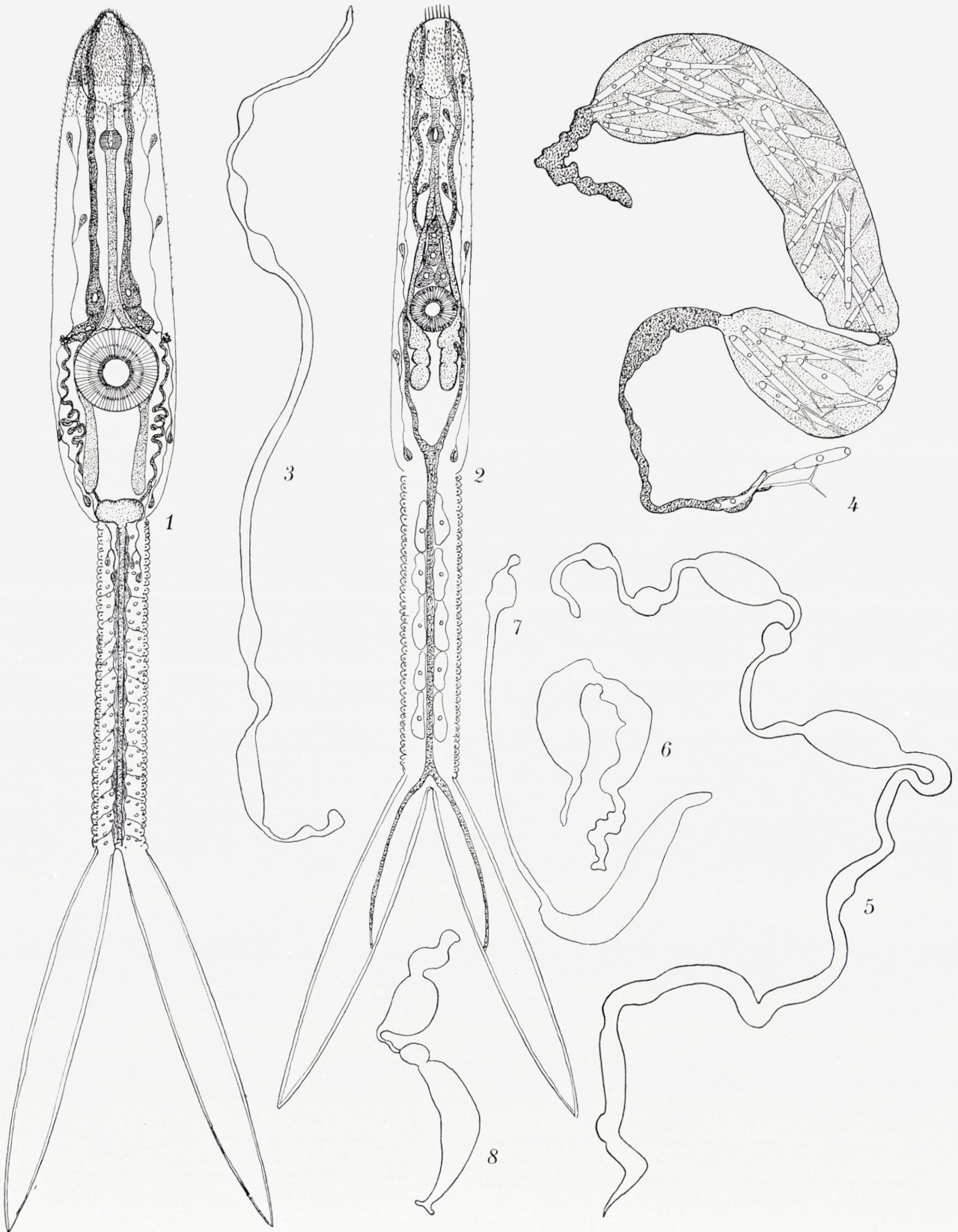


Plate XXVIII.

Furcocercaria.

Fig. 1.	<i>Furcocercaria I</i> Petersen	.....	<i>Limnaea ovata</i>	.....	Hørsholm	.....	12/VIII	32	Oc. 4	Obj. 4
- 2.	—	.....	<i>Physa fontinalis</i>	.....	Tjustrup Lake	.....	12/VIII	31	- 4	- 4
- 3.	—	contracted	.....	.....	.....	.....	12/VIII	31	- 6	- 4
- 4.	<i>Furcocercaria vivax</i> .	Posterior end of the Sporocyst	.....	<i>Bithynia tentaculata</i>	Hellebæk	.....	25/V	32	- 2	- 4
- 5.	—	The Cercaria seen laterally. The dorsal attachment of the tail and the six openings for the penetration glands are seen	.....	—	—	.....	25/V	32	- 4	- 4
- 6.	—	Sporocyst	.....	—	.....	.....	25/V	32	- 4	- 16
- 7.	<i>Furcocercaria ocellata</i> .	The figures illustrate the different positions of the Cercariae when attached to the substratum	.....	<i>Limnaea stagnalis</i>	Hørsholm	.....	5/VIII	32		
- 8.	—	Sporocysts	.....	—	.....	.....	5/VIII	32	- 4	- 16
- 9.	—	Sporocyst	.....	—	.....	.....	5/VIII	32	- 4	- 16

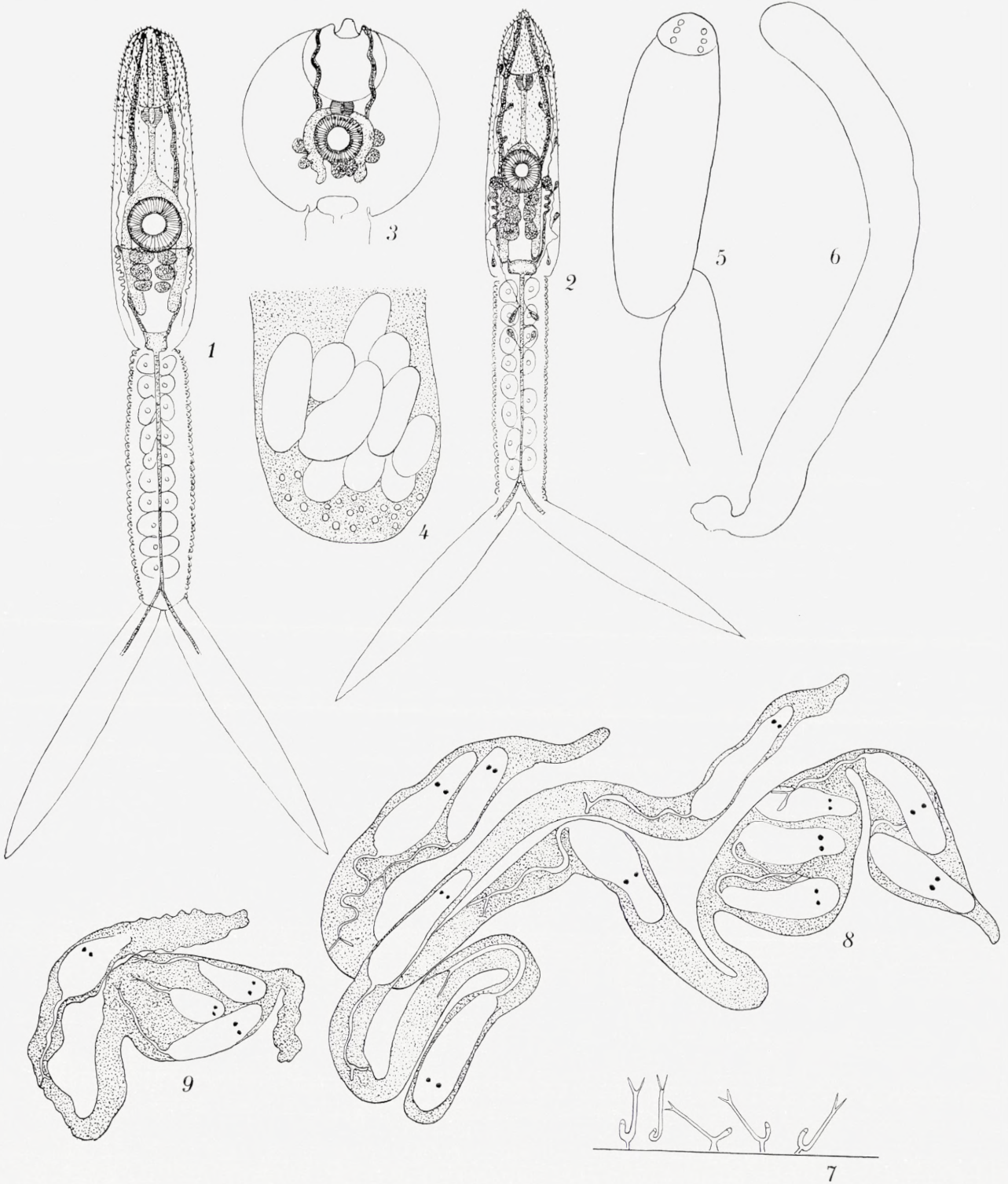


Plate XXIX.
Furcocercaria.

Oc. 4 Obj. 4.

Fig. 1.	<i>Furcocercaria vivax</i>	<i>Bilhyhia tentaculata</i> ...	Værebrosø.....	7/VII	31
- 2.	<i>Furcocercaria No. 4 Petersen</i>	—	Furesø.....	19/IX	31
- 3.	<i>Furcocercaria</i> sp.....	—	Hellebæk.....	15/V	32

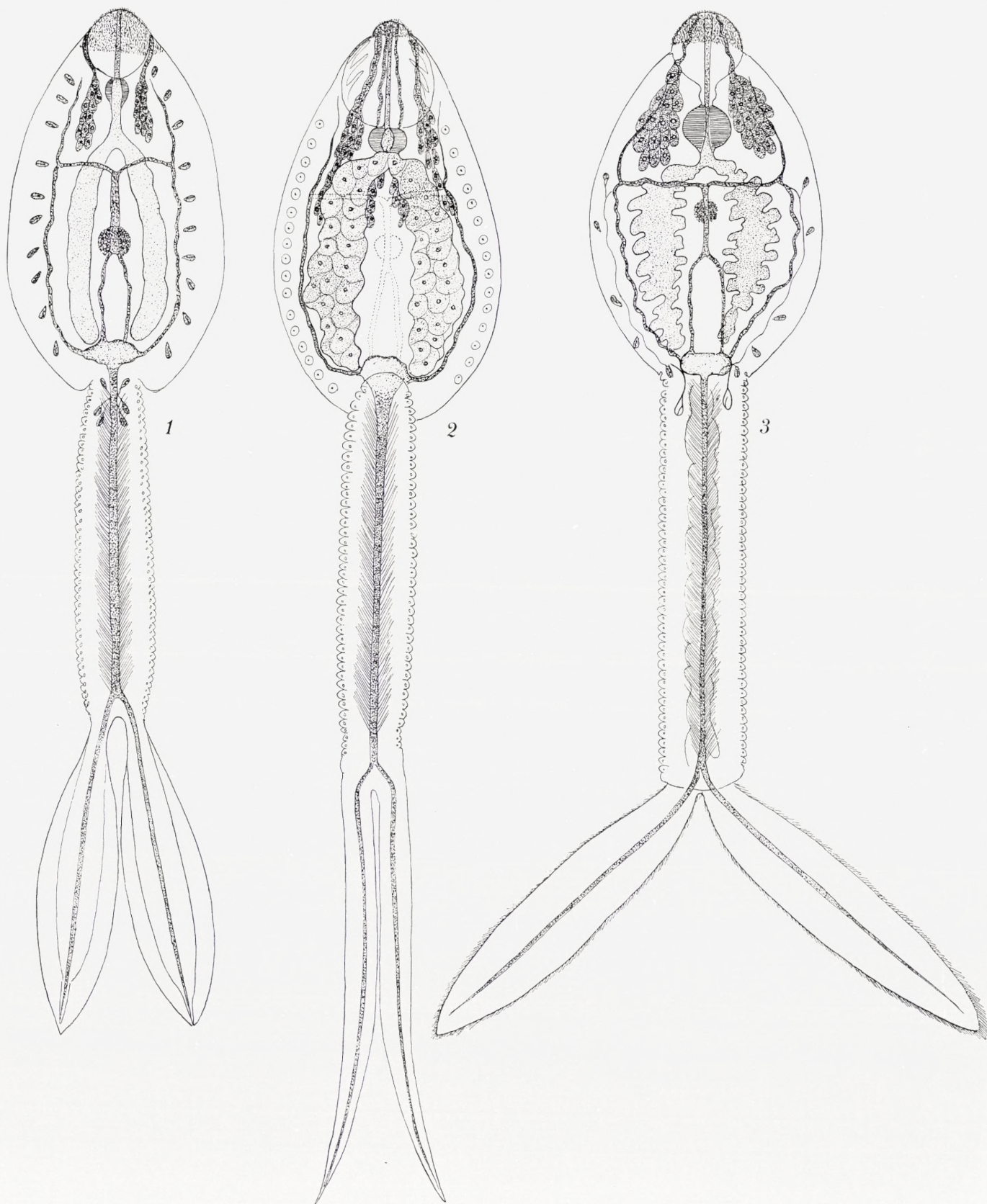


Plate XXX.
Furcocercaria.

- Fig. 1. *Bucephalus polymorphus* on the bottom *Anodonta* Hørsholm /V 33
 - 2. }
 - 3. } — different resting positions..... —
 - 4—8. — suspended in the water layers; in fig. 4 the larva stands deepest, in
 figs. 5 and 6 the rami of the furca are extended; in fig. 7 the rami are
 bent outwards; during the extension of the arms the animal is lifted
 upwards; using the cross section resistance, the animal stands for a mo-
 ment in the new water layer; when they are again drawn in (fig. 8), the
 animal slowly sinks downwards again. The drawings are half camera
 half free-hand-drawings.
 - 9. — Sporocyst..... Oc. 5 Obj. 16

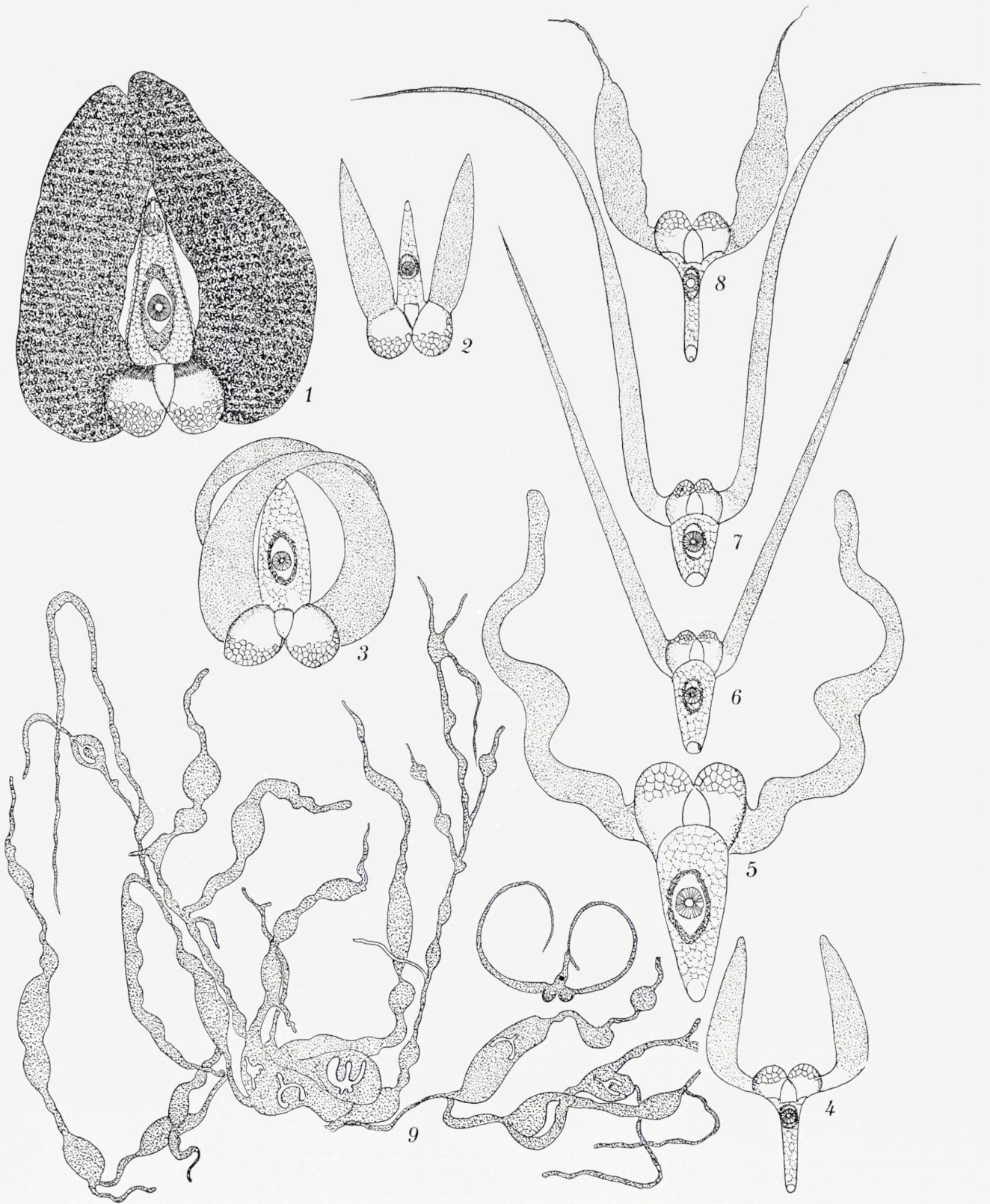


Plate XXXI.
Microcercaria.

Fig. 1.	<i>Cercaria micrura</i>	<i>Bithynia tentaculata</i> Furesø	18/IX 31	Oc. 4	Obj. 4
- 2.	— Redia	—	—	18/IX 31	- 4 - 16
- 3.	—	—	Esrom Lake	27/IX 31	- 4 - 4
- 4.	— extended	—	—	27/IX 31	- 4 - 4
- 5. }	— Rediae packed with Microcercariae and a few Cercariae	—	—	27/IX 31	- 2 - 16
- 6. }	—	—	—	27/IX 31	- 2 - 16
- 7.	— The same Redia drawn in the course of 5 minutes	—	—	27/IX 31	- 2 - 16
- 8.	— The lower part of a Redia with a Microcercaria and a Cercariaeum cyst	—	—	27/IX 31	- 2 - 16
- 9.	— A cyst found in the Redia of a <i>Cercaria micrura</i>	—	—	27/IX 31	- 4 - 4
- 10.	— A Cercariaeum taken out of a cyst found in the Redia of <i>Cercaria micrura</i>	—	—	27/IX 31	- 4 - 4

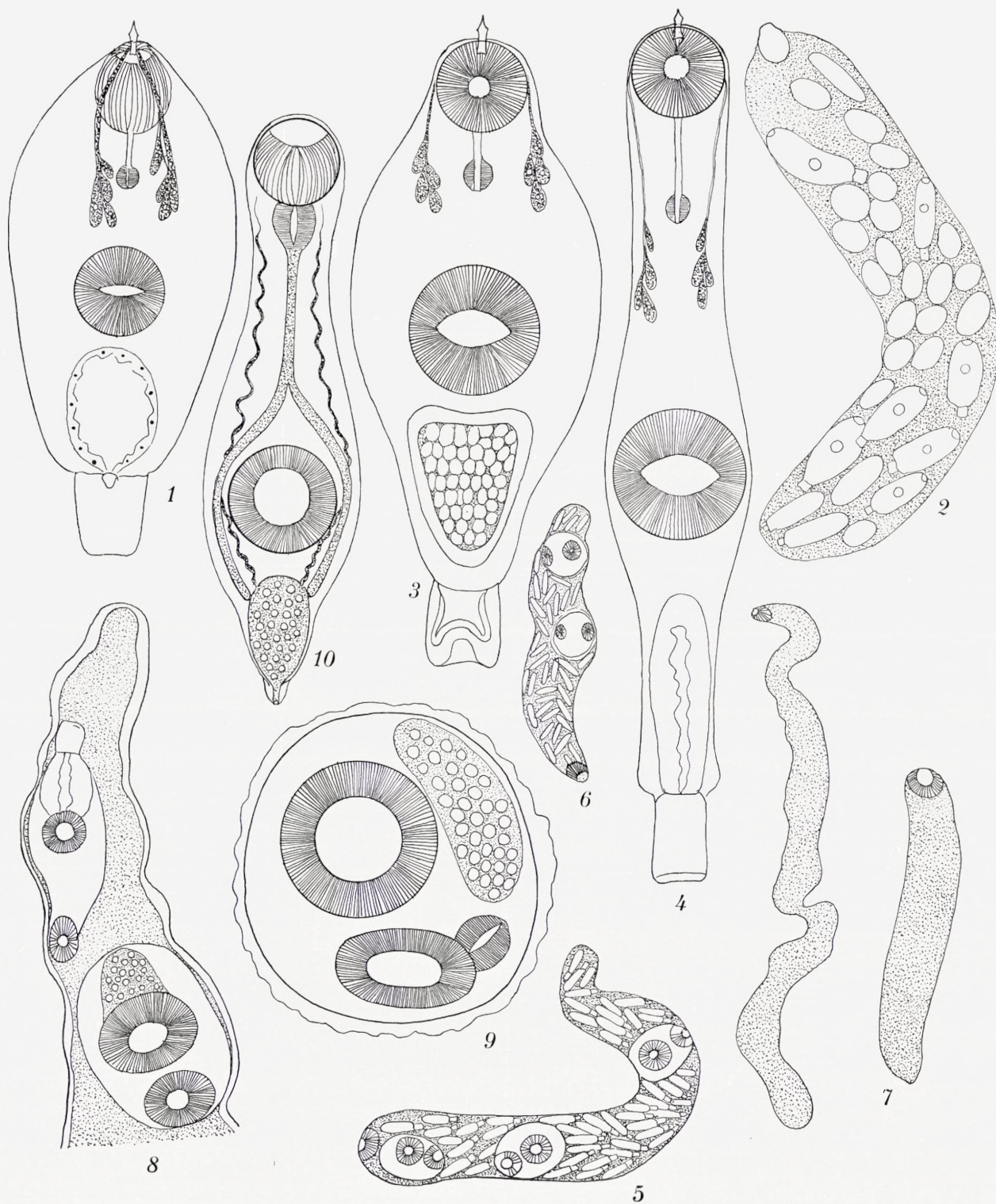


Plate XXXII.

Fig. 1.	<i>Cercariaeum paludinae impurae</i>	<i>Bithynia tentaculata</i>	Langesø, Hillerød	21/VI 31	Oc. 2	Obj. 4		
- 2.—3.	— The same specimen drawn in the course of 5 minutes	—	—	21/VI 31	- 4	- 16		
- 4.	— Redia	—	—	21/VI 31	- 2	- 16		
- 5.	— Redia	—	—	21/VI 31	- 2	- 16		
- 6.	— Cyst	—	—	21/IV 31	- 2	- 16		
- 7.	<i>Leucochloridium paradoxum</i>	<i>Succinea putris</i>	Tjustруп	13/V 33	- 2	- 4		
- 8.	— Cyst	—	—	13/V 33	- 2	- 4		

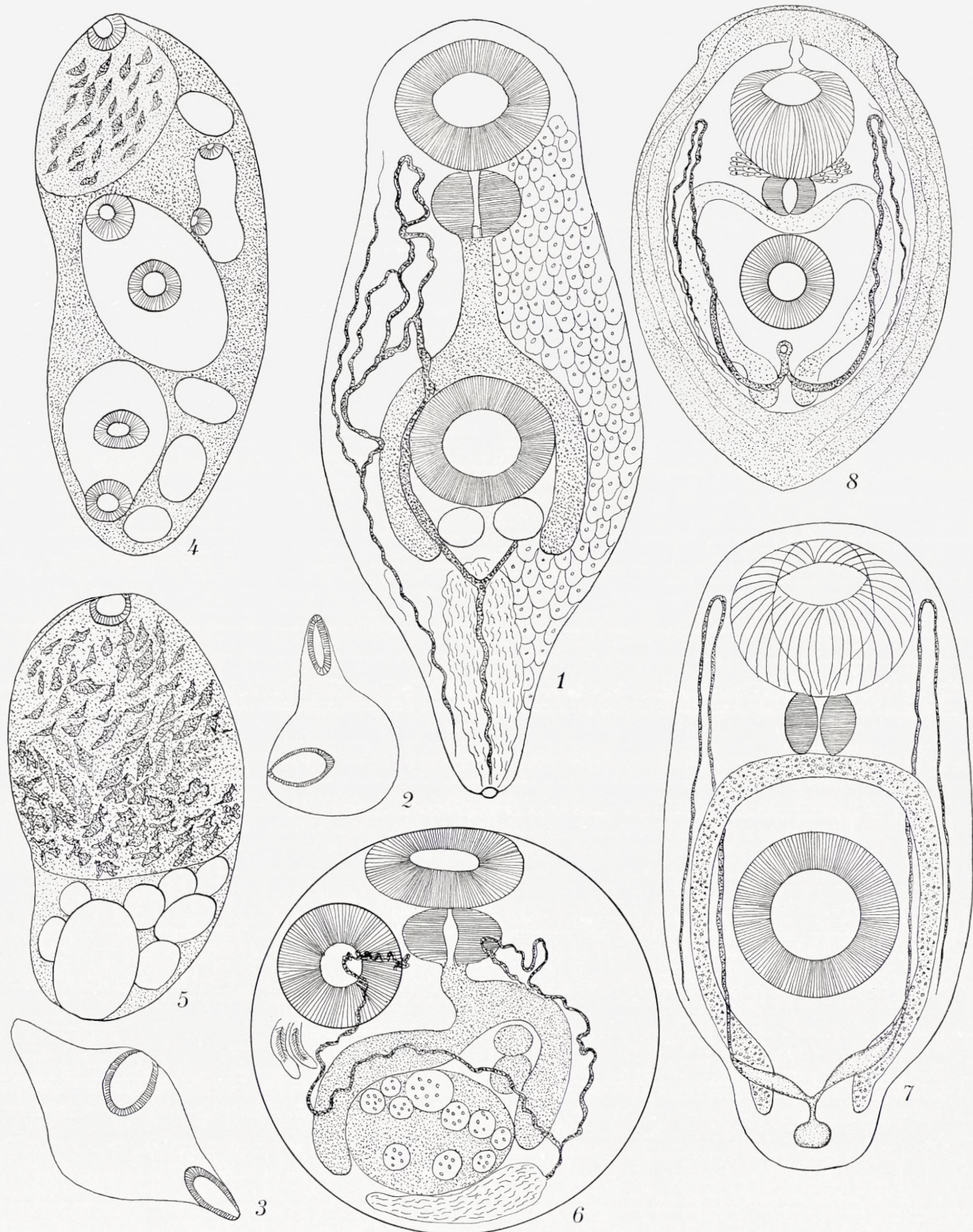


Plate XXXIII.

Cercariaeum.

Fig. 1.	<i>Cercariaeum paludinae impurae</i> ..	<i>Bithynia tentaculata</i>	Langesø	.....	17/V	32	Oc. 4	Obj. 16
- 2.	— attached to the an-			.....			
	tennae of a Bithynia	—	—	.....			
- 3.	<i>Cercariaeum limnaeae obscurae</i> ..	<i>Limnaea ovata</i>	Torkeris Pond, Hillerød	.....	15/V	31	- 4	- 16
- 4.	<i>Cercariaeum gibba</i> n. sp.....	<i>Valvata piscinalis</i> ..	Furesø	.....	22/IX	31	- 4	- 4
- 5.	— Redia .....	—	—	.....	22/IX	31	- 4	- 4
- 6.	<i>Cercariaeum crassa</i> n. sp.....	<i>Pisidium amnicum</i>.	—	.....	20/IX	31	- 2	- 4
- 7.	<i>Cercariaeum limnaeae auriculariae</i>	<i>Limnaea auricularia</i>	Hulso	.....	25/VI	32	- 4	- 4

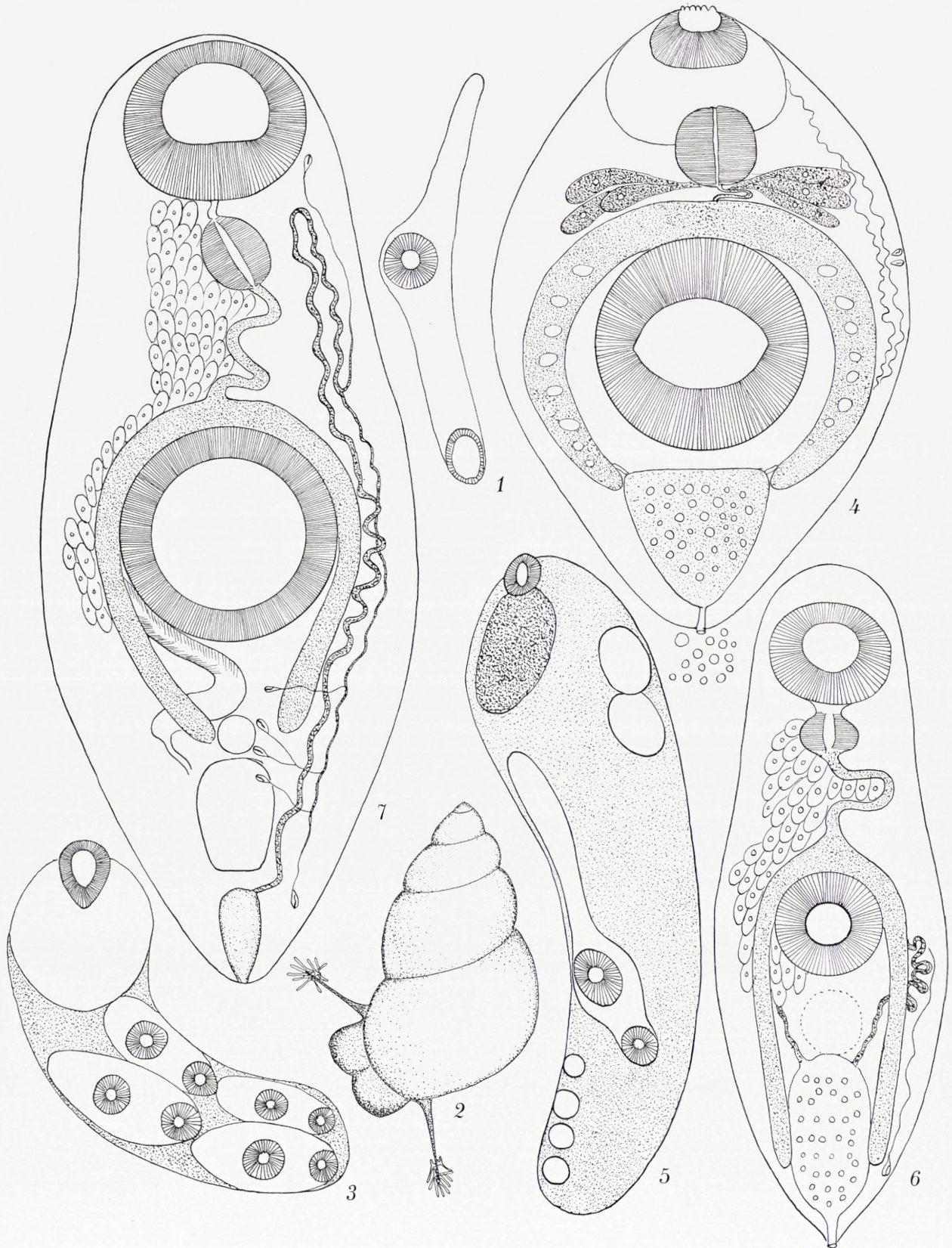


Plate XXXIV.

Cercariaeum.

Fig. 1.	<i>Cercariaeum limnaeae obscurae</i> ..	<i>Limnaea ovata</i>	Torkeris Pond, Hillerød	15/V	31	Oc. 4	Obj. 16		
- 2.	<i>Cercariaeum Petersen I</i>	<i>Paludina vivipara</i> . .	Hellebæk	2/II	32	- 6	- 16		
- 3 a—d.	— The same specimen drawn in the course of 5 minutes	—	—	2/II	32	- 4	- 4		
- 4.	— group of Spococysts	—	—	2/II	32	- 2	- 4		
- 5.	— A single Sporocyst	—	—	2/II	32	- 2	- 4		
- 6.	<i>Cercariaeum gibba</i> n.sp. taken out of the cyst	<i>Valvata piscinalis</i> . .	Furesø	22/IX	31	- 6	- 16		
- 7.	<i>Cercariaeum limnaeae auriculariae</i> group of Rediae from the borders of the mantle of the snail	<i>Limnaea auricularia</i>	Hulso	25/VI	32	- 4	- a*		
- 8.	<i>Cercariaeum crassa</i> n.sp. Redia . .	<i>Pisidium amnicum</i> .	Furesø	20/IX	32	- 4	- 16		
- 9.	— taken out of the Sporocyst	—	—	20/IX	32	- 4	- 16		

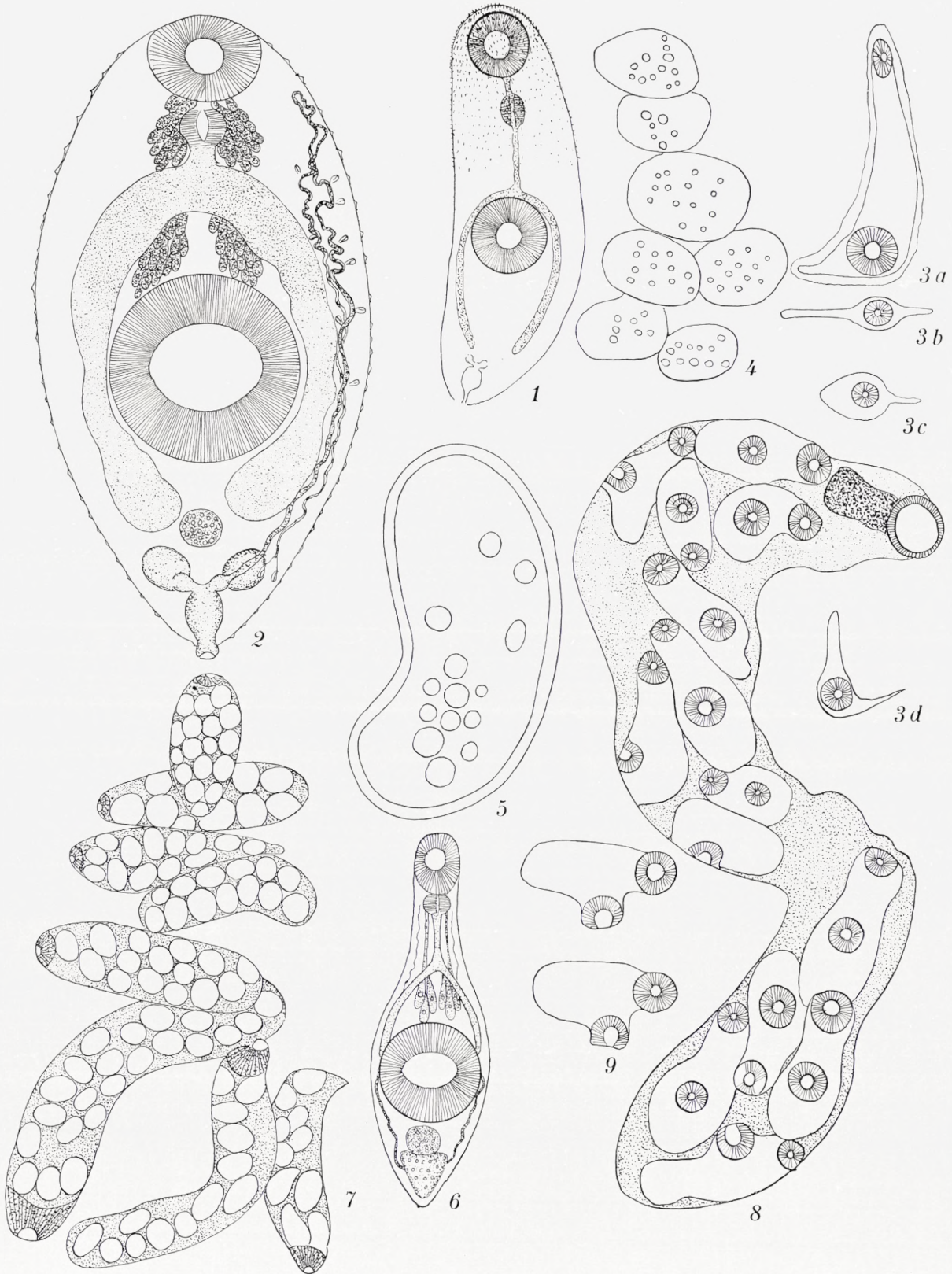
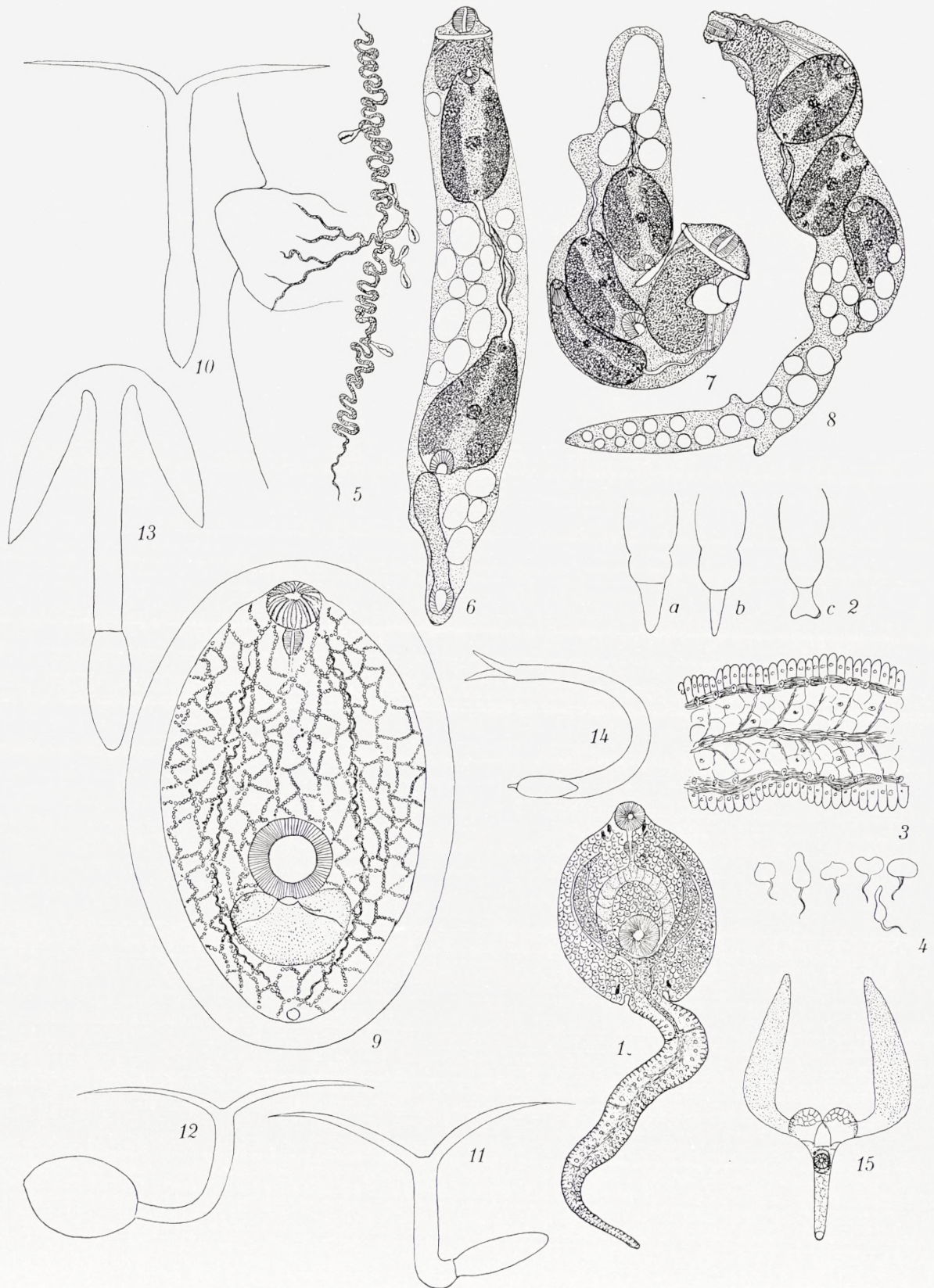


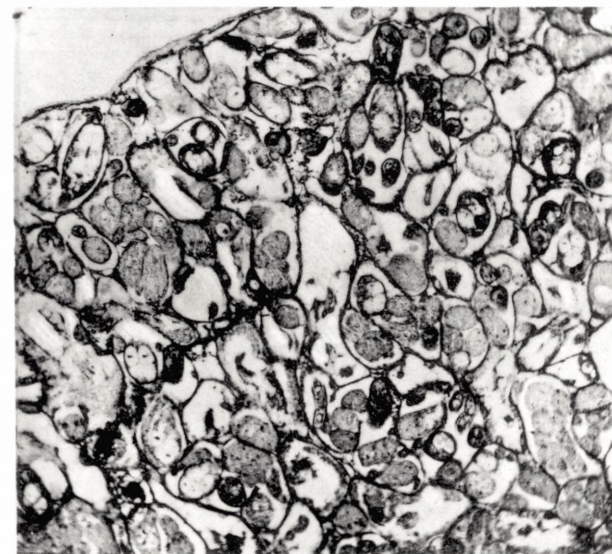
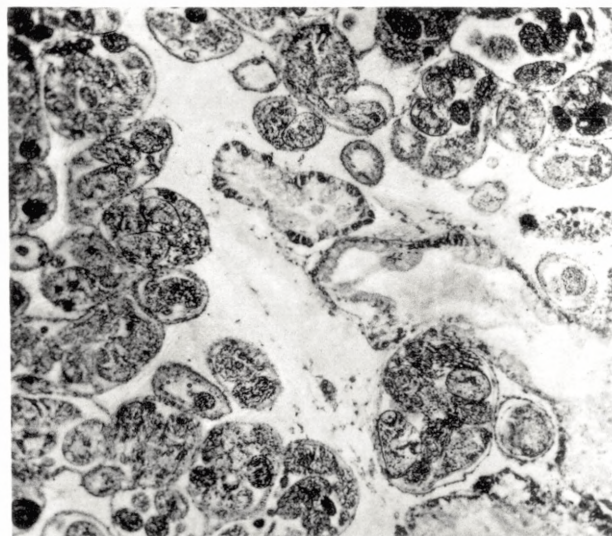
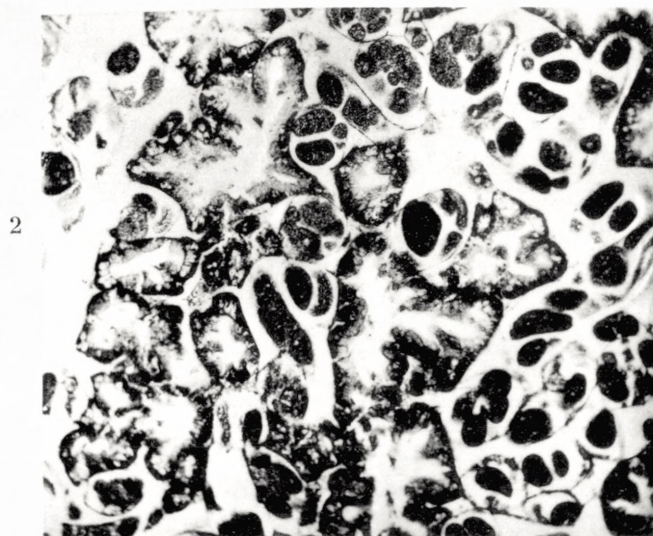
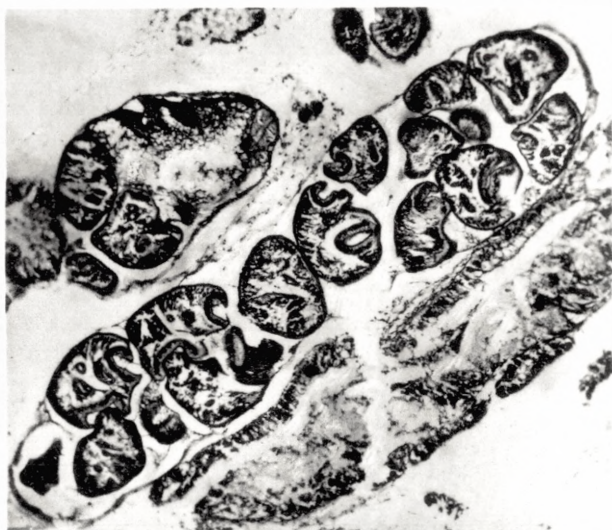
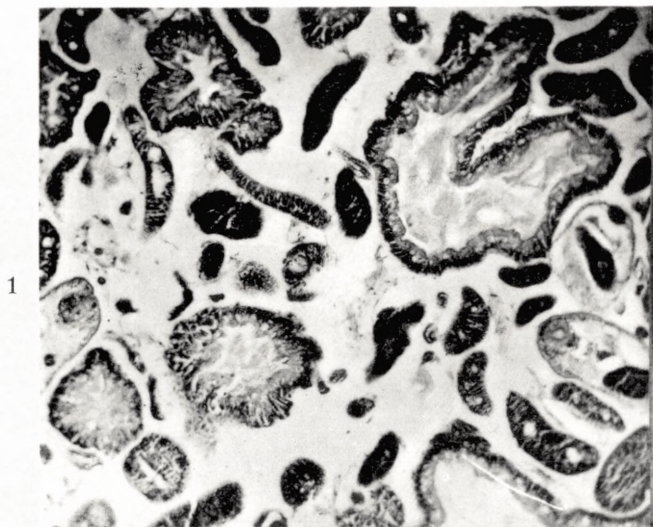
Plate XXXV.

Fig. 1.	<i>Cercaria Fasciolae hepaticae</i>	<i>Limnaea truncatula</i>	North west part	/X 33	Oc. 4	Obj. 16	
- 2 a—c.	— The apex of the tail drawn		of Sealand				
	in the course of 5 minutes	—		/X 33	- 4	- 16	
- 3.	— part of the tail to show						
	the transversal and lateral	—		/X 33	- 4	- 4	
	musculature.						
- 4.	— shows the form altering						
	power of the Cercaria.	—		/X 33			
- 5.	— Redia. Part of the excretory						
	system	—		/X 33	- 4	- 4	
- 6.	— Redia with a daughter redia						
	and two Cercariae	—		/X 33	- 4	- 16	
- 7.	— An old Redia.	—		/X 33	- 4	- 16	
- 8.	— An old Redia.	—			- 4	- 16	
- 9.	<i>Cercaria C. Szidat</i> ; cyst found upon the						
	intestine of <i>Gobio fluviatilis</i> , the same						
	specimen which contained more than a						
	hundred <i>Diplostomum</i> in the lens.	—			- 6	- 16	
- 10.	<i>Cercaria A. Szidat</i>	} Floating positions					
- 11.	<i>Cercaria C. Szidat</i>						
- 12.	<i>Cercaria vivax</i>						
- 13.	<i>Cercaria anchoroides</i>					- 6	- 16
- 14.	<i>Cercaria cristata</i>						
- 15.	<i>Bucephalus polymorphus</i>						



Microphotos.
Plate XXXVI.

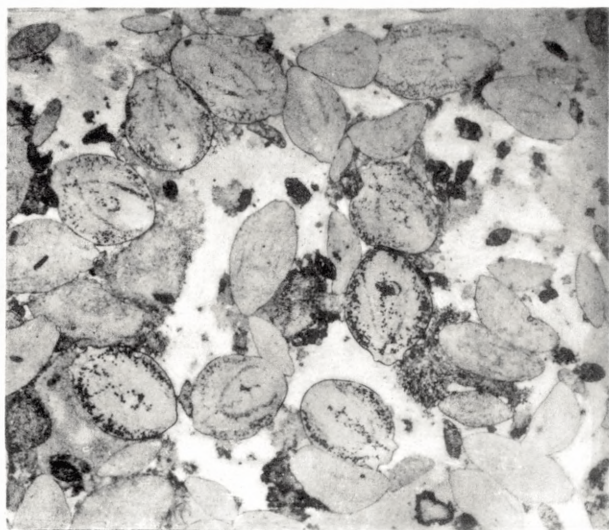
- Fig. 1. Monostome Cercaria, *C. ephemera*. Liver from *Planorbis corneus* (Donse Pond 10/XI 31). The photo shows that the Cercariae are lying partly in Rediae partly free in the liver. Haematoxyline. Aurantia. $\times 70$.
- 2. *Furcocercaria C. Szidat*. Liver from *Bithynia tentaculata* (Tjustrup Lake 6/VIII 31). The Furcocercariae lie in Sporocysts. Haematoxyline. Aurantia. $\times 70$.
 - 3. *Cercariaeum limnaeae auriculariae* from the border of the mantle at the base of the antennae, here forming large yellow tumor like swellings. From *Limnaea auricularia* Hulsø (20/VI 33). Haematoxyline. Aurantia. $\times 70$.
 - 4. The same. The photo shows conspicuously the Sporocyst with the Cercariaea. Haematoxyline. Aurantia. $\times 70$.
 - 5. *Bilharziella polonica* from the liver of *Planorbis corneus* (Hørsholm Pond 7/VIII 32). The tissues of the liver are almost totally destroyed. Haematoxyline. Aurantia. $\times 70$.
 - 6. *Furcocercaria linearis* n. sp. From the liver of *Planorbis corneus* (Torkeris Pond 4/VII 31). Hardly anything is left of the liver tissues. Thionine, Picrin acid. Acid fuchsine. $\times 70$.



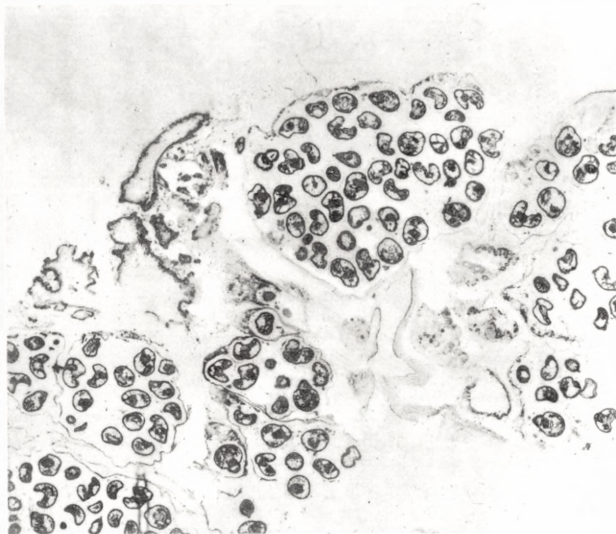
Microphotos.
Plate XXXVII.

- Fig. 7. Diplostomum from the lens of *Gobio fluviatilis*. The parasite is photographed in the living state. $\times 70$.
- 8. Cysts upon the intestine of *Gobio fluviatilis*. From the same specimen which had Diplostomum in the lens. $\times 70$.
 - 9. Tetracotyle. Sagittal section. (*Limnaea stagnalis* Strødam 22/IV 32). The photo shows the oral and ventral suckers; the holdfast organ and the great secondary excretory canals. Haematoxyline. Aurantia. $\times 260$.
 - 10. Tetracotyle from the hermaphroditic gland of *Limnaea stagnalis* (Strødam Pond 11/VII 31). Haematoxyline. Aurantia $\times 105$.
 - 11. Tetracotyle (Strødam Pond 11/VII 31). Almost the whole gland is destroyed. The Tetracotyles lie in the acini; at several points are seen eggs along the borders. Haematoxyline. Aurantia. $\times 105$.
 - 12. Tetracotyle (Strødam Pond 11/VII 31). The photo shows several well-developed Tetracotyle in the creeping as well as in the resting stage. Near the centre and to the left lie Tetracotyle in the creeping stage. At the lower edge a specimen which has the holdfast organ developed as two long projections. Haematoxyline. Aurantia. $\times 42$.

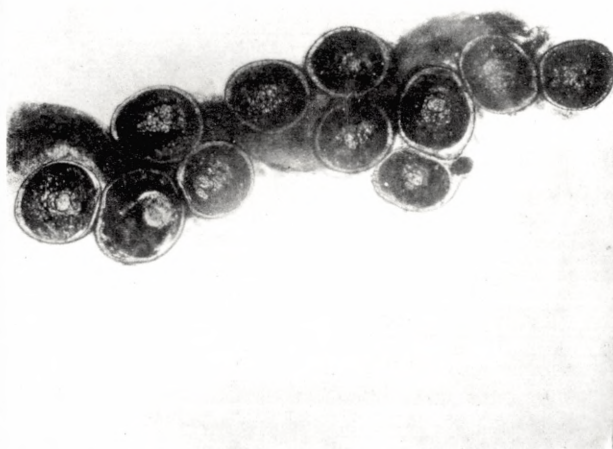
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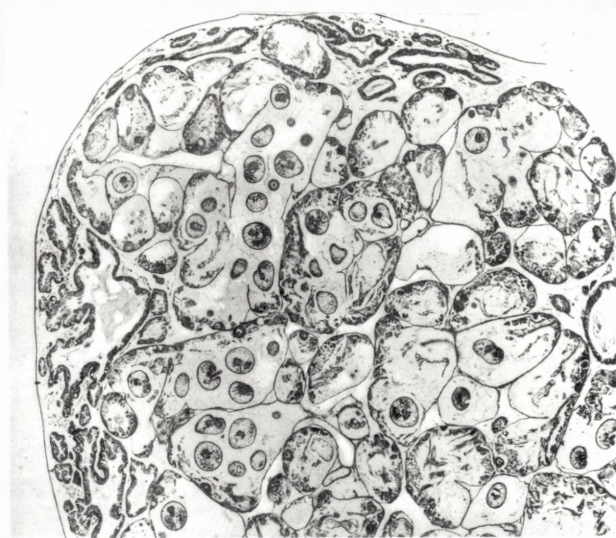
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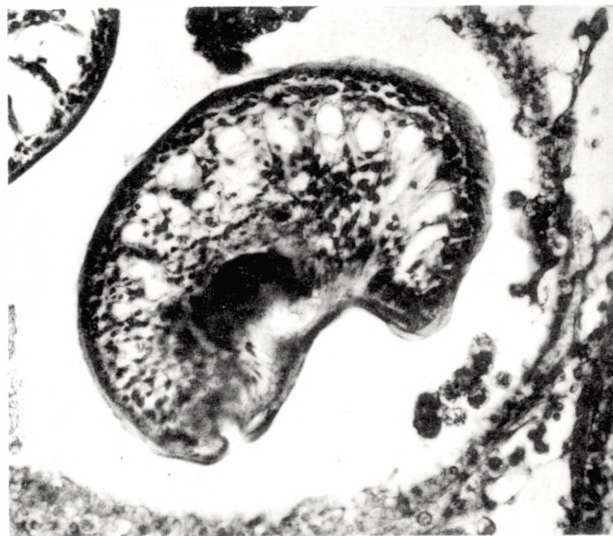
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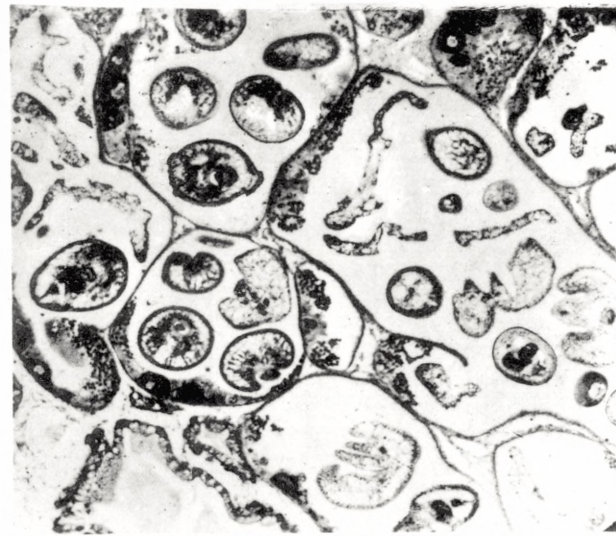
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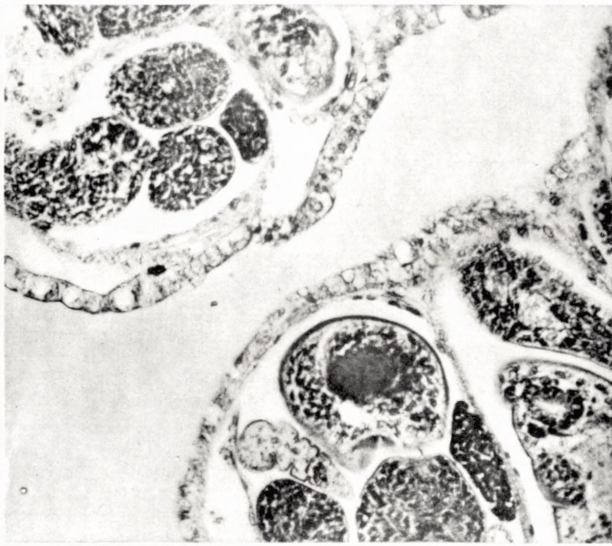
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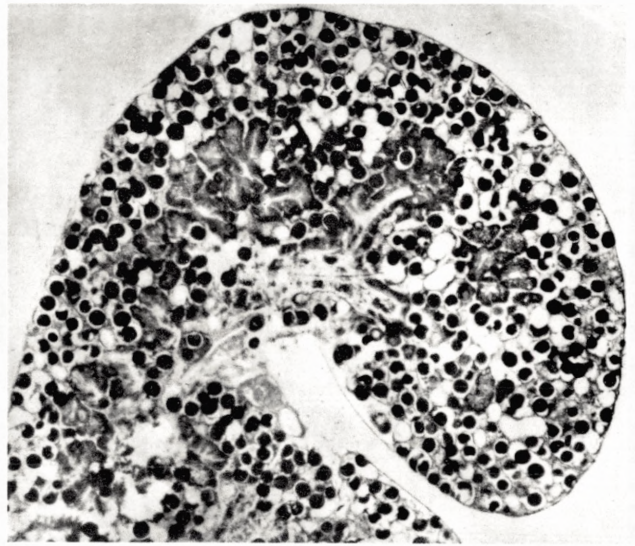
Microphotos.
Plate XXXVIII.

- Fig. 13. *Cercaria virgula* from the liver of *Bithynia tentaculata*. Værebrosø, Hillerød 17/VII 31. Haematoxyline. Aurantia. $\times 260$.
- 14. Echinostome Redia from *Planorbis corneus*. Torkeris Pond 6/V 31. The Redia is devouring another Redia, having hatched a bit of it which now lies in the oral sucker. Below, another Redia with one of the locomotoric appendages. Haematoxyline. Aurantia. $\times 70$.
 - 15. Cysts of echinostome Cercariae in the liver of *Limnaea stagnalis* (Strødam 26/I 32). The bright points in the cysts are the collar spines. Haematoxyline. Aurantia. $\times 70$.
 - 16. Cysts of Xiphidiocercariae present in a number of many thousands. The liver is almost totally destroyed. *Bithynia tentaculata*. Hellebæk 30/VII 31. Haematoxyline. Aurantia. $\times 18.5$.
 - 17. Echinostome Rediae and Cercariae lying in the liver of *Planorbis corneus*. Torkeris Pond 6/V 31. The tissues are almost entirely destroyed. Haematoxyline. Aurantia. $\times 70$.
 - 18. Amphistome Cercariae lying at the borders of the mantle of *Planorbis umbilicatus*. Rejnstrup 15/VIII 32. Thionine, Acid fuchsine. Picrin acid. $\times 70$.

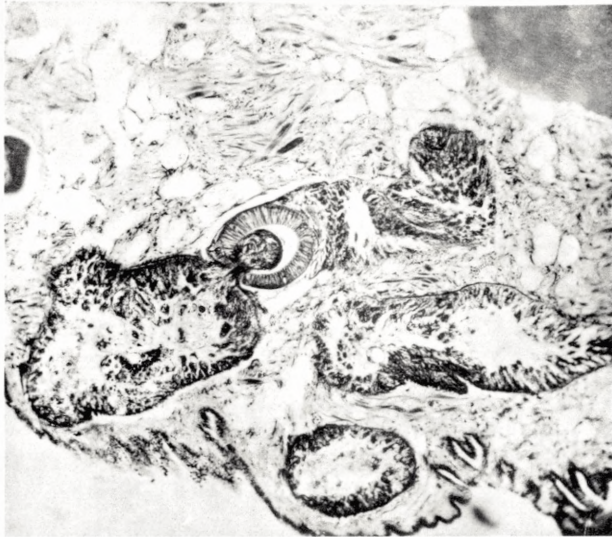
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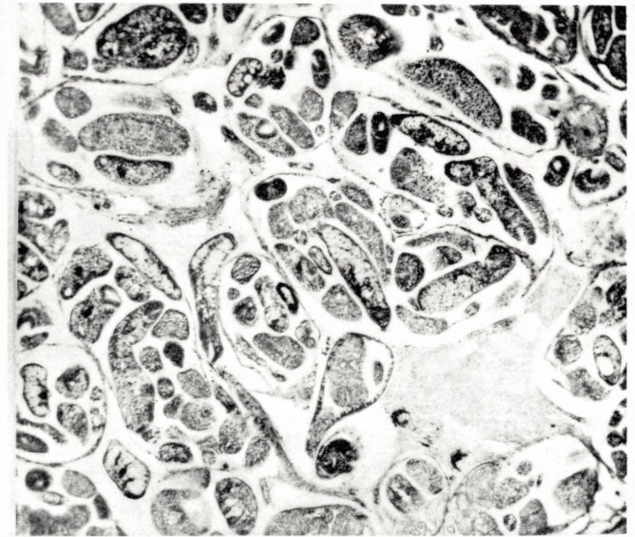
16



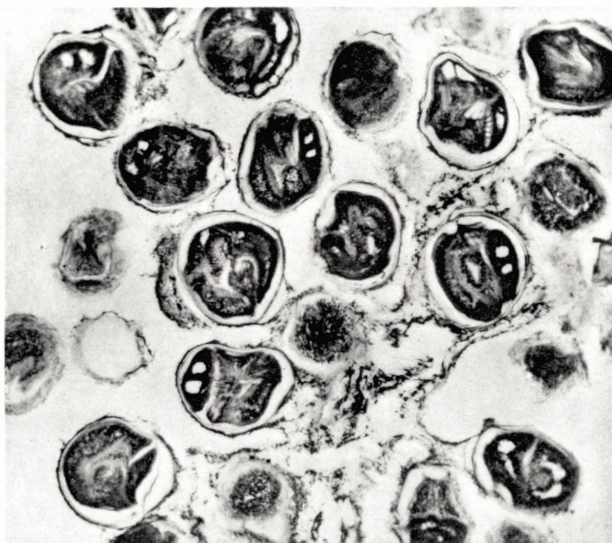
14



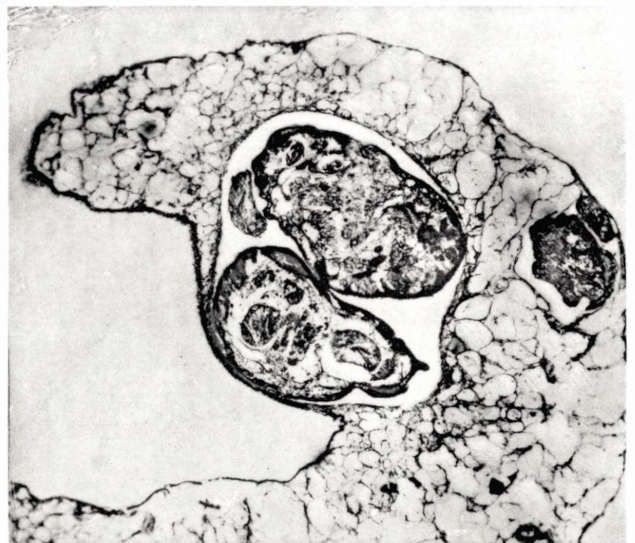
17



15



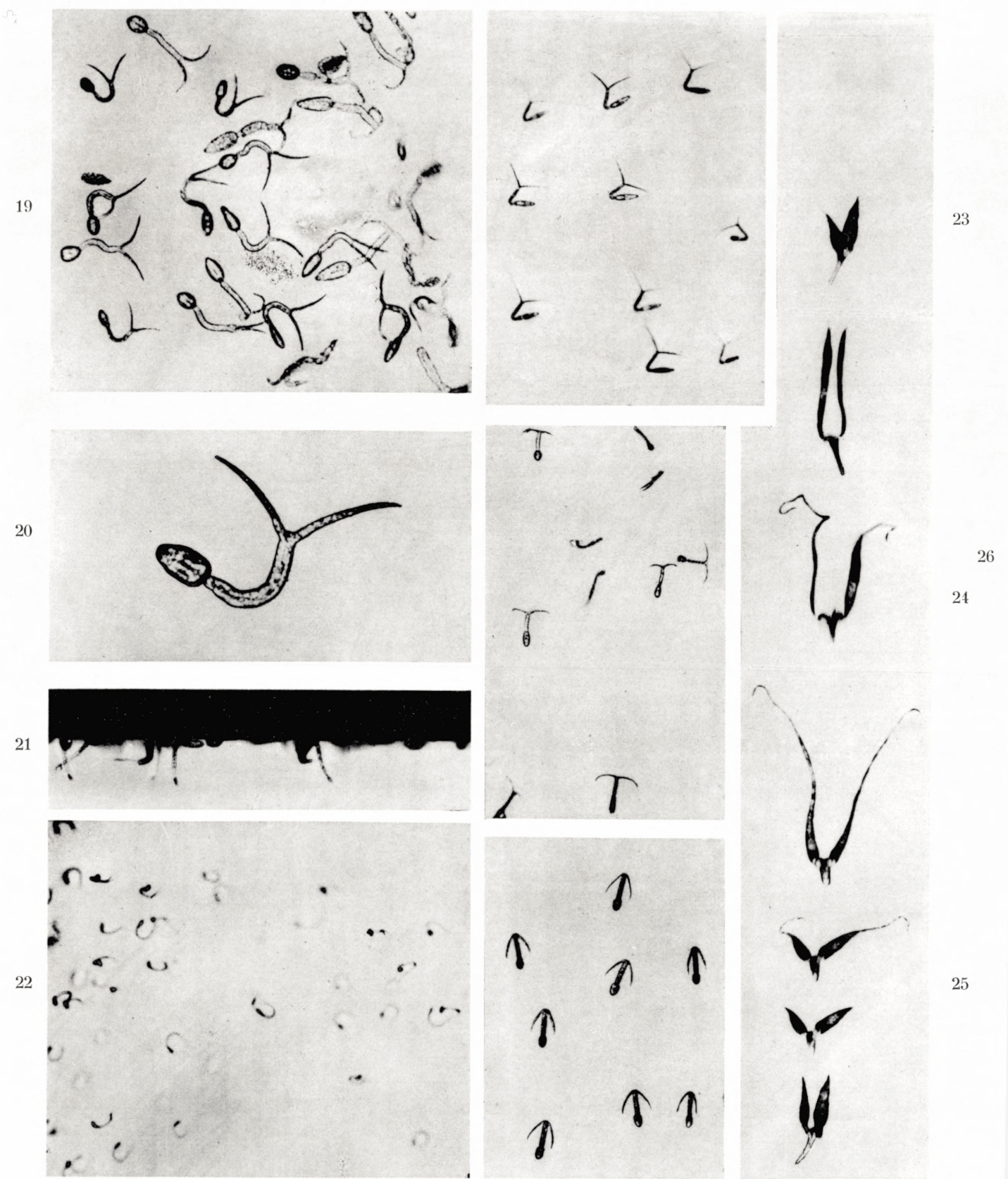
18



Microphotos.
Plate XXXIX.

All photos are taken from living animals.

- Fig. 19. *Cercaria vivax* from *Bithynia tentaculata*. Tjustrup Lake 14/V 31. The animals have been disturbed by the strong light. Some of them show the normal position. $\times 24$.
- 20. *Cercaria vivax*; a single individual showing the normal position. $\times 24$.
 - 21. *Bilharziella polonica* hanging down from the surface. Hørsholm Pond. $\times 24$.
 - 22. *Cercaria cristata* from *Limnaea stagnalis*. Langesø 26/VI 31. The larva is able to float in all positions. The typical positions of the Cercariae illustrated on the Microphotos are drawn on Pl. XXXV, figs. 10—15.
 - 23. *Cercaria C. Szidat*. The typical floating position with the body held almost parallel with one of the rami.
 - 24. *Cercaria helvetica* XXXI Dubois. The typical floating position with the two rami used as outriggers, lying horizontally. $\times 24$.
 - 25. *Cercaria 1 Petersen*. The typical floating position, the whole body forming a parachute to prevent the fall. $\times 31$.
 - 26. *Bucephalus polymorphus* (*Anodonta* sp.). A series of photos taken from a dancing larva which, in the fourth figure, has lifted itself up into a higher water layer, and is now using its rami for a moment to anchor itself there. Then, when it withdraws its arms as the three upper photos show, it sinks downwards again to the water layer in which it was originally suspended. $\times 26$.



Det Kongelige Danske Videnskabernes Selskab.

Skrifter, naturvidenskabelig og matematisk Afdeling.

9. Række.

	Kr.	Øre
I , med 35 Tavler	30.	50.
1. Ravn, J. P. J.: De regulære Echinider i Danmarks Kridtaflejringer. Med 6 Tavler. 1928	7.	00.
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