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CONTRIBUTIONS

TO

THE BIOLOGY OF THE ROTIFERA

I. THE MALES OF THE ROTIFERA

BY

C. WESENBERG-LUND

WITH 15 PLATES AND 17 TEXTFIGURES

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, NATURVIDENSK. OG MATHEM. AFD., 8. RÆKKE, IV. 3

KØBENHAVN
HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL
BIANCO LUNOS BOGTRYKKERI
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Introduction.

From the moment when the microscope was invented, the Rotifera have interested the naturalists in a very high degree. They were studied by the great naturalists of the eighteenth century together with the innumerable unicellular organisms which, in a single drop, were brought under the microscope in many hundreds of specimens. As well known, our own countryman O. F. Müller (1786) has contributed in a very great degree to the study of these charming little creatures. Even if some of these old naturalists had a conception that Infusoria and Rotifera really only were identic with regard to size, but differed very much from each other in all essential points, they were actually, until 1838 when Ehrenberg's famous work arrived, treated in the same great division of lower organisms, which the different authors gave very different names.

It was Ehrenberg who was the first to definitively separate the Rotifera from the Protozoa; as of course at the then existing stage of science he could have no idea of the fact that the first group comprised multicellular, the other unicellular organisms, he had also no idea of how great the gulf between the two divisions really was. The word Protozoa was first formed by v. Sieboed in 1845, the word Metazoa by Haeckel, and he is really the first to contrast the Protozoa with "die Gewebetiere" (Metazoa). Until 1838 all described and figured Rotifers have most probably only been females. Almost all the hundreds of Rotifers which Ehrenberg figured and described in such an admirable manner were females. But Ehrenberg did not regard them as such, but as hermaphrodites; according to him the excretory organ with the lateral canals and contractile vesicle were the male organs. It was later on shown that two of his Rotifers, *Enteroplea hydatina* and *Notommata granularis*, were really Rotifer males, but he was so convinced of the correctness of his view of the hermaphroditic character of the group, that the two above named males, the first-named the male of *Hydatina senta*, the last-named the male of *Brachionus pala*, were described as Rotifers, quite like all the other Rotifers and regarded as hermaphroditic like these. Already the naturalists of the time in which Ehrenberg lived, understood that the organs which Ehrenberg described as male organs, could not be interpreted as such; on the other hand true male organs could not be found. In his "Vergleichende Anatomie" Sieboed (1848, p. 184) is therefore forced to confess: „Trotz der sorgfältigsten Bemühungen hat sich bis jetzt kein befriedigendes Resultat

über die wahre Beschaffenheit ihrer männlichen Geschlechtswerkzeuge erzielen lassen, so dass es noch zweifelhaft ist, ob die Rotatorien Hermaphroditen sind oder getrennte Geschlechter besitzen." —

It was BRIGHTWELL who in 1848 was the first to find a male of the Rotifera and regard it as such. In 1849 it was more thoroughly described by DALRYMPLE. It was the male of *Asplanchna Brightwelli*. In 1850 GOSSE (p. 18) described the male of *A. priodonta*. In 1851 WEISSE (p. 347) described the male of *Diglena catellina*, but did not regard it as such, describing it as a new species, *D. granularis*. In 1854 a LEYDIG (p. 99) supposed that the above named two species, *Enteroplea hydatina* and *Notommata granularis*, and further the *D. granularis* of WEISSE were really all males of Rotifers; he gave exhaustive reasons for his suppositions, but was not able to prove them; he however described the male of *Asplanchna Sieboldi* simultaneously. In 1856 COHN found the male of *Hydatina senta* and showed that LEYDIG's supposition was correct and that the *Enteroplea hydatina* of EHRENBERG was really the male of *Hydatina senta*. In 1857 LEYDIG (p. 404) himself found the *Hydatina* male and gave valuable contributions to the anatomy of this animal. Already in 1858 GOSSE's paper: *On the Dioecious Character of the Rotifera* appeared. In this paper 10 Rotifer males were described: of these the seven were really the males of *Brachionus*, the others belonging to *Polyarthra platyptera*, *Sacculus viridis*, and *Synchæta tremula* (?).

With this paper the common dioecious character of the whole group was really demonstrated; curiously enough, during the following forty years only very few males were observed; and if they were observed, they were almost always insufficiently described and very badly drawn. Even the large work of HUDSON GOSSE, with regard to the structure of the males, was hardly of any significance at all. From these forty years there exists only a good description and drawing of *Euchlanis dilatata* (COHN 1858) and of *Copeus pachyurus* (DIXON-NUTTALL 1894). Further, PLATE has (1886 a) contributed to the study of the males of *Brachionus*, *Hertwigia*, *Polyarthra*, *Triarthra* and *Asplanchnopus*. HUDSON-GOSSE (1886) described the exterior of the male of *Pedalion*; of the other males mentioned in the work the drawings and descriptions are very insufficient. From this period several papers relating to the structure of the males certainly appear (METSCHNIKOFF 1866: *Apsilus*; DADAY 1883, 1891: *Asplanchna*; MILNE 1885: *Diglena*; WESTERN 1888: *Asplanchnopus*; *Gastropus clavulatus*; 1892 *Triphylus lacustris*; *Asplanchna* 1890; THORPE 1889: *Megalotrocha*; ANDERSSON 1889: *Megalotrocha*; ROUSSELET 1892 b *Conochilus*, 1894 *Cyrtosia*; DIXON-NUTTALL: *Stephanoceros* 1896). But almost all these males are very insufficiently drawn; generally the authors confess that they have only seen a single male and that it died before further observations could be made.

In the time from 1896—1908 a series of very valuable papers appears and our knowledge of the structure of the males is much augmented. ROTHERT (1896) and ROUSSELET (1897 d) study the males of *Proales Wernecki*. WEBER (1897—1898) gives a series of excellent drawings of males several of which have never been found

again later (*Salpina, Colurus, Dinocharis, Diglena, Scaridium, Hydatina, Copeus, Colurus*). Almost simultaneously ROUSSELET's descriptions of *Rhinops* (1897 a) and of *Pterodina* (1898) appeared. Very exhaustive descriptions and elaborate drawings are furnished by MONTGOMERY of the males of *Floscularia proboscidea* (1903), by HAMBURGER of *Lacinularia socialis* (1907) by KRÄTSCHMAR of *Anuræa aculeata* (1908) and by DE BEAUCHAMP of *Eosphora digitata* (1905). In 1903, ROUSSELET (p. 172) gives a list of all known Rotifer males, indicating more than 100. Very many of these males have however only been observed, neither described nor drawn. Simultaneously with these papers others appear in which males certainly are described but often in such a manner that it is almost impossible to recognise them; this especially holds good with regard to the descriptions and drawings by WECHÉ and MARKS & WECHÉ (1902 and 1903). Even in this period very valuable monographs on different families of Rotifera appear, especially ROUSSELET's on *Synchætadæ* (1902), DIXON-NUTTALL's on *Diaschiza* (1903), JENNINGS on *Rattulidæ* (1903), HLAVA on *Melicertidæ* (1908 a). Whereas these monographs augment our knowledge very much with regard to the females, the males are either not mentioned at all (*Rattulidæ*) or only rather cursorily mentioned and figured. Apart from a very superficial drawing and description of *Anuræa aculeata* by MONTET (1915) after 1908, as far as I know, no new males are described.

If now we will try to collect in a few lines our present knowledge with regard to the males of Rotifers it may be expressed as follows. Of the more than 1000 Rotifers described the males have only been observed in a little more than 100 species, but of these scarcely one score may be said to have been more exhaustively studied. Of the 25 families of Rotifera the males are wholly unknown in eight (*Philodinidæ, Adinetadæ, Microcodidæ, Rattulidæ, Gastropodidæ, Ploesomatidæ, Cathypnadæ* and *Anapodidæ*). In several of the others which contain a large number of species, only the male of a single one or a few has been observed and often only once. The male of the most common Rotifer *A. cochlearis* is unknown. This in other words means, that our whole present knowledge of the Rotifera has hithertho been built almost exclusively upon the female sex; further that all systematical arrangement of the group has only been tried with regard to this very sex. This rather peculiar result of so many exhaustive and elaborate studies, carried on for about two hundred years and most probably almost unique in the history of Zoology, is due to a series of very intelligible factors.

The males are generally regarded as very rare, much rarer than the females; this may really be true for several genera and perhaps families, but according to my experience only for relatively few; the fact is that the males appear only in strongly marked periods in the lifetime of the species; these periods are bound to fairly fixed seasons of the year, the so-called sexual periods, which for many species occur twice a year, in spring and autumn, for others only once a year, and then almost always at the highest summer temperatures; in a few cases during the winter season, and then even at temperatures near zero, below the ice. The first-named species are termed polycyclic, the others monocyclic. Almost simultaneously LAUTERBORN and myself have tried to elucidate the periodicity of the Rotifera; LAUTERBORN's papers appeared in

1893—1900 just at the period when mine should have been printed; as the results of the researches were almost quite congruent, I provisionally retracted most of my paper, but have carried on my investigations to this very day. Every year it became more and more obvious how difficult it really was to get a clear understanding of the phenomena and how necessary it was to extend the investigation over as long a time as possible. During the long period from 1898 to 1920 these investigations have not always been in the foreground. Those who know the publications from this laboratory, will be acquainted with a series of investigations, which have nothing to do with the study of Rotifera. As however very many of the investigations have been carried on in ponds and moors, and I have almost always had a Rotifer net with me, a lot of rather casual observations have been gathered. It was noted when rather rare Rotifers were observed in the different ponds, and when maxima or sexual periods were detected. The material which was collected in this way and which was derived from more than twenty years of observation, originated from many hundreds of ponds, lying partly in North, partly in Middle Seeland, mainly with a radius of only a few kilometers from the laboratory.

Firstly my attention was directed towards the study of the periodicity of the Rotifera; simultaneously herewith, I had ample opportunity of getting to know a long series of males, and I saw how many of them had never been described. I therefore made a great many notes with regard to their occurrence. Simultaneously herewith a great many cursory drawings and notes relating to the males were made. When all this material was collected and overlooked in 1919, it was clear that it contained many new males and many new observations relating to males hitherto slightly known. A monographical treatment of the males of the Rotifera was then planned. From the many separate casual observations from the foregoing years I was able to begin the investigations upon a long series of fixed localities and upon fixed times. From the earlier observations I knew exactly when and where I might expect to find the males of very many Rotifers. In the spring of 1920 these studies were the chief aim of the laboratory. — In very many cases my calculations were correct, but there were of course also cases where it was impossible to find the species seen many years before. What has been in a very high degree unfortunate for the investigation is the devastation of so very many small ponds, either lying in the fields or in the forests, and which cultivation has either totally closed or filled with material that has killed the fauna. However, if I had not had the preliminary investigations of the years 1900 to 1920 as a support, it would unquestionably have been quite impossible for me in the course of only two years of observation to procure sufficient material for drawing about fifty Rotifer males. Most of the authors who have studied the group for a long series of years have commonly only seen a glimpse of the males of very few species. The now published investigation gives camera-drawn figures of 45 males; of these males more than twenty are quite new to science and eight belong to families in which males have hitherto been wholly unknown. Many of the other males here described and figured

have been observed at an earlier date, but are often mentioned in the literature only in few words and are very insufficiently drawn.

It would by no means have been difficult to increase the number of the now published males considerably; in all those cases where I have not been fairly sure of the determination, or where I have been unable to distinguish the males from other described males, they have been omitted. This has especially been the case with the males of the fam. *Notommatidæ*, *Flosculariadæ*, *Synchætadæ* and *Brachionidæ*.

In the present stage of knowledge we still lack every acquaintance with the males of the families *Philodinidæ*, *Adinetadæ*, *Microcodidæ*, *Cathypnadæ* and *Anapodidæ*. Simultaneously with the preliminary investigations, a long series of papers appeared which were the results of very many exhaustive and excellent studies, relating to sex determination, mainly studied in Rotifera. Even if the chief object of these investigations was by no means to elucidate the cyclic propagation of the Rotifera, they gave a long series of contributions which were of the greatest significance to the elucidation of all problems relating to this difficult matter; most of these investigations were carried out in North America. First it troubled me greatly that all the results, gained in this way, were in the most striking contradiction to all that I saw; and for years I saw no means of bringing the results from the laboratory investigations in harmony with those carried out in Nature. The laboratory investigations were almost all carried on upon *Hydatina senta*, partly upon *Asplanchna* and *Proales*, and it was only after I had found in Nature the natural conditions under which these species lived, and regular observations had begun here, that it was possible for me to understand how the differences were to be interpreted.

In this first part of the work I only wish to describe and figure the males, give a general sketch of their anatomy, and contribute to the understanding of the phenomenon, unique in the animal kingdom, that the one sex of the species in a whole group of animals, counting more than 1000 species, all without any parasitic phenomena, and living side by side with the other sex, in some cases is subject to such an enormous reduction, that it is merely reduced to swimming testes "perambulating bags of spermatozoa" (Rousselet 1897 a, p. 6), surrounded by a thin cuticula, on its anterior part covered with a bunch of cilia; we have here to do with freeswimming metazoa with the number of cells most probably smaller than in any other organism in the animal kingdom, with a size not greater than a few times that of a blood corpuscle, which pair at the very moment of birth and most probably in some species die in almost the same hour in which they are born.

Before entering upon the description of the males, it will be necessary to give a preliminary sketch of the localities from which I have gathered the material; the results with regard to the sexual periods, as they manifest themselves in nature under natural conditions; further of the methods I have used for the study of the males and lastly, a short view of my systematic conception of the whole group.

All the investigations have almost exclusively been carried on in ponds not in lakes. It is a well-known fact that the Rotifera really form a rather prominent part of the lake plancton. But the investigations have also shown that from the plancton of lakes we only know extremely few, perhaps not a single Rotifer, which is not also to be found in the pond plancton: even *Ploesoma Hudsoni*; *Gastropus stylifer* are pond forms; here in the ponds the maxima are much more pronounced than in the lakes. It is also a well-known fact that many of the colonies of the most pronounced plancton Rotifers from the pelagic region of larger lakes only rarely carry resting eggs, and that it seems that we often have to do with acyclic colonies. The pelagic region therefore is not the right spot for those who wish to study the males of the Rotifera.

The Rotifer life in ponds may of course be divided into a series of rather different societies or associations. Any one who wishes to get an idea of the Rotifera of a pond need only reckon with three associations viz. the Rotifer life in the central part of the pond, free from vegetation, "the pelagic" fauna; the creeping or swimming Rotifer fauna of the vegetation, and the fixed Rotifer fauna. Each of these faunas may be collected by special apparatus, and in different ways, the first by means of plancton net Müllergaze No. 20, the second with a plancton net Müllergaze No. 15, provided with a sieve to keep back the algæ. These two nets are provided with a cord of about 10 meter and are used as throwing nets; the fixed fauna is best gathered by means of a net, placed upon a 1 meter long stick. — For the study ot the "pelagic" fauna a boat is always desirable. — A special Rotifer fauna strongly associated with ponds of quite a special type cannot, according to my experience, as a rule be pointed out; the single exception is the Rotifer life in ponds which dry out early and only possess water for a month or two after the ice has melted; especially if these ponds are simultaneously polluted by dark water from dunghills, we shall find quite a special fauna with *Hydatina* and some species of *Notommatidæ* as the most characteristic Rotifer forms in them. A special Rotifer fauna only associated with peaty water does not exist; some species, viz. *Pedalion*, occur mainly in localities of this nature, but this species may also be found in ponds with clear most probably chalky water. It is of interest that the different holes in a peat moor often contain a very different Rotifer fauna simultaneously.

Any one who wishes to become acquainted with the Rotifer fauna of a locality, must further remember always to take a series of samples, as far as possible at regular intervals, best every week; a single sample has only very little scientific value. The Rotifer fauna differs from week to week; this especially holds good with regard to the "pelagic" Rotifer fauna; for any one who wishes to study the periodicity, the temporal variations, the occurrence of sexual periods etc., this manner of proceeding is of course a conditio sine qua non. In the time from 1900 to 1920 regular observations have been carried on in very many ponds or smaller lakes; the researches which are now going to be published, make use of twenty-two series of ob-

servations, carried out in twenty-two different smaller lakes and ponds and accomplished in 12—16 months with intervals of eight to fourteen days.

I am inclined to think it a tacit supposition that the Rotifer life in ponds is almost totally obliterated during the winter half-year, and that the many different species all spend the winter as resting eggs; this is a very great mistake. Very many species, belonging to all the three above-named associations, may be found at temperatures very near zero, and in those cases where I have been able to study the life in ponds which have been iced, I have found at airtemperatures of ÷ 10° C., even if the pond was icebound for a month, almost quite the same pelagic Rotifer fauna as before the pond was icecovered.

The sexual periods manifest themselves not so much owing to the presence of the males which, because they are so exceedingly small, are almost always overlooked, but much more owing to the presence of the dark resting eggs which on the one hand are the result of the pairing process, on the other hand cannot be formed, if a pairing process does not take place, the presence of which therefore indicates the point of time when the males have appeared.

A long series of investigations carried on from this laboratory have shown that in the different species of Rotifera the sexual periods differ very much with regard to strength and distinctness. There are species which year after year have very pronounced sexual periods simultaneously in very many localities and in which the males in these sexual periods occur in millions, other species where the sexual periods almost always and everywhere are very little pronounced, and which mainly seem to propagate parthenogenetically. In all these species the number of males in a given locality is exceedingly small. Finally, there are species in which sexual periods have never been observed, and which really seem to propagate parthenogenetically the whole year round. The investigations have further shown, that just those species in which pronounced sexual periods in very many localities appear almost simultaneously, when appearing under special conditions, here seem to be almost acyclic i, e. without pronounced sexual periods. This is the case with those species which are not only to be found in the plancton of smaller ponds, but also occur in the pelagic region in larger lakes. These species may in the ponds be di- or polycyclic, whereas as plancton organisms in the larger lakes they are monocyclic, or for several years even acyclic.

It will be understood that, when hunting for Rotifer males, it is of the greatest significance to know, when the sexual periods for the different species occur; then only, in these often very sharply defined periods, the males occur. If however we only use the resting eggs as indicators of a sexual period, we shall very often be too late to get the males; the life of the males is often restricted to only a few hours and is sure never to last more than four or five days; as these days for the total amount of specimens of a given species almost coincide and are only rarely distributed over more than about 10 days, and as further the resting eggs appear in the last part of this period and are often carried by the females for rather a

long time, it will be understood that the males have commonly disappeared when a colony mainly carrying resting eggs has come under observation. Stress must therefore be laid upon the point of tracing a sexual period before it comes. To do this we possess different means.

It has in an earlier paper (1898) been shown that, before a sexual period sets in, the species in a given locality will very often increase enormously in number. The species attains to what we commonly call its maximum. This observation has been corroborated by almost all later authors.

The magnitude of these maxima differs very much from species to species; for the same species they are neither of the same magnitude in different localities, nor in different years in the same locality. In the same locality they may be displaced a little from year to year, but all in all they occur at rather fixed seasons; competition with other species, climatic conditions, variation in nourishment determine the magnitude. If the general conditions are of such a kind that they cannot develop at the time which may be regarded as the natural one, the maxima as far as my experience goes are not developed that year; a compensation later on in the year very rarely takes place.

The maxima are almost always greatest and most conspicuous in the "plancton society". They may be so large, that the said Rotifers determine the colour of the water. This f. i. was the case with some of the ponds, where *Asplanchna priodonta* had its great maximum; the water was then of a milky appearance; this is however rather a rare case; it is commonly the colour of the chromatophores of the food algæ which determines the colour of the pondwater. Especially in spring the maxima in the pelagic pond Rotifers, owing to enormous parthenogenetic propagation, may set in with an almost incredible force; the large females of *S. pectinata* may have seven or eight eggs in the oviduct; *Rhinops* and *Asplanchna* eight or ten young ones and the young ones, before they are hatched, may have half developed young ones in their oviducts. The duration of the maxima differs very much; for some species it is several weeks, for others only six or seven days; they may suddenly be cut off either because of the setting in of a sexual period, or owing to unfavourable climatic conditions. Now and then two or more species have their maxima simultaneously, but commonly they succeed each other; regular observations carried on for years show clearly that the succession, in which they appear in the same pond, is almost the same year after year; most probably the species, with regard to rapid propagation upon which the great maxima of course depend, are bound to the great regular variations in climatic conditions upon which again the amount of nourishment for the Rotifera depends.

With regard to the creeping or slowly swimming Rotifer association, whose habitat is the vegetation zone of perennial ponds, the maxima, according to my experience, are by no means so great; they do not appear with that wonderful regularity which is so characteristic of the plancton Rotifers. Whereas for very many of my ponds I am able to say in what week exactly the maximum of that plancton

Rotifer will begin, I am never able to say the same for the Rotifers from the vegetation zone. With regard to this association, year after year the investigation offers unsuspected surprises. Here, with regard to time as well as to quantity the maxima have an extremely casual character. To this point we will shortly return.

Ponds in which rare Rotifera have been found once, have been under regular observation for years; these rare pond forms may in some months totally disappear; in others year after year they always seem to be rare. To these very species belong all those badly described males, of which the naturalist has only had the good fortune to get a "glimpse", but not material enough for a more thorough study. And even with regard to these species it certainly happens that exhaustive studies in nature itself will now and then fall in a locality, where such a rare species really has a great maximum with succeeding sexual periods and occurrence of males and resting eggs. Elaborate studies year after year in the same locality and at the same time and the same temperature will then very often result in the failure to find the phenomenon again later on; the colony now year after year propagates only parthenogenetically with abated propagation in winter and with a little quicker propagation in the summer half-year. — This is f. i. the case with the *Triphylus* colonies, in North Sealand.

With regard to the fixed Rotifer societies, those composed of the families *Melicertidæ* and *Flosculariadæ*, it might at a first glance seem difficult to speak of maxima at all. More thorough investigations from recent years have shown that this is really allowable. *Lacinularia socialis* as well as different *Melicerta*-species may, mainly at the highest summer temperatures, develop real carpets, with which they coat the substratum upon which they are fastened. I shall return to this point in the second part of this work.

As soon as a maximum for a given species is observed in nature, the time has arrived when it may be taken into the laboratory. Owing to the enormous amount of specimens, pure cultures are easily procured. In very many cases the males then appear in the cultures in the very week in which the material was taken in from nature. The life time of these cultures is commonly very short, often only a few days, but the time is long enough to procure the males. In the winter half-year, when no sexual period occurs, they may live for months.

If we will try to found cultures from a few specimens of the same species and at other times of the year, as far as my experience goes, it is quite impossible to produce a maximum or a sexual period. Most probably, this is only possible for the Rotifera of the pools that are drying out. At all events all these Rotifera, which have been used for experimental work in the laboratory, and in which it has been possible to develop sexual periods experimentally, belong to this category. It must however be emphasised, that the researches, now published, have not been combined with more thorough experimental work. It would be of the greatest interest if this was one day carried out upon Rotifera belonging to localities which do not dry out. In the winter half-year I have often had different species of *Brachionidæ*, *Eu-*

chlanidæ, *Anuræadæ*, in my aquaria. I have here never seen a trace of a sexual period. In the summer half-year the cultures of all these species have always died out in the course of a few weeks, during the sexual periods in the course af a few days.

The investigations in nature have further shown that very many of those Rotifers which are really very common pond Rotifers belonging to the vegetation zone and occurring in almost every pond f. i. *Dinocharis pocillum*, *Cathypna luna*, *Monostyla cornuta*, many of the *Philodinidæ*, *Pterodina patina*, *Metopidia* and many others, hardly ever occur in those great maxima which are characteristic of many plancton Rotifers, or for such species which are living in pools that are drying out (f. i. *Hytina senta*). They are common the whole year round, perhaps a little more common in summer than in winter, but all in all, great variation in number the whole year round cannot be demonstrated. Even in these pond species, the males are either totally unknown or only observed once in a single specimen. If however these very pond Rotifers are studied year after year and in very many localities, it happens, as stated above, that the naturalist now and then comes across ponds, where now one now another of the above-named specimens occurs in countless numbers, i. e. has one of its great maxima. I have seen these great maxima in several of the *Philodinidæ*, *Pterodina patina*, *Metopidia lepadella*, *Monostyla cornuta*, but only a few times in the course of twenty years and only in a single locality. Commonly these great maxima occurred in the winter half-year. They were enormous immediately before the ponds were frozen; they were observed under the ice during the first weeks, but when the ponds thawed in April, they had disappeared again. These species were cultivated in the laboratory during the maxima, the localities were visited at intervals of only a few days, the results were always the same: not the slightest sign of sexual periods: neither males nor resting eggs. Nevertheless the observation is by no means without scientific value; more thorough investigations may perhaps really find the males in other localities and fix the sexual periods. There is f. i. no doubt that very many of the *Philodinidæ* have their greatest maxima in the winter below the ice; if a sexual period should exist in this family too, and the males most probable occur only sporadically and only at great intervals in the life history of a colony, it is most probable that this would especially take place during the winter half-year.

It may besides be emphasised, that it is very dangerous to conclude from the failure to discover the sexual periods in a species (demonstration of resting eggs and males), that this does not exist. Firstly it must be remembered that even if a species in a given locality or a given latitude usually only propagates partheno genetically, in other localities and other latitudes males may occur and sexual periods set in. This seems f. i. to be the rule with regard to many Ostracoda. the males of which seem to be wholly absent already in our country, whereas they appear in Bohemia and are common in Algeria.

Experience further shows that even for the very same pond, in which the investigations are carried on, it is dangerous, on failing to ascertain a sexual period,

to conjecture that the species in this locality only propagates parthenogenetically. For many years this investigation totally lacked the males of very many genera, even such in which the males were described by earlier authors. Maxima were observed, sexual periods, however, not.

In 1920—22 a rather extensive investigation relating to the study of the sexual propagation in *Oligochæta* was planned. It was shown that the *Oligochæta*, in those periods when the sexual products were to ripen, were in search of those algæ-carpets which cover the surface of small ponds like scum, especially at the highest summer temperatures. It was further shown that the tp. in these algæ carpets might in spring rise to about twenty-eight degrees celsius, even if the tp. a few inches below the surface was only about 18—20 C. Undoubtedly the worms used the extremely high temperatures to ripen the sexual products; very many of our Oligochæta hitherto regarded as rare f. i. *Vejdowskyella, Pristina, Slavina, Ripistes* were found here, and almost all were found in the sexual period, this being for many of the species either totally unknown, or at all events only observed rarely. The investigation, carried on by one of my assistants Mag. LAKJER, whose death was a great loss to my laboratory, induced a wish on my part to see whether the Rotifera did not also use the algæ carpets in the same way as the Oligochæta. My idea was correct, and it was shown that in the very same ponds, in which I had for years been in search of Rotifer males, belonging to species which were extremely common here in the female sex, and of which, nevertheless, I never saw any of the males, the latter could be procured as soon as the algæ carpets were peeled off from the surface by means of glassplates. These algæ carpets acted as a substratum upon the underside of which very many creeping Rotifers, at other times of the year living in the littoral or upon the bottom of the pond, were to be found in great numbers in the sexual period. Almost all the Rotifera which passed their sexual periods on the undersurface of the algæ carpets, belonged to the creeping or slowly swimming species. Just these species hardly ever carry their eggs; they were deposited upon the underside of the carpets and owing to the high temperatures ripened there in the course of very few hours.

On the algæ carpets in various pitholes, on the same moor, different Rotifers would simultaneously show great maxima; in seven pitholes on the same moor I simultaneously found maxima of *Salpina mucronata, Metopidia triptera, Euchlanis dilatata, Triphylus lacustris, Copeus labiatus, Dinocharis pocillum, Scaridium longicaudum.*

Commonly every little pithole had almost pure cultures of the different species; a more thorough investigation further showed that the different species succeeded each other in the hole; in one pithole great maxima of *Euchlanis dilatata, Dinocharis pocillum, Scaridium longicaudum* and *Triphylus lacustris* succeeded each other serially. The algæ carpets came on the surface in the middle of May at an airtp. of about 18—20° C., they were used by the Oligochæta and Rotifera (most probably also by some *Copepoda*, especially *Harpacticidæ*, and *Ostracoda*), till the first part of July; then very high summer temperatures set in, and the tp. in the algæ carpets reached

28—30° C. Then almost suddenly the rich microscopical life in the carpets disappeared. Quite the same result was gained the next year, when heavy and incessant showers filled the pitholes and diluted the water. The algæ carpets did not disappear, but during the rest of the year, they were not, or only very rarely, used.

During the stay of the animals upon the carpets, the underside was used as a locality in which the eggs were laid. As well known, the male eggs are commonly smaller than the female eggs; simultaneously with the hatching of the eggmasses on the algæ carpets in the vessels, we tried to find male eggs, and if possible isolate them. The investigation showed, that just in these species, the difference in the size of the two sorts of eggs is really but small, and that with regard to the length of the diameter they overlap each other.

Many of these pond Rotifers have been studied at regular very short intervals in the very same ponds from the moment they appeared on the algæ carpets and to the moment they again disappeared — the period commonly lasted three or four weeks —; fresh material was brought to the laboratory every second or third day. Often great maxima were developed before the eyes of the observer; great quantities of eggs were deposited in the vessels. The main task was to procure the males, and in many cases the task was really accomplished. There is no doubt, that if it had not been observed that these carpets were used as localities in which the eggs were deposited. most of the males belonging to the creeping or slowly swimming Rotifers would not have been found.

I am inclined to suppose that the investigation, in the manner in which it is carried on, is more likely to give an idea of the occurrence of the males under natural conditions than previous investigations. The common impression is that the males among these Rotifers from perennial ponds are extremely rare. Huge maxima may really set in, the ponds may teem with females, but the females are almost all female producers, only very few male producers occur. When the specimens are hatched in the vessels, most of them seek the lighted edge of the vessels; hour after hour the edges are sucked clean by a pipette and the material brought under the microscope; among many hundreds of females belonging to specimens of the common pond rotifer life, one or two males appeared; during the whole period the number was not augmented. Often the vessels have teemed with *Dinocharis*, *Triphylus*, *Stephanops*, *Scaridium*, species of *Diurella*, *Metopidia*, *Cathypna*, *Monostyla*, *Rattulus*, *Notommata* but of most of the species, even if they were studied in freshly gathered material, collected at intervals of only a few days, it was impossible to get a single male. Of some of the species f. i. *Dinocharis* and *Scaridium longicaudum* WEBER observed the males in Switzerland. What especially favours the supposition that a sexual period really does not appear in our latitudes, at all events not in all localities, and not every year, is the circumstance that of these species it has almost always been impossible to get the resting eggs. Just upon this point there is the greatest difference between the species from perennial ponds and those from pools drying out, where the males are regularly found. The algæ carpets, upon which *Hydatina* colonies have

laid their eggs, are often after the sexual periods so to speak dark spotted with resting eggs.

Only for some of the Rotifers from perennial ponds f. i. *Triphylus lacustris*, *Asplanchnopus myrmeleo* did the resting eggs appear and clearly showed that the males, in spite of the utmost care, had escaped observation. In connection with this fact, it must be remembered that just because so very many of these Rotifers in my area of investigation developed their maxima simultaneously, it was necessary in the very same weeks, in the time from about 15 May to 15 June, to work at the highest pressure possible. What could not be managed in this time, could not be carried out before the next year. When that year arrived, fresh investigations were carried out upon those Rotifers in which the males had escaped my attention then, but it often happened that, in these very localities, just these species did not appear that year. In this way, it happened that the males of *Eosphora digitata*, *Triphylus lacustris*, several *Notommatidæ* and others could not be procured.

That the males of all these Rotifers from perennial ponds are able to escape the investigation is due not only to their presumed rarity, but also to several other facts. Even if they are in some degree attracted by the light, this is not so much the case as with the plancton Rotifers; all the specimens do not seek the lighted edges of the vessels, very many of them never leave the algæ coatings upon which they are born, and which cover the whole surface of the vessel, this makes it much more difficult to find the males of these species than of the plancton Rotifers, of which both sexes immediately dart towards the light source. Rotifers from outdrying ponds especially *Hydatina senta* are only in a very slight degree attracted by light.

Another factor which makes it difficult to find the males of very many pond Rotifers is that the males in many of them are almost of the same structure as the females; they are certainly smaller but not smaller than young newly born females. Whereas a male of a plancton Rotifer, owing to its extremely small size, its peculiar shape, and the enormous speed with which it moves, is easily recognised, the slowly moving males of many of the pond Rotifers, shaped like young females, are very difficult to interpret for what they really are; much time is therefore wasted in bringing presumed males, which are really only young females, under high power.

If however it is correct that many of these pond Rotifers attain huge maxima, without any sexual period as the result, the question is, how this presumed fact may be understood. — I am here inclined to suppose that, in all species, the huge maxima inaugurate a sexual period, but that external factors, climatic conditions, prevent its further development. The investigation has shown that, owing to sudden heat, and especially owing to sudden and very heavy rain, the large maxima may almost immediately be arrested. It seems, as if a strong and sudden dilution of the water is able to kill the specimens in the course of very few hours; the eggs which these specimens have laid, are then developed, but the external conditions, under which this new brood is to live, do not allow of the rapid development of the sexual products which is the condition of the development of the great maxima.

Even if many maxima seem to be arrested without any pronounced sexual period, a closer study of the colony will show that a sexual period has really been intended. In the sexual periods the ovary commonly gets darker, and often changes its colour from yellow to blue; this change in colour characteristic of impregnated male producers may take place in a colony almost simultaneously in very many of the females and rather suddenly, often in the course of only a few days.

Almost simultaneously with the change of colour, the males appear; in a few cases I have, during large maxima seen this alteration in colour of the ovaria; then the maxima were suddenly brought to cessation, and no resting eggs were observed.

A more thorough investigation will perhaps further show that we may also in other ways calculate beforehand when the sexual periods will occur. Even if this must be mainly regarded as music of the future some few observations seem already now to make the following worth mentioning.

Maupas and later on especially American authors have made it highly probable that, at all events in *Hydatina senta*, we possess two sorts of females, the female producers and the male producers; the first-named produce only eggs from which females appear, the others eggs which, when unfertilised, give rise to males, when fertilised, to resting eggs. In how far these observations may be brought to bear upon all Rotifera, we do not know. For the present we only know, that in outer form and in general anatomical structure the two sorts of females cannot be distinguished from each other. — There is however the possibility, that more thorough investigations will find out these differences and furthermore, that they will perhaps prove much more conspicuous in other species than in *Hydatina*. — For several of the plancton Rotifers it may often be shown that the specimens which carry the small male eggs, are of a smaller size than those which carry the fewer and much larger female eggs. This may be even more conspicuously observed in *Polyarthra platyptera*, where the male producers are often only half the size of the female producers, and have a much more pointed form. Already Hudson-Gosse have observed this; in Tab. XIII fig. 5, 5 b the two sorts of females are clearly figured. As however the females that carry the resting eggs, are larger than those that carry the male eggs, and have not the peculiar acuminated form, it is probable that the acumination of the body in the male egg carrying females, is only a juvenile character which is obliterated during growth. In some ponds I have seen *Triarthra mystacina* suddenly disappear at the moment when the male producers appeared, and be replaced by *T. longiseta*, which at that time was male egg carrying.

As I have never been able to keep *T. longiseta* in the aquaria for more than a few days, I have not been able to pursue the observations more thoroughly.

At all events, after we have learned that the female sex in the Rotifera is most probably divided into two forms: female and male producers, it is a natural course to enquire, whether there might not, here as in the case of the Aphids, possibly be some difference in the outer form of the two sorts of females, and all the more so

since, of several species, we know rather peculiar varieties, which almost in all localities where the species occur, appear rather suddenly and then disappear again. How much stress we are able to lay upon that point is however questionable as some of these varieties carry as well male eggs as female eggs. This is the case f. i. with *Polyarthra platyptera* var. *euryptera*. Already ROUSSELET (1896 p. 265 Tab. XI. fig. 2) has shown this.

With regard to the modes I have used to study the structure of the males, the following information may be given. As the males of almost all the species are extremely small. it was very difficult to isolate them. Most of them have only a size of about 100 μ; many only 40—50 μ. Males which are more than $^1/_2$ mm. may be regarded as veritable giants and occur mainly among the *Asplanchnadæ*, and some genera of *Notommatidæ*. The isolation was done by extremely fine pipettes, by means of which they, after having been detected under a Seibert Microscope lensen Obj. 0 Oc. 0, were sucked up and brought under a Zeisz Microscope. The drop of water was then made as small as possible, and a cover laid directly upon the drop, no waxfeet were used. Commonly there was sufficient water under the cover for the free swimming motion of the male; owing to slow evaporation of the water, the time arrived when the male was found to modify its motions; asphyxia owing to diminution of the amount of oxygen or to the accumulation of carbonic acid caused the animal to lie in the same spot, motionless, but with the wheel-organ wholly stretched out and with the cilia moving in the water. In this situation the animal could live from thirty to sixty minutes and in this time it was studied and drawn. Commonly there were in the vessels many or very many males of most of the species; if so, male after male was used. The animals were lying without any motion at all, and it was possible to draw them with Abbes camera. The lenses which were used, were almost always homogen immersion Apochrom. 2 mm. and Comp. Oc. 6, if necessary also the excellent Orthoscopical ocular, which with hom. im. gave the power of 1500 times. A strong electric lamp was almost always necessary. The greatest difficulty was to watch the male under low power, often for hours, until that moment arrived when the animal had ceased to move.

When studying the male under hom. immersion, it could further be shown that, when the time arrived when the strength of the animal was almost exhausted and the cover slowly pressed it more and more, the different organs appeared, one after one, with increasing clearness; this was due to the stronger and stronger compression of the hypodermal layer.

All drawings are made by means of Abbes camera; as however the males did not live for more than an hour, and often many males were used, many drawings of the same males were worked out, whereupon all the drawings were combined into one single one; commonly the outer contour of a male was given from one specimen, and the anatomical details from another or very often from a whole series of males.

Narcotic fluids and staining fluids have only been used for the largest males,

especially those of *Asplanchna*. Narcoticising fluids may really help to keep the animals more steady; on the other hand they die faster; then the results were only very badly preserved wheel organs, with the cilia without any regularity straddling in all directions; fixation and staining methods have only been used for the largest males (*Asplanchna* and *Hydatina*) but even here I do not think that the result corresponded to the labour. More than a general anatomical description the methods, employed by me, are not able to give; the histology of the animals cannot be studied in this way. Owing to the exceedingly small size of the animals, and the great difficulties connected with procuring sufficient material, this investigation will be extremely difficult. When I have restricted the investigation strictly to the anatomical description, it is because I am of opinion that the more elaborate histological investigations, as well as many others, do not belong to the series of researches which should be carried out at the freshwater biological stations but in a much higher degree have their natural home in the laboratories, belonging to the great universities. According to my experience it is impossible for a single person to carry out an investigation such as this, in all its different phases. What is gained, is here as always, only a step up the ladder of our knowledge; others, with other abilities and another training, may then try to take the next step.

Chapter II.

Systematical Remarks.

With regard to my views concerning the systematic position of the Rotifera and their mutual relationship, I will not here enter too much into details. Already in 1899 I tried in a paper published in Danish to reform the system of HUDSON-GOSSE, which in my opinion is only in a very slight degree the natural expression of the mutual relationship of the families. It has been a great satisfaction to me to see, that DE BEAUCHAMP, (1909) whose paper inaugurates a new era in our knowledge of these most interesting animals, is in accordance with my view upon many essential points. Published in Danish, my paper has suffered the fate of being misunderstood or not understood at all, especially in the chapters relating to the wheelorgan and mouthparts. As far as I have been able to see, the points of agreements between DE BEAUCHAMP's and my results are more numerous than DE BEAUCHAMP seems to think. The system was further adopted by HLAVA (1908), and v. HOFSTEN (1909). Now, about twenty five years later, I am quite aware that the system, even if upon some points perhaps it was an advance, upon others, suffered from considerable errors. DE BEAUCHAMP has tried to correct these errors; owing to insuf-

ficient knowledge of those genera, which DE BEAUCHAMP maintains are placed very incorrectly and used by me as intermediate stages between forms which according to his idea have nothing to do with each other, I do not wish here to enter too much into details. I hope later on to be able to show that on some of the points where our views do not coincide, my arrangement is not so "fantastic" as DE BEAUCHAMP seems to think.

Here I only take the liberty to give a short summary of the results at which I arrived in 1899, and which I am unable to alter upon essential points. It is upon these results that my systematic views, which I shall finally set forth in a few words, are based.

The cuticula of the Rotifera is originally segmented; the lorica, which arises owing to coalescence of the middle segments, and in which the anterior and posterior segments may be drawn in, is a derivation of the hyaline segmented cuticula.

The original wheel-organ of the Rotifera is a ventrally placed ciliacovered disc, without any specially developed wreath of cilia, bordering the disc; the mouth lies excentrically in the hindpart of the disc. Animals, equipped with wheel-organs of this type, are slowly creeping; the swimming power is extremely small, and the motion, in swimming, is along a straight line, not rotating. The wheel-organ is unable to procure food during the swimming motion.

The more a type of the Rotifera is emancipated from the substratum, passing over from a creeping to a swimming organism, the more terminally is the ciliacovered disc placed, and the more will the cilia, bordering the disc, be equipped as a ciliary wreath; simultaneously with this, the cilia coating of the disc will diminish, and finally the disc will be almost or totally nude. The locomotion passes over from straight to screwformed; the number of rotations is dependent on how much the ciliary wreath is developed in relation to the cilia of the disc. In the most aberrant types of the wheel-organ, it is further modified in such a way, that it is able to capture food during the swimming motion. In accordance with this the disc is often first cleft in two half, between which the mouth is placed; then a new wreath of cilia will be developed, either inside or outside the primary ciliary wreath; the main purpose of this second wreath is to prevent the organisms, caught by the primary wreath, from escaping and to carry them safely to the mouth opening. In accordance with this, a furrow, bordered by the two ciliary wreaths, the locomotory wreath and the stopping wreath, is developed; through this furrow the nourishment is carried to the mouth by means of cilia.

I arrived at this main result with regard to the wheel-organ, more from the study of the manner in which the animals used the organ, than from an anatomical investigation. With low powers, equipped with a small microscope, often in nature itself, I studied the animals in open vessels; later on I only used a very strong lens, observing the animals in high cylindrical vessels. From his anatomical studies, as far as I can see without a more thorough study of the freeswimming organisms, DE BEAUCHAMP (in 1907 and later on in 1909) arrived at a result, which in its

main lines may be said to be almost congruent with mine. On many essential points he has elucidated the facts, given my suppositions a solid basis, and corrected some of my views that were undoubtedly wrong. On the other hand, having for years studied the wheel-organs with his elaborate studies in mind, I feel convinced, that the want of observations of the freeswimming animals has on some points been unfortunate for his views, just as the want of a more thorough anatomical examination has been unfortunate for my views.

I have referred the wheel-organs to six different types, of these the first, *Notommatidæ*, the fifth the *Melicertidæ*, *Pedalionidæ* etc. the fourth (*Hydatinidæ*, *Brachionidæ*, *Anuræadæ*) have many points of contact with those of DE BEAUCHAMP. My type No. 2 comprising the *Dinocharidæ*, *Coluridæ*, *Rattulidæ*, *Salpinadæ*, *Cathypnadæ*, *Euchlanidæ*, *Ploesomatidæ*) are by DE BEAUCHAMP referred to his type No. 4. This is perhaps more correct, the primitive form *Cyrtonia*, which is of great significance for the understanding of this group, being unknown to me. My type No. 3 comprising the *Synchætadæ* and *Asplanchnadæ* is the most erroneous; here the study of the wheel-organ of *Eosphora*, which was also unknown to me, has shown how the wheel-organ of the *Asplanchnadæ* is to be interpreted, and that that of the *Synchætadæ* is better connected with his type No. 4. My type No. 6, the wheel-organ of the *Floscularidæ* DE BEAUCHAMP also refers to a special type; his attempt to connect it with that of the *Melicertidæ* is in my opinion a great mistake.

One of the greatest merits of DE BEAUCHAMP is his excellent studies of the retrocerebral organ; just the clear indications of the openings for this organ has made it possible for him to establish his excellent scheme of the general type of the wheel-organ, and find the homologies in the different special types. I am inclined to think that, if my work had been written in another language, it would be manifest that by my mode of investigation I have through observation and reasoning arrived at many of those mainpoints in the anatomy of the wheel-organ in the Rotifera which were only fully scientifically elucidated through DE BEAUCHAMP'S researches.

Simultaneously with the wheel-organ undergoing very considerable modifications the mouthparts are also modified. Originally the mouthparts play a prominent part in the procurement of food; in accordance herewith they are shaped as prehensile organs, by means of which the food is seized and carried into the mouth. The more the wheel-organ is modified to catch the food, the more too they are altered to be only a masticatory organ. Only in the freeswimming families *Asplanchnadæ* and *Synchætadæ*, where the wheel-organ is only a locomotory organ, the mouthparts are prehensile or clasping organs. There is really the most conspicuous conformity between the different types of wheel-organs and mouthparts. These last named organs may be referred to two main types, the malleate and the forcipate, those of the mainly detritus and planteaters and those of the typical animals af prey. Both types are to be found in the primitive forms. The more the wheel-organ during the forming of the secondary wreath of cilia is able to procure food for the animal, the more the significance of the mouth parts as prehensile organs is diminished (the malleate

mouth parts of the *Brachionidæ*), and where the wheel-organ is finally transformed in such a way that a real canal for the food between the two wreaths is performed, this function is totally lost. In accordance with the fact that the mouthparts are unable to procure food and be forced out into the mouth opening, they are more and more withdrawn from it. A beginning of the transformation already takes place in types with malleoramate mouthparts, but is fully developed in the *Philodinidæ* and *Flosculariadæ*. They have here, especially in the *Philodinidæ*, lost all significance as prehensile organs, and placed in the middle of the body, they only play a rôle as triturating masticatory organs.

In the creeping Rotifera the foot is an organ of locomotion and fixation; in the swimming Rotifera, it is mainly a steering organ; it is reduced or often totally lost in most of the real planctonorganisms. As the foot is highly variable and modified in accordance with the main functions it has to fulfil, systematical characters can only in a very slight degree be gathered from this organ.

The Rotifera possess two pairs of almost conform sensitive organs, which may be designated as the anterior and posterior lateral organs; whereas the posterior preserve their orginal position, this is not the case with the anterior organs, which as a rule meet each other dorsally in the middle line and here coalesce to an unpaired sensitive organ of different form; for this organ the name dorsal organ is often used. Only rarely, f. i. in the *Asplanchnadæ* and in *Apsilus*, they have their primitive position, lying separated laterally before the posterior lateral organs.

The light preserving organs are one median, commonly larger unpaired eyespot, below the brain, and two paired spots, placed before this, and often in a special part of the ciliary disc. Only rarely all the three eyespots are present, commonly only the unpaired one, more rarely the paired one. With regard to the retrocerebral organ the reader is referred to the excellent studies of DE BEAUCHAMP, who was the first to show that this very peculiar organ is typical of very many, and most probably of all, the Rotifer-families. It is most strongly developed in the more primitive families of the Rotifera, and strongly reduced in the typical plancton Rotifera and in the fixed families.

The nerve system has only been very little studied, thoroughly only in a very few species; it is of interest that everywhere where more thorough investigations have been carried out, these studies have ascertained the presence of suboesophageal as well as pedal ganglia.

The excretory organs are of almost quite the same structure in the whole group, and present no characters which may be used for the systematical arrangement of the different families. On the other hand, perhaps just this organ, more than any other, clearly shows the systematical position of the whole group in the animal kingdom.

With regard to the muscle system it may be pointed out, that in this quite especially, as well as in the cuticula, and in the arrangement of the lateral organs, in the more primitive forms we find certain rather conspicuous indications of

a segmentation in the organisation, which on one side cannot be quite overlooked, but upon which, on the other side, not too much stress must be laid.

It now will be understood that I regard the soft indistinctly segmented cuticula as more primitive than an unsegmented lorica, the ventral ciliary disc as the primary wheel-organ from which the wheel-organ with two ciliary wreaths has been developed, the foot which is not sharply defined from the remaining body and provided with two toes as the most primitive footform of the Rotifera; further that I regard the dorsal organ as developed from coalescence of two originally separated lateral organs. As I further call attention to the fact that the great reduction in the structure of the males is most feebly pronounced in the *Notommatidæ*, it will be understood that I regard this family, in which all the above-named primitive body structures are more or less distinctly developed, as the most primitive of all the families of the Rotifera. A closer study will show that just this family possesses the developmental possibilities of the plurality of the other families, and that remarkably many of the Rotifer-families, through more or less conspicuous transitional stages, seem more connected with this family than with each other mutually. It seems as if most of the other families of Rotifera may be arranged in a series of parallel developmental lines, all deriving from the *Notommatidæ*; some of the lines may be drawn with almost full certainty; with others this is not the case; some, showing no connection at all, seem to be totally aberrant forms.

In my opinion the Rotifera were originally creeping organisms, bound to the bottom and the vegetation. Secondarily in different ways their organisation has been altered in such a way, that from creeping organisms they have been changed into freeswimming creatures, more or less independent of the substratum, in the aberrant forms true plancton organisms. These processes of modification by means of which it is only possible to understand many of the most peculiar body-structures, (the connection between distinct types of mouthparts and of the wheel-organ, the structure of the foot, the development of the lorica, the loss of segmentation, the peculiar balloon shape, manifesting itself in very different genera (*Asplanchna, Synchæta, Notops* (*N. pelagicus* Jennings) have begun not from a single but from different *Notommatidæ*, the results of which are series of different developmental lines running parallel. The *Notommatidæ*, themselves, are almost all creeping or very slowly swimming organisms. Only one plancton organism (*Proalidies* DE BEAUCHAMP 1917 p. 148) is known.

In 1899, when this view was published, even if some of the main points had already been observed by previous authors (METCHNIKOW 1866 p. 354; JOLIET 1883 p. 204) the system, set forth by HUDSON-GOSSE (Vol II p. 14), was the dominating one. Upon all essential points their views differed totally from mine. According to them the *Notommatidæ* were the most highly developed family of all the Rotifera; the typical wheel-organ was two ciliary wreaths (*cingulum* and *trochus*). Great stress was laid upon the fact whether a lorica was present or not. Characters deriving from homogeneous life conditions were used as characters which connected families together in the same order, and which had no affinities at all. The old interpreta-

tion deriving from BURMEISTER and LEYDIG and still maintained by HUDSON-GOSSE, that the Rotifera were Arthropoda, either related to Crustacea or Insects, caused *Pedalion*, when found, to be referred to a special order, showing special affinity to the Arthropoda (v. DADAY 1886 p. 214). In all essential points the system was adopted by PLATE (1891 p. 320) who only introduced the apparent and commonly adopted improvement: The removal of the *Philodinidæ* and *Seisonacea* as *Digononta* in contradiction to all other Rotifera (*Monogononta).* Especially after CLAUS (1895 p. 1) and LEVANDER (1894 p. 32) had shown that *Pedalion* had no Artropod characters at all, the old supposition, that the Rotifera showed affinity to the Arthropoda, was abandoned, but nevertheless the systematical arrangement of HUDSON-GOSSE was still preserved and mainly used in Deutschlands Süsswasserfauna (1912) as well as in WEBER's (1898) and MONTET's (1918) treatment of the Rotifera in Switzerland. A great improvement was made by HARTOG (1910 p. 220) who separated the Rhizota into two orders, *Flosculariacea* and *Melicertacea*, otherwise the system of HUDSON-GOSSE was preserved rather unaltered. This rather persistent adherence to this system, was mainly due to the fact that the Rotifera, almost simultaneously with their happily escaping affinity whith the Arthropoda, owing to a superficial resemblance between some Rotifera, especially the *Trochosphæra* just detected at that time and the *Trochophora* larva, were regarded either as forerunners of the Annelida (SEMPER 1872 p. 305, HATSCHÈK 1878 p. 100 a. o.) or as larvæ of Annelida which have arrived at maturity, neotenic Annelidalarvæ (LANG 1888 p. 186). It will be clearly understood that this view can only be adopted when the typical wheel-organ is regarded as two ciliary wreaths, corresponding with those found in the *Trochophora* larva and must be totally abandoned, if the ventrally placed, cilia-covered disc is regarded as the typical one. As mentioned, already in 1899 I found the comparison with the *Trochophora* larva and the attempt to connect the Rotifera with the Annelida to be a total mistake, almost just as great as the attempt to connect them with the Arthropoda. The Rotifera are nearly connected with the Turbellaria, in which I am inclined to see their nearest allies. As far as I understand, this is also mainly the opinion af DE BEAUCHAMP (1900 p. 56), who especially seems to lay stress upon the *Gastrotrica* as the connecting link between the two groups.

Before entering upon the description of the males I think it most reasonable to give a short sketch of my views on the relationship between the families. My systematical views, set forth in 1899, have been criticised by DE BEAUCHAMP who, even if he is in accordance with me on many points, in many others differs considerably from me. DE BEAUCHAMP has summarised his criticism in the following sentence "Il (W-L) a pressenté les vrais rapports dans les cas, ou il les a énoncée, plutôt qu'il ne les a démontrés". This remark, is indeed quite correct. As it may most probably be used as a motto over almost all my papers, as well as over all zoological work, carried on in Nature herself and performed upon the basis of thoughts and ideas which have arisen during the excursions themselves, more from

the study of the living organisms, than from that of the organisms in hardened and stained condition, I embrace the opportunity to offer the following remarks.

De Beauchamp and I have quite independently of each other in opposite ways tried to reach the same goals, a more correct understanding of the position of the Rotifera in the animal kingdom and of the systematical relationship between the families. In de Beauchamp's work the centre of gravity unquestionably lies in the laboratory work, in mine it is in Nature herself. The way which I have been forced to follow, is determined by personal inclination and by my scientific position as the leader of a biological laboratory situated in the midst of Nature far removed from the large centres of culture. May I here insert the following remarks.

The establishment of biological stations was, based upon the clear understanding of the fact that in the long run the practice of carrying out zoological and botanical studies to a greater and greater extent in large laboratories, situated in the large towns, far away from living Nature was connected with great danger. When it has so often been urged that so many of these laboratories, especially the freshwater biological laboratories, have not yielded the expected scientific results, this, apart from many other causes, is also due to the fact, that they have not sufficiently marked out the limits of their investigations, aiming sometimes too low and sometimes too high. What has been lacking is the cooperation between the two kinds of laboratories; what has augmented the difficulties of cooperation is on the one side the, certainly not always unfounded, want of respect for the studies from the freshwater biological laboratories combined with too great a confidence in the exactness of the scientific methods used in the town laboratories, and on the other side a lack of power from the freshwater biological laboratories to carry out their investigations in Nature herself, and an often rather unfortunate need to prepare and accomplish the investigations in ways which only in a very slight degree differ from those which the great laboratories in the towns are forced to follow.

Laboratory investigations, especially those relating to the biology, but partly also those relating to the anatomy of animals, very often give one the impression of being somewhat accidental both in regard to their plan and their results. The reason for this must probably be sought in the fact that the observer unconsciously works with the individual as an isolated element. He has great difficulty in maintaining a clear perception of the organism as a link of a whole, transformed, and influenced by the circumstances under which it lives, and in turn exercising a similar influence on its surroundings. Laboratory studies may at any rate lead to results, which dazzle by a seemingly far greater accuracy than that which it is, as a rule, possible to attain through studies in nature. It must, however, be borne in mind, that these so-called accurate results are arrived at by methods of research, which have their strength especially in their one-sidedness, but on account of this, they have also hidden in them all the sources of erroneous inferences, which necessarily arise from all one-sided researches. For my own part I am very often in doubt as to how far this "accuracy" in many cases is anything more than an illusion, and

whether the results arrived at in nature, with due consideration to its endless and manifold qualities, have not on the whole, as great a scientific value, even if the results in question appear in a more unostentatious, and less dazzling form.

The investigations which are commenced and rest upon profound studies in Nature and the results of which are later on subjected to thorough investigations in the laboratories, are those which most promote science.

As far as I am able to see DE BEAUCHAMP agrees with me in the following main points: We have both arrived at the result, that the *Turbellaria* may be regarded as the nearest allies of the Rotifera; that the primitive wheel-organ of the Rotifera is a ciliary disc, placed ventrally and encircled by long cilia; that the system of HUDSON-GOSSE must upon all essential points be regarded as very unnatural. With re gard to the order *Scirtopoda* DE BEAUCHAMP confesses that HUDSON-GOSSE "exagérait l'importance" of *Pedalion*. The division of the Ploïmes in *Loricata* and *Illoricata* is "nefaste". In contradiction to HUDSON-GOSSE but in accordance with my views DE BEAUCHAMP regards the *Notommatidæ* as the most primitive of the families; upon my "groupement des familles en séries divergentes à partir des Notommatidæ" he says that it has "peu de changements à subir et se retrouve en bonne partie dans le tableau ci-contre (p. 41)".

On the other hand we disagree upon very essential points, and it is easy to show that this is due to the different mode in which we have studied the great questions in which we have both been interested.

The three main points are the following: (1) The systematical position of the Rotifera; (2) the different use we make of our criticism of the system HUDSON-GOSSE, and (3) the systematical arrangement of some of the families.

1. Even if DE BEAUCHAMP is like myself inclined to see in the *Turbellaria* the nearest allies of the Rotifera, he also believes he can find affinities with the *Gephyrea*, the *Brachiopoda*, the *Axobranchia* and quite especially with the *Mollusca*. I shall not here enter into detail with regard to the discussion of the affinities with these groups, but only pay attention to one point which I think has hitherto been rather overlooked.

In contradiction almost to all other great divisions of the animal kingdom which are bound to fresh water, the fresh waters seem to be the real home of the Rotifera, the element in which the group originated. What characterizes the freshwater fauna is, that it is an emigrant fauna, either deriving from the sea or from the land, a fauna of emigrants, the home of which was originally to be found everywhere, not only in the element in which it lives nowadays, i. e. in the freshwater itself. Owing to the peculiar conservatory power of the freshwater with regard to all types of animals which, from the oldest epochs of the earth and to our own day, escape into it, the freshwater fauna is a relict fauna, to which the oldest prehistoric oceans, as well as our present ones have provided and still provide their contingents. We are not for a moment in doubt that the developmental centres, with regard to *Bryozoa*, *Spongia*, *Crustacea*, *Coelentera*, *Insecta*, *Mollusca*, *Fishes*, have never lain in the fresh-

waters; what occurs of these great divisions in freshwater, is only to be regarded as remnants, separated from the main stock, often in the dawn of the earth. As far as I have been able to see, the Rotifera is the only division of freshwater organisms which cannot be regarded from this point of view. It seems as if their developmental centre has really been in the freshwaters: they are almost lacking in the sea, and apart from the very aberrant *Seisonacea*, they never develop special forms there. That the land Rotifera, the moss fauna of the trees, derive from freshwater, needs no further explanation. Owing to this view, which is allowable, especially with regard to animals about whose Phylogeni Palæontology gives no answers at all, I am disinclined to see near relationship with marine animals.

The view given above is further strengthened by the following fact. If we look over the other freshwater organisms with marine derivation, it is easy to show that the members of these different divisions, the *Spongia*, the *Bryozoa*, the *Coelenterata*, the *Crustacea*, the *Fishes*, are a remarkably casual medley of organisms, the affinities of which are often either much nearer to marine organisms than to freshwater organisms belonging to the same division of animals, and with which they live side by side. At the present time they very often show no affinities at all with organisms from this very geological epoch, whereas their affinities with extinct marine animals are regarded as established facts. However different the Rotifera may be, this view cannot be shared with regard to them; just this very peculiar phenomenon, that so very many of the families of the Rotifera may be arranged in developmental lines with their extreme stages finishing in plancton organisms, and with their starting points traced back to creeping organisms, gives support to the idea that they have a common source.

That further all these developmental lines really originated in freshwater and not in the sea, is in my opinion obvious, because during their development they adapted themselves biologically in accordance with those rules which many other freshwater organisms have been forced to follow, if exactly this element, the freshwater of the earth, was to be used as a home for these organisms. I am here thinking especially of the propagation, the heterogoni, the great rôle the resting eggs play in the life of the Rotifera, the absence of larva stages, all phenomena which the Rotifera share with so many other freshwater organisms, and which can only be pointed out in a very slight degree or not at all in the marine fauna. That the reduction of the male sex may be partly observed from the same point of view, I shall try to show later on.

If the above-named supposition, that the freshwater is the native home of the Rotifera is correct, and if further it is correct that the creeping, slowly swimming bottom and littoral forms are the most primitive forms, the *Turbellaria* must be regarded as those freshwater organisms from which we are best able to trace the derivation of the Rotifera. Simultaneously it will be understood that I am only with difficulty able to share the views of DE BEAUCHAMP, according to which the Rotifera should be more or less related to a great number of marine animals. My view is especially based upon the structure of the excretory organs, common to both divi-

sions, and on the view of the wheel-organ advanced above. And it is at all events not weakened by the fact that, with regard to the biology of the animals, especially with regard to the propagation in the Freshwater-Turbellaria, we find all those phenomena again in greater or smaller degree, which govern the propagation of the Rotifera (heterogoni, parthenogenetic propagation, resting eggs, no larval stages) whereas in the marine Planaria, if present at all, they must be regarded as great exceptions (see v. Graff 1882, p. 145). During recent years several authors especially Grobben in his "Lehrbuch" and partly Martini (1912, p. 627) have tried by means of the Gastrotricha to connect the Rotifera with the Nematoda. As far as I can see, the structure of the excretory organ and that of the Nematoda present great difficulties for this arrangement.

As well known, most of the authors before me have maintained, that the developmental centre of the Rotifera should be looked for in the freshwaters and not in the sea. This is the case with Hudson (1889, p. 437), Daday (1892, p. 95), Lie Petersen (1905, p. 1), de Beauchamp (1909, p. 59), v. Hofsten (1912, p. 163). Only Zelinka (1907, p. 1) has maintained quite the opposite view, asserting that the developmental centre should be looked for in the sea. He has been opposed especially by de Beauchamp, and mainly by quite the same arguments as I would have used. It is not necessary to go into details upon this point; I refer the reader to the above-named papers, especially those of de Beauchamp and of v. Hofsten. I only wish to add that the authors, as far as I have been able to see, with regard to their conception of the systematical position of the Rotifera have not drawn the consistent conclusion from their interpretion of the original home of the Rotifera.

2. It has been pointed out that upon many essential points de Beauchamp and myself agree in our criticism of the system of Hudson-Gosse. Whereas I draw the inference of the criticism and, working upon it, try to reform the system, de Beauchamp returns to the system of the English authors saying: "le vieux groupement en ordres emprunté à Dujardin et à Hudson demeure le meilleure avec les corrections que nous avons faits" (p. 40). As however the conception of the *Notommatidæ* as the most primitive of all Rotifer families, the arrangement of the other families in developmental lines deriving from them, and the interpretation of the division of Ploima into Lorica and Illoricata as "nefaste", so to speak totally subverts the whole system of Hudson-Gosse, I cannot see that it is scientifically defensible to return to it. When de Beauchamp says about my system: "Son groupement en ordres et sous-ordres est beaucoup plus contestable" (p. 39) than my arrangement of developmental lines, deriving from the *Notommatidæ*, I fully agree with him. I only take the liberty to add that the system of Hudson-Gosse cannot be regarded as better for that reason. When de Beauchamp is able to return to this system while I am not, this is due to the different starting points of our investigations. He who has based his investigations of the Rotifera upon studies in Nature, and understood how the developmental lines, starting from the creeping animals and ending in the plancton organisms, have slowly been developed, and further seen how the organisation has

been altered in accordance with variation in life conditions, will never be able, because of his investigations, to return to this system. I only wish to add that even if I have been forced to attack the system of the learned English authors, my admiration for what these two Scientists have done to promote science in this difficult domain of natural history, has in no way been abated. It will always be the work to which all students of this group of animals will return; in my opinion this is mainly due to the excellent and exact contour drawings of the animals, which only rarely give room for doubts with regard to the conception of the animals which the authors have described.

3. With regard to my arrangement of the Rotifera in developmental lines, starting from the *Notommatidæ*, it is with the greatest interest I have seen that DE BEAUCHAMP has arrived at quite the same result for some of them. This especially holds good for the line *Notommatidæ, Hydatina, Notops brachionus, Brachionus* and *Anuræa.*

I suppose that it is quite correct, as DE BEAUCHAMP has done, to separate the *Ploesomatidæ* from the next line, consisting of *Triphylus, Harringia, Asplanchnopus* and *Asplanchna.* Nearly related to it, is the small developmental line of *Notops hyptopus, Ploesoma, Gastropus* and perhaps *Anapus,* a line which begins in the Notommatidæ, especially with forms related to *Copeus.*

The *Synchætadæ* which are taken by both of us with quite the same restrictions, are in my opinion nothing but *Notommatidæ* that have emancipated themselves from a substratum; they are closely associated with the *Notommatidæ* through such species as *N. aurita* and *N. pilarius.* Researches from recent years show that the last stages in this developmental series show structures very similar to those which we find in the genus *Asplanchna* (balloonshape, peculiar humps etc.). See especially PLATE (1889, p. 1), LEVANDER (1895, p. 21), ROUSSELET (1909, p. 170).

The lines comprising the old loricate families *Rattulidæ, Diaschizadæ, Euchlanidæ, Coluridæ, Dinocharidæ* and *Cathypnadæ* cannot be drawn with such great certainty as the above-named; in the *Notommatidæ-Rattulidæ* and in the *Notommatidæ, Diaschiza, Salpina, Euchlanidæ* I see two different developmental lines. The genera may perhaps be arranged in a somewhat different way, and the families *Coluridæ, Dinocharidæ* and *Cathypnadæ* placed in this great division. All in all this does not obviate the greater difficulties of the systematic view which is advanced here, and DE BEAUCHAMP's arrangement may most probably be said to come as near to the truth as possible; great differences between his results and mine do not seem to exist.

Upon all these points there is no doubt that DE BEAUCHAMP has given my views upon the systematical arrangement of the Rotifera that scientific basis which they most certainly lacked, and upon many points he has introduced improvements. Some of the most aberrant families, the *Trochosphæridæ* and *Seisonacea,* are still without any systematical connection with the other Rotifera, and for my own part I am doubtful as to whether the *Seisonacea* may be referred to the Rotifera at all.

With regard to the *Bdelloida* DE BEAUCHAMP is in doubt as well as myself as to whether the placing of them and the *Seisonacea* in a special division, *Digononta,* in

contradistinction to all other Rotifera is really correct (PLATE). Along quite different roads we have arrived at the same results, he starting from the wheel-organ af *Adineta* and I especially from the behaviour of the creeping *Diglena*. In the present state of our knowledge I suppose it is impossible to come nearer to the truth than DE BEAUCHAMP gives it (1909, p. 36). "On ne s'aurait donner les Notommatides comme ancêtres aux Bdelloides, mais le rapprochement nous éclaire beaucoup, plus même que celui de ZELINKA avec *Rhinops*, d'ailleurs soutenable avec les mêmes réserves, sur la morphologie de l'extremité céphalique des Philodinidés." *Adineta* as well as *Microdina paradoxa* show structures which further seem to strengthen this view.

Because of insufficient knowledge with regard to the dorsal organ and lateral organs and in consequence of the presumed want of a contractile vesicle PLATE (1887, p. 258) has been inclined to see in the *Pterodinidæ* a family which was related to the *Philodinidæ*. Owing to great resemblances in the mouth parts (malleo-ramate and ramate) and in the wheel-organ, I confess I have shared this view. As however ROUSSELET (1898, p. 24) has shown that a dorsal antenna is present, that the lateral antennæ are only placed further forward than in most of the other Rotifers, and has further pointed out the existence of a contractile vesicle, I admit that this view cannot be maintained. As further he has described the very peculiar *Brachionus pterodinoides* from Devil's Lake, North Dakota (1913, p. 59), which really seems to be related to the *Pterodinidæ*, it is perhaps most correct to refer this family nearer to the *Brachionidæ*.

With regard to the *Rhizota*, DE BEAUCHAMP and I take quite different views, and upon this point I cannot alter the systematical arrangement set forth in 1899. The order *Rhizota* is only established owing to the common stamp which, everywhere in the animal kingdom, and quite especially among fixed animals, common modes of life set upon the organisms. The characters of the order given by HUDSON-GOSSE are: "Fixed when adult, usually inhabiting a gelatinous tube, excreted from the skin: foot transversely wrinkled, not retracted within the body, ending in an adhesive disc or cup" (1889, p. 43). Later authors (COLLINS, WEBER) have certainly expanded the description of the order, but as far as I can see, they have not augmented the characters which should justify its establishment. If the description of HUDSON-GOSSE is altered a little with regard to the sentence "foot transversely wrinkled", it will be seen that it may be used as a characteristic of many groups of fixed animals (f. i. fixed Infusoria), and it will be understood that all these characters are wholly adaptive. The *Rhizota* contain species with the most different wheel-organs, one wreath of cilia, two wreaths of cilia, no wreath at all; the greatest possible differences in the structure and form of the coronal disc; the placing of the cilia and their structure. The mouthparts are malleate, malleo-ramate, and uncinate; the buccal orifice placed centrally and ventrally; the anus ventrally, terminally or dorsally, often situated high up upon the dorsal side, the rest of the alimentary canal of the most different structure. In the arrangement and structure of the lateral organs the differences are also great.

Already DUJARDIN but more especially HARTOG (1910, p. 220) understood this. The last-named author referred the two families, the *Floscullariadæ* and the *Melicertidæ*, to two different orders *Floscullariacea* and *Melicertacea*. DE BEAUCHAMP (1909, p. 32) again refers them to the order *Rhizota*, comprising the two suborders *Melicertiens* and *Floscullariens*. HLAVA (1904, p. 25) has divided the *Melicertidæ* into two subfamilies *Melicertiens* and *Conochiloidiens* and DE BEAUCHAMP (1908, p. 129) refers them to two different families *Melicertidæ* and *Conochiloidæ*. Later on DE BEAUCHAMP (1912, p. 242), in accordance with the work of Miss FOULKE, (1884, p. 37) divides the *Floscullariens* into two families, the one comprising the three genera *Acyclus*, *Cupelopagis* (= *Apsilus*) and *Atrochus*, the other the genera *Floscularia* and *Stephanoceros*. The order *Rhizota* is then according to DE BEAUCHAMP divided into two suborders *Melicertiens* and *Floscullariens*, each with the above-named two families. With regard to the standpoint of HARTOG and myself he further adds: "Il ne faut pas exagerer, comme l'a fait W.-L., jusqu'à nier tout rapport entre ces deux groups et leur en attribuer de très artificiels avec d'autres." (p. 32) In my opinion there is not the slightest affinity between the two great families, each of them is much more closely related to various freeswimming Rotifera than to each other, and as long as this is not clearly understood, these very families cannot be systematically placed.

Owing to the structure of the mouth parts, the wheel-organ, the form of the body, the peculiar "limbs" (*Triarthra brachiata* ROUSSELET 1901, p. 143. Pl. VIII, fig. 7.) *Triarthra* and *Pedalion* may be referred to the same family, *Pedalionidæ*. This was done by me in 1899 and so far DE BEAUCHAMP shares my views. A close examination will further show great mutual congruity upon all essential points between the *Melicertidæ*, and *Pedalionidæ* (mouth parts, wheel-organ with two ciliary wreaths). In my opinion *Pedalion* is a pelagic Melicertid which has preserved the wheel-organ and the mouth parts of the *Melicertidæ*; the changed mode of life as a freeswimming organism has caused the loss of the foot and the peculiarly shaped "limbs". How the two peculiar stylate ciliated appendages in *Pedalion* are to be interpreted, I do not know.

To see adaptive features due to common life conditions in all these common characters is quite impossible, the one family being fixed, the other consisting of freeswimming plancton organisms. DE BEAUCHAMP (1909, p. 29) says: "Par ce double charactère (malleoramate mouth parts and two ciliary wreaths) on a voulu les rapprocher des Rhizotes Melicertiens, qui les possèdent également. J'ai montré que la convergence due à un même mode d'alimentation suffisait à les expliquer." His views have been set forth at greater length already in 1908 (p. 128). Upon this point I quite disagree with the learned author; of course the mode of nourishment is the same in the two families; but whence does this mode arrive, which is common to them both and which, being once elaborated in this form, is unique among the families of the Rotifera.

Which seems the more natural to suppose, that the combination of malleoramate mouth parts and the two ciliary wreaths showing in all their details the greatest

conformity in the two families *Melicertidæ* and *Pedalionidæ*, have been developed independently of each other in fixed as well as in freeswimming organisms, or to conjecture, that this unique combination, used under very different life conditions, suggests affinity between the two families. Most probably the wheel-organ in the *Melicertidæ* is the best for procuring detritus food, on the other hand it is rather weak as a swimming organ, the result of this being the development of the jerking thorns and limbs which are more developed in the *Pedalionidæ* than in any other family. The thorns are used to alter the direction, which these footless species would otherwise have been unable to do. In my opinion the *Melicertidæ* and *Pedalionidæ* may be placed in the same division; to connect this with the *Notommatidæ* is at the present time impossible.

When DE BEAUCHAMP claims that he has "montré" (1909, p. 29) that convergence due to the same mode of nourishment enables us to demonstrate the conformity between the two families *Melicertidæ* and *Flosculariadæ* I confess that, from my standpoint, I can only see that, in these domains of investigation, whether our researches are carried on in Nature or in the laboratories, we can never get any further than to "enoncer", never to "montrer" anything (vide pag. 40).

The *Flosculariadæ* in my opinion form a rather heterogeneous group; as I however have never had an opportunity to see *Apsilus* and only on a journey a glimpse of *Stephanoceros*, my views are of no value. I have thought that *Microcodon* was in some way related to the *Flosculariacea*. WEBER seems to have been of the same opinion (1888, p. 18). DE BEAUCHAMP maintains, that its wheel-organ "se rattache facilement à celui de *Cyrtonia* par l'intermediaire du genre voisin *Microcodides*." I hope to return to this point later on.

Chapter III.

The Males of the Rotifera.

Fam. **Notommatidæ.**

As mentioned before I regard the fam. *Notommatidæ* as the most primitive of all the families from which most, perhaps all, of the other families may be derived. I regard it as quite impossible to indicate more thoroughly the closer relationship between the many genera of Notommatidæ. In the following I draw upon the work of MAX VOIGT (1912, p. 82).

Nowadays very few males of the fam. *Notommatidæ* are known. The males of the genera *Albertia, Drilophagus, Pleurotrocha, Theorus, Taphrocampa, Monommata, Arthroglena, Distemma, Triopthalmus, Otoglena* are all quite unknown; for a few of them now one, now another, author has stated that he has seen "a glimpse of a male", but this of course is of no scientific value.

Only the males of the genera *Cyrtonia, Proales, Diglena, Copeus, Notommata* and

Triphylus have been described and figured; those of *Cyrtonia*, *Triphylus* and *Notommata* only a single time and very insufficiently. On the other side WEBER's descriptions of *Diglena catellina*, *Diglena forcipata* and *Copeus labiatus* and further ROTHERT's and ROUSSELET's descriptions of *Proales Wernecki* belong to the best descriptions hitherto known of males of Rotifers.

Cyrtonia tuba ♂ (Ehrbg.) after Rousselet.

Cyrtonia tuba (Ehrbg.)

Male: Rousselet 1894 p. 433.

ROUSSELET (1894, p. 433. Pl. XX, fig. 4) describes the male as follows.

The male of *Cyrtonia tuba* is a small elongated, cone-shaped creature with only a slight indication of being humped, and otherwise quite straight, having a simple ciliary wreath, a prominent red eye, dorsal and lateral antennæ, a contractile vesicle and two small toes. The jaws and alimentary canal are quite absent, the elongated sperm sac filling the whole body cavity. The usual longitudinal muscular bands, which are striated, are present, and the circular bands are more apparent than is generally the case. The two small toes are conical and have the usual foot glands. Size of female $\frac{1}{70}$ inch to $\frac{1}{100}$ inch; of male $\frac{1}{250}$. Time: June—August.

Proales Wernecki Erhbg.

Male: Rothert 1896 p. 702.
Rousselet 1897 d p. 415.

Proales Wernecki ♂ Ehrbg. after Rousselet.

In 1896 ROTHERT described the male but gave no drawing of it; next year ROUSSELET found the male again and gave a new description and two figures. In the following I have tried to combine the two descriptions.

The male is of much the same appearance as the female; this especially holds good with regard to the form of the body, foot and wheel-organ. It differs from almost all other male rotifers in having a well-developed alimentary canal. It has a mastax of a structure almost quite like the female. The jaws are like those of the female. All the usual parts are well developed, and, in addition, there is a small triangular plate on each side articulated between the ramus and uncus. There is a well-defined oesophagus and small salivary glands. The stomach is also present, but takes up a very small portion of the body cavity; an intestine cannot be seen. The gastric glands are only small, much smaller than those of the female. There is a large testis but no prostata gland; the spermsac opens as usual into a penis on the back of the foot. The brain and the red eye correspond with those of the female. The excretory organ is only insufficiently observed; there seems to be no contractile vesicle. The toes and foot glands are large. A dorsal antenna but no lateral antennæ are observed.

The males are found swimming in the water; in form and structure they are very like the young females but differ strongly from the old, stout, almost globular females found in the galls. Size of male 149 μ, of young female 159 μ, of adult female 195 μ. Time: according to Rothert, December, according to Rousselet, April.

The young female when first hatched is of much the same size and appearance as the male; but the large, white, rounded, salivary glands attached by a narrow neck to the mastax, and the large and full gastric glands, as well as the ovary and stomach, which together fill up the whole body cavity, serve to distinguish it at once. Both the young male and female escape from the galls in which they have been hatched by an opening which is formed at the apex. They swim about in the open water for a time, whereupon the young female again enters a *Vaucheria* filament, but where and by what means is not exactly known. It causes the plant to produce a rounded or elongated gall of considerable size; it seems that the female is unable to develop and lay eggs outside the *Vaucheria* filament or gall. The adult female is almost globular with a large number of immature eggs. Most probably intestine and stomach are active. Some galls contain all female eggs, others both female eggs and the smaller and fewer male eggs. Fertilised resting eggs were found by ROTHERT in a number of 30—54 in one gall, all laid by a single female.

Proales parasita Ehrbg.

Tab. I, fig. 4—6. Tab. IX, fig. 7—12.

Description: Body cylindric, very short. Wheel-organ placed almost vertically, consisting of a row of cilia; upon the disc a horse-shoe shaped second row with somewhat longer cilia. (Tab. I, Fig. 6). Brain very large; dorsal antenna most probably present, but has not been observed; lateral antennæ not observed; a very large red eye placed behind the brain; no trace of alimentary canal. Testis very large, pearshaped, opening dorsally; no penis but the ductus seminalis can be turned inside out; at the opening a tuft of cilia. Two prostata glands. No trace of excretory organs. A real foot does not exist, but there is a peculiar sharply defined small appendix, ending in two spinelike projections. There are six or seven transversal muscle bands and two pairs of longitudinal ones. The interior is filled with a greyish mass, containing very many oil globules. Size of male 40 μ, of female 160 μ.

It is only with some doubt that I refer this species to *Proales parasita*. This as far as I know has hitherto only been found in *Volvox*, in which I have often found the animals too. My specimens all derive from *Uroglena volvox*. Owing to the smaller size of this alga the animals do not always live in the colonies; very often they sit on the outside, feeding upon the surface. Often they jump off, swimming round the colonies. The eggs are laid upon them. When newly hatched, the females are small, narrow and rather quick in their movements; but in the course of a few days, after having fed upon the *Uroglenas* they begin to swell; the foot with the toes is almost always held withdrawn, and at last the whole body is quite deformed. (Tab. I, fig. 7—12). In this shape the animals hardly ever leave the colonies, often living within them and almost filling them up. When *Uroglena* colonies are not at hand, the animals live their life as freeswimming organisms, and the females keep the shape indicated in fig. 8. The females possess no tentacle in the wheel-organ and cannot therefore be identified with *Hertwigia volvocicola* Plate. As I cannot find any difference between the *Proales parasita* Ehrbg. and my specimens, deriving from the *Uroglena* colonies, I refer them to this species. In my area of exploration it is common in May.

Hertwigia volvocicola Plate.

Male: Plate 1886 p. 27.

Plate describes the male as follows. (1886 p. 27).

Die Männchen fanden sich nicht eben selten, meist in 3—4 Zahl, innerhalb der Gallerte der Volvoxkugel. Sie sind walzenförmig und haben eine Grösse von nur 0.08, übertreffen daher die Hälfte der Länge des Weibchens um ein Weniges. Sie sind sehr einfach gebaut und entbehren der Mundöffnung, des Kauapparates und eines besonderen Penis. Der Räderapparat besteht aus einem Cilienkranze, der die Mitte der Bauchseite freilässt und über den die Cuticula sich etwas hervorwölbt zu einer dichte mit kleinen Wimpern besetzten Calotte. Besonders bemerkenswerth ist das Fehlen des kegelförmigen Hautzapfens, welcher den Kopf des Weibchens überragt. Der Leibessaum wird vornehmlich von dem Hoden erfüllt, dessen flimmernder Ausführgang am hinteren, etwas verjüngten Körperend, ausmündet. Das Gehirn stellt ein im Verhälltnis zur Körpergrösse enorm entwickeltes Organ dar, dem am Hinterrande ein roter Augenfleck ansitzt. Mit Sicherkeit habe ich nur einen dorsalen Taster bemerkt, doch ist der andere wohl übersehen worden. Uber dem Hoden liegt der rudimentäre Darm, der vorn bis an das Gehirn reicht und mit diesem so eng zusammenhängt, dass ich often einige Körnchen des Augenpigmentes auf ihn übergetreten fand. Die Wassergefässe sind verhanden, doch nur sehr schwierig zu erkennen, sodass mir die Art ihrer Ausmündung verborgen blieb. Nur dass ist sicher, dass eine contractile Blase fehlt. In dem rudimentären Darm habe ich nie Spuren von Kalkkörperchen, wohl aber zuweilen einige Fetttropfen gefunden. Das Hinter- und Vorderende des Körpers können etwas eingestülpt werden.

Notommata naias Ehrbg.

Male: Rousselet 1903 p. 176.
Wesché 1902 p. 327.
Tab. I, fig. 1—2.

Rousselet says that he has described the male of *Notommata naias*. I have not hitherto been able to find the description. Wesché (1902, p. 327 Pl. XVII, fig. 2 a b) has described the male as follows:

The general shape is fusiform, with a slight tendency to angularity. The head is well separated from the body, which is long in proportion to its breadth and distinctly annulated. The foot is long with four annulations. The toes are identical with those of the female, each furnished with a big gland which extends into the body some distance beyond the orifice of the penis. The cilia are moderately long, with several indistinct setæ. The brain is large, and retracted by two powerful bifurcate muscles. The eye is very large, dark red, standing out from the brain (as in ♀), and there is a slight constriction where it joins the brain. The dorsal antenna seemed placed very much forward on the brain, but was not distinct. The lateral antennæ were quite clear, and on the lower part of the body. Below the brain was a granular mass, and adjoining were some nebulous glands, which seem to be the remains of the digestive organs. The vascular system was distinct, but no contractile vesicle could be seen. The spermatheca was very large, extending well into the middle of the body. Size 212 μ. Time January, March.

Description. Body elongate, truncated in front, attenuated behind, foot long thick, three jointed, not sharply defined from the other part of the body. Two short toes. The whole body very soft, flexible, altering in form, covered by a very soft hyaline cuticula; at the attachment of the transversal muscles regularly constricted

and with regular longitudinal folds which are especially conspicuous on the foot. Wheel-organ a slanting cilia-covered disc, surrounded by a wreath of somewhat longer cilia and with a broad bunch of long cilia on the top; no visible auricles.

No mastax; as a remnant of the alimentary canal a longitudinal folded sac-like body lying over the testis and fastened by ligaments to the body wall. Brain large with a broad red eye; a dorsal antenna with a bunch of short bristles; no lateral antennæ have been observed. Four longitudinal muscles. Very conspicuous are six transversal muscle bands which regularly contract and expand the body; during swimming and creeping this is always altering its form. The two lateral canals carry each three vibratile tags; no contractile vesicle visible. A very large pyriform testis with two sorts of spermatozoa; a long ductus seminalis covered with cilia; penis short ending dorsally upon the second foot segment; cilia coating round the opening; two short foot glands. —

The descriptions of WESCHÉ and myself do not agree very well but as there is also considerable discrepancy between his drawings and his description a comparison is difficult.

Size of male 120 μ, of female 300—400 μ. Time: April. Several times I have met with this slowly swimming or creeping animal. It appeared rather often in cultures which contained only *N. naias*; the very thick foot and no, or at all events very small, auricles are both characters which the male shares with the female.

Notommata aurita (Müll.)

Tab. I, fig. 3.

Description. Body subcylindric, ventricose, furnished behind with a short tail, by no means so conspicuous as in the female. Cuticula thin, extremely flexible, altering in form with a peculiar, rather constant system of longitudinal lines dorsally; the course of these lines will best be understood from the figure. Foot short with two joints, well separated from the body; two rather short acute toes. Wheel-organ a cilia-covered slanting disc of triangular form, surrounded by a wreath of rather short cilia. Seen dorsally the wheel-organ presents itself as bent inward; there are two well-developed auricles. Alimentary canal absent; as rudiment above the testis a rather inconspicuous sac or band. Brain very large, broad, with a large flattened eye, a conspicuous dorsal antenna lying remarkably near the wheel-organ. Of the retrocerebral organ a very conspicuous opaque part containing a large number of concrements; further two subcerebral organs which I have not been able to see in so conspicuous a position that I have ventured to draw them; they are concealed between the six large cells of hypodermal nature and are indicated in the figure. That they really exist, is so much the more probable, as shortly before the death of the single specimen I have seen, I with certainty observed two rounded openings which most probably are the openings of the organ. The lateral antennæ I have not been able to see. Two lateral canals with three vibratile tags each, but no contractile vesicle.

Three pair of longitudinal muscles for the wheel-organ and one pair acting as a retractor for the foot. Testis very large, globular, with two kinds of spermatozoa; a thick ductus seminalis covered with cilia; genital opening upon the first foot segment; the opening surrounded by a wreath of cilia. Two prostata glands; above the testis a globular mass of opaque concrements. Two small foot glands. Size of male 180 μ; of female 250—330 μ. Time July.

Diglena forcipata. Ehrbg.

Male: Weber 1897 p. 94. 1898 p. 487 Pl. XIX fig. 8.

Weber (1897 p. 94 Pl. IV, fig. 2) has described and figured the male.

It is of almost the same form as the female and also almost of the same size. It terminates in two long toes, widely spread and separated at their base by means of a little proboscisform tubercle. As in the female the body is covered with a rather thick, hyaline cuticle, representing a sort of lorica; this is restricted to the dorsal side and ending a little below the forepart of the body; behind it reaches the base of the foot. The head is curved downwards and the coating with cilia reaches the niveau of the mastax. The forepart of the body carries two strong transversal folds, the one passing over the dorsal antenna, the other passing over the end of the brain. The foot is thick, the footglands are well developed, pyriform. The wheel-organ is a large, ventral plate, covered with cilia, concave. Four longitudinal anterior, two longitudinal posterior and five transversal muscles, forming regular folds in the skin. No proboscidiform tubercle at the front of the head as in the female. No trace of alimentary canal. Two excretory canals each carrying three vibratile tags open upon each side of the penis. The brain is oblong with two frontal eyes. A brilliant point above the brain is observed; whether this is a dorsal antenna is doubtful. The testis is relatively small; the penis is terminated by a crown of small stiff cilia. Prostata glands are not observed but yolkmasses above the testis.

Diglena grandis Ehrbg.

Tab. I, fig. 7.

Description. The male has almost quite the same form as the female and is but little smaller. It is cylindrical, tapering behind and also a little in front. Cuticula extremely thin and hyaline, provided with a system of regular longitudinal folds. It is thickest dorsally and in the middlepart of the body; forepart and foot can partly be drawn into the middlepart. No chitinous arched plate as in the female. The body terminates in two long acute toes. Brain large; it gives off a nerve for the dorsal antenna; lateral antennæ I have not been able to observe. Two red eyes placed very near each other. Wheel-organ a large disc, placed almost vertically to the longitudinal axis, highest in the middle and drawn out dorsally and ventrally in small auricles. It is surrounded by a wreath of long cilia. No particular styli observed. Of the alimentary canal there is only present the connecting band between testis and wheel organ. The two lateral canals carry three or four pairs of vibratile tags; there is no contractile vesicle. Testis pear-shaped large; ductus seminalis without cilia. Opening for the copulatory organ at the posterior border of the last foot segment. The co-

pulatory organ consists of a chitinous sheath which may be regarded as a continuation of the envelopment of the testis. The sheath consists of two hyaline chitinous bands, separated from each other; between them is the real penis, which is a little shorter than the sheath. The penis can be protruded and then the whole body will be curved often in such a high degree, that it is almost ball-shaped. There are two prostata glands. Above the testis is a globular mass, containing many opaque corns of irregular, often quadrangular, form. At all events there are three or four transversal muscle bands, most probably more, and four strong pairs of longitudinal muscles. Oil globules wanting. Two foot glands. Size of male 300 μ of female 300 —350 μ.

The species was common in a little pond near Hellebæk, North Seeland (Time $^{14}/_{V}$ 22); it was easily recognisable from almost all other Diglenas only by means of its size. The pond was covered by a peculiar carpet of waterplants mainly formed by *Myriophyllum* and *Lemna polyrrhiza*. When squeezing this material in a plancton net, very many different Rotifers appeared. Among them one of the most characteristic was this large, extremely voracious animal, which preyed upon all that came near it. Isolated in the vessels many eggs were laid upon algæthreads and a few males appeared in the light-illuminated border of the vessel.

Diglena catellina Ehrbg.

Male: Weber. 1888 p. 46.
— 1898 p. 494. Pl. XIX fig. 13.
Tab. I, fig. 8.

Weber (1888 p. 46; Pl. XXXIV fig. 1, 4, 5) describes the male as follows.

Body cylindrical, differing in form from that of the female, a little smaller, more stretched, narrower and slightly curved on the dorsum. Cuticula very thin and hyaline. The wheel-organ exactly in accordance with that of the female; a feeble groove where the mouth is to be found in the female. A well-developed muscular system which has not been more thoroughly studied. The digestive system totally absent; in its place a long series of granulations. Vasculary system consisting in two canals, beginning near the brain and opening on each side of the penis; the opening round, encircled by cilia; only three vibratile tags seen; in the female four. No contractile vesicle; an olive-formed brain with a dorsal antenna. Two eyes on the forepart of the head. The foot with long; slender, acute toes. Testis piriform, very large, suspended by means of fine ligaments from the bodywall and by means of a muscle to the wheel-organ. Near the base a longitudinal striation, probably deriving from muscles. Penis covered by a cuticula, it is very different from those hitherto described in Rotifera. Weber describes it as follows: »A la base du testicule et y faisant suite, nous voyons chez *D. catellina* un organe en forme de navette, formé de deux bandes aplaties, concaves à l'interieur et convexes a l'exterieur, se réunissant et se terminant en pointe à l'extrémité postérieure du pénis. Les deux bandes chitineuses sont la continuation de l'enveloppe du testicule; elles sont dures, séparées l'un de l'autre par un espace dans lequel se trouve le pénis. Cette enveloppe chitineuse protège le pénis délicat et sert à forcer le cloaque de la femelle. C'est un étui protecteur, droit, long et étroit. Le pénis lui-même est fort mince et cylindrique; son orifice n'atteint pas l'extrémité de l'étui, qui est ouvert, fendu dans toute sa longueur. Autour de cette gaine cornée du pénis, nous voyons une gaine musculaire en fourreau et des muscles rétracteurs de cet

ensemble que j'appelle l'organe copulateur. Le pénis est placé sur la face dorsale du pied. Lorsqu'il est complètement retiré son extrémité arrive juste à la racine des doigts du pied et est protégée par deux petits bourrelets circulaires. Au même niveau, de chaque côté, debouchent les canaux latéraux du système excréteur.«

Description. Male of almost the same form as the female, but in front almost cylindrical, only tapering behind. It is more elongate, narrower than the female, but curved on the dorsum like this sex. The cuticula is very thin, hyaline and extremely flexible, it is thickest dorsally and in the middle part of the body; the forepart can be withdrawn, the posterior part only in slighter degree. The wheel-organ formed exactly like that of the female; some stronger hairs on two elevations on the disc. No frontal hood. The brain is large, perhaps not always faintly bilobed behind, and with a nerve to the dorsal antenna; no lateral antennæ have been observed. Two red eyes as in the female. Of the alimentary canal only a connecting band between the testis and wheel-organ; WEBER regards this band as being of muscular substance. The excretory organ consisting of two canals with three vibratile tags; no contractile vesicle; WEBER has seen the opening of the canals on both sides of the penis; I have failed to see them. Testis large pyriform, suspended by means of fine ligaments. The copulatory organ formed as in *Diglena grandis* and in close accordance with the admirable description of WEBER. Two very small prostata glands. Above the testis a globular mass. Four transversal muscle bands; four pairs of longitudinal bands and at all events one pair of slanting muscles from the base of the foot to the dorsal antenna. Two foot glands. No oil globules. Size of the male 140 μ of the female 150 μ.

Diglena catellina is here as everywhere an extremely common animal. In May it was found in the algæ carpets almost in every pond; and many eggs were laid in parts of these carpets which were brought into the vessels. The males were rather common, though always rarer than the females.

Diglena giraffa. Gosse.

Tab. I, fig. 9.

Description. Male extraordinarily slender, tapering posteriorly, straight, of an almost incredible hyalinity, flexible in a degree which has perhaps never been observed and moving with an enormous speed. I never succeeded in making camera drawings of it, but I got some measures when the animal was fully stretched out, and could study the internal structure rather exactly. The form differs very much from that of the female, having no marked neck and no tumid abdominal part, the whole body being almost hairshaped, only a little thicker in front than behind; the toes are very long, straight, the cuticle is soft, without any longitudinal folds, the whole animal bluish hyaline almost quite invisible. The wheel-organ as in the female, but without any frontal hood, insufficiently observed. Brain pearshaped with nerves for the dorsal organ; two red eyes placed very near each other. Of the alimentary canal only a band. Lateral canals with three vibratile tags; no contractile vesicle.

A large strongly elongated testis; owing to the extreme slenderness of the body a copulatory organ could not be observed; only a long ductus seminalis but not covered with cilia; a bunch of cilia at the opening of the penis on the posterior border of the last segment. No prostata glands observed. Six transversal muscle bands and at all events three longitudinal muscles. Two pedal glands. No oil globules. Length of male 250—280, but measured without pressure most probably only 15—20 μ broad. Length of female 250—280 μ.

It is only with some hesitation, that I have determined this species as *D. giraffa* Gosse. It was found in great quantities in a little pond, near Hellebæk, North Sealand (Time $^{12}/_{V}$ 22). The female was characterized by a well marked neck and a very tumid abdomen; a frontal hood, two red eyes and two long slender straight toes; it was in full accordance with the figure by HUDSON-GOSSE (Pl. XIX, fig. 9). It was extremely restless and variable in form. It lived in the alga coverings on the surface of the pond; a little of this material was isolated with many hundred specimens; two days later the males appeared; it was only by means of the greatest accuracy and with the best possible light conditions that it was possible to detect the males which, with regard to restlessness, hyalinity and especially slenderness, surpassed all that has hitherto been observed. The eggs were laid on the carpets, resting eggs were not observed.

Diglena mustela Milne.

Male: Milne 1885 p. 188.

According to Hudson-Gosse Suppl. p. 31, MILNE has described the male: "It is a much smaller animal than the female, more elongated, and with a more developed hood. Its structure is normal." I have not been able to get MILNE's paper.

Diglena volvocicola Zawadovsky.

Male: Zawadovsky 1916 p. 1.

ZAWADOVSKY (1916 p. 1) has described and figured a *Diglena* from *V. globator*; he describes the male, gives some figures of the pairing process and mentions that some minutes after having been hatched the males are ready to copulate. The paper is written in Russian with a very short resumé.

General remarks. The *Diglena* males are characterized by being shaped almost like the females; they are only more slender than these; there does not seem to be any neck; they only taper posteriorly not in front and there is no frontal hood. They are extremely hyaline without any lorica, but the skin is thicker in the middle part of the body and thickest on the dorsal side; commonly the foot is not sharply defined. The species described have all the wheel-organ formed like that of the female, but it has a more vertical not a ventral position. The two eyes are visible; only the dorsal antenna has been observed; no mastax and only feeble rudiments of the alimentary canal; no contractile vesicle; vibratile tags fewer in number than in the female; most probably the lateral canals always open on the side of the

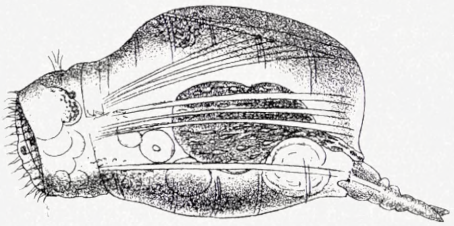
penis at the posterior border of the last segment. The testis is pyriform and the copulatory organ has probably always a rather complicated structure; with regard to this point I refer the reader to WEBER's description. Remains of yolk almost always present. Two foot glands and no oil globules.

The *Diglena* males have hitherto only been observed by WEBER. For a long time I vainly searched for them. Not till 1920, when I learnt that, in the sexual period, the eggs were laid in the algæ carpets on the surface of ponds, was I able to detect the males of three species. The males which always seem to be much rarer than the females, are only met with in May; they are creeping like the females but swimming too and with much greater speed than the females; the motion is always straight; no rotating motion has been observed. I have never seen the pairing process, so well described by Weber for *D. catellina*.

Triphylus lacustris Ehrbg.

Male: Western: 1892 p. 374.

WESTERN (1892 p. 374. Pl. XXV fig. 5) has observed the male but only once and has only given a very insufficient description and figure of it. He only says:



Triphylus lacustris ♂. Ehbrg. after Western.

"The digestive viscera are entirely wanting; their space is occupied by the large sperm sac. A large penis protruded behind the foot was observed. The males were found swimming amongst females. Length $^1/_{88}$."

The first time I met with this peculiar rotifer was in May 1898 in a little pond near Furesø. It was very common, but I missed the sexual period. The pond was then almost filled with dead leaves, branches etc., and I could never find the species again.

In later years I have often seen the animal and have visited the ponds where it was common at regular intervals. In summer as well as in winter I found females with resting eggs, but curiously enough I never succeeded in finding the males.

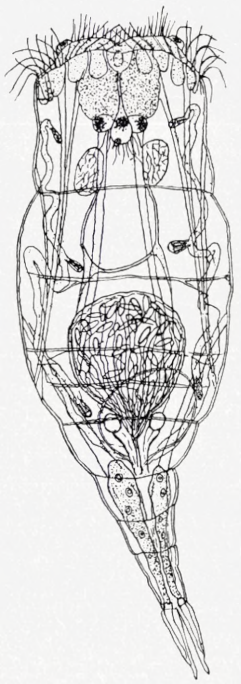
Eosphora digitata Ehrbg.

Male: De Beauchamp 1905 p. CCXXX.

DE BEAUCHAMP describes the male as follows.

"Le male d'*E. digitata* est remarquable par sa dégradation beaucoup moins grande qu'elle n'est habituelle chez les Rotifères; sa forme générale est absolument celle de la femelle et sa taille n'est pas beaucoup inférieure (310 μ contre 415 en moyenne); son aspect est tout a fait celui d'une jeune femelle, d'autant plus qu'il a conservé les amas de granulations de part et d'autre de l'œil qu'elle possède à ce degré de développement. Couronne, cerveau, pied et ses glandes, muscles, vessie sont exactement semblables; sur les canaux excréteurs je n'ai pu compter que trois flammes vibratiles de chaque coté alors qu'il en existe quatre chez la femelle comme l'a figuré WEBER; mais mon observation sur le vivant n'a pas été assez prolongée pour

que je puisse affirmer l'absence de la quatrième. Le tube digestif existe, mais en cul-de-sac et sans mastax; on n'y peut distinguer que deux régions, la prémière flanquée juste derrière la couronne de deux masses granuleuses, d'apparance glandulaire, la seconde à parois uniformément minces, renflée et terminée par deux ligaments qui semblent aller se confondre avec les muscles longitudinaux. Ce tube digestif n'est probablement pas fonctionnel; du moins était-il entièrement vide chez mon individu. Les deux masses latérales représentent-elles les glandes gastriques? Il est beaucoup plus probable, étant donné leur forme et leur rapports, qu'elles correspondent à celles que j'ai décrites dans le mastax. Le testicule occupe la moitié postérieure du corps; il est globuleux, à parois minces, renferment de nombreux spermatozoides de grande taille qui s'y remuent avec vivacité. De part et d'autre de son canal déférent existent deux petites masses rondes qui sont les glandes annexes dites prostatiques. Je n'ai pas vue le pénis evaginé."



Eosphora digitata ♂. Ehrbg. after de Beauchamp.

Finally DE BEAUCHAMP mentions that *Otoglena papillosa* Ehrbg. may perhaps be identical with the male of *Eosphora digitata*.

The animal is common in many of the ponds near Hillerød; I have met with the male several times and convinced myself that I was only able to add little to the description of DE BEAUCHAMP. I only remark that I have not been able to observe any contractile vesicle; I have counted five transversal muscle bands; the two small glands on the sides of the rudiment of the mastax are found. As well known *Eosphora digitata* is a slowly swimming or creeping animal, and the male does not move much faster than the female; the hyalinity of the male is much greater than that of the female, but seen with a low power it much resembles a young female.

Copeus labiatus Gosse.

Male: Weber 1897 p. 92. Pl. IV fig. 6.
Tab. II, fig. 1.

The mainpoints in WEBER's excellent description are as follows:

Cuticula thin, homogeneous. The general form of the male is that of an elongated cylinder, rounded in its anterior part, thickest in the middle and attenuated behind, ending in a foot with two short toes between which, as in the female, is placed a little "éperon". Two normal foot glands. The form of the body differs very much from that of the female which is much broader behind, abruptly finishing with a tail and well marked foot, the tail in the male being almost absent. Head a little broader than the forepart of the body. No gelatinous cover which is so characteristic of the female. No alimentary canal, only oesophagus represented by a transparent mass. Wheel-organ strongly reduced, only a single wreath of cilia, two feebly developed ears; it is doubtful whether there exists a ventral lip; the muscle system consists of a series of longitudinal muscles, retractors of the wheel-organ and of the foot, of muscles for the penis and suspensor muscles of the testis. A threelobed brain is found; the central part is pyriform and carries the eye. There is a dorsal antenna and two large lateral antennæ, either with a tuft of cilia or with a single one. Four pyriform cells behind the wheel-organ and without connection with the brain. The excretory organ consists of two lateral canals each carrying five vibratile tags; contractile vesicle doubtful. Testis pyriform,

large; penis short with a muscle sheath and prostata glands. Above the testis a hyaline ovoid mass regarded as rudiment of the alimentary canal; further some globules regarded as remains of yolk. Length of female 600—700 μ, male "plus petit". Time: May, July.

Description. The form of the male differs rather from that of the female; there is no neck, no inflated posterior part and hardly any tail. It has an ellipzoidic form, faintly tapering in the posterior part; it ends in two well developed toes, between which a little protuberance is observed in the female. I have never found any gelatinous sheath, so characteristic of the female. The wheel-organ consists of a vertically placed convex disc with a row of short cilia. The auricles are well developed, but very often withdrawn; they are unfolded in swimming, but commonly withdrawn in creeping. On the disc a broad band of long cilia. I have never seen any rudiment of a lip, which is extremely well developed in the female. The brain is broad, carrying a red eye. The dorsal antenna has not been observed; it is mentioned in WEBER's text, but not found in his figure. The two lateral organs, provided with long, sensitive hairs, are very conspicuous. The retrocerebral organ is a large broad pouch, containing rounded or pentagonal vacuoles; at the sides are two small lateral lobes. No openings for the organ have been observed. No sure rudiment of the alimentary canal, but between the retrocerebral organ and the testis lies a peculiar large, rather hyaline globule also mentioned by WEBER; that this, as supposed by WEBER, is a remnant of the alimentary canal, is possible. The excretory organ consists of two long curled canals, provided with four vibratile tags; there is no contractile vesicle; openings for the canals have not been observed. There are two prostata glands near the beginning of the ductus seminalis and two smaller ones more posteriorly. The testis is large, almost globular. As far as I have been able to see, the ductus seminalis which is twisted debouches into a very distended much broader part wholly covered on its interior part with cilia. This part opens on the posterior border of the last segment. If and how it is used as penis, I do not know. WEBER's drawing indicates the same distension but also that, in his opinion, it has nothing to do with the genital opening. In his drawing the penis opens above this distension which is quite independent of the genital organ. In his description the organ is not mentioned. There are two normal foot glands. There are eight transversal muscle bands, five pairs of longitudinal muscle bands for the wheel-organ and two for the foot. These bands overlap in the middle line of the body. Length of female 6—700 μ, that of male ca. 300 μ.

In a little peat bog divided into a great many smaller pits at Strødam about three kilom. from Hillerød I found, in May, in the algæ coverings of the surface in one of the pits, *C. labiatus,* in the other, *C. pachyurus*; especially *C. pachyurus* was very common; for years the two pits have had no connection with each other. Having isolated about a hundred specimens of both species, some days later a few males appeared. In samples taken in directly from nature, I never saw any males. The colonies were observed in May, but as heavy downpours began in June, the animals became rarer and rarer and finally totally disappeared.

Copeus pachyurus Gosse.

Male: Dixon Nuttall 1893.
Tab. II fig. 2.

Dixon-Nuttall (1893 p. 333 Tab. 15) has given a good description and fine drawings of the male.

"In general outline they are very much like that of a young female, are restless little fellows, and, unlike the females, seldom withdraw their auricles, but keep swimming in a somewhat spiral mode. The brain, as in the females, is threelobed and of the same shape (though I am of opinion the two smaller lobes are a little more pointed, and in some cases slightly more granular or opaque). Each sac is filled with numerous cells, which give the covering or skin the appearance of being beautifully and evenly marked with a fine hexagonal pattern. This I have noticed is the case in the female too. The occipital antenna stands at the base of the long lobe of the brain, and I also find this in both genders. The eye is seated on a small ganglion, which rests between the two sides or small lobes, and under the long, narrow neck of the centre lobe of the brain. The cavity of the body, which in the female contains the mastax, stomach etc. is filled with a large empty sac. The lumbar tentacles, with their retractile setæ are the same as in the female. Four vibratile tags run down each side. The large sperm sac and protrusile, ciliated penis are obvious. I noticed the spermatozoa in active movement inside the sperm sac. The size overall is $^1/_{95}$"."

Description. Body shaped like that of the female but much more hyaline. The great fat, ventricose, tail highly characteristic of the female is but slightly developed in the male. As in the female the body is short and thick, constricted in the anterior part. The wheel-organ consists of a rather vertically situated convex disc, surrounded by cilia and two large auricles which, in contradistinction to the female, are almost always extruded. On the disc stand some bunches of long bristles; there is no lip. The brain is large, bilobed, carrying a large red eye and gives nerves to the dorsal antenna and the two lateral antennæ, lying in the posterior part of the body. The tips of the tubules carry strong setæ (this according to Gosse is not the case with those of the female). Just as in the female the retro-cerebral organ is highly developed, consisting of a large median lobe, constricted in front, and anteriorly with two much smaller lateral lobes. The interior of the large sac is filled with a great quantity of vacuoles, often, owing to the pressure, almost penta- or hexagonal. As staining methods have not been used I cannot give a more thorough description of the organ; the ducts and the openings for the organ I have not been able to detect. The so-called "granulations calcaires or bacterioides" (de Beauchamp) may be present, but may also be almost wholly absent. Of the alimentary canal there is only a rudiment between testis and wheel-organ. Lateral canals strongly curved with five or six vibratile tags. There is no contractile vesicle; the openings of the canals at the tip of the penis have not been seen. The testis is extremely large, almost globular, often placed laterally. The penis itself opens on the posterior border of the last segment; it is protrusile and the canal is covered with cilia; a bundle of cilia at apex; there are two large prostata glands and two large pedal glands. There are seven transversal muscle-bands, at all events four longitudinal

muscles and four pedal muscles, overlapping each other in the middle part of the body; there is no gelatinous enveloping. In different development in the different species I have found a peculiar structure of globules, arranged in something like a very widemeshed net of which I have tried to give an idea in the figure. Length of male 300 μ. of female 350 μ.

With regard to the males of the genus *Copeus* at our present stage of knowledge it may be established, that they are relatively highly developed organisms but differing from the females in having no lip, no gelatinous cover, no real tail, no alimentary canal and no contractile vesicle.

General remarks with regard to the Notommatidæ. It will be understood that our knowledge of the males of the large family of Notommatidæ is but slight; only a few of the males belonging to the genera: *Proales, Diglena, Copeus* and *Notommata* are well known. From the descriptions of WEBER, ROTHERT, ROUSSELET and now from my own it seems that the males in outer form rather resemble the females. The size is comparatively large, but always smaller than that of the female; in some of them f. i. *Proales Wernecki* both sexes are at birth almost equally large, whereas the female grows larger later on. The cuticula is always thin. A sort of lorica is present in *Diglena forcipata* (WEBER). In the peculiar male of *Hertwigia volvocicola* the foot is wholly absent; in the other males described, it is almost as well developed as in the female; the body is always extremely flexible, constantly changing its form. Where the wheel-organ has been more thoroughly observed, a ventrally curved cilia-covered disc of oblong often triangular form has almost always been found; it is bordered by somewhat longer cilia; auricles may be present, but most probably they are generally slightly developed.

It is very interesting that the alimentary canal either seems to be developed in almost the same degree as in the female or, at all events, with conspicuous rudiments; in *Proales Wernecki* even the mastax and the small gastric glands are present. In the other species a longitudinally folded band or sac, lying above the testis, is often and most probably always observed; in some of them gastric glands may be present, a more thorough examination will most probably always show the lateral antennæ. It will be of great interest to know the developmental stage of the retrocerebral organ which according to DE BEAUCHAMP's investigation, just in the females of *Notommatidæ*, has reached so high and so peculiar a development. Our knowledge with regard to the organ in the males is at present extremely small; only of the male of *Copeus pachyurus* there exists a figure seen laterally (DIXON NUTTALL 1893 Tab, XV) in which the whole organ is well drawn. Most probably this figure has been unknown to DE BEAUCHAMP. The figure shows a long club-shaped sac strongly attenuated in the forepart and with two lateral sacs. Behind, the sacs are filled with a granular mass, more anteriorly with something like a reticulated tissue. The two openings for the organ I have seen in a conspicuous position in *Notommata aurita*. The excretory organ presents no peculiarities; the two lateral canals carry from

three to six vibratile tags; a contractile vesicle is hardly ever observed with certainty (*Cyrtonia:* Rousselet). The testis is formed as in most of the rotifers; prostata glands are almost always present; the ductus seminalis opens upon one of the first foot joints; commonly it is the same organ which when turned inside out is used as penis. Only in the *Diglena*-species do we find a highly complicated structure, a real penis differing much from what we commonly find among the Rotifers. The muscle system seems in the whole family to be of a very conform structure; it is always highly developed, especially the transversal muscle bands are very conspicuous and are present in a number from five to seven. Conglomerates of opaque corns are almost always observed over the testis. Two foot glands seem always to be present. As far as I have seen, most of the males of *Notommatidæ* are almost just as slowly creeping or slowly swimming animals as the females; only the males of *Diglena* are vigorous swimmers. They are difficult to detect, many of them resembling young females. For that very reason I suppose they are so rarely observed.

Hydatinidæ.

The family *Hydatinidæ*, as I understand it, comprises only three genera *Hydatina* with *H. senta*, *Rhinops* with *R. vitrea* and *Notops* with *N. brachionus*. Of all the three species the males are known; that of *N. brachionus* however only slightly. Best described of all Rotifera males is that of *H. senta*.

Hydatina senta Ehrbg.

Male: Ehrenberg: 1838 p. 412.
Leydig: 1855 p. 98.
Cohn: 1856 p. 435.
— 1858 p. 284.
Leydig: 1857 p. 410.
Plate: 1886 a p. 36.
Weber: 1888 p. 42.
Female: de Beauchamp: 1909.
Martini: 1912 p. 425.

Tab. VIII, fig. 1—2; Tab. IX, fig. 1—6; Tab. X, fig. 3—4.

As well known the female, anatomically as well as biologically is one of the best studied Rotifera of all, especially owing to the admirable investigations of de Beauchamp (1909) and Martini (1912 p. 425).

As mentioned above the male was already described by Ehrenrerg but as a special form: *Enteroplea hydatina*; Leydig, Cohn, Plate and Weber have all contributed to the study of its anatomy. It was my intention to use *Hydatina* as the main form on which to base all my studies of the males of Rotifera. The male was found in 1901 in a single pond; this was filled up and I did not see the male again before 1920. According to my experience *H. senta* is restricted to very slowly outdrying pools, polluted by outflows from dung-hills; further it is only to be found in the early spring. Of these two points I had no clear understanding before the spring of 1920.

Combining the descriptions of the above-named authors the male may be described as follows.

The body has exactly the form of that of the female, the skin is softer and more hyaline. Earlier authors have only rather cursorily studied the wheel-organ, but WEBER has shown, that it possesses five lobes, situated dorsally and equipped with rather long cilia, but they are not so well developed as in the female. Whereas the wheel-organ in the female is almost triangular with a deep notch ventrally and medially, the triangle in the male is much lower (WEBER, PLATE), the borders equipped with a series of long cilia. The mouth is closed, of the alimentary canal only a band remains, the function of which is only to support the testis. In it yellow or brown bodies, most probably fat oil, are found (PLATE). The muscle system is highly developed; the transversal muscles are numerous (WEBER); of the longitudinal muscles, the strong retractors of the wheel-organ, the muscles of the foot, and the transversally striped muscles of the penis, are especially mentioned. The nervous system consists of a large brain giving off two nerves for the dorsal antenna; lateral antennæ are only observed by PLATE. On the brain a circular light-refracting but not red spot is regarded as the eye. Of the excretory system the two long canals equipped with four vibratile tags are observed; the canals possess two openings one upon each side of the penis; the openings are round and surrounded with short and stiff cilia (PLATE and WEBER). There is no commissure between the canals and in accordance with PLATE and WEBER but in contrast to earlier observers no contractile vesicle; the foot glands are in accordance with those of the female. The testis is piriform enveloped in a thick muscular layer (COHN, WEBER not LEYDIG). It is fixed to the body wall by means of three pairs of ligaments; the base of it is longitudinally striated; at this base the penis is attached; it consists of a sheath transversally striated by fine and numerous muscles; it is cylindrical and long. The external orifice is surrounded by a crown of short cilia; in this thick sheath lies the real penis, a very thin pointed organ (WEBER). At both sides of the penis two glands commonly regarded as prostata glands are observed. On both sides of the testis and above it opaque granular masses, according to COHN, WEISSE and WEBER remains of the yolk, according to LEYDIG urin concrements, are observed. Size of female 4—500 μ of male 200—250 μ. Time March—May.

Description: Body form almost that of the female, but the dorsal side somewhat more vaulted. Cuticula extremely thin and the whole animal extremely hyaline. Foot short, confluent with the body; two short acute toes. Wheel-organ highly differentiated, still not so much as that of the female. The ciliary wreath (couronne postorale of the authors) constitutes a band of short, very fine cilia, in which I have not hitherto been able to point out the strong sensorial hairs mentioned by DE BEAUCHAMP in the wreath of the female. It encircles a disc somewhat ventrally placed. This disc, which is triangular in the female, is of a somewhat different form in the male, the ciliary wreath on the ventral side only forming a great curve. In the female the mouth is situated in a furrow, lying a little above that point where the two sloping sides of the ventral contour of the disc meet each other; the furrow and part of the disc above this is covered with fine cilia. Where the mouth opening is situated in the female, there is a cupshaped cilia-covered elevation, carrying on its top about 10 strong setæ. The other part of the disc seems to be destitute of any cilia coating, but carries strong setæ (membranelles DE BEAUCHAMP) in an arrangement similar to that in the female, though somewhat reduced. On the disc nearest to the dorsal side stands a series of five elevations, of which the median is

the most conspicuous, carrying on its top 7—9 membranelles; laterally to it are two others, carrying about six membranelles of different size. All this is in close accordance with what we find in the female; more ventrally in the same place, as in the female, but more reduced are found two convergent lamelles, bearing on their borders series of membranelles, diminishing in size dorsally ventrally; above these membranelles again are two other elevations with a series of hairs, much more developed in the female than in the male. The two series of strong hairs which border the mouth opening dorsally, I have not been able to find in the male. The hypodermal cells of the corona have not been studied.

The brain is rectangular, giving off nerves for the wheel-organ, but neither they nor the retrocerebral organ have been subjected to a close inspection; the last named seems to be very small, resembling in form that of the female; the openings have not been detected. From the brain proceed nerves for the dorsal organ and from the hind corners the long nerves for the lateral organs. I have hitherto been unable to detect the two muscles which go to the dorsal organ in the female, though they are most probably present. As in the female we find no eye spot. As all other authors have pointed out, there is no alimentary canal. In accordance with LEYDIG (1857, p. 411) the suspensor testis (COHN) may however be regarded as a rudiment of the alimentary canal. Seen laterally it may be shown that the suspensor testis, which extends forward from the frontal border of the testis to the hypodermal cells of the wheel-organ, being fastened just where the mouth parts are to be found in the female, is directly continued in the remarkably well developed indusium, which is fastened dorsally to the transversal muscle bands at three to five points, and in which further the testis is suspended. The form of this indusium differs from specimen to specimen; it can only be observed laterally and has been well figured by WEBER (1888, Pl. 33, fig. 2) and mentioned by LEYDIG (1857, Tab. 16,fig. 3—4).

When WEBER states that the indusium is to be regarded as a real "réseau musculaire", and that it is enveloped "par la continuation des masses granuleuses représentant des rudiments du tractus intestinal" this is rather dificult to understand from a histological point of view. LEYDIG's supposition, that the suspensor testis and the indusium are parts of the rudiment of the alimentary canal, is more intelligible, inasmuch as, according to him, it is said to contain "grosse Blasen mit Häufchen solcher gelbbraunen Körner welche die Magencellen aller Rotatorien erfüllen". The real connection between the testis, its modus of suspension and the real derivation of the suspending tissues can only be studied in cuts.

The excretory organ consists in two lateral canals which, directly below the hypodermal cells of the wheel-organ, anastomose with each other, and are provided with two slings, the one immediately below the wheel-organ, the other a little more in the middle of the body; there is no contractile vesicle though curiously enough it has been indicated by all the earlier authors (COHN, LEYDIG, DADAY and HUDSON). WEBER supposes that they have seen with "les yeux de la foi" (1888 p. 43). It is much more probable that, with the more primitive instruments at their command, they have

regarded some parts of the indusium or of the sac, filled with opaque corns, (often almost empty) as the contractile vesicle; PLATE and WEBER state correctly that there is no contractile vesicle; the two canals debouch directly on both sides of the genital opening. Special setæ round the two openings (PLATE, WEBER) I have not been able to see. As in the female so also in the male on both sides we really find two canals; the straighter one carries the vibratile tags to a number of four, the other is secretory and exhibits numerous slings; how these two canals are connected with each other, I have not been able to elucidate.

The testis is large, pyriform, containing numerous spermatozoa of two different kinds, the acute staff-formed ones are here always lying in the place, where the testis passes into the ductus seminalis; this is long, in its interior covered with cilia and provided with two prostata glands of very different size. The ductus seminalis is further transversely striped with fine and numerous muscle bands. This has also been seen by WEBER who further states, that it is only a thick cuticular sheath, containing in its interior the true penis, "cordon fin, delicat et très pointu" (1888 p. 45). I have always been quite unable to see anything of that. The ductus seminalis opens dorsally at some distance from the toes; more than once I have seen the evaginated ductus seminalis surrounded by a crown of cilia turned out; I am inclined to think that, in *Hydatina senta* just as in most of the *Notommatidæ* there is no real penis, but that it is the ductus seminalis which, turned inside out, is used as such (Tab. X, fig. 3). There are two very large foot glands.

The muscle system is highly developed; in the figs. 1—2, Tab. VIII I have tried to give a sketch of it; compared with the figures of MARTINI (female) it will be seen, that there is great accordance between his and my drawings; but on the other hand also some very conspicuous differences. As the muscle system has been studied only upon living animals I do not think it is correct to go into details, in as much as I hope that a more elaborate study of the anatomy of the male will appear later on. I only wish to remark that, also in the male, the muscles of the forepart and those of the hindpart overlap each other in the middle line of the body. When the animal has been lying under pressure for some hours and is almost dying, a moment arrives, when some parts of the muscles are extremely conspicuous. This is especially the case with the transversal muscles. In Fig. 1, Tab. IX I have tried by means of the camera to give as thorough a drawing of the transversal muscles as possible. The figure shows the peculiar manner in which these transversal muscle bands are connected with each other and are provided with large nuclei, situated in expansions of the bands. When comparing the figure with those of ZELINCKA of *Discopus* I have now and then thought that I had to do with some parts of the sympathic nerve system, which has only been observed by him, but continuous examinations have convinced me that this was not the case.

Above the testis there are from one to three hyaline sacs containing a number of opaque corns of different size and numbers; these sacs are in accordance with those which are almost always found in the males and very often in the females,

especially in the young animals. As well known, especially with regard to *Hydatina*, LEYDIG has regarded the corns as urine concrements, and the sac itself as a rudiment of the alimentary canal. WEISSE and COHN regard them as yolk masses, deriving from egg. WEBER follows the last named authors. Size of female 4—500 μ, of male 200—250 μ. Time: March—May.

Rhinops vitrea Hudson.

Male: Rousselet 1897 a, p. 6.
Tab. X, fig. 1—2.

ROUSSELET (1897 a, p. 6. Pl. I) describes the male as follows:

The shape of the male differs somewhat from that of the female; the body becomes suddenly narrower in the lumbar region, whilst in the female it tapers very gradually down to the toes. The body is very lithe and soft, bending constantly in every direction. The corona with its proboscis-like dorsal projection resembles that of the female in every way, and two red eyes are in the same manner situated near the extremity of the proboscis, each having a minute spherical crystalline lens imbedded in the red pigment. A dorsal antenna is seen on the dorsal side, a little below the eyes, and the two lateral antennæ are very conspicuous at the projecting angle of the lumbar region each furnished with a brush of abnormally long setæ; in the female the lateral antennæ are very small. The foot is short, consisting apparently of one joint containing the two foot-glands, and terminating in two minute toes. The chief characteristic and the most abnormal feature about this male is the possession of functional jaws and intestine. The jaws are like those of the female in structure, but in one specimen I thought the right malleus shorter than its companion on the left side. The oesophagus is a thin, narrow tube leading to an elongated thick-walled stomach, with two gastric glands attached, and continued behind into a narrow intestine, all ciliated in the interior. The jaws were frequently moving, but the contents of stomach and intestine were very slight and of a greenish tinge, without solid particles of large size. It seems clear, however, that the male of *Rhinops* can take in some food, and therefore sustain life and live longer than all other known male Rotifers. There is a rounded spermsac, at the lower end of which the spermatozoa could be plainly seen in motion, terminating in a duct with the usual retractile and ciliated copulatory organ. A small contractile vesicle and lateral canals with flame cells attached are present as usual. Size of male 188—212 μ. Size of female 300 μ. Time May.

Description: Body more elongated than in the female; it becomes suddenly narrower in the lumbar region, whilst in the female it tapers very gradually down to the toes; the foot very long. The body is very soft and extremely hyaline. As in the female a long clubshaped proboscis proceeds dorsally; it can be more or less distended and retracted. When living it is always distended, but when the animal is dead, it may almost wholly disappear, and especially when the animal is seen laterally, be very inconspicuous. In these animals also the foot is withdrawn, so that it seems much smaller than it really is. (See Tab. X, fig. 2.) Wheel-organ highly developed and very difficult to study. It consists of a ciliary wreath, provided with two flattened, large auricles; dorsally it is almost interrupted, not coating the sides of the proboscis; ventrally it shows a deep furrow. On the disc another ciliary wreath, running from the sides of the proboscis in great curves downwards and meeting the above-named furrow. Where these two ciliary wreaths meet each other,

lies the mouth; between the two wreaths laterally two lobes carrying bunches of cilia. The proboscis itself at the corners with two bunches of strong cilia; itself on its whole under surface covered with a coating of very short fine hairs. A fully developed alimentary canal with well developed mastax, furnished with trophi of quite the same structure as in the female; a rather short oesophagus, a large stomach with thick walls; to them are attached two coneshaped, gastric glands. There is further a conspicuous intestine, but I have not been able to see any anus. Like ROUSSELET I have seen the jaws move. There is a large brain, sending off nerves to the proboscis and dorsally to the dorsal antenna; two lateral antennæ are present. In the proboscis there are, as in the female, two red eyes, furnished with lenses. There are two lateral canals, carrying four, perhaps five, pairs of vibratile tags. I have not been able to see any contractile vesicle, as observed by ROUSSELET. There is a large testis with two pairs of prostata glands; ductus seminalis long, coated with cilia and opening in the hind part of the first foot joint, carrying a double row of cilia, second foot joint with two long foot glands; two very short toes. There are nine transversal muscles, and a very complex system of longitudinal muscles for the wheel-organ, the foot, the penis and the testis. The course of these muscles will best be studied in the figure. Size of male 300—360 μ, of female 360—400 μ.

R. vitrea is found in about ten small ponds, all rich in organic matter and very often of a green colour; a few times I have also met with it in the pelagic regions of peat bogs. It is a spring form which appears in the middle of April often disappearing already in May, lying all the rest of the year as resting eggs.

Notops brachionus Ehrbg.

Male: Hudson-Gosse: 1889 II, p. 12.
Montet: 1815, p. 320.
Tab. X, fig. 5—6.

HUDSON-GOSSE (1889_{II}, p. 12, Pl. XV, fig. 1 b) figure and describe the male.

It is very unlike its mother in shape and size; a side view shows that the head slopes back to a hump on the apex of which is a bunch of tactile setæ. A nerve-thread from the nervous ganglion passes to these and lies between two fine muscular fibres. A moderately sized sperm-sack ends in a ciliated penis, just above the foot, which contains two large club-shaped glands. Close to the sac is a small contractile vesicle, the lateral canals of which can be traced on either side of the ventral surface.

MONTET (1815, p. 320, Pl. 12, fig. 31) gives a figure of the male but no description at all. He has seen the testis, the foot glands and excretory organ, the wheel-organ is represented as a circle of cilia with three hair-pads on the disc and two strong tactile hairs. As far as I can see two small tubercle-like protuberances without cilia are present. There is a rudiment of the alimentary canal containing a round body (most probably an oilglobule).

Description: Body almost broadest anteriorly, tapering behind with a peculiar

hump dorsally, a well developed three joint foot; cuticula very hyaline. Wheel-organ a ciliary wreath encircling a disc in the middle with a broad elevation, carrying along its borders a series of long hairs. Of the alimentary canal a large ligament which embraces the testis and reaches the corona; it seems to contain a number of small oilglobules. There is a large brain with a red eye and two nerves which run up to the dorsal antenna, situated upon the top of the hump. Two lateral antennæ. The excretory organ consists in two curled lateral canals with three or four vibratile tags. but I have not been able to find any contractile vesicle. Testis very large, containing two sorts of spermatozoa; it is suspended by means of a ligamentum or inducium; on the dorsal side, the ligamentum is fastened at four or five points on the transversal bands. Two prostata glands. Genital opening dorsally on the first foot joints; ductus seminalis coated with cilia and a bunch of cilia round the opening. A large oilglobule over the testis. At all events three pairs of longitudinal muscles for the wheel-organ and six or seven very conspicuous transversal muscle bands. In the foot two foot glands. Size: male 160 μ, female 450 μ.

Notops brachionus which seems to be a rare animal eyerywhere, is never found in this country. I have vainly been in search of it for many years. The males which have been used for the above given description have kindly been forwarded to me by Dr. Rousselet in 1907. He sent me some females which arrived safe and laid male eggs; a few males were hatched. Later on Mr. F. E. Cocks has been kind enough to forward to me two slides of males and a drawing. By means of this foreign material the above given drawings have been worked up.

General remarks.

It is characteristic of the males of this interesting family that they are only slightly reduced; the size is only about half that of the female; more in *Rhinops*, not quite so much in *N. brachionus*. The form is the same as that of the female; this especially holds good for *Rhinops* and *Hydatina*. The wheel-organ resembles that of the female sex and in *Rhinops* is almost identic in the two sexes. *Rhinops* is one of the few known Rotifers with full development of the alimentary canal, with mouth, mastax, gastral glands and intestine (anus?). In the two other species only the common rudiment exists; a brain with dorsal and lateral organs is most probably always present; the eye is wanting in *Hydatina senta*; traces of retrocerebral organ most probably present; further investigations necessary. Two lateral canals with three or four pairs of vibratile tags; no contractile vesicle; a large testis, prostata glands, no real penis; the ductus seminalis turned inside out, when used as such. Sacs with opaque contents often or always over the testis. Highly developed muscle system, which needs further investigation.

Brachionidæ.

The family contains the three genera: *Noteus*, *Brachionus* and *Schizocerca*; only the males of the genus *Brachionus* are hitherto known.

Brachionus.

Of the ten males of Rotifers which Gosse (1856, p. 313) described and figured in his famous work, the seven belonged to the genus *Brachionus*. Some of these seven species (*B. amphiceros, dorcas*) are unquestionably only temporary forms of the same species. It is not possible, from the description and drawings, to distinguish these species in the male sex from each other. It is stated with regard to these males that the lorica is only feebly developed, that the head is more or less conical, set with large setiform cilia all over the front, that behind the front there are several lobes, with a red eye commonly on the truncate apex of the posterior lobe. The body cavity is filled behind with a mass in the middle of which is situated the group of opaque white granules, contained in an irregular bladder. The central part is occupied by the spermatic sac, connected by a bottle-like neck with the head-mass, where a distinct corrugation probably marks an orifice, closed by a sphincter, which leads to the discharging duct. The spermatozoa are observed (about thirty). With the spermatozoa are extruded many spicula-like bodies. The penis is thick and united to the foot, terminating in a short truncate tube, the excretory organs are seen and described as a chain of irregular masses, running down from the head to the posterior part of the body, extending down into the penis-foot.

Even if it is impossible to distinguish the different *Brachionus* males, which Gosse has described and figured, he who has observed the males of *B. angularis* and *B. dorcas* (= *B. pala*) will unquestionably understand, that Gosse really has observed and figured the males of these two species. Quite correctly Gosse described the male of *B. angularis* as covered with a tortoise-like lorica, and states that there is a conspicuous construction between head and body, and that all internal organs are invisible, the interior being occupied by a vast number of minute granules or globules, irregularly clustered. In contrast to this little opaque male (length $\frac{1}{250}$th) stands the large, highly hyaline male of *B. dorcas*, measuring $\frac{1}{220}$th of an inch in length and very well figured (fig. 18—19) and described.

Hitherto the following Brachionus males have been observed:

Brachionus pala Ehrbg. . . . . Gosse (1856, p. 316, Tab. I, fig. 2); Weber (1898, p. 672, Pl. 23, fig. 16); Plate (1886, p. 67, Pl. 3, fig. 25).

— *urceolaris* O. F. M. . . Cohn (1856, p. 470, Tab. 24, fig. 8—9); Weber (1888, p. 56, Pl. 35, fig. 2; 1898, p. 678, Pl. 23, fig. 20); Toth (1861, Tab. I, fig. 9).

— *Mülleri* Ehrbg. . . . . Gosse (1856, p. 319, Tab. II, fig. 20).

— *angularis* Gosse . . . . Gosse (1856, p. 317, Tab. I, fig. 13—14).

— *Bakeri* O. F. M. . . . . Gosse (1856, p. 318, Tab. I, fig. 12). Rousselet 1897, p. 328, Pl. 16.

— *rubens* Ehrbg. . . . . Rousselet (1907, p. 153, Pl. 12, fig. 11).

— *quadratus* Rousselet. Rousselet (1907, p. 150, Pl. 12, fig. 7).

— *sericus* Rousselet . . . Rousselet (1907, p. 149, Pl. 11, fig. 4).

— *furculatus* . . . . . Thorpe (1891, p. 301); Rousselet (1906, p. 397, Pl. XIV, fig. 5).

Brachionus pala Ehrbg.

Male: Plate 1886, p. 65.
Weber 1898, p. 672.
Pl. XI, fig. 1—3.

Plate (1886, p. 67, Pl. III, fig. 25) describes the male under *B. amphiceros*.

The wheel-organ is described as follows: "Der Räderorgan besteht aus einem continuirlichen Wimpersaume, über den der Kopf halbkugelig vorspringt. Auf der ventralen Hälfte dieser Calotte befinden sich noch eine Anzahl Cilien, deren Stellung und Grösse die Zeichnung veranschaulicht. Die stärksten unter ihnen sind an der Spitze oft zerfasert." There is a rudiment of an alimentary canal: "Zwischen der Unterseite des Gehirns und der Rückenseite des Hodens spannt sich als ein unregelmässiges Band der rudimentäre Darm aus. Das dies Gebilde eine solche Deutung verdient, geht daraus hervor dass sein hinterster Abschnitt, der also dem Enddarm entsprechen würde, blasenartig erweitert ist und dieselbe schwarze Körnermasse enthällt, wie sie im Darm der jungen Weibchen vorkommt. Bei manchen Exemplaren ist der Zusammenhang zwischen der vorderen und hinteren Hälfte des rudimentären Darmes freilich nicht mehr vorhanden oder sehr undeutlich geworden." Brain with red eye; one dorsal and two lateral antennæ. Two lateral canals, no contractile vesicle. Testis normal, penis longer than foot; two foot glands.

Weber (1898, p. 672, Pl. 23, fig. 16) gives a short description of the male. His figure shows that he has seen the lateral canals, and four transversal muscle bands; his drawing of the wheel-organ resembles mine; laterally round the forepart of the testis are drawn two organs which I have not been able to find and the function of which I do not know.

Description: Body cylindrical, provided with a short, inconspicuously divided foot, with two small toes. A faintly developed lorica, consisting of a larger dorsal and smaller ventral plate. No spines. The lorica very hyaline. The wheel-organ and partly the foot can be withdrawn in it. A terminally placed wheel-organ, consisting of a ciliary wreath, encircling a disc with three cushion-shaped elevations, carrying a number of long, rather stiff cilia; further six strong setæ. Of the alimentary canal only a rudiment, used as ligamentum for the testis. A large brain with a red eye spot; two dorsal nerves, running to one single dorsal antenna and two lateral antennæ far behind. Two conspicuous lateral canals with three pairs of vibratile tags; no contractile vesicle. Testis large, pyriform, with two kinds of spermatozoa; ductus seminalis in its anterior part coated with cilia. Penis, when not used, withdrawn; opening dorsally on the foot; when fully extended, thick, enormous, wrinkled, tapering behind, ending in a body like a glans, provided anteriorly with a wreath of long cilia. Ductus seminalis in its posterior part consisting of a chitinous tube, a real penis, disc-shaped at apex and here bearing an opening. When fully extended, the whole organ is much longer than the small foot, which hangs down ventrally as a lateral appendix of the penis. When not used, the whole organ disappears in the foot; it is pressed out, not so much by means of muscles as by means of blood pressure. When it is fully extended the wheel-organ is withdrawn. Two prostata glands. In the middle part of the penis two other glandlike bodies. Above the testis a globular light-refracting body, containing numerous sharply edged opaque grains, any connection with the rudiment of the alimentary canal I have never

been able to see. Strong, well-developed retractor muscles for the wheel-organ; from six to seven transversal muscle bands. Size male 120 μ, female 250—400 μ.

Brachionus urceolaris O. F. M.

Male: Cohn 1856, p. 470.
Weber 1888, p. 56.
Tab. XI, fig. 4.

Cohn (1856, p. 470, Tab. 24, fig. 8—9) has given a good description and two fine small figures of the male.

He correctly states that there are no lorica and spines; a short foot; a wheel-organ consisting of a ciliary wreath, encircling a disc with long stiff setæ. No opening for the mouth; no trace of alimentary canal. A testis with stiff walls, which most probably are of muscular structure. A penis almost of the length of the foot. The canal and the opening of it carries cilia. The foot is annulated and carries two small toes. Foot glands present. Lateral canals with vibratile tags and a contractile vesicle. A brain with a red eye. Above the testis a mass of opaque grains, regarded either as part of the sexual organs, or as a remnant of the yolk.

Weber (1888, p. 56, Pl. 35, fig. 2 and 1898, p. 678, Pl. 23, fig. 20) has figured the male; he has only had one single specimen. He especially pays attention to the following fact:

"Si les mâles n'ont pas de cuirasse complètement formée comme la femelle, ils ont cependant une enveloppe chitineuse analogue" une cuirasse modifiée, qui n'avait pas encore été mentionnée. C'est une cuticule beaucoup plus dure que celle des autres mâles, observés jusqu'ici. Weber has not had occasion to see the vibratile tags of the excretory canals. There is no contractile vesicle, but prostata glands.

With regard to the wheel-organ Weber says: "Je n'ai pu distinguer les couronnes ciliaires de la femelle; cinq lobes seulement se montraient à différentes hauteurs. De chaque côté, on voit deux petits cônes, surmontés d'un long cil tactile et plusieurs touffes ciliaires."

B. urceolaris Ehrbg. var. *rubens* Ehrbg. Description. Body as in *B. pala*, not so hyaline; lorica consisting of a dorsal and a ventral plate; the first-named the largest. The wheel-organ can be withdrawn into the lorica. No spines. Foot short, consisting of only one joint; two toes which are very acute and better developed than in *B. pala*. Seen ventrally, the wheel-organ as in the female shows a conspicuous cleft; on the disc are four cushion-shaped elevations dorsally, with strong stiff cilia, and more ventrally a single cushion with a bunch of bristles; on the disc further two, perhaps four strong setæ. The brain is very large. With regard to rudiment of alimentary canal, antennæ, lateral canals, testis, penis and foot glands I find no differences between *B. rubens* and *B. pala*. The longitudinal muscles have a somewhat different course. The penis may be protruded just as in *B. pala*; it is then of quite the same form and composition; on the figure it is shown withdrawn. Size male 120—130 μ, female 250—280 μ.

B. rubens, which is often regarded as a variety of *B. urceolaris*, (not by Rousselet 1907, p. 151) has the peculiar custom almost always to fasten itself to the carapace of the parthenogenetic generations of *D. pulex*, coating them with a thick mantle. It is a pronounced pond form; I have only met with it in late spring and midsummer.

Brachionus quadratus Rouss.

Male: Marks & Wesché 1903, p. 508.

Marks & Wesché (1903, p. 508, Pl. 26, fig. 1) describe the male as follows.

Stoutly fusiform in shape, a lateral view shows the head and foot curved downwards when swimming free. Head inclined to be globular, a little variable in shape, the constriction of the neck also varies with position. Head capable of retraction within the body. Body cylindrical, stout, has marks of the edge of the carapace, as in *Diaschiza*. A fold of skin is sometimes seen in dorsal view. Foot stout, short and wrinkled, tapering from body and retractile. Toes minute, triangular; sometimes a thread is spun from their extremities. Cilia long. Brain large, three-lobed on the front. Sometimes oval glands seem to form part of it, in dorsal view. Eye, rather nebulous, not well defined, faintly red, and variable in shape. Antennæ dorsal, well forward on the head; lateral, low down on sides of body, as in the female, with long setæ. There is no digestive system. Lateral canals difficult to make out; at all events two flame-cells on each canal. Two well marked foot glands. A very large sperm sack tapering from the centre of the body cavity to the middle of the foot. A dark granular mass, contained in a vesicle shows above the testis in dorsal view. Size: male 127—141 μ. Time March 8th and 21st.

Brachionus Bakeri O. F. M.

Male: Rousselet 1897 c, p. 331.

Rousselet (1897, p. 331) says with regard to the males of the different varieties of *B. Bakeri*, that they cannot be distinguished from each other. This is unquestionably quite correct. I have often seen the males; but they differ only slightly from those of *B. urceolaris* var. *B. rubens*.

B. angularis Gosse.

Tab. XII, fig. 1—2.

Male: Description: Body elongate, provided with a very peculiar lorica, which Gosse very correctly mentions as tortoise-shaped. There is a rather small, narrow dorsal lorica and a much broader, but shorter ventral lorica, the posterior edge of which is not seen with certainty. An inconspicuous divided foot with two toes. No spines. Before the lorica a sharply defined part, carrying the ciliary wreath, surrounding a cone-shaped disc with about ten long, stiff cilia centrally and six long setæ. Owing to the thickness of the lorica it is very difficult to see the interior organs. No remains of an alimentary canal are observed. There is a brain with a red eye and a dorsal antenna and two lateral antennæ. Immediately below the shield, extending forwards from the dorsal antenna to the forepart of the lorica, is observed a peculiar elongate structure, consisting of small grains, present in all the males I have seen; it is possible that here we have a retrocerebral organ. Excretory organs have not been observed. With regard to testis, penis, ductus seminalis, prostata glands and sac with conglomerates, the structure of the male is in accordance with that of the other *Brachionis* males described. Only a few longitudinal muscles are observed and no transversal muscles. No foot glands observed. Size of male 90 μ, of female 200 μ.

B. angularis is, of all our Brachionus species, that which is most commonly

found in the pelagic region of smaller lakes; besides, it is a pronounced pondform occurring together with *B. pala*. With regard to sexual periods, maxima, number of eggs etc. it is in accordance with *B. pala*; still the cluster of male eggs is not so large, the number not being above from six to eight.

Schizocerca diversicornis Daday.

Tab. XII, fig. 3—4.

Male: Description: Body somewhat flattened, almost rectangular. A well defined lorica, consisting of a dorsal and a ventral plate, the first provided with some peculiar elegantly curved lines (see figure). Lorica rather thick; no spines. A forepart which can be wholly withdrawn into the lorica; a relatively well-developed foot with two joints and two short toes. The wheel-organ consisting of a ciliary wreath, surrounding a cone-shaped disc; the top of the cone carries a strong bunch of long bristles; on the sides of the cone two strong, long setæ. Of the alimentary canal remains only a band running forward from the testis below the brain. This is extremely large, carrying a red eye; there is a conspicuous dorsal antenna and two lateral antennæ, lying near the posterior edges of the body. Owing to the thickness of the lorica I have not been able to see the lateral canals; there is no contractile vesicle. Testis very large; two large prostata glands. Penis of quite the same structure as described in *B. pala*, only when fully extended still larger and thicker. When not used, fully retracted.

A chitinous tube ending with a disc and glands round the tube; no special penis muscles. Dorsally, behind the dorsal antenna and over the posterior part of the testis two round globular masses, containing a number of opaque, sharply edged grains. Only some longitudinal retractors of the wheel-organ seen. Size of male 160 μ, of female 300 μ.

Schizocerca diversicornis is common in larger ponds and smaller lakes; it is here a pronounced plancton organism; it is a stenotherm summer form, with maximum at highest temperatures and sexual period in Aug.—September. The female carries one or two parth. female eggs, rarely more than four male eggs and one resting egg.

General remarks.

In the structure of the males of the fam. *Brachionidæ* I especially wish to call attention to the following facts.

The males are very small, strongly reduced. There exists, at all events in the two genera *Brachionus* and *Schizocerca*, a real lorica, consisting of a dorsal and a ventral plate; spines are always absent, and so also is all other equipment of the lorica (facetted structure etc.), even if these structures are highly developed in the female. The wheel-organ can be wholly retracted into the lorica, but commonly not the foot; this is always present, provided with two toes. The number and place of bunches of cilia and long stiff single setæ vary from species to species; a retrocerebral organ has never been observed with certainty. Rudiments of the alimentary

canal now used as ligamentum for the testis are most probably almost always present. The brain carries a red eye; dorsal and lateral antennæ are in all likelyhood always present. In the excretory organ the contractile vesicle is absent; three or four vibratile tags; a large testis with prostata glands. Very peculiar is the structure of the penis; with regard to this point I refer to *B. pala*. Above the testis a conglomerate of opaque, sharp edged grains. It is of interest, that a series of transversal muscle bands can often be pointed out.

The males are all extremely quick and are hatched in great numbers in the sexual periods. Often I have had small clouds in the vessels, consisting almost entirely of newly hatched males.

Anuræadæ.

The family *Anuræadæ* consists of the three genera *Anuræa*, *Anuræopsis* and *Notholca*. Apart from *A. aculeata* there exists no drawing or description of any male, belonging to this family; the male of the most common Rotifer, that of *A. cochlearis* has hitherto been unknown. Rousselet (1903, p. 176) states that the male of *N. heptodon* has been observed, but gives neither description nor figure.

Anuræa aculeata Ehrbg.

Male: Plate 1886, p. 64.
Marks & Wesché 1903, p. 509.
Krätzschmar 1908, p. 630.
Montet 1915, p. 342.
Tab. XIII, fig. 1—2.

Plate (1886, p. 65) with regard to the male says only as follows:

"Sie haben cylindrische Gestalt: vorn sitzt der Räderorgan, unter dessen Wimpern sich einige durch besondere Länge auszeichnen, hinten verjüngt sich der Körper zum Penis und endet mit flimmernder, breiter Spitze. Von den übrigen Organen habe ich leider nur den grossen Hoden und das Gehirn erkennen können, das ein dorsales Tastgrübchen versorgt und einen Augenfleck trägt. — Grösse 100 μ."

A. aculeata var. *brevispina*. Marks & Wesché (1903, p. 509, Pl. 26, fig. 2).

The shape of this minute rotifer is inclined to be truncate, but globular, not so broad as it is long, and the body, unlike that of the female, in a foot, ends usually pendant. — Head stout, with a chitinous covering on the dorsal side, well marked in lateral view; this folds up and encloses the head when the animal retracts the cilia. There is a deep constriction at the neck. Body, enclosed in a carapace which has openings on the dorsum and sides, so that it appears to be enclosed in three more or less arched plates; in the specimens seen there was a conspicuous oil globule. The foot has a chitinous sheath, down which the passage from the sperm-sack passes, so that it may be said to take the place of the penis. At the extremety are two hyaline threads, as in Triarthra. Toes, none. Cilia fairly long. Brain, large occupying all the head and part of the body. Eye large, bright red, circular in dorsal view, narrow in lateral view, nearer the ventral than the dorsal side. Antennæ very minute on head and sides of carapace. No digestive system. No foot glands seen but the animal seems to spin a thread from foot. Vascular system very indistinct. No contractile vesicle. Generative system a large pouch containing spermatozoa and other bodies; the pouch narrows to a

long neck, which is worked up and down the foot, and is capable of protrusion from its extremity. Size male 84 μ. Time 2nd April.

KRÄTZSCHMAR (1908, p. 630, Tab. XIV, fig. 1—2) has given a very thorough description of the male and three interesting figures. His paper is of great interest, because his observations are based upon cuts; as far as I know, it is the first time a Rotifer male has been treated under microtome.

The main points in the description are as follows:

Body conical; a dorsal lorica with a median cleft; ventral side without lorica; wheel-organ can be withdrawn in the lorica by means of strong muscles. It presents no peculiarities. No alimentary canal; a large brain with a crimson eye; no antennæ observed; a large testis with spermatids and spermatozoa; penis large, in cross section oval; the ductus seminalis covered with cilia; two ventrally and two dorsally situated muscles. Over the testis a large oil globule. KRÄTZSCHMAR supposes that the function of this oil globule is to prevent the rotating motion in such a way that the swimming course becomes straight, the way being shortened in this manner, and the speed of the male sex being augmented. The phenomenon is due to the fact that the buoyancy of the oil globule is greater than the force which is used during the rotating motion. It is further of the greatest interest, that KRÄTSCHMAR has been able to show by means of cuts, that this organ is in connection with the excretory organ. The oil globule is surrounded by a light-refracting sphere, which is further surrounded by an opaque mass of dark grains; the two lateral canals unite below the brain and dilate into a large sack, enveloping the oil globule and the surrounding cell masses; from the underside of the sack runs a canal which opens dorsally upon the animal in the median line; the opening is surrounded by a ring; the lumen of the canal is always conspicuous, and the walls are stiff; it is supposed, that there is always a connection between sack and outer medium. It is of special interest that KRÄTSCHMAR has shown that the muscles are transversally striped. One pair of transversal muscles are observed. Size: Length of body 70 μ. Breadth 35 μ. Penis 20 μ.

MONTET (1915, p. 342, Pl. 13, fig. 39) figures the male, but gives no description at all; the figure is very difficult to understand.

Male: Description: Body broad, conical, tailless, broadest in the middle, and with a peculiar notch dorsally. A relatively thick cuticula, but no conspicuous lorica; this is most developed on the dorsal side. Ventrally is found a quadrangular plate from the edges of which lines run out to the sides of the body. In some individuals I think, I have seen a lorica, somewhat resembling that of *Salpina* with a median cleft running from a little below the wheel-organ downwards to the penis. But this line is not conspicuous in all individuals. The wheel-organ consists in a single ciliary wreath, slanting a little ventrally, encircling a disc with three bunches of longer cilia and four strong setæ. No alimentary canal; a very large, remarkably broad brain with a broad red eye spot. I have not been able to see any dorsal antenna. Two conspicuous lateral antennæ are situated in the posterior part of the body. Of the excretory organ I have only been able to see a short part, lying between brain and testis; it is provided with two vibratile tags; no contractile vesicle. Testis large, globular, with two sorts of spermatozoa. Penis well-developed, strong, rather thick, with two small muscles; ductus seminalis covered with cilia and round the opening a tuft of cilia; in the posterior corners of the penis two strong hairs. Well-

developed prostata glands. Above the penis remarkably large oil globules, and often a great many others, deposited round and especially above the testis. There are three pairs of strong longitudinal muscles for the wheel-organ and one shorter slanting pair, further smaller muscles for the penis. When compressed three transversal bands are observed. Size of male 100 μ, that of penis 20 μ. Size of female 200—250 μ.

Anuræa cochlearis Gosse.

Tab. XIII, fig. 3—4.

Male: Description. Body broad, conical, broadest in the middle, tailless. Cuticula thick with a rather well developed dorsal lorica, divided into three parts, a forepart which consists of a transversally placed rectangular part and two lateral elytralike parts, separated from each other by means of a cleft. Ventral side without lorica. Wheel-organ consisting of a single ciliary wreath, slanting ventrally, surrounding a somewhat vaulted disc and provided dorsally with a bunch of long cilia. More ventrally, where the opening for the mouth is in the female, is a curve of long cilia. Four strong setæ. No alimentary canal. Brain large, with a red eye spot; a conspicuous dorsal antenna before eye and two lateral antennæ near the hind edges of the "elytra". Owing to the thick lorica the muscle system is difficult to observe. Two lateral canals with three vibratile tags, no contractile vesicle. Testis and penis constructed in quite the same manner as in *A. aculeata*. Special muscles for penis have not been observed. We find at the end of the penis two quite similar long setæ as in *A. aculeata*. Two small prostata glands. Above and around the testis a number of large oil globules; one of them, lying directly over the testis, is commonly much larger than the other. Size of male 80—90 μ, of penis 20 μ. Size of female 160—200 μ.

Anuræopsis hypelasma Gosse.

Tab. XIII, fig. 5—6.

Male: Description. Body elongate, very soft, hyaline without any distinct lorica but dorsally with two and ventrally with one deep longitudinal furrow. No foot. Wheel-organ almost vertical upon the longitudinal axis, consisting of a ciliary wreath, encircling a disc, which, when slightly compressed, especially seen ventrally, shows a central coneshaped and two lateral parts, the first equipped with about eight to ten setæ, the lateral ones with a bunch of long cilia; between the three parts two long strong setæ. No alimentary canal. Brain large with a large red eye. Neither dorsal nor ventral antennæ have been observed. Two pairs of longitudinal muscles, running from the wheel-organ to the root of the penis. Two conspicuous lateral canals with three vibratile tags each; no contractile vesicle. A rather small elongate testis surrounded by a large prostata mass. Penis of enormous and extraordinary length, more than half the length of the body, very soft, flexible; ductus seminalis very long, double-contured, with rather stiffened sides and ending in a cup-shaped body, surrounded by cilia; internally the canal is covered with long cilia. No setæ at apex. In

the penis itself two glandlike bodies the openings of which I have not been able to see. Between the brain and testis a very large constant oilglobule, and scattered in the body cavity many smaller oil globules.

Size: Male 80—90 μ, penis alone 30 μ. Size of female 120 μ. *A. hypelasma* is a typical pondform, only rarely met with in the pelagic region of larger lakes; it is a summerform, not appearing before May and with its maximum at the highest temperature. The female as well known carries one large oblique female egg; two or three small male eggs and a very large resting egg.

During the large maxima in August, Sept. the males have appeared in my vessels in great masses; even with slight magnifying powers they are easily recognisable owing to their large penis; swimming with enormous speed and always in straight lines, they seem to use the penis as a helm.

Notholca longispina Kel.

I have seen the male in great numbers; it was on a journey, when I was only equipped with a very insufficient microscope; it resembled the males of *Anuræa* and had no spines.

N. acuminata Ehrbg.

Tab. XIII, fig. 7.

Male: Description. Body elongate, very soft, hyaline without any distinct lorica neither dorsally nor ventrally; without any deep longitudinal furrows, behind with a large pouch of different form in the different specimens. No foot. Wheel-organ vertical upon the longitudinal axis, consisting of a ciliary wreath, encircling a disc carrying another interrupted row of cilia and a number of small hills, provided with bunches of bristles. No alimentary canal. Brain large, with a large red eye. Neither dorsal nor ventral antennæ have been detected. There is no contractile vesicle, and the lateral canals I have observed are only very inconspicuous. Testis large with two sorts of spermatozoa. Penis extremely long, almost as long as the animal, faintly kneed, narrow, strongly tapering at apex, flexible. It is traversed by the seminal ducts, which are covered with cilia and near the testis provided with two small prostata glands. As far as I have been able to see, there is not, as in *Brachionus*, stiffened sides and no cup-shaped body at apex. On the other hand I here found a peculiarly formed globular body hanging down from the apex. No transversal muscles and only three pairs of longitudinal muscles could be observed. The whole body was very opaque, containing large oil globules, especially in the posterior part.

For a long time I have been in search of the *Notholca*, males. Apart from *N. longispina* most of the other species seem to have their maxima at rather low temperatures, being most common in the winter half year. In April 1921, in one of the bays of the little river Susaa, near my summer laboratory, I observed that it contained enormous maxima of *N. acuminata*; they carried their eggs for a short time, but they very soon dropped off and were to be found at the bottom. The next

day, among some hundred isolated females in the margin of the vessels nearest to the window, I saw numerous males encircling the females and swimming with an extraordinary speed. Most probably the pairing took place during the encircling, lasting only a fraction of a second.

General remarks.

The males of the *Anuræadæ* are mainly characterized by having a rather feebly developed lorica, without facets and thorns of any kind; there is no foot, but an often very long flexible penis which cannot be withdrawn. The wheel-organ carries upon its disc some protuberances, carrying strong bunches of cilia or strong setæ often to a number of four. Any trace of an alimentary canal has never been observed. There is a large brain, most probably dorsal as well as lateral antennæ, but they are only rarely observed. A large red eye; no retrocerebral organ observed. Two lateral canals, but no contractile vesicle. Of great interest is the connection KRÄTSCHMAR has shown in *A. aculeata* between the excretory organ and the great oil globule above the testis; the excretory porus medially on dorsum is unique in the kingdom of Rotifera. The large testis opens in a thick penis; the ductus seminalis is covered with cilia; the opening with a bunch of cilia often with two strong setæ at apex. Prostata glands present. A well-developed muscle system, also transversal muscles. KRÄTSCHMAR has shown that they are striped in *A. aculeata*.

Synchætadæ.

The family comprises the three genera: *Synchæta*, *Polyarthra* and *Anarthra*. The genus *Polyarthra* was formerly referred to the fam. *Triarthradæ*. In 1899 (p. 135) I dissolved the familly, referred *Triarthra* to *Pedalionidæ* and *Polyarthra* to *Synchætadæ*; DE BEAUCHAMP (1909 p. 28) has followed me in this. I still regard *Polyarthra* and *Synchæta* as nearly allied; on the other hand in many respects especially with regard to the wheel-organ, the differences are rather great, and after we have studied the structure of the males a little more closely, these differences have been augmented.

Only the males of *Synchæta* and *Polyarthra* are known. Both have been studied insufficiently by GOSSE and later on more thoroughly by PLATE (*Polyarthra*) and by ROUSSELET (*Synchæta*).

Synchæta pectinata Ehrbg.

Tab. III, fig. 1.

Male: Description. The body is conical, tapering behind, the skin very soft, hyaline, ending in a sharply defined foot, consisting of one rather large segment, carrying two short acute toes. The wheel-organ is only a ciliary wreath, encircling a terminally placed disc, covered with very short cilia; on this disc there are four strong hairs; no auricles are found; the two club-shaped prominences in front, so charac-

teristic of the female, are wanting. I have been unable to find any retro-cerebral organ, but there is a very conspicuous dorsal antenna, furnished with two nerves. The brain is large, carrying the large red eye. No lateral antennæ are seen; as ROUSSELET however has found them in some of the other species, they may possibly be present here too. There are seven or eight conspicuous transversal bands and powerful retractors of the wheel-organ. Above the testis is a large sac of different form, ending below the brain and reaching the penis behind. In the sac is always found a different number of rather large oil globules; in my opinion we here have a very conspicuous rudiment of the alimentary canal. There are two lateral canals which, in the specimens I have observed, seem to reach the brain. This is of interest, as the canals in the female sex do not reach much more than half-way into the body cavity. The canals carry four vibratile tags; there is no contractile vesicle, the canals opening on each side of the penis. The testis is very large of different form and size, provided laterally with two small prostata glands; the penis is remarkably small with a tuft of hairs at its base. There are two conspicuous foot glands. Size: Male 160 μ. Female 300 μ.

Synchæta tremula Gosse.

Male: Gosse 1856, p. 321.
Hudson-Gosse 1889, p. 128.
Rousselet 1902, p. 283.
Tab. III, fig. 2.

GOSSE (1856 p. 321, Pl. XV, fig. 30—31) has given a short description which, together with the drawing, makes it very probable that he has really observed the male: An obconical form with rounded front, set with long cilia. A red eye, sharply defined, a central granular viscus, contained in a longitudinal cavity, in the bottom a large, irregular opaque white mass. The foot seemed to carry a great protrusile penis and to terminate in two minute toes. Size $^1/_{220}$ in. HUDSON-GOSSE (1889 p. 128 Pl. XIII, fig. 2) have seen a glimpse of a male and also state, that they have seen the four styli on the coronal head.

ROUSSELET (1902 p. 283, Tab. III fig. 3 a). It is a small conical creature with a bent towards the ventral side, close behind the head. The front is truncate, with four styles. The red eye, dorsal antenna, large sperm sack and two acute toes are prominent. The mastax and stomach are quite absent, and replaced by the sperm sack. Size 110 μ. October.

Description. The male of *S. tremula* is most probably indistinguishable from *S. pectinata*. We find the same conspicuous rudiment of intestine (denied by ROUSSELET 1902, p. 283). It must only be pointed out that the foot is much smaller, only a small tap with inconspicuous toes but well-developed foot glands; it is perhaps placed more ventrally and the penis is somewhat more prominent. Size of male 120 μ, of female 250. — Time: May.

Synchæta oblonga Ehrbg.

Male: Rousselet 1902, p. 287.

ROUSSELET (1902 p. 287, Tab. III, fig. 2a). The discription and figure of the male are not so plain that it can be distinguished from that of *S. tremula*.

Synchæta littoralis Rouss.

Male: Rousselet 1902, p. 397.

Rousselet (1902, p. 397.) only says: "The male has been seen several times, and has much analogy with *S. oblonga*."

Synchæta gyrina Hood.

Male: Hood 1887, p. 149.

Hood (1887, p. 149) only says: "The male is a conical slender creature, 85 μ."

Synchæta tavina Hood.

Male: Rousselet 1902, p. 397.

Rousselet (1902, p. 397) gives no drawing. It is only stated that the brain is long with opaque granules at the tip of which red granules forming a double eye are imbedded.

Synchæta neapolitana Rouss.

Male: Rousselet 1902, p. 410.

Rousselet (1902 p. 410, Tab. V, fig. 9 b, c) has found the male. He only states: "It is of usual structure. Size of male 75, of female 109—163 μ."

Synchæta cecilia Rouss.

Male: Rousselet 1902, p. 407.

Rousselet (1902, p. 407, Tab. VII, fig. 16 b). The male of this species seems to be distinguishable owing to the large dorsal antenna, which is seen to emerge just above the red eye, and which is slanting backwards. Further the lateral antennæ are also conspicuous by their size, protruding low down at the sides of the body. Size of male 78 μ, of female 142 μ.

Synchæta vorax Rouss.

Male: Rousselet 1902, p. 408.
Lie Petersen 1905, p. 20.

Rousselet (1902, p. 408, Pl. VIII, fig. 19 a) describes the male as follows: "The median tubular antenna, which is so prominent and characteristic in the female, is also present but of small size; in addition to this, the male has on the front two small tubular antennæ, one on each side, which is very strange. Further it has at the extreme front of the head but slightly ventral in position two stout fleshy, freely movable processes, surmounted by a broad brush of long stiff hairs. In no other males have I seen such organs." Size of male 149 μ, of female 272 μ.

Lie Petersen (1905, p. 20, Tab. I, fig. 5) gives a very good figure of the male, but no description. It seems that he has interpreted the alimentary canal correctly.

It will be seen that the males of the genus *Synchæta* are found rather frequently. Especially Rousselet has described and figured the males of several species, but as far as I can see all these males are not described in such a way, that they may be distinguished from each other; most probably the majority of them are really indistinguishable. Still it seems that there are two species *S. cecilia* and *S. vorax* which are characteristic.

Characteristic of all hitherto observed males is their conical shape, their often short foot, with two toes and well-developed foot glands. The wheel-organ is simplified to a terminally placed disc, surrounded by cilia, carrying on the disc the same four long hairs which characterise the females; auricles are absent and fleshy protuberances only observed in one species. A retrocerebral organ has not hitherto been observed; most probably dorsal as well as lateral antennæ are always present. Below the large brain a large red eye. Rudiment of alimentary canal hollow and often containing globules, most probably present in all species; it has hitherto mainly been overlooked, but it seems to have been observed by Lie Petersen in *S. voraæ*; some of Rousselet's figures seem to show rudiments of the alimentary canal. Whereas Plate (1886, p. 45) states that the length of the excretory canals in the females is very different, Rousselet (1902, p. 272) maintains that they always are very short in the male sex, not extending much over the anterior end of the gastric glands. In the males examined by me I have seen them reaching the brain. The testis is large, pearshaped; there are two short prostata glands; the penis opens dorsally: it is short and round, the opening provided with short hairs; the muscle system, especially the transversal muscles are highly developed.

Polyarthra platyptera Ehrbg.

Male: Gosse 1856, p. 320.
Plate 1886, p. 18.
Tab. III, fig. 3—4.

Gosse (1856, p. 321, Pl. XV, fig. 27—29). The small drawings give the figure very well and the comparison with a *Vorticella* is really excellent. Gosse says that the head is very large, with the body tapering quickly to the posterior part; both extremities are truncate. The front bears two warts, between which the rotatory cilia are placed, but the cilia (perhaps setæ) are longer on the warts. The hinder part is bifid, the smaller division being the caudal extremity or toeless foot, and the larger a protrusile truncate penis, ciliated at the tip. No internal organisation is discoverable. In one there was a globule in the middle of the great head. Towards the posterior dorsal parts a few irregular dark specks were visible, but generally the whole animal was clear, colourless, highly refracting, and showing an indistinct granulation. Its motions were swift and impatient, gliding about the field at headlong speed, occasionally remaining in one place for a few minutes, but not in stillness, for it was rapidly oscillating to and fro, and quivering.

Plate (1886, p. 18, Tab. I, fig. 4) describes the male mainly as follows:

"In ihrer Gestalt weichen sie durchaus von den Weibchen ab und entbehren, wie fast alle Rädertiermännchen, einer Mundöffnung und eines Kauapparates. Die flossenartigen Anhänge des Weibchens fehlen völlig und auch von einem Augenfleck ist nichts am Gehirn zu erkennen ... Die Männchen lassen eine Bauch- und eine Rückenseite unterscheiden, von denen diese etwas schmäler ist als jene. Beide hängen durch zwei nach innen gebogene Seitenflächen mit einander zusammen. Nach hinten verjüngt sich der Körper in den Penis, der am freien Ende bewimpert ist und während des Umherschwimmens teilweise eingezogen wird. Ein Fuss an den sich der Penis nach Gosse ansetzen soll, ist nicht vorhanden. Vorn bildet der Körper einen halbkugelig vorspringenden, einstülpbaren Kopf, der mit einem einfachen Cilienkranze und innerhalb desselben mit 2 Büscheln starker Wimpern besetzt ist. Der grösste Teil der

Leibeshöhle wird von dem Hoden eingenommen, der sich nach hinten in einen flimmernden Ausführgang fortsetzt. Neben dem Sperma, dessen feinere Structur bei der Kleinheit des Objectes nicht zu ermitteln war, liessen sich deutlich die unbeweglichen, schmalspindelförmigen Stäbchen erkennen ... Der dem Hoden aufgelagerte rudimentäre Darm wies constant einige Fetttropfen auf. An dem ausleitenden Kanal des Spermasackes liegt eine Prostata ähnliche Drüse. Wassergefässsystem und Sinnesborsten vermochte ich nicht aufzufinden. Grösze 44 μ.

Description. Body almost globular, more or less accuminated behind, very variable in form, often when swimming with a globular forepart, sharply set off from a more acuminated cylindrical hindpart. No thorns, foot or toes. The wheel-organ seen from above, a cilia-covered cup with some stronger cilia laterally; from beneath a triangular space, dorsally carrying a series of long cilia, ventrally with a wreath of cilia, following the borders of the triangular space. In the middle of that a few faintly protruding hills carrying on their tops a bunch of cilia. I have been unable to confirm PLATE's description of the body; conspicuous dorsal and ventral sides, separated from each other by means of lateral planes "Seitenfläche", I have never seen. My conception is much more in accordance with the very small figures which GOSSE has given of the male. Near the anterior border below the wheel-organ are seen some hypodermal cells with conspicuous nuclei; I have been unable to detect a brain; eye and antennæ, dorsal as well as lateral antennæ seem to be absent. Most probably there exist two longitudinal muscles to withdraw the wheel-organ, but I have not ventured to draw them. The whole of the interior is filled by an enormous testis, almost reaching the wheel-organ and provided with two sorts of spermatozoa; laterally the testis is surrounded by two prostata glands, the size of which differs very much individually. At the posterior border there is a rather large opening, surrounded by a wreath of rather long cilia; it is the opening for the testis; as far as I can see, there is no real penis, but during copulation, and when the male whirls round the body of the female, the whole body as shown in fig. 4, is attenuated behind; in a peculiar amoeboid manner it is now drawn out into a cylindrical part which functions as penis. The testis is then pressed downwards and shows a similar prolongation to the body itself. A penis tube, ciliated on its interior walls, I have been unable to observe. Every sign of an alimentary canal and of excretory organs seems to be wholly lacking. The testis and prostata glands are surrounded by a greyish mass, in which are inbedded numerous often very large oil globules. The males swim with an almost incredible speed, and owing to their extremely small size, they are difficult to isolate and draw by means of camera.

Asplanchnadæ.

Closely allied to the Notommatidæ through the two genera *Eosphora* and *Triphylus* the family comprises the three genera *Harringia* (= *Dinops*), *Asplanchnopus* and *Asplanchna*. The first-named genus has become best known through the excellent studies of DE BEAUCHAMP (1912 a, p. 223) and he being the first to show the connection with the *Notommatidæ* through the genera *Eosphora* and *Triphylus* (see especially

DE BEAUCHAMP 1909, p. 24—25). The males of *Harringia* are unknown, that of *Asplanchnopus* has been seen by PLATE and rather superficially studied by WEBER. The males of the genus *Asplanchna* belong to the oldest and best known of the Rotifera males.

Asplanchnopus myrmeleo Ehrbg.

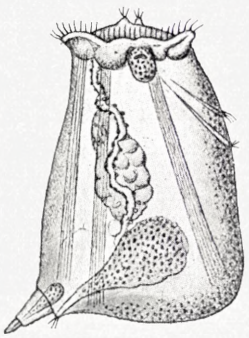
Male: Western 1888, p. 647.
Hudson Gosse, Suppl. p. 15. Pl. XXXII, fig. 13 b.
Weber 1898, p. 384.
Plate 1886, p. 83.

WESTERN (1888, p. 647) has briefly described the male as follows:

The presumed male is found in a trough filled with water, where the female *A. myrmeleo* was then abundant. "It had the characteristic foot of the female. The brain is large, tripartite; an eye spot; two dorsal antennæ; a very large contractile vesicle, and numerous vibratile tags. There are the usual sperm-sack and protrusile penis, the latter lying behind the foot under a valve-like flap. — Size female: $\frac{1}{25}$, of male $\frac{1}{50}$'."

WEBER (1898, p. 384. Pl. 16, fig. 11) has observed the male only in one specimen. He only says:

"Il possède un repli membraneux, en forme de valvule, qui fait saillie en arrière du pied et protège le pénis. Le testicule et le pénis sont placés plutôt transversalement dans la cavité du corps et très en arrière." Size of female 960 μ à 1000; of male 460 à 500 μ.



Asplanchnopus myrmeleo ♂. after Weber.

PLATE (1886, p. 83) remarks:

"Von den bis jetzt noch nicht bekannten Männchen ist mir nur einmal ein halbtotes Tier zu Gesicht gekommen, das hinsichtlich der äusseren Gestalt so gut wie nichts erkennen liess. Der Hoden war dicht gefüllt mit runden Zellen, halbreifen Spermatozoen und jenen schmalspindelförmigen unbeweglichen Körpern, die auch bei allen andern Männchen beobachtet sind. Ein Teil derselben flottierte frei umher, andere aber sassen mit ihrer Mitte den runden Zellen an, von denen sie daher offenbar gebildet werden."

It will be seen that the male may almost be regarded as unknown. For many years I have in vain searched for this form which, because of its intermediate stage between *Harringia* and *Asplanchna*, is of the greatest interest. Finally in the autumn of 1921 I found the animal in numerous little ponds, spread over a remarkable stone-covered heath in the middle of Seeland near Sorø (Rejstrup Oredrev). Only females with large yellow resting eggs were observed.

Asplanchna.

A rather long series of Asplanchna-species have been described. The main forms are the following.

A. Ebbesbornii Hudson.	*A. Girodi* de Guerne.
- *Brightwelli* Gosse.	- *Imhofi* de Guerne.
- *priodonta* Gosse.	- *Krameri* de Guerne.
- *Sieboldi* Leydig.	- *bowesii* Gosse.
- *intermedia* Hudson.	- *ceylonica* Daday.
- *triophthalma* Daday.	- *cincinnatiensis* Turner.
- *amphora* Hudson.	- *hungarica* Daday.
- *helvetica* Imhof.	- *syringoides* Plate.
- *Herrickii* de Guerne.	- *Silvestrii.*

Harring (1913, p. 15) has reduced the number to only 6.

A. Brightwelli Gosse.	*A. priodonta* Gosse.
- *Herrickii* de Guerne.	- *Sieboldii* Leydig.
- *intermedia* Hudson.	- *Silvestrii* Daday.

The species have been founded upon the structure of the jaws, number of eyes, form of ovarium, form of the body, form of the gastric glands, number of vibratile tags, and shell structure of resting egg. In his admirable studies on *A. amphora*, Powers (1912, p. 441) has made it probable that the difference in numbers of vibratile tags are correlated with the general differences in the size of the organisms; further that in the same species (*A. Brightwelli*) we may find trophi with and without innertooth, and finally that the body-form in the same species undergoes the greatest variation. This is to be understood in this way that no single animal goes through all the various shapes; they are born with the shape they possess, and do not change it in their life time; but their progeny may have a shape, different from that of the parent.

It will be understood that nowadays it is a harzardous matter to found species upon the three characters: number of vibratile tags, the jaws, and the outer form of the body. As far as I can see, there is only a single good character, the shape of the ovarium, by means of which the genus may be divided into two groups, those with a round ovarium, and those with a horseshoe-shaped one. The main form for the first group is *A. priodonta* for the other *A. Brightwelli*; to the first group may further be referred *A. Herricki* de Guerne characterised by a peculiar glandular organ, near the urogenital opening. It has been well described by *Wierzejski.*

Most probably all *Asplanchna*-species with a horseshoe-shaped ovarium are subject to a greater or less polymorphism. To this group have been referred six species. *A. Brightwelli*, *A. amphora*, *A. Sieboldii*, *A. Silvestri*, *A. intermedia* and *A. Ebbesbornii*. Of these species *A. Silvestri* characterised by the double humped form of the female, well-described by Rousselet, has hitherto only been found in America and in brackish water; it seems to be a rather distinct species. *A. Sieboldi* Leyd. and *A. Ebbesborni* Hudson are unquestionably synonyms. According to the descriptions it seems impossible to separate *A. intermedia* from *A. amphora* and provisionally *A. intermedia* may be regarded as a synonym for *A. amphora*. If this is correct, we

should only have four *Asplanchna*-species with a horse shoe-shaped ovarium *A. Brightwelli, A. Sieboldi, A. amphora* and *A. Silvestri.* With regard to *A. Brightwelli* it may be emphasised, that, even if there exist races of *A. Brightwelli* with inner tooth upon the rami (Powers), this is commonly not the case. Undoubtedly in numerous localities there exists an *Asplanchna*-species with a horseshoe-shaped ovarium; it does not undergo any variation in form and the rami are always destitute of an inner tooth. At all events this is the case in Denmark. These species are referred to *A. Brightwelli.*

With regard to *A. Sieboldi* the polymorphism has been studied by v. Daday (1888, p. 140) Wierzeysky (1893, p. 57) and Lange (1911, p. 433), that of *A. Sylvestri* by Rousselet (1913, p. 57) that of *A. priodonta* especially by Langhans (1906, p. 439) and W.-L. (1908, p. 82) and that of *A. amphora* by Powers. I for one confess that from the descriptions I am unable to distinguish *A. amphora* from *A. Sieboldi* but suppose that provisionally it is most correct to keep them distinct.

Asplanchna priodonta Gosse.

Male: Gosse 1850, p. 18.
Hudson-Gosse 1889, p. 123.
Daday 1891, p. 79.
Weber 1898, p. 378.
Tab. V, fig. 6; Tab. VII, fig. 1; Tab. VI, fig. 6—7.

Hudson-Gosse (1889, p. 123, Pl. XII, fig. 2) describes the male as follows:

The male differs hardly at all in its internal structure from that of *A. Ebbesbornii*: though very different in shape. Its sperm-sack is supported by a strip of tissue that hangs from the head and resembles in shape and position the alimentary canal of the female. It is, however, imperforate and structureless and seems to have no other office than to support the sperm-sack and penis. The nervous ganglion unusually conspicuous. Two of its four diverging threads pass downwards to the dorso lateral rocket-headed antennæ, and two pass upwards to similar antennæ on the two apices of the corona. By slightly compressing a male, I put beyond question the fact that the contractile vesicle empties itself outward trough the cloaca; for under slight pressure the vesicle contracted slowly, by stages as it were, collapsing partially in separate efforts instead of closing at once. As it did so, I distinctly saw, at each effort, the gradual passage of a plug of fluid down the cloaca, dilating its walls as it went. Size male: 200—400 μ, female 600—1000 μ.

The male of *A. priodonta* is most probably one of the most frequently observed and figured Rotifer males. Nevertheless, as far as I know, no better or more exhaustive description than that of Gosse exists nor a better figure than that in Hudson-Gosse (compare f. i. this figure with Dadays (1891: Tab. II, fig. 6—7, description p. 79) and the figure and description by Weber (1898, p. 378).

It must only be added that Masius (1890, p. 651) without describing the male has given a good description and drawing of the male organs of *A. priodonta.* He gives the following very interesting observation hitherto unique and not corroborated by any other observer: "Tel est l'aspect ordinaire du canal déferent dont l'énorme diamètre semble peu en rapport avec ses fonctions. La raison du diamètre considérable de ce conduit s'exqlique par ce fait que (dans certains cas du moins) les spermatozoïdes sont rejetés à l'extérieur dans un volumineux *spermatophore.*" Masius has observed the spermatophore three times and describes it as follows: "Il est sphérique ou légèrement allongé, jaune brunâtre et formé par la réunion d'un grand nombre d'éléments chitineux, polyédriques, de dimensions variables. Les plus grands

de ces éléments sont réunis aux environs de l'un des pôles; les éléments plus petits entourent le pôle opposé. La cavité du spermatophore est circulaire, mais excentriquement placée, de sorte qu'au niveau des éléments chitineux les plus petits, la paroi est aussi la plus mince. Le canal contenant un spermatophore a perdu son aspect glandulaire, le produit de sécrétion jaunâtre de ses cellules a disparu, il est probablement utilisé à la formation du spermatophore."

Description: The form of the male differs only very little from that of the female, but the head is not so conical, and the whole body somewhat narrower. The wheel-organ is a simple ring of cilia, surrounding the conical cone, it has no interruption dorsally or ventrally; at all events it is only very small. On the top of the conical disc there are two tufts of hairs; seen laterally, only one tuft is observed. I have not been able to detect prominences, carrying styli. The wreath is situated upon a ring of hypodermal cells. In the place where the mouth is in the female, is found a peculiar globular body, often provided with a prominence, formed like the beak of a parrot; to this globular body is fastened a long band, narrow in its anterior part, broader in the middle and narrower again near the testis, to the upper part of which it is fastened, and which it embraces. I am not quite sure, that this band is not hollow since it contains many globular bodies of different size which resemble oil globules, and which are not commonly found in any other part of the body. They are also indicated on the figures of Hudson-Gosse (Pl. XII, fig. 2c) and Weber (1898, Tab. 16, fig. 8); a histological examination would indeed be very desirable. That the whole apparatus functions as a suspensor testis is in my opinion without doubt; on the other hand that morphologically it may be regarded as a rudiment of the alimentary canal is highly probable; the above-named globular body, lying where the mouth of the female is, may most probably best be regarded as a rudimentary mastax; like other rudimentary organs its stage of development undergoes large individual variation. The brain is mainly an elongate, large pear-shaped body, sending off forwards nerve threads to the cup-shaped disc and backwards threads to the two dorsal antennæ, situated before the middle of the body and two ventrally more behind; the heads are very broad, carrying on their blunt rounded outer ends long radiating setæ. On the underside of the brain is the large red eye; upon two prominences in the wheel-organ, two other somewhat smaller eye spots.

Of the longitudinal muscles we especially call attention to the two pairs of very strong muscles, running almost through the whole body; the two ventral ones are cleft near the corona and fastened to the above-named globular body; with the other end they are fastened to the cuticula, very near the testis and perhaps to this very same organ. The dorsal pair are fastened to the hypodermal cells of the corona and follow the intestinal band or suspensor testis, to which this is fastened; the other point of attachment is dorsally, almost in line with the first-named pair. These two powerful muscles draw in the wheel-organ. Near the middle of the body and near the two strong dorsal muscles is a point in which most of the other slighter muscles meet. At this point there are two long cleft muscles, which are fastened

dorsally to the hypodermal cells, further two parallel muscles which run ventrally aslope and are fastened with the other end near the globular body, the presumed rudimentary mastax; these muscles bend the forepart of the body and are able to give the corona a slanting position in relation to the axis of the body; further the muscles which run downward, one more dorsally and two more ventrally. Finally we find on the ventral side two pairs of rather narrow very long muscles, the one pair fastened with one end below the corona, with the other to the outer end of the ductus seminalis, the other pair with the cleft to the globular body, with the other to the opening for the urogenital canal. When this muscle is contracted, the whole posterior part of the body is bent downwards and forwards. Simultaneously with this, the muscles which are fastened to the opening of the penis, are loosened and, partly by means of augmented pressure in the body cavity and the numerous muscle threads in the cuticula, the testis is pressed downwards out into the urogenital canal. Transversally over the body are stretched some transversal muscle bands, running between the dorsal and ventral muscle system. A closer examination will further show a system of extremely fine muscle threads which mainly form a very wide-meshed net-work, directly under the cuticula; where these threads meet each other, we find a granular protoplasmatic structure, in which often a nucleus is seen; this net-work is most developed in the hind part of the body; where the threads meet each other, long, extremely fine, threads run downwards, mainly from the wheel-organ; if we observe a living *Asplanchna*, we shall see that it very often alters its form; now this now that part of the cuticula is drawn in and on the smooth surface of the body a larger or smaller hollow may be shown; this power of altering its form comes from the muscle network; if two specimens are compared, it will be seen, that it is never developed in quite the same manner.

As far as I have been able to see, in *A. priodonta* just as in the other specimens here mentioned, we find two sorts of lateral canals in the excretory organ on both sides of the body. The one may be described as a curved ribbon with strong curves and knots; they are tubes of a loose granular substance, with clear nuclei imbedded in their walls; at the sides of these tubes are the other sort; these canals are straighter, narrower and their lumen is more hyaline; they carry four vibratile tags; as far as I have seen, neither more nor less.

The real connection between the two canals I have not been able to see. With regard to the finer structure of the organ in the female I refer the reader to the excellent paper of Willem (1910, p. 21). The canals debouch into the contractile vesicle, which is very large; over its surface run a number of very fine muscle threads meeting each other almost in the centre of the bladder; it opens in the urogenital canal, very near the opening of the penis. To this point are further attached two small, short muscles, fastened with the other end to the bladder. The testis is rather small, pyriform, containing the two sorts of spermatozoa and opening in a urogenital canal. When used under the mating process, the urogenital canal

is forced outward, the whole hind part of the body is curved and the urogenital canal is now in two tempi, figured in figgs. 6—7, forced outwards and turned inside out; in this case it is altered into a hyaline cup traversed by the ductus seminalis and furnished at its base with a wreath of fine not vibrating cilia. In this position at the moment when the sperma is to be thrown over into the female, the testis has altered its form, now being much more slender and more longitudinally stretched. If the animal is held in this position by means of pressure, we see the bladder slowly fill itself; it cannot be emptied, and as the figure shows, it has now a constriction in its lower part. The short ureter and its opening in the urogenital canal is now very conspicuous; the canal in its outer part is covered with short cilia. Sometimes I think I have seen a series of parallel transversal stripes as indicated in the figure in this shape of the bladder.

I may add that the variation in form and size of *A. priodonta*, so characteristic in the female (LANGHANS 1905, p. 171; 1906, p. 439; W.-L. 1908, p. 82), has not been observed in the male sex.

A. Brightwelli Gosse.

Male: Brightwell 1848, p. 153.
Dalrymple 1849, p. 340.
Hudson-Gosse 1888, p. 122.
Rousselet 1901, p. 1.
Daday 1891, p. 84.
Tab. VII, fig. 2.

DALRYMPLE (1849, p. 340, Tab. 34, fig. 11—14) has described the male; in the following the description is given in somewhat abbreviated form.

The male is about three-fifths the size of the female, generally resembling in shape, but more flattened at the lower part or fundus, and more prolonged at the side, corresponding to the vaginal opening in the female, and which in the male presents a similar valvular opening though comparatively smaller in extent. Within this valve is observed a short canal, leading to a large spherical bag which may be distinctly seen, filled with molecular bodies in constant tremulous motion. From this body (the sperm-sack) a short but thick rounded body projects into the canal, before mentioned as leading to the lateral opening; around the extremity of this projecting process, and even within it to a short distance, is a visible ciliary motion, indicating a canal. The whole organ is regarded as a penis; a very exhaustive description is given of the muscles which draw in and out the presumed penis. Lateral canals, vibratile tags and contractile vesicle as in the female, but there are no mandibles, pharynx, oesophagus, pancreatic glands or stomach; globular masses in the body cavity; they are to be regarded as rudiments of the stomach.

HUDSON-GOSSE (1889, p. 122, Pl. XII, fig. 1 c) gives a figure of the male but hardly any description.

ROUSSELET (1901, p. 1) only remarks that the male is without a hump.

DADAY (1891, p. 84) only says: „Körper cylindrisch, oval, hinten etwas abgestutzt, ohne Fortsätze. Grösse 300—500 μ."

Description. The male in many respects differs very conspicuously from the male of *A. priodonta*. It is much more globular, almost isodiametric, still somewhat

attenuated in front. It is extremely hyaline; very often I have found specimens which, in contracted form, show a tendency to make lateral humps; when swimming, they always disappear. The wheel-organ is constructed just as in *A. priodonta* and so also is most probably the coronal disc, but owing to the slight material, I am not quite sure upon this point. The most peculiar structure in the anatomy of the species is that the long intestinal band, to which the testis is fastened in *A. priodonta*, is totally lacking here; the result hereof is that, whereas the testis in *A. priodonta* lies almost in the longitudinal axis of the body, in *A. Brightwelli* it lies almost transversally. Remains of the alimentary canal are totally absent in this species. The brain and the two pairs of antennæ are constructed in accordance with that of *A. priodonta*, but there is only a single eye lying upon the underside of the brain; not two eyes in the ciliary wreath. The muscles are mainly in accordance with those of *A. priodonta*. There are the same two pairs of strong longitudinal muscles, hauling in the wheel-organ; the ventral pair is deeply cleft posteriorly, embracing with its two parts the testis which is kept in place mainly by these muscles; very conspicuous also are the much narrower muscles dorsally and ventrally, which take the same position and have the same significance as in *A. priodonta*. A little behind the middle we find the same spot dorsally as in this species, to which two longitudinal as well as two slanting muscles with two other pairs running parallel, are fastened; to the same point is further attached the downward directed muscle which with its other end is fastened to the opening of the testis in the urogenital canal. Almost to the same spots are also fastened two small muscles to the contractile vesicle. Apart from the number of vibratile tags which, in this sex as in the female, is greater (about 10) than in *A. priodonta*, I cannot find any difference with regard to the excretory organ. The contractile vesicle may be very large. There is the same wide meshed system of extremely fine threads under the cuticle; it seems, as if one of the turning points in this system is just the point where the above-named many stronger muscles meet. I have often observed that at the same moment when these muscles are contracted, all the fine muscle threads are simultaneously contracted, and the whole form of the posterior part of the body altered. Below the corona is a series of small parallel muscle bands. The testis is almost globular; in the ductus seminalis, and in the urogenital canal I find no differences from *A. priodonta*. In the testis are found the two sorts of spermatozoa. It is rather peculiar that, whereas *A. priodonta* at the first glance is distinguishable from almost all other *Asplanchna*-species, owing to the globular ovarium, the ovarium being horseshoe-shaped in most of the others, the testis in all species has quite the same globular form.

It may further be added that, on the dorsal side of the animal we almost always find some globular masses of very different size, form, and number. In my opinion we have here rudiments of yolkmasses, in some way of nutrimental use to the animal; they diminish during growth. They are mentioned by DALRYMPLE and are indicated in the figure of Hudson-Gosse (1889, Pl. XII, fig. 1 c). Size: male 166—200 μ, of female 500—1500 μ.

Curiously enough it seems that the male has only been found a few times after it has been observed by BRIGHTWELL and DALRYMLPE; it is figured by HUDSON-GOSSE 1889, Pl. XII, Pl, 1 c, but no new observations are added to the old ones.

Asplanchna Sieboldi Leydig.

Male: Leydig (1855, p. 30).
Hudson-Gosse (1889, p. 121).
Daday (1891, p. 87).
Tab. VII, fig. 3.

LEYDIG (1855, p. 30, Tab. II, fig. 12—14) has given an excellent description and very good drawings of the male.

The form differs from that of the female, not being campanulate but cone-shaped, with two pairs of humps, one pair larger; almost in the middle of the body, and one pair nearer to the corona; during the swimming motion the arms are stretched out and drawn in. The wheel-organ is in full accordance with that of the female, the coronal disc carrying the same elevations with stiff setæ and bunches of bristles as this sex; the brain gives off nerves to the elevations with the setæ on the disc and to the ventral lateral antennæ; the dorsal pair is not mentioned. No alimentary canal; the excretory organ in full accordance with that of the female (vibratile tags about 50). The large testis pear-shaped; ductus seminalis in its interior covered with cilia and provided with prostata glands; the structure of the spermatozoa is thoroughly described. Muscular system in accordance with that of the female, strong longitudinal muscles and fine transversal bands, of which one pair are used to draw in the humps; on the base of the humps they appear "sternförmig", sending off fine threads to the periphery. In the body cavity behind the great humps cell material which LEYDIG regards as stored nutriment deriving from embryo. LEYDIG's drawings were subsequently reproduced by TOTH (1861, p. 178, Tab. II, fig. 13—14).

HUDSON-GOSSE (1889, p. 121, Pl. XI, fig. 3) have given a very good description and drawing of the male as *Asplanchna ebbesborni.*

It must especially be pointed out that H.-G. have observed the rounded masses adhering to the dorsal surface, just below the humps. They are in accordance with LEYDIG but with some doubt, regarded as "a kind of stored-up material to compensate for the male's inability to take nourishment«. The muscle system of the penis and testis is well described and so also especially the excretory system with the flocculent ribbons, the tubes and the large number of vibratile tags (about forty on either side).

DADAY (1891, p. 87) gives a very insufficient drawing of the female and describes it shortly as follows:

"Körper vorn cylindrish, mit zwei bauchständigen Anhängen, hinten conish, mit zwei kräftigen Seitenanhängen; — mit einem einzigen Stirnauge." Size 200—400 μ, female 800—1500 μ.

Description. Form of the body not bellshaped as in the female, but conical as indicated by LEYDIG. It is provided with two sleeve-like prolongations, situated almost in the middle of the body; of the two others placed nearer the wheel-organ and indicated by LEYDIG and HUDSON-GOSSE I have only seen slight vestiges. The prolongations may be drawn in and out during the swimming motion; they are always empty; the whole animal extremely hyaline.

The coronal disc is conical with two apices. The ciliary wreath is a simple ring of cilia, as far as I have been able to see without any interruption either dorsally or ventrally. The brain is large, flattened; when the animal, as the figure shows, is seen laterally, pear-shaped. On the coronal disc are found two hairtufts, and each of these receives nerves from the brain; four long nerves, two ventrally and two dorsally, run down to the two pairs of antennæ; there is only one red eye and no eye spots in the corona. As in *A. Brightwelli* it is not possible to point out the slightest trace of an intestinal band; the testis is only fastened by muscles, and here also has an almost transversal position.

With regard to the muscular system it will be seen by comparison with the figures of *A. priodonta* and *A. Brightwelli* that especially with regard to the great retractors of the wheel-organ, the slanting transversal muscles, and some of the muscles to the penis, there is a great resemblance in all three species. There is only this difference, that ventrally we find a rather large muscle, fastened upon the testis and running up to the wheel-organ; this muscle has no congruent in the two other species. Peculiar too is the much coarser equipment of fine muscle threads below the cuticle; further that these threads almost run parallel and are especially developed in the hind part of the body; it is on this system of cuticular muscles that the almost incredible variation in outer form in the first line depends. In specimens, deriving from the locality where the species was first found, a very little duck pond belonging to a little farm a few kilom. from Hillerød, this system of muscle threads was very conspicuous: this was also the case with the specimens deriving from the duck pond in the little village of Fjenneslev near Sorø. In the vascular system two sorts of canals are distinguished, the one very large and long forming windings and slings, the other more straight carrying in a long row at all events more than thirty vibratile tags and perhaps more. Leydig (1855, p. 27) mentions about 50, Hudson-Gosse often more than forty (1889, p. 122). The contractile vesicle when fully distended, occupies a very large part of the body cavity; it is covered with a conspicuous muscular network, the muscle threads meeting each other in two opposite points.

The testis is pear-shaped and very like that of *A. Brightwelli*; it is as always in the Asplanchnas rather small in comparison with the size of the animal. The ductus seminalis and urogenital canal are formed quite as in the other species; on the sides of the canal are a series of glands which may be regarded as prostata glands; similar ones I think I have seen in *A. Brightwelli*, but not so conspicuous as here.

Especially in the middle of the body and near the sleeve-like prolongations but also otherwise we find peculiar irregular bodies also mentioned by Leydig. He is of opinion "dass diese Masse ein Rudiment des Zellenmaterials ist, welches beim Embryo zum Aufbau des Magens bestimmt wird, aber da einmal die Männchen ohne Nahrungskanal sein sollen, nicht zum Verbrauch kommt". I agree with Leydig in the first part of this sentence, but am not quite sure that this store nutriment is of no significance for the animal. Size of male 250—300 μ, of female 600—1000 μ.

A. Sieboldi (= *A. Ebbesborni*) seems to be a very rare animal in our country.

I saw it more than 25 years ago; it was found in the above-named little duck pond lying very near the birth place of my good friend, the celebrated Danish Naturalist Dr. TH. MORTENSEN. The drawing derives from these specimens. Later on I never found the animals in this little pond, and when I explored the pond again in 1921, I found it quite altered and with hardly any Rotifers in it at all. I have been in search of the animal during all these years; not till 10/VIII 1921 did I find it again in another duck pond in the little village of Fjenneslev near Sorø. I had the good fortune to come across it in the sexual period and got several males. In the samples were only humped females and males, but it was in the last part of the sexual period, the pond being almost dried up. In 1922 I never succeeded in finding the species again.

I am not quite sure that my determination is quite right. The species being equipped with large humps, well developed in all the many females and in the males which I have seen, but really often withdrawn when swimming, it is impossible to refer it to *A. Brightwelli*. Equipped with one single eye, conspicuous humps and horse-shoe-shaped ovarium the animal must be referred to the group *A. intermedia, amphora* and *Sieboldi*. As the jaws have a large innertooth and as there are more than thirty vibratile tags, it cannot be referred to *intermedia*, a species which in my opinion is rather doubtful. *A. amphora* is really a proteus among the *Asplanchna* species; only if a population from a pond were observed the whole year round, would it be possible with certainty to determine *A. amphora* from the other species; as however I never found the campanulate and saccate forms, characteristic of *A. amphora* in the colonies from Frerslev and Fjenneslev, and the first-named colony was observed four times in the course of two months (May—June), I do not think it can be correct to refer these populations to *A. amphora*. Comparing my material with the long descriptions of HUDSON-GOSSE and LEYDIG I find great conformity upon all essential points; I only lack the two humps upon the neck below the wheel-organ but as even these humps are subject to great variation I cannot see that it would be impossible, only because of that, to refer my specimen to this form.

It was in this species that DADAY (1889, p. 140) observed the polymorphism of the *Asplanchnadæ*. He found two different forms of females, partly saccate, partly humped; both forms are able to produce partly females of their own form, partly those of others, partly males and, after fertilization, resting eggs. I then found a peculiar species in North Seeland; it was in May, and in the pond only the humped form existed which, during swimming, had very often drawn in the humps. I therefore supposed, (1898, p. 200) that there really only existed one form with great power of altering the shape of the body. At that time I did not know WIERZEJSKI's paper (1893 a, p. 57); he too had observed the phenomenon and interpreted it in accordance with v. DADAY. In 1911 LANGE (p. 433) found an *Asplanchna* at Schönau near Leipzig. By studies in cultures, he showed that the females deriving from resting eggs were always of the saccate form, and that the humped form did not arrive before the third generation. The appearance was quite sudden. From his own observations on *A. amphora* POWERS (1912, p. 536) concluded

that my statement that the two forms could not be distinguished from each other, was wrong. From the combined investigations of WIERZEJSKI, LANGE and POWERS, I am sure that I have been wrong in my supposition. The chief reason for that was, that in my pond, I did not at that period see any of the saccate forms, and secondly, that v. DADAY had not mentioned that the humped forms, when the humps were drawn in, were indistinguishable from the saccate ones.

I regret very much that I have not been able to find the species again in time and so complete my observations. When ($^{10}/_{8}$ 1920) I found the new locality (Fjenneslev) it was most probably too late in the year to get the saccate form, and the pond was so far away from my laboratory that regular proofs could not be obtained.

Asplanchna intermedia Hudson.

Male: Hudson-Gosse. Supp. 1889, p. 12.
Rousselet 1901a, p. 9.
Daday 1891, p. 87.

HUDSON-GOSSE (Supp. 1889, p. 12, Pl. XXXII, fig. 15).

"The contractile vesicle and sperm-sac of the male are very small; and the lateral canals have the vibratile tags arranged in a straight line on either side. The creature is so wonderfully transparent and empty that it is difficult to see... The hind dorsal corner of the body is somewhat prolonged into a sort of third hump, and darts out stiff and obvious (as do the lateral arms) when the head is retracted. The opposite ventral corner is prolonged to a blunt point, and is the sheath of a long protrusile penis. What appears to be an atrophied oesophagus and stomach hangs freely in the body-cavity, between the head and the above-named dorsal hump. In one specimen I saw tags in which no ciliary motion was visible. Length m. $\frac{1}{60}$ i."

ROUSSELET (1901a, p. 9, Pl. I, fig. 2).

The males of *A. intermedia* and *A. amphora* resemble each other very much; both have two humps, projecting laterally on the sides of the body, only the male of *A. intermedia* is much smaller than that of *A. amphora*.

v. DADAY (1891, p. 87) only says:

"Körper conisch, mit zwei Seiten- und einem Rückenanhang; mit einem einzigen Stirnauge."

Asplanchna amphora Hudson.

Male: Hudson 1889 Supp. p. 13.
Powers 1912, p. 441.
Western 1890, p. 65.
Daday 1891, p. 85.
Tab. VII, fig. 4.

WESTERN (1890, p. 65) remarks that he has observed

that as the females grow larger and older the lateral humps almost, if not entirely, disappear. Among these large apparently humpless females he has however found two large humpless females with young ones in utero, which were undoubtedly of the humped variety. He has

also seen the humped males in utero. He has further observed that *A. amphora* may entirely disappear from the pond, whereupon *A. Brightwellii* turned up in great abundance.

DADAY (1891, p. 85) only says: "Körper conisch mit zwei Seitenfortsätzen."

Description. Body form very peculiar; almost triangular with circular top, a triangular base, a broad dorsal side and rather narrow rounded ventral side; on each of the two side-planes are two sleeve-like prolongations, two humps of the cuticle; they differ in size and form from specimen to specimen, are not equally developed at all times of the year, and have never quite the same appearance in different ponds; they are often drawn in during the swimming motion and can suddenly be unfolded; this always takes place, when the wheel-organ is withdrawn or when the swimming direction is altered. They are always destitute of inner organs. The whole animal is extremely hyaline, crystalline. I have never found more than two humps. The coronal disc is conical with two apices. The ciliary wreath is a simple ring of cilia, as far as I have been able to see, without any interruption dorsally or ventrally. The brain is large, flattened, much broader than long, indistinctly divided into two parts, and sending nerves off from the corners to the coronal disc and to the body behind. On the coronal disc are found four hairtufts, each of these receive nerves, as shown in the figure of the animal, seen dorsally. There is only one red eye; no eye-spots in the corona; four long nerves, two ventrally and two dorsally run down to the lateral antennæ. Seen from the dorsal or ventral side, a long cylindric rather narrow faintly curved body is seen, hanging down from the corona; during swimming the organ is seen dangling hither and thither; it differs in size and development from specimen to specimen; it has hitherto only be observed in *A. intermedia* by HUDSON. Like this author I regard it as a rudiment of the alimentary canal; at all events it does not reach the testis which, just as in *A. Brightwelli*, is free and has no intestinal band connecting it with the wheel-organ. The muscle system is, especially in this form, very conspicuous, on the other hand owing to the peculiar form of the animal difficult to study. Seen dorsally *A. amphora* exhibits some remarkable differences in the course of the great retractors of the wheel-organ. As in the other species they really run from wheel-organ to testis, but, if I am not mistaken, before they reach the wheel-organ, they cross each other in a rather peculiar manner (see Tab. VII, fig. 4), perhaps this is a peculiarity in some individuals or in the whole population investigated. Seen laterally it may be shown that the other muscles dorsally and ventrally as well as those to the testis, are in full accordance with those of *A. priodonta* and *A. Brightwelli*; the special muscle from corona to testis in *A. Sieboldi* I have not found here. Of peculiar interest are the four very conspicuous transversal muscles, one of which crosses the body on a level with the humps, dissolving themselves into three or four very fine threads, fastened to the cuticula of the humps. After these four more conspicuous bands, one or two other very fine threads, parallel with the others, are visible. The whole body, especially in the hind part, has a very conspicuous wide-meshed network of fine threads, running below the cuticula.

The almost incredible formshifting power of the animal depends chiefly upon the muscle system. The excretory system exhibits a series of peculiar anatomical structures. The canals are not to such a high degree curled up, as is the case especially with *A. priodonta*. On each side of the body run three canals, the two of the structure indicated by HUDSON-GOSSE as tubes of loose granular stuff; the third one is somewhat clearer, perhaps with more solid walls, bearing about forty and often fifty vibratile tags; this canal has a peculiar cul de sac appendix, running down in the vicinity of the dorsal antennæ. How these three canals are connected with each other I do not know with certainty; in their whole course they are almost free of each other, only meeting near the corona and the bladder. This, when fully distended, may be extremely large, filling up a great part of the body cavity. The testis is rather small; the structure of the ductus seminalis and urogenital canal with the opening of the vesicle just at the boundary between both is in accordance with the facts found in the other three species. Dorsally round the testis there is deposited stored nutriment in the shape of yolkmass in different amounts. — Size of a male 500 μ, of female 1500—2000 μ.

This very peculiar Rotifer I have only met with in a single pond, extremely shallow, rich in organic matter; as it was found, the pond two months before had just been dried out; before, it was almost overgrown with vegetation, and the water a frumenty, overfilled with green algæ.

It was in the last part of August that the first sample was taken, and till the middle of October the pond was visited every week. The first time I found this Rotifer, I immediately saw that I had found a population of an *Asplanchna* which corresponded with those colonies which were found by POWERS. In the following I shall try to give an extract of his paper.

A. amphora was living in vile pools on the alkaline flat west of the city of Lincoln, Nebrasca. The water was here dark brown with alkali and the essence of compost. It was shown that the culture only thrived well where the "water" had the original composition of the native home of the animals. In nature, every rain-shower which diluted to an appreciable extent the vile ponds in which this *Asplanchna* flourished, resulted in the death of the entire stock, which was only replaced by the hatching of new individuals from resting eggs. The main result of the studies of POWERS was, that *A. amphora* was a trimorphic species divided into three different forms: the saccate, the humped and the campanulate form. The first (A) was invariably produced from resting eggs, multiplying by rapid parthenogenesis through several generations. It always preponderated in the beginning of the year, but was then rarer and rarer. It was succeeded by the humped form (B), originating from the former by rapid saltation; it produced chiefly its own type; the size of the humps may differ very much according to nourishment. Owing to canibalism then a third form (C) arose, the campanulate type, which reproduced both its own form and B. The three forms differ from each other in the following main points: in A the corona is about equal to the diameter of the body; and nearly circular in outline; there are no humps;

the number of flame cells vary from 20—40, the contractile vesicle is large; trophi are constructed as in the next form but somewhat smaller (95—135 μ long). Length of entire animal 500—1200 μ.

In B. the corona is oval; the flame cells 40—60. The contractile vesicle small; trophi strong 130—200 μ mainly 150—170 μ, enclosing, when closed, an area which is not oval, but widest in its distal third, with prominent tooth projecting inward, delicate lamellate teeth near the tips, and the two rami interlocking, when closed, by means of one bifid and one pointed tip. Length 1000 to 1800 μ.

In C the body is very broadly saccate to broadly campanulate with very heavy walls and muscles strongly flattened dorso-ventrally, never with humps; corona oval and very broad, its breath frequently equalling the length of the animal; coronal disc concave, instead of convex; flame cells 80—115, contractile vesicle small; trophi 300—340 μ, very large, enclosing a narrowly oval area; inner teeth comparatively less prominent than in preceding types, set at an acute angle with the ramus, and more firmly fused with it than in the preceding types; lamellate teeth near tips of rami much developed and meeting with cutting edges in middle line; tips of rami not interlocking, but shearing past each other when closed. Length of entire animal approximately 1800 to 2500 μ.

It was further shown that intermediate stages were commonly rare, and that the three forms were standing sharply against each other; they were not all to be found in the same sample, and all three forms were not necessarily developed in all the small localities, where the species was examined.

There are also other differences to point out in the three forms, especially with regard to propagation; the saccate form which most probably is the only one which develops from the resting egg, is usually crowded with embryos, nine or more; the humped form as a rule contains only one single young one and the campanulate form contains a few; by means of degeneration in cultures the saccate form may derive from the humped one, but this is an exception. The campanulate forms make their appearance within at most a week. Sometimes a single individual, either young or fully developed, would first be discovered. In every instance the sudden appearance of the campanulate form was followed by its very rapid multiplication, coincident with a still more rapid diminution in numbers of the humped form. The latter were eaten up by the former. Campanulate forms were also reared in the cultures by using the young *Moinas* as food, and a pond was discovered where the natural appearance of *Moina* caused an enormous production of campanulate forms, even directly from saccate ones, without humped ones as an intermediate stage. The entire population of a teeming *Asplanchna*-pond readily changes from the saccate to the humped type in one week; the saccate forms giving rise to the humped ones in the first generation, almost of the same size as the mothers. The next generation gives large-sized, typical humped individuals; later on the campanulate form appear among them with the utmost abruptness owing to canibalism. Between the alterations in the colonies, when they pass from one form into another, transitional periods appear; in these

the colonies have an almost incredibly chaotic appearance, but commonly the transitional periods are brief. Unfavourable conditions prolong these periods. POWERS could further show that exhaustive nutriment, for instance copious feeding with *Moina*, not only gave rise to the campanulate form, but also the humped forms, deriving from it, which possessed very long, highly developed humps that may be so long that they exceed the animal's length. It is supposed that each of the minor fluctuations which the three forms of the species undergo, will almost certainly resolve themselves into factors of nutrition.

POWERS has pointed out the very essential fact that the above-named three forms are all able to produce males, and that these males all have the same appearance; they are produced copiously by the humped and campanulate types, rarely and only in distinct periods by the saccate type; the size of the males varies greatly, from 300 to 1500 μ. Also the resting eggs are produced by all three forms, rarely by the saccate; in the humped three to six, rarely nine, are seen; in the campanulate also a high number.

It will be understood that the saccate form in almost all respects is very near to *A. Brightwelli*. The main difference between *A. amphora* and *A. Brightwelli* is that the trophi of the lastnamed species invariably lack the large inner tooth, whereas it is always well developed in all three forms of *A. amphora*. POWERS has however found a population of *A. Brightwelli*, where the trophi bore a strong inner tooth in the exact position in which this is found in *A. amphora*. He has further shown, that parallel cultures with identical conditions as to food and temperature, the one with the saccate forms of *A. amphora*, the other with the typical *A. Brightwelli*, invariably gave the same results; the saccate forms gave the humped forms; *A. Brightwelli* always *A. Brightwelli*; further that cultures of *A. Brightwelli* with inner tooth, continued over 6 weeks, invariably only gave the same type. He therefore concludes, that *A. amphora* and *Brightwelli* are really distinct species, and that there may be found special races also in *Brightwelli*.

The colony which I found in August in the above-named little pond contained the species in enormous masses. The main form was the above described humped one, but among them were numerous giants of the campanulate form, often measuring about 2000 μ; a very few specimens of the saccate form occurred; only the two first-named forms produced males; these were always humped. As far as I know, this is the first time after POWER's investigations that the species with all its three forms was found. The campanulate form fed upon the humped form and upon the young ones of *Daphnia*. In September resting eggs appeared in the humped and the campanulate form. In the last part of October the males disappeared, the humped ones became rarer and rarer, and in the first days of November only a few very large campanulate forms remained. By 15/XI *Asplanchna* was found no more. In December we had a short frost period; the pond thawed again and was finally frozen about 6/I 22. The very interesting discovery occurred at a moment when I was very much occupied with studies relating to other Rotifers, and I was unable to pay as much attention to the colony

as I should have wished. A more thorough investigation was planned for the year 1922, and on $^5/_5$ 1922 shortly after the pond had thawed, the first sample was taken. The whole year round every ten days samples were taken, and I was prepared for a more thorough investigation. On 5/V the first females appeared; they were, as expected, of the saccate form, but not to be distinguished from a typical *A. Brightwelli*, the rami being without inner tooth. The species was observed during the whole of May and June; it was rather rare, and no humped forms appeared. Then a period of heavy showers occurred, and during the whole time from July to late in August the downpour was extremely high; the temperature was low not above 14—16° C. In the last part of June the species disappeared. The pond was under regular observation till 29/I when the frost appeared, and the pond was frozen over. During this time not a single *Asplanchna* was observed in the pond. Most probably the melancholy result of so many excursions was due to the bad weather. In 1921 the whole summer was very dry, the temperature was above twenty degrees Celsius, and often rose to twenty-five; the downpour was extremely small. Whereas in 1921 the pond teemed with flagellates, often forming scum upon the surface, it was brown in 1922; of flagellates appeared only *Eudorina* and later on *Volvox* both in relatively few numbers. The pond will be under regular observation also in 1923.

Asplanchna triophtalma Daday.

Male: Daday 1883, p. 261.

v. Daday (1883, p. 261, Tab. fig. 3) gives a long description of the male unfortunately in Hungarian.

It is furnished with a figure, which in a very high degree differs from all other figures of the males of *Asplanchnadæ*. It is much more in accordance with the males of *Brachionus*; this holds good especially with regard to the structure of the testis and penis. The three eyes which are stated to be one of the most characteristic peculiarities in the specimen are indicated in the figure.

v. Daday (91, p. 84) only says: Körper cylindrisch, nach hinten verengt, ohne Fortsätze; mit zwei Seitenaugen und einem Stirnauge. Size male 200 μ—400 μ; female 800—1200 μ.

Asplanchna Sylvestrii Daday.

Male: Rousselet 1913, p. 61.

Rousselet (1913, p. 61, Pl. 5, fig. 5—6) gives the following short description.

A. Silvestrii is mainly characterized by the double-humped form of the female. Rousselet (p. 62) shortly states "that the male is humped but the side humps are not bifid. According to the description it is indistinguishable from the male of *A. amphora*. Length of female 1150 μ. of male 408 μ. The species is described by Daday (1902) from Chile, and later on found in Devil's Lake, North Dakota; the water is brackish."

General remarks.

The males of the genus *Asplanchna* are very little reduced; apart from the reduction of the alimentary canal they are almost constructed quite like the females.

They belong to the largest known Rotifer males, reaching about 500 μ; as far as we know, they never present variation in outer form; they are not polymorphic, and if they belong to species where females in one of their forms are humped, they are always humped.

The wheel-organ and disc differ but little from those of the female; the alimentary canal is always rudimentary, best developed as suspensor testis with a rudiment of a mastax in *A. priodonta*; very short in *A. amphora* and totally absent in *A. Brightwelli* and *A. Sieboldi*; in these species the testis is only supported by strong muscles. The nerve system is constructed in accordance with that of the female, and so are the different sensitive organs. This is also the case with the excretory organ; the number of vibratile tags correspond with those of the female, and a large contractile vesicle is always present. There is great coincidence with regard to the muscle system, peculiar is the great development of fine muscle threads below the cuticula. Whether the ovary is horseshoe-shaped or globular in the female, the testis is always globular; there is no real penis, the ductus seminalis opens into a canal in which also the canal for the contractile vesicle opens; during the copulatory act the ductus seminalis is pushed forwards, turned inside out and used as penis; it has a wreath of cilia.

Almost all observers have seen some globular bodies different in size and number, lying in different parts of the body. They are commonly (Leydig, Hudson) regarded as stored nutriment for the males, which have no possibility of getting food; they derive from yolk masses, which the embryo has not used. Lange (1911, p. 439) has shown that this supposition is correct. He says as follows: "1910 züchtete ich *A. Brigthwelli* und habe dabei ein ♂ 7 Tage lang lebendig erhalten. Die darauffolgende Untersuchung des Zellhaufens ergabe, dass er sich während dieser Zeit fast völlig aufgezehrt hatte. Auch für *A. Sieboldii* habe ich in allen Fällen nach 1—2 Tagen eine starke Abnahne in den Flächenausdehnung und Dicke des dorsalen Zellenkomplexes konstatiert." I can further remark as follows. The *Asplanchna* males most probably belong to those with the greatest longevity. Powers has kept them alive for 2—4 days (1912, p. 534). Lange for 7. I myself for 4. I have isolated males, whose birth I have observed; they had, at birth, a size of about 300μ, when they died four days later, the size was about 400 μ. At birth there was a great deal of store nutriment, at death it had disappeared; growth after birth has hitherto not been observed in Rotifer males.

Rattulidæ.

The family comprises the two genera *Diurella* and *Rattulus*. The males in this family have hitherto been quite unknown. Characteristically enough, Jennings, in his excellent monograph of the family (1903 a, p. 273), does not mention the males with a single word.

The males of the genus *Diurella* are still unknown; of the genus *Rattulus* I have found the males of three species.

Rattulus stylatus (Gosse).

Tab. III, fig. 5.

Description. Body pearshaped, rather soft with thin hyaline cuticula, presenting three rather well-marked transversal lines; wheel-organ a terminally situated disc, surrounded by a wreath of rather short cilia; the disc itself covered with short hairs, in the middle a tuft of long, strongly developed hairs. No antennæ observed. A brain with a large red irregular eye-spot. The whole body cavity filled with a greyish mass, containing numerous oil-globules. In this mass a very large almost globular testis, reaching up before the eye; two sorts of spermatozoa; the testis opens into a peculiar chitinized penis-tube which ends in a disc with the opening of the penis in the middle of the disc; the penistube can be withdrawn and again protruded. I have been unable to find any remains of an alimentary canal, of excretory organ, retrocerebral organ, antennæ, prostata or even muscles in the male; I suppose that the muscles, at all events, may have been present. Size of male 60 μ, of female 140—180 μ.

In one of my experimental ponds near Hillerød *R. stylatus* is very common; it has a large maximum in May; when I had isolated from the lighted border of the vessel many hundred females, the males appeared. The eggs were laid on the bottom, and the extremely small and extremely rapid males appeared.

Rattulus pusillus (Lauterborn.)

Tab. III, fig. 6.

Description. Body pyriform, hyaline with a rather soft cuticula furnished in front with a peculiar system of longitudinal folds, by means of which the cuticula can be folded over the wheel-organ, when this is drawn in; at the posterior end an inconspicuous cleft; a wheel-organ which can be placed vertically on the longitudinal axis and be bent slightly ventrally. It consists of a wreath of short cilia, surrounding a cilia-covered disc with a protuberance bearing a tuft of cilia. The brain is very large, sending two nerves to a little dorsal antennal organ; a large red eye is situated on the underside. Testis large, globular with two prostata glands; the penis chitinized, somewhat curved, ending again in a somewhat hollowed circular disc with a central opening; two sorts of spermatozoa. No trace of alimentary canal, excretory organ, or retrocerebral organ; lateral antennæ have been observed; four very conspicuous transversal muscle bands, but no longitudinal muscles have been seen. Size of male 60 μ, of female 115 μ.

R. pusillus was found common on 3/VIII 1921 in a pond near Sorø; of other Rotifers there were only *Anuræa hypelasma* and *Synchæta oblonga* in the sample. Having taken a proof with many hundreds of *R. pusillus* in a little cup, the next day I had more than twenty males which were hatched from eggs laid on the bottom during the night. The males were extremely rapid; three times I observed the mating process, the male sitting on the back of the female. Eight days later *R. pusillus* was

only found in very small numbers. Males which were isolated one day in the morning, were always dead before evening; most probably they only live some few hours.

Rattulus cylindricus (Imhof).

Tab. III, fig. 8.

Description. Body somewhat edged, much broader in front than behind, a soft hyaline cuticula with lines which seem to indicate a rather incomplete lorica; a deep transversal furrow divides the body into a forepart, faintly longitudinally folded in such a way that this part can be folded round the retracted wheel-organ; a posterior part attenuating posteriorly; dorsally this part, when faintly compressed, shows lines which are indicated on the figure. The wheel-organ shows a circle of rather short cilia and on the disc, three tufts of hairs; of these the median is most strongly developed: above it, a very conspicuous fleshy antenna; a broad brain; no eye spot; dorsally a well-developed dorsal antenna and sidewards two conspicuous lateral antennæ, each with a strongly developed sensitive hair. Of the excretory organ two short canals, each bearing two vibratile tags, are seen; no contractile vesicle. A very large globular testis, containing the two sorts of spermatozoa, and above it a very large oilglobule, surrounded by an irregular, often quadrangular dark mass. On the sides of the testis two large prostata glands. The testis debouches into a strongly developed, protrusile penis-tube, chitinised, but, as far as I could see, provided inside with cilia and ending in a disc with the penis opening lying centrally. No trace of alimentary canal. The whole body containing numerous oilglobules. Size of male 80 μ, of female 300 μ.

R. cylindricus is rather common in many of our smaller lakes; in contrast to almost all the other members of its genus it is a real plancton organism; as such it carries its eggs; of the female eggs only one or two; of the male eggs a small chain of three or four eggs; of these females carrying male eggs I have isolated several, hatched the males and seen them in great numbers in my vessels; they were extremely rapid and very difficult to isolate and study. Their form was more flattened than in the other species described; the large oilglobule and the numerous other globules, deposited round the organs, may be regarded as plancton characters.

General remarks.

As the males of *Diurella* have hitherto been entirely unknown, we are unable to indicate the family character of the males. With regard to *Rattulus* it may be pointed out that the males are extremely small, only measuring about $^1/_3$ to $^1/_4$ of the female. They lack every trace of a foot, the long differently formed toes, and the foot glands so highly developed especially in this family; also, all indications of a carina and thorns on the forepart of the lorica are absent. The body is only a cylindrical or flattened sack with a faintly developed lorica. The wheel-organ is a terminally situated disc, surrounded by a wreath of cilia, and on the disc some bunches of long bristles; when retracted, the forepart of the body is folded over it.

At all events in *R. cylindricus* a well developed antenna; a retrocerebral organ has hitherto not been found, but always a dorsal antenna, and in the male of *R. cylindricus* two lateral ones, symmetrically situated (in the female asymmetrically). An excretory organ may often have been overlooked; it is only found in *R. cylindricus*. The testis is globular, a prostata gland is perhaps always present; peculiar is the long, thin, protrusile, chitinised penis-tube, ending in a disc without a wreath of cilia. No trace of alimentary canal found. The muscle system is slightly developed. Whereas the females are highly asymmetrical, the males are symmetrical animals.

Euchlanidæ.

The family comprises the two genera *Euchlanis* and *Diplois*. The males of *Diplois* are unknown. As far as I know, only COHN has seen and given a more thorough description of a male of an *Euchlanis* (*E. dilatata*). The species of the genus *Euchlanis* are even in the female sex very difficult to distinguish from each other, and a revision most necessary. The main characters are to be found in the size, in the relation between the dorsal and ventral plate, in the anterior and posterior borders of the carapace, in the number of teeth in the unci and in the number of the long hairs on the foot.

At different times I have seen the males of the four species *E. dilatata* Ehrbg. *E. oropha* Gosse (= *parva* Rouss.). *E. triquetra* Ehrbg. and *E. lyra* Huds. As the males are almost all of the same size, and the posterior and anterior borders are subject to great variation and difficult to study upon dead animals, as further the mastax is wanting, and I have never been able to find the long hairs on the foot of the male, it will be understood that it is very difficult to distinguish the males from each other; only the male of *E. triquetra* is always recognisable.

Euchlanis dilatata Ehrbg.

Male: Cohn 1858, p. 290.
Weber 1898, p. 580.
Tab. IV, fig. 1, Tab. V, fig. 5.

COHN (1858, p. 290, Tab. XIII, fig. 5—7) gives one of the best descriptions and drawings of a male Rotifer which has hitherto been published.

The male is remarkably large, being 260 μ, almost as large as the female, the latter being often only 290 μ. The body is the same as that of the female but the male is much more hyaline. The carapace, the wheel-organ and the foot are formed in full accordance with these organs in the female. On the other hand the whole alimentary canal is lacking. The retrocerebral organ, which is remarkably correctly drawn, is regarded as a brain; no lateral organs; but the dorsal antenna, indicated as "sporn", has been observed. So also are the excretory canals with three or four vibratile tags; it is stated that there exists a contractile vesicle. The testis is described as a long sac with elastic walls. The band which runs from the testis and forwards and which LEYDIG regards as a rudiment of the intestine, is described. A prostata is found. Penis is traversed by a canal, coated with cilia and ends on the first joint of the foot. The sack with light refracting grains over the testis has only been observed in very young animals. Mating process not observed.

WEBER (1898, p. 580) describes the male as follows:

"Le male est morphologiquement identique à la femelle. Il est seulement plus délicat, de taille plus petite et ne possède pas de tractus intestinal. Les organes excréteurs du mâle sont aussi développés que ceux de la femelle et les canaux latéraux se déversent dans une vessie contractile. Le système nerveux, les tentacules et l'organe sacciforme ont la même structure que chez la femelle. La cavité du corps est occupée en grande partie par un longue testicule piriforme. Le penis est court, mais de structure normale. Les glandes prostates sont bien développées. La musculature et les organes excréteurs sont faciles à étudier chez le mâle, à cause de la grande transparence du corps et de l'absence de système digestif." Size of female 290—380 μ, of male 260 μ.

Description. Form of the body the same as that of the female, carapace too almost in full accordance, only a little more hyaline; on the dorsal shield some crests make a peculiar figure which will be better understood when studied in Tab. V, fig. 5; the dorsal antenna is situated where two well marked lines meet each other in the middle lines of the body; laterally, a little from the two posterior corners of the dorsal shield, the two lateral antennæ are found (Tab. V, fig. 5). Ventral plate in the male somewhat larger than in the female; the excavation of the anterior border not so deep as in this sex; foot three-jointed, but when compressed and when the penis is protruded, the segmentation inconspicuous; toes long, well-developed; in my specimens broader than those which are drawn by COHN. I have been unable to find conspicuous foot glands, well-developed in the female sex; also the long tactile hairs seem to be wholly absent. The wheel-organ is highly developed; it consists of a strong ciliary wreath, most probably interrupted dorsally and ventrally; laterally two rather inconspicuous ears; on the disc a median furrow, covered with cilia, terminating in a strong tuft; laterally three pairs of prominences covered with cilia; the two pairs nearest to the furrow; one pair more laterally. The two pairs which are nearest to the median furrow, carry a series of taps, each with a long hair. I have been unable to find the papillæ of the female, mentioned by almost all authors from recent times, and which DE BEAUCHAMP has shown carry the openings of the retrocerebral organ. All in all the wheel-organ of the male resembles that of the female very much. I especially refer the reader to WEBER (Pl. XXI, fig. 21); it is highly interesting, that also in the male we are able to point out the cilia-covered furrow which in the female leads into the mouth, and which may be regarded as closed in the male.

The retrocerebral organ is very large, reaching almost to the middle line of the body; as I have never been able to get a side view of the male, I have not been able to find out if it sends a cul de sac downwards between mastax and brain; the opening outwards I have not been able to see; the organ is filled with numerous areoles which show a polyhedrous structure, caused by pressure. According to DE BEAUCHAMP they derive from the protoplasmatic layer in the bottom of the sac which is due to a vacuolisation of the protoplasma. I refer the reader to the admirable investigations of DE BEAUCHAMP (1909, p. 127). Above the organ is the red eye with a conspicuous lens. On either side of the sac are some large piriform cells

which may most probably be regarded as ganglia cells. Medially through the body is stretched a long, bright band, reaching from the wheel-organ down to the testis, embracing this with two arms. It is a remarkable fact that I have quite distinctly seen, almost in the middle line of the band, on the sides, two pyriform bodies which, according to place and structure, can only be interpreted as gastric glands, only rarely found in the male sex, and not in the other males hitherto known in this genus. I am not quite sure, that the band is not hollow; it seems to contain a number of globules, most probably of oily structure.

Hitherto I have never seen coloured particles, which could be regarded as food in it, but often those bodies which LEYDIG has described as "unverkennbare Reste der Magenzellen, grosse Blasen nämlich, mit Häufchen solcher gelbbrauner Körner welche die Magenzellen aller Rotatorien erfüllen (1857, p. 404)."

The excretory organ with regard to the canals shows great resemblance to that of the female; the number of vibratile tags are three or four; whereas COHN mentions and conspicuously draws a contractile vesicle, I have never been able to observe this; the openings of the canals have not been seen. The large testis, containing a great number of two sorts of spermatozoa, is flanked by two large prostata glands and debouches into a long penis tube ciliated inside and with the opening surrounded by a circle of cilia. Above the testis and shining through the animal is the great globular, hyaline sac-like body, filled with an opaque mass. Size of male 200 μ, of female 260—380 μ.

I have met with this male rather often during the time from April to May. The mating process I have not seen, but it was found in different small pools, where *Euchlanis dilatata* was very common, and where I have never seen other *Euchlanis* species than this one.

Euchlanis lyra Hudson.

Tab. IV, fig. 2; Tab. V, fig. 4.

Description. It is with some doubt, that I have referred this male to this beautiful, but rather rare species; the female is best characterised by the peculiar ventral plate, with its curiously rounded end of the flange, unlike that of any other *Euchlanis*; it is further broadest at the hind end and elliptical in outline; the dorsal plate has no notch behind. In the above-named male the ventral plate had almost straight sides and the posterior edge was slightly excavated, formed in another way than the ventral plate of the female; as the whole form of the male was exactly that of the female, and the male was hatched in the vessel containing the true *E. lyra*, with its characteristic ventral plate, I provisionally refer this male to this species.

There are two auricles, separated from the other part of the ciliary wreath by a short space without cilia; the whole ventrally curved disc was covered with a coating of cilia; dorsally three tubercles coated with long, strong cilia. Fig. 4, Tab. V gives a sketch of the wheel-organ, seen ventrally; as the animal died it was not studied thoroughly enough. The retrocerebral organ was very large, but I could find

no protuberances on the disc into which the organ opened. No gastric glands. Above the large testis was the hyaline sac containing numerous sharply edged, light refracting grains; I got the impression that the two lateral canals opened directly into the sac. This may perhaps be a mistake; it is possible that they turned downwards between the sac and testis and, as might be expected, opened on both sides of the first foot joint, near the opening for the penis; there are three or four vibratile tags upon either side of the lateral canals, but no contractile bladder; with regard to brain, testis, prostata, penis, antennæ, eye, intestinal band and muscle system it is in full accordance with the former species. In the body cavity many oil globules. Size of male 250 μ, of female 450—500 μ.

This species was found rather common in some ditches, covered with vegetation, near Hillerød, time May—June; the male was observed on $^{25}/_{5}$ 1921. I have only seen two specimens, both dying before it was possible to get the wheel-organ fully described; the males appeared in my vessels a week after the samples were taken.

Euchlanis triquetra Ehrbg.

Tab. IV, fig. 3.

Description. The male has quite the same form as the female; the dorsal plate bears the same extremely high crest as that of the female, and as here is laterally expanded; the lateral furrow between the dorsal and ventral plate is very deep as in the female. When Hudson (1889, p. 91) says of the carapace in the female that the crest is formed by a "special high thin vertical plate, which rises like a crest from the dorsal surface", I do not understand him. As far as I can see it is the real dorsal plate which is crested in both sexes; in this way it is also drawn in Hudson's figure (Tab. XXIII, 4 c). The dorsal occipital edge of the male is not or only slightly notched, whereas this is the case with the hind edge; the foot has a structure differing from that of other *Euchlanis* species; it is without any segmentation, peculiarly hairy, and dorsally bears a protuberance, in which the penis opens; the toes are long, acute, possessing rather conspicuous foot glands. The wheel-organ is formed as a ciliary wreath, most probably with an interruption dorsally as well as ventrally; two rather well-developed auricles; ventrally in the middle line the hairs are very long; ventrally on the disc are some elevations, bearing strong bundles of long setæ. When the animal was dying, and the bristles had almost ceased to strike, I got the impression of two series of peculiar curved, membranelles, inserted medially and ventrally on the disc; similar membranelles have been pointed out by De Beauchamp in the female of *E. dilatata* (1909, Pl. I, fig. 5). As well known the female of *E. triquetra* is extraordinarily hyaline, and this holds good if possible in a still higher degree about the male; seen laterally almost all the viscera are visible through the lateral cleft; the retrocerebral organ is very large, filled with polyhedrous areoles; it sends a short cul de sac downwards to the brain where this bears the large red eye; above the organ is a conspicuous hill, bearing the large dorsal antenna. Now and then I think I have seen the protuberances bearing the openings of the retrocerebral

organ, but they have always been concealed under the bristles of the wheel-organ. There are two lateral antennæ. The intestinal band is rather narrow, running from the brain down to the testis which is embraced by it. There is no doubt that this band is really hollow in this species, containing large globules, most probably of oily structure; it may be shown that the band is widened over the largest globules and narrowed in over the smaller ones; no globules are found in any other part of the body than the band; no coloured food is found. The lateral canals are very conspicuous owing to the hyalinity; they bear six vibratile tags each; there is no contractile vesicle; I have with certainty seen the canals open ventrally on the foot. The testis is long, remarkably narrow, flanked by two long pyriform glands; over them are one or two large, hyaline sacs, in those specimens which I have seen, containing only one single globular opaque mass. The muscles, which are wonderfully conspicuous, run as indicated in the figure. Size of male 180 μ, of female 450 μ. The male has been observed several times in May—June.

General remarks.

It will be seen, that the males of the genus *Euchlanis* are highy organised animals, resembling the females in form and structure of the carapace; the wheel-organ is almost in the same stage of development. Characteristic is the remarkably well-developed intestinal band which in *E. dilatata* is provided with gastric glands; in *E. triquetra* it is hollow. There is no contractile vesicle (indicated by COHN for *E. dilatata*). In *E. triquetra* the lateral canals open on the side of the foot. In *E. lyra* I have the impression, that they debouch in the sac, filled with opaque grains; further investigations are here necessary.

Salpinadæ.

The family comprises the two genera *Diaschiza* and *Salpina*; three males of *Diaschiza* and two of the genus *Salpina* are known.

Diaschiza gracilis (Ehrbg.)

Male: Dixon-Nuttall 1903, p. 10.

DIXON-NUTTALL (1903, p. 10, Pl. I, fig. 4a) describes the male

"as a very hyaline, soft, restless male contorting itself into a variety of form, which it is impossible to represent in a drawing. It has a frontal eye, slightly marked clefts, short toes, almost straight, slightly recurved. The sperm-sack fills the greater part of the body-cavity. The three antennæ are to be found in their usual situations. It is without manducatory organs. Length a little more than half that of the female, being 150 μ. Time July."

Diaschiza gibba (Ehrbg.)

Male: Dixon-Nuttall 1903, p. 7.

DIXON-NUTTALL (1903, p. 7, Pl. I, fig. 1a) describes and figures the male.

"It has the same four plates as the female; the setæ on the foot; the three antennæ; the lateral compression, and the frontal eye; all just like the female. In contrast to those of

the female the toes are decurved, sharp and short. A large sperm-sack fills the greater part of the body-cavity; there are no manducatory organs. It is a remarkably large male 233 μ, the size of the female measuring 282 μ. It is described as very soft and flexible, contracting and elongating itself and in fact contorting itself into all sorts of shapes and sizes. Time April—May."

Diaschiza Hoodii Gosse ♂ after Dixon-Nuttall.

Diaschiza Hoodii Gosse.

Male: Dixon-Nuttall 1903, p. 131.

Dixon-Nuttall (1903, p. 131, Pl. II, fig. 5i) has described the male as follows:

"It has the four plates, the usual clefts between them and the cervical eye exactly as in the female. The toes are fairly long in proportion to the trunk, thin and decurved. The sperm-sack fills the greater part of the trunk. It is without manducatory organs. Size 113 μ, that of female 194 μ. Time November."

Salpina spinigera (Ehrbg.)

Tab. V, fig. 2.

Description. Lorica much resembling that of the female. The hind border of the lorica is straight, provided with two strongly curved spines. The wheel-organ, the brain, the eye and the dorsal antenna are in accordance with those of the female; the foot is remarkably well developed, of almost quite the same shape as in this sex. From the testis and to the eye spot, where the mouth is to be found in the female, runs a hollow band in which is a peculiar dark mass, pointed in front. As far as I can see, this is a remnant of the mastax, rudimentary, without any trace of teeth. The testis is very large, globular, provided with a very long ductus seminalis; two prostata glands; the ductus seminalis is coated with long cilia, during the mating process it is most probably turned inside out; the genital opening with a bunch of bristles. Above the testis a globular mass with opaque white, quadrangular grains. No trace of the excretory organ observed; as Weber has observed it in *S. brevispina* it certainly exists; according to him there are five vibratile tags, but no contractile vesicle. A large oil globule is situated dorsally in the posterior part of the body. As in the female it is very difficult to see any trace of the muscle system and like Weber I have not ventured to give any sketch of it. There are two small foot glands. Size of male 150 μ, of female 180 μ. It is only with some hesitation that I refer this male to *S. spinigera*. I have only seen a single specimen found 20/V 22 in algæ carpets in Strødam moor near Hillerød. *S. spinigera* was very common in the sample and during the whole season the main form in the little moor.

Salpina mucronata Ehrbg.

Male: Weber 1897, p. 98.
— 1898, p. 558.
Tab. V, fig. 1.

Weber (1897, p. 98, Pl. 4, fig. 3; 1898, p. 558, Pl. 21, fig. 7) has seen a single male.

"Les formes extérieures correspondent à celles de la femelle; seul l'organe rotatoire paraît plus simplifié. La lorica est très épaisse et granuleuse. Je n'ai pu en déchiffrer l'anatomie interne, l'animal étant mort très rapidement. La cavité du corps est occupée en grande partie par les organes genitaux. La testicule est allongé et s'avance jusque sous le cerveau. Le pénis est long, étroit, et sa gaine apparaît unie; il est également terminé par une couronne de cils raides. Vu l'opacité de la carapace, je n'ai rien pu voir des organes excréteurs, ni de la musculature. Pas trace d'organes masticateurs, ni digestifs.,'

Hudson (1889 II, p. 83) says that Bousfield has seen the male; but there is no description.

Salpina brevispina Ehrbg.

Male: Weber 1897, p. 98.
— 1898, p. 564.

Weber (1897, p. 98, Pl. 4, fig. 4; 1898, p. 564, Pl. 21, fig. 16) has studied the male.

"Le male est légèrement plus petit que la femelle (200 μ). La lorica est bien constituée et ressemble en tous points à celle de la femelle. L'organe rotatoire, le pied et ses glandes ont le même développement que chez la femelle. Les organes des sens sont identiques. Quant au système excréteur, que j'ai réussi à bien voir, vu la transparence de la lorica, il se compose de deux canaux latéraux, portant chacun cinq flammes vibratiles. Les canaux latéraux debouchent de chaque coté du pénis à la base du pied; donc abscence de vessie contractile. Les organes digestifs et masticateurs font complètement défaut. Le testicule occupe la plus grande partie de la cavité du corps; à sa base, on trouve les restes du jaune d'œuf. Le pénis est puissant et long; son enveloppe chitineuse est fortement annelée et se termine par une couronne de cils raides et longs. Time: May."

Description. Carapace rather thick, almost identic with that of the female, only differing a little with regard to the posterior edge; the posterior spines being a little more acute than in the female. The wheel-organ, the brain, the eye, the dorsal antenna, the foot with the toes and the foot glands are of almost quite the same structure as those of the female. From the testis and to the spot where the mouth is to be found in the female, runs a hollow band; in it is a peculiar dark mass, pointed in front. The whole is interpreted as a rudimentary alimentary canal; the dark mass as a rudiment of the mastax, without any trace of teeth. The testis is very large, globular, provided with a very long ductus seminalis, coated with long cilia; the last part, most probably turned inside out, used as penis; a bunch of bristles at the genital opening. Above the testis some large dark masses, differing in form and size in the different specimens. The excretory canals have been observed, they are provided with four vibratile tags; no contractile vesicle; the canals open near the sexual opening. Round the posterior part of the brain a large number of small reddish globules; no muscles traceable. Size of male 150—180 μ, of female 200—250 μ. A few specimens found in algæ carpets 15/V 22 near Hillerød.

General remarks.

It seems as if the males of the family *Salpinadæ* are remarkably large, being two-thirds the length of the female, and apart from the rudimentary alimentary canal

and the want of contractile vesicle as highly organised. This especially holds good with regard to wheel-organ, brain and sensitive organs. The lorica is well developed, corresponding in composition, clefts and thorns with that of female; only it is much softer in the male sex; especially the *Diaschiza* males seem to be very slender animals. The foot and toes are well-developed; the peculiar tuft of hairs characteristic of the genus *Diaschiza* and situated upon the dorsal side of the foot, is also found in the male. The wheel-organ is almost the same as that of the female, but in the centre of the head there are not the projecting lips at the buccal orifice, especially characteristic in *Diaschiza*. In the *Salpina* males a rudimentary alimentary canal with rudiments of mastax without teeth. The two excretory canals are most probably always present with openings near the genital opening. The testis is large, filling the greater part of the body cavity. The genital opening is on the dorsal side of the foot; it is surrounded by cilia.

Cathypnadæ.

The family comprises three genera: *Monostyla*, *Cathypna* and *Distyla*. Curiously enough, though some of the species f. i. *Monostyla cornuta* and *Cathypna luna* belong to the most common Rotifers in ponds overgrown with vegetation, males are quite unknown in this family.

Coluridæ.

The family comprises the two genera: *Colurus* and *Metopidia*; we only know the males of *Colurus bicuspidatus*, *Metopidia lepadella* and *Metopidia solidus*.

Metopidia lepadella Ehrbg.

Male: Gosse 1889II, p. 106.
Harring 1917, p. 534.
Tab. V, fig. 3.

Gosse (in Hudson-Gosse 1889II, p. 106) thinks he has seen the male:

"A minute creature, in form a very long cone, tapering to a point, with two slender toes; in front, quite truncate, with a sharp horn projecting from its forehead. No organisation was visible within, save two conspicuous clear vesicles, side by side in the middle of the body, not at all like oil-globules, being irregularly oblong: nor accidental, being found in each of a large number of individuals, seen at different times. A pair of fine lines ran far down the two sides of the body, and in the hinder part was a large web of thin yellowish tissue. Else the whole seemed structureless and of hyaline clearness. It contracted into a shorter oval figure."

Harring (1917, p. 534, Pl. 91, fig. 1—2)
gives a figure of the male but no description.

Description. Body cone-shaped, without any real lorica, extremely hyaline tapering behind and provided with two well developed toes. A frontal hood, formed as an extremely hyaline plate. Wheel-organ a ventrally placed quadrangular disc, covered with a coating of short hairs, laterally limited by two patches, covered with a similar hair coating; two conspicuous red eyes. The whole body cavity filled with

a greyish mass, containing many small oil globules. In this mass it has only been possible to detect a brain, a large pear-shaped testis with a long ductus seminalis, covered with long cilia. No prostata glands and no protrusile penis observed. Above the testis a hyaline mass, containing many white quadrangular grains. No trace of alimentary canal, excretory organs or antennæ have been detected. There are two foot-glands. Five transversal muscle bands and four longitudinal muscles have been seen. Length of male 50 μ, of female 150 μ.

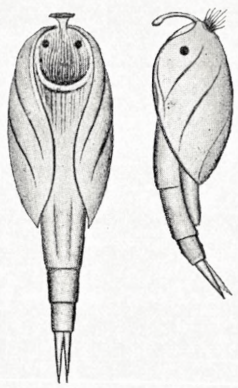
I have only found one single specimen, found 3/V 22. The females were present in millions in the algæ carpets; many eggs were laid but none which could be regarded as male eggs. Some points in Gosse's description are very unintelligible.

Metopidia solidus Gosse.

Male: Wesché 1901, p. 123.

Wesché (1901, p. 123, textfig. 1—4) has observed the female.

It is mainly described as follows. Carapace not well defined, without the smoothness and symmetry that characterises the lorica of the female; an anterior and posterior edge is observed: form somewhat oblong or rounded. As in the female the foot is divided into four segments. At the end of the second from the base is the ciliated orifice of the penis, while the fourth carries the toes, the joint in the middle of the foot is not so flexible in the female, the toes are pliable and sometimes take a well-defined curve which shows on the lateral view. The "Cowl" or "Pick" on the front is well developed; two eyes are visible, the cilia are long, arranged as in the female. Dorsal antenna is well defined; lateral antennæ approximately in the same place as in the female. Owing to the presence of oil globules, and the denseness of the lorica only little of the internal structure could be seen. No lateral canals of the vascular system are observed; a testis with spermatozoa was found. In one specimen a transparent sac was seen in the dorsal region; this is interpreted as the remains of a digestive system. Time February. Size 113 μ. As the size of the female is 140 to 170 μ the male seems to be remarkably large.



Colurus bicuspidatus ♂ after Weber.

Colurus bicuspidatus Ehrbg.

Male: Weber 1898, p. 623.

Weber (1898, p. 623, Pl. 22, fig. 19—20) is the only one who has seen the male.

"La lorica est semblable à celle de la femelle, mais les bords ventraux des deux plaques de la carapace sont moins convexes, moins repliés sous la face ventrale et laissent entre eux une fente assez large, même dans sa région moyenne. Le bord dorsal des sillons céphalique et pédieux n'est pas échancré. La lorica, moins résistante que celle de la femelle, est marquée de deux plis transversaux obliques et parallèles. Le pied est comparativement plus long et plus vigoureux que celui de la femelle. Il est tri-segmenté et se termine par deux doigts pointus, relativement plus courts que ceux de la femelle. Le pénis fait saillie hors de la lorica, à la face dorsale du pied. Le bouclier céphalique est semblable à celui de la femelle, mais plus étroit. L'organe rotatoire ne comprend qu'une couronne ciliaire. La tête porte deux petits yeux latéro-frontaux. Le tentacule dorsal est bien visible. Time: August."

General remarks.

The males of this genus seem to be smaller than the females, much more slender and more hyaline. The characteristic chitinous arched plate or hood which surmounts the head in most of the species, is found again in all the males, but a real lorica is but faintly developed. The foot and toes and the two red eyes are in accordance with those of the female. The wheel-organ is mainly a circular or quadrangular, ventrally situated disc, without any special development of the hairs bordering the disc. No sign of an alimentary canal have been found nor of an excretory organ; the testis is large; at the second joint of the foot is the opening for the penis.

Fam. **Dinocharidæ.**

The family comprises the four genera: *Polychætus*, *Dinocharis*, *Scaridium* and *Stephanops*. WEBER has described the males of the two genera *Dinocharis* and *Scaridium*.

Very often I have seen large maxima of *Dinocharis pocillum*, two times of *Stephanops lamellaris* and several times of *Scaridium longicaudum*. Curiously enough I have never seen the males. In the following are given the descriptions and figures of WEBER.

Dinocharis pocillum ♂ after Weber.

Dinocharis pocillum (O. F. M.).

Male: Weber 1897, p. 96; 1898, p. 523.

WEBER (1897, p. 96, Pl. 4, fig. 5; 1898, p. 523, Pl. 20, fig. 11) has observed the male.

"Il est beaucoup plus petit que la femelle, il est aussi plus agile. Carapace grice, opaque et mal définie. On n'observe plus la carapace à facettes de la femelle; le corps a une forme plus arrondie. Le grand pied à éperons et long doigts, de la femelle, est considérablement réduit. Ici, le pied est droit, cylindrique, a quatre segments et terminé par deux doigts entre lesquels se trouve une épine courte. La tête est assez développée, protégée par la cuirasse, à couronne ciliaire simple. Cerveau peu visible, portant l'œil; au-dessous de ce dernier se trouve le tentacule dorsal. Je n'ai pas observé de tentacules latéraux. Testicule arrondi; pénis épais, sortant entre le pied et la carapace. Deux globules de jaune d'œuf sont faciles à voir à la base du testicule. On distingue les deux canaux latéraux de l'organe excréteur, mais je n'ai pu découvrir de flammes vibratiles. Seul les muscles du pied sont visible. Time: July.«

Scaridium longicaudum ♂ after Weber.

Scaridium longicaudum Ehrbg.

Male: Weber 1897, p. 97.
— 1898, p. 529.

WEBER (1897, p. 97, Pl. 4, fig. 1; 1898, p. 529, Pl. 20, fig. 16) has observed two males.

"Le male diffère passablement de la femelle... Le pied est court, cylindrique, à quatre articulations et terminé par deux doigts légèrement recourbés. La lorica est faible et a la forme d'un cône tronqué à sa base, au niveau du pied, et présente une sorte de capuchon recouvrant la tête. Le corps, vu latéralement, a la surface ventrale droite, la surface dorsale

bombée et déprimée vers la tête. L'organe rotatoire est muni de touffes de longs cils sensitifs raides et ressemble à celui de la femelle. On apercoit, comme chez la femelle, une sorte de capsule transparente sur laquelle repose l'œil. Le testicule occupe une grande partie de la cavité du corps, le pénis est long, mince, terminé par la couronne de cils et entouré d'une forte gaine chitineuse qui s'étend parallèment au pied et va de la lorica au deuxième anneau du pied; la queue est rayée transversalement. Je n'ai pu voir ni organes digestifs, ni organes excréteurs. Ce mâle est vif et saute à la façon de la femelle. Les muscles du pied sont au nombre de deux paires. Time: July."

Ploesomatidæ.

The family contains one single genus *Ploesoma* with four species: *P. hudsoni* Imh., *P. triacanthum* Berg, *P. lenticulare* Herrick and *P. truncatum* Lev. The males are unknown. With regard to *P. hudsoni* Wierzejski and Zacharias (1893, p. 236) only write that:

Zacharias has observed the male. "Es zeichnet sich durch einen zehenlosen Fuss aus, der wahrscheinlich als Copulationsorgan fungiert. An seiner Ursprungsstelle befand sich eine mit Samen gefüllte Blase."

Ploesoma Hudsoni Imh.

Tab. XIV, fig. 5—6.

Description. Body with parallel sides; somewhat flattened, a little broader behind, covered with a conspicuous lorica; dorsally provided with a series of thicker, parallel longitudinal lines, two of which forming ellipses open anteriorly; ventrally with a system of transversal ridges in a number of four round a little plate, behind which most probably lies the opening for the penis. No foot observed; in swimming it is always retracted, and I never succeeded in seeing it come out by means of pressure upon the cover. In its anterior part the lorica dorsally bears medially a rather stout tag and laterally some smaller indentations. Wheel-organ a ciliary wreath with rather conspicuous auricles, surrounding a disc, which, when fully expanded, presents some peculiarities; in the middle a cushion-shaped elevation, covered with short cilia and laterally two protuberances, carrying a tuft of long cilia; ventrally on the disc two long, thick fleshy club-shaped antennæ. The whole body quite untransparent, greyish, filled with a peculiar granular mass, in which are imbedded large quantities of oil-globules; of those, one especially is always present; this globule, which is lying dorsally in the posterior part, and medially, is very large; the peculiar foam-structure of the lorica in the female has not been observed in that of the male.

Owing to the intransparency of the body, only very little of the internal structure is seen. No brain is observed; only a dorsal antenna; laterally in two skin folds are seen two strong, single sensitive hairs, long and stiff. Seen ventrally the relatively small testis with the two sorts of spermatozoa has been pointed out, but I have not succeeded in finding the ductus seminalis and a penis; also the whole excretory organ has been undiscoverable. Above the testis is a large globular mass, containing a number of sharp edged opaque grains. No muscle system was observed. Size of male 80 μ, of female 400—500 μ. Time 23/VIII 21.

I found the species in enormous masses in a little lake: Klaresø near Hellebæk, North Seeland; there were many pelagic eggs found by ZACHARIAS (1893, p. 35) and APSTEIN (1896, p. 160). Male eggs were not observed. In the samples which besides contained only *Rattulus stylatus*, *Brachionus militaris*, *Polyarthra platyptera*, *Synchæta pectinata* and *Gastropus stylifer*, the male was rather common; it was unquestionably hatched in my vessels and could not be referred to other species than *Ploesoma*, which was the most common species.

Gastropodidæ.

In my opinion the fam. *Gastropodidæ* comprises the four species: *G. clavulatus* (Ehrbg), *G. hyptopus* (Ehrbg), *G. minor* Rouss. and *G. stylifer* Imh. Of these species *G. clavulatus* and *G. hyptopus* together with *Notops brachionus* are referred to the genus *Notops* under the fam. *Hydatinidæ*. In the descriptions I find but very little conformity between these two first named species, but as I have never had the good luck to find the large and rare *G. clavulatus* I do not venture to alter their systematical position. If my supposition should be correct the genus *Gastropus* should be divided into two genera one of which should contain *G. clavulatus* and *G. hyptopus*, the other *G. minor* and *G. stylifer*.

The males of this family have hitherto been almost wholly unknown; there exists a very cursory sketch of the male of *G. clavulatus* by Western, and a figure and description of *G. hyptopus* by Wesché, but this differs very much from that which I shall give in the following pages.

Gastropus clavulatus (Ehrbg.).
= **Notops clavulatus** Ehrbg.

Male: Western. 1892, p. 374.

WESTERN (1892, p. 374, Pl. 25, fig. 6) has given the following description of the male:

The general contour is that of the female even to the deep furrow at the posterior extremity. . . . There is no sign of the foot; the digestive organs are totally absent. No vascular canal, vibratile tags and contractile vesicle are observed. A large sperm-sack. A large ganglion or brain carries an eye spot on its ventral side, and numerous nerve fibres may be traced from it to various parts of the body. The males were hatched from small white eggs. Size $^1/_{40}$.

Gastropus hyptopus (Ehrbg.).
= **Notops hyptopus** Ehrbg.

Male: Wesché 1902, p. 327.
Tab. VI, fig. 3—5.

Wesché (1902, p. 327, Pl. 17, fig. 3) gives the following description of the male:

"The male has much the same shape as the female, i. e. a rather globular sack. The head is defined by folds of skin which can be traced on the surface. The body is globose, with a tough skin, which it requires some imagination to describe as lorica. There is the folds of skin on the dorsum. Strictly speaking the foot is absent, but its place is occupied by the penis. The cilia are very long and filiform. The brain is exceedingly large, and comes down

in an elongated mass from the front. At its lower extremity a very large reddish-black granular mass seems to concentrate into a dark-red eye on the ventral side. Four powerful muscles are attached to the brain and cilia. The antennæ are as in the female. There are some minute glands below the orifice of the penis on the ventral side. A curious circular gland, connected with the brain by a long muscle, may have some relation to the contractile vesicle. The penis, which is rather long, is ciliated and kept retracted. On pressure being applied it was protruded through an opening which corresponds with the orifice of the foot in the female. I was able to see the spermatozoa individually in the spermatheca." Size male 127μ. Time: Marsh.

Description. Body peculiarly shaped, trunk fish-formed, resembling that of the female; as in the female without any conspicuous lorica, but with the same longitudinal keels and furrows along the dorsal edge of the trunk; here the skin seems thicker than in other parts of the body; a very short, truncate foot which can be wholly retracted into the skin. The whole animal very hyaline. The wheel-organ consists of a ciliary wreath, without the two styli characteristic of the female; on the disc which is rather flattened and not protusile as in this sex, stand a number of bunches of long bristles; also the whole alimentary canal is absent. The brain is large with a large red eye; behind this a large, reddish-black mass. Two nerves to the dorsal antenna and two lateral antennæ. Lateral canals with three or four vibratile tags; no contractile vesicle. Testis very large, almost globular with a peculiar form; two prostata glands and above them two peculiar irregularly formed cells, connected with the testis and moving together with it and almost incessantly. A peculiarly shaped foot hardly ever seen during swimming; it is undivided and has no toes; dorsally is the opening for the penis which, when fully stretched out, is much larger than the foot, this being placed laterally, only as a small appendix. The testis opens into a ductus seminalis which is coated with cilia and ends in a bunch of cilia. Above the testis many oil globules. There are five transversal muscles, running from the dorsal keels downwards; four pairs of longitudinal muscles for the wheel-organ and two short muscles for the foot. The males resemble young, newly born females very much. Size of male 80 μ, of female 360 μ. Time 1/V 21.

As will be seen, there is not the best harmony between Wesché's description and mine; Wesché has observed the place of the antenna; what he regards as a gland connected with the brain and what he supposes to have some relation to the contractile vesicle, I do not know; his description of the penis differs very much from what I have seen.

Gastropus stylifer Imh.

Tab. XIV, fig. 2—3.

Description. Body elliptical, attenuated behind with a rather thick lorica; hyaline, no strongly marked colours. A dorsal plate carrying medially and anteriorly a shield-like structure with parallel sides and an acute point. The wheel-organ which is wholly retractile, consists in a ciliary wreath, contouring a disc which carries some bunches of cilia and as far as I have been able to see one single digitiform thick fleshy antenna. A large brain upon which I have been unable to

see any eyespot, but over the forepart of the brain two bright double, contoured light refracting spots, which are most probably openings from a retrocerebral organ which has not been observed. Neither dorsal nor lateral antennæ observed; nor excretory organs; alimentary canal seems to be wholly wanting. A large piriform testis, containing two sorts of spermatozoa, ending in a ductus seminalis coated with cilia and with a tuft of small cilia at the opening, this situated somewhat ventrally; large prostata glands. When swimming the animal shows no peculiar structural features behind, but when it is pressed below the cover a little tap appears, provided at its tip with a styliform body, perhaps a seta. In this tap lies a rather large gland-like body, immediately over which the prostata gland lies. I regard this tap as the rudiment of a foot, and the gland as the foot gland. Above the testis lies a very large light refracting oil globule and between it and the brain a large globular opaque body, containing numerous sharply edged small bodies. Only a few longitudinal muscles have been seen. At a first glance and, when the animal is swimming, the whole body is almost quite opaque, filled as it is by a greyish mass with many small oil globules. It is only by means of pressure that the internal structure has been somewhat elucidated. Size of male 80 μ, of female 170—200 μ. Time 1/VIII 21. In a plancton sample which only contained this species, *Polyarthra* and *Synchæta*, 10 specimens of the above described peculiar male appeared.

Ascomorphidæ.

This little family comprising the two genera *Ascomorpha* and *Anapus* may best be connected with the fam. *Gastropodidæ*; DE BEAUCHAMP refers the genus *Ascomorpha* to this family. It differs from it in very essential points; its systematic position and restriction has always been difficult; owing to want of foot it was formerly referred to the fam. *Asplanchnadæ*, with which it has no affinities at all. It comprises such different forms as *Ascomorpha (= Sacculus) viridis* Gosse; *Ascomorpha saltans* Bartsch (= *A. agilis* Zach). Also the genus *Anapus* is referred to this group.

In my opinion the whole group is very unnatural. The *Ascomorpha (= Sacculus) viridis* Gosse has only slight affinities to the other *Ascomorpha*-species. *A. saltans* Bartsch, which is perhaps identic with *A. agilis* Zacharias is well known to many planctologists, but almost unknown in the literature relating to Rotifera; the genus *Anapus* differs in all essential points from *Ascomorpha*.

Sacculus viridis is common in the vegetation zone of smaller ponds; it carries its eggs, female as well as male eggs.

Ascomorpha saltans and the genus *Anapus* with the two species *A. testudo* Lauterb. and *A. ovalis* Bergend. are all typical plancton organisms in the pelagic region of smaller lakes, but especially in the central free parts of ponds. The species prey upon the Dinoflagellata (*Ceratium hirundinella*, *Peridinium*), which they suck out, whereupon the empty hyaline carapaces fall to the bottom. Their maxima coincide with those of the *Dinoflagellata*. The eggs are laid upon other plancton organisms, especially *Uroglena volvox*. In my opinion the genus *Anapus* may be

referred to a special family. As far as I can see an anus is wanting, as well in the *Ascomorphidæ* as in *Anapodidæ*; characteristic of both is a thick fleshy antenna, situated on the disc of the wheel-organ.

I hope I shall later on be able to return to these very interesting and but slightly studied animals. The males are almost quite unknown. Of *A.* (= *Sacculus*) *viridis* Gosse (1856, p. 320, Pl. XV, fig. 26) has given a small but rather good drawing of the male: He only says: "I could not detect any eye, nor any internal organization; nothing but a confused assemblage of granules and globules; even the ordinary opaque masses were not present. The form somewhat resembled that of an amphora with a short wide neck; the frontal cilia were very large, but the motion was not rapid, nor was the animal wild as male Rotifera usually are. Female $\frac{1}{150}$ in., male $\frac{1}{270}$ in.

I have often had females with male eggs and hatched the males; these commonly appear in spring; the males are extremely small; I have always failed in getting a good drawing of them. Tab. XIV, fig. 4 gives a little sketch of the animal.

Pterodinidæ.

The family comprises the two genera: *Pterodina* and *Pompholyx*; the males of the genus *Pompholyx* have hitherto been unknown; of the genus *Pterodina* only Rousselet and Marks & Wesché have described the males.

Pterodina elliptica Ehrbg.

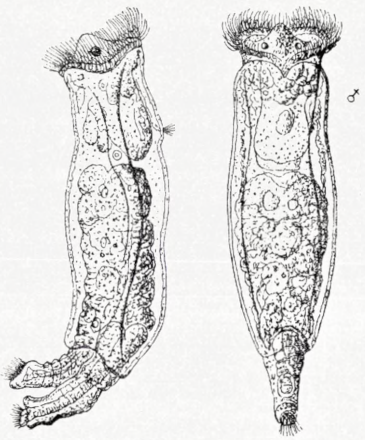
Male: Rousselet 1898, p. 27.

Rousselet (1898, p. 27, Pl. IV, fig. 4 e, f.) writes.

"In outline it is very narrow, elongated, and quite unlike the female. It has a decided, but rather soft, lorica and two red eyes in front, but is devoid of jaws. The copulatory organ projects dorsally above the foot, which is of usual structure and ciliated at the end. Size of male 127 μ, of female 136 μ."

Weber (1898, p. 653) only states

that the male has been observed by several naturalists.



Pterodina elliptica ♂
after Rousselet.

Pterodina patina Ehrbg.

Male: Marks & Wesché 1903, p. 509.

The Male has been observed by Marks & Wesché (1903 p. 509, Pl. 26, fig. 3).

"Seen laterally, rather vermiform, resembling a young *Proales petromyzon*. Dorsally, somewhat broad, but having no approximation to the plate shape of the female. Head, rather short, without quasi-auricles as in female; constriction of neck not well marked. Body, rather broad, but fairly long; edge of carapace visible laterally, and two folds on the posterior sides, when viewed dorsally. The two muscles, so prominent in the female, and used to retract the head, are present and well marked, and best seen on the dorsal view. Foot, short, stout, retractile, with a gland at the extremity. Toes, none. Cilia, moderately long. Brain, large, occupying all the head and sending

a long process to the dorsal antennæ. Eyes, two, red and well marked. Antennæ, all three in the centre of the body, almost in a line. Setæ very fine and difficult to make out. Digestive system, represented by a hyaline membrane, appearing to be in an atrophied condition. Vascular system, faint; no contractile vesicle seen. Generative system, very large; spermatozoa masses in testis; orifice of penis slightly ciliated and situated down the dorsal side of the foot; no granular masses as in Brachionus. Size male 127—135 μ. Time May 12th."

ROUSSELET (1908, p. 27) says that,

according to a letter to him, BILFINGER has observed the male, which agrees with that of *P. elliptica* in every particular.

It seems that also DIEFFENBACH (1912, p. 196)

has seen it and confirms the above named observation.

Though I have seen very large maxima of *P. patina* especially in the winter season I have failed to get the male.

Pompholyx sulcata Hudson.

Tab. XIV, fig. 1.

Description. Body globular, without the four longitudinal furrows, characteristic of the female; the skin very soft, no regular lorica; a dorsal surface slightly separated from the ventral one by means of a rather indistinct line, ending round the opening for the testis. Near the forepart of the body a transversal line; before it the chitine folded longitudinally, so that the body, seen from the front, when the wheel-organ is drawn in, is crater-shaped. The wheel-organ consists only of a single row of rather short cilia; as far as I have been able to see, the disc is not bare as in the female, but covered with cilia. The band of cilia encircles the disc without any interruption ventrally in the middle line.

Below the ciliary wreath a series of indistinct hypodermal cells; a large brain, carrying two red eyespots, each with a lens, situated in a spot, corresponding to that of the female. I have not been able to see either dorsal or lateral antennæ; as far as I know, they have never been observed in the female either. There is not the slightest trace of an alimentary canal; nor have I seen any part of the excretory organ. There are two pairs of rather conspicuous muscles, running from the forepart of the wheel-organ, one pair fastened near the middle of the body, the other nearer to the hindpart. The whole animal seems to consist almost entirely of an extremely large pyriform testis, filling more than two thirds of the body cavity. Scattered over and round the testis are large oil globules, different in number and size; the testis itself contains rather few spermatozoa; I have hitherto not seen any of the staff-formed ones. No prostata glands are found, and I have seen no penis. When strongly contracted the body tapers behind, into two small tubercles, limiting the opening for the testis; this opening is rather large and encircled by a row of short cilia. Size of male 40 μ, of female 90 μ. Time 25/VIII 21. I have never seen the copula, but very often observed the male rotating round the female. The males were hatched in great numbers from the male eggs, carried by the females in my vessel.

Pedalionidæ.

The family comprises the three genera *Triarthra*, *Tetramastix* and *Pedalion*. The males of the peculiar genus *Tetramastix* first described by ZACHARIAS 1898 (p. 132) and later by ROUSSELET (1906, p. 431) are unknown.

PLATE has described the male of *T. breviseta*, but the description is very short and no figure is given. WESCHÉ has figured and described a male, which he refers to *T. longiseta*, but whatever WESCHÉ has found, it is very difficult to understand that it is a male of the genus *Triarthra* he has observed.

Triarthra longiseta Ehrbg.

Tab. XV, fig. 1.

ROUSSELET (1903, p. 176)

has observed the male but there exists no description).

WESCHÉ (1902, p. 325, Pl. 17, fig. 1 a, b) has perhaps seen the male.

"The head is well defined, and its limits are marked by several folds of skin. The body is broad and stout. The foot is well separated from the body, without toes, but with two short setæ on the orifice of the penis, which goes down to the extremity of the foot... There is a large brain with a conspicuous sub-circular eyespot. Four powerful muscles are attached to the brain and cilia... The dorsal antenna is connected with the brain by a flexible tube. The lateral antennæ are well marked, and have the usual tapering gland, noticeable in the female. There is no trace whatever of a digestive system. The lateral canals are well marked, and the contractile vesicle large. The skin is thick, but flexible. A large spermatheca tapers down to the end of the foot, which practically forms the penis. Size 70—90 μ. Time: February."

Description. Body elongate, attenuated behind, soft, hyaline, two or three times slightly constricted. The wheel-organ a closed ciliary wreath without any tongue-like projection ventrally. In the middle of the disc a peculiar broad rectangular projection of a proboscis-like appearance; it is covered with a coating of very short hairs and, near its base, bears the two semiglobular red eyes, each with a lens. There is a brain, but no retrocerebral organ; neither dorsal nor lateral antennæ have been observed. Only a large pyriform testis is found, containing two sorts of spermatozoa and ending in a long "penis" tube ciliated in its interior. During the pairing-process the body behind is acuminated; in this and in the following species the penis is really only the acuminated hindpart of the body. Near its opening this latter bears two small chitin-pieces, which can be folded in and out; there is no ciliary wreath round the opening, but a little above it two strong sensitive hairs. Round the testis two prostata glands. A faintly developed system of longitudinal muscles has been observed, but no conspicuous transversal muscles. The body is extremely flexible, when not compressed much, more globular than the drawing shows, but during the mating process still more attenuated behind. The body contains very many oilglobules often arranged in a half circle round the testis. Size male 80 μ, female about 170. Time 15/V 21.

As mentioned above WESCHÉ has described and figured the male; according to the figure, with regard to the opening for the penis, it may be regarded as pos-

sible, that he really has observed the male, but besides it must be emphasised that some main points in the structure have been overlooked or uncorrectly interpreted. This especially holds good with regard to the proboscis-like projection, within the ciliary wreath. WESCHÉ further indicates one single eye. It is highly remarkable, that he has further found dorsal and lateral antennæ, excretory canals and even a large contractile vesicle and a foot well separated from the body; neither PLATE nor myself have in any of the males belonging to this genus been able to see anything of this kind. The contractile vesicle indicated by WESCHÉ in his text is not found in his figures.

In the sexual periods the males occur in great numbers and may then be caught in the lighted borders of the vessel.

Triarthra mystacina Ehrbg.

Tab. XV, fig. 2.

Description. The male resembles that of *T. longiseta* very much. The proboscis-like projection is much shorter; I have been unable to find any organs but the very large testis and the two red eyes; no prostata glands: the penis is shaped as in *T. longiseta* but no sensitive hairs have been found. Size of male 70 μ, of female 200 μ. *T. mystacina* is extremely common in smaller ponds. During the two maxima April—May and Sept.—Oct. the males occur in great numbers.

Triarthra breviseta Gosse.

= **T. cornuta** Weisse.

Male: Plate 1886, p. 21.
Tab. XV, fig. 3.

PLATE describes the male as follows.

"Die Männchen haben ungefähr eine Grösse von 0,08 und in der Gestalt viel Ähnlichkeit mit den Männchen der noch zu bescreibenden *Hertwigia volvocicola*. Sie sind cylindrisch, besitzen vorn einen Cilienkranz, über den die Cuticula, ohne weiter bewimpert zu sein, halbkugelich vorspringt. In den daselbst gelegenen Matrixverdickungen, vielleicht auch in Verbindung mit dem grossen Gehirn, sitzen zwei rote Augenflecke, die wie bei den Weibchen deutliche lichtbrechende Körperchen erkennen lassen. Nach hinten verjüngt sich das Tier, und da der enge, flimmernde Ausführgang des Hodens am aboralen Körperende ausmündet, dient dieses zugleich als Penis. Gehirn und rudimentärer Darm bieten nichts Bemerkenswerthes. Tastbüchel, Wassergefässe und contractile Blase habe ich bei der steten Beweglichkeit des Tierchens vergebens gesucht."

Description. The male resembles those of the just described two species very much, but the proboscis-like projection is very short, often rising only a little above the ciliary wreath. Of inner organs I have only been able to observe the brain and the very large testis. The penis is very short; the peculiar chitin staffs in the two other species I have not found here. Size of male 60 μ, of female 120 μ.

As mentioned above PLATE has seen the male, but gives no figure; his description and mine agree fairly well.

The species is rather rare. On 17/V 21 I had the good luck to get a sample from a little outdrying pond near Hillerød, containing a maximum of this charming little creature, some of the specimens carried male eggs, and from them the male was hatched.

Pedalion.

The old order *Scirtopoda* originally contained only the genus *Pedalion* with the two species *P. mirum* Huds. and *P. Fennicum* Lev. In 1899 (p. 142) I referred *Triarthra* to the fam. *Pedalionidæ* and DE BEAUCHAMP (1909, p. 41) has adopted this view. One of the most striking structures in *Pedalion* are the two stylate ciliated appendages on the posterior dorsal surface, unique in Rotifera. As they are totally absent in *Triarthra* it should really be regarded as rather hazardous to refer *Triarthra* to this family, but as these appendages are also totally absent in one of the two known species of *Pedalion P. Fennicum* Lev. they seem to have no particular systematic value.

Pedalion mirum Hudson.

Male: Hudson-Gosse 1889 II, p. 133.
Tab. XIV, fig. 7—8.

HUDSON GOSSE (1889 II, p. 133, Pl. XXX, fig. 1 h, 1 g).

The male is the merest caricature of the adult female. The large shapely corona, with its flowing curves has become a ciliated knob; the six limbs, with their fan-shaped plumes, have been altered into three little stumps, with a bristle or two at the end of each; even the huge ventral limb has vanished, and the whole creature has shrunk up to barely one-fifth of the length of the adult female. It swims very differently from its mother; for it spins constantly round its own length, like a joint on a spit, while at the same time moving forward. Now and then it jerks its side limbs, and it uses them to free itself from its shell. There are two longitudinal muscles for retracting the head and a pair of red eyes, but I could discover no other internal organs except the testis and penis. This latter I have seen protruded to a length quite equal to that of half the animal. Size: female $\frac{1}{120}$ inch, male $\frac{1}{570}$.

Description: The male is remarkably broad, almost globular with the forepart rather sharply removed from the other part of the body; directly backwards protrudes dorsally a thick humpback-like protuberance; laterally two others are found; these protuberances differ in form in the different specimens and most probably in the same specimen; they may be rather broad, faintly acute, very broad at base with a sharply defined wing-like outer part; they end in a bunch of about five very short bristles. Seen from above, the body is rounded behind. The wheel-organ consists only of a ciliated disc, the marginal cilia of which are somewhat longer than those in the middle of the disc. Of internal organs I have only been able to observe a large brain with two curved red pigment spots, each with a lens and a very large globular testis, containing comparatively few spermatozoa of both sorts. There are no prostata glands. The penis is remarkably long, almost half the length of the body, traversed by a long canal, covered with cilia; at the apex a wreath of short cilia. If the penis in this genus too, is really only the posterior part of the body, drawn out when it is to be used as a pairing organ, or if it is a real organ, concealed in

the body, I do not know; when the animal swims, it seems as if it is wholly withdrawn into the body. At all events the ductus seminalis may be able to be elongated and again abbreviated in a very high degree. Size of male 50 μ, of female 350—400 μ. Time 25/VIII 21.

As mentioned above, only HUDSON has seen the male; our descriptions and drawings agree rather well; I have however never seen such long setæ as HUDSON describes and figures; also the penis is much thicker. It will be understood, that the male is extremely reduced; of the six "limbs" only three are present and these only transformed into very short, fleshy protuberances with a few stiff bristles. The two ciliated straight processes behind on the body of the female are totally absent in the male.

In the sexual period in August the males are extremely common.

General remarks.

Common to all the males belonging to this family is the extreme reduction; the wheel-organ consists of a wreath of cilia, encircling a disc covered with cilia, in *Triarthra* provided with a proboscis-like organ, but dorsal and lateral antennæ have not been observed. There are two eyes, a brain. Of inner organs only the testis has been observed. Perhaps in all species the hindpart of the body is acuminated during the paring process and then used as a penis.

Melicertidæ.

Of the Melicertidæ genera the males are quite unknown in the genera *Oecistes*, *Limnias* and *Cephalosiphon*; also the males of most of the other species are very badly described; well known is only the male of *Lacinularia socialis*, described by HAMBURGER.

Conochilus volvox Ehrbg.

Male: Cohn 1862, p. 205.
Hlava 1908, p. 28.
Tab. XV, fig. 4—5.

COHN (1862, p. 205, Tab. 21, fig. 16—19).

Die Gestalt lässt sich mit einem langen Sack vergleichen der vorn abgestumpft ist, nach hinten kreiselförmig sich etwas verjüngt. Das vordere Kopende trägt den flimmernden Wimperrand, der jedoch weniger ausgearbeitet ist, wie bei den Weibchen;.. der Stiel und Fuss läuft in einem Wimperbuschel aus. Verdauungsapparat fehlt ganz; das Wassergefässsystem wurde nicht deutlich, ist aber wohl vorhanden; Gehirn grosz, eiförmig; zwei rothe Augen mit brechender Linse und Pigmentumhüllen. Ein grosser birnförmiger Hoden mit den Spermatozoiden vollgestopft. Der Hoden führt in einen Samenleiter, der nach aussen in einen besondern Penis mündet; Höhle und hinteren Rand desselben flimmern.

HLAVA (1908, p. 28, fig. 9 D).

"Das Männchen ist klein walzenförmig. Die Krone ist einfach, in der Mitte des Räderorgans erhebt sich ein stumpfer, zwei hellrote Augen tragender Kegel; die Augen sind mit

deutlichen Linsen versehen. Verdauungsapparat fehlt; anstatt desselben ist ein umfangreicher Hoden entwickelt. Penis ist kurt und liegt auf der Dorsalseite nahe bei dem Körperende; dieses ist verengt und bewimpert". Size of male 50 μ, of female 500 μ.

Description. Male conical about four times broader in front than behind; wheel-organ an apically placed disc, encircled by a row of cilia. In the middle of the disc a cone-shaped projection, covered with short cilia and provided with two red eyes with well-developed lenses. The interior of the body a greyish mass which only allows of a very superficial study. The brain is undoubtedly present but its contours only faintly observable. Not the slightest remains of an alimentary canal or excretory organs have been observed. There is a large pyriform testis and a ductus seminalis, covered with cilia in its interior; there are two well developed foot glands. The genital opening apically; it is surrounded by cilia; the last part of the ductus seminalis may be turned inside out and during the mating process the body acuminates. I have not been able to see the slightest sign of transversal muscles, but according to the movements of the animal, they are undoubtedly present. Of longitudinal muscles only two slanting muscles have been observed. In the greyish homogeneous mass are imbedded a lot of smaller and larger oil globules; most conspicuous are a few very large ones, commonly situated dorsally before or above the testis. Size of male 50 μ, of female 600—650 μ.

On 27/IV 22 colonies of *C. volvox* were found in which resting eggs as well as very minute eggs were found. The next day extremely minute creatures were found encircling the coronas of the females. They were isolated and ascertained to be males. They were incredibly variable in form. Encircling the coronas of the females, they bent the body in all directions simultaneously; it looked as if they were dancing a regular cakewalk round the selected individuals of the colonies; often more than twenty males simultaneously encircled a single colony; then it very often happened that two males butted against each other and then were flung out of their orbits, away into the "empty" space, where they whirled round restlessly till they again touched a colony in one of their large circles. I have tried in fig. 5 (Tab. XV) to give a sketch of such a spasmodic male; it will be seen that the ductus seminalis has been turned inside out and the cilia, now covers a distended ballshaped mass, upon the tip of which the genital opening is seen. For a moment the males were often fastened to the corona or directly below it; most probably this was the pairing act, but it did not last more than a fraction of a second.

Conochilus unicornis Rouss.

Male: Rousselet 1892, p. 276.
Hlava 1908, p. 28.

Rousselet (1892, p. 276, fig. 6) writes.

"The male is a small pear shaped creature, with a small ciliated head and a large wreath of cilia just below on a wider shoulder. Two red eyes in the head are conspicuous; the body cavity is wholly taken up with the spermsack, and the pointed lower end is ciliated as usual."

Hlava (1908, p. 28, fig. 10 c) writes:

"Das Männchen ist klein, birnförmig; der Kopf ist klein, bewimpert und ragt auf dem verbreiteten vorderen Körperende empor; die Krone ist einfach und mit langen Wimpern versehen. Zwei rothe Augen deutlich. Der Hoden ist mächtig und nimmt die ganze Leibeshöhle ein; das verengte Hinterende ist bewimpert."

Conochiloides natans (Seligo).

Male: Hlava 1908, p. 34.

Hlava (1908, p. 34) writes:

Das Männchen ist kegelförmig, farblos; das Vorderende des Körpers ist kegelförmig erhöht und auf dieser Erhöhung befinden sich zwei rote, mit deutlicher Linse versehene Augen. Die Krone ist einfach. Die Spermatozoen sind ungemein gross, und der Hoden nimmt den grösseren Teil der Leibeshöhle ein. Das hintere Ende des Körpers ist bewimpert. Size male 80—100 μ, female 300—500 μ.

Megalotrocha alboflavicans Ehrbg. ♂ after Hlava.

Megalotrocha alboflavicans Ehrbg.

Male: Anderson 1889, p. 348.
Hlava 1908, p. 38.

Anderson (1889, p. 348, Pl. 20, fig. 3) writes:

"The males were moving in and out of clusters of the female, but I did not see actual connection. There is a certain amount of resemblance to the male of *Lacinularia*, the chief difference being the presence of a very large, clear, circular space, situated in front of the sperm sack which had all the appearance of a contractile vesicle, though I did not see any contraction. The body is cylindrical with a foot projecting from the lower side. The foot glands are very large; the large nervous ganglion has branches to the antenna and to the two eyes, and one proceeding backwards embracing the top of the contractile vesicle. The integument, which is very transparent, occasionally takes the ringed appearance noted above as occurring in the female. There is a regular network of muscles. The cilia surrounding the head are large, setting up a strong current."

Hlava (1908, p. 38) writes:

Das Männchen hat einen walzenförmigen, hinten in einen kurzen konischen Fuss verengten Körper. Der Räderapparat besteht aus einem einfachen Kranze von starken, rege schwingenden Wimpern. Der Hoden ist gross, vor ihm befindet sich ein grosser, heller, kreisförmiger Zwischenraum, ein Rest der Verdauungsapparates. Das Hirnganglion ist gross, zwei Augen und Dorsaltentakel deutlich. Die Fussdrüsen sind gross. Das Integument ist sehr durchsichtig. Penis ist kurz, bewimpert, zurückziehbar. Size Male: 160 μ, Female 1000—2000 μ.

Megalotrocha procera Thorpe.

Male: Thorpe 1893 a, p. 151.

Thorpe (1893 a, p. 151) writes:

I had the good fortune to find the male, the anatomy of which follows the usual type, possessing a circular wreath of cilia, two bright eyes, a foot and sperm-sack with penis.

Megalotrocha semibullata Huds.

Male: Thorpe 1889, p. 614.

Thorpe (1889, p. 614, Pl. XII)

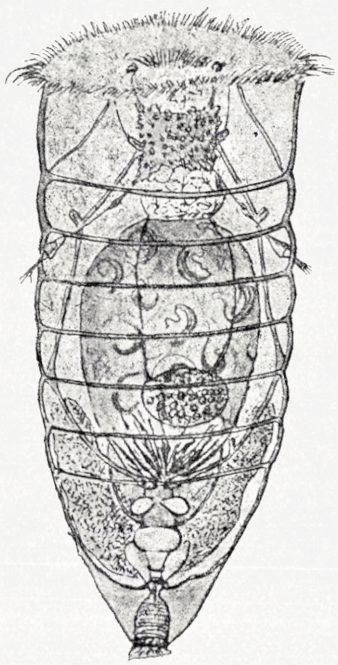
gives a short description and a very insufficient figure of the male.

Lacinularia socialis (Pall).

Male: Hudson 1875, p. 75.
Plate 1886 a, p. 4.
Hudson Gosse 1889, p. 86.
Hlava 1908, p. 46.
Hamburger 1907, p. 625.
Wierzejki 1893 a, p. 47.

Plate (1886 a, p. 4) describes the male but gives no figure. In the description the following points are of special interest.

The males are only 1/5 the length of the female; body cylindrical with a bunch of cilia near apex. Wheel-organ a wreath of cilia round a vaulted disc with a bunch of cilia at its top. Brain large, quadrangular. A dorsal organ but no lateral organs and two red eye-spots observed. A rudimentary alimentary canal used as suspensor testis. Two lateral canals with vibratile tags, no contractile vesicle. A very large piriform testis; vas deferens coated with cilia; a penis. Prostata gland. Two sorts of spermatozoa.



Lacinularia socialis ♂ after Hamburger.

Hudson-Gosse (1889, p. 86, Pl. 8, fig. 1 c) writes:

The male has a conical head fringed with a wreath of long cilia, a cylindrical soft trunk, and a short, pointed, ciliated foot. There are strong longitudinal muscles for withdrawing the corona into the trunk, and several transverse muscle bands in the integument. The nutritive system is wholly absent. Two secreting foot glands are present, as well as the lateral canals and their vibratile tags. Several times I thought I caught sight of the edge of the contractile vesicle, behind the upperpart of the sperm sack. There is a large nervous ganglion, sending threads to a dorsal antenna and two red eyes. A large sperm-sack fills nearly the whole trunk, and ends in a broad, tubular ciliated and protrusile penis.

Hlava (1908, p. 46, fig. 14 c).

Die Männchen haben einen walzenförmigen Körper, welcher mit einem stumpfen Fuss versehen ist. Vor dem Ende dieses befindet sich auf der Ventralseite ein bewimpertes Grübchen. Der Hoden ist birnförmig, gross und nimmt in der Regel die ganze Leibeshöhle ein. Die Excretionsorgane münden am Anfang von Vas deferens ein. Penis ist röhrenförmig, bewimpert, zurückziehbar und ist mit einem halbkreisförmigen Hornring versehen. Beiderseits sind drüsige Zellen gelegen, welche wahrscheinlich die Funktion der Prostata haben. Oberhalb des Hodens sieht man den Rest des Verdauungskanals als einen Streifen von veränderlicher Breite und häufig mit zahlreichen Vakuolen. Das Gehirn hat die Form eines Rechteckes. Zwei Ventraltentakel und eine dorsale sind gut sichbar. Die Augen sind mit deutlicher Linse versehen. Die Männchen schwimmen

frei in der Nähe der Kolonien und zwar 3—7 bei einer Kolonie; nur bisweilen befestigen sie sich. Size Male: 300—700 μ. Female 1500—2000.

HAMBURGER (1907, p. 625, Tab. XXXI) has given a very thorough description of the male. The following is a condensed abstract of her text.

The body of the male is somewhat conical; the coronal disc somewhat vaulted; encircled by a closed ciliary wreath and carrying on its top a bunch of cilia and other cilia spread over the disc. The hypodermal cells large and regularly arranged. Brain rectangular, giving off nerves for the two red eyes and for the two lateral organs lying between the second and third transversal muscle, and for the dorsal organ, which has not been observed with certainty. It is of interest that HAMBURGER has pointed out an oesophogeal commissure only rarely observed in the Rotifera: *Discopus* Zelinka (1888, p. 235) and *Conochiloides* (HLAVA 1905, p. 282). No alimentary canal, but rudiments between testis and the hypodermal cells of the wheel-organ; even a rudimentary mastax is supposed. Two lateral canals which are supposed to be in connection with each other by means of a transversal commissure beneath the brain; they debouch in the proximal part of vas deferens. The number of vibratile tags is not indicated, but "Treibwimpern" in the lateral canals are observed. The testis is very large and contains two sorts of spermatozoa; the vas deferens (= ductus seminalis) is built of a layer of ring muscles and covered inside with a coating of long cilia. Two prostata glands; to the posterior part of vas deferens two muscles are attached, which, according to HAMBURGER, come into action when the spermatozoa are to be forced out. After a restriction the vas deferens is again expanded and coated with long cilia; there is no penis, but HAMBURGER correctly supposes that it is this part of vas deferens which, when turned inside out, acts as a penis. The opening of vas deferens is situated dorsally. Over the testis an opaque mass, which Hamburger in accordance with PLATE regards as a remnant of a rectum. Below the genital aperture on the very apex of the body a cilia-coated sucker is found, into the bottom of which two glands open. These glands may be homologous with the foot glands of the female; the vasa deferentia for these glands are swollen and used as reservoirs for the secretions of the glands. Seven or eight transversal musclebands are indicated, further the great retractors of the wheel-organ. Length of animal 200—300 μ. HAMBURGER has given a valuable contribution to the spermatogenese and pointed out the great difference between the two sorts of spermatozoa. PLATE and HAMBURGER suppose that the males fasten themselves by means of their sucker upon any part of the body and that the staffformed spermatozoa are used as weapons by means of which the bodywall is pierced. The mating process has not been observed.

The species was found in Gudenaa twenty years ago. It occurred here in countless numbers, and in July the males swarmed round the colonies. As the animal was observed on a journey, it was only badly drawn; later on it was found on the underside of the leaves of *Nymphæa* in a pond near Hillerød (Carlsø); in 1920 when the colonies should have been collected a boat could not be obtained. Finally in 1921 it was found in Susaa near my summer laboratory, and I had good opportunity to study the male. Comparing my description with that of Hamburger I could find no differences and I therefore refer the reader to hers.

Oecistes mucicola Kell.

Male. Western 1891, p. 321.

WESTERN (1891, p. 321, Pl. XXI 1 c) writes:

"I also found what appears to be the male, though I did not actually see it hatched from the egg."

Limnias ceratophylli Schrank.

Hudson-Gosse 1889, p. 76.

Gosse in Hudson-Gosse (1889, p. 76, Pl. VI, fig. 7) states

that he has seen a young animal push out of the tube; he regards it as a male; but it has a mastax; testis is not seen. It is only from its manners that Gosse supposes that it might be a male.

Melicerta ringens Schrank.

Male: Bedwell 1878, p. 249.
Joliet 1883, p. 165.
Hudson Gosse, 1889, p. 71.
Weber 1898, p. 288.
Hlava 1908, p. 71.

Bedwell (1878, p. 249) according to Hudson & Gosse (1889, p. 71) supposes that he has seen the male and gives a description of its behaviour.

As he however maintains that he has observed trophi and a forked foot, it is more probable, as Hudson states, that he has seen another Rotifer f. i. one of the *Notommatidæ*. When the tubes were broken up in Dcbr. Bedwell found the presumed males in them; in one single tube four individuals. It is also conceivable, that we here have to do with young females.

Joliet (1883, p. 165) gives a rather exhaustive description but rather rough figures (pl. XIII, fig. 51; pl. XI, fig. 11). The following is a summary of the description.

The male resembles the larva of the female; the coronal disc is covered with cilia; there are two red eyes with lenses; the body cylindrical with a conical tail ending in a bunch of cilia. Near the apex dorsally a protrusile elevation with the genital opening surrounded by five or six cilia. No alimentary canal, only two blackish bodies situated near the base of the tail, and two bright bodies on both sides of the testis and which Joliet regards as "les glandes stomacales". A large pyriform testis containing numerous spermatozoa occupies the greater part of the body cavity; a brain is indicated with some doubt; of the excretory organ only two vibratile tags near the forepart of the animal are observed. A few muscles are detected.

Weber (1898, p. 288) writes

Le male atteint en grandeur à peine les deux tiers de la femelle. Il ressemble à une jeune larve de femelle. Son corps est presque cylindrique; il est terminé en avant par une tête arrondie à couronne ciliaire bilobée mais mal définie. Sa tête est nettement séparée du tronc par un étranglement. Le pied est court, conique, terminé par une couronne de cils raides. Le système excréteur est réduit; les organes digestifs absents. Les organes des sens réduits à un ganglion cérébroïde et à deux yeux. Le testicule est volumineux; le pénis est dorsal, cylindrique et terminé comme le pied par une couronne de cils. Je n'ai trouvé qu'un seul exemplaire W. has reproduced Joliet's figure (Pl. 11, fig. 6).

Hlava (1908, p. 71, fig. 25 D) writes

Das Männchen ist dem jungen Weibchen ähnlich. Das Vorderende ist abgerundet und schwach von dem Rumpfe abgeseht; die Krone ist mässig zweilappig. Auf der Dorsalseite dicht unter dem Kronenrande sind zwei rote, mit deutlicher Linse versehene Augen gelegen. Der Körper ist annähernd walzenförmig und mit einem kurzen, konischen Fusse versehen. Am Ende desselben befindet sich ein Borstenbüschel. Dorsal an der Fussbasis ist ein kleiner

walzenförmiger, zurückziebarer und am Ende bewimperter Penis gelegen. Verdauungskana feht; anstatt desselben ist ein grosser, birnförmiger Hoden entwickelt.

Size: Male 400—600 μ, female 1300—2000.

Melicerta conifera Hudson.

Hudson-Gosse 1889, p. 72.

Gosse in Hudson-Gosse (1889, p. 72, Pl. D, fig. 6) supposes

that he has seen the male; but the figure and description are so sketchy that they have only very slight scientific value.

Melicerta janus Huds.

Hudson-Gosse 1889, p. 75.

Hudson-Gosse (1889, p. 75) writes:

"Mr. Hood tells me that he has seen the male, and that it resembles that which I have figured as the male of M. *tubicolaria*."

Melicerta tubicolaria Ehrbg.

Hudson-Gosse 1889, p. 73.

Hudson-Gosse (1889, p. 73, Pl. 5, fig. 3 c). Hudson supposes

that he has seen the male. "The nervous ganglion, spermsack and penis were plainly visible, and I could see the motion of the spermatozoa, though not the individual spermatozoa themselves; neither could I make out the muscles nor the water vascular system."

The *Melicerta* colonies, especially those of *M. ringens*, but also those of *M. janus*, are very common in our ponds. Curiously enough I have never had the good luck to observe the males.

General remarks.

It will be seen that we possess only a limited knowledge of the males of *Conochilus volvox*, *Lacinularia socialis* and *Melicerta ringens*. The males are always small often only about 50 μ; that of *L. socialis* 2—300 μ; coneshaped without any conspicuous foot, but often with a cupshaped body, a sucker in which the foot glands debouch. The wheel-organ is a single ciliary wreath, encircling a disc, which is commonly cone-shaped, carrying two eyes, provided with lenses. A large brain; most probably always a dorsal and two ventral antennæ, but they have not always been observed. No mastax and often no trace of alimentary canal at all. Lateral canals with vibratile tags not always detected, but perhaps always present; no contractile vesicle. A large pyriform testis, a cilia-covered ductus seminalis, no real penis but the ductus seminalis may be partly turned inside out; large masses of oil globules. Muscular system insufficiently known; many transversal muscle bands seem to be a rule. The males are extremely active animals and very variable in form.

Microcodonidæ.

The family comprises the two genera *Microcodon* and *Microcodides*. The males are almost unknown.

Microcodon clavus Ehrbg.

Gosse 1889, p. 119.

Gosse (Hudson-Gosse 1889, p. 119) supposes he has seen the male.

"A female had been playing in my live-box within an area formed by bounding filaments of *Myriophyllum*. Presently I saw a slender worm, about as long as this charming subject itself, of almost aerial transparency, very slender, darting about the same limited area. It was a nearly perfect cylinder, but gradually tapering to an acute extremity, which may possibly have been a minute conical toe. The front, slightly bent downward, was transversely truncate; its circular margin carrying a wreath of locomotive cilia, by whose vibrations it shot vigorously and rapidly about. The whole body was refractive of light, but one vesicle, situate about two-thirds from the front was more intensely refractive. This I suspect to have been the sperm-sack. I could detect no other organ or viscus in the animal, but the entire length and breadth was full of minute granules." Gosse further supposes that he did indeed observe the male, because the motions exactly resemble those of the female, because it appeared at the same time and in the same dip. In support of his supposition he also emphasised the apparent attention, which the supposed male paid to the female.

Microcodides robustus (Glascott).

Tab. VI, fig. 1—2.

Description. Body about twice longer than broad, sackformed behind; cross section almost circular. The forepart of the body rather sharply defined from the broader hindpart; cuticula thin, very hyaline. Foot remarkably strongly developed, almost more so than in the female, but only with two joints; ventrally placed two rather blunt short toes. Wheel-organ resembling that of the female, but the cilia as far as I have been able to see, form a closed wreath round the somewhat obliquely placed disc; upon this a few faintly developed elevations, carrying bunches of long cilia. Below the hypodermal cells the large brain with a red eye below. Dorsal antennæ two, situated near each other, united in a dorsal organ; two lateral antennæ far behind. There are four conspicuous transversal muscle-bands; of longitudinal bands three or four dorsal bands and two ventral ones; some of them are deeply cleft. There is a conspicuous, but rather narrow rudiment of the alimentary canal, embracing the testis; the lateral canals are very conspicuous, furnished with three vibratile tags each. No contractile vesicle has been found. The testis is large, pyriform, suspended in a very hyaline indusium of a similar structure to that which is found in *Hydatina*; there are two sorts of spermatozoa; two small prostata glands. Peculiar are the two highly developed footglands, ending at the tip of the toes. The opening for the testis is situated dorsally over the first footsegment; the penis seems to be rather short, protrusile, the opening is surrounded by a wreath of cilia. Size of female 6—700 μ, of foot 250. Size of male 160 μ.

It is only with the greatest hesitation that I refer this peculiar male to the genus *Microcodides*, but of all known Rotifers I cannot find any which it resembles more than the female of *Microdides robustus* described by Glascott (1892) and later on figured and redescribed by Rousselet (1895, p. 3).

In May 1921 I found, in a little pond near Hillerød, a large, slowly swimming Rotifer with sharply defined, ventrally placed strong foot; the mastax was very pe-

culiar, differing from every thing, that I have hitherto seen. In the same sample I soon found a few males; thinking that the female could be found again, I thoroughly studied the males for some days. On returning to the pond however, I was unable to find a single specimen more, neither male, nor female. In the autumn of 1921, during the whole of 1922, and in the spring of 1923 the pond was under regular observation, but all efforts were fruitless. For a time I supposed that a closer examination of the female would show that I had a *Harringia* (= *Dinops*) before me. As I am sure however, that the two dorsal antennæ are united in a single dorsal organ, and a cursory examination of the mouthparts showed no resemblance to those of *Harringia*, this was not the case. The wheel-organ of the female was quite in accordance with that of *Microcodides*, and the hindpart of the body showed the same parallel furrows which are so characteristic in ROUSSELET's figure.

Flosculariidæ.

The family comprises the three genera *Floscularia*, *Stephanoceros* and *Apsilus*, all three with only very slight mutual relationship. Of many of the species it is stated that the males have been observed, but they are neither described nor figured.

Floscularia proboscidea Ehrbg.
= **F. campanulata** Dob.

Male: Hudson 1875, p. 45.
Hudson-Gosse 1889, p. 52.
Weber 1888, p. 10.
— 1898, p. 277.
Montgomery 1903, p. 363.

HUDSON-GOSSE (1889, p. 52, Pl. I, fig. 1 c.)

The sperm sack and penis are indistinctly shown in the figure. but the dead specimen from which I drew the figure was so lately hatched that its cuticle was more than usually opaque.

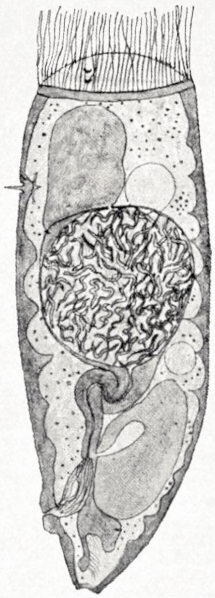
WEBER (1888, p. 10, Pl. 26, fig. 2; 1898, p. 277, Pl. 10, fig. 11).

"Le male de *F. proboscidea* est rare et je n'ai réussi à en trouver qu'un seul exemplaire. Il est de petite taille et ressemble à une toute jeune femelle. Il a la forme d'un sac allongé, tronqué aux deux extrémités. Pied très court et obtus. Le sommet de la tête est très légèrement divisé en lobes et porte une couronne de cils fins et longs. Les deux yeux sont bien visibles. Le système digestif fait défaut, le système excréteur est réduit, deux canaux latéraux, commençant dans la tête et se terminant de chaque côté du pénis au dessous du pied. La majeure partie de la cavité du corps est occupée par un testicule granuleux. Le pénis est court, dorsal, muni d'une couronne ciliée à son extrémité. Le système musculaire est composé de deux forts muscles latéraux, rétracteurs de la partie antérieure du corps, la tête, et des muscles fins du pénis et du testicule."

HUDSON's observation, that the males pierce the tube, Weber (1888, p. 11) regards as highly improbable.

MONTGOMERY (1903, p. 363, Pl. 21, fig. 36). Out of the more exhaustive picture we point out the following facts.

The mature male in size and general structure, disregarding the sexual organs and the alimentary tract, shows a great similarity to the immature females. It lacks an alimentary tract entirely; M. was unable to find a nephridial system, though undoubtedly the latter must be present. The thickened hypodermal ring at the anterior end of the body bears a single ring of long, vibratile cilia, and in the projection of the trunk, anterior to this ring, lie two semicircular, dorsal, red eyes. The foot is very short, without peduncle. The hypodermis is thickened and with an irregular scalloped inner contour. A dorsal sense-organ is well developed. In the anterior region of the trunk lies a large mass, which may in part represent a cerebral ganglion. The genital organs consist of a huge sperm sack, connected with a cirrus. This sperm sack is filled with spermatozoa, and its walls thin, except at one point on its dorsal surface, which is thickened; probably this thickening represents the germinal epithelium and therefore the testis proper. A curled thick-walled tube, the cirrhus, follows the sperm-sack; its lumen, the vas deferens is very narrow. A thin-walled short tube connects the posterior end of this cirrhus with the dorsal genital aperture; and within this tube beat long cilia, which are attached to the posterior end of the cirrhus. The cirrhus may be protruded some distance out of the genital aperture, and probably serves as an intromittent copulatory organ. On the ventral side of the cirrhus, in close attachment to its wall, is a large dense body, with an axial pyriform clear space, a gland; the clear space being its ductus. Just posterior to this gland is a lobed body, projecting into the body cavity, bearing on one of its surfaces long cilia, which beat in the body cavity.



Floscularia proboscidea ♂ after Montgomery.

Floscularia calva Hudson.

Male: Hudson-Gosse 1889, p. 56.

Hudson-Gosse (1889, p. 56, Pl. III, fig. 3 a, 3 b). Hudson states:

"I am indebted to Mr. Hood for drawings of the young male and female each of which he saw hatched from egg laid in the tube. The male is about $\frac{1}{210}$ inch in length and resembles that of *F. campanulata*."

Floscularia mutabilis Bolton.

Male: Hudson-Gosse 1889, p. 56.

Hudson-Gosse (1889, p. 56, Pl. III, fig. 2 c). Hudson says:

"I have seen what I believe to be the male but I failed to isolate it so as to make out its internal organs."

Floscularia cucullata Hood.

Male: Hood 1894, p. 335.

Hood (1894, p. 335, Tab. XVI, fig. 3) writes:

"The male has a prominent dorsal antenna; all other males of Floscules, so far as observed, having no such antenna; it has also two small eyes close together."

Floscularia ambigua Hudson.

Hudson-Gosse 1889, p. 53.

Hudson-Gosse (1889, p. 53) writes:

"Mr. Hood has twice seen the male, hatched from the egg, laid in the tube, and noticed the motion of its spermatozoa in the sperm-sack."

Floscularia pelagica Rouss.

Rousselet 1893, p. 444.

ROUSSELET (1893, p. 444, Pl. 7, fig. 1 d).

"I saw a young male born; it is of usual shape with two red eyes."

Floscularia ornata Ehrbg.

Tab. XV, fig. 6—7.

Description. The male cone-shaped, attenuated at posterior end, but without peduncle and without any coating of gelatinous substance. The coronal disc cone-shaped, covered with a coating of short cilia encircled by a ring of long cilia but wholly destitute of the long stiff setæ so characteristic of the corona of the *Floscularia*-females. A hypodermal ring of thick, large cells, a large brain; anteriorly inside the ciliary wreath two red eyes. From the brain two antennæ running to a sharply defined dorsal organ, provided with a tuft of cilia; no lateral antennæ have been observed. No alimentary canal but before the testis a large globular body, perhaps a rudiment thereof, perhaps a large oil-globule. Two lateral canals ending near the opening of the penis, each provided with three vibratile tags; no contractile vesicle. A large testis, filled with spermatozoa; hitherto staff-formed ones have not been observed; ductus seminalis is curved, provided with cilia in its interior, and with two prostata glands laterally. At its apex a bunch of cilia; during copula the canal is turned inside out and presents itself as a dorsal conical projection, provided with a ring of cilia. Ten transversal muscle bands, which in a very high degree are able to constrict the body and alter its form; at all events two pairs of longitudinal muscle bands. Size of the male 45 μ. Size of the female 750 μ.

The male eggs were found in the tubes; for some time the males are in the egg shell; then for a short time they swim round in the tube of the female where upon they leave the tube; during the few hours they live, they do not seem to leave the female colonies, always encircling the coronas and upper part of the tube.

Stephanoceros Eichhornii Ehrbg.

Male: Western 1893, p. 157.
Dixon-Nuttall 1897, p. 166.

WESTERN (1893, p. 157) states that HOOD is the first who has seen the male and later on sent him females with male eggs in the tubes (April).

"The eggs were laid in batches of three or four, some two or three hours before the young males ermerged from them. . . . After birth the young males, measuring about $^1/_{180}$ in., were within the tube, and from it I distinctly saw two or three of them bore their way out through the side, leaving in one case a hole with ragged edges. This process took them six or eight hours. . . . There is a sort of head with two red eyespots. This is surrounded by a ciliary wreath, of which the cilia are very long and active. Below this the body gradually

tapers to the foot. There are two antennæ, to which as to the eye spots, nerves could be traced from a largish square-shaped ganglion in the neck. The sperm-sack occupies the lower half of the body cavity. There is also a small contractile vesicle, and the lateral canals, with at least three vibratile tags on each side, are easy to make out.

Stephanoceros Eichhornii ♂ after Dixon-Nuttall.

Dixon-Nuttall (1896, p. 166, Pl. V, fig. 1—2).

"Like most male Rotifers they are restless and swim about in an apparently aimless manner. The dorsal antenna is situated on a small hump, and at each side of it lie the lateral antennæ. In some animals these are furnished with a bunch of long fine setæ, though in several examples that I looked at most carefully I was unable to find them; it is possible they may get broken off. The many celled sperm-sack (in which may be seen the spermatozoa actively lashing their flagella) takes the place of the stomach and intestine. The vascular system, with its contractile vesicle, is normal. The corona is circular, and furnished with a wreath of fine vibratile cilia; the front of the head is conical, and two red eyes rather wide apart, are conspicuous. $^1/_{90}$—$^1/_{60}$ inch.

Weber (1898, p. 282) has observed the male.

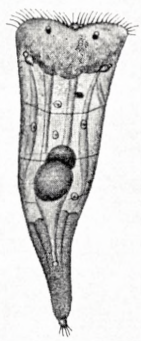
I have only found *Stephanoceros Eichhornii* once in Gudenaa near Silkeborg and never seen the male.

Apsilus lentiformis Metchnikov.

Male: Metchnikov 1866, p. 354.

Metchnikov (1866, p. 354, Tab. 19, fig. 4). Abstract:

"Form conish, nach hinten zugespitzt; Kopfwimperapparat besteht aus einem geschlossenen Ring von langen Flimmern; am Hinterende noch eine Anzahl auf einem abgesonderten Zapfen sitzender Flimmerhaare. Cuticula dick; darunter eine Anzahl vereinzelter Zellenkerne. Ein grosses Hirnganglion mit zwei Augen von rothen Pigmentflecken und einem Krystallkörper zusammengesetzt. An beiden Seiten des Gehirns zwei besondere Gefühlsorgane von birnförmiger Gestalt; sie tragen auf ihrem vordern äusseren Ende je ein Knöpfchen mit einem davon auslaufenden feinen Härchen; das hintere Ende dieses Organs, welches vielleicht einer spindelförmigen Nervencelle entspricht, geht in einem dünnen Nervenfaser über. Ringsum Längmusskeln, welche von einzelnen Fasern gebildet werden, die sich dadurch auszeichnen, dass jede nur aus einer Zelle besteht, und je einen hellen mit einem Nucleolus versehenen Kern enthalten. Keine Verdauungsorgane. Excretionsorgane vorhanden: Eine contractile in die Geschlechtsöffnung einmündende Blase und zwei seitlichen, von dieser ausgehenden Gefässen; jede tragen drei Trichter. Testis unpaar; besteht aus einem aus Zellen zusammengesetzten Teil und einen untern mit reifen Zoospermien erfüllten grössern Behälter. Von letzteren entspringt ein ziemlich langer Samenausführgang, welcher an der Spitze des Penis ausmündet. Dieser stellt einen aus- und einstülpbaren Zapfen dar an dem ein Bückel ziemlich starker Flimmerhaare aufsitz. Zweierlei Zoospermien. Hinten einen aus feinkörnigen Inhalt bestehende Drüsen (Prostata). Grosse 0,28."



Apsilus lentiformis ♂ after Metchnikov.

General remarks.

The males of the Flosculariidæ are very insufficiently known. Hitherto only the male of *F. campanulata* has been fairly well described (Montgomery); further the rather peculiar male of *Apsilus* hitherto only found by Metchnikov.

As far as we hitherto know, all the males of the *Flosculariidæ* are freeswimming animals, without gelatinous tube, cylindric or cone-shaped; no peduncle; it is doubtful if there exists a sucker, by means of which the male may fasten itself to the female; something in this direction may perhaps be interpreted in this way in the figure of MONTGOMERY (fig. 36 x y). In the male of *Floscularia ornata*, I could find nothing of that.

The coronal disc is always placed vertically, covered with a rather uniform coating of short cilia and encircled by a simple wreath of cilia; no setigerous lobes or long setæ have ever been observed in a male of the *Flosculariidæ*, and as the whole alimentary canal is absent, there is not the slightest trace of the highly specialized vestibulum, so characteristic of the female. All species present two red eye spots, placed on the cone-shaped disc. From brain conspicuous nerves are given off to a dorsal organ, which is most probably always present; whether the same is the case with the lateral antennæ is doubtful; hitherto they have only been observed in *Stephanoceros* and in *Apsilus*, The alimentary canal is wholly absent, a rudiment as a suspensor testis perhaps present. Excretory organs present as two lateral canals with a series (3—4) of vibratile tags; they have only been observed with certainty in *Stephanoceros*, *Apsilus* and *Floscularia proboscidea* (by WEBER) and in *F. ornata* (by myself); the contractile vesicle is supposed to be present in *Stephanoceros* and in *Apsilus*.

The testis is always large, pyriform; whether it always contains two sorts of spermatozoa is rather doubtful, pointed out in *Apsilus*; the ductus seminalis is short, now and then curved, coated with cilia inside, opening dorsally. There is no real penis but most probably during the mating process the last part of the ductus seminalis is turned inside out. Prostata glands are always present. A long series of transversal muscle bands and strong longitudinal muscles.

The males are hatched in the tubes of the females and their freeswimming period most probably very short.[1]

Chapter IV.

Anatomical Remarks Relating to the Males of the Rotifera.

In the following lines I have tried to give a sketch of the structure of the males of the Rotifera. With regard to some of the organs, this is only possible with full consideration of the same organ in the female sex. When this is the case, the description has been begun with a more general survey of the organ in this sex, laying weight upon just those points which are of significance for the understanding of the structure of the same organ in the male sex.

[1] ROUSSELET (1903, p. 174) states that THORPE has found the male of *Trochosphæra æquatorialis*; with regard to the very aberrant males of the *Seisonacea*, I refer the reader to the papers by PLATE and CLAUS.

The body of the Rotifera females is commonly described as consisting of three parts, an anterior part carrying the wheel-organ and mouth and enclosing the brain and retrocerebral organ, the middle part containing the viscera, and finally the foot. It is covered by a cuticula which, in the middle part, is often thickened to a lorica in which head as well as foot may often be drawn in; where a lorica is wanting, the body is commonly more or less segmented or as in the sessile families, where the three main parts of the body are not distinctly separated from each other, highly contractile. Besides, the body of the females is characterised by the most extraordinary variation, relating to the shape of the body, the form and composition of the lorica, the thickness of the cuticula, the development of the foot, and the shape of the disc and the wheel-organ. This great variation is developed in a much slighter degree in the males of the Rotifera.

Firstly sessile male Rotifers are hitherto wholly unknown and most probably do not exist, all males belonging to sessile females being conical without any conspicuous differentiation of the body; the cuticula is always extremely thin, much thinner than in the female and therefore also very hyaline. In the more primitive families, as especially the *Notommatidæ*, where the body is conspicuously segmented and more or less telescopic, the segmentation in the males, especially in *Diglena*, in some species of *Notommata*, and perhaps also in *Copeus*, is often rather obvious, but the telescopic power is much smaller; f. i. *C. labiatus* and *C. pachyurus* in the female sex can telescope themselves in such a way that the body is ballshaped, whereas this is not the case with the few males I have seen. In many cases, especially where there is no lorica, the body of the male is almost a true repetition of that of the female, the body being only much smaller, commonly only one third of that of the female. This is the case with the males of *Hydatina*, *Rhinops*, *Notops brachionus*, partly also with those of *Synchæta*, and some of the *Notommatidæ* f. i. *Diglena*. Here it is interesting to see how the shape of the males is in accordance with the shape of the female; the thinner the female is, the thinner too is the male. This is also the case with the *Asplanchnas* where the male of the broad ballshaped *A. Brightwelli* and *A. Sieboldi* is also ballshaped, whereas the male of *A. priodonta* is oblong.

On the contrary especially in the plancton Rotifers where the size of the male is very much reduced, there is not the slightest resemblance between the shape of the two sexes. To these, the most reduced of the Rotifer males, we shall return later on.

As well known the skin of the female Rotifers consists of an extremely thin protoplasmatic layer, a syncytium without cell limits and with relatively few nuclei. It is covered with an often very thin cuticula which, when thicker, is termed a lorica. In the males the protoplasmatic layer is commonly still thinner, and the cuticula so thin and hyaline that the males f. i. those of the *Asplanchna*-species resemble crystalline bubbles. On the other hand some of the males are very opaque so that it is almost impossible to see the interior organs. This is the case with the males of *Salpina*, of *Metopidia*, the *Gastropus* species and others. Most probably this is due to a thick hypodermic layer; the males in this regard resembling the newly

born females which only attain hyalinity during growth. In the few cases where I have been able to observe the longevity of the males (*Asplanchna*, *Hydatina*) I have seen that the males, too, are more transparent in the last part of their life and that just these males grow larger during the few days they live. The greater hyalinity is most probably due to the spreading out and flattening of the hypodermic layer behind an always increasing surface; this will especially be understood when we remember that the males get no food during life.

If the body of the female is covered with a lorica, the lorica of the male may in some and relatively few cases be a true picture of that of the female; this is the case with the lorica in the hitherto known specimens of *Salpina* and *Euchlanis* perhaps also in *Metopidia*. In those species in which we commonly do not speak of a real lorica but in the cuticula of which we find characteristic keels and furrows f. i. *N. hyptopus*, we find this system again in the male.

In the great families of loricate Rotifers: *Brachionidæ* and *Anuræadæ* in which the lorica in the female reaches almost its highest development, we can hardly speak of a true lorica in the males; there exists a rather thick cuticula, provided with some conspicuous and constant keels and furrows which are not as a rule in accordance with anything in the structure of the lorica of the female; the facettation of the lorica which is so highly characteristic of that of many of the females, is here wholly wanting.

This lorica is further characterised by the peculiar, commonly strongly developed spines at the anterior and posterior ends; we do not know any equivalents to these spines in the males. It is a peculiar fact, that the males of the Rotifers even if the females have highly developed spines, hardly ever possess spines of any kind. Apart from the *Brachionidæ* and *Anuræadæ*, this also holds good for the *Triarthra* and *Polyarthra*, further for all the hitherto known males of *Rattulidæ* and *Dinocharidæ*. We only meet with spines similar to those which we find in the lorica of the females, in the *Salpinadæ* and in the peculiar spiny process on the head of *Colurellidæ*. Where the lorica presents peculiar structures in the female sex, these peculiarities are absent in that of the males; we have in the males no facettation of the lorica and no anterior ring of plates in the faintly developed lorica of *Dinocharis* (Weber) and no hint of the peculiar foam-like structure of the lorica of *Ploesoma hudsoni* ♀. Further we never find any trace in the males of that peculiar yelly envelopment so characteristic of the female of *Copeus labiatus*.

Foot. Female sex. Especially among the creeping Rotifers with ventrally situated disc the foot is not sharply separated as a special organ from the other part of the body. It consists of from two to four "segments" which are feebly telescopic; on the last "segment" it carries two toes which are provided each with a foot gland. By means of sticking material from these glands the animals are able to fasten themselves to a substratum. A foot of this structure is designated as a creeping or crawling foot and is mainly found in the *Notommatidæ;* by means of the sticking material from the foot glands the animals now and then fasten themselves to the

substratum; many of them are really mainly sedentary animals. The more the Rotifers pass over to a swimming motion, the more the foot loses its importance as a creeping organ; it is now mainly used partly as a steering organ partly as an organ of attachment. In accordance with the first named function, but in very different ways, it is now almost always conspicuously separated from the other part of the body; only in the *Synchætadæ* where parts of the wheel-organ (the auricles) play the rôle of steering organs, the foot is the typical foot of the creeping Rotifers now only used as an organ of attachment.

In the freeswimming Rotifers the foot has a very different shape but is often formed in accordance with its main function of steering organ. This for instance is the case with the foot in the two families *Salpinadæ* and *Euchlanidæ* where it may be shown how the broad toes are used; this is also the case with the annulated foot of *Pterodina*, *Ploesoma*, further with many of the *Brachionidæ*, where the foot is only used at the special moment when the direction of the movement is to be greatly altered; during the slowly rotating motion, the foot is often withdrawn into the lorica, especially in one of the most pelagic species *B. pala*. Still it preserves its significance as an organ of attachment. In many of the plancton Rotifers the foot glands either atrophiate or are feebly developed.

Very many of the true plancton Rotifers have no foot at all; they are therefore unable to attach themselves (*Asplanchna, Triarthra, Polyarthra, Pompholyx, Pedalion, Anuræa, Notholca, Ascomorpha, Anapus*) and if not provided with leaping thorns unable suddenly to alter the direction.

Even if the foot disappears, it is not quite certain on that account that the foot glands also disappear. Many of the plancton Rotifers carry their eggs glued to the posterior part of the body, in *Pompholyx* fastened by a peculiar system of threads, which can be pushed out and in from an apical opening. Further investigations will show if the glutinating matter is derived from rudimentary foot glands which have undergone a change in function.

Among the slowly swimming inhabitants of the small ponds, covered with carpets of leaves, and those from the pelagic region of the lakes, with regard to the reduction of the foot there exists the most beautiful series of reductions (e. g. *Hydatina, Notops brachionus, Brachionus, Anuræa.* — further *Asplanchnopus, Asplanchna Herricki; Asplanchna priodonta.* — Species of the genus *Synchæta* and of the *Ploesomatidæ* show other examples in the same direction. — Peculiar foot forms are especially found among the half swimming, half creeping, Rotifers of the ponds e. g. the jumping foot of *Scaridium, Dinocharis* and some *Furcularia*-species. Even if the foot among freeswimming Rotifers is used as a steering organ still it is in very many cases here also used as an organ of attachment; very many of the so-called freeswimming Rotifers are in a still higher degree than commonly supposed fixed animals, which the net has thrown off from their substratum and which live a more swimming life in the vessels than in nature. Even among the freeswimming Rotifers we often find very peculiar structures of the foot glands; these organs may develop to a very

high degree of perfection. This f. i. is the case with the *Rattulidæ*. With regard to the significance of the asymmetry in the foot forms in this family I especially refer the reader to JENNING's admirable paper.

The foot of the *Bdelloidæ* which is used telescopically in creeping, and withdrawn in swimming, is in many species mainly an organ of attachment and the foot provided with a series of until five pairs of foot glands, the glands lying above each other. In the moss living *Callidina* species and *Discopus* it is only used as an organ of attachment, and here provided with a sucker. Also in the *Floscullariidæ* and *Melicertidæ* the foot is only an organ of attachment, but simultaneously, it has here the rôle of carrying the fully distended animal back into the bottom of the tube again when contracted. In accordance herewith it is provided with long powerful muscles in fixed numbers. In the young freeswimming animals the greater part of the foot is occupied by large foot glands; later on, when the animals have fastened themselves, they atrophiate. Whether the peculiar stick-like appendages of *Pedalion* may morphologically be regarded as parts of the foot is doubtful.

Foot, male sex. If we will now try to take a survey of the different foot forms in the male sex, it will soon be obvious that the differences here are by no means so great as in the female sex. In the most primitive family, the *Notommatidæ*, the foot in the two sexes is almost of quite the same structure. It is also used quite as in the female as a creeping organ and because the foot glands are always well developed, also as an organ of fixation. In the males of the *Synchæta* the foot and foot glands are much more reduced than in the female sex, the organ being here a true appendix to the penis. In *Hydatina* and *Rhinops* it is well developed, reduced in *Notops brachionus*, and still more in *Brachionus*; the foot is here not retractile as in the female sex; it is short and thick, is never used as a steering organ and only for attachment. Very often the *Brachionus* males swim with the enormous penis fully evaginated and with the foot then hanging downwards as a small ventral appendage. In the *Anuræa* there is no foot at all either in the male or the female sex; at a first glance it looks as if the males are provided with a long fleshy appendix that looks like a foot; this is however only the long penis which, especially in *A. hypelasma*, is flexible and is used in some way as a steering organ during the swimming motion. It is always protruded. In *G. hyptopus* the foot in the male sex is very inconspicuous and always carried retracted; only during the copulatory act it is protruded together with the penis, then hanging downwards as a small inconspicuous appendage. In *Gastropus stylifer* the female sex has a remarkable narrow foot without toes while in the male sex it is reduced to a very inconspicuous styliform process, but provided with a comparatively large foot gland. In some genera in which the female has a foot (*Ploesoma, Rattulus*) the foot in the male sex is wholly wanting, and in all those genera where the female sex has no foot at all, it is also absent in the male sex. As regards the freeswimming Rotifers, where the foot is used as a steering organ, it is only among the *Euchlanidæ* and *Salpinadæ* that it is used in that way also in the male sex where it is used as a leaping organ in the female

sex (*Dinocharis, Scaridium*), it is reduced to a simple swimming organ in the male sex. As the males of the fixed Rotifers, the *Melicertidæ* and *Flosculariidæ* are always freeswimming organisms, never living in tubes, the foot of these species is not provided with all those peculiarities which characterise the female foot in these families, and which help the females to sink down in the protecting tube. All in all it will be understood that the foot in the male sex is a much more reduced organ than in the female sex. As a swimming organ it has lost its significance in many families; but it has preserved its significance as an organ of fixation. In accordance herewith the foot glands only rarely disappear. The substratum upon which the males mainly use the foot is the body of the female; therefore it has mainly significance during the mating process. It disappears for the benefit of the development of the penis which is partly formed by means of blood pressure upon the dorsal side of the foot.

Wheel-organ. Female. As mentioned above the wheel-organ of the Rotifera was formerly interpreted as consisting of two zones of cilia, the inner one termed trochus the outer termed cingulum, both encircling a circular funnel and with a finely ciliated groove between them. This is the interpretation of LEYDIG, HUXLEY and PLATE. This view was adopted as late as 1910 (HARTROG). As mentioned above already METCHNIKOV and JOLIET, later on myself and lastly DE BEAUCHAMP have tried to show that the original wheel-organ of the Rotifera is really a ventrally situated ciliated disc ("la plaque ciliée buccale" DE BEAUCHAMP). In the most primitive types (some of the *Notommatidæ* and the *Adinetadæ*) this ciliated disc without any bordering zone of longer cilia is still preserved. This ciliated plate is simultaneously an organ of locomotion with which the animal moves slowly over the substratum, partly an organ with which the food is brushed off into the mouth; the organ cannot be used for swimming, and the animals creep in Turbellaria-manner over the substratum. As the Rotifera accustomed themselves to the swimming motion, the cilia at the borders of the disc were forced to overcome a much greater resistance than those covering the centre of the disc. The result was the development of the bordering zone of cilia, the "bande circumapicale" DE BEUCHAMP. In the most primitive types this band is in the main only developed in quite particular lateral parts of the disc, and these parts, the socalled auricles (oreillettes) or "Wimperohren", are then capable of being withdrawn and extended again. When withdrawn, the animal is still a creeping, when protuded, a swimming animal (many *Notommatidæ*). They are especially well developed in those families where the foot is not well marked off from the other part of the body, and preserved in those swimming families where the foot cannot therefore be used as a steering apparatus, the auricles being used in this way (some *Notommatidæ, Synchætadæ*).

Simultaneously with the development of a wheel-organ, consisting of a ciliary disc, bordered by a more or less continuous row of longer cilia, the position of the disc is altered from a more ventral to a more vertical one. The more the animals

emancipate themselves from a substratum and pass over to being strongly freeswimming animals, the more vertically is the wheel-organ placed. In the families of the *Notommatidæ*, in the developmental series *Hydatina*, *Rhinops*, *Notops brachionus*, and the *Brachionidæ*, we find excellent examples of this phenomenon. A wheel-organ of these hitherto mentioned types is really a swimming organ, but has no importance as an organ by means of which the nourishment may be seized. This is only done by means of the mouth parts, which are near the mouth opening, and are often capable of being protruded as catching organs. Very many of the wheel-organs of the freeswimming Rotifers are really modifications of this very type.

The more the animals pass over to being freeswimming individuals, quite emancipating themselves from a substratum, the more often is the disc, in accordance herewith, placed terminally. The homogeneous cilia-covering of the disc disappears, giving place to elevations of different kinds, hills, plates, etc., covered with much stronger cilia; simultaneously herewith the bordering band of cilia of the disc, commonly reduced in the middle line dorsally and ventrally, is more strongly developed, and great parts of the disc itself may be quite destitute of cilia. In different ways the strong cilia of the disc planted upon small elevations, hairpads are of significance as stopping apparatus for the catching of prey; but still the mouth parts play a prominent part in this way. Wheel-organs of this type we meet with in the *Euchlanidæ*, *Salpinadæ*, *Coluridæ*, *Cathypnadæ*, *Dinocharidæ*, *Ploesomatidæ*, *Gastropodidæ*, *Rattulidæ*, *Hydatinidæ* and *Brachionidæ*. Almost all these Rotifers belong to smaller ponds rich in plants and whose surface is divided by means of floating leaves in innumerable small pelagical regions in which most of these animals live their lives, half swimming, half creeping, often fastened to the leaves. Many of them are typical vegetarians, gnawing the diatoms coatings etc. upon the leaves, most of them get their food when, half swimming half creeping, they move over the substratum using their wheel-organ mainly locomotorically; the most elaborate forms are really plancton organisms, inhabiting the pelagic regions in ponds, pond lakes and exceptionally also real lakes. As such may mainly be mentioned most of the *Brachionidæ*, and a few *Gastropodidæ* and *Ploesomatidæ*. In the *Brachionidæ* the wheel-organ, in accordance with its structure, is used as well locomotorically as for the catching of nourishment; in the two last named families mainly locomotorically, the mouth parts being here used as organs which catch the prey when the animal crosses its way through the water layers. In one of the most typical groups of plancton Rotifers the *Asplanchnadæ* the ciliary disc is quite destitute of cilia, a wreath of cilia encircling the nude disc, only provided with some tufts of cilia with sensorial functions; but also this wheel-organ is only locomotive, the prey being caught with the mouth parts during swimming.

In case the wheel-organ in freeswimming or sessile Rotifers is to act simultaneously as an organ fitted both for locomotion and for provision of food, two ciliary wreaths, separated from each other by a cilia covered furrow, are developed. The material caught by the wheel-organ is carried down into the furrow between the

two wreaths, and conveyed further to the mouth. In this case the mouth parts have no significance or only a slight significance for catching the food, and do not reach the mouth opening; in some families they are far removed from it. It reaches its highest development in *Pedalion* among the plancton Rotifers and in the *Melicertidæ* among the sessile Rotifers. In some of the plancton Rotifers such as *Triarthra*, *Pompholyx*, *Pterodina*, it is only faintly developed. Below the ciliary wreath there is here a faintly developed furrow, covered with very fine cilia, but this space is not limited here by a lower ciliary wreath. To this type also belongs the wheel-organ of the *Philodinidæ* built in another way, but also destined to be used simultaneously for locomotion and for gathering nourishment. In many of the almost sessile moss-*Philodinidæ* it is used almost exclusively in this way; here its significance as a locomotory organ is almost lost. This is also the case with the wheel-organ in some of the above-named types, some of them being almost sessile organisms; this f. i. is the case with many of the *Brachionidæ* which, once fastened to a substratum, only very rarely leave it. (*B. rubens* upon Daphnids). By means of a peculiar structure it obtains significance also as a tube forming organ in some of the *Melicertidæ*. A very peculiar wheel-organ occurs in the *Flosculariidæ* which can only be understood on the view that we have here organisms which are simultaneously sessile and animals of prey (DE BEAUCHAMP). The disc is here formed like a funnel whose borders commonly taper into lobes and arms which carry long stiff cilia. Centrally at the bottom of the funnel lies a second chamber, the vestibulum, encircled by a horse shoe-shaped ciliated rim, and in the base of the vestibulum is a long slit, the buccal orifice, bounded by two chitinous lips. Organisms which have got into the funnel, cannot get out because of the long bristles which extend over its orifice; when victims enough are gathered in the vestibule they are swallowed down into the alimentary canal.

Wheel-organ, males. If we will now try to understand the wheel-organ of the males we must remember that apart from a few rather doubtful exceptions, it is only an organ of locomotion and has nothing to do with procuring food. The alimentary canal is obliterated or rudimentary and the animal gets no food whatever.

It must further be remembered that, whereas the females of the Rotifera, when swimming, mainly move along a screw line, the males mainly move along a straight line. As far as I understand, when the animals are moving along a screw line it is most probably impossible to steer towards a definite point, especially when this point is moving. They are unable to follow a moving prey or a rotating female. We therefore see that the few plancton-Rotifers which in the female sex live on other planctonts which are seized and sucked out, f. i. *Ploesoma Hudsoni*, in the male sex really often follow straight lines, at all events when they are in pursuit of prey. With regard to the males of the Rotifers which are always in search of the females during their short life time it would be almost impossible for them to find and reach a female when discovered, if the motion were only rotating. It is in accordance with this that the males almost

always dart off in straight lines or in large circles, but during this motion they do not as a rule rotate round themselves.

It will further be understood that an organ of locomotion destined to move the organism along a screw line cannot be formed like one which is to move it along a straight line. I suppose that a rotating motion is mainly dependent first upon a strong development of a ciliary wreath, sharply defined from the nude coronal disc, and secondly upon the wheel-organ being placed terminally; if this is not the case, and it is nevertheless to be used as a rotating organ, the oblique position of the wheel-organ must be counterbalanced in some other way. Wheel-organs consisting of a cilia-covered disc with no stronger development of a special wreath of cilia is not an organ well fitted for rotation.

In the above-named rather cursory remarks with regard to the use of the wheel-organ in the Rotifera I have endeavoured to point out some of the main conditions for the understanding of the differences between the organ in the male and the female sex.

It must firstly be emphasised that the wheel-organ in the male sex is placed almost terminally, very rarely ventrally, and even more terminally in those species where it is more or less ventral in the females. This is in accordance with the fact that the part of the wheel-organ surrounding the mouth and which is the most ventrally placed part is obliterated in the male sex. This is especially the case with the hitherto known males of *Notommata, Copeus, Diglena* and partly also with *Hydatina*. The disc is very often vaulted, it may be flattened, but very rarely funnel shaped. It is very often covered with a coating of cilia, almost of the same length and in many cases the ciliary wreath round the disc is but slighly developed. It is just the wheel-organ which we should expect in animals which are incapable of constant rotating movements during the swimming motion. A terminally placed, almost totally nude, flattened disc encircled by a wreath of cilia we only find in the *Asplanchna*-males and just these males rotate during swimming as well as the females. Where auricles exist in the females, they are commonly not present or more slightly developed in the male sex. In the *Synchætadæ* I have not been able to trace them; and in the many figures of *Synchæta* which ROUSSELET has given, they are also absent; in *Ploesoma Hudsoni* they are but faintly developed, and occur only in the male sex in some males of the genera *Copeus* and *Notommata*.

From the ventral part of the disc no special part is set off as a cilia-covered furrow, almost always developed in the female, and here leading down to the mouth. It is only well developed in the males of *Rhinops* and partly also in *Euchlanis*, at all events in *E. dilatata*.

As mentioned above the disc in the female very often carries elevations of different kinds and on the tops setæ varying in numbers and size in the different species. Common to all these hair structures is the fact that in the females they are arranged in relation to the mouth; they play a rôle either as sense organs or more directly as organs for capturing the prey; they serve as a means of procuring

nourishment. In the males these hair structures are in a few cases arranged as in the females. This is especially the case with *Rhinops*, where in my opinion the wheel-organ of the two sexes is almost identical also in *Euchlanis* and in *Hydatina senta* we find a similar though somewhat simplified arrangement; where the mouth lies in the female, there is a cilia-covered spot, surrounded by hairpaths very similar to those in the females. In very many cases, especially in the most rudimentary males, the whole wheel-organ consists of some bunches of long bristles standing upon a disc, homogeneously covered with very short cilia and encircled by a wreath which is more or less sharply set off from the coating of the disc. It is a wheel-organ which is quite unable to catch any organism destined for food and which has only locomotory significance.

No males have hitherto been described with two bands of cilia round the disc. In the males of *Pedalion* and in the *Melicertidæ* there is not the slightest trace of either a furrow or posterior band of cilia so characteristic of the females; in the males of *Pterodina* and *Triarthra* no fine coatings of minute cilia below the corona are observed, and in the males of the *Floscullariidæ* we find nothing which may be compared with the highly elaborated wheel-organ of the females; no stiff setæ are observed; all that we find is a simple somewhat vaulted terminal disc, encircled by a single uninterrupted band of cilia equally long. It is of great interest to see how the typical wheel-organ of the Rotifers, a cilia-covered disc encircled by a single band of cilia is improved in very different ways and in accordance with the use of the organ, in the two families, the *Melicertidæ* and *Floscullariidæ*, and in the two sexes of both. In both families as the animals are sessile in the female sex the organ is here almost exclusively formed and used for catching food, but in the two families one of them being detritus-eaters, the other, the Floscullariidæ, true beasts of prey catching the single organisms which arrive in the funnel-shaped corona and later on lacerating them with their teeth, the wheel-organs are as differently developed as possible. In the male sex in both families and where they play no rôle for procuring food and are only organs of locomotion, they are improved in very different ways from what is the type for the females. However differently the wheel-organs may be developed in the females of the two families, in the males they are of quite the same structure, formed as simply as possible, a ciliary disc encircled by a single, uninterrupted row of cilia; all those structures which in the wheel-organs of the females play a rôle for procuring food, and in the two families develop in very different ways, are here totally absent.

We are therefore able to conclude that all those different structures, which in the female sex play a rôle for catching the prey, are absent. On the other hand as the males must be more active in their movements than the females and be able to follow them, stress is laid upon improvement of the organ as strongly locomotive.

In many cases we find hairs of unquestionably sensitive significance upon the disc. In very many cases e. g. in the *Synchætatæ*, *Brachionidæ*, *Anuræadæ* and others we find quite the same arrangements of these hairs in both sexes; also the fleshy

digitiform processes which are found in the females of *Ploesoma*, *Gastropus*, *Rattulus*, we find again in the male sex.

Only rarely do we find organs which do not occur in the female sex on the disc of the males. This is however the case with the genus *Triarthra*, and with some, perhaps almost all *Melicertidæ*. The disc here carries a peculiar hill; where it exists it always carries the two red eyes, which in this way are brought beyond the wheel-organ and not, as in the females, concealed on a level with it.

A very peculiar organ is the so-called retrocerebral organ, which was formerly described as "Kalkbeutel" ("brain mass" HUDSON-GOSSE) and which has been studied by very many authors. It is justly due to DE BEAUCHAMP, that we now have a more thorough comprehension of this organ which is unquestionably the most enigmatic in the Rotifera. Still, there are very many unsolved questions connected with it, especially its physiological significance is still almost wholly unknown. DE BEAUCHAMP has found it in 15 of the 27 families; B. supposes that it really has existed in all families and regards it as a regressive organ, which has disappeared in the *Melicertidæ* and *Seisonacea*. It consists of a retrocerebral sac, flanked by a commonly double subcerebral gland; the organ opens inside the wheel-organ with two openings, often placed upon a pair of protuberances; these openings are however very difficult to observe; the organ shows a peculiar correlation with the eye-spots, the unpaired eye being always in contact with the sac and the brain; in those species in which we find paired eye-spots, these are always placed very near the openings for the organ. It may be regarded as a glandular invagination of the ectoderm, situated in the nonciliated part of the apical zone of the wheel-organ. With regard to its significance the organ may mainly be regarded as a secretory one; it is highly probable that the two parts of the organ have not the same significance, that it is by no means the same in the different families and that its development and structure in the same species may differ from specimen to specimen, and be of different development especially at different ages. The organ is best studied in *Euchlanis*, where DE BEAUCHAMP has shown that the contents of the median sac are transformed into vacuoles, which are expelled through the orifices, after which the sac shrivels up to a much smaller circumference. Whether this emptying of the sac is a process taking place at regular intervals or only under special outer or inner conditions we do not know. In *Notommata* the secretory activity is by no means so large. In the so-called "bourses a calcaire" the secreted matter is designated as bacterioïdes, regarded as an excretion "un depôt dans certaines cellules de produits destinés à être éliminés lentement ou à rester là jusqu'à la mort de l'animal (DE BEAUCHAMP 1909, p. 174). In the *Euchlanidæ*, where we have a secretion, the secreted matter was formerly regarded as a poison. DE BEAUCHAMP supposes that it plays a rôle in the action of the cilia, perhaps that of lubricating organ and remarks that it is best developed in creeping Rotifers. In my opinion this is a very essential point. The organ is inherited from the Turbellaria as mentioned by DE BEAUCHAMP "la similitude d'une glande subcérébrale avec certaines glandes muqueses à col très allongé et réduit

à une traînée de sécrétion comme on en connaît chez les Triclades, les Néoméniens etc. est indéniable." The more the Rotifers passed over to being either freeswimming or sessile animals and, in some of their most aberrant forms, real plancton organisms, the organ lost its significance and was gradually reduced.

The retrocerebral organ in the males has hardly ever been studied. As far as I know, it is well figured only by DIXON-NUTTALL (1892—94, p. 333, Pl. XV), but he regarded the whole organ as the brain. It would have been of the greatest interest if the investigation of the males could have brought anything special to light with regard to this organ, its structure or its significance. This is however not the case, staining methods of living animals not having been used. Owing to the slight size this will always be very difficult but is surely possible for some of the largest males of *Hydatina*, *Euchlanis* and *Copeus*. It is of interest to see that in the two genera *Euchlanis* and *Copeus*, where the organ is most strongly developed in the female, it is also strongest in the males. It has also been observed in the males of the other *Notommatidæ*, and when it has not been figured and mentioned in the descriptions of the other males, much stress must not be laid upon that point. I think that more elaborate investigations will establish its existence. In the males of *Euchlanis* and *Copeus* I have found it to be of exactly the same structure as mentioned by DE BEAUCHAMP for the females. Only I have been unable to see the Bacteroides in the median sac in the last-named genus, but that is perhaps morely accidental. In the figures of *Euchlanis* I have not ventured to draw the protuberances provided with the opening. On material from Esrom lake in October 1922 I however found very conspicuous protuberances, corresponding exactly to those figured by DE BEAUCHAMP.

Alimentary canal. In its most complete shape the alimentary canal consists of eight parts in the female sex.

1. Vestibulum, which is only a depression in the disc of the wheel-organ. 2. The Pharynx or Mastax, one of the most peculiar organs of the Rotifera 3. an oesophagus covered with Cuticula and only regarded as a prolongation of the Mastax. 4. an oesophagus covered with cilia. 5. The gastral glands commonly in a number of two. 6. The ventricle formed by a single cell-layer; the cells are often arranged serially and separated from each other by means of muscle fibres; they are almost always covered with cilia and contain stored nutriment or excreta. 7. The intestine, often indistinctly separated from the ventricle. 8. The rectum, in which the excretory organ debouches; often it acts as vesica.

Even in the female sex all these eight parts are only rarely developed. The oesophagus is extremely short in the *Euchlanidæ*, the intestine is absent in the *Seisonidæ*; rectum and anus in the *Gastropodidæ*, *Asplanchna*, and *Paraseison*. Apart from the different forms of mastax, also the other parts of the alimentary canal shows the greatest possible variation in the different families.

As well known, the alimentary canal is almost always rudimentary in the male sex, does not function, and in many cases it is impossible to show only the slightest trace of it. Like other rudimentary organs, its development even in the same species

differs from specimen to specimen, and in its rudimentary form it undergoes a change of function.

A fully developed alimentary canal we only find in the male of *Rhinops vitrea* and in *Notommata Werneckii*. It is a question if really the male of *Rhinops* takes food, at all events I have never been able to see an anus or a defecation; it is further a very peculiar fact that the alimentary canal is very rudimentary in its nearest allies, *Hydatina* and *Notops brachionus*, further that it is also lost in all the primitive Rotifers, only excepting *N. Wernecki* and in all other freeswimming Rotifers. With regard to *N. Wernecki* it is perhaps a question, if the mouth parts are not mainly used to bite holes in the algæ; but having never seen this rare animal, I have no opinion about this matter.

In all other Rotifer males the alimentary canal does not function; a mouth opening never exists, and also the mastax is absent. In the place where the alimentary canal is to be found in the female, there is commonly a long broad band, which with its posterior end embraces the testis and with the other is fastened to the hypodermic cells of the wheel-organ. This band in a few cases carries a peculiar bulk like body in its anterior part immediately below the wheel-organ, in *A. priodonta* it is of a remarkable form like a parrot's beak. In *A. priodonta* it is not always present, at all events not equally developed; it is further found in the males of the two *Salpina* species which I have seen; it contains no chitinous mouth parts, but nevertheless I regard it as a rudimentary mastax. In a few cases we find two organs on the side of the band which are regarded as rudimentary gastral glands. Especially in *A. priodonta* it looks as if the band contained vacuoles, but more thorough investigations on this point would be desirable. Also in the *Synchæta* males it looks as if the band was hollow. In very many cases it is reduced to a simple band, stretched out between the testis and the hypodermic cells below the wheel-organ; even in this form it is by many authors, with whom I fully agree, regarded as a remnant of the alimentary canal; but even this is wholly wanting in the males of many species. This for instance is the case with all the most reduced males, those of *Triarthra*, *Polyarthra*, *Pedalion*, *Conochilus*, *Pompholyx*, *Rattulus*, but also of many others which are not so much reduced f. i. *G. hyptopus*, *G. stylifer*. How sporadic and capricious the occurrence of the rudiment of the alimentary canal really is, is best seen in the *Asplanchnas*, where in *A. priodonta*, as mentioned above, it embraces the testis and is stretched out like a long band through almost the whole animal; in *A. Brightwelli* it has not been possible to find even the slightest trace of it, while in *A. Sieboldi* a peculiar rodlike body stretched out from the corona and hanging free in the body cavity can hardly be interpreted otherwise than as a rudiment of this organ. Where it is in connection with the testis, it may be regarded as highly probable that it is here used as a means to keep the testis in place.

The brain in the male as well as in the female lies dorsally over the alimentary canal; it is commonly pear shaped, now and then a little bifid. I have the impression that it is perhaps larger in the male than in the female sex but it is

possible that I have made the same mistake, with regard to the male sex as earlier authors with regard to the female sex, viz. the mistake of describing some parts of the retrocerebral organ as parts of the brain; the extreme smallness of the objects must here be my apology. In the *Polyarthra* male I have not been able to see any trace of the brain. Neither a peripheric nervesystem nor an oesophageal nor a pedal ganglion shown in the female sex in several species (e. g. in *Callidina* and *Discopus* by ZELINKA; in *Hydatina* by DE BEAUCHAMP and MARTINI (1912, p. 612) and in *Conochiloides* by HLAVA (1905, p. 209) have been found in the males; but the necessary methods of investigation have not been used.

Sensitive organs. Female. As mentioned above the most typical sensitive organs of the Rotifers are two pairs of tactile organs, the anterior and posterior lateral organs, which are connected by long nervethreads either directly with the brain or with peripheric ganglia-cells, lying laterally to the brain.

Only in a few cases both the two anterior and two posterior lateral organs are far removed from each other. This is the case with *Asplanchnadæ* and *Apsilus*, and they are then connected with each other by means of a transversal commissure; in the *Synchætadæ* the two anterior ones meet each other, but in most of the Rotifera they coalesce to a single so-called dorsal organ, or dorsal antenna. Commonly two nerves are present, more rarely only one. It lies in the middle line dorsally, and is only rarely asymmetric (*Rattulidæ*, *Gastropus*). The cuticula is often elevated to a little hill, on the top of which a bunch of sensitive hairs, rarely only one single hair, is visible. In some cases, especially in loricate Rotifers, the hill is converted into a real antenna often situated immediately behind the wheel-organ, is drawn in together with the latter, and is the first which makes its appearance when the wheel-organ is again unfolded (*Brachionidæ*, *Anuræadæ*, *Salpinadæ*). In the *Bdelloida* it is segmented and provided with muscle threads, and may here as well as in some of the *Melicertidæ* reach a length of about one third of the body (*Cephaloziphon*); in *Eosphora* HIRSCHFELDER (1910, p. 69) has interpreted the organ as a combination of a tactile and a static organ. The dorsal organ is very rarely absent (*Conochilus*). The posterior or ventral lateral organs hardly ever coalesce (perhaps in *Copeus caudatus*); they are almost always widely separated lying on the borders between the dorsal and ventral side and are provided either with a bunch of sensitive hairs or one single hair; they have not been ascertained in the *Bdelloida*. In the tubedwelling Rotifers they are often placed ventrally, situated upon long antenna-like organs, which are placed anteriorly so that their tips are the first part of the body which appears when the animals make their appearance outside the edge of the tube.

In the males these sensitive organs are constructed in accordance with those of the females; here however they are very difficult to detect; especially in many of the strongly reduced plancton Rotifers they are almost always unknown, and it is a question if they really exist here. In the *Asplanchna* they are identic in both sexes, and in many males, e. g. those of the genus *Synchæta*, *Hydatina*, *Gastropus hyptopus* and others two nerves to the common dorsal organ are present. It is especially the

lateral organs, which are difficult to observe, and probably often overlooked. In the sessile families the *Flosculariidæ* and *Melicertidæ*, where the sense organs in the female sex show so many peculiar structures, they seem to be very much simplified in the male sex, and are never elongated into long antenna-like organs.

Most of the Rotifers possess sense organs for light in the female sex. They are lacking in *Pleurotrocha, Noteus, Callidina, Adineta*-species, and in the *Flosculariidæ* and *Melicertidæ*, when sessile; in the freeswimming stage they possess two eye spots. In accordance with DE BEAUCHAMP the position of the eye spots in Rotifera may be referred to the following scheme: an eye occipitale, often double and in contact with the brain, and the retrocerebral organ and two superior eyes on the disc or in the corona. As far as I know, the two sorts of light perceiving organs do not as a rule occur simultaneously. The common occurrence is the unpaired eye spot, below the brain; we have here a simple pigmented spot, a typical lens has not often been observed; it is however possible that the bacteroides in some species f. i. *N. pseudocerberus*, being situated in contact with the eye spot, and on its underside, may play a secondary rôle as light perceiving (DE BEAUCHAMP 1909, p. 174). Two eye spots exist in *Pterodinidæ*, *Pedalionidæ*, *Coluridæ*, in some of the *Notommatidæ* (*Diglena*) and a few *Asplanchna*-species. In the genus *Rotifer* they are placed upon the tip of the proboscis; as mentioned above they occur in the freeswimming stage of *Flosculariidæ* and *Melicertidæ* but very often disappear in the fixed stage. Two eye spots lateral also occur in *Eosphora*-species, but according to HIRSCHFELDER (1910, p. 86) these spots are not eye spots.

In the male sex it is interesting to see, that the number and position of the eye spots are almost always in accordance with those of the female. In those females which have one single eye spot, this is also found in the males; and when the females have two anterior eye spots, this is also the case with the males; in the *Eosphora* males we find three "eyes" as in the female; also the position of the eyes in the males of *Asplanchna*, is the same as in the females. This is also the case with *Triarthra*, but here as well as in the *Flosculariidæ* it must be emphazised that the two eye spots in the male sex are placed upon a hill-like prolongation which, especially in *Triarthra*, has almost the character of a proboscis. In *Rhinops* the eye spots are situated upon the proboscis-like prolongation in both sexes. Especially in *Triarthra* and *Pedalion* typical lens organs have been observed. In some of the most reduced males I have been unable to find any trace of eye spots (*Polyarthra, Gastropus, Ploesoma*).

Nephridia. As well known, the nephridia of the Rotifera consist of two lateral canals, equipped with a number of vibratile tags and opening into the contractile bladder, which again debouches in the rectum. Commonly a transversal commissure between the two longitudinal canals is not observed; hitherto it has only been detected in *Stephanoceros, Atrochus, Conochiloides natans, Apsilus, Lascinularia* and *Hydatina*; it must however be remembered that just these Rotifers are the best studied of all. Everywhere where more elaborate investigations are carried on, it

has further been shown that the longitudinal canals really consist of two tubes, the secretory one (the Drüsengang MARTINI's) with relatively thick walls, often of glandular structure, and the excretory one (the "Flimmergang" MARTINI's) or capillary tube, which has very thin walls; it is this tube which carries the vibratile tags; the tube with the glandular structure commonly forms one or two windings or meanders in many loops and curves. It has much thicker walls and often contains oil globules. It is of great interest that HLAVA has found vibratile "Treibwimpern" (*Lacinularia*, *Megalotrocha*) in these tubes. The capillary tube debouches into the maintube by means of one or two transversal commissures. The structure of these two tubes, the excretory and secretory ones, their course and the manner in which they are connected with each other are subject to great variation in the different genera and species. The vibratile tags are connected with the tubes by means of short stalks, and project into the body cavity; their number is commonly from five to six on each side, but may in some *Asplanchna* species rise to about fifty. Most of the authors, especially those of recent years, are of opinion that the free broad end is closed; they are here provided with a protoplasmatic plug, which on the part turning towards the body cavity is as a rule provided with two flagellæ and upon the other part carries the vibratile flames, deriving from many cilia coalescent with each other: they are situated in the open space of the vibratile tags and are in constant motion. The canals debouch into the contractile vesicle, the walls of which are extremely thin and provided with very fine muscle threads; often, f. i. in *Asplanchna*, two large star-like cells with very long threads are observed; these cells have the function of contracting the bladder. This latter is commonly regarded as originating from the coalescense of the two excretory tubes. Only rarely is the vesicle absent (*Lacinularia, Tubicularia*). Here the two lateral canals coalesce into a common unpaired part; this part is in accordance with the contractile vesicle of Rotifers, but regular contractions have not been observed, the last part of the rectum functioning in this way (HLAVA). In the *Philodinidæ* part of the rectum is transformed and used as a contractile vesicle, being capable of rhythmical movements.

Commonly the whole organ is only regarded as an excretory organ; through the vibratile tags useless or destructive materia are carried out of the body. GOSSE however has supposed that the organ is respiratory, and as well known, EHRENBERG regarded it as the male sexual organ. In most of the Rotifers it may be observed that the bladder suddenly contracts regularly about four times a minute, in *Asplanchna priodonta* according to WILLEM (1910, p. 26) 4 times a minute, according to MASIUS (1890, p. 661) ten times; in *Adineta barbata* according to JANSEN (1893, p. 8) three to four times; then, in the intervals, it slowly fills again. The size of the bladder differs very much; WILLEM supposed that, in an *Asplanchna*, when distended, it is almost $^1/_5$ of the body volume. In other words, during a time of only one to three hours, the organ was supposed to be able to collect and expel a volume of water, equivalent to the whole volume of the body. Apart from the difficulty of understanding that the body cavity should incessantly be run through by this enormous mass of

water, the question arises from where this enormous water current comes. Further, where are the forces which uninterruptedly drive the currents through the body cavity and where are the openings, through which the water finds its way into it? And lastly why should the body cavity be run through by such enormous water-masses? COHN, COSMOVICI and JANSEN have supposed that the bladder is in some way filled from the alimentary canal, and that its main task is to carry out of the body the water-masses which the animal has taken in through the mouth together with the food. "Sie hat, entgegen den früheren Ansichten, die Aufgabe, den durch die Räderorgane mit den Nahrungsteilchen in den Verdauungskanal hineingetrudelten Wasserstrom, der durch die starke Bewimperung des letzteren weiterbefördert wird, zu sammeln. Die Blase d. h. der dehnbare, dünnwandige Teil des Enddarmes wird durch das gesammelte Wasser aufgebläht und befordert dasselbe periodenweise durch Zusammenziehung nach aussen" (JANSON 1893, p. 8). JANSON further shows that the vesicle was contracted every 18 seconds, if the wheel-organ was fully expanded. If it was contracted, the contractions of the bladder were slower, first every twenty seconds, then every 25, 30, 40, 50 seconds and lastly they almost totally disappeared. As soon as the wheel-organ was again expanded, the contractions — about four in a minute — began again. According to JANSON this can only be interpreted to mean that the water is forced into the alimentary canal through the mouth, passes through the alimentary canal into the bladder, from which it is again poured out. Owing to the peculiar derivation and position of the contractile vesicle in the *Bdelloida*, the explanation of COSMOVICI and JANSON may be correct for these animals; but in the other divisions of the Rotifera it is difficult to understand that it can be quite exhaustive. The same ideas have, by the way, been set forth by WILLEM (1910, p. 26), who supposes that the watermasses especially pass through the thin walls of the oesophagus, and by GOSSE (1889, p. 138), who maintains that they "pass at the head."

In the male sex the excretory organ is only fully developed in the genus *Asplanchna*. Exactly as in the females we here find the two sorts of lateral canals, the secreting glandular tubes and the excreting capillary tubes which carry the vibratile tags. In the different species we find the same great difference with regard to the number of tags in the male sex as in the female sex; in *A. priodonta* in both sexes from 4 to 5 in *A. Sieboldi* about 40—50. The two lateral canals as in the female open in the contractile vesicle, and this again opens into the ductus seminalis. The vesicle is filled and contracted as far as I have been able to see quite in the same manner in the male as in the female. Fully extended it reaches an enormous size, in the male of *A. Sieboldi*, more than $^1/_5$ of the body cavity. Apart from the *Asplanchnas* the contractile vesicle seems to be absent in almost all other Rotifer males. The two lateral canals which show a more simplified structure in the males than in the females, almost always seem to open with two small openings at the sides of the opening for the penis; but these openings are difficult to see. I for my own part have only been able to see them with certainty in *Salpina*,

Floscularia and *Hydatina*. Only rarely (*Asplanchna*) have two different kinds of lateral canals on each side been observed. As far as I have been able to observe, the vibratile tags are commonly implanted directly upon the glandular tubes, the capillary tubes being often absent; upon this point more thorough observations are however necessary. Even if the excretory organs are overlooked in many cases owing to the smallness of the organisms, there can be no doubt that they really do not exist in many of the smallest and most reduced males. This is the case with the males of *Conochilus*, *Notholca acuminata*, *Pompholyx sulcata*, *Polyarthra platyptera*, *Gastropus stylifer*, *Ploesoma Hudsoni*, *Rattulus*, *Triarthra*, *Pedalion*. If we remember that the life of these organisms most probably can be counted only in hours, this is quite intelligible.

The knowledge we have now gained with regard to the excretory organs in the males gives rise to the following remarks. There might be reason to suppose, that there could, in the male sex, be pointed out some connection between the occurrence of the alimentary canal and the developmental stage of the excretory organ; especially those who suppose that the water must come in through the alimentary canal, and the contractile bladder therefore in some way be filled from this organ, might expect that the contractile bladder would disappear where the alimentary canal is lacking, rudimentary, or functionless. That this is in some way really the case cannot be wholly denied; as mentioned above, it is a common rule that all males without alimentary canal are destitute of the contractile vesicle. On the other hand it must be remembered, that neither ROUSSELET nor I have been able to find this last named organ in *Rhinops vitrea*, one of the very few males which possess a fully developed alimentary canal and where therefore a bladder might be expected. Further, that the *Asplanchna* males which are entirely destitute of any alimentary canal, really possess a bladder, which is just as large as that of the female and functions perfectly. With regard to all those authors who suppose that the water currents in some way pass through the walls of the alimentary canal, it must now be emphasized that the contractile vesicle in the males of the *Asplanchna* is distended and emptied in quite the same manner as in the female sex, and this in spite of the total absence of an alimentary canal. As far as I can make out from our present standpoint of knowledge no other explanation is possible than that the water must pass into the body cavity from the whole surface of the animal. The driving forces are of course not the vibratile tags but only the difference between the density of the two fluids inside and outside the body wall. It is the main task of the vibratile tags to drive the water currents out of the body again. In the female sex they are provisionally stored up in the contractile vesicle from which they are at regular intervals forced out of the body, in the male sex this is not as a rule the case, and the water currents flow out uninterruptedly through the two openings at the side of the genital opening. This view is only of value as a working theory, but it might be tested by experimental investigation. If it is correct, our apprehension of the whole organ as only excretory must be somewhat altered; its main task being

not only to drive noxious material, deriving from the metabolism, out of the body, but also and mainly the volumina of water which by purely physical causes are forced into the body cavity. This supposition is by no means new; it has already been set forth by LEYDIG (1855, p. 82).

Remembering that in *A. priodonta* we only find about from 4 to 5 vibratile tags and in *A. Sieboldi* from 40 to 50 it is possible that a more thorough observation relating to the process of the filling of the bladder in these two species might perhaps elucidate something with regard to the function of the organ; lack of material has hindered me from making these investigations.

I cannot see better than, that there is still, in the anatomy of the Rotifera, an essential point relating to the excretory organ about which we lack almost all knowledge.

As we know that the *Asplanchna* males are most probably the males with the greatest longevity (about 4—7 days) whereas the strongly reduced males most probably only live for some hours and never 24 hours, it seems to me that the presence of the contractile vesicle is more dependent upon the longevity of the animal than upon the presence of a functioning alimentary canal.

Different authors have supposed that we should find special pores in the cuticula through which the water poured into the body cavity. LEYDIG (1855, p. 82) has supposed something in this direction, and EHRENBERG regarded the dorsal organ as a sipho.

In this connection we may call attention to the fact, set forth by KRÄTSCHMAR (1908) but hitherto never corroborated, that the peculiar sac which contains the great oil globule which is lying over the testis and which in some way "in enger Beziehung zu dem sehr schwierig zu beobachtenden Excretionsorgans steht", by means of a canal, ending in an always open porus, is in connection with the outer medium. "Es ist unschwer einzusehen, dass diese Einrichtungen darauf abzielen ständig das Excretionsorgan offen zu halten (1908, p. 9)." How great is the bearing of this observation, we do not really know. In this connection I take the liberty to call attention to the fact, that I have with absolute certainty seen in *Euchlanis* that the two lateral canals debouch in the sac above the testis and that I was unable to see the canals follow the ductus seminalis to the opening of the penis.

Muscles. Females. It is quite impossible in our present stage of knowledge to give a correct picture of the muscle system of the Rotifera. The muscles may be divided into transversal muscles, longitudinal muscles and muscles belonging to special organs, especially those of the mastax, the contractile vesicle and the stomach. The transversal muscles are particularly well-developed in the *Bdelloida*, where they often encircle the body at regular intervals to a number of twelve; they are here commonly interrupted ventrally. In the other orders and families their number is much smaller, commonly six or seven; extremely large only in *Atrochus*. In the loricate Rotifers they are not so well-developed; in most of the figures and descriptions they are wanting. The main task of the transversal muscle system is most

probably to press out the wheel-organ and foot by means of altering the pressure in the body cavity, when the organs have been drawn in by means of the longitudinal muscles.

The longitudinal muscles may commonly be divided into two groups, those of the anterior and those of the posterior part of the body; the former draw in the wheel-organ, the latter the foot; where the foot is rudimentary or absent, they are commonly greatly reduced. The two muscle groups overlap each other in the middle part of the body. The number, place and function of these longitudinal muscles are remarkably constant in the different genera and species, f. i. in the *Flosculariidæ* and *Melicertidæ*, where long longitudinal muscles pass through the whole body from the wheel-organ to the end of the foot. They have only been more thoroughly studied in very few species. The old division of ZELINKA in "Haut und Leibeshöhlemusculature" has now been discarded. It seems as if we find striated as well as smooth muscles; in some species special muscles, especially those of the wheel-organ, are conspicuously striated; MARTINI (1912, p. 614) maintains that, in *Hydatina*, excepting only two muscles, he only finds striated ones. Whether the muscle elements are to be regarded as muscle threads or muscle cells, cannot be stated with certainty. With regard to *Hydatina*, MARTINI has arrived at the main result that all the transversal muscles and all the more significant muscles are really muscle cells, muscle individuals with one nucleus only (exceptionally two).

Muscles. Males. The nature of the investigation prevents any elucidation of the histological structure of the muscles in the male sex; the division of the muscles in transversal muscles, longitudinal muscles, and those belonging to special organs, may also be maintained for the male sex; in most of the males we find from five to six transversal bands, most conspicuous in the more primitive families, in a few of them f. i. *Hydatina* even more. In some of the males, belonging to loricate families, the transversal bands are even more conspicuous in the males than in the females, (*Brachionidæ*) but, especially in the males of the plancton Rotifers, not the slightest trace of a transversal muscle system has been detected (*Pedalion*, *Triarthra*, *Polyarthra*, *Pompholyx* a. o.). The longitudinal muscles are highly developed, especially the anterior group, in all the more primitive families, and where the foot is absent in the males, the posterior group is very much reduced.

Muscles belonging to special organs are almost absent; almost only the muscles of the penis belong to these and of the contractile vesicle of the *Asplanchna*; but in the most reduced males this seems almost to be lacking, the penis being protruded by means of alternation in pressure in the body cavity.

Body cavity. The body cavity of the Rotifera is filled with a fluid the nature of which is entirely unknown to us. In some Rotifers, f. i. the *Asplanchna*, it is extremely large, all the organs lying in their whole extension bathed in the fluid; in others it seems that the thickness of the hypodermis diminishes its space in a very high degree. As the hypodermis is thickest in the young, just born individuals, it will be understood that its size is augmented during growth. In the fluid are found

elements of different kinds; real blood cells have hitherto never been observed with certainty. In the body cavity of the females Spermatozoa which are often observed may be found swimming round in the fluid for a long time after pairing. In the plancton Rotifers it seems as if the body cavity often contains large quantities of oil globules; whether these are deposited in the hypodermic cells or are lying free in the body cavity it is difficult to say, but as I have seen them move when the animal is pressed, I have supposed that the last supposition in some cases may be correct; in the same species they may be developed to very different degrees, upon the greater or smaller quantities the hyalinity of the animal often depends. The quantity of oil is greatest in the newly hatched animals and may almost disappear when they have lived their longest time. It differs very much in the different families and species; in some of them it is very large, in others f. i. in most of the *Asplanchnadæ* it is almost entirely absent.

In the male sex, especially in the plancton Rotifers, it may be shown that the oil globules are mainly deposited on the dorsal side and that often a single, very large one, may be found almost in the middle of the animal, above or just before the testis. This f. i. is the case with the male of *Conochilus volvox*, *Floscularia*, *Notops brachionus*, *Gastropus stylifer*, *Ploesoma Hudsoni*. In others f. i. *Polyarthra platyptera* and *Pompholyx sulcata* large oil globules in different numbers are deposited above or before the testis. In others again especially the *Triarthra* males and those of *Pedalion* the globules are deposited quite irregularly throughout the whole body.

Where, in the plancton Rotifers, we have a single oil globule or a few dorsally situated fixed oil globules, I suppose that these globules have some bearing upon equilibration; it may be due to them that the males, during swimming, are always forced to turn the dorsal side upwards, preventing the rotating motion so characteristic of almost all females of Rotifers, but only rarely observed in the males which, contrary to the females, when swimming slowly, very often move in straight lines. A constant rotating motion of the males I have only observed in the males of *Asplanchna* that, as mentioned above, are also wholly destitute of oil globules.

Especially Plate and Eckstein, but also Masius and with regard to *Apsilus* also Gast have stated that the body cavity contains threads and cells of connective tissue. It must however be pointed out, that with specific methods connective tissue has not hitherto been observed (*Hydatina* Martini 1912, p. 601). It may be possible that we really have to do with extremely fine muscle threads; as such I have regarded those threads which in the male sex are especially mentioned with regard to the *Asplanchna* species.

Now and then in some species we find, lying free in the body cavity, greater or smaller quantities of dark, often yellow coloured irregular masses; in the species they may in some specimens be comparatively large, in others they are but small or almost absent; their places differ from specimen to specimen, and it is most probable that they diminish with age; they are very conspicuous e. g. in the *Asplanchna* species. They have often been observed, and have always been regarded

as stored nutriment, yolkmasses, deriving from the egg. As it has been pointed out with regard to the *Asplanchna* species that the animals grow very considerably and that simultaneously herewith these masses diminish in size, it is most probable that this stored nutriment is really of significance in the short life time of these animals.

Male organs: The male organs in the Rotifera consist in 1) the testis, 2) the vas deferens or ductus seminalis, 3) the so-called prostata glands, 4) the penis.

The testis is a large, pearshaped or globular organ, lying in the middle of the body and often filling the greater part of the body cavity. Especially in the rudimentary males of the plancton Rotifers, f. i. *Polyarthra*, *Triarthra*, it is extremely large in comparison with the whole body. It is held in place by means of a broad, flattened band which reaches from the forepart of the testis to the wheel-organ, and as mentioned before commonly regarded as a rudiment of the alimentary canal. In some species, e. g. *Hydatina*, it is further fastened to the dorsal side by means of a special tissue, fastened to from three to five of the transversal muscle bands.

The development of the spermatozoa has been studied by WHITNEY (1917, p. 305 and 1918, p. 325), he states that the number in all the species investigated is remarkably small; the highest number of mature spermatozoa found in the testis being about 300 (*Asplanchna*). Earlier authors have often pointed out that the testis of the Rotifera contains two sorts of spermatozoa; the one sort has a well-developed head, and long undulating tail; these spermatozoa are very motile; the other sort are short, stiffened staffs, without head and immotile; the last named, almost always lie pressed together near the opening of the testis, almost parallel with each other; they were formerly (COHN) interpreted as a peculiar muscular structure of the testis; they are always much smaller in number than the motile ones. In two consecutive papers WHITNEY (1917, p. 305 and 1918, p. 325) has shown that the number of motile spermatozoa is exactly twice the number of immotile spermatozoa produced. Both sorts of spermatozoa possess heads, but the immotile spermatozoa are regarded as rudimentary and functionless. The functional spermatozoa, having fertilised a parthenogenetic male egg, always gives rise to a female individual. If the male egg had not been fertilised, a male would have been produced. Now as it has been ascertained, that in every male a certain percentage of the sperm-cells degenerate, and a certain percentage develop normally, thus giving a definite ratio of degenerate and normal sperm-cells, and as all fertilised eggs develop into female young, it seems safe to conclude that the degenerate sperm-cells are the male-determining ones, and that the normal sperm-cells are the female-determining ones (WHITNEY 1918, p. 333). It has often been supposed that the function of the staff-like rudimentary spermatozoa is to perforate the skin of the female during the pairing process.

The vas deferens, its length and its structure, is dependent upon the occurrence of a true penis.

In the most primitive forms the male sexual opening lies dorsally on the foot;

commonly on the last segment but one; the opening is almost always marked by means of a tuft of cilia. In the pairing moment the vas deferens in these forms is evaginated turned inside out, now showing a hyaline tube or cupshaped body, commonly at its base surrounded by a wreath of cilia, the same which originally presented itself as a tuft round the opening; a penis of this kind is found in all the *Notommatidæ* hitherto observed, in *Hydatina*, in the *Flosculariidæ* and in the *Melicertidæ*, where it is placed on the very apex of the animal; it is of quite the same type in *Asplanchna*.

In many Rotifers we find a penis of a somewhat different kind. Round the opening for the penis on the dorsal side of the foot, the skin is folded, often somewhat resembling the so-called tail in the genus *Copeus*. By means of the transversal muscles and during the bending of the body, the fluid of the body cavity is pressed out into this part of the body; this is now altered into a stiff erectile organ, often much longer than the foot which only hangs down as a little ventral appendage.

A penis of this kind is most conspicuous in the *Brachionidæ*, most probably also in *Euchlanidæ* and *Salpinadæ* and in *Gastropus hyptopus*. In these species the vas deferens is much longer than in the former group, and capable of great alterations with regard to length; as in *Hydatina* it is often transversally banded, most probably by very fine muscle threads.

In the *Anuræadæ* where both sexes lack a foot, the penis is always in an erect condition, hanging down from the posterior end; it cannot be drawn in. A penis of this peculiar type is best developed in *Anuræa hypelasma*.

In the most reduced males we find a penis of quite another type; here is really no penis at all. In the pairing moment the whole posterior part of the body is prolonged and often formed like a tube; this is most conspicuous in *Polyarthra*, *Pedalion* and *Triarthra*, where the posterior part of the body, when the animal is swimming, is rounded, but when used as penis, it is tapering. As mentioned above we commonly find a tuft of hairs at the opening, but in some species, f. i. of the genus *Anuræa*, we find two lateral hairs; this is also the case with *Triarthra* but here the opening is further supported by a chitinous frame.

The length of the vas deferens differs very much, and is in accordance with the structure of the penis; it is almost always coated with cilia; the walls are thin, transversally striped with muscle threads. In some cases f. i. *Brachionus* and *Diglena* the last part of vas deferens is transformed into a chitinous tube which, when used, is forced out of the genital opening. In *Brachionus* it ends in a cupshaped dilation; this is also the case with the penis in the genus *Rattulus*. In *Copeus labiatus* it is widened to a large sac.

At the sides of the vas deferens are two, rarely four glands, commonly designated as prostata glands.

They may be very large as in *Asplanchnopus* and *Hydatina* and where they are not indicated, it is most probably because they have been overlooked. In some species, f. i. *Polyarthra* and especially *G. hyptopus*, they have a peculiar lobate ap-

pearance. Above the testis, at the point where the testis tapers into the vas deferens, we very often, in the male sex, find one or two globular bodies, commonly hyaline sacs, filled either with one, two or many opaque corpuscles, often with sharp sides. They also occur now and then in the females, but much more rarely, their structure and size differ from specimen to specimen. They have been interpreted in very different ways by COHN and WEISSE as remnants of yolkmasses, deriving from the eggs, by LEYDIG as "Harnkonkremente" and the globular vesicle as rudiments of the rectum. Whether the last supposition is correct is perhaps doubtful, but as I have seen the lateral canals open into it, in *Euchlanis lyra*, I am inclined to think that LEYDIG's interpretation is really correct.

Chapter V.

Remarks Relating to the Reduction of the Male Sex.

In the foregoing pages many examples have been given relating to the reduction of the male sex in the Rotifera. We have seen that the reduction may be carried so far that, as in *Polyarthra*, the male is really nothing but a sperm-sac, surrounded by a protoplasma, containing a number of oil globules and coated with a cuticula, anteriorly carrying a tuft of long cilia. If a freeswimming organism is really to play a rôle as a fertilising creature, it is obvious that a greater reduction, cannot take place. The question now is: What has caused this enormous reduction, a reduction so great that in the whole animal kingdom it is only very rarely met with, and most probably is really the most complete we, upon the whole, know.

As well known, the reduction of the male sex in the animal kingdom is by no means only restricted to the Rotifera. However, where it is not only limited to reduction with regard to size, it is almost always combined with parasitism. This is always the case where we have a reduction of such a radical nature that the males are really reduced only to sperm-sacs almost, with the necessary clasping organs for fastening or for locomotion. In many cases the males are parasitic upon or within the females. Strongly reduced males of this kind we find for instance in the *Cirripedia*, parasitic *Isopoda*, *Copepoda*, and in *Bonellia*. In the Rotifera however we have animals where parasitism of the males is an unknown phenomenon. Males and females live a freeswimming or freely creeping life, swimming side by side in the same water masses; at first sight it is wholly unintelligible what has caused this enormous reduction in the male sex.

We are here facing a problem which has not hitherto been solved, mainly because it has not been set up. Our hitherto very restricted knowledge of the male sex in the Rotifera is the main cause of this in itself very peculiar phenomenon. In the following pages an attempt is made to solve the question.

As mentioned often in this work, the most primitive types of the Rotifera like the Turbellaria live a creeping life either on the bottom or upon the vegetation. In all these primitive Rotifers, the eggs are not carried by the mother animal but laid upon a substratum. The difference in size between the three kinds of eggs, parthenogenetic female- and male-eggs, and fertilised resting eggs, is but small; the male eggs being most probably no more than one half shorter in diameter than the female eggs (See Tab. IX, fig. 2—6). The males are but slightly reduced; commonly the alimentary canal is rudimentary, but all the other organs are present, and even if the males are smaller than the females, they are of the same form and often resemble the females in a high degree.

The Rotifers which have diverged most from the primitive type, are the plancton Rotifers, those which have totally emancipated themselves from a substratum, living a pelagic life in the open water volumina, far away from a substratum of any kind. These Rotifers in the main lack all areas of support for depositing the eggs; commonly they carry the eggs themselves; a few of them either deposit them upon other plancton organisms or bring forth living young. Now it is just among these plancton Rotifers that the most reduced males occur.

If we study the size of the three kinds of eggs in one of the plancton Rotifers, it will be seen that there is here the greatest difference in size; especially the male eggs are extremely small; further that whereas a female producer carries only from two to four eggs. the male producer carries about 12—16 eggs; if they carry resting eggs their number is hardly ever more than one, rarely two. Moreover if we compare the amount of the total yolk-mass which is to be found in the total lot of male eggs with that which is found either in the female parthenogenetic eggs or in the resting egg, it will be seen that in all three cases it is almost of equal size, smallest perhaps in the resting egg (See Tab. XI, fig. 5—6). This in other words means that the total amount of yolk-mass which is at disposal in the given moment of egg-laying, is almost the same in all three cases. In one case the total amount is used for a single egg, in the other for two or four, but when the males are to be produced it is divided in no less than about sixteen different parts. The result is that the amount of nutriment with which each male egg is provided, is only about $^1/_8$ to $^1/_4$ of what a parthenogenetic female egg possesses. In accordance herewith the males must at birth be smaller than the females.

From these observations we are now able to understand the diminution in size of the plancton rotifers, but of the most interesting fact, that the males are not only reduced in size but also in their whole organisation, we have not hitherto got the slightest explanation. For this we must take quite different phenomena into consideration.

It is a well-known fact that the eggs of the plancton organisms are commonly very small; as often set forth this has most probably some connection with the fact that the plancton organisms are mainly forced to carry the eggs and that therefore the quantity of yolk-mass with which the eggs may be provided can only be relatively

small, in accordance with the force of the mother animal. This fact is again connected with the phenomenon that the individuals, on coming out of the eggs, are very much smaller than the parents and are in a stage of development far from that in which the parents were. It is only through a series of larva stages that these young ones, by means of food reception, slowly grow up to the mature stages. Often they take about a year before these are reached (f. i. many Copepoda which are hatched in the autumn months). In some plancton organisms we find care for the offspring, the young ones living for a long time in the brood-room of the mother animal.

Now as far as I know, among all Metazoa, the Rotifera are the only plancton organisms which neither possess any metamorphosis nor show any care for the young.

Deriving from fresh water turbellaria where a metamorphosis does not exist, they were originally found to live in a medium where larva stages are either totally suppressed or at any rate only play a very inconspicuous rôle. As well known, with regard to the pelagic region of the sea and the freshwaters, there is the great difference that, whereas the firstnamed teems with larva stages, especially belonging to benthonic animals, these are almost quite absent in the pelagic region of the freshwaters, where the Benthos hardly ever produces pelagic larva stages and where, of the plancton organisms, these as a rule occur only in the Copepoda. — This lack of metamorphosis in the Rotifera must enter into our calculations, if we will try to understand the main causes of the reduction of the male sex.

In those cases where we possess a more thorough knowledge with regard to the rate of development of the male eggs in the Rotifera, we know that this may be finished in the course of only 24—36 hours. Only one or two days after the egg has left the mother animal and has been attached to the posterior part of its body, the cleavage process is finished, the egg shell bursts, and the male is a free-swimming organism. We are further able to substantiate that the spermatozoa in the testis are in full motion for several hours before the eggs are hatched. Finally if we have some *Polyarthra* or *Anuræa* females (male producers) in a drop, we will see that in the very same hour in which they are hatched the pairing will take place. The males so to speak rush from the eggshell directly upon the females, ready to pair in the moment of birth.

From the two now etablished facts, that the total amount of yolkmass of the female is to be distributed over many individuals, and that this is just the case with a group of animals where metamorphosis does not occur, I find some clues to the explanation of the reduction of the male sex in the Rotifera. It is in the first place dependent on the fact that the amount of yolk mass, which the egg is provided with in the plancton Rotifers as well as in almost all other plancton organisms, is extremely small. This caused the diminution in size of the male sex. The great reduction of the common organisation is based upon the second phenomenon, that the Rotifera belong to those organisms which are destitute of a metamorphosis, larva stages like those of so many freshwater organisms being wholly unknown. After birth the males get no time to build up their bodies by the reception of food beyond

the stage in which they are born. During the embryonic development stress is only laid upon the formation of the male organs, the material given to the egg not allowing of a more elaborate development of the organism.

We have now I presume got some material to elucidate some of the facts which produced the strongly marked reduction of the male sex, most pronounced in the plancton Rotifers. But of the deeper lying causes why the reduction of the male sex especially in the plancton Rotifers was really a conditio sine qua non for these organisms from the moment, when they were to pass from creeping bottom organisms into freeswimming organisms, take possession of the open waters, and emancipate themselves from any substratum therein, we have hitherto had no explanation at all. — The strongly marked reduction of the male sex is really of the greatest advantage for the species. This will be understood from the following considerations and observations.

When the quantity of yolk mass which is at the disposal of the female, and which is to be used for the preparation of the males, is distributed over as large a number of individuals as possible, it is obvious that it is possible for the males, in comparison with the females, to come in an enormous majority. Now it is a well-known fact that the male producing females in a lake almost all come up simultaneously, viz. in the last part of a maximum, further, that the enormous amount of male eggs all develop almost simultaneously, viz. in the course of about eight days. This again in other words means that the total amount of material of impregnation in these very eight days is distributed over an enormous quantity of individuals. The possibility of pairing between the two sexes is augmented in a very high degree, that phenomenon upon which depends in the first line the formation of resting eggs, which again in many cases is a conditio sine qua non for keeping the locality for the species.

As the smallest males of the plancton Rotifers cannot be caught with our plancton nets, we have not the slightest idea of the incredible numbers of males developed in the water layers, during the sexual period of a species. But if in this period we catch large amounts of plancton, as far as possible strain away the larger plancton organisms f. i. Daphnids and Copepoda, and let the rest stand over for a night in great jars, the next morning at the surface rim, turning towards the light source, we shall find a milky border, consisting almost entirely of males. This phenomenon I have observed often enough with regard to *Polyarthra platyptera*, *Pompholyx sulcata* the *Anuræa* and *Brachionus* species. — But it can only be observed in the short sexual periods, never outside these; the occurrence of the sexual period in the plancton Rotifers may be compared with phenomena that are well known in the vegetable kingdom f. i. the period, when the conifera throw their pollen, and the flowering season of the rye.

In all cases it is the material for impregnation which, in a few days and hours, fills the surrounding medium; the result of the process is in the one case the seed, in the other, the resting-egg. In the autumn the resting eggs come to the surface;

on putting a milky white glass plate immediately under the surface of a calm lake, it will be seen that its surface film carries an enormous amount of resting eggs, these are later on, when swept away by the autumn storms, deposited as dark lines near by or upon its shores.

It is this spreading of the impregnating material to innumerable individuals which was in my opinion a conditio sine qua non for the remodelling of an originally creeping organism into a freeswimming one, and which could only take place at the sacrifice of the size and stage of development of the males.

Thus I suppose we have some leading points that will enable us to understand partly the underlying principles which made the reduction of the male sex desirable for the species, and partly why the males if the species was to try to fulfill the claims which were laid upon it in this respect must necessarily, owing to want of food, be reduced in size.

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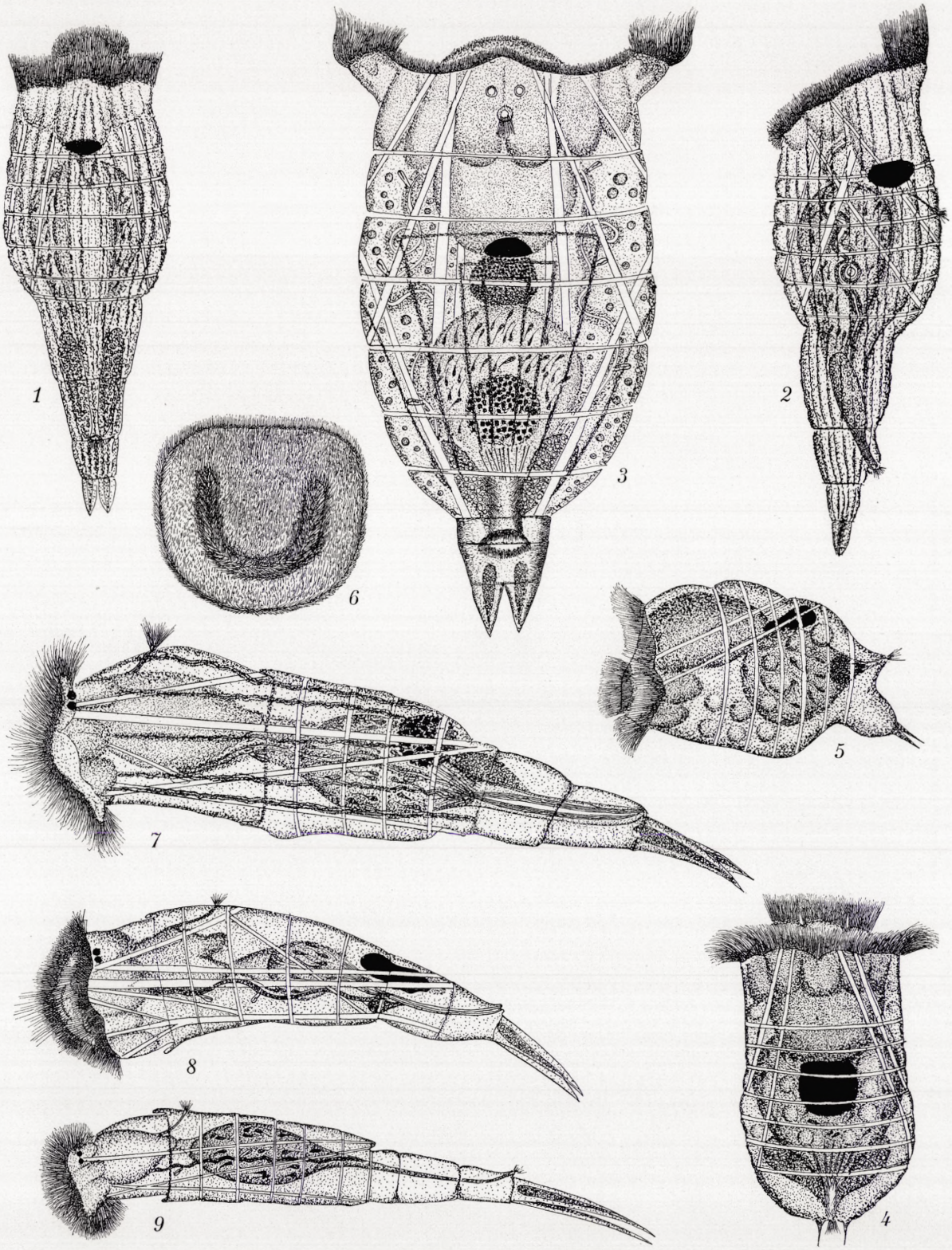

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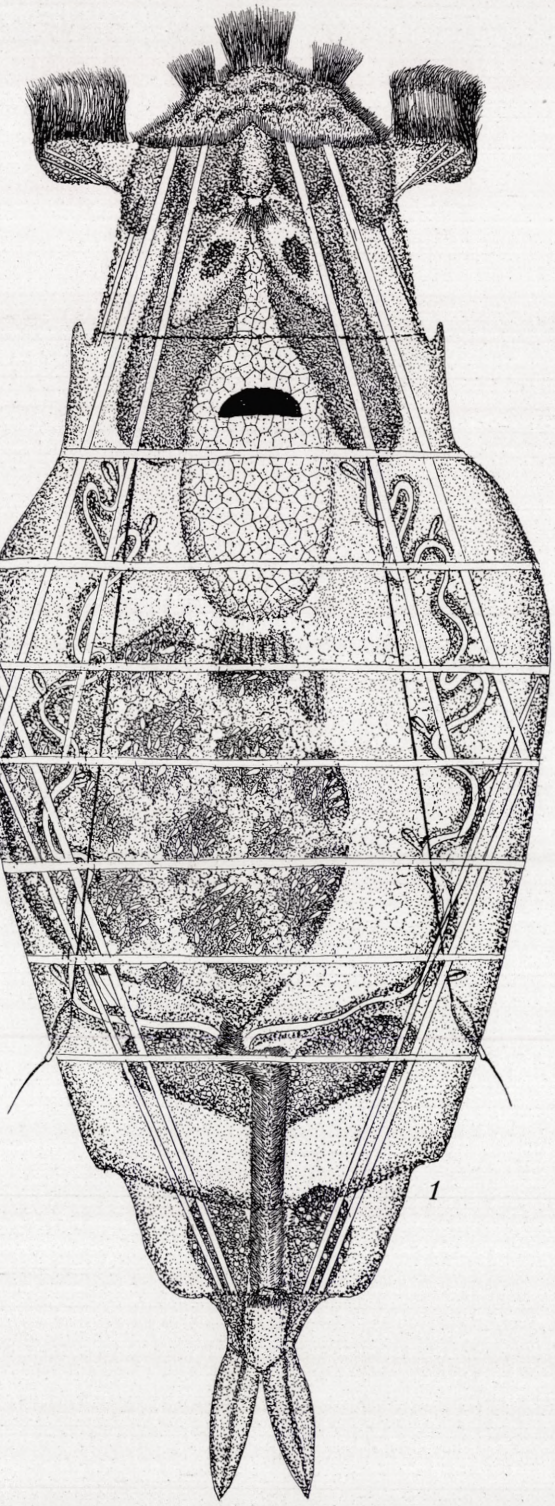

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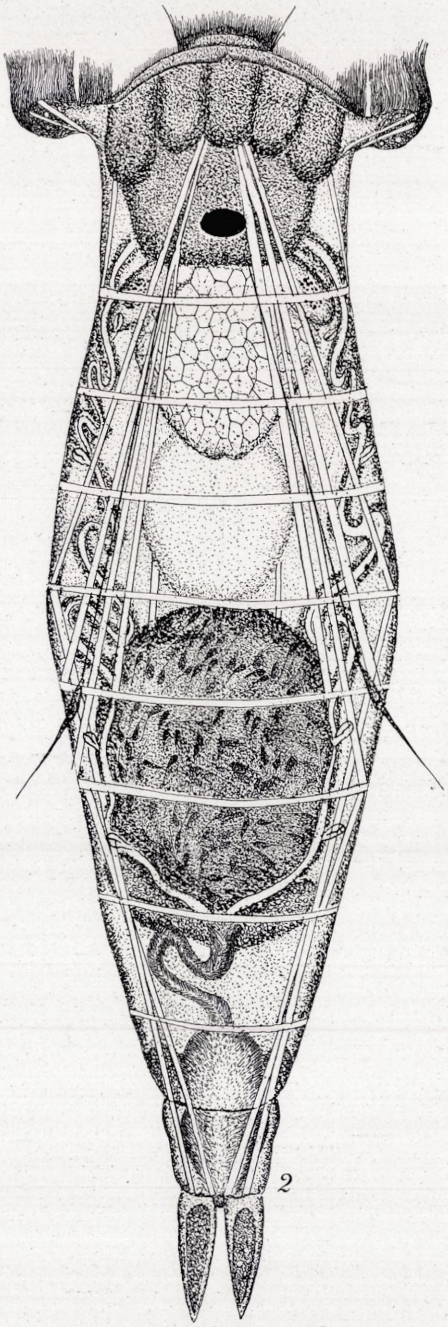

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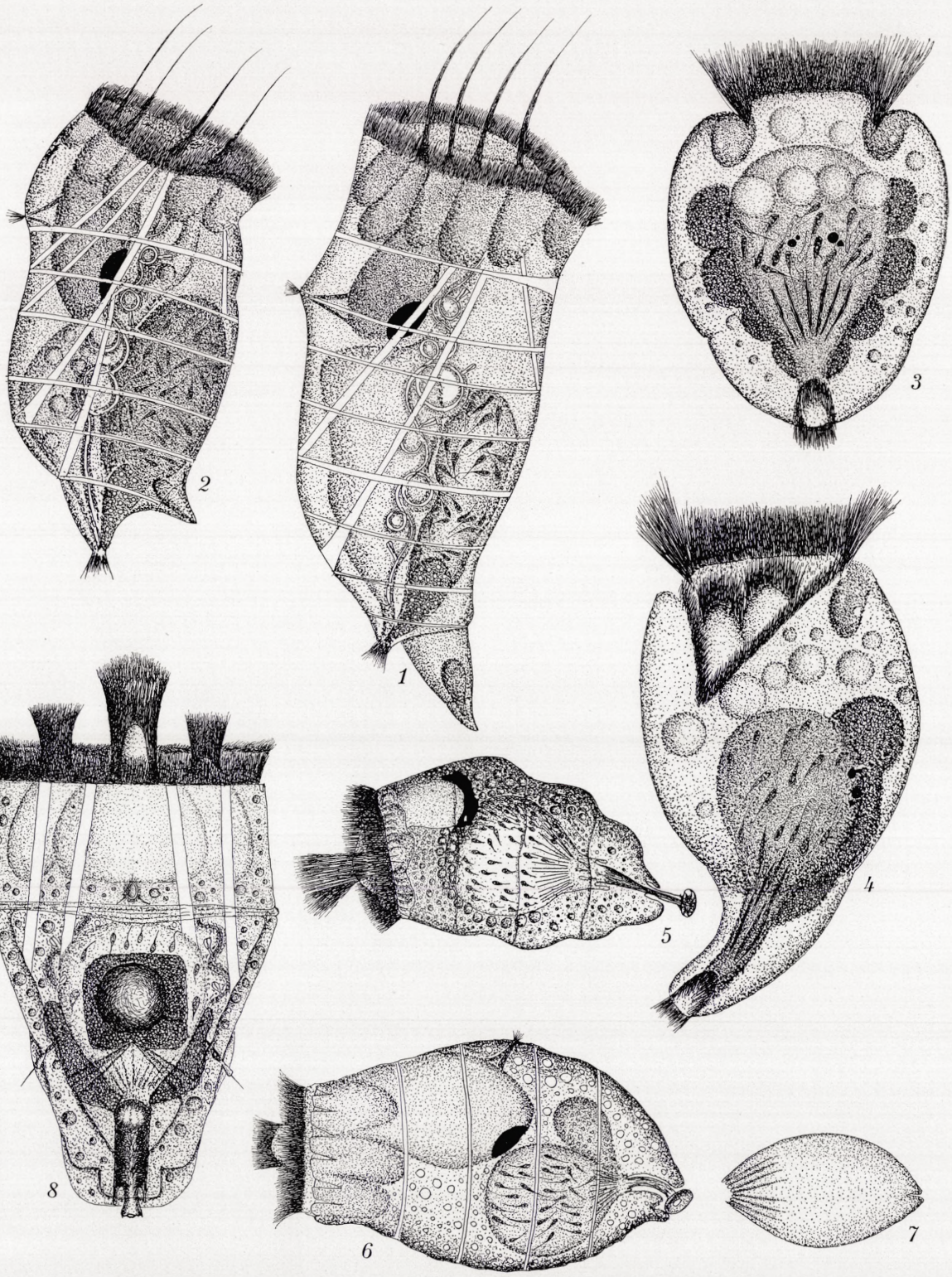

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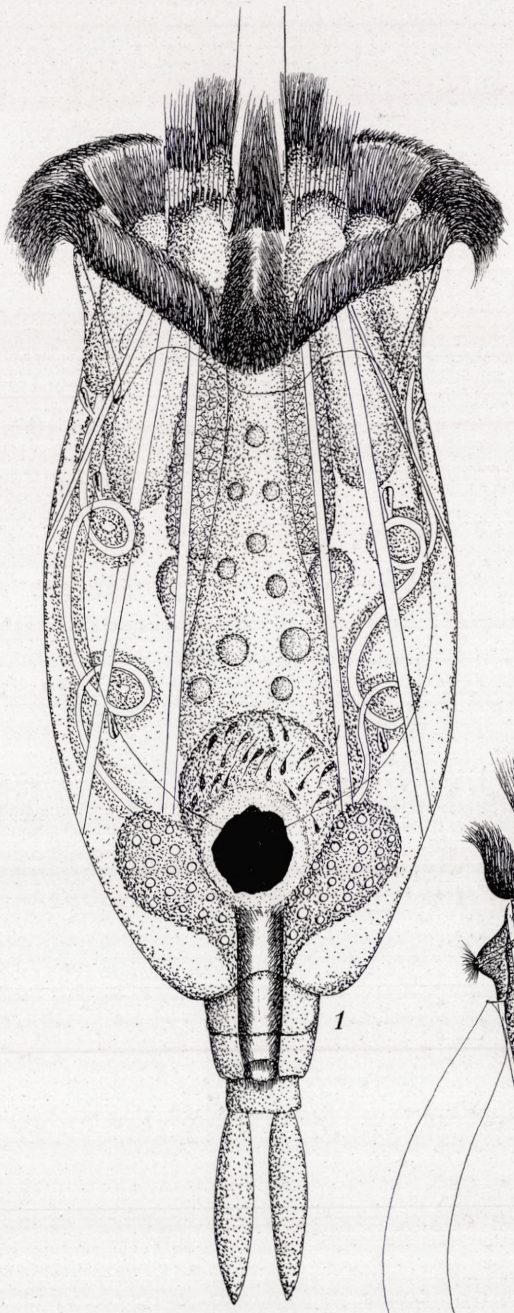

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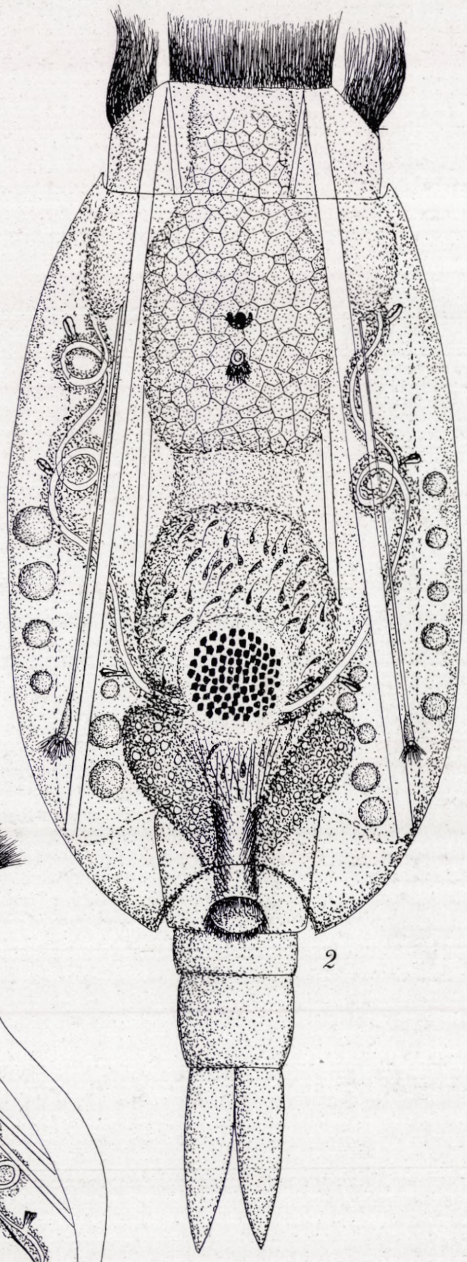

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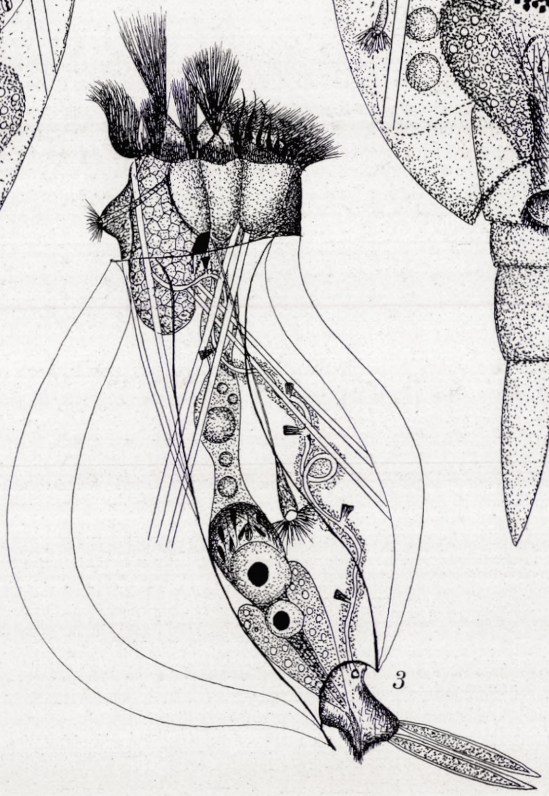

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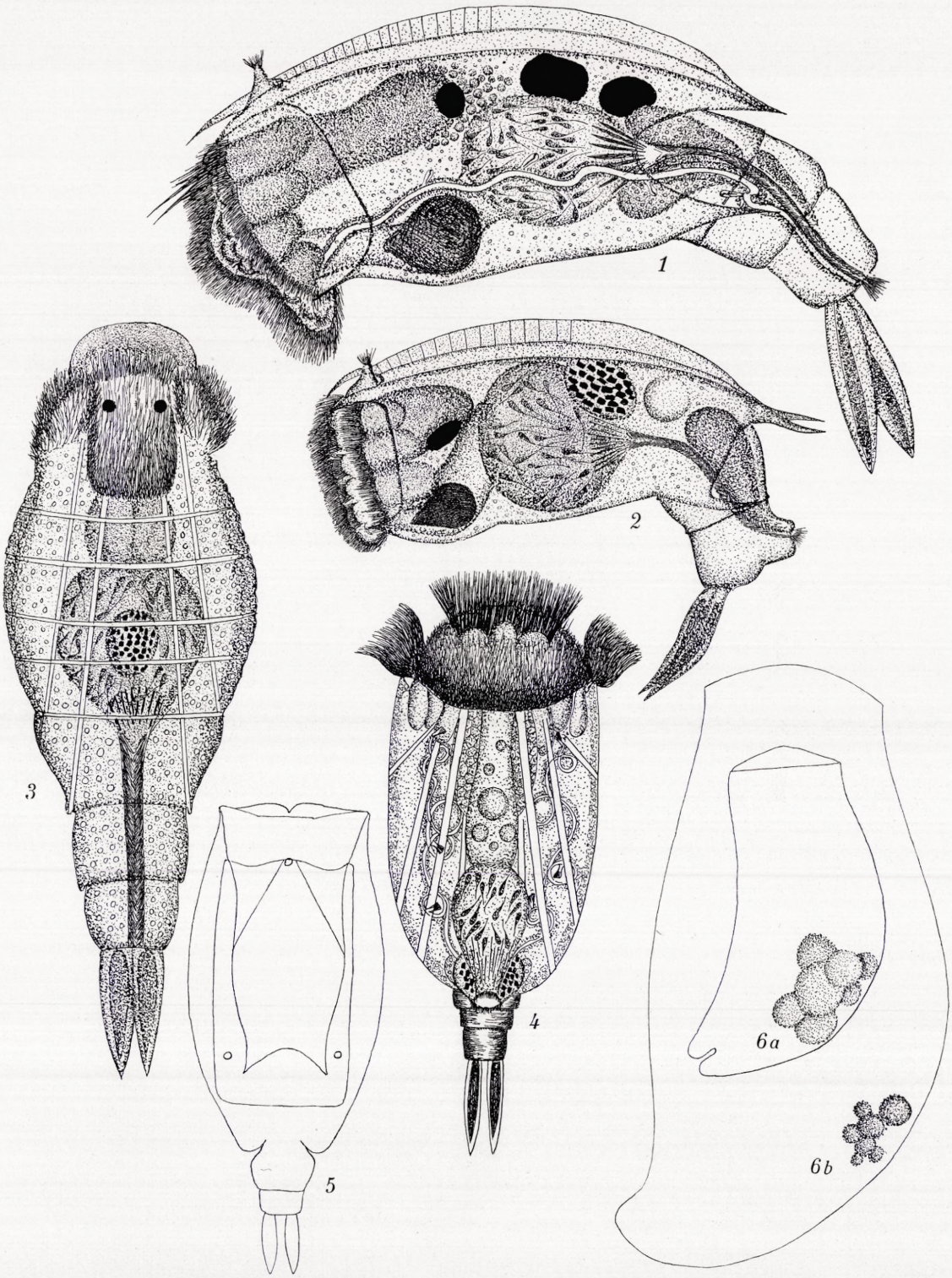

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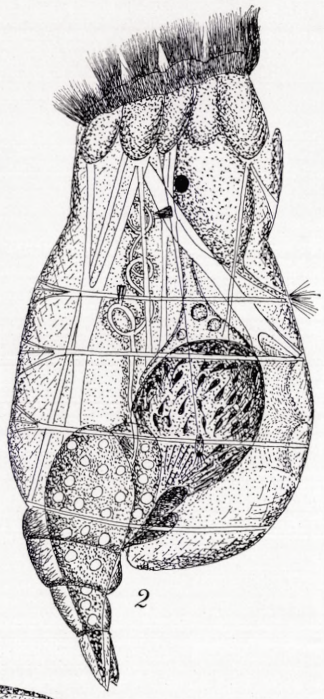

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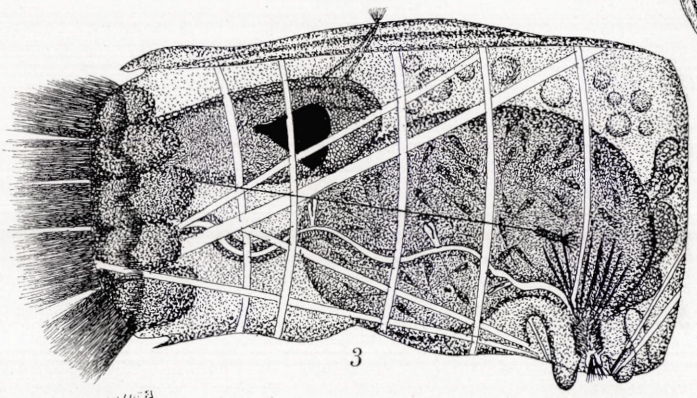

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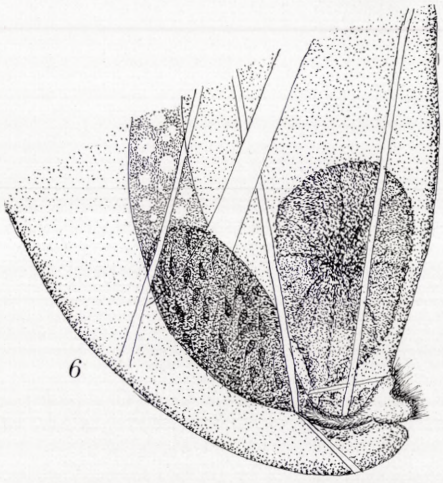

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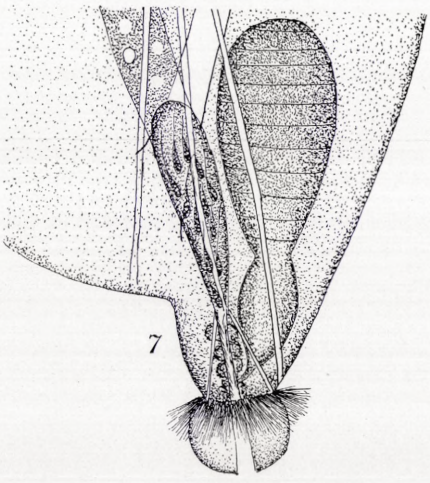

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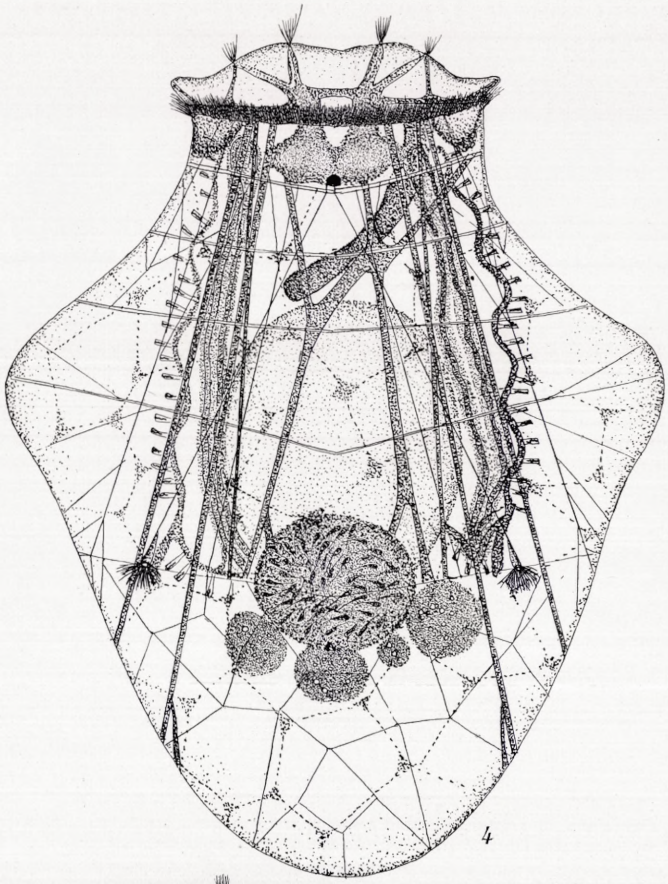

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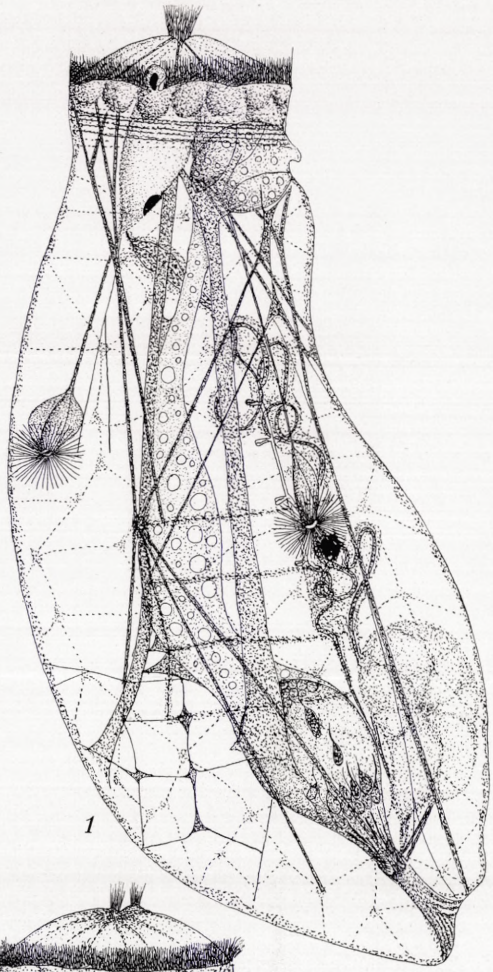

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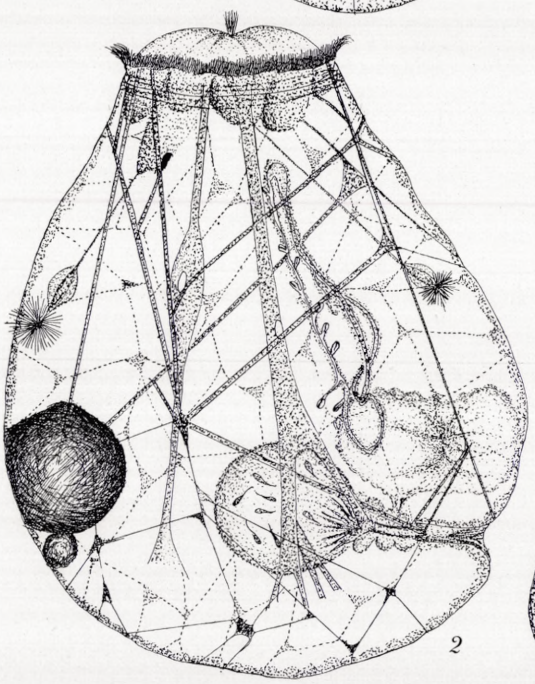

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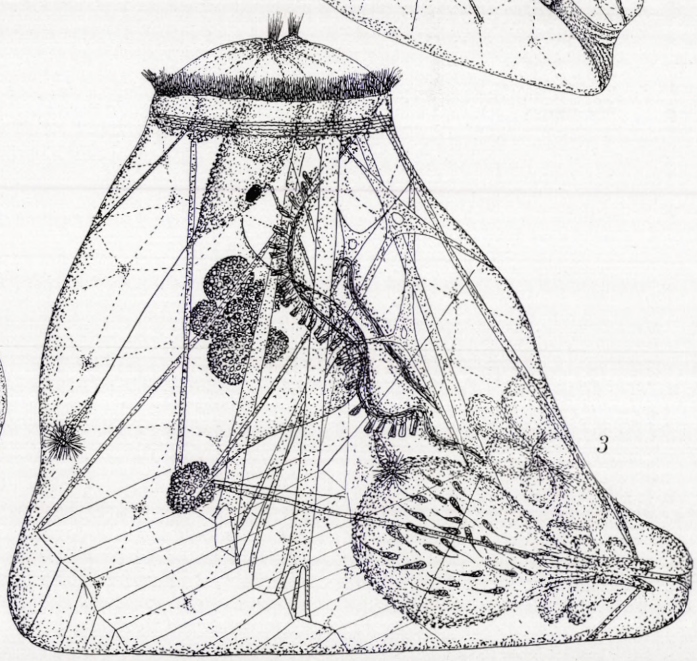

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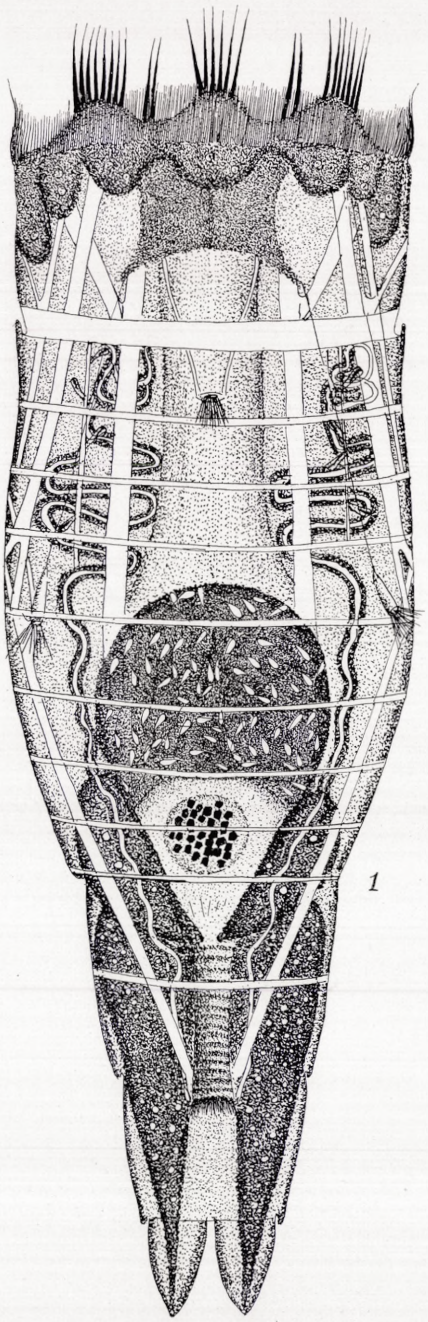

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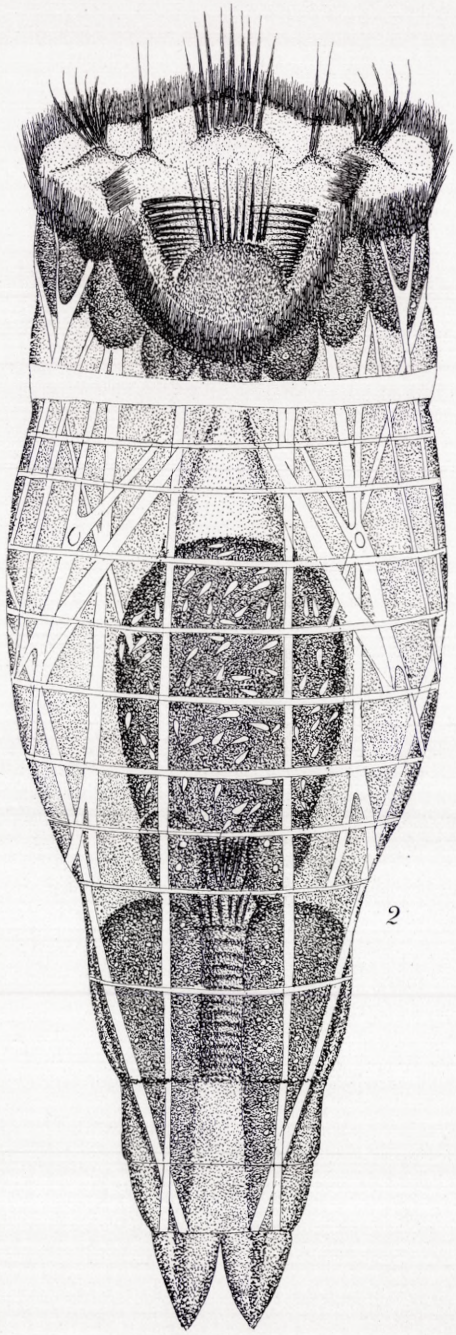

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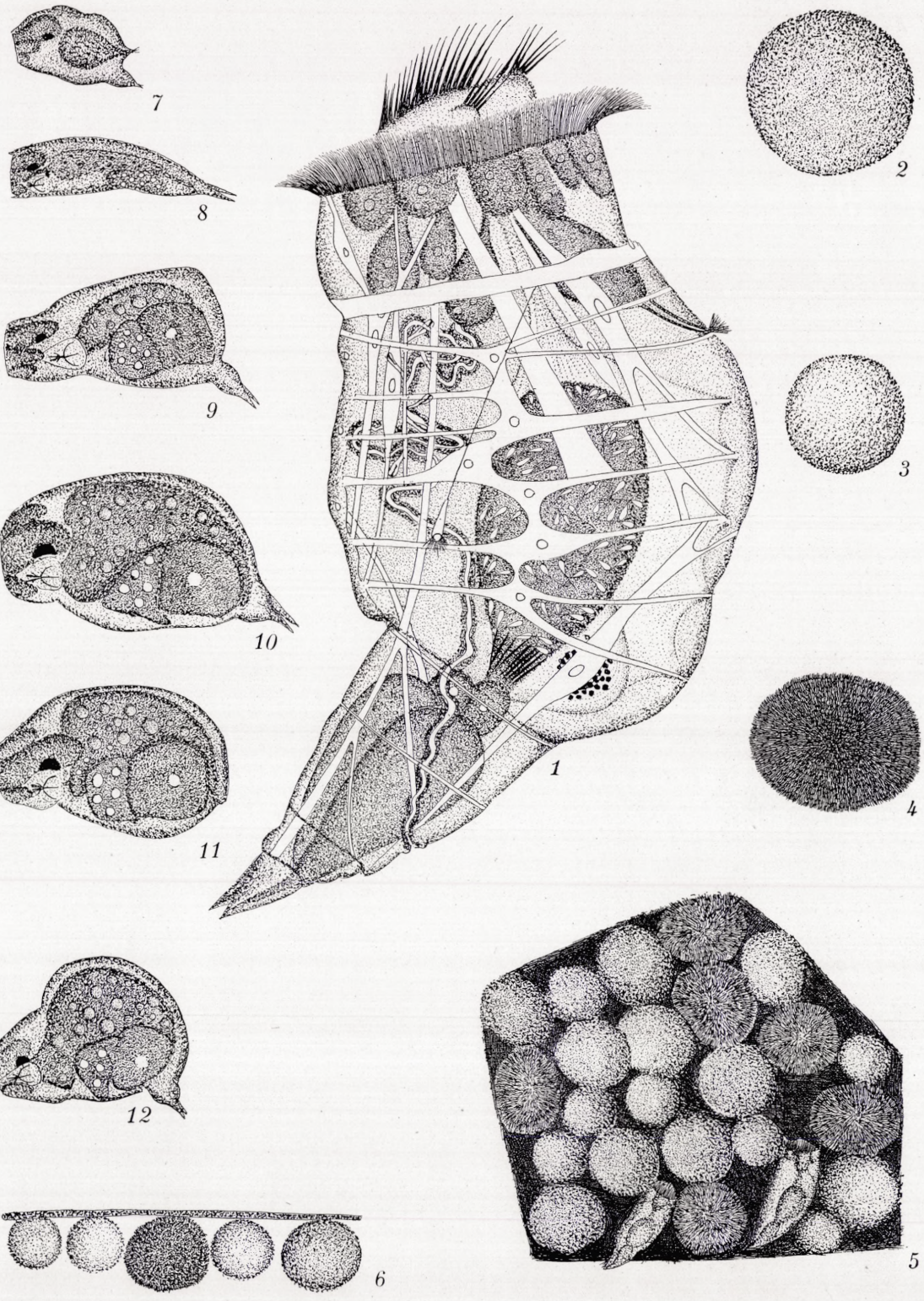

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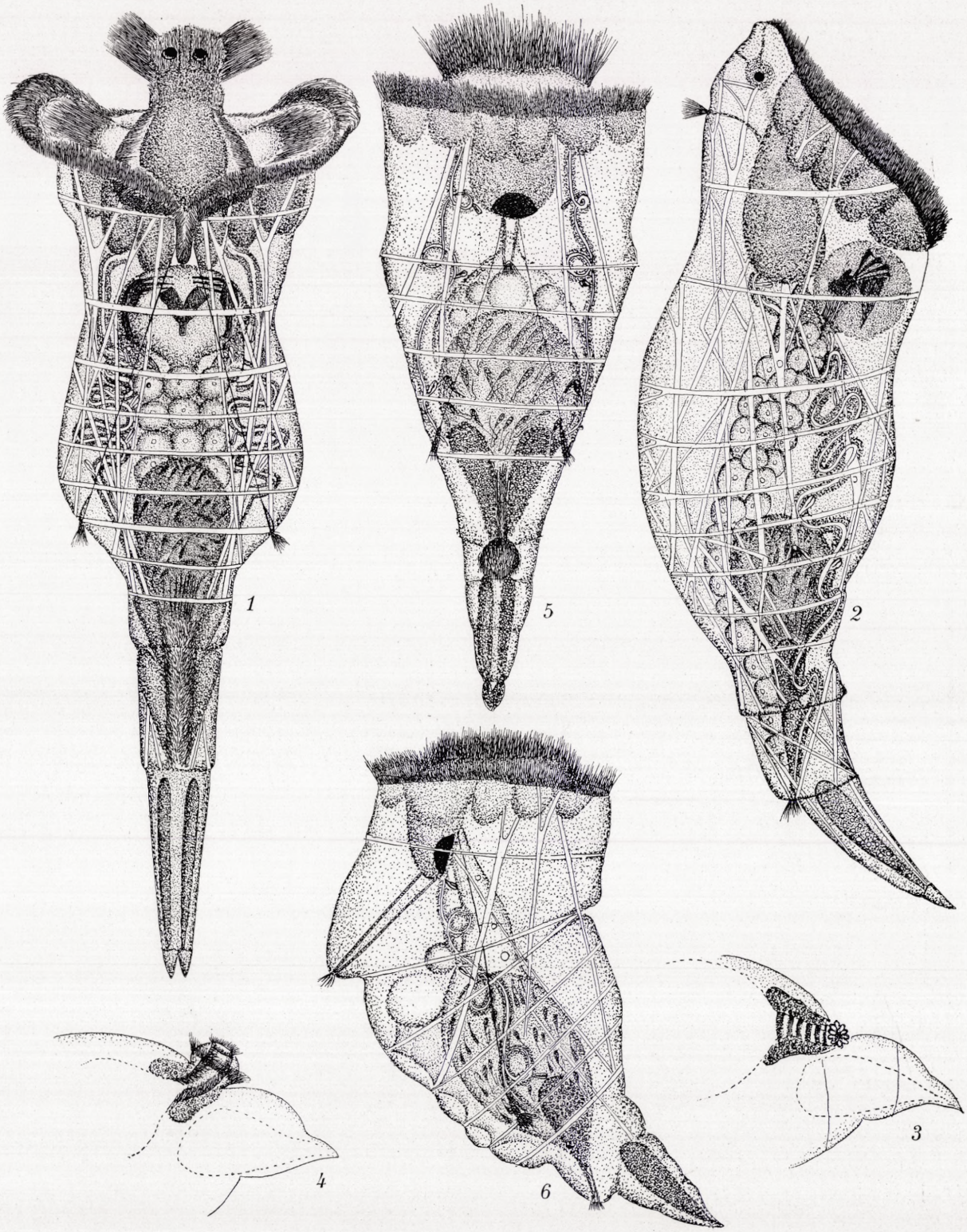

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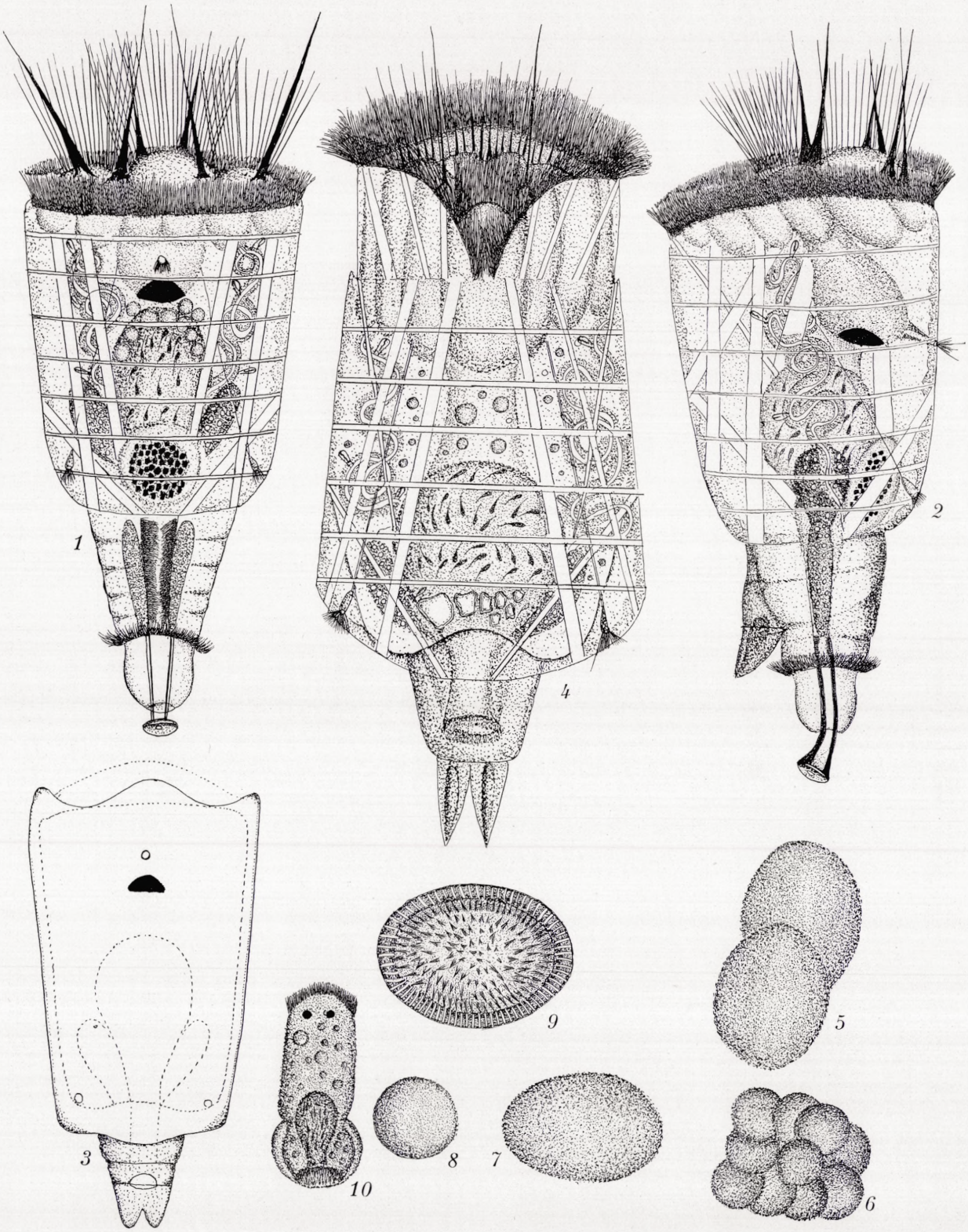

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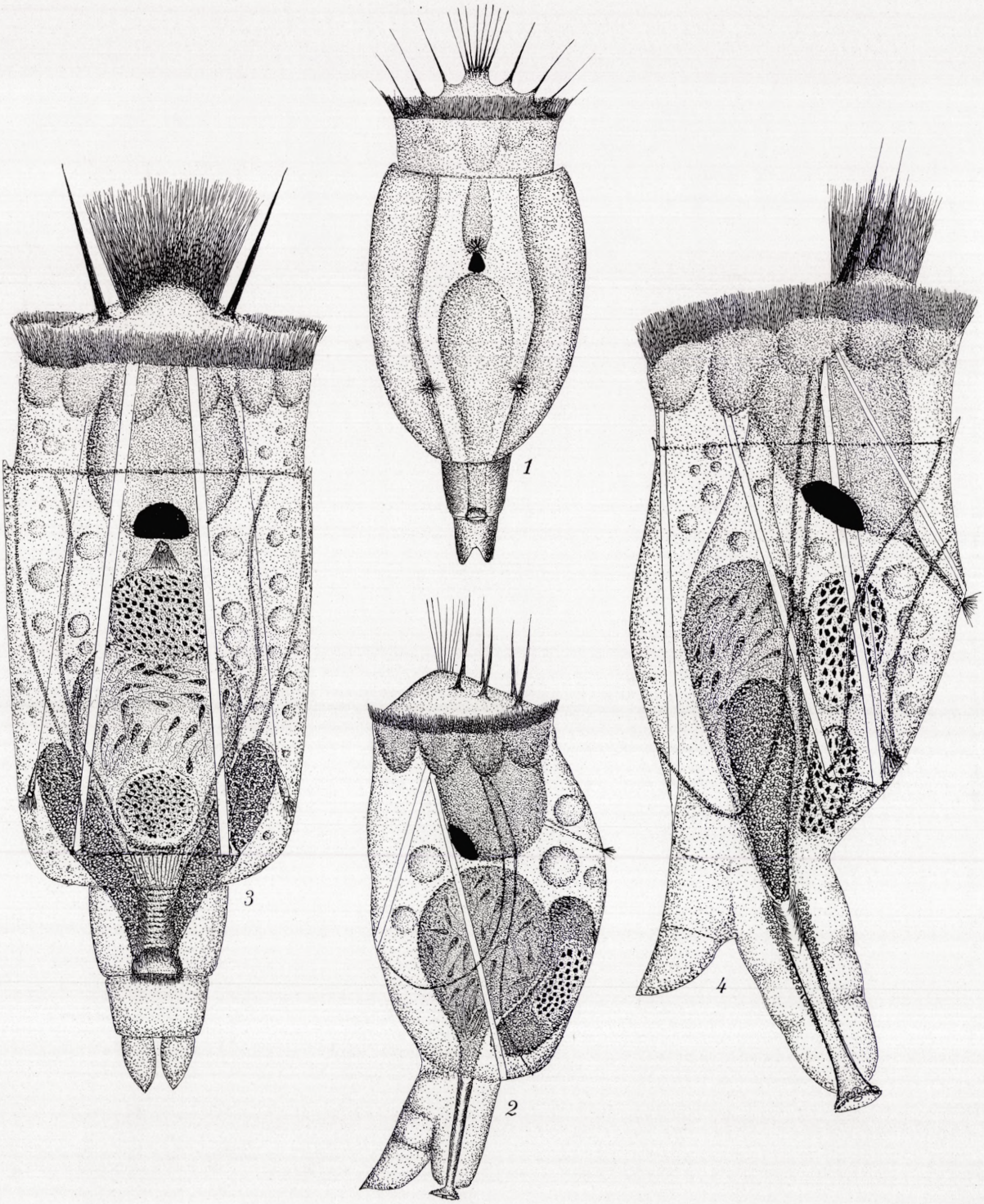

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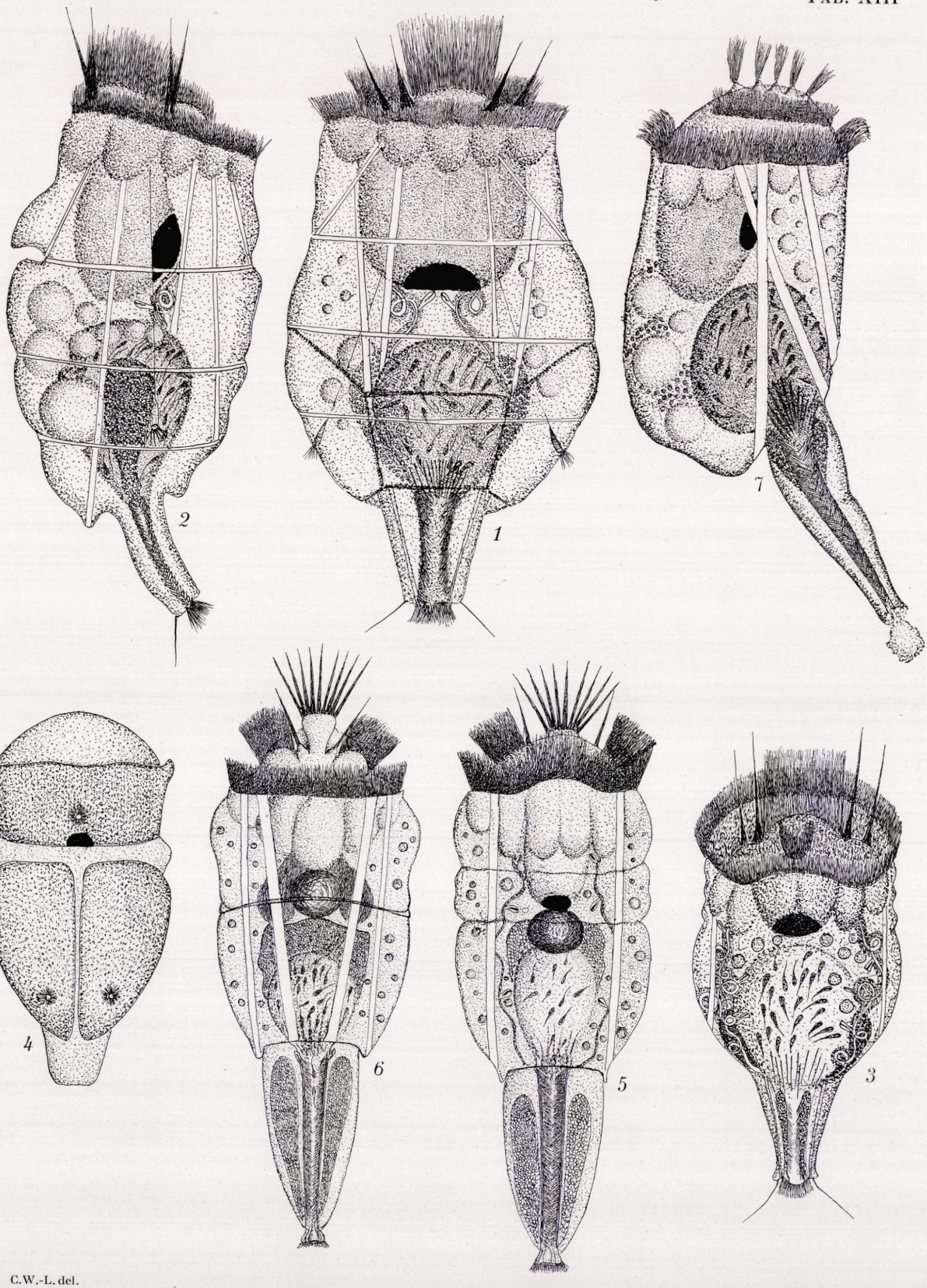

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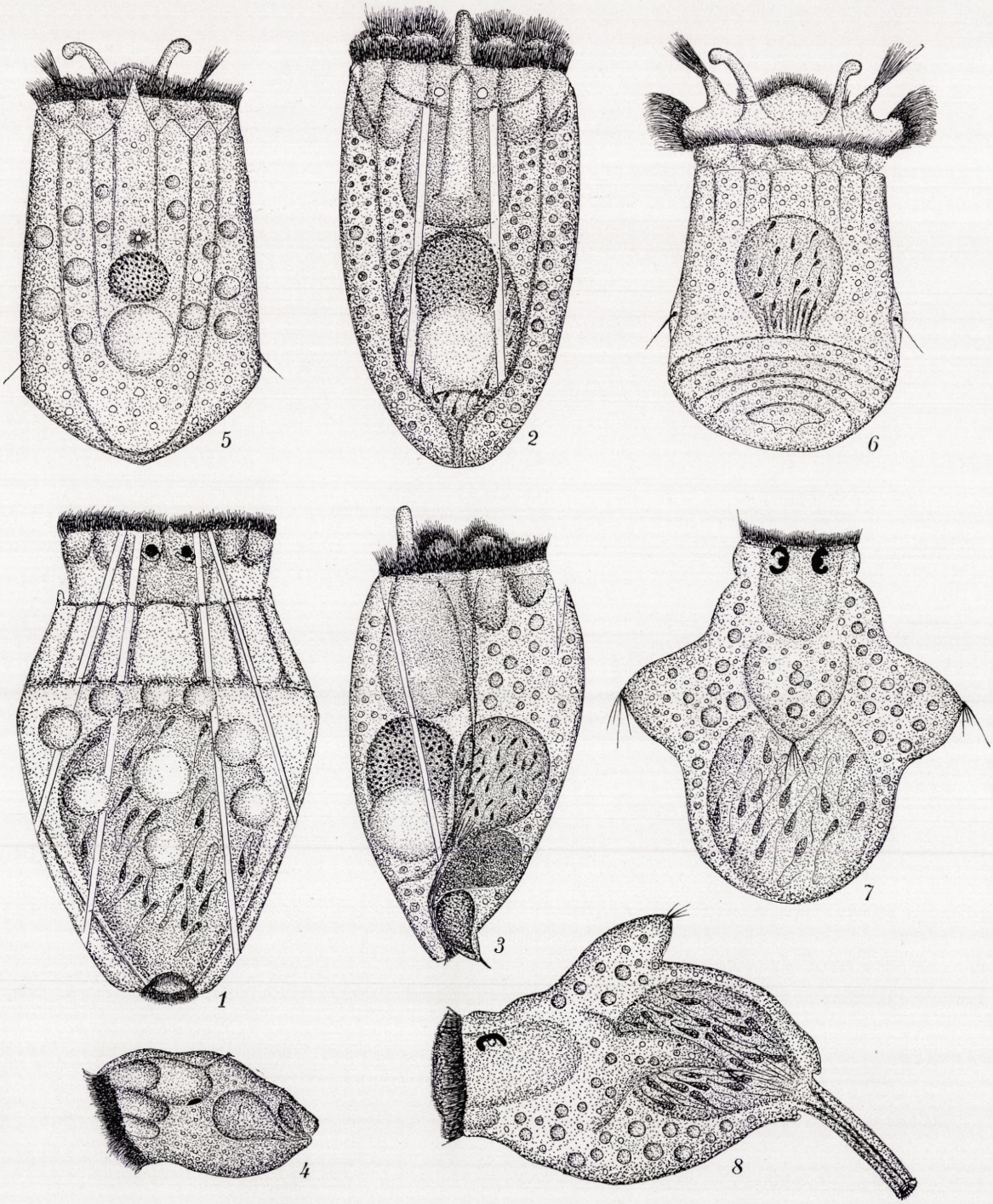

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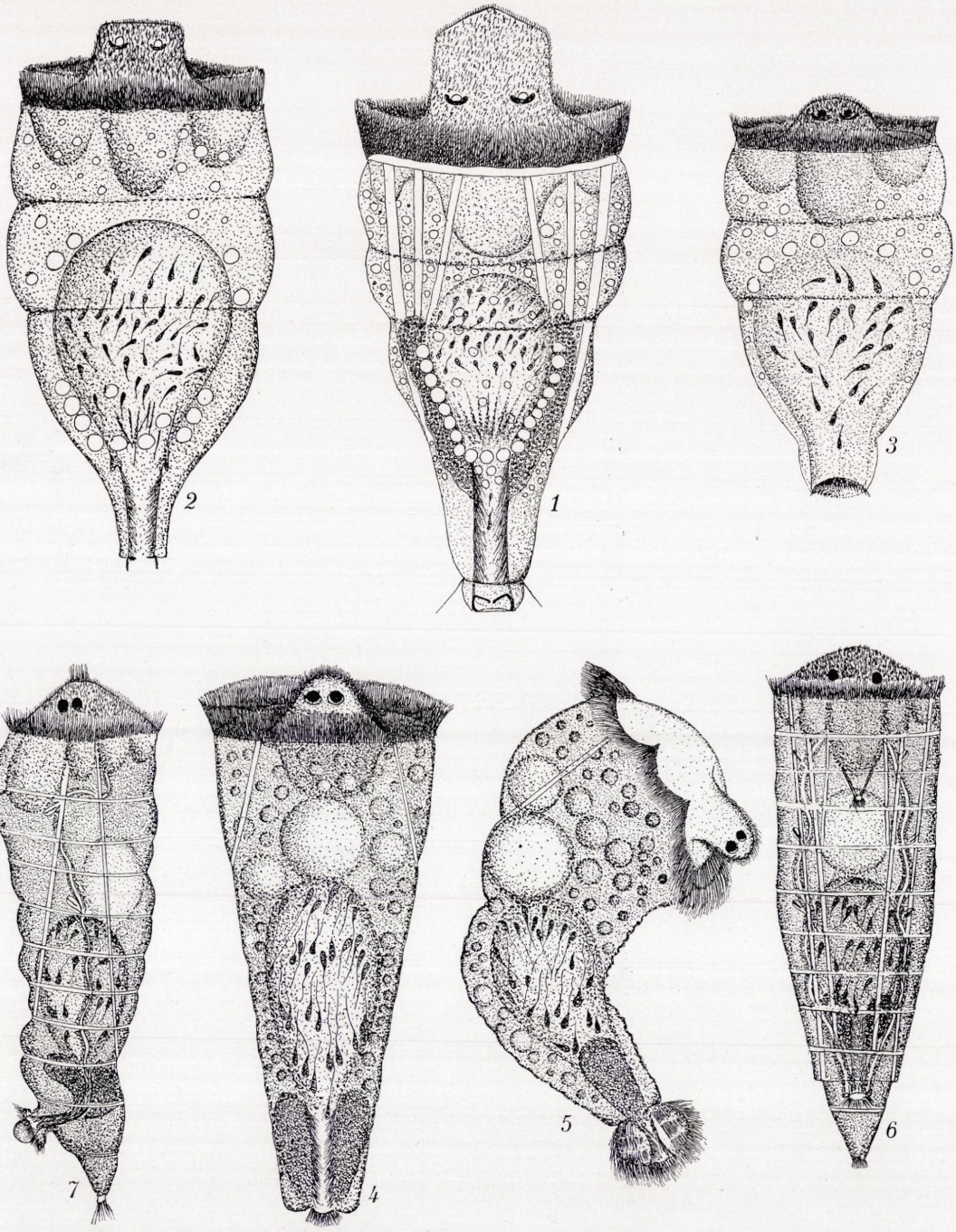

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Det Kgl. Danske Videnskabernes Selskabs Skrifter.

Naturvidenskabelig og mathematisk Afdeling,

8de Række.

		Kr.	Øre
	I, 1915—1917	10.	75.
1.	**Prytz, K.** og **J. N. Nielsen:** Undersøgelser til Fremstilling af Normaler i Metersystemet, grundet paa Sammenligning med de danske Rigsprototyper for Kilogrammet og Meteren. 1915	1.	55.
2.	**Rasmussen, Hans Baggesgaard:** Om Bestemmelse af Nikotin i Tobak og Tobaksextrakter. En kritisk Undersøgelse. 1916	1.	75.
3.	**Christiansen, M.:** Bakterier af Tyfus-Coligruppen, forekommende i Tarmen hos sunde Spædkalve og ved disses Tarminfektioner. Sammenlignende Undersøgelser. 1916	2.	25.
4.	**Juel, C.:** Die elementare Ringfläche vierter Ordnung. 1916	»	60.
5.	**Zeuthen, H. G.:** Hvorledes Mathematiken i Tiden fra Platon til Euklid blev en rationel Videnskab. Avec un résumé en français. 1917	8.	»
	II, med 4 Tavler, 1916—1918	11.	50.
1.	**Jørgensen, S. M.:** Det kemiske Syrebegrebs Udviklingshistorie indtil 1830. Efterladt Manuskript, udgivet af *Ove Jørgensen* og *S. P. L. Sørensen.* 1916	3.	45.
2.	**Hansen-Ostenfeld, Carl:** De danske Farvandes Plankton i Aarene 1898—1901. Phytoplankton og Protozoer. 2. Protozoer; Organismer med usikker Stilling; Parasiter i Phytoplanktonter. Med 4 Figurgrupper og 7 Tabeller i Teksten. Avec un résumé en français. 1916	2.	75.
3.	**Jensen, J. L. W. V.:** Undersøgelser over en Klasse fundamentale Uligheder i de analytiske Funktioners Theori. I. 1916	»	90.
4.	**Pedersen, P. O.:** Om Poulsen-Buen og dens Teori. En Experimentalundersøgelse. Med 4 Tavler. 1917	2.	90.
5.	**Juel, C.:** Die gewundenen Kurven vom Maximalindex auf einer Regelfläche zweiter Ordnung. 1917	»	75.
6.	**Warming, Eug.:** Om Jordudløbere. With a Résumé in English. 1918	3.	65.
	III, med 14 Kort og 12 Tavler, 1917—1919	26.	00.
1.	**Wesenberg-Lund, C.:** Furesøstudier. En bathymetrisk Undersøgelse af Mølleaaens Søer. Under Medvirkning af Oberst *M. J. Sand*, Mag. *J. Boye Petersen*, Frk. *A. Seidelin Raunkiær* og Mag. sc. *C. M. Steenberg.* Med 7 bathymetriske Kort, 7 Vegetationskort, 8 Tavler og ca. 50 i Texten trykte Figurer. Avec un résumé en français. 1917	22.	»
2.	**Lehmann, Alfr.:** Stofskifte ved sjælelig Virksomhed. With a Résumé in English. 1918	3.	15.
3.	**Kramers, H. A.:** Intensities of Spectral Lines. On the application of the Quantum Theory to the problem of the relative intensities of the components of the fine structure and of the Stark effect of the lines of the hydrogen spectrum. With 4 plates. 1919	9.	50.
	IV (under Pressen).		
1.	**Bohr, N.:** On the Quantum Theory of Line-Spectra. Part I. 1918	2.	25.
	— Samme. Part. II. 1918	4.	00.
	— — — III. 1922	1.	25.
2.	**Warming, Eug.:** Økologiens Grundformer. Udkast til en systematisk Ordning. 1923	4.	50.
3.	**Wesenberg-Lund, C.:** Contributions to the Biology of the Danish Rotifera. With 15 Plates and 18 Textfigures. 1923	21.	25.
	V (under Pressen).		
1.	**Bjerrum, Niels** und **Kirschner, Aage:** Die Rhodanide des Goldes und das freie Rhodan. Mit einem Anhang über das Goldchlorid. 1918	3.	50.
2.	**Orla-Jensen, S.:** The lactic acid Bacteria. With 51 Plates. 1919	46.	00.
3.	**Brünnich Nielsen, K.:** Zoantharia from Senone and Paleocene Deposits in Denmark and Skaane. With 4 Plates. 1922	5.	25.
	VI (under Pressen).		
1.	**Christensen, Carl:** A Monograph of the genus Dryopteris. Part II. 1920	8.	25.
2.	**Lundblad, O.:** Süsswasseracarinen aus Dänemark. Mit 12 Tafeln und 34 Figuren im Text. 1920.	18.	50.
	VII (under Pressen).		
1.	**Wesenberg-Lund, C.:** Contributions to the Biology of the Danish Culicidæ. With 21 Plates and 19 Figures in the text. 1920—21	29.	00.
	VIII.		
	Jessen, Knud og **Jens Lind:** Det danske Markukrudts Historie. Med 1 Oversigtsskema. 1922—23.	31.	50.