XVIII. *Description of an Infusory Animalcule allied to the Genus Notommata of* Ehrenberg, *hitherto undescribed.* *By* John Dalrymple, *F.R.C.S.* *Communicated by* Thomas Bell, *Sec. R.S.*

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THE animalcule I propose to describe in the present memoir bears so close a resemblance to *Notommata Syrinx* of Ehrenberg, that were there not special differences in its internal anatomy, such as I believe could not have been overlooked by that great observer, one might almost believe it to be the same animal.

The character of the genus is thus given by the Professor in the great folio of 1838:—"Animal ex Hydatinæorum familia, ocello unico occipitali, *pede bisulco, caudam furcatam referente*; et organo rotatorio, simpliciter ciliato, instructum." These characteristics are mostly taken from its external organs; but we find, on reference to the description of the animal, that it possesses an intestinal tube terminating in a cloaca or anal orifice, which appears from the plates to be situated at the point where the foot or forcipated tail emerges. The grand structural difference, then, to be remarked in the animalcule that forms the subject of the following pages, is that there exists no intestine, and therefore no *anal* orifice, nor any tail or forcipated extremity. This want of intestine removes it into a lower position, as regards animal life, and I would therefore refer it to a subgenus of Notommata, if it be even entitled to a place so high in the scale of Infusoria.

In shape it resembles a flask or bell-flower (corpore campanulato) (Plate XXXIII. fig. 1), narrower towards the head and expanded below, of such extreme transparency as to permit all the internal organs to be clearly visible, even to the contents of the stomach.

It moves slowly and equably, describing, while feeding, narrow circles in the water, so as seldom to be far out of the field of an half-inch object-glass; but when disturbed it will go off in a direct line until it again becomes quiet, or resumes its former slow circular motion. It is visible to the unassisted eye as a minute semi-transparent spot, and is readily drawn into a glass tube when it is desired to select one for examination. Its average length is rather less than half a line, and at its broadest part about the fifth of a line in breadth.

In order to convey a correct idea of its anatomy, it will be desirable to describe, first, its general appearance and the grouping of the organs, and subsequently to take the latter under the heads of the assimilative and reproductive functions.

It has already been said that in shape this animalcule resembles a bell-flower, or

flask, pellucid in the highest degree, possessing no colour except what is due to a small pink eye and to the stomach, which varies in hue according to the food, but generally of a yellowish brown hue. When seen laterally, or in profile (if one may so say), the lower part is not equally convex, for it slopes off from one side, so that the most inferior part of the outer case is somewhat oblique, and one side somewhat longer than the other. It is towards the inferior part of this longer side that an opening (Plate XXXIII. fig. 1 S), valvularly closed, is observed in profile, which, when seen in front, is represented by a semilunar slit (Plate XXXIII. fig. 2 H), whose concavity is turned downwards; this is the vaginal aperture, whence the embryo, when mature, or the ova, are expelled. Each leaf of this valve is provided with special muscles for opening it, while it appears to be kept closed partly by its own elasticity, and partly by the pressure of the fluid contained in the body of the animalcule. Upon the hyaline tegument of the body may be seen, faintly indicated, transverse or circular bands or rings (Plate XXXIII. fig. 1 R) that mark the points where folds are developed upon muscular contractions of the animal, and it is on the inner side of this tegumentary covering, at the place where the rings are seen, that the long, ribbon-shaped muscles are symmetrically attached (Plate XXXIII. fig. 1 M).

The principal movements of progression are effected by means of the ciliary or rotatory apparatus, at the head or superior extremity of the body, and which seem to be independent of the more special rotatory mechanism, whereby two currents are produced in the water, that draw within their influence the smaller animals that serve as food: on reaching the point where the two opposite moving vortices meet, the food is immediately directed backwards in a straight line intermediate between the two, and so enters the oral orifice of the animal (Plate XXXIII. fig. 1 B). There seems however to be a distinct power of selection, for the slightest lateral movement of the head of the animal enables it to avoid objects too large for admission, or which it wishes to reject.

The cilia, by which all these motions are effected, appear to be placed upon raised eminences or processes, rising at regular intervals from the upper circlet or coronet of the animal (Plate XXXIII. fig. 1 A); and when the power is feeble from exhaustion, the lashing movements of the cilia are very visible. Immediately below the oral orifice is a considerable dilatation, closed above by the union of three portions of firm integument, forming as it were a labial apparatus, or at least a mechanism for closing the mouth, which resembles very closely the visor which conceals the powerful jaws of the larvæ of the Libellulæ. Within the mouth are situated a powerful pair of forcipated jaws (Plate XXXIII. fig. 1 E) which seize the prey, and if large comminute and break it down. Each ramus of the jaw is jointed (Plate XXXIII. fig. 3) on a short arm, which is again moveable upon a central axis prolonged posteriorly; and each short arm has a curved and strong process, to which the very powerful and somewhat complicated muscles are attached. The forcipated extremities of the jaws are bifid, and may be fairly designated teeth, one being sharp and hooked, the other flat or chisel-edged,

for the purpose of comminution. A third sharp and curved tooth is observed on the centre of the long arm of the jaw. I have thought also to have observed a second much more slender and pointed pair of jaws (Plate XXXIII. fig. 3 H), but this requires confirmation. When a small animalcule is seized, a Gonium for instance, on which it feeds greedily, it is placed as it were on a firm cushion in front of, and somewhat below, the jaws, and is thus prevented from escaping beyond the action of the teeth. Opposite the jaws appears the red eye, of which a further description will be given presently.

Below the mandibular apparatus the tissues expand into a sort of membranous pharyngeal cavity (Plate XXXIII. fig. 1 F), terminating below in a funnel-like apex, leading to the œsophagus (Plate XXXIII. fig. 1 G). The pharynx is very contractile, and furnished accordingly with a muscular tissue.

The œsophagus is narrow, and, while not in the act of giving passage to the food, is closely contracted; when, however, a morsel is about to be transferred from the pharynx to the stomach, the latter organ is brought up by special muscles to within a short distance of the former, and the transfer quickly takes place down the now dilated œsophagus; and if the prey be of considerable size, it is even forced downwards by the strong action of the united jaws.

Immediately before the junction of the œsophagus with the stomach, two kidney-shaped glands (Plate XXXIII. fig. 1 H) are seen attached, one before and one behind this tube. The glands seem composed of nucleated cells, imbedded in a granular stroma; and in the concavity of the kidney-shaped organ may be seen a definitely-shaped granular mass leading to the duct, conveying the secretion to the stomach, which it enters just above, or by the side of the insertion of the œsophagus. These glands are evidently salivary or pancreatic, and at least are subservient to the process of digestion.

The stomach (Plate XXXIII. fig. 1 I) itself is a comparatively large and sacculated cavity, of an ovoid shape, the sacculi giving it somewhat the aspect of a bunch of grapes where the berries are closely compacted together. Each little pouch or sacculus has in its centre a large clear nucleus; and on comparing it with the stomach of *Notommata claviculata* (Ehren.), in which hepatic cæca are appended to each sacculus, there is reason to think these nucleated cells also subserve the function of a liver. This belief is further countenanced by the fact of the stomach, when employed in the digestion of the food, assuming a yellowish brown colour, and at least the whole process of *assimilation* is performed in this cavity alone. There is no other orifice to the stomach except the cardiac or œsophageal one; hence there is no intestine, and the siliceous shells of its prey, and other rejectamenta, are brought back to the pharynx and rejected by the oral orifice. In this process also we see the forcipated jaws frequently assisting to eject the larger portions of the digested food. I have frequently seen this act performed, and the empty shells of Brachioni and Closteria returned and forced out again by the action of the jaws. There are apparently long ribbon-shaped muscles (Plate XXXIII. fig. 6) that pass from the pharynx along the œso-

phagus and embrace on many sides the stomach to its very fundus, where they meet and interlace. These muscles not only approximate the stomach to the pharynx, but compress it also, enabling it to discharge the debris of the food. Two or three fine filamentous muscles are attached to the fundus and fixed to the lowest part of the tegumentary case of the animal, serving to retract the stomach again when it has discharged its contents. The principal food appears to be species of Gonium, and other small infusoria; but also at times it will swallow hard and thorny Brachioni, and even the young of its own species. The total absence of all intestinal canal separates this animal from Notommata, which has a distinct gut and cloaca, as is well observed in the *N. claviculata*; and if development of digestive apparatus be taken as a distinctive character, it removes this form to a lower grade than any rotiferous animal I am yet acquainted with.

As it is clear that the growth and nutrition of the animal must proceed from the digestion of appropriate food, and as there is no true vascular system, it follows that the assimilated fluid must permeate the parietes of the stomach and enter the general or peritoneal cavity of the animal, which, however transparent the whole of the body appears to be, must be filled with this colourless nutrient fluid or blood.

In this animal, as well as in the Notommata figured by Ehrenberg, there is a peculiar organ, which in the explanation of figure 2 of plate 49, he designates "kie men" or gills, and as "kiemengefässe," "gill-vessels thicker than the gill, for which reason the tremulously moving gill cannot be a heart."

This peculiar organ consists in a double series of transparent filaments (Plate XXXIII. fig. 1 K) (for there is no proof of their being tubes or vessels) arranged from above downwards in a curved or semicircular form, symmetrical when viewed in front; or when seen in profile (the most common position of the animal under the microscope) as two series of filaments whose convexity is turned towards the exterior of the body. These filaments above and below are interlaced, loop-like, while another fine filament (Plate XXXIII. fig. 1 L) passes in a straight line, like the chord of an arc, uniting the two looped extremities. To this delicate filament are attached little tags, or appendices, whose free extremities are directed towards the interior of the animal, and which are observed to be affected by a tremulous, apparently spiral motion, like the twisting of a screw. This is undoubtedly due to cilia arranged round these minute appendices.

The tags (Plate XXXIII. fig. 7 B) above described are from eight, twelve, or even twenty in number, varying in different specimens, though always present in greater or less numbers. There seems to be much obscurity in Ehrenberg's description, and he does not appear to be quite decided as to their proper function; for though the designation of kiemen or gills would infer that he supposed them subservient to the purpose of respiration, other observers have suspected them to belong to a cardiac system. Now it does not appear consistent with the class of animals to which these infusoria belong, to expect tubular vessels or a heart, but nevertheless I believe the organs in question to be a peculiar circulating system.

I have said that the body of the animal is filled with fluid, most probably analogous to blood, while the ciliated tags, or appendices, in perpetual motion, must produce currents in this fluid, and probably in an uniform and determinate direction. In this way the nutrient plasma will be brought regularly in contact with all parts of the interior of the body, and the process of nutrition go on as in insects, without the intervention of tubular vessels, the dorsal heart in them serving only to give direction and circulation to the blood. I am the more impressed with this belief, since these filamentous organs are in close approximation with a large contractile sac, presently to be described, which probably performs a respiratory function.

As, however, this is a much-disputed part of the organization of the family of Hydatineæ, I shall here quote EHRENBERG's own observations upon *Hydatina Senta*, which he takes as the type of the whole family.

" It happened to me in 1832 to obtain a clear view of the vibratory corpuscles which CORTI in 1794 saw, and doubtingly considered to be four hearts. I found here eight of these bodies, four on each side in two rows affixed to the *sexual glands*. In other Rotifera I saw many more of the same kind; and in *Notommata Syrinx* and *claviculata*, a larger vessel was attached to the free and separated glands. These vibrating corpuscles are small and pear-shaped, free at one extremity and attached at the other, on all sides like little shaking purses, which either have on them a longer spiral coil, or within them four small separate vibrating folds, which are not under the volition of the animal. One only sees them clearly when the animal is flattened by the superimposition of a very thin light plate of glass, not crushing them. In Hydatina these vibrating valves or folds appear to be placed within the little purses. In *Notommata collaris* I have lately seen something prominent on their edges, and must therefore believe these folds to be placed on the outside. Besides, there appears in the neck of Hydatina to be present an opening in direct and important connexion with these organs, that in many other Rotifera projects as a spur-shaped horn. Close round this opening are placed the nerve-loops of the neck, and a nerve-ring appears to encircle it as a ganglion.

" The animalcule appears to take in, and expel alternately, clear water through this opening in the neck, and thus each vibrating organ throughout may be an internal gill producing respiration, although a circulation of the nutrient fluid (säfte), partly on account of the extremely small diameters of the vessels, and partly from the transparency and minuteness of the blood-corpuscles, remains as yet undiscovered, though probably not deficient. Many of the older, as well as more recent observers, who speak of a heart in Rotifera, mistook the pharynx for this organ. CORTI took the moving jaws and gills for it; moreover, while no true heart has been discovered hitherto, it is impossible that it should hereafter be found to exist, especially as no congenerous animalcules have one, although by the tremulous motions of the vascular partitions (*gefässwände*) the circulation of the blood is carried on."—EHRENBERG, page 415, fol. edit. 1838.

Besides this development of his views, it will be found that the great naturalist, in the explanation of the plate illustrating the anatomy of *Hydatina Senta*, believed the cords to which the gills or vibratory corpuscles are attached to be male organs, "testiculi" (*männliche drüsen*); a position most unlikely for the location of respiratory organs, were they even probably such. As it will be proved that in the animalcule I am describing no such male organ exists under this form, and that another apparatus appears to subserve the office of respiration, it is far more probable that they are part of the mechanism of circulation, and, as such, secondary to the function of respiration.

It has been previously stated that a valvular opening exists in the inferior part of the animal that gives exit to the matured embryo or to ova, and may therefore, from its obvious and demonstrable purpose, be denominated the vaginal aperture. This communicates with a membranous, highly extensible and very contractile ovisac (Plate XXXIII. fig. 1 P), in which the fœtus is matured, and by the contractions of which it is finally expelled from the mother.

Just above the ovisac, and communicating with the vaginal canal, is a considerable transparent sac (Plate XXXIII. fig. 1 N), which, when distended, presents a spherical shape. It is exceedingly delicate, and may be seen to contract by the action of slender muscular fibres with great rapidity, in which act it is thrown into numerous regular folds or pouches, and in that condition appears not very dissimilar to the large cellular lungs of Batrachia. These contractions and subsequent dilatations go on with some approach to regularity, and I have counted from six to eight in a minute; but when the animal is disturbed, or attempting to escape from the pressure of the "live cage," or in the act of expelling an embryo, the contractions and dilatations of the sac are greatly and irregularly increased, sometimes to twenty in the minute. It is on the outside and over this sac that the principal ciliated tags of the circulatory organ are placed. The explanation which I venture to give is, that this sac draws in the water in which the animal lives, and expels it again by the vaginal orifice, and it is by bringing the blood by means of the ciliary movements of the little bodies just described into intermediate contact with the air of the water, the fine membrane of the contractile sac alone intervening, that aëration or respiration is performed. An analogous contractile sac may be seen in *Rotifer vulgaris*, situated near the cloacal orifice.

At first sight this pulmonary sac (Plate XXXIII. fig. 7 C) appears to be an appendage to the ovisac (Plate XXXIII. fig. 7 D), but frequent observation of the female in all stages of gestation convince me that it has no relation to the generative function. The same sac is described by Ehrenberg, in the explanation to the figure of *Notommata Myrmeleo*, as a contractile *male* vesicle with evident vascular ramification. The position and the description of a contractile bladder show that the learned Professor is speaking of the same organ I have described, but it will be clearly shown by and by that it has no concern with sex, while the vascular ramifications are neither more nor less than the muscular fibrillæ by which the contractions are effected.

Every animal, however low in the scale of beings, is nourished by some process of converting either animal or vegetable products into themselves; but when we observe such elaborate organs of alimentation in Notommata, such as those of prehension, mastication, deglutition and digestion, we may infer at least the existence of some apparatus that may suffice to circulate and aërate the elaborated fluid or blood. A process of respiration is equally important to these beings as food and digestion, for it is well known that the higher forms of infusory animals will not exist in water either deprived of air or in which the air has been consumed by long inhabitation. The contractions of the vesicle I have described resemble very closely the expirations of a vesicular lung, and in some forms of Rotifera it appears almost wholly to vanish when contracted, and by expansion again to become suddenly apparent.

With regard to the nervous system, traces of such an apparatus may be distinctly recognised in the optic lobe or mass of ganglionic matter, on the centre of which is placed the pink pigmentous matter constituting the organ of vision (Plate XXXIII. fig. 1 C); from this nervous mass a fine filament may be observed passing obliquely down the body of the animal, attached at about the centre of the outer tegumentary case, Plate XXXIII. fig. 1 T. At this point exist two small tubercles, around which are set three or four short hairs, cilia, or setæ. The filament connecting these tubercles with the optic lobe, is enlarged at its lower part by the addition of two or three small ganglionic globules (Plate XXXIII. fig. 7 E), and appears to send off delicate filaments to the stomach, salivary glands, ovaries and ovisac. It may be a question also whether the curved and looped fibres connected with the circulatory organ may not have ganglionic corpuscles intermingled with them.

The muscular system is best explained by reference to the drawing, Plate XXXIII. fig. 8. It is merely necessary to remark here, that besides the long ribbon-shaped muscles that serve to contract and to retract the head and body, there are numerous muscular filaments having their fixed points in the integumentary case, and inserted into the various internal organs upon which they act; thus, there are delicate muscles attached to the fundus of the stomach to retract it into its situation after it has been drawn up to the pharynx either to receive or reject its food.

Other muscles are fixed to the ovaries; and a very intricate set of reticular fibres are expanded over both the respiratory sac and ovisac, producing in the one case the strong expiratory contractions of this vesicle, and in the other the expulsatory action attending the birth of the embryo.

The broad ribbon-shaped muscles have faint indications of cross markings, as seen in the voluntary muscles of higher animals, and in young specimens have frequently still remaining the nuclei of the cells imbedded in the fibre, whence this tissue has been originally developed.

The other more conspicuous organs visible within the transparent body of this animalcule are those appropriated to the reproduction of the species, and are very perfect in their kind.

It may be stated, *in limine*, that it is now certain that these animals are divided into female and male, the latter being one of the most curious organisms I am acquainted with.

As however the general description has hitherto been taken from the female, I shall describe the reproductive organs in them first.

There is an ovary, ovisac, expulsory mechanism, vaginal canal and vulva.

The ovary (Plate XXXIII. fig. 1 O) consists of an elongated mass, curved into the general form of a horseshoe, either extremity being rounded and slightly enlarged. In texture it appears gelatinous, with numerous interspersed granules, forming a stroma, in which are imbedded many nucleated cells (Plate XXXIII. fig. 1) that afterwards become ova. The ovary is larger in proportion as the animal is young, and visibly shrinks and becomes almost atrophied as it is advanced in age and has produced many embryos. This ovary, like the stomach, is very moveable in the general cavity of the body, but in the newly-born female, before many movements have taken place, and especially before the stomach has been distended with food, its position is such that the two horns are pointed upwards, and the digestive sac is placed within the concavity of the horseshoe (Plate XXXIII. fig. 2 O O): thus the ovary is symmetrically placed, and appears like a double organ united by a broad bridge in the centre. To either horn are attached slender muscles or tegumentary fibres that retain it in its general position, although either producing or permitting free movements; for when the ovisac becomes distended with one or more embryos, which always occupy the lower part of the animal, it, as well as the stomach, is pushed out of its ordinary or original position.

To the lower part of the ovary appears, connected by slight muscular or ligamentous fasciculi, the extremity of the ovisac, which, if unoccupied by an embryo, is closely contracted, and appears like a wavy, extremely delicate membrane. The female is both oviparous and ovo-viviparous, the latter condition being the one most frequently observed; and in fine hot weather it is not unusual to find females with four or five young in various stages of development, from the early ovum to the mature embryo, ready for expulsion.

The extreme transparency of the animal permits the ready observation of all stages of development. We can trace the germinal vesicle, surrounded by a gelatinous and granular mass or yelk, and enveloped in a delicate chorion, still attached to the ovary. The germinal vesicle is generally very distinct and excentric (Plate XXXIV. fig. 2), the whole egg being an ovoid figure. The ovum is then enveloped by the open end of the ovisac, and the base of attachment to the ovary being gradually narrowed to a small peduncle, it finally escapes free into the membranous ovisac, where the further development is carried on. We then shortly observe the ovum to increase in size, the distinct and dark granules appearing to become surrounded with cell-walls, and the gelatinous mass is converted into a large number of distinct nucleated cells, Plate XXXIV. fig. 3. I cannot say I have traced the division of the original cell into two, four, eight, &c. in

arithmetical progression, though this is not improbable, since in an early ovum I have once observed the separation into two distinct portions, in each of which there were several large granules or oil-globules, Plate XXXIV. fig. 5″.

Each granular point, however, seems subsequently to become the nucleus of a cell, round which the wall is developed. After a short time the numerous cells assume a more definite arrangement (Plate XXXIV. fig. 4), and are grouped together in masses, at which time, from the slight irregularities in their contour, the fine chorion is seen around them, forming an envelope for the whole.

By and by the groups of cells become more distinct masses, and a larger collection of them at one end of the ovum (Plate XXXIV. fig. 5) indicates the future position of the head; while smaller subdivisions are symmetrically arranged around another group, which finally becomes the stomach.

Soon after this period, the cells, or groups of them, evidently become developed into tissues, and the embryo begins to assume a definite shape, and the outline of the tegumentary covering is visible. Presently a slight ciliary movement is observed at one end, indicating the head of the animal, and the chorion shortly after bursting, the embryo becomes free, although closely surrounded by the delicate contractile membrane of the ovisac.

Having arrived at this epoch (Plate XXXIV. fig. 10 A), the perfection of the organs rapidly takes place, and we begin to recognise the stomach, salivary glands, ovary, and the ribbon-shaped muscles of voluntary motion; in these latter the original nucleus of the cell, which has elongated and been developed into muscular tissue, is still plainly visible, imbedded, as it were, in the fibre. The embryo has now voluntary motion, for while rapid ciliary movements are constantly going on around the head, the animal frequently contracts and extends its body, rolls over, or changes its position in the ovisac. The jaws may now be seen, and are not unfrequently moved as if exercising or trying their power. The red eye has previously been visible, and now and then the head of the animal is so placed that we are enabled to look down upon it, and observe the symmetrical position of the jaws with the eye placed opposite to the entrance of the mouth and pharynx, a position it is difficult to meet with for any continued period in the adult, from its instability and frequent movements under the glass.

The embryo may now be said to be ready to quit the parent, but some time previous to its exit it is seen exercising various and energetic movements, attempting as it were to escape; but until the valvular opening of the vagina is opened or retracted by special muscles, the forward movements of the fœtus only press the valve closer down, and shuts it more firmly against the side.

At length, after one or two partial openings of the valve, the muscles withdraw it completely, and the ovisac contracting energetically at the same moment, the embryo is suddenly and forcibly expelled into the surrounding water. No sooner however does it escape than it begins to swim about with the peculiar semicircular movements

of the parent, and a few moments after is actively engaged in searching for its food.

Such is the most common form of reproduction; but towards the latter end of the season, the females are found with a totally different form of ovum within them, Plate XXXIV. fig. 9. This ovum is spherical and dark, the outer covering appearing to consist of an aggregation of cells whose rounded form may best be seen at the circumference, where they appear clear and semi-transparent. Beneath this external layer is a second stratum of cells containing pigmentary molecules, that obscure the view of the yelk within, although there may be faintly seen four or five larger cells, with so highly a refracting outline as to give them much the appearance at least of oil-globules, Plate XXXIV. fig. 6. As the ovum becomes a little further advanced the peripheral cells are expanded, slightly club-shaped and striated, giving the whole ovum the aspect of a dark spherical body regularly covered with fine striæ (Plate XXXIV. fig. 7), radiating from a centre: from the want of general transparency no distinct germinal vesicle can be seen.

I have not had sufficient opportunities to trace the further development of these ova, but Mr. Brightwell of Norwich, an excellent and most accurate observer, has watched them for some months after their expulsion from the parent, without observing any further change. These ova are however so totally distinct in their physiological relations to the production of the embryo from the germinal vesicle of the ovum lying naked in the ovisac, that I think it probable they are destined to remain through the winter undeveloped, until the following year, as it will be seen that the period of the summer, during which this animalcule is found, is unusually short, as compared with the date of existence of congenerous species.

A third appearance (or description of ovum) is met with in the ovisac of the parent female. We observe an embryo developed gradually from a germinal vesicle, until it begins to assume a definite shape and independent movement, when we are at once struck with the great difference of its form, size and organization. This is the male, and as it is in itself most curious, and as I believe up to this time quite new and unique, it will require special description.

This male (Plate XXXIV. fig. 11) is about three-fifths the size of the female, generally resembling it 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, Plate XXXIV. fig. 12 E. Within this valve is observed a short canal leading to a large spherical bag (Plate XXXIV. fig. 12 G), which may be distinctly seen filled with molecular bodies in constant tremulous movement. From this sac, which I shall denominate the sperm-bag, a short but thick rounded body (Plate XXXIV. fig. 12 F) projects into the canal before mentioned as leading to the lateral opening, and around the extremity of this projecting process, and even within it to a short distance, is a visible ciliary motion indicating a canal (Plate XXXIV. fig. 14 C): on the neck of the

sperm-bag is a fasciculus of muscular fibres (Plate XXXIV. fig. 14 B) which are inserted along the commencement of this evident *penis*, and over the latter organ the membranous sheath is reflected. Muscular bands arising from the tegumentary parietes of the animal, in the vicinity of the valvular opening, go to be inserted into the root of the penis (Plate XXXIV. fig. 14 A A), and may be frequently observed drawing it up to the opening, and even extending it beyond the body of the animal. Muscles also for the purpose of opening the valve (Plate XXXIV. fig. 14 E E), very similar to those for the same purpose in the female, and the bands which bring the penis forward, clearly show it to be an extrusory organ, and form a complete male apparatus.

The sperm-bag evidently contains active spermatozoa (Plate XXXIV. fig. 13), having an oval flattened body (of a high refracting power), and a caudal appendage, that, while in the sac, is in constant vibratile movement; they are somewhat larger than, and of the same general form as, human spermatozoa.

I myself have never observed any action beyond the extrusion of the penis, but my friend Mr. BRIGHTWELL has observed in seven different instances the direct copulation of the two sexes. The following quotation from his notice of the fact in the Annals of Natural History for September 1848, clearly demonstrates this important circumstance.

"*Observations as to the Union between the Sexes.*

"June 15th.—Placed a male and six females in a small glass trough by themselves, and two males and about thirty females in a large trough.

"June 16th, between 7 and 8 A.M.—On examining the small trough observed that the male on approaching one of the females attached himself to its side by the spermatozoid projection, and remained so attached from twenty to thirty seconds. The same male acted precisely in the same manner with four other females. These five connexions took place in about fifteen minutes.

"At 5 P.M.—Saw one of the males in the larger trough attach himself to a young one of the other sex for about twenty seconds, and afterwards to a full-grown female for a somewhat longer time. Saw this last connexion in a clear light most distinctly. The end of the sperm-tube was attached to the side of the female, and the rest of the body of the male was quite free. Saw the same male soon after fix itself by its head to the glass and remain so for thirty seconds, and during this time it continued puffing out and drawing in the sides of its body as if to give them their utmost dilatation.

"June 20th, 5 P.M.—Placed a young female and a male in a trough by themselves and watched them very frequently till eleven at night, and though they came very near each other no conjunction took place.

"June 21st, 8 A.M.—Found the female dead and the male alive. Put three other females to this male, and in a few minutes saw the male as soon as he approached one of the females attach his sperm-tube to its side and remain so attached fifty

seconds. Soon afterwards he attached himself to another very young female and remained so attached seventy seconds. Could discern this latter connexion of the end of the sperm-tube with the side of the female very distinctly.

"4 P.M.—Saw in the trough, by the aid of the microscope with a one-inch achromatic object-glass, a conjunction of a male with a female. On approaching the female the male attached himself by the sperm-tube to her side, and remained so attached nearly a minute. Saw this most clearly, but owing to the movement of the animals in the water it is almost impossible to see more than that there is a distinct adhesion.

"Most of the above observations were made with a single lens only, of two inches focus, and the others with the microscope."

So acute an observer as Mr. BRIGHTWELL could not possibly have been mistaken in the fact so repeatedly observed, and it leaves us therefore in no doubt as to the dicœcious character of this singular family; but there is another circumstance connected with the anatomy of the male, so curious as possibly to be unique. The male I have said possesses the same general figure as the female, it has also the contractile vesicle, which I have ventured to name the respiratory sac (Plate XXXIV. fig. 12 D C), as well as the fibres furnished with the vibratory or ciliated tags, subservient to the office of a circulation. It has also the ordinary rotiferous apparatus at the head, through the agency of which its various movements of locomotion are performed; the pink eye (Plate XXXIV. fig. 12 B) is distinct. *It has however no mandibles, no pharynx, œsophagus, pancreatic glands or stomach*; there appear to be no organs of prehension, deglutition, digestion or assimilation. At the lower part of the animal, on the other side of, and opposite to the valvular opening, are three small oval bodies (Plate XXXIV. fig. 12 H), massed together, having no communications by tube or otherwise, but fixed in their place by short ligaments, that may be rudiments of a stomach.

They are not testes, for they have no communications with the sperm-bag, and they do not exist in the female. I have therefore provisionally regarded them as the rudiments of a digestive apparatus.

The difference of sex in these two forms is plainly evidenced by the fact, not only of the difference of structure, the presence of active spermatozoa in the male, but by the observed fact of the intromission of the male organ into the vaginal canal of the female. That the male animal is produced by the female and developed within the ovisac in the same manner as the female embryo, is also proved by many observations; and one of the drawings of the male has been made from a specimen still in the interior of the parent, and even at that period having its sperm-bag filled with active spermatozoa.

Thus this animal is not androgynous, and a careful reconsideration of the whole family of Hydatina is desirable to determine whether this law prevails in this extensive group of infusory animalcules. Had the male not been traced *ab ovo*, or had it been met with apart from female specimens in the water, it had been taken for a

wholly distinct species, and I can easily imagine the males of other species may so far differ in size and apparent organization, as to have been mistaken for distinct races, and their physiological position overlooked.

The absence of all organs for the sustentation of life by food leads to the belief that it is created for a single purpose, and that its duration or term of existence is very short. In this respect it somewhat resembles the drone or male bee, whose utility seems confined to the impregnation of the perfect female or queen. The short existence of this male is further proved by the fact that it is impossible to keep these animals alive for any extended space, and the observer who has not frequent access to the natural pools in which they exist, is dependent for subjects of experiment on their occasional production by the females in the water wherein they are confined.

That a single impregnation is sufficient for the production of many young, is proved by the female continuing to breed in water in which no male can be discovered; but young females so produced will not go on to develope others unless a male be born amongst them.

In what light then are we to look upon an animal wanting those organs, that in the most elementary beings appear to constitute the almost entire structure having a single function to discharge, that of continuing the species, which once effected, it perishes? Such indeed appears to be the case, and is another of those marvellous instances of endless variety in the accomplishment of a particular object by the Creator, in which His works abound.

A few words are necessary as to the habitat of this curious animal. It was first discovered by Mr. Brightwell in 1841, in a pit immediately without the city of Norwich. For a long time it was met with in no other locality, although constant search was made for it in localities likely to abound in Infusoria. Even in this particular pond in some summers no specimens have been detected, while in others it has swarmed in June, July and August. It has however this year been discovered by Mr. King of Norwich in a pool on Mousehold Heath, within a short distance of the same city. I have for many years been accustomed to search the pits and ditches in the neighbourhood of London, and although almost every genus described by Ehrenberg has furnished some species, and abundance of Notommata, especially at Hillingdon near Uxbridge, there have been seen no specimens of this curious animal until by chance I detected it in August of the present year in a pond in Warwickshire, not far from Leamington. As however infusorial animalcules have a very wide range, it is to be hoped it will hereafter be more extensively met with than hitherto, and more especially as from its exquisite transparency and the perfection of its ovaries and ovisacs, as well as from the discovery of a separate male, the process of development can be so easily watched and traced from its earliest commencement. As far as has been hitherto observed, the development of the ovum, through all the phases of germinal vesicle, granular nuclei, nucleated cell, and the conversion of cell into tissue, appears to follow the same type as has been so well described by Burdach,

Von Baer, Von Siebold, Bischoff, Barry and a host of others. The rapidity of the processes, as well as the great clearness with which the changes can be seen, are very favourable for observation; while the viviparous nature of the animal assimilates the conditions more to that of higher organizations, than where development takes place in a true egg expelled from the body of the mother, and dependent upon its own *vis insita* alone.

Explanation of the Plates.

PLATE XXXIII.

Fig. 1. Exhibits the animalcule, of which the preceding pages are a description, seen in the position most generally observed, viz. in profile.

A. The ciliated coronet that surrounds the head.
B. The mouth or anterior aperture.
C. The pink eye.
D. The ganglionic mass on which the eye is placed.
E. The jaws or mandibles.
F. The pharyngeal cavity.
G. The œsophagus.
H. Salivary or pancreatic glands.
I. The stomach.
K. The circulatory apparatus.
L. The ciliated tags appended thereto.
M. Muscles.
N. Contractile or pulmonary sac.
O. Ovary.
P. Ovisac surrounding.
Q. An embryo.
R. Circular bands on the integument.
S. Vaginal or posterior orifice.
T. Lateral aperture, ciliated or setaceous.

Fig. 2. Represents the animalcule seen frontwise or on the abdominal aspect; organs symmetrically placed.

A. The axis of the jaws.
B B. Muscles moving the rami of the jaws.
C. The pharynx.
D. The œsophagus.
E. Salivary glands.
F. Circulatory apparatus, with

Fig. 1.

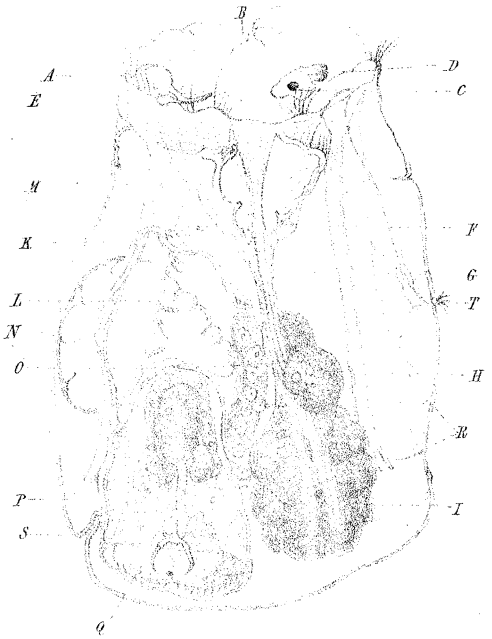


Fig. 3.

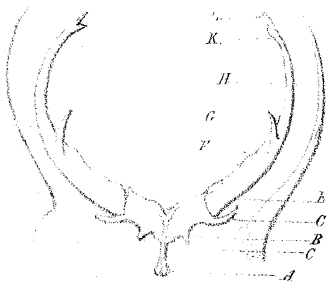


Fig. 4.

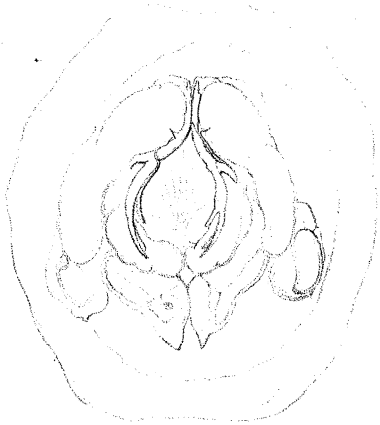


Fig. 2.

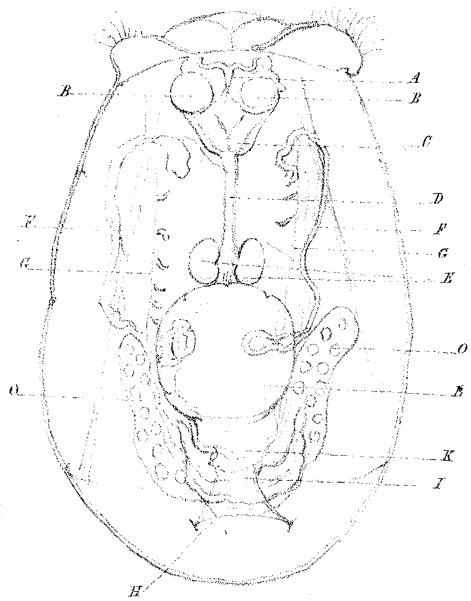


Fig. 5.

Fig. 7.

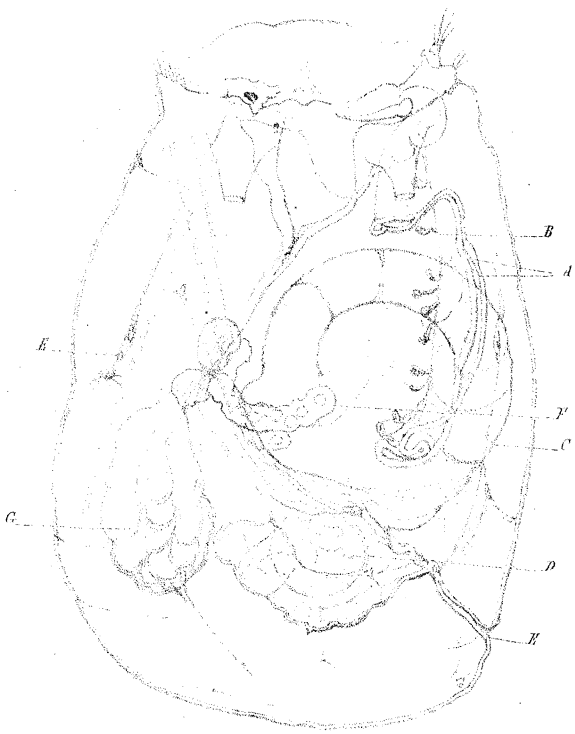
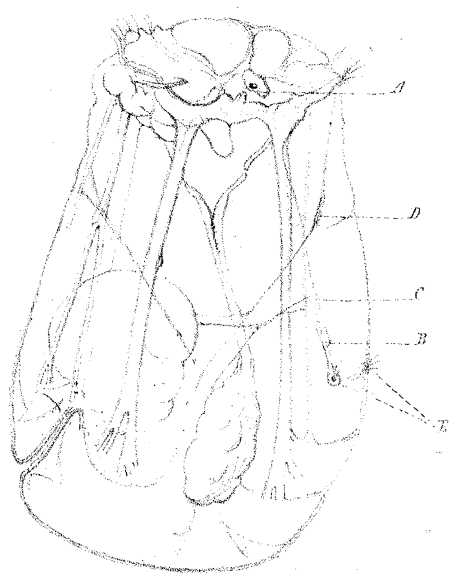


Fig. 6.

Fig. 8.



J. Basire, Lith.

G G. Ciliated or vibratile tags.
H. Semilunar slit of the vaginal orifice.
I. Internal valve of vagina.
K. Ovisac.
L. Contractile vesicle.
O O. Ovary.

Fig. 3. The forcipated jaws.
A. The axis.
B. The short ramus.
C C. Processes for the attachment of muscles.
E. Joint.
F. Long ramus of the jaws.
G. Lateral tooth or hook.
H. External or second slender forceps.
I. Sharp or hooked extremity of jaw.
K. Flat or chisel-shaped tooth.

Fig. 4. Represents the oral apparatus seen by looking directly down upon the head. The forcipated jaws are symmetrically placed, surrounded by powerful masses of muscles, and situated above the pharyngeal cavity. The pink eye is seen in front of the jaws and somewhat to one side, overlooking the entrance into the pharynx.

Fig. 5. A salivary gland, highly magnified, 650 diameters.
The gland shows the secreting cells with their central nuclei dispersed in a granular stroma while around what appears to be a duct, entering the œsophagus immediately above the stomach ; the cells appear to give place to a delicate granular structure, which may indicate the resolution of the cells into the secreted matter.

Fig. 6. Represents the multilocular stomach, with the œsophagus and salivary or pancreatic glands attached.
Each loculus of the stomach has a clear nucleus on its centre, and while the whole cavity is a digestive sac, it is not improbable the loculi and their nuclei represent rudimentary hepatic cæca.
Within the stomach are seen a Closterium and a Gonium on which the animalcule has fed.
Muscular fibres may be seen passing over the stomach sunk in the depressions between the sacculi of the organ ; and attached to the fundus are slender muscles, which are also fixed to the lowest part of the tegumentary case of the animalcule, and serve to retract the stomach after displacement and regurgitation of the digested food.

Fig. 7. Shows a female animalcule, for the purpose of representing more distinctly the circulatory organs (A), with their attached ciliated or vibratile tags (B),

and the contractile vesicle or respiratory bag (C). Both it and the ovisac (D) appear to communicate with the valvular opening or vagina (E), but whether by a separate or common passage is as yet doubtful. The ovisac is partially contracted and thrown into folds, and attached by muscular or ligamentous bands to the yoke-shaped ovary (F). The stomach (G) is displaced to one side.

Fig. 8. Represents the muscular system and what appears to be a rudimentary nervous system.

The muscular bands which retract the body of the animalcule are seen rising by broad origins from the firm coronet of the animalcule, and pass down the interior of the body, free and unattached, to be inserted by digitated processes into those circular tegumentary rings which have been described as vessels by EHRENBERG.

Over the stomach, which is here represented empty and somewhat flattened, muscular bands may be seen extending from the œsophagus to its very fundus. Two delicate muscular bands are fixed to the interior or bottom of the tegumentary case, and inserted into the fundus of the stomach, and are retractors of this organ.

A. Shows the pink eye situated in a mass of nervous or ganglionic matter, from which proceeds a delicate chord, having at B two ganglionic corpuscles and terminating at the two setaceous tubercles at the side of the animalcule at E. At C, delicate nervous chords go off to be distributed to the stomach, pancreatic or salivary glands and ovaries; and at D, another ganglion appears to give off fibrillæ too doubtful to be here indicated.

PLATE XXXIV.

Fig. 1. A portion (one horn) of an ovary, magnified 700 diameters, showing the granular stroma, and the vesicles and their included nuclei and bright nucleoli.

Fig. 2. An ovum, as yet attached to the ovary, exhibiting the granular yelk, and the excentric germinal vesicle, with a bright nucleus.

Fig. 3. The resolution of the yelk into several cells, each having a nucleus.

Fig. 4. A further development of nucleated cells, beginning to be massed together in groups.

Fig. 5. Symmetrical arrangement of the groups of cells, the uppermost group indicating the future position of the head.

Fig 5″. A condition of the ovum seen once only, in which the yelk appears divided into two masses, without regular nucleated cells: a few oil-globules are seen irregularly distributed. Whether this be a fertile ovum is doubtful, but further changes were not observed, the parent animalcule dying.

Fig. 1.

Fig. 2.

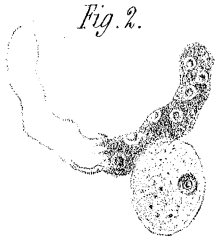


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 5."

Fig. 10.

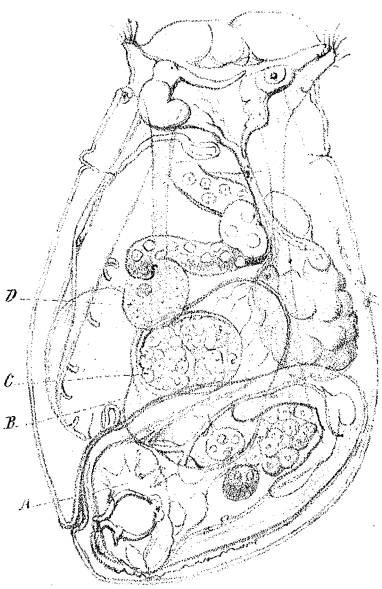
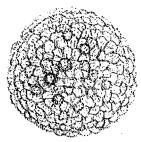


Fig. 6.

Fig. 7.



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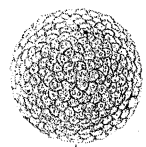


Fig. 8."

Fig. 9.

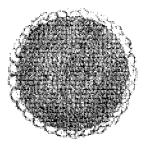


Fig. 11.

Fig. 13.

Fig. 14.

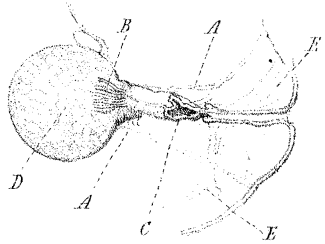
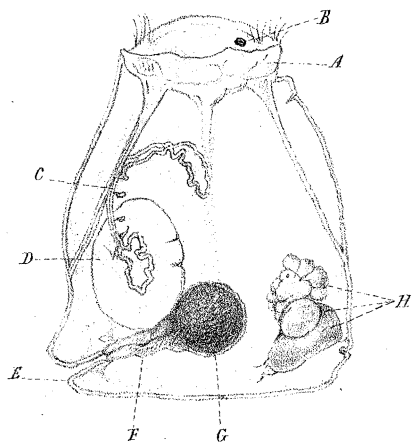


Fig. 12.



Figs. 6, 7, 8, 8″ and 9, represent the ova in shelly cases, supposed to be ova that persist unhatched during the winter, or at least which are not developed within the body of the parent female.

Fig. 6. The early stage of the ovum, through the coriaceous coat of which are seen numerous oil-globules in the yelk; the ovum is, however, too opake to permit the germinal vesicle to be seen.

Fig. 7. Further advancement of the ovum, in which a peculiar striated appearance of the flattened cells, which constitute the outer covering, may be observed.

Fig. 8. A similar ovum, and fig. 8″, a portion of these flattened cells, more highly magnified, to show to what is due the peculiar striated appearance.

Fig. 9. An ovum ready to be expelled, in which the dark pigment has been added, which obscures all appearance of cells except at the margin.

Fig. 10. Represents the impregnated female and the development of the ova, those destined to evolve living embryos.

In this figure the ovisac contains four ova in different stages of maturity, viz. one (A) situated at the most inferior part of the animalcule, already nearly developed, in which the various internal organs are seen almost perfected; cell nuclei are still visible in the two long muscles of the body, and as the embryo is seen frontwise, the organs are observed symmetrically placed.

Immediately above this embryo is a second (B) obliquely situated, with the head downwards, and partially obscured by an ovum (C) lying over it, which has proceeded only as far as the conversion of the granular yelk into nucleated cells; while above this is a fourth (D) still attached to the ovary, in which the germinal vesicle is very obvious and excentrically placed.

Fig. 11. Represents the male animalcule in which the various organs are distinctly expressed. This specimen was found swimming free in water, taken from a pond in Warwickshire in August 1848. The spermatozoa are distinctly seen in the sperm-bag.

Fig. 12. A male animalcule drawn from a specimen still in the ovisac of the female.

A. The ciliated coronet.
B. The pink eye.
C. The circulatory organs with their ciliated tags.
D. Contractile or pulmonary sac.
E. The lateral opening, through which
F. The penis, or male extrusory organ, is projected.
G. The sperm-bag filled with spermatozoa.
H. The glandiform bodies, or rudimentary structures, uses at present unascertained.

Fig 13. Spermatozoa from the sperm-bag, obtained by compression.

Fig. 14. Exhibits the organs of generation.

A A. Muscles which extrude the penis.

B. Fasciculus of muscular fibres, which arising from the neck of the sperm-bag are inserted on the body of the penis and expel the spermatozoa. "Ejaculatores seminis."

C. Preputial sheath, within which is seen a ciliary movement.

D. Epithelium lining the sperm-bag, seen by gently expressing the spermatozoa.

E. Muscles which open the external valve or lateral opening through which the penis passes.