in Gabes and discovered that the larva of an insect (probably a species of ephemerida) was also an efficient intermediary host. With the view of making control experiments I proceeded to Gafsa, as I had been assured by the principal medical officer of the military hospital of that place that bilharzia disease was endemic there. Here I had access to several cases of indigenous origin. I found that not only is the disease very common in Gafsa in the native population, but that the cases were sometimes of a grave character, such as I had previously frequently met with in Egypt. I may say that my researches in Gafsa confirm the conclusions above detailed in so far as I succeeded in rearing bilharzia embryos in the aquatic larva of an insect; but, strange to say, I did not meet with this insect larva at Gabes; nor did I succeed in finding in Gafsa the larva of the insect nor the crustacean which served me as subjects for my experiments at Gabes. Thus I concluded that several kinds of aquatic arthropoda may act as efficient intermediary hosts for bilharzia, whilst molluscs seem to have nothing to do with its life history. I may add that in these intermediary hosts the cysts of bilharzia resemble very closely the asexually generated cysts of young distomes. They are globular, having a double outline and a diameter of from 0.075 mm. to 0.120 mm. If the included parasite be not moving spontaneously, movement may be elicited by adding to the slide a little warm water. The cyst is elastic and compressible, but it is difficult to rupture. Up to the present I have failed to liberate the parasite without completely destroying it. As seen in the cyst it presents no features by which it can be distinguished from other kinds of encysted distomes, with the exception that its integument is firmly and characteristically beaded, just as in the earlier stage of the embryo bilharzia, as described by Cobbold¹ in 1872, and as I figured it in my first paper² on this parasite in 1874. I may mention that as regards the anatomy of the embryo bilharzia I can confirm what has quite recently been announced by Railliet,³ but which I have long known, that whilst still *in ovo* it is provided with two pairs of ciliated infundibula, one pair being in the anterior third and one pair in the posterior third of the body. These infundibula are very apparent and are to be best seen by slowly lowering the focus of the microscope whilst examining the embryo. As the larval phase of bilharzia found encapsuled in the intermediate host is, in a biological sense, different from the encysted cercaria phase of the typical distomes—inasmuch as it is a direct encystment of the embryo and not, as in the case of the cercaria of the distomes, the encystment of the asexually generated progeny of a redia developed from an embryo distome,—it is desirable to provide this larval encysted stage of bilharzia with a distinctive name. As the corresponding larval phase of the holostomes—which, as regards this part of their life history, bilharzia closely resembles—is designated “tetracotyle,” the term “dicotyle” appears to be appropriate, the bilharzia larva having only two suckers. The insect aquatic larvæ in which the dicotyle of bilharzia is found encysted have a length of 7–8 mm. and a thickness of about 0.3 mm. The crustacean is about the same size. The magnitude of these intermediary hosts renders it easy by a little attention being paid to the drinking water to preserve a community from infection by bilharzia, as the investigation I have made would tend to show that the drinking water which is obtained from pools, tanks and streams which contain arthropoda is the medium by which this parasite gains access to the human body and it is probably the only medium; therefore bathing in such water, if the bather should swallow the water, is dangerous. Filtration, even rough filtration through linen, will afford complete immunity. It will thus be seen that the rules I laid down many years ago for the prevention of bilharzial infection, which were repeated in a paper read by me at the last International Congress of Hygiene (1891), and which appeared in THE LANCET of Aug. 22nd and 29th, 1891, are still appropriate.

I wish also to note that the discovery of the life history of bilharzia, to which I applied myself now more than ten years ago, and which, perhaps, I would have effected much sooner could I have continued my earlier researches in the Khedivial

Laboratory at Cairo, gives prophetic significance to the forecast which I made in a paper published in 1884, the concluding words of which I reproduce in their original language: “Non é improbabile che la bilharzia che per tante particolarità s'allontana dagli altri generi di distomi offra ancora questa singolarità di avere per ospiti intermediari animali di classi diverse da quelle che servono allo sviluppo degli altri distomi o quella di compire tutto il suo vilo vitale in parte libero nell' acqua e in parte parassita in un solo ospite finale e forte senza riproduzione alternante.”

Gafsa, Tunis.

ANATOMY AND PHYSIOLOGY OF THE BILHARZIA OVUM:

EXTRACT FROM A SUMMARY OF A THESIS ON BILHARZIA HÆMATOBIA.

By GEORGE SANDISON BROCK, M.D. EDIN.

I WISH, in the first place, to describe with some minuteness the ovum of the bilharzia. In itself it is both curious and interesting, and it is well worth study; and, as a complete knowledge of it seems to be the only means of putting the question of its identity with that of the Egyptian parasite beyond dispute, I have bestowed a good deal of attention upon the subject. It has been a difficult matter in studying such a delicate object to make out its various parts with accuracy, and I cannot pretend to have done so; yet I have been able to find out some important points that, so far as I am aware, have not been noticed by any previous observer. As already mentioned, the ova of the bilharzia have been seen in the ovisac of the mature worm, but I have only been able to study them as they appeared in the urine of patients who were suffering from the disease. In this situation they may, however, be met with in all stages of development, and in enormous numbers. The most immature ova have a simple envelope with a short spine at one end, and they are filled with granules of various sizes. They are (Cobbold) about $\frac{1}{16}$ in. in length, and about $\frac{1}{16}$ in. in breadth. In older specimens segmentation may be seen in different stages of advancement, and by searching carefully one may trace, step by step, the development from a simple chaotic granular mass through all the stages until the creature finally attains the definite and comparatively complex structure of the mature embryo. The fully matured ovum (see p. 623) is very similar in shape to a hen's egg and measures from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. in length and about $\frac{1}{16}$ in. in diameter (all measurements are taken from Cobbold). There is, however, much irregularity to be seen even in mature specimens, both as regards size and shape. Some are a little larger and others are a good deal smaller; whilst some are long and narrow others have more the shape of a pear or a boy's kite. The outer envelope or shell is so clear and smooth that it scarcely, if at all, interferes with one's view of its contents. By reflected light it appears to be shiny and of a brownish or pinkish neutral tint. It is soft, delicate, and very thin, but its double contour can be made out under a high power, especially at the narrower end of the egg, at which part a sharp, projecting spine of varying length is usually placed. This spine is often very short and it is sometimes altogether absent. Its average length is about $\frac{1}{16}$ in. or one-tenth of the total length of the egg. According to Cobbold it is the homologue of a very much larger structure in certain other trematode ova, where it serves as a “holdfast” by which the eggs attach themselves to the body of their host. In the bilharzia its use in this respect, if it has any, must from its straightness and trifling length be very slight. In eggs which have been voided through the rectum it is said that these spines are often placed laterally. I have never been able to obtain any so passed, but I can confirm Harley's assertion that those from the urinary passages never present this peculiarity. Lining the interior of the shell and intervening between it and the embryo is a delicate granular membrane. The space between this membrane and the embryo varies much according to the size and state of contraction of the latter, shortly before whose escape it becomes filled with numbers of bright granules which are extruded through certain apertures (which are presently to be described) in the sides of the embryo. These granules exhibit Brownian movements and are often further agitated

¹ On the Development of bilharzia hæmatobia, being a paper read before the Metropolitan Counties Branch of the British Medical Association on May 17th, 1872. (Brit. Med. Jour.)

² Ricente intorno alla Bilharzia Hæmatobia in relazione colla Imaturia Endemica in Egitto. Rendiconto della R. Accademia della Scienze di Napoli, 1874.

³ Observations sur l'Embryon du Gynecophorus Hæmatobius Bilharzia. Par A. Railliet, Paris, 1892. Bulletin de la Société Zoologique de France, 1892, tome xvii., p. 151.

by the action of the cilia with which the body of the embryo is covered. I next come to the embryo itself which, until the time draws near for obtaining its liberty, lies quiescent in its shell, only occasionally moving its head from side to side or drawing its whole body upwards with a jerking movement by means of attachments between the front part of its body and the adjoining part of the vitelline membrane. A cursory glance shows what at first appears to be a structureless sarcodic mass roughly corresponding in shape to the surrounding envelope; but closer examination shows that this apparently simple mass is a creature of very considerable complexity of structure. The cephalic end of the embryo, which is sometimes placed at that end of the shell which terminates in the spine

Embryo of *bilharzia haematobia* *in ovo*, as seen with magnifying power of 580 diam. (enlarged $\times 4$). Dorsal aspect. A, Oral aperture. B, Oral papilla. C, Projecting point of stalk of pyriform body. D, Esophagus. E, Esophageal bulb. F, Stalked mass with nucleus. G, Anterior series of coronal apertures. H, Point showing rhythmic contractile movement (right anterior). I, Stomach. J, Commencement of intestine. K, Posterior series of coronal apertures. L, Extruded globule. M, Point showing rhythmic contractile movement (right posterior). N, Water vascular system. O, Cilia. P, Spine.

and sometimes at the other, is distinguished from the caudal end by its shape, which is that of a truncated cone with the extremity further prolonged into a button-like projection—the oral papilla. The whole body, with the exception of this papilla, is covered with cilia, which are arranged both longitudinally and transversely in beautifully regular lines. This regularity is interrupted at two situations, where certain lateral apertures are placed round the body, thus dividing the surface into three zones—cephalic, caudal and intermediate. Close to the base of the papilla the cilia are short, but further back they gradually increase in length, until at

a point where the anterior series of apertures open they reach their extreme length of about $\frac{1}{800}$ in. The cilia of this cephalic zone are stronger and more active than those of the intermediate and caudal zones. They are nearly always in motion, even before the embryo escapes from the shell, and are the last to retain their movements when the embryo is dying. Those of the intermediate and caudal zones are fairly uniform in length and they are very delicate and are easily injured. One circular row of them, which is placed at the junction of the zones beside the posterior series of apertures, has the peculiarity of frequently standing straight out from the body, vibrating slightly or quite motionless, whilst all the other cilia are moving rapidly. Before speaking of the structures in the interior of the embryo certain orifices on its surface remain to be noticed. The mouth is placed in the centre of the tip of the oral papilla. At the extremity of the caudal end, where the alimentary canal in distomes terminates caecally, a slight depression generally exists. It is probably only a rudimentary structure, for I have never been able to find any connexion between it and the alimentary canal, and I have never seen anything being extruded from it; or it may possibly be an open *foramen caudale* which is connected with the water vascular system of the embryo. The function of excretion seems to be performed by the two series of lateral apertures which have already been referred to. These are placed coronally at about an equal distance from each pole of the embryo, the distance between the poles being about a quarter of the embryo's whole length. Those of the anterior series merge into one another so as to form a coronal slit in the ciliated covering of the animal, into which excretory ducts probably open. The posterior series is much more distinct and the apertures number about thirty. From both series extruded matters are often to be seen emerging in the shape of globules and granules, and it is from such extrusion that the granules, which have been previously mentioned as being contained in the space in the ovum between the embryo and its inner envelope, are probably derived. So far as I am aware no similar structure is described as having been observed in the embryos of any of the other entozoa and not one of the descriptions I have seen of the bilharzia ovum contains any reference to them. The body of the bilharzia embryo consists of contractile protoplasm, through which refractile granules and globules of various sizes are interspersed. It is furnished with a digestive and a water vascular system, and it contains other structures as well. There is a distinct oesophagus, terminating anteriorly at the oral papilla in a somewhat dilated funnel-shaped end, which has transverse markings that give it the appearance of being ringed. Posteriorly is the large stomach, which occupies a considerable space in the anterior half of the embryo and terminates behind in a tube of large size, which is so indistinctly differentiated from the surrounding sarcoderm that I have been able to trace it for only a short distance, when it appears to bifurcate. From the manner in which excretion takes place—namely, by the numerous lateral apertures—it is probable that the tube divides and subdivides in the body and that its branches open at these various points. The presence in the embryo of a water vascular system was noticed by Cobbold; but without being aware of this I had satisfied myself of its existence and made out certain other interesting points about it before I obtained Cobbold's paper. It is to be best seen after the embryo has escaped from the shell and has been swimming about for some time in water. It begins at the oral papilla, round the base of which there seems to be a circular vessel, and one branch passes down either side of the body, nearer the dorsal than the ventral aspect, until the two branches meet one another near the depression which has been previously noticed at the caudal extremity. In their passage downwards they give off several anastomosing branches, which ramify over the whole body of the embryo, but which specially concentrate and arrange themselves about four particular points, being placed in pairs, one pair lying in the anterior half and the other pair in the posterior half of the body. If the embryo be alive there will always be seen at these four points a rhythmic contractile movement, varying in rapidity from two or three up to many beats per second, being slow or rapid according as the embryo is active or the reverse. It has nothing to do with the movements of the surface cilia, which are often quiescent whilst the contractile organs are active. The members of each pair are situated symmetrically on either side of the body about $\frac{1}{800}$ in. apart, those of the anterior pair usually lying in the interval between the sides of the

stomach and the two pyriform masses (which are presently to be described), those of the posterior pair being a little way behind the plane of the posterior series of apertures. Placed in the centre of a complicated network of tubes, and exhibiting such well-marked contractile movements always in a definite direction, these remarkable organs can hardly be other than circulatory in their function, serving to propel a nourishing fluid through the aquiferous system and probably also to establish communication between that system and the fluid in which the embryo swims. A short tube can be seen to pass from each to the nearest of the lateral apertures, the anterior pair of contractile vesicles or tubes communicating with the anterior series of apertures, and the posterior pair with the posterior series. I have, however, entirely failed to detect any circulation either in the tubes immediately surrounding the contractile organs or in any of the numerous branches which are distributed elsewhere in the body; but this failure I attribute to the transparent character of the circulating fluid. The most prominent of the structures in the interior of the embryo yet remain to be described—namely, two rounded masses lying in the anterior half of the embryo, one on either side. In the various accounts of the ovum which I have seen these masses are spoken of as pyriform bodies, and they often have a pear-like shape, although more generally they are irregularly rounded on quadrilateral and are frequently to be seen with a notch in their posterior border. They are roughly granular bodies measuring about $\frac{1}{2500}$ in. in diameter, with a bright double outline and containing in their interior one or more prominent nuclei. They are situated on either side of the stomach about the junction of the anterior and middle thirds of the body, being nearer to its dorsal than its ventral aspect. From the forepart of each a stalk-like process passes forward, one on either side of the œsophagus, which has just room to pass between and below them, and terminates in a small point projecting slightly beyond the surface on either side of the oral papilla. These stalk-like processes have been described by Harley as tubes, but I have not been able to see any appearance of their being hollow, and I believe them to be solid and possibly muscular organs which give the head more rigidity and help in its movements. I find that these two pedunculated masses are invariably present in the mature ovum. It would be interesting to know what part they play in the later phases of development. Cobbold speaks of them as varying in number, but he was probably looking at them in profile when he saw only one. (Fig. 1.) His description, indeed, both of the digestive

Fig. 1.

apparatus and of the stalked masses, gives altogether only a vague idea of their structure and relations. After the ovum is voided with the urine, if it be mature, certain changes go on in it, resulting in rupture of the envelopes and escape of the contained embryo. The cilia of the cephalic zone first begin to move rapidly and the creature moves its head about in all directions (Fig. 2) evidently endeavouring to free itself from its attachments to the inner envelope, extruding at the same time from its lateral apertures numbers of granules and globules of various

sizes similar to those which are to be seen within the body substance, as well, probably, as a fluid, so as to distend the space between itself and that envelope. All the cilia are soon at work, creating a great commotion amongst these particles, vigorous contractions of the body taking place the

Fig. 2.

Embryo preparing for its escape.

while, by means of which it is considerably increased in breadth and presses upon the sides of the shell. The oral papilla is also used with great vigour as a proboscis to rub against the investing membrane in all directions, the creature

Fig. 3.

Embryo in shell, but free from all its attachments, just prior to its escape.

twisting itself about, drawing itself up and even eventually, when quite loosened from its attachments, turning complete somersaults in the shell. (Fig. 3.) The shell meanwhile grows more and more delicate and thin until at length a

Fig. 4.

Empty egg-shell with lateral rupture.

longitudinal lateral rupture takes place by which the embryo promptly emerges, presenting indifferently by cephalic or caudal end. The membranous envelope either remains behind in the outer shell, or protrudes through the slit (Fig. 4). If

the urine be watery, or if it has previously been replaced by pure water, the escaped embryo, relieved from the confining pressure of the shell, assumes its natural conical elongated form and swims away with great rapidity (Fig. 5). If there

Free swimming embryo.

be much impurity in the surrounding fluid, or if the weather be cold, or if the embryo has been prematurely launched into it, strange and unnatural shapes are assumed (Fig. 6), a very

Anomalous forms of liberated embryo.

common form being that of an hour-glass. The time required for hatching varies very much according to the temperature of the air and the state of development of the embryo. As a rule, in the case of an ovum fully matured, rupture occurs within two days in warm weather, but under other circumstances it may be delayed for many days. Cobbold, Sonsino and others have made many attempts to keep alive the liberated embryo, but after a few days—and before, as a rule, any further development has taken place—the death of the embryo defeats the inquiry. One experimenter states that very soon larvæ make their appearance, by means of a sort of internal budding, in the embryo, which dies and is ruptured in order to be delivered of them. Judging by analogy, however, it is most probable that the larvæ become encysted on or in some aquatic animal, possibly passing through more than one phase and through more than one host before attaining their perfect development in the human system. They have been experimentally brought in contact with different species of fishes, mollusca, crustacea, larvæ of other insects &c., but have in no single instance been found to attack any of them. The further steps in its development, therefore, still remain a mystery.

Rustenberg, Transvaal.

LONDON AND COUNTIES MEDICAL PROTECTION SOCIETY.—On Wednesday, Aug. 23rd, at the Thames Police-court, “Dr.” Blumberg, of 230A, Commercial-road, E., was brought up on a warrant and charged with obtaining money by false pretences from Mrs. Donenberg, on whom he had operated, with disastrous results, for the cure of sterility. The case was adjourned till Thursday, Aug. 31st, when “Dr.” Blumberg was again brought up, and a further remand was granted until Thursday, Sept. 7th. “Dr.” Blumberg was, moreover, charged with violation of the Medical Act, he not being registered in the Medical Register.

AN ANALYSIS OF THE GASES OF THE BLOOD DURING CHLOROFORM, ETHER, BICHLORIDE OF METHYLENE AND NITROUS OXIDE ANÆSTHESIA.

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THE following notes on the gases of the blood in anæsthesia must be regarded as prefatory to future papers rather than as in any way conclusive. There have been many difficulties connected with our researches and a series of interruptions over which we have had no control. There is, too, comparatively speaking, an absence of literature dealing with the subject. The investigations of Richardson, Schmiedeberg, Böhr, Paul Bert, Grehant and De Saint Martin cannot in this respect, however, be overlooked. Sudden death in chloroform anæsthesia is so appalling that any effort which is put forward to solve the problem of its causation is worthy of attention. The purely physiological side of the question has been most ably studied by Brunton, Lawrie, Gaskell and Shore, and by Horatio Wood and Hare, not to mention others. It is scarcely necessary for us to do more than to repeat these names to recall the high-class character of the work they have accomplished. Does the composition of the blood in anæsthesia throw any light upon sudden death? We have analysed the gases of the blood in chloroform, ether, bichloride of methylene and nitrous oxide anæsthesia; and, whilst there is no one feature that stands out prominently in the results we have obtained, there are certain facts that become valuable by comparison and which are not without suggestiveness. The animals which have been experimented upon were rabbits—not at all a suitable class,—but the best which we could obtain under the circumstances. Rabbits, speaking generally, are too easily killed by chloroform. Dogs are better, but we only employed one. In all our experiments narcosis was complete before the blood was removed, no pain was experienced and the animal was never allowed to regain consciousness. In the present investigation we have been satisfied simply with the production of anæsthesia without reference to the amount of the anæsthetic employed. That subject, together with a more elaborate analysis of the expired air, we hope to undertake on a future occasion. Arterial blood, unless otherwise stated, was employed for analysis. As the composition of arterial blood varies in different vessels, we generally removed it from a large branch of the abdominal aorta—e.g., the external iliac artery. The blood was withdrawn through a hollow needle and rubber tubing—which had been previously filled with a weak solution of chloride of sodium—into a pipette containing mercury; the heart's beat in almost every instance being sufficient to fill the tube, aided, no doubt, by the suction influence of the mercury as it escaped from the other end of the pipette. The amount of blood which was removed was, on the average, 26 c.c. The pipette was then hermetically closed and afterwards plunged into a column of ice, in which it was removed to the chemical laboratory. Clotting never occurred. Subsequently the pipette was attached to a Pflüger's gas pump modified by Professor Bedson of the Durham College of Science, to whom we are indebted for his kindly supervision of our work, and also for many suggestions. When the gases were given off by the blood in vacuo they were analysed in Dittmar's apparatus, using the Hempel pipettes as modified by Professor Bedson. The carbonic acid was determined by absorption with caustic potash, the oxygen by absorption by means of ferrous tartrate, and the vapour of the anæsthetic by combustion with oxygen, a little electrolytic gas being employed to bring about the explosion. After the explosion the excess of oxygen was removed and the residual nitrogen measured. All the volumes given in this