SPERMATOPHORES AS A MEANS OF HYPODERMIC IMPREGNATION.

C. O. WHITMAN.

ALTHOUGH it is well known that spermatophores are of very general occurrence among the invertebrates, and even among many vertebrates, the assertion that, as a perfectly regular and normal affair, in animals as highly organized as the leeches, *they represent an injecting apparatus, by means of which the spermatic elements of one individual are forced through the body-wall of another, at any point whatsoever*, may appear almost incredible, even when supported by direct observation many times repeated on different species. That such is certainly the case, however, is very easily demonstrated, and any one can verify it as often as he likes on almost any species of Clepsine that happens to be accessible. The observations to be presented in this paper will make this fact abundantly evident.

But what becomes of these spermatic injections? Do they ever reach the eggs and fertilize them? and if so, is this the normal method of bringing the sexual products together? Although I cannot affirm this as a positive certainty, the evidence seems to me to fall but little short of being conclusive. I have studied closely the habits of these leeches in Europe, Japan, and America, and with especial reference to settling the question of when and how impregnation is effected. Long-continued observation under most favorable circumstances has never given me so much as a single indication that the genital pores are ever united in the act of copulation. On the other hand, the planting of spermatophores on the surface of the body at any point that happens to come first, is a common occurrence, which one may often see repeated several times in the course of a few hours by the same individual. I have followed the track of the spermatozoa from the point of penetration to the cœlomic cavity in which the ovaries lie, but I have not pursued the subject far enough to determine when or how the spermatozoa pass through the wall of the ovisacs. That spermatozoa get

into the ovisacs, and that fertilization takes place before oviposition, can be demonstrated by facts that admit of no doubt. The passage through the wall of the ovisac — the only link in the chain of direct evidence yet to be supplied — seems to be an inference justified by all the known facts. Such a passage, in the absence of any definite openings in the ovarian walls, would have to be a forced one, depending upon the action of the spermatozoa themselves. As these walls are represented by a thin membrane which becomes enormously distended as the eggs enlarge to maturity, the difficulty of penetration could not be great; and the case of Peripatus and the Turbellarians seems to show that spermatozoa are capable of effecting automatically such a passage.

The view here taken finds a very strong confirmation in the fact that precisely the same mode of copulation occurs in many Turbellarians, in the Rotifers, and in Dinophilus, as the citations from Lang, Plate, and Harmer, given farther on, fully show. The indications are that it occurs also in many oligochætous annelids, as well as in several genera of leeches besides Clepsine, — perhaps in all the Rhynchobdellidæ. The occurrence of such a mode of copulation among so many of the lower bilateral animals appears not only to render explicable the pluripenial condition of many Turbellarians and some of the higher worms, but also to clear up many puzzling observations in regard to fertilization in animals that have no intromittent organ. It is no longer necessary to suppose that the spermatophores found attached to different parts of the body of Peripatus must be carried through the vagina and up the uteri in order to reach the eggs; and the discovery of spermatozoa projecting through the ovarian walls of this animal, as reported by Moseley and Sedgwick, ceases to be so complete a mystery. The difficulties in the way of understanding how spermatophores can be of any use when attached at a considerable distance from any genital pore, and completely closed externally, as described by Vejdovsky for many annelids, may not be so great as they have hitherto appeared.

The facts and bibliographical notes to be presented in this paper are sufficient, I think, to make it at least probable that the original function of the spermatophore was precisely what it now is in the Turbellarians, the Rotifers, Dinophilus, and

Clepsine, — *the injection of spermatozoa through the body-wall, or hypodermic impregnation,* as we may call it.

This mode of impregnation represents an important economical step in advance of the more primitive mode of setting the seminal elements free in the water. The deposition of sperm-capsules at random on any point of the external surface that happens to be accessible at the moment of meeting, is improved upon by restricting the act to a definite region, as one or more segments of the clitellum in certain annelids, or the surface around the external openings of the oviducts, as in the crayfish; and, still further, by limitation to the edge of genital pores or seminal receptacles, as in the copepods. The seminal reservoir of the lobster, discovered by Bumpus,[1] marks an advance on the conditions obtaining in the crayfish.

The habit of discharging spermatophores directly into the vaginal orifice, presupposing direct union of the sexual pores, brings us to relations where such copulatory organs as we find in the Gnathobdellidæ would become useful. The penis is here only an eversible end-piece of the *vasa deferentia* — a simple tubular elongation of what in its simplest form would be represented by a pore.

Lang, who was the first to discover this mode of impregnation in the Turbellaria, has thrown out the interesting suggestion, that in these animals the penes may have been primarily organs of attack and defence, which assumed secondarily the office of copulatory organs. The grounds for the suggestion may be seen from a citation to be introduced farther on. Such a mode of origin, though it may be true for the Turbellaria, does not invalidate the suggestion I have made for the Gnathobdellidæ, except on the supposition that the penes represent homologous organs in the two groups. Such a supposition appears to be forbidden by the absence of these organs in the lower leeches. It seems to me, therefore, altogether more probable that in the higher leeches they have been independently acquired, and that their evolution began after, or simultaneously with, the establishment of the habit of true copulation.

The structural and ontogenetic resemblances of the penes in the two groups cannot be taken as decisive proof of genetic identity. The resemblances between the penis and the pharynx

[1] *The Embryology of the American Lobster.* Journ. Morph., Vol. V. [In press.]

of a Turbellarian are of the same nature and equally close; but no one would in this case be likely to mistake such resemblances for homologies.[1]

In view of the fact that the spermatophores of Clepsine were discovered nearly half a century ago by Friedrich Müller, and described as a "*phaenomenon cujus neque analogon inter reliqua animalia reperire*," and that they have since been observed by Max Schultze, Leuckart, Leydig, and Schneider, it may appear a little remarkable that their function should have so long escaped detection. But when we consider how totally unprepared were the minds of investigators for such a mode of impregnation, we find no difficulty in understanding how it comes to pass that the old belief still prevails, that all the Hirudinea, penis or no penis, copulate in essentially the same manner, and fecundate by conveying the spermatic fluid of one individual (or of both reciprocally) directly into the female genital orifice of the other, thus placing it where it can pass unobstructed into the so-called uterus, or, in the absence of such a specialized part, into the ovarian sacs.

While this has been, and still is, the opinion generally received, the possibilities of the eggs being fertilized after deposit, of self-fertilization, and of parthenogenetic development, have not been overlooked. The following notes and extracts are designed to give the history of the subject, and to show what questions have been left unsettled.

HISTORICAL NOTES AND EXTRACTS RELATING TO THE HIRUDINEA.

1. *Clepsine complanata.*

FRIDERICUS MUELLER. De Hirudinibus circa Berolinum hucusque observatis. Berolini, 1844. pp. 33, 34.

"Cleps. complanatas, quamvis plurimas amoris tempore continua attentione observaverim, *coëuntes nunquam observavi*;[2] sed eodem

[1] We are continually reminded that *parallel development* has been a much more important factor in evolution than has generally been supposed. Similar bases, similar needs, similar variations (because predetermined by like causes), guided by parallel selective influences, which would be sustained by like environments, have unquestionably resulted in numberless analogies which are usually allowed to pass as evidences of genetic affinity.

[2] Braun (*Systematische Beschreibung einiger Egelarten*, Berlin, 1805, p. 60) makes the same observation.

fere ante ovorum partum tempore, quo Cleps. tessulatae coire solent, singulare mihi in Cleps. complanatis sese obtulit phaenomenon, *cujus neque analogon inter reliqua animalia reperire*,[1] neque explicationem dare valeo. Ad utrumque nimirum faciei ventralis latus *organa singularia filiformia*, tres usque quinque corporis annulos longitudine aequantia modo simplicia, modo ad basin usque bipartita exseruntur, modo singula modo plura, modo in anteriore modo in posteriore corporis parte. Haec per plures dies propendent, dum animal, alioquin segnissimum, multo alacrius in vitro suo circumvagatur. Simul substantiae floccosae albidae magna copia secernitur, totam mox vasis in quo servantur aquam turbidam reddens.

"*Inter phaenomenon hoc et propagationem relationem quandam existere, nullus dubito;* plurimas enim Cleps. complanatas per tria semestria domu observavi, neque vero alio unquam tempore *organa haec filiformia* eas exserere vidi, dum amoris tempore ne una quidem inter triginta et plures non exserebat. Praeterea his organis exsertis, ut in Cleps. tessulata post coitum, ovariorum motus peristalticus, quo ova a funiculis suis solvuntur, incipit. *Quo vero munere fungantur haec organa, nescio; anatomica quoque disquisitione nihil de eo docente.* Nam corpora quidem in crura dua reflexa divisa in tertio quovis annulo utrinque sub tractus intestinalis appendicibus latentes reperi, quibus replicatis organa illa filiformia fortassis formantur; num autem cum testiculis, quibus interjacent, aliave apparatus sexualis parte cohaereant, videre haud contigit.

"Corpora similia etiam in *C. verrucata, marginata, tessulata*, inveni, quamvis in nulla praeter complanatam specie organa filiformia exseri vidi."

MAX SCHULTZE. Zoologische Skizzen. *Zeit. f. w. Zool.* IV. 1853. pp. 186, 187.

"Höchst auffallend ist, dass bei *Planaria torva* der Same in festen, retortenförmigen Spermatophoren verpackt übergeführt wird, welche man ein oder zwei an der Zahl nach der Begattung in dem beschriebenen Raume [recept. sem.] findet. Die aus einer braunen, chitinartigen Hülle bestehenden Spermatophoren platzen später, und fallen nach Entleerung des Inhaltes ganz zusammen. In diesem Zustande kann man sie im ersten Frühjahr bei fast jedem Individuum dieser Species sehen. *Ich erinnere hier an die Beobachtungen von Fr. Müller* (*Zei-*

[1] Nisi forte appendiculae generatrices a Morrenio (*De Lumbr. terrestr.* p. 77) sic dicta, quas in Lumbrico terrestr. auctor laudatus, in aliis pluribus Lumbricinis Cel. Dr. Hoffmeister et ipse observavimus, Cleps. complanatae organis filiformibus analogae.

tung für Zoologie etc. von D'Alton und Burmeister, No. 25, Juli, 1849), welche ich selbst bestätigen kann, dass bei Clepsine complanata und wahrscheinlich bei vielen Regenwürmern die Begattung durch Spermatophoren vermittelt wird."

A very important observation was made by Filippi, and confirmed by Grube; namely, that individuals isolated for some days before oviposition produced fertile eggs. This fact and the absence of a penis suggested self-fertilization (Filippi), or possibly an early internal fertilization (Grube).

F. DE FILIPPI. Lettera sopra l' Anatomia e lo Sviluppo delle Clepsine. 1839. p. 15.

"Tutti i zoologi si accordano nel dire che le sanguisughe sono ermafrodite; il che è vero anche per riguardo alle Clepsine; ma in queste gli organi de' due sessi sono totalmente diversi che negli altri generi della famiglia. È anche ammesso da tutti che le sanguisughe non possono fecondarsi da se, ma hanno bisogno del reciproco congiungimento di due individui; e qui mi occorre di far rimarcare un' eccezione che ci presentano le Clepsine. Infatti per le condizioni speciali de' loro organi generativi non può nemmeno aver luogo in esse una fecondazione interiore; *al che si aggiunga aver io l' essempio di un individuo, il quale mantenuto isolato in un vaso di cristallo nella mia camera partorì uova che in seguito si svilupparono.*"

ADOLPH EDUARD GRUBE. Untersuchungen ueber die Entwicklung der Clepsinen. Königsberg, 1844. p. 11.

"Gegen die Vermuthung, dass sich die Clepsinen äusserlich selbst befruchten, spricht der Umstand, dass ich an den frischgelegten Dotterkugeln oder in der Eiflüssigkeit nie Spermatozoen gefunden, was doch, wenn die Samenflüssigkeit mit den Dottern zugleich ausgeschüttet würde, kaum anders sein könnte, gegen die Annahme in's Besondere, dass sie sich äusserlich gegenseitig befruchten, der Beweis, dass wenn ein mehrere Tage abgesperrtes Individuum Eier legte, diese sämmtlich zur Entwicklung kamen. Vielleicht also erfolgt die Begattung doch innerlich, aber zu einer frühern Zeit? In diesem Fall müsste sie wenigstens 11 Tage vor dem Eierlegen eintreten, denn so lange hatte ich eine Clepsine abgesondert, deren Eier sich vollständig entwickelten, und die Enden der Samenleiter müssten dann sich umstülpen und als Ruthen dienen, oder die Spermatozoen gelangen in besondere Behälter geschlossen in die weiblichen Genitalien."

RUDOLF LEUCKART. Die Menschlichen Parasiten. I. 1863. pp. 675–680.

The place and mode of origin, and the form of the spermatophore were long ago correctly described by Leuckart. Speaking of the terminal double sac of the male organs of the Rhynchobdellidæ, he says: —

"Der körnige Inhalt derselben dient zur Umhüllung des Samens und formt denselben im Innern des Begattungsapparates zu einer gleichfalls *zweihörnigen plumpen Spermatophore, die bei der Begattung in die weibliche Oeffnung eingeschoben wird.*" [pp. 675, 676.]

Leuckart assumes that in such forms as Clepsine there is direct copulation, — that is, by union of the sexual orifices, — and further, that fertilization is reciprocal (p. 673). But Leuckart has also seen spermatophores attached to the external pore of the female organs; for he says: —

"*Wo eine eigentliche Scheide fehlt* (*Bei den Rüsselegeln*), *da wird die Spermatophore in der weiblichen Oeffnung festgeklebt. Man sieht sie hier noch halbe Tage lang nach der Begattung ansitzen, bis die Spermatozoen in den Eierstocksschlauch übergetrieben sind. Auch bei den Arten mit Scheide findet man die Samenfäden später im Innern der Eierstock.*" [p. 680.]

2. *Clepsine tessulata.*

F. MÜLLER. Über die Geschlechtstheile von Clepsine und Nephelis. Müller's *Archiv.* 1846. p. 145.

"Mit dem Fusse festsitzend saugt jedes der beiden Individuen mit dem Kopf sich an der Bauchseite des andern fest, worauf *ein konisches Organ aus der vordern Geschlechtsöffnung sich ausstülpt und in die hintere des anderen Thieres eintritt;* so vereinigt sitzen die Thiere meist mehrere Tage lang."

C. tessulata, if Müller's observation be correct, takes an exceptional position, which is all the more difficult to explain, as *C. marginata*, and a number of other closely allied species found in America and Japan, certainly all agree in the habit of attaching their spermatophores to the exterior.

3. *Clepsine* var. Porte-chaîne.

Moq.-Tand. 1846. Pl. xiv. Fig. 5.

ÉBRARD. Nouvelle Monographie des Sangsues Médicinales. Paris, 1857.

"Aux derniers jours du mois de mai, en 1854, j'ai trouvé deux glossiphonies (variété dite *Porte-chaîne*) qui étaient accouplées. Elles étaient fixées, tête à tête, à la face inférieure d'une pierre par leurs ventouses qui étaient très-rapprochées. Leur corps était contourné de telle sorte qu'un de ses côtés touchait la pierre, et que l'autre était libre; *elles étaient accolées par la surface abdominale.* Une seule de ces annélides fécondait l'autre; car, les ayant séparées, je n'aperçus qu'une verge. Les ovaires de l'une d'elles se gonflérent et se colorèrent peu à peu en blanc, et *quarante-cinq jours après elle fit des œufs.*" [pp. 60, 61.]

Ébrard had the question of reciprocal fecundation in mind, and entirely overlooked the spermatophores.

4. *Clepsine marginata.*

C. O. WHITMAN. The Embryology of Clepsine. 1878. pp. 8, 9.

"I have found that eggs taken from the ovary at the time they are about to be laid develop in the normal manner, and have taken advantage of this to watch the earliest changes in the ripe egg. I have done this many times, and always with success. I regard this as very strong evidence that *impregnation takes place while the eggs are in the ovaries.* This is in harmony with the fact that I have found spermatozoa in the ovary two or three days before the time for depositing the eggs. It is barely possible that these spermatozoa found their way into the ovary accidentally during the dissecting. I can only say that no testicular sacs were ruptured during the process; but the *vasa deferentia* may have been severed, as they are so minute that one cannot easily see them. *The unchanged condition of the germinal vesicle at the time the eggs have attained their full size renders it probable that fecundation does not take place more than four or five days at the longest before the deposit;* but this does not prove that copulation may not have taken place at a much earlier date. *I isolated an individual which had just sucked itself full of blood, and which showed no signs of eggs through the body-wall, and after fifteen days obtained eggs that developed in the usual manner.* Recalling the fact that the growth of the egg from the primary egg-cell requires only twelve to fifteen days, it appears that this specimen was isolated about, or just before, the time when the egg-cell began to grow. *In another case eggs were obtained at the end of twelve days, which developed in the normal way.*

"These facts raise a suspicion that Clepsine is capable of self-fecundation. The question as to whether copulation occurs will be most satisfactorily settled by isolating young individuals and keeping them until they produce eggs.

May 2, 1878. — "Five individuals were isolated in the summer of 1877, at the time of hatching. Each has been kept in a separate vessel from that time to the present. Eggs were laid by one April 24th (this year), and hatched May 1st; by two others, April 29th. The latter are now in the germ-band stage. The eggs had in each case passed the pronuclear stage, at the time they were first noticed, so that I was unable to demonstrate by section the existence of a male pronucleus. As the eggs developed in the normal manner, it is very probable that they were fecundated. Here is an unquestionable case of *self-fructification*, or of *parthenogenesis* — more probably the former."

The above statements not only confirm the observation of Filippi and Grube, as to isolated individuals producing fertile eggs, but they also make it probable that fertilization is internal. To the evidence given by eggs taken artificially from the ovaries, I can now add another which seems to be perfectly conclusive. I have succeeded in finding a perfectly distinct and indubitable male pronucleus in the ripe ovarian egg of *C. marginata*.

What I formerly regarded as positive proof, either of self-fructification or of parthenogenesis, in the light of what I now know about the use of spermatophores, is open to some doubt. At the time of my experiment of rearing individuals from the egg in isolation, the possibility of hypodermic impregnation never crossed my mind, and I can now see where my observation was not sufficiently guarded to remove all doubt. In order to bring the five individuals to maturity, I had to feed them some ten or twelve times. I allowed them to take their meals from the same fish, only thinking it necessary to watch them from beginning to end, in order to see that no copulation took place. Whether I ever allowed them to come in contact long enough to deposit spermatophores, my notes do not show, and here is where the doubt comes in. The experiment ought to be repeated under conditions that would exclude every possibility of contact, and *C. marginata* would be one of the best species for such a purpose, as it is so easily reared. It would be well to isolate a large number of individuals, so as to have material

enough to allow of taking the ripe eggs from the ovaries in a few cases. The demonstration of the male pronucleus in such eggs would show that the leech is able to fertilize itself internally. If the male pronucleus were not found before oviposition, and should be found some time after it, one could infer external self-fecundation. If the male pronucleus proved to be wanting in both cases, we should have conclusive evidence of parthenogenesis, provided a considerable number of tests all gave like results, and provided, further, that the rest of the eggs developed embryos.

The importance of the experiment will be readily seen; for should self-fertilization be clearly proved under the conditions named, I think that fact, in the light of what we know about the breeding habits, would be sufficient to make it extremely probable that self-fertilization is a normal affair. That view would compel us to look upon the spermatophores attached to the surface as having nothing to do with fertilization. While self-fertilization certainly seems very improbable, we are not to forget that it is a possibility. It is believed to take place in Cestodes, and perhaps also in some Trematodes and Turbellaria. V Baer (*Mül. Arch.*, 1835, p. 224) long ago reported a case in *Limnæus auricularis*, and Oken (*Isis*, 1817, p. 320) obtained fertile eggs from an individual of the same species reared in isolation.

5. *Nephelis.*

ISAO IIJIMA. Origin and Growth of the Eggs and Egg-strings in Nephelis. *Quart. Jour. Micr. Sci.* N. S. LXXXVI. April, 1882. pp. 196–197.

"The anterior portions of two individuals, attached by their suckers to the glass vessel near each other, are spirally entwined in such a manner that the ventral surfaces of their genital bands are always brought into apposition. They maintain this position for a considerable time, now and then changing the direction of their winding, and relaxing or tightening their hold. Sometimes the act is of short duration, and two or three times renewed at short intervals. At other times, and when disturbed, the act ceases altogether, or else they combine with other individuals. It is evident that there can be no reciprocal fecundation while the leeches are coupling in the position above described.

"*As there is no intromittent organ, it is probable that the male orifice with its prominent muscular lips clasps the female orifice, while the spermatozoa are forced onward by the action of the ejaculatory organ.*

"I am unable to say precisely at what time of the year copulation begins; but I found spermatozoa in the ovaries of one leech on the 20th of February, for the first time in this year. The act of coupling, so far as my experience goes, takes place almost always in the morning.

"ABNORMAL COPULATION. — *I have often found individuals with a small, two-horned, whitish body adhering to some portion of the genital band. The position of this cornuous body was always on or near the genital band, sometimes on the dorsal surface, sometimes on the extreme margin, but more frequently on the ventral surface than elsewhere. It consisted of two thin-walled bottle-shaped tubes* (ca. 5 mm. long), *the broader ends of which were inserted, close to each other, into a small disc-like portion. This portion, the margin of which presented a villiform appearance, was partially embedded in the epidermis. Around the disc was a discolored area, which proved to be, on examination of sections, a macerated portion of the epidermis. The two bottle-shaped tubes were filled with spermatozoa, and opened by means of two distinct holes in the disc. From each of these openings a stream of spermatozoa was found, penetrating to a considerable depth into the underlying tissues.* In section the substance of the two-horned body appeared dotted and longitudinally striated, but I was unable to recognize any cellular structure.

"For a long time I was much puzzled as to the meaning of all this, but from further observation was led to regard it as *a case of abnormal or unsuccessful copulation.*

"When disturbed during the act of copulation, the two leeches usually separate immediately; but *in one instance they did not separate even after putting them into chromic acid. On examination I found that the female orifice of each leech was not in contact with the male orifice of the other, but that each individual was attached to the ventral surface of the other by its male orifice, the female orifice remaining free. On separating them by force, each male orifice left the two-horned object on the body of the other.*

"*In another instance that came under my notice, only one individual had already deposited the two-horned body, while the other had a mass of spermatozoa hanging from its male orifice.* The latter was dissected, and the two-horned body found occupying the whole interior of the ejaculatory organ, with the cavity of which it exactly corresponded in shape. It came out without any resistance. It thus became evident that the two-horned body belongs to the interior of the ejaculatory organ. That it forms no permanent part of the male organ seems evident, from the fact that sections made in the winter show no trace of such a body. *I have not thus far been able to determine whether this body forms in the case of normal copulation also.* As to its mode of

formation, I have nothing to offer except the conjecture that it may be the hardened secretion of some of the glands of the ejaculatory organ.

"*On many leeches were found scars, which very likely may have been the marks left by these peculiar bodies.*

"It is hardly to be doubted that the normal mode of charging the ovaries with spermatophores is through the female orifice. It would certainly be impossible for the spermatozoa to find their way into the ovaries in many of those cases which we have described as abnormal, especially where the injection takes place far in front of the male orifice."

Professor Iijima's observations were made under my direction, and at the time I certainly concurred with him in his conclusions. Professor Iijima's incredulity was wholly due, as one may readily see from his own words, to the conviction that there was only one way provided by nature whereby the spermatozoa could reach the eggs within the ovaries; namely, through the female genital pore. The whole description tallies so closely with what I have seen in Clepsine, that I feel confident that the spermatophores serve the same end in both genera.

Schneider's observations on Nephelis are much less complete than Iijima's, and spermatophores seem to have entirely escaped him.

ANTON SCHNEIDER. Das Ei und seine Befruchtung. 1883. pp. 22, 32, 65.

"Die Begattung beginnt damit, dass sich die Thiere umeinander winden. Ihre Körper sind dabei gleich gerichtet, so dass immer nur ein Thier mit Samen versehen wird. Eine Ausstülpung des sehr kurzen Penis habe ich nicht beobachtet. Bei der Begattung geht viel Samen verloren. Moquin-Tandon, gestützt auf eine Angabe von Bojanus, nimmt an, dass die Körper der *Hirudineen* bei der Begattung entgegengesetzt gerichtet sind. Indess hat schon Ébrard*) in seinem sehr lesenswerthen Werke die Begattung von *Hirudo medicinalis* mit gleicher Richtung der Körper vor sich gehen sehen. Auch Iijima hat dies bei *Nephelis* bestätigt. Man kann die Begattung leicht beobachten. Wenn man zwei Thiere, welche 3–4 Tage isolirt waren, vereinigt, findet die Begattung sofort statt. Bei der von Iijima beobachteten Species findet ausser dieser Begattung eine andre Art statt, indem Spermatophoren von dem einen Thiere auf die Haut des andern befestigt werden. Bei unsern *Nephelis* habe ich diese Spermatophoren nie gesehen, obgleich mir das Vorkommen dieser Körper bei *Pontobdella* und *Piscicola* wohl bekannt ist."

6. *Piscicola.*

J. LEO. Verhältnisse der *Piscicola geometra*. Müller's *Arch. f. Anat.*, etc. 1835. p. 425.

"Die Begattung dieser Thiere geschieht auf folgende Weise. Die Fussscheiben zweier Individuen sind in einiger Entfernung von einander auf einer Ebene angeheftet und die Körper erhalten sich schwebend an den äusseren Öffnungen der Geschlechtstheile dergestalt Bauch an Bauch mit einander verschlungen, dass sie die Form eines X bilden, wobei aber das Kopfende jedes Thieres nach derselben Seite zurückgebogen ist, an welcher seine Fussscheibe haftet. Hinter der Umschlingung sind beide Körper bedeutend angeschwollen und dicht vor dieser Anschwellung sieht man in der Nähe der weiblichen Geschlechtsöffnung *eine weisse Masse hervortreten, die sich nach und nach vermehrt, und unter dem Microscope sich als ein Säckchen mit einer weissen, feinkörnigen und schleimigen Substanz erfüllt darstellt.* Ich glaube, dass *diese Masse ohnerachtet des häutigen Ueberzuges dennoch nichts anders als der aus den weiblichen Geschlechtstheilen überfliessende männliche Same ist, dessen Oberfläche aber wahrscheinlich durch den Einfluss des Mediums zu einer Haut gerinnt.* Dass die Ruthe in die weibliche Geschlechtsöffnung eindringt bemerkt man erst, wenn sich die Thiere von einander durch bewirkte Störung trennen, in welchem Falle dieselbe dann eine Zeit lang steif hervorsteht, wie es abgebildet ist."

Leo's description of the spermatophore falls considerably short of being a discovery, and his remarks about the penis are wide of the mark. He seems to have mistaken the proboscis for a penis, as Leydig has pointed out.

T. BRIGHTWELL. Ueber die *Hirudo geometra*, Linn., und einige andere Arten von Susswasser-Egeln. Froriep's *Neue Notizen*. XXII, No. 467. 1842. p. 65.

Somewhat later than Leo, Brightwell again saw the spermatophore of Piscicola ("weisse Substanz"), but without understanding it. During copulation, as Brightwell puts it,

"Man bemerkte auf jeder Seite des Theils, wo die Körper ihre Vereinigung bewirkten, *eine weisse Substanz.* So blieben die Thiere gewöhnlich mehrere Stunden, in einem Falle sogar den ganzen Tag ueber verbunden. Als sie sich von einander trennten, löste sich von den Stellen, mit denen sie aneinandergehangen hatten, *eine weisse, spinnewebenartige Substanz ab*, welche sich in einem Falle wie ein Ei ausnahm, sich aber bei fernern Beobachtungen als ein Theil des Haütchens herausstellte,

von welchem die Eier umhüllt sind. Innerhalb 24 Stunden nach dem Begattungsacte wurden Eier gelegt."

FRANZ LEYDIG. Zur Anatomie von *Piscicola geometrica* mit theilweiser Vergleichung anderer einheimischer Hirudineen. *Zeitschr. f. w. Zool.* I. 1849. p. 124.

"Bei der Begattung stülpt sich aus der männlichen Geschlechtsöffnung eine Blase, welche die Ausmündungsstelle der Ductus def., sowie einen Theil der gelappten Drüse enthält. Dieser hervorgestülpte Theil gibt an die weibliche Geschlechtsöffnung die Samenmasse ab, welche als weisslicher Körper auch nach der Begattung an der weiblichen Genitalmündung sitzen bleibt. Die weissliche Masse, näher untersucht, erweist sich als *eine gedoppelte Blase mit doppeltem Stiel*, an welcher die Membran und die Stiele als aus dem Secret der gelappten Drüse bestehend, erkannt werden. Im Innern sind die Spermatozoiden in schön gelockter Weise geschichtet enthalten, so dass man wohl den ganzen weissen Körper als Spermatophoren bezeichnen kann. Schon im Ductus def. brünstiger Individuen lagern sich die Spermatozoiden zu solchen gelockten Bündeln zusammen, wie man sie nacher in den Spermatophoren findet. Es braucht also nur das Secret der gelappten Drüsen die Spermatozoiden bei der Ejaculation zu umhüllen, um die treffenden weissen Körper zu bilden. *Aus den Spermatophoren, welche halbe Tage lang nach der Begattung an der weiblichen Geschlechtsöffnung sitzen bleiben, bewegen sich die Spermatozoiden in den Eierstocksschlauch und dringen bis zu dessen blindem Ende vor. Ein solcher Eierstock mit eingewanderten Spermatozoiden hat ein schon dem blossem Auge wahrnehmbar verändertes, weissliches Aussehen.*"

Schneider confirms Leydig's account, and adds *Pontobdella* to the list of leeches which attach their spermatophores to the exterior. The definite location of the spermatophores in *Piscicola* is noteworthy, in comparison with Nephelis and Clepsine. Leydig assumes that the spermatozoa pass through the female genital pore into the ovaries; but he gives no proof of this. Perhaps his persuasion that it must be so, was the only reason he had for concluding that it was so. Schneider expressly states that the spermatophores of Pontobdella are attached to any point of the exterior *except at the genital pore.*

ANTON SCHNEIDER. Das Ei u. seine Befruchtung. 1883. pp. 32, 65.

PISCICOLA GEOMETRICA. — "Zwei Exemplare heften sich mit dem hintern Saugnapf fest, in entgegengesetzter Richtung und in der Entfernung, dass sie sich mit dem Vorderende erreichen können. Sie

krümmen das Vorderende und haken sich in einander. Solange die Reife der Eier nicht eingetreten, ist dies nur ein Vorspiel der Begattung, denn man findet in den Eileitern keinen Samen. *Dagegen werden bei dieser Gelegenheit Spermatophoren abgesetzt, welche man häufig auf dem Boden der Gefässe findet.*"

7. *Pontobdella.*

SCHNEIDER, *l.c.*

"Die Spermatophoren von *Piscicola* und *Pontobdella* sind kurze keulenförmige Röhren, deren Wand aus *agglutinirten*[1] *Spermatozoen* besteht, während das Innere mit freien Spermatozoen erfüllt ist. *Leydig hat dieselben bei Piscicola entdeckt und auch nachgewiesen, dass sie bei der Begattung an die weibliche Geschlechtsöffnung befestigt werden.* Wie schon oben bemerkt, werden diese Spermatophoren schon gebildet und abgelegt zu einer Zeit, wo die Thiere noch nicht geschlechtsreif sind und kein Samen in die Eileiter eintritt. Man findet die Spermatophoren dann auf dem Boden der Gefässe, worin die Thiere leben.

"Aehnlich wird die Begattung bei *Pontobdella* vor sich gehen. *Zur Zeit als ich Pontobdella lebend beobachtete* [April in Triest], *fand keine Begattung, sondern nur das Absetzen von Spermatophoren statt. Die Thiere befestigten sich dieselben gegenseitig an beliebige Körperstellen, nur nicht an die Geschlechtsöffnung.*"

8. *Hirudo.*

The ten-eyed leeches (Hirudo, Aulostoma, etc.) all have a well-developed intromittent organ, and observers now agree that in copulation the male organ of one individual is inserted in the female orifice of the other, and that fertilization is one-sided, not reciprocal. No one, so far as I know, has ever reported external spermatophores, and there is no reason to suppose that hypodermic impregnation ever occurs in the Gnathobdellidæ. Some of the older authorities maintained that fecundation was reciprocal, and Moquin-Tandon, as late as 1846, declared this to be a settled fact. Ébrard, however, disputes this point, and brings many facts to show that only one individual is fertilized at a time. Perhaps the conflicting testimony warrants the suggestion that fecundation may sometimes be reciprocal, at other times not. If copulation happened between two individuals equally ready to fecundate reciprocally, there

[1] An error corrected by Vejdovsky.

would be no difficulty in their doing so, provided the position taken were such as to admit of it. On the other hand, if one individual only were ready to discharge the male function, only one individual would be fecundated. I incline to take this view, as it offers a complete reconciliation of otherwise contradictory observations.

Ebrard's experiments in isolating leeches are not only interesting *per se*, but also in connection with the results before given of isolation of Clepsine.

A. MOQUIN-TANDON. Monographie des Hirudinées. 1846. pp. 166–68.

"Bibiéna, Thomas, Vitet, Mérat, Derheims et Fée, ont pensé que les Hirudinées se reproduisaient sans accouplement réciproque. Suivant Filippi, les *Glossiphonies* seulement sont capables de se féconder toutes seules.

"Weser, Cuvier, Carena, Virey et Blainville, ont admis, d'après la structure des organes sexuels, que chaque individu était incapable de se reproduire sans s'accoupler avec un autre. Leur opinion a été trouvée conforme à la nature, après les observations de Hebb et de Evans de Worcester (cités par Johnson), qui ont fait connaître que l'acte du coït se passait, chez ces Annelides, de la même manière que dans les Arions et les Hélices. Depuis cette époque, Kuntzmann, Bojanus, Odier et plusieurs autres naturalistes, ont eu l'occasion de voir des Hirudinées au moment de l'accouplement, et ont confirmé les observations des deux savants anglais.

"Dans l'accouplement des *Sangsues* médicinales, deux individus se rapprochent, ventre contre ventre et en sens inverse, de telle sorte que la ventouse orale de chacun est tournée, ou à peu près tournée, vers la ventouse anale de l'autre. On conçoit que, dans cette position respective, les organes génitaux se trouvant également situés en sens inverse, de manière que chaque verge doit se rencontrer en face d'une vulve. Les deux individus s'enlacent, et l'accouplement a lieu (Bojanus). Quelquefois les *Sangsues* s'attachent ensemble par leurs ventouses anales et laissent pendre librement leur partie antérieure (Burdach). Kuntzmann a cru reconnaître que, dans l'union sexuelle, les deux verges sont entortillées en spirale comme celle des Hélices; cette disposition est sans doute accidentelle (Bojanus).

"Le docteur Gaspard a prétendu que, dans chaque accouplement, un seul individu fécondait l'autre, lequel, après vingt-cinq ou trente jours, fécondait le premier dans un autre accouplement. Il est bien démontré aujourd'hui, par l'observation, *que le coit est réciproque comme* celui des Escargots.

"Johnson a observé l'accouplement de la *Néphélis*, et a reconnu qu'il était entièrement semblable à celui de la *Sangsue médicinale*."

ÉBRARD. Nouvelle Monographie des Sangsues Médicinales. Paris, 1857. pp. 104, 105.

"Comment se fait-il donc que Bibiéna, Thomas, Vitet, Mérat leur aient accordé la faculté de se reproduire sans accouplement préalable? *Ils ont probablement été trompés par cette circonstance qu'une sangsue produit des cocons féconds trois, six, huit, et même dix mois après avoir été tenue isolée.* C'est là un fait dont il ne m'est pas permis de douter, quoique l'intervalle séparant l'accouplement des sangsues de la pose ou production des cocons ait été évaluée par divers auteurs à trente ou quarante jours.

"J'ai déjà publié, en 1851, l'histoire d'une sangsue verte de Hongrie qui, renfermée seule vers le 15 mai 1850, produisit le 15 et le 27 août des cocons féconds.

"En 1852, soupçonnant que les cocons de sangsues ne donnant pas le jour à des filets proviennent (de même que cela arrive pour les œufs stériles des femelles d'oiseaux tenues en cage) de sangsues ne s'étant pas accouplées, et, voulant m'en assurer, je plaçai, le 15 septembre, sept sangsues vaches dans autant de bocaux contenant de la terre et de la mousse, une sangsue dans chaque bocal (je les gorgeai et je les changeai de terre en mars (1853). Six de ces sangsues posèrent des cocons aux mois de juillet et d'août suivant, c'est-à-dire *après neuf à dix mois d'isolement, et, à mon grand ètonnement, des filets sortirent de ces cocons.*

"En face de ces résultats si inattendus, je me demandai, je l'avouerai franchement, si les sangsues, tout en s'accouplant, ne pouvaient pas produire des cocons sans un accouplement préalable, ou plutôt si un rapprochement ne suffisait pas pour plusieurs années. Je me livrai, en conséquence à de nouvelles expèriences:—

"1° Je continuai à tenir séparés quatre des sangsues précédentes qui étaient isolées depuis un an, et deux autres sangsues qui l'étaient depuis deux mois, depuis le mois de juin, et avaient récemment posé des cocons; *toutes furent stériles l'année suivante*, quoique j'eusse pris soin de les gorger légèrement aux premiers jours du printemps.

"2° Je réunis, le 17 septembre, trois des sangsues ayant été tenues isolées depuis un an, puis je les séparai le 20 octobre. Je séparai le 17 septembre quatre autres sangsues qui étaient renfermées depuis quelque temps dans le même bocal. Une de ces sangsues périt, cinq des autres posèrent des cocons féconds pendant les mois d'août et de juillet de l'année suivante.

"Il est dès lors évident, ce me semble, que *les sangsues ont besoin de*

s'accoupler chaque année pour être fécondées, mais que, semblables en cela à plusieurs insectes, elles peuvent ne se reproduire que huit ou neuf mois après avoir été fécondées. Ce fait de la reproduction ayant lieu dans une année autre que celle de l'accouplement a d'ailleurs son analogue chez une hirudinée non médicinale; car les *glossiphonies* [Clepsine] *que, aux premières chaleurs du printemps et peu de jours après leur sortie de leur retraite hivernale, portent souvent déjà des œufs sous l'abdomen, ont certainement été fécondées dans l'année précédente.*"

9. *Aulostoma.*

EBRARD, *l.c.* p. 67.

"Deux aulastomes que j'ai trouvées accouplées étaient rapprochées tête à tête. Une seule fécondait l'autre; car je n'aperçus qu'une seule verge lorsque je les séparai. L'une d'elles posa son premier cocon, œuf polysperme, quinze jours avant l'autre annélide."

10. *Macrobdella.*

Copulation has not, so far as I know, been observed in our common Macrobdella. That copulation occurs there can be little doubt. These leeches are remarkable for having so-called "copulatory glands," opening on the ventral side, a few rings behind the ♀ pore. It was Leidy who suggested that these glands are "provided for the adherence of individuals in sexual intercourse," and their position supports this view. This peculiarity makes it all the more desirable to witness the process of copulation. From what we know of other leeches, it is probable that individuals captured in early spring, and kept some days in isolation, would, on being brought together, very soon copulate.

OBSERVATIONS ON CLEPSINE PLANA (*n. sp.*).

The specimens on which my observations were first made were two large species obtained from Charles River, at Watertown, near Cambridge, in September, 1884. I am unable to identify them with any species hitherto described. Five of the nine individuals captured were dark brown, variously marked with yellow above, and with twelve or thirteen longitudinal lines below; the remaining four were yellowish brown both above and below.

Clepsine parasitica, as described by Say[1] and Verrill,[2] agrees in certain features closely with the dark species, and Verrill's *C. papillifera var. carinata may* be identical with the light species. The descriptions, however, do not point out any characters which can be relied upon for identification.

The dark specimens, to be described in the following paper under the name *C. plana*, were ready to copulate whenever they met; but they always avoided the light species, which may be provisionally designated as *C. carinata*. The latter showed no disposition to copulate until early the following spring. They remained quiet during the winter; but on being started up in May, they began to deposit sperm-cases.

The observations which follow are confined mainly to *C. plana*. Two of this species bore young still stuffed with yolk, and another had eggs in its ovaries that were nearly mature.

When I first placed these Clepsines in a dish together, I noticed several long white bodies attached by one end to the dorsal surface of one or two individuals. I pulled them off for examination, thinking that they were parasites of some kind. Putting them under the microscope, I saw, to my great surprise, a stream of spermatozoa slowly issuing from the end that had been detached. At first I could hardly believe that these sperm-cases belonged to the leech, never having detected the animal in the act of depositing them, and not suspecting that they could discharge their contents through the skin. My curiosity having been thus aroused, I watched the leeches more closely, and soon had an opportunity to see the whole operation. The leeches were moving about as they usually do when first captured, before becoming wonted to new quarters. One individual, coming in contact with another, fixed itself by its oral sucker to some convenient point, and then, while pressing its protruded male pore against the back of its fellow, planted a fresh sperm-case. During the operation, which lasted only a few seconds, the body in the region of the genital pores was more or less constricted, somewhat as it is in the act of forming an egg-cocoon. The constriction seemed to be the expression

[1] Thomas Say: *Major Long's Expedition to the Source of St. Peter's River, etc., in 1823*. Vol. II, Appendix, p. 14. Keating's Compilation, London, 1825.

[2] A. E. Verrill: *Synopsis of North-American Fresh-water Leeches*. Professor Baird's Report for 1872–73.

of an effort to press the sperm-case firmly to the surface of attachment, and very likely the case was filled with spermatozoa by the same act. After a few moments of steady pressure, — just long enough to allow the sticky secretion to "set," — the leech released its head and slowly drew back, allowing the spermatophore to be gradually *pulled* out of the two sac-like ends of the *vasa deferentia.* I saw this operation repeated several times by the same individual at intervals of about thirty minutes.

Among twenty or thirty spermatophores, I found only one on the ventral surface, and this was near the margin of the body; the rest were attached to the dorsal side, sometimes between two rings, sometimes in the middle of a ring, without any discrimination of place, so far as I could see.

Although the sperm-case is formed in two distinct sacs, uniting in a common pore, its two halves are firmly glued together, as the result of being pulled out through the single pore, while they are still in an adhesive condition. The moment they are set free, they are hardened by the action of the water, and only the small free ends sometimes remain distinct and separate.

One of the spermatophores first deposited measured 8 mm. in length and 1 mm. in width. Some of the last obtained measured only 3 mm. or even less. Repetition of the act seemed to exhaust the individual's power of forming spermatophores. Widely as they varied in size, they always showed essentially the same form as that shown in Fig. 4, *a* and *b*.

In the spermatophore we may distinguish (1) a short, constricted, basal portion with a single tubular lumen, formed in the median unpaired portion of the male organs; (2) an elongated body with a double saccular lumen, formed in the enlarged end-portions of the *vasa deferentia communia;* and (3) a free end, consisting of two distinct parts, adherent or separate, with lumen closed, or reduced to a narrow line, formed in the ends of the ejaculatory ducts (*d*) at the point marked *w* in Fig. 5. The wall of the spermatophore, which is thickest at the base and thinnest in the saccular body, is composed of two well-defined layers: an outer, thin, transparent, finely striated, non-stainable, cuticular-like layer (Fig. 2, *o*), which appears to fill the angles between the two halves of the case (Fig. 4 *b*), and to serve as a medium whereby the case is firmly glued to the

surface; and an inner, denser, thicker, stainable layer (Fig. 2, *i*). The outer layer is so extremely thin over the saccular portion of the fresh spermatophore that it is difficult to recognize it;[1] but it is easily demonstrated on sections. In the basal portion, this layer thickens, and then expands to form a broad base, so closely applied to the underlying cuticula as to form almost a continuum with it (Fig. 2). The striations of this layer may be due to the pull given to the sac as it is liberated from the genital pore, or more probably, as I think, to its mode of formation by numerous gland-cells.

When first placed, the spermatophore usually stands nearly perpendicular to the surface. It is tough and elastic, and considerable force is required to detach it. The skin of the leech around the place of attachment is at first strongly corrugated, as if by contraction; but this appearance gradually passes away after the sac is emptied, although the sacs often remain for several days, or even weeks. Whether they are ultimately dissolved, or shed with the cuticula, or drop off as the result either of vital processes in the underlying skin, or of the solvent action of water, I am unable to say.

The mouth of the fresh spermatophore is completely plugged with a peculiar secretion (Fig. 4, *a*, *gs*), made up of elongated elliptical or spherical corpuscles (Fig. 4, *c*), varying from 0.02 mm. in diameter to much smaller dimensions. These bodies dissolve in water in the course of a few minutes. At first appearance, they are coarsely granular, but rapidly become perfectly homogeneous and transparent, and, growing paler and paler, fade away by insensible degrees. At first I took these bodies to be cells, as some of them appeared to be nucleated; but having traced them to their origin in glands of a definite region of the *vasa deferentia*, I now think that the nucleus-like centre (Fig. 4, *c*) merely marks the depth to which the water had penetrated at the moment of examination. Their great variation in size is also in harmony with their origin as globular secretions.

This granular secretion probably serves a double purpose: first, to protect the spermatozoa inclosed in the saccular portion against contact with water; and secondly, as a means of opening and clearing the way for the safer penetration of the sper-

[1] Exposed to acetic acid, it swells, and is thus made evident without the aid of sections.

matozoa. This mass is expelled through the skin in advance of the spermatic elements; and the disappearance of the pigment and the clarification of the tissues at the point of penetration, all of which is noticeable in sections (Fig. 2), suggest that it may have a softening effect on the tissues.[1] This, however, is pure conjecture. With plenty of material, the action of this secretion on fresh pigmented tissue might possibly be determined experimentally; but thus far I have not tried this.

If the leech is placed under a magnifying power of twenty or forty diameters, immediately after receiving one of the spermatophores, one may see the spermatozoa slowly flowing from the narrow mouth of the case through the skin. In the course of an hour the greater part of the contents has escaped, and the case itself is reduced to less than half of its original diameter. As soon as the case is planted, it begins to shrink; and this contraction, induced by the action of the water, is probably what forces the spermatic fluid through the skin. When the sac is first placed, the spermatozoa may be seen through the wall united in close bundles. Soon after deposit, as one may see towards the free end of the sac, these bundles begin to swell up, and the individual spermatozoa begin to show themselves. The appearance might raise a suspicion that a part of the spermatozoa undergo histolytic changes, serving by expansion as a means of expelling the rest, somewhat as described by Gruber in the Copepoda (v. extract). I think, however, that Leuckart's suggestion in regard to the spermatophore of *Astacus* is the explanation to be adopted here, as it is perfectly certain that the sperm-case gradually contracts as its contents escape. I find that a few spermatozoa are always left in the case after it has reached the limit of contraction, showing that the expelling force ceases to act after this. As distinct spermatozoa were found in a sperm-sac two days old, I infer that the sac is water-proof. If a fresh sac be detached and exposed to the pressure of a cover-slip, the sperm is rapidly driven out in the form of a white flaky string, consisting of a viscid fluid, with numerous bundles of spermatozoa.

In order to learn precisely where the spermatophore is formed, as well as the origin and relative positions of the various elements with which it is to be charged, it will be necessary to

[1] Isjima's observations on Nephelis favor this view.

examine briefly the form, structure, and contents of the male efferent ducts. A glance at Fig. 5 will show that these ducts are differentiated into a number of different regions, each of which seems to have a special function. Beginning with the pore, which lies between the tenth and the eleventh ganglia, we find a very short median tube, which bifurcates beneath the ventral cord, giving rise to two diverging horns (*s*), which are continued into a convoluted tube (*w*, *g*, *d*) of nearly uniform, but much smaller, diameter; then follows an enlarged sigmoid coil (*vs*), and finally the long narrow tube (*vdc*), which receives the six short testicular ducts (*vd*). The sigmoid portion is a thin-walled reservoir completely filled with sperm-bundles, fulfilling the

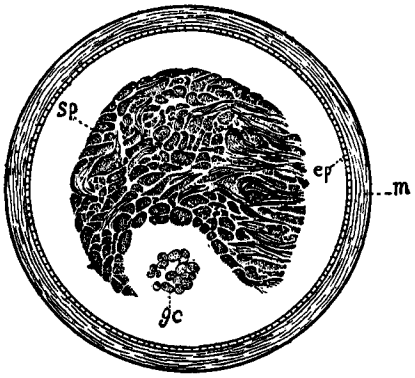


FIG. 1. — Section from the posterior half of the *ductus ejaculatorius*, showing bundles of spermatozoa (*sp*) massed together, and a few granular corpuscles (*gc*), probably secretions from the anterior, glandular half of the duct. The muscular layer (*m*) is strongly developed, and the large lumen is lined with a thin epithelium (*ep*).

office of a *vesicula seminalis*. The convoluted portion connecting the *vesicula seminalis* with the terminal horn-like enlargement (*s*) appears externally to be a nearly uniform tube, and is usually called the *ductus ejaculatorius* (*d*). But an examination of the structure and contents of this portion reveals the fact that it is really differentiated into two parts which fulfil different functions. The posterior half (*d*) has a thicker muscular wall, and a much larger lumen than the anterior half (*w* and *g*); it is lined with a thin epithelium, and is filled with spermatozoa. In the anterior half this epithelial lining takes the form of long columnar gland-cells, radially disposed, with the

nucleated ends next to the muscular wall. The reduction of the lumen in this part is due to the development of this glandular epithelium. It is in this glandular portion that the granular corpuscles (*gc*) which plug the spermatophore are produced.

I have a series of sections of this region, showing the gland-cells fixed in the very act of secreting these corpuscles. The corpuscles are somewhat pyriform in shape, with the smaller end tapering to a fine thread, which is connected with the central end of the producing cell (Fig. 2, *gc*). As soon as the corpuscle is fully liberated, it assumes a more or less elliptical form. These corpuscles sometimes nearly fill the whole lumen of the duct; sometimes they lie in masses that resemble clusters of

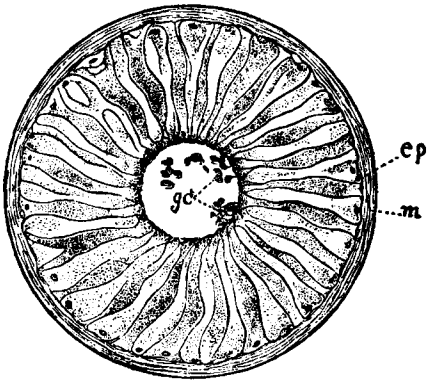


FIG. 2. — Section from the glandular anterior half of the duct, in which the lining epithelium (*ep*) is transformed into radial, pyramidal gland-cells, with nuclei at the external bases. Granular corpuscles (*gc*) in process of formation. Muscular layer thinner than in Fig. 1. The lumen of the canal is very much reduced by the thickening of the epithelial lining.

blood-corpuscles. I find a few such clusters in the posterior non-glandular region (*d*), but I doubt if they move backward to this part as a regular thing. They were more probably thrown backward from the place of origin by irregular, peristaltic contractions during the process of killing. At the anterior end (*w*) of the corpuscle-secreting region, the glandular lining becomes thicker, and passes imperceptibly into the still thicker lining of the terminal horns. I find no corpuscles at this level (*w*), and it is here that the free end of the spermatophore is evidently secreted. The saccular part of the spermatophore, as before noticed, is secreted in the horns (*s*), while the narrower base is

formed in the median unpaired tube lying beneath the nerve-cord.

The foregoing facts enable us to form some idea of what probably goes on each time a spermatophore is produced. My conjecture is as follows: As soon as the sperm-case is ready for the reception of its burden, the corpuscular secretion and the spermatic fluid contained in the convoluted tube (*w*, *g*, and *d*) are driven forward into it. The contents of this whole tube between the horn (*s*) and the vesicle (*vs*) is probably required

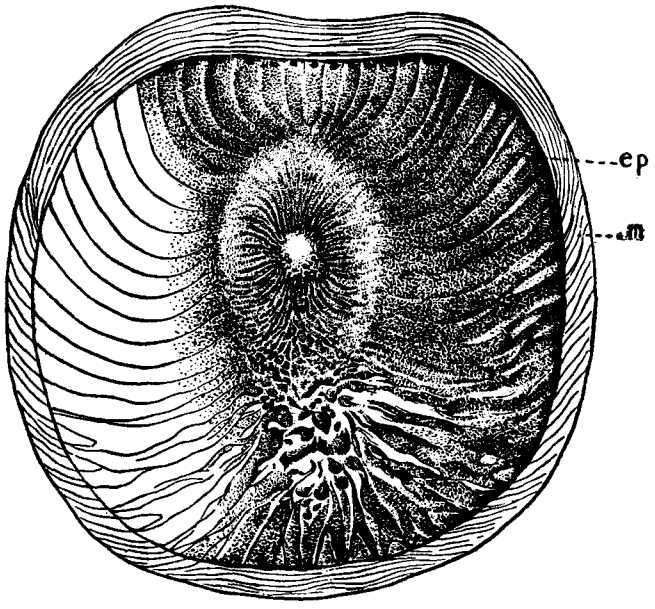


FIG. 3. — Section of the terminal horn of the efferent duct, just below the point of union with the ejaculatory coil. The epithelial layer is still more strongly developed. The cells are fixed in the act of secreting a spermatophore; the secretion still shows its origin from numerous single cells.

for a single charge. The spermatic fluid would sweep the corpuscular mass before it, and leave it in the basal portion of the sperm-case. Whether any portion of the contents of the *vesicula seminalis* is needed in addition to that of the *ductus ejaculatorius* to complete a single charge, is a matter of doubt. I am inclined to think that the charge is measured off each time in the ejaculatory ducts, and that the contents of the *vesiculæ seminales* is brought forward only to replace what has been ejected.

In this connection I desire to call attention to a peculiar feature of the ovaries of this species. A little behind the point of union of the two ovaries (Fig. 5) is seen a large cæcal diverticulum (*ca*) directed obliquely forward and outward, and terminated by a fibrous prolongation. I have not examined the minute structure of this part. I wish here merely to suggest that the ovarian sac of Clepsine may have been derived from a looped form like that of Nephelis. The free end of the loop in Nephelis (according to Iijima, *l.c.*) terminates with a fibrous prolongation similar to that of the cul-de-sac of *C. plana.* A drawing of the same organs in *C. marginata* (Leipzig), made when I was in Leuckart's laboratory, shows this same fibrous prolongation, arising, not from a cæcal appendage, but from the anterior angle of the simple ovary.

NOTES AND EXTRACTS RELATING TO THE PHENOMENA OF IMPREGNATION BY MEANS OF SPERMATOPHORES IN THE TURBELLARIA, THE ROTATORIA, DINOPHILUS, THE CHÆTOPODS, PERIPATUS, ETC.[1]

1. *The Turbellaria.*

ARNOLD LANG. Der Bau von Gunda segmentata, etc. *Mitt. a. d. Zool. St. z. Neapel.* III, 1 and 2. pp. 222–24. 1882.

"Die Endapparate der Geschlechtsorgane sind bei den Polycladen äusserst mannigfaltig gebaut. Betrachten wir diese Thiere als kriechende Coelenteraten, so darf uns diese Mannigfaltigkeit nicht wundern, denn *dann sind die Polycladen die ersten Thiere, bei denen eine wahre Copulation vorkommt.* Dann setzt uns auch ein gewisser Copulationsmodus, den ich bei mehreren Arten verschiedener Gattungen von Polycladen beobachtet habe, nicht mehr in zu grosses Erstaunen.

"Lange Zeit hatte ich nämlich vergeblich nach einer Erklärung der eigenthümlichen Thatsache gesucht, dass bei *Thysanozoon* 2 männliche Öffnungen und 2 Penes vorkommen, daneben aber eine einzige weibliche Öffnung existirt. Für die Erklärung war wenig gewonnen, als ich bei andern Gattungen von Polycladen dieselbe Thatsache entdeckte und sogar bei einer neuen Art und Gattung bei einem jungen *Thiere* 9, *bei*

[1] As the literature on the subject of hypodermic impregnation has not hitherto been collected, I have given at length such reports as seemed to me to be of especial interest. Doubtless I may have overlooked much that would be of value in this connection. What I have given will suffice to show that the subject is worthy of further investigation.

einem 15 *Penes in zwei seitlichen Längsreihen angeordnet vorfand.* Daneben bestand immer nur eine einzige weibliche Öffnung. Auf die richtige Spur brachte mich endlich eine Beobachtung, die ich vor zwei Jahren an einer in die Nähe der Gattung *Leptoplana* gehörenden Art wiederholt anzustellen Gelegenheit hatte. *Die meisten Exemplare dieser Art, die mir von den Fischern gebracht wurden, trugen nämlich eine geringere oder grössere Anzahl weisser, ziemlich resistenter Fäden, die ohne irgend welche Regelmässigkeit auf der Bauch- oder auf der Rückseite, oder auf beiden zugleich im Körper der Thiere befestigt waren. Zuerst dachte ich, dass ich es hier mit Parasiten zu thun habe. Die genaue Untersuchung ergab jedoch, das die erwähnten Anhänge weiter nichts sind, als Spermatophoren.* Sie bestehen aus einer structurlosen, resistenten Hüllmembran, welche in ihrem Innern einen Haufen Spermatozoen enthält. An Schnitten und an lebenden Thieren zeigte es sich, *dass diese Spermatophoren mit Gewalt und unter Zerreissen des Epithels der Basalmembran und der Musculatur in den Körper der Thiere eingesteckt worden waren. Der Samen ergiesst sich von den Spermatophoren in alle Hohlräume des Körpers, so dass man öfter im Lumen der Darmäste Sperma in reichlicher Quantität antrifft. Zufällig gelangt er auch in die Eileiter, die im ganzen Körper sich verästeln. Hier findet die Befruchtung der Eier statt.*

"Die Untersuchung des Penis ergab Resultate, die mit dieser eigenthümlichen Art der Copulation vollständig in Einklang stehen. Er besteht aus einem hintern drüsigen Theil, welcher offenbar die structurlose Hülle der Spermatophoren bildet und aus einem vordern sehr musculösen und langgezogenen Theil, dessen Höhlung spiralig gewunden ist. In Folge dieser Beschaffenheit des Penis kann das Spermataphor wie ein Korkzieher in den Körper des die Misshandlung erleidenden Individuums eingebohrt werden. *Die weibliche Öffnung dient bei dieser Species ausschliesslich zur Eiablage. . . .*

"Diese eigenthümliche Copulationsart, neben der bei vielen Arten *auch eine richtige Begattung vorkommt,* erklärt nach meiner Ansicht so vollständig das Vorkommen mehrerer Penes[1] neben einer einzigen weiblichen Geschlechtsöffnung, dass ich weitere Commentare für unnöthig halte. *In wie weit sie als eine ursprüngliche zu bezeichnen ist, wage ich nicht zu entscheiden. Jedenfalls scheint es mir charakteristisch, dass sie ausschliesslich bei denjenigen Thieren vorkommt, die ich für die ältesten Bilaterien halten muss und bei denen wahrscheinlich zum ersten Male die Befruchtung durch eine Copulation eingeleitet wurde.*"

[1] In *Histriodrilus Benedeni*, Foet. (*Histriobdella homari*, P. J. v. Ben.), Alexandre Foettinger finds three penes. It is possible that this "archiannelid" accomplishes the act of fertilization in the same manner as the pluri-penial Polyclads. Arch. de Biol., Vol. III, pp. 482–83 and 510. 1884.

ARNOLD LANG. Die Polycladen. *Fauna und Flora des Golfes von Neapel.* XI. Monographie. 2d Hälfte. pp. 636–38. 1884.

"Ich habe nur bei einer einzigen Art, nämlich bei *Stylochus neapolitanus*, den Vorgang der Copulation im gewöhnlichen Sinne des Wortes, d. h. die Einführung von Sperma in den weiblichen Begattungsapparat durch den männlichen beobachtet. . . .

"Es ist sehr wahrscheinlich, dass noch bei vielen anderen Polycladen sich eine normale Begattung vollzieht. Bei einer Reihe von Formen aber *geschieht die Copulation in einer bis jetzt im Thierreiche ganz allein dastehenden, höchst merkwürdigen Art und Weise.* Der Umstand, dass *Thysanozoon Brocchii* zwei Penes und zwei getrennte männliche Geschlechtsapparat besitzt, hatte meine Neugierde, zu sehen, wie sich bei diesen Organisations-verhältnissen die Begattung bei dieser Art vollziehe, schon lange wach gerufen. Diese wurde noch gesteigert, als ich noch andere Pseudoceriden mit doppeltem männlichen Begattungsapparat entdeckte, und gar erst, als ich den merkwürdigen *Anonymus virilis* mit seinen zahlreichen Penes, aber nur einer weiblichen Oeffnung auffand. Die genauere Untersuchung der Einrichtung und des Baues der Begattungsapparate dieser Formen brachte keine Aufklärung darüber, in welcher Weise bei ihnen die Copulation sich vollziehen könne, sie zeigte vielmehr, dass die ganze Organisation und Anordnung der in Frage stehenden Apparate für eine richtige Begattung so unpassend wie möglich ist. Den ersten Schritt auf dem Wege zur Aufklärung der Verhältnisse machte ich eines Tages, als man mir den prächtigen *Pseudoceros superbus* brachte. Ich setzte ihn in ein Bassin, in welchem sich mehrere schöne Exemplare, von *Yungia aurantiaca* und *Thysanozoon Brocchii* befanden. Das Thier kroch an den Wänden des Gefässes umher, stiess zufällig auf eine *Yungia*, wurde nun plötzlich sehr aufgeregt, liess seine beiden Penes weit hervortreten, und glitt über das Exemplar von *Yungia* hinweg. Bei seinem eiligen Umherkriechen traf es noch öfter mit Exemplaren von *Yungia* und *Thysanozoon* zusammen. Jedesmal wenn dies geschah, wurden die Penes hervorgestreckt, so dass ich mich veranlasst fühlte, die Individuen, über die der *Pseudoceros superbus* hinweg gekrochen war, aus dem Bassin heraus zu nehmen und zu examiniren. *Da stellte sich heraus, dass alle diese Exemplare mehr oder weniger zahlreiche Wunden hatten, und zwar an allen möglichen Körperstellen, und in den Wunden fanden sich ansehnliche weisse Klumpen von Sperma* (ich will hier noch beiläufig bemerken, dass sowohl bei *Pseudoceros superbus* als bei den anderen *Pseudoceriden* die Penes beim Schwimmen häufig weit hervor gestreckt werden). Diese Beobachtung brachte mich zuerst auf den Gedanken, dass die männlichen Begattungsapparate der Polycladen neben ihrer eigentlichen Func-

tion auch noch die von Waffen zum Angriff oder zur Vertheidigung haben könnten; sie rief mir zugleich eine alte Beobachtung die ich gemacht hatte, in das Gedächtniss zurück. Ich hatte nämlich schon mehrere Male in den Aquarien, in denen ich *Thysanozoon* hielt, diese Thiere mit vorgestrecktem Penis aufgeregt herum und übereinander hinweg kriechen sehen. Es bot sich mir bald die Gelegenheit, diese Beobachtung wieder zu erneuern, und ich unterliess es diesmal nicht, nach dem Ereignisse die Thiere zu untersuchen. *Mein Erstaunen war gross, als ich fand, dass sich auch die Exemplare von Thysanozoon gegenseitig verletzt und Häufchen von Sperma in die Wunden abgelegt hatten. Dies brachte mich zum ersten Mal auf den Gedanken, dass wenigstens bei den Polycladen mit doppeltem oder vielfachem männlichen Begattungsapparat und einfacher weiblicher Geschlechtsöffnung die Begattung sich so vollziehe, dass die Begattungsglieder eines Individuums an irgend einer Körperstelle anstechen, Sperma in die Wunde entleeren, und dass dann das Sperma zufällig in die im Körper reich verzweigten Eileiter gelange.* Ich fand sodann auf Schnitten in der That bei vielen Pseudoceriden Sperma nicht nur in den Eileitern, sondern auch *in Darmästen, im Parenchym,* etc. Diese Art der Copulation erschien mir aber doch so eigenthümlich, so ganz verschieden von allem, was bis dahin bekannt war, und hauptsächlich so unnatürlich, dass sich immer wieder Zweifel an der Richtigkeit meiner Auffassung der oben beschriebenen Vorgänge in mir regten. *Diese Zweifel verschwanden aber vollständig, als ich die Entdeckung machte, dass bei Cryptocelis alba im männlichen Begattungsapparat Spermatophoren erzeugt werden, die dazu bestimmt sind, mit Gewalt in die Leibeswand anderer Individuen derselben Art eingepflanzt zu werden. Als ich zuerst Individuen von Cryptocelis alba bekam, die an den verschiedensten Körperstellen mit einer wechselnden Anzahl dieser weissen, fadenförmigen, zähen Spermatophoren besetzt waren, glaubte ich erst, dass es Parasiten seien, bis ich ein solches Gebilde öffnete und eine Unmasse von Spermatozoen von der Form derjenigen von Cryptocelis alba* heraustreten sah. Die Spermatophoren sind unter Durchbrechung des Epithels, der Basalmembran und der Musculatur so fest in den Körper eingepflanzt, dass sie sich bis auf ihre doppelte und dreifache Länge zu langen, dünnen Fäden ausziehen lassen, bevor sie sich loslösen. *Die durch das Einpflanzen der Spermatophoren hervorgerufenen Wunden lassen deutliche Narben zurück.* Man trifft sie bei zahlreichen Individuen an. Der grosse kräftige, äusserst musculöse Begattungsapparat von *Cryptocelis* erscheint seiner Function sehr gut angepasst.

"Spermatophoren werden auch noch bei anderen Polycladen producirt. Im Körperparenchym von *Prostheceraeus albocinctus* fand ich unzählige Häufchen von Samenfäden, deren Kopfenden alle in einer

Ebene lagen und deren Schwänze nach einer und derselben Seite gerichtet waren. Ballen von Sperma fand ich auch sehr häufig vor dem Eingang zum weiblichen Begattungsapparat von *Leptoplana tremellaris*. Diese Spermatophoren unterscheiden sich von denen der *Cryptocelis alba* dadurch, dass sie nicht in eine Membran oder Kapsel eingeschlossen sind."

Id. ibid. 1st Hälfte. pp. 231–32.

"Wie im biologischen Theile auzeinandergesetzt werden wird, dienen die männlichen Copulationsorgane mehreren Polycladen nicht zu einer eigentlichen Copulation im gewöhnlichen Sinne des Wortes, d. h. sie werden nicht in die weiblichen Copulationsorgane eingeführt. Sie dienen vielmehr diesen Formen dazu, den Körper eines anderen Individuums derselben Art an irgend einer Stelle anzustechen und den Samen in die so erzeugte Wunde zu ergiessen, oder eigens bereitete Spermatophoren mit Gewalt in den Körper des die Misshandlung erleidenden Individuums einzupflanzen. *Diese eigenthümliche, bis jetzt, so viel ich weiss, bei allen Thieren ganz allein dastehende Art der Begattung macht es verständlich, dass bei Pseudoceriden und Anonymiden neben einem einzigen weiblichen Begattungsapparat zwei oder mehrere männliche vorkommen.*

"*Ich erblicke in ihr aber ferner auch einen Vorgang, der auf die phylogenetische Bedeutung der Copulationsorgane der Polycladen vielleicht einiges Licht wirft.* Wenn, wie ich anzunehmen geneigt bin, die Polycladen aus Coelenteraten durch Anpassung an die kriechende Lebenweise hervorgegangen sind, so haben ihre Vorfahren keine Begattungsapparate besessen. Es bleibt also die Schwierigkeit, die Entstehung dieser oft so complicirten Organe bei den Polycladen zu erklären. Ich weiss sehr wohl, dass diese Schwierigkeit gegenwärtig noch nicht zu beseitigen ist, doch dürften vielleicht die folgenden Bemerkungen einen Fingerzeig abgeben, in welcher Richtung die Lösung der Frage zu suchen sein wird. *Die männlichen Begattungsapparate vieler Polycladen, ganz besonders diejenigen, welche an ihren Ende ein hartes Stilett tragen, stehen nämlich sicher nicht ausschliesslich im Dienste geschlechtlicher Functionen, sondern sie dienen auch als Waffen zum Angriff und vielleicht auch zur Vertheidigung.* Schon O. Schmidt, Hallez und v. Graff haben für die harten Stilette der männlichen Geschlectsapparate gewisser Rhabdocoeliden diese Auffassung ausgesprochen, die ersten beiden haben dieselbe sogar durch directe Beobachtung erhärtet. Ich habe bei Pseudoceriden ebenfalls direct beobachtet, dass die Penes als Waffen gebraucht werden. Ein grosses und schönes Exemplar von *Pseudoceros superbus* sah ich in einem meiner Aquarien, in denen sich

mehrere Exemplare von *Thysanozoon Diesingii* und *Yungia aurantiaca* befanden, in grosser Aufregung umher kriechen und von Zeit zu Zeit die beiden Penes weit vorstrecken. Es kroch öfter über die anderen erwähnten Polycladen hinweg und brachte ihnen durch Vorstossen der Penes zahlreiche Wunden bei, in denen ich stets ein Häufchen Sperma vorfand. Ganz ähnliches habe ich zu wiederholten Malen auch bei *Thysanozoon Diesingii* beobachtet. Aber noch ein anderer Umstand spricht zu Gunsten der gelegentlichen Verwendung der Copulationsorgane als Waffen. Das Lagerungsverhältniss des männlichen Begattungsapparates von *Stylostomum* zu Pharyngealtasche und Pharynx bringt es, wie ich weiter unten nachweisen werde, mit sich, dass der Pharynx nicht vorgestreckt werden kann, ohne dass nicht auch der mit einem harten Stilett versehene Penis vorgestossen wird. Wenn wir uns nun ferner daran erinnern, dass bei der Begattung mehrerer Polycladen-Arten eine gewaltsame Verwundung der Individuen durch den Penis an den verschiedensten Körperstellen erfolgt, so liegt der Gedanke doch gewiss nahe, dass die Copulationsorgane der Polycladen ursprünglich Angriffs- und Vertheidigungswaffen waren, die erst secundär in den Dienst geschlectlicher Functionen traten. Von diesem Gesichtspunkte aus ist das Vorhandensein einer grossen Anzahl von Begattungsorganen bei dem ursprünglichen Genus *Anonymus* sehr leicht erklärlich, und die oben erwähnte Begattungsweise erscheint uns viel weniger seltsam.

2. *Rotatoria.*

LUDWIG PLATE. Beiträge zur Naturgeschichte der Rotatorien. *Jen. Zeit. für Nat.* XIX. 1885. pp. 110–11.

"Dass die Spermatozoen bei den begatteten Weibchen frei in der perienterischen Flüssigkeit sich umhertummeln, ist eine von vielen Forschern wiederholt gemachte Beobachtung: aber wie sie hinein gelangen, ist von denselben nicht erkannt worden. Cohn und Brightwell konnten, da sie nur mit Lupen arbeiteten, weiter nichts bemerken, als dass die Männchen sich dicht an die Weibchen anhefteten, und ersterer vermutete bei *Hydatina* und *Conochilus* einen besonderen, in der Halsgegend befindlichen Genitalporus. Eyferth berichtet: 'bei *Diglena catellina* habe ich die Anheftung (der Männchen) an die Kloakenmündung gesehen.' Hudson[1] dagegen fand bei *Asplanchna Ebbesbornii* 'ein Männchen, das mit der Spitze des Penis dem Weibchen anhing.' Aber es war an der Aussenseite der Bauchflächenmitte und nicht an der Oviductöffnung.' Alle diese widersprechenden Angaben erklären sich leicht aus den Beobachtungen, die im speciellen Teile

[1] Jour. Roy. Micr. Soc., Vol. III, Part 5, 1883, p. 622.

bei *Hydatina senta* geschildert wurden. *Sie führten zu dem merkwürdigen und, soviel ich weiss, im ganzen Tierreich nur noch bei einigen Planarien vorkommenden Ergebnis, dass der Penis die Körperwandung des Weibchens bei der Copulation an irgend einer beliebigen Stelle durchbohrt, derselbe dagegen nicht, wie man erwarten solte, in die Kloake gesteckt wird. Unter geeigneten Umständen vermag daher auch dasselbe Weibchen gleichzeitig von mehreren Männchen begattet zu werden. Da schon bei so vielen anderen Specien Sperma frei in der Leibeshöhle flottierend gefunden worden ist, kann kaum bezweifelt werden, dass auch bei diesen die Begattung in gleicher Weise vollzogen wird.* Es fragt sich nun, ob wir annehmen dürfen, dass auch zu jener Zeit, als die Männchen wie die Weibchen mit Mundöffnung und Darm versehen und in ihrer ganzen Organisation noch nicht rückgebildet waren, der männliche Same auf dieselbe Weise in den weiblichen Körper gebracht wurde. Ehe bei *Seison*, dem einzigen Rädertier, dessen Männchen noch nicht retrometamorphosiert ist, die Copulation nicht beobachtet worden ist, lässt sich freilich die angeregte Frage nicht mit Sicherheit entscheiden. Da jedoch Claus von dieser Gattung glaubt mit Sicherheit behaupten zu können, dass die Samenfäden nicht frei in der Leibeshöhle, sondern in dem dünnhäutigen Ovar sich befinden, *scheint es mir das Wahrscheinlichste zu sein, dass ursprünglich der Penis in die Kloake geschoben*, und auf diesem allein natürlichen Wege das Sperma mit den Keimzellen zusammengebracht wurde. Wir müssen dann annehmen, dass mit der *Rückbildung der Männchen oder vielleicht bewirkt durch dieselbe eine Änderung in der Art des Coitus eingetreten ist.*"

pp. 37–39.

"Um den Akt der Begattung zu beobachten, thut man gut, gleichzeitig eine grössere Anzahl (6–10) Männchen mit einem Weibchen in einem kleinen Tropfen zu isolieren. Die ersteren besitzen nämlich nicht die Fähigkeit, die Nähe des anderen Geschlechts zu wittern, auch nicht dann, wenn das siedende Gewimmel der Samenfäden,—welches manchmal erst am zweiten Tage nach dem Verlassen des Eis eintritt,—anzeigt, dass sich die Tierchen in einem begattungsfähigen Zustande befinden. Auch die Weibchen bekümmern sich nicht um die Männchen; beide werden lediglich durch den Zufall zusammengeführt, und bringt man daher 1 oder 2 Männchen mit einem oder wenigen Weibchen zusammen, so muss man oft Stunden lang warten, bis eine Begattung wirklich eintritt. Oft kommen beide Geschlechter vielfach mit einander in Berührung, ohne zu copulieren, wie auch schon Cohn mit der Lupe beobachtet hat, dass die Männchen 'die Wiebchen umschwärmen, sich an diese anlegen, meist aber von diesen . . . wieder zurückgeschreckt werden.' *Bei der Begattung wird merkwürdiger Weise der Penis des Männchens, nicht in*

die Kloake oder in eine andere Öffnung der Cuticula geschoben, sondern durchbricht letztere an irgend einer beliebigen Stelle und befördert wahrscheinlich durch eine energische Contraction der Muskulatur des Hodens die stäbchenförmigen Körper und das Sperma in die Leibeshöhle. Während der Begattung Krümmt sich der Körper des Männchens so, dass die Bauchseite einen concaven Bogen darstellt. Die Zehen werden hierbei nicht gebraucht, sondern auch der Ventralfläche zugewendet, sodass, das ganze Tier eine halbmondförmige Gestalt annimmt und nur mit dem ausgestreckten Penis sich festheftet. Da eine besondere Genitalöffnung nicht vorhanden ist, kann ein Weibchen gleichzeitig von mehreren Männchen begattet werden, ein Vorgang, der in der Natur wegen der Seltenheit der letzteren wohl kaum vorkommen dürfte, den ich aber unter den oben angegeben Bedingungen wiederholt beobachtet habe; so *sah ich 2, 3, 5, und einmal eine noch grössere Zahl von Männchen (6–8) gleichzeitig mit demselben Weibchen copulieren.* Es ist mir öfters aufgefallen, dass, wenn man Tiere beiderlei Geschlechts in einem kleinen Tropfen isoliert, dieselben zunächst längere Zeit gleichgültig an einander vorbeischwimmen; umschwärmt jedoch erst ein Männchen das Weibchen, so sammeln sich bald mehrere der ersteren um dasselbe, gleichsam als ob die Männchen sich gegenseitig bemerkten. *Bei der Begattung wird der Penis nicht in seiner ganzen Länge durch die gebildete Öffnung der Cuticula in die Leibeshöhle hereingeschoben, sondern klebt nur äusserlich derselben an.* Sie wird nur sehr klein sein, denn ich habe nie nach erfolgter Begattung Spuren derselben in der Haut wahrnehmen können. Leider kann ich nicht mit Sicherheit angeben, wie die Öffnung zum Übertritt des Sperma ensteht, da die stete Beweglichkeit der copulierenden Tiere die Untersuchung sehr erschwert. Aus der Beobachtung von Tieren, die gleichzeitig von mehreren Männchen begattet und in diesem Augenblicke durch ein Deckglas festgehalten wurden, glaube ich jedoch schliessen zu dürfen, dass *die grossen Borsten an der Penisöffnung und die pfeilartigen Stäbchen, die wegen ihrer Lage im Vas deferens zuerst herausgepresst werden, die Körperwand des Weibchens durchbrechen.* Alle diese zweifelhaften Punkte würden sich ohne Schwierigkeit an den grossen Asplanchnaarten lösen lassen. An demselben Genus würde man auch relativ leicht beobachten können, welchen Einfluss das Sperma auf die Bildung der Eier ausübt, ob die Begattung auch eine Befruchtung nach sich zieht oder ob, — *wie ich glaube, — die Samenfäden in der Leibeshöhle der Weibchen sämtlich nach einiger Zeit zu Grunde gehen, und der Begattungsakt durch das Auftreten der Parthenogenese seine weiteren Folgen verloren hat. Es wäre dies ein in der Tierreihe nach unsern jetzigen Kenntnissen wohl einzig dastehender Fall, den man als einen 'rudimentaren Vorgang' in demselben Sinne bezeichnen Könnte, wie man Organe, die ausser Function getreten sind, rudi-*

mentär nennt. Leider wusste ich, als ich das Verhalten der Spermatozoen in der Leibeshöhle verfolgte, noch nicht, dass nur ein Teil der Geschlechtsorgane, nämlich der Eierstock, bei Entscheidung jener Frage in Betracht kommen kann und richtete meine Aufmerksamkeit daher nicht besonders auf den Vorderrand des Dotterstockes. Was man an den begatteten Tieren beobachtet, ist eigentlich nur sehr wenig. Das Sperma häuft sich zuweilen in einem Klumpen innen um die gebildete Hautöffnung herum an, flottiert jedoch in der Regel frei in der Leibeshöhle, verteilt sich zwischen allen Organen, *zwischen den Fäden des Gehirns so gut,* wie in der Nähe der Klebdrüsen und sammelt sich weder in der Umgegend der Geschlechtsorgane vorzugsweise an, noch habe ich je beobachten können, dass die Samenfäden den Versuch gemacht hatten, in dieselben einzudringen. Der Dotterstock eines gut genährten Tieres bildet nächst dem Darm das grösste Organ im Körper, und es ist natürlich, dass sich an siener Oberfläche mehr Spermatozoen ansammeln als auf einem kleineren, z. B. der contractilen Blase. Übten die Fortpflanzungsorgane ferner eine besondere Anziehungskraft auf das Sperma aus (wie Cohn es bei *Conochilus* gesehen haben will), so müsste sich dasselbe vorn in der Nähe des Keimstockes ansammeln, was mir sicherlich nicht entgangen wäre, auch ohne zu wissen, warum gerade dieser Teil von den Samentierchen bevorzugt würde. Während die eben in die Leibeshöhle gelangten Spermatozoen sich zunächst noch sehr lebhaft bewegen und daher, wenn sie der Genitaldrüse dicht anliegen, durch das hin und her Schlängeln ihres Schwanzes leicht den Eindruck hervorrufen können, als ob sie sich in dieselbe einzubohren suchten, werden diese Bewegungen nach einigen Stunden immer matter. Dabei schwellen sie am vorderen Ende dick an, werden allmählich kugelförmig und im Innern vacuolisiert, kurz, *es ist offenbar, dass sie einen längeren Aufenthalt in der perienterischen Flüssigkeit nicht zu vetragen vermögen, sondern darin sterben und sich zersetzen. Untersucht man ein begattetes Tier nach 24 Stunden, so nimmt man nichts mehr von denselben wahr.*

"Die ausgesprochene Ansicht, dass sich die *Hydatina senta ausschliesslich parthenogenetisch fortpflanzt,* stützt sich vornehmlich auf den Mangel einer anziehenden Wirkung der Geschlechtsorgane auf das Sperma, und darauf, dass nie das Eindringen des Samens in jene beobachtet wurde."

3. *Dinophilus.*

SIDNEY F. HARMER. Notes on the Anatomy of Dinophilus. *Studies from Morph. Lab. Univ. Cambridge.* Vol. I, pp. 49, 50. 1890. [Reprint from *Jour. Mar. Biol. Assoc.* N. S. Vol. I.]

"So far as I am aware, copulation has not hitherto been actually proved to take place in any species of *Dinophilus.* The proof that such a

process takes place in *D. tæniatus* is very readily obtained by merely placing a considerable number of individuals of both sexes in a small quantity of sea-water, as in a watch-glass. Under these circumstances, it is noticed, even a very short time after the animals have been placed together, that here and there a male is attached, by means of its penis, to the body of a female. In these cases, the terminal, conical portion of the penis is protruded through the generative pore, and *is passed into the skin of the female; spermatozoa are then seen to have passed, from the vesiculæ seminales, through the skin of the female, and to be accumulating themselves into a mass immediately beneath the perforation made by the penis.*

"There seems to be no localization of the spot at which spermatozoa can be introduced into the female. The penis can obviously be inserted into the skin at any point, as is shown by the fact that, in the cases actually observed, the point selected was sometimes in the region of the neck, in other cases far back in the body of the female, and in other cases near the middle of the body.

"The act of copulation has no relation to the maturity of the ova of the female, nor is it prevented by the fact that the female has already received an ample supply of spermatozoa by a preceding operation. It was extremely difficult to discover any female, in which ovaries were recognizably developed, which did not contain large numbers of spermatozoa in its body-cavity. These were observed in almost any part of the body of the animal, their position being probably partly dependent on the manner in which fertilization had been previously effected. The spermatozoa show, however, a great tendency to accumulate into a large, compact mass, situated in a space on the ventral side of the stomach. *In some cases it was observed that the female was receiving spermatozoa simultaneously from two males;* in others that while, for instance, fertilization was being effected near the posterior end of the body, a great mass of spermatozoa (obviously obtained on a previous occasion) was visible at the anterior end of the body. In many cases the females were enormously distended with spermatozoa, which could hardly have been all received at one time.

"The common occurrence of great numbers of spermatozoa in the body of the supposed female might suggest that *D. tæniatus* was hermaphrodite. Such a supposition is rendered sufficiently improbable by the following considerations: (I) That no other species of *Dinophilus* is known to be hermaphrodite; (II) that the process of fertilization was frequently observed in *D. tæniatus;* (III) that the spermatozoa so constantly seen in the female of the same species were, without exception, ripe and actively moving, no trace of spermmorulæ or unripe spermatozoa being discernible. Such stages in the development of the spermatozoa were never missed in any adult male individual."

4. *Chætopods.*

a. THE TUBIFICIDÆ. — Spermatophores are of very general occurrence among the oligochætous annelids. They were observed in the seminal vesicles of the Tubificidæ as long ago as 1828 by Dugés, and in 1850 by Budge; but their significance escaped these older authors, and even as late as 1861–62 Claparède described them as *opalina-like* parasites, under the name of *Pachydermon acuminatum* and *P. elongatum*. It was not until 1869, in a joint work with Metschnikoff, that Claparède recognized the real nature of his "opalinoid parasites."

In 1848 Kölliker saw the spermatophore of Spio attached to the surface of the worm, and supposed it to be a *Gregarina*. The first to discover their meaning, according to Vejdovsky, was Doyère (1854–55).

In some of these spermatophores the tails of the inclosed spermatozoa project through the wall of the capsule, giving it the appearance of being clothed with vibratile cilia. Such spermatophores, in motion, resemble living organisms so closely as to deceive the trained eye, as the *Pachydermon* of Claparède well illustrates. Sometimes, as in *Psammoryctes*, these vibratile portions adhere in bundles on the neck of the capsule, giving it the appearance of being armed with recurved hooks like the proboscis of an Echinorhynchus. Vejdovsky himself first described these as "Widerhaken," but corrected himself in his later monograph.

Among the earlier contributions to a more definite knowledge of these structures are two papers by E. Ray Lankester,[1] and one by Franz Vejdovsky.[2]

Lankester remarks on "The Structure and Origin of the Spermatophores of Two Species of Tubifex" (pp. 180, 181, 187) as follows:—

"The very curious structure of these built-up masses of spermatophores, the fact that they are an example of *a kind of organization* elsewhere without parallel, — a secondary aggregation, not due to growth as ordinarily presented by organized beings, but to accumulation of free independently developed elements, — gives them a claim on our attention, as well as the facts that they have been misunderstood by the

[1] Quart. Journ. Mic. Sci., 1870 and 1871.
[2] Zeitschr. f. w. Zool., XXVII, 1876.

ablest and latest writer (M. Claparède) on the animals which present them; and that they exhibit marked variations in form in the various genera and species of Oligochœt worms."

"Did we know of a number of free unicellular organisms after complete development becoming fixed together by a cement to form a secondary organism capable of locomotion and possibly of nutrition, we should have a parallel to the spermatophores; as it is, they are, I believe, the only examples of the building up of an organ or quasi-organism by agglomeration instead of histogenesis."

"The sperm-ropes of *Tubifex rivulorum* I have found in the copulatory pouches both in summer and winter, but especially abundant and well formed in the winter. They have a worm-like figure, with a curious conical head, an average from $\frac{1}{20}$ to $\frac{1}{15}$ of an inch in length, and from $\frac{1}{300}$ to $\frac{1}{200}$ of an inch in breadth, the narrowest part being that immediately succeeding the conical head, which has a breadth of about $\frac{3}{1000}$ of an inch."

"The general form of the sperm-rope is due to its being moulded in the long neck of the copulatory pouch. . . .

"It appears that the material of which the sperm-ropes are formed, namely, spermatozoa and a cementing matrix, must be introduced in a viscid form from the male efferent duct, through the penis of one worm into the copulatory reservoir of another, and in the neck of that reservoir a 'setting' occurs; for the sperm-ropes, when fully formed, are very firm and compact bodies, of high light-breaking power. The wall of the copulatory pouch is glandular, and undoubtedly furnishes a secretion which occupies part of its cavity, and in all probability also assists as a cementing material in the formation of the sperm-ropes."

b. The Lumbricidæ. — The account given by Vejdovsky[1] of the spermatophores of the Lumbricidæ comes more closely in several respects to what I have seen in the leeches. It is in these worms that spermatophores have often been seen attached to the surface of the body, usually on the first segments of the sexual girdle. According to Vejdovsky, they were known to the earlier naturalists of this century, and were usually described, after Morren's example, as "*appendiculæ generatrices*," or as "*penes*." Friedrich Müller (1849) first recognized them as spermatophores. Later (1857), however, they are referred to by Ewald Hering as "unimportant formations." Hering's description (Zeitschr. f. w. Zool., IV, 1857), nevertheless, seems to be of some value: —

[1] *System und Morphologie der Oligochæten*, Prag., 1884.

"Nach der Begattung tragen die Würmer meist in der Gegend des 26 Segments, *selten am Gürtel*, jederseits einen kleinen plattkolbenförmigen, ungefähr 1‴ langen Anhang, den sogenannten Penis. . . . Er ist anfangs weich, wird aber allmählig härter und besteht aus einer hyalinen Substanz, in die am freien Ende ein Tröpfchen Samenmasse eingebettet ist. Er ist nachweisbar ein Product der Begattung und besteht nach meiner Ansicht aus *erhärtetem Schleime*."

Leuckart (Bericht, 1854–55) remarks as follows: —

"Referent hat an der vorderen Bauchseite der Regenwürmer zur Brunstzeit nicht selten kleine *spindelförmige Gebilde* angetroffen, die mit Samenfäden gefüllt waren und wohl als Spermatophoren zu betrachten sein dürften."

Fraisse (Semper's Arbeiten, V, 1879) devoted a special paper to the spermatophores of the earthworms, giving figures illustrating their form. Fraisse came to the conclusion that the outer homogeneous envelope of the capsule is not formed in the male efferent ducts, nor in the seminal vesicles, but probably by the glands associated with the sexual setæ. Vejdovsky finds the spermatophores attached sometimes in the intersegmental furrows, and considers this evidence against the glands ("tubercula") having any share in their formation. In opposition to Fraisse, Vejdovsky thinks it probable that the seminal vesicles furnish the secretion which forms the envelope in question.

Vejdovsky concludes his account with some remarks about the difficulty of understanding how the spermatozoa inclosed in spermatophores can reach the eggs. The female genital pore is located in the fourteenth somite, and the spermatophores are usually placed in the twenty-seventh to thirtieth somites. Furthermore, no external opening could be found in the spermatophore, by which the contents could escape. These facts naturally suggest to me the possibility of the spermatophores emptying themselves as they do in Clepsine. Such a possibility, however, is not mentioned by Vejdovsky, who suggests that the spermatozoa may be freed during the formation of the cocoon.

The mode of attachment of the spermatophores appears to be precisely the same as in Clepsine.

"*Ihre Basis wächst mit der Cuticula des Leibesschlauches zusammen und ist von der letzteren überhaupt nicht zu unterscheiden.*"

5. *The Capitellidæ.*

Among the polychætous annelids and the Capitellidæ there seems to be little that can be said to fall in the direct line of our inquiry. In very many cases the sexual products are set free in the water, and external fertilization takes place without the intervention of spermatophores. In *Polygordius*, according to Fraipont, the whole body undergoes a regressive metamorphosis at sexual maturity; and the sexual products, as the result, perhaps, of mechanical pressure upon the body-wall, weakened by almost complete atrophy, burst through, and escape into the water. The animal does not survive the evacuation of its sexual cells.

In one of the Capitellidæ (*Clistomastus lineatus*), according to Eisig, the whole abdominal region, in which the sexual cells are lodged, undergoes a histolytic metamorphosis at sexual maturity; and the sexual elements are set free by fragmentation of this region. The thoracic region alone remains intact, and this is supposed to be able to regenerate a new abdomen.

In Capitella we find spermatophores, but no evidence that they are ever attached to the exterior. Dr. Eisig has made a number of most interesting discoveries in regard to the mode of copulation and fertilization in these worms; and although they do not touch very closely the phenomena under consideration in the leeches, I think they are not so remote as to be out of place here.

Monog. XVI. Fauna und Flora von Neapel. 1887. pp. 284, 674–75, 790–93.

The organs of copulation in *Capitella* consist of (1) two pairs of modified hæmal parapodia belonging to the eighth and ninth somites; (2) a copulation gland lying between the genital parapodia of the ninth somite; and (3) a pair of genital sacs in the eighth segment, which function as *vesiculæ seminales*, *vasa efferentia*, and *penes*. The female possesses a like pair of genital sacs in the same segment, and these serve not only as organs of copulation (*vulvæ*), but also as *receptacula seminis* and *oviducts*. Dr. Eisig thinks the glandular *porophore* of the female, like the clitellum of the oligochæta, assists in copulation by its sticky secretion.

From the position of the copulatory organs, Dr. Eisig con-

cludes that in copulation the two individuals lie back to back, and that the terminal portions of the genital sacs of the male are everted and inserted as penes in the corresponding non-everted parts of the female.

The spermatozoa, originating like the ova in a so-called "genital plate," fall into the body-cavity in an imperfectly developed state; after attaining maturity, they collect in the genital sacs, and are there united into bundles or spermatophores [p. 793]. In this form they may pass, during the act of copulation, into the genital sacs of the female, thence into her body-cavity, where they meet and penetrate the ova. Fecundation is thus accomplished before oviposition.

Although Dr. Eisig does not seem to have witnessed the act of copulation, his statements rest on many concurrent evidences.

The most remarkable feature of this copulation remains to be mentioned. Dr. Eisig reports [pp. 791–92] that the ripe males copulate not only with adult females, but also with unripe females, and even with juvenes in which the sex has not yet become manifest; and what is still more astounding, *with young individuals of their own sex.* The proof of this lies in the fact that the genital sacs of young males were found stuffed with spermatophores before their genital plates had come into functional activity. They must therefore have received their spermatozoa from without.

These facts prove that the male is capable of discharging his function effectively without the aid of any co-operative act on the part of the female, and in this respect the copulation bears some resemblance to that of Clepsine. But there seems to be no evidence of spermatophores attached to the exterior.

6. *Arthropods.*

The spermatophores of *Eupagurus* were seen by Swammerdam (*Bibel der Nature*, p. 87), and described as "lauter regelmässigen Theilchen." Whether they represented eggs or spermatozoa was left undecided. About a century later, in 1841–42, the decapod spermatophores were rediscovered by Kölliker, and their purpose and origin made known through his observations and those of Von Siebold (*cf.* Mül. Arch., 1842, pp. cxxxv–vi). It seems probable, from Grobben's observations (Claus's *Arbeiten*, I, 1881, p. 67), that all decapods produce spermatophores. The

question as to how the spermatophores empty themselves, and whether fecundation is internal or external, has received different answers. Grobben (*l.c.*, p. 75) does not attempt to decide by what agent the spermatophore is made to burst and discharge its contents. In the Brachyura they are supposed to be dissolved in the *bursa copulatrix* of the female. Leuckart (*Zeugung.*, p. 900) accounts for the escape of the contents of the sperm-case thus: "The walls gradually harden and compress the contents until the capsule bursts, or (as in the case of Astacus and insects) until it flows out of the open end." Paul Meyer (Jen. Zeitschr., 1877, p. 204) thinks it is not the water that causes the spermatophore to burst (in Galathea and Pagura), and suggests that the secretion with which the female fastens the eggs to its legs may be the agent that accomplishes this.

It is in Peripatus and the Copepods that we find modes of impregnation more or less closely analogous to what takes place in the Rhynchobdellidæ.

ADAM SEDGWICK. The Development of Peripatus Capensis. *Quart. Jour. Micr. Sci.* N. S. XCIX. July, 1885. pp. 453–54.

a. PERIPATUS. — "The ovaries contain spermatozoa, *some of which project through the ovarian walls into the body-cavity.* This condition has been figured and described by Moseley.[1]

"The ovaries always contain spermatozoa, but in smaller numbers directly after the eggs have passed into the oviduct than at any other time. This is a very marked feature of an ovary, say, at the beginning of April, when compared with an ovary from which the ova have just passed into the oviducts, say, at the beginning of May, the former being of an opaque white color to the naked eye, while the lat er has a much more transparent appearance.

"This fact would seem to imply that fresh spermatozoa pass each year into the ovaries. This brings me to the question of the manner in which the male discharges his function. The *vesiculæ seminales* (testes of Moseley and Balfour) are almost empty of spermatozoa in the months of February, March, and April. At the end of April, however, they begin to swell again and contain spermatozoa, which increase in number as time goes on, until, in October, they are fully distended with spermatozoa in all stages of development. *There seems to be no functional intromittent organ, but the male deposits little oval spermatophores quite casually on any part of the body of the female, and, for all that I know,*

[1] Phil. Trans., Vol. 164.

of the male also; e.g. *I have often seen them on the head. How these little packets of spermatozoa get into the vagina, and then up the uteri, which are always full of embryos, I cannot conceive.* The spermatozoa exhibit a certain amount of vibratory movement, and no doubt, once within the vagina, they are set free from the spermatophore and make their way up the female generative tube, between the embryos and the uterine walls. Inasmuch as the deposition of spermatophores lasts from June until January, *each female probably has a large number of spermatophores deposited on her, and some of these are probably near the generative opening, and are, somehow or another, transported through it into the vagina.*

"Fertilization is apparently effected in the ovary. I have never seen spermatozoa in any part of the female apparatus except in the ovaries, and in small numbers in the upper end of the oviducts at the time when the ova are entering the latter."

AUGUST GRUBER. Beiträge zur Kenntniss der Generationsorgane der freilebenden Copepoden. *Zeitschr. f. w. Zoology.* 1879. p. 407.

b. COPEPODA. — Fertilization is accomplished by means of spermatophores in the Copepoda; but here the sperm-cases are always, so far as known, affixed to the body of the female in the immediate neighborhood of the genital openings, and the contents are never forced through the body-wall.

The whole history of the spermatophore has been carefully traced out by Gruber. Its formation in *Heterocope* is considered to be typical for the entire group.

The *vas deferens* forms two secretions, one of which forms the elongated, sausage-shaped spermatophore, while the other is incased along with the spermatozoa. The spermatophore is attached to the vulva of the female by one end, which is drawn out into a tubular neck. As soon as this is accomplished, the contents of the capsule begin to flow out, as the result of a sort of histolytic metamorphosis which overtakes the larger part of the inclosed spermatozoa. These swell up to pale spherules, which grow larger and larger, fuse, and finally give rise to a network of polygonal spaces. Meanwhile the inclosed secretion has been gradually expelled, and now forms a slimy mass in the vulva, into which, as a sort of secondary capsule, the remnant of spermatozoa is driven. Oviposition follows. The eggs on their way out of course meet the spermatozoa, and both are carried out together.

In those species of the Calanidæ which have one or a pair of *receptacula seminis*, the phenomena are the same, except that the spermatophores are attached to the pores of these receptacles, and their contents pass into the receptacles, instead of directly into the *vulva*. The spermatozoa find their way into the vulva through connecting ducts, when the eggs appear.

In the Calanidæ, the male catches the spermatophore, as it is extruded, with his fifth pair of limbs, and then places it on the body of the female. The secretion which begins at once to escape from the neck of the capsule serves to fix the latter first to the limb and then to the genital pore of the female [p. 424].

In other families, the male and female lie with their ventral surfaces together; the male seizes with his antennæ the last pair of swimming-legs of the female, then bends his abdomen forward, and fixes the spermatophore directly on the opening of the *receptaculum seminis* by means of a special secretion [pp. 424–25].

c. GAMMARUS. — Della Valle[1] states that the oviducts end blindly, and that what should be the opening at the base of the fifth pair of legs is completely closed, except at the moment of oviposition.

Copulation occurs while the female is still bearing young in her pouch. The young leave the pouch; and the female moults, the male assisting in the operation. The ventral surfaces are together, so that the papillæ of the male are in apposition with the region of the oviducal extremities of the female. As soon as the moulting is finished, ejaculation of spermatozoa occurs: the ova appear half an hour later. The spermatozoa are not inclosed in sperm-cases, but they adhere to the ventral surface of the fifth segment and on the plates of the pouch. The oviducts are forced open by pressure from within, and the ova are covered with a viscid gelatinous mass which binds them and the spermatozoa together. For this abstract I am indebted to Dr. McMurrich.

C. SPENCE BATE. Report on the Present State of our Knowledge of the Crustacea. *Report British Assoc. f. Adv. of Sc.* 1880. pp. 230–32.

d. ASTACUS. — "Copulation of the crayfish takes place, according to the observations of M. Chantran,[2] during a period which includes the

[1] Atti. Soc. Nat. Modena (3), VIII, 1889.

[2] Comptes Rendus, July 4, 1870, LXXI, pp. 42–45; Ann. Nat. Hist., 4th Ser., Vol. VI, p. 265.

months of November, December, and January. The male seizes the female with his large nippers, turns her over, and whilst he holds her lying on her back, places himself in such a manner as to pour out the fecundating material upon the two outer lamellæ of the tail. After this first operation, which lasts some minutes, he conveys her rapidly beneath his pleon, in order to effect a second deposition of semen upon the plastron round the external opening of the oviducts, by means of the curious mechanism so accurately described by M. Coste, upon the plates of the caudal fan. (*Ripisura.*)

"According to the degree of the maturity of the ova at the time of the union of the sexes, oviposition takes place at a period varying from ten to forty-five days after copulation. . . . Immediately after oviposition (which usually takes place during the night, and is accompanied with an emission of mucus for securing the eggs) we may detect in this mucus and water the presence of spermatozoids, precisely similar to those which are contained in the spermatophores attached to the plastron, and derived from them."

These spermatophores still remain attached to the plastron long after oviposition.

"They consist of small white coriaceous filaments, either isolated or mutually adherent; they no longer show anything but a central cavity, in which the microscope reveals only a few more or less withered spermatozoids. The wall of these spermatophores retains its thickness, and remains, as before, composed of a concrete, striated, tenacious mucus."[1]

Fecundation [p. 230] is thus accomplished after oviposition. This is concluded from the fact that spermatozoa are found in the mucus surrounding the eggs, and from the fact that the spermatophores are then empty.[2]

POSTSCRIPT.

Dr. C. T. Hudson, who has recently given us the results of observations continued for upwards of thirty years on the Rotifera, seems to doubt Plate's statements regarding the injection of spermatozoa through the body-wall. In his presidential

[1] Comptes Rendus, Jan. 15, 1872, LXXIV, pp. 201–2; Ann. Nat. Hist., 4th Ser., IX, pp. 173–74.

[2] Cf. A. Lereboullet: *Recherches d'Embryologie comparée sur le Développement du Brochet, de la Perche et de l'Ecrevise.* Paris, 1862. p. 652.

address [1] to the Royal Microscopical Society, referring to Plate's account, he says: "It is not necessary to comment further on this strange theory than to say that Gosse has seen intercourse take place at the cloaca in the case of *Brachionus pala;* M. E. F. Weber, in that of *Diglena catellina;* and Mr. J. Hood, not only in *Floscularia ornata, Synchæta gyrina, Euchlanis triquetra,* and *Melicerta tubicolaria,* but also more than a score of times in *Hydatina senta* itself."

"The frequent presence of spermatozoa in the perivisceral cavity" is, however, one of "the doubtful points" for which Dr. Hudson offers no explanation. No opening is known by which they could reach this cavity. "Neither the oviduct, nor the cloaca, is known to have an opening into the perivisceral cavity, and yet the spermatozoa in several species have been seen in that cavity, *adhering to the outside of the ovary.* How did they get there?"

Plate's observations answer this question, and it will not do to dismiss them as "a strange theory," since the same strange thing is reported from so many different sources.

[1] *On Some Doubtful Points in the Natural History of the Rotifera.* Journal Royal Microscopical Society, February, 1891, p. 6.

EXPLANATION OF PLATE XIV.

LETTERS.

I-XXXIII = somites.
1-66. = number of rings.
al. = alimentary canal.
alc. = gastric cæcum.
b. = brain.
c. = cœlomic cavity leading up to the ovaries.
ca. = cæcal appendage of the ovary.
c.ep. = cœlomic epithelium.
cg. = caudal appendage.
d. = ductus ejaculatorius.
es. = egg-string.
f. = fibrous prolongation.
g. = glandular part of the ejaculatory duct.
gs. = granular secretion.
i. = inner layer of the spermatophore.
lm. = longitudinal muscles.
lu. = lumen of the base of the spermatophore.
nc. = ventral nerve-cord.
n. = nerve.
nph. = nephridial pores.
o. = outer layer of the spermatophore.
œ. = œsophagus.
œg. = œsophageal pair of glands.
ov. = ovary.
p. = proboscis.
phg^1. = first pair of pharyngeal glands.
phg^2. = second pair of pharyngeal glands.
s. = enlarged end-portion of vas deferens commune.
sp. = spermatozoa.
t. = testes.
vd. = vas deferens.
vdc. = vas deferens commune.
vs. = vesicula seminalis.
w. = end of ejaculatory duct.
x. = position of the spermatophore.
y. = course of the spermatozoa.

FIG. 1. — Transverse section of *Clepsine plana*, showing cœlomic cavities filled with spermatozoa (red), which penetrated the epidermis at the level of the point marked ×. The cœlomic cavities communicate with the cavity in which the ovaries (*ov*) lie at the point *c*. Only about one-half of the section is represented in the figure. × 25.

FIG. 2. — A part of one of the following sections, showing the base of the spermatophore and the spermatozoa issuing from it. The arrows show the direction of penetration through the muscular layers. × 120.

FIG. 3. — Section of cœlomic cavities with their peculiar epithelium. × 120.

FIG. 4*a*. — Spermatophore, just placed (3.4 mm. long), and full of spermatozoa. The granular substance issuing from the mouth seems to serve the purpose of preparing the way for the penetration of the spermatic elements. × 55.

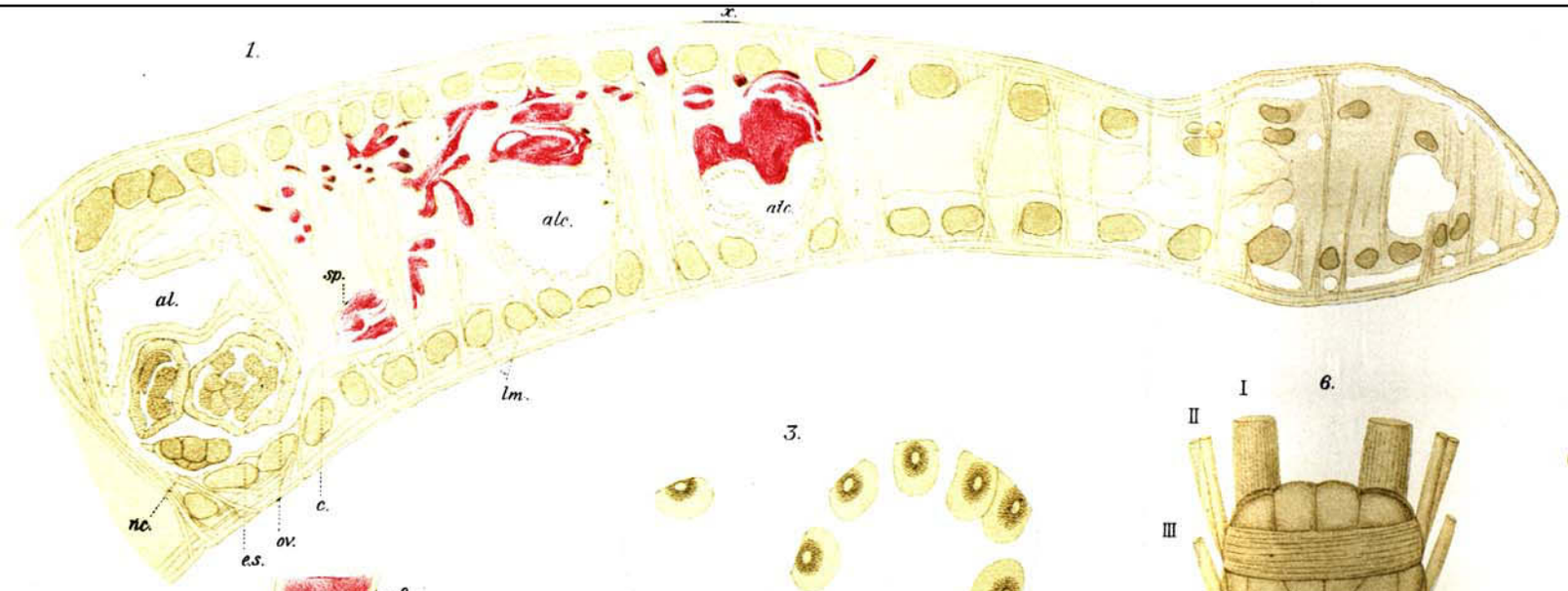
b = section of the case two days after the escape of the spermatozoa; *c* = corpuscles filling the mouth of the spermatophore. × 280.

FIG. 5. — The central nervous system and sexual organs, together with the proboscis, œsophagus, and the so-called salivary glands. × 4½.

FIG. 6. — The supra and sub-œsophageal ganglia, seen from the dorsal side. × 50.

FIG. 7. — The same, seen from the side. × 50.

1.



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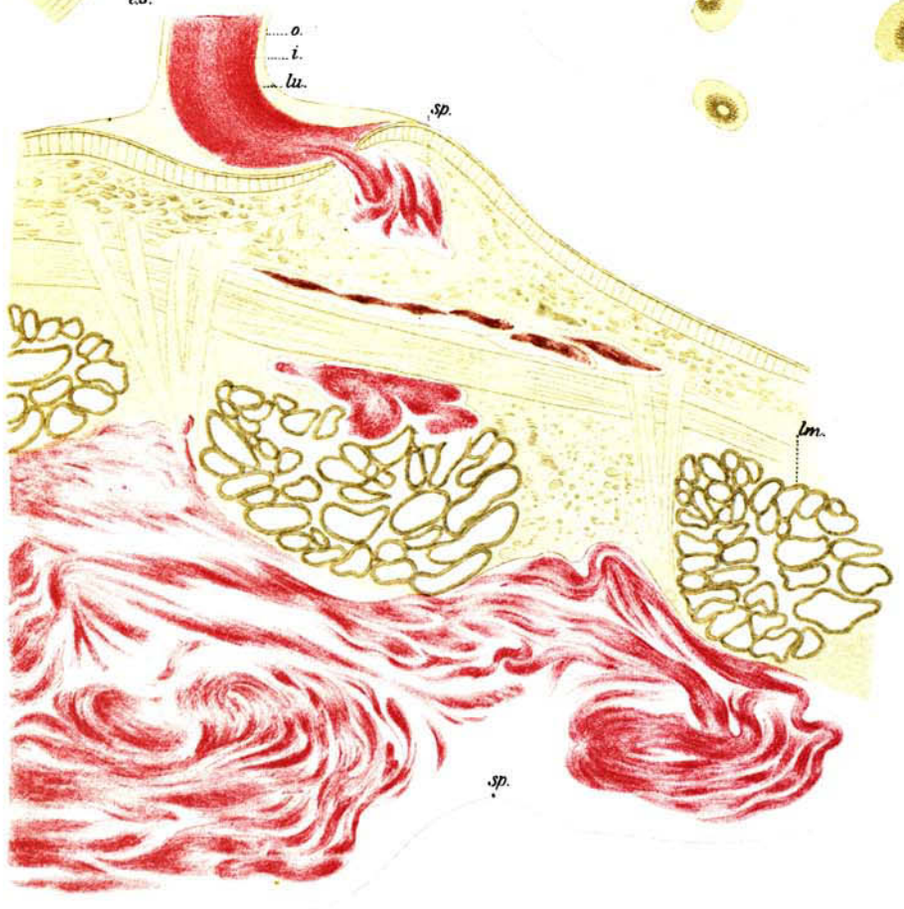

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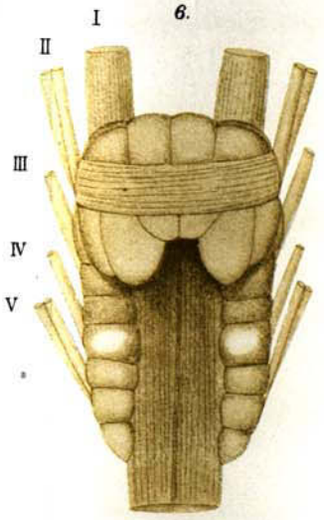

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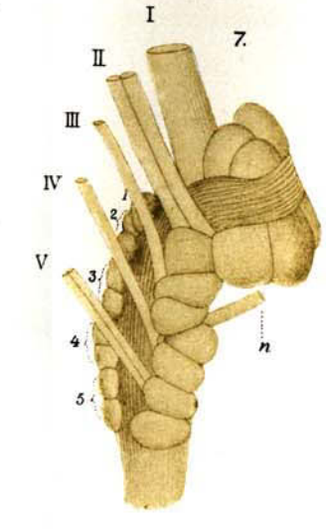

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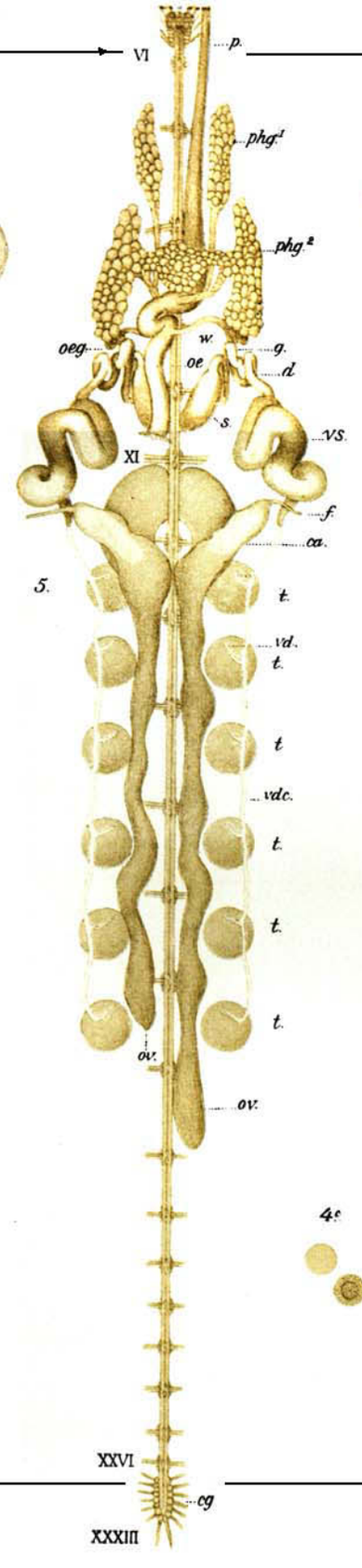

4.

C O Whitman, del.

B Meisel, lith. Boston.