XXXIII.—LECTURE ON THE ORGANS OF REPRODUCTION AND THE FECUNDATION OF FISHES AND ESPECIALLY OF EELS.*

By Dr. Syrski.

INTRODUCTION.

The subject which I propose to speak of on this occasion is "On the organs of reproduction of fishes, and especially of eels", a subject belonging to zoology.

Every one knows what this word means, and its derivation is quite clear, viz, from the Greek word "*zoon*", a living being, an animal, and "*logos*", a word, a rational discourse. Any further definition of this branch of natural science might therefore seem superfluous. And still we hear people call "zoology" what is taught in the lower classes of our "real-schools" as well as what is studied in the higher courses of the university. Most people understand by this name the description of the external forms of animals. In general, by zoology is meant a description of animals.

In the first place, it is only an exposition of some zoological data; in the second place, it is the expression of what is known of the inner life of animals during a certain given period, and indicates a simple period in the development of zoology, the standard of the first and last development, *i. e.*, the genealogical as well as philogenetic and individual development of animals, the conformity of their outer forms to their inner organization, of their functions, of the mutual relations between them and the rest of nature, and finally the manner in which man makes use of them. Zoology therefore embraces *zoogeny*, treating of the origin of animals; *philogeny*, *i e.*, the development of the species; *ontogeny*, also called *embryology*, *i. e.*, the development of the individual being; *morphology*, which treats of the form; *anatomy*, which relates to structure; *physiology*, which concerns itself with functions, and which, in a wider sense, also comprises ontogeny, the geographical distribution of animals, and their uses.

The classification of animals according to their affinities, being nothing but the result of a knowledge of the animals, must therefore naturally be modified as this knowledge increases.

Some also comprise zoology together with botany, mineralogy, geology, paleontology, in some cases even geography, under the common name *natural history*, only applying the designation *natural science* to

* Degli organi della riproduzione e della fecondazione dei pesci ed in ispecialità dello anguille, *in Bollettino della Società Adriatica di Scienze naturali in Trieste*, No. 1, pp. 10-32, December, 1874. Trieste, 1875.

chemistry, physics, and astronomy. But the objects of the first, which consist of organic and inorganic forms and vital phenomena, being nothing but the results of chemico-physical forces, also properly belong to the domain of natural science. My lecture to-day will be confined to the description of the organs of reproduction in fish, in so far as relates to anatomy and in part to physiology.

THE ORGANS OF REPRODUCTION AND FECUNDATION IN FISH IN GENERAL.

The organs of reproduction in nearly all fish are distributed between two individuals, in which the sexes are separate, viz, female and male. So far we know only three species of hermaphrodites, in which the male and female organs are found united in one and the same individual. These hermaphrodites are the well-known "*Perga comune*" (*Serranus scriba*), "*Perga dalmata*" (*Serranus cabrilla*), and the "*Sacchetto*" (*Serranus hepatus*).*

There are three typical forms of the female organs, or ovaries, in fish.

Fig 1.

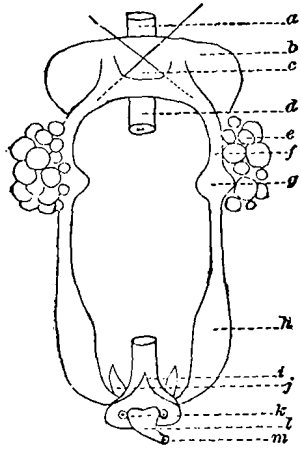

FIG. 1. *Ovaries with oviducts, seen from below.*
a. Œsophagus, front part.
b. Peritonæum.
c. Inner opening, common to the two oviducts.
d. Œsophagus, rear part.
e. Left ovary.
f. Oviduct, front part.
g. Glandula of the oviduct.
h. Uterine part of the oviduct.
i. Intestine, partly split open lengthwise.
j. Urinary bladder.
k. Separate outer openings of the oviducts.
l. Urethral papilla.
m. Outlet of the urethra.

Fig. 2.

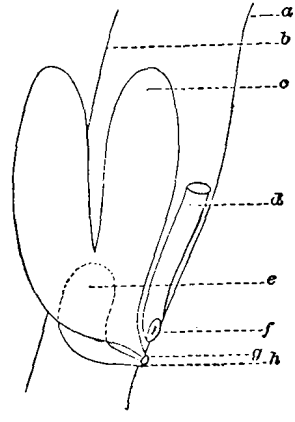

FIG. 2. *Ovaries, seen from the right side of the abdomen.*
a. Abdominal wall.
b. Dorsal wall.
c. Left ovary.
d. Intestine.
e. Urinary bladder.
f. Anus.
g. Genital orifice, with its outlet in the—
h. Urethral orifice.

The *first form* (fig. 1), peculiar to the plagiostomes, among which we mention the "pesci-cani" (dog-fish, or *Mustelus*), the "gatte" (*Scyllium*),

* Hermaphroditism also occurs in the genus Lutjanus or Ocyurus, Poey having discovered a hermaphrodite of his *Ocyurus ambiguus*.—(T. G.)

"squæne" (*Squatina*), "tremoli" (cramp-fish, or *Torpedo*), "rase" (ray, or *Raja*), consists of one or two masses of eggs inclosed in a cellular tissue which resembles that of the ovaries of birds. The eggs, when loosened from the ovary in the abdominal cavity, enter two tubes, placed laterally, called the oviducts, across their inner, common orifice; and in some species, such as the majority of the dog-fishes (*Mustelus*), the cramp-fish (*Torpedo*), &c., develop there till they become perfect animals, while in others the eggs are surrounded by a solid horny shell, and their development is completed in the water. The oviducts debouch in the terminal part of the intestine.

The *second form* (fig. 2), which is the most common among fish, is found in nearly all osseous fishes, and consists of two sacs (one in the "girai," &c.), uniting toward the posterior end in a single oviduct, which discharges outside behind the anus. Of a similar form are also the ovaries of the hermaphrodites, so far known (fig. 3), in the parietes of which are found the spermatic organs, and of which the vasa deferentia discharge into the orifice of the oviduct. The ova contained in such sacs taken from the "volpine" and the "branzini" during the spawning-season are sold by our fishermen under the name of "*Bottarga*".

Fig. 3.

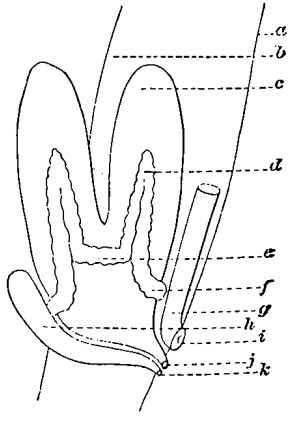

Fig. 4.

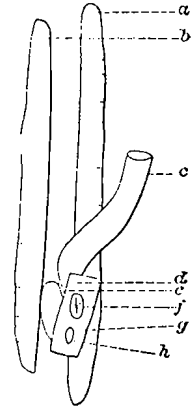

FIG. 3. *Hermaphrodite organs.*

a. Abdominal wall.
b. Dorsal wall.
c. Left ovary.
d. Left testicle.
e. Abdominal commissure.
f. Dorsal commissure.
g. Intestine.
h. Urinary bladder.
i. Anus.
j. Genital orifice.
k. Urethral orifice.

FIG. 4. *Ovaries.*

a. Right ovary.
b. Left ovary.
c. Intestine.
d. Part of the abdominal wall.
e. Urinary bladder.
f. Anus.
g. Genital orifice.
h. Urethral orifice.

In nearly all fish (except the "scarpene," &c.), these sacs have on their inner surface leaflets, placed crosswise or lengthwise, and containing the eggs by thousands, which increase in number and size during the spawning-season, and distend the ovarian sacs.

In some other fishes, the ovaries resemble two ribbons (fig. 4), more or less twisted, running along both sides of the intestine to the dorsal wall of the abdominal cavity, as in the sturgeons, salmons, and also in the eels. The ripe egg, when it separates from the ovary in the abdominal cavity, passes through a hole which opens on the outside behind the anus.

The *male organs* of fish, or spermatic organs, commonly called milts [testicles,] which produce the sperm—*i. e.*, a fluid containing small organic bodies, which, moving about, penetrate the egg, impregnate it, and start the development of the embryo—are likewise of different forms.

In the "pesci-cani" (dog-fish, *i. e.*, *Mustelus*), the "rase" (ray, *i. e.*, *Raja*), &c., the male organs resemble two thin laminæ (fig. 5) elongated, twisted, and partly lobate, composed of partitions, from which small tubes start, which unite and compose a somewhat larger tube, terminating in the right as well as the left side in a canal, which serves for the emission of the sperm.

Fig. 5.

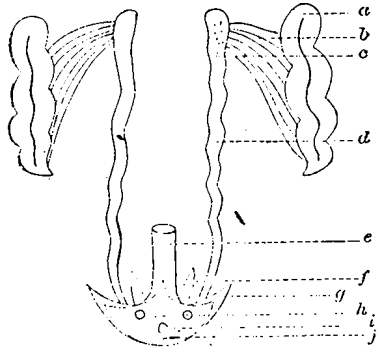

FIG. 5. *Testicles.*

a. Left testicle.
b. Vasa efferentia.
c. Left epididymis.
d. Deferent canal.
e. Intestine.
f. Urinary bladder.
g. Left seminal vesicle.
h. Opening of the deferent canals.
i. Urethral orifice.
j. Cloaca.

Fig. 6.

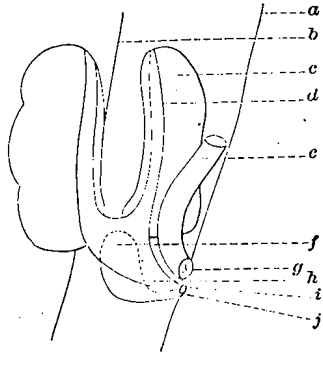

FIG. 6. *Testicles.*

a. Abdominal wall.
b. Dorsal wall.
c. Left testicle.
d. Left deferent canal.
e. Intestine.
f. Urinary bladder.
g. Anus.
i. Genital orifice.
j. Urethral orifice.

In the greater number of *osseous fish*, the spermatic organs consist of two elongated bodies (fig. 6), more or less triangular, or in the form of thin laminæ, composed of compartments, which, beginning on the outer surface, converge toward the interior of the organ, giving rise to a canal called "*vas deferens*", which in many fishes consists of a net-work of conduits; which "vasa", those of the opposite sides uniting, form a single excretory canal, which debouches in many fish first in the urethra, usually on a small papilla placed behind the anus.

In other fishes, the spermatic organs are composed of lobes united by means of vasa deferentia.

Fig. 7.

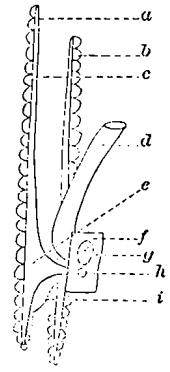

FIG. 7. *Testicles.*
a. Right testicle.
b. Left testicle.
c. Deferent canal.
d. Intestine.
e. Seminal pouch.
f. Part of the abdominal wall.
g. Anus.
h. Uro-genital orifice.
i. Urinary bladder.

In the male eel, these lobes form two lateral rows (fig. 7), extending nearly the whole length of the abdominal cavity.

The eggs of fish (like those of other animals) are, in the beginning of their development, of microscopic size, and consist of a transparent yolk, which incloses the germinal cell (fig. 8). In the state of maturity, however, they differ considerably in size, and in some cases, though rarely, in form, as to their contents, and in their covering.

Fig. 8.

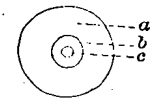

FIG. 8. *Young transparent egg.*
a. Yolk.
b. Germinative vesicle.
c. Germinative dot.

Fig. 9.

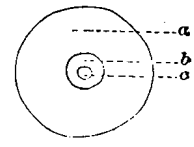

FIG. 9. *Egg.*
a. Yolk.
b. Germinative vesicle.
c. Germinative dot.

Fig. 10.

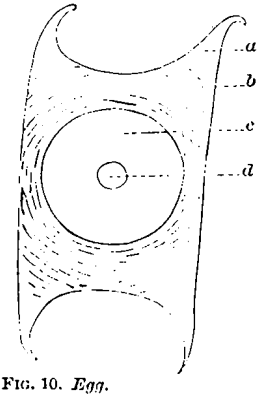

FIG. 10. *Egg.*
a. Corner of the shell.
b. Horney shell of the egg.
c. Yolk of the egg or nutrive yolk.
d. Germinative disk, or yolk of evolution.
e. Gelatinous matter surrounding the yolk in the same manner as the white of the egg in birds' eggs.

The mature eggs of the "pesci-cani" (dog-fish), the "tremoli" (*Torpedo*), &c., which are as large as hen or goose eggs, consist of a yellow yolk inclosed in a membrane, and a germinative disk, measuring about three millimeters in diameter, placed on the surface of the yolk under the membrane, and which contains the germinative cell (fig. 9). From the disk of the fecundated egg is formed the embryo, to which the yolk serves as food.

When the egg has entered the oviduct, it becomes covered with a layer of gelatinous matter, and in the "gatte" (*Scyllium*), "rase" (*Raja*), &c., also with a solid horny case, produced by the glands of the oviduct (fig. 10).

The mature eggs of osseous fish (fig. 11) are about one to six millimeters in diameter, and sometimes even less than one. When they are half-matured, they are of a yellow or white color; and when quite mature, they are almost transparent.

The sperm of fish, commonly called *milt*, is a thick, white liquid, containing innumerable small spermatic bodies, or

spermatozoa, forming the essential part of the sperm, and moving about when in a fresh condition. They consist of an anterior thicker part, the so-called head, and a more attenuated part, or tail.

The spermatic corpuscules vary both in size and shape. In the "pesci-cani" (*Mustelus*), the "rase" (*Raja*), &c., they are larger, with the head more or less fusiform, and the tail more or less spiral (fig. 12).

In the osseous fishes, the spermatic corpuscules are, as a general rule, smaller, with the head rounder, and the tail quite attenuated and filiform (fig. 13).

Fig. 11.

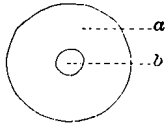

FIG. 11. *Ripe egg of the Pike* (ESOX LUCIUS), *seen from above.*
a. Nutritive yolk.
b. Germinative disk.

Fig. 12.

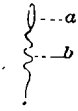

FIG. 12. *Spermatic corpuscle.*
a. The elongated head.
b. The spiral-formed tail.
These corpuscles execute rotary movements with their spiral part, while the other part has a trembling, vibrating, and darting motion.

Fig. 13.

FIG. 13. *Spermatic corpuscle.*
a. Head nearly round.
b. Filiform tail.

The fecundation of the egg consists in the entry of the spermatic corpuscules into the egg (fig. 14), and in the production of a division of the germinative disk, which phenomenon is called the process of segmentation, or furrowing (fig. 15), followed by a series of successive changes, of which the final result is the embryo, which, feeding on the yolk, gradually develops into the perfect fish.

Fig. 14.

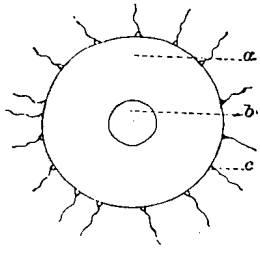

FIG. 14. *Ripe transparent egg of the "Rayno"* (*Weaver*=TRACHINUS RADIATUS), *with spermatic corpuscles.*
a. Yolk.
b. Lump of fat.
c. Supermatic corpuscles.

Fig. 15.

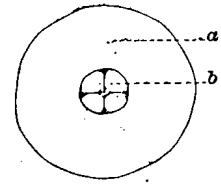

FIG. 15. *Egg after fecundation, during the period of segmentation, or sulcation, of the germinative disk.*
a. Nutritive yolk.
b. Germinative disk, or yolk of evolution, divided into four segments.

The fecundation of the egg is effected in the "pesci-cani" (*Mustelus*) and other viviparous species inside the body of the animal, while in the great majority of fish it takes place outside the body in the water, where the male fish, during the spawning-season, pursues the female, squirting his sperm over the eggs; and this fact makes artificial fecundation and pisciculture possible.

THE REPRODUCTIVE ORGANS OF THE EEL.

Although the eel is one of the most common fishes, it is, nevertheless, one of the least known. As, even up to the present day, only the female of the eel is known, and this even imperfectly, some naturalists have supposed that the females propagate the species without the help of the male, which mode of reproduction actually takes place in some insects, and is called *parthenogenesis;* while others, having recently recognized in a fatty formation, which is found in the abdominal cavity by the side of the ovaries, the male organs of the eel, have declared it be a *hermaphrodite—i. e.*, an animal in which both male and female organs are found in the same individual.

Only a few naturalists have maintained, and as we shall see not without reason, that male individuals must be found among the eels.

Basing their opinion on the reproductive organs, the majority of naturalists have with good reason supposed that the eels are *oviparous* animals, while others, almost exclusively amateurs, have always considered them as *viviparous* animals.

It will be of interest to cast a glance on the endeavors of the more distinguished naturalists to find the ovaries and the spermatic organs of the eel, and on some erroneous assertions with regard to this matter, in order to bring out in bolder relief the object in view, viz, to give through a history of a science an outline of this science.

Aristotle (fourth century before Christ[1]), the greatest naturalist of antiquity, the founder of zoology, recognized the ovaries of the "grongo" (*Conger vulgaris*) by the crackling of the eggs when placed over the fire, but maintained that the eel, notwithstanding that its ovaries resemble those of the "grongo" in every respect, is born from worms produced by mud.

Pliny (first century A. D.[2]), who, in great part, like the majority of his compatriots, only copied Greek works, especially those of Aristotle, differs from him as regards the reproduction of the eel, maintaining that it rubs itself against rocks, and that from the fragments coming off during this rubbing process the young eels are born.

Albertus Magnus (thirteenth century A. D.[3]) accepts Pliny's hypothesis, but says that he has heard that eels are also born alive from eels.

Rondelet (sixteenth century[4]) asserts that eels are born not only from putrefied matter, but also from eggs produced by the copulation of male and female eels.

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[1] *Aristotle:* Περὶ ζώων ἱστορίας, lib. iii, cap. 10, § 1; lib. v, cap. 3, § 2, and cap. 9, § 4; lib. vi, cap. 15, § 1–2, and cap. 16, § 6.

[2] *C. Plinii Secundi* Naturalis historiæ, lib. ix, cap. 51.

[3] *Albertus Magnus:* De animalibus libri viginti sex; written about the year 1254, and published at Venice 1495.

[4] *Rondeletii* Universæ aquatium historiæ pars altera. De piscibus fluviatilibus liber, p. 200, An. 1555.

Conrad Gesner (sixteenth century[1]) attributes the reproduction of eels to putrefying matter, and also to copulation.

Malpighi (seventeenth century[2]), a great anatomist and expert microscopist, declares that the ovaries not only of the eels but also of similar fish, such as the "grongo" and the "murena" (*Muræna helena*), are fatty productions, and calls them "*striæ adiposæ*."

Redi (toward the end of the seventeenth century[3]), who has dissected many eels and "murenas," (*Muræna helena*), and also illustrated as such the ovaries of the last-mentioned fish, nevertheless, does not recognize the ovaries of the eel.

He opposes the hypothesis that the eel can be reproduced from putrefying matter; he proves, moreover, that what are called young eels are nothing but intestinal worms, and that therefore eels are not viviparous animals, but are reproduced by means of eggs in the same manner as other fish.

Leeuwenhoek (toward the end of the seventeenth century[4]), who has occupied himself much with microscopic observations, and was the first who made known the infusoria, having found, in the urinary bladder of an eel, very small parasitic worms, mistook them for young eels, and the bladder itself for the uterus.

Georg Elsner[5] relates that a fish-vender showed him an eel whose uterus was full of young ones, which, to quote his own words, *hærebant in diversis membranis involutæ anguillæ.*

Vallisneri (beginning of the eighteenth century[6]) has given illustrations of the true ovaries of the eel, but, following Malpighi and Redi, calls them *vasi adiposi* [fatty vessels]; and, having accidentally found in an eel a pathologically-deformed swimming-bladder, announced with great joy to the Academy of Bologna and the whole scientific world that he had found the true ovary of the eel.

Linné[7] maintains that eels are viviparous.

Carlo Mundini,[8] professor of anatomy at the University of Bologna, was the first discoverer of the ovary of the eel, of which he gave a detailed description to the Academy of Bologna the 19th day of May, 1777, which, however, was not published till 1783.

Otto Müller[9] writes, in 1780, that he has found eggs in the fringed

[1] *Conradi Gesneri* Historiæ animalium liber iv. Tiguri 1558.

[2] Tetras epistolarum, &c. Dissertatio de Omento, 1665.

[3] Osservazioni intorno agli animali viventi che si trovano negli animali viventi. Florent. 1684.

[4] Arcana naturæ. Epistola 75. An. 1692.

[5] Acad. Cæs. Leopold. Miscellanea medico-physica. Observat. 119, p. 219.

[6] Prima raccolta d'osservazioni &c. Venice, 1710.—De ovario anguillarum. Ephemerides Acad. Nat. Curios. ad Centur. I et II appendix, p. 152, fig. *h*; An. 1712.—La terza volta lo stesso: Nuova scoperta delle uova, ovaje delle anguille &c. nelle opere Fisico-Mediche, raccolta del suo figliulo. An. 1733.

[7] Systema naturæ, 1750.

[8] De anguillæ ovariis. De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii. Vol. vi. 1783.

[9] Schriften der Berliner Gesellschaft naturforschender Freunde. Vol. i, p. 204. 1780.

bodies; but the description which he gives of them being in some respects inaccurate, pre-eminence must be accorded to that of Mundini.

Spallanzani,[1] a distinguished naturalist who lived toward the end of the eighteenth and in the beginning of the present century, basing his opinion on the examination of 497 eels, casts doubts on the discovery of Mundini, remarking "that not content with destroying, he wishes to erect on the Vallisnerian ruins a new edifice." These words, however, lead us to suppose that a certain animosity toward the anatomist Mundini, whom he possibly considered as an intruder among the zoologists, has led his judgment astray. In another place, moreover, he contradicts himself when he adds: "If the masses of little globules were eggs, and if they were found united with the fecundating semen, the eels would be true hermaphrodites."

Rathke,[2] who first, since Mundini, has in detail described (1824, 1838, and 1850) the ovaries of the eel, is considered by some to have recognized them; but this, however, is not true, the additions made by him to Mundini's description being to a great extent erroneous. It is not true that the transverse leaflets are wanting in the ovaries of the eel, as he asserts in his last work, contrary to his former description, which was probably based on the law of analogy, and that thereby they are distinguished from those of the salmon and sturgeon. It is not true, what Rathke likewise asserts, that the genital opening of the eel consists of two small canals, for I have invariably only found one, which opens in the urethra. Rathke has certainly described the eggs quite exactly, distinguishing the larger whitish ones, having a diameter of about one-fifteenth of a line, and the smaller transparent ones, with the germinal vesicle inside; but Mundini likewise says: "*innumeras sphærulas minimas, æquales, pellucidas, divisas tamen, quæ in centro maculam ostendebant ecc. vidi*", thus showing the true nature of the ovaries and the eggs, and contrasting them with the fatty formation and with the ovaries and eggs of other osseous fish.

If, as we have thus seen, it took more than two thousand years to find out, and this even inaccurately, the ovaries, which are much larger than the spermatic organs, it is but natural that it was no easy matter to find these, which resemble two rows of small lobes, about two to three millimeters large, and are of almost glassy appearance, starting from the same place where in the females the ovaries are found, and running both on the right and left side along the whole length of the abdominal cavity.

Mundini[3] and *Spallanzani* have sought the spermatic organs of the eel in vain.

[1] Due opuscoli sulle anguille. Appendice ai viaggi alle due Sicilie. Vol. vi. 1792.

[2] Beiträge zur Geschichte der Thierwelt. Halle, 1824.—Wiegmann's Archiv für Naturgeschichte. Vol. i. p. 299. 1838.—Müller's Archiv für Anatomie, Physiologie, &c. Vol. i, p. 203. 1850.

[3] Memoria autografa del Mundini, del 1788, in the possession of Mr. Gualtiero Sacchetti, engineer.

Hornbaum-Hornschuch,[1] who re-echoes Rathke's erroneous assertions, claims to have found in the fringed bodies of many eels, instead of eggs, round bodies inclosing small granules, and has declared that such eels are male individuals.

Schlüsser[2] was not able to confirm Hornbaum-Hornschuch's assertion.

I have found only once, and that in an eel 390 millimeters long, dissected on the 5th July, in the fringed organs, besides eggs, the above-described small bodies in compartments similar to those of the testicles of eels and other fish.

The rare phenomenon of spermatic compartments and ovarian leaflets occurring side by side, I also found once in *Ophidium barbatum* and *Smaris alcedo*, where the compartments were interlarded with groups of eggs.

Professor Siebold,[3] after having passed in review the different hypotheses regarding the male organs of reproduction in the eel, and having reached a negative conclusion, says that eels may reproduce by means of parthenogenesis, or by being of different sex, or also by being hermaphrodites.

In 1872 was published a memoir,[4] accompanied by an illustrative plate, by Prof. G. B. Ercolani, in which the author distinguishes, as a rudimental testicle, the fat which is found attached to the swimming-bladder between the intestine and the right ovary and the intestine itself, while he calls "true testicle" a sac on the left side, formed exceptionally by the peritoneum, and found in the place which corresponds to the position of the fat on the right side. In the parietes of this sac, Professor Ercolani found fat and self-moving spermatozoa, which movements, however, seem to be nothing else but the molecular movement of the granules found so frequently in the tissues of the animal body. I have, instead of all this, found in the same place a fatty formation, resembling that of the right side, and only in two eels have I found a sac which could be inflated through the genital opening.

The so-called alveolar or proligenous cells of the testicle are, therefore, —as the illustration in Ercolani's article also shows—nothing else than the common and well-known alveolar vessels of the adipose tissue.

In the same year (1872) was published the results of researches by *G. Balsamo Crivelli* and *L. Maggi*,[5] professors at the University of Pavia, who, contrary to the assertions of Professor Ercolani, maintained that the fat on the right side was a well-developed testicle, and that of the left an atrophied testicle. They, too, have therein found, and also given illustrations of, spermatozoa.

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[1] De Anguillarum sexu ac generatione. Gryphiæ, 1842.

[2] De Petromyzontum et Anguillarum sexu. Dorpati, 1849.

[3] Die Süsswasserfische von Mittel-Europa, p. 348. Leipzig, 1863.

[4] Del perfetto ermafroditismo delle anguille. Memoria del Prof. Comm. G. B. Ercolani, nelle Memorie dell'Accademia delle Scienze dell'Istituto di Bologna. Serie iii, tomo i, fascicolo 4. Bologna, 1872.

[5] Intorno agli organi essenziali della riproduzione delle anguille &c. nelle Memorie del Reale Istituto Lombardo di Scienze e Lettere, vol. xii-xiii, della serie iii, fascicola 4. Milano, 1872.

I have found similar formations in almost all eels, usually more developed on the right side than on the left, sometimes fringed, as shown in the illustration accompanying Ercolani's article, or with long borders, as shown in Professor Maggi's illustration, but always of a structure which is, so to speak, typical of adipose tissues.

Recently there appeared in No. 7 for the year 1874, of the German periodical "*Die Gartenlaube*", an article, accompanied by an illustration, which represents a pseudo-embryo of an eel of the length of 24 millimeters, with the head and eyes very large, the belly swollen, and a yellow yolk-sac, described by Dr. Eberhard, of Rostock, who says that he received it in December last from a student, who again had got it from a woman who had found in the abdominal cavity of an eel a net-like sac containing about a thousand similar embryos. This story reminds one of that told more than a century ago by George Elsner.

With regard to this matter, Professor Grube, at a session of the Society of Natural History in Breslau (Prussia), expressed himself in the following manner:—

"The journals have recently brought us from Rostock the intelligence that an eel had given birth to living young ones. Similar statements have been made in former times, but afterward corrected, to the effect that the parasitic worms which are frequently found in the abdominal cavity or, in the urinary bladder, had been mistaken for young eels. The statement, however, which has come to us from Rostock owes its origin to the fact that a really viviparous fish, the *Zoarces viviparus*, has been mistaken for an eel, as was proved when the supposed young eel was sent to me by Professor Aubert. Young eels have never been found in the bodies of mother eels."

During the month of March or April of this year (1874), there appeared in the Miscellanea of the "Neue Freie Presse" of Vienna, a notice entitled "The reproduction of eels", where it is stated, "Not unfrequently persons ignorant of zoology believe that they have found in the bodies of eels young living eels, which, however—as was recently brought out strongly by Professor Münter, director of the Zoological Museum of Greifswald—when subjected to the critical examination of competent persons were found to be intestinal worms. The above-mentioned professor observes: 'It is not difficult to find in the eels of the Baltic Sea curled ovaries resembling a drapery; I myself [Münter] having invariably found ovaries in about 3,000 eels examined by me for that purpose. Unfortunately, my numerous observations have never yet been rewarded with the discovery of a male eel—*i. e.*, a milter; all the eels examined by me with all possible care for a number of years having turned out to be females. I must therefore admit that eels are reproduced by parthenogenesis, *i. e.*, from non-fecundated eggs, as is the case with some insects. In all probability, the eggs are deposited at the bottom of the Baltic Sea from the middle of March to the middle of April, and the young eels, one-half to two inches long, born from such eggs, migrate into fresh water about the beginning of May.'"

Thus but few results have been obtained with great difficulty in all the numerous researches, and the observations have frequently been erroneous. This historical review is also, from an anthropologic point of view, very instructive, showing that not only the masses of the people but also highly intelligent and cultivated men are liable to err.

I commenced my investigations on the 29th November last year (1873), and already in the second eel which I dissected on that day I found the testicles, and therefore a male individual of the eel. I sent in March of the following year (1874) to the Academy of Sciences in Vienna a preliminary communication, which was read at the public session held the 15th April, and printed in the Reports of the Academy.

Having in the course of my investigations met with similar errors regarding the female organs of reproduction in the descriptions hitherto given of them, with the view of rectifying and completing the details, and also for the purpose of comparison with the male organs, I determined to commence by describing the former, *i. e.*, female organs.

THE OVARIES OF THE EEL.

These organs (fig. 16), two in number, are ribbon-shaped, with leaflets on their outer face, and with transverse folds. In the natural position of the live fish, the one extends to the left and the other to the right of the alimentary tube, following most of its angles nearly the whole length of the abdominal cavity to the place where the dorsal parietes is confluent with the lateral.

The right ovary commences at a point nearly corresponding to that where on the outside the right pectoral fin ends, and the left ovary commences about two centimeters and ends three to four centimeters behind the former. They extend three to six centimeters back of the anus, into the caudal part of the animal's body; they do not, however, unite in a single body, as some have asserted, but both are toward the end inclosed in a peritoneal membrane, and are separated from each other by the union of these membranes, having each on their inner face an accessory ovary (*pars recurrens ovarii*). In rare cases is such an accessory ovary wanting either on the right or on the left side.

The ovaries in fully-grown eels are in the middle about two centimeters larger, and posteriorly terminate in a thread-like form. They are not smooth on both sides, but have, as was said above, on their outer side numerous transverse folds (fig. 17) full of eggs (fig. 18).

It is another of Rathke's erroneous assertions, likewise maintained by others, that the genital opening through which the eggs pass out from the abdominal cavity is formed by two holes, a right one and a left one. I have invariably found in all specimens examined a simple hole, which communicated with the right and left half of the abdominal cavity by means of a transverse fissure between the straight intestine and the urinary bladder (*fissura recto-vesicalis*) and opens in the urethra (fig. 19).

Fig. 16.

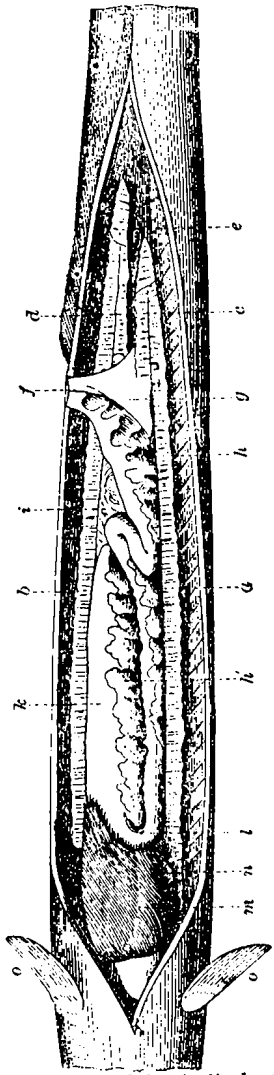

FIG. 16. *Female eel, longitudinal section of the abdomen; natural size.*

a. Right ovary.
b. Left ovary.
c. Accessory part of the right ovary.
d. Left accessory part.
e. Dividing membrane.
f. Anal depression.
g. Urinary bladder.
h. Fat on the right side erroneously taken for the testicles by some.
h'. Similar fat, covering the stomach.
i. Fat on the left side.
k. Stomach.
l. Pylorus.
m. Liver.
n. Gall-bladder.
oo. Pectoral fins

Fig. 17.

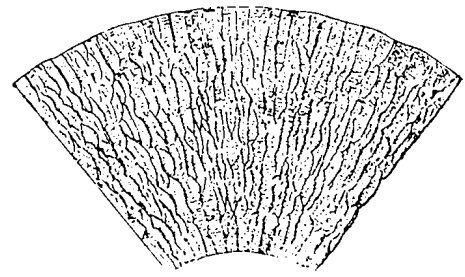

FIG. 17. *Piece of the ovary, twice its natural size, with ovarian leaflets arranged in transversal rows, on its outer surface.*
The shorter border attached to the dorsal wall of the abdominal cavity; the longer being free.

Fig. 18.

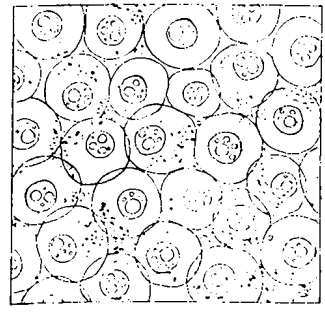

FIG. 18. *Piece of a somewhat developed ovary, one hundred times the natural size, showing the transparent eggs with the germinative vesicles and the germinative dots.*

Fig. 19.

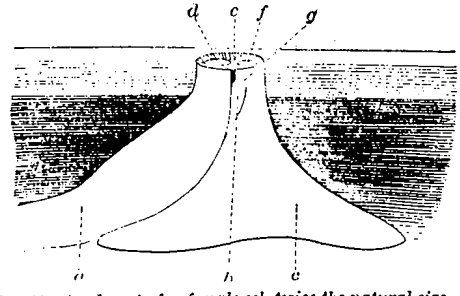

FIG. 19. *Anal part of a female eel, twice the natural size.*

a. Straight intestine.
b. *Fissura recto-vesicalis.*
c. Urinary bladder.
d. Anus.
e. Partition.
f. Uro-genital opening.
g. Outlet of the genital opening in the urethra.

It is generally admitted that the eggs, when loosened from the ovaries, fall indiscriminately into the abdominal cavity, but it is not said which way they take in order to go out through the genital aperture. As I have invariably found that the fully-developed ovaries lean with their outer surface against the side of the abdominal cavity, and approach with their free edges the lower portion of this side, forming, so to speak, a furrow, I must conclude that the loosened eggs descend between the abdominal partition and the folds and leaflets of the ovary in the above-mentioned furrow, and from it pass to the genital aperture without scattering in the abdominal cavity.

As to the development which the ovaries undergo, I have observed, from the end of November till the beginning of March, in many adult eels, of the length of 530 millimeters and more, that the ovaries were of the breadth of 15 to 25 millimeters, and of a yellowish and sometimes reddish-white color, produced by the development of adipose tissues and of the blood-vessels, and not by the eggs filled with little globules of fat; the genital aperture and the *fissura recto-vesicalis* were open.

In other eels of a length sometimes of 600 millimeters and more, I found the ovaries less broad, with but little fat, and of a mucous and almost glassy appearance, so that I could discern the so-called vesicles and germinative dots (*nuclei* and *nucleoli*); the genital aperture and the *fissura recto-vesicalis* were closed.

The ovaries of young eels, of the length of about 500 millimeters, contained invariably but little fat, and the eggs were without globules. The gradual growth and enlargement of the ovaries go on simultaneously with the opening of the genital orifice. According to the quantity of fat contained in the ovaries, they have a mucous and glassy, or more or less opaque or white, appearance, or have small shining white dots.

From the end of March till October, I found in the majority of eels which I examined, measuring 600 to 700 millimeters in length, that the ovaries were scarcely white, and that the genital aperture was closed.

The number of eggs contained in both developed ovaries reaches, according to my calculation, five millions. The larger eggs measured by me had a diameter of one-fourth to one-fifth millimeter, while the eggs of an adult "grongo" (*Conger*) had, according to my measurements, a diameter of one-third of a millimeter, and those of the "murena" (*Muræna helena*) almost one millimeter, which explains to me why the ovaries of the two last-mentioned species of fish have long since become known.

In an eel measuring 590 millimeters, examined on the 6th July, the left ovary was entirely wanting, and replaced by a mass of fat.

THE SPERMATIC ORGANS.

The position of these organs, (fig. 20), which are not ribbon-shaped like the ovaries, but represent two longitudinal rows each with about fifty lobules (fig. 21) of the width at most of three millimeters, and found

only in eels not more than 430 millimeters long, corresponds entirely with that of the ovaries. In these organs are likewise found, toward the posterior end, the spermatic accessory organs (*partes recurrentes*), which, however, as is the case with the ovaries, are sometimes wanting.

The spermatic organs can be distinguished at the first glance from the ovaries of the adult eels and those of young eels, not only by their lobular form, but also by their shining glassy appearance, by the surface of the individual lobes, which is smooth and without leaflets, and by the much greater density of the tissue, so that with a pair of pincers one can take off a large portion of the organ, which could not possibly be done with a more developed ovary whose tissue is as tender as a cobweb, and is composed of small vessels formed of a thin membrane and filled with eggs and fat.

The fibrous tissue of the spermatic organs is composed of vascular compartments with thicker partitions, inclosing, according to the development of the organ, granular globules (fig. 22).

These compartments are joined toward the inside and the base of the lobes, which are united to a tube (*vas deferens*), which, cæcal at the commencement, runs along the entire length of the abdominal cavity, and opens near the straight intestine (*rectum*) in a triangular pouch, which likewise contains a *vas deferens* starting from the caudal part of the spermatic organ. This pouch has its outlet in the genital orifice, which opens in the urethra (fig. 23).

As regards the development of the spermatic organs, I have observed that the lobes of these organs in young eels, measuring not more than 200 to 300 millimeters in length, are not yet very distinct, forming two thin ribbons differing but little from ovaries of the female in their average size. In eels measring about 400 millimeters in length, the testicles can easily be distinguished from the ovaries. The former, much straighter, and with tissue, as has been already remarked, much more solid, are provided with

Fig. 20.

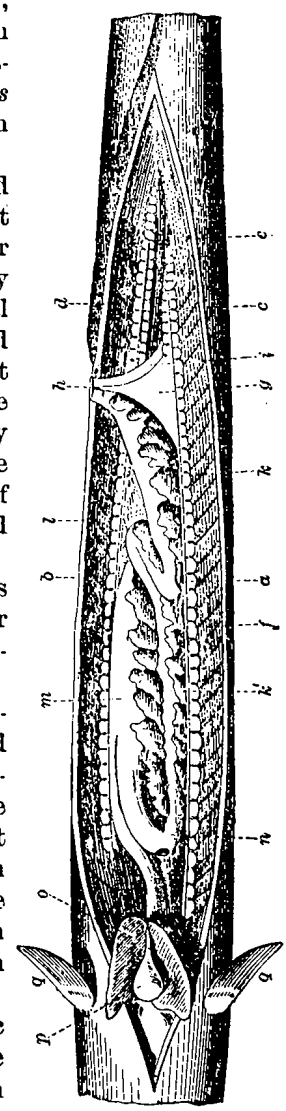

FIG. 20. *Male eel (natural size).*

a. Right testicle.
b. Left testicle.
c. Right accessory part.
d. Left accessory part.
e. Dividing membrane.
f. Deferent canal.
g. Seminal pouch.
h. Anal depression.
i. Urinary bladder, covered to a great extent by the seminal pouch.
k. Fat on the right side.
k'. Similar fat covering the stomach.
l. Fat on the left side.
m. Stomach.
n. Pylorus.
o. Liver, turned up to show the inner surface adhering to the œsophagus and the stomach.
p. Gall-bladder.
qq. Pectoral fins.

a much more developed net-work of vessels; their lobes are very distinct, and the deferent canals are usually open, while the ovaries present the appearance of two continuous ribbons, have a more delicate tissue,

Fig. 21.

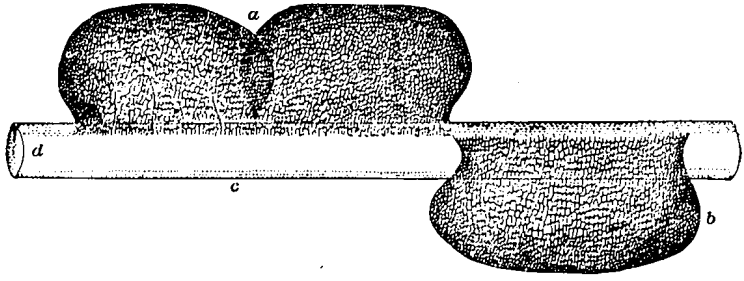

FIG. 21. *Three lobes of the right testicle, with the deferent canal (enlarged ten times).*

a. Lobes, seen from their outer surface.
b. Lobe, seen from its inner surface.
c. Deferent canal.
d. Anterior part of the same.

and an almost mucous appearance, and contain the eggs with the germinative vesicles.

The deferent canals and the genital orifice are closed in young eels of the male sex, and open simultaneously with the development of the lobes.

In the male eels examined by me from March to October, I have found individuals of 400 millimeters and more in length, whose genital orifice and deferent canals were invariably open, while in some of the smaller ones they were closed and in others open.

Fig. 22.

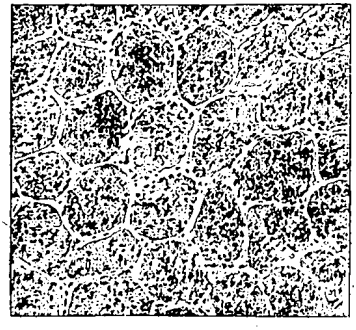

FIG. 22. *Piece of the testicle (one hundred and sixty times enlarged), showing the vascular tissue and the small granules.*

Fig. 23.

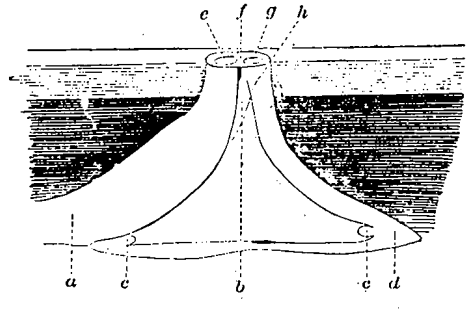

FIG. 23. *Anal part of the male eel, enlarged twice.*

a. Straight intestine.
b. *Fissura recto-vesicalis*, covered by the outside wall of the seminal pouch.
cc. Outlet of the anterior and posterior part of the deferent canal in the pouch.
d. Urinary bladder.

Of the 258 eels examined by me, the males and females were in about even proportion; the greatest length of the former was about 430 millimeters, while the latter were of all sizes up to 1,050 millimeters, which shows that the males are smaller than the females.