IV.—THE EEL QUESTION.

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[From "Der Fischfang in der Lagune von Comacchio nebst einer Darstellung der Aalfrage. Von Dr. L. Jacoby." Berlin, 1880.]

I.

HISTORY OF THE EEL QUESTION.—ANTIQUITY (ARISTOTLE).—MEDIEVAL AND MODERN FABLES REGARDING THE EEL.—HISTORY OF THE DISCOVERY OF THE FEMALE EEL.—DESCRIPTION OF ITS OVARIA.

"Among all the animals that surround us the eel is the only one which has never unveiled the secret of its propagation even to the most persevering investigators." This assertion, made almost forty years ago by Martens in his work "Italien," is true to some extent even at the present day. To a person not acquainted with the circumstances of the case it must seem astonishing, and it certainly is somewhat humiliating to men of science, that a fish which is commoner in many parts of the world than any other fish, the herring perhaps excepted, which is daily seen in the market and on the table, has been able, in spite of the powerful aid of modern science, to shroud the manner of its propagation, its birth, and its death, in darkness, which even to the present day has not been completely dispelled. There has been an eel question ever since the existence of natural science.†

To the ancient Greeks the eel seems to have been a strange mystery. Even in very ancient times people were astonished to find that, whilst all other fish at certain seasons of the year contained eggs and semen—spawn and milt—such were never found in eels, although many thousands were opened for culinary purposes. A proof that the ancients at a very early time took an interest in this question is found in the jocose remark made by several Greek poets, that, since all children whose paternity was doubtful were ascribed to Jupiter, he must be considered as the progenitor of the eels.‡

*Die Aalfrage. Von Dr. L. Jacoby.—Translated by Herman Jacobson.

†"Non mediocre Philosophis ac Naturæ scrutatoribus negotium facessere semper est visa Anguillarum procreatio." (The procreation of the eel has at all times been a difficult problem for philosophers and naturalists.) With these words Cajetan Monti begins his article on the procreation of the eel in the "Transactions of the Academy of Bologna," 1783.

‡"Hæc fuit nimirum causa, cur Græci quidam poëtæ, quasi per jocum quod certus earum stirpis auctor deesset, Jove natas dixerint."—Cajetan Monti in the treatise quoted above, p. 393.

Aristotle is the first among the ancients who expressed a definite opinion regarding the origin of the eel. This great philosopher and investigator, whose knowledge concerning many questions of natural history has been corroborated by the discoveries of modern times, unfortunately expressed the most singular and primitive views regarding the eel question. In his "Natural History of Animals" he says:* "Among the articulates and among the fish there are some which in no respect show any difference of sex. Thus the eel is neither male nor female and is procreated from nothing. Those, however, who maintain that occasionally eels are found which contain worm-like objects speak without reason, because they have not seen where the eels carry these objects; for no other animal produces young without eggs; but no eel has ever been found to contain an egg." And in another place he says:† "Eels are not produced by copulation, nor do they lay eggs. No eel has ever been found to contain semen or eggs; and when eels have been opened neither seminal nor ovarian ducts have been discovered. Among all the animals having blood the eel is the only one which does not originate from copulation or eggs. It is evident that this is a correct statement, for eels will make their appearance in marshy lakes, even after all the water has been allowed to flow out and the mud has been taken out, as soon as rain-water begins to fill such lakes. In dry weather they will not be produced, not even in lakes which are full of water all the time, for they live on rain-water. It is therefore evident that they originate neither from procreation nor from eggs. Nevertheless some people think that they produce live young ones, because intestinal worms have been found in some eels, which these people think, are the young of the eel. This, however, is an erroneous opinion, for they are produced from the so-called 'bowels of the earth,'‡ which are spontaneously produced from mud and moist soil."

Considering the high esteem in which Aristotle was held among the ancients, and still more in the Middle Ages, it will not be astonishing that these marvelous statements were believed and embellished by a number of other fables and legends, many of which are current among the common people to this very day. There is in fact no other animal regarding whose origin and life so many erroneous opinions are prevalent as the eel. These opinions, some of which are entirely fabulous, whilst others are within the range of possibility, but have been proved to be wrong, may be divided into three groups.

The first comprises those opinions which, based on Aristotle's descriptions, supposed the eel to be procreated not directly from the mud of the earth, but from a slimy mass, which is said to be produced when eels, which otherwise show no difference of sex, rub their bodies against each

*Book IV, chapter 11.

†Book VI, chapter 16.

‡Aristotle understands by these "bowels or intestines of the earth," the earth-worm (*Lumbricus terrestris* L.), as appears from his treatise on the procreation of animals.

other. This opinion was held by Pliny, by Athenæus, and Oppian, and was again taken up in the sixteenth century by Rondelet, and later by Conrad Gessner.

The second group comprises the opinions held by people who accidentally found worm-like organisms in the entrails of the eel, who described these, and therefore considered the eel as an animal producing live young ones. Although even Aristotle rejected this opinion as erroneous, and rightly supposed that these worms were nothing but intestinal worms, there have been discoverers of live young eels up to the present time. I find this opinion in the Middle Ages in the "Thierbuch"—book of animals—by Albertus Magnus, and later in the works of naturalists like Leuwenhœk, Elsner, Redi, and Fahlberg. Linné likewise inclined towards this opinion, and maintained that the eel produced live young ones. A few years ago a professor at the gymnasium (college) of Rostock published an article in the "Gartenlaube,"* in which he gave a rapturous description of the young eels discovered by him in a female eel, and the same opinion was again advanced by others during the summer of 1877. It is quite natural that persons who are not versed in natural history, and who, on opening an eel, find in its inside a more or less considerable number of live worm-like beings, are at once inclined to consider them as the young of the eel. It must be stated, however, that whenever such so-called young eels were subjected to a scientific examination, they turned out to be intestinal worms.†

The last group comprises the opinion that eels are born, not from *eels* but from *other* fish, and even from other animals. Absurd as this opinion is—which in a certain sense must also be traced back to Aristotle—it is very common, even at the present day, among all eel fishermen, especially those living on the coast near the mouths of rivers. A slimy fish—the *Zoarces viviparus* L.—owes the name by which it is commonly known—the "Eel-mother"—to this opinion. In Comacchio I have again met with instances of the inexterminable belief of the fishermen that the eel is born from other fish. They even go so far as to point out certain differences in the color and shape of the *Mugil cephalus* as the causes of the different color and shape of eels. It is a very old opinion, prevalent to this day, that eels copulate with water snakes, but it seems incredible, and is nevertheless a positive fact, that the Sardinian fishermen consider a beetle, the *Dytiscus Roeselii*, as the procreator of the eel. They very generally call this beetle "Eel-mother."

No scientific investigation of the question of the procreation of the eel could be made until, towards the end of the Middle Ages, the influence which Aristotle had hitherto exercised over the opinions of all learned men began to wane. At the revival of natural sciences in the sixteenth century naturalists took up this special question with

*Volume for 1874, p. 120.

†Most of the worms inhabiting the intestines of the eel belong to the species *Ascaris labiata*.

great zeal, and we have treatises on the procreation of the eel by the most famous naturalists of that period, such as Rondelet, Salviano, Aldrovandi. This (the sixteenth) and the following century, however, did not get beyond the discussion regarding young ones said to have been found in eels. I have already mentioned some of the naturalists who held this opinion. Franz Redi and Christian Franz Paullini, both living in the seventeenth century, were the first who, without, however, having made personal observations, expressed the opinion that eels had both semen and eggs, and that their procreation differed in no wise from that of other fish.

It was reserved for the eighteenth century at last to discover at least the female organs of the eel, and settle this part of the question definitely. It is an interesting fact that Comacchio has been the birthplace of many erroneous opinions, and of the final truth in this matter.

Dr. Sancassini, a learned physician of Comacchio, who, in the year 1707, visited one of the eel-houses, found an eel whose stomach appeared considerably bloated. He opened it and found inside an organ closely resembling an ovarium, which contained what appeared to him mature eggs. He preserved this eel and sent it to his friend, the famous naturalist, Professor Vallisneri, of the University of Padua, who carefully examined the organ and rejoiced that he had at length found the ovarium of the eel. He wrote a learned treatise on the subject* and sent it to the Academy of Bologna. Strong doubts as to the correctness of this discovery were immediately raised, especially outside of Italy. These doubts seem to have been shared by Professor Valsava, the first anatomical authority of Bologna, especially when soon after another Comacchio physician, Dr. Francesco Bonaveri, author of a "History of Comacchio," sent an eel to Bologna, which in every respect resembled the one described by Vallisneri.† The discussion grew quite animated, and the Bologna scientists seemed actually possessed with a passionate desire to discover the ovaria of the eel. Prof. Pietro Molinelli had promised several fishermen of Comacchio whom he knew a large reward if they would get him a pregnant eel; and in 1752 a fisherman brought him a live eel, whose stomach was very much bloated, and which, when opened by him in the presence of a friend, was found to be full of eggs. The great hopes connected with this discovery were, unfortunately, not realized, for it turned out that the sly fisherman had previously opened the eel and stuffed it with the eggs of some other fish. The eel question entered upon another and more successful stage when, in the beginning of the year 1777, a third eel, resembling the two former ones, was caught near Comacchio. Luigi Bonafede sent it to the Academy of

*Published with illustrations at Venice in 1710, and also in 1712, under the title "De ovario anguillarum" in the "Ephemeriden der Leopoldinischen Akademie der Naturforscher."

†Bonaveri says in his "History of Comacchio" that he is fully convinced of the correctness of Vallisneri's idea and discovery.

Bologna, which handed it over to Prof. Cajetan Monti. As he was sick and could not in person superintend the investigation, he called a number of his scientific friends together for a consultation on the subject. There were present at his house, among others, the anatomists Carlo Mondini and Germano Azzoguidio, the famous discoverer of galvanism, then an unknown student, Camillo Galvani, whose eminent scientific talents are specially mentioned in the report.* The eel was examined by all the persons present at this conference, and recognized as closely resembling the one described seventy years previous by Vallisneri. It was finally unanimously resolved to request the famous anatomist Mondini to make a thorough examination of this precious fish. He entered upon his work with great zeal, and the paper which was its result was read at the academy in May, 1777. This treatise is entitled "De anguillæ ovariis," but was not published till six years later in the "Commentarii," &c., of the academy.† Mondini, first of all, showed in the most convincing manner that the supposed ovarium described by Vallisneri had been nothing but the swimming-bladder of the eel distended unnaturally by sickness, and that the small round grains which had been mistaken for eggs were only swelled glands. Mondini at the same time published an accurate description, accompanied by excellent illustrations, of the true ovaria of the eel discovered by him. This work, which contains a very fine illustration of the magnified eggs, may, both as to form and contents, be termed a standard work; and it is an act of historic justice to say that it was not O. F. Müller or Rathke, but Carlo Mondini, who first discovered and described the female organs of the eel, which for centuries had been sought after in vain.‡ Three years later, and as it seems independently of Mondini, the eminent zoologist, Otto Friedrich Müller, published his discovery of the ovaria of the eel in the publications of the Berlin Society of Naturalists.§ A peculiar

* Monti (p. 393) calls him "præclara indole adolescens, ad naturalem historiam excolendam natus" (a young man of remarkable talents, born for the study of natural sciences).

† De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii. Tomus VI. Bononiæ, 1783, p. 406. *et seq.*

‡ Prof. G. B. Ercolani, of Bologna, and Professors Crivelli and Maggi, in articles published by them in 1872, very justly complain that the priority of Mondini's discovery had been overlooked in Germany. Neither Rathke, nor Hohnbaum-Hornschuch, nor Schlüser have mentioned his work. S. Nilsson, in his "Skandinavisk Fauna," 1855, knows nothing of Mondini. In his "Histoire naturelle des Poissons" he mentions O. F. Müller and Cuvier as the first who had described the ovaria, and Rathke as the first discoverer of the eggs. As far as I know, Th. von Siebold was the first who, in 1863, in his work, "Die Süsswasserfische von Mitteleuropa" (p. 349), mentioned that Mondini had discovered the ovaria of the eel almost simultaneously with O. F. Müller, and that the two discoveries had been entirely independent of each other. The erroneous opinion that the Italian discovery had been made after the German is easily explained by the fact that Müller's treatise was published in 1780, and Mondini's, though written and read in 1777, not till 1783.

§ "Schriften der Berlinischen Gesellschaft naturforschender Freunde," vol. i, 1780, p. 204, article entitled "Bemühungen bei den Intestinalwürmern"

fate awaited the discovery of Mondini at the hands of Lazzaro Spallanzani. This famous naturalist, in October, 1792, undertook a journey from Pavia to the Po lagoons, near Comacchio, for the sole purpose of studying the eel question in that locality. He spent the greater part of the autumn in Comacchio, but did not discover anything new, whilst in the published description of his journey * he entirely rejected Mondini's discovery, and maintained that the ovaria which Mondini had described were in reality nothing but the unusually fat folds of the diaphragm. It is probably this absolutely negative result of the investigations made by so famous a naturalist as Spallanzani which deterred others for some time from any further investigations of the eel question, and which made all that had been so far discovered appear doubtful and fall into oblivion. When, therefore, Professor Rathke, of Königsberg, in his large work on the generative organs of fish, 1824,† described the ovaria of the eel as two organs resembling frills, extending along both sides of the backbone, and described them a second time‡ in an article in "Wiegmann's Archiv für Naturgeschichte," 1838, he was generally in Germany, even to the present day, considered as the discoverer of the ovaria of the eel. The first drawing of the ovaria after Mondini, and the first microscopic drawing of the eggs of the eel, were given by Hohnbaum-Hornschuch in a dissertation published in 1842,§ which will always occupy a prominent place in the literature of the eel question. The question regarding the ovaria of the eel was definitely settled by Rathke, who, in 1850, published an article in "Müller's Archiv" on a pregnant female eel examined by him, the first and only specimen of a pregnant eel which so far had been seen by a naturalist.‖

It will be proper to give in this place a short description of the ovaria of the eel. If an eel be opened along its lower side from the breast to a point behind the anus, there is seen besides the entrails and stomach, and underneath the back part of the liver, the long swimming-bladder, growing narrower toward both ends, and extending on the one side as far as the diaphragm, and on the other a little distance beyond the anal opening. Along both sides of the swim-bladder there extends a white or yellowish band, tolerably broad and shaped exactly like a frill, whose inner edge is attached to the swim-bladder by a narrow skin, a duplicature of the inner skin of the abdomen, but whose other edge hangs down free in the abdominal cavity. Each of these frill-like bands extends forward

* Lazzaro Spallanzani: "Opusculi due sopra le anguille, dove singolarmente si ragiona di quelle che si pescano nelle valli di Comacchio." Opere. (Milan edition, 1826.) Vol. iii, p. 518.

† "Neueste Schriften der Naturforschenden Gesellschaft zu Danzig," vol. i, part 3, Halle, 1824. "Ueber den Darmkanal und die Erzeugungsorgane der Fische," von Dr. Heinrich Rathke, p. 122.

‡ Wiegmann's Archiv, 1838, i, p. 299.

§ "De Anguillarum sexu ac generatione." Inaugural dissertation by Reinhold Hohnbaum-Hornschuch. Greifswald, 1842.

‖ Müller's Archiv, 1850, p. 203.

to the fore part of the liver, passes along the whole abdominal cavity, and ends a little distance back of the anal opening, with which, however, it is in nowise connected. In these bands, which contain a great deal of fat, numberless eggs are imbedded. By tearing a little piece of this band with a pin and carefully wiping off the small drops of fat, one can recognize the eggs with the naked eye as very small white dots. The microscope, however, will distinctly reveal their form and inner construction. They are generally round, surrounded by a skin, which forms a clear transparent ring—the *zona pellucida*. Inside of this skin there is a large mass of small grains, the yolk of the egg. In the larger eggs nothing but these grains is seen, especially when the eggs have lain in water for some time, because then the small grains composing the yolk have congealed and become opaque. But if one takes from the same ovarium the smaller and less developed eggs, one may very distinctly recognize the small and entirely colorless bladder, called the Purkinjean vesicle. There can, therefore, be no doubt that we have before us the ovaria and eggs of the eel. The fact that it took several centuries of eager search to discover these ovaria is, to some extent at least, explained by the circumstance, that up to the present day all attempts to discover larger and more developed eel-eggs have proved futile. It is well known that there were no good microscopes till about thirty years ago. Even the eel which was examined by Rathke, the only pregnant eel which has been found, although its distended ovaria filled the whole abdominal cavity, contained only very small eggs, the largest measuring .1 millimeter in diameter. Larger eel-eggs, on the point of cutting loose from the ovaria and turning to young eels, have still to be discovered.

Running alongside of each of the two ovaria, extending through the abdominal cavity of the eel, there is nearly always an irregular band of fat, with many points, developed more on one side than on the other; this is a fold of the inner skin of the abdomen.

II.

HISTORY OF THE EEL QUESTION (CONTINUED).—DISCOVERY OF THE MALE EEL.—DESCRIPTION OF THE MALE ORGANS.—OUTWARD DISTINCTIONS BETWEEN MALE AND FEMALE EELS.—THE EEL QUESTION IN GERMANY IN 1877.

No less interesting than the history of the discovery of the ovaria of the eel, is the history of the researches for the male organs of the eel, although it is not many years old.

In the above-mentioned dissertation by Hohnbaum-Hornschuch (1842) we find the opinion expressed, that certain cells discovered by the author inside the ovaria, which are said to differ from the egg cells both in shape and contents, must be considered as the seminal cells of the eel, which, therefore, would be a hermaphrodite. Six years later, Schlüser

published an interesting dissertation on the sex of the lamprey and the eel,* in which he pronounced Hohnbaum's view as erroneous, and expressed the supposition that male eels were either very scarce, or that they differed in shape from the females. Till the seventh decade of our century no male eel has ever been seen, nor has any opinion been advanced regarding the shape of the male eel and its organs of generation.† By a strange accident the University of Bologna was again destined to open the discussion of the eel question and enter upon a scientific tournament with the University of Pavia. In the session of the Academy of Bologna of December 28, 1871, G. B. Ercolani, professor of anatomy, read an essay entitled, "The complete hermaphroditism of the eel."‡ Two weeks later two professors of the University of Pavia, Balsamo Crivelli and L. Maggi, also read a paper on the eel entitled "The principal organs of generation of the eel." These three scientists had, therefore, without the slightest preconcerted knowledge, again taken up the famous discussion of the eighteenth century, this time chiefly with regard to the male organs of the eel. Both parties were convinced that they had at last discovered these organs, and it must be confessed that the results of their investigations were strange enough. In Ercolani's treatise it is shown that the above-mentioned fatty band running alongside of the ovarium is the male organ (testicle) of the eel; the left band, distended by air, being the real testicle, whilst the right one had been in some way checked in its growth, and was not capable of performing its function. In Crivelli's and Maggi's essay,§ on the other hand, these fatty bands are likewise described as the testicles of the eel, but with this difference, that the right one is declared to be the only productive organ. These two last-mentioned scientists even give drawings of the spermatozoids, which they say they have observed in the fatty band extending along the right side. As these bands are invariably found

* "De Petromyzontum et Anguillarum sexu." Inaugural dissertation, Dorpat, 1848.

† Rathke, strange to say, in his above-mentioned treatise on the sexual organs of fish (Halle, 1824), also speaks of the male organs, the testicles of the eel, and always in connection with those of the lampreys (see p. 128 and p. 158); yea, he even describes the inner construction and substance of the testicles of the eel, pp. 185, 186, 187, 190, and 193. It is a positive fact, however, that Rathke has never informed the scientific world of the discovery of a male eel, although in the above-mentioned article in "Wiegmann's Archiv" (1838, p. 299) we find the following sentence: "Regarding the male organs of the eel, I hope to give further particulars at no distant period." It would be interesting to ascertain whether in the posthumous papers of the famous author some notice of or memorandum on male eels which, however imperfect, would be valuable, has been found.

‡ Ercolani's essay is entitled, "Del perfetto ermafroditismo delle Anguille," and is reprinted in the "Memorie dell' Academia delle Scienze del Istituto di Bologna," 1872, part 4, p. 529.

§ Balsamo Crivelli's and L. Maggi's essay has been published under the title: "Intorno agli organi essenziali della riproduzione delle Anguille" in the Memoire del Istituto Lombardo di Scienze e Lettere a Milano," vol. xii, 1872, part 4, p. 229. It has been translated into German in "Wiegmann's Archiv für Naturgeschichte" 1872, part I, p. 59 *et seq.*

in all eels having an ovarium, Crivelli and Maggi must, according to their own view, declare the eel as a hermaphrodite. Professor Ercolani's essay begins with this assertion, that "the author this day appears before the academy with fear and trembling, since he intends to present something new regarding a question which has been the rock on which the vessels of so many distinguished scientists have foundered." He thereupon points to the famous scientist Vallisneri, whose great mistake had exactly a hundred years ago been shown up by Mondini in this very same academy, when the latter, referring to Vallisneri's joy at his supposed discovery, had uttered the following words: "Oh, that the truth had been equal to his joy"! and Ercolani adds that when writing his essay he had often to think of these words.

We are sorry to say that this feeling of fear and trembling which the highly esteemed Bolognese savant and anatomist manifests in a manner so modest, and at the same time honorable for himself, as well as his reference to Vallisneri's mistake, were entirely justified. The organ of the eel described both by Ercolani and Crivelli and Maggi as the testicle, has, on careful examination, been shown in the most unmistakable manner to have not even the slightest trace of a testicle-like construction. The cells of this organ extending alongside of the ovarium are only simple fatty cells having all the distinguishing marks of such cells as given in manuals of histology.

Professor Rauber, of Leipzig, has carefully examined these cells; and I have also examined them in a great many eels; and nothing has ever been discovered in them but fat and the roots of blood-vessels. The supposed spermatozoids depicted in Crivelli's and Maggi's work have under a good microscope been shown to be nothing but small fatty particles or crystalline particles, such as are frequently found in fatty cells.*

Meanwhile the question regarding the male organs of the eel was to enter upon a new and highly significant stage, bringing it nearer toward its final solution. Darwin has directed attention to the circumstance that the male of nearly all fish is smaller than the female.† He says that Dr. Günther, the eminent ichthyologist of the London Museum, had assured him that he never yet met with a single instance where the male fish had been larger than the female of the same species. This utterance may possibly have induced Dr. Syrski, formerly director of the Museum of Natural Sciences at Trieste, now professor at the University at Lemberg—when commissioned by the authorities of Trieste to ascertain the actual spawning season of all the fish caught near Trieste, which of course would include the eel—to direct his attention

* In making microscopic examinations of fatty tissues the so-called "Brown's molecular movement" may easily deceive the observer and cause him to imagine that he sees moving spermatozoids; especially will this be the case in fish, of whose spermatozoids—unless they are extraordinarily magnified—only the head can be recognized, and which have an entirely globular shape.

† Charles Darwin, "The descent of Man," translated by Carus, 1871, vol. ii, p. 5.

principally to small eels. Hitherto the largest eels had been picked out for purposes of scientific examination, because people reasoned in this wise, that the larger and, therefore, the older the eel the farther developed their organs of generation must be. As early as the 2d of January, 1874, Syrski found in the second eel which he examined, and which measured 40 centimeters in length—the specimen in question has been preserved in the Museo Civico in Trieste—an entirely new organ which no scientist had hitherto discovered in an eel, although thousands and tens of thousands of eels had been examined.* Syrski published his discovery in the number for April, 1874, of the "Abhandlungen der Kaiserlichen Akademie der Wissenschaften zu Wien." The most important feature of the new discovery was, that in all those eels which contain Syrski's organ the frill-like ovarium, the female organ of generation, was entirely wanting. This proves in the first place that the eel is not a hermaphrodite. But now the question arises: Does the newly discovered organ, both as to its outward form and inner construction, differ so much from the ovarium that it is out of the question to consider it as an irregularly developed or sickly ovarium? After all the preceding investigations, it must be considered highly probable that the newly-discovered organ is really the long-sought-for male organ of generation of the eel, but as yet it cannot be asserted with absolute certainty, because the most important proof, the presence of spermatozoids, has so far not been furnished.

The first important difference between the newly-discovered organ and the ovarium, which in itself is a strong point in favor of declaring the former to be the testicles, is the presence of a seminal duct, which, when filled with air or quicksilver, can be distinctly recognized with the naked eye, and which by its base is attached to and runs along the whole length of the organ. The ovarium never has any duct of this kind, no indication even of ovarian ducts, so that the eggs when ripe fall into the abdominal cavity, and from there through two very small genital apertures, which were discovered by Rathke, into the outer world. In the second place, the outward shape of the newly-discovered organ, at any rate in eels which are not too diminutive, differs very much from the well-known ovarium. The organ which occupies the same place in the abdominal cavity as the ovarium does not show the slightest trace of the characteristic frill-like folds, but appears more like a very narrow, light band,† whose free edge, protruding into the abdominal cavity,

*If we remember that in our times Professor Münther alone has opened and examined 3,000 eels without discovering the Syrski organ, we are justified in supposing that many mysteries in the nature of the eel are still reserved for future discoveries.

† If an eel is opened with a view of finding the Syrski organ, one may easily be deceived by the two fatty-bands which have been mentioned several times, and which play so important a part in the treatises of Ercolani and Maggi, who mistook them for the frill-like ovaria. Most people will then think that they are examining a female eel, and will lay it aside. A more thorough examination will leave no room for doubt as to the irregularly indented fatty fold and the frill-like organ. If the latter is not found, one has before him a Syrski eel, and the Syrski organ will be found

shows a beautiful and regularly wavy outline. By these convex indentations the whole band is regularly divided into small pieces, or little lobes, from which the organ, in contradistinction to the frill-organ of the ovarium, is called the lobe-organ ("Lappen-organ"). This organ, which in such perfection is not found in any other fish, is now generally called, from its discoverer, the Syrski organ. The inner structure and histological construction of this organ is also very different from that of the ovarium. Whilst the contents of the latter, even when only moderately magnified, appear beyond a doubt as eggs imbedded in layers of fat, the elementary structure of the lobe-organ can only be recognized when strongly magnified. Under a powerful microscope no ovarian cells can be seen, but a net-work resembling closely the histological structure of the immature testicles of other fish. Professor Claus, of Vienna, who like other German scientists, for instance, Professor Siebold, of Munich, and Professor Virchow, of Berlin, takes a very lively interest in this question, had one of his scholars, Mr. S. Freud, a student of medicine, examine histologically the lobe-organ of a large number of eels. Although this observer could not pass a definite opinion, because he was not able to prove the presence of spermatozoids, he likewise draws attention to the great difference between the ovarium and the lobe-organ, and to the probability that the latter is the testicle.* When engaged at the zoological station at Trieste, I devoted considerable time to an examination of this question. In September, 1877, I obtained an eel which had unusually large lobes, and which, at the special desire of Professor Claus, was sent to Professor Siebold, of Munich, for examination by the naturalists then in convention in that city. I had succeeded in showing in this eel a more advanced stage of development of the inner construction, namely, tube-like ducts filled with cells, exhibiting an unmistakable resemblance to the seminal cells of the testicles of other fish.

It is interesting to observe the outward difference between live eels having an ovarium and those having a lobe-organ. The most important difference is (1) that of length and size, already referred to. Syrski says that the largest eels with lobe-organs discovered by him measured 430 millimeters. I have, however, both at Trieste and Comacchio, found eels with this organ measuring 450, 460, 470, and 480 millimeters. All eels longer than this—and it is well known that they reach the length of one meter, and the thickness of a man's arm—have so far at least been invariably found to be females. The other outward differences are (2), the broader point of the snout in the female in contradistinction to the narrow, extended, or short and pointed snout of the eel with lobe-

by carefully turning over and laying back the fatty folds. The lobe-shaped band fastened to the backbone is, however, often so narrow, and its substance is so glass-like and transparent, that this organ when attached to its base can only be recognized with the naked eye when it is held in an oblique direction towards the sun.

* Published in the March number of the "Sitzungsberichte der K. Academie der Wissenschaften zu Wien." 1877.

organs; (3) the lighter color of the female, green on the back and yellow or yellowish on the lower side, the back of the male generally being a dark green, often almost black, whilst its sides have invariably a metallic glitter. I often found eels having a bronze color, which were always eels with a Syrski organ—and their lower side white; (4) a very striking difference in the height of the dorsal fin. All females have a higher and broader dorsal fin than eels with the lobe-organs of equal size; and finally (5) the generally—for it is not always the case—larger diameter of the eye in eels with lobe-organs. Eels with particularly small eyes are nearly always females, whilst eels with a Syrski organ have generally large eyes, although many female eels have also large eyes.

The following measurements are the averages of a very large number of eels which I examined, and may be of general interest; *a* is the total length of the eel, *b* the breadth of the point of the snout between the nostrils, *c* the breadth of the snout between the eyes, *d* the length of the mouth from the center of the eye to the point, *e* diameter of the eye, *f* length of the head to the gill aperture, *g* height of the dorsal fin; all these measurements are in millimeters:

	A. Eels with lobe-organs.								B. Female eels.						
	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*		*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*
I.	480	6	13.5	15	8	52	5	I.	480	8.5	15	17	5	62	9
II.	470	6	10.5	12	7	54	6	II.	475	7.5	14.5	16	8	59	9.5
III.	445	5	11	12	6	47	6	III.	440	8	12	14	5	56	7.5
IV.	411	4	9	12	5.5	47	6	IV.	410	8	12.5	13	7.5	51	7
V.	386	4.5	9	12	5.5	46	4	V.	378	7.5	11	12	5	49	7.5
VI.	370	3.5	7	10.5	5	40	6	VI.	369	7.5	11	13	6.5	51.5	7
VII.	344	4	7.5	10	4.5	40	5	VII.	342	6	8	11	4.5	44	6.5
VIII.	319	4	7	10	5	40	4.5	VIII.	313	5.5	8	10.5	3.5	41	6

By observing these differences, and paying special attention to the height or narrowness of the live eel, eels with Syrski organs have been successfully picked out from among a large number of eels in the Trieste fish market. Absolute certainty in recognizing eels by these marks can of course not be guaranteed. If without knowing these distinguishing marks, with the exception of the first, one indiscriminately picks out eels from a large number measuring not more than 45 centimeters in length, he will on an average find among 10 eels 8 females, and 2 with lobe-organs; but if every one of the distinguishing marks are carefully observed, this ratio is reversed, and 8 eels with Syrski organs are found among every 10.

It was to be expected that Syrski's discovery would revive interest in the eel question. This was, however, not the case—at least so far as the general public was concerned—until the beginning of the year 1877. During the spring and summer of that year all German and Austrian journals and periodicals contained articles and notices regarding the eel question. Among other things the following notice made the round of the press: "In spite of all our modern aids, science has not yet succeeded in clearing up the mystery of the propagation of the eel. The German Fishery Association at Berlin, will, therefore, pay a reward of

50 marks ($11.90) to any one who will send to Professor Virchow, at Berlin, an eel in a state of pregnancy, sufficiently advanced to throw some light on the propagation of the eel." The Royal Superintendent of Fisheries, Mr. Dallmer, in Schleswig, had volunteered to forward letters and eels to Berlin, and in the January numbers, 1878, of the "Deutsche Fischerie-Zeitung," published at Stettin, he gave a long and interesting report. He says, in the course of his remarks, that he had by no means counted on having the above-mentioned notice published in nearly every German paper, from the Rhine to the Vistula, and from the Alps to the sea. At first he was delighted with the number of letters he received; next he was astonished, and finally he was horrified, and had to refuse to forward any more letters. At the same time an equally large number of letters, &c., had been sent direct to Berlin, to Dr. Virchow, from all parts of Germany. Dozens of so-called young eels, all said to have been cut out of grown eels, were sent to him, and invariably turned out to be intestinal worms; the most incredible statements were made in letters, especially by ladies, regarding large eggs which they said had been found in eels. ..... Finally, Mr. Dallmer was compelled to publish the following notice in the "Schleswiger Nachrichten": "Since the German Fishery Association has promised a reward for a pregnant eel, the desire to obtain this reward, as well as inquisitiveness and a sincere desire for knowledge, have greatly excited a large number of people. I had offered to forward letters, &c., to Berlin, but the enormous increase of my expenses for postage has induced me to ask all senders henceforth to send everything direct to Berlin to Professor Virchow. I am compelled to direct the attention of the public to a few matters in this connection. The reward will only be paid for a pregnant eel, and not for its contents alone, for if the latter alone are sent, there is no guarantee that they really came from an eel. The eel should therefore be sent in all cases. Most of the senders have sent me only the intestines, or also the supposed young of the eel, which invariably turned out to be intestinal worms. Most of the senders had eaten the eel, and nevertheless requested to have the 50 marks forwarded to them, often by return mail." By directing the unceasing current of letters, packages, &c., to Professor Virchow's address, Mr. Dallmer had not rendered a service to the professor; for very soon a notice appeared in several papers, by Professor Virchow, urgently requesting people not to forward anything more. Some Berlin funny papers thereupon published a notice that henceforth all eels sent to scientists should be smoked. This episode will show, however, how great and how general an interest was taken in the eel question.

In January, 1879, the "Zoologische Anzeiger," published at Leipsic by Victor Carus,* contained a notice that a Mr. Edwards, of New Bed-

*In No. 18, January 13, 1879. The notice has been taken from Putnam in the "Proceedings of the Boston Society of Natural History," and communicated by Prof. A. S. Packard. The eels were said to have been caught in brackish water near Providence.

ford,* Mass., had, in December, 1878, discovered male eels of the variety *Anguilla bostoniensis*, having fully developed seminal cells with spermatozoids, which, under the microscope, could be seen moving about in a lively manner. Unfortunately, this glorious news was soon proved to be incorrect. In No. 26, April 21, 1879, of the "Zoologische Anzeiger" there was a notice to the effect that the American observer had been deceived by Brown's molecular movement of the particles, and had mistaken the grains of the yolk of the egg for spermatozoids.†

III.

THE EEL QUESTION (CONCLUDED).—JOURNEY OF THE AUTHOR TO COMACCHIO, AND RESULTS OF HIS INVESTIGATIONS.—COMPARATIVE STATEMENT OF ALL THE DOUBTFUL QUESTIONS AND DIFFERENT OPINIONS REGARDING THEM.

Late in the autumn of 1877 I undertook a journey to Comacchio, going from Trieste by sea via Ravenna. Convinced by my own experience of the difficulty of the questions which had yet to be solved, I did not set out with very sanguine expectations as to the prospect of finding fully-matured eels, both pregnant females and males containing semen. My chief object, from the very beginning, was to find out—

(1) Whether among the eels which in autumn migrate to the sea any sign could be discovered pointing to a preparation for the act of propagation;

(2) Whether, and if so to what degree, eels with the Syrski organ participate in these migrations; and, finally,

(3) If possible, to catch some eels which had migrated to the sea, with a view of comparing their organs of generation with those of the lagoon eels.

With regard to the first two questions I was able to solve the problem which I had set myself, and I have succeeded in discovering a new and interesting fact; but as to the last question, all my eager endeavors have proved futile.

I found, first of all, that the eels which migrate to the sea in autumn take no food during this period. The stomachs of the many hundreds of eels which I caught during their migration were, on examination, invariably found empty. All the fishermen and officials of the Comacchio lagoons are well acquainted with the fact that the eels take no food during this period. In contradistinction to this the stomachs of those eels which do not migrate but remain in the lagoon, both of those which are

[* These eels were taken by Mr. Edwards at his home, Woods Holl, Mass.—Ed.]

† "Zoologische Anzeiger," by J. V. Carus, No. 26, April 21, 1879, p. 193, under "Literature": Packard, A. S. "The breeding habits of the eel." "A correction in the 'American Naturalist,' Vol. XIII, February, pp. 125, 126: the motile bodies were not spermatozoa but yolk particles."

not yet able to migrate and of those which never go into the sea but spend their whole life in the lagoons, were more or less filled with remnants of food.

In Comacchio, and doubtless wherever large masses of eels live in brackish water near the sea-coast, a certain variety of eels exists which I found were barren females of the common species. They are female eels whose ovarium shows an entirely anomalous condition. On opening such an eel one finds, instead of the well-known, yellowish-white, and very fatty, frill-like organ, a frothy, thin band, without any fat, and having but few folds, often as transparent as glass, otherwise of the same breadth and length as the frill-like organ, varying, of course, according to the size of the eel. If this band is examined under the microscope the eggs appear entirely transparent, containing but very few grains of yolk or none at all. This band, therefore, appears to be an anomalously-developed barren ovarium. The outward distinguishing marks of these barren females, which I found of all lengths to upwards of 70 centimeters, are very striking. They show all the above-mentioned distinguishing marks of the female intensified. Their snout is broader, often—especially the point of the lower jaw—extraordinarily broad, the dorsal fin generally higher, the eyes decidedly smaller—in large specimens astonishingly small—and the color is generally a light, almost yellowish green; the back is of a lighter green, and the belly of a brighter yellow than in the common female eels. The flesh of these barren eels has a very delicate but different flavor from that of the other eels. I was surprised at its delicious flavor when I, for the first time, ate such eels at Comacchio; the flesh actually melts on the tongue. Even in the live eels one can, in feeling them with the hand, distinguish their soft flesh from the hard, firm, and muscular flesh of other eels.*

In Comacchio this eel is called "pasciute." Coste, who has not paid any attention to the scientific side of the eel question or to the distinction of the sexes, called them "priscetti," and characterized them as eels which had not yet reached maturity, but weighed at least one pound.† The name "priscetti" is certainly incorrect, and I became convinced of this by repeatedly questioning the superintendents of the fisheries and by listening to conversations of the fishermen.‡ "Pasciuto" means pastured, and lagoon fishers by this expression understand, first of all, those eels which do not migrate, which do not enter the basins where eels are caught during autumn, but which feed all the year round, and therefore keep in the lagoon, which is their pasture ground. But they further-

*The author of the "History of Comacchio," Francesco Bonaveri, who wrote during the last century, already considered this eel, which he called "Buratello," a very interesting fish. He thought it must be a variety peculiar to the Comacchio Lagoon.

†M. Coste: "Voyage d'exploration sur le littoral de la France et de l'Italie." Paris, 1861, p. 49.

‡Spallanzani, in his above-quoted work: "Sopre le anguille" (Opere, vol. iii, Milano, 1826, p. 518), calls them "presciutte."

more designate by this name the above-described variety of eel with broad mouth, small eyes, bright green color, and tender flesh. The use of this word "pasciuto" for two totally different categories of eels, the one comprising both those which have not yet reached maturity, the normally developed females which migrate later, and the eels with the lobe-organ, and the other comprising the barren females, which never migrate, and which, as I remarked above, are found of all sizes, is apt to create some confusion, which will make scientific investigations in the beginning somewhat difficult. When Spallanzani, a hundred years ago, visited Comacchio he encountered the very same difficulty, although he had no knowledge of sexual differences in eels.*

The second part of the problem was of special interest, namely, to prove the occurrence in Comacchio of eels with lobe-organs and to show what sort of life they led. I can state that among the 1,200 eels (more or less) which I dissected at Comacchio (including in this number the larger eels, which are invariably females), I found that on an average 5 per cent. had the Syrski organ; but that of all the eels which measured less than 45 centimeters on an average 20 per cent. had it; the result was therefore the same as in Trieste, whose fish market is, for the greater part, supplied with eels from Chioggia, a comparatively small portion only coming from Comacchio. I found at Comacchio the largest eel with a lobe-organ which has so far been discovered, measuring 48 centimeters, and also the smallest, measuring 24 centimeters. All these were

* Several of the older naturalists have already stated that there are some eels which never migrate to the sea; *e. g.*, Risso, in his "Histoire naturelle de l'Europe méridionale," vol. iii, p. 198; also S. Nilsson, in his "Skandinavisk Fauna," vol. iv, p. 663. Nilsson calls the variety of the eel which does not migrate "grass-eel," and makes special mention of its yellowish-green color and its tender and delicate flesh. Both these naturalists, however, strange to say, describe this very variety as having a more pointed snout than the others; and Risso, who gives it as a special variety—the *Anguilla acutirostris* (the eel with the pointed snout), describes it as dark-colored on the back and of a light silver color on the belly. This statement differs in every particular from the appearance of the non-migratory eel of Comacchio. I must state that all the "pasciuti" which I found to be barren females, and which from this reason do not migrate, are distinguished by a broad snout. It will be interesting in this connection to compare the following measurements taken in Comacchio; *a* means the whole length of the body of the eel, and *b* the breadth of the point of the snout between the nasal tubes, in millimeters:

A.			B.			C.		
Barren females. "Pasciuti."			Normal females.			Eels with lobe-organs.		
	a.	*b.*		*a.*	*b.*		*a.*	*b.*
I.	508	10	I.	511	8	I.	.....	.....
II.	480	8.5	II.	497	7	II.	480	6
III.	458	11	III.	465	9	III.	470	6
IV.	443	9	IV.	447	7	IV.	445	5
V.	426	8.5	V.	425	6	V.	428	5
VI.	408	8	VI.	407	6	VI.	403	5
VII.	395	11	VII.	396	7	VII.	390	5.5

among eels which had been caught during their migration to the sea, and like the female eels which were migrating showed an entirely empty stomach, containing only a small quantity of slime. A farther advanced development of the lobe-organs, in contradistinction to those caught during summer near Trieste, could not be noticed in any of them.

Before entering upon the third and concluding portion of this treatise on the eel question, I must describe and determine scientifically the varieties of eels found in the lagoon of Comacchio. As I could not discover an actual difference of species, they must all come under the common designation of *Anguilla fluviatilis* (Fleming). I give the distinguishing marks of the different varieties according to Siebold.*

Distinguishing marks of the species.—Lower jaw longer than the upper jaw; dorsal fin begins far behind the head, anal fin begins the length of a head back of the beginning of the dorsal fin; body, as far as the anus, cylindrical; from there to the tail, compressed.

Of this species the following sexual varieties can be distinguished:

(1.) *Anguilla fluviatilis, Femina vera.*—The fully developed female eel: Snout generally broad, dorsal fin comparatively high, color on the whole light, back brownish green—never intensely black; belly whitish yellow; little or no metallic glitter; flesh coarse and firm; grows more than one meter in length; the frill-like ovarium contains much fat, and the eggs contain many yolk-grains. Migrates to the sea in autumn, and during that time ceases to eat.

(2.) *Anguilla fluviatilis, Femina sterilis.*—The barren female eel, called in Comacchio "pasciuto": Snout decidedly broad, dorsal fin high, eyes remarkably small, color green—almost yellowish, back green, belly yellow, no metallic glitter, flesh soft and tender, grows three-quarters of a meter in length; the ovarium contains no fat, and is, near the edges, frothy, thin, and bright, often as transparent as glass; the eggs contain few or no yolk-grains. Never migrates to the sea and feeds all the year round.

(3.) *Aguilla fluviatilis, Mas.*(?)—The eel with a lobe-organ (the male eel?): Snout either attenuate and pointed, or short and pointed; dorsal fin narrow, eyes generally large, color decidedly dark, the back a dark green, often quite black; belly bluish or silvery white with little or no yellow, has a metallic glitter, often a bronze color; flesh coarse and firm; so far no specimens have been found measuring more than 48 centimeters. Instead of the frill-like ovarium, it has an organ resembling a narrow band divided into many lobes, probably of the nature of testicles. Migrates to the sea in autumn, and during that time does not take any food.

According to size and weight the Comacchio fishermen distinguish the eels by different names. The young eels, thin as threads, which in spring come from the sea they call "*Capillari*," those weighing less than

* With his usual ingenuity Siebold as far back as 1863 (Süsswasserfische Mitteleuropas, p. 352), asked the question, whether those eels which never migrate could be barren eels, whilst the migrating eels were the fully developed males and females.

3 pounds "*Anguille*," those between 3 and 4 pounds "*Anguillaci*," from 4 up to 6 pounds "*Rocche*," and the largest, weighing 5½–6 pounds and more "*Miglioramenti*." During autumn eels are frequently caught near Comacchio weighing 10 and even 15 pounds.

As regards the third aim which I had set myself, and which brings us to the most important point of the whole eel question, namely, to catch in the open sea eels which had got there on their migrations, in order to obtain in this way a fully matured milter and spawner, I have, as far as my modest means would allow, done everything which would bring me nearer to the solution of this problem. I have gone to sea in Chioggia fishing vessels, both from Magnavacca and from Codigero; I have accompanied the fishermen on their expeditions to the open sea; I have fished with them, and by offering them rewards I have urged them to catch eels out at sea. I have arrived at the conviction that this problem can only be solved by employing extraordinary means. Sensible old Chioggia fishermen, who know every nook and corner of this part of the Adriatic,* have assured me that during a long life-time they have never yet caught a fully-grown river eel at any distance from the coast. The eels which were handed me in the harbor of Magnavacca, which were said to have been caught in the open sea, and which I found to be common female eels, or eels with lobe-organs, had invariably been caught in the immediate neighborhood of the coast, or even in the Palotta Canal. There was no lack of attempts to deceive me; fishermen would take eels along from the shore, and on their return exhibit them to me as having been caught in the sea. Near the coast eels are frequently found, as I have mentioned above, in the sea, and differ in no respect from the lagoon eels. I found both female eels and eels with lobe-organs with the same immature organs of generation as in Comacchio; these eels had evidently just entered the sea from the lagoon by way of the Palotta Canal. At some distance, however, 1 to 2 nautical miles from the coast, none of the many thousands of grown eels which have migrated to the sea are seen; every trace of them is absolutely lost.† Inexplicable as this phenomenon appears at first sight,

*The inhabitants of Chioggia are the boldest fishermen and sailors on the whole coast of Italy, and are famous as such under the name "*lupi di mar*"—sea-wolves It is a great pleasure, especially when the waves are high, to watch their maneuvers, which they execute shouting and singing. Two Chioggia vessels with reddish-brown sails set out on their expedition. One sails far ahead, and at a suitable place casts the net; thereupon both vessels rapidly sail towards each other; it looks as if they must run into each other. When very close to each other a fisherman holding the line of the net in his hand leaps from the first into the second vessel, amid the shouts and laughter of his companions. In a few moments both vessels are again far from each other, and haul in the net.

†Wherever the coast has long and shallow bays, like near Goro, north of the Po di Volano, as also in Schleswig and Denmark, eels are found at a considerable distance from the coast. I have seen eels speared at a great distance from the coast in the Bay Sacca di Goro. The difficulty or impossibility only begins in deep water, and this is the very place from which eels are desired. After my experiences I must contest the

it is easily explained when one thinks of the method of fishing, and the nets employed by the sea fishermen. These nets, which, like those used in the lobster fisheries, are intended to be dragged along the bottom of the sea, have very wide meshes, much too wide to retain an eel, which can slip through a very small hole. And those nets which have narrow meshes never reach to the bottom of the sea; the eels, however, can only be brought up from the bottom of the sea. The drag-nets which the fishermen employ are, moreover, deficient in this respect, that they do not have an apparatus to dig up the mud which is the favorate habitation of the eel, but glide over it gently. The fishermen would very justly fear for their expensive nets if they were to make an attempt at digging up the bottom. To catch a river eel in the open sea, which is an essential condition of solving the most perplexing question of the eel problem, will therefore remain an impossibility as long as we do not possess vessels and apparatus specially adapted to this purpose.

When one, as I did, has spent weeks in the company of the fishermen and officers of the lagoon, superintendents of fisheries, and private fishermen, who year after year and during the fishing season by day and night think and talk of nothing else but of the eel, on which their prosperity depends, which was fished for by their ancestors centuries ago, so that their power of observation of the mode of life of this fish has naturally been sharpened, it will not be surprising to find that the more intelligent fishermen have quietly formed some opinions regarding this mysterious fish and its procreation, which, laying aside the common fables, are calculated to give some hints to the naturalist as to the way and direction in which he should pursue his investigations. Such opinions I have heard expressed by some of the more intelligent of the fishermen, and the opinion which I had formed concerning some of the unsolved problems of the eel question has thereby been confirmed. These problems, which are intimately connected with each other, are the following:

(1) How can it be explained that no fully-developed males and females—milters and spawners—of the eel have ever been found?

(2) When and where do the organs of generation of the eel develop to that degree of maturity which is necessary for the procreation of young eels?

(3) Where do eels spawn, and where are their eggs impregnated?

(4) What becomes of the fully-grown eels after the spawning season; why do they never return to the rivers, but disappear altogether?

Drawing rational conclusions from our present knowledge of the eel question, these questions should be answered as follows:

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assertion made by Professor Ercolani, that the eels which were sent to him from Ancona had been caught in the open sea. I am convinced that they had never seen the open sea; the fishermen, however, described them as "caught in the sea," which, of course, was true in a certain sense, although, no doubt, they had caught them near the coast. Through the kindness of Mr. von Littrow, harbor-master at Fiume, I received a large number of eels which the lobster-fishermen had caught in the harbor of Fiume, and which in no respect differed from the common lagoon eels.

(1) For the development of their organs of generation eels need salt water.* As has now been ascertained beyond a doubt, the eels leave the rivers and brackish lakes when their organs of generation have scarcely begun to develop, and enter the sea that these organs may there reach their full development. That this migration to the sea is undertaken for the purpose of spawning is fully proved by the fact that in spring the young eels come from the sea, and this view is further strengthened by the circumstance that when the eels commence to migrate they cease to eat, just like other fish do, during the spawning season.

(2) The development of the organs of generation takes place in the sea, not near the coast, but farther out in deep water. Considering the immature condition of the eels when they begin to migrate, the development is exceedingly rapid. In a few (five to six) weeks they reach maturity, according to the time when they enter the sea. Near Comacchio the eels migrate from the beginning of October till the end of December.

(3) The river eels have their settled spawning places in the sea.† These are mud-banks which the eels visit in large numbers for the purpose of spawning. The young fry develop on these banks, and go to the mouths of the rivers in the beginning of spring, about eight to ten weeks after their birth.

(4) The old eels, both males and females, die soon after the spawning season. The extraordinarily rapid development of their organs of generation exhausts them to such a degree that they die soon after having spawned. This is the reason why they are never seen to return.‡

It is hoped that this short treatise on the eel question may do its share in giving a new impetus to its scientific investigation and may aid in

* Some peculiarity in the chemical composition or the organic contents of the water of the Black Sea must be assigned as the reason why there are no eels in the whole territory of the Black Sea nor in the Danube and its tributaries.

† The Chioggia fishermen have pointed out to me several of these mud-banks in the Adriatic.

‡ Siebold was the first to express this opinion (see farther below). An intelligent Chioggia fisherman, owner of a vessel, in answer to my question, what became of the old eels, replied: "They die on the mud-banks after they have made young ones." This view finds its scientifically proved analogy in the lamprey. Panizza in describing the sea lamprey (*Petromyzon marinus* L.) remarks that both the males and females of this kind of lamprey are invariably found dead after the spawning season. (See Panizza: "Memoria sulla lampreda marina" in the "Memorie dell' Instituto Lombardo di scienze," vol. ii, Milan, 1845, p. 48.) Regarding the river-lamprey (*Petromyzon fluviatilis* L.) Statius Martens, the translator of Linné's System of Nature, says (vol. iii, 1774, p. 232), that after it has finished spawning it gradually declines and finally dies. Concerning the small lamprey (*Petromyzon Planeri*, Bloch), the discoverer of its larva (the *Ammocœtes branchialis*), August Müller, who had observed the spawning process of this fish in the river Panke near Berlin, says that he had witnessed the very same phenomenon. (See A. Müller, "Vorläufiger Bericht über die Entwickelung der Neunaugen" in "J. Müller's Archiv," 1856, pp. 323, 324.) Theodor von Siebold (in his "Die Süsswasserfische Mitteleuropa's," p. 378) says: "A very interesting fact, discovered by A. Müller in the course of his observations, is the complete dis-

leading us to its final solution. Would that all who possess the necessary means might constantly remember Spallanzani's words, uttered by him a century ago after his many vain attempts to solve the eel problem: "Our still prevailing ignorance regarding the procreation of the eel, instead of deterring us from further investigations, should spur us on to strain every nerve to dispel this dark cloud of ignorance, having ever before us the examples of seekers of truth in other fields of natural science, who by careful and persevering search at last succeeded in removing the seemingly impenetrable vail from many a mystery of nature." (Opere di Lazzaro Spallanzani, vol. iii, pp. 561, 562, Milan, 1826.)

appearance of the small lampreys after the spawning season is over. In spite of the most diligent search A. Müller could not find any trace of them except a few dead ones floating about in the water. As moreover the ovaria of these lampreys never contained eggs in different stages of development, as is the case with other fish, but after the spawning season contained nothing but the empty cells, A. Müller was justified in concluding from this that the organs of generation of these small lampreys are after the spawning-season completely exhausted, and that the fish consequently die. By personal observation I have convinced myself that after the spawning season the ovaria of the small lampreys are entirely void of eggs, and I must therefore agree with Müller that the supposition seems very natural that the same is the case with *Petromyzon marinus* and *Petromyzon fluviatilis*. I even go a step farther and ask the question whether, perhaps, such a generative activity, only occurring once during life and followed by death, is the reason why the eels which have migrated to the sea never return from there." It may not be out of place to point to the striking similarity between the generative organs of the lamprey and the eel, to which Rathke has directed attention in his treatise on the organs of generation in fish, not only as regards the female, but, strange to say, also the male eel.

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