

**NOTES ON THE LIFE-HISTORY OF THE EEL, CHIEFLY DERIVED
FROM A STUDY OF RECENT EUROPEAN AUTHORITIES.**

BY G. BROWN GOODE.

- I. Number of species of eels and the method of classification.
 - a.* Gunther's views. *b.* Daresté's views.
- II. Number of species of eels in America.
- III. Geographical distribution of the eel.
- IV. General note on habits.—Professor Baird.
 - V. Introduction of eels into new waters in the United States.
- VI. Günther on the life-habits of the eel.
- VII. Benecke on the general natural history of the eel.
- VIII. Ancient beliefs concerning the reproduction of the eel.
- IX. Search for and discovery of the female eel.
- X. Hunt for the male eel and discovery of Syrski.
- XI. How to distinguish male and female eels.
 - a.* Internal characteristics.—Benecke and Syrski.
 - b.* External characteristics.—Jacoby.
- XII. Questions as to the viviparous nature of eels.—Benecke.
- XIII. Hunt for young eels.—Jacoby.
- XIV. Undoubted normal reproductive habits of eels.—Benecke.
- XV. Do male eels leave the sea and enter fresh water?
- XVI. Strange mistatements concerning the breeding of the eel.
- XVII. Benecke on the movements of young eels.
- XVIII. Observations of Dr. Hermes in 1881, on the conger.
- XIX. Jacoby's tour to Comacchio in 1877 and his conclusions.
- XX. A list of the most important books and papers concerning the eel and its habits of reproduction.

I. NUMBER OF SPECIES OF EELS.

a. GÜNTHER'S VIEWS.

There is no group of fishes concerning the classification and history of which there is so much doubt as the eel family; an infinite number have been described, but most are so badly characterized or founded on individual or so trivial characters that the majority of ichthyologists will reject them.*

In his Catalogue of the Fishes in the British Museum, Dr. Günther has claimed to retain those as species which are distinguished by such characters that they may be recognized, though he remarks that he is by no means certain whether really specific value should be attached to them, remarking that the snout, the form of the eyes, the width of the bands of teeth, &c., are evidently subject to much variation. In his more recent work he remarks, "Some twenty-five species of eels are known from the coast waters of the temperate and tropical zones."

* Günther, Catalogue of Fishes British Museum, viii, p. 24.

b. DARESTE'S VIEWS.

Other recent writers have cut the knot by combining all of the eels into three or four, or even into one, species, and it seems as if no other course were really practicable, since the different forms merge into one another with almost imperceptible gradations. In his monograph of the family of *Anguilla*-formed fishes* M. C. M. Dareste remarks :

“Dr. Günther has recently published a monograph of the apodal fishes in which he begins the work of reducing the number of specific types. The study of the ichthyological collection of the Paris Museum, which contains nearly all of Kaup's types, has given me the opportunity of completing the work begun by Dr. Günther, and of striking from the catalogue a large number of nominal species which are founded solely upon individual peculiarities.

“How are we to distinguish individual peculiarities from the true specific characters? In this matter I have followed the suggestions made with such great force by M. Siebold in his History of the Freshwater Fishes of Central Europe. This accomplished naturalist has shown that the relative proportions of the different parts of the body and the head vary considerably in fishes of the same species, in accordance with certain physiological conditions, and that consequently they are far from having the importance which has usually been attributed to them in the determination of specific characters. .

“The study of a very large number of individuals of the genera *Conger* and *Anguilla* has fully convinced me of the justice of this observation of Siebold; for the extreme variability of proportions forbids us to consider them as furnishing true specific characters.

“I also think, with Siebold, that albinism and melanism, that is to say, the diminution or augmentation of the number of chromatophores are only individual anomalies and cannot be ranked as specific characters. Risso long since separated the black congers under the name *Muraena nigra*. Kaup described as distinct species many black *Anguillas*. These species should be suppressed. I have elsewhere proved the frequent occurrence of melanism and albinism more or less complete in nearly all the types of fishes belonging to this family, a fact especially interesting since albinism has hitherto been regarded as a very exceptional phenomenon in the group of fishes. This also occurs in the *Symbranchidæ*: I have recently shown it in a specimen of *Monopterus* from Cochin China presented to the museum by M. Geoffroy St. Hilaire.

“I must also signalize a new cause of multiplication of species; it is partial or total absence of ossification in certain individuals. This phenomenon, which may be explained as a kind of *rachitis* (rickets), has not to my knowledge been noticed, yet I have found it in a large number of specimens. I had prepared the skeleton of a *Conger* of medium size, the bones of which are flexible and have remained in an entirely

* Comptes rendus of the Academy of Sciences, Paris.

cartilaginous state. Still it is not necessary to prepare the skeleton to determine the absence of ossification, for we can establish this easily in unskinned specimens by the flexibility of the jaws. It is very remarkable that this modification of the skeleton is not incompatible with healthy existence, and that it does not prevent the fish in which it is found from attaining a very large size.

"Those fishes in which ossification is absent are remarkable by reason of the great reduction of the number of teeth, which, although the only parts which become hard by the deposit of calcareous salts, remain however much smaller than in individuals whose skeletons are completely ossified.

"We can thus understand how such specimens could present characters apparently specific, and that they should have been considered by Kaup as types of new species. These considerations have led me to reduce, on an extensive scale, the number of species in the family.

"So, in the genus *Anguilla*, I find but four species: *Anguilla vulgaris* occurring throughout the northern hemisphere, in the new world as well as the old. *Anguilla marmorata* and *A. mowa* of the Indian Ocean, and *Anguilla megalostoma* of Oceanica.

"There are at least four distinct types, resulting from the combination of a certain number of characters; but the study of a very large number of specimens belonging to these four specific types has convinced me that each of these characters may vary independently, and that consequently certain individuals exhibit a combination of characters belonging to two distinct types. It is therefore impossible to establish clearly-defined barriers separating these four types.

"The genus *Anguilla* exhibits, then, a phenomenon which is also found in many other genera, and even in the genus *Homo* itself, and which can be explained in only two ways: Either these four forms have had a common origin and are merely races, not species, or else they are distinct in origin, and are true species, but have been more or less intermingled, and have produced by their mingling intermediate forms which coexist with those which were primitive. Science is not in the position to decide positively between these alternatives."

II. NUMBER OF SPECIES OF EELS IN AMERICA.

It is the disposition of American ichthyologists, at least, to accept the views of Daresté, and to consider all the eels of the northern hemisphere as members of one polymorphic species. Günther is inclined to recognize three species in North America: one the common eel of Europe, *Anguilla vulgaris*; one the common American eel, *Anguilla bostoniensis*, which he finds also in Japan and China; and the third, *Anguilla texana*, described and illustrated by Girard, in the Report of the United States and Mexican Boundary Survey, under the name of *A. texana*, which, he remarks, is scarcely specifically distinct from *A. bostoniensis*, from which it differs only in the greater development of the lips. The distinction

between *A. bostoniensis* and *A. vulgaris*, as stated by him, consists chiefly in the fact that the dorsal fin is situated a little farther back upon the body, so that in the former the distance between the commencement of the dorsal and anal fin is shorter than the head, while in the latter it is equal to or somewhat longer than it. This character does not appear to be at all constant.

III. GEOGRAPHICAL DISTRIBUTION OF THE EEL.

We may therefore provisionally assume the specific identity of the eels of the old and the new world, and define their distribution of the common eel somewhat as follows: In the rivers and along the ocean shores of Eastern North America, south to Texas and Mexico, and north at least to the Gulf of Saint Lawrence, but absent in the waters tributary to Hudson Bay, the Arctic Sea, and the Pacific; present in Southern Greenland (?) and Iceland, latitude 65° north; on the entire coast of Norway, from the North Cape, latitude 71°, southward; abundant in the Baltic and in the rivers of Russia and Germany, which are its tributaries, and along the entire western and Mediterranean coasts of Europe, though not present in the Black Sea, in the Danube or any of its other tributaries, or in the Caspian; occurring also off Japan and China and Formosa; also in various islands of the Atlantic, Grenada, Dominica, the Bermudas, Madeira, and the Azores.

IV. GENERAL NOTE ON HABITS. [Professor BAIRD.]

The habits of the eel are very different from those of any other fish, and are as yet but little understood.

"This, so far as we know," writes Prof. Baird, "is the only fish the young of which ascend from the sea to attain maturity, instead of descending from the fresh to the salt water. Its natural history has been a matter of considerable inquiry within a few years, although even now we are far from having that information concerning it that would be desirable, in view of its enormous abundance and its great value as a food fish.

"The eggs of the eel are for the most part laid in the sea, and in the early spring, the period varying with the latitude, the young fish may be seen ascending the rivers in vast numbers, and when arrested by an apparently impassable barrier, natural or artificial, they will leave the water and make their way above the obstruction, in endeavoring to reach the point at which they aim. Here they bury themselves in the mud and feed on any kind of animal substance, the spawn of fish, the roes of shad, small fish, &c. At the end of their sojourn in the ponds or streams they return to the sea, and are then captured in immense numbers in many rivers in what are called fish-baskets. A V-shaped fence is made, with the opening down-stream into the basket, into which the eels fall, and from which they cannot easily escape. This same device, it may be incidentally stated, captures also great numbers of other fish,

such as shad, salmon, and other anadromous fish, to their grievous destruction.

"As might be expected, however, the Falls of Niagara constitute an impassable barrier to their ascent. The fish is very abundant in Lake Ontario, and until artificially introduced was unknown in Lake Erie. At the present time, in the spring and summer, the visitor who enters under the sheet of water at the foot of the falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year.

The economical value of the eel as a food fish has been well established, and it is now greatly sought after for introduction into the localities where, for some physical or other reason, it is unknown. The advantages, as summed up by a German writer, are, first, that an eel will live and grow in any water, however warm, and whatever be the general character of the bottom, though it prefers the latter when muddy and boggy; second, the eel requires no special food, but devours any thing, living or dead; it is an excellent scavenger, feeding upon dead fish, crabs, etc., as well as upon any living prey it can secure; third, but few conditions can interfere with its development, while it grows with very great rapidity, being marketable at the age of three years; fourth, the young, on account of their hardiness, can be transported in a crowded condition, and to any distance, with very little risk of destruction. These considerations are, in the main, well established, and there is no question but that the eel can be introduced in many waters to advantage, supplementing the earlier inhabitants. It has been planted in the waters of the upper lakes and the Mississippi River; in the latter they have reached an advanced development. It is, however, a very undesirable inmate of rivers in which fish are taken by means of gill-nets, the destruction of shad and herring in the waters of the Susquehanna and others further south being enormous. It is not unfrequent that when a gill-net is hauled up, the greater part of the catch consists simply of heads and backbones, the remainder being devoured by myriads of eels in the short time the net is left out. The spawning shad are considered by them a special delicacy, and are found emptied at the vent and completely gutted of the ovaries. Sometimes a shad, apparently full, is found to contain several eels of considerable size. They do not seem to be very destructive of living fish of any magnitude, although the young fry are devoured with gusto."*

V. INTRODUCTION OF EELS INTO NEW WATERS IN THE UNITED STATES.

In describing the geographical distribution of the eel it was stated that it occurs in the rivers and along the ocean shores of North America.

* MS. note by Professor Baird.

This being the case, as might be supposed, there are many inland lakes and streams of the United States in which this fish does not occur; for instance, in the chain of the great lakes above Niagara Falls and in the upper waters of other streams in which there are considerable obstructions. The cutting of canals in various parts of the country has, however, produced a great change in their distribution; for instance, it is stated by Mitchell* that eels were unknown in the Passaic above the Great Falls until a canal was cut at Paterson, since which time they have become plentiful in the upper branches of that river. They have also been placed in many new localities by the agency of man. Concerning this Mr. Milner remarks:

"The eel (*Anguilla bostoniensis*), appreciated in some localities and much vilified in others, is another species that has been frequently transplanted. It is pretty evident that it never existed naturally in the chain of great lakes any higher up than Niagara Falls, although specimens have been taken in Lakes Erie and Michigan. Their existence there is with little doubt traceable to artificial transportation.

"A captain of a lake vessel informed me that it was quite a common thing some years ago to carry a quantity of live eels in a tub on the deck of a vessel while on Lake Ontario, and they were often taken in this manner through the Welland Canal. He said that it was a frequent occurrence on his vessel when they had become tired of them, or had procured better fishes, to turn the remainder alive into the waters of Lake Erie.

"In 1871 Mr. A. Booth, a large dealer of Chicago, had an eel of four pounds weight sent him from the south end of Lake Michigan, and a few weeks afterward a fisherman of Ahneepee, Wis., nearly 200 miles to the northward, wrote him that he had taken a few eels at that point. It was a matter of interest to account for their presence, and a long time afterward we learned that some parties at Eaton Rapids, Mich., on a tributary of the lake, had imported a number of eels and put them in the stream at that place, from which they had doubtless made their way to the points where they were taken. The unfortunate aquarium-car in June, 1873, by means of the accident that occurred at Elkhorn River, released a number of eels into that stream, and about four thousand were placed by the United States commission in the Calumet River at South Chicago, Ill., two hundred in Dead River, Waukegan, Ill., and three thousand eight hundred in Fox River, Wisconsin."†

They have since been successfully introduced into California.

VI. GÜNTHER ON THE LIFE-HABITS OF THE EEL.

Concerning the life-history of the eel much has been written, and there have been many disputes even so late as 1880. In the article upon

* Transactions Lit. and Phil. Soc. New York, I, p. 48.

† Report U. S. Fish Commission, p. 2, 1874, 526.

ichthyology, contributed to the Encyclopedia Britannica, Günther writes:

"Their mode of propagation is still unknown. So much only is certain, that they do not spawn in fresh water; that many full-grown individuals, but not all, descend rivers during the winter months, and that some of them at least must spawn in brackish water or in deep water in the sea; for in the course of the summer young individuals from 3 to 5 inches long ascend rivers in incredible numbers, overcoming all obstacles, ascending vertical walls or flood-gates, entering every larger and swollen tributary, and making their way even over *terra firma* to waters shut off from all communication with rivers. Such emigrations have long been known by the name '*Eel-fairs*'. The majority of the eels which migrate to the sea appear to return to fresh water, but not in a body, but irregularly, and throughout the warmer part of the year. No naturalist has ever observed these fishes in the act of spawning, or found mature ova; and the organs of reproduction in individuals caught in fresh water are so little developed and so much alike, that the female organ can be distinguished from the male only with the aid of a microscope."

VII. BENECKE ON THE GENERAL NATURAL HISTORY OF THE EEL.

In attempting to present a review of this subject I am sure I cannot do better than to translate at length a communication just received from my friend Dr. Berthold Benecke, professor in the University of Königsberg:

"The coloration of eels varies greatly not only in different localities, but in the very same places: the back may be dark blue or greenish black; the sides, lighter blue or green; the belly, white; sometimes the back is only slightly darker than the sides; sometimes there are olive green individuals with a golden-yellow band upon their back, sometimes they are entirely golden-yellow and, very rarely, entirely white. The eel lives in deep quiet waters with muddy bottom; it burrows out holes and tunnels in which it rests quietly during the day, while at night it comes out in search of food. From the deck of a steamer passing through rivers or canals one may see upon the banks, which are laid bare by the waves produced by the motion of the vessels, numerous eels with half of their bodies projecting from their lurking holes.

"The eel feeds upon all kinds of small water-animals, and may be found on the spawning places of other fish in great troops, going there for the purpose of feeding upon the eggs. They feed also upon crabs at the period when they are shedding their shells, and have in many localities in Germany completely exterminated them. Since the eel is everywhere known as a greedy robber, many accounts have been given of their wanderings, in which they have made their way into the peapatches to feed upon pease. The oldest reference of this kind is that of Albertus Magnus, who remarks in his book of animals, published at Frankfort-on-the-Main in 1545: 'The eel also comes out of the water in

the night time into the fields, where he can find pease, beans, or lentils.' This statement was contradicted in 1666 by Baldner,* who writes concerning the eel: 'They eat fish, do not come on the land, and do not eat pease, but remain in the water always, and are nocturnal animals.'

"Forthwith, new statements were made which tended to show the actuality of the wanderings of the eels in the pea-patches. For instance, Bach, in his 'Natural History of East and West Prussia,' published in 1784, maintained that eels frequently were caught in the pea-patches in the vicinity of the water, where they fed upon the leaves or, according to other accounts, upon the pease themselves, and continues: 'These movements explain the paradoxical fact that in Prussia and Pomerania fish have been caught upon dry land by the use of the plough, for the peasants, in warm nights when the eels are in search of the pease, towards morning when it is not yet day, make furrows with the plough between them and the water, and these are the nets in which the eels are caught. Since the eel moves with ease only upon the grass, its return to the water is cut off by the soil which has been thrown up. The peasants consider it as a sign of approaching stormy weather when the eels come out of the water upon dry land.'†

"A person writes to me from Lyck: 'In storms they come out into the pea-patches, and at this time people spread sand or ashes around, and thus prevent their return.' Such tales are even now numerous in the newspapers.

"The small size of the gill-opening makes it possible for the eel to live for a long time out of the water, and it is possible that in their wanderings over moist meadows they may find places in which there are snails and other desirable food. The explanation of their supposed wanderings over the pea-patches is, that the eels, which have been found at different times in the fields or meadows, have been lost by poachers, who threw them away in their flight. Many times dead eels have been found upon meadows over which they have swam, the meadows being flooded, and, in spite of the nearness of the water, have afterwards been unable to return to it.

"Although the activity and tendency among young eels to wander is very great, yet we cannot believe in the wandering of adult eels over wide stretches of land. According to Spallanzani, in Comacchio, where for many centuries an eel fishery of immense extent has been carried on, these fish are found in numerous ponds and lagoons, the fishermen have never yet seen an eel wandering over the land; and once when, on account of the drying up of the water, the eels died by the thousand,

* *Recht natürliche Beschreibung und Abmahlung der Wasser-Vögel, Fischen, vierfüßigen Thier, Insecten und Gewirm, so bey Strassburg in den Wassern sind, die ich selber geschossen und die Fisch gefangen, auch alles in meiner Hand gehabt. Leonhard Baldner, Fischer und Hagemeister in Strassburg gefertigt worden 1666. Manuscript. (Cited by von Siebold, Süßwasserfische von Mitteleuropa. Leipzig, 1863.)*

† A live and active eel, a few days since, was dug out from a depth of five feet in the soil of Exeter, N. H.—Gloucester Telegraph, Oct. 26, 1870.

not one of them made the attempt to escape by a short journey over land into the neighboring lake or into the river Po.

"The eel occurs in all our waters, with the exception of small, rapid brooks. The fishermen distinguish many varieties based upon the differences in the form of the head or color and the varying proportions in the length of the body and tail; and the older ichthyologists have followed their opinions without sufficient reason.

"By rapid growth the eel attains the length of 24 to 30 inches, and often a greater size. On account of their fat, which is very highly flavored, and the absence of bones, they are everywhere valued, and are caught in various ways. The most profitable method of capture is in eel weirs and eel baskets and in traps by the use of nets, and on hooks they are also caught in great quantities. In winter many eels are taken with spears on the shelving shores where they lie buried in the mud in a state of torpidity. In this fishery very often more are wounded than captured, and, in addition to the large eels, great quantities of small ones are taken."

VIII. ANCIENT BELIEFS CONCERNING THE REPRODUCTION OF THE EEL.

The reproduction of the eel, continues Benecke, has been an unsolved riddle since the time of Aristotle, and has given rise to the most wonderful conjectures and assertions. Leaving out of question the old theories that the eels are generated from slime, from dew, from horse-hair, from the skins of the old eels, or from those of snakes, and the question as to whether they are produced by the female of the eel or by that of some other species of fish, it has for centuries been a question of dispute whether the eel is an egg-laying animal or whether it produces its young alive; although the fishermen believe that they can tell the male and female eels by the form of the snout. A hundred years ago no man had ever found the sexual organs in the eel.

Jacoby has remarked that the eel was from the earliest times a riddle to the Greeks; while ages ago it was known by them at what periods all other kinds of fishes laid their eggs, such discoveries were never made with reference to the eel, though thousands upon thousands were yearly applied to culinary uses. The Greek poets, following the usage of their day, which was to attribute to Jupiter all children whose paternity was doubtful, were accustomed to say that Jupiter was also progenitor of the eel.

"When we bear in mind," writes Jacoby, "the veneration in which Aristotle was held in ancient times, and still more throughout the middle ages—a period of nearly two thousand years—it could not be otherwise than that this wonderful statement should be believed and that it should be embellished by numerous additional legends and amplifications, many of which have held their own in the popular mind until the present day. There is no animal concerning whose origin and existence

there is such a number of false beliefs and ridiculous fables. Some of these may be put aside as fabrications; others were, probably, more or less true, but all the opinions concerning the propagation of the eel may be grouped together as errors into three classes:

“(I.) The beliefs which, in accordance with the description of Aristotle, account for the origin of the eel not by their development from the mud of the earth, but from slimy masses which are found where the eels rub their bodies against each other. This opinion was advanced by Pliny, by Athenæus, and by Oppian, and in the sixteenth century was again advocated by Rondelet and reiterated by Conrad Gessner.

“(II.) Other authorities base their claims upon the occasional discovery of worm-like animals in the intestines of the eels, which they described, with more or less zealous belief, as the young eels, claiming that the eel should be considered as an animal which brought forth its young alive, although Aristotle in his day had pronounced this belief erroneous, and very rightly had stated that these objects were probably intestinal worms. Those who discovered them anew had no hesitation in pronouncing them young eels which were to be born alive. This opinion was first brought up in the middle ages in the writings of Albertus Magnus, and in the following centuries by the zoölogists Leuwenhoek, Elsner, Redi, and Fahlberg; even Linnæus assented to this belief and stated that the eel was viviparous. It is but natural that unskilled observers, when they open an eel and find inside of it a greater or smaller number of living creatures with elongated bodies, should be satisfied, without further observation, that these are the young of the eel; it may be distinctly stated, however, that in all cases where eels of this sort have been scientifically investigated, they have been found to be intestinal worms.*

“(III.) The last group of errors includes the various suppositions that eels are born not from eels, but from other fishes, and even from animals which do not belong at all to the class of fishes. Absurd as this supposition, which, in fact, was contradicted by Aristotle, may seem, it is found at the present day among the eel-catchers in many parts of the world.

“On the coast of Germany a fish related to the cod, *Zoarces viviparus*, which brings its young living into the world, owes to this circumstance its name *Allmater*, or eel mother, and similar names are found on the coast of Scandinavia.”

“In the lagoon of Comacchio,” continues Jacoby, “I have again convinced myself of the ineradicable belief among the fishermen that the eel is born of other fishes; they point to special differences in color,

* It is very strange that an observer, so careful as Dr. Jacoby, should denounce in this connection the well-known error of Dr. Eberhard, of Rostock, who mistook a species of *zoarces* for an eel, and described the young, which he found alive within the body of its mother, as the embryo of the eel. In Jacoby's essay, p. 24, he states that the animal described by Eberhard was simply an intestinal worm, an error which will be manifest to all who will take the pains to examine the figure.

and especially in the common mullett, *Mugil cephalus*, as the causes of variations in color and form among eels. It is a very ancient belief, widely prevalent to the present day, that eels pair with water snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus Roeselii*, is the progenitor of eels, and they therefore call this "mother of eels."

IX.—SEARCH FOR AND DISCOVERY OF THE FEMALE EEL.

A scientific investigation into the generation of eels could only begin when, at the end of the middle ages, the prohibition which the veneration for Aristotle had thrown over the investigations of learned men was thrown aside. With the revival of the natural sciences in the sixteenth century we find that investigators turned themselves with great zeal to this special question. There are treatises upon the generation of the eel written by the most renowned investigators of that period, such as Rondelet, Salviani, and Aldrovandi. Nevertheless, this, like the following century, was burdened with the memory of the numerous past opinions upon the eel question, and with the supposed finding of young inside the body of the eel.

The principal supporters of the theory that the eel was viviparous, were Albertus Magnus, Leeuwenhoek, Elsnor, Redi, and Fahlberg. The naturalists, Franz Redi and Christian Franz Paullini, who lived in the seventeenth century, must be mentioned as the first who were of the opinion, founded, however, upon no special observations, that the generation of the eel was in no respect different from that of other fishes.

In the eighteenth century it was for the first time maintained that the female organs of the eel could certainly be recognized. It is interesting that the lake of Comacchio was the starting point for this conclusion as well as for many of the errors which had preceded it. The learned surgeon, Sancassini, of Comacchio, visiting an eel fishery at that place in 1707, found an eel with its belly conspicuously enlarged; he opened it and found an organ resembling an ovary, and, as it appeared to him, ripe eggs. Thereupon he sent his find, properly preserved, to his friend, the celebrated naturalist, Valisneri, professor in the university of Padua, who examined it carefully and finally, to his own great delight, became satisfied that he had found the ovaries of the eel. He prepared an elaborate communication upon the subject, which he sent to the Academy at Bologna.*

At the very beginning there were grave questions raised as to the correctness of this discovery. The principal anatomical authority at Bologna, Professor Valsalva, appears to have shared these doubts, especially since shortly after that a second specimen of eel, which pre-

* I fail to find any record of the publication of this paper, except that given by Jacoby, who states that it was printed at Venice in 1710 with a plate, and subsequently, in 1712, under the title "Di ovario Anguillarum," in the proceedings of the Leopold Academy.

sented the same appearance as that which was described by Vallisneri, was sent from Comacchio to Bologna. The discussion continued, and it soon came to be regarded by the scientific men of Bologna as a matter of extreme importance to find the true ovaries of the eel. Pietro Molinelli offered to the fishermen of Comacchio a valuable reward if they would bring him a gravid eel. In 1752 he received from a fisherman a living eel with its belly much extended, which, when opened in the presence of a friend, he found to be filled with eggs. Unfortunately the joyful hopes which had been excited by this fortunate discovery were bitterly disappointed when it was shown that the eel had been cunningly opened by the fisherman and filled with the eggs of another fish. The eel question came up again with somewhat more satisfactory results when, in the year 1777, another eel was taken at Comacchio which showed the same appearance as the two which had preceded it. This eel was received by Prof. Cajetan Monti, who, being indisposed and unable to carry on the investigation alone, sent a number of his favorite pupils to a council at his house, among whom was the celebrated Camillo Galvani, the discoverer of galvanism. This eel was examined by them all and pronounced to be precisely similar to the one which had been described by Vallisneri seventy years before. It was unanimously decided that this precious specimen should be sent for exhaustive examination to the naturalist Mondini, who applied himself with great zeal to the task, the results of which were published in May, 1777. The paper is entitled "De Anguillæ ovarii," and was published six years later in the transactions of the Bologna Academy.* Mondini was satisfied that the supposed fish which Vallisneri described was nothing but the swimming bladder of the eel in a diseased state, and that the bodies supposed to be eggs were simply postules in this diseased tissue. In connection with this opinion, however, Mondini gave, and illustrated by magnificent plates, a good description and demonstration of the true ovaries of the eel, as found by himself. This work, which in its beautiful plates illustrates also the eggs in a magnified fold of the ovary, must be regarded as classical work, and it is an act of historic justice to state that neither O. F. Müller nor Rathke, but really Carlo Mondini was the first discoverer, describer, and demonstrator of the female organs of the eel, which had been sought for so many centuries.†

* De Bononiensi Scientarum et Arterium Institute atque Academia Commentarii. Tomus VI. Bononiæ, 1783, p. 406, seq.

† Prof. G. B. Ercolani, of Bologna, and also Crivelli and Maggi, in their essays published in 1872, have rightly stated that Mondini's priority of discovery has been overlooked in Germany. Neither Rathke nor Hohnbaum-Hornschech nor Schlüser have mentioned his work. S. Nilsson, in his *Skandinavisk Fauna*, 1855, says nothing of Mondini. He mentioned as the first discoverer of the ovaries O. F. Müller, while Cuvier, in his "*Historic Maurelle de Poissons*," assigning the honor rather to Rathke. Th. von Siebold is the first to announce in his work, published in 1863, *Die Süßwasserfische Von Mitteleuropa*, page 349, that Mondini, almost contemporaneously with

Three years later, entirely independent of Mondini, the celebrated zoölogist, Otto Friedrich Müller, published his discovery of the ovary of the eel in the "Proceedings of the Society of Naturalists," at Berlin.*

The discovery of Mondini was next specially brought into prominence through Lazzaro Spallanzani. This renowned investigator, in October, 1792, went from Pavia to the lagoons of the Po, near Comacchio, for the sole purpose of there studying the eel question. He remained at Comacchio through the autumn; he was, however, unable to find anything that was new regarding the question, but in the report upon his journey of investigation he entirely threw aside the discovery of Mondini, and announced that the ovaries discovered by this authority were simply fatty folds of the lining of the stomach.†

It was without doubt this absolute negative statement of such a skilled investigator as Spallanzani which for a long time discouraged further investigations on the eel question, and allowed what had already been discovered to be regarded as doubtful, as finally to be forgotten. So when Professor Rathke, of Königsberg, in his assiduous labors upon the reproductive organs of fishes, in the year 1824, described the ovaries of the eel as two cuff and collar shaped organs on both sides of the backbone, and in the year 1838 described them as new, he was everywhere in Germany (and to a large extent to the present day) regarded as the discoverer.‡ The first picture of the ovary after that of Mondini, and the first microscopical plate of the egg of the eel Hohnbaum-Hornschuch presented in a dissertation published in 1842—a paper which should be rightly considered as of great importance in the literature of this question. The questions concerning the ovaries of the eel may be regarded as having been brought to a distinct conclusion by Rathke, who, in the year 1850, published an article describing a gravid female eel, the first and only gravid specimen which had, up to that time, come into the hands of an investigator.

O. F. Müller, and independently from him, discovered the ovaries of the eel. The error, as was discovered by Italian zoölogists later than by those of Germany, arose from the fact that the announcement of Müller's discovery was printed in 1780, while that of Mondini, which was made in 1777, was first printed in 1783.

*O. F. Müller, Bemühungen, bei den Intestinal Wurmern.

†Rathke, who first, since Mondini, 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 Mondini'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 Mondini likewise says: "*innumeras sphaerulas minimas, aequales, pellucidas, divisas tamen, quae 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." (Syrski.)

X. HUNT FOR THE MALE EEL AND ITS DISCOVERY BY SYRSKI.

The history of the search for the female of the eel having been given, for the most part, in a translation of the work of Dr. Jacoby, it seems appropriate to quote the same author concerning the search for the male eel, which, though much shorter, is none the less interesting.

In the dissertation of Hohnbaum-Hornschuch, published in 1842, the opinion was expressed that certain cells found by the author in the ovaries which differed from the egg cells by their form and contents, should be regarded as the spermary cells of the eel, and that the eel should be regarded as hermaphrodite. Six years later Schlüser presented an interesting dissertation upon the sexes of lampreys and eels in which he pronounced these opinions of Hohnbaum-Hornschuch to be erroneous, and expressed the opinion that the male eel must be extremely rare, or that it was different, perhaps, from the female. From this time up to the beginning of 1870 a male eel was never seen, nor do we find any opinions expressed concerning the form of the male of the eel or its reproductive organs.*

According to Robin in 1846, George Louis Duvernoy (Cuvier, *Anatomie Comparée*, ed. 2, 1848, tome viii, p. 117) described the ruffle-tube type of the testis of the lampreys and eels, with the free margin festooned in lobules, shorter to the right than to the left, like the ovaries, &c. He added: "At the breeding season, we perceive in it an innumerable quantity of granulations, or small spermatic capsules, the rounded form of which has often led to their being confounded with the ovules, at least in the eels, in which, in reality, these capsules are nearly of the same size as the ovules, but the latter are distinguished by their oval form." The ovules are spherical, and not oval; but the other facts are fundamentally correct. It is also in error that Duvernoy adds (p. 133): "The eels and the lampreys have no deferent canal, any more than an oviduct. Like the ova the semen ruptures the capsules in which it has collected and diffuses itself in the abdominal cavity, whence it is expelled in the same way as in the ova."

By some droll coincidence the university of Bologna and, soon after, that of Pavia, were again prominent participants in the eel tournament. At the meeting of the Bologna Academy, December 28, 1871, Prof. G. B. Ercolani read a paper upon the perfect hermaphroditism in the eel.†

Fourteen days later Prof. Balsamo Crivelli and L. Maggi read a detailed and elaborate paper upon the "true organs of generation in

* Robin, *Comptes Rendus*, 1881, p. 383.

† Jacoby states that in a paper by Rathke, published in 1838 in the *Archiv für naturgeschichte*, he remarked, "I expect soon to be able to say something concerning the male organs of the eel."

It would be very interesting to know whether in the papers left by this skillful investigator there may not have been recorded some valuable observations concerning the male eel.

eels." These investigators, without concerted action, had all at once brought up the celebrated issue of the previous century; this time, however, having specially in view the male organs of the eel, while all were convinced that they had reached a final result by their investigations. The results were certainly very peculiar. In the paper of Ercolani it was claimed that the snake-like folds of fat, which had formerly been noticed near the ovarium, were nothing else than the spermaries of the eel, and that upon the left side of the animal this organ developed into a true testicle, while the one upon the right side shrank up and became functionless. In the work of Crivelli and Maggi, on the other hand, the folds of fat next to the ovary were also considered to be the male organs of the eel, while the one on the right-hand side of the animal was considered without any doubt to be the male reproductive organ. The last-named authorities described the spermatozoa which they had seen in this stripe of fat upon the right side. Since these stripes of fat were universally found in all eels, and always in connection with the former, the investigators could come to no other conclusion than that the eels were complete hermaphrodites.

The male organ of the eel, as described by Ercolani, as also by Crivelli and Maggi, shows how carefully investigations may be expended upon things which are not in the least equivocal, since there was not the slightest trace of structure like that of a spermary. The cells of this body in the lining of the stomach next to the ovary are simply fat cells, with all the characteristic peculiarities, just as they are given in all the manuals of histology. Professor Rauber, of Leipsic has examined these fat cells carefully, and they have also been investigated in many eels by the writer, Dr. Jacoby. Never has anything but fat cells and blood vessels been found in them. The so-called spermatozoa, described in the work of Maggi and Crivelli, proved to be microscopic fat particles or crystalline bodies, such as are commonly found in fat cells. *

In the meantime, at Trieste, the question concerning the male organs of the eel was making a very important advance. Darwin had already expressed the opinion that among nearly all fishes the female was larger than the male. He states that Dr. Günther had assured him that there was not a single instance among fishes in which the male was naturally larger than the female. This opinion may, perhaps, have induced Dr. Syrski, director of the Museum of National History at Trieste, now professor in the university of Lemberg, when he undertook, at the request of the marine officials of Trieste, the determination of the spawning time of the fish which were caught in that region, and was obliged to take up the eel question, to devote his attention especially to the smaller eels. Dr.

* In a microscopic investigation of fatty tissues it is very easy for the so-called Brownian molecular movements to be mistaken for moving spermatozoa, especially in fishes whose spermatozoa, if not very much magnified, show only the head and appear like little bodies globular in form.

Hermes, in behalf of Dr. Syrski, protests against this idea, stating, on the authority of the latter, that the published opinions of Günther and Darwin were unknown to him prior to the publication of Jacoby's paper. Up to that time every investigator had chosen for investigation the largest and fattest of eels, thinking that the largest and oldest specimens must have the most highly-developed organs of generation. On Nov. vembr e29, 1873, Syrski found in the second specimen which he investigated—an individual 15 inches long, which is now preserved in the museum at Trieste—a completely new organ, which had never before been seen within the eel by any former investigator, although tens of thousands of eels had been zealously studied.* Syrski published his discovery in the April number of the proceedings of the Imperial Academy of Sciences, Vienna, in 1874.† The most important point of the discovery was stated to be that in all the specimens of eels in which the Syrskian organ was found, the well known collar-and-cuff shaped ovary, the female organ of generation, was entirely wanting. It was evident from this that eels were not hermaphrodites. The question now arose, is the newly discovered organ in the eel, in its external form, as well as inner structure, so different from the ovary that it could be considered as a partially developed or peculiarly shrunken ovary? According to all researches which have up to this time been made, there is the highest kind of probability that this newly discovered structure is actually the long sought male organ of generation. The investigator cannot, however, answer this question with complete certainty, since the thing which is most necessary to the solution of this question, namely, the finding and the recognition of the spermatozoa, has not yet been accomplished.

In February, 1879, Professor Packard announced the discovery of spermatozoa in eels from Wood's Holl, Mass., but soon after declared that this was a mistake, and that he had been deceived by molecular movements among the yolk nuclei in the female organs. The discovery of spermatozoa in the spermaries of the conger-eel, recently announced by Dr. Hermes, of Berlin, is, however, sufficient to demonstrate fully the correctness of Syrski's theory. The confirmation in the case of the common eel is solely a matter of time.

XI. HOW TO DISTINGUISH MALE AND FEMALE EELS.

a. INTERNAL CHARACTERISTICS.—BENECKE.

The differences between the organs of sex in the eel are well described by Benecke. The ovaries of the eel are two yellowish or reddish-white

* "I commenced my investigations," writes Syrski, "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."

† In 1875, Professor Von Siebold found male eels in the Baltic at Wismar, although this discovery was not at that time made known to the public. They have since been found in the German Ocean, in the Atlantic, and in the Mediterranean.

elongate organs as broad as one's finger, situated alongside of the backbone, arranged in numerous transverse folds, extending through the entire length of the abdominal cavity. They have no special opening to the outside of the body, and their contents must be discharged into the abdominal cavity and must find exit through the very small opening situated behind the anus. These two bodies, on account of their great size, are of course not easily overlooked, but they contain such a great quantity of fatty cells and the eggs imbedded in them are so small and delicate that one might easily believe, even after a superficial microscopic examination, that the whole organ consists only of fat. While the eggs of other fishes measure from one to three millimeters in diameter—and sometimes are much larger—still the eggs in the ovary of the eel have, on an average, a diameter of about .1 millimeter, and are so closely surrounded by fatty cells with outlines much more strongly marked that it requires great skill to prepare a microscopic slide in which they shall be as plainly visible as they are in the accompanying illustration, in which they are magnified 150 diameters. When a person has a microscope which magnifies only 100 diameters, it is best to put a portion of the ovary in water when dissecting it, in order that the eggs may be easily found. It is much easier to find the eggs in young eels, 7 or 8 inches in length, than in the adult fish, since in the former, although the ovaries and the eggs are smaller, the fat cells have not made their appearance, and the eggs are, therefore, plainly visible at the first glance through the microscope. The number of eggs is extraordinarily large, amounting to many millions. The eggs of larger size, which sometimes are found in great quantities in eels that have been cut up and have been considered to be eel eggs, have always proved to be the eggs of other fish which they have swallowed, and in the course of cutting them up have been found in the eel's belly.

The male eels, which are found only in the sea and in the brackish water, are much smaller than the females, rarely exceeding 15 or 16 inches in length; in them, in the place of the ovaries in the female, are found spermaries, which differ in appearance in the manner shown in the illustration. These consist of two tubes which stretch the whole length of the body cavity, situated close to each other, and provided with numerous sacculations. Ripe spermatozoa are as rarely found in these organs as eggs ready to be laid have been found in the ovaries of the female. According to many accounts the male eels, which later were found also by Von Siebold in the Baltic Sea at Wismar, differ from the females in the possession of a proportionally sharper snout, less conspicuous dorsal fins, darker coloration of the back, a more prominent and metallic luster upon the sides, the clean white coloration of the belly, and the larger size of the eyes. I propose to reproduce here the original descriptions and figures of Syrski, the discoverer of the male eel.

Having met, writes Syrski, with many errors regarding the female

organs of reproduction in the descriptions hitherto given of them, I intend to commence by describing these organs, first, with the view of rectifying and completing the details, and also for the purpose of comparison with the male 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. 2) full of eggs (fig. 3).

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. 4).

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

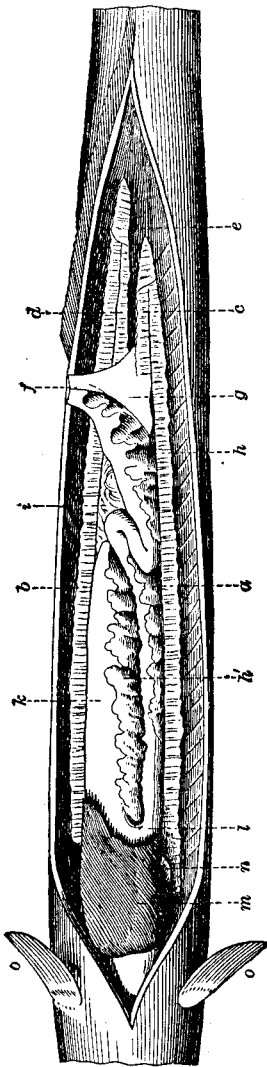


FIG. 1. Female eel, longitudinal section of the abdomen; natural size.

- 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.

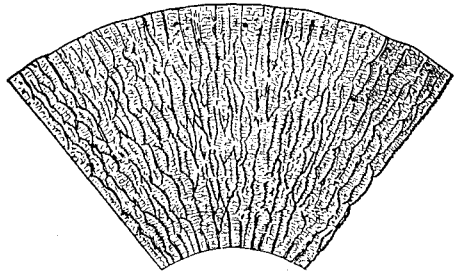


FIG. 2. Piece of the ovary, twice its natural size, with ovarian leaflets arranged in transversal rows, on its outer surface. The shorter border attached to the dorsal wall of the abdominal cavity; the longer being free.

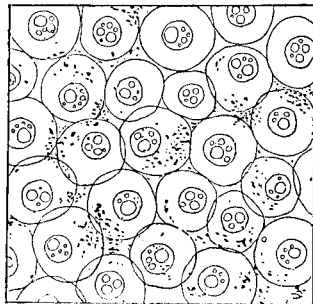


FIG. 3. Piece of a somewhat developed ovary, one hundred times the natural size, showing the transparent eggs with the germinative vesicles and the germinative dots.

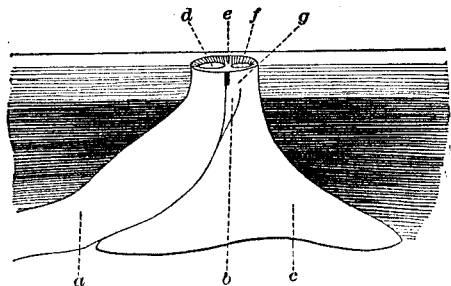


FIG. 4. Anal part of a female eel, twice the natural size.

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

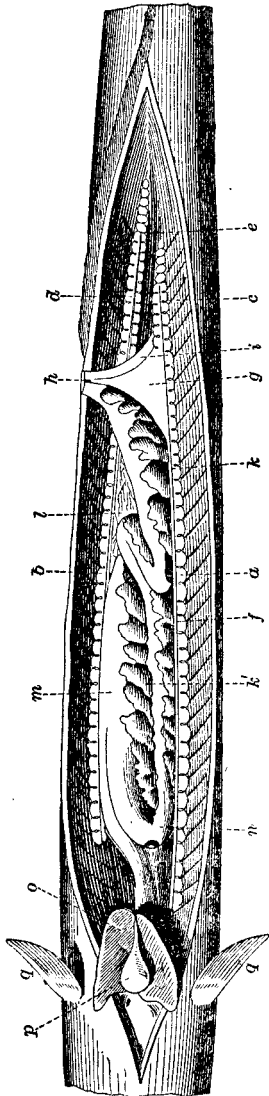


FIG. 5. Male eel (natural size).
 a. Right testicle. b. Left testicle. c. Right accessory part. d. Left accessory part. e. Dividing membrane. f. Deferent canal. g. Anal depression. i. Urinary bladder, covered to a great extent by the seminal pouch. k. Fat on the right side. k'. Similar fat covering the stomach. l. Fat on the left side. m. Seminal pouch. n. Pylorus. o. Liver, turned up to show the inner surface adhering to the oesophagus and the stomach. p. Gall-bladder. qq. Pectoral fins.

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" (*Murena 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. 5), which are not ribbon-shaped like the ovaries, but represent two longitudinal rows each with about fifty lobules

(fig. 6) 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 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 the 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. 7).

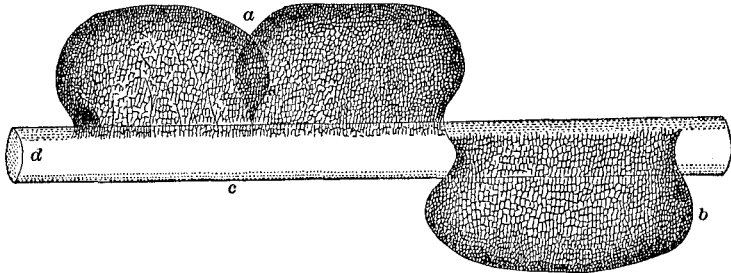


FIG. 6. Three lobes of the right testicle, with the deferent canal (enlarged ten times.)

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

These compartments are joined toward the inside and the base of the lobes, which are united to a tube (*vas deferens*), which, caecal 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 general orifice, which opens in the urethra (fig. 8).

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 measuring 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 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, 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.

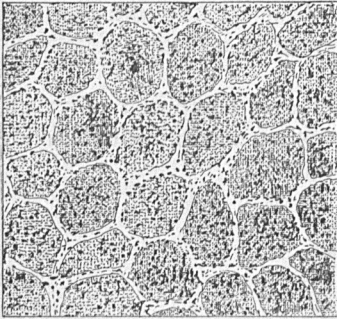


FIG. 7. Piece of the testicle (one hundred and sixty times enlarged), showing the vascular tissue and the small granules.

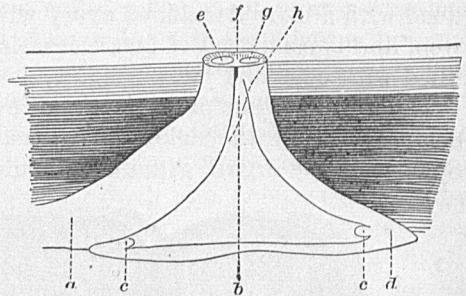


FIG. 8. Anal part of the male eel, enlarged twice.

- 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.

b. EXTERNAL CHARACTERISTICS.—JACOBY.

The external differences presented by living eels (remarks Jacoby), corresponding to the presence of an ovary and the supposed male organ, are very interesting.

The most important, writes Jacoby, is (1) the difference in the size and length of the animal. Syrski states that the largest eels found by him with the supposed male organ measured about 17 inches, 430^{mm}. I have, however, found specimens with this organ at Trieste and in Comacchio which measured 17 to 19 inches, 450 to 480^{mm}. All the eels which exceeded this size, for instance those which were over 3 feet in length, 1^m, many of them growing to the thickness of the arm of a strong man, have been hitherto found to be females. The other recognizable external character in the female are (2) a much broader tip of the snout in comparison with the small, either attenuated or short and sharply pointed, snout of the eel with the supposed male organ; also (3) a clearer coloration in the female, usually of a greenish hue on the back, and yellowish or yellow upon the belly, while the others have a deep darkish

green, or often a very deep black upon the back and always a more perceptible metallic luster upon the sides (I, once in a while, found eels covered all over with a brownish tint, always possessing the organ of Syrski), usually exhibiting also a white color upon the belly. In addition (4) there is an important external character in the height of the dorsal fin; all females have these fins much higher and broader than the eels of the same size which possess the supposed male organ. Finally (5) there is a character, which is not always a safe one, in the greater diameter of the eye in the eels with the supposed male organ. Eels with quite small eyes are almost always found to be females; eels with the organ of Syrski usually have comparatively large eyes, yet female eels with quite large eyes are not unusual.

The following proportional measurements, the average results of the study of a great number of eels measured by me, will be of general interest; column *a* gives the total length of the eel; *b* the breadth of the snout between the nostrils; *c* the breadth of the snout between the eyes; *d* the length of the snout from the center of the eye to its tip; *e* the average measurement of the eyes; *f* the length of the head to the gill-opening; *g* the height of the dorsal fins, all the measurements being given in millimeters.

	A. Eels with supposed male organ.							B. Female eels.							
	<i>a.</i>	<i>b.</i>	<i>c.</i>	<i>d.</i>	<i>e.</i>	<i>f.</i>	<i>g.</i>	<i>a.</i>	<i>b.</i>	<i>c.</i>	<i>d.</i>	<i>e.</i>	<i>f.</i>	<i>g.</i>	
I	480	6	13.5	15	8	52	5	480	8.5	12	17	5	62	9	I
II	470	6	10.5	12	7	54	6	475	7.5	14.5	16	8	59	9.5	II
III	445	5	11	12	6	47	6	440	8	12	14	5	56	7.5	III
IV	411	4	9	12	5.5	47	6	410	8	12.5	13	7.5	51	7	IV
V	388	4.5	9	12	5.5	46	4	378	7.5	11	12	5	49	7.5	V
VI	370	3.5	7	10.5	5	40	6	369	7.5	11	13	6.5	51.5	7	VI
VII	344	4	7.5	10	4.5	40	5	342	6	8	11	4.5	44	6.5	VII
VIII	319	4	7	10	5	40	4.5	313	5.5	8	10.5	3.5	41	6	VIII

According to the distinguishing marks which have been given, special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the eels which possessed the organ of Syrski; absolute certainty in recognizing them cannot, however, be guaranteed. If one is searching among living eels with no characters in mind with the exception of the first—that of length—he will find in every ten eels, on an average, eight females, and two with the supposed male organ; but, if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ.

For another excellent discussion with figures of the characters of male and female eels, the reader is referred to a translation of an article by S. Th. Cattie, in the Proceedings of the U. S. National Museum, vol. iii, pp. 280-4.

XII. QUESTION AS TO THE VIVIPAROUS NATURE OF EELS.—BENECKE.

The discovery of the two sexes has not, however, writes Benecke, settled the question whether the eel lays eggs or brings its young alive into the world. There has always been a strong disposition to adopt the latter hypothesis, and there are many people at the present day who claim to have been present at the birth of young eels, or to have found a quantity of young eels in adult eels which have been cut open. Frequently ichthyologists hear accounts of occurrences of this kind, and receive specimens of supposed little eels from one to two inches in length, which have been kept alive for several days in a glass of water. These are usually thread worms, *Ascaris libeata*, which live by the hundred in the intestinal cavity of the eel, and which may be easily distinguished from the eels of the same size by the sharp ends of the body, the absence of fins, of eyes and mouth, and by the sluggishness of their motions. The smallest eels, less than an inch in length, have already the complete form of the adult, and are also transparent, so that with a magnifying glass one may perceive the pulsations of the heart, and see behind it the brownish-red liver; the mouth, the pectoral, dorsal, anal, and caudal fins are easily seen, and the black eyes cannot be overlooked. In addition to the intestinal worms, the young of a fish of another family, *Zoarces viviparus*, have given opportunity to the ignorant for many discoveries; for instance, Dr. Eberhard, in No. 4 of the "Gartenlaube" for 1874, described and illustrated an "embryo of the eel," which, in company with about a thousand similar embryos, had been cut out of the belly of an eel. This tolerably good drawing at first sight is seen to represent the embryo of zoarces which is almost ready for birth, since it still possesses a very minute umbilical sac. It is very evident that the minute egg of the eel could hardly produce a great embryo with an umbilical sac which exceeds by more than a hundred times in size the whole egg. It is also evident that the imagination of the writer had exaggerated the 200 or 300 young in the *Zoarces* to a thousand.

XIII. HUNT FOR YOUNG EELS.—JACOBY.

As might have been foreseen, remarks Jacoby, Syrski's discovery drew attention anew to the solution of the eel problem. In the spring and summer of 1877, the German and Austrian papers and journals were full of articles and paragraphs upon this subject. Among others the following announcement made the rounds of the press: "Hitherto, in spite of all efforts, science has not succeeded in discovering the secret of the reproduction of the eel. The German Fischerei-Verein in Berlin offers a premium of 50 marks to the person who shall first find a gravid eel which shall be sufficiently developed to enable Professor Virchow in Berlin to dissipate the doubts concerning the propagation of the eel. Herr Dallmer, of Schleswig, inspector of fisheries in that province, offered to transmit communications to Berlin, and in 1878, in the January number of the German Fishery Gazette, he published a detailed and very in-

teresting report of his proceedings. He wrote, among other things, that it was quite beyond his expectation that this announcement would have found its way into nearly all the German journals between the Rhine and the Weichsel, and from the Alps to the sea. The number of letters which he received first rejoiced him, then surprised him, finally terrified him, so that at last he was obliged to refuse to attend to the communications. He had learned at Berlin that an equal number of communications from all parts of Germany had been received, sent directly to the address of Professor Virchow. Objects which professed to be young eels cut out of the parents, but which were really thread worms, were sent to him by dozens; the most incredible stories, usually from women, about great thick eggs which they had found in eels, were received by him. A witty Berliner communicated to him in a packet sent by express the information that the eel problem was now happily solved since a lady eel in Berlin had given birth to twins. Finally Herr Dallmer found himself compelled to insert the following notice in the *Schleswiger Nachrichten*: 'Since the German *Fischerei-Verein* has offered a premium for the first gravid eel, the desire to obtain the prize, curiosity, or the desire for knowledge has created so lively an interest upon this point that it might almost be called a revolution. I at one time offered, when necessary, to serve as an agent for communications, but since business has compelled me to be absent from home a great part of the time, I would urgently request that hereafter packages should be sent direct to Professor Virchow in Berlin. I feel myself obliged to inform the public upon certain special points. The premium is offered for a gravid eel, not for the contents of such an eel, since if only these were sent it would be uncertain whether they were actually taken from an eel. The eel must always be sent alone; the majority of senders have hitherto sent me only the intestines or the supposed young of the eel, which were generally intestinal worms; the eel itself they have eaten; nevertheless the prize of 50 marks has been expected by nearly all senders, &c. By this transfer of the responsibilities, the inspector of fisheries has rendered a very unthankful service to Professor Virchow; he was obliged to publish a notice in the papers in which he urgently stated that he wished to be excused from receiving any more packages, for he would hardly know what to do with them. The comic papers of Berlin now circulated the suggestion that hereafter the eel should be sent to the investigators only in a smoked state. This amusing episode is interesting in showing how remarkable an interest the whole world was beginning to take in the eel problem.'*

XIV. UNDOUBTED NORMAL REPRODUCTIVE HABITS OF THE EEL.— BENECKE.

It may be assumed with the greatest safety (writes Benecke) that the eel lays its eggs like most other fish, and that, like the lamprey, it only

* *Zoologischer Anzeiger* No. 26, p. 193; *American Naturalist*, vol. 13, p. 125, and *Jacoby*, p. 44.

spawns once and then dies. All the eggs of a female eel show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are destined to mature hereafter, and to be deposited in other years. It is very hard to understand how young eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a very long time supported by the little yolk, but when this is gone it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the eel takes place only in the sea: (I) that the male eel is found only in the sea or brackish water, while female eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of eels by the use of fixed apparatus is dependent; (II) that the young eels with the greatest regularity ascend from the sea into the rivers and lakes.

All statements in opposition to this theory are untenable, since the young eels never find their way into land-locked ponds in the course of their wanderings, while eels planted in such isolated bodies of water thrive and grow rapidly but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many eels, but which, by the erection of impassable weirs, have been cut off from the sea, the supply of eels has diminished, and after a time only scattering individuals, old and of great size are taken in them. An instance of this sort occurred in Lake Müskendorf, in West Prussia. If an instance of the reproduction of the eel in fresh water could be found, such occurrences as these would be quite inexplicable.

In the upper stretches of long rivers, the migration of the eels begins in April or May, in their lower stretches and shorter streams, later in the season. In all running waters the eel fishery depends upon the downward migrations; the eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the eels have once returned to the sea, and there deposit their spawn, they never can return into fresh water but remain there to die. A great migration of grown eels in spring or summer has never been reported, and it appears certain that all the female eels which have once found their way to the sea are lost to the fisherman. In No. 8 of the German *Fischerei Zeitung* for 1878, Dr. Schock published certain statements sent to him by Dr. Jacoby. It is remarked in this paper, among other things, that after the deposition of the spawn, the female eel dies a physiological death, and that occasionally the sea in the neighborhood of the mouths of rivers has been found covered with dead eels whose ovaries were empty. When, where, and by whom this observation was made,

and who pronounced upon the empty ovaries in these dead fish is unfortunately not mentioned.

A great number of the eels remain in inland waters while others proceed to the sea, either because their eggs are at this time not sufficiently ripe, or perhaps because they are sterile. It would seem probable that the increase in the size of the eggs in the wandering eels begins to be very rapid after August and September, while in the earlier months of the year, in all eels of moderate size, the eggs were at the utmost but about 0.09 in diameter. In September of the same year, I found (as an average of numerous measurements) a diameter of 0.10; in October, 0.16; in November, 0.18 to 0.23, while the eggs showed other characters connected with approaching maturity which earlier in the season were not to be seen. All the eels which were captured later—in December and in January—part of which came from rivers and harbors, part from the harbor of Putzig (Putziger Wiek) had eggs measuring from 0.09 to 0.09^{mm}, while, very exceptionally, some measured 0.16^{mm}, although among the fish examined were some which measured 3 feet in length.

XV. DO MALE EELS LEAVE THE SEA AND ENTER FRESH WATER.

This problem is one of great interest, both to the biologist and the fish culturist; it is, in fact, the one disputed point still remaining to be solved. Upon its solution appears to depend the final decision of the question, still so warmly debated both in Europe and America, "Do eels breed in fresh water only, in salt water only, or in both fresh and salt water?" As has already been stated, the theory for a long time generally accepted is that the eels are "catadromous," descending to the sea to spawn. This theory is, however, sharply contested by many observers, chief among whom on this side of the Atlantic is the Hon. Robert B. Roosevelt, President of the American Fish Culture Association. It appears probable to the writer that the truth lies somewhere between these two extremes, and that it will be hereafter ascertained that the eel, like a majority of other animals, has flexible habits, sometimes deviating from its ordinary custom, which appears to be to spawn in salt or brackish water.

Male eels have been found in the following localities:

- (1.) In 1874, by Syrski, in the fish markets of Trieste, these markets being supplied with eels from Chroggia on the Adriatic, and to a lesser extent from the lagoons of Comacchio.
- (2.) In 1875, on the coasts of France, by Daresté.
- (3.) In 1875, among specimens of *Anguilla marmorata* from India.
- (4.) In 1875, in the Baltic, at Wismar on the Danish coast, by Prof. Von Siebold.
- (5.) In 1877, in the lagoons of Comacchio, by Jacoby. Among 1200 specimens, five per cent. were males; while among those less than 15 inches in length 20 per cent were males. This was in brackish water. (See paragraph XIX).

- (6.) In 1879, at Trieste, by Dr. Hermes, who found 15 males among 20 eels selected by Dr. Syrski.
- (7.) In 1880, on the Baltic coasts of Denmark, by Dr. Hermes. Out of one lot of 36 from Wismar, he obtained 8 males, thus repeating Van Siebold's observation.
- (8.) In 1880, from the Baltic between Zealand and Saland, Denmark. Out of one lot of 36, Dr. Hermes obtained 8 males.
- (9.) In 1880, in France, by Robin.
- (10.) In 1880, by Cattie.
- (11.) In 1880, by Dr. Hermes, at Cumlosen, on the Elbe, about 120 miles from the German Ocean.
- (12.) In 1880, at Rùgers on the Baltic, by Dr. Hermes, who found 44½ per cent. males in one lot of 137.
- (13.) By Dr. Pauly, among eels planted at Hùnnigen, in Elsass-Lothringen. See below.

It has been shown by Dr. Pauly that among the very young eels [montée] taken near the mouths of rivers is a considerable percentage of males, which, when transplanted to fresh water, will there retain their masculine characters and develop into perfect adult males. This discovery is, of course, of the utmost importance to fish culturists making the attempt to introduce eels into new waters. Its importance has already been pointed out by Director Haack.

The practical lesson to be learned is simply this—that young eels, for introduction into strange waters, must be taken from very near the mouths of rivers, in order that both males and females may be secured. The interest to zoologists lies in the fact that Pauly's discovery renders the theory of Van Siebold less plausible, indicating that the sexes of the young eels are differentiated before they begin to mount the rivers and that the males do not ascend beyond the limits of brackish water.

Dr. Pauly's discovery is so interesting that I propose to translate his own account of it. The investigation was made, I believe, in Munich, and the report from which I quote was published in the Austro-Hungarian Fishery Gazette, of Vienna, December 23, 1880. Dr. Pauly writes: "During the past year I have received from Court-fisherman Kuffer a large number of eels, which I have used in my investigations. The large individuals, all of which came from the lakes of northern Italy, were females. I received, however, from the same individual, another lot of eels, consisting of much smaller individuals, weighing from 20 to 90 grams ($\frac{2}{3}$ of an ounce to 3 ounces), also taken in fresh water. At the request of Professor Von Siebold, I had paid particular attention to the sexes of the eels which I was engaged in investigating, and to my great astonishment I found that a large majority of these small eels (19 out of 27) were males, possessing, instead of the familiar ovaries, the "lappenorgan" described by Dr. Syrski. A histological

examination of these organs convinced me that the structure of these tissues agreed with that described by Freud.

* * * * *

My next inquiry was very naturally concerning the locality whence these eels had been obtained. I learned that Kuffer had received them two years before from Director Haack at Hüningen, and upon questioning Director Haack learned that they had been brought from a French river, the *sèvre niortaise*, where they were caught as young fry [montée] at a distance of ten or twelve miles from its mouth, and furthermore were at the time of examination about four years old. The small size of these fish, their age being taken into consideration, satisfied me that they had been reared in captivity, since uncultivated eels would have been much heavier. The females in this lot of eels exceeded the males in length and weight and also exhibited those external characters described by Jacoby as indicating sex.

The locality in the *sèvre niortaise* where these fish were taken may easily, especially at flood tide, have been within the limits of brackish water; my observations do not prove, therefore, that male eels enter fresh water.

Dr. Jacoby found male eels in the lagoons of Comacchio, where the water is brackish. These males must have ascended in the "mounting" as fry, and probably at the approach of sexual maturity descend with the females to the sea. My investigations and those of Jacoby prove only this: that the young female eels do not necessarily break away from their parents and from their birth-places at sea, and entirely alone proceed upon their migrations, while the males scatter through the sea, but that their brothers seem to accompany them part of the way upon their journey. But how far? Do the males know where pure fresh water begins, and are the fry of different sexes found mingled together only at the river mouths? If we bear in mind the fact that the male organs had so long escaped discovery, that, on account of their crystal-like transparency, their detection in a fresh eel is so difficult, etc., may we not admit that past conclusions are probably erroneous, and that although thousands of fresh-water eels have been studied by different investigators, male eels may yet be found in our streams, especially when more of the smaller individuals have been examined."

* * * * *

Dr. Pauly then discusses the observations of Dr. Hermes, who found 11 per cent. of males among eels taken at Willenberg, on the Elbe, about 120 miles from the German Ocean, and no males whatever at Havelberg, 20 or 30 miles higher up the stream, and closes his essay with the following conclusions: "*Male eels undoubtedly ascend the rivers, but the numerical percentage of males to females appears to diminish as one proceeds up the streams.*" This fact is opposed to the theory proposed by some one that young eels are at first of undifferentiated sex and have the tendency, under the influence of fresh water to become females, under that of salt water to develop male characters."

XVI. STRANGE MISSTATEMENTS IN ICHTHYOLOGICAL LITERATURE.

One may conclude from these observations that the eels preparing to spawn leave the inner waters early in December and seek out the deeper places of the sea, where they cannot be caught with our ordinary implements of capture. The eel eggs can only be found by a systematic investigation of certain parts of the sea bottom with the dredge and the microscope. This investigation might also include the sinking of the migrating eels in special cases to the bottom of the sea, in order to determine whether, under these circumstances, the eggs would ripen more rapidly. By using the largest fish for this purpose one could arrange, by means of small openings in the cages, to permit the entrance of the small male eels. At any rate, there is no doubt from these observations that the spawning period of the eel takes place in winter.

In an article by Guido Lindenhain, entitled "The Natural History of the Eel" (*Zur Naturgeschichte der Aale*), which has recently been published in the Austro-Hungarian Fishery Gazette, extending through six numbers, a fanciful contributor of that paper, among other wonderful things, claims to have discovered the spawning of the eel in rivers and ponds. I will allow the very sagacious gentleman to recount his summer-night's dream in his own words, in order to show with what certainty and precision the most baseless fables concerning the natural history of the eel are even yet narrated :

"The methods of spawning by the eel," writes this keen observer, "are very interesting, but to observe them is very difficult and tiresome, and, indeed, only possible when the spawning places have already been determined by experience. One must remain for many nights upon the shore, hidden behind the bushes, with unflagging attention, until these nocturnal adventurers have come into the shallow water and made their presence known by their snake-like motions at the surface. As soon as they have gathered together upon their chosen haunts there is a great commotion in the water, and powerful blows are heard, so that the water splashes up a considerable distance, and the surface is covered with little waves, as if some great object were moving about, after which one gets glimpses of parts of the bodies of the contending rivals of the happy spawning fishes themselves. After the duration of an hour or so it is again quiet, and one sees that the water is moved in different directions in serpent-like waves, which become less and less apparent to the eye of the observer, while the eels are leaving the spawning-places and are betaking themselves to hunt for food or are seeking their customary quiet dwelling-places. If the observer, moved by overwhelming curiosity, comes on the following day to the same place, he sees nothing, but if he looks with a strong magnifying-glass carefully over the water-plants, he discovers little greenish-white eggs resting upon the bottom, out of which the young eels will escape in about six weeks."

"It is only to be regretted that the enterprising observer has not illustrated the whole development of the egg by photographic views of his fancies."

Another wonderful story was narrated by Dallmer.*

A Fleusburg eel-smoker told him that once, in April, one of the sacks in which eels had been sent to him, after it had been emptied, was put into the water with the others; after having been tied up he found, after eight to fourteen days, millions of living young eels from one to two inches long. He thought that fertilized spawn had been left in the bag which, in eight to fourteen days, had developed into fishes of one to two inches in length. A million of young eels of $1\frac{1}{2}$ inches in length would take a space of 9,761 cubic inches, which would be much more than a sack could contain. Such a quantity of little fishes would scarcely be able to find in a sack tied together at its mouth food enough to enable them to grow from a very minute size (the eggs in the ovary have been found only 0.23^{mm} large, and may, perhaps, when laid, measure 0.5^{mm}) in eight days to a length of from one to two inches; let us, however, suppose that the eel-smoker had confounded a hundred little eels with as many millions, it could hardly, even then, happen that these little animals in from eight to fourteen days could have grown to 160 times their original dimensions. The story would be much more probable if it were supposed that the young eels in their wanderings toward the fresh waters had, perhaps, found their way into a bag which was not tied up at its mouth.

In De La Blanchère's "Nouveau Dictionnaire general de peche, Paris, 1868," occurs the following paragraph, without any indication of its source: "Chenu and Desmarest do not hesitate to state that the eel spawns upon the mud after a kind of copulation; that the eggs remain, adhering together, joined by a glutinous substance analogous to that which connects the eggs of the fresh-water perch, and forms little pellets or rounded globules. Each female, as they have succeeded in observing, produces annually many of these masses. The little fish soon hatch out and remain, for the first few days after their birth, together in these masses, but when they have reached a length of 4 or 5^{mm} they shake off the bonds which hold them and soon ascend in great bodies the streams and brooklets near which they find themselves."

According to this, the eggs are deposited in masses of slime, inside of which the young hatch out in the course of a few days, and a few days later they shake themselves free and swim about at liberty.

When and where these investigators have made such observations is not to be found out from the "Dictionnaire"; at any rate, it is very hard to understand how they have proved that the same female eel yearly lays several sets of eggs.

XVII. BENECKE ON THE MOVEMENTS OF YOUNG EELS.

Benecke gives the following thorough discussion of the movements of young eels:

The young eels, hatched out of the eggs at sea, doubtless live at the

* Fische und Fischerei im Sussen Wasser, Segeberg, 1877.

bottom until they grow, through consumption of rich food substances there to be found, to a size from 1 to 3 centimeters. When they have attained this size they begin their wanderings in immense schools, proceeding to ascend into the rivers and lakes. These wanderings of the young eels have been known for a very long time; for instance, in the lagoons of Comacchio, in which they may be found, for the most part, after they have gained the length of from 6 to 8 millimeters, and in France, later also in England, Denmark, Sweden, and, more recently, in Germany they have also been observed.

According to the French reports young eels are hatched out early in the winter, and in February, having attained the length of 4 or 5 centimeters, they appear in the brackish water at the mouth of the Loire in immense numbers, soon to begin their wanderings up the stream. They swim in crowded schools at the surface of the river right up to the banks, and little detachments of the army deploy at the mouth of each tributary and pursue their wanderings along its course. These swarms of young eels are called in France "Montée," in Italy, "Montata." The number of the young fish is, as might be expected from the number of the eggs in the ovary of the eel, wonderfully large. Redi has recounted that from the end of January to the end of April the young fish continue wandering up the Arno, and that in 1867 over 3,000,000 pounds of them were taken in five hours. Into the lagoons of the Comacchio the eels pour from February to April. In March and April they have been noticed in many French rivers, in which the migration continues for from eight to fourteen days. The first account of these wanderings in Germany was that given by Von Ehlers. In 1863 he wrote to Von Siebold: "This took place about ten years ago, in the village of Drennhausen, in the Province of Wesen, in the Kingdom of Hanover. As we were walking, towards the end of June or the beginning of July, on a dike, which at that place projects out into the Elbe, we noticed that along the entire shore there might be seen a moving band of a dark color. Since everything which takes place in the Elbe is of interest to the inhabitants of that region, this phenomenon immediately attracted attention, and it soon became apparent that this dark band was composed of an innumerable body of young eels, which were pressing against each other, as, at the surface of the stream, they were forcing their way upwards towards its source, while they kept themselves so close to the shore that they followed all its bendings and curves. The width of this band of fish at the place where it was observed (where the Elbe has a considerable depth) was perhaps a foot, but how deep it was could not be observed, so thickly crowded together were the young eels. As they swam a great number could be taken in a bucket, and it was very annoying to the people who lived along the Elbe that so long as the procession of fish lasted no water could be taken out of the river which was not full of the little fish. The length of the young eels was, on an average, from 3 to 4 inches; the thickness of the body was about equal to that of a goose-quill. By

themselves might here and there be seen swimming eels of greater size, but none of them were probably more than 8 inches in length. All of them, even the smallest, were dark colored. This wonderful procession of fishes continued unbroken and of the same density throughout the whole of the day on which it was first observed, and continued also upon the following day. On the morning of the third day, however, not one of the young eels was to be seen."

Similar observations have been made at Wittenberg, on the Elbe. Kuppfer observed great quantities of young eels, of about 3 centimeters in length, in the brackish water of the Eider, at Freiderickstadt; so also did Von Stemann.

"Every year," writes the latter, "from April to the end of June, there appear great masses of young eels, which are present in large schools toward the Upper Eider, seeking in every way to pass each other. In April the first eels show themselves generally singly; cold weather has evidently kept them back up to this time; since this year, until to-day, no ascent whatever has taken place, and now the approach of the great schools is beginning. Where the current is feeble, the procession is broad; but where the eels encounter a strong current—near a mill—it becomes small, and presses close to the shore, in order to overcome the currents. The little animals swim eagerly and rapidly along near the banks until they find a place over which they decide to climb. Here they lie in great heaps, and appear to await the rising of the tide, which makes their ascent easier. The tide having risen, the whole mass begins to separate without delay; eel after eel climbs up on the steep wall of rock, determined to reach the little pools, at the height of 15 or 20 inches, into which some of the water from the Upper Eider has found its way. Into these holes the little animals creep, and have yet to travel a distance of 40 or 50 feet under the roadway before they can reach the Upper Eider. Another detachment betakes itself to the sluice-ways, and clings to the cracks in the wood; also around the mills their ascent may be observed, especially about sunrise."*

Davy sends a similar account from Ireland. He was a witness of the ascent of young eels, or "elvas," at Ballyshannon, at the end of July, 1823; he speaks of the mouth of the river under the fall being "blackened by millions of little eels about as long as a finger, which were constantly urging their way up the moist rock beside of the fall." "Thousands," he adds, "died; but their bodies, remaining, served as a ladder by which the rest could make their way; and I saw some ascending even perpendicular stones, making their way through wet moss or adhering to some eels that had died in the attempt."*

* Professor Benecke had in his possession some of the young eels, which escaped from all the vessels in which they were confined, and even climbed to the ceiling of his room.

* EEL-FAIRS IN CONNECTICUT.—Fresh-water eels may be caught in large numbers, in weirs along the lake streams, when descending at the fall equinox to deposit their spawn in some lower region, and in the following August their offspring, from three

Such is the energy of these little animals that they continued to find their way in immense numbers to Loch Erne.

In the little eels which ascend the rivers there are no traces of sexual organs, but in the fresh water they develop only into females. One of the most recent observations made by Dr. Pauly, in Munich, would appear to contradict this idea, since he discovered male eels among the fish which were brought with a lot of young eels to Hünigen, were kept there for two years in ponds, and were finally released in the fish pond of Court-Fisherman Kaufer. We should bear in mind, however, that these young eels were captured at the mouths of fresh rivers in brackish water; and that among the numerous small eels which swim in the brackish water there must be many larger specimens, in which the male organs have already begun to develop. Such are doubtless those which were sent in the male condition to Hünigen and Munich, and were there recognized as males. This presumption can be set aside only if male eels shall hereafter be found among the fish which are caught in the upper part of rivers in the condition of young fry.

Concerning another important fact which is connected with the movements of the young fry of the eel, I became acquainted last year (in the course of an exploration of the waters of the district of Konitzkünde) with the river Brahe, at Mühlhof, above Rittel, where a high dam was built in 1846 and 1847 for the purpose of watering a large system of meadows by the overflowing of the stream. Below the dam is an inclined plane (constructed of boards), about 300 feet long, built for the purpose of preventing the water, which rushes out when the sluice-gate is opened, from washing away the bottom of the stream and its banks. This plank floor consists of two layers, the lower one of 2-inch, the upper one of 3-inch boards. The grade of the dam at Mühlhof (33 feet 3 inches) has entirely cut off the ascent of the fry of the eel into the upper part of the Brahe and the lakes tributary to it, and the number of eels caught above the dam—which was formerly very considerable—has become reduced almost to nothing. In the year 1847 the construction of the dam and the inclined plane was completed; in 1852 the upper layer of the planks on the plane had warped and sprung up in many places, so that it had to be torn up for repairs. The cause of the warping was immediately discovered: thousands of eels—as thick as a man's finger—somewhat flattened in shape, and, on account of the absence of light, of a pure white color, filled the space between the two layers of planks, and their united pressure from beneath had caused the upper

to six inches long, return in immense numbers. The basin of the Still River Falls, near Colebrooke line, is for several days alive with them. They may be seen laboriously crawling up every rock which is moistened by the spray of the fall, and endeavoring to reach their ancestral lake or dam. At the foot of the Niagara Falls this phenomenon may be witnessed on a large scale at the same season of the year or later, and probably in other places where the fall is too high and the current too swift for the young eels to stem it without contact with the rocks.—Annals of Winchester, Conn., Boyd, p. 26.

layer to yield; these eels had found their way between the boards as fry, where they had found sufficient food and had grown to such a size that the pressure of their united strength had pushed up the roof of their prison. These facts, observed by an old millwright, were communicated to me by Privy Counsellor Schmid, of Marienwerder, who supervised the construction of the Mühlhof dam, and he fully confirmed them.

Eels of 4 inches in length, which in May are plenty in fish-ponds, by the end of October reach a length of 10 inches and the thickness of a man's little finger; in the following fall they measure from 20 to 24 inches, and in the third year are ready to be eaten. On account of their rapid growth and hardy nature, in consequence of which latter they live in mud-holes and unprofitable waters of all kinds, the breeding of eels is a very remunerative business. The young fish (of which, at the time of their first appearance at the mouths of rivers, it takes 1,500 to 1,700 to make a pound, while, when taken later and a little further from the sea, it takes only 350 to 400 for the same weight) may be obtained at low prices from France through Hüningen, or in Germany from Randesberg and, through the Berlin Aquarium, from Wittenberg, and, when the temperature of the air is not too high, may be carried in soft moss throughout all Germany.

According to the statement of the well-known Paris fish-merchant, Millet, two pounds of eels, planted in a muddy pond in 1840, in five years yielded 5,000 pounds of fine eels.

XVIII. OBSERVATIONS OF DR. HERMES IN 1881 ON THE CONGER.

The observations of Dr. Otto Hermes, director of the Berlin Aquarium, who has recently discovered the true nature of the organ of Syrski in the conger, are extremely interesting.

"Since Syrski, in 1874, found the organs in *Anguilla vulgaris*—which are called by his name, and which, by him and most zoölogists, were taken for the male reproductive organs—it is only necessary that a ripe male eel should be found in order to settle forever the question of the sexes of the eel. Up to this time all efforts have failed to reach the desired result. The histological investigations of the Syrskian organs pursued by S. Freud render it more probable that these were young roes; yet there remained all the time a doubt, since the spermatozoa had not been actually observed, and this uncertainty is an insuperable obstacle to the acceptance of the Syrskian discovery. The supposed discovery of spermatozoa by A. S. Packard in the male eel proved to be another delusion. The contradiction of this imaginary discovery appeared in No. 26 of the second volume of the *Zoologische Anzeiger*, p. 193, in which it was stated that the motile bodies were not spermatozoa, but yolk particles. This correction was also made by Von Siebold's assistant, Dr. Paul,* and by S. Th. Cattie.

*Austrian Fishery Gazette, 1880, No. 12, p. 90.

"The reproductive organs of *Conger vulgaris* are very similar to those of *Anguilla vulgaris*; in the undeveloped condition they show the ovaries

lying in the same position in a cuff-shaped band of a proportionally large size. Since *C. vulgaris* reaches nearly twice the size of *A. vulgaris*, individuals of 6 feet in length are not rare. The ovary is developed in the captivity, and this, I am convinced, is often the cause of the death of the eel. In a *Conger* which died in the Berlin Aquarium, and was cut open, the ovaries protruded very extensively, and a specimen which lies in the Frankfort Aquarium burst on account of the extraordinary development of the ovaries. The ovaries of this eel, which weighed 22½ pounds, themselves weighed 8 pounds, and the number of eggs was about 3,300,000. The want of a natural opening for the escape of the eggs was evidently in this case the cause of death. Male specimens of the *Conger* in an undeveloped condition I have hitherto never had the opportunity to investigate. I received, however, in the fall of 1879 a number of sea-eels, taken in the vicinity of Hayre, whose average length was from 24 to 27 inches. These eels ate greedily and grew rapidly. Only one was tardy in its development, so that it could be easily distinguished from the rest. This, which was the smallest of the *Congers* in the aquarium, died on the 20th of June, 1880, and

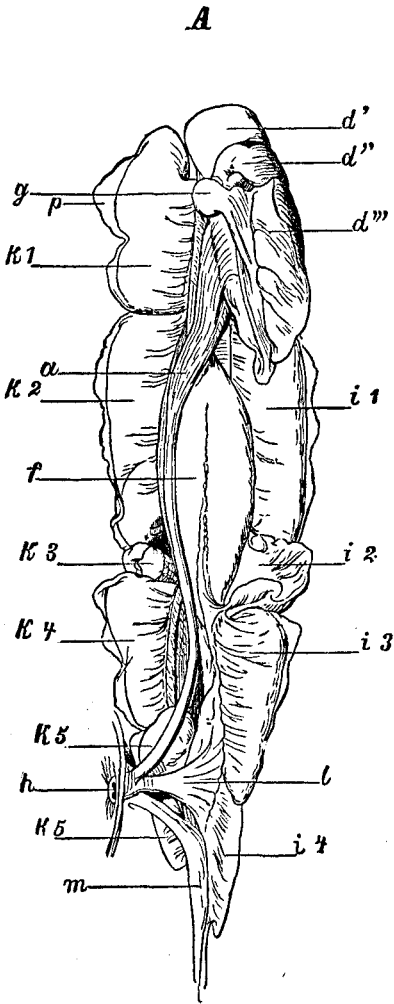


FIG. 9.—A, ripe male reproductive organs of a *Conger-eel*, thirty inches in length, ½ natural size.
 a, intestinal canal.
 d', upper, d'' middle, d''' lower portion of the liver, which has been thrown to one side.
 f, air-bladder.
 g, gall-bladder.
 h, anal aperture.
 i₁, i₂, i₃, i₄, folds of the left spermary.
 k₁, k₂, k₃, k₄, k₅, folds of the right spermary.
 l, seminal pouch.
 m, urinary bladder.
 p, skinny covering of the spermary.
 B, spermatozoa.

was examined by me on the same day. I was very much delighted when I found the sexual organs very different from those which I had ever noticed before. After a single cut into them, there flowed out a milky

fluid, which, under the microscope, with a power of 450 diameters, showed a great number of spermatozoa, in the liveliest motion, and in which head and tail were evidently visible. There could be no doubt that I had found a sexually mature male of *Conger vulgaris*. Two fragments of the roe were laid aside for further investigation, and the eel, which was 28 inches long, was prepared first in alcohol and then in Wickersheimer fluid.

In the paper before us Dr. Jacoby presents a full anatomical description of the generative organs of the conger as demonstrated by himself and Dr. Rabl-Rückhard. It seems unnecessary to repeat this description since the organs are very similar to those in the common eel. By the kindness of Dr. Hermes we are permitted to reproduce the drawings which accompany this description.

Compared with the description of the roe and the figure of the organ found by Syrski and by me, called 'lappen organ,' a great similarity is noticed between them. It must be borne in mind that in this case we were comparing the entirely undeveloped organs of the eel with the fully ripe reproductive organs of the *Conger*, so every doubt as to the male nature of the Syrskian organs ought to be thrown aside. Also in the comparison of the size of the male with that of the female the *Conger* shows the same relations as the eel investigated by Syrski, to wit: that the males are smaller than the females.

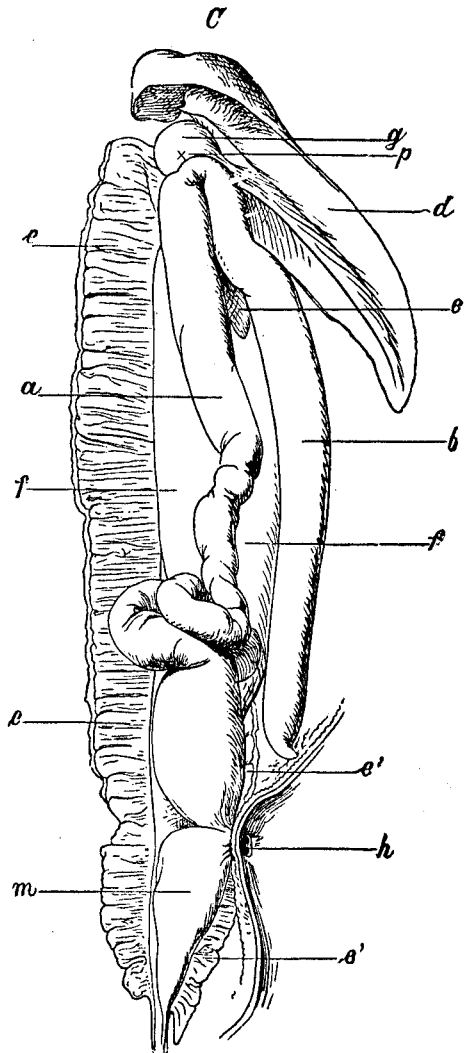


FIG. 10.—C. Undeveloped reproductive organ of a female *Conger*-eel, 34 inches long, $\frac{1}{4}$ natural size.

- a. Stomach.
- b. Coecal appendage.
- c. Spleen.
- d. Liver.
- e. Right ovary.
- e'. Left ovary.
- f. Air-bladder.
- g. Gall-bladder.
- h. Anal aperture.
- m. Urinary bladder.
- p. End of left ovary.

It is well known, as Von Siebold remarks, that young eels, ascending the rivers, developed into females and that the males remain in the sea

or at the mouths of rivers. This statement cannot be exactly demonstrated, since among 250 eels, from 11 to 15 inches in length, taken in the vicinity of Cumlosen, I found 13 males or 5 per cent. (Cumlosen is situated in the vicinity of Wittenberg and is at least 120 miles from the mouth of the Elbe). How large the percentage of difference between the neighborhood of the mouth of Elbe and places situated farther up the stream, as regards the proportion of males and females, may be, I have hitherto, from want of material, been unable to decide. Forty from the Havel at Havelberg (about 20 miles above Cumlosen) were all females. Out of 137 eels taken in the bays at Rügen, in the Baltic, I found 61 or 44½ per cent. males, while at Wismar, on the Danish coast, the males only constituted 11 per cent. Whether these facts have any connection with the discovery of the hitherto unknown spawning places of the eels, it is hoped that further observations will determine.

When Cattie, in his already cited work, gives it as a determined fact that the eels wander into deep water here, in order to let their generative organs attain maturity, which happens in six or eight weeks, and that the old male and female eels, after the reproductive act, die, according to my knowledge, there are wanting observations which will give this a scientific foundation. What Von Siebold and Jacoby only state as probable appear to him (Cattie) to have become already established facts.

As far as the distinction between male and female eels by external characters is concerned, the eels sent to me, some time in November, from the coast of Schleswig showed so great difference in color that their sender, the fish-master Hinkleman, was able to decide without difficulty between males and females. The former were distinguished by a specially brown coloration, while the females, in addition to greater size, almost without exception exhibited a dull steel-gray color. Among the males were found many specimens of 17½ inches in length, which I was careful to note because Syrski had only found the size of 16½ inches. In Comacchio, according to Jacoby, a specimen of 18½ inches had been found.

XIX. JACOBY'S TOUR TO COMACCHIO IN 1877, AND HIS CONCLUSIONS.

"In the fall of 1877," writes Jacoby, "I undertook a journey from Trieste, by way of Ravenna, to Comacchio; convinced of the difficulty of the questions to be solved by my own previous labors, I had not great hopes of finding sexually immature eels, either gravid females or mature males. My highest aim was at the beginning to determine the following points: (I) Whether evidences of preparation for breeding might not be found in the eels which were wandering in the fall toward the sea; (II) to what extent eels with the organ of Syrski could be found participating in this migration; (III) as far as possible to obtain eels from the sea at a distance from the coast in order to compare their organs of reproduction with those of the eels in the lagoons.

"In determining the answers to the first two questions I was able to make some new and interesting discoveries, but with regard to the latter, my most diligent efforts were absolutely fruitless.

"I found that the eels when migrating to the sea in the fall took no food. In many hundreds examined by me, caught during their movement, I found stomach and intestines entirely empty; that the eels during their migrations eat nothing is also known to all fishermen and watermen of Comacchio. At the same time, the eels which remained in the lagoons were more or less filled with food, not only those which were not sufficiently mature to migrate, but also a breed of eels which never goes to the sea, but remains throughout its entire life in the lagoons.

"There may be found in Comacchio, and doubtless everywhere where eels live in great numbers in brackish water along the coast, a peculiar group of eels which, as far as I could determine, consists entirely of sterile females. These female eels with ovaries present a very peculiar phenomenon; when they are opened one finds instead of the well-known yellowish-white, very fatty, cuff-shaped organ, a thin, scummy, slightly folded membrane, not at all fatty, often as transparent as glass, and of about the same proportional size as the so-called cuff-shaped organ. When this membrane is examined under the microscope there may be seen in it eggs very transparent in appearance, with yolk-dots absent or with yolk-dots very small and few. This organ appears to be an abnormally-developed ovary incapable of fertilization. These sterile females, which I found of all sizes, even up to the length of 27 inches, present all of the acknowledged female characters in great prominence and in an exaggerated degree; the snout is broader, and often, especially at the tip of the under jaw, extraordinarily broad; the dorsal fins are, on the average, higher; the eyes are much smaller, especially in large specimens, and the coloring is clearer; the back of a clearer green and the belly yellower than in the normal female. The flesh of these sterile females has a very delicate flavor, and quite different from that of other eels. I was quite astonished at the fine flavor when I tasted them for the first time in Comacchio. The flesh, as the expression goes, melts upon the tongue. It is even possible to distinguish them while living, by feeling them with the hand, their soft bodies being very different from the hard, solid, muscular flesh of the others.

"In Comacchio these eels are called 'Pasciuti.' Coste called them 'Priscetti,' and defined them to be those eels which had not become ripe, but which were at least a pound in weight. The name 'Priscetti' is, however, very incorrect, as I have become convinced by questioning the fish inspectors and by hearing the conversations of the fishermen. 'Pasciuto' means 'pastured,' and the fishermen understand by this, those eels which do not migrate, but which remain through the whole year feeding in the lagoons. They include, however, under this name, eels of two kinds—the sterile females already described, and the eels which are not yet ripe, as well as the normal females and supposed

males, whose period of migration is somewhat remote. This circumstance is a cause of much difficulty to the investigator.*

A.—Sterile females or Pasciuti.			B.—Normal Females.			C.—Eels with supposed male 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.	396	5.5

“The studies on the second point to be solved were of special interest, viz, the determination of the presence at Comacchio, and the behavior of eels with organs of Syrski. I can answer this question very briefly, since among 1,200 specimens examined by me at the fishing stations and at the so-called eel-factories (with the exception of the largest specimens, which are always females), I found on an average of five per cent. with the organ of Syrski; of the eels under 15 inches in length (45 centimeters) on an average there were 20 per cent., so that the conclusions as to their abundance were very similar to those at Trieste, where the fish market is supplied, for the greater part, with eels from Chioggia, and to a less extent with those from Comacchio.

“In Comacchio the largest eels with the organ of Syrski, which I have observed, were about 17 inches (48 centimeters) in length, the smallest about 9 inches (24 centimeters). All of these were found among the eels taken during their migration to the sea, and, like the females, were found with stomachs completely empty or slightly filled with a slimy substance. It was impossible to find in any specimen a more advanced development of the Syrskian organ than in those examined in summer at Trieste.

“With reference to the third question undertaken by me, which relates to the actual kernel of the eel question, that is, the possibility of obtaining the eels which have migrated out to sea, in order to obtain in this manner the sexually mature milters and spawners, I have been unable to obtain any results. I have, so far as my opportunities permitted, left no stone unturned to gain its solution. I went out to sea

* It has been noticed by many early writers that there are certain eels which never come to the sea—Risso, in his “Histoire Naturelle,” tome 3, p. 198, and S. Nilsson, in his “Scandinavisk Fauna,” tome 4, p. 663. The latter called this variety “Grasaal,” or grass-eel, and spoke of its yellowish-green coloration and the soft, delicious flesh. Strange enough, both these writers spoke of the sharper snout of this eel, and Risso, who founded upon it another species, *Anguila acutirostris*, described it as blackish above and silvery below. These descriptions apply in every particular to the non-migratory eel of Comacchio. Jacoby remarks that all the sterile females brought to him under the name “Pasciuti,” were distinguished by their broad snouts. The following tables were prepared at Comacchio. *a* gives the total length of the body of the eel; *b*, the breadth of the snout between the nasal tubes, in millimeters.

from Magnavacca and from Codigoro, on Chioggian vessels, and many times have fished myself, and have stimulated the fishermen by offers of reward to endeavor to obtain eels at sea, but I am forced to the conclusion that with the ordinary means this cannot be done.

"Intelligent, grey-headed fishermen of Chioggia, who by means of their fishing apparatus know this part of the Adriatic as well as they know their own pockets, have assured me that throughout their entire lives they have never caught a grown-up river eel in the sea at any distance from the coast. The eels which were brought to me at Mannbach as having been caught in the sea, and which I found to be the ordinary females, or eels with the Syrskian organ, were either from localities close to the shore where they are not rare, or were taken in the Palotta canal. There was no lack of attempts at deception. Fishermen took eels from the shore with them in order to be able, on their return, to claim that they had been caught at sea. In the immediate neighborhood of the coast they are, as it has been stated, in the spring-time not rare, and there are not the slightest differences between these and the eels of the lagoons. I found both females and eels with the organ of Syrski with their reproductive organs in the same immature condition as in Comacchio; evidently they had just come through the Palotta canal from the lagoon into the sea. A certain distance, perhaps one or two marine miles from the coast, every trace is lost of the adult eels which wander by the many thousand into the sea. Strange as this problem appears at first sight, it is easily understood when the character of the fishing apparatus is considered; the nets are those used in the capture of lobsters, and are thrown over the bottom; they have meshes much too large to hold the eels, or, when they are small-meshed, they do not touch the bottom. The problem can only be solved by using apparatus constructed especially for the purpose."

Jacoby proposes the following questions, which, in his opinion, cover the still unanswered points concerning the natural history of the eel, and answers them in accordance with the results of his own observations:

Question 1. How can the fact be accounted for that no one has ever found mature females and males, spawners and milters, among the eels?

Answer. The eels require the influence of sea-water for the development of their reproductive organs. As is now definitely understood, they leave the rivers and the brackish lakes on account of the undeveloped condition of their reproductive organs, for the purpose of becoming sexually mature at sea; that these migrations to the sea take place for the purpose of reproduction appears to be certainly proved by the fact that the young eels leave the sea in the spring, and that the migrating eels, like other fishes at the spawning season, abstain from eating.

Question 2. When and where occurs the necessary development of the reproductive organs of the eel to a condition in which they are capable of fertilization?

Answer. Development of the reproductive organs takes place in the

sea, not close to the shore, but at a distance and in deep waters. This development is extraordinarily rapid when the immature state, in which the migrating eels are found, is taken into consideration; they must become sexually mature within a few, probably five or six, weeks of the time that they enter the sea. At Comacchio the emigration takes place between the beginning of October and the end of December.

Question 3. Where does the act of spawning take place, the fertilization, and the deposition of the eggs?

Answer. There are probably certain definite spawning places in the sea, off the mouths of the rivers. These are the mud-banks to which the eels go, for the purpose of spawning, in great numbers. The young fish are developed upon these mud-banks, and from eight to ten weeks after their birth, at the beginning of spring, find their way to the mouths of rivers, which they ascend.

Question 4. What becomes of the grown-up eels after spawning time, and why do they remain lost to sight and never again come back into the rivers?

Answer. The old eels, male and female, without doubt, die soon after the spawning season. The very unusual rapid development of their reproductive organs has such an effect upon the systems of the adult eels that they die soon after the act of reproduction. This is the reason why they are never seen to wander back again.*

An intelligent Chioggian, the owner of a fishing vessel, in answer to my question, as to where the old eels staid, answered, "They die on the mud-banks after they have propagated their young."

This hypothesis may be confirmed in a scientific manner by the analogous circumstances in the history of the lamprey. Panizza, in his description of the sea lamprey, *Petromyzon marina*, remarks, that both the males and females of this species after the spawning period are brought up dead. Concerning the river lamprey, *P. fluviatilis*, Statius Müller remarks that when they spawn they slowly fall away and die. Concerning the little lamprey, *P. planeri*, August Müller, the discoverer of its larval form, has recorded the same opinion.

XX.—A LIST OF THE MOST IMPORTANT PAPERS CONCERNING THE EEL AND ITS REPRODUCTION.

1684. REDI, FRANCISCO. Osservazioni intorno agli animali viventi che se trovano negli animali viventi. Florence, 1684.

[“On living animals which occur within other animals.” Refers to the mounting of the young eels in the Arno, and particularly to an enormous capture of young eels at Pisa, in 1667, [p. 100]. Illustrates the ovaries of a maray (*Murana helena*). Proves that the objects ordinarily supposed to be young eels are intestinal worms, and argues that eels must be viviparous.]

* As a confirmation of this view, Von Siebold was the first to make this hypothesis.

1692. LEEUWENHOEK, ANTON DE. <Arcana Naturæ, 1692.

[Leeuwenhoek describes the urinary bladder of the eel as its uterus, and parasitic worms found therein as the young of the species.]

1697. ALLEN, BENJAMIN. On the Generation of Eels. <Philosophical Transactions, London, xix, 1697, pp. 664-666.

[Allen claimed that eels were ovo-viviparous.]

1698. DALE, —. An account of a very large eel lately caught at Malden, in Essex, with some considerations about the generation of eels. <Philosophical Transactions, xx, 1698, pp. 90-97.

1712. VALLISNERI, ANTONIO. De Ovario Anguillarum. <Ephemer. Leopoldinischen Academie der Naturforscher, 1712, pp. 153-165, Fig. 4.

[Contains an announcement of a supposed discovery of the ovary of the eel; the organ described by him was a diseased and deformed swimming-bladder.]

1746. ARDERON, WILLIAM. On the Perpendicular Ascent of Eels. <Philosophical Transactions, London, xlv, 1746, pp. 395-396.

1750. FAHLBERG, ALGOT. Von der Fortpflanzung und Vermehrung der Aale. <Abhandl. Schwed. Akad., xii, 1750, pp. 199-202.

[Not seen. Title from Syrski.]

1766. LINNÆUS, CAROLUS. Muræna Anguilla. <Systema Naturæ, i, 1766 (12th ed.), p. 426.

[Under the head of the eel, the father of modern natural history sums up its life history as known to him: "Habitat in Europa, maxima in lacu Comachio Ferrariensi; non fert Danubiam, nisi rarissime; nocturna latet in cæno duplici foramine, coercetur trunco albo betulæ; cutis tenacissima; parit vivipara sub canicula. * * * Hybernat; noctu tenebricosa obambulat; cadaveribus viçtitat."]

1777-83. MONDINI, CARLO. De Anguillæ Ovariis. <De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii, tom. vi, 1783, pp. 406-418. [Bologna, 1783.]

[Read before the Bologna Academy in 1777. After a comment upon the discovery of Spallanzani, which was shown to be untenable, the supposed ovary described by that investigator having been simply a diseased swimming-bladder, Mondini describes the true ovary of the eel, illustrating his discovery by excellent drawings. In the opinion of Jacoby and others this was the first demonstration of the ovary of the eel.]

1780. MÜLLER, OTTO FRIEDRICH. Unterbrochne Bemühungen bei den Intestinalwürmern. <Schriften, Berliner Gesellsch. Naturf. Freunde, i, 1780, pp. 202-218.

[Announces the discovery of the ovary of the eels—a discovery independent from that of Mondini, though made three years later. Many authors have given the honor of discovery to Müller, owing to the fact that Mondini's paper, read to the Bologna Academy in 1777, was not published until 1783.]

1783. MONTE, CAJETAN. De Anguillarum Ortu et Propagatione. <Comment. Acad. Bonon., vi, 1783, pp. 392-405.

Bull. U. S. F. C., 81—8

[1792?] SPALLANZANI, LAZZARO. *Opusculi due sopra le anguille, dove singolarmente si ragiona di quelle che se pescano nelle valle di Comacchio.* <Opere [ed. Milano, 1826], iii, p. 518. *Appendice ai Viaggi alle due Sicilie*, vi, [1752.]

[An attempt to overthrow the claim of Mondini.]

1803. AMORETTI, CARLO. *Osservazioni sulle Anguille.* <Mem. Soc. Italiana, x, 1803, pp. 679-680.

1807. MITCHILL, SAMUEL L. *Facts concerning the Generation of Eels.* <N. Y. Medical Repository, iv, 2d hexade, 1807, pp. 201-203.

[Records the independent discovery of eel ovaries in eels from Long Island.]

1809. CARR, JOHN. *On the Generation and other obscure facts in the Natural History of the Common Eel.* <Philosophical Magazine, xxxiv, 1809, pp. 272-277.

1815. CLINTON, DE WITT. *An Introductory Discourse [before the Literary and Philosophical Society of New York], delivered on the 4th of May, 1814.* <Trans. Literary and Philosophical Society of New York, ii, 1815, pp. 17-184.

[In note AA., pp. 146-148, Clinton expresses the following opinion: "The eels migrate every autumn to the sea for the purpose of propagation, and the young ones return up the streams in spring and summer in immense numbers. Some stay in fresh water all the year, but they do not breed; and it seems to be a fact well established that they do never breed in fresh water, the periodical descent of the old ones to the ocean and the ascent of the young ones from thence prove that the scene of their propagation is in the sea itself."]

1815. MITCHILL, SAMUEL L. *The Fishes of New York described and arranged.* <Trans. Literary and Philosophical Society of New York, i, 1815, pp. 355-492, 6 plates.

[Discussing the eel, p. 360, Mitchill remarks: "The roes or ovaries of eels may be seen, by those who will look for them in the proper season, like those of other fish. By inattentive observers they may be mistaken for masses of fat."]

1822. CARLISLE, ARTHUR. *On the Breeding of Eels.* <Philosophical Magazine, lix, 1822, pp. 109-110.

1824. RATHKE, MARTIN HEINRICH. *Ueber den Darmkanal und die Erzeugungsorgane der Fische.* <Neueste Schriften der Naturforschenden Gesellschaft zu Danzig, i, part iii, Halle, 1824, p. (122?); *Wiegmann's Archiv*, i, 1828, p. 299.

1828. MONDINI, CARLO. *On the Generation and Migration of Eels.* <Edinburgh Journal of Science, ix, 1828, pp. 328-330.

[Not seen. Title from Carus and Engelmann.]

1829. DAVY, SIR HUMPHREY. *Salmonia, or Days of Fly Fishing, &c.* London, 1829.

[Refers to the "eel-fairs" of England, describing the ascent of the young brood into Loch Erne.]

1831. YARRELL, WILLIAM. On the Generation of Eels and Lampreys. <Proceedings of the Committee of the Zoological Society, i, 1831, pp. 132-134.
1834. YARRELL, WILLIAM. On the Reproduction of the Eel. <Report, British Association for the Advancement of Science, 1833 (1834), pp. 446-447.
1838. RATHKE, MARTIN HEINRICH. Ueber die weibliche Geschlechtswerkzeuge des Aales. <Archiv für Naturgeschichte, iv, 1838, pp. 299-301.
1838. DESLONGCHAMPS, ÉUDES. Sur le Mode de Propagation des Anguilles. <L'Institut, vi, 1838; Suppl., pp. 133-134.
1839. JOANNIS, L. DE. Notice sur la Parturition et la Génération des Anguilles. <Revue Zoologique, 1839, pp. 48-53.
1839. JOANNIS, L. DE. Notice sur la Génération des Anguilles. <Comptes Rendus, Académie des Sciences, Paris, viii, 1839, pp. 301-312; L'Institut, vii, 1839, p. 67.
1842. HOHNBAUM-HORN SCHUCH, REINHOLD. De Anguillarum Sexu ac Generatione. Inaugural dissertation. Greifswald, 1842.
[According to Jacoby, this paper contained the first figure, since that of Mondini, of the ovary of the eel, and the first illustration of its appearance under the microscope.]
1845. PANIZZA, BARTOLOMEO. Memoria sulla Lampreda Marina. <Mem. dell' Instituto Lombardo di Scienze, Milano, ii, 1845, p. 48.
[Panizza here refers to the death of male lampreys after their reproductive functions have been performed.]
1848. SCHLÜSER, GUILIELMUS. De Petromyzontum et Anguillarum Sexu. Inaugural dissertation. Dorpat, 1848. 8°. p. 42.
[In this paper, according to Jacoby, Schlüser contradicts the opinion of Hornschuch that eels might possibly be hermaphrodite, advancing the idea that male eels are either very few in number or that they differ much from the females in size or appearance.]
1841. CREPLIN, FRIEDRICH CHRISTIAN HEINRICH. Ueber die Fortpflanzungsweise des Aals. <Archiv für Naturgeschichte, vii, 1841, pp. 230-232.
1842. WIDDRINGTON, S. E. [Captain, Royal Navy]. On the Eel and the Fresh-water Fish of Austria. <Annals of Natural History, viii, 1842, pp. 207-210.
[Claims that the absence of eels in the lower Danube is due to the admixture of water from cold Alpine streams.]
1850. RATHKE, MARTIN HEINRICH. Bemerkungen über einen hochträchtigen Aal. <Müllers Archiv für Anatomie und Physiologie, i, 1850, pp. 203-206.
[For comment on the work of Rathke, see the translation of Jacoby's memoirs, Report U. S. Fish Commission, iii, (1874), 1876, p. 727.]

1850. COSTA, ORONZ. GABRIEL. *Storia ed Anatomia dell' Anguilla e Monografia della nostrali Specie di questo Genere.* Naples, 1850. 4^o, with 9 plates.
1859. VOGT, CARL. "Künstliche Fischzucht." Leipzig, 1859.
[Refers to the mounting of the young eels in France, p. 52.]
1861. COSTE, P. *Voyage d'Exploration sur le Littoral de la France et de l'Italie.* Paris, 1861.
[On p. 49 Coste discusses the peculiar supposed sterile forms, known in Comacchio by the name "*Pascente*."]]
1863. SIEBOLD, CARL THEODOR ERNST VON. *Die Süßwasserfische Mitteleuropas.* Leipzig, 1863.
[In this work, pp. 348-352, von Siebold suggests the idea that the sedentary eels of the inland waters were permanently sterile individuals. He admits that the eels may reproduce either by parthenogenesis, by copulation, or that they may even be hermaphrodites.]]
1866. DESMAREST, M. <Revue et Magazin de Zoologie, 1866, pp. 161-165.
[Observations on an eel kept in a tank of water for the last thirty-seven years.]]
1867. JACOBY, L. *Ueber den Knochenbau der Oberkinnlade bei den Aalen.* <Inaugural dissertation of L. Jacoby, with 8 plates. Reprinted in Giebel & Sieweit's *Wissenschaftliche Zeitschrift*, Sept. and Oct., 1867. Halle, 1867.
[Concerning the bony structure of the upper jaw of the eel.]]
1872. ERCOLANI, GIOVANNI BATTISTO. *Del Perfetto Ermafroditismo delle Anguille.* <Mem. dell' *Accademia delle Scienze di Bologna*, 1872, p. 529.
[In this paper "Upon the perfect hermaphroditism of eels," Ercolani maintained that the snaky-like folds of fat formerly noticed near the ovary were nothing else than the true spermaries of the eel, and that upon the left side of the animal the spermary developed into a true testicle, while the one upon the right side shrunk up and became functionless. The spermatozoa (supposed) observed by him have been pronounced by Syrski and others to have been founded on a false interpretation of the molecular movement of the fat particles.]]
1872. BAIRD, SPENCER F. *Generation of Eels.* <*Annual Record of Science and Industry, 1872 (1873)*, p. 299.
[A review of Ercolani's paper.]]
1872. CRIVELLI, BALSAMO, and MAGGI, L. *Intorno agli Organi Essenziali della Reproduzione delle Anguille.* <*Mem. del Istituto Lombardo di Scienze e lettere a Milano*, xii, 1872, pp. 229-240, with plate; *Wiegmanns Archiv für Naturgeschichte*, I, 1872, p. 59 (German translation). Review by Canestrini, *Atti Soc. Padua*, i, 1872, pp. 70-74.
[In this paper, read fourteen days later than that of Ercolani, the authors, like Ercolani, considered the folds of fat next to the ovary to be the male organs. While they, too, advocated the hermaphroditism of the eel, they maintained that the active male organ was located upon the right side of the animal. They described spermatozoa (supposed) found by them in this organ.]]

1874. DARESTE, CAMILLE. Monographie de la Famille des Poissons Anguilliformes. < Comptes Rendus de l'Académie des Sciences, Paris, lxxix, pp. 988-990.
[An abstract of this paper is given above in the section on number of species of eels.]
1874. EBERHARD, Dr. R. [of Rostock]. Die Fortpflanzung des Aales. < Gartenlaube, 1874, p. 120.
[Identifies the young of *Zoarces viviparus* as young eels.]
1874. SYRSKI, Dr. [Professor in University of Lemburg.] Ueber die Reproductions-Organe der Aale. < Sitzungsber. d. k. Akad. d. Wissensch., Wien, lxxix, 1874, April, pp. 315-326, 2 cuts. [Dated Trieste, March 15, 1874.]
[The famous paper in which the discovery of the male eel was announced.]
1875. SYRSKI, Dr. Degli Organi della Riproduzione e della Fecondazione dei pesci ed in specialità delle Anguille. < Bolletino delle Società Adriatica di Scienze Naturali in Trieste. No. 1, pp. 10-32, Dec. 1874. Trieste, 1875 (with figures).
[Translated for Report of U. S. Fish Commission. Part iii, pp. 719-734. See below.]
1875. WITTMACK, Dr. LUDWIG. Beiträge zur Fischerei-Statistik des deutschen Reichs sowie eines Theiles von Oesterreich-Ungarn und der Schweiz im Auftrage des Deutschen Fischerei-Vereins bearbeitet von Dr. L. Wittmack. Circular des Deutschen Fischerei-Vereins, i, 1875. 4^o, pp. 251, (1) 2 folding tables and a map. The Eel, pp. 124-129.
[An excellent summary of facts concerning the distribution of the eel in Germany, with special reference to physical characters of the water, also discussions of mooted points in its life history, and statistics of its capture and use.]
1875. DARESTE, CAMILLE. Résumé d'une Monographie des Poissons Anguilliformes. < Archives de Zoologie Expérimentale et Générale, Paris, iv, pp. 215-325; Comptes Rendus de l'Académie des Sciences, Paris, lxxxi, pp. 159-162; Annals and Magazine of Natural History, (4), xv, p. 304, xvi, p. 442.
[Confirms the observations of Syrski. Records discovery of males of *Anguilla marmorata*, a species native to India.]
1876. DE LA BLANCHÈRE, H. Génération de l'Anguille. < Bulletin de la Société d'Acclimatation, 3^{me} sér., iii, 1876, pp. 489-494.
[Confirming the discovery of Syrski from observations in France.]
1876. DUIGAN, J. Is Access to the Sea a Necessity to Eels? < Transactions New Zealand Institute, viii, pp. 221.
[Claims that eels thrive in certain land-locked lakes in New Zealand where access to the sea is impossible.]
1876. SYRSKI, Dr. Lecture on the Organs of Reproduction and the Fecondation of Fishes, and especially of Eels. < Report U. S. Fish Commission, iii (1874), 1876, pp. 719-734, 23 figures.

1877. DALLMER, Herr [Head Fishmaster in Schleswig]. Fische und Fischerei im süßsen Wasser. Segeberg, 1877.

[An account of young eels found in an empty sack in which dead eels had been transported. Not seen. Title from Benecke.]

1877. LAND, GORDON. Fresh and Salt Water Eels. < Forest and Stream, viii, 1877, p. 261.

[Records capture of eels in Grand River, a tributary of Lake Erie on Canada side; in Conejos River, 1,000 miles from Gulf of Mexico, and in tributary Platte River above Denver, Colo.]

1877. ROOSEVELT, ROBERT B. New Discoveries respecting Eels. < Forest and Stream, viii, 1877, p. 267.

[Advances the idea that eels lived in fresh water in his trout ponds on Long Island.]

1878. DALLMER, Herr. Ueber die Fortpflanzung der Aale. < Deutsche Fischerei-Zeitung, i, 1878, pp. 1-3, 9-10, 17-18.

[This interesting paper is discussed in above in section xiii. A translation in part appeared in *Chicago Field*, 1878.]

1878. SCHOCH, Dr. GUSTAV [of Zurich], and Head Fishmaster DALLMER. Noch ein Beitrag zur Aalfrage. < Deutsche Fischerei-Zeitung, i, 1878, pp. 57-58 (Feb. 19).

[A discussion between Schoch and Dallmer in which there are many words and few demonstrations. Dr. Schoch, of Zurich, presents the following conclusions stated to him by Jacoby as summing up the points which may be considered as essentially substantiated: First, the eel is a fresh-water fish, which passes the greater part of its life in fresh water, but spawns in the sea. Second, it is extremely improbable that the eel brings forth living young. Third, the river eel of the headwaters or upper portion of the rivers is almost always a female, with undeveloped ovaries. Fourth, at the age of four years the eel goes down to the sea to spawn, and never returns to the fresh water. Fifth, by the deposit of the eggs the life of the female is greatly endangered, sometimes eels being found by thousands near the mouths of rivers with the ovaries entirely empty. Sixth, the descent of the eel to the sea does not appear to take place at any definite period; it probably, however, relates to the spawning season. Seventh, the male eel is always much smaller than the female, none of the former being known over fifty centimeters in length. Eighth, the males never ascend high up toward the headwaters of the rivers, but keep either continually in the sea or in the brackish water or the lower reaches of the stream. Thus a male eel has never been found in the Rhine from Basle upward. Ninth, nothing is known definitely about the spawning season. Tenth, according to all that is known, it is probable that the eels spawn in the deep sea, perhaps not very far from the mouths of the rivers.]

1878. ABBOTT, C. C. Notes on Fishes of the Delaware River. < Report U. S. Fish Commission, iv, 1875-'76 (1878), pp. 826-845 (p. 82).

[Abbott acquits the common eel of the charge of destroying large quantities of ova of other fish, but states that this is a characteristic habit of the lamprey. This fish, which is found occasionally hibernating in the soft mud at the mouths of some of the inflowing creeks, appears to come from the bay or

1878. ABBOTT, C. C.—Continued.

ocean (at any rate, from the lower portion of the river) in immense numbers, early in March, and remains about the rocks at the head of tide-water for some time, as though waiting for the coming shad and herring. With the shad they pass up the river beyond tide-water, and in the rapid, rocky portions of the river, having deposited their own ova, they wander over the breeding grounds of other fishes, and devour every egg they can find. "I have found lampreys in Crosswick's Creek in the month of May gathering up the eggs from sunfishes' nests; and several times, when at the shad fisheries, I have taken small lampreys—from five to seven inches in length—that were attached to shad, with their sucking disks (mouths) firmly closed on the vaginal orifice, through which they were sucking the eggs."]

1878. KAUMANN, Herr [of Halle]. Zur Aalfrage. <Deutsche Fischerei-Zeitung, i, 1878, pp. 214–215, June 2.

[“On the eel problem.” Generalizations, apparently of little moment.]

1878. N. Y. EVENING POST. Where do Eels Breed? Seth Green's solution of a piscatorial problem. <N. Y. Evening Post, Aug., 1878.

[Seth Green maintains that eels breed only in salt water; describes the mounting in the Hudson River, and, *mirabile dictu*, says that eels are hybrids (of what origin not stated), and that they never contain eggs or reproduce their own kind. Mr. Green's views are doubtless misrepresented by the reporter.]

1878. FINN, W. [of Berlin]. Zur Aalfrage. <Deutsche Fischerei-Zeitung, i, 1878, p. 254, Aug. 13.

[“On the eel question.” Herr Finn calls attention to criticisms on Dallmer's paper by Gerhard v. Yhlen, of Sweden, and Arthur Føddersen, of Denmark, and suggests several objections to the idea that eels are born only in salt water.]

1878. SELLIN, W. [“On Nematoid Parasites mistaken for Young Eels.”] <Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, xxxi, 1878, pp. 111–112.

[Not seen. Title from Zoological Record.]

1878. EDITORIAL. Propagation of Eels. <Sunbury (Pa.) American, Aug. 21, 1880.

[Quoting from London “Country” and “Augsburger Abend-Zeitung” Eberhard's observations.]

1878. BAIRD, SPENCER F. Propagation of Eels. <Sunbury (Pa.) American, Aug. 30 or Sept. 6, 1878.

[Letter, dated Gloucester, Aug. 27, 1878, criticising Eberhardt's article on propagation of eels, first published in the *Gartenlaube*.]

1878. MATHER, FRED. An Eel has 9,000,000 Eggs. <N. Y. Times, Dec. 13, 1878.

1878. ANONYMOUS. Professor Packard's Discovery. <N. Y. Sun, Dec. 8, 1878.

1878. ROOSEVELT, ROBERT B. Habits of Eels. <Forest and Stream, June 13, 1878.

[A reiteration and recapitulation of the claims that eelspawn in fresh water in the writer's Long Island ponds.]

1878. ROOSEVELT, ROBERT B. Reproductive Habits of Eels. <Transactions of the American Fish Cultural Association, seventh meeting, 1878, pp. 90-98.

[Mr. Roosevelt maintains that eels were hatched in fresh water in his trout ponds, on Great South Bay, Long Island.]

1878. CAPE ANN ADVERTISER. Bobbing for Eels by Moonlight. <Cape Ann Advertiser, July 19, 1878, p. 2.

1878. CAPE ANN ADVERTISER. The Eel Fisheries of South Deer Isle, Maine. <Cape Ann Advertiser, Dec. 20, 1878, p. 4.

1878. "ONCE A FISHERMAN." The Great Eel Question. <N. Y. Evening Post, Oct. 4, 1878.

[Another man who mistakes intestinal worms for small eels.]

1878. SCHMIDT, Herr. ["On the Economy of the Eel."] <Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, xxxi, pp. 102-110.

[Not seen. Title from Zoological Record.]

1879. ROOSEVELT, ROBERT B. Reproductive Habits of Eels. <Transactions American Fish Cultural Association, eighth meeting, 1879, pp. 32-44.

[A summation of recent discoveries, the author still maintaining that eels breed in fresh water.]

1879. SAWYER, J. G. [of Sawmill Rift, Pike Co., Pa.] That Male Eel. <New York Sun, May 17, 1879.

[An observer forty years familiar with the fisheries of the Delaware River describes the differences between male and female eels; gives an account of the mounting of the young eels in the Delaware about June 1, and speaks of the abundance of eels in Metaqua Pond, Sullivan County, and other inland waters in that vicinity separated from the sea by high waterfalls.]

1879. PUTNAM, FREDERICK W. "Mr. F. W. Putnam exhibited a specimen of the common eel (*Anguilla bostoniensis*)." <Proceedings Boston Society of Natural History, xix, 1879, pp. 279-280.

[Notes on recent history of this discussion. Attention called to the eggs in the specimens exhibited, all of which were "silver bellies." The question asked, "Will 'golden bellies' prove to be males?"]

1879. DUNKER. Geht der Aal in Erbsenfelder? <Deutscher Fischerei-Verein, ii, 1879, Nov. 4, pp. 357-358.

["Do eels frequent pea-patches?"—a discussion of the question.]

1879. NICKLAS, CARL. Der Aal (*Anguilla vulgaris*). <Deutscher Fischerei-Verein, ii, 1879, Oct. 7, pp. 326-328. Extract from "Lehrbuch für Teichwirthschaft."

[A popular synopsis of the natural history of the eel from the standpoint of the fish-culturist.]

1879. HAACK, H. Die Einführung von Aalbrut in deutsche Gewässer. <Deutsche Fischerei-Zeitung, ii, 1879, March 4, p. 65.

[Practical suggestions to fish-culturists concerning the planting of young eels.]

1879. PACKARD, A. S., jr. The Breeding Habits of the Eel. <American Naturalist, xiii, 1879, pp. 25-30, and 125 (a correction).

[On the 18th and 20th of February, 1879, Dr. Packard found three specimens which were supposed to contain the organs of Syrski, and in which he thought he detected the presence of living spermatozoa. He subsequently came to the conclusion that the movements observed by him were simply Brownian movements among the fat corpuscles, and that the supposed spermatozoa were only yolk particles. See, also, Zoologischer Anzeiger, April, 1879, p. 193; Jan. 13, 1879; April 21, 1879.]

1880. BALLOU, WILLIAM HOSEA. Eels (*Anguilla acutirostris*). <Chicago Field, xiv, 1880, pp. 291-292.

[A description of the eel fisheries of Oswego River, New York. Claims that eels spawn in Oneida Lake.]

1880. HERMES, Dr. OTTO [Director, Berlin Aquarium.] Ueber Aalbrut und Aufzucht junger Aale. <Circular, Deutscher Fischerei-Verein, 1880, Feb. 12, No. 1, pp. 23-25.

[“Concerning young eels and their propagation.” Describes the mounting of the young eels in June in the river Elbe; gives directions for transporting young eels.]

1880. HERMES, Dr. OTTO. Ueber Aalmännchen und Aalweibchen. <Circular, Deutscher Fischerei-Verein, 1880, No. 2, March 27, pp. 55-57, cut.

[“Concerning male eels and female eels.” Dr. Hermes gives a brief history of the search for male and female eels, with an account of the discovery of male eels by Syrski. He recounts the external and internal marks of males and females, as indicated by Syrski and Jacoby.

Dr. Hermes, visiting the fish market of Trieste in company with Dr. Syrski, found fifteen males among twenty selected according to these indications, but in Berlin could find none. He indorses the opinion that males occur as a rule only in the sea and in the mouths of rivers. He calls attention to the importance of searching for male eels on the coasts of the German Ocean and the Baltic, and advises that examinations shall be confined to examples less than 18 inches long, since the male eel rarely exceeds this size.

1880. HERMES, Dr. OTTO. Zur Fortpflanzung des Aals. <Deutsche Fischerei-Zeitung, iii, 1880, June 8, pp. 244-245.

[Announces the discovery of male eels in the Baltic. Dr. Hermes examined two lots of 72 each of eels 38 to 42 centimeters long, one lot from Wismar, another from the region between Seeland and Laland. In each of these lots he found 8 males.]

1880. HERMES, Dr. OTTO. Zur Fortpflanzung des Aales. <Circular, Deutscher Fischerei-Verein, vi, 1880, Nov. 25, pp. 197-201, 2 cuts; Zoologischer Anzeiger, 1881, No. 74, pp. 39-44.

[“On the reproduction of the eel.”]

1880. HERMES, Dr. OTTO. Ueber Aalbrut und Aufzucht junger Aale. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 11, March 16, pp. 83-84.

[Dr. Hermes suggests methods for the transportation of young eels.]

1880. HAACK, H. Acclimatisirung des Aales im Donaugebiete. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 9, March 1, p. 65.
 [“The acclimatization of eels in the Danube” Haack proposes to effect by transporting several hundred thousand young eels (montée) from near the mouths of rivers before the young males have dropped out in the course of their upward ascent.]
1880. LINDENHAIN, GUIDO. Zur Naturgeschichte der Aale. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 6, Feb. 8, pp. 46-47; No. 7, Feb. 16, p. 54; No. 8, Feb. 23, p. 60; No. 9, March 1, p. 68; No. 10, March 8, p. 75; No. 11, March 16, pp. 84-85.
 [A very worthless compilation, subsequently severely criticised by Dr. Pauly in the same periodical.]
1880. PAULY, DR. A. Die Fortpflanzung des Aales (*Anguilla vulgaris* Fleming). <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 12, March 23, pp. 89-90; No. 48, Dec. 23, pp. 389-390 (correction to first article).
 [This essay, drawn out by Lindenhain’s pretentious and mendacious article on the natural history of the eel, gives a very clear and sensible exposition of the present state of knowledge upon the reproduction of the eel, as well as a satisfactory historical résumé of the subject.]
1880. [BENECKE, BERTHOLD.] Vom Aal. <Berichte, Ost- und West-Preussischen Fischerei-Vereins, 1880, May, pp. 33-36, 4 figs.; Deutsche Fischerei-Zeitung, iii, Feb. 3, 1880, p. 44.
 [General natural history. These articles were incorporated in the author’s later work.]
1880. GLÖCKNER GEBRÜDER. Aalbrut. <Deutsche Fischerei-Zeitung, iii, 1880, May 25, p. 217.
 [Narrates that young eels were planted in the river Tschirne in 1877, and that after an extraordinary freshet in 1880, by which for the first time since 1845 the water was raised higher than a dam at the entrance to a small pond, young eels were found in that pond. Suggests that there were eels of three years’ growth.]
1880. DUNKER, Herr [of Stettin]. Der Aal auf der Ausstellung. <Deutsche Fischerei-Zeitung, iii, 1880, May 25, pp. 218-219, with cut.
 [An account of the male eels exhibited at the Berlin Fishery Exhibition, with a history of recent investigations and discoveries.]
1880. DUNKER, Herr. Vom Aale. <*Ibid.*, iii, 1880, March 31, p. 113.
 [Concerning the migrations of eels, old and young.]
1880. DANNER, HERMANN. Der Aal geht aufs Land. <Deutsche Fischerei-Zeitung, iii, 1880, Oct. 26, p. 422.
 [“Eels go over the land.” Narrates two instances where eels have escaped from tanks, and have been found at considerable distances in ditches and under stones.]
1880. MCGOVERN, HUGH D. On the Curious Habits of Eels. <Trans. American Fish Cultural Association, 1880, pp. 19-20.
 [Note on the climbing power of young eels.]

1880. JACOBY, L. Der Fischfang | in der Lagune von Comacchio | nebst einer | Darstellung der Aalfrage | von | Dr. L. Jacoby. | Mit zwei Tafeln. | Berlin, 1880. | Verlag von August Hirschwald. | n. w. Unter den Linden, 68. | 8°. pp. vi, 93 (1), plates, map.

[A thorough and scholarly review of the whole history of the eel, with a full account of the eel-fishery in the lagoon of Comacchio.]

1880. CATTIE, S. TH. Ueber die Genitalien der männlichen Aale und ihre Sexualunterschiede, von S. Th. Cattie, Phil. Nat. Cand., Docent an der Realschule zu Arnheim, Holland. <Zoologischer Anzeiger, June 7, 1880, pp. 275-279, 2 cuts. Also, in translation, "On the Genitalia of Male Eels and their Sexual Characters." <Proceedings U. S. National Museum, iii, 1880, pp. 280-284. [Translated by John A. Ryder.]

[Gives a description of the internal and external characters of male eels.]

1880. BENECKE, BERTHOLD. Fische, Fischerei, und Fischzucht | in | Ost- und Westpreussen. | ——— | Von | Dr. Berthold Benecke, | Professor an der Universität Königsberg. | Mit zahlreichen Abbildungen von Braune. | [Erste Lieferung.] | ——— | Königsberg in Pr. | Hartungsche Verlagsdruckerei | 1880. 8°. pp. —. [Unfinished; 320 pages published up to date.] The Eel, pp. 173-188.

[A masterly review of the present state of knowledge upon the history of the eel.]

1881. ROBIN, C. The Male Eels compared with the Females. <Annals and Magazine of Natural History, (5), vii, May, 1881, pp. 386-392. [Translated from Comptes Rendus, Feb. 21, 1881, pp. 378-383.]

[Describes the male and female organs, and calls attention to the paper of Duvernoy, who, in his judgment, described correctly the ruffle-like or male type of the genitalia of the eel. Except for this, the paper is, like those of Dareste, Cattie, and others, simply a confirmation and extension of previous observations.]

1881. HERMES, DR. OTTO. Zur Fortpflanzung des Aales. <Circular, Deutscher Fischerei-Verein, 1881, No. 1, Jan. 31, pp. 17-18.

[“On the reproduction of the eel.” States the fact that, according to the observations of Upper Fishmaster Dallmer, the eels taken from August to November (especially in September and October) in the Baltic along the Flensburg-Alsen coast and in the Lesser Belt were apparently migrating from the south to the north, this being indicated by the manner in which the leaders of the eel-pots were attached—to wit, to the northern wing of the eel-pot.]

1881. HERMES, DR. OTTO. Zur Aufzucht junger Aale. <Circular, Deutscher Fischerei-Verein, i, 1881, Jan. 31, pp. 20-21.

[“On the propagation of young eels.” An argument in favor of selecting for transplanting into land-locked waters eels between one and two years of age, rather than the miniature fish usually used for that purpose.]

1881. HINCKELMANN, Herr [Fishmaster at Flensburg]. Beitrag zur Naturgeschichte des Aals. <Circular, Deutscher Fischerei-Verein, i, 1881, Jan. 31, pp. 18-19.

[“A contribution to the natural history of the eel.” Notes on the periods of greatest abundance of eels about Flensburg and on the Danish coast. Hinckelmann speaks of the size of the eels at different seasons, and of the influence of the weather upon their capture. He confirms the view that eels migrate in the fall from south to north, or from brackish toward salt water, stating that the earliest catches are made at the south, the latest in the most northern localities.]

1881. DECKER, Herr [Fishmaster of Altona]. Zur Naturgeschichte der Aale. <Deutsche Fischerei-Zeitung, 1881, May 24, pp. 165-166.

[An interesting communication, claiming that eels spawn and are hatched on muddy and slimy bottoms at a depth of ten to fifteen feet.]

A LIST OF OHIO RIVER FISHES SOLD IN THE MARKETS.

By ORLANDO HOBBS.

JEFFERSONVILLE, IND., March 20, 1881.

Prof. SPENCER F. BAIRD,

Secretary Smithsonian Institution :

DEAR SIR: Mr. Luke, the postmaster at this place, called on me to furnish a list of the fish caught at the Falls of the Ohio. I was very unwell at the time, and too much occupied with business affairs to attend to it at that time. I have since, by going to the fishing grounds, seeing the lines run and the captures by the nets, been enabled to make the following list, that comprises about all the fish caught here. I also send with this a list written and furnished by William Taylor & Co., who have fished here and supplied the market for the last forty years. They claim it is a full list, and it agrees with that I have collected from every other source of information. Should there be anything you wish information of at this locality, and will send directions for properly obtaining the same, it will give me pleasure to attend to it for you.

I have the honor to remain, very respectfully, yours,

ORLANDO HOBBS.

LIST OF FISH CAUGHT AT FALLS OF OHIO.

Stizostethium vitreum var. *salmonium* (Raf.), Jor. & Copeland.—White Salmon.

Stizostethium vitreum (Mitch.), Jor. & Copeland.—Black Salmon.

Percopsis guttatus, Ag.—Trout Perch.

Perca fluviatilis, Linn.—Yellow Perch.

Pomoxys annularis, Raf.—White Perch, Bachelor Perch.

Bubalichthys urus, Ag.—Black Buffalo.