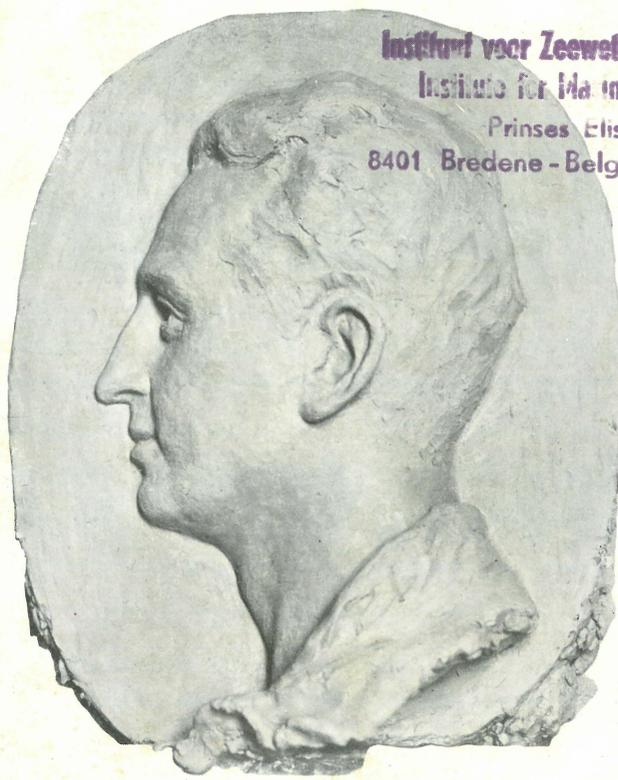


Eigendom van het
Westvlaams Economisch Studie-bureau
Brugge Reeks Boek

THE CARLSBERG FOUNDATION'S OCEANOGRAPHICAL EXPEDITION ROUND THE
WORLD 1928—30 AND PREVIOUS DANISH OCEANOGRAPHICAL EXPEDITIONS
UNDER THE LEADERSHIP OF THE LATE PROFESSOR JOHANNES SCHMIDT

DANISH EEL INVESTIGATIONS DURING 25 YEARS

1905 - 1930



Instituut voor Zeewetenschappelijk onderzoek
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JOHS. SCHMIDT
1877—1933

EEL

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DANISH EEL

INVESTIGATIONS DURING 25 YEARS

(1905—1930)

by

JOHS. SCHMIDT

THE question regarding the genesis of the Eel is a very ancient one. Since the time it was raised by the great Greek naturalist ARISTOTLE, 2000 years ago, it has been enveloped in mystery and it has to no ordinary extent succeeded in occupying the minds of those living in the countries of Europe, where the Eel is a common and well known animal.

As no ripe roe was found in the Eel, it was concluded that it did not come into existence in the same way as other fish and therefore some remarkable explanations were offered regarding the phenomenon. ARISTOTLE maintained that it had its origin in the mud, both in fresh and salt water, others that its origin is small worms or horsehair that is dropped into the water, or dew which falls in May, indeed for want of something better, even the common Viviparous Blenny (*Zoarces viviparus*) — which in German is called "Aalmutter" (Eel Mother) — has been accused of bringing the little Eels into the world. Such fanciful theories and others, no better founded, have in fact been believed and some of them have continued to be credited right up to our time, in spite of the fact that science has proved that the Eel like other animals has male and female individuals.

Now that we know that the breeding of the Eel occurs thousands of kilometers away, and that the youngest stage of development is not found here at all, it is easier to understand that the human longing to explain phenomena in nature has, in this instance, led merely to fantastic ideas like those I have just mentioned. An explanation of the genesis of the Eel had of necessity to be found, and, in the absence of facts, people let their imaginations run riot.

So now we understand that there had been absolutely no possibility of making the least progress as regards this question before the modern expeditions undertook the study of the open ocean, at the beginning of the present century. At that time the Dane, Dr. C. G. JOH. PETERSEN; had already brought the matter as far forward as it was possible by investigations in Danish waters, while in the Mediterranean it was carried a step still further by a discovery made by two Italian investigators, GRASSI and CALANDRUCCIO. They had, to wit, been able to show that a little fish, transparent as glass, is the larval stage which in the development of the Eel precedes that of the young Eel, the elver. This little fish (*Leptocephalus brevirostris*), found in the Strait of Messina was shaped like a willow leaf and a trifle larger than an elver in size. The top specimen in Fig. 5, p. 4, is a picture of the fish in question. This important discovery was made as early as the nineties in the last century, but it did not bring us any closer to a better understanding of where our Eels come into existence, and the question was again allowed to rest in abeyance for ten years or so. Then, one night in May 1904, it happened that while we were with the research vessel "Thor" fishing for cod-fry in the Atlantic to the west of the Faroes, we fished up an Eel larva in a net which was being drawn through the water in the vicinity of the surface. This find once again brought the

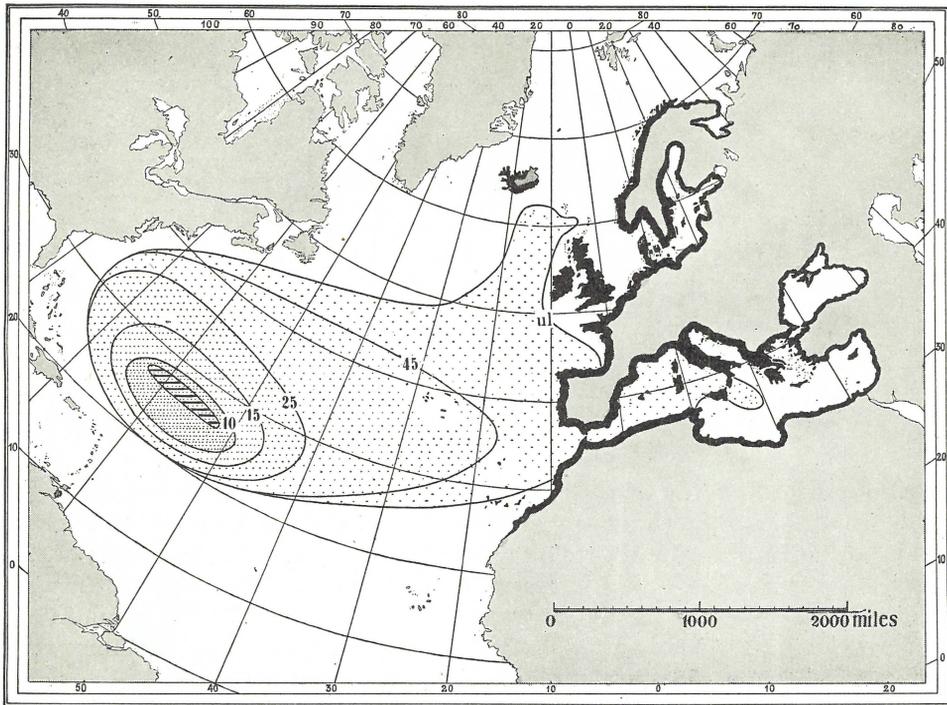


Fig. 1. The distribution of the *European Eel* (*Anguilla vulgaris*) during its various stages of development.

Distribution. The European Eel is found as an adult in Europe, North Africa and Asia Minor. On the map the countries where the freshwater Eel is found, are indicated by a black strip along the coasts.

Postlarval stages. These occur, according to our investigations, in the whole of the large dotted area on the map, which, it will be observed, stretches across the whole of the Atlantic. In the vicinity of Europe only large, fully developed larvæ, of about $7\frac{1}{2}$ centimeters in length, are found. Further to the west, in the direction of the West Indies, the larvæ decrease gradually in size. The curves show limits of occurrence: i. e. larvæ less than 10 mm. have only been found inside the 10 mm. curve etc. The outermost curve denotes the limit of occurrence of unmetamorphosed larvæ (ul).

Spawning place. The area within the 10 mm. curve in the Sargasso Sea is the spawning place of the Eel and is the only place where the newly hatched larvæ, measuring 5 to 7 mm. in length, are found (striated area). From here they travel in the direction of Europe and arrive at the coasts of that continent after a journey which occupies 2 to $2\frac{1}{2}$ years. Then they are metamorphosed to elvers of which the majority make their way into the rivers of western Europe. A number of them, however, get into the North Sea and further to the Baltic waters and a number of them also get into the Mediterranean through the Straits of Gibraltar. They arrive at the European waters in the spring and are then three years old.

(According to SCHMIDT (1925); recent finds by U. S. R/S "Atlantis" and R/S "Dana" are added.)

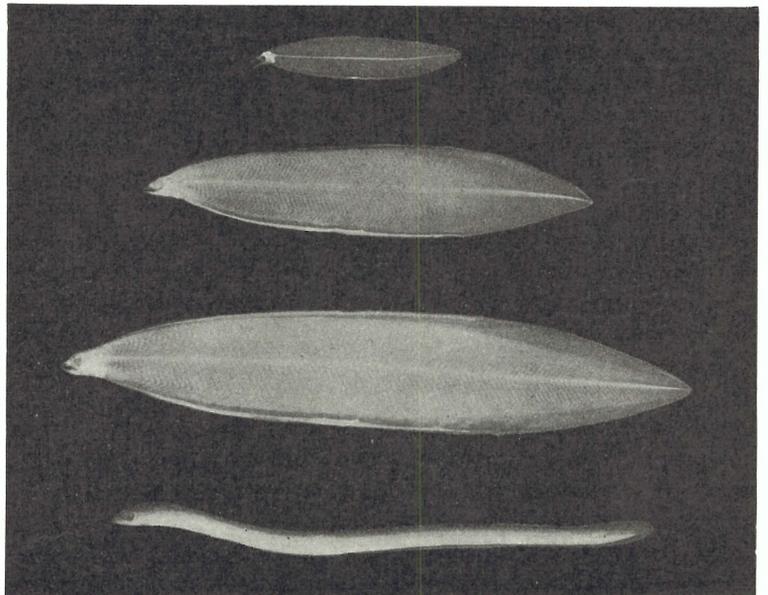


Fig. 2. European Eel (*Anguilla vulgaris*). Showing the size of the four youngest year-classes in June (about natural size). Number of vertebrae: 110—119, average: 114.7.

question into prominence; for it was the first time a larval Eel had been found anywhere else than off south Italy and the effect was an ardent desire on the part of the Danes to make vigorous efforts to reach further. It was only natural that the Danish Commission for Fishery Investigations took the question in hand; for I don't suppose that the Eel fishery is of greater importance for any country than it is for Denmark, and besides Danish investigators — I may mention KRØYER, LETH and C. G. JOH. PETERSEN — had made very important contributions to the elucidation of the life of the Eel in Danish waters. Therefore when in 1905 we from this our mother country placed the "Eel Question" on our programme, we were following up a tradition.

Here I cannot of course go more closely into these investigations which lasted from 1905 to 1922, but I shall at any rate mention the leading idea in them because it was this same idea that formed the basis of the Eel investigation on the cruise round the world in 1928—1930¹).

The larva of our European Eel which we caught in 1904 in the Atlantic, to the west of the Faroes had a length of 75 millimeters; like the larvæ from the Strait of Messina this was therefore approaching the full-grown size. Of

¹) In various publications mentioned on p. 14 the readers will find an exhaustive description of the course of these investigations and a discussion of the facts procured from other sources. Eel-larvæ from the Norwegian Professor JOHAN HJORT's cruise in the "Michael Sars" in 1910 and from the pelagic collections made about 1860 by the Danish Captain ANDREA were also of importance for the clearing up of the matter.

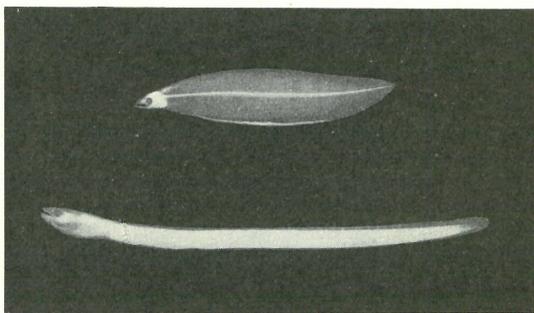


Fig. 4. American Eel (*Anguilla rostrata*). Showing the size of the two youngest year-classes in June (about natural size). Number of vertebræ: 103—111, average: 107.2.

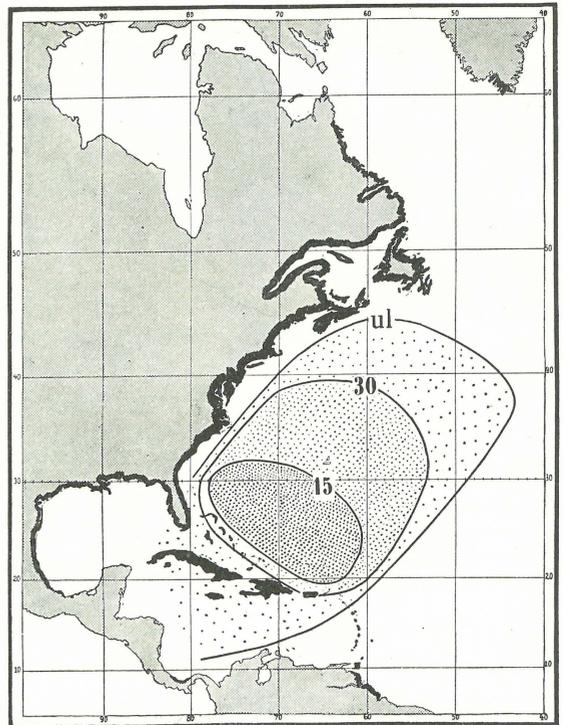


Fig. 3. The distribution of the various stages of development of the American Eel (*Anguilla rostrata*).

Distribution. The American Eel is found as an adult at the east coast of North America from Labrador and southwards, it has besides been recorded at the south point of Greenland, at several places on the east coast of Central America, at places here and there on the north coast of South America and at several places on the West Indian Islands. (The distribution is given as a black strip along the coasts where this species occurs.)

Postlarval Stages. The curves show limits of occurrence; i. e. larvæ less than 15 mm. have only been found inside the 15 mm. curve, etc.; the outermost curve denotes limit of occurrence of unmetamorphosed larvæ (ul).

Spawning place. A glance at the chart above shows that the center of production for the larvæ of *Anguilla rostrata* is situated north of the West Indies (inside the 15 mm. curve) and that the larvæ as they increase in size spread out to the north and only to a smaller extent to the south.

On our cruises we found masses of larvæ north of the West Indies and in the Gulf Stream region off the Atlantic coasts of the States, but comparatively very few south of the West Indies in the Caribbean Sea and in the Gulf of Mexico.

The American Eel completes its full development from egg to elver in about one year (whereas the European Eel takes about three years).

(According to SCHMIDT (1925); recent finds made by U.S. R/S "Atlantis" and R/S "Dana" are added.)

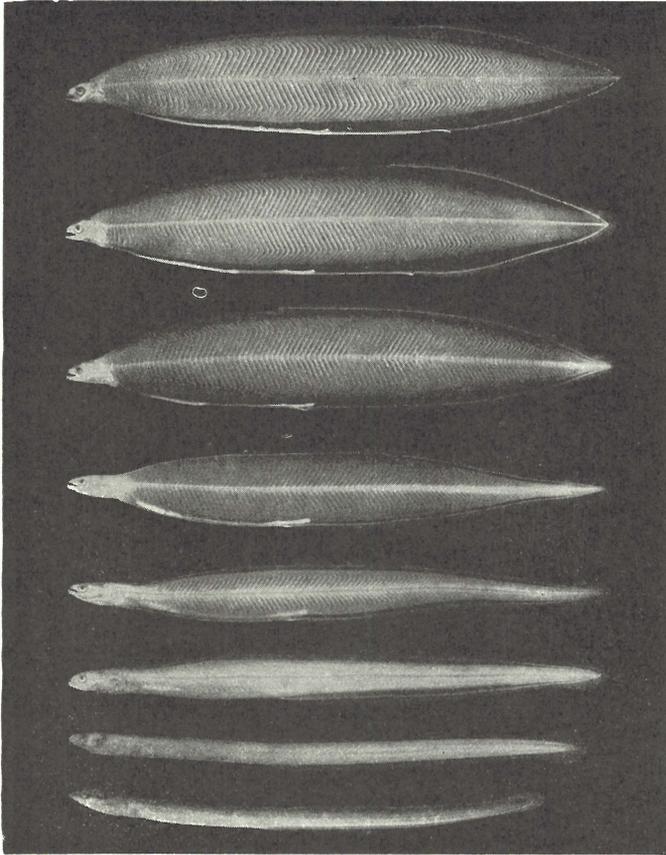
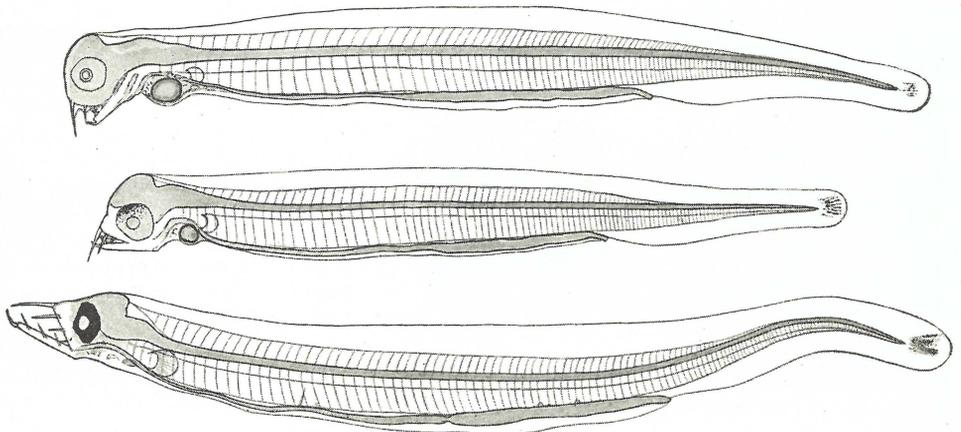


Fig. 5. Metamorphosis of European Eel larvæ to elvers, young Eels. The top specimen is a full grown larva before metamorphosis, the lowest in an elver. Natural size.

not smaller (younger) than the Faroe larva. On the other hand the tracks pointed towards the south west of the Atlantic; in that direction the larvæ appeared to diminish in size and, as it became possible to resume the investigations after the war was over, we were able in 1922 to conclude our work.

Fig. 6. The European Eel (*Anguilla vulgaris*). The two upper figures are "Prelarvæ" 6 and 5 mm. long, the lowest is quite a young larva, 7 mm. long. The top figure depicts the youngest developmental stage known with absolute certainty to be of our Eel. All are from the Sargasso Sea. Drawn by Dr. Å. VEDEL TÅNING.



its age we knew nothing; perhaps it was rather considerable and, therefore, the possibility of its having been carried by the ocean currents far away from the place where it had come into existence, could not be rejected. Our working plan for the investigations was now — with the large Faroe larva as a starting point — to endeavour to trace steadily smaller and smaller larvæ in the expectation of at last reaching the spot in the ocean where tiny newly hatched larvæ were to be found. For if we could succeed in doing that, we should have progressed so far as to be able to answer the burning question, in what part of the world our Eel has its origin.

Consequently we proceeded in accordance with this plan, but interrupted by misfortune and stopped by the Great War it was a very much more difficult and protracted task than we had expected, and in the course of the years involved voyages from Iceland to Morocco and from Egypt to America. It turned out that neither the ocean beyond the west coast of Europe nor the Mediterranean could answer the question, as indeed the larvæ we found there were

In the Sargasso Sea the newly hatched larvæ of our eel were found (Fig. 6), and with the aid of numerous sections of fishing-experiments we had been able to determine their distribution and settle conclusively that they are found in an area to the north-east of St. Thomas and south-east of the Bermudas and nowhere else. Thus was the breeding place for our European Eel charted, and I was enabled to draw the conclusion that the Eels from Europe travel over the Atlantic to the Sargasso Sea where they spawn in the spring, and furthermore that the larvæ, assisted by the North Atlantic Current, make a journey in the opposite direction to Europe; a journey that lasts between two and three years. At the same time it was evident that the fully developed larvæ, which during the summer are found off the west-coast of Europe, are about two and a quarter years old and that the elvers which next spring will swarm into our waters will be about three years old.

One pleasure I have experienced from this protracted task is that scientists all the world

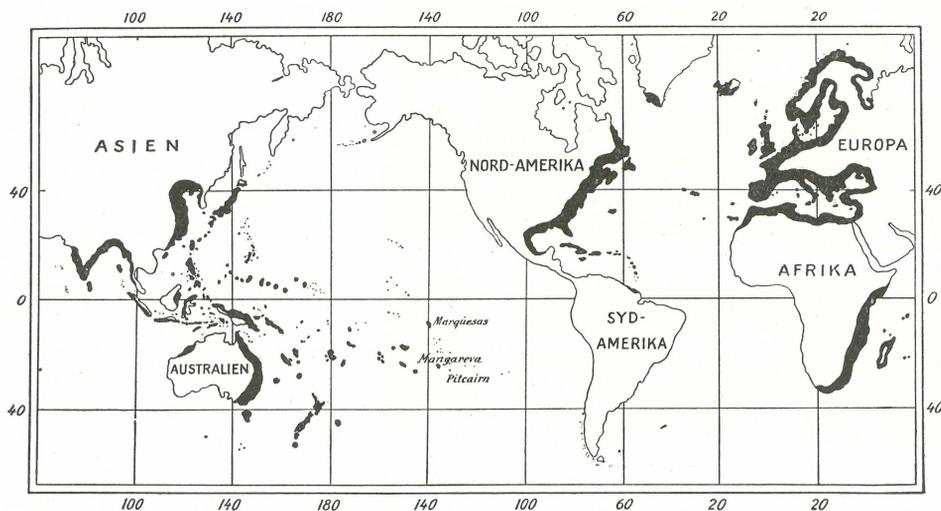


Fig. 7. The distribution of the fresh-water Eels (*Anguilla*) throughout the world, marked with black. Notice the absence on the west coasts of Africa and America and the Atlantic coast of South America. The eastern limit in the Pacific is formed by the Marquesas Is. and Pitcairn I.

over have accepted these conclusions¹⁾ and likewise that the recognition of their correctness has led to practical results²⁾. But, unfortunately I cannot maintain that the discovery of the breeding place of the Eels has been generally believed outside professional circles, that is judging by the numerous letters sent to me in the course of years from Denmark and abroad, by those interested in Eels and which as a rule are to the effect that "Science" is quite on the wrong track in this matter, as the writer in question can prove from his practical experience³⁾.

¹⁾ Except that Italian scientists, without adducing any satisfactory counter proof, have refused to agree that the Eels of the Mediterranean countries originate in the Sargasso Sea, as our Eels do.

²⁾ The Germans have carried out on a large scale the transplanting of elvers from the Atlantic coast of England, where they are in abundance, to other places particularly in central Europe where elvers do not reach, in the natural way, in sufficiently large quantities.

³⁾ It is principally the long journeys of the Eel-fry that are not accepted, as it is asserted with certainty that the Eel spawns in this or that pond or marl pit and incidentally I am referred to the biologist ARTHUR FEDDERSEN, who about thirty-five years ago suggested that the Silkeborg lakes in Jutland were the breeding places of the Eels in Denmark. Eels are also sent to me which are said to have ripe roe in them or even young ones, but "the ripe roe" is the roe of other fish which the Eel has swallowed, and "the young ones" are small parasitic roundworms. As a matter of fact there does not exist in Denmark any younger stage of the eel development than the 6 to 7 centimeter elvers, and as regards these I have been able to show that they are three years old.

Some of the letters have even been quite rude in style, but on the whole they have been a pleasant intimation of the lively interest that the eel question, in its new phases, has aroused outside the limited circle of scientists, and time and further enlightenment will achieve the rest.

By examining samples of Eels from a large number of countries I was able in 1913 to prove that all Eels found in Europe belong to the same species (*Anguilla vulgaris*). Seen from the restricted European point of view there is, therefore, but one Eel question, the question of the biology of the European Eel, the most prominent feature of which has been shown to be the many thousands of kilometers this fish travels on two occasions during its life, as fry and as full grown fish.

In reality, however, it is otherwise; the Eel question is not by any means confined to Europe; for in many places in the world, particularly in tropical countries, fresh water Eels are to be found (see fig. 7, p. 5). They are moreover closely related to our European species and therefore it is only reasonable to presume that a more specific biological study of these blood relations to our Eels in far off lands might help to throw a fresh light on and possibly enable us to get a better idea of the history of their lives, which is so different from that of the European species. But before being able to study the biology of the exotic species of Eels, one must be able both to distinguish them from one another and to be acquainted with the distribution of each individual species. It soon became evident that these conditions could not be fulfilled without the subject being intensively studied afresh right from the very beginning.

Since 1922 we have been working at this at the Carlsberg Laboratory, Copenhagen; many thousands of Eels from all parts of the globe have been examined, and in 1926 I made a journey to Australia, New Zealand and Tahiti with this object in view. The result of this many years' work has been that the distribution of the Eels — of the *Anguilla*-genus — is probably better known than that of many other cosmopolitan genera of fish and it is most likely that there are not other species of that genus than we have already found and have been able to define. The investigations have shown that, besides the two Atlantic species the European (*A. vulgaris*) and the North American (*A. rostrata*), there are six species in the

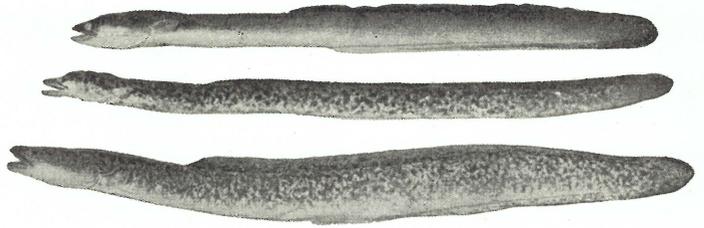


Fig. 8. The three species of Eel of the Central Pacific; above *Anguilla obscura* (uniformly coloured and short finned, i. e. dorsal and anal fins nearly of same length); below *Ang. megastoma* and *Ang. mauritiana* (both spotted and long finned, i. e. dorsal fin reaches far in front of anal fin).

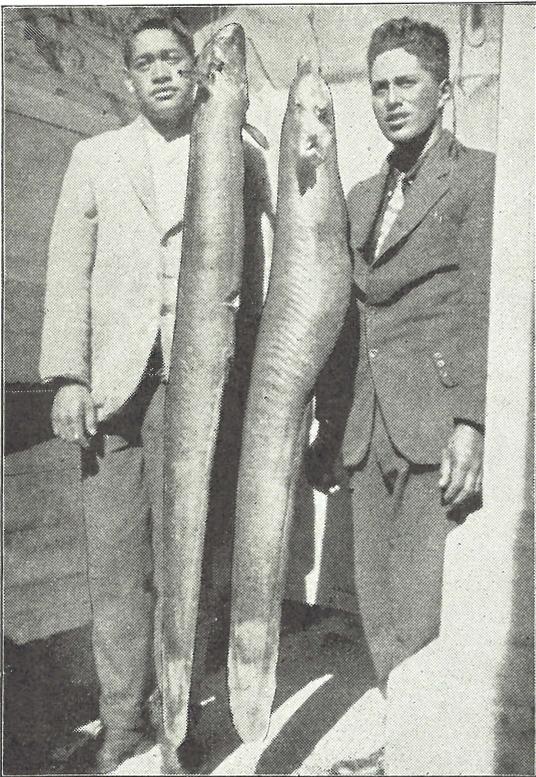


Fig. 9. The fresh-water Eels of New Zealand are giants compared with the Atlantic species. "Giant-eels" in Europe belong to quite another genus of fish, the Conger-eel (*Conger*), which never enters fresh-water.

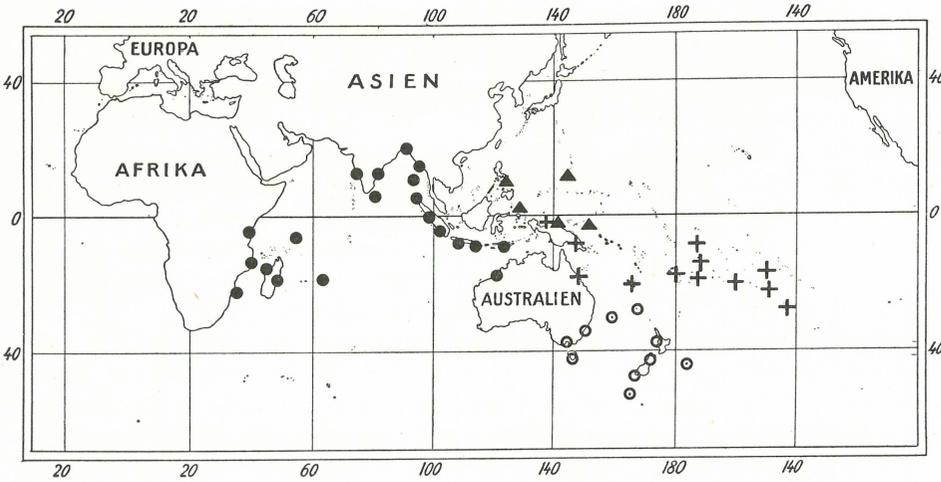
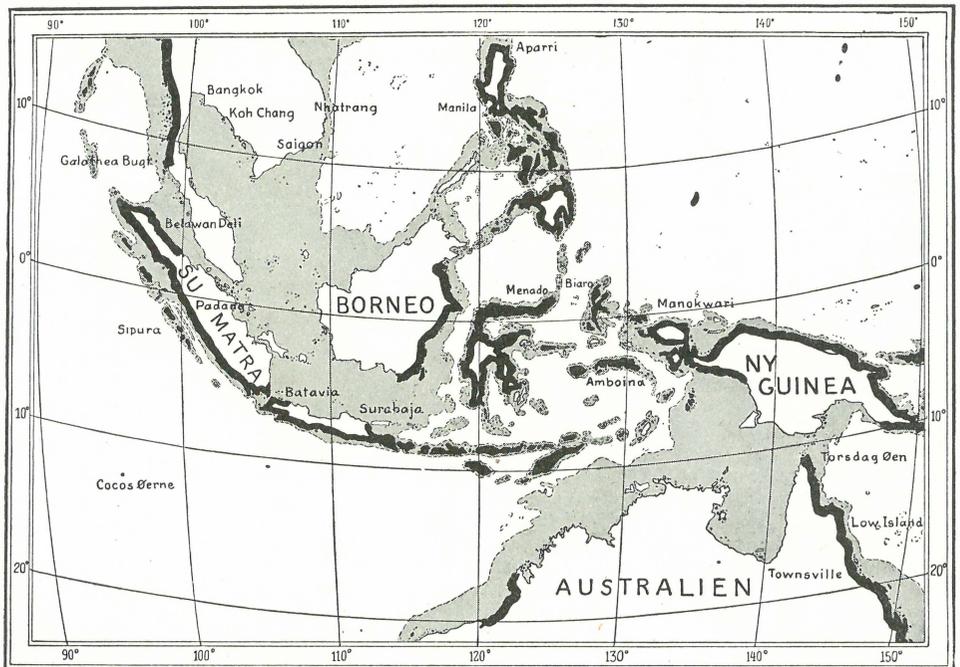


Fig. 10. The distribution of the "short finned" fresh-water Eels (formerly all identified as "*Anguilla australis*"), which include four different species. ● *Ang. bicolor*, ▲ *Ang. pacifica*, + *Ang. obscura*, ○ *Ang. australis*.

countries bordering the Indian Ocean and about twelve in the countries by the Pacific. Of these, however, some are common to both oceans.

Fig. 8 gives a picture of three species from the South Sea. I found all three at Tahiti and when one considers that in the whole of Europe and North Africa there is only one species of Eel, it seems extraordinary that a little island, 33 miles at its greatest length, should have no less than three. Nowhere in the world, however, are there so many species as on the Pacific side of Indo-Malaya, on the north coast of New Guinea and in the Molucca Sea. Here we have proved the existence of no less than seven species, that is to say more than in the Indian Ocean, and more than half of what are found in the whole of the Pacific and among them are representatives of all the groups of species into which the genus Eel admits of being naturally divided. This circumstance is of especial interest and I interpret it thus, that the most westerly equatorial Pacific is the domicile of the Eel genus from which it has distributed itself

Fig. 11. The distribution of the Eel (*Anguilla*) in Indo-Malaya is given in black. The shallow water region with depths less than 200 m. is shaded. The deep water and land are white. It will be noticed that Eels do not occur on the coasts — of Sumatra, Java, Borneo, Siam etc. — facing the shallow water region.



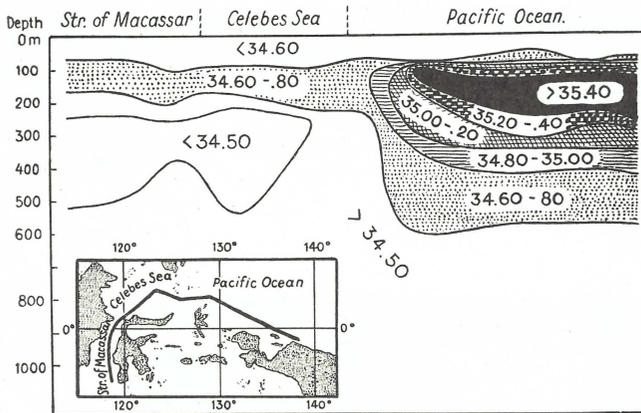


Fig. 12. Salinity down to a depth of 1000 m. in a section between the Macassar Strait, the Celebes Sea, the Molucca Passage and the Pacific situated as shown on the sketch-map. The figures give the salinity in ‰ i. e. the number of grams of salt found in a kg. of sea water — from the drawing it appears that the water in the Pacific north of New Guinea at a depth of 100 to 200 m. has a salinity of over 35.40 ‰ while at the same depths in the Celebes Sea it was not over 34.80 ‰. Observations were taken in July—August; in the Celebes Sea they were, however, taken in March.

possibility of identifying the larval stages of the exotic species which nobody had ever seen.

It proved to be fairly easy to distinguish the larvæ of the exotic fresh water Eel (*Anguilla*) from those of all the many hundreds of species of marine Eels, (*Muraenoidea*), which the nets brought up at the same time; so closely did they resemble the larvæ of our own and of the north American Eels which we knew so well from the Atlantic. But to begin with there were great difficulties in separating the larvæ of the various species each for itself and here we had again to do a new and considerable piece of work which would not have been possible had we not previously acquired a thorough knowledge of the species of exotic Eels in their full grown state.

I shall confine myself to speak about the results of the “Dana” Eel investigations in Indo-Malaya which was the area where the expedition stayed longest and where the greatest number of Eel larvæ was caught¹⁾. I have already

¹⁾ In the southern part of the Pacific we found the larvæ of three species: — *Anguilla obscura*, *Anguilla australis* and *Anguilla mauritiana* and in the western part of the Indian Ocean the larvæ of three species were found viz. *Anguilla bicolor*, *Anguilla mossambica* and *Anguilla mauritiana*. On the Indian side of Indo-Malaya we found the larvæ of *Anguilla bicolor*, *Anguilla mauritiana*, *Anguilla celebesensis* and *Anguilla bengalensis* and on the Pacific side the larvæ of *Anguilla pacifica*, *Anguilla mauritiana*, *Anguilla celebesensis*, and also a species which for the present I shall refer to as *Anguilla borneensis*. In all areas we found that the larvæ of what is known as the “short finned” Eel species (see Fig. 8, p. 6) dominated in number which agreed with what we had experienced in respect of the samples of adult Eels sent to the Carlsberg Laboratory from these very areas, to be examined.

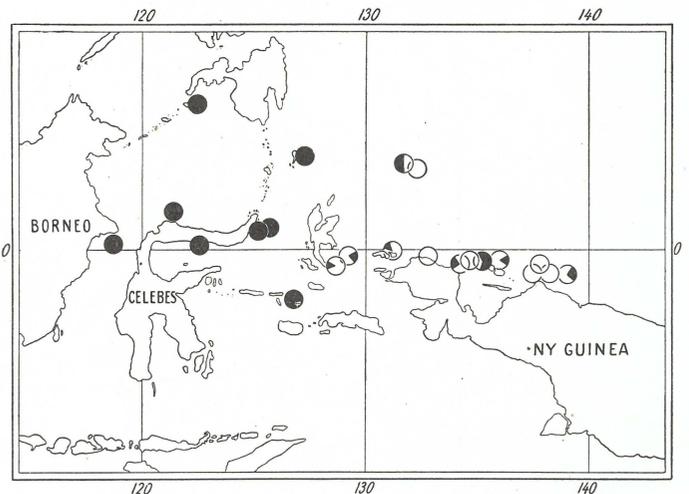


Fig. 13. Stations where larvæ of fresh water Eels (*Anguilla*) were found. ○ All the specimens were under 45 Millimeters long. ● All the specimens were over 45 Millimeters long. ◐ Half were under, half were over 45 Millimeters long.

dealt with the "Eel question" in Indo-Malaya as far as it was possible without having made investigations on the spot itself. For reference see the chart on p. 7 where the great shallow water region is shown in a shaded tint, on the coasts of Sumatra, Java, Borneo and Farther India. On a basis of the reports regarding the presence or absence of Eels in the fresh waters of Indo-Malaya, which were available to me and which I could check, I had a chart made, showing the distribution of the Eels in these districts, which was published in 1925 by the Danish Royal Society of Sciences. The result, which later on was confirmed and elaborated by the Dutch Zoologist, Dr. H. DELSMAN, was clear,

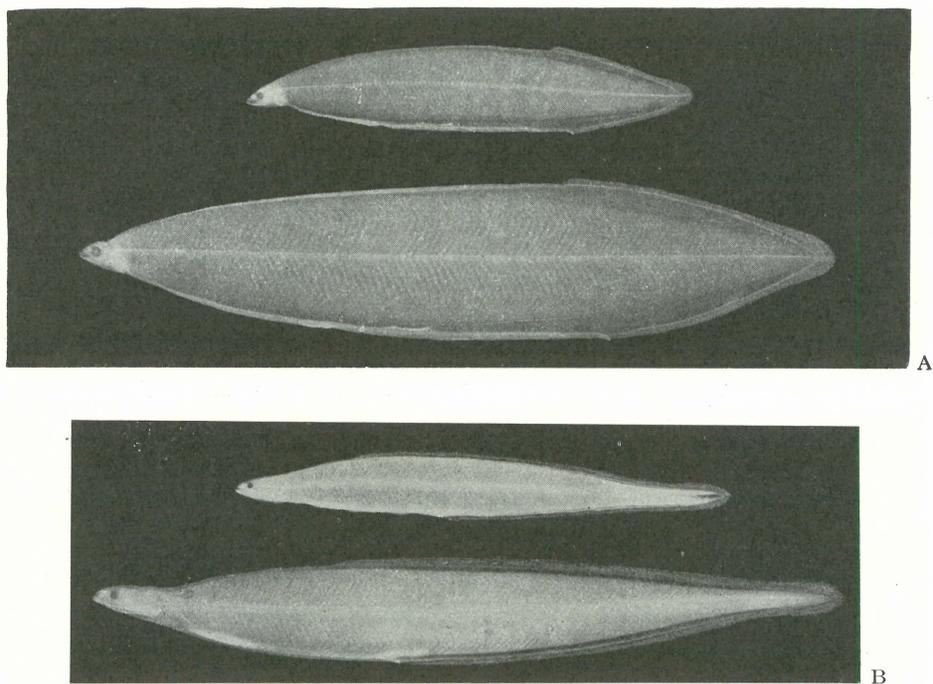


Fig. 14. Compared with the large larvæ of the European Eel those of the Indo-Malayan are mere dwarfs. — A: Fully developed larvæ before metamorphosis of *Anguilla bicolor* (on top) and of the European Eel. — B: Stages of metamorphosis of *Anguilla mauritiana* (on top) and the corresponding stage of the European Eel. *Ang. mauritiana* is known inter alia, by the dark stripe on the tail. Both figures somewhat magnified.

as will be seen in Fig. 11, p. 7: On all the coasts bordering the deep sea Eels are present but not on those that are washed by the shallow water. From this I could already at that time — before we had been there on the "Dana" — conclude that the Indo-Malayan Eels, like our own, require deep water for their propagation and that conclusion was fully confirmed by the "Dana" expedition. All the younger developmental stages of the Eels, which came up in our nets, were found in the deep ocean.

The next question, and that could be solved only by an expedition, was the origin of the Indo-Malayan Eels which live at the Moluccas and on the whole in the countries washed by the deep Indo-Malayan seas as the Banda Sea, Celebes Sea, etc. In these seas the depths are great enough; in the Banda Sea for example the "Dana" sounded a depth of 7380 waters — but on the other hand the salinity is not so high here as in the adjacent parts of the Pacific north of New Guinea with which these seas are connected. All over the world the small Eel larvæ seem to require a high salinity (and temperature) in order to thrive. Our investigations,

the results of which are given in figures 12 and 13, p. 8, seem to show that the Eel larvæ of the seas originate from the ocean outside and that they make a comparatively short migration from here into the Banda and Celebes Seas probably assisted by the inflow of salter and warmer water from the waters north of New Guinea, which, according to HELGE THOMSEN's observations occurs in the course of the summer¹). The distribution of our larvæ both in respect of size and number seems to indicate this.

This was as regards the deep, eastern seas, the Eel species of which are the same as those found in the countries bordering the open Pacific. The easterly Indo-Malayan Eels are separated by the large shallow water region from the westerly ones which inhabit the rivers

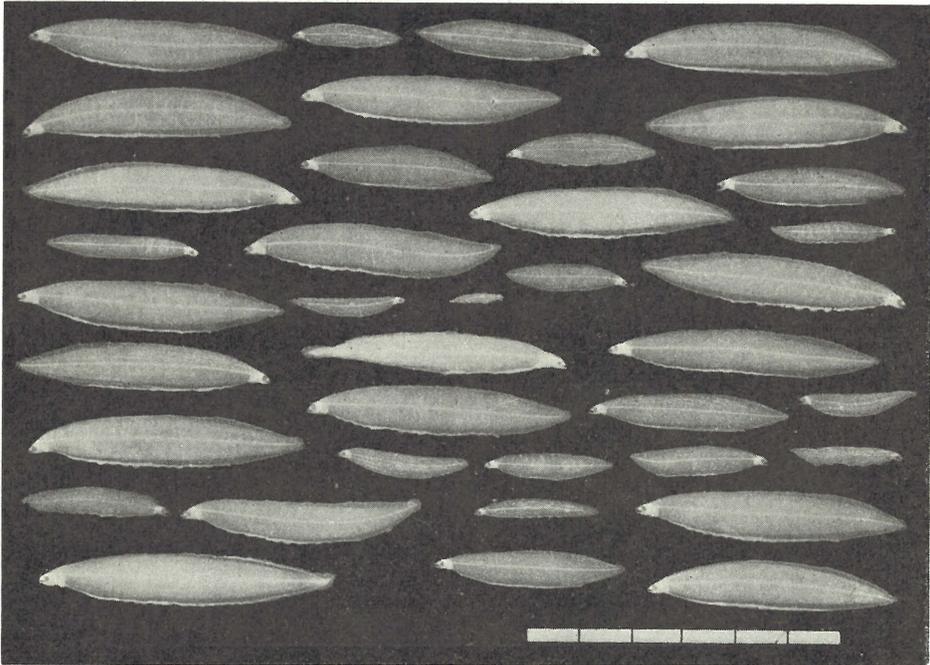


Fig. 15. Larvæ of fresh water Eels (*Anguilla*) from three hauls made at the same time. The "Dana" station No. 3860 in the Mentawai Deep west of Sumatra (the black area in Fig. 17). The majority belong to *Ang. bicolor*, but *Ang. mauritiana* and *Ang. bengalensis* are also represented. The little larva in the middle of the picture and the one immediately below it in metamorphosis are both *Ang. bicolor*. The picture shows that all stages of development from the tiny to the fully developed larvæ are found in the same locality. Scale in centimeters below.

on Sumatra, Java and the other Sunda Islands. The protracted investigation of the occurrence in the Indian Ocean of Eel larvæ was carried out by us in the autumn of 1929 with the *Emmahaven* on the west coast of Sumatra as a base and was concluded with the arrival of the "Dana" at Belawan Deli on the 10th of November. I shall here give a brief account of the results.

In spite of the fact that some of the Indo Malayan Eels attain a much more considerable size than our Eels, their larvæ are virtually smaller. In their fully developed state — i. e. just before the metamorphosis to elvers begins — our Eel larvæ measure 75 to 80 millimeters in length while the elvers are 70 to 75 millimeters long. On the other hand the length of the

¹) This inflow of salter, warmer water from the Pacific, must take place during April to August and shows itself very distinctly. Particularly if one places the results of the "Dana" observations side by side with those which during the same year, but partly at different seasons, were made by the Dutch ship "Willebrord Snellius" under the command of the naval officer VAN RIEL.

Indo-Malayan Eel larvæ is only about 55 millimeters and that of their elvers about 50 millimeters. If placed beside the larvæ of our Eels it is obvious that in shape and general appearance there is quite a striking resemblance, but in comparison with ours, the others are mere dwarfs (Fig. 14). Nevertheless they grow much more rapidly than the European Eels, whose larvæ take over two years to reach their full development and apparently more rapidly than the larvæ of the North American Eels, which do not take half that time to reach that stage.

To the west of Sumatra there is a series of islands, the Mentawai Isles and beyond these the bed of the ocean drops suddenly to a depth of over 5000 meters forming a deep trough which bears the name of the Mentawai Deep. In this place, which the "Dana" covered with hundreds of echo-soundings, we found larvæ of all the four Eel species which live in Sumatra, and on the whole in the westerly part of Indo-Malaya, and what is of particular interest is

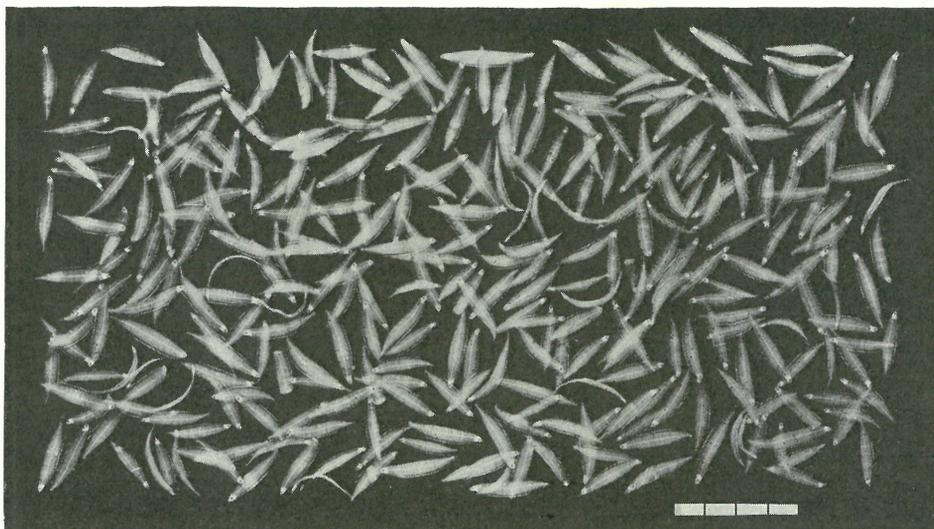


Fig. 16. In the Sargasso Sea where the European Eel breeds (the black area in Fig. 18) no fully developed larvæ are found. As the picture shows the larvæ here are small and all about the same size. Scale in centimeters below.

that so very small specimens of the species were found — right down to a size of only 8 millimeters — that we can conclude that the Mentawai Deep is the breeding place of all four species.

While the larvæ are found only in places where the sea is deep the elvers were found also within the 200 meter contour. Chart Fig. 17, p. 12 shows the distribution of the larvæ in a part of the investigated area to the west of Sumatra. It will be seen that towards the south, somewhere about 5° S. Lat. they are no longer to be found. — This agrees with the decreasing salinity in the water-layers in question — but closer to the land and right into the Sunda Strait pelagic elvers were found and in the deeper parts of the waters between Sumatra and the Mentawai Isles there were large larvæ. To the north the larvæ had extended further than the chart reaches; they were found right to the west of the Nicobar Islands and in the vicinity of Ceylon there were pelagic elvers near the surface above the deep waters.

Small larvæ were found only within the black portion of the area in the chart Fig. 17 but it must not be thought that all the larvæ found there were tiny. In Fig. 15 are depicted the larvæ which came up in three nets at a station within the "black" area on the chart in Fig. 17. A consideration of the picture will at once make it evident that all sizes of larvæ, right from the tiny to the fully developed indeed even such as have already begun to metamorphose

into elvers, occurred in the same locality. Such a state of things does not exist as regards our European Eel. In the Sargasso Sea where its small larvæ occur there are, as can be seen from Fig. 16, no large larvæ, not to mention such as have already begun to metamorphose into elvers. Here we are in the face of an important biological difference between our Eel and its Indo-Malayan blood relations and this will become yet more noticeable when we compare the distribution chart of the Sumatra area with that of a chart of the Atlantic where the occurrence of the stages of development of our European Eels from tiny larvæ to elvers is given with the same distinctive symbols, viz. black for tiny larvæ, dotted for larger larvæ and hatched for elvers.

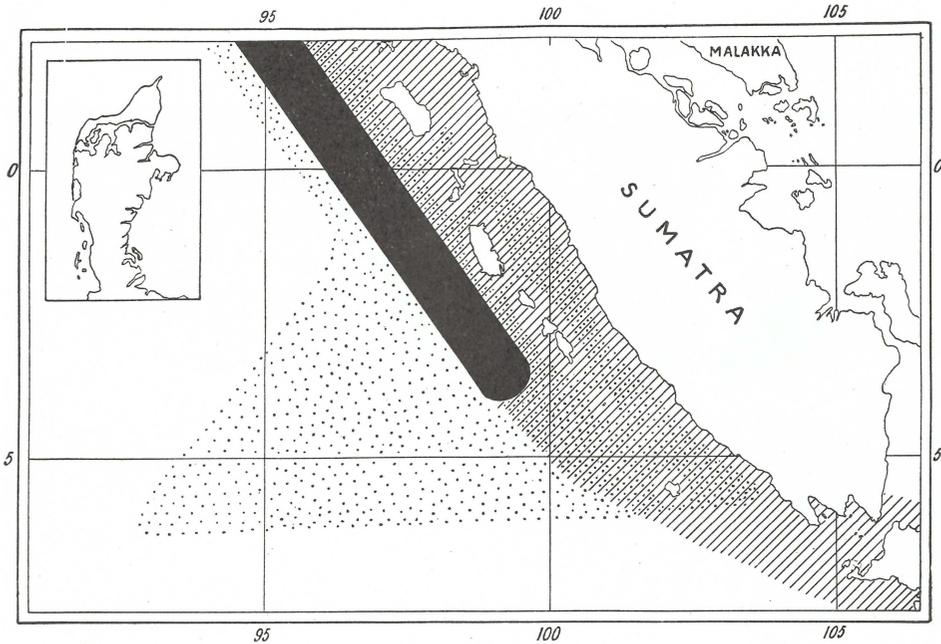


Fig. 17. The result of the "Dana" Eel investigation west of Sumatra (for comparison with Fig. 18). Black: tiny larvæ, dotted: large larvæ, hatched: elvers. The black area where the Eels breed lies close to the land so that the Eels have only a short distance to the breeding places. Towards the south the pelagic larvæ no longer appear as we approach the Sunda Strait. The blank area where an outline sketch of Jutland is given, (drawn on the same scale as the main chart) was not investigated by the "Dana".

If when observing the two charts Fig. 17 and 18, one fixes the attention on the distance in space between the small larvæ and the elvers — that is to say between the black and the hatched areas — the difference is easy to discern: at Sumatra the distance is practically nil, but in the Atlantic the tiny larvæ and the elvers are separated by a belt measuring several thousands kilometers. In comparison with the migrations across the ocean which the European Eels undertake to reach the breeding places in the Sargasso Sea, and which the fry undertake to get to Europe, those migrations of the Sumatra Eels and their fry are as nothing; the sketch of the peninsular of Jutland inserted in left hand corner of chart 17 shows how comparatively little are the distances one has to deal with here. When the Eels coming from the coasts have passed the Mentawai Isles, the deep Mentawai Deep, where spawning takes place, lies right in front of them. In the same way the journey of the larvæ is, of course, shorter and thus their more rapid development and miniature size are well in keeping; these tropical Eels which, so to speak, breed "just outside the door" do not need so long a larval period as our Eels do. In this respect therefore they resemble other "ordinary" fish whose entire life-time is spent within a comparatively limited area.

Had conditions been so simple with regard to the European Eel we should not have needed eighteen years to chart their breeding places, and I have no doubt whatever that when in 1905 we began our work with the European Eel, it was with the "most difficult" of all the Eel species in the world.

On the other hand the work of the "Dana" expedition on the life history of the Indo-Malayan Eel has succeeded in throwing a new light on the European species, which as com-

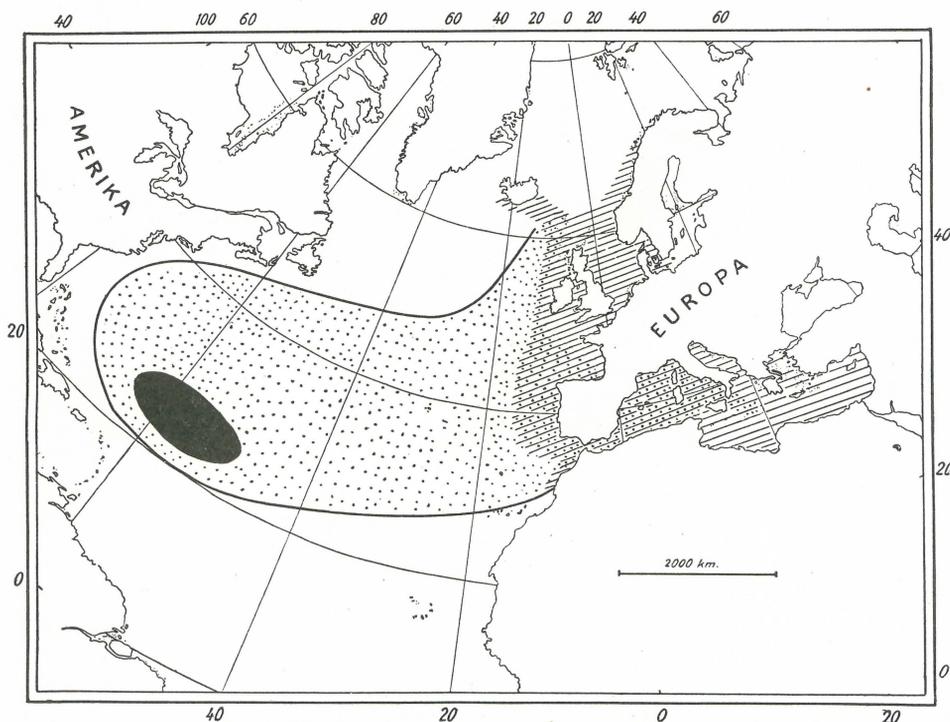


Fig. 18. The European Eel (for comparison with Fig. 17. Black: tiny larvæ (breeding place), dotted: large larvæ, hatched: elvers. Notice the great distance between the black and the hatched area. The chart shows that the European Eel, in contrast to those of Sumatra, has a very long distance to the breeding places.

pared with these blood relations, whose whole life is passed within the tropics appears as a biologically more specialised type. By the unique prolongation of its larval stages it has received an instinct for migration — already as pelagic fry — which not only exceeds that of other fresh water Eels, but perhaps that of all other fishes. An instinct for travel which makes it possible for this species of fish — without breaking the tradition underlying the tropical origin of the genus, viz. during its breeding season — to leave the warmer zones and to take possession of a whole continent on the other side of the ocean for its haunts during its period of growth.

PAPERS ON EEL-INVESTIGATIONS

BY

JOHS. SCHMIDT

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- "Remarks on the metamorphosis and distribution of the larvae of the Eel. (*Anguilla vulgaris* Turt.)". (Medd. Komm. Havundersøgelser, Serie: Fiskeri, Bd. III Nr. 3, pp. 1—17. 1909 København.)
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- "Danish researches in the Atlantic and Mediterranean on the life-history of the Fresh-water Eel (*Anguilla vulgaris* Turt.)". (Internationale Revue der gesamten Hydrobiologie und Hydrographie V, pp. 317—342, 1912 Leipzig.)
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- "First report on Eel investigations 1913". (Rapports et Procès-Verbaux du Conseil Intern. p. l'Explorat. de la Mer, Vol. 18. pp. 1—30, 1913 København.)
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- "Breeding Places and Migrations of the Eel". (Nature, No. 2776, Vol. 111, pp. 51—54, 1923 London.)
- "Die Laichplätze des Flussaals". (Internat. Revue der ges. Hydrobiol. u. Hydrographie, Bd. 11, Heft. 1—2, pp. 1—40, 1923 Leipzig.)
- "L'immigration des larves d'Anguille, dans la Méditerranée, par le détroit de Gibraltar". (Comptes-rendus des séances de l'Académie des Sciences, t. 179, pp. 729—732, 1924 Paris.) (= La Nature, pp. 379—381, 1924 Paris.)
- "The breeding places of the Eel". (Smithsonian Report for 1924, pp. 279—316, 1925 Washington.)
- "On the distribution of the Fresh-water Eels (*Anguilla*) throughout the world. II. Indo-Pacific region". (D. Kgl. Danske Vidensk. Selskab. Skrifter, Naturvidenskab. og Mathem. Afd., 8. Række, 10. 4, pp. 329—382, 1925 København.)
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- "25 Jahre dänische Aaluntersuchungen (1905—30)". (Natur und Museum, 62. 7, pp. 213—228. Frankfurt a. Main, Juli 1932.)

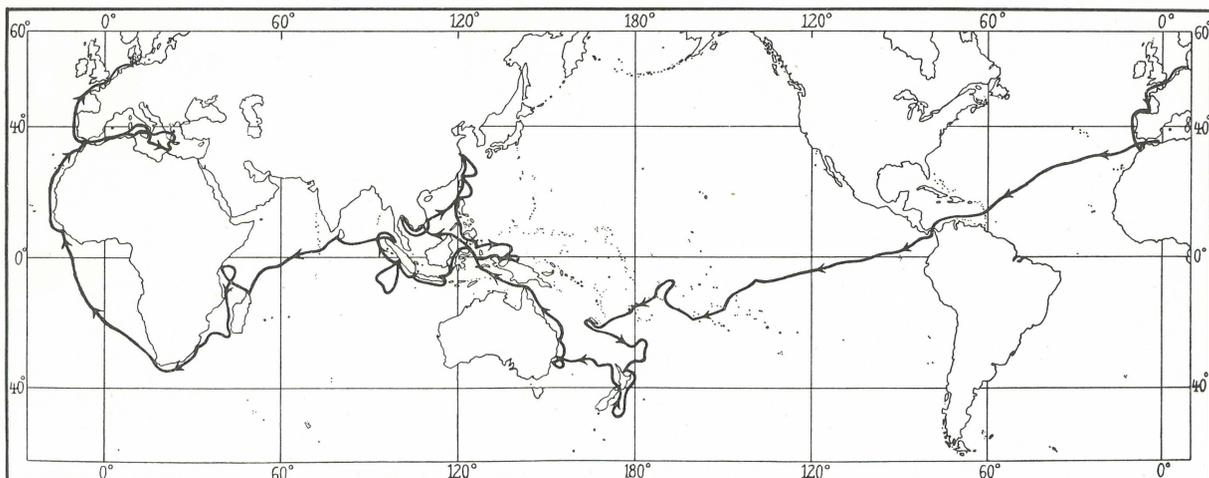


Fig. 19. Route of The Carlsberg Foundation's Expedition round the World 1928—30.

JOHS. SCHMIDT'S EEL-EXPEDITIONS

THE Danish Eel investigations made under the leadership of the late Professor JOHS. SCHMIDT has consisted of a long series of oceanic expeditions and collections made by merchant vessels and in other ways; these are mentioned below together with the names of the vessels employed, the institutions that have defrayed the expences of the cruises etc.

"Thor" 1905—06, Iceland to the Bay of Biscay (expense defrayed by the State) — "Thor" 1908—10, Mediterranean and West of Europe (expense defrayed by the Carlsberg Foundation and privately) — Various merchant ships collecting in the Atlantic, West Indies, Mediterranean etc. 1911—15 (expense defrayed privately and by the State) — Collection in the Straits of Messina (by Captain G. Hansen) 1911 — "Margrethe" 1913, Faroes to West Indies (defrayed by the State and Vendsyssel Packing Company) — "Dana I" 1920 and 1921, North Atlantic, especially the Sargasso Sea (defrayed by the East Asiatic Company and others) — "Dana II" 1921—22, Mediterranean and North Atlantic (defrayed by the State, the Carlsberg Foundation and privately) — "Dana II" 1928—30, circumnavigation (defrayed by the Carlsberg Foundation) — "Dana II" 1931, North Atlantic south to Madeira and the Azores (defrayed by the State). The charts Figs. 19—24 show the routes of some of the most important expeditions.

Though the chief aim has been to investigate the biology and migrations of the fresh water eels, various oceanographical investigations have been carried out and very rich collections of all pelagic

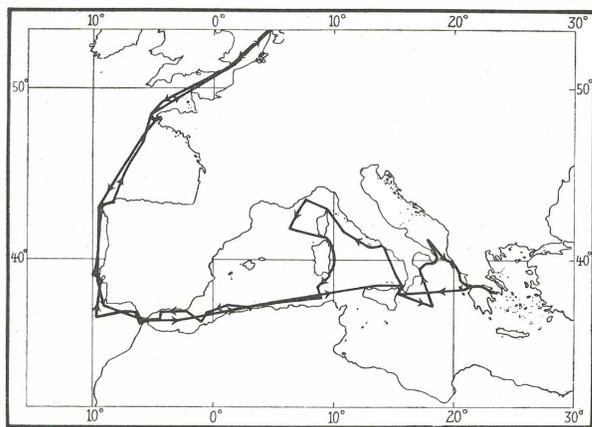


Fig. 20. Route of the "Thor" Expedition 1908—09.

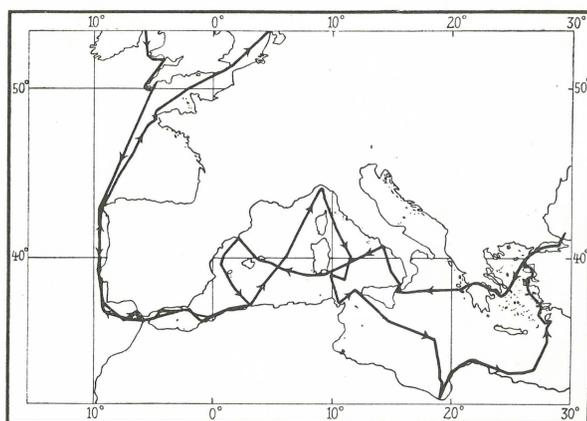


Fig. 21. Route of the "Thor" Expedition 1910.

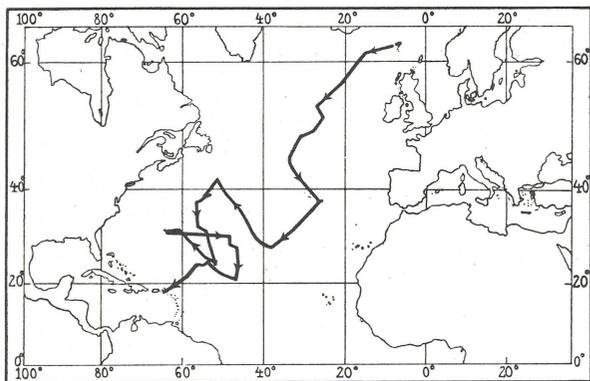


Fig. 22. Route of the "Margrethe" Expedition 1913.

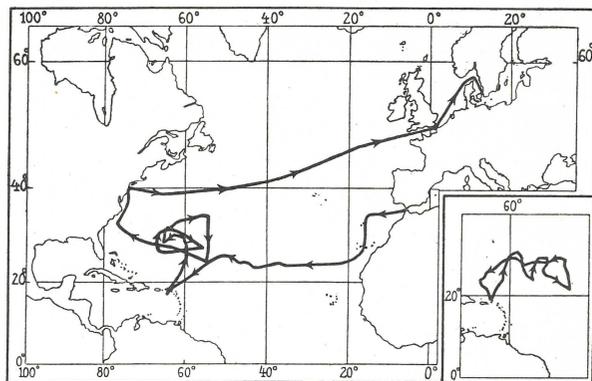


Fig. 23. Route of the "Dana I" Expedition 1920. In right corner of the "Dana I" Expedition 1921.

organisms from all oceans have been procured. On the results the following series of scientific papers have been published besides many papers in scientific periodicals and elsewhere, e. g. in "Meddelelser fra Kommissionen for Danmarks Fiskeri- og Havundersøgelser" during the years 1909—1921 and in "Rapports et Procès-Verbaux des Réunions du Conseil permanent international pour l'exploration de la Mer" during the years 1906—1932.

Report on the Danish Oceanographical Expeditions 1908—10 to the Mediterranean and adjacent Seas. From 1912 Reports Nos. 1—10. (Published by the Carlsberg Foundation.)

The Danish "Dana"-Expeditions 1920—22 in the North Atlantic and the Gulf of Panama. From 1926 Reports Nos. 1—8. (Published at the cost of the Rask-Ørsted Fund.)

The Carlsberg Foundation's Oceanographical Expedition round the world 1928—30 and previous "Dana"-Expeditions. From 1932 Reports Nos. 1—8. (Published by the Carlsberg Foundation.)

The extensive oceanographical collections from the expeditions mentioned are now in the Marine Biological Laboratory, Vestre Boulevard 42, Copenhagen V, where the sorting out and partial working up of the material takes place.

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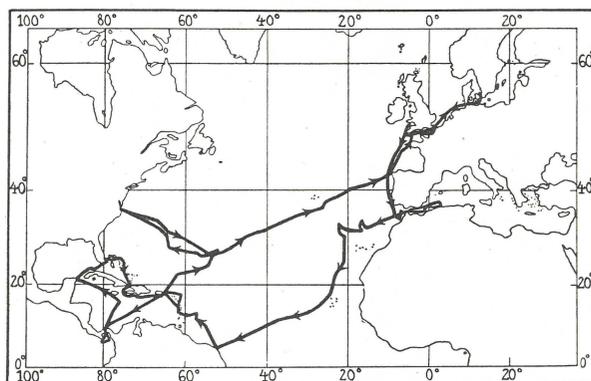
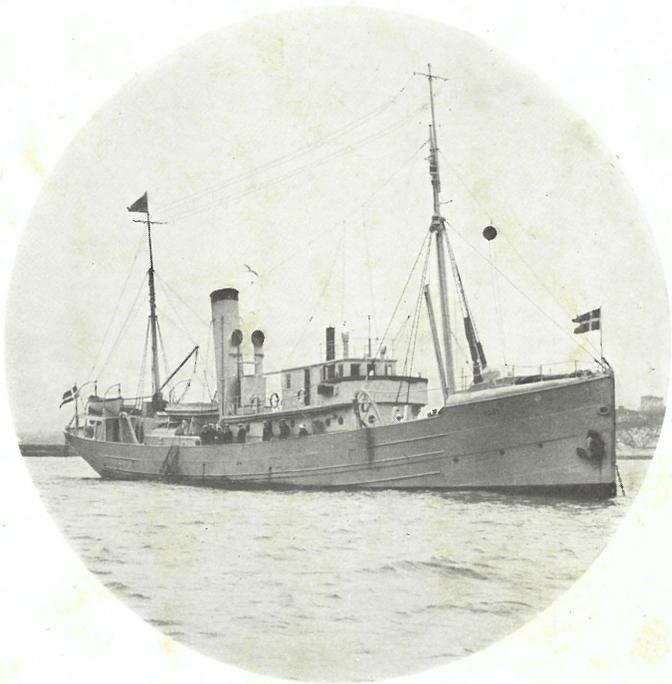


Fig. 24. Route of the "Dana II" Expedition 1921—22.



»DANA«

RESEARCH SHIP OF THE DANISH COMMITTEE FOR FISHERIES
INVESTIGATIONS AND THE STUDY OF THE SEA