Birthplace of the Eels: A Biological Detective Story

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Aristotle could not figure out how the eels he loved to eat reproduced. No one had seen one spawn or give birth. In fact, no one had seen an eel smaller than six centimeters. And of all the eels that crossed Aristotle's dinner table, not one had exhibited a single egg or drop of milt. Aristotle concluded that eels were a by-product of decomposition. "The eels come from what we call the entrails of the earth," he wrote in 350 BC. "They are found where there is much rotting matter, such as in the sea, where seaweeds accumulate, and in the rivers, at the water's edge, for there, as the sun's heat develops, it induces putrefaction."

Other great minds, not constrained by the demands of the scientific method, offered other fanciful explanations of eel procreation. Pliny the Elder (circa 77 AD) said that eels reproduced by rubbing their bodies against rocks, whereupon bits of skin come to life. Linneaus, the father of taxonomy, and Leeuwenhoek, the father of microbiology, said parasitic worms living inside eels were fetal eels waiting to be born. Other theories attributed eels to the dew of May mornings, horse hairs falling into the water, the gills of fishes, and even a small beetle.

As it turns out, the facts of how eels spawn is actually much more fantastic than anyone could ever have imagined. Every freshwater eel that eels its way through the waters of North America and Europe begins its life as a microscopic egg up to 3480 miles away, off the southwest coast of Bermuda, in the unseen depths of the weed-choked Sargasso Sea. Upon hatching, the newborn eel—a see-through, leaf-shaped waif of a fish called a leptocephalus—slowly travels north, drifting with the current, radically changing shape along the way. Some eels stay near the coast, others move upstream, feeding and growing in fresh water until an unknown urge compels them to begin the journey back to their tropical birthplace, where they spawn and then die.

The life of the American eel, *Anguilla rostrata* (and its European counterpart, *Anguilla anguilla*) is one of the great epic odysseys of natural history. How the mystery of its spawning was finally unveiled is one of the great biological detective stories of all time.

The first big break in solving the mystery came in an aquarium. The year was 1892. Scientists assumed that the 7.5-centimeter elvers that swam in the freshwater streams of Europe were baby eels. But where did they hatch? Where did they live before they got to be three inches long? Why hadn't anyone seen or captured an eel that was smaller? These were burning biological questions, to be sure, but they were not on the minds of two Italian biologists, G. B. Grassi and his pupil, S. Calandruccio, when they placed into an aquarium some transparent, leaf-shaped, fishlike creatures they had trawled from the Mediterranean using a plankton net. Although Grassi's 1896 account retains an air of scientific detachment, the two biologists must have been stunned as they watched the bizarre larval fish, over the course of a month, change into three-inch elvers. And they must have been downright giddy when they realized what they had discovered. Grassi and his pupil quickly realized that leptocephali weren't separate species, but baby eels, and that elvers, thought to have been babies, were actually 1-3 years old.

Now that scientists knew that leptocephali were baby eels, it became apparent that eels were born in the ocean. But where? At first, scientists preoccupied themselves in looking for breeding places along the coast of Europe, assuming that eels were born near the rivers they would ultimately ascend. However, the farther out to sea leptocephali were collected,

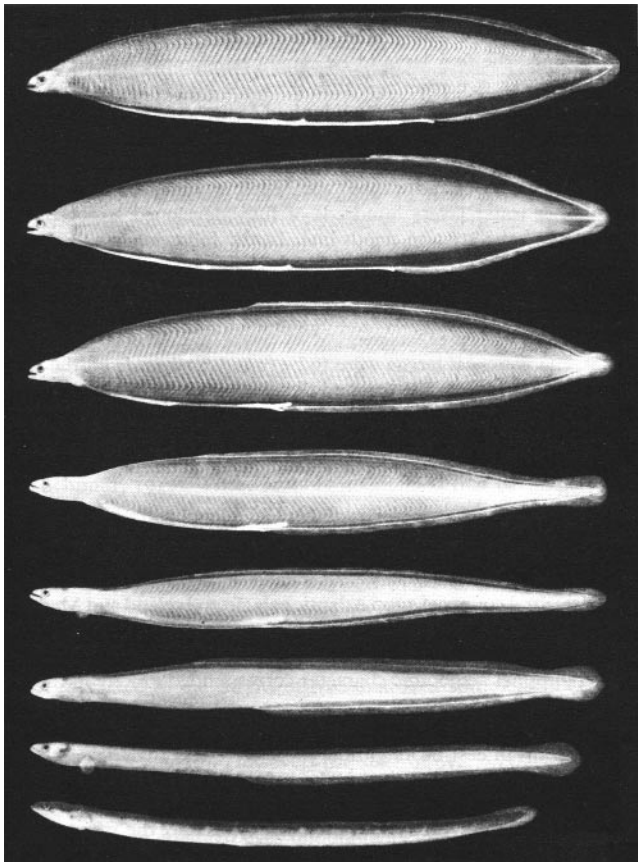

Fig. 1.
Johannes Schmidt's famous 1909 photograph showing for the first time the metamorphosis of a European eel (*Anguilla anguilla*). The top specimen is a fully grown (75 mm) leptocephalus, once thought to be a different species of fish. The bottom specimen is an elver. The transformation takes 1-3 years as the leptocephalus drifts north towards coastal and inland waterways from its birthplace in the Sargasso Sea.

the smaller they were. Scientists now began to suspect that eels were born somewhere in the depths of the sea. But, once again, where?

In 1905, the government of Denmark assigned an oceanographer named Johannes Schmidt the case of finding the eel's spawning ground. They couldn't have picked a more dogged investigator for the job. Schmidt had previously located the spawning grounds of several species of cod, but eels were a much bigger challenge. He knew that the entire Atlantic Ocean would have to be searched, yet he had only one small ship at his disposal. Fortunately, Schmidt was as resourceful as he was thorough. He persuaded the owners of transatlantic shipping companies to do much of the work for him. Schmidt supplied ships with plankton nets, and the ships' captains were more than happy to supply specimens. For the next 16 years Schmidt and his volunteer fleet scoured the Atlantic, from Greenland to Puerto Rico, from the English Channel to Chesapeake Bay.

Year after year, collection after collection, Schmidt painstakingly correlated the size of each leptocephalus with the location of where it was caught. He reasoned that the smallest leptocephali would be the closest to the breeding area. A potential stumbling block was the complication of there being two species of eels in the Atlantic, the American and the European. If and when Schmidt located a breeding area, how would he know which species was breeding in it? Here Schmidt's thoroughness paid off. He had recorded the number of vertebrae of every leptocephalus collected. One day, while analyzing specimens from the same haul, he found that they fell into two categories, with the one (European eel) having seven more vertebrae than the other (American eel). This indicated that both species traveled to the same spawning ground. Based on his data so far, Schmidt realized that this spawning ground was much farther west in the Atlantic than he had anticipated.

Gradually, a pattern began to emerge indicating that eels spawned somewhere near the Sargasso Sea. Schmidt needed a few more collections to verify what his numbers told him, but fate caused a five-year delay. His own research vessel ran aground in the West Indies, and the First World War shut down commercial ship traffic during the latter years of the war. Schmidt retreated to the laboratory to study eel anatomy, then returned to the sea in 1920 to explore the Sargasso Sea.

The Sargasso Sea is an oval area in the middle of the western Atlantic Ocean, between the West Indies and the Azores, some two million square miles wide. Portuguese sailors named the area for its abundant floating seaweed, which has bulbous floats that look like grapes (*sargaco* is Portuguese for grape). Here Schmidt found the smallest leptocephali yet—just 10 millimeters long. "These are so tiny," he wrote, "that there can be no question of their having moved any considerable distance from the spot where the eggs were spawned." After 16 years of exacting detective work, Johannes Schmidt solved one of the oldest mysteries of nature.

It should be noted that Schmidt's solution has never been verified. Careful scientists like to call the Sargasso Sea the eel's *presumed* breeding ground. After all, no one has actually seen eels spawn there. What happens in the inaccessible depths beneath the tangled seaweed when hundreds of thousands, perhaps millions, of silver eels converge to intertwine their bodies and (presumably) die, is just one mystery among the many that still surround these incredible fishes, waiting for the next Johannes Schmidt to come along and solve it.