*THE DEVELOPMENT OF THE CONGER EEL.**

ON July 31st, Dr. Porter E. Sargent, while on the U. S. Fish Commission vessel *Grampus* on the tile-fish banks (about 40 miles south of South Shoal), secured a number of species of pelagic fish eggs. One of these is very probably that of the Conger eel.

I have followed the development of this egg, and the larvæ hatched from it during two weeks. In view of the fact that no ripe eel eggs had been seen except in a limited region of the Mediterranean, a brief résumé of the results of my work on these eggs may be of interest. But first a note on the modern phase of the eel question will not be out of place.

In 1888, Raffaele figured and described a number of species of pelagic eggs which, on account of the shape of the larvæ they produced, he referred to various species of eels without a further attempt to refer them to definite species.

In 1897, Grassi published his series of epoch-making works on the eel question. He also found the eggs described by Raffaele, but of more importance was his identification of various species of Leptocephali as the normal larval stages of various eels. His conclusions in brief were: 1st, that the eggs of eels mature at great depths, 500 meters; 2d, that the eggs, except occasionally, develop at great depths; 3d, that the eggs give rise to a præ-larva, that this gives rise to a larva (the Leptocephalus), that this in turn gives rise to a hemilarva which finally is metamorphosed into the definitive adult which may be much shorter than the Leptocephalus from which it arose; 4th, that the egg of the common eel is without an oil globule.

The eggs secured during this summer are very nearly, if not quite like one of those described by Raffaele. They have all the characters of a pelagic egg, and Grassi was probably mistaken when he stated that these eggs come to the surface only occasionally. They are large, measuring from 2.4 to 2.75 mm. from membrane to membrane. The yolk is in segments, and measures 1.75 to 2 mm. in diameter, thus leaving a large perivitelline space. There are usually several oil globules, one of which is very much larger than the others. Some of these eggs hatched on the fourth day, others not until several days later. There are several distinct and unique features in the development, most of which have been well described and figured by Raffaele. (I have not seen Grassi's illustrated work.)

First among the peculiar features is the shape of the yolk. This in later stages of development becomes a long, slender mass reaching from the heart along the base of the alimentary canal to near the anus. This mass becomes constricted in places and the last seen of the yolk is a series of small disconnected bead-like masses distributed at intervals along the base of the alimentary canal. The yolk mass in the yolk sack diminishes very rapidly, partly by absorption, and partly, no doubt, by becoming located in the sub-alimentary yolk mass. A constriction is formed between it and the posterior yolk to which it forms a sort of handle. The oil spheres remain in the handle of the yolk mass. This elongation of the yolk is a definite adaptation to the elongate body and eeling progression of the larva.

The number of abdominal protovertebræ is exceptionally large, numbering between 65 and 71 in the present case.

The medulla becomes early and remains late a large, conspicuous, thin-roofed vesicle.

The color appears late. Only black pigments appear. In the last stages reached it

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consists of a series of ten spots along the region of the alimentary canal and lower part of the tail, a black spot about the end of the tail and another at the tip of the lower jaw, with a few cells on the upper jaw.

Especially noteworthy is the development of enormous fang-like teeth, four pairs in each jaw. The upper decrease in length from the front backwards, while those of the lower jaw are nearly of uniform size.

When first hatched the larvæ floated vertically, near the surface, heads up, tails down. Later they assumed the horizontal position and explored all parts of the vessel in which they were contained, progressing in approved eel fashion and biting at nearly everything touched.

The evidence that the eggs are those of the Conger is not positive. If Grassi is right, these eggs cannot belong to the common eel. The Conger eel is the only other one abundant in the region in which the eggs were collected and was caught in numbers at the time the eggs were collected. The serious objection to referring them to the Conger is the large number of segments in front of the anus. Since, however, according to Grassi, the anus migrates to near the end of the tail during the changes to the Leptocephalus stage, the number of segments in front of the anus is probably not positively available in the identification of the larva.

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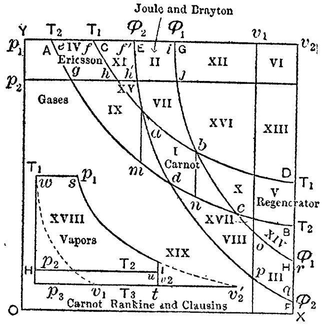
Woods Holl, Mass., August 25, 1900.

HEAT-ENGINE DIAGRAMS.

The accompanying diagram, in which are shown the possible compositions of the four standard thermodynamic lines in the formation of heat-engine diagrams or thermodynamic cycles, has been found so useful during twenty years' experience in its employment that it has seemed possible that it may prove deserving of extended publication. It has just been engraved in this particular form for illustration of a new edition of the 'Manual of the Steam-engine.' Gas-engine cycles are seen to number no less than seventeen, of which a large proportion are mechanically and kinematically practical, and a half-dozen of which have been adopted or designed by engineers.

The Carnot, or Sterling—*I*, *a b c d*—and its equivalent, *a b n m*, or *V*, the regenerator cycle, only, it is recognized, can yield maximum efficiency, as a thermodynamic



proposition; but the Joule, or Brayton, and the Ericsson, among the gas-engine cycles and the Rankins and Clausius among vapor-engine cycles have been found available by designers and builders, and it is probable that, among the infinite number of conceivable cycles outside the class here illustrated, many may be found capable of meeting the demand of the engineer for a practical union of thermodynamic, mechanical and kinematic closed cycles.

The production of the cycle of Carnot is not a difficult task as a matter of design but, in the case of the gas-engine, it involves too extensive a variation of volume to find place in application. It is far more practicable with vapor-engines and Cotterill long since suggested a practical approximation of which the engineers of our own day are beginning to avail themselves.

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