system are not significant. This might be expected for the two tyrosinase reactions, because the monohydric oxidation involves conversion to *o*-dihydric form as a first step (*7*). For this reason the α measured for the complete monohydric oxidation is an average for the two steps in the reaction, and this average is weighted toward the *o*-dihydric step, since two molecules of oxygen are involved in the *o*-dihydric step for each molecule of oxygen in the monohydric step. For other enzymatically controlled processes a significant difference in α for two different reactions catalyzed by the same enzyme would indicate the presence of more than one active site on the enzyme.

In the previously reported data on living systems average α values ranged from 1.007 for frogs to 1.025 for spinach leaves (*1*). It is probable, therefore, that fractionation processes other than the three enzyme reactions occur in living systems, and further research is indicated. The fractionation factors obtained in the present work would be expected to be closest to the values for unicellular organisms, because in these organisms there are no complex oxygen transport systems which might cause significantly different fractionation. At present the only data available on unicellular organisms are for bacteria, for which Lane and Dole (*1*) reported an average value of 1.015. The significance of this average value is questionable, however, since it is the result of a simple average of seven values of α ranging from 1.008 to 1.029 for two different types of bacteria. Therefore, the fact that 1.015 is close to the values for the enzymes reported here is not necessarily significant.

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20 August 1958

Condylostoma—an Enemy of Bivalve Larvae

Abstract. In laboratory cultures, where larvae of such bivalves as oysters and clams were kept together with large ciliates of the family Condylostomidae, the latter were seen ingesting the larvae. A single *Condylostoma* could contain as many as six larvae. Related species may destroy many bivalve larvae in nature.

Because of their small size and long pelagic existence, larvae of such bivalves as oysters, clams, and mussels are eaten by many holoplanktonic animals ranging from protozoans to fishes. Thorson (*1*), in his excellent account of reproduction and larval development of Danish marine invertebrates, offers a brief review of the enemies of pelagic larvae. His review, however, shows that, with the exception of the dinoflagellate *Noctiluca,* few protozoa subsist, in part, on lamellibranch larvae. My co-workers and I think, therefore, that our observations of *Condylostoma* sp., a heterotrich of the family Condylostomidae, feeding on larvae of the hard clam, *Venus mercenaria,* and the American oyster, *Crassostrea virginica,* are of biological interest and, perhaps, practical significance.

The discovery that *Condylostoma* feeds on lamellibranch larvae was made last winter when populations of an unidentified species of *Condylostoma* established themselves in several large glass vessels serving as intermediate reservoirs for mixed phytoplankton cultures which were fed routinely to the oysters and clams maintained in special trays during the winter (*2*). The temperature in these vessels usually ranged between 16.0° and 20.0°C, and the salinity of the water was normally near 27.0 parts per thousand. Individual *Condylostoma* varied in size from approximately 400 to 900 μ when expanded. In some instances their peristomes reached a length of 225 to 250 μ. They were apparently well adapted to the conditions under which they existed, because small groups, when placed in 500-cm^3 beakers to which a considerable quantity of mixed phytoplankton was added, lived for 2 to 3 months.

The first observation that *Condylostoma* ingests lamellibranch larvae was made when some of the plankton containing these ciliates was fed to cultures of young larvae of the common clam, *Venus mercenaria.* While examining the larvae, we noticed that some were guided into the gullet by the undulating membrane in the peristome of *Condylostoma* and that they were finally engulfed by the ciliates.

The number of larvae that can be ingested by a single *Condylostoma* depends upon the size of the predator and the size of the larvae. In one individual, measuring 661 μ and having a peristome approximately 178 μ long, six larvae could be seen. In smaller individuals, such as the one shown in Fig. 1, only one or two larvae were found. Progressive digestion of the soft parts of the ingested larvae was indicated by the changes occurring in their appearance. Usually the ones ingested first were distinctly paler in color than those ingested later, probably because of the disappearance of the fleshy part. Regardless of the frequent and prolonged observations on feeding *Condylostoma,* ejection of the shells of the larvae has never been observed. It is possible, therefore, that the shells also are eventually entirely digested within the body of the predator.

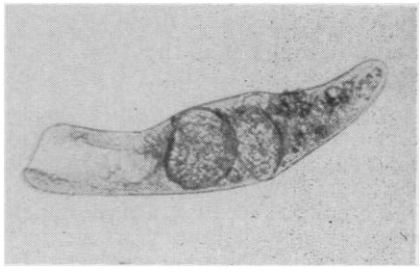

Fig. 1. *Condylostoma* with two ingested larvae of *Venus mercenaria* (*3*). (About × 100)

Perhaps what we saw taking place under laboratory conditions occurred because of the crowding of *Condylostoma* and lamellibranch larvae. It would probably seldom take place in nature, largely because *Condylostoma* is not very common on oyster bottoms or in the masses of water over the oyster beds where larvae are found during the summer. Our observations suggest, however, that members of another closely related family, Folliculinidae, may present a danger. These ciliates are at times extremely numerous in oyster-producing areas such as Chesapeake Bay, where, on occasion, they virtually cover the oyster shells planted as cultch to obtain a new generation of oysters. Some of these may be capable of engulfing oyster larvae, especially when the latter descend to the bottom to undergo metamorphosis into juvenile oysters. The same may be true of other members of the suborder Heterotrichina in which the peristomes and gullets may expand to become large enough for the passage of lamellibranch larvae. Such studies suggest many interesting possibilities.

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