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LIFE HISTORY OF THE LOW-SALINITY BORING SPONGE, CLIONA TRUITTI, AND IMPACT ON OYSTERS IN THE UPPER CHESAPEAKE BAY

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EDITORS' PREFACE

While oysters in the Chesapeake Bay have been subjected to a battery of manmade stresses, nature, too, has dealt her own -- and those have often had consequences as dire as man's. Sometimes they are violent -- Tropical storm Agnes, for example, almost decimated the Bay's oyster fishery in 1972 -- but often they operate more quietly. In recent years, the oyster has been subjected to periodic attacks by MSX, a protozoan parasite responsible for heavy mortalities. Less evident has been the impact of a boring sponge, Cliona truitti, on oysters in the upper Bay. It has long been thought that this parasite plays only a minor role in oyster stress and mortality; however, in the last several years research by Shirley Pomponi and Donald Meritt appears to be proving otherwise.

Their sampling of boring sponge incidence in the low salinity waters of the upper Bay indicates that C. truitti may play a role in the deterioration of oyster quality. In warding off invasion by sponges, the oyster may be using energy to better wall itself in, thus diverting energy that might otherwise be used for growth and greater reproductive capability. Ironically, the relatively widespread incidence of C. truitti in seed-producing regions may be the result, in part, of the upper Bay seed transplanting program in which spat are transported from areas of high recruitment to public oyster bars. If this is the case, resource managers need to consider the optimum time for moving spat to minimize such occurrences in the future; this means knowing when the sponge is least likely to be effective in preying upon young oysters. Towards such ends, the authors monitored the occurrence and distribution of boring sponges on certain oyster bars in the upper Bay, while analyzing its life history in the laboratory. Their aim has been to examine just how that life history correlates with the life history of the oyster and the transplanting of oysters in the Chesapeake Bay.

INTRODUCTION

Cliona truitti Old is an estuarine sponge which bores into the calcium carbonate shell of the American oyster Crassostrea virginica. In 1941, Old estimated that from 25 per cent to 75 per cent of all oysters and cultch in low salinity waters of the Bay were affected by this species. Although C. truitti can be found in empty shells, it is most commonly associated with live oysters, including recently metamorphosed larvae, or spat. The oyster responds to boring organisms by depositing more shell to wall off penetration (Bailey-Brock and Ringwood 1982). In shells which are heavily bored, the oyster tissue appears thin and watery (Fasten 1931) and the shell becomes weakened, increasing the oyster's susceptibility to predation. According to some estimates, shell deposition may require as much as one-third of the total energy of growth (Wilbur and Saleuddin 1983). Shell repair in response to boring could result in reduced growth rates and stunting (Cole and Waugh 1959; Kennedy and Breisch 1981) and, consequently, in reduced oyster productivity and marketability. Stunting has been observed in at least two oyster bars in the upper Chesapeake Bay (Berg and Newell 1986).

C. truitti populations at Deep Neck Bar in Broad Creek, a subestuary of the Choptank River, were monitored for abundance, growth, sexual reproductive activity, gemmule production and dormancy from 1981 through 1983. Populations were sampled bi-weekly from October 1982 through April 1983 and weekly from May through September 1983 and examined histologically.

OBJECTIVES

Our objectives were to study the life history of Cliona truitti, to determine its distribution and abundance, to examine relationships between the annual reproductive cycles of sponge and oyster and to assess the impact of sponge boring on oysters by measuring rates of boring.

DISCUSSION

Life History

C. truitti reproduces both sexually and asexually; asexual reproduction is through gemmules, small structures 1-2 mm in diameter, collagenous and often close together. Though we have not observed either the release of gametes or the development of larvae, oviparity (egg production) seems to be the rule. Formation and development of the gametes occur as early as March and continue through mid-June. Oocytes (eggs before formation of the first polar bodies) form both prior to gemmule hatching by cells which have overwintered and subsequent to gemmule hatching by differentiated gemmular cells.

We have observed spermatogenesis only rarely during May and June. Spermatozoa are grouped in large cysts, though we could not discern the details of spermatogenesis within these cysts. We have no field or histological evidence for larval development or metamorphosis, although new borings were observed in July in one-month old, hatchery-reared oyster spat which were not in contact with bored adult oysters. This indicates that larvae were present in the water at the same time. Field and laboratory observations suggest, therefore, that C. truitti larval settlement coincides with oyster spat settlement.

C. truitti demonstrates characteristics of both fresh and marine water sponges. For example, gemmules in certain species are an obligate stage in their life history (Simpson 1984); in other marine sponges which do not produce gemmules, adult tissue may regress during the winter to a smaller mass of cells lacking choanocytes, cells with funnel-shaped rims or collars around the base of flagella. During winter, there are few incurrent and excurrent papillae present; tissue is reduced but not completely absent.

When water temperature rises above 15° C in mid-March, gemmules begin to hatch. As they develop, they begin to bore immediately into the oyster shell. Complete gemmule hatching and rapid cell proliferation occur after the water temperature rises above 20° C in late May and early June. Empty gemmule coats can be found within the sponge tissue, but generally cells develop within broken capsules or coats. We rarely observed intact gemmules in the sponge tissue during the summer. When temperature drops below 20° C in early fall, sponge cells again regroup to form gemmules.

Boring resumes in early April and continues through September or October. Spherulous cells observed in cavities within the matrix of decalcified oyster shell are believed to be accessory etching cells (Pomponi 1979). Adult tissue begins regressing in mid-October, after gemmules have formed.

Distribution

We dredged oysters from 53 commercially important oyster bars in the upper Chesapeake in October 1981 and recorded abundances of boring sponge species for each site; observations on selected bars were made using scuba. In addition, from 1981 to 1983 we monitored C. truitti populations at Deep Neck Bar in Broad Creek, a sub-estuary on the Choptank River, for abundance, growth, sexual reproductive activity, gemmule production and dormancy. From October 1982 through April 1983, we sampled C. truitti weekly and from May through September, weekly; we also examined specimens histologically.

We observed C. truitti in oyster on 90 per cent of the bars surveyed in the upper Chesapeake Bay (Figure 1). The most abundant populations occurred on three oyster seed-producing sites: Broad Creek, the Little Choptank River and the lower Potomac River. An oyster seed-producing bar is characterized by good settlement substrate, or cultch, and high spat set.

Sponges and Oysters

Oysters from two of the three sites, Broad Creek and the Little Choptank, are characterized by stunting, or poor growth to market size, while oysters from the Tred Avon reach marketable sizes. Comparisons of nutrients, chlorophyll levels and phytoplankton size and biochemistry in both Broad Creek and the Tred Avon reveal no differences between the two systems (T. Jones, personal communication). Berg and Newell (1986), however, report that while "food quality" between both subestuaries is similar, "food quantity" was higher in the Tred Avon during the two summers of their study. They suggest that the higher quantity of food accounts for the larger size of oysters. Another factor could be the presence of C. truitti.

C. truitti generally does not occur in the Tred Avon, where oysters grow to normal size, but does occur in Broad Creek, where oysters are stunted. Reduction in somatic growth rates could result if energy is diverted for shell repair (Cole and Waugh 1959; Kennedy and Breisch 1981), particularly since boring occurs at the same time as oyster gametogenesis, which imposes an additional energy demand on many bivalves (Bayne and Newell 1983).

Rates of Boring

Boring rates were calculated by measuring the area bored in X-radiographs of oyster shells. Total shell area, as well as area containing borings ("bored area"), were measured with a digitizer tablet. We measured 328 two-year old and 62 one-year old oysters to determine if boring rates varied over time.

We assessed the impact of C. truitti boring on oysters by calculating the ratio of bored area to total area of the shell (Table 1). These measurements indicate the percentage of the shell weakened by sponge borings and, therefore, the oyster's susceptibility to predation. The ratio was about equal for both year classes: 46 per cent in two-year old oysters and 45 per cent in one-year old oysters, or nearly half of the shell weakened by boring.

In estimating the amount of substrate removed, we calculated the ratio of actual bored area to total shell area. Because of differences in shell thickness, volume measurements were difficult to make; consequently, we based estimates on area instead of volume. Again, no significant differences were evident between the two year classes: 13 per cent for two-year olds and 12 per cent for one-year olds. These observations are similar to those reported for clionids boring into coral skeletons (Hein and Risk 1975; MacGeachy 1977; Moore and Shedd 1977).

To determine monthly boring rates during the annual growth period of the sponge, we calculated the ratio of actual bored area to bored area. The most intense boring occurred during July and August, coinciding with the period of rapid somatic growth in both adult and recently settled sponges. High boring rates may be due to a stimulation of new shell substrate or diversion of energy from reproduction to somatic growth (Ruetzler 1975). MacGeachy (1977) observed differences in boring rates of sponges in corals and suggested they were due, in part, to differences in rates of calcium carbonate depositions by the "host" organisms.

The low rates calculated for the months of May and June may be the result of high rates of shell area increase by oysters at this time (Loosanoff and Nomejko 1949). Therefore, even though boring may be intense during this period, calculated rates may be low as a result of simultaneous increases in rates of skeleton formation and, perhaps, repair by the oysters.

CONCLUSION

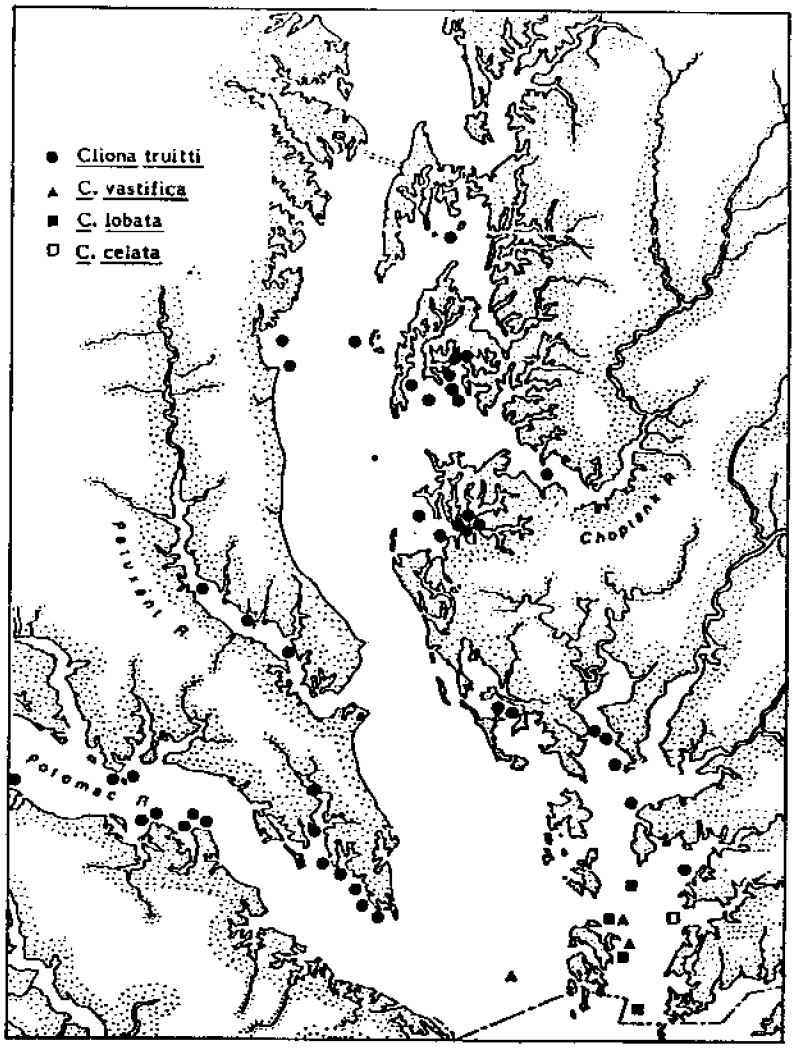
The annual growth cycle of Cliona truitti correlates with the American oyster Crassostrea virginica, into which it bores. Gemmule hatching and somatic growth coincide with periods of oyster shell deposition. Sponge larval settlement occurs at the same time as new cultch is available for oyster larval settlement.

Measured rates of boring indicate that in areas of stunted oyster growth such as Broad Creek and the Little Choptank River, approximately 50 per cent of the shell is weakened by sponge borings and, thus, is susceptible to predation.

It is likely that C. truitti has an effect on oyster growth and productivity, a conclusion supported by studies indicating there is no difference in nutrient levels and phytoplankton biochemistry between two adjacent subestuaries: Broad Creek, in which C. truitti occurs and oysters are stunted, and the Tred Avon River, in which C. truitti does not occur and the oysters are not stunted.

Table 1. Cliona truitti boring rates, Broad Creek

Year Class	Total Area (CM^2)	Bored Area (CM^2)	Actual Bored Area (CM^2)	Bored Area / Total Area (%)	Actual Bored Area / Total Area (%)	Actual Bored Area / Bored Area (%)	Bored Area / Age (CM^2/Yr)	Actual Bored Area / Age (CM^2/Yr)
1980 (N=328)	7.38	3.36	0.95	46	13	28	1.68	0.48
1981 (N=62)	3.27	1.48	0.40	45	12	27	1.48	0.40



Distribution of boring sponges in the Upper Chesapeake Bay, Fall 1981.

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