Maryland Sea Grant

RESEARCH NOTES

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MORPHOLOGICAL, PHYSIOLOGICAL, AND BIOCHEMICAL ASPECTS OF VARIABLE DEVELOPMENTAL AND GROWTH RATES IN OYSTER LARVAE

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Dale B. Bonar

All species have inherent mechanisms designed to insure their survival in the event normal cycles of reproduction and growth are interrupted. For the oyster, one of these mechanisms is its ability to delay a metamorphosis that takes it from a free-swimming larval stage to a bottom-living bivalve. A few days after hatching, larvae are ready to begin growing their shells, which they must do if they are to survive. They fall from the planktonic community in near-surface waters and seek the hard substrate oysters require to achieve their metamorphosis. If this substrate is unavailable, the larvae have only a few days in which to find it elsewhere. Each day that passes diminishes the chances for successful setting and thus survival.

This project examines the metamorphosis in laboratory conditions and what happens during the few days the larva is able to delay it. Combined with research exploring other facets of the oyster's life, the project will help identify regions of the Bay where larvae are likely to settle best. This information will be valuable for state resource managers who, in an effort to promote spatfall (and thus future commercial harvests), plant millions of bushels of old shell in order to provide the hard substrate on which larvae need to metamorphose.

--The Editors

INTRODUCTION

It is characteristic of oyster larvae cultured in the laboratory to display a wide range of growth rates, even though all the larvae are exposed to the same feeding regime, temperature, and salinity conditions. Throughout the project period (extending into spring of 1980), we carried out experiments designed to determine the nature and pattern of these variable developmental rates in oyster larvae. Our initial investigations aimed at characterizing the spectrum of growth rates of sibling larvae, trying to establish whether there is a continuum of rates within a population or whether there are finite subsets of larvae with similar growth rates (i.e. "classes").

NOTE: Dale Bonar is an associate professor of zoology at the University of Maryland, College Park.

RESULTS

Our results show that all larvae begin the larval "D-hinge" stage at approximately the same time and size, but that with time a dichotomy appears. One group of larvae develops faster and has a greater survivorship than another. Size-frequency distribution plots of larval size are bimodal; one group of larvae continues to grow while a smaller portion of the larvae arrest as D-stage veligers. Experiments designed to determine the growth potential of the retarded group showed that when this small-size group was separated from the larger group, it was able to overcome the apparent inhibition of growth, and within a few days "catch up" to the size ranges of the former, larger group. In reality, this means that those smaller larvae must develop even faster than the larger larvae in order to catch up. Whether this phenomenon of "growth classes" is a result of some normal developmental program or is brought about by the same "inhibiting factor" produced by the faster-developing larvae will be examined in future studies. We suspect that there is no inhibitory factor operating here, since our cultures contained low densities of larvae and the culture fluid was changed every day or every other day.

The characteristic of variable developmental rates in oyster larvae may provide the species with a reproductive strategy ensuring widespread distribution of sibling offspring and an increased chance of finding appropriate settlement sites. As this factor may be a determinant of recruitment of new spat on existing oyster bars in the Chesapeake Bay, it is important to know the potential developmental success of larvae from different growth rate groups and to know the biological characteristics of those larvae. Our preliminary experiments suggest that any larva capable of developing to the eyespot-pediveliger state (regardless of rate) is capable of successful metamorphosis. As noted below, however, the process of metamorphosis appears to be closely tied to a specific developmental stage of the larvae, and when the larvae have passed this stage they lose the ability to metamorphose.

Delay of Metamorphosis: General Effects

Another factor which may greatly affect the potential of larvae to disperse and find suitable sites (substrate) for settlement is the ability of larvae to delay metamorphosis. Larvae which are developmentally competent to metamorphose are thought to be able to delay metamorphosis until presented with an environmental cue indicating the presence of a suitable adult habitat. The objective of a second portion of our research was to determine experimentally the capacity of oyster larvae to delay metamorphosis and to examine the nature of their development during the delay phase. Our results from two separate experiments indicate that competent larvae are able to delay metamorphosis for several days, but soon show less response to cues for settlement and may have a reduced ability to metamorphose after three or more days of delay. Once a developmental rate class of larvae become competent to metamorphose, virtually all of them will set if given oyster shell substrate. However, if this group is kept in clean sea water, after a week only 13% will metamorphose when supplied with shell. These experiments are summarized in Figure 1.

Larvae which experience delay of metamorphosis are found to suffer a rapid decrease in protein synthesis that is correlated directly to the duration of the delay.

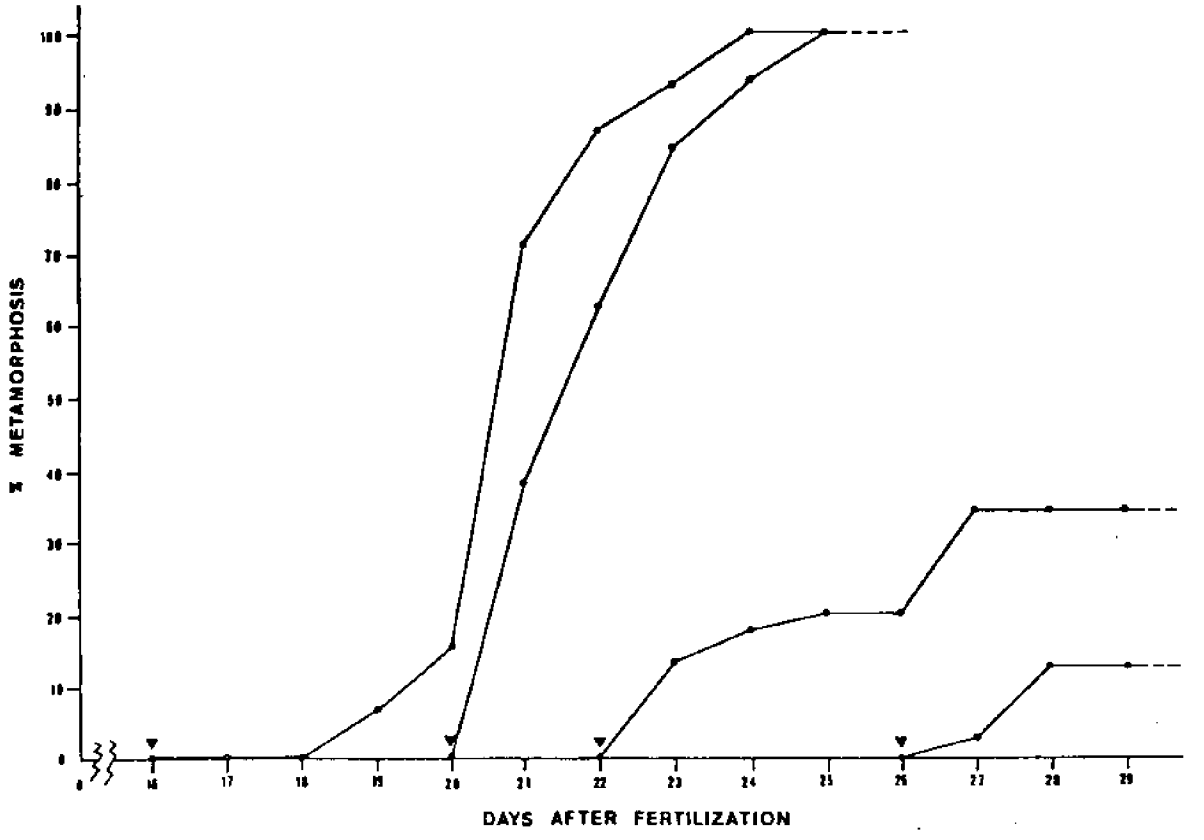

Figure 1. Metamorphosis of *C. virginica* larvae following increasing periods of metamorphic delay. Sibling larvae of equivalent developmental stage from two-parent broods were used in all experiments. Cultures of approximately 50 larvae/vessel were cleaned, fed, and counted daily. No metamorphosis occurred in clean control cultures. Metamorphosis was induced by the addition of cultch and 0.1% "adult mantle liquor" on indicated days (▼). In our culture regime, larvae acquired metamorphic competence at day 18. Maximum rates of metamorphosis were seen between days 20 and 21. As the delay period increased prior to metamorphic induction, the population's ability to metamorphose decreased. After a delay period of one week, only 13% of the larvae were capable of metamorphosis.

Delay of Metamorphosis: Morphological Effects

We have examined various cytological and histological aspects of specific larval and adult tissues to compare development before and during metamorphosis with development during the delay of metamorphosis. An example of this is the adult gill which forms rapidly following metamorphosis. Prior to the initiation of metamorphosis, the gill exists only as an unspecialized rudiment, but once metamorphosis ("setting") begins, the gill develops very rapidly, so that within 24 hours it is a complex, functioning organ. The other tissues of the oyster larvae seem to be in a comparable stage of "arrest" until their development is renewed at metamorphosis. Apparently then, when an oyster larva becomes competent to metamorphose, it develops no further as a larva, but must soon settle and metamorphose if it is to survive.

SUMMARY

We have shown that clear "rate classes" of growth and development exist for the American oyster, and that these rates may change with time. Once larvae have become competent to metamorphose, they must do so within a short time, or will perish because they lose the ability to undergo the complex of changes which occur at this time. Once a larva has "matured," it ceases development and only re-initiates substantial growth and development if it metamorphoses.

FUTURE RESEARCH

Further examination of the nature of the different "rate classes" may determine whether slower development (or delayed development) of certain larvae is caused by some environmental factor (such as an inhibition factor produced by other larvae) or by an inherent genetic program. The postlarval survivorship of members of the different rate classes may also determine what effect, if any, larval developmental rate has on adult growth rate.