# DIFFERENTIAL GROWTH RATE INFLUENCES DISPERSAL POTENTIAL OF QUEEN CONCH LARVAE

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ABSTRACT

Spatial differences in phytoplankton biomass and quality caused variation in the larval life-span of queen conch, *Strombus gigas*. Conch larvae were grown in the laboratory on three assemblages of phytoplankton: 1) seawater from the Great Bahama Bank, 2) seawater from the Exuma Sound shelf, and 3) an algal mixture of cultured Caicos *Isochrysis* and *Chaetoceros gracilis*. Larvae in a field mesocosm system were also fed a continuous supply of natural phytoplankton from Bahamian Bank water. In the mesocosm system larvae acheived metamorphic competence in only 13 days. In the laboratory, larvae in the Bank and cultured algal treatments acheived competence in 20 days, but none in the shelf water ever became competent. Individual variation within a cohort occurred in all treatments, with the largest larvae in each treatment approximately twice the size of the smallest. The results suggest that duration of larval life-span for conch larvae could range from 13 to 83 days, if growth was linear. The magnitude of this range means that larvae have the potential to metamorphose in local waters or be transported between countries in the Caribbean. To understand larval recruitment, both larval development and transport processes need to be considered.

Key Words: Dispersal, Growth Rates, In situ, Larvae, Natural Food, *Strombus gigas.*

## INTRODUCTION

Great controversy has centered on determining if planktotrophic invertebrate larvae, especially those found in oligotrophic waters, encounter periods of limited food or are exposed to food concentrations sufficient to grow at near-maximal rates in the ocean (Scheltema 1986, Olson & Olson 1989). Growth rate is one of the many factors influencing survival and location at settlement. For example, if growth is rapid, larval life span may be shorten. As a result, the potential for dispersal away from favorable settlement habitats is reduced as is the time exposed to planktonic predators (Thorson, 1950; Scheltema, 1986).

Growth and development of planktotrophic gastropods are poorly understood (Olson & Olson 1989, Bell 1993). Larvae of queen conch, *Strombus*

*gigas*, hatch during a 6-8 month reproductive season, disperse over a wide geographic range, and migrate vertically; therefore, they are exposed to variations in nutrition over temporal and spatial scales. We know from laboratory results that conch larvae fed on cultured algae are competent for metamorphosis in 12 - 32 days (D'Asaro, 1965; Brownell, 1977; Ballantine & Appeldoorn, 1983; Davis & Hesse, 1983; Aldana Aranda et al., 1989); and that this variation is influenced by nutrition, temperature, and larval density. Conch larvae can develop on natural seawater (Brownell, 1977; Boidron-Metairon, 1992); however, rigorous studies have yet to be accomplished.

The goal of these laboratory and field studies were to examine growth rates of conch larvae fed different sources of natural phytoplankton from the oligotrophic waters of the Bahamas. The results of these data are used to discuss how spatial changes in nutrition affect larval life span and dispersal potential.

## METHODS AND MATERIALS

Laboratory and mesocosm experiments in larval nutrition were conducted at Lee Stocking Island, Exuma Cays, Bahamas from 5-30 August 1994. Veligers of Strombus gigas for all experiments were obtained from a single egg mass collected at an offshore breeding site near Lee Stocking Island. In the laboratory, conch larvae were fed phytoplankton assemblages from 3 different sources: 1) natural seawater collected on the Great Bahama Bank (Bank), 2) natural seawater collected on the shelf of the Exuma Sound (Shelf), and 3) an algal mixture of cultured Caicos Isochrysis and Chaetoceros gracilis, staple foods used in conch larviculture (Davis, 1994). Each treatment had 5 replicates and each replicate had an initial density of 12 newly-hatched veligers/L and a final density of 4/L.

Experimental containers (1 L) were kept in an incubator at 29 °C with a light cycle of 12 h light: 12 h dark. Larvae were maintained in static treatment water, which was exchanged daily. Seawater from the Bank and Shelf was coarse filtered (250 μm) prior to being used in the experiment. To avoid introducing natural phytoplankton into the cultured algal treatment, all water was 0.45 μm filter prior to adding a mixture of 7,000 - 10,000 cells/ml of Caicos *Isochrysis* and *Chaetoceros gracilis.*

An in situ mesocosm system, free from laboratory artifacts, was deployed on the Bank (2 m depth) near Lee Stocking Island as an alternate system for testing the affects of nutrition on growth of conch larvae. It consisted of a moored platform (3 m dia) which supported 6 conical bottom clear, fiberglass cylinders (200 L). The mesocosm cylinders were submerged except for 0.5 m which remained emersed to prevent sample loss and wash-over of waves. Unlike any other mesocosm design, the nonporous enclosures in this study had the advantage of a continuous flow (1

L/min) of filtered water supplied by a solar powered submersible pump. Seawater was filtered through 50 µm bags, which allowed phytoplankton to enter the mesocosms, but blocked predators and most competitors. Newly-hatched larvae were stocked into 2 mesocosms at a density of 20/L. Every 4 days density was reduced by counting veligers out of one mesocosm into a newly-filled mesocosm. Final density at the end of the experiment was 0.75 veligers/L.

To determine growth and developmental rates of veligers, observations and shell measurements were made every other day using a dissecting microscope (40x) (Davis et al., 1993). After measurements, laboratory veligers were returned to their appropriate containers, and the mesocosm veligers were preserved. Both experiments continued until >50% of the veligers in one treatment were competent for metamorphosis.

Replicate water samples (800 mls) were filtered from the Bank, Shelf, cultured algae and mesocosm treatments every other day to determine chlorophyll a concentration (ng/L). Extraction of chlorophyll a and fluorometric readings were performed according to standard methods (Strickland & Parsons, 1972).

## RESULTS

### Laboratory

When veligers were fed natural concentrations of Bank phytoplankton and high concentrations of cultured algae they grew at similar rates from day 4 - 18 (ANOVA, $p > 0.05$). On day 20, 25% of the veligers fed Bank phytoplankton were metamorphically competent, and 60% of the veligers fed cultured algae were competent. No veligers fed Shelf phytoplankton became competent. By day 20, these veligers averaged only 560 µm shell length (SL) compared to 915 µm SL for veligers fed Bank water and 1029 µm SL for veligers fed cultured algae.

Although veligers grown on Bank and cultured algae grew at similiar rates, the chlorophyll a concentrations were remarkedly different. Average concentration for the Bank water was 176 ng/L, whereas, the cultured algae was 4700 ng/L, almost a 50 fold difference. Even though veligers grew faster in Bank water than Shelf water, chlorophyll a concentrations were different, but not as extreme. The average chlorophyll a concentration for Shelf water was 107 ng/L, 64% less than Bank water.

There was considerable variation in growth within this larval cohort. By the end of the experiment, veligers fed Bank phytoplankton had the highest variation in shell lengths (750 to 1175 µm ), and veligers fed cultured algae were next (850 to1125 µm). Because of slow growth, veligers fed Shelf phytoplankton showed the least variation (500 to 650 µm).

### Mesocosm

Veligers in the mesocosm system grew faster than their laboratory siblings. Metamorphosis for veligers fed 50 µm filtered phytoplankton was first seen on day 13. By day 16, 95% of the veligers were competent or had completed metamorphosis with an average size of 993 µm SL.

Results from routine chlorophyll a sampling showed that phytoplankton accumulation or retention in the mesocosms did not occur. With 8 exchanges of water per day in each mesocosm cylinder, there was no difference in chlorophyll a concentration inside and outside the mesocosm on day 2 ($t(12)=1.65$, $p=0.12$) or on day 4 ($t(13)=-0.76$, $p=0.46$). The average chlorophyll a concentration in the mesocosm was 160 ng/L.

## DISCUSSION

Ecological conditions, such as food quality and quantity are important variables that influence length of planktonic life within a cohort of larvae (Schooltime, 1986). In this study, veligers fed Bank water and cultured algae clearly demonstrated the effects of food quality. For even though, chlorophyll a levels were considerable higher with cultured algae (4700 ng/L) than Bank water (176 ng/L), growth rates were almost identical. This suggests that the few cells available in the Bank water were nutritionally superior to the high number of cultured algal cells fed to the veligers. On the other hand, food quantity proved to be the key factor in determining growth rates for larvae fed Bank or Shelf water. Since it is likely that similar phytoplankton assemblages were available in both water masses, the lower chlorophyll a level (107 ng/L) for Shelf water probably caused low veliger growth (11 µm/day vs 29 µm/day for veligers fed Bank phytoplankton). It appears that the food supply in the oligotrophic waters of the Bahamas resulted in adequate growth for *Strombus gigas* larvae fed phytoplankton from the Great Bahama Bank, however, larvae fed phytoplankton from the Exuma Sound shelf were probable starved and food limited. These results support the hypothesis that food limitation is most likely to occur in offshore, oceanic locations rather than in nearshore environments (Huntley and Boyd, 1984).

Individual variation in growth rates within a cohort was evident in all 3 treatments. The largest variation, observed in veligers fed Bank phytoplankton, may be due to foraging ability. With so few cells some veligers may have been more efficient at capturing higher quantities and qualities of phytoplankton, enabling them to grow faster than others. The least amount of variation was observed in veligers fed Shelf phytoplankton, though this is expected since growth was slow amongst all veligers in this treatment. If we consider the fastest growth rate of an individual, which occurred in the mesocosm (46 µm/day) and the slowest growth rate, which occurred in Shelf water (8 µm/day), the larval life span for *Strombus*

*gigas* veligers could be as short as 13 days and as long as 83 days if the veligers survived to metamorphosis. However, to accurately determine length of larval life-span, additional investigations using different concentrations of chlorophyll a from the natural seawater need to be conducted.

Because of the continual supply of phytoplankton into the mesocosms, veliger growth was rapid and represented a more accurate potential for growth than laboratory veligers in static water. However, laboratory experiments with natural seawater did provide a comparison of water masses and revealed the potential artifacts of using cultured algae. Overall veligers in Bank water and the mesocosm were more active when fed natural phytoplankton than when fed cultured algae. This was probably due to the availability of many species of phytoplankton and the high nutritional value of these species.

Dispersal potential and recruitment to favorable habitats for larvae of Strombus gigas is strongly influenced by food supply. For example, larvae which hatch in the Exuma Sound and are transported onto the Great Bahama Bank and the nearshore waters of the islands are more likely to grow at a fast rate due to exposure to high phytoplankton biomass (chl a > 100 ng/L) (Stoner, unpublish.). These larvae would improve their chance of recruitment due to fast growth and proximity to settlement habitats. However, larvae which hatch in the Sound and are advected to the middle of the Exuma Sound where chlorophyll a concentration is only 25-50 ng/L (Stoner, unpulish.) may never attain their maximum possible growth rate and may be lost to starvation or predation because of their long larval period.

The dispersal potential of veligers of *Strombus gigas* throughout the Caribbean region is also strongly influenced by oceanographic currents. Conch larvae are either retained locally as planktotrophic veligers or they drift as teleplanic veligers and settle 100's of km away from their origin. Understanding the affects of temporal and spatial variations of food quantity and quality on larval life span will assist ecologists and fisheries managers in identifying local and regional spawning stocks which influence the recruitment in this important fisheries species.

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