Effect of photoperiod and feeding schedule on growth and survival of larvae of the fighting conch Strombus pugilis Linné, 1758 (Mollusca, Gastropoda)

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A B S T R A C T

The combined influence of feeding schedule and photoperiod on fighting conch, Strombus pugilis (Linné, 1758) larvae growth and survival was studied using two feeding schedules (12 h and 24 h with food) and three photoperiods (0 h light, 12 h light and 24 h light). This effect of feeding and photoperiods was tested in three months (May, June and July). Shell length was measured every two days to establish growth for each treatment. For the three experiments, continuous darkness and feeding were advantageous for larvae growth with the higher growth rate (42 μm d−1) and survival (13%). However the highest survival (44%) was obtained in 12 h light and 24 h feeding.

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1. Introduction

Although there is considerable knowledge of the general life history and larval culture of Strombus gigas (Linné 1758), the species Strombus pugilis has rarely been studied (Bradwhaw-Hawkins, 1982; Brito-Manzano et al., 1999; Brownell, 1977). The fighting conch, S. pugilis, is one of six species of conches distributed throughout the Caribbean inshore waters on sandy bottoms (Berg, 1976; Berg et al., 1983; Brownell and Stevely, 1981). Conches are an important source of protein of great economic and cultural significance to the inhabitants of the Caribbean and Yucatan Peninsula, Mexico regions. Conches are considered new marine aquarium organism. Aquacultured specimens are the alternative to wild caught conches and it is the goal to ensure the future as well as conserve the natural populations. For this reason why it is important research and produce, through aquaculture, for the marine aquarium trade. Aquarium prices for conches are in the range 4.5 to 15 Euros for a unit in the South East of Florida, Brazil, Hawaii and West Indies. It is important to develop aquaculture techniques to enhance production through private and public mariculture. However, the use of this for the production of conch seeds have been proposed as a basis for restoring depleted natural populations of this species, although it has only been done for S. gigas and S. costatus (Baqueiro-Cárdenas, 1997). On the other hand, while studies on fisheries and mariculture are numerous, those of specific larval preferences and the importance of feeding schedule for the success of larviculture are limited. To maximize spat production in hatcheries it is necessary to understand the environmental preferences of the larvae. Optimization of these parameters and achieving the correct balance can result in improved growth and survival rates, a reduction in the larval rearing period and a subsequent reduction in production costs.

Little is known of the larval development, dispersal, nutrition, photoperiod and settlement of S. pugilis. The effect of photoperiod on growth has been studied in molluscs, but with contradictory results. Dodd (1969) reported that light had no effect on the absolute rate of growth measured as calcium deposition in Mytilus edulis and M. californianus, although a reduction in shell growth was noted. Strömgren (1976a) also showed that darkness encouraged length growth of M. edulis, and Strömgren (1976b) found that Modiolus modiolus increased its growth rate significantly during continuous darkness, while no such effect was found for Cerastoderma edule. Nielsen (1985) has shown that in juvenile M. edulis grown in dim day-light there is a linear relationship between shell length growth and ash-free dry weight growth. Barilé et al. (1994) found that larvae of S. gigas presented strong positive phototaxis and negative geotaxis during early stages and that positive phototaxis...
Table 1
Feeding schedules and photoperiods used for larval culture of Strombus pugilis.

<table>
<thead>
<tr>
<th>Photoperiods (Light hours)</th>
<th>Feeding schedules (h)</th>
<th>12</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0/12 (set A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12/12 (set B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>24/24 (set E)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

decreased as a function of age. No information is available on the effects of photoperiod on Strombus larvae. The goal of this work was to determine the effect under photoperiods and feeding schedules on growth, settlement and survival on larvae of S. pugilis in laboratory culture.

2. Materials and methods

The fertilized egg mass used for the experiment was collected in May, June and July at Seyba Playa, in Yucatan Peninsula Mexico. It was collected by scuba diving from a depth of 4 m from under a female conch to ensure species identity and egg freshness. Afterwards, it was transported to the laboratory, where epibions and sand particles were removed. The egg mass was cleaned with 10-μm filter and UV-sterilized seawater. The cleaned egg mass was placed over a 300 μm mesh and kept immersed in a 25-L aquarium with seawater filtered through 2 μm cotton filters and UV-sterilized. Temperature was maintained at 29 ± 1 °C.

The asterisk indicates significant difference between means, n.s. indicate no significance. ANOVA and Tukey tests were used to determine if settlement and survival were significantly different for veligers in different treatments. Significance was assumed when \( P < 0.001 \) for settlement and \( P < 0.0001 \) for survival.

3. Results

At 29 days of culture the larvae of May and June were competent for settlement, 100% of the larvae, was recorded in sets C and D while sets A, B and E had only 97%, 80% and 84%, respectively, and had settled at 31 days (Table 2). Settlement does not exhibit significant differences between months (\( P > 0.001 \)).

Fig. 1 shows that average shell length was reduced in larvae in sets A (0 light conditions and 12 h feeding) and E (24 light conditions and 12 h feeding) and D (12 light conditions and 24 h feeding) had an average growth rate of 26 and 22 μm d~−1, respectively. Larvae under 0 light conditions and 24 h feeding (set C) showed the fastest growth rate during the experiment and it was significantly higher than for the others sets, but survival tended to be lower compared with other treatments. The highest survival was attained under set D with 44%, which was significantly higher than for set E and C with 11 and 21 %, respectively. ANOVA test showed a significant difference between treatments (\( P < 0.0001 \)). Moreover ANOVA does not demonstrate a significant difference between months.

4. Discussion

The three experimental series demonstrated that the optimal photoperiod and feeding schedule for maximal growth of larvae of S. pugilis was 0 L/24 F. The darkness had a direct influence on growth with continuous feeding, but with a lower survival. Shell lengths of larvae were consistently lowest for treatments A and E regardless of culture month. The growth of the larvae presented the same behavior reported for settlement, average size at settlement, growth rate, larval survival for each feeding schedule and photoperiods conditions for the veliger of Strombus pugilis and Mytilus edulis reported by Lucas et al. (1986) with larvae of Mytilus edulis, and Garcia Santaella and Aldana Aranda (1994) with larvae of survival, a subsamples of 10 larvae were sampled at random every 48 h from each of three replicates (\( n = 30 \)). Growth rate was calculated according to Garcia Santaella and Aldana Aranda (1994) as: average growth rate in μm d~−1 = (average shell length at the end of the experiment − average shell length at the beginning)/total growth period in days. Settlement was examined by reabsorption of velar lobes, outward migration of eyes, foot and adult operculum claw appears and swim-crawl behavior. Survival in the culture for the three months was calculated using the number of living larvae at the beginning and end of the experiment. ANOVA and Tukey tests were used to determine if settlement and survival were significantly different for veligers in different treatments. Significance was assumed when \( P < 0.001 \) for settlement and \( P < 0.0001 \) for survival.

Table 2
Settlement, average size at settlement, growth rate, larval survival for each feeding schedule and photoperiods conditions for the veliger of S. pugilis, fed T. suecica and reared at 29 ± 1 °C, for three months.

<table>
<thead>
<tr>
<th>Treatment A</th>
<th>Treatment B</th>
<th>Treatment C</th>
<th>Treatment D</th>
<th>Treatment E</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>June</td>
<td>July</td>
<td>May</td>
<td>June</td>
</tr>
<tr>
<td>Setlement</td>
<td>Days</td>
<td>31</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>%</td>
<td>97n.s.</td>
<td>97n.s.</td>
<td>96n.s.</td>
<td>80*</td>
</tr>
<tr>
<td>Growth</td>
<td>Average (μm)</td>
<td>933</td>
<td>937</td>
<td>933</td>
</tr>
<tr>
<td>Rate (μm d~−1)</td>
<td>23n.s.</td>
<td>24n.s.</td>
<td>23n.s.</td>
<td>26ns.</td>
</tr>
<tr>
<td>Survival</td>
<td>%</td>
<td>26*</td>
<td>25*</td>
<td>25*</td>
</tr>
</tbody>
</table>

The asterisk indicates significant difference between treatments, n.s. indicate no significant difference.
attributed to the differences in biochemical composition of the egg. The only differences found were in rate of kinetic development. It was during these months that developmental characteristics were the same.

Several months (March to September). They found for all larvae reared the growth; the fi point was established with n = 30 larvae measured.

References
