Aquaculture 408–409 (2013) 47–50

Contents lists available at SciVerse ScienceDirect

Aquaculture

journal homepage: www.elsevier.com/locate/aqua-online

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

Nancy Brito-Manzano [a,*], Dalila Aldana-Aranda [b]

[a] *División Académica de Ciencias Agropecuarias (DACA) de la Universidad Juárez Autónoma de Tabasco (UJAT), Km 25 carretera Villahermosa-Teapa R/A La Huasteca 2ª. Sección, Villahermosa, Tabasco, C.P. 86260, Mexico*
[b] *CINVESTAV IPN Unidad Mérida, Km 6 antigua carretera a Progreso, Mérida, Yucatán, C.P. 97310, Mexico*

ARTICLE INFO

Article history:
Received 20 December 2012
Received in revised form 6 April 2013
Accepted 8 April 2013
Available online 31 May 2013

Keywords:
Feeding schedule
Photoperiod
Growth
Strombus
Larvae

ABSTRACT

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}) while continuous light and feeding had a negative effect on growth (29 μm d^{-1}) and survival (13%). However the highest survival (44%) was obtained in 12 h light and 24 h feeding.

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

* Corresponding author. Tel.: +52 993 358 15 84.
E-mail address: nancy.brito@ujat.mx (N. Brito-Manzano).

0044-8486/$ – see front matter © 2013 The Authors. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.aquaculture.2013.04.006

Table 1
Feeding schedules and photoperiods used for larvae culture of *Strombus pugilis*.

Photoperiods (Light hours)	Feeding schedules (h)	
	12	24
0	0/12 (set A)	0/24 (set C)
12	12/12 (set B)	12/24 (set D)
24	–	24/24 (set E)

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 epibionts 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. Each month one single egg mass was used to avoid variability among egg masses from different parents.

For the three experimental cultures, larvae were reared according to the method described by Brito-Manzano et al. (1999). Larvae were reared from hatching to settlement in three photoperiods (0 L, 12 L and 24 L) and two feeding schedules (12 F and 24 F), as shown in Table 1. For sets A (0 L/12 F) and B (12 L/12 F) the change of water was 12 h each, while for the sets C (0 L/24 F), D (12 L/24 F) and E (24 L/24 F) each 24 h. For each set, there were three replicates. Larvae were stocked in 4-L container with a density of 200 larvae L^{-1}. Larvae of each treatment were fed of fresh algae *Tetraselmis suecica* at a concentration of 1000 cell mL^{-1} (Garcia Santaella and Aldana Aranda, 1994). There was a single addition of food at the beginning of each feeding schedule. Every two days, 30 larvae were collected at random from each replicate for the observation of growth. Three light bulbs with tungsten filament (Phillips 60 w), placed above water surface, were used as light source. The light was turned on at 06:30. Darkness was obtained by covering the container with black plastic covers. Each morning veligers were transferred to new containers with fresh seawater filtered through 10 and 2 μm cotton filters. It took approximately 5 min for these procedures; therefore, 0 light had a five minutes light phase per day.

For each month, growth was assessed recording increments of siphonal length. Larvae were measured using a compound microscope with a calibrated ocular micrometer to the nearest 0.10 μm. Differences between means were tested by ANOVA and Tukey tests. Significance was assumed when $P < 0.05$. With the target of not altering the results 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.

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 had settled at 31 days (Table 2). Settlement does not exhibited 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 and feeding conditions) with 912 and 933 μm ($P < 0.001$), respectively, in the three months evaluated, otherwise in set C (under 0 light conditions and 24 h feeding) growth was significantly higher with an average of 1499 μm ($P < 0.001$).

Settlement day and percentages, average size at settlement, growth rates and survival for cultures realized in May, June and July are shown in Table 2, for the five treatments. The ANOVA and Tukey tests showed significant difference ($P < 0.001$). Larvae in sets B (12 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 by Lucas et al. (1986) with larvae of *Mytilus edulis*, and Garcia Santaella (1992) and Garcia Santaella and Aldana Aranda (1994) with larvae

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.

		Treatment A			Treatment B			Treatment C			Treatment D			Treatment E		
		May	Jun	July	May	Jun	July	May	Jun	July	May	Jun	July	May	Jun	July
Settlement	Days	31	30	31	31	31	31	29	29	28	29	29	30	31	31	31
	%	97n.s.	97n.s.	96n.s.	80*	80*	76*	100n.s.	100n.s.	98n.s.	100n.s.	100n.s.	99n.s.	83*	85*	83*
Growth	Average (μm)	933	937	933	1023	1028	1025	1496	1501	1499	1117	1117	1119	912	910	913
	Rate (μm d^{-1})	23n.s.	24n.s.	23n.s.	26n.s.	27n.s.	26n.s.	41*	42*	42*	22n.s.	22n.s.	23n.s.	29n.s.	29n.s.	29n.s.
Survival	%	26*	25*	25*	34*	34*	34*	22*	20*	22*	44*	46*	44*	13*	10*	11*

The asterisk indicates significant difference between treatments, n.s. indicate no significant difference.