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A PRELIMINARY STUDY OF THE EFFECT OF SUPPLEMENTARY FEEDING ON THE GROWTH OF TRIDACNA MAXIMA (RODING)(BIVALVIA: TRIDACNIDAE)

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The effect of supplementary feeding on the growth of the giant clam Tridacna maxima was studied using Isochrysis galbana, Tetraselmis sp. and a mixture of both. Juvenile clams fed with the mixed culture had significantly higher growth rates, after the second and third months, followed by Isochrysis and Tetraselmis alone. Unfed clams supplied with filtered seawater had the slowest growth.

Tridacnid clams are currently being studied in view of their possible extinction and mariculture potential (Beckvar, 1981; Gwyther and Munro, 1981; Heslinga et al., 1985). They are attractive mariculture subjects since their juveniles and adults contain a symbiotic dinoflagellate, Symbiodinium microadriaticum Freudenthal, which contributes significantly to the nutrition of the clam (Trench et al., 1981). These specialized dinoflagellates, zooxanthellae, live in the mantle tissues of the clam and may account for the large size attained by some species. Permanent symbiosis with the dinoflagellate is not established until after metamorphosis. Also, the larvae or juvenile must acquire complement symbionts from the environment (Fitt et al., 1984) as adult tridacnids do not pass them on to their young (LaBarbera, 1975; Jameson, 1976).

Very little is known about the nutritional requirements of larval and juvenile clams. Gwyther and Munro (1981), Fitt et al. (1984) and Crawford et al. (in press) added unicellular algae to tridacnid larvae and studied the effect of feeding on survival, while Beckvar (1981) and Heslinga et al. (1984) maintained juvenile and small adult clams without food additions until reaching a size at which they could be transplanted onto the reef. This study attempts to determine the possible effect of supplementary feeding on the growth of young T. maxima using various microalgal cultures.

MATERIALS AND METHODS

Nine-month-old laboratory-reared T. maxima were used in our study. These clams were divided into three treatment groups and a control group, with three replicates for each group. Each replicate contained 17 clams. The experimental clams were placed in 58cm x 50cm x 16.5cm basins supplied with unfiltered seawater, except for the control group, which was supplied with filtered seawater only, for eight hours a day at most. The first treatment group was fed with Isochrysis galbana; the second, with Tetraselmis sp.; and the third, with a mixture of both algae. Feeding was every other day, in the afternoon, with 30 ml of each microalgal culture, with a cell density of 10^4 to 10^7 cells/ml. Seawater flow to all basins was discontinued during feeding, resuming the following day. The clams were measured monthly using a plastic caliper. Growth was approximated by subtracting monthly measurements from initial lengths. Water temperature and salinity were monitored daily using a field thermometer and refractometer.

Growth data obtained were tested with Cochran's Test for homogeneity of variances. Three separate analyses were done using 1-Factor Nested Analysis of Variance for the first (September - October 1983), second (October - November 1983) and third (November - December 1983) months, with the various treatments as the factor.

RESULTS

Results of the analysis for the first month failed Cochran's Test; therefore, we did not proceed with ANOVA. However, if the means of each treatment were plotted for this month, clams fed with Isochrysis would appear to have had greater growth rate at this stage. Results of months two and three, on the other hand, passed Cochran's Test, and the 1-Factor Nested ANOVA was done. Results revealed significant treatment effects during these months (Table 1). Student-Neuman-Keuls (SNK) Tests were carried out to compare individual means of each treatment for both months. Results showed that clams on the mixed Isochrysis-Tetraselmis diet had significantly higher growth, followed by Isochrysis and Tetraselmis (Table 1). Clams in the control group (basins supplied only with filtered seawater) had the slowest growth. Mean growth of fed and unfed clams after the second and third months is shown in Table 2. After three months, clams fed with mixed Isochrysis-Tetraselmis had a growth of 8.47mm (SD=1.77), followed by Isochrysis galbana, 7.63mm (SD=1.66), Tetraselmis, 5.75mm (SD=1.47) and the control, 3.25mm (SD=0.18). The same pattern was obtained for the fourth month, with the mixed culture having 10.61mm (SD=2.35), Isochrysis, 10.15mm (SD=1.58), Tetraselmis, 8.58mm (SD=1.85) and the control, 6.74mm (SD=2.08). Means were based on 51 measurements. The overall result showed significantly higher growth for clams fed with the mixed cultures than clams fed with either Isochrysis or Tetraselmis alone. Water temperature and salinity were fairly constant throughout the study, averaging 27 ± 1°C and 31 ± 1 ppt.

DISCUSSION

In a review of the literature on bivalve nutrition, de Pauw (1981) included *T. galbana* and various species of *Tetraselmis* in a list of algal species that promoted excellent growth of juvenile bivalves. He found that bivalve juveniles showed better growth in mixed cultures of suitable species (citing *T. galbana-Tetraselmis* sp. mixture) than in either culture alone.

Fitt et al. (1984) reported that appropriate nutrition of tridacnid larvae enhanced survival and growth, which may in turn influence the growth of metamorphosed juveniles. Gwyther and Munro (1981), on the other hand, reported that feeding did not so much serve to promote growth as to increase survival during metamorphosis. However, Gwyther and Munro suggested that food must be made available to the larval culture both throughout pelagic larval life and during growth from spat to adult, and unicellular algae should be introduced to encourage rapid growth of young clams.

Crawford et al. (in press) reported that densities of five-month-old juveniles of *T. gigas* which were fed with either *I. galbana* or *Chlorella* sp. from the larval to the juvenile stage differed significantly from unfed clams. Higher densities were obtained from tanks containing clams which were not fed. In the raceway where microalgae were added, they observed the development of more benthic algae, which grew over the juveniles and probably resulted in higher mortalities by the reduction of light intensity and competition for nutrients with the zooxanthellae. However, Crawford et al. could not reach any conclusion regarding the influence of supplementary feeding on the growth rates of newly-metamorphosed juveniles.

Results of the present study indicated faster growth for clams with supplementary feeding. Differences among treatments, however, were not apparent until the second month of the study. These results contrasted with those of Crawford et al. (in press), who reported that supplementary feeding was not necessary. However, the duration of their study was only two months, while, in our study, significant differences in the growth rates of the clams occurred only after two months.

The highest growth rates obtained for the *Isochrysis-Tetraselmis* culture agree with the evaluation of de Pauw (1981) for bivalve molluscs. As mentioned, the combination of *Isochrysis* and *Tetraselmis* resulted in better growth of the juveniles of some commercially important bivalves, compared to *Isochrysis* and *Tetraselmis* alone. De Pauw emphasized, however, that the use of mixed algal species does not lead to an improvement of a poor species. Differences in food value between mixed and single algal diets may be explained by two types of interactions among combinations of algae: first, synergistic nutritional interaction, explained by the deficiency in micronutrients and fatty acids; second, non-additive interaction, explained by the

Table 1. 1-factor nested ANOVA table of the growth of Tridacna maxima from September to November 1985 (A) and September to December 1985 (B). * - $p < 0.05$; *** - $p < 0.001$.

(A)

Source of Variation	SS	df	MS	F	P
Diets	39.01	3	13.00	16.033	*** (3,8)
Basins	6.49	8	0.811	9.541	*** (8,192)
Residual	16.39	192	0.085		
TOTAL		203			

(B)

Source of Variation	SS	df	MS	F	P
Diets	14.46	3	4.82	5.618	* (3,8)
Basins	6.86	8	0.858	9.64	*** (8,192)
Residuals	17.25	192	0.089		
TOTAL		203			

Table 2. Growth of T. maxima juveniles in the laboratory.

TREATMENT	N	MEAN GROWTH (mm) ± SD	
		after 2 months	after 3 months
Mixed Isochrysis-Tetraselmis	51	8.47 ± 1.77	10.61 ± 2.35
Isochrysis alone	51	7.63 ± 1.66	10.15 ± 1.58
Tetraselmis alone	51	5.75 ± 1.47	8.58 ± 1.85
Control	51	3.25 ± 0.18	6.74 ± 2.08

ration of the algae versus the rate of extra-cellular digestion.

The contrasting reports of the effect of supplementary feeding on juvenile giant clams suggest that a longer study using several species of different ages would probably be able to gauge the importance and duration of feeding in clams until such a time as they are self-sufficient enough to be transplanted to reefs.

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LITERATURE CITED

Beckvar, N. 1981. Cultivation, spawning, and growth of the giant clams Tridacna gigas, T. derasa and T. squamosa in Palau, Caroline Islands. Aquaculture 24:21-30.

Crawford, C. M., W. J. Nash and J. S. Lucas (in press). Spawning induction and larval and juvenile rearing of the giant clam, Tridacna gigas, in preliminary mariculture experiments. Aquaculture (1986).

De Pauw, N. 1981. Use and production of microalgae as food for nursery bivalves. European Mariculture Soc. Spec. Publ.7:35-69.

Fitt, W. K., and R. K. Trench 1981. Spawning, development and acquisition of zooxanthellae by Tridacna squamosa (Mollusca: Bivalvia). Biol. Bull. 161:213-235.

__________,C. R. Fischer and R. K. Trench 1984. Larval biology of tridacnid clams. Aquaculture 39:181-195.

Gwyther, J. and J. L. Munro 1981. Spawning induction and rearing of larvae of tridacnid clams (Bivalvia:Tridacnidae). Aquaculture 24:197-212.

Heslinga, G. A., F. E. Perron and O. Orak 1984. Mass culture of giant clams (F.Tridacnidae) in Palau. Aquaculture 39:197-215.

Jameson, S. C. 1976. Early life history of the giant clam Tridacna crocea (Lamarck), Tridacna maxima (Roding), and Hippopus hippopus (Linnaeus). Pac.Sci.30:219-233.

LaBarbera, M. 1975. Larval and postlarval development of the giant clams Tridacna maxima and Tridacna squamosa (Bivalvia: Tridacnidae). Malacologia 15:69-79.

Trench, R. K., D. S. Whithey and J. W. Porter 1981. Observations on the symbiosis with zooxanthellae among the tridacnidae (Mollusca, Bivalvia). Biol. Bull. 161:180-198.

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