SEED SUPPLY

EXPERIMENTS ON LARVAL REARING AND SEED PRODUCTION OF THE MUD CRAB *Scylla serrata* (Forskal)

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ABSTRACT

The minimum period for the larvae of syclla serrata *to metamorphosise into the crab stage from the time of hatching is* 24-30 *days. The incubation period of berried female crab is 8-15 days. Embryo development is faster during summer. Temperature and salinity have a significant effect on survival and development of the crab larvae. The most suitable range qt temperature is 27- - 30° C. with salinity around 35 ppt. In the present experiments. rotifers developed from* chlorella *diet, were fed to early :oea while newly hatched* artemia *nauplii were given to later :oeal stages. A maximum of 15 per cent of the larval Sto(k attained the crab stage The rate of production could he considerably increased with improved feeding strategies and water quality management.*

INTRODUCTION

Among portunid crab, the mud crab, *Scvlla serrata* (Forskal) is subject to intensive fishing in areas where they are concentrated, such as estuaries and contiguous brackishwater mangrove shores. Over fishing has stimulated aquaculture ventures in some Southeast Asian Countries (Escritor 1972; Marichamy *et al.,* 1986). Experiments on rearing larval stages to juveniles under controlled conditions have been conducted in Malaysia, the Philippines, Thailand and Australia with varying degrees of success. Practical techniques for commercial production of juveniles in hatcheries have been developed in Taiwan and Japan. A review of the literature shows that there have been a few efforts in recent years to culture the larvae of mud crab in other regions using a variety of techniques (Ong, 1964. 1966; DuPlesis, 1971; Brick 1974; Hill 1974, 1975; Heasman and Fielder 1983; Marichamy and Rajapackiam, 1984). The present investigation attempted to evolve in a hatchery in Tuticorin, India, suitable techniques for the mass rearing of larvae to produce crab seed.

MATERIALS AND METHODS

Ovigerous females are easily obtainable year round from the commercial catches of bottom set gilinets operated at 7-10 m depth off Kayalpatnam, south of Tuticorin. The percentage of females was relatively high during April-June and September-October.

Brood stock were kept in fibreglass tanks of l t capacity and covered with black cloth to cut out light and avoid physical disturbances. Filtered and aerated seawater was used. The spawner crab were separated after their eggs hatched and were kept separately so that subsequent spawnings could be observed. Soon after hatching, the active larvae were segregated and placed in small tanks of 300 litre capacity at stocking densities varying from 25-75/litre. Cultures of *Chlorella* and rotifers were also maintained simultaneously in the wet laboratory to feeding early zoea larvae. Locally collected *Artemia* cysts were used to feed later zoea. Frozen nauplil from *Artemia* cysts were fed to megalopa. Macerated prawn meat and boiled clam meat constituted the food for megalopa and crab stages. Dead larvae and exuviae were removed every day to prevent contamination of the rearing media. Active zoeae normally congregated in corners of the rearing tanks and were strongly photopositive. Such behaviour facilitated cleaning and water changing. Excess food was removed and three-fourths of the tank volume replaced every day. Larval numbers were estimated daily by counting five replicates of 200 ml samples collected from the rearing tanks.

Assessment of each zoeal stage was done at the completion of different levels of metamorphosis to determine feeding rates. Larvae were fed at 6-hour intervals. Tanks were completely covered with a black cloth to maintain equal distribution of larvae and feed in the tank. The experiments were carried out to find natural environmental conditions suitable for the production of crab seed. Temperature and salinity were not controlled.

REARING OF BROODS AND INCUBATION

Sevila serrata spawns throughout the year in tropical waters. It is believed that maturation and spawning take place in the sea (Ong, 1964). However, Heasman and Fielder (1983) developed spawner crab by bilaterial eyestalk ablation under controlled laboratory conditions.

Spawner crab were obtained from brood stock at Tuticorin during the summer months when salinity was 34-36 ppt. Male and female crab of sufficient size for maturation (9-1 1cmin carapace width (CW)) were stocked at the rate of $1/m^2$ in a separate fenced area inside the crab culture ponds and fed intensively with fish offal and bivalves. After an interval of 4-6 weeks, 13 females out of 25 become ovigerous. These were removed from the ponds for further rearing in the laboratory. Gonadal maturation and spawning, it was apparent, is possible even in coastal ponds and confined waters. Ovigerous females collected from commercial catches were kept in the hatchery after releasing zoea in order to observe further spawning in aquarium tanks. Wild specimens reared as brood stock in separate tanks spawned more than twice in 5-6 months without undergoing any copulatory ecdysis and further mating. This kind of multiple spawning within a single mature instar was also observed by Ong (1966).

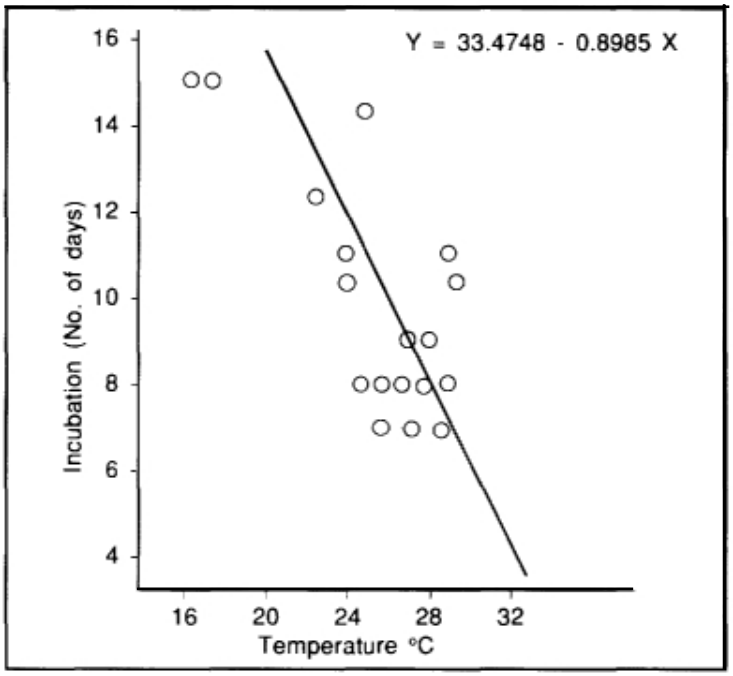
Twenty specimens of active, berried females measuring 117-140 mm CW were selected for hatchery operation. The duration of successful incubation varied from 7-15 days (Table 1).

Table 1: The results of crab seed production

Temperature regimen	*Expt. No.*	*Incubation period (Dates)*	No. *of* days	*Larval period*	*Salinity*		*Crab seed prodn.*	*% rate of prodn.*
					Range	*Mean*		
i. Low range	11	25.9.83 - 4.10.83	10	18	33.0-34.0	33.5	-	
22-24°C	12	1.10.83 - 11.10.83	11	22	33.0.34.5	33.8		-
	13	13.11.83 - 24.11.83	12	16	32.0-34.0	33.0	-	-
	17	30.11.84 - 14.12.84	15	15	33.0-35.0	34.0	-	
ii. Medium range	10	15.9.83 - 22.9.83	8	30	34.0-36.0	35.0	160	4.00
25-27°C	14	22.12.83 - 4.1.84	14	35	30.0-31.0	30.5	50	1.00
	16	8.9.84 - 16.9.84	9	30	33.0-35.0	34.2	85	2,13
	18	28.1.85 - 4.2.85	8	31	32.0-33.0	32.5	22	1.10
	19	6.2.85 - 12.2.85	7	30	32.0.33.0	32.6	320	5.33
	20	3.11.86 - 9.11.86	7	28	31.5-33.0	32.2	110	11.00
iii. High range	1	8.3.83 - 14.3.83	7	30	35.5.37.0	36.2	9	0.05
28-30°C	2	25.3.83 - 1.4.83	8	28	35.8.37.0	36.5	20	0.09
	3	29.3.83 - 7.4.83	10	28	36.0-37.5	36.8	20	0.13
	4	12.4.83 - 18.4.83	7	28	35.5-37.0	36.5	115	1.00
	5	13,5.83 - 20.5.83	8	27	35.0-36.5	35.8	180	3.60
	6	20.6.83 - 27.6.83	8	27	35.0.36.0	35.5	126	2.52
	7	5.7.83 - 14.7.83	10	26	35.0-37.0	35.2	527	13.20
	8	29.7.83 - 7.8.83	10	26	34.0.36.0	35.0	877	15.70
	9	25.8.83 - 4.9.83	11	28	34.0-36.5	35.2	582	11.60
	15	12.5.84 - 19.5.84	8	28	34.5-35.5	35.2	360	15.27

Fecundity was recorded in the range of 1.5 to 2 million eggs and the size of eggs measured 280-390 m/dia. The mean temperature during the incubation period varied from 23 to 29°C and the salinity fluctuated between 32.2 and 36.8 ppt. The influence of temperature on the incubation period is well recognized: the higher the temperature, the shorter the period of incubation, resulting in faster embryo development in eggs. During summer, it took 8-10 days, as the mean temperature varied only between 28 and 29°C. Similarly, during winter, due to low temperatures around 24°C, the period of incubation extended 12-15 days. The readings of mean daily water temperature plotted against the number of days of incubation revealed an inverse relationship (Figure 1).

Fig. 1: The influence of temperature on incubation of berried female in the hatchery

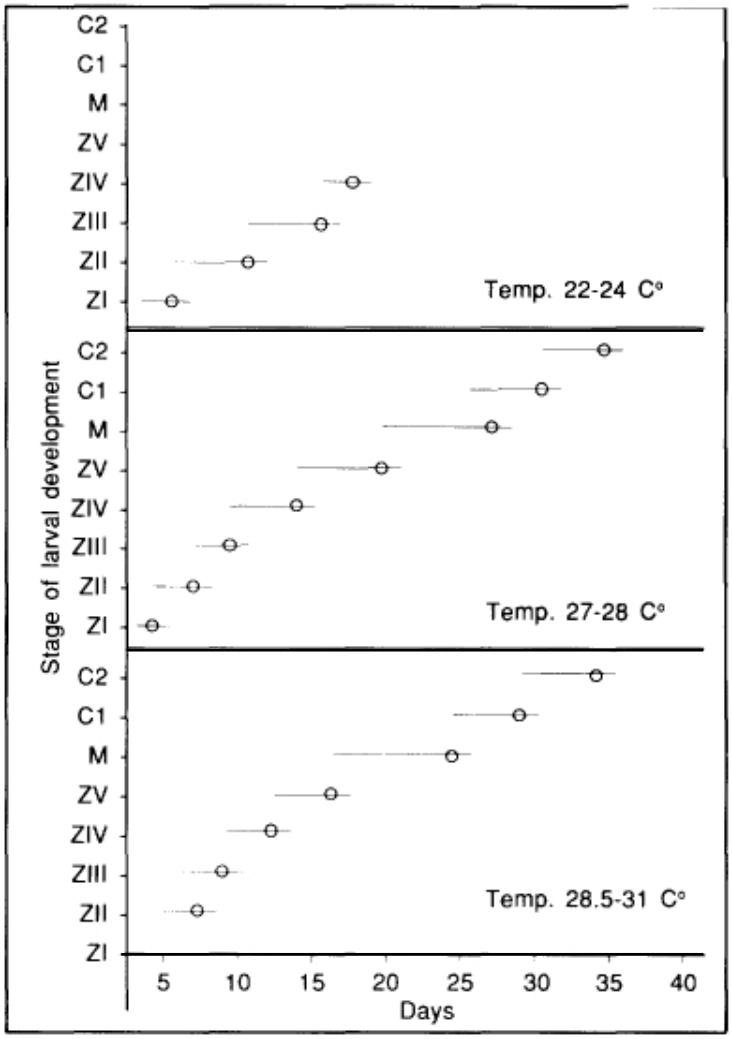


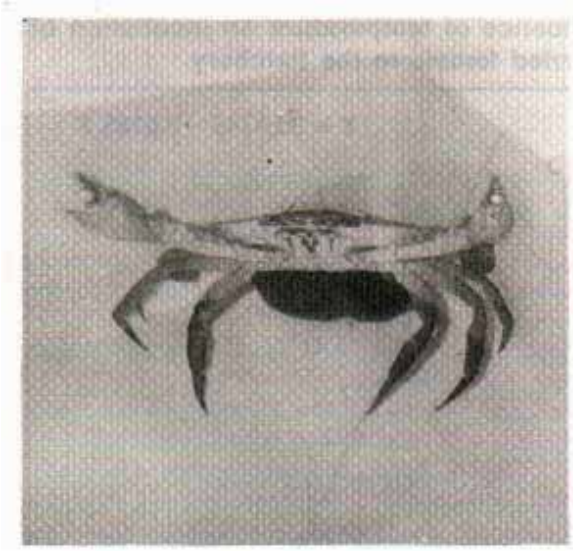
LARVAL DEVELOPMENT AND REARING

Marichamy and Rajapackiam (1984) have described the morphological features and development process of various stages of larvae. There were five zoea stages, each of duration 3-4 days, and a megalopa stage of 8-11 days in the complete larval development of S. *serrata* (Figure 2).

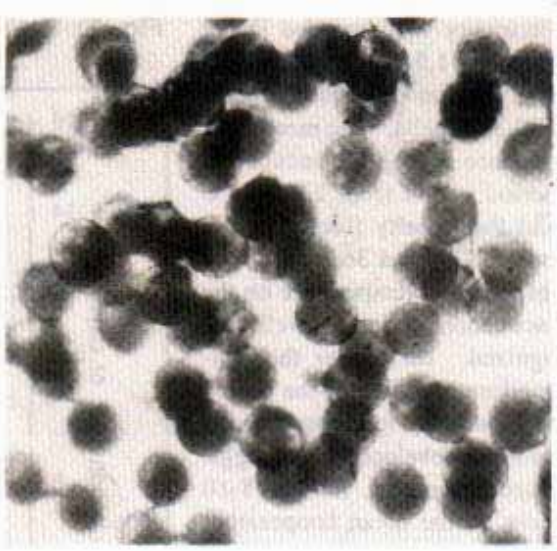
With subsequent metamorphosis, the first crab instar was obtained 26-31 days after hatching. Heavy mortality was recorded during the first, second and fifth zoea as well as in the megalopa stages. Bunches of nylon fibres were suspended in the rearing tank to serve as artificial weeds to which megalopa could cling. This arrangement increased the survival of megalopa to some extent. The first crab instar moulted into the second crab

Fig 2. Stages of larval development

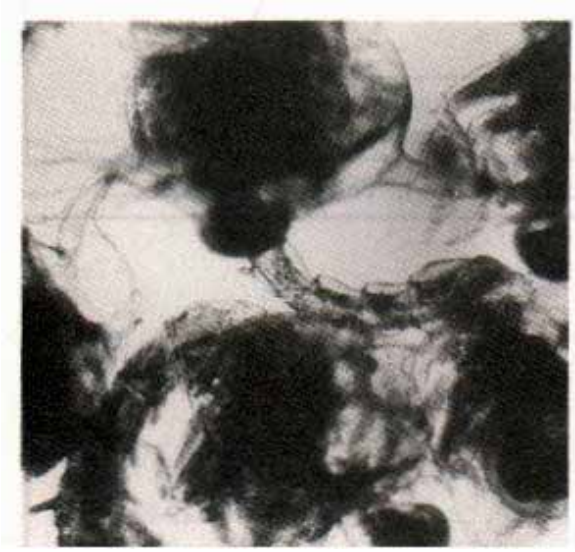




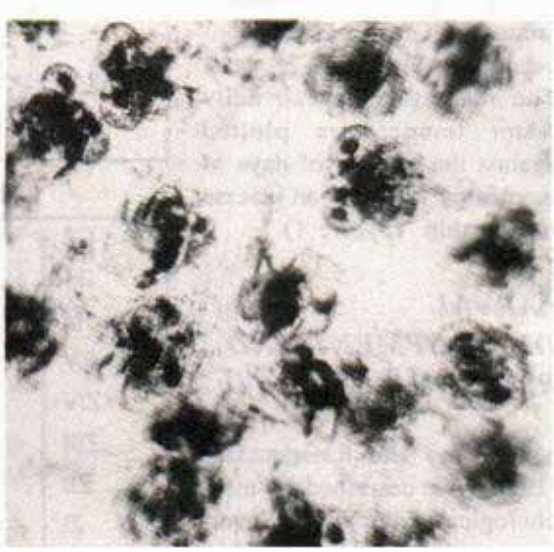
Berried Scylla serrata *in advanced stage of incubation*



Fully developed eggs with embryo



First zoea



Fifth *zoea*

Megalopa

Crab seed

Photographs taken during experiments on larval rearing and seed production of mud crab Scylla serrata *in Tuticorin, Tamil Nadu, India, by R. Marichamy and S. Rajapackiam of the CMFRI.*

in five days. After the seventh moult, the carapace appeared greenish-grey and the crab became henthic.

Rotifers. *Brachinonus plicatilis* at a density of 150—200/mi. developed in *Chiorella* culture medium, constituted the food for the first three zoeal stages. Newly hatched *Arternia* nauplii were added to the diet when the larvae reached Stage Ill. The larvae in the later stages were fed exclusively with the nauplii of *Artemia salina* at a concentration of 15/ml Both crab larvae and the *Artemia* are positively phototactic and this was utilized to concentrate them in a well-lighted rearing tank, improving feeding efficiency. Maccrated clam and shrimp meat, as well as live copepods. were given to megalopa. Frozen *Artemia* were also fed. Bits of bivalve and shrimp meat were supplied to young crab which crawled along the bottom of the tank.

The hatchery-produced seed were stocked in coastal ponds for further growth. In addition. SO seed were selected for stocking in individual containers, so that their growth could be followed under laboratory conditions (Table 2). The moulting behaviour and progress in growth was observed up to 15 months, by which time the crab had attained 88 mm CW /110 g weight. The moulting frequency was delayed as the crab grew. The rate of increment was higher in smaller crab.

Table 2: Trends of growth observed in hatchery produced crab seed

No.of crab instar	Min.no.of days frurn hatching	No.of specimen	No.of days from preceding instar Min.	Max	Mean	Size of crab seed (mm CW)	Average mouli increment (mm)	Average increment	Weight inc rement	Average inc rement (g)	Average percentage increment
I	24	50	-	-	7	3.5	-	-	0.004	-	-
2	27	50	-	-	3	5.2	1.7	48.6	0.022	0.018	-
3	31	48	3	4	4	7.5	2.3	44.2	0.062	0.040	-
4	37	46	5	7	6	9.9	2.4	32.0	0.123	0.061	98.4
5	45	43	7	-	8	12.8	3.!	31.3	0.257	0.134	-
6	54	40	9	10	9	16.1	3.3	25.8	0.527	0.270	-
7	66	41	11	3	2	20.0	3.9	24.2	1.022	0.495	94.0
8	78	36	11	4	12	25.0	5.0	25.0	2.000	0.978	95.7
9	92	37	13	15	4	31.2	6.2	24.8	3.950	1,950	97.5
10	107	34	13	16	15	38.0	6.5	20.8	7.800	3.850	97.5
11	127	32	14	22	20	45.0	7.0	18.4	13.850	6.050	77.6
12	155	30	9	33	28	53.0	8.0	17.8	2 .200	8.350	60.3
13	187	28	23	38	32	62.5	9.5	7.9	36.600	14.400	67.9
14	223	25	28	40	36	75.2	12.7	20.3	62.360	26.760	75.2
IS	265	23	38	46	42	88.0	3.8	18,4	110.200	47.840	76.7

EFFECT OF HYDROLOGICAL CONDITIONS ON GROWTH AND SURVIVAL

Temperature and salinity had a direct effect on the development of' larvae through metamorphosis. survival and production. A significant difference in the percentage survival of larval stock and growth can be seen in the experiments conducted in three different temperature regimes, ranging from 22-24°C to 28.5-3 1°C. Maximum production and fast growth, with an increased survival at each stage. was observed in Experiments 7 and 8 because of the higher temperature (28.5-31°C).

The crab stage appeared on the 26th day after hatching (Figure 3).

In the experiment conducted at 27-28°C, the intermoult period was prolonged and the survival rate was lower. Most metamorphosed to C 30 days after hatching. The larval rearing period was longer (35 days) with still less production at 25-26°C, as seen in Expt. 14 (Table 1). The role of temperature on the growth of larval stock can further be seen in the poor results of Expts. 11-13 carried out during the monsoon season. The water temperature ranged from 22 to 24°C. In these experiments, the survival of Z_1 to Z_4 gradually declined from 24 to 7 per cent. Moreover, it took more intermoult days and the stock was completely lost on the 17th day, without any further development or production. It would seem from this study that during cold weather, the temperature in rearing tanks would have to be raised and controlled to ensure a uniform production of crab seed.

The highest production of larval growth occurred at a mean salinity of 35 ppt in Expts. 7-9 and 15 (Table 1). In the rest of the experiments. survival was either poor or nil because of the lower salinity (32-33 ppt.). High salinity of about 36 ppt was also not suitable, as observed in Expts. 1-4. Generally, the survival of larvae varied in the different stages, although water quality appeared suitable (Figure 4). Unsuccessful moulting and cannibalistic behaviour of megalopa were major causes of poor survival.

Fig. 3. The influence of temperature on the survival of the larvae of *S.serrata*

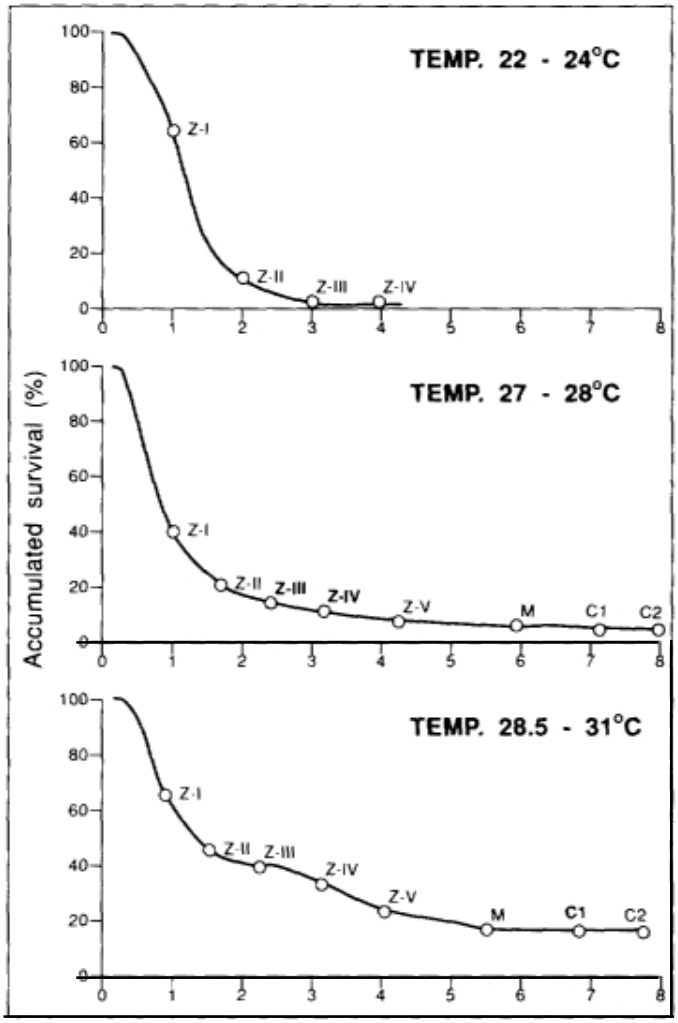
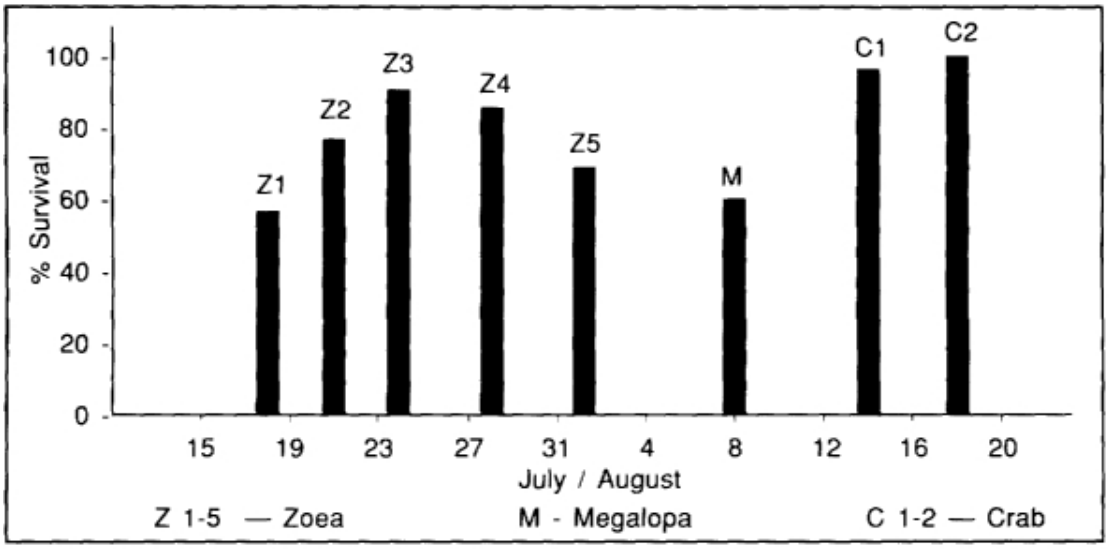


Fig 4. Survival of larval stock in each stage of growth



DISCUSSION

In the present study, a simple, inexpensive system has been designed and tested for mass rearing of mud crab larvae. The best survival level, 15 per cent, can be increased by improving the rearing tank structure using an upwelling system and maintaining the water temperature with thermostatically controlled heaters. Heasman and Fielder (1983) developed a system for thorough and continuous mixing of water in the rearing tank and achieved survival up to 30 per cent by increasing the feed concentration. Brick (1974) obtained a maximum larval survival rate of 41 per cent by adding Chlorella and antibiotics to culture media, thereby minimizing bacterial infection.

Japanese workers have perfected a reliable technique for large scale commercial production of the blue swimming crab, Portunus trituberculatus, but achieved only a 6 per cent survival rate with mud crab larvae. Scientists from the National Taiwan University observed a maximum production of 60 per cent of mud crab seed by rearing the larvae in water treated with sand filter, UV light and antibiotics. Their success has also been due to a variety of nutritive supplementary live feads, such as sea hare veligers, copepods, rotifers and Artemia nauplii, given to the larvae at different stages. In the present study, the early stages were fed with *Artemia* nauplii and copepods. Brick (1974) found better results with Artemia nauplii alone.

Ong (1964, 1966) maintained zoea at a mean temperature of 27.5°C. and salinity at 31 ±2ppt. DuPlessis (1971) did so at 24°C, Brick (1974) at 22°C and salinity in the range 33.0-34.5 ppt, and Heasman and Fielder (1983) at 27°C and 30 ± 2 ppt salinity. All of them reared megalopa larvae in a reduced salinity range of 26-28 ppt, as the post-larval stages are expected to have greater tolerance to reduced salinity and high temperature. This is reflected in the higher survival rate of later zoeal stages.

The present study indicates that the most suitable range of temperature for crab larvae, including the megalopa stage, is 28-31°C and salinity of around 35 ppt. It is significant to note that even though the salinity was maintained at the same rate, the duration of megalopa instars was only 7-9 days in a few experiments. However, an accelerated rate of growth and survival was noticed in trials made to rear megalopa in reduced salinity levels, of 27 ppt. The larvae of Syclla serrata from tropical areas may tolerate high temperatures and salinity more than those from other regions.

The success of shrimp farming, including the advance made in hatcheries, is largely due to the availability of technology in larval nutrition and micro-encapsulated diets. These new techniques should be applied in rearing the larvae of the mud crab, so that crab culture will become as practicable and profitable as shrimp culture.

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PRELIMINARY STUDIES ON REARING THE LARVAE OF THE MUD CRAB *(Scylla serrata)* IN MALAYSIA

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ABSTRACT

Larval rearing of the mud crab Scylla serrata was carried out in the NAPFRE hatchery. The developmental period from Z, C, took 25-28 days Feeding the larvae with Branchionus sp. ***and frozen*** Artemia *nauplii during the zoea stages gave a better survival rate than feeding* with live Artemia nauplii alone. broodstock of 350-520 g gave 800,000 - 2.0 million Z, *larvae. The hatching rate was close to 100 per cent. Feeding regimes are described in detail. A survival rate of up to 20 per cent has been obtained from Z, to C,.*

INTRODUCTION

Aquaculture production in Malaysia has increased significantly during the last decade. The main production, which includes cockle, tiger shrimp and fish, comes from brackishwaters. Technical advances and the overcoming of several constraints have been the reasons for the growth of aquaculture in Malaysia. However, a major problem has been the lack of seed supply for most of the cultured species. In the late Eighties, there were considerable advances in breeding technology for all important culture species, including tiger shrimp, sea bass and the giant freshwater prawn (Choo 1983; A1i *et al* 1985; Yaakob 1988; Zainoddin, in press). Artificial propagation of several other species is still not well developed.

Crab fattening is carried out in Malaysia in a limited way, using either ponds or cages (Abu Seman, 1983: Abdul Manan, 1979). The principal constraint in the expansion of this activity is lack of seed or stockable crab. Crab collected from the wild vary in size, age and with the seasons. Imported crab seed also fluctuates in price. This hinders the development of large-scale crab culture, although there is sufficient market demand. In an attempt to solve the seed supply problem, the Malaysian Department of Fisheries recently began experiments on larval rearing of crab. The main objectives of this effort were the improvement of hatchery technology and the large-scale production of crab. Crab larval rearing was initiated at the Fisheries Research Institute, Department of Fisheries, Malaysia in Glugor, Penang, where the successful larval and post-larval culture of *Scylla serrata* was carried out in the early 60s (Ong, 1964). This paper reports the results obtained from crab larviculture conducted at the Department of Fisheries, National Prawn Fry Production and Research Centre, in Kampung Pulau Sayak, Kedah.

MATERIALS AND METHODS

Hatchery design

A variety of tanks are used for larval rearing. Two types used by NAPFRE were: circular tanks with conical bottoms (2 t capacity) and those with a slope (10 t capacity). Both types were located indoors under transparent roofs.

Sea water supply and water quality

Sea water was pumped from the end of a 100 m jetty perpendicular to a muddy beach. The water was passed through a sand filter after settling overnight in receiver and sedimentation tanks. After

passing through the sand filters, the water, now with reduced suspended materials, was pumped into gravity tanks, from where it flowed by gravity into the hatchery. The water quality parameters at the NAPFRE hatchery were :

Salinity	:	29 to 32 ppt
ph		8.0 8.7
D.O.		> 8.0 ppm
Temperature	:	28.5 - 32°C

Broodstock selection

Berried females of Scylla serrata were bought from gillnet fishermen whose fishing area was 5 - 6 n miles from the mainland. Only berried females with yellow and grey eggs were bought: broodstock with incomplete appendages were rejected.

The females with yellow eggs were kept in holding tanks with a stocking density of 10 pcs./10 t of water. Normally, the eggs of the berried females mature in 5 - 7 days. Some regressed after a few days, probably due to stress during transportation and handling. Squid was given twice daily as food.

The brookstock with grey eggs were transferred either to hatching tanks or direct to the rearing tanks, depending on the size of broodstock and the tank capacity used.

Hatching took place at 10 pm or between 5 and 8 am. The hatching time for Scylla serrata has been reported as between 7 and 8 am at 23°C and between 5 and 6 am at 27°C (Cowan 1984). The hatching rate was close to 100 per cent. This is similar to Portunus trituberculatus (Cowan 1984). During hatching, females were noticed swimming with legs twisted and their abdomens jerking up and down. This jerking action was presumably to disperse newly-hatched larvae.

The berried females of Scylla serrata (350 - 520 g) gave between 800,000 and 2,000,000 Z_1, while those of lesser weight (100 - 150 g) gave about 700,000 1,000,000 Z_1. Broodstock of 200 - 250 g can produce 800,000 - 1,500,000 Z_1 (Cowan 1984).

Larviculture

After hatching, the number of larvae was estimated and the larvae were transferred to rearing tanks. The stocking density ranged from 20-30/l. The diatom Skeletonema costatum was introduced in the rearing tanks at the rate of 5,000 - 8.000 cells/ml. Alternatively, Isochrysis sp. could also be used at the same rate. Isochrysis sp. has been used in the culture of P. trituberculatus (JASFFA, 1981). Larvae in the early zoeal stage fed with mixed diafoms have shown good survival, but do not moult (Simon 1974). However, development of the zoea stage can be accelerated when the larvae arc fed with mixed diatoms and rotifer (Branchionus sp). Ting (1980) used rotifer, *Chlorella* sp., *Spirulina* and *Artemia* nauplii as feed.

Larvae were fed twice daily, in the morning and afternoon. Feeding began four hours after newly hatched larvae were stocked in the rearing tanks. From Z_2 onwards. *Artemia* was fed exclusively in the afternoon (Table 1) Upon reaching the megalopa stage, two-day old *Artemia* nauplii, supplemented with artificial feed, were used When live rotifers were insufficient, frozen rotifers were used and supplemented with artificial feed during the zoeal stages. In the NAPFRE hatchery it was found that larviculture with Skeletonema costatum or Isochrysis sp. given in the early stages gave a better survival rate than those without microalgae. Simon 1974 found that feeding with *Artemiu* nauplii at more than 10/ml improved survival. From Z_2 - Z_4 frozen *Artemia* nauplii were used because live animals were more difficult for the zoea to catch; Artemia nauplii are active swimmers and move faster than the zoea themselves, especially during the early zoea stage.

Table 1: Feeding regime practices in NAPFRE hatchery

Larval stages	Morning *(pcs/ml)*	*Afternoon (pcs/larvae)*	*Supplement* (g/ml)
Z_1	Rotifer 5-10	Rotifer 5-10/ml	Artifical feed. 3[a]
Z_2	Rotifer 5-10	Frozen Artemia 6	" 5[a]
Z_3	Rotifer 10-15	Frozen Artemia 10	" 7[a]
Z_4	Rotifer 20-30	Frozen Artemia 15	" 9[a]
Z_5	Frozen Artemia 10	Frozen Artemia 20	" 12[a]
M	2 days Artemia 10	2 days Artemia 40	" 15[a]
C	2 days Artemia 10	2 days Artemia>40m	" 15-20[b]

Note: a = BMC (feed for shrimp larvae imported from Japan).
Protein = 49%. fat = 31%, ash = 5.5% and moisture = 4.3 %
b = SUTIMAL (feed for giant freshwater prawn)
Protein = 55%. fat = 8%, ash = 7% and moisture = 5.5 %.
Z = zoea stage M = megalopa stage C = crab stage

The **number** of rotifers refers to the quantity of live Branchionus sp. given per ml of water in the culture tank. When the supply of live animals was inadequate, frozen rotifers were used as a supplement. The number of *Artemia* nauplii refers to the number of *Artemia* nauplii given to each crab larvae. The amount of artificial feed is the weight of feed given per million crab larvae.

Medication

Treflan at 0.7 to 10 ppm was added to control fungal growth. No other chemical was used.

RESULT AND DISCUSSION

Scylla serrata has five zoeal stages and one megalopa stage before metamorphosing into the first crab. It takes about 25 - 28 days to pass from the zoea through the megalopa to the first crab (C,) at 28°C - 30°C. with salinity at 25-30 ppt. Exposure to salinity below 17 ppt resulted in death, therefore zoea are not adaptable to estuarine regions (Brick 1974; Hill 1974; and Ong 1964). Dominisac and Dejasme (1974) found that the time needed from Z, to megalopa stage was 16 days and from megalopa to first crab stage another 8 days. In the NAPFRE hatchery, each substage of zoea took 2 - 4 days before moulting into the next substage. But in the megalopa, moulting occurred several times before the crab stage was reached. It is therefore suspected that there might be more than one substage in megalopa, but this is yet to be verified. The details of larval development are provided in Table 2.

Table 2: Days of interval metamorphose of crab larvae

Days	**1**	**5**	**10**	**15**	**20**	**25**	**30**		
Stages									
Z_1								Day	**(3 - 4)**
Z_2		——						"	**(4 - 8)**
Z_3								"	**(7 - 12)**
Z_4				——				"	**(10-16)**
Z_5					——			"	**(15-20)**
M					——	——		"	**(18 25)**
C								"	**(25-28)**

Note: Z = zoea stage: M = megalopa stage; C = crab stage

Survival and speed of development from Z_1 to C_1 were maximum at 27°C and when fed with ***Artemia*** nauplii at 30/ml (Heasman and Fielder 1987). Mortality was high (50 - 70%) between Z_1 and Z_3 stages. Sudden death occurred due to the inability of the larvae to moult. Zoea were killed occasionally by chitin-destroying bacteria attacking the carapace spine (Ting et ***al. 1981*).** The survival rate was high from Z_3 to megalopa stage (mortality: 10 - 20%). But from megalopa to first crab, cannibalism became serious and resulted in a significant drop in the population. Larvae that survived up to 19 days usually reached the megalopa stage. However, only a few metamorphosed into C_1. Megalopa have reportedly been observed attacking newly metamorphosed crab (Anonymous 1975). Also, the later metamorphosing crab are usually attacked by the earlier ones. In ***Portunus trituberculatus,*** the crab attack the megalopa. If a big percentage of megalopa metamorphose to the C_1 stage simultaneously, then cannibalism is likely to be reduced. The quality of newly-hatched larvae is also an important factor in determining the success of larviculture.

Feeding with rotifer and frozen ***Artemiu*** nauplii from Z_1 - Z_4 has shown better results compared to feeding with frozen ***Artemia*** nauplii alone. A combination of rotifers and frozen ***Artemia*** nauplii from Z_1 - Z_5 and 2-day-old ***Artemia*** nauplii for megalopa-crab stage gave better results. Rotifers are a good source of live feed for the early stages, but their culture is time-consuming and labour-intensive.

Live 2-day old ***Artemia*** nauplii were given from megalopa stage onwards because of their bigger size. Out of a total of 27 trials, 19 batches successfully produced C_1 and eight batches were abandoned due to mass mortality during the Z_2 to Z_4 stages as a result of unsuccessful moulting (Table 3).

Table 3: Summarized results of crab larval rearing

Culture number	Water volume (m ton)	Density travelll	Iso.[1] (/ml)	Skeleto..[2] (Iml)	Rotifer	Artemia nauplii	Formulated feed	Survival rate	Total Cl[3]	Crab per litre	Remarks
1	2	20	5,000		/	/		7.0	2,800	I	
2	2	20	5,000		/	/		5.5	2,200	I	
3	2	30		5,000	/	/		0.9	540	0	
4	2	30	5,000		/	/		6.0	3,600	2	
5	2	20	5,000		/	/		2.4	960	0	
6	10	20		5,000	/	/	/	0.0	0	0	died at Z
7	10	20	5,000		/	/	/	0.0	0	0	died atZ₂
8	10	20	5,000		/	/	/	0.0	0	0	died atZ₂
9	2	30	5,000		/	/	/	3.5	2.100	I	
10	2	30		5,000	/	/	/	2.0	I.200	I	
11	2	30	5,000		/	/	/	12.0	7,200	4	
12	2	30	5,000		/	/	/	4.0	2,400	1	
13	2	20	5,000		/	/	/	0.0	0	0	died at Z
14	2	20	5,000		/	/		0.0	0	0	died atZ₂
15	2	20	5,000		/	/		0.0	0	0	died at Z_3
16	2	20		5,000	/	/		3.5	1,400		
17	2	20	5,000		/	/		21.0	8,400	4	
18	10	20	5,000		/	/		4.0	8,000	I	
19	10	30	5,000		/	/		2.0	6,000		
20	10	20	5,000		/	/		0.0	0	0	died atZ₂
21	2	20	5,000		/	/		15.0	6,000	3	
22	2	20	5,000		/	/		2.5	1,000	1	
23	2	20	5,000		/	/		6.0	2,400	1	
24	2	30	5,000		/	/		6.8	4,080	2	
25	2	30	5,000		/	/		4.0	2,400	1	
26	10	20	5,000		/	/		0.0	0	0	died at Z
27	2	30	5,000		/	/		12.0	7,200	4	

[1] *Iso.* = *Isochrysis sp.* *2Skelet.* = *Skeletonema sp.* Cl = crab stage

Artificial shrimp or prawn feeds can be given as a supplement when there is a shortage of rotifers. From these experiments it appeared that when supplementary feed was given, the amount of rotifers could be reduced. Two types of artificial feeds are used in NAPFRE — BMC and SUTIMAL. BMC is from Japan and SUTIMAL is an artificial feed produced in NAPFRE for giant freshwater prawn larvae (Zainoddin and Yaakob, 1989). BMC of the size 50 to 100 µm was used from Z_1 to Z_2 and SUTIMAL, 150 µm to 300 µm was used from Z_3 to C_1. Frozen *Artemia* nauplii were given in the early stages because the zoea apparently could not catch the actively swimming *Artemia* nauplii. Excess of uneaten live *Arremia* nauplii in the tanks affect the water quality.

The high cannibalism during the C_1 stage and onwards is again a constraint in the nursery. Cannibalism can be as high as 60 per cent within a few days at a stocking density of 10 pcs/litre. Cannibalism continued even when enough food was provided. It may be reduced by lowering the stocking density to 5 pcs/litre. To reduce high mortality caused by cannibalism, direct stocking from hatchery to the pond is recommended.

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