An Introduction to the Rearing Methods of Prawn, Penaeus japonicus BATE, in Japan

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An Introduction to the Rearing Methods of Prawn, *Penaeus japonicus* BATE, in Japan

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Abstract

The rearing methods of prawn, *Penaeus japonicus* BATE, are briefly introduced, including a general aspect of larval metamorphosis.

In Japan, three culture methods have been basically practiced; 1) monoculture, 2) muli-species culture, and 3) ecosystem culture. A monoculture method requires two tanks, one to grow the algae and another one to rear the larvae. In this method, the food is directly supplied to the zoeal larvae. In multispecies culture, only one tank is necessary because the algae are grown in the rearing tank by inorganic nutrients which are supplied at the beginning of nauplius stage. On the contrary, organic nutrients like a soy-cake particles are provided to grow both zoea and algae in the ecosystem culture. Special caution was taken to provide strong aeration with a movable aerator for cleaning the bottom and for promoting the energy flow by the oxidation process.

In 1969, the ecosystem culture tank, 2,500 m^3 water-volume with the movable aerator, was designed at the Shibushi Station, Seto Inland Sea Farming Fisheries Association. A survival rate of up to 90% from nauplii-1 to postlarva-15 (days old) was obtained by this method. An average yield of the tank was about 22,000,000 juveniles at a time in 1975.

Introduction

The rearing of the prawn, *Penaeus japonicus* BATE, was initiated in 1938 by the late Dr. HUDINAGA. The method prevailed and has been improved (HUDINAGA and KITTAKA, 1966; 1967; HUDINAGA and MIYAMURA, 1962). With the growing need of mass seed, more efficient rearing methods were found (FURUKAWA, 1972; HIRATA, MORI and WATANABE, 1975). These methods are being discussed in this paper all the more because the technique have been improved year by year. The author shall also give a brief synopsis of the metamorphosis in the larval stage after HUDINAGA (1942), MATSUNAGA (1973) and MIYAMURA (1965).

1. General Aspects of the Development

1–1. *Spawning season*

The spawning seasons of the prawn, *P. japonicus,* is from the end of March to the beginning of October in Kyusyu, Southern Japan, and from the end of April to the middle of October in Eastern Seto Inland Sea and Central Japan. The main season is from July to August in both areas, but sometimes extends up to May in the

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Southern Japan. A gravid female, 50–120 g in body weight, release 300,000–700,000 eggs at once between 9 p.m. and midnight in the spring. As the spawning season progresses, the release of the eggs occurs gradually later until 4 or 5 a.m. in October. The average size of an egg is about 0.25 mm.

1–2. *Hatching*

Number of fresh-hatching nauplii is 50,000–500,000 larvae per female depending on mother size and spawning season. In general, larger females are obtained during earlier season.

Hatching of the eggs occurs 16 hours after spawning at an optimum temperature of 25–27°C. The hatching periods depend on the temperature and varies from 13 hours at 28°C to 20 hours at 22°C. The upper and lower temperature limits are considered to be 32 and 20°C, respectively. The salinity may vary from 30 to 35‰. A dissolved oxygen-content of 5–7 ppm is optimum, although the tolerable range is 3–10 ppm.

1–3. *Development of larvae*

1–3–1. *Nauplii stages*

The nauplii molts six times and is referred to as six substages (N1–N6) (HUDINAGA, 1942). The time to reach the zoea stage depends on the temperature and ranges from 36 to 48 hours for 28 and 23°C, respectively. It grows from 0.3 mm at N1 to 0.5 mm at N6. It feeds itself on its own yolk and presents a planktonic life. After the nauplii has sunk 2 or 3 cm with standing still, it jumps up again. It seems to prefer the surface layer of the water in the tank.

1–3–2. *Zoea stage*

The span of the three zoea stages (Z1–Z3) depend more on the feeding as on the temperature and last for four to six days at 25–27°C. The sizes are as follows: Z1–0.8 mm, Z2–1.4 mm and Z3–2.2 mm (MIYAMURA, 1965). The larval zoea is herbivoric, and feeds on diatoms, yeasts, suspended humus, bacterial flocks, etc. (FURUKAWA, 1972; HIRATA, MORI and WATANABE, 1975; IMAMURA and SUGITA, 1972).

The animal swims horizontally straight ahead. By its movements, one can easily distinguished the zoea stage from the nauplii or the following mysis stage.

1–3–3. *Mysis stage*

Again, there are three stages (M1–M3). Its growth depends on food and temperature and is as follows: M1–2.9 mm, M2–3.6 mm and M3–4.3 mm (MIYAMURA, 1965). The span of mysis stage is about 3 days at 28°C. The animal is now omnivoric. Marine rotifer (*Brachionus plicatilis*) and brine shrimp (*Artemia salina*) are preferable foods as an additional one after diatoms feeding.

For the first time, the animal moves backwards. From stage M1 to M3, the number of forward movements gradually decrease.

1–3–4. *Postlarval stage*

The molting period of the postlarva increase with respect to time. Since the behaviour from one molting stage to another is not radically different, the age of the postlarva is usually referred to the number of days old. For instance, P1 indicates

one day old postlarva, etc.

The postlarva feeds on *Artemia* nauplii and minced frozen shrimp or short-necked clam in culture. The larva develops from 5 mm at P1 to 12 or 15 mm at P15. And no circardian rhythm in feeding activity is found at this stage. Animal is transferred from the hatching tank to a nursery pond when it grows up to 16 or 18 mm in body length.

2. Food and Media

2–1. *Monoculture*

The monoculture method was developed by HUDINAGA (1942) and HUDINAGA and MIYAMURA (1962). This method requires two tanks, one to grow the algae and another one to rear the larvae. The food is directly supplied to the larvae. A pure-culture method is carried out for algal growth. Excess nutrient resources, particularly feces, are removed out by water changing.

2–2. *Multispecies culture*

Only one tank is necessary for multispecies culture, because the alga is grown in the rearing tank. Inorganic nutrients such as KNO_3 and KH_2PO_4 are usually used at the beginning of nauplii stage. The alga grows up at the time around occurring of metamorphosis from nauplii to zoea stage. Then, a herbivorous zoea can feed on the algae. The rearing water is partly changed after mysis stage, since the floor of the tank is polluted by the feces, etc.

An idea of ecological succession is based on this method. The techniques are well established by HUDINAGA and KITTAKA (1966; 1967), and have been prevailed now in Japan.

2–3. *Ecosystem culture*

When the biodepositions are accumulated on the floor of the rearing tank, an ecological energy does not flow well. An attempt of "triple player" (HIRATA, 1964) was tried at a rate to keep the three ecological dimensions; plants, animals and decomposers, as much stable as possible. In order to realize such a stabilized water, three trials; 1) large scale hatchery (HIRATA and WADA, 1969), 2) movable aerator system (HIRATA, 1968) and 3) laboratory stream system (ODUM, 1956) were constructed at the Shibushi Station, Seto Inland Sea Farming Fisheries Association. Following these trials, a 2,500 m^3 prawn hatchery (4 m in depth) with attachments of movable aerators (blowing 18 m^3 per min.) and laboratory stream unit (450 m in length) was designed by the author and has been built during 1968 to 1970 at the Station (HIRATA, 1972; KUREHA and NAKANISHI, 1972). After this movable aerator was deviced, a gearing agitator was also tried at the Tamano Station (AKAZAWA, 1973).

Instead of taking off the biodepositions, they are re-cycled by the oxidation. As shown in Fig. 1, moving pipes of the aerators supply a strong air directly to the bottom and thus prevent the deposition of particles. A relative highly dissolved oxygen-content of 4–7 ppm ensure the oxidation which is obtained from an air supply of

0.5–1.0% of the water volume per minute. Laboratory stream system, however, is still under experimentation.

Presently, this method is as follows: To induce diatom growth particularly of

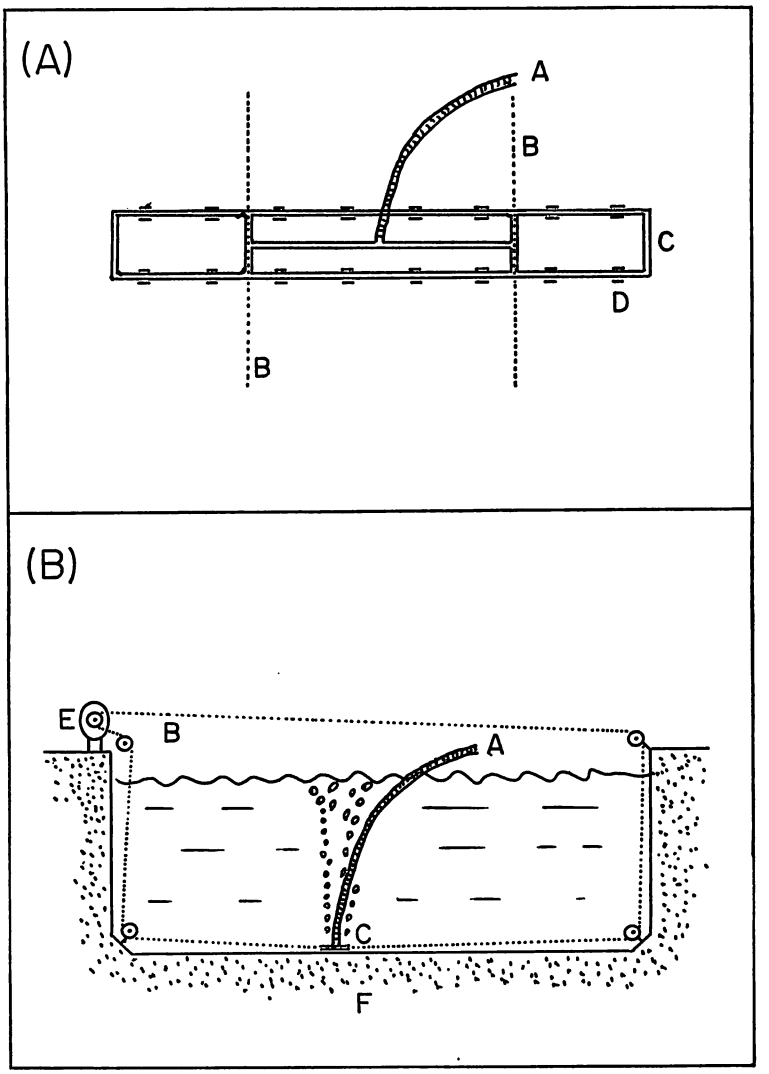

Fig. 1. Schematic views of a movable aerator. The figures (A) and (B) show a plane figure of air bubbling pipe and a cross section of the rearing tank set with the movable aerator, respectively. Each lettering in the figures shows main parts of the construction as follows: **A**; flexible hose for air supplying, **B**; stainless wire, **C**; air bubbling pipe (13mm in diameter) set up a number of air noses at a bottom side, **D**; china fishing-rope-sinker likewise wheel, **E**; reduction motor, and **F**; rearing tank. The air bubbling pipe **C** is shuttled automatically between one corner and the other with a driving speed of 1 m per minute by reduction motor **E**.

Table 1. An example of daily feeding.[1)]

Stage	Substage	Age (days)	Feeding (per day)
Nauplius	N1–4	0–1	no feeding
	N5–6	1–2	1 g S. C.[2)]
Zoea	Z1	3–4	1 g S. C.+0.1 g baking yeast[2)]
	Z2	5–6	1 g S. C.+0.5 g baking yeast
	Z3	7–8	1 g S. C.+500 marine rotifer[3)]
Mysis	M1	9–10	1 g S. C.+50 brine shrimp[3)]
	M2	11–12	1 g S. C.+100 brine shrimp
	M3	13–14	1 g S. C.+150 brine shrimp
Postlarvae	P1	15	150% larval B. W. of neck clam[4)]+100 brine shrimp
	P2	16	150% larval B. W. of neck clam+50 brine shrimp
	P3–5	17–19	100% larval B. W. of neck clam and frozen shrimp[5)]
	P6–10	20–24	80% larval B. W. of neck clam and frozen shrimp
	P11–20	25–34	80% larval B. W. of neck clam and frozen shrimp
	P21–	35–	60% larval B. W. of neck clam and frozen shrimp

1) temperature, 20–25°C; salinity, 30–35%; pH, 7.8–8.4; dissolved oxygen, 5–7 ppm.
2) S. C. (soy cake) and baking yeast per 10,000 larvae
3) marine rotifer and brine shrimp per larva
4) neck clam meat minced
5) weight ratio of neck clam and frozen shrimp is 2: 1.

Chaetoceros spp., *Skeletonema costatum* and *Nitzschia* spp., an average of 1.6 g soy cake per 10,000 larvae is supplied daily from the end of nauplius stage (HIRATA, MORI and WATANABE, 1975). As for any food supply, it is spread over 5 equal feedings during day and evening starting at 7 a.m. From the third zoea stage on, additional feeding of *Brachionus* and *Artemia* nauplii becomes necessary. This additional feed is gradually changed at the postlarval stage to minced frozen shrimps and neckedclam meat or artificial diet (DESHIMARU and SHIGENO, 1973). If the diatom population increases more than 500,000 cells per ml, the water is changed to maintain a population of about 100,000 cells per ml (KANDA, Unpublished). The feeding schedules are presented in Table 1.

Conclusion

Using the 2,500 m^3 hatching tank, a survival rate of up to 90% from N1 to P17 is obtained in 1975 while it was only about 30% in 1971. Average yields in the tank at a time were 10×10^6 juveniles in 1971 and 22×10^6 juveniles in 1975, respectively. The production cost of 1,000 juveniles in 1971 and 1975 was estimated roughly to be 2 U.S. Dollar. (An inflation rate was more than 40% during those four years). These results are few examples to show how successful the methods were.

The methods practiced, however, were not perfect ecosystem cultures. These were adulterated community culture with monoculture, due to conspicuous lack of cooperation with the laboratory stream. The rearing methods of the prawn will be more improved when an idea of microcosm is introduced to the rearing studies.

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