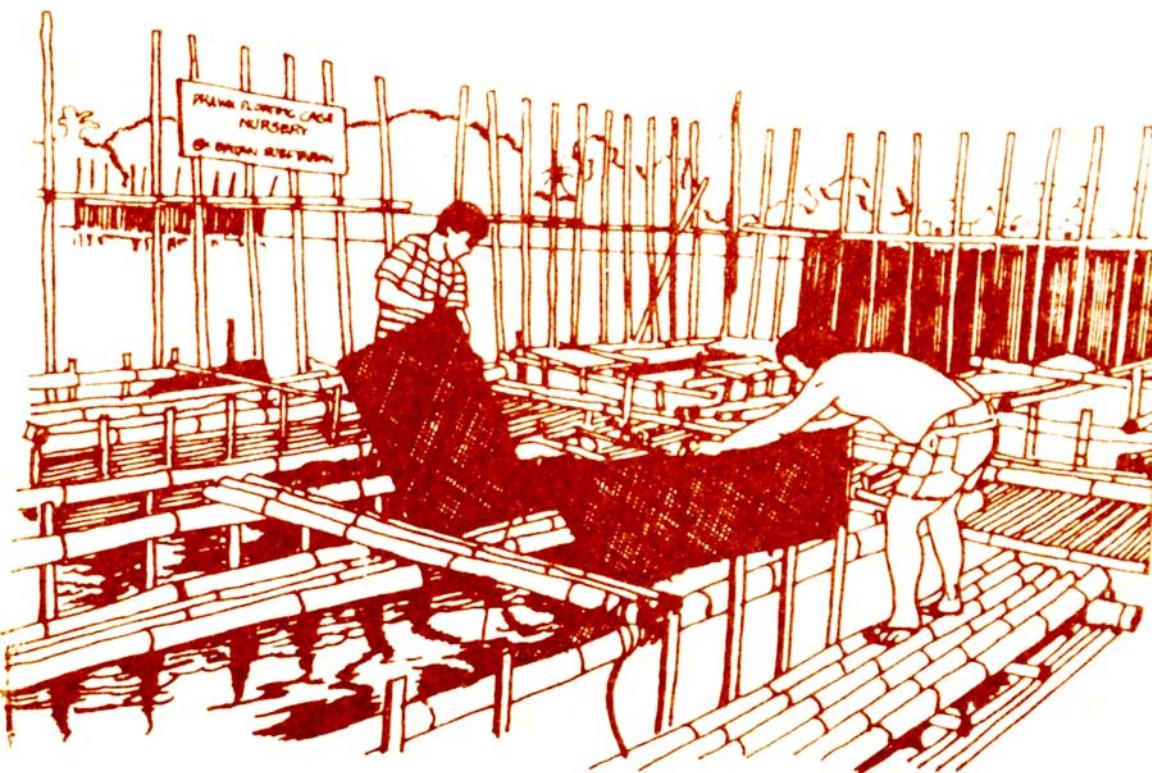


FLOATING CAGE NURSERY FOR TIGER PRAWN

D.T. de la Peña Jr., O.Q. Prospero and A.T.G. Young



AQUACULTURE DEPARTMENT
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines

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PREFACE

This Aquaculture Technology module is a result of pioneering research on postlarval rearing of *P. monodon* conducted at the Batan Substation of the SEAFDEC Aquaculture Department. The module has been pre-tested among prawn operators from Capiz, Aklan, Iloilo, Cebu, Davao del Sur, Davao City and Surigao del Sur.

The floating cage nursery for tiger prawn has been demonstrated to be superior to land-based nursery tanks. The floating cages are cheaper to construct using primarily available local materials such as bamboo and wood. It is also easier to manage and operational costs are significantly reduced by eliminating aeration and pumping, not to mention reduced feeding requirements. Higher stocking densities are obtainable with this system at 10,000 PL₈/ton. It has also been shown that survival rates are higher and juveniles are stronger than those raised in tanks. Harvesting efficiency is also increased as all one has to do is lift the nets and transport preparation is made easier since water is taken directly from the nursery area. However, it must be emphasized that in the choice of a culture site, the selection criteria mentioned in this module should be followed.

For the over-zealous beginner in fishfarming who tends to overfeed his postlarvae, the floating cage has a decided advantage of avoiding the resultant pollution caused by decaying feeds.

The floating cage nursery system for sugpo should contribute greatly to augmenting the supply of prawn postlarvae as more operators adopt the technology.

ANTONIO ORTIZ, LL.B.
President
Capiz Fishpond Owners Association
December 1985, Roxas City

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FLOATING CAGE NURSERY FOR TIGER PRAWN

INTRODUCTION

The availability of fry is an important factor to consider in most aquaculture ventures. In the prawn industry, the presence of sufficient seed can trigger intensified pond culture and increase production of marketable size prawns particularly the tiger prawn, *Penaeus monodon*, locally known as *sugpo*, (Tagalog), *lukon* (Hiligaynon) or *pansat* (Cebuano). This need partly led to the establishment of numerous prawn hatcheries in various parts of the Philippines where prawn culture is a growing industry.

Earlier attempts to stock young *sugpo* postlarvae (PL₅ or 5-day old postlarvae, approximately 14-15 days after hatching) from the hatchery directly in ponds were generally not successful. Inadequate pond preparation associated with ponds originally intended for milkfish culture yielded poor results. Considering the need for bigger and healthier post-larvae for pond stocking, a nursery has been integrated into the hatchery complex.

At present, nursery or postlarval rearing of *sugpo* is popularly done in hatchery tanks where fry are reared for about two weeks or until they become juveniles. The juvenile stage begins at 30 days old from the postlarval stage when the prawns are the size of a matchstick with the minimum weight of 0.1 gm.

A recent development is the use of floating cages installed in protected inshore waters like bays and coves. This can be operated independently or as an integral part of the hatchery. Promising results of studies conducted in 1983 and 1984 at SEAFDEC AQD Batan Substation can be potentially adopted in other similar areas.

Rationale

A floating cage nursery has the following advantages:

- it allows high stocking density;
- assures high survival of postlarvae;
- easy to manage;
- minimizes water fouling due to excess feeds;
- eliminates the need for pumping and aeration systems; and
- low capital and operating costs.

One consideration in using this nursery system is its site specificity. Some fishpond operators in Northern Panay, Philippines, however, have tried setting up and operating nursery floating cage net enclosures inside their ponds and have reported significant success.

Objectives

This AQUACULTURE TECHNOLOGY module will serve as a guide in applying the techniques of operating a nursery floating cage for tiger prawn or *sugpo*. After going through this module, you should be able to:

- Select a suitable site for floating cage nursery for *sugpo*
- Design, construct and install a floating cage nursery
- Operate and manage the nursery.

SITE SELECTION

A good site for a prawn hatchery may not necessarily be suitable for a floating nursery cage. Whether you construct your floating nursery cage to be integrated with the hatchery in the same site or set it up independently, consider the following:

1. Protection from Natural Hazards

Protected areas like bays and coves are ideal sites for floating nursery cages (Fig. 1). They should be sheltered from strong winds, waves and drift wood which can destroy the cages.

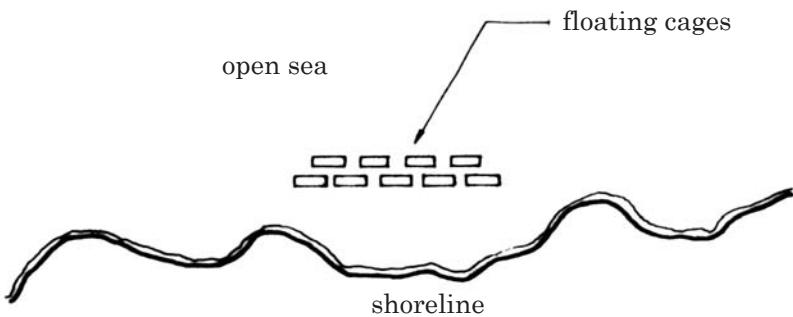
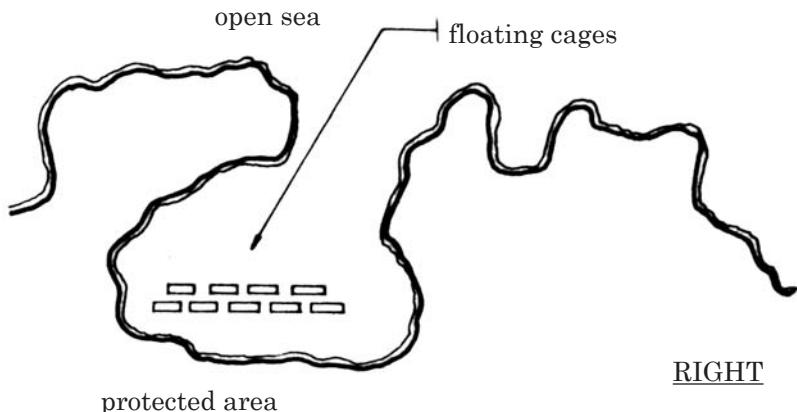


Fig. 1. Floating nursery cages should be properly located.

2. Water Quality

The site should be far from freshwater tributaries to avoid wide salinity fluctuations. It should also be free from domestic, agricultural and industrial wastes. Turbid water is one indication of a poor site.

3. Water Current

The site should have moderate water current to allow sufficient water exchange inside the cages.

4. Supply of Postlarvae

There should be a reliable source of postlarvae (PL_8 - PL_{10}) if the cages are operated independently. The site should preferably be near prawn hatcheries to reduce transport costs and mortality of postlarvae in transit.

5. Proximity to Market

Harvested postlarvae (PL_{20} or older) should have a ready and accessible market. Short transport duration from 1 to 3 hours is advisable to reduce mortality.

DESIGN AND CONSTRUCTION OF A FLOATING CAGE

The size of the cage varies depending on the number of postlarvae that can be obtained from the wild or from the hatchery. A 10 m^3 capacity cage can hold from 50,000 to 100,000 postlarvae at a density of $5,000\text{-}10,000/\text{m}^3$. You may add more cages depending upon the total number of postlarvae you wish to stock. Smaller cages are easier to manage compared to bigger ones but they are more expensive per unit area when you consider the netting materials used.

The frame of floating nursery cages can be constructed using bamboo. Other materials like wood and coconut lumber, a galvanized iron (G.I.) pipes or polyvinyl chloride (PVC) pipes may also be used.

A floating nursery cage consists of three major parts (Fig. 2), namely:

1. cage frame,
2. floats, and
3. netting materials.

The cage also has two important accessories: feeding nets and stone sinkers.

To construct a floating nursery cage, you will need the following materials the quantity of which can be determined according to the size and number of cages needed.

Bill of materials needed to construct a 10 m³ floating nursery cage (2 x 5 x 1.5 m)

<i>Materials</i>	<i>Quantity</i>
Bamboo poles (10-12 m long)	40 pcs
Monofilament No. 180	3 kg
A-net (single width, 5 mm mesh size)	31 m
White nylon hapa net (single width, 1 mm mesh size)	31 m
Copper nail 1 in.	0.25 kg
2 in.	0.50 kg
Polyethylene rope 4 mm dia	140 m
8 mm dia	50 m
Cement coated styrofoam floats (0.45 x 0.9 x 0.45m)	4 pcs
Nylon twine 210/90	1 spool

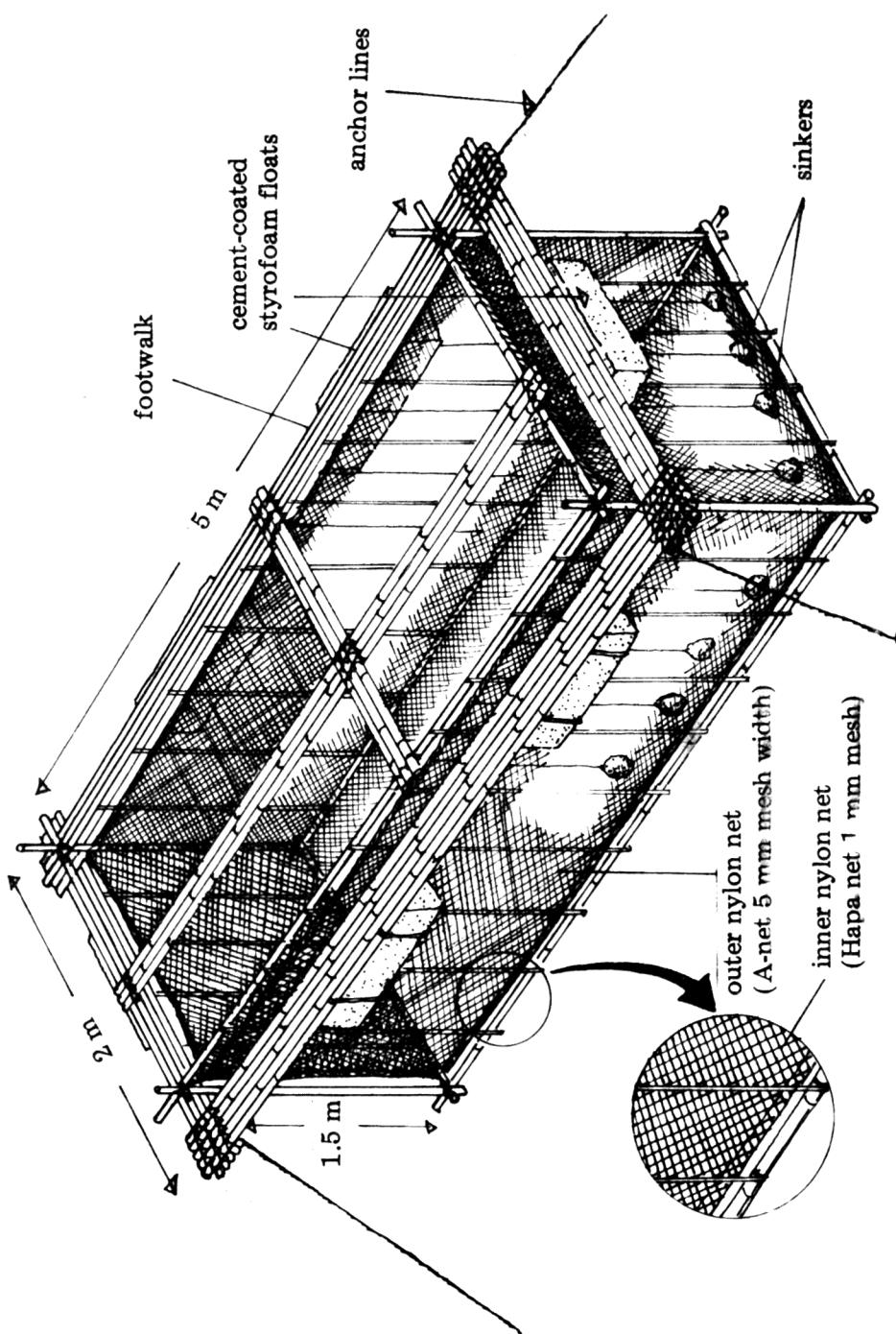


Fig 2. Full view of a floating nursery cage with bamboo cage frame, floats and netting materials.

To construct a 10-ton floating nursery cage and its accessories, you need to prepare the following:

1. *Cage Frame*

Construct a 2 x 5 x 1.5 meter cage frame using bamboo poles for the framework and bamboo slats for the 4 sides.

Each nursery cage will need 5 pieces of bamboo poles installed around the top portion of the frame to serve as foot-walk.

2. *Floats*

Various kinds of floating materials can be used to float the cage: cement-coated styrofoam sheets, marine plywood box, empty oil drum (200 liters), and empty plastic container (Fig. 3). Among these, the styrofoam float coated with cement has been tested to be the most effective.

Here is how to prepare a cement-coated styrofoam float:

- a. Cut a styrofoam sheet measuring 0.9 x 1.8 x 0.1 m equally into four parts with each part measuring 0.45 x 0.9 x 0.1 m
- b. Glue the cut styrofoam sheets by placing a surgical gauze moistened with gasoline between each sheet to form a float now measuring 0.45 x 0.9 x 0.4 m.
- c. Wrap the float with a nylon netting material (10 mm mesh width). Sew the net on all sides using pamo twine No. 210/90.
- d. Coat the styrofoam block with cement mix (1 part cement: 2 parts sand) and allow to dry for 3 days.

Four floats are needed for a 10-ton floating cage.

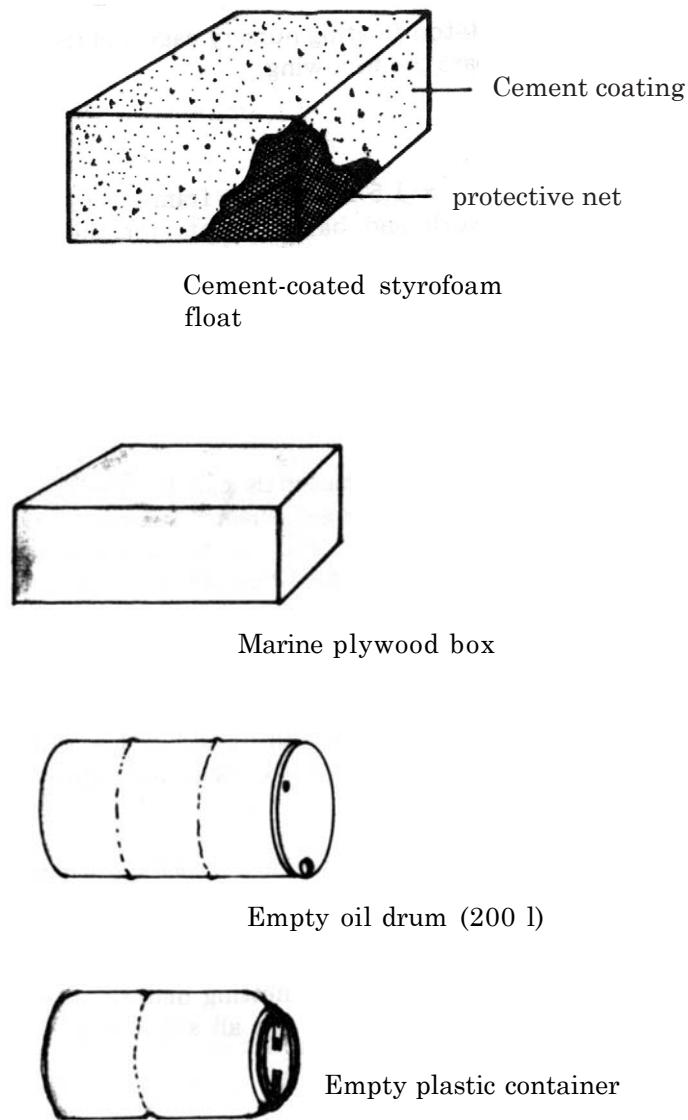


Fig. 3. Kinds of float for a floating nursery cage.

3. Netting Materials

Prepare nylon nets (inner and outer) each measuring 2 x 5 x 1.5 m. Sew all sides of each net together to form an inverted mosquito net (Fig. 4). The nets can be sewn either by machine or by hand.

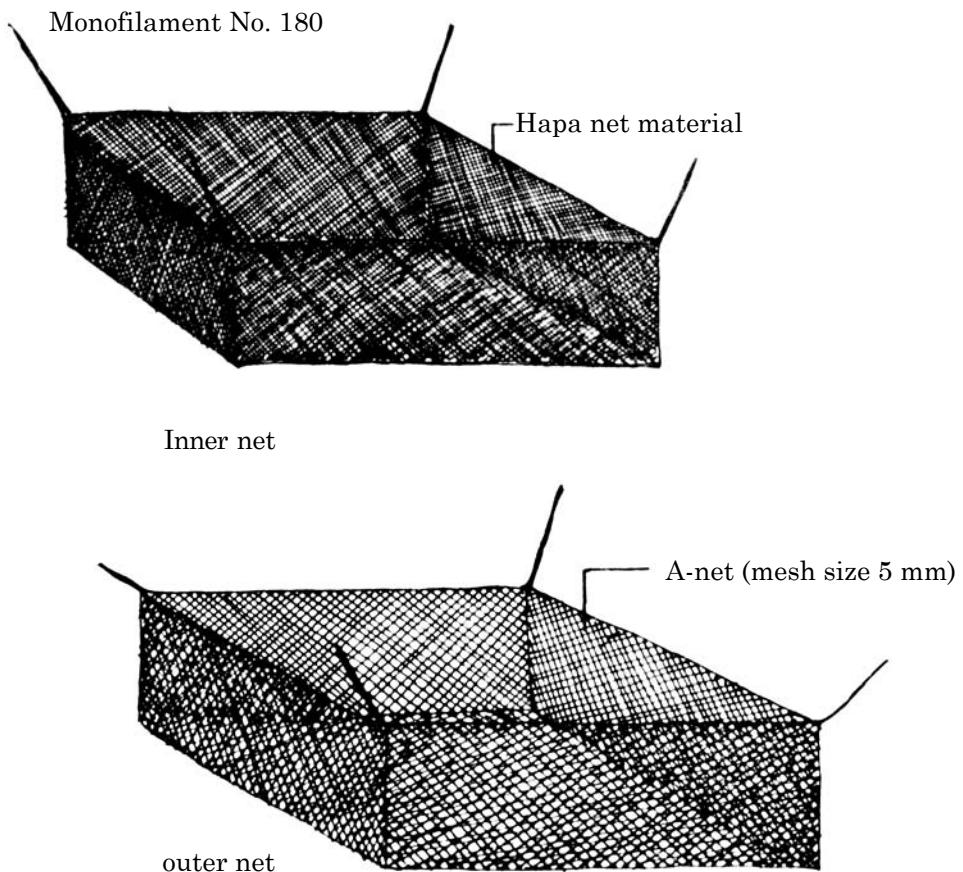


Fig. 4. Inner and outer nylon nets.

4. Feeding Nets

At least six feeding nets are needed for a 10-ton floating cage. To construct a feeding net, use G.I. wire No. 5 and form a rectangular frame 1.5×0.6 m. Sew a nylon netting material (1 mm mesh size) around the edges of the G.I. frame, constantly stretching out the net to keep it firm (Fig. 5).

Tie the 2 upper corners of the feeding frame suspended vertically using monofilament measuring 1.5 meters long to suspend them vertically from the upper bamboo frame of the cage during feeding.

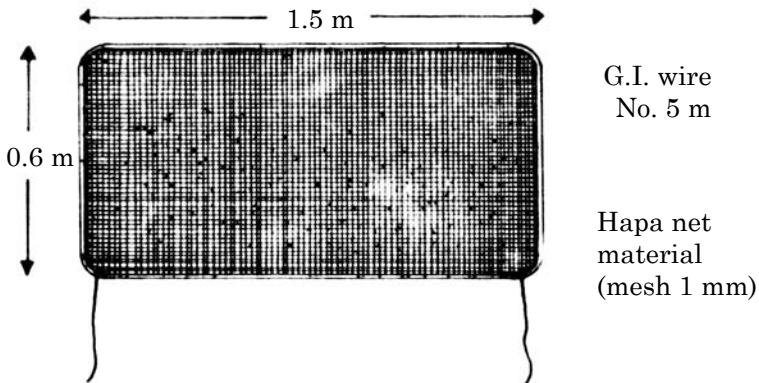


Fig. 5. Details of a feeding net

5. Stone Sinkers

Each stone sinker should weigh approximately 1 kg (with one piece of stone or several smaller pieces of stones). Wrap big stones individually and small stones together with a nylon net. Tie each沉器 with a monofilament 1.5 m (Fig. 6a). Secure the sinkers to the upper bamboo frame and suspend them inside to prevent net folds (Fig. 6b).

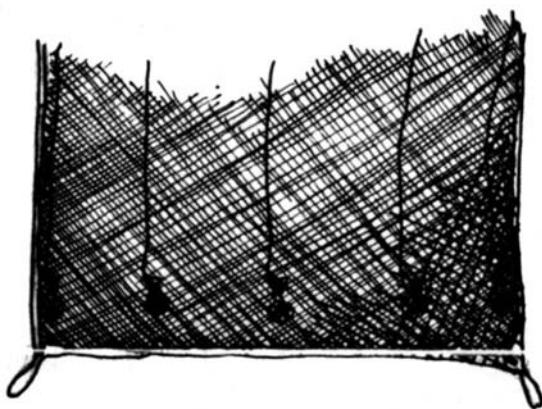


Fig. 6a Side view of the cage showing stone sinkers suspended from the upper bamboo cage frame

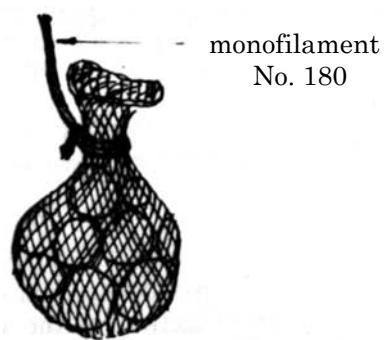


Fig. 6b. Details of a stone sinker

INSTALLATION OF FLOATING NURSERY CAGES

Install the floating nursery cages in the selected site. The cages should not touch the sea bottom even during extreme low tide. Allow at least one meter distance from the sea bottom (Fig. 7). Installed this way, the cages can sway with the waves; otherwise, they may be damaged.

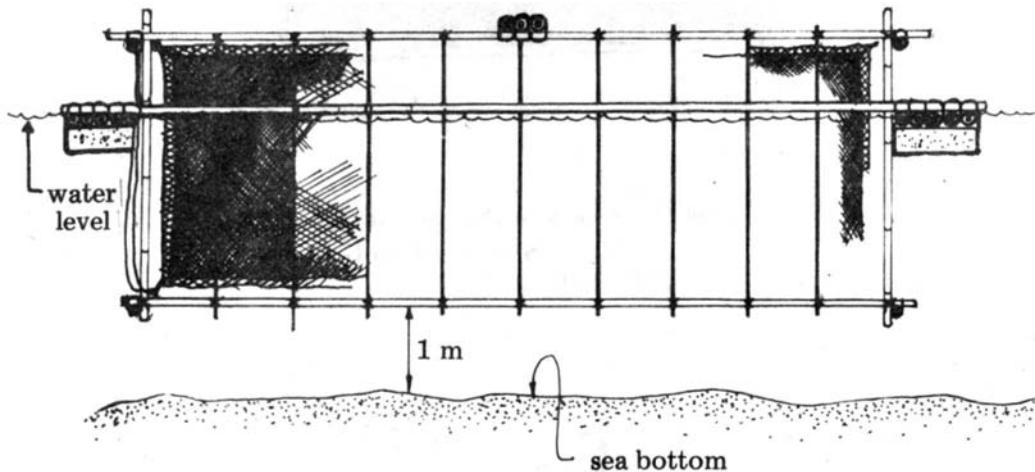


Fig. 7. Bottom net material of floating cage during low tide at least one (1) meter above the sea bottom.

Arrange the cages parallel to each other in alternate positions and facing the direction of the water current to allow efficient water exchange (Fig. 8). Allow a safe distance of at least 2-5 meters between the cages to prevent collision.

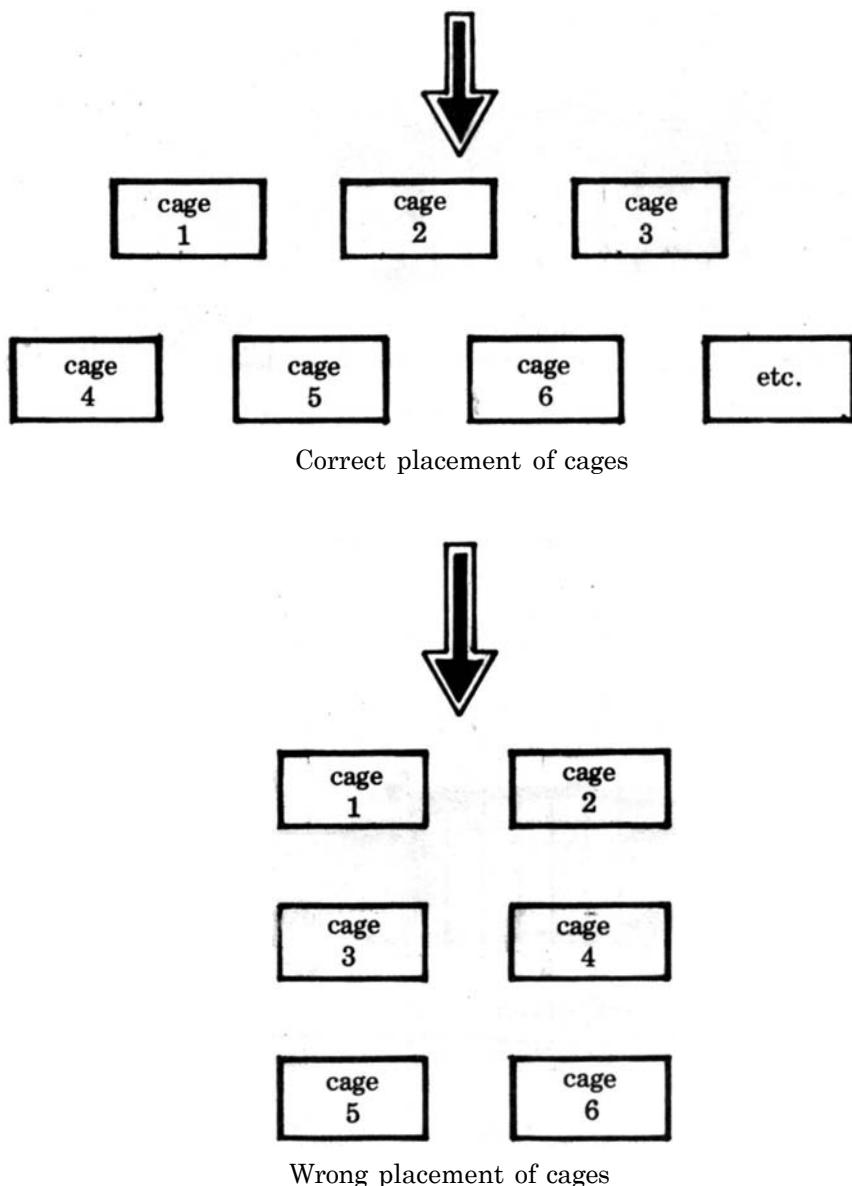


Fig. 8. Placement of cages facing water current direction.

Provide cages with anchors to prevent collision (Fig. 9).
Each anchor weighs about 50 kgs.

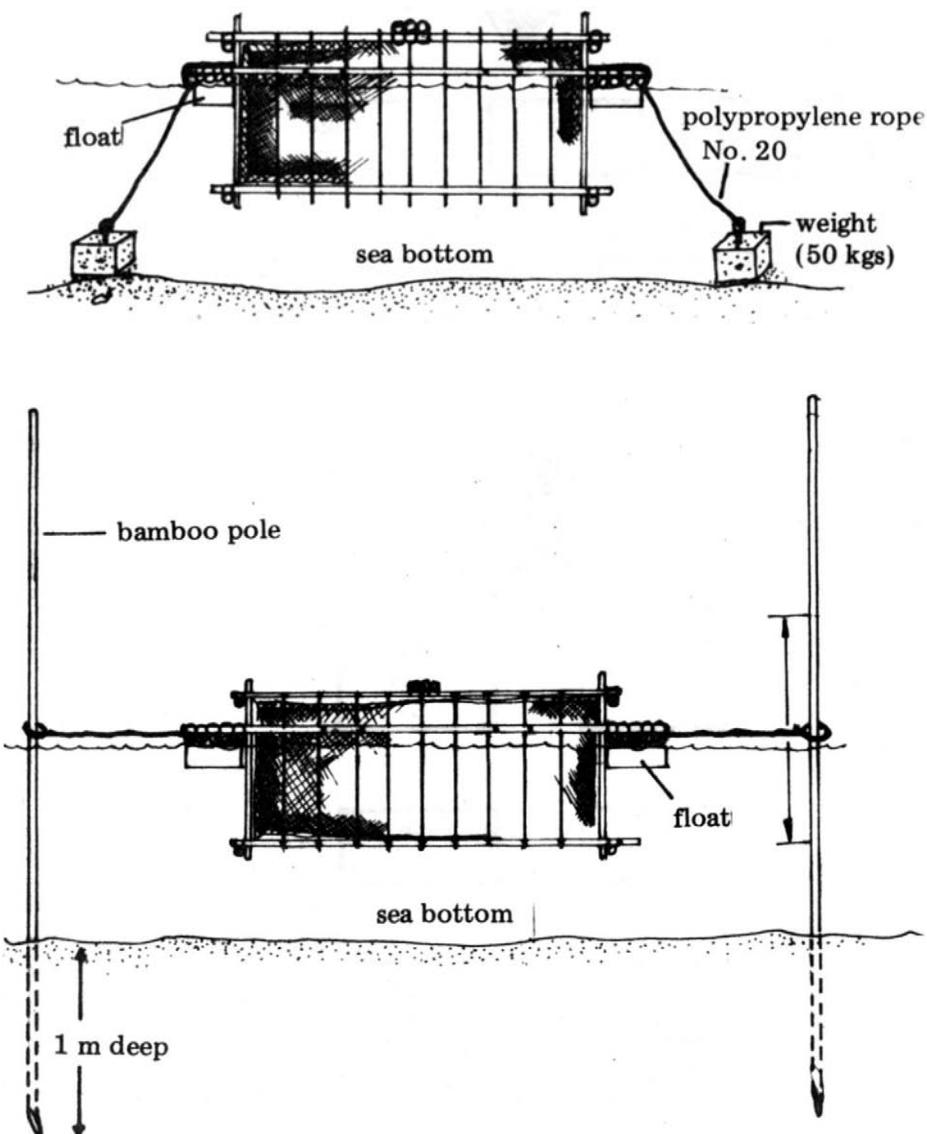


Fig. 9. Two methods of anchoring

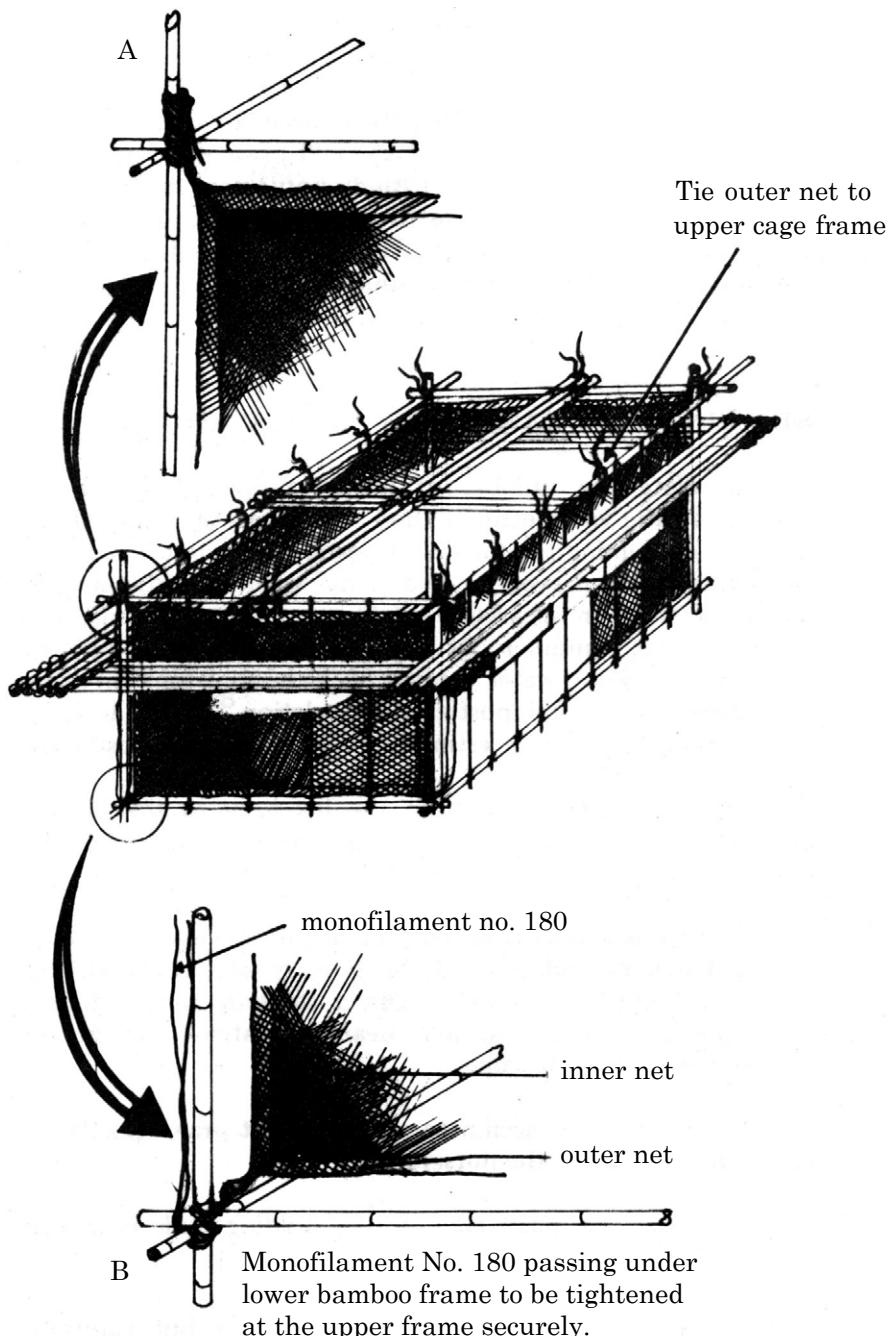


Fig. 10. Tie the nylon nets at the upper (A) and lower (B) portions.

Tie the outer and inner nets securely to the cage frame to maintain their rectangular shape and prevent the nets from folding. Secure the outer net with monofilament running down the lower cage frame and tie to the upper cage frame at one meter intervals as shown in Fig. 10. Repeat the procedure for the inner net and suspend stone sinkers.

STOCKING AND TRANSFER OF POSTLARVAE

Estimate the number of postlarvae (PL_8-PL_{10}) to be stocked by the volumetric method. Stir the water in the holding tank containing the harvested postlarvae from the hatchery to distribute them evenly. Scoop five random 1-liter samples and place them in separate containers. Count the number of postlarvae per container. Multiply the average count of these five samples by the water volume of the holding tank (in liters) to estimate the total postlarval population. Fig. 11 shows the 3 steps involved in estimating the number of postlarvae.

Stock the postlarvae from the hatchery to the nursery gradually to minimize stress due to sudden change in water salinity and temperature.

If there is a wide difference in salinity between the water in the hatchery and that of the nursery site, acclimate the postlarvae right at its source. Direct stocking can be done if the nursery cages are located near the hatchery where the seawater salinity is the same.

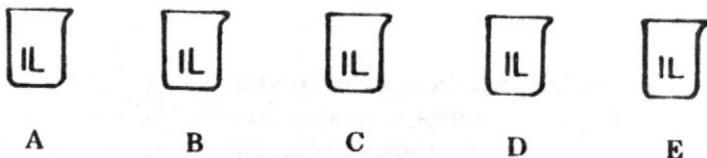
Here is how to acclimate and transport prawn postlarvae from the hatchery to the nursery.

- a. Place the postlarvae into a holding tank or plastic basin;
- b. Aerate or stir the water constantly but carefully;

GIVEN: Tank Y = 1,000 liters



PROCEDURE: Using 1-liter beaker get 5 samples



FORMULA:

$$\text{Larval Population} = \left(\frac{\text{larval count in A} + \text{B} + \text{C} + \text{D} + \text{E}}{5} \right) \times 1,000$$

Fig. 11. Estimating the number of postlarvae.

- c. Gradually add freshwater or seawater, as the case may be, every 10 minutes until the desired water salinity of the nursery site is attained.
- d. Transport the postlarvae using plastic bags.

Pack the postlarvae (PL_8-PL_{10}) at 20,000-30,000 per plastic bag containing 4-6 liters of seawater. Add oxygen at about the same volume. Pandan bags or styrofoam boxes may be used as containers and protection for the plastic bags. Transport the postlarvae from the hatchery to the site either early in the morning or late in the afternoon to protect the fry from getting stressed due to high temperature.

The plastic bag containing postlarvae should be allowed to float for a few minutes to approximate the water temperature in the cage before stocking (Fig. 12).

Stock from 5,000 to 10,000 postlarvae (PL_8-PL_{10}) per cubic meter in the cage already provided with feed. The density should be thinned out to around 3,000 to 4,000 per cubic meter when the postlarvae become $PL_{20} - PL_{25}$ to reduce mortality due to overcrowding. This is done by transferring the postlarvae to other prepared nursery cages. When the inner net of the cage accumulates dirt, and water exchange becomes inefficient, the whole population of postlarvae should be transferred to another cage.

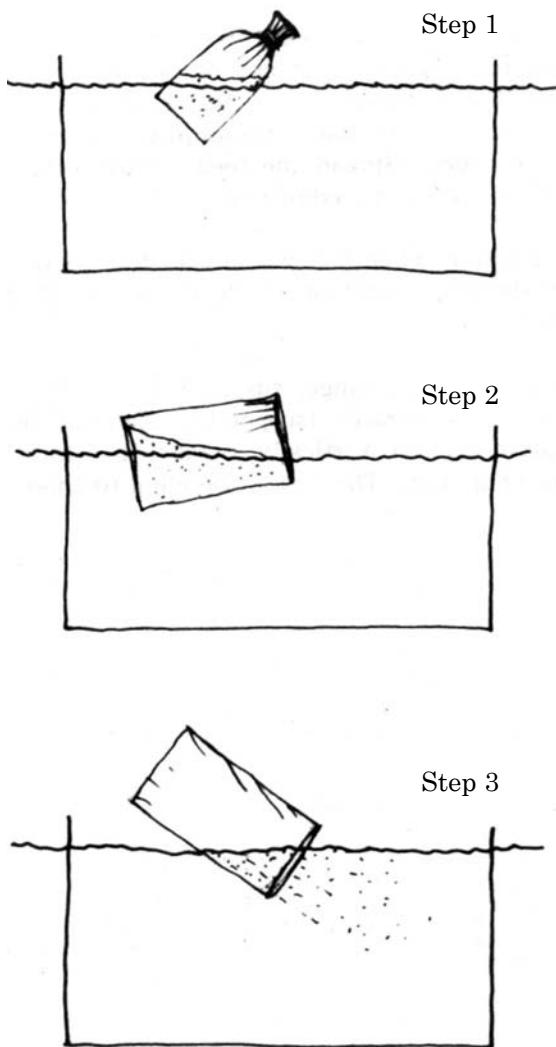


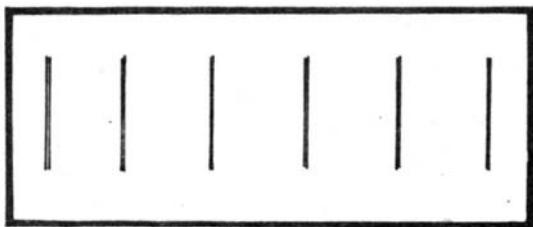
Fig. 12. Releasing postlarvae into the nursery cage

FEEDS AND FEEDING

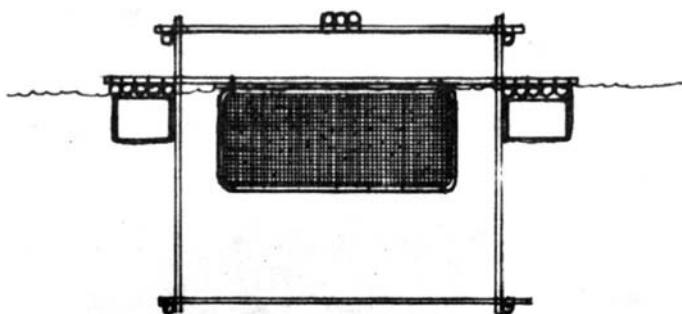
Feed the postlarvae every other day preferably in the morning with raw finely ground fish and mussel meat at about 1 kg per 50,000-75,000 population. Add more feed as the postlarvae grow and increase their consumption indicated by the absence of left-overs. Spread the feed evenly using your fingers, a spoon or a spatula in feeding nets.

At PL₁₅ or older, when the postlarvae start to become benthic (bottom dwelling), part of the feed (about 10%-20%) can be broadcast.

For efficient water exchange, suspend the feeding nets which also serve as substrates (suspended materials which provide more attachments) vertically parallel to the water current direction (Fig. 13). The postlarvae cling to these nets to feed.



Top view of feeding nets
inside the floating cage



Side view of feeding net

Fig. 13. Top and side view of feeding nets.

HARVESTING

Harvest after 2-3 weeks when the postlarvae become PL₂₂PL₃₁. Steps in harvesting postlarvae are shown in Fig. 14.
(a) Remove sinkers and feeding nets; (b) untie the inner net; (c) concentrate the postlarvae at one end of the net; and
(d) scoop and place them in basins using a scoop net (Fig. 15).

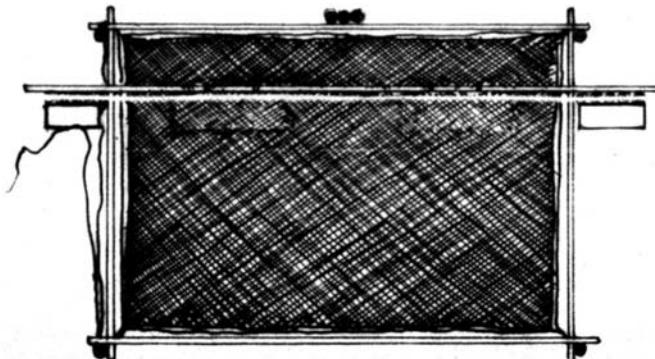


Fig. 14a

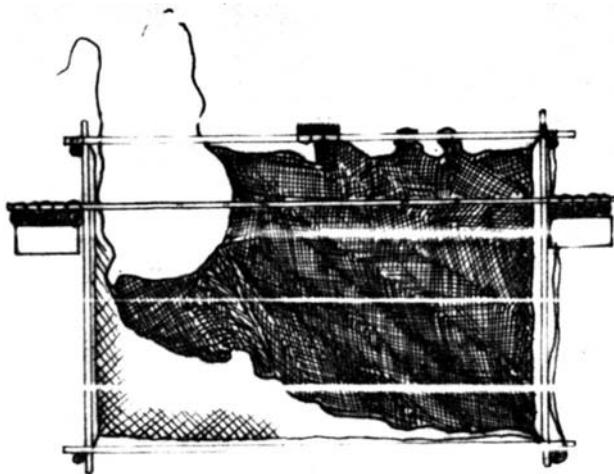


Fig. 14b

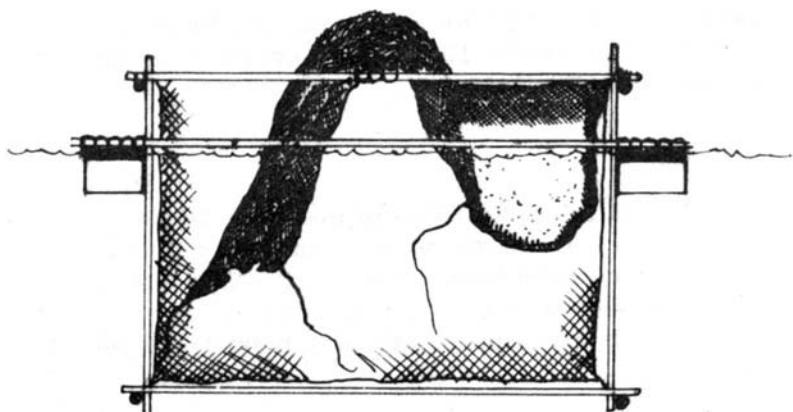


Fig. 14c

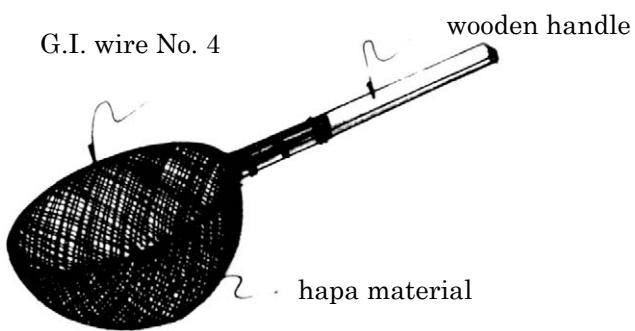


Fig. 15. Details of a scoop net.

Count and pack the postlarvae for disposal. Packing and transport are done similarly as in PL₈-PL₁₀, but reduce only the density to 2,000 for long distance transport (4-6 hours travel time) and up to 10,000 for short distance transport (less than one hour travel time).

A floating working area or house can be set conveniently adjacent to the floating cages. Counting and packing of post-larvae can be done here. Although it is optional, the floating house can serve as a working area, a guard house, and a storage for materials and supplies like nets, basins, pails, etc. (Fig. 16 and 17).

The size of the floating house depends on the capacity of the nursery cages. It should accommodate the activities of counting and packing postlarvae harvested from one cage.

FRY SURVIVAL

By adopting this culture system, one can be assured of survival of postlarvae as high as 90% or better. The average survival of 60% for the whole year is quite reasonable. These survival rates were based on 18 production runs conducted from March to November in 1983 and 1984 during new moon and full moon at the SEAFDEC AQD Batan Research Sub-station in Aklan, Panay Island.

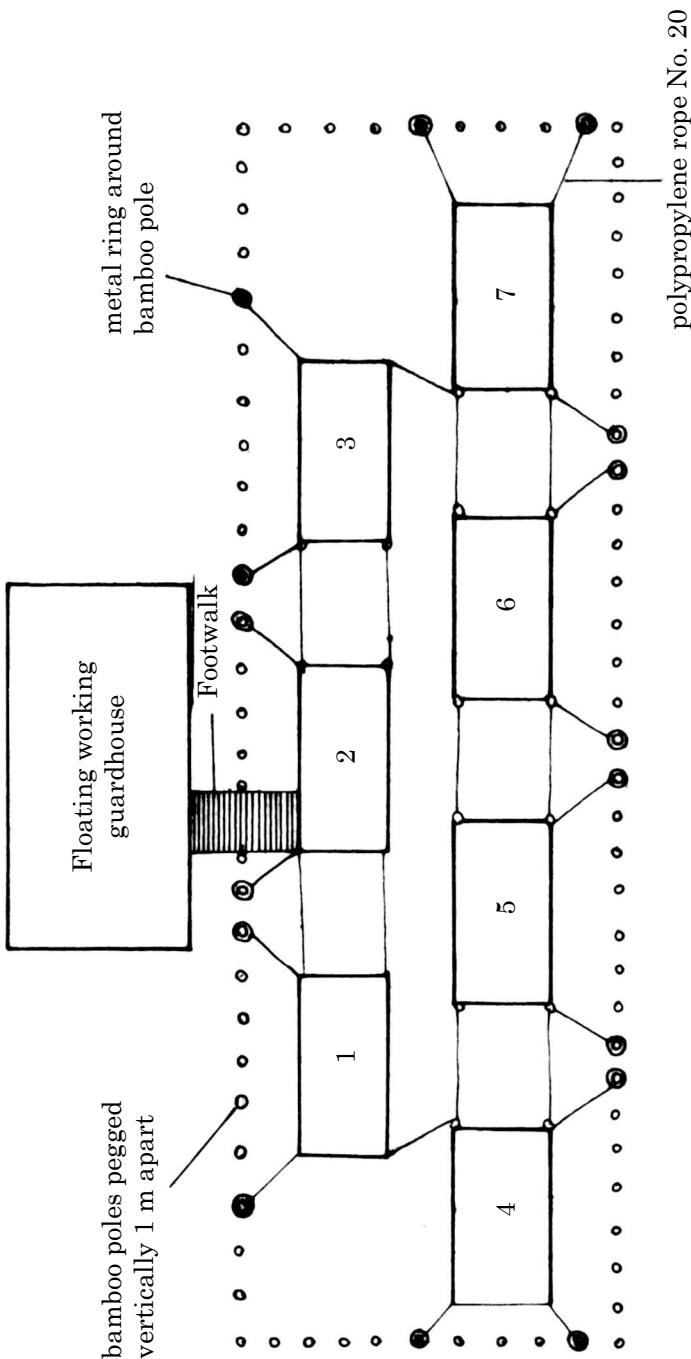


Fig. 16. Top view of floating cages with a floating working house.

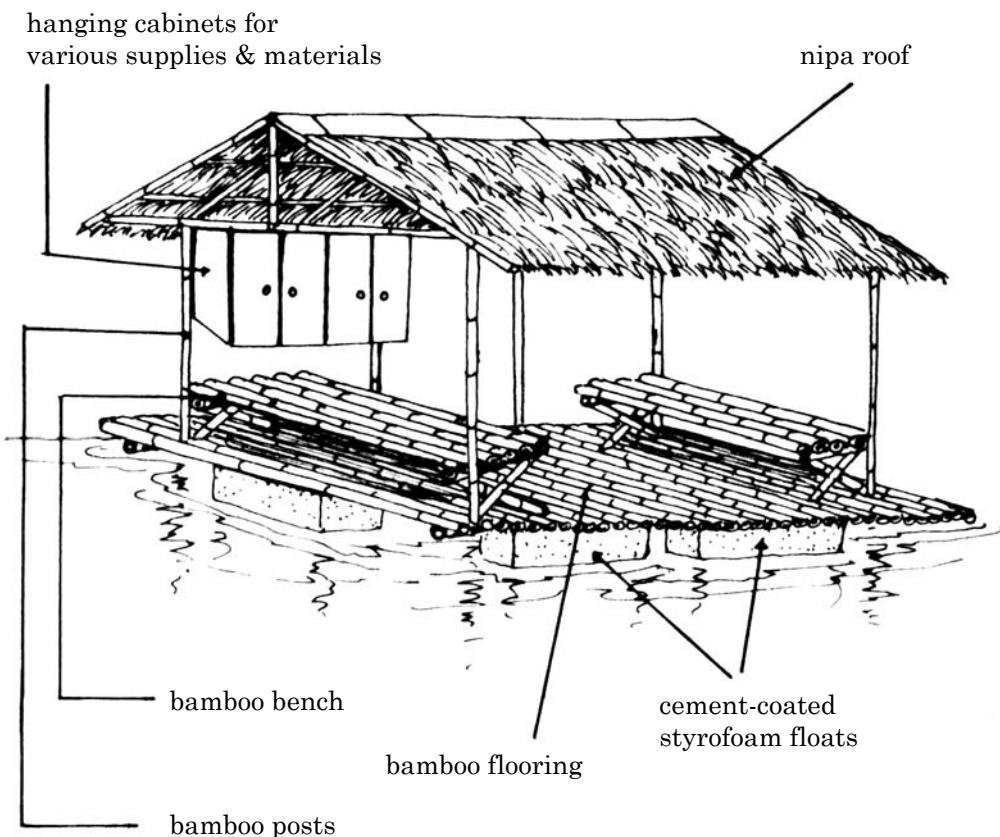


Fig. 17. Parts of a floating working and guardhouse.

CARE OF THE NETS

The net cages are normally changed twice every 30 days or less depending on the degree of siltation or clogging.

After harvesting, remove and clean the inner nets by following this procedure:

1. soak nets in freshwater for at least 2 days;
2. remove dirt and fouling organisms, like oyster spats from the nets using a nylon brush;
3. dry the nets under the sun; and
4. repair nets with holes by patching them with the same net material.

ECONOMICS

Presented below are estimates of costs and returns for a prawn floating cage nursery project scaled according to operational sizes of 2 cages. One can easily adjust the cost and return estimates for 4 cages and 8 cages. The comparative analysis provides prospective investors enough financial information necessary for deciding on the size of floating nursery operation. Technical estimates were based on 18 production runs conducted at the SEAFDEC AQD Batan Research Substation from March to November in 1983 and 1984 while financial elements were provided by the Aquaculture Economics Discipline of SEAFDEC AQD.

Table 1. Inventory of Physical Facilities and Schedule of Depreciation

<u>Item</u>		<u>Price/Unit</u>	<u>Economic Life</u>	<u>Total Cost</u>	<u>Salvage Value</u>	<u>Annual Depreciation</u>
A.	Floating Cages	P 3,900.00	2 yrs	7,800.00	P2,400.00	P2,700.00
	Bamboo poles	1,000.00	2 yrs	(2,000.00)		(1,000.00)
	Labor	300.00	2 yrs	(600.00)		(300.00)
	Nets (inner & outer)	400.00	2 yrs	(800.00)		(400.00)
	Polypropylene ropes	200.00	2 yrs	(400.00)		(200.00)
	Buoys	2,000.00	5 yrs	(4,000.00)		(800.00)
B.	Bamboo quadrangle	5,000.00	2 yrs	5,000.00		2,500.00
C.	Caretaker's hut	8,000.00	5 yrs	8,000.00	800.00	1,440.00
D.	Floating house	10,000.00	5 yrs			
E.	Barca	3,000.00	5 yrs	3,000.00	300.00	540.00
F.	Miscellaneous		5 yrs	5,000.00		1,000.00
	Total			P28,800.00	P3,500.00	P8,180.00

Note: Multiply the figures indicated for a 2-cage operation according to the number of cages you want to operate.

Table 2. Prawn Floating Cage Nursery and Returns Per Run of 12 Days

	Quantity/Cage	Price/Unit	2-Cage Operation Total Value
<i>Variable Costs</i>			
1. Fry PL ₈	75,000 ind.	P 0.10	P15,000.00
2. Feeds (trash fish)	6 kg	30.00	360.00
3. Marketing			630.00
4. Sales Tax			315.00
5. Miscellaneous			815.00
<i>Fixed Costs</i>			
1. Labor	1 aide	1,000/mo	500.00
2. Repair & Maintenance			90.00
3. Depreciation			511.00
4. Interest			400.00
<i>Total Costs</i>			P18,621.00
<i>Revenues</i>	45,000 ind. (P ₂₀)	0.35	31,500.00
<i>Net Income Per Run</i>			
<i>Before Income Tax</i>			12,879.00
<i>Annual Net Income</i>			
<i>Before Income Tax</i>			206,064.00
<i>Income Tax</i>			62,122.00
<i>Annual Net Income</i>			
<i>After Tax</i>			143,942.00

Note: Multiply the figures indicated for a 2-cage operation according to the number of cages you want to operate.

Table 3. Investment Requirement

<u>2-Cage Operation</u>	
Fixed investment	P28,800.00
Working Capital	35,240.00
Total	<u>P64,040.00</u>

Table 4. Financial Indicators

<u>2-Cage Operation</u>	
A. Annual Net Income After Tax	P143,942.00
B. Payback Period	5 months
C. Return on Investment	225%

List 1. Technical and Financial Assumptions Used:

1. Survival rate from PL₈ to PL₂₀ is 60%.
2. Feeding per cage is at a rate of 1kg for every two days.
3. There are eight operational months per year and two operational runs per month.
4. Marketing cost is 2% of gross income.
5. Sales tax is 1% of gross income.
6. Miscellaneous cost is 5% of variable costs.
7. Labor is paid the minimum wage for plantation worker of P33.00 per day.
8. Repair and maintenance is 5% of fixed investments.
9. Interest is 25% per annum.
10. Investment requirement is 60% loaned and 40% owner's equity.
11. Working capital is total variable cost plus labor cost for one month of operation.
12. Prices indicated are as of April 1985.

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Research Article

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The Continuous Culture of Rotifer *Brachionus plicatilis* with Sea water

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Abstract

Rotifers are the favourable live food for fish larvae. A steady supply of rotifers is key factor for successful larviculture. The present study aimed to develop a simple zootechnique to reduce labour for high density culture of rotifers. *Brachionus plicatilis* (inoculation density: 737 ± 80 organisms/ml) were cultured in 100 l plastic, cylindrical tanks using 100% sea water. The water was renewed on every 5th day of culture without any further exchange of water in between. The culture was continued for 32 days. Rotifers were fed with *Chlorella* spp. at the rate of 200/ml, twice daily. Total 1059 ± 25 organisms/ml was recorded on day-1 of culture. Significantly ($P < 0.05$) higher number of rotifers was recorded on day-4 compared to day-1. A 13.12% higher density was recorded on day-8 compared to day-4; the population was reduced 5% on day-12 compared to the previous day. Then the number of rotifer increased gradually. Significantly ($P < 0.05$) higher number of rotifer (1798 ± 25 /ml) was recorded on day-20 compared to the remaining culture period. A gradual decreasing trend was found thereafter. Still the number of organism was more than 1000/ml.

Keywords: *Brachionus plicatilis*; *Chlorella* spp.; Exchange of water; Production.

Introduction

The mixohaline rotifer *Brachionus* spp. (both L type and S type) is most commonly used live food in marine larviculture. Rotifers are important forage zooplankton as their size is appropriate for larval fish as a starter food during early exogenous feeding [1]. In Japan, an average hatchery requires 20 billion rotifers/day [2], [3]. Various culture techniques have been used for the production of this important live food organism. The production of *Brachionus plicatilis* (L type) is labour intensive. This species requires intensive care. The growth rate of L type rotifer tends to decrease above 26°C, whereas the S type rotifer (*Brachionus rotundiformis*) grows well even at 28°C or higher temperature. In Japan, most of the hatcheries use S type rotifer during summer when the temperature is >28°C. Usually, the concentration of rotifer in the culture system is around 100 organisms/ml, but the concentration may reach more than 1000 organisms/ml [4]. Various algae like *Chlorella*, *Scenedesmus*, *Nanochloropsis*, *Isochrysis*, *Monochrysis*, *Dunaliella*, etc. are used as food for *Brachionus plicatilis*. *Brachionus plicatilis* are fed with *Dunaliella* sp. at the salinity of 25-33 ppt and it is found that crowding up to 200 organisms/ml has no impact on reproduction [5]. Hirata [6] observes that the density of rotifer fed with microalgae and yeast can be maintained up to 500 organisms/ml. *Brachionus rubens* are grown on *Scenedesmus* at the density of 500 organisms/ml [7]. *Brachionus plicatilis* fed

with *Chlorella* and baker's yeast shows a growth efficiency of 25.4% [8]. Rotifers are batch-cultured at density of 100 to 300/ml on a diet of microalgae and baker's yeast; higher density of 300 to 700 organisms/ml may be grown by feeding with commercial diet Culture Selco and Rotimac [9].

The production of rotifers is influenced by various factors like temperature, salinity, quality and quantity of food, crowding etc. [5]. The instability of rotifer mass culture is an important unresolved problem. In European hatcheries, the major problem of rotifer culture is the unpredictability of production [10]. Cultures occasionally crash due to unexplained reasons [11]. Besides scarcity of food during crowding, high level of un-ionized ammonia may be harmful to rotifers.

In the traditional Japanese rotifer culture, a combination of marine and freshwater (70: 30) is used. The water temperature is usually maintained at 20°C under high aeration condition. Once the culture has been started, there is exchange of water in the following sequence: 30, 50 and 70% on days 2, 3 and 4. On fifth day, a fresh culture starts with 100% new water. Rotifers are fed with *Chlorella* spp. A piece of mat has been used for removal of dead algae and organic debris; the mat is cleaned every day. The density of rotifers is maintained around 400-500 organisms/l to achieve sustainable production. This is a labour intensive method.

The present investigation aims to develop a simple zootechnique for the production of *Brachionus plicatilis* with reduced labour and water exchange. Maintenance of higher density of organisms is also other objective of the study. This modified technique may attract aquaculturists for its simplicity, easy maintenance and higher production.

Methods

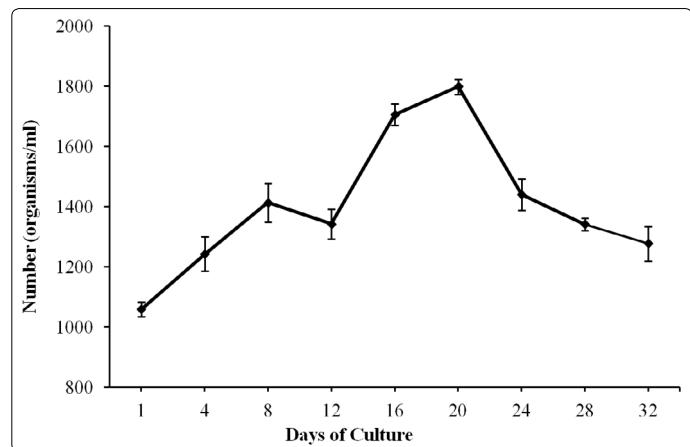
Brachionus plicatilis was cultured at Maizuru Fisheries Research Station, Kyoto University in 100 l plastic, cylindrical tanks using 100% sea water. This strain has been cultured for larval rearing at Fisheries Research Station since long time. The inoculation density was 737 ± 80 organisms/ml. Three replicates were used for the study. The culture tanks were cleaned on every 5th day (day-5) and were filled with 100% fresh sea water. The mat used for the removal of algae was cleaned on every other day. Rotifers were fed with *Chlorella* spp. at the rate of 200 algae/ml twice daily at 8.00 a.m. and 5.00 p.m. The culture was continued for 32 days. Water quality parameters like temperature, pH, salinity and dissolved oxygen were monitored at regular interval. Data were compiled as means \pm S.E. All data were analyzed using one-way analysis of variance (ANOVA). Statistical significance was accepted at $P < 0.05$ level.

Results

The abundance of *Brachionus plicatilis* was recorded as 1059 ± 25 organisms/ml on day-1 after inoculation. The number of rotifers gradually increased. Significantly ($P < 0.05$) higher (17.28%) number of rotifers was recorded on day-4 compared to day-1. The density of rotifer was 13.12% higher

on day-8 compared to the density found on day-4. A 5% reduced rotifer number was recorded on day-12 of culture (Fig. 1). Significantly ($P < 0.05$) higher number of rotifers was recorded on day-16.

Figure 1. Production of *Brachionus plicatilis* during 32 days of culture



This rotifer density was 21.27% higher on day-16 compared to day-12. Then the number increased gradually. Significantly ($P < 0.05$) higher number of rotifers was recorded on day-20 compared to the rest of the culture period. Then a gradual decreasing trend was found. On day-24, the number of rotifer was significantly ($P < 0.05$) lower compared to day-20. The number of organisms further reduced and the number was 9.32% reduced on day-28 compared to day-24. On day-32, *Brachionus plicatilis* density was 5% lower compared to day-28. Still this number was significantly ($P < 0.05$) higher compared to day-1. The number of *Brachionus plicatilis* was always above 1000/ml. This is most interesting to record that there was no crash of culture during the entire study period. There was no significant ($P > 0.05$) difference in water quality parameters among replicates during the culture period (Table 1).

Table 1. Water quality parameters found during the culture of *Brachionus plicatilis*

Parameter	Range	Mean \pm SE
Temperature (°C)	19.2 - 20.2	19.72 \pm 0.23
Dissolved oxygen (mg/l)	4.28 - 5.64	5.01 \pm 0.28
Salinity (ppt.)	32.8 - 34.1	33.6 \pm 0.30

Discussion

The present culture technique of rotifer was different from the traditional Japanese rotifer culture. Unlike traditional culture, cent percent sea water was used in the present study and there was no exchange of water. This is very useful for farmers; they have not to depend on freshwater. The tanks were cleaned on every 5th day and mat was cleaned on alternate day. This modified method saved manpower. Lavens and Sorgeloos [12] reported that *Brachionus plicatilis* were cultured (starting density 200/ml) with diluted sea water (25 ppt) at 25°C. Rotifers were fed with small amount of Culture Selco at 1 h intervals and the number of rotifers was 600/ml after four days in Europe. In a high density cultivation of *Brachionus*, *Nannochloropsis* was supplemented with concentrated baker's yeast and yeast containing fish oil. Freshwater *Chlorella* was

used with B_{12} supplementation. Using this system average 1000 rotifers/ml was obtained in Japan [12]. Suantika et al. [13] reported that daily 100% exchange of water enhanced the duration of culture period up to one week without any positive effect on the production of rotifer. In recirculating system, *Brachionus plicatilis* were cultured at three stocking densities of 3000, 5000 and 7000 individual/ml; a reliable production of 2.2 billion rotifers was obtained on daily basis during 3 weeks of culture [14].

In a 110 days continuous culture of *B. rotundiformis* (S-type) and *B. plicatilis* (L-type), *Chlorella vulgaris* was used as food and the production was 3000 - 6000 organisms/ml and 1100 - 2200 organisms/ml for S-type and L-type, respectively. The water temperature was 24°C (for L-type) and 30°C (for S-type); the salinity was 20 ppt [15]. In the present study, the density of *Brachionus plicatilis* ranged from 1059 - 1798 organisms/l during 32 days culture period. The water temperature and salinity ranged from 19.2 - 20.2 and 32.8 - 34.1 ppt respectively. In high density culture of rotifer, low dissolved oxygen, foaming separation and NH_3 were inhibitory factors. Supply of oxygen in the culture system may help to overcome these problems [15]. In the present study, dissolved oxygen level ranged from 4.28 - 5.64 mg/l with an average value of 5.01 ± 0.28 mg/l. The water quality parameters in the present study were conducive for the culture for *Brachionus plicatilis*.

The present technique of rotifer culture has some advantages over the traditional culture method and the sophisticated culture techniques like recirculating culture. This is very simple. Rotifers were fed with *Chlorella* spp. and sea water was directly used without any dilution. Culture water was renewed only on every 5th day. The density of rotifers was obtained within the range of earlier study [16]. Therefore, this technique is less expensive in terms of price and labour.

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ROTIFER CULTURE TECHNIQUES FOR MARINE FINFISH LARVAL REARING

Sekar Megarajan, Chinni B and Narasimhulu Sadhu

Rotifers are considered as valuable live food for fish and crustacean larvae because of the small size of the rotifer. Several important characteristics of rotifers have contributed to their usefulness as good prey for active larvae of marine fish,

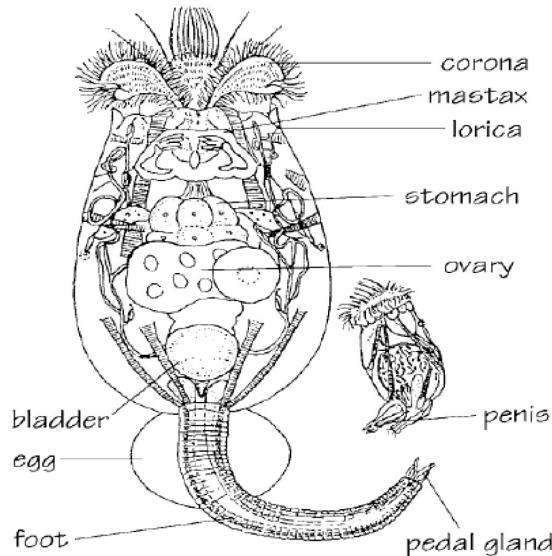
- ◆ Nutritional quality: Rotifers have an excellent nutritional profile, if they are fed with right quality feeds
- ◆ Small size: They are easily consumed by almost all marine fish larvae
- ◆ Relatively slow motility – It helps for easy prey capture by fish larvae
- ◆ Good tolerance to marine environment
- ◆ Easy to culture in large scale rapidly and inexpensively
- ◆ Ability to stay suspended in the water column.

Marine rotifers *Brachionus* spp. are most commonly used for intensive culture of marine finfish larvae in many hatcheries throughout the world. The most common *Brachionus* species used are *Brachionus plicatilis* (L-strain) with a size range of 130 to 340 µm (Average - 240 µm) and *B. rotundiformis* (S-strain) with a size range of 100 to 210 µm (average size-160 µm). There are differences in weight, shape of occipital spines and optimal growth in different temperatures (L-type rotifers have a wider temperature range while S-type rotifers have a higher temperature resistance). S-type rotifers are suitable as first food for fish larvae with a mouth opening smaller than 200 µm at first feeding, such as gilthead seabream, groupers, and rabbitfish.

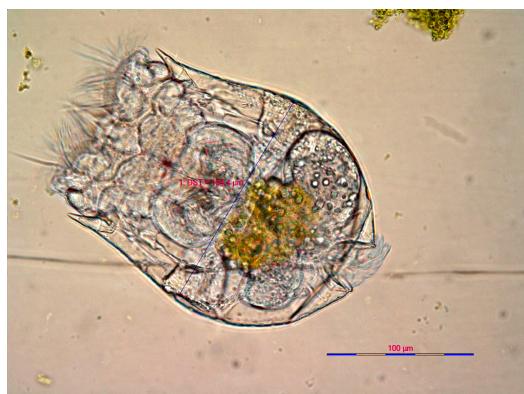
These rotifers are commonly offered to larvae during the first 3–30 days of exogenous feeding. *Rotifers* are supplied at the required concentrations for meeting larval metabolic demands and yielding high survival rates during the larval rearing. Larvae are first fed on a small strain of rotifers, and as larvae increase in size, a larger strain of rotifers is introduced. Rotifers are regarded as living food capsules for transferring nutrients to fish larvae. These nutrients include highly unsaturated fatty acids essential for survival of marine fish larvae. In addition, rotifers treated with antibiotics may promote higher survival rates.

Morphology

Rotifer's body is divided into three different parts namely head, trunk and foot. The corona is found in the head. The corona has an annular ciliation and is retractable, which allows them to move and makes easier the intake of small food particles through a whirling water movement. The digestive tract, the excretory system and the genital organs are in the trunk. The foot is a ring-type retractable structure without segmentation and ends in one or four toes. The body parts of a female and male *Brachionus plicatilis* is depicted in fig 1.



Male and female of *Brachionus plicatilis* strain (Source FAO)



View of rotifer *Brachionus plicatilis* (10 X)

Life history

The life span of rotifers depends on their reproduction cycle. Reproduction frequency of rotifer varies according to the temperature of the culture environment; for example at 25 °C it is of about 4-5 days and at 20-22 °C the average life span is 10.5 days. Generally, the larvae become adult after 0.5 to 1.5 days at 25°C and then the females start to lay eggs approximately every four hours. It is believed that females can produce ten generations of offspring and then die.

The *Brachionus* spp. can reproduce in two different mode of reproduction i.e., both sexually (mictic) and asexually (amictic), depending on the conditions, environmental and also on the rotifer density of the population. During female parthenogenesis, the amictic females produce amictic (diploid, 2n chromosomes) eggs which develop and hatch into amictic females. Under specific environmental conditions the females switch to a more complicated sexual reproduction resulting in mictic and amictic females. The mictic females produce haploid (n- chromosomes) eggs. Larvae hatching out of these unfertilized mictic eggs develop into haploid males. These males are about one quarter of the size of the female; they have no digestive tract and no bladder but have single testis filled with sperm. During the mictic mode, resting eggs are produced that will only develop and hatch into amictic females, after they are exposed to specific conditions. This is probably a mechanism to preserve the survival of the population even under unfavourable conditions

Rotifer culture

The process of rotifer culture can be divided in to 4 different phases.

- i. Maintenance of stock cultures
- ii. Inoculation phase: This phase is the start of new cultures based on inoculums from stock cultures, or more commonly from production cultures.
- iii. Early growth phase: It is the critical phase when food rations and rotifer density are increased gradually.
- iv. Late growth or production phase: It is the final phase, before harvest.

Maintenance of stock culture

Maintenance of stock culture is very important in rotifer culture, and it should be kept physically isolated from the production facility of microalgae, rotifers and other zooplanktons culture in order to avoid contamination and transfer of diseases. Algal cultures used to feed the stock cultures of rotifers must also be free from harmful contaminants. Contaminated algal cultures are most easily purified by plating techniques using solid agar. Stock cultures of rotifers can be maintained in small units (0.1-1 l) and the water used must be sterilised. A stock culture is prepared by transferring 5-10 ml of mature stock culture to a beaker 0.1 - 0.5 l of sterilised water. The cultures can be maintained at room temperature, but the feeding and renewal frequencies are lower if the rotifers are kept in the light at low temperature (7-10 °C). The stock cultures have to be renewed approximately once every month, or even less frequently at low temperatures. If all the stock cultures become contaminated by other zooplankton, single rotifers should be selected carefully under the microscope, and repeatedly washed in sterilised water, and then transferred to small units containing sterilised water and microalgae.

Rotifer culture methods

There are two general methods followed for culturing rotifers:

i. Batch culture: In this method, the given volume of water is added or exchanged each day and the culture is restarted at regular intervals.

Batch culture system normally follows a 4-5 day culture period. In batch culture method, a tank is inoculated with rotifers on day 1. The rotifers are then fed each day; accordingly the volume of the culture is also increased to keep up with rotifer growth. The maximum rotifer density reached in this method normally goes up to 500 rotifers/ml. At the end of the cycle, most of the rotifers are harvested and fed to fish larvae. However, some of the rotifers are kept aside from the harvest for the next tank inoculation. The duration of the cycle can be extended slightly by performing regular water exchanges once a high terminal density is reached. When culture duration is increased, removing 10% to 30% of the water volume on a daily basis can help to keep water quality within desired parameters, however, the culture will eventually need to be restarted due to the accumulation of uneaten feed.

ii. Continuous culture: Recirculation-based technology is employed in this method to increase the density of rotifers cultured while minimizing the need to restart cultures.

In continuous culture method, a supply of fertilized seawater is continuously pumped into a growth chamber and the excess culture is simultaneously washed out or harvested. This method permits the maintenance of cultures very close to the maximum growth rate using water recirculation. A typical rotifer recirculation system has units like culture tank, bio filter unit, protein skimmer, algal storage tank and pumps. This system employs a standpipe with 55 mm mesh screen located within the culture tank. The standpipe allows uneaten feed and ciliated protozoans to pass out of the culture tank when the rotifers are cultured in the tank. The waste coming out of the stand pipe travels through a biological filter and foam fractionators (Protein skimmer) before returning back into the culture tank. Flow rates in this type of system are typically two to five tank turnovers per day through the recirculation system. Daily maintenance for this type of system involves cleaning the screened standpipe and floc traps and removal of settled materials from the bottom of the tank. In general, a daily water exchange of 20-30 % of the culture volume should be incorporated for long-term maintenance. This culture method gives production maximum of up to 1,000 rotifers/ml.

Feeding of rotifers

Rotifers feed by grazing actively in the water column, feed on particles of approximately 1 to 10 µm in size. Many species of microalgae such as *Nannochloropsis* sp., *Pavlova* sp. and *Isochrysis* sp. etc, are good food for rotifers. In addition, there is a number of artificial feed like yeast; algae based rations and other organic feeds are suitable for rotifer culture. Activated baker's yeast has been used successfully as an inexpensive grow-out diet when fed at approximately 0.5g/ million rotifers. However, use of yeast along with microalgae gives better growth. It is important to note that the diet that is devoid of beneficial amino acid, fatty acids and lack certain vitamins is need to be supplemented in order to achieve maximal culture performance.

Water quality parameters in rotifer culture

The culture environment in the tank is one of the factors, which plays a major role in maintaining proper multiplication of rotifers. The water quality parameters such as salinity, temperature, dissolved oxygen, pH, ammonia need to be maintained and the optimum range of these parameters are follows.

Water quality parameters	Optimal Ranges
Salinity	10-35 ppt
Temperature	22-30°C
Dissolved oxygen	>4 ppm
pH	7-8.5
Total ammonia nitrogen	<5 ppm

Rotifer enrichment

Rotifer enrichment is an important aspect in marine finfish hatchery, because rotifer as such acts as carrier, and nutritional quality of the rotifer depends on the nutritional content of the feed supplied. Rotifers can be fed on a variety of small micron feeds and the resulting rotifers will have the nutritional profile of those feeds. There are several diets available for growing rotifers, but the best diets are marine microalgae. Marine microalgae contain the full spectrum of important nutritional components that is needed for larval development, including fatty acids (especially ARA, EPA, or DHA), sterols, carbohydrates, proteins, and vitamins.

The most commonly used algae for growing rotifers are *Chlorella* and *Nannochloropsis*, which provide high growth rates and healthy rotifers. However, *Chlorella* provides essentially no ARA, EPA and DHA. *Nannochloropsis* contains a high content of EPA, which can be converted to DHA by some fishes. Apart from this, *Isochrysis* is an important feed for rotifers, contains DHA which could be directly used by the fish larvae. However, many fishes require a good amount of DHA concentration in their feed, and to provide sufficient concentration, the rotifers must be enriched with other artificial feed/products that containing exceptionally high amount of DHA. There are different products available in the market for the purpose of enrichment; therefore, suitable products could be selected and used for enrichment. Some of the commonly used products

are products under AlgaMag (Bio-Marine) brand (AlgaMag Protein Plus, AlgaMag Red and AlgaMag- 3050), S. presso (INVE), Red Pepper (Bern Aqua), etc.

The last 12-24 hours of feeding are the most important for determining the nutritional value of the rotifer. This provides substantial enrichment by gut loading of the rotifer with the desired feed. Optimum time need to be identified for proper incorporation of enrichment media into the rotifer tissues and 8 hours of enrichment has been found to be optimum in different studies. Enrichment for more than 24 hours needs to be avoided because; this may lead to wastage of nutrients. Rotifer enrichment can be done in two methods i) The enrichment media can be directly added to the rotifer tank, that is planned for harvest in the next day or eight hours later. ii) The rotifers are harvested first and then the enrichment media added to the concentrated rotifers. The dose of enrichment media used depends on the manufacturer's recommendations.

Feed calculation/determination for rotifer

Generally, feed given to the rotifers depends on the number of rotifers present in the culture tank and number of rotifers needed to be harvested for feeding the fish larvae. Rotifer egg production is high for only the first 3-5 days of their 7-15 days (depending on temperature) of lifespan, so for the best production it is important to harvest at least 25% of the culture each day to keep the population young and reproducing vigorously. In a healthy culture, the number of rotifers produced each day directly corresponds to the amount of feed provided. If more rotifers are needed, the same harvest rate should be maintained and more feed should be added; if less number of rotifers required, less feed should be added to the tank. If feeding rate is changed, then rotifers will take 1-3 days (depending on the magnitude of the change in feed rate) for the culture to reach a new equilibrium and stabilize production.

Rotifer counts

For counting the rotifers, 20-25 ml of sample is collected from middle of the culture tank/near by the aeration where there is good circulation of the water and rotifers in the tank. Add few drops of formalin/vinegar to immobilize the rotifers in a relaxed state, mix and pipette 1 ml from sample onto a Sedgewick-Rafter counting slide, which is etched with a grid of 10 x 10/ 50x20. Count the rotifers in

the grid under microscope. Count the rotifers in the entire grid or middle of two grids and then multiply to get the rotifer in all the grids. The count obtained from Sedgewick-Rafter counting slide is for 1 ml, which is then multiplied accordingly to get the total count in the culture tank. Counting rotifers daily will give the exact stock of the rotifers in the culture tanks.

Important points to be considered in rotifer culture

- ◆ When starting a new culture, initial stocking densities should be e"200 rotifers/ml of culture water. Lower stocking densities will result in delayed start-up time and may help promote the growth of unwanted contaminants.
- ◆ Rotifers need a consistent supply of free algae in the water at all times, allowing them to graze continuously. Therefore, frequent feeding need to be given in less concentration, so that feeds could be efficiently utilised and wastage also avoided.
- ◆ Batch culture method may be extended up to 6-7 days and during this period bottom should be siphoned at least once to avoid the building up of ammonia in the culture environment.
- ◆ Rotifers harvested between 4-5th day after inoculation gives maximum numbers in batch culture method.

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- <http://216.25.82.220/Rotifer.PDF>, Online scientific article on mass culture of rotifers.