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INTENSIVE LARVAL REARING OF MACROBRACHIUM ROSENBERGII IN RECIRCULATING SYSTEM

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ABSTRACT

Growing ponds for the freshwater prawn Macrobrachium rosenbergii are most of the time far from the sea, and good quality fresh or sea water may also be in short supply seasonally. With an open system with water exchange every day the hatcheries have to be located near the sea whereas closed systems allow to set free from environmental conditions, and have been developed in Tahiti (Centre Océanologique du Pacifique) in collaboration with the ORERO (Office de la Recherche et de l'Exploitation des Ressources Océaniques formerly Fisheries Service).

The development and the use of a recirculation system for larval culture of freshwater prawn is described. Biological and economical results are presented.

In spite of its small size (less than one liter for ten liters of tank), the biological filter allows the production of more than fifty post-larvae per liter in thirty five days on average, without water exchange

INTRODUCTION

The Macrobrachium program was initiated in Tahiti in 1973 as a cooperation between the CNEXO (Centre National pour l'Exploitation des Océans, french state agency) and the French Polynesia Territory represented by the ORERO (Office de la Recherche et de l'Exploitation des Ressources Océaniques, formerly Fisheries Service). Studies were performed in the COP "Centre Océanologique du Pacifique" at VAIRAO, in Tahiti island.

Till 1976 the studies were carried out at experimental scale and an original technology in open-system was designed (Aquacop, 1977 a). Technical feasibility was determinated from 1976 to 1980 in pilot scale (Aquacop, 1977b) and economical feasibility in the 1978-1981 period (Aquacop 1979 c ; 1980 d).

As far as 1980, the first experimentations started in closed-system.

This technology utilizes biological and mechanical filtrations. It allows to set more free from difficult conditions as :

- growing ponds far from the sea ;

- incertain water supply ;

- energy dependence,

and to increase the production capacity of an open system hatchery without multiplying the needs of water and energy. In Tahiti two closed-systems have been tested, and one of them runs nowadays in routine production for the local farms needs.

MATERIAL

1) Hatchery : Post-larvae productions have been worked out inside a 200 m2 closed hatchery oriented N/S, with opaque roof, concrete walls and large windows (fig. 1). The larval rearing tanks are placed along the wall to obtain a good light intensity inside the tanks. The brackish-water is prepared and stored into 4 polyester 10 m3 tanks : two for the brackish water preparation and treatment, two for the storage (open system).
Among the 9 rearing tanks, placed along the west-side, 6 are utilized for the closed-system and 3 for the open-system.

2) Tank design : Two types of tanks already described are utilized :

- the 2 m3 cylindro-conical tanks are polyester moulded (fig.2) ;
- the U-shaped 5 m3 tank is constructed with fiberglass sheet, plywood and galvanized iron supports (fig.4).

3) Closed-system components : Two closed systems run in the hatchery since 1981 .

3.1. U-shaped 5 m3 unit

The main elements are :

- mechanical filter : a plywood box (1.30 x 0.70 x 0.50m) containing 65 L of sand (0.1 mm in diameter) ;
- biological filter : a partionned plywood box (1.30 x 0.65 x 0.60m) containing 150 L of coral pieces (3 to 5 cm in diameter fig.3) distributed in net bags (volume 10L mesh 1cm).
  Water passed through the sand filter where it is pumped and injected into the biological filter (fig.4).

3.2. 2m3 Units (fig. 5,6 & 7)

They include :

- a cylindrincal flat bottom 2 m3 collecting-tank receiving waste water from the rearing tanks and the overflow from the biological filter ;
- a pump injecting water from the collecting-tank to the sand-filter ;
- a swimming pool sand filter (30 kg sand, 0.1 mm in diameter) working at a water pressure of 0.8 bar ;
- a biological filter : this filter is a partitionned box (1.8x1.3x0.50m) containing 450L of coral pieces distributed as previously described (fig.6).

METHOD

The open-system technology has been described in detail elsewhere (Aquacop, 1977 b,c ; 1982). In closed-system the main steps of the larval-rearing procedure remain quite the same than in open system ; water exchanges and artemia distribution time are the only differences.

Summary description :

- Salinity (table 1)

  Day 1 to Day 3 : Salinity increases gradually from 5 p.p.t. to 12 p.p.t. by addition of brackish water without water exchange.

  Day 4 to Day 25: Water recirculation starts and runs until Day 25.

Day 25 : Decrease of salinity from 12 p.p.t. to 10 p.p.t. by a partial water-exchange, biological filter included (the inner side of the rearing tank is cleaned).

Day 30 : First post-larvae cropping and decrease of salinity to 8 p.p.t. for remaining larvae into the rearing tank until Day 38-40 (second and last post-larvae cropping.)

- Temperature :
  In closed-system, rearing temperature is nearly constant.
  In Tahiti, during the warm season, it is not necessary to heat the hatchery : the rearing temperature remains between 30°C and 31°C (October to March).
  During the cold season, heating becomes necessary : hot fresh water comes from the cooling circuit generators. It is used as a fresh water source and for heating the hatchery.

- The turnover of water is once every 6 hours for a 2m3 tank (flow rate : 5L/mn) and every 2 hours for the 5m3 tank (flow rate : 40L/mn).

- Feeding (table 2)
  Artificial food and artemia nauplii are utilized. Compound pellets are given at day time from the 12th day, without stopping the water recirculation ; the amount is given in accordance with table 2.

- The recirculation water is stopped during the newly hatched artemia distribution (from 1 P.M. to 4 P.M.).

Two or three productions can be done continuously without stopping and cleaning the biological filter. After that, the hatchery is washed, and kept empty and dry for a week (sanitary break). The biological filter is reinoculated with ammonium salt and then another mass production can start.

- Antibiotic treatment: No treatment is necessary in the closed-system larval rearing.

RESULTS

The biological filter maintains a good water quality with regards to bacterial level as well as ammonia and nitrite concentrations :

- the bacterial level (total population) decreases 10 times after 15 hours of recirculation and remains less than 10 bacterial/ml ;
- the residual concentrations of ammonia and nitrite are less than 0.3 mg N/l ;
- the nitrate level is more than 5 mg N. NO_3 /l and pH decreases from 8.2 to 7.8 with no observed effect on larvae.

The post-larvae production has gradually increased from 13 000 PL in 1973 to 5.2 $\bar{M}$ in 1982 (fig.8). The 5 m3 experimental closed-system unit has produced more than 1.5 $\bar{M}$ PL in 8 trials since the end of 1980. The 2 m3 closed-system unit, running since June 1981, experimentaly for the first trials, then for the production, has produced more than 4.5 $\bar{M}$ PL.*

Table 3 shows the results in the 3 types of larval-rearing. The open system globally gives better results than the closed systems (survival, duration and PL/L table 4) but the apparently "worse results" of the 2 m3 rearings in closed system have to be correlated to a poor artemia quality at the time of the experiment. Recent data shows clearly that survival in closed system is comparable to the one obtained in open-system, pointing out that the principle of the method is good.

The results in the 2 m3 closed-system unit (west-side of the hatchery) are better than those in 5 m3 unit (east-side of the hatchery). We think that, the shape and the capacity of the 5 m3 tank , associated with the exposure to light and insufficient bubbling-aeration are responsible of the heterogeneous repartition of larvae. Thus the consumption of the food is not the same for each one. This is proved by the following observations :

- The "IR" (repletion rate of stomachs in percentage) varies widely in the 5 m3 tank from one place to another.
- The heterogeneity of the larvae size at the same larval-stage.
- The long displaying of metamorphosis (at day 30, 30% in the 5 m3 unit instead of 50% in the 2 m3 unit on average).

Concerning the exposure to light, trials have been performed with 800 liters tanks and it has been observed that the results of those placed on the west-side of the hatchery are better than those on the east-side.

In the 5 m3 U-shaped tank, bubbling aeration is sufficient to distribute the larvae till Day 12, afterwards the larvae get stronger and swarm.

* PL : post-larvae.

DISCUSSION

We view to fit out the hatchery entirely with closed-systems. Now and hence forth the fact of converting six 2 m3 open-system tanks into closed-system has awared us of really possible economies.

1) Hatchery staff :

Nowadays the hatchery of Tahiti operates with 1 biologist, 1 technician and two workers, and produces post-larvae for the local needs and for experimentations.

A 10 $\bar{M}$ PL/year production hatchery, in 2m3 units, would require (8 production cycles yearly):

. in open-system :
- 1 biologist
- 1 technician
- 5 workers.

. in closed-system
- 1 biologist
- 1 technician
- 3 workers.

In closed-system, neither water exchange, nor tanks cleaning, nor brackish water preparation are to be operated daily but each squad is recommended because of the normal five days and occasional absenteeism.

2) Material & Water :

According to a projected production of 10 M/PL yearly, the volume of storage brackish water basins is 80 m3 in open-system and 40 m3 in closed-system.

Table 5 shows that the turning of closed-system leads to save more than 90% of brackish water. One third of total water is utilized for artemia hatching.
A recycling of artemia hatching water would be interesting : in that case, 3 m3 of brackish water would be enough.

3) Energy :

With regards to the tahitian climatological conditions, a production hatchery entirely in closed-system, would save :

- 25 % of heating energy
- 60 % of pumping energy, the main quantity of it being devoted to the brackish water processing and storage.

4) Larval-rearing duration :

The larval rearing duration depends greatly on the artemia quality : hatching rate, hatching time (newly hatched artemia - 24h to 30h contain more reserves than the older-48h).
A poor artemia quality induces a long displaying of metamorphosis : the fastness of the metamorphosis is tightly bound to the good feeding with artemia, particularly during the first 18 days.

In a well feeded larval rearing, 85 % of post-larvae are obtained in 30 days in only one harvesting.
If artemia quality is poor, two or three harvestings are necessary ; post-larvae rate is worse (55%) and rearing duration is longer (45-50 days).

The operating production cost in open-system shares among three items :

- staff	: 67.5 %
- food	: 14 %
- pumping-energy	: 10.2 %
- heating energy	: 8.3 %

The closed system utilization involves the saving of 28.5 % of staff cost, 60% of pumping and 25 % of heating.
Table 6 gives the operating costs for 1000 PL in Tahiti for the two systems.

CONCLUSION

The closed system larval rearing in 2m3 units is satisfying. Nowadays the artemia quality seems to be the main stumbling block for obtaining routinely the best results.

The assays in greater volumes have pointed out the heterogeneous larval repartition, and the difficulty to get rid of it.

A new 5 m3 tank shape, is on the verge of being tested to avoid the swarm larvae genesis.

From now on, in Tahiti hatchery most of the tanks are utilized in closed system and prove the economical reliability of this technology : the operating production cost of post-larvae in closed system is 30 % less expensive than in open system.

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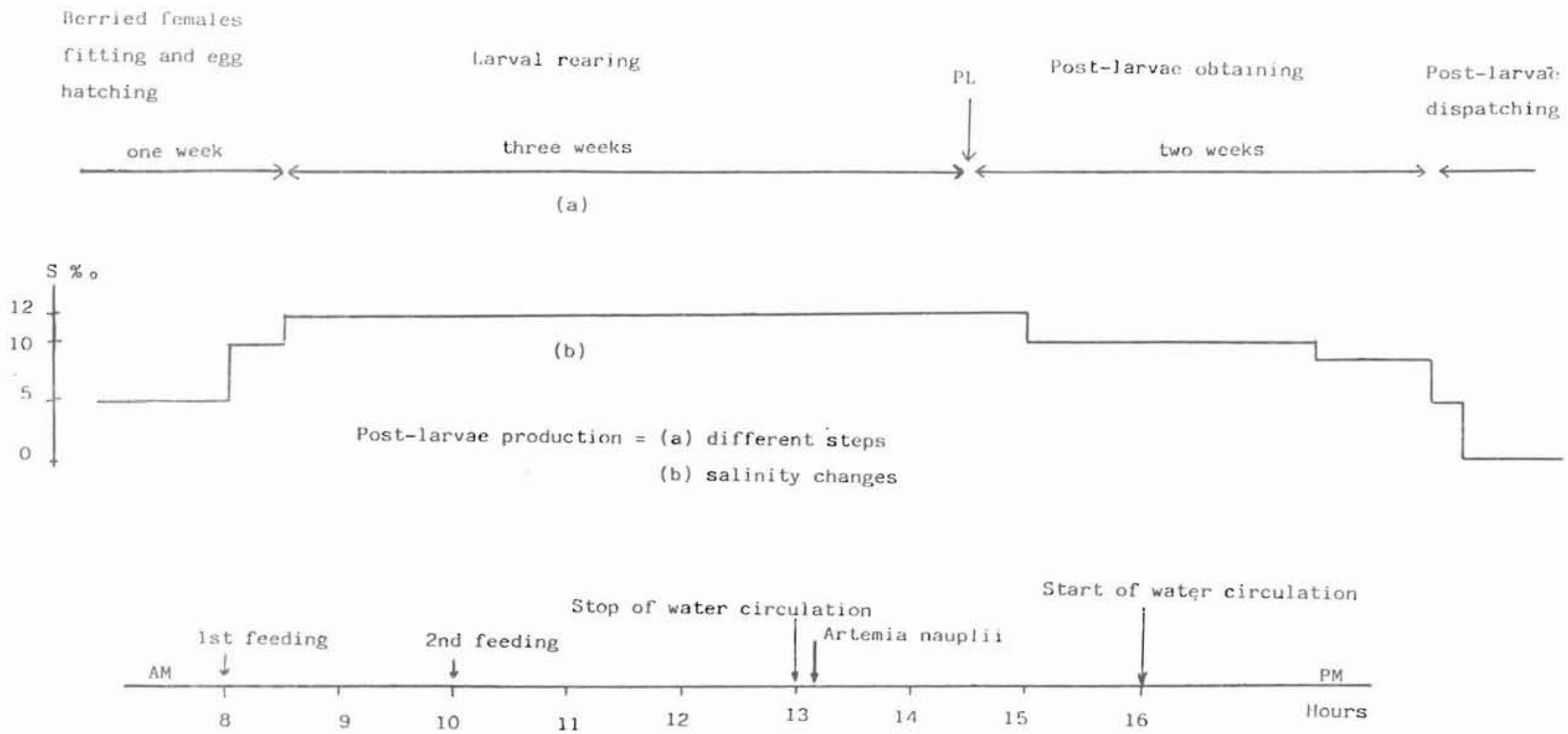


Table 1. - DIFFERENT STEPS OF MACROBRACHIUM POST-LARVAE PRODUCTION

Table 2. - VARIATIONS OF FOOD AMOUNT/LARVAL/DAY DURING LARVAL REARING.

Day	Artemia nauplii	Pellets (microgram) dry weight
3	5	0
4	10	0
5-6	15	0
7	20	0
8	25	0
9	30	0
10-11	35	0
12	40	70
13-14	45	80-90
15-24	50	100-180
25-30	45	200
30-+	40	200

Table 3. - RESULTS OF 3 TYPES OF LARVAL REARING - TWO YEAR AVERAGE VALVES

PRODUCTION			5 m3 Tank in Closed system			2 m3 Tanks in Closed System				2 m3 Tank in open systems			
			Post Larvae Rate	Number of P.L.	Number of days	Post-larvae Rate	Number of P.L.	Number of days	Number of 2m3 tanks	Post-larvae Rate	Number of P.L.	Number of days	Number of tanks
80	81	2	30 %	96 000	36								
80	81	3	54 %	202 000	36								
80	81	4	58 %	248 000	29 -								
80	81	6	85 %	323 000	39 -	64 %	407 500	31	4	88,6 %	168 300	30	1
81	82	1				64,5%	495 000	33	4				
81	82	1a				58 %	235 500	38	2				
81	82	1b				45 %	330 000	41	4				
81	82	2	55 %	210 000	40	82,5%	507 900	36	3	70 %	112 500	35	1
81	82	3	39,5%	178 000	51	56,5%	511 250	42	5	67,3 %	410 500	40	3
81	82	3a				58,6%	128 850	44	1				
81	82	3b				45 %	330	41	4				
81	82	4	45 %	202 500	40	78,8%	323 300	32	2	73,9 %	464 400	34	3
82	83	1	45 %	202 800	47	58,8 %	597 400	46	5	60 %	409 700	47	3
82	83	2				84 %	657 300	40	5	81,7 %	255 000	39	2
			51.4 %	1 663 000	39.5	65 %	4 194 000	38.5		73.6 %	1820 000	37,5	
			41.5 PL/l.			56.7 PL/l.				70 PL/l.			

SYSTEM	SURVIVAL %	DURATION (DAYS)	POST LARVAE PER LITER
OPEN	73.6	37.4	70
CLOSED $2m^3$	65.	38.3	56.7
CLOSED $5m^3$	51.4	39.5	41.5

Table4. RESULTS OF THREE TYPES OF LARVAL REARING . TWO YEARS AVERAGE VALUES.

	OPEN SYSTEM	CLOSED SYSTEM
BRACKISH REARING WATER 12‰	$1600 m^3$	$70 m^3$
ARTEMIA HATCHING WATER 15‰	$30 m^3$	$30 m^3$

Table5: BRACKISH WATER NEEDS FOR 1.250M POST LARVAE (1 CYCLE)

ITEMS	OPEN SYSTEM	CLOSED SYSTEM
STAFF	6.61	4.73
FOOD	1 37	1.37
PUMPING	1.00	0.39
HEATING	0.82	0.61
TOTAL OPERATING COST	9.80	7.10

Table 6 OPERATING PRODUCTION COSTS IN $ US FOR 1000 POST LARVAE

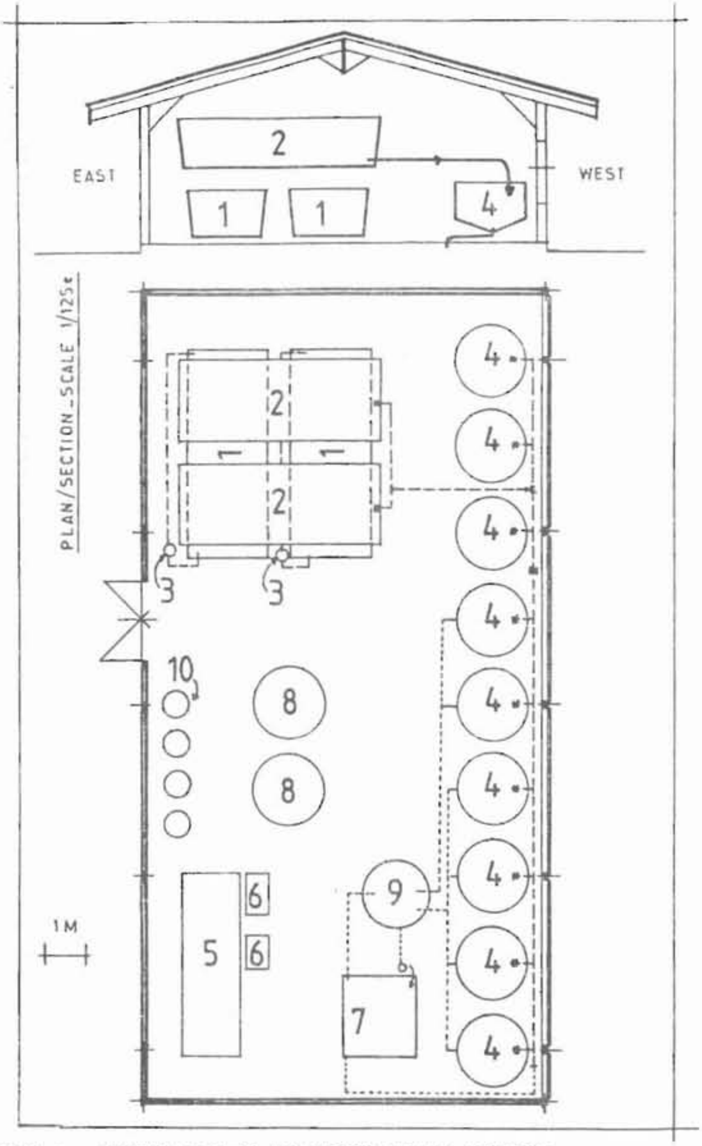


FIGURE 1 : GENERAL PLAN OF THE MACROBRACHIUM HATCHERY

1 : Tanks for the preparation and treatment of brackish water (2 x 10 m3)

2 : Storage tank of brackish water (2 x 10 m3)

3 : Swimming-pool filters

4 : Larval rearing tanks (9 x 2 m3)

5 : Larval rearing tank (5 m3)

6 : Biological filter for the 5 cubic meters tank

7 : Biological filter for four 2 cubic meters tanks

8 : Tanks for spawners and post-larvae storage

9 : Collecting tank

10 : Artemia hatching tank

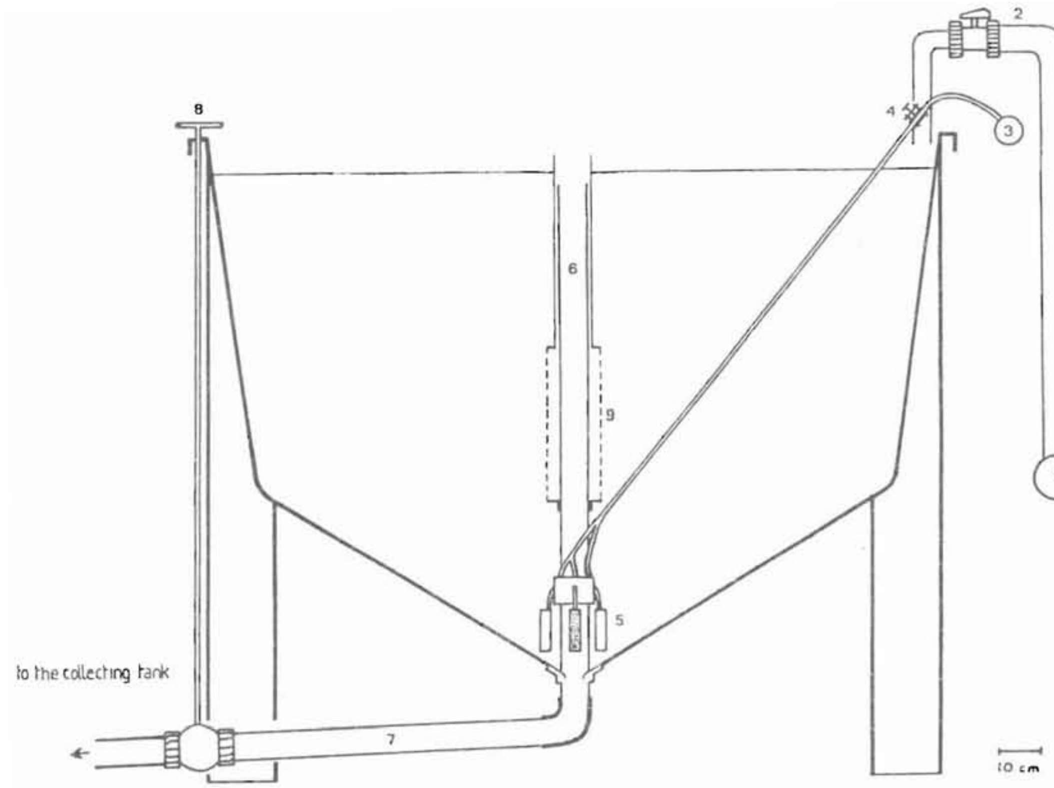


FIGURE 2 : TWO CUBIC METERS LARVAL REARING TANK (STATIC SYSTEM)

1 : Brackish water pipe

2 : Water-gate

3 : Air pipe

4 : Mohr clip to adjust air flow rate

5 : Air stones

6 : Closing pipe

7 : Draining pipe

8 : Operating lever of the water-gate

9 : Plankton mesh.

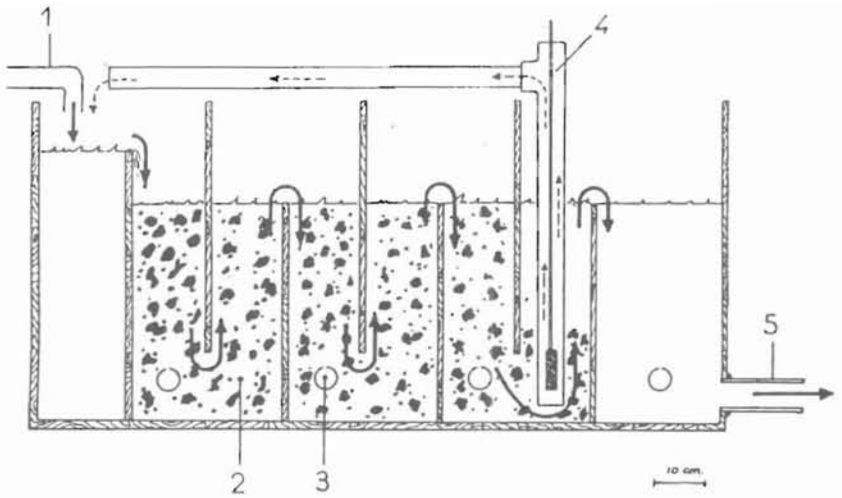


FIGURE 3 : SCHEMA OF THE BIOLOGICAL FILTER USED WITH 5 CUBIC METERS LARVAL REARING TANK

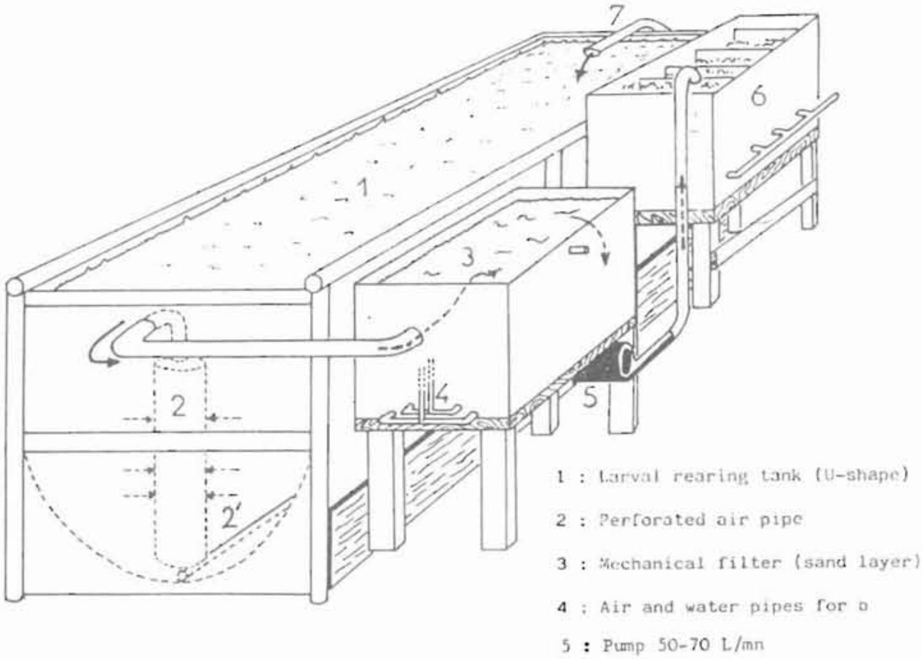
1 : Water inlet

2 : Coral gravels

3 : Aeration pipe

4 : Air lift for secondary recirculation

5 . Water outlet.



1 : Larval rearing tank (U-shape)

2 : Perforated air pipe

3 : Mechanical filter (sand layer)

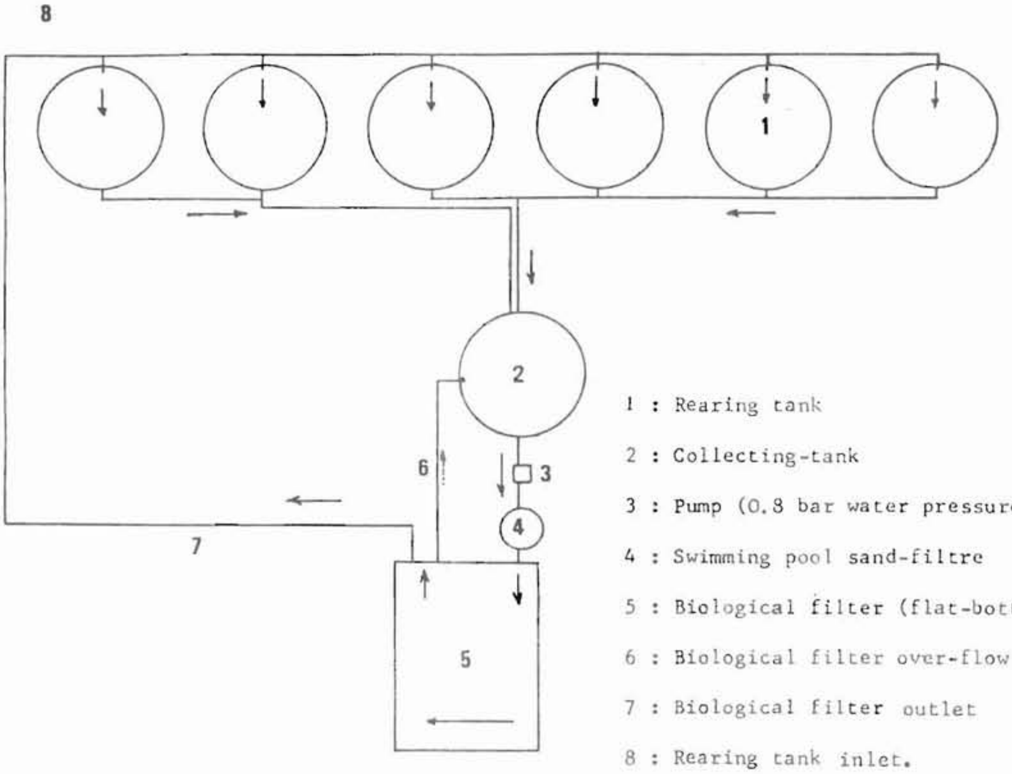
4 : Air and water pipes for o

5 : Pump 50-70 L/mn

6 : Biological filter

7 : Water outlet

FIGURE 4 : FIVE CUBIC METERS LARVAL REARING TANK AND RECIRCULATING SYSTEM



1 : Rearing tank

2 : Collecting-tank

3 : Pump (0.8 bar water pressure)

4 : Swimming pool sand-filtre

5 : Biological filter (flat-bottom)

6 : Biological filter over-flow

7 : Biological filter outlet

8 : Rearing tank inlet.

FIGURE 5 : SCHEMA OF THE 2 m3 UNITS IN CLOSED SYSTEM

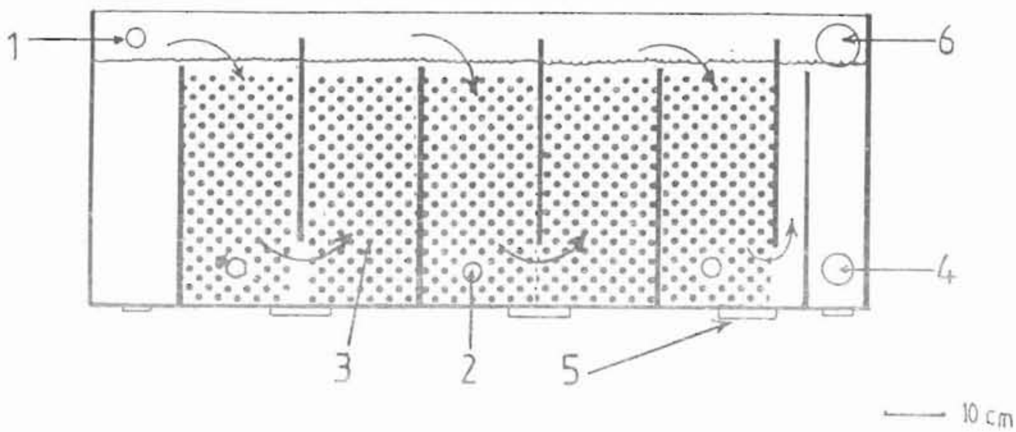


FIGURE 6 : SCHEMA OF BIOLOGICAL FILTER USED WITH THE 2m3 LARVAL REARING TANKS.

1 : Inlet

2 : Coral gravels

3 : Aeration pipe

4 : Water out-let

5 : Draining cap.

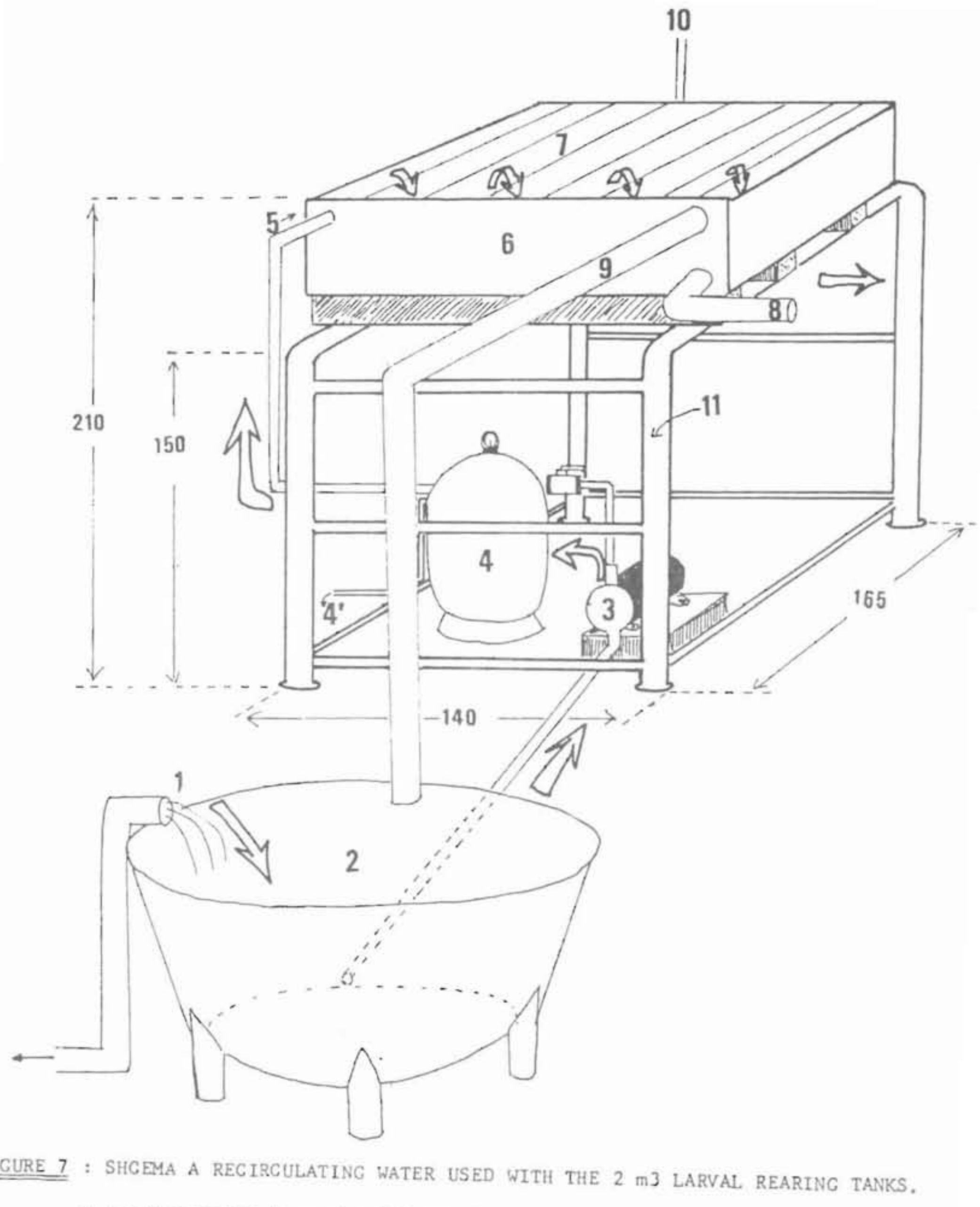


FIGURE 7 : SHCEMA A RECIRCULATING WATER USED WITH THE 2 m3 LARVAL REARING TANKS.

1 : Waste water from the 2m3 rearing tanks

2 : Collecting tank

3 : Pump

4 : Swimming pool sand filter

5 : Biological filter inlet

6 : Biological filter

7 : Coral gravel location

8 : Biological outlet

9 : Biological filter over flow

10 : Aeration pipe

11 : Galvanized iron supports.

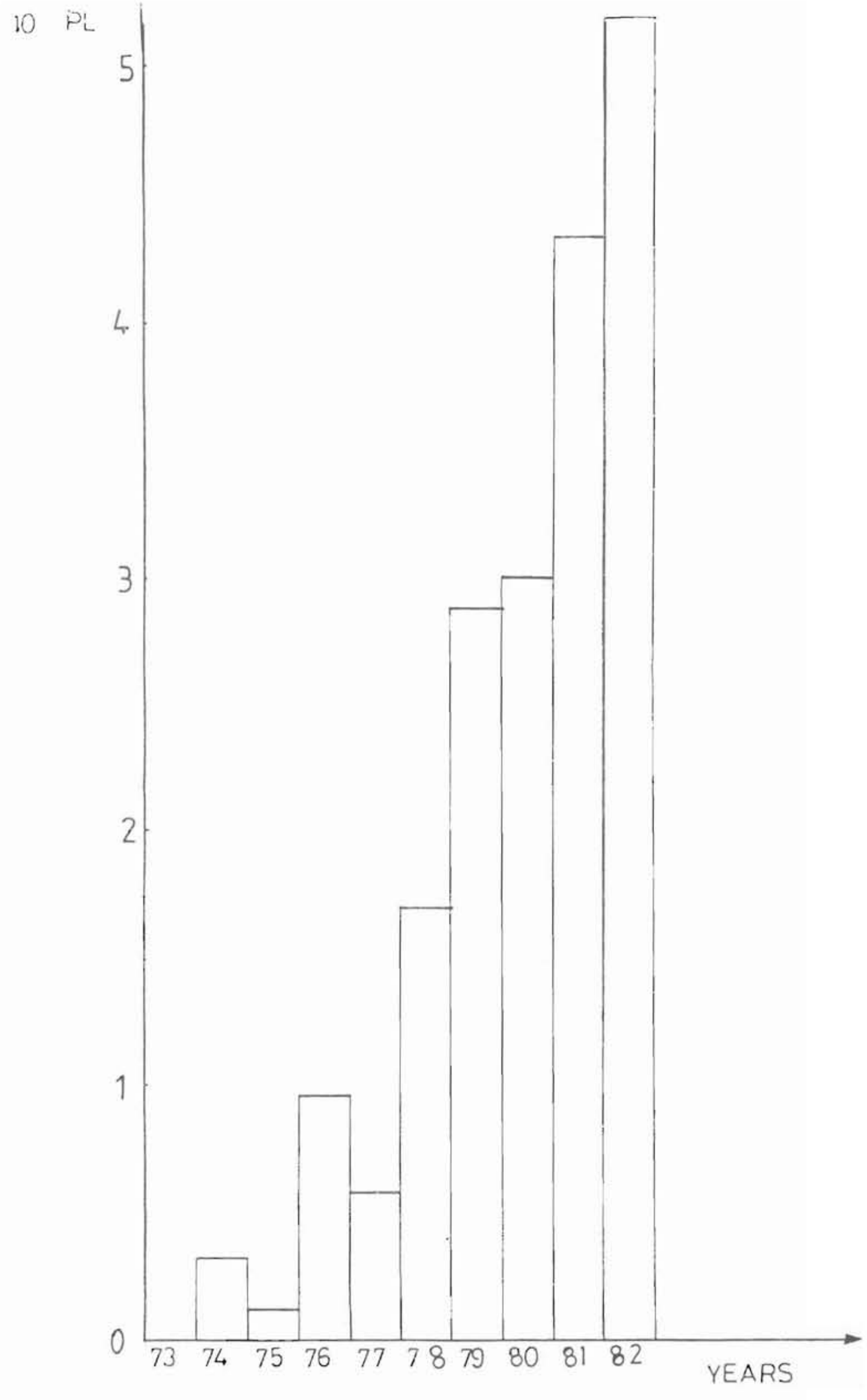


Fig 8_ POST. LARVAE PRODUCTION IN TAHITI