Macrobrachium rosenbergii culture in French West Indies and French Guiana :

"Validity of the Continuous Grow-out System as a mean of Development".

D. LACROIX, JM. GRIESSINGER, JC. FALGUIERE and TH. POLLET.

Started by the end of the 70's, the development of Freshwater Prawn Culture (*Macrobrachium rosenbergii*) in the French West Indies (Martinique and Guadeloupe) and in French Guiana, reached in 1987 a significant level with 150 ha of ponds exploited by 80 farmers. The present production of 170 metric tons meets the needs of the local market and allows exportation to France.

The continuous grow-out rearing method, adapted from the traditional Hawaiian technique, was generalized to these 3 regions. The post-larvae stocking sequence has been adapted in order to get a steady production over the years. A theoretical model is used by technical assistance teams as a reference to help farmers to apply this method. Results thus obtained are presented.

Advantages and limits of this method are discussed. Improvements are proposed and compared to other recent population management models. The continuous grow-out method turned out to be an excellent way of developing Freshwater Prawn culture.

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INTRODUCTION

Macrobrachium rosenbergii culture was introduced to Martinique and Guadeloupe (French West Indies) to diversify the agricultural economy and to satisfy local market demand, and in French Guiana as part of economic development plans. For this reason a product with necessary qualities for exportation to France and EEC was needed.

Started by the end of the 70's, this culture reached in 1987 for these 3 regions, a production over 170 metric tons for a total pond surface of 150 ha, corresponding to 80 farms (farm size ranging from 1 to 30 ha). Most of the time it is practiced as a secondary activity of traditional farming (nevertheless half of cultured areas are hold by a few specialized farms). Table 1 shows its evolution since 1980; the regular increment of cultured surfaces requires to adjust productions to the areas seeded the year before.

This development has been assisted by IFREMER's subsidiary, FRANCE - AQUACULTURE, present in Martinique and French Guiana since 1979. A contractual organization with professional structures has been obtained from the outset of prawn culture in each region.

The culture origin, in the West Indies-Guiana region, is situated in Martinique in 1976 (LACROIX et AL., 1983), under the initiative of local economy responsibles. The applied culture system was the Fujimura method (1974), developed to exploit a population of Macrobrachium rosenbergii, characterized by an heterogeneous growth animal rate. It is based on a regular harvesting of animals reaching market size (30-45 g) to let remaining animals grow into the size classes left by the largest ones.

The system is kept in constant operation by periodical introductions of post-larvae into the pond.

This original method was progressively adapted to the local context, since 1979, to optimize and to stabilize the production in time. Principal points of research have been :

- identification of an optimal quantity of post-larvae to stock all through the year (18 PL/m²),
- elaboration of a stocking sequence to obtain a regular production,
- determination of a feeding rate (AQUACOP, 1986).

This method has shown to be a good popularization instrument of freshwater prawn culture : easily applicable, no sophisticated equipments or qualified labour are required to get satisfactory yields. The adaptations and principles, practical application and an example showing the obtained results, are presented. Its advantages, drawbacks and the way to improve yields are discussed in relation with other culture methods recently developed.

I. DESCRIPTION OF THE CONTINUOUS GROW-OUT SYSTEM ADAPTED TO THE WEST INDIES AND FRENCH GUIANA REGIONS

1.1. Origins and principles

FUJIMURA method has been utilized in Martinique since 1977. It was caracterized by an initial stocking of 15 PL/m², followed by a 1st restocking right afer 1st harvesting, around the 8th month, of a number of PL twice the one of harvested animals. Following restockings were done according to the same principle, every other month.

Results systematically showed from the 12th to the 20th month an important drop in production. After studying all the hypothesis that could explained this phenomenon, we discovered that the problem was bound to pond population structure. The idea of realizing the first restocking the 4th month, i.e. before the 1st harvesting in order to eliminate this production lowering 8 or 16 months later, first appeared in 1979 and was immediatly applied.

The problem was effectively resolved and researches were directed to the elaboration of a stocking sequence model to regulate production. This model was created progressively by the analysis of Martinique culture results, which had shown :

- that optimal stocking rate should be 18 PL/m^2 all trough the year,
- that the maximal time interval between 2 stockings should be 4 months to maintain a constant production. This frequency has the advantage, compared with shorter ones, that successive cohorts can be followed by population samplings to analyze culture development.

In a same way, a production curve of a single cohort selectively (25 mm mesh-side) and regularly harvested (every other week), obtained under the conditions of Martinique (Fig. 1), was used to build up the French West Indies/Guiana continuous grow-out system (Fig. 2).

The addition of each cohort yield gives a global stabilized production of 3 T/ha/year. Restockings take place every 4 months at a rate of 6 PL/ m^2. This sequence was modified in the first year of culture to optimize the available surface and to start production as soon as possible. In this way the beginning of sequence was defined as 9 - 4 - 5 : initial stocking of 9 PL /m^2; 4 months later a first restocking of 4 PL/m^2 and 4 months later a second restocking of 5 PL/m^2 to obtain a total of 18 PL/m^2. The third restocking is realized at the beginning of the 13th month.

The forward mouvement of the successive cohorts is verified by size frequency histograms (Fig. 3), which show the progressive advance of first cohorts up to commercial size (115 mm from eyestalk to tip of telson), but also the implantation, within the culture, around the 20th month, of a virtually permanent population, the "productive stock". This population, once constituted, ensures a regular production of homogeneous size animals (20 to 25 prawns/kg).

1.2. Application

In its practical application this exploitation method meets, at its normal production level, both the common requirements of other methods as the batch system than its own requirements.

1.2.1. The common requirements deal with culture medium and feed. Indeed

we cannot expect to get good yields if the parameters, as dissolved oxygen for example, are not within the suitable limits for freshwater prawn, or if the feed has an inedaquate nutritional composition and a low water stability.

In practice, the farmer must correctly manage the ponds by the interpretation of the physico-chemical parameters and has to watch over the quality of feed and its homogeneous distribution.

1.2.2. Its own requirements are linked to the nature of the system which is based on a long period of culture (4 - 5 years) without draining the pond. These needs essentially concern the control of the "ageing" of pond, stocking and harvesting.

1.2.2.1. The pond gets old by the accumulation of organic wastes. These wastes essentially come from the bad water stability of pellets (optimal stability time : 6 H), which easily crumble and reduce the prawns alimentation possibilities. Their degradation beeing slow, regular feeding creates a bottom accumulation with inherent dissolved oxygen problems (D.O lower than 1 mg/l). The farmer will observe a production fall and a general deterioration of harvested animals, manifested by shell necrosis (Black spot disease, Brock 1983). To avoid this situation, the farmer has to take care of the pellets quality (water stability), control its consumption (bottom observations), determine the dissolved oxygen concentration in the pond and make regular water renewals.

The installation of sedimentation tanks, frequently practised in French West Indies, reduces the suspended mineral matter inflow which accelerate the ageing of ponds. Farmers can eliminate the bottom sludges by aspiration (succion pump), a common practice in Martinique where a lot of ponds have been producing for more than 4 years without any draindown.

1.2.2.2. Post larvae ($\bar{w}$ = 15 mg) are directly transfered into earthen ponds and mixed with the resident population. This transfert gives rise to important losses principally due to fish predation and high pH values (higher than 9).

Fish must be systematically controlled, especially in the continous grow-out system ponds where they can proliferate in time. The farmer has to realize a permanent filtration of the water supply (0,5 mm mesh) and if necessary, apply a rotenone treatment (0.07 to 0.20 mg/l of a 5 percent formulation depending on water pH, T° and hardness). Any stocking into ponds containing fish must be avoided.

At high pH values (9 or greater) post larval mortality occures (L. Sarver et al. 1979, Hummel, 1986). These values coincide with phytoplankton blooms (green waters) and are produced by CO_2 consumption during photosynthesis. They are even higher (10 or more) and their variation are more important when the bicarbonate system of water is weak (L. BOYD,1979) general case of the acid waters of French Guiana.

The farmer must carefully control pH values. In practice, an augmentation of water renewal is frequently utilized to diluate phytoplankton. If that is not enough, an herbicide treatment may be applied. In such case, the Clarosan CIBA GEIGY at 0.02 mg/l (AQUACOP, 1979) seems to be very efficient.

An absolute control of stocking success is not possible. The farmer can utilize a survival cage test (similar to the 72 hours bag test described by MALECHA, 1983) to estimate post larval stocking mortality. An acclimatation period is suggested to avoid thermal shocks due to medium transfer.

1.2.2.3. Harvesting is of fundamental importance in the application of the system :

- it has to be made punctually, at constant time intervals (10 - 15 days) in order to obtain a regular translation of animals until harvest-size,

- it has to be efficient, that means that all market-sized animals have to be fished out of the pond. Inefficient harvesting allows a growth suppression of smaller animals by larger ones, represented by dominant blue-clawed males;
- it has to be selective, i.e. to cull the market-sized animals without harvesting sub-marketable animals or yields are significantly lowered;

Net selectivity is not applied to the earliest blue-clawed males that appear in the population which are smaller than marketable prawns (Ra'Anan 1982) and have to be eliminated regularly because they suppress growth of smaller animals.

In this way, a population continuously managed, under a regular, selective and efficient harvesting operation, should not present blue-clawded male. This dominant morphotype reveals an inefficient culture control.

The farmer can realize a double-harvesting if he is not sure of the fishing efficiency; he can also utilize size grading cages (22 - 25 mm mesh side), to increase selectivity. Population sampling (size frequency histograms) could be done before and after harvesting to estimate fishing efficiency.

The work of the harvest crew is of the highest importance for farm results. Nets are made of light materials (polyethylene twine). In order to maintain the net sealed against pond bottom, lead lines must be used. A synthetic mudline, coating the lead line, prevents the net from cutting into the mud.

II. EXAMPLE OF OBTAINED RESULTS

The example of a 3.3. hectare farm, built in a banana plantation is chosen. Ponds were filled in 1983 and are still in 1987, exploited with the continous system without draining. It is located on the East coast of Martinique. The site, exposed to trade winds, is well aerated; soil is sandy loam that induced percolation during the filling. The farm is composed of 8 gravity filled ponds, ranging from 2 500 to 5 200 m². A decantation tank has been added to the water supply. Water renewal in ponds averages 10 percent per day. Mean characteristics of river water are :

- temperature	25.2° C
- pH	7.5
- dissolved oxygen	7.2 mg/l
- alkalinity	37 mg/l of $CaCO_3$
- total hardness	50 mg/l equivalent $CaCO_3$.

The main physico-chemical parameters of rearing water are as follows (minimum recorded, average calculated and maximum recorded) :

- bottom temperature (evening)	24.2 -	28.3 -	31.9° C
- surface pH (evening)	7.4 -	8.5 -	9.1
- dissolved oxygen on bottom	1.1 -	4.9 -	7.5 mg/l.

Stockings follow the sequence previously described. Feed is locally processed, according to a formula elaborated by IFREMER (Proteins 28 %, fat content 5 %, minerals 12 - 14 %, moistness 10 - 12 %, synthetic binder 1 %). Feeding ratio is the one proposed to all the prawn farmers in French West Indies and French Guiana by technical assistance teams. It has been calculated from biomass evolution (taking harvesting and a steady mortality in account) and a feeding rate ranging from 5 the first month of rearing to 1 the 16th month. This table is shown in Table 2; through a regular observation of food consumption, the farmer adapts this table to population needs.

Harvest is made twice a week (an average of 2 ponds are fished, each pond being harvested every other week) by a crew of 4 people. A full time technician works on the exploitation helped by 3 part time farm workers. Double harvesting is systematically done.

Production data have been collected since the beginning by the local technical assistance team. Data presented in Table 1 have been reset at a same time origin (the farm has been in fact stocked over 5 months) and at the hectare of pond.

The first year, production was 865 kg/ha; the second year, it reached 2 990 kg/ha; the third year 2 940 kg/ha; the fourth year 2 670 kg/ha, i.e. an average of 2 366 kg/ha year since the beginning of the farm.

The drop in production during the fourth year seems to be linked to the ageing of ponds that silt up. Mud siphoning was done from the beginning of 1987 and production went up, in accordance with previous years results.

III. DISCUSSION

The continuous rearing method, the traditional Hawaiian technique was the first method designed to rationally use the main characteristics of a *Macrobrachium rosenbergii* population, i.e heterogeneous individual growth (H.I.G.), in tropical regions with temperature ranging all year round from 25 to 30° C. The announced yield by FUJIMURA in 1974 was 3 300 kg/ha/year. Then other methods have been identified and developed to raise freshwater prawns in different climates, in Israel (Ra'Anan and Cohen, 1982) and South Carolina (Sandifer et al., 1983) where the favorable season is limited to a few months.

Advantages of the continuous system have been already described.

Its utilization in French West Indies and French Guiana emphasized the following points :

- concerning the production system, one pond is sufficient. Biomass is stabilized around 100 to 120 g/m² after the 16th month when the productive stock is constituted. Regular inputs (feed, water ...) and a constant biomass stabilize the ecosystem.

- as for rearing technique, the farmer smoothly manage, all year round, pond and population. He only manipulates commercial sized animals during harvesting. Restocking might be somewhat delayed with no real prejudice for future production, in case of irregular post-larvae supply.

- as for production, commercialized animals are large and homogeneous (20 to 25 prawns per kg); production is constant all year round.

These accepted advantages are supported by a significant development of the number of farms in the regions where this system was introduced (50 exploitations in Martinique in 1986).

Limits of the continuous rearing method are expressed in the fact that the raised population cannot be efficiently managed. Actually, the farmer knows for sure what he introduces and what he gets out of the pond. There is no possibility to evaluate the population during a long time, until final draindown. In the previous example, the ponds still have not been drained down after 4 years of production. The farmer can get an approximate knowledge of pond population through samplings giving a partial "picture" of population and through biomass evaluations. But in fact, only the large scale farms, rearing prawn as a main activity, can afford to systematically use these techniques.

MALECHA (1983) holds this lack of control responsible for the important differences between FUJIMURA'S previsions (3 314 kg/ha/year) and the observed results of the traditional method estimated to less than 2 metric tons/ha/year in Hawaiî.

One of its major drawback is that farm management can't be rigorously predicted, the stock beeing only guessed.

In order to sharply manage the reared population, a multi-stage rotational stocking and harvesting system was identified in Hawaîi (MALECHA et al., 1981).

Fish culture techniques must be used (fish pumps, "rotating cylinders" size graders) to get a quick and efficient handling of prawns during draindown. Perfected models would use many ponds (of at least 2 different surfaces, nursery pond, intermediate grow-out pond and final grow-out pond) to distribute graded sub-populations.

In the final grow-out phase,a "seine and cull" harvest would eliminate market-sized animals, as in the continous system. Non-marketable animals are sent back to a same pond to continue their growth.

For MALECHA et al. (1981), the advantage of this management system is, in addition to the control at short time intervals of the whole population, to benefit from behavioral characteristics of prawns :

- Heterogeneous individual growth (HIG) which appears very early within a population due to inter-age and size class competition (Ra'anan and Cohen, 1984)

- A compensatory growth is shown by small dominated individuals once the large dominant ones have been removed.

This second characteristic might be a drawback in the continuous system as culling of large size prawns is never 100 % efficient; remaining animals inhibate the growth of the rest of population (Ra'anan, 1982). Annual yield could reach 6 metric tons/ha with these management models (MALECHA personal communication).

Choosing a rearing method is based on the knowledge of effective results that can be obtained in standard conditions. Bad results are mainly due to a misapplication of the method.

A yield inferior to 2 metric tons/ha/year does not correspond to the real limits of the method. It shows that its application is imperfect either in managing environmental conditions (prawns are in poor growth or survival conditions) or in an inefficient harvesting. Many times these two causes are combined.

For farmers some methods are easier to apply, in accordance with standard conditions, than others. These are the methods demanding constant interventions in the activities. This uninterrupted practical application is often synonymous with production reliability.

This objective guides the creation of new culture methods. They show their real limits in reproductivity when transferred to other places, to other teams.

To illustrate this process, the clear water high density post-larvae production method, developed at the Pacific Oceanical Center of Tahiti (AQUACOP, 1977) can be cited. The system answered to this purpose of reproductiveness, in relation to the hawaian method, the only post-larvae mass production method(green water, low density) existing at that time.

In that way, in the comparison of the two freshwater prawn production methods (continuous and multi-stage rational systems), it is the possibility to apply the second one in a stricter way than the first one that can be used for argument's sake.

To diminish the intrinsec drawbacks of the continuous method, application conditions can be strictly controled by the utilization of complementary procedures or by the organization of a technical assistance to farms, too small to have qualified technicians.

The simplest complementary procedures to carry out would be :

- mechanical aeration, which facilitates culture medium management. A permanent mix up of surface and bottom waters gives a favorable habitat for animal growth; pond ageing is retarded by a better oxidation of organic wastes. Recommanded power is 2 HP/0,5 pond/ha,
- utilization of post-larvae acclimatation tanks, acting as a buffer between hatchery and grow-out ponds, allows to get good results at each stocking operation (concrete tanks from 50 to 100 m^3; aeration, post-larvae shelters; stocking rate of 2 000 PL/m^3; 15 days acclimatation period, starting with farm inlet water, that can be lightly salted at 1 $^{\circ}/_{\circ\circ}$ and ending with pond water),
- an other procedure presently under experimentation in French Guiana is the introduction into the system of gradded juveniles after 2 months of nursery, in order to reduce the stock of "residents" which will be inhibited in the pond.

Technical assistance teams must guide farmers to realize an efficient and selective harvesting; it is the most important parameter in the application of the system : if harvesting is well practiced, the system is kept in evolution, if not there is a drop in production.

This assistance will also be in charge of teaching to farmers the utilization of size frequency histograms and models for estimating prawn population, two useful instruments to evaluate the biological stock in ponds.

In this way, continuous method leads to productions of 3 T/ha/year and can be favourably compared with other culture methods.
If an economic comparison is made, does the production profit, obtained

with more complicated methods, really compensate the excessive costs in equipments and skilled labor ? Do the obligations imposed by a strict culture method make it long dated feasible ?

In practice, the choice of a method, particularly in Macrobrachium rosenbergii culture, which is closely bound to the medium (water, soil, weather), is determinated by a previous analysis of the context where culture will be practiced and a complete knowledge of culture methods, especially the conditions that define their applications.

CONCLUSION

The continuous grow-out system practiced in the French West Indies and French Guiana has been an excellent instrument of development and culture propagation. A lot of agriculturists and investors have discovered aquaculture through the simple application of this method and its good initial results, particularly in the homogeneous harvesting size of prawns. It is not sure that same results would have been obtained with another harder method.

Practical application of the method must be strictly realized to avoid significant production lowerings; a selective and efficient harvesting operation is the principal factor to control.

In regions where a planified development is present, technical assistance teams could be set up to give advice to farmers to strictly apply the method.

The mastery of the method will allow any commercial farm, having the possibilities to complete farm structures and equipments and if the economic analysis is positive, to get better yields.

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TABLE 1. Evolution of cultivated surfaces and production of *Macrobrachium rosenbergii* in French West Indies and French Guiana since 1980.

YEAR	80	81	82	83	84	85	86	87
SURFACE (ha)	7.5	10	19.6	35	59	106	136	150
PRODUCTION (mt)	-	8	11.6	24	47.5	80	130	170

TABLE 2. Prawn feeding ratio utilized in French West Indies and French Guiana (Quantity in kg/ha/day).

MONTH	QUANTITY	MONTH	QUANTITY	MONTH	QUANTITY	MONTH	QUANTITY
1	1.9	7	17.2	13	25.0	19	30.6
2	4.1	8	19.0	14	26.4	20	32.0
3	6.5	9	21.0	15	27.0	21	32.0
4	8.4	10	22.7	16	27.3	22	32.0
5	11.0	11	23.6	17	28.0	23	32.0
6	14.4	12	24.2	18	29.7	24	32.0

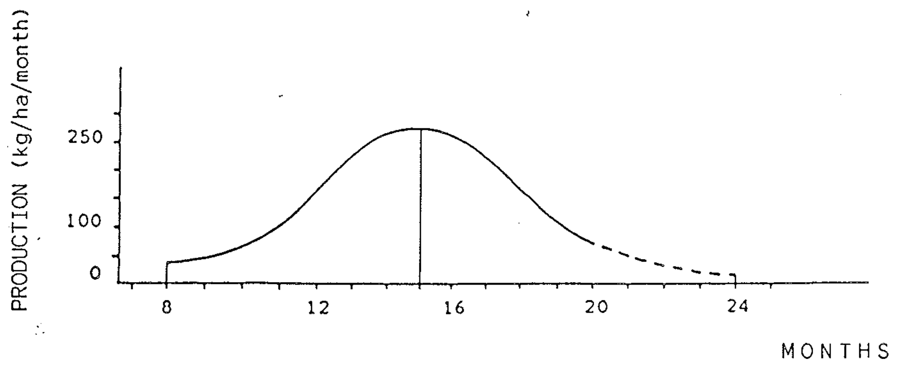


FIGURE 1. Theorical evolution of production for a single stocking (15 PL/m²).

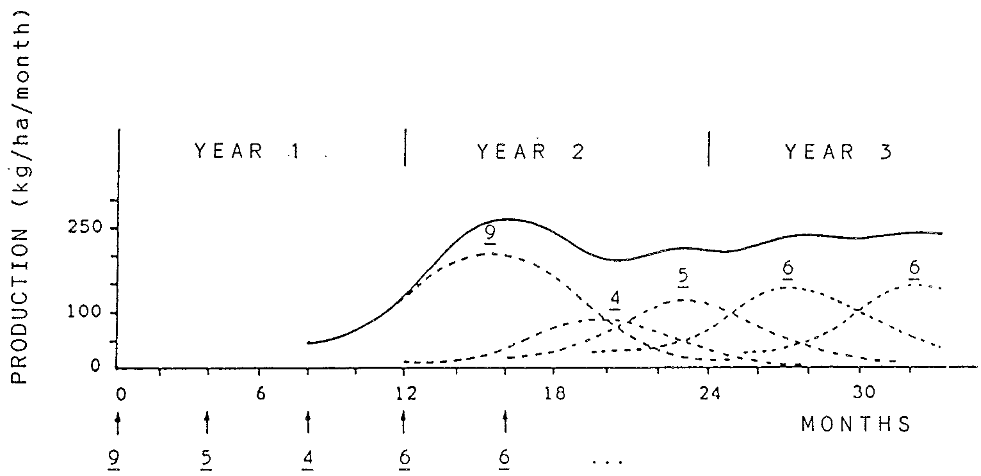
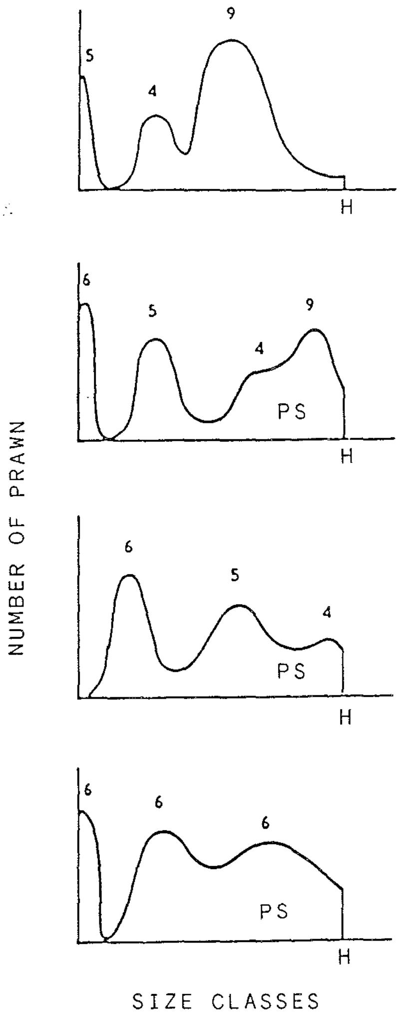


FIGURE 2. Theorical evolution of production in the continuous grow-out system. ↑ = partial stockings.
9-5-4-6... = number of P.L seeded per m².



<u>9th month</u>

- Identification of the first 3 stockings. Beginning of production.

<u>13th month</u>

- Appearance of the fourth cohort and of a productive stock.

<u>16th month</u>

- Extinction of the first cohort. The second one enters into production.

<u>21th month</u>

- Stabilization of the productive stock.

FIGURE 3. Representation of the progression of cohorts and of constitution of a productive stock through size frequency histograms.
H = harvest size. 9-4-5-6 ... = number of PL seeded per m².
PS = productive stock.

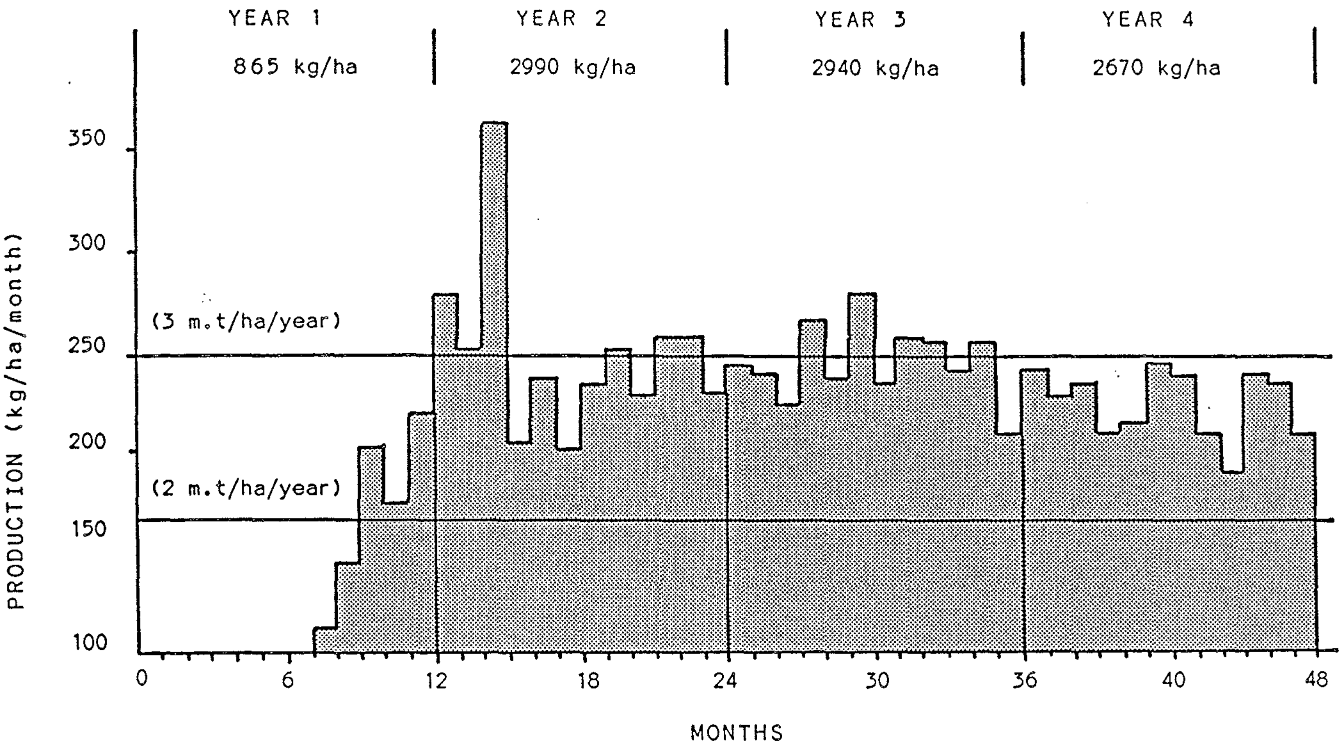


FIGURE 4: Evolution of production of a commercial farm of *Macrobrachium rosenbergii* in Martinique (Production brought back to a same time origin).