Final report for Mini-project MS0402:

Monoculture of the freshwater prawn, *Macrobrachium lar*, in Vanuatu and integrated prawn-taro farming in Wallis & Futuna

Julien Barbier¹, Robert Jimmy² and Satya Nandlal³

¹ Service d’Etat agriculture, forêt et pêche, Futuna
² Department of Fisheries, Vanuatu
³ Secretariat of the Pacific Community, Noumea, New Caledonia
Summary

This study was conducted on-farm to evaluate the effects of monoculture and integrated systems on growth and survival of native freshwater prawn, *Macrobrachium lar* under standardized culture conditions.

Juvenile prawns averaging 2.66g were stocked at 5 specimens/m² into 2 ponds (total area 100 m²) at Sarete. A total of 6 ponds (total surface area 184 m²) were stocked with various sizes of juveniles (range 3.3 -3.8g) and at densities ranging from 3-18 specimen/m² at Futuna. The water temperature in ponds ranged from 24.5 – 26.2 °C.

Prawn stocking, sampling and harvest dates were similar (within a week) at both sites, Sarete and Futuna. Juvenile prawns were collected from nearby streams by push nets and hands for stocking. Samplings were carried out monthly by collecting with push nets a sub-sample of approximately 10% of the number stocked. Feeding rations were calculated based on the total biomass of the prawns.

The diet used at both sites was high quality shrimp feed obtained from a single production run at Noumea, New Caledonia and was stored under refrigerated conditions. Prawns were fed twice daily according to a feeding schedule at an initial rate of 15% of live weight during the first month and reduced by 5% every month until 5% in the final month. Feeding was carried out twice daily with 30% of the feed ration given in the morning and 70% in the evening. At the final sampling, prawns were individually identified according to sexual morphotypes. At harvest (120 days after stocking) all prawns were counted, morphotyped and weighed. Mature morphotypes were first captured in the third sampling i.e., day 90. Overall prawn weights were higher at the Sarete site. There were fewer berried females (more virgins) at Sarete site than Futuna sites. There were significant differences between the two sites in prawn survival. (284% at Sarete may be due escape of prawns from pond 1 to pond 2) compared to 62% at Futuna for data collected from 2 ponds. The average weight at harvest was 36.3g at Sarete and 21g (males 21.57 g and females 6.79 g) at Futuna with some specimens exceeding 30g. The feed conversion ratio was not calculated due late shipment (feeds were held in Customs Office in Vila) of feeds to sites and also proper records were not maintained. Production was significantly greater at Sarete (1800kg/ha) than Futuna (348 kg/ha). One of the ponds at Futuna was infested with eels and this could be a reason for low productivity. There was higher average weight of some morphotypes. Differences in proportions and sizes of female morphotypes probably indicate delayed sexual maturation at the Sarete (southerly site), prolonging somatic growth which normally ceases when food energies are directed to reproductive activities.

The baseline data obtained from this study indicates monoculture and integrated systems of farming *M. lar* has a great potential for production of a food source and income, especially in agricultural island countries in Pacific where it would be most beneficial to farmers already engaged in various farming systems. It is also a potential alternative to introduced species. To fully exploit the integrated farming system involving *M. lar* a better understanding of the pond dynamics and recruitment study on juveniles should be a priority. Studies to elucidate feed types, feed conversion ratio, pond designs and pond water quality, with differing juvenile prawn stocking densities are also emphasized.
Activity report: Experiment on integrating river prawn (*Macrobrachium lar*) grow-out into an irrigated taro crop system on Futuna

Introduction, background

A visit to Wallis and Futuna by an aquaculture specialist from the SPC (Secretariat of the Pacific Community), Mr. Ben Ponia, made it possible to assess the Territory’s aquaculture potential. The main conclusions of this initial visit showed a clear potential for the development of extensive indigenous river prawn (creek prawn or "ula ula" in Futunan, *Macrobrachium lar*) farming in taro patches. An initial study was immediately set up. This study was piloted by the SPC and funded by ACIAR (Australian Centre for International Agriculture Research) and was supposed to cover the growth potential of *Macrobrachium lar*. It should be noted that two regional sites were identified for conducting full-scale experimental work, i.e. one in Vanuatu where river prawns are raised in monoculture, and the other on Futuna, where they would be raised in taro patches.

Outline of the study and experimental protocol

Using the terms of the funding agreement signed by the Prefect on 30 January 2005, the project is described as follows:

**Title:** Integrate shrimp/taro farming of the river prawn, *Macrobrachium lar*, on Wallis and Futuna

**Goal:** Assess the growth potential of *M lar* in an integrated mixed system

**Objectives:**
1. Collect growth data on *M. lar* in association with taro crops
2. Assess the feasibility of integrated *M. lar* farming as a sustainable source of protein

On Futuna, it was decided to catch wild post-larvae in the rivers and raise them in fallow taro patches, on the theory that the presence of river prawns would enrich the soil for taro crops during the following rotation. Two distinct protocols, i.e. with and without feed supplements, were planned in order to make the necessary comparisons on the impact nutritional supplements have on specimen growth.

The study, initially planned to run three months, began with a visit by Mr. Nandlal (Head of Aquaculture at the SPC) in February 2005. Some post larvae were caught, and the experimental protocol was implemented in collaboration with the Fisheries Department. The various components can be summarised as follows:

**Note:**

1. This is indeed an activity report and not an experiment report as although the author did take part in setting up and monitoring the experiment, creating a body of data and initial statistical processing of the main results in partnership with the SPC and STARP, he does not have scientific credentials in aquaculture. In addition, the data’s lack of historical depth and of any comparative and repeated dimensions heightened that aspect. To date, and despite repeated reminders, the SPC has not sent us any experiment report or summary.

2. For further details, please refer to the report, *Mission d’appui de la CPS (Direction des Pêches) du 22 au 26 février 2005 » ; 3contribution à l’étude du cycle et des facteurs influençant s la reproduction de la chevrette Macrourachium lar sur l’île de Futuna, Wallis Fisheries Department*, for a presentation of the main supposed advantages linked to that type of aquaculture (NB: These are the only documents available for consultation at the Futuna office).

3. This mainly involves the technical aspect of production potential; we will see later that if a socio-economic aspect had been given to this initial study, this would have made it possible to identify the major trends of what may be the specific traits of aquaculture on Futuna, in comparison to other countries or territories covered by the SPC.

4. Here, we find the rational of the “food security” approach used by the SPC, whose relevance to work in the Territory should, for this specific example, be debated.

5. For further details and in the original document, reference is made to the funding agreement appendix.
Construction of basins, possible adaptation of existing basins, in line with Mr. Nandlal’s recommendations (dimensions, depth, water inlet and outlet pipes, installing filters, etc. [Figure 1]).

Collecting identified wild *M. lar* post-larvae from the rivers
Measuring specimen lengths and weights (sampling effort: 50 specimens)
Stocking them in mixed taro/shrimp basin at a density of 5 specimens/m².

Daily feedings in the basin that was supposed to receive feed supplements at a ratio of 15% of daily live weight during the first month, decreasing the supplements by 5% the following months.

Measuring baseline basin water parameters (i.e. temperature, dissolved O2, pH, flow).

Monthly fishing sessions and measurement of the weight of 10% of the initial number of specimens [Figure 2].

Harvest and complete measurement (sex, length, weight) of all the specimens after four months of farming.

The STARP, through its agents, was in charge of finalising the sampling protocol, carrying out the fieldwork (daily monitoring) and analysing the results.

---

**Figure 1**: Summary diagrams of a few farming basin configurations recommended by the SPC

**Figure 2**: Various stages of the experiment

Construction of a basin
Collecting juveniles
Monthly fishing session
Measurements
Weighing
Final harvest
Since the initial experiment begun in February 2005 did not lead to the creation of a body of exploitable data, notably due to a lack of continuity and thoroughness in the monitoring and a less-than-optimal selection of experimental sites, it was decided to repeat the experiment in June 2005, with a new visit from Mr. Nandlal.

1) Various basin configurations and farming techniques

For this new experiment, the selection criteria for the first two basin were: proximity to the STARP offices so as to facilitate monitoring and work, the motivation of the basin’s owners, water flow at the basin inlet, location in the taro patch (one upstream and one in the taro patch, the status of the taro crop (opening a new basin and taro plantation/taro farming already in place (i.e. water coverage)).

With regards to the first two basins, i.e. in Nuku at Ateliano Keletaona’s place and at Vaisei at Niséfolo Finau’s – work to build and adapt the basins was carried out by STARP agents assisted by the “owners”. The juveniles were collected by two STARP agents and the “owners” with the help of Mr. Nandlal. On the very first day after stocking, feeding began with a nutritional supplement based on shrimp feed, and was carried out by the “owner” in Vasei, and by the Service in Nuku.

Following this, two private individuals asked Mr. Nandlal and the STARP to be able to benefit from support and counsel in setting up this type of aquacultural activity. They were Simioné Vanai in Tavai and Esékiélé Lie in Fikavi. We supported these project “sponsors” by assisting and participating in work to build basins and collect juveniles and by counselling them on basin maintenance and the required monitoring.

In agreement with the respective “owners”, we experimented with new:

i) basin locations, configurations and dimensions;

ii) farming techniques: stocking densities; feeds based on local, ready available products; river prawn monoculture;

iii) taro/river prawn combinations: sequential integration –as opposed to the spatial integration in the first two basins– of the taro/shrimp system (1-farming basin upstream that then flowed into the Tavai taro patch basin; 2-farming basin downstream from the taro patch and planting taro and banana tree on the ‘Fikavi’ dykes);

iv) technical innovations such as setting up a shading system and various filtering systems.

Table 1: Summary of the physical characteristics of the different basins

<table>
<thead>
<tr>
<th>Village</th>
<th>Location / taro patch</th>
<th>Crop status</th>
<th>Type of aquaculture</th>
<th>Surface (m²)</th>
<th>Intake flow rate (L/sec)</th>
<th>Ave. temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuku</td>
<td>middle</td>
<td>Already in place</td>
<td>Spatial integration</td>
<td>64</td>
<td>2</td>
<td>25.6</td>
</tr>
<tr>
<td>Vaisei</td>
<td>upstream</td>
<td>Opening fallow</td>
<td>Spatial integration</td>
<td>66</td>
<td>0.58</td>
<td>24.5</td>
</tr>
<tr>
<td>Tavai</td>
<td>upstream</td>
<td>Opening fallow</td>
<td>Sequential integration</td>
<td>9 + 11</td>
<td>0.3</td>
<td>26.2</td>
</tr>
<tr>
<td>Fikavi</td>
<td>downstream</td>
<td>Opening fallow</td>
<td>Sequential integration</td>
<td>10 + 14</td>
<td>0.4</td>
<td>25.2</td>
</tr>
</tbody>
</table>
Some drawings and a few photos of the various basins built and seeded during this experiment are given below.

Nuku Basin

Vasei Basin

Tavai Basin

Fikavi Basin

Figure 3: Basin in Nuku

Figure 4: Basin in Vasei

Figure 5: Basin in Tavai

Figure 6: Basin in Fikavi
The table below summarises the farming technique parameters used in the basins.

**Table 2: Farming technique parameters for the various basins**

<table>
<thead>
<tr>
<th>Basins</th>
<th>Start-up number (specimens)</th>
<th>Start-up density (spec./m²)</th>
<th>Daily feed ration</th>
<th>Feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuku</td>
<td>320</td>
<td>5</td>
<td>Shrimp feed, cf protocol</td>
<td>STARP</td>
</tr>
<tr>
<td>Vasei</td>
<td>350</td>
<td>5, 3</td>
<td>Shrimp feed, cf protocol</td>
<td>Owner</td>
</tr>
<tr>
<td>Tavai</td>
<td>300</td>
<td>15</td>
<td>Grated coconut, 100g pig feed</td>
<td>Owner</td>
</tr>
<tr>
<td>Fikavi</td>
<td>460</td>
<td>18 - 21</td>
<td>Grated coconut, bread</td>
<td>Owner</td>
</tr>
</tbody>
</table>

2) Follow-up to the activity and difficulties encountered

The STARP carried out daily feedings at the Nuku basin as per the protocol directives. In Vasei, we provided an adequate amount of shrimp feed each week to the owner, who fed the river shrimp every evening. It should be noted that he modified the doses of feed given in line with the demand (leftovers from the previous day or not) and the amounts were relatively smaller than those given at Nuku. In Tavai and Fikavi, it was the owners who carried out feedings, usually once a day, based on one or two coconuts, possibly some leftover bread or food, rounded off by 100g of pig feed from the second month onwards for the first. Care was taken not to leave old feed decomposing in the basins by adjusting the quantities given as much as possible. In the same way, the filters were checked on a daily basis.

We visited all the basins once a week to check on their state and, where needs be, contact the owners about the changes to be made or to provide new recommendations, measure the water, etc.

Once a month, with the help of the owners, we caught and weighed between 50 and 60 specimens per basin (better coverage than the 10% sample rate recommended in the protocol). Already we can state that this operation was much easier to carry out and more efficient (length of time, disturbance to the basin, etc.) in the monoculture basins. In fact, capture was completed there with a few “swipes of the net” whereas in the mixed basins which had much greater surface areas, lower densities and which were very muddy, this operation proved to be much more difficult and we often had to empty a good portion of those basins in order to catch the specimens and complete our sampling.

We recorded the baseline parameters for the water in the basins (i.e. temperature, dissolved O₂, pH, flow rate) on a monthly basis.

Whenever necessary, we carried out work, with or without the owners (emergencies, not available, etc.) concerning the break in the dyke, water level, state of the filters, making some kind of protection against the wind at Nuku [Figure 3]. Outside this “formalised” monitoring and in a view to giving a certain continuity to it, a great deal of latitude was left to dialogue with the project sponsors. This made it possible to note their growing experience and feelings about this new activity, facilitate the emergence of individual or joint initiatives and try to get out of a patronage mentality by attempting to give interesting dynamics to the project.

We summarised the main difficulties encountered during this experiment and any responses in the table below:

---

6 Something which was, in our opinion, in itself one of the first signs of a project holder taking ownership of this innovative activity by freeing himself from the “rigid” protocol.
### Table 3: Summary of the main difficulties encountered and solutions

<table>
<thead>
<tr>
<th>Experimental phase</th>
<th>Major difficulties</th>
<th>Solutions given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture of post-larvae in the rivers</td>
<td>No aerator, so fairly short conservation time for juveniles</td>
<td>Capture in rivers near the basins, several return trips to minimize transit time</td>
</tr>
<tr>
<td>Monthly fishing</td>
<td>Difficult capture–high fishing effort in the mixed basins (surface area, mud, density), river prawns suffocated (mud)</td>
<td>Construction of monoculture basins with a ditch in the middle or on one side to facilitate fishing, on non-muddy substrate (Tavai, Fikavi)</td>
</tr>
<tr>
<td>Final harvest</td>
<td>Impossible to keep the juveniles and egg-bearing females as there was no aerator</td>
<td></td>
</tr>
<tr>
<td>Future of this production</td>
<td>No preliminary study on the actual possibility of putting this product on the local market and so, of its economic feasibility</td>
<td>Arguments in favor of subsistence uses, gifts … and added-value for the product</td>
</tr>
<tr>
<td>Equipment</td>
<td>Repeating obstruction of the filters (muddy water supply, mosquito net openings that were too small)</td>
<td>Clearing out the water inlets upstream, cleaning the filters on a daily basis and designing a new type of filter with metal and plastic mesh (larger openings, greater surface area)</td>
</tr>
<tr>
<td>Basin water quality</td>
<td>Destruction of the tarp sides of the basins by the wind</td>
<td>Construction of a coconut leaf windbreak (Nuku)</td>
</tr>
<tr>
<td></td>
<td>Water heating up too much</td>
<td>Increased inflow Laid coconut and banana leaves on the surface Built a sun screen (Fikavi) Built basins upstream from the taro patches closer to supply water sources (Vasei, Tavai)</td>
</tr>
<tr>
<td></td>
<td>Turbidity too high</td>
<td>Decreased inflow Built monoculture basin and/or non-muddy substrate Basin placed upstream from the taro patch</td>
</tr>
</tbody>
</table>

3) Initial results

Our intention here is to present the initial results of the experiment. The processing carried out mainly involved the specimens (survival rates, mean weight-density correlations, etc.) and the mean weights measured on a monthly basis for 50 to 60 specimens\(^7\), weights and sizes at final harvest (growth rates).

The body of data seems to be quite satisfactory, both quantitatively and qualitatively. We must admit, however, that the experiment at the Nuku basin was halted after the third month due to unsatisfactory sampling rates during the monthly fishing sessions on top of repeated difficulties in maintaining optimal farming conditions and in management and the difficulties fishing in that basin.

---

\(^7\) The initial protocol set out by the SPC gave a sampling effort of 10% of the total number, however, this 10% rule could not be applied to numbers as low as ours (200-300 specimens), so in a view to better representation, we sampled at least 50 to 60 river prawns during the monthly fishing session. In the same way and from a more qualitative perspective, that allowed us to assess fishing effort (time, difficulties in collecting X specimens)
Graph 1: Mean weight curves by basin

Graph 2: Chart of mean monthly weights for each basin
According to these initial graphs, we can state that:

- growth rates were good overall;
- after 4 months of farming, the river prawns reached mean weights that were good for consumption (20-22g, with some specimens exceeding 30g);
- rapid analysis of the data did not allow us to uncover any significant influence by the various parameters (feeding mode, physical and chemical parameters of the water). Our thoughts in this regard are that the densities used (relatively low) did not make it possible to show the influence of certain parameters (additional feed);
- growth rates declined over the course of the months, which suggests that it would not be profitable in terms of time and space usage to continue farming for five months.

In addition, we would note that survival rates after four months were acceptable for an initial experiment. At Vasei, overall mortality was 52%; supposing that there had been equal distribution of males and females at the outset, it was 40% in males and 65% in females. At Tavai, overall mortality was 24%, divided up as follows: 30% in males and 25% in females. The capture of eels in the Vasei basin during final harvest could explain, in part, the higher mortality.

After reading the respective numbers, secondary but no less interesting data appeared concerning the mean and total weights of males and females at the end of the experiment. We noted that mean and total weights tended to be much higher for males. This undoubtedly comes back to the notions of territoriality and aggressiveness inherent to this species and could raise questions as to basin management (e.g. identification and separation of the two sexes from the first months).
**Vaisei: Sexual distribution of total and mean weights at harvest**

Graph 4: Vaisei basin: sexual distribution of total and mean weights at harvest

**Tavai: Sexual distribution of total and mean weights at harvest**

Graph 5: Tavai basin: sexual distribution of total and mean weights at harvest
4) Conclusions and future prospects

Given that river prawn farming is new to the Territory, that this was an initial experiment, intended to be simple in its technical design, we can state that the results obtained (in terms of grow-out, mortality, etc.) were satisfactory and encouraging.

Beyond that, we must point out that innovations of any kind, especially in the specific context of Futuna, must not lead to increased difficulty and work time in order to be adopted, while providing a plus to the project sponsor.

So, we must continue to support this activity by remaining as simple as possible for the moment while, at the same time, trying to optimise the farming technique (overall profitability, determining optimal and critical densities in line with the feed given, territoriality and aggressiveness inherent to the species). At the current time, given the initial results and the size of this activity, it does not seem justified to provide any special food supplements (which are, in addition, nonsensical economically).

As far as the aspect of integrating river prawn farming into irrigated taro crops, our conclusions are quite reserved. First we would note that above and beyond the problems with the basins’ substrates and water supply in the taro patches, irrigated taro crop growth cycles do not mesh very well with the river prawn farming cycle. For example, the almost daily work during certain phases of taro development leads to too much turbidity in basin water and suffocation of the river prawns. On the other end, fishing and other work with the prawns is prohibited at the end of the taro’s growing cycle when the corms are very fragile and walking on them causes rotting. In addition, it is not good farming to put water in fallow taro patches, for reasons related to soil restoration, limiting the growth of aquatic weeds (whose removal takes up the greatest amount of time in the work schedule for irrigated taro) and limiting the impact of pythium through a dry fallow period.

In a view to continuing this activity on Futuna, we should base ourselves on growing local know-how concerning techniques and practices in terms of basin location, layout, and construction; identifying and collecting post-larvae, feed (local: adapt to needs), basin management and various innovations (shade system, filter and emptying system). However, this activity - through an experimental stage that was purposefully very technical - is still disconnected from any marketing approach - which does not mean that it is not interesting or that it cannot raise interest. This fact should simply guide us for the future of this activity, whose initial recommendations could be:

- Less investment (time, money)
- Reduced-size monoculture basins (land pressure)
- Density of about 20 spec./m²
- Try to set up a semi-continuous cycle (other than filling a single basin and waiting four months before a single harvest) and try to space out harvests and possible income, afterwards. This could be done by setting up a schedule of several basins (at least 3) or trying to seed the basins with specimens at various stages of development.