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Final report

project

Freshwater prawn aquaculture in the Pacific region: improving culture stock quality and nutrition in Fiji

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2 Executive summary

Fish constitute an important protein resource in Fiji, with aquaculture now providing a growing contribution. In recent years, declining wild fish catches have in part, been offset by increases from aquaculture production. According to Fiji's Aquaculture Sector Plan 2005-2010, future growth in fisheries is expected to come mainly from aquaculture. In general however, the freshwater aquaculture sector in Fiji has not progressed as rapidly as was initially anticipated. Total production in 2003 was just 400mt (mainly tilapia) valued at F$1.9M. There is a need therefore to improve farming technologies, to develop and farm more productive stocks and to assist farmers to improve their farming practices.

Queensland University of Technology (QUT) and Ministry of Fisheries and Forests (MFF) collaborated on a project to evaluate and identify a high performing culture line of GFP to assist development of the freshwater prawn culture industry in Fiji. The impetus for this project came from recognition by MFF officers that the local prawn culture strain first introduced to Fiji in the 1980s may have declined in relative productivity over time, in part, due to poor management practices. The project sought to compare the relative productivity of the prawn stock currently farmed in Fiji against a number of productive culture stocks available in Asia and to assist with development of relatively low cost, nutritionally adequate feeds, based on locally-available ingredients formulated specifically for freshwater prawns.

The Project identified productive lines in Asia with the help of local government agencies and collaborators on earlier ACIAR projects in each country and introduced (under strict quarantine) 3 exotic culture lines (post larvae) from diverse geographical locations in S.E Asia (Vietnam, Indonesia and Malaysia) to Naduruloulou Research Station (NRS). After 3 weeks of quarantine, each stock was raised to broodstock stage and then these stocks were developed as inbred lines to produce post larvae. The four strains (Fiji, Vietnam, Indonesia and Malaysia) were then evaluated in fully replicated trials in experimental ponds. Following this trial, the best-performing strain (Vietnam) was evaluated in a commercial grow-out trial with the Fiji strain. This trial concluded in March 2011. Data from this trial, in combination with that available from the experimental strain evaluation trial, suggested that the Vietnamese strain appeared to be the strain of choice when both relative survival rate and growth rate were considered together (among other parameters measured). While pond replication was inadequate to provide sufficient statistical power to compensate for high 'among pond' variation, overall results indicate that pond productivity was better with the Vietnamese strain than that achieved with the local Fijian culture strain that has been used in culture in Fiji for more than 20 years. Broodstock from the best performing strain (Vietnam) were formally handed over to Fiji government officials in June 2011 at the end of the project workshop and are now used routinely to produce PLs for the local culture industry.

In parallel, experimental aqua-feeds designed to meet the specific nutritional requirements of GFP based on formulations incorporating local feed ingredients were developed. Pond trials of experimental and control formulations (tilapia pellets) were completed in July 2011. In addition, PL production at NRS was re-invigorated and improved via provision of training in better hatchery methodologies and by working with local MFF aquaculture staff to improve culture systems. Local hatchery staff can now routinely provide PLs to meet demand from local growers, a development that has encouraged a rapid increase in interest from farmers to begin farming prawns and hence demand has also increased for quality PLs. Thus at the conclusion of the project, Fijian farmers have a productive culture stock and we have developed a low-cost

feed formulation for GFP that incorporates local feed ingredients. In parallel, hatchery practices have been improved to maintain supply of PL's to local farmers. Together, these developments should encourage expansion of the local freshwater prawn culture industry and help to address issues associated with reducing poverty and improving local livelihoods and nutritional status.

3 Background

A number of exotic freshwater species of fish and crustaceans are widely acknowledged as having excellent potential for culture in the Pacific region. ACIAR, since the early 1990s, has supported research on stock evaluation and genetic improvement programs for tilapia in Fiji and development of smallholder tilapia aquaculture in PNG. In Fiji, provision of an improved strain of tilapia (GIFT) resulted in a significant expansion of tilapia farming, leading to better economic status for many poor rural Fijian farmers to the point where a number have diversified into higher value aquaculture species like giant freshwater prawn (GFP). While the importance of farming a productive culture strain of tilapia was demonstrated in this early work and tilapia remains the dominant freshwater species cultured in Fiji, GFP can offer better financial returns, so some farmers have attempted to diversify to GFP farming since the infrastructure required for prawn farming is very similar to that required for tilapia farming.

GFP is cultured in many parts of the tropical and subtropical world with the industry now worth approximately US$1Billion annually in Asia alone. The natural distribution of GFP encompasses much of South Asia, South-east Asia and Australasia but the species is not native to the Pacific Islands except for PNG. Stocks of GFP used in culture in Fiji were first introduced from Hawaii in 1978 and later from Tahiti in 1997, and form a small but relatively high value culture industry in Fiji. In recent times, as a consequence of local growth of the GFP culture industry, fisheries agencies in other PINs have also considered developing GFP aquaculture. While the origins of the GFP stock farmed in Fiji are not well documented, the strain was imported from Tahiti, most probably the Anuenue strain originally sourced from Malaysia and domesticated in Hawaii. Very little is known about the population base used to establish the Fijian freshwater prawn industry or how past husbandry practices there may have affected relative stock productivity in culture, so essentially the relative quality of this stock has never been formerly assessed.

The level of genetic diversity in a farmed stock of any species is a fundamental resource that can influence its long-term productivity. As has been seen in other culture industries, when inbreeding levels increase, genetic diversity levels will decline and stocks are likely to lose productivity as a consequence. Thus productive culture stocks must be managed actively to conserve their levels of genetic diversity over the long-term so as to avoid the potentially negative effects of inbreeding depression. Where stocks are highly inbred they are also unlikely to respond positively in stock improvement programs, particularly those that apply selective breeding approaches. The relative impact of processes that GFP may have been exposed to during introduction to Fiji are unknown but most probably involved exposure to sequential population bottlenecks where genetic diversity levels may have declined. This fact, and the way that the stock has been managed for culture since (no active management of remaining genetic diversity), are likely to have resulted in significant declines in natural levels of genetic variation and high levels of inbreeding. Both factors if present are likely to affect long-term culture stock productivity. Any future expansion of the culture industry in Fiji and more widely in the region needs to be based therefore, on a genetically diverse and productive culture stock.

The likelihood is that the remaining levels of genetic diversity in Fijian culture stocks of GFP are low and are likely to continue to decline. This could affect development of the industry in the future. To support this contention, Fijian Fisheries staff had reported that many female prawns appear to reach sexual maturation at much smaller size than in the past, a likely consequence of inbreeding and past poor management. This phenomenon had also been observed in a number of Asian countries where GFP is cultured and where little attention has been paid to sound husbandry practices, particularly management of genetic resources. A number of PINs

are looking to Fiji as a source of supply for GFP culture stocks and for assistance with developing their own GFP culture industries (e.g. Vanuatu, PNG, Samoa and Cook Is). Before any expansion of the industry occurs in the Pacific region, it is imperative that the quality of existing culture stocks be assessed and decisions made about the need (or otherwise) for introductions of new culture stocks to sustain industry development in Fiji and before there are translocations from Fiji to other PINs.

While sustainable productive farming systems generally require high quality stocks, adequate nutrition is also essential because farmed organisms require nutritionally adequate diets to perform well. In order to formulate an effective feed, it is essential to understand each species' individual nutritional requirements and to obtain relevant data on potential ingredients that could be included in a nutritious diet. Digestibility reflects the extent that an ingredient is digested and is available for utilisation. Adequate nutrition is of particular importance in most aquaculture systems because feed can represent from 40 to 60% or more of total production costs. The development of low-cost diet formulations specific for a target species will aid aquaculture industries as they expand.

Protein is the most expensive part of any aqua-feed, so it is important to determine accurately the minimum protein requirement for each culture species, and even for specific size cohorts during development, to minimise production costs associated with the provision of feed. Proteins are formed by amino acid linkages and while over 200 amino acids occur in nature, only about 20 are common. Of these, 10 are essential (indispensable) amino acids that cannot be synthesized by aquatic organisms directly and so need to be obtained from their diets in appropriate amounts. These essential nutrients are usually supplied in aqua-feeds in the fishmeal component that contributes the single most expensive, major ingredient to any feed. Other animal and even plant protein sources can in theory however, provide these essential nutrients, potentially at much lower cost of inclusion providing they are both palatable and digestible to the animal. Currently, even in Asia where GFP culture is extensive, there are very few commercial aqua-feeds designed specifically for GFP.

In Fiji, most freshwater prawn farmers cannot afford imported or even locally manufactured aqua-feeds that have been developed for marine prawns. So most farmers either feed their GFP stocks with commercial tilapia feeds or provide limited quantities of low cost feed components when available, such as rice-bran, coconut meal and or wheat bran. Thus growth performance of freshwater prawns in culture in Fiji is most likely sub-optimal and cost-effectiveness is low as a consequence. Even if farmers can afford marine prawn feeds there is strong evidence that this may be an inefficient practice. Specifically, many formulated feeds designed for marine prawns contain 50% to 60% crude protein which is also typically the most expensive component of the diet. Studies however, on the dietary protein requirements of GFP in other countries, have indicated that optimum dietary protein requirements for this species may be closer to 30%. In addition, there is mounting evidence that GFP can use low-cost plant proteins in artificial formulated diets and these components may provide cost effective alternatives to expensive fish-meals commonly incorporated into marine prawn feeds. It is critical therefore, that when addressing the stock quality issue that in parallel, farmers are able to afford nutritious aqua-feeds that allow productive farm stocks to perform at their best. For optimum productivity the two factors are inherently linked.

Experience has shown repeatedly that the best returns from culture are achieved by farming high quality stocks that are well managed and that are supplied with adequate nutrition. There is little or no advantage in farming high performing stocks while providing poor nutrition. To date even in Fiji where GFP has been farmed for nearly 20 years, there has not been any systematic attempt to develop nutritionally adequate, low cost formulated diets based on local feed ingredients specifically for GFP. ACIAR in the past supported a mini-project on artificial feed

formulation for tilapia and freshwater prawns in Fiji and PNG. This project formulated and tested diets resulting in specific growth rates of an average of 4mg per day for tilapia, however only 0.69mg per day was achieved using the same diet formulation for GFP. A likely explanation for this contrasting result is that published studies have suggested that GFP may prefer lower levels of protein and more dietary fibre in their diets than tilapia and also perform poorly on diets that include relatively high lipid levels. Thus the strategy adopted in the mini-project of developing a single diet formulation for both species in tandem was unlikely to be successful and low cost diet formulations for the freshwater prawn industry in Fiji need to be developed independently.

An integrated approach that combines stock evaluation to identify a high-performing genetic strain(s) for culture in the region with basic research on development and farm trials of nutritionally adequate low cost diets based on local ingredients provides the best opportunity to enhance GFP culture productivity in Fiji.

Other pressing issues affecting the GFP industry in Fiji include sustainable production of PLs and producing marketable-sized prawns. These issues need to be addressed to ensure the new industry remains viable. The current project commenced in mid-2008 and sought to address these important issues by comparing the relative productivity of the prawn strain currently farmed in Fiji against three exotic culture stocks introduced from Asia and in parallel, to develop a low-cost feed formulation based on local feed ingredients for the industry.

Experimental work for FIS/2005/108 was based primarily at NRS, MFF, Fiji. The project commenced in mid 2007 at QUT. Due to local political issues, it was not until mid 2008 however, that project activities actually commenced in Fiji. All project activities in Fiji as a consequence were re-scheduled. The project finished in July 2011 following an extension of one year agreed to by ACIAR Program manager (Dr Chris Barlow). This included an addition to the project budget of $75,000. This report profiles the progress made against the original project work plan and includes core project outputs and additional activities that were conducted to address core objectives. Issues that slowed progress in the project included difficulties with; obtaining post larvae (PLs) of similar age from discrete stocks of *M. rosenbergii* introduced from Asia, transhipment of PLs via Sydney, improvement of the new quarantine facilities at NRS, development of quarantine protocols for introduction of exotic strains, operation of a second hatchery at Galoa, lack of supply of water due to breakdown of the main water pump at NRS, construction and improvement of new research ponds for trials and appointment of a Project Officer position in Fiji.

4 Objectives

The major goal of the current project was to promote development of the freshwater prawn culture industry in Fiji and the Pacific region more widely by identifying a productive culture stock and developing a nutritionally adequate low-cost feed formulation specifically for freshwater prawns based on locally-available ingredients. Specific aims identified for the project include:

1. Identify a number of culture lines of freshwater prawn from different genetic backgrounds in Asia and introduce them to Fiji for comparative growth trials.
   This involved 3 activities:
   - Activity 1: Data from FIS/2002/083 and regional collaborators were used to identify productive Asian culture lines of diverse genetic background.
   - Activity 2: An import risk assessment was conducted for introduction of Asian freshwater prawn culture strains to Fiji.
   - Activity 3: Asian culture lines were introduced to Fiji under quarantine for comparative growth trials

2. Assess the relative levels of genetic diversity in each introduced inbred line and the indigenous Fijian line using microsatellite markers developed previously at QUT for the western form of *M. rosenbergii* as a foundation for identifying a genetically diverse line for culture and to establish a foundation for future monitoring of the impacts of hatchery practices on exploitable levels of diversity.
   This involved 1 activity:
   - Activity 1: 8 microsatellite markers were used to document relative genetic diversity in each of the inbred lines brought to Fiji and the indigenous Fijian strain

3. Replicated evaluation trials were undertaken at NRS to identify the most productive culture strain(s) for Fijian conditions.
   This involved 2 activities:
   - Replicated grow out trials on each inbred line were conducted at NRS.
   - An evaluation trial of the best-performing strain (Vietnam) was conducted with the Fijian strain under full commercial production conditions.

4. Develop experimental feed formulations specifically for freshwater prawns based on local low cost feed ingredients using as a starting point, data generated in the SPC/ACIAR feeds mini-project.
   This involved 3 activities:
   - Fijian ingredients with potential use in aquaculture feeds were identified (based on availability, composition and cost).
   - Utilisation of each ingredient was evaluated.
   - Two experimental diets were formulated incorporating local ingredients.

5. Undertake pond trials that compared the performance of the best performing culture stock indentified with the experimental low-cost freshwater prawn feed formulations against two commercially available aqua-feeds.

6. Develop the capacity of NRS staff to manage the genetic health and culture productivity of the best performing freshwater prawn stock identified in the project and enhance their capacity to undertake basic aqua-feed development and evaluation trials.
   This involved 1 activity:
   - Develop protocols for maintaining 'genetic health' and productivity of the best inbred stock and provide training to NRS staff in stock management and husbandry.

7. With assistance from SPC and USP, conduct training in stock husbandry, aqua-feed development and feed production for Fijian and regional government fisheries staff from PINs that are planning to develop their own freshwater prawn industries in the future.
   This involved 1 activity:
   - Run workshops at NRS for regional fisheries agency staff on maintenance and production of the high performing inbred line.

5 Methodology

The major project activities involving comparative pond grow out and pond nutrition trails were carried out at NRS. The Galoa Brackishwater Hatchery at Navua and NRS Prawn hatchery were used for PL production required by the project. Feed ingredient evaluation trials were conducted at the Physicochemical Laboratory Facilities, Marine Studies Division (USP) including a part of the commercial pond grow out trials at Dairy farms, Navua operated by USP.

5.1 Strain Evaluation

5.1.1 Identify a number of high-performing culture lines of freshwater prawn from different genetic backgrounds in Asia and to introduce them to Fiji.

- **Identification of high-performing culture lines**

Scientists from QUT with the help of government agencies and collaborators visited Indonesia, Malaysia, and Vietnam to identify productive culture lines in April 2008.The following centres were identified as having the necessary productive exotic strains;

1. Research Institute for Freshwater Aquaculture, JI Sempur No 1. Bogor 16154, West Java, Indonesia.
2. National Fry Production and Research Centre, Department of Fisheries, Kg. Pulau Sayak, 08500 Kota Kuala Muda, Kedah, Malaysia.
3. National Centre for Freshwater Fish Breeding of Southern Vietnam, Cai Be District, Tien Giang Province, Vietnam.

Follow-up correspondence confirmed production of PLs at Research Institute for Freshwater Aquaculture, Indonesia; Department of Fisheries, Malaysia and Research Institute for Aquaculture No.2 (RIA 2) in Ho Chi Minh City, Vietnam. A set of criteria for hatchery operations was developed and discussed with staff at all centres to produce PLs including requirements for packing and shipment.

- **Inspection and refurbishment of facilities at NRS**

The project leader and project scientists visited Fiji in May 2008 to view NRS facilities and to discuss the project schedule of activities. Following the inspection, it was recognised that some facilities required either refurbishment or needed to be built to complete the project successfully. Facilities for a quarantine centre and hatchery were improved but existing ponds for experimental grow-out trials were not considered to be appropriate for the planned trials and MFF agreed to build a new set of fourteen 20m x 8m experimental ponds. MFF also undertook improvement of existing broodstock holding ponds and other related facilities specifically for the purpose of implementation of the project activities. These activities were funded jointly from project funds and the MFF in Fiji.

Delays were experienced during construction of the experimental ponds due to flow of funding and poor weather conditions at the time.

- **Import Health Standard**

A simple 'Import Health Standard' for freshwater prawn importation was drafted in collaboration with MFF and Fiji Quarantine and Inspection Service (FQIS) to allow for importation of the PLs. See Appendix 1.for details.

- **Introduction of exotic culture lines**

1000 PLs form each exotic GFP culture line from Indonesia, Malaysia and Vietnam were organised for introduction to Fiji under quarantine conditions by October 2008. Due, however to delays in PL production in source countries, difficulties associated with obtaining formal approval from the Australian Quarantine and Inspection Service (AQIS) to tranship through Sydney, non-availability of appropriate quarantine protocols in Fiji and a delay in setting up the quarantine facilities at NRS, importation of PLs were staggered with the Malaysia stock arriving on 16th October, followed by the Indonesian stock on 8th November and the Vietnam strain on 13th November, 2008.

After arrival of PLs at Nadi, Fiji and inspection by Fiji Quarantine and Inspection Service (FQIS) staff, they were transported to NRS. At NRS, the number of surviving PLs were counted and transferred into prepared holding tanks. PLs were maintained under quarantine conditions for 21 days in isolation from local stocks to ensure that they were disease free before release to the NRS ponds for rearing to broodstock size.

5.1.2 Assess the relative levels of genetic diversity (allelic diversity and heterozygosity) of each introduced inbred line and the indigenous line using microsatellite markers developed previously for western form *M. rosenbergii* at QUT as a foundation for choosing a genetically diverse line for culture and to establish a foundation for future monitoring of the impacts of hatchery practices on exploitable diversity.

- **Collection of tissue samples**

Prawn tissue samples from the 3 exotic strains and the indigenous strain in Fiji were collected and samples preserved in vials in 70% alcohol and brought to QUT for genetic analysis.

- **Characterization of stocks**

A bank of 8 microsatellite marker loci developed for GFP were optimised on an ABI3500 Genetic Analyser for multiplex analysis in the Molecular Genetics Research Facility (MGRF) at QUT.

5.1.3 Undertake replicated evaluation trials of the 3 exotic strains vs Fiji at NRS to identify the most productive strain(s) under Fijian conditions.

- **Broodstock production**

Three earthen ponds, each of 300 m² were prepared following standard procedures of de-silting, pond drying and liming. Shelters were provided in each pond to act as substrate for prawns. Following completion of the quarantine period, at total of 130 PLs from the Indonesian strain, 250 from the Malaysian and 300 from the Vietnam strain were stocked into separate ponds on 7th December 2008. Remaining PLs of each strain were maintained in tanks inside the quarantine building to ensure that stocks were available in case of accidental loss or total

mortality. Normal conditions for growing prawns in Fiji were employed to prepare broodstock of each strain to produce PLs for the evaluation trials.

- **First Hatchery run**

The first hatchery run for the exotic strains was carried out from May to late July 2009 at NRS. Due to water supply and disease outbreak problems at NRS hatchery a back-up operation was set-up at Galoa Brackishwater Station, Navua. Additional heaters, feed and other accessories were imported to allow for hatchery operations at Galoa. PLs were produced successfully from each strain and then maintained in tanks ready for stocking for the initial strain evaluation trial.

- **First pond grow-out trial**

The first set of grow-out trials on each line commenced in late July 2009. Four strains: Indonesia, Malaysia, Vietnam and Fiji were compared for relative growth rate. Growth trials were conducted in 12 earthen ponds, with each strain (n=4) replicated in 3 ponds (4 strain x 3 pond) - details given in Table 1.

PLs from each line were transported to NRS and conditioned for one day prior to stocking. The mean stocking weight of each line was determined from a sub-sample of 300 PLs and separated in 3 lots of 100 individuals and weighed collectively. Individual mean stocking weight ranged from 0.012 to 0.018g. PLs for stocking were hand-counted at a stocking density 5PLs/m^2 of pond surface area, the equivalent of approximately 50,000/ha.

Prawns were fed with a commercial tilapia grow-out diet containing 29% crude protein. The amount of feed ration given per day was based on estimated prawn biomass (on a live weight basis) per pond determined on levels employed for *M. rosenbergii* culture in semi-intensive ponds following a simple calculation:

$N_i \times S_t \times W_t \times FR_t$= daily ration (in g)

Where

N_i = the initial number of prawns stocked in the pond;

S_t = estimated survival at time t- a rough mortality of 5% per month;

W_t = mean prawn weight (in g) at time t;

FR_t = the recommended feed rate for period t.

Feed rate at the time of stocking was 100% of body biomass and this rate was adjusted at the end on of the first month based on a percentage of estimated total body biomass at 15% and this rate then reduced to 10% at day 63 (first scheduled sampled) and to 5% by day 126 (second scheduled sampling) over the 147-day grow-out period. A 5% mortality rate per month was also factored in when calculating feed rations. The daily ration was divided between AM and PM feedings with 30% of ration given in the morning and the remaining 70% in the afternoon.

Dissolved oxygen, water temperature and pH were monitored twice daily (0800 and 1600 h).

Details of stocking are given in Table1. This trial was abandoned after the first sampling on 9-10th October due to very low survival as a result of algal contamination.

Table1. Record of initial stocking data of abandoned trial.

Pond No.	Pond area (m^2)	Stocking date	Manure ($kg/10m^2$)	Strain	SD ($5PL/m^2$)	Av. Wt. (g)	Feed ration (g) Am	Pm
1	113	24 July	11.3	Vietnam	565	0.023	8	18
2	116	24 July	11.6	Indonesia	580	0.028	10	23
3	105	29 July	10.5	Malaysia	525	0.022	7	16
4	105	24 July	10.5	Fiji	525	0.023	7	17
5	121	24 July	12.1	Fiji	605	0.023	8	20
6	100	24 July	10.0	Malaysia	500	0.012	4	8
7	126	24 July	12.6	Indonesia	630	0.028	11	25
8	138	24 July	13.8	Vietnam	690	0.023	10	22
9	138	3 August	13.8	Malaysia	690	0.017	2	4
10	149	24 July	14.9	Indonesia	745	0.028	13	29
11	140	24 July	14.0	Vietnam	700	0.023	10	23
12	157	24 July	15.7	Fiji	785	0.023	11	25

- **Second hatchery operation**

The second hatchery operation was carried out at Galoa government hatchery from November to December 2009. Over 500,000 PLs from the 4 lines were produced.

- **Second pond grow-out trial**

The second grow-out trial commenced on 7th January 2010. The same ponds were used following standard preparatory activities similar to that carried out in Trial 1 except that ponds were not fertilized. Ponds were not fertilized to reduce growth of algae and 2 Chinese carps (*Ctenypherygodon idella*) with an average weight of 1.7kg (see Table 2) were added to each pond to control weeds.

Prawn mean weight or growth rate were determined on day 63 and 105 by seine net-sampling.

Table 2. Pond stocking data and feed rations at time of initial stocking for Trial 2.

Pond No.	Pond area(m^2)	Stocking date	Manure ($kg/10m^2$)	Strain	SD ($5PL/m^2$)	Av. Wt. (g)	Feed ration (g) Am	Pm	Grass carp wt (kg)
1	113	07 Jan	11.3	Vietnam	565	0.015	1.3	3.0	4.1
2	116	07 Jan	11.6	Indonesia	580	0.018	1.6	3.7	3.0
3	105	07 Jan	10.5	Malaysia	525	0.013	1.0	2.4	4.4
4	105	07 Jan	10.5	Fiji	525	0.018	1.4	3.3	4.1
5	121	07 Jan	12.1	Fiji	605	0.018	1.6	3.8	2.9
6	100	07 Jan	10.0	Malaysia	500	0.013	1.0	2.3	3.5
7	126	07 Jan	12.6	Indonesia	630	0.018	1.7	4.0	3.1
8	138	07 Jan	13.8	Vietnam	690	0.015	1.6	3.6	3.5
9	138	07 Jan	13.8	Malaysia	690	0.013	1.4	3.1	3.1
10	149	07 Jan	14.9	Indonesia	745	0.018	2.0	4.7	3.2
11	140	07 Jan	14.0	Vietnam	700	0.015	1.6	3.7	2.9
12	157	07 Jan	15.7	Fiji	785	0.018	2.1	5.0	3.0

Pond grow out trials lasted for 147 days. At final harvest, the water level in ponds was lowered and a seine net dragged once across the length of the pond and prawns were collected in buckets and transferred into a holding tank. Thereafter, the pond was drained and all remaining prawns were harvested by hand using dip nets and individuals transferred to holding tanks. Prawns were measured to the nearest 0.1mm with aid of an electronic calliper followed by weighing individually (to nearest 0.01g). Prawns were classified into either one of three female morphotypes: berried (egg carrying), shed or open (previously egg carrying), juvenile/runt, or three male morphotypes: blue claw (BC), orange claw (OC), juvenile/runts. All data presented were from the total sampling of all prawns surviving in each pond. Following sampling all market-size prawns were transferred to ice slurry for chill-killing and thereafter packed and sold.

- **Commercial pond trials**

Following identification of the most promising strain (Vietnam) in the evaluation trials at NRS, a commercial trial was conducted to confirm performance under commercial production conditions. This trial compared the Vietnam and Fiji strain in commercial-sized ponds. The first set of commercial grow-out trials commenced at NRS on 25th October 2010 followed at Dairy Farm Fiji Limited (a private prawn farm) at Navua on 27th October 2010. Replicated trials were conducted in 12 earthen ponds ranging in size from 600-1118 m^2 (actual size-is given in Table 4).

Descriptions of pond preparation and general pond management were based on procedures employed for GFP culture in semi-intensive systems in Fiji. PLs for stocking at both locations were obtained from Galoa government hatchery. On the stocking date, mean stocking weight was determined for each strain and PLs stocked at 5 PLs/m^2. The diet used was the same as that used in the experimental strain evaluation trial and contained approximately 29% crude protein including the rate of feeding i.e., daily feed rations were the same as in experimental trials. At the end of growing period, ponds were harvested and all individuals weighed and measured.

Table.4. Pond stocking data and feeding rates at initial stocking study sites: NRS and DDF.

Pond No.	Strain	Pond size(m²)	Date stocked	Av. Wt (g)	No. stocked	Feed ration (g) am	pm
Naduruloulou Research Station							
1	Vietnam	470	25/10	0.022	2350	16	36
2	Fiji	600	25/10	0.018	3000	16	38
3	Vietnam	600	25/10	0.022	3000	20	46
4	Fiji	600	25/10	0.018	3000	16	38
5	Vietnam	600	25/10	0.022	3000	20	46
6	Fiji	1118	25/10	0.018	5600	30	71
Dairy Farms Fiji Limited (DDF)							
1	Fiji	748	27/10	0.018	3740	20	47
2	Vietnam	680	27/10	0.022	3400	23	52
3	Fiji	660	27/10	0.018	3300	18	41
4	Vietnam	627	27/10	0.022	3135	21	48
5	Fiji	608	27/10	0.018	3040	17	32
6	Vietnam	640	27/10	0.022	3200	21	49

- **Statistical analysis**

Growth performance was measured by calculating mean individual prawn wet weight (g) and survival (%) of each strain. Population structure was evaluated from average weight data and proportion (by number) of each morphotype present in each population.

5.2 Development of a low cost feed for freshwater prawns

5.2.1 Develop experimental feed formulations specifically for freshwater prawns based on low cost local feed ingredients

- **Ingredients Identification**

Feed ingredients available locally in Fiji identified as potential components for inclusion in experimental diets for *M. rosenbergii* in this study are shown in Table 5. Feedstuffs were collected in Fiji and analysed at the ARI laboratory in Brisbane.

Table 5. Centesimal Composition of Selected Fijian Feedstuff

Ingredient	DM	Ash	N	GE MJ/Kg	Fat	CF	CP	GE Kcal/Kg	FJ$/Ton	AU$/Ton
Fish Meal	95.6	26.3	8.89	19.1	14.6		55.56	4561	800	662
Meat Bone Meal	96.1	24.7	8.61	19.75	18.6	0.1	53.81	4716	760	629
Meat & Fish Meal	91.0	20.4	9.91	20.25	15.2	-	61.94	4836	800	662
Copra Meal	97.3	5.7	3.71	20.81	13.2	11.9	23.19	4969	580	480
Wheat	89.2	1.7	2.89	18.68	1.9	2.0	16.47	4461	825	682
Mill Mix	87.5	4.2	2.82	19.42	4.1	8.8	17.63	4637	350	289
Rice Meal	91.3	8.7	2.62	22.37	22.7	6.4	16.38	5342	560	463
Pea Meal	90.0	2.8	2.96	18.43	1.5	22.3	18.50	4401	550	455
Brewery	27.3	3.3	3.83	21.62	-	-	23.94	5163		
Sorghum	88.3	1.3	1.81	18.73	3.7	1.7	11.31	4473	650	538

- **Ingredients evaluated at USP**

Assessment of feed ingredients for use in aquaculture diets can be done using different approaches. These include assessment of digestibility, palatability and utilisation studies. The following practical approach was adopted for these studies.

Provided a diet is formulated based on a digestible nutrient and energy basis, and it satisfies an animal's nutrient and energy requirements, most of the variation in performance can then

usually be attributed to differences in feed intake. Utilisation can be measured in several ways. One of the most obvious ways is to assess weight gain achieved when fish are fed specific diets. In this regard, animals were fed a particular diet for a certain period of time and their weight gain measured between two time points. Comparisons were then made among treatments and inferences made according to the results obtained.

- **Methodology in assessing feed ingredients**

In order to define the maximum inclusion levels of ingredients in the experimental diets, we conducted feed intake trials using diets with incremental inclusion of the tested ingredients. Ingredient inclusion trials are probably the simplest way to examine effects of feed intake. An ingredient can be included in a reference diet to create a test diet and then the reference and test diets are fed to apparent satiety to replicate groups of animals for each diet (Glencross et al., 2007). Significant differences in feed intake between the reference and test diets reflect the apparent diet palatability.

The issue of how much ingredient to include however, in a test diet is somewhat subjective. Ideally, a range of test ingredient inclusion levels that cover what would be the practical inclusion levels should be used, as this also allows examination of critical palatability levels or break points (Shearer 2000). In this experiment, we attempted to answer, how much of the tested ingredients (meat & bone meal and meat & fish meal) could be used to replace fish meal in diets for freshwater prawn without affecting growth, feed consumption or feed palatability.

In order to assess the level of inclusion of selected local ingredients, ingredients were tested in two separate experiments. The first experiment tested sources of animal protein, including fish meal, meat & fish meal & meat & bone meal. The proximal composition of these ingredients is shown on Table 6.

Table 6. Proximal analysis of experimental ingredients

Ingredient	**DM %**	**Ash %**	**Fat %**	**CP %**	**GE Kcal/Kg**	**FJ$/Ton**	**AU$/Ton**
Fish Meal	93.2	24.5	20.5	54.63	5015	800	662
Meat & Bone Meal	92.8	16.9	26.5	53.69	5717	760	629
Meat & Fish Meal	94.6	17.3	26.1	57.69	5595	800	662

Six experimental diets were formulated for each step with varying levels of each in the experimental diets to produce the same level of protein, lipids and gross energy in each (Table 7). The six treatments were replicated three times in each trial set.

Table 7. Experimental diets formulation

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Fish Meal	41.2%	16.5%	8.2%	0.0%	8.2%	0.0%
Wheat	53.8%	55.6%	56.2%	56.8%	58.2%	59.3%
Premix	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Meat & Bone Meal	0.0%	24.7%	33.0%	41.2%	0.0%	0.0%
Meat & Fish Meal	0.0%	0.0%	0.0%	0.0%	30.2%	37.7%
Fish Oil	3.0%	1.2%	0.6%	0.0%	1.4%	1.0%

The second experiment tested carbohydrate sources including wheat, copra, pea meal and mill mix. The composition of these ingredients is shown in Table 8.

Table 8. Proximal composition of experimental ingredients

Ingredient	DM %	Ash %	Fat %	CP %	GE Kcal/Kg	FJ$/Ton	AU$/Ton
Wheat	89.0	1.7	1.9	16.47	4461	825	682
Copra Meal	97.3	5.7	13.2	23.19	4969	580	480
Pea Meal	90.0	2.8	1.5	18.50	4401	550	455
Mill Mix	87.5	4.2	4.1	17.63	4637	350	289

Using the selected ingredients 5 experimental diets were formulated. Composition of the diets is presented in Table 9. We used Crest Tilapia pellets as a reference diet to compare feed intake with experimental diets. Diets were prepared in the Physicochemical Laboratory facilities, Sciences Technology & Environment, Marine Studies Division, USP.

Table 9. Experimental diets-percentage inclusion level in the diets (Crest diet formula not available)

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Crest diet
Fish Meal	44	44	35	30	40	N/A
Mill Mix	0	54	38	23	2	
Copra Meal	0	0	25	45	0	
Pea Meal	0	0	0	0	30	
Wheat	54	0	0	0	26	
Premix	2	2	2	2	2	

The experimental system at the Sea Water Wet Laboratory, USP used for these trials had 18 aquaria (60 x 45 x 44 cm) connected to a closed temperature controlled recirculation system (Figure 1). Water flow rate was constant at 0.3 L/min, 29^{o}C, pH 6.5 – 7, DO > 6 mg/L & Ammonia <0.1 mg/L.

Figure 1 Experimental system at USP.

Prawns were fed *ad libitum*, twice a day, seven days a week, for a period of four weeks. At each feeding, prawns were given one hour to consume their feed ration (5% biomass daily – to be verified depending on size of prawns), after which any uneaten feed was removed by siphoning from each aquaria.

All dry ingredients (except Premix) were sieved through 1mm & 0.5 mm diameter mesh dies (Figure 2.

Figure 2 Sieving dry ingredients

5.2.2 Undertake pond trials comparing the performance of the best performing culture stock indentified with the experimental low-cost freshwater prawn feed formulations against a commercially-available penaeid aqua-feed.

- **Formulations of experimental low-cost diets**

Using the ingredients previously assessed, two experimental diets were formulated: **Diet 1** used premium local ingredients of highest quality in the feed in order to achieve the best growth performance regardless of cost while **Diet 2** was formulated from cheaper ingredients while meeting basic prawn nutritional requirements. In order to evaluate their relative performance the two experimental formulations were tested against two commercially-available feeds (Tilapia Crest Feeds & Prawn Pacific Feeds) in pond trials using the best performing GFP strain indentified (Vietnam strain) (Table 10). Experimental diets were formulated to be isonitrogenous (30% CP) and isoenergetic (19 MJ/Kg) on a digestible nutrient basis.

Table 10. Proximal Composition of Experimental diets

	DM %	Ash %	CP %	Lipids %	GE MJ/kg	FJ$/kg	AU$/kg
Diet 1	90.1	13.1	32.75	10.2	19.34	1.084	0.577
Diet 2	94.9	11.2	32.19	11.5	20.13	0.705	0.375
Crest Diet	90.2	10.9	22.81	5.3	18.21	1.21	0.644
Pacific Diet	91.0	12.3	30.25	8.7	19.21	1.52	0.809

- **Pond Feed Trials**

The trial was conducted using 12 replicate earthen ponds at NRS, during March-July 2011. Four treatments were conducted with 3 replicates per diet: (a) Diet 1; (b) Diet 2; (c) Commercial tilapia feed from Crest Feeds International, and Commercial Prawn feed from Pacific Feeds Limited. The experimental design employed in this experiment is shown in Figure 3.

Ponds were prepared following standard procedures (see grow-out trial 2). Two days before stocking, ponds were filled.

Prawn PLs (nursed indoor for three weeks at a density of 300PLs/m^2 of tank surface area) of average weight 0.083g and length 19.03mm were selected randomly and stocked in the ponds at a density of 7 PLs and 9 PLs per m^2 of total area. They were fed with diets at 8.00am and 4.00pm at the rate of 5% of body weight. The feed ration was broadcast along the pond edges.

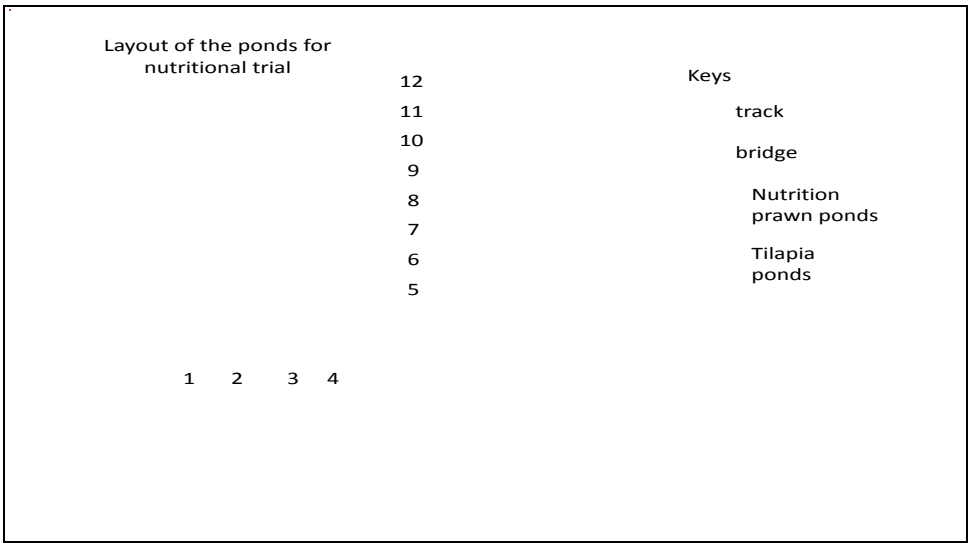

Figure 3. Diagram of the layout of the experimental ponds

Prawn growth performance was determined by weighing 30 individuals randomly caught from each pond every month and all surviving prawns caught at the final harvest. Details of stocking and survival rates are shown in Table 11.

Water quality in ponds was assessed for dissolved oxygen (DO), pH and temperature at 8.00am and 4.00pm at the time of daily feeding, at 10cm below water surface using an YSI oxygen meter.

Table 11. Experimental design & survival rates

Pond	Pond area (m^2)	Density	Initial # animals	Final # animals	Survival (%)
1	113	7	791	713	90
2	116	7	812	728	90
3	105	7	735	649	88
4	105	7	735	654	89
5	121	7	847	727	86
6	100	7	700	622	89
7	126	9	1134	958	84
8	138	9	1242	1022	82
9	138	9	1242	1044	84
10	149	9	1341	1180	88
11	140	7	980	790	81
12	157	7	1099	856	78

The results of the prawn growth performance were analysed for significant differences among treatments using ANOVA. Differences were considered to be significant at the level of 0.05.

5.3 Training and capacity building

5.3.1 Develop the capacity of NRS staff to manage the genetic health and productivity of the best performing freshwater prawn stock identified in the project and to enhance their capacity to undertake basic aqua-feed development and evaluation trials.

- **Training in managing improved stocks**

Before implementation of project activities in October 2008, a two-day training of MFF staff was conducted at NRS. The training activities were composed of lectures and field exercises. The lectures focussing on quarantine procedures and formulation of protocols for satisfying 'Import Health Standards' for introduction of new strains from Indonesia, Malaysia and Vietnam to Fiji, pond preparation, water quality management, broodstock production, hatchery operations, maintenance of prawn stocks and pond grow-out trial were delivered by the project scientist. Hands-on exercises on how to produce PLs successfully, pond preparation, PL weighing, prawn sampling, measurement of water flow rates and water quality management were conducted on the second day.

Under the auspices of this project a simple 'Import Health Standard' was developed for MFF and FQIS that allowed importation of stocks. MFF and FQIS staff are expected to contribute to development of import requirements for freshwater prawns to be legislated through their appropriate agencies.

- **Training in hatchery Operations**

A series of one-day hands-on training workshops were held on prawn hatchery operations for project staff. Previous work conducted at NRS had established mass PL rearing techniques using the clear water method. Parallel efforts were trialled at Galoa government brackishwater hatchery to develop the first large-scale commercial hatchery operation to produce in access of 500,000 PLs in a single cycle.

- **Training in grow-out operations**

Before commencement of grow-out trials, discussions and hands-on exercises were conducted on pond preparations, weighing of individuals, feed and feeding rates, water parameter recordings, water quality management, sampling and final harvest. Training was also provided in harvesting, handling and processing for marketing of prawn in December 2009/January 2010 and April 2011. During harvests, staff were provided with additional training on identification and scoring morphotypes by project scientists.

5.3.2 With assistance from SPC and USP, conduct training in stock husbandry, aqua-feed development and feed production to Fijian and regional government fisheries staff from PINs that are planning to develop their own freshwater prawn industries in the future.

- **Training workshop - NRS 9-12th June 2011**

1. A 4-day training course was held at NRS from 9-12th June to demonstrate practices for hatchery operations, stock husbandry, feed development and management of genetic resources of freshwater prawn (*Macrobrachium rosenbergii*) and Tilapia (*Oreochromis niloticus*) to government fisheries staff who are currently operating or who are planning to develop their own prawn or tilapia farms in the future.

Key objectives were:

i. To demonstrate practical freshwater prawn and tilapia hatchery operations.
ii. To discuss broodstock production and management, stock husbandry and basic principles of developing simple farm-made feeds.
iii. To demonstrate making of simple feeds for prawn and tilapia hatchery operations, juvenile prawn and fingerling production, and for grow-out in ponds.

The following field activities and discussions were conducted to enable participants to acquire skills and knowledge in:

- Developing a base population of broodstock and managing broodstock quality.
- Facility requirements & types of prawn and tilapia hatcheries.
- Methods of post larvae and tilapia fry production (hatcheries operations were set-up for participants to participate in practical activities).
- Managing PL and fry.
- Management of ponds: stocking to marketing.
- Developing simple feeds for: broodstock, hatchery operations, PL & fry nursery, and grow-out in ponds.

Training was conducted by project staff and attended by Fiji's MFF staff and aquaculture scientists from PNG, Solomon Islands, Vanuatu, Nauru, Samoa and Cook Islands. Participants visited local farmer's prawn and tilapia farms in Navua, Waila and Baulevu, and also met with the farmers.

- **Final Project workshop**

The final project workshop was conducted at Holiday Inn, Suva from 13-14th June 2011 to summarize the activities, outputs and outcomes of the project and to make recommendations for scaling-up activities for Fiji and regional governments (see agenda in Appendix 2.). The two-day meeting was attended by project staff and key partners, scientists from Secretariat of the Pacific Community, USP, University of Malaya, fisheries staff from PNG, Solomon islands, Vanuatu, Samoa, Nauru and Cook Islands. The workshop was run in parallel with that for FIS/2008/031: "An assessment of the extent of genetic introgression in exotic culture stocks of tilapia in the Pacific".

6 Achievements against activities and outputs/milestones

Objective 1: To Identify a number of high performing culture lines of freshwater prawn from different genetic backgrounds in Asia and to introduce them to Fiji.

no.	activity	outputs/ milestones	completion date	comments
1.1	Use data from FIS/2002/083 and regional collaborators to identify productive Asian culture lines of diverse genetic background	Divergent culture stocks identified from Indonesia, Malaysia and Vietnam	June 2008	Project Leader and scientist visited and collected prawn tissue samples from several research centres in Asia.
1.2	Undertake import risk assessment for introduction of Asian F/W prawn culture strains.	Protocol for satisfying for Import Health Standard completed	November 2008	Protocols applied and accepted by Fiji government
1.3	Introduce selected Asian culture lines for comparative trials.	Quarantine facilities at NRS improved. A 1,000 PLs of each strain purchased and transferred to NRS. Survival upon arrival to NRS: 21.5%, 45% and 45% from **I**, **M**& **V** respectively. Inbred lines established at NRS-broodstock produced & successful PL production of all strains	December 2008 March 2009 May 2009	PLs transferred to Nadi, Fiji via Sydney. FQIS inspected PLs on arrival. PLs disease free & kept under quarantine conditions for 21 days. A total of 130, 250 and 300 PLs from **I**, **M & V** respectively, stocked into ponds to produce broodstock. Remaining PLs **I** -30, **M**-100 & **V** 100PLs held in tanks (safe keeping). PLs in ponds affected by water supply & flood problems. Hatchery operation- produced over 100,000PLs

PC = partner country, A = Australia, I = Indonesia, M = Malaysia, V = Vietnam

Objective 2: To assess the relative levels of genetic diversity (allelic diversity and heterozygosity) of each introduced inbred line and the indigenous line using microsatellite markers developed previously from western form M. rosenbergii at QUT as a foundation for choosing a genetically diverse line for culture and to establish a foundation for future monitoring of the impact of hatchery practices on exploitable genetic diversity.

no.	activity	outputs/ milestones	completion date	comments
2.1	Use microsatellite markers to document relative allelic diversity and heterozygosity in each of the inbred lines brought to Fiji and the indigenous strain	Relative genetic diversity is known for each inbred line.	May 2009	Tissue samples collected from a randomly collected 100 individuals from each inbred line. Allelic diversity & heterozygosity levels screened.

PC = partner country, A = Australia

Objective 3: To undertake replicated evaluation trials in different production environments at NRs to identify the most productive strain(s) for Fijian conditions.

no.	activity	outputs/ milestones	completion date	comments
3.1	Undertake replicate grow-out trials on each inbred line in different production environments at NRS.	Vietnam strain identified as the best strain. Vietnam strain selected for feed evaluation trials	First trial discontinued Sept.2009. Second trial completed. May 2011	First pond trial commenced in August 2009. Second pond grow-out trial commenced in January 2010First trial affected by water weed infestation in the ponds due to insufficient preparation. Second trial completed successfully Commercial trial completed successfully

Objective 4: Develop experimental feed formulations specifically for freshwater prawns based on low cost local feed ingredients.

no.	activity	outputs/ milestones	completion date	comments
4.1	Identify the most appropriate Fijian ingredients to develop a sustainable diet (availability, composition, and cost) and ensure a reliable laboratory is available for analysis.	Data base of ingredients including composition, availability and price is established.	November 2008	Samples analysed at QDPI laboratory, Brisbane
4.2	Assessment of selected ingredients	Determine suitability of use of these ingredients for aqua feeds for the freshwater prawn	September 2010 December 2010	Protein source ingredients tested Carbohydrates ingredients sources tested

Objective 5: Undertake pond trials comparing the performance of the best performing culture stocks identified above with the experimental low-cost freshwater prawn feed formulations against a commercially- available penaeid aqua-feed.

no.	activity	outputs/ milestones	completion date	comments
5.1	Formulation of experimental diets	Compare growth performance with commercial feeds	July/August 2011	Experimental diets formulated. Pond nutrition trials conducted at NRS with Vietnam strain

Objective 6: Develop the capacity of NRS staff to manage the genetic health and productivity of the best performing freshwater prawn identified in the project and to enhance their capacity to undertake basic aqua-feed development and evaluation trials.

no.	activity	outputs/ milestones	completion date	comments
6.1	Develop protocols for maintaining 'genetic health' and productivity of best inbred stock and provide training to NRS staff.	Simple 'Import health Standard' protocol developed instead of manual. Key NRS staff trained	November 2008 December 2008-May 2011	no existing protocols were available for maintaining genetic health of animals

Objective 7: With assistance from the SPC and USP conduct training in stock husbandry, aqua-feed development and feed production to Fijian and regional government fisheries staff from PINs that are planning to develop their own freshwater prawn industries in the future.

no.	activity	outputs/ milestones	completion date	comments
7.1	Run workshops at NRS for regional fisheries agency staff on maintenance and production of the high performing inbred prawn line.	Training workshop on hatchery developed and delivered. Workshop program developed and workshop delivered to staff in the region	December 2008 June 2011	Series of hands-on workshops on hatchery operation conducted. Regional workshop conducted on 9-14June 2011.

PC = partner country, A = Australia

7 Key results and discussion

7.1 Strain evaluation

7.1.1 Identify a number of productive culture lines of freshwater prawns with different genetic backgrounds in Asia and introduce to Fiji.

- Identification of culture lines

Selected GFP culture stocks from Indonesia, Malaysia and Vietnam identified as having high genetic variability were chosen for introduction to Fiji.

- Import Health Standard

A simple 'Import Health Standard' for freshwater prawn importation was drafted in collaboration with MFF and FQIS for importation of exotic PLs.

- Refurbishment of quarantine facilities

The quarantine facilities at NRS were refurbished to accommodate exotic GFP lines. Quarantine and Import Health Standard requirements were addressed in collaboration with NRS and FQIS staff.

- Purchase and transfer of PLs

Post-larvae production from source countries encountered some difficulties and delayed planned shipments. As result the shipment scheduled for April 2008 was delayed until November 2008. Difficulties were also experienced with obtaining formal clearances from quarantine departments in the respective countries including importing into Fiji and with AQIS for transhipment via Sydney. After delays a total of 1,000 PLs of each exotic strain were purchased and transported to Fiji (Nadi International Airport) via Sydney (International Airport).

Transit through Sydney and long flights led to low PL survival on arrival at Nadi and transport to NRS. Percent survival of PLs on arrival at NRS were 21.5%, 45% and 45% from Indonesia, Malaysia and Vietnam, respectively.

- Establishment of lines and PLs production

On arrival at NRS, all PLs were placed into quarantine for a period of 21 days. Quarantine was completed successfully in November/December 2008 following which juveniles of each line were stocked into separate ponds to produce broodstocks.

Brood stocks were produced successfully and were available by the end of April 2009, but PL production for the experimental trials was delayed. Eventually, more than 200,000 PLs were produced from the 4 strains in late July/ early August 2009. The Malaysian strain required the longest time to reach metamorphosis stage.

7.1.2 Assessment of the relative levels of genetic diversity

A random sample of PLs from each line (n=100) were taken from each brood tank and preserved in 70% ethanol for genetic analysis at QUT. Figure 4 contains estimates of mean allelic richness calculated across 8 microsatellites loci for the four strains. Mean allelic richness varied from 9 alleles per locus in the Fijian line to a low of 3 alleles per locus in the Malaysia line. The only significant difference however, in estimates between lines was evident between Malaysia and the other lines. This result suggests that the

Fijian line had not experienced any greater impact of population bottlenecks in the past after more than 20 years in captivity than was evident in two exotic culture lines (Vietnam and Indonesia) that had been domesticated for only a short time (3-5 years). In contrast, the Malaysia line showed significant effects (loss of diversity) compared with other lines with less than half the allelic diversity remaining, even though this strain was domesticated recently.

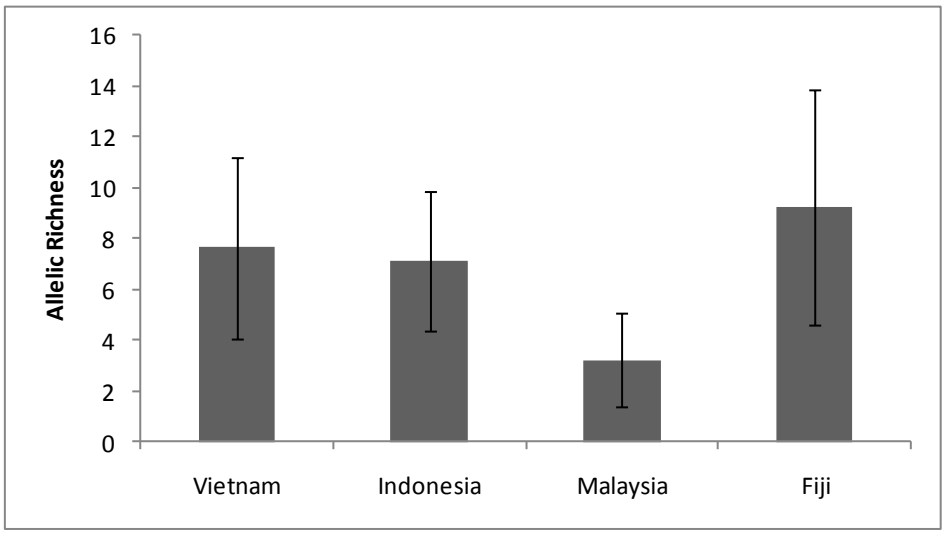

Figure 4. Mean allelic richness of the 4 strains of prawns. Error bars represent +/- 2SE.

7.1.3 Compare relative growth performance of experimental lines.

- First strain-evaluation trial.

The first comparative growth trial commenced in late July 2009 with 3 replicate ponds for each strain (3x4 design) set up. Following the first scheduled sampling on 9-10th October, survival rates in some ponds were very poor, and in some ponds, for example, (Pond 7- Indonesia line and Pond 11 - Vietnam line), no survivors were observed. Blooms of a filamentous alga were observed in affected ponds. Excessive alga growth produced poor environmental conditions in experimental ponds compounded by affects of high rainfall. The trial was discontinued.

- Second strain evaluation trial

Prawn mean weights are presented in Figure 5. At the first sampling (day 63) the mean weight of the Vietnam strain was highest followed by that of Fiji, Indonesia and then Malaysia and this trend continued for the duration of the trial. Differences among lines were only statistically significant ($P<0.05$) at the second sampling (day 105).

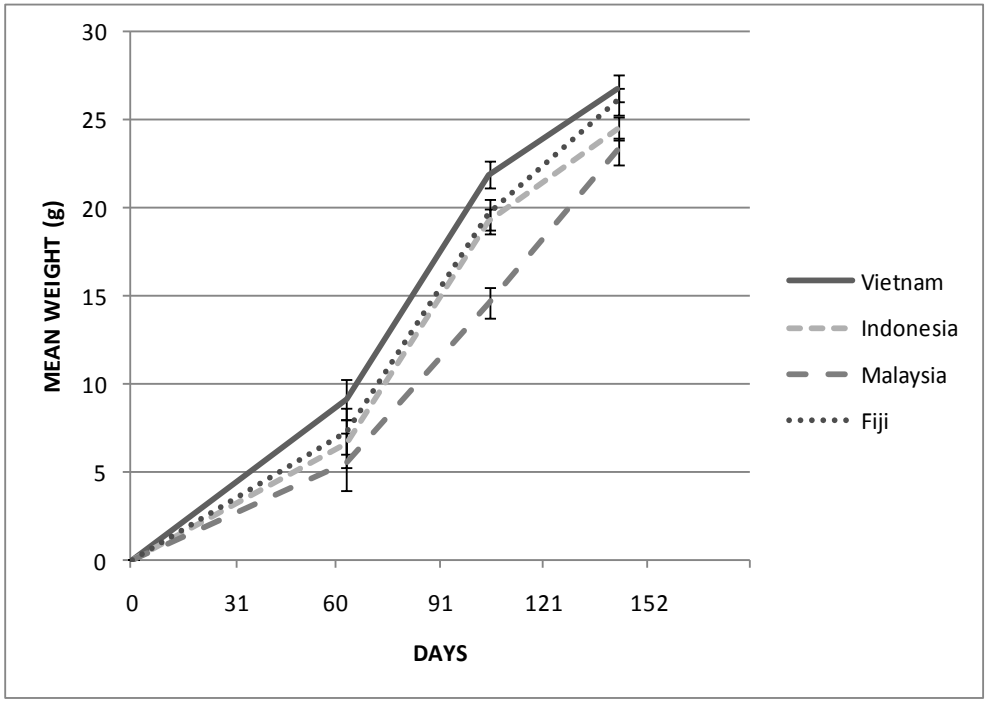

Figure 5. Mean sample weights of prawns sampled from growth trial ponds. Each data point represents mean weight (g) of three ponds combined (+/-2SE).

At final sampling there was no statistical difference in overall survival among strains (Figure 6), however the Vietnam strain showed the highest (>80%) and the Fijian strain showed lowest survival rates (<72%).

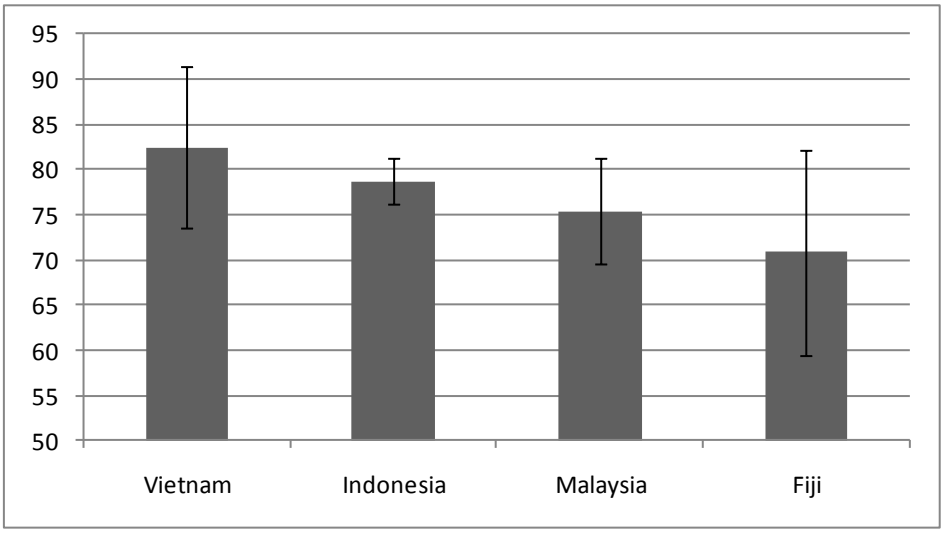

Figure 6. Percentage survival rates by strain at final harvest (+/-2SE).

While no significant differences were detected among strains for single indicators of relative strain productivity (growth rate or survival), individually these measures potentially can be misleading. For example, it is possible for a particular strain to possess a superior

growth rate but also show a poor survival rate, or the reverse. Therefore, we tested for differences among strains when mean growth rate and relative survival rate were combined into a single measure by determining the total weight of prawns produced per pond standardised by the number of prawns that had been stocked into individual ponds at the start of the experiment (equivalent to average weight per stocked prawn). Using ponds as replicates, there was no significant difference among strains ($F_{3.8}$=2.968, p=0.097). The Vietnam strain however, did show the best overall productivity (Figure 7), with the Malaysia strain performing significantly poorer than all others (Ranking V=I=F>M).

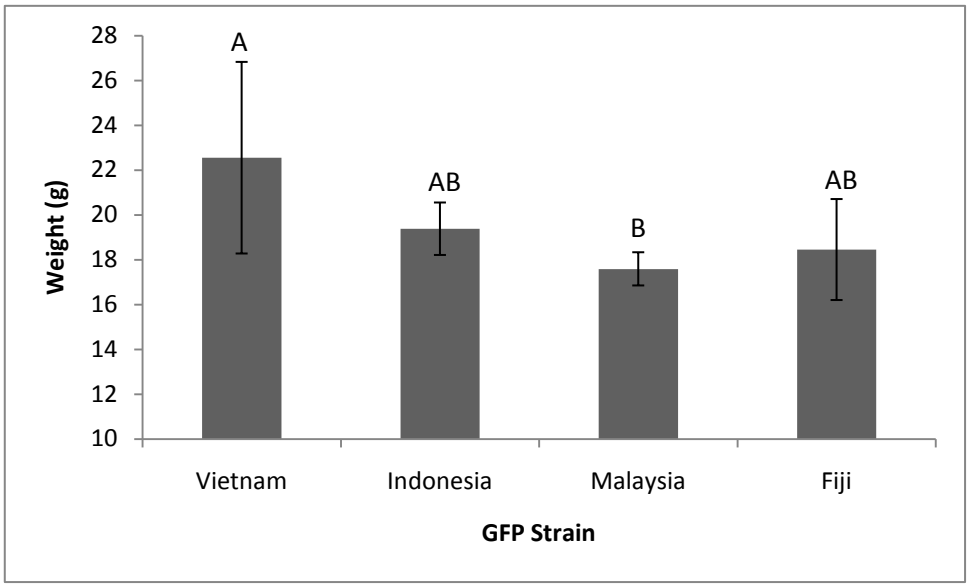

Figure 7. Assessment of both growth rate and survival combined, measured as the mean individual weight per stocked PL, replicated by pond (+/-2SE). Letters above bars indicate differences identified by Turkey's *posthoc* test (p=0.089)

Large differences in the percentage of adult females achieving egg bearing status among strains were observed at first sampling time (Figure 8). The Indonesia strain showed the highest proportion of females achieving egg bearing status early, suggesting that this strain on average, matured at a fastest rate but did so at relative small size (Figure 9) compared with other strains. The Malaysia strain was slowest to mature and was on average also relatively small in size at maturity.

The relationship between mean weight of females achieving reproductive status (berried or spawned) is presented in Figure 9. The average weight of berried females of the Vietnam strain was significantly heavier (P<0.05) than that of berried females of either the Malaysia or Indonesia strains. On average for females, the Vietnam strain was largest in size followed by Fiji strain at time of spawning.

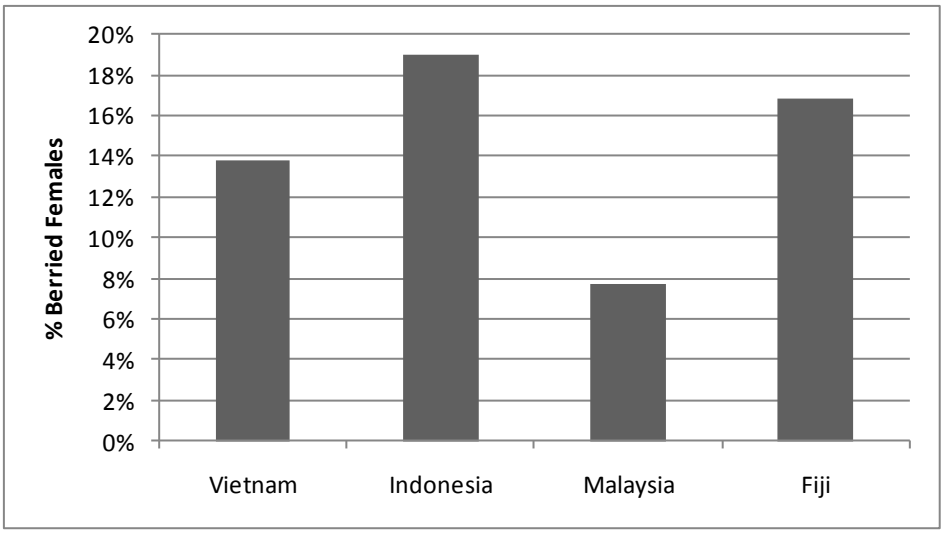

Figure 8. Relationship among percentages of females achieving reproductive status at day 63.

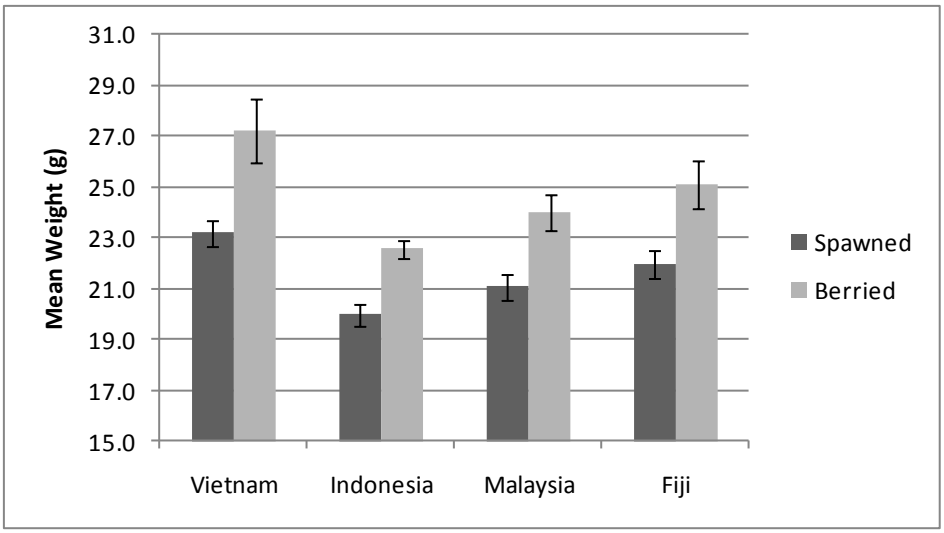

Figure 9. Average individual weights (g) of females: spawned and berried at final harvest.

7.1.4 Commercial pond grow-out trials

In the commercial trial, there was a very high degree of variability within strains, both among ponds within sites and between sites. It is not surprising therefore, that no statistically significant differences were detected in mean weight (Figure 10), percent survival (Figure 11), or productivity overall (Figure 12) between the Vietnam and Fijian strain at final harvest (P>0.05).

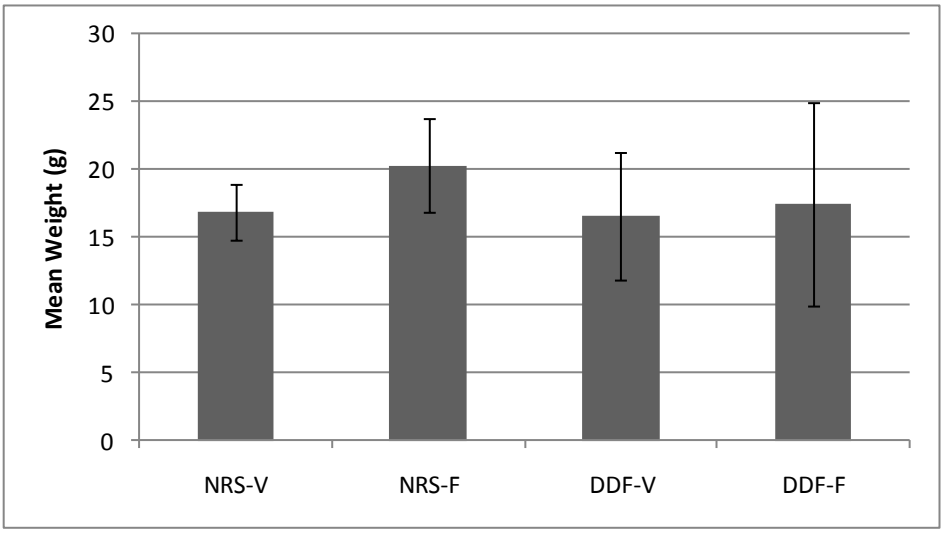

Figure 10. Mean weights at two study sites (NRS & DDF) at final harvest in the commercial trial. Each bar represents average of 3 ponds +/-2SE. NRS-Naduruloulou Research Station; DFF-Dairy farms Fiji.

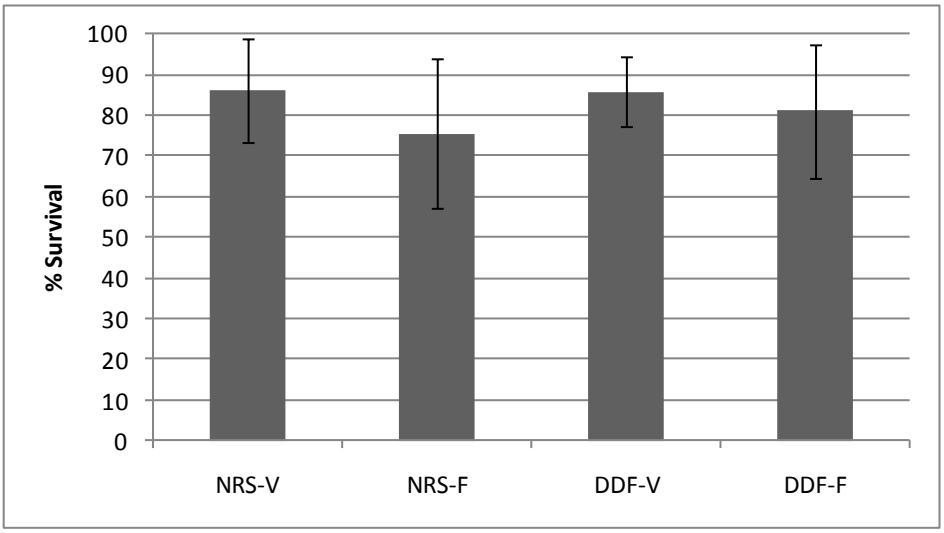

Figure 11. Mean survival rate of the two strains at NRS and DDF. Error bars represent +/- 2SE.

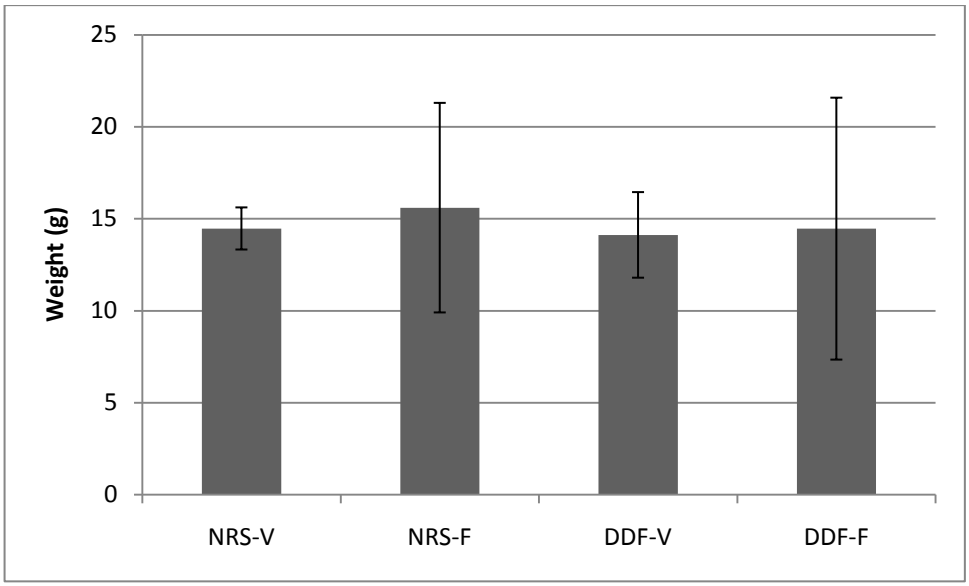

Figure 12. Mean individual weight per stocked PL averaged over three ponds per strain per site. Error bars represent +/- 2SE.

Figure 12 suggests that there was very little difference in production performance between the Vietnam and Fiji strain reared under full commercial grow out conditions. It is notable however, that there was much less variability among Vietnam strain replicates than that evident for the Fiji strain. Notwithstanding, the high variation among ponds regardless of strain, precluded any clear outcomes in the commercial trial.

Given these results, the degree of variation is unlikely to be attributed to differences in genetic quality between the two strains (i.e. no apparent differences were strain specific). Another non-strain related difference was size and time of maturation in females that showed a trend for earlier spawning at DDF (i.e., site specific). These results suggest that other variables associated with grow out are equally important as the quality of the GFP broodstock. This is highlighted when mean prawn weight and pond size were correlated (Figure 13). There was a strongly significant negative correlation ($r=0.774$; $p<0.001$) between pond size and mean weight of prawn at final harvest. This result indicates that individual growth performance was strongly linked to pond size regardless of stocking density, so prawns on average performed better in small-sized ponds than in large ponds at the same relative density. While pond size *per se* may not be the determining factor, it would be pertinent to investigate co-variables associated with pond size such as DO, temperature, water exchange rates, spatial distribution of feed etc.

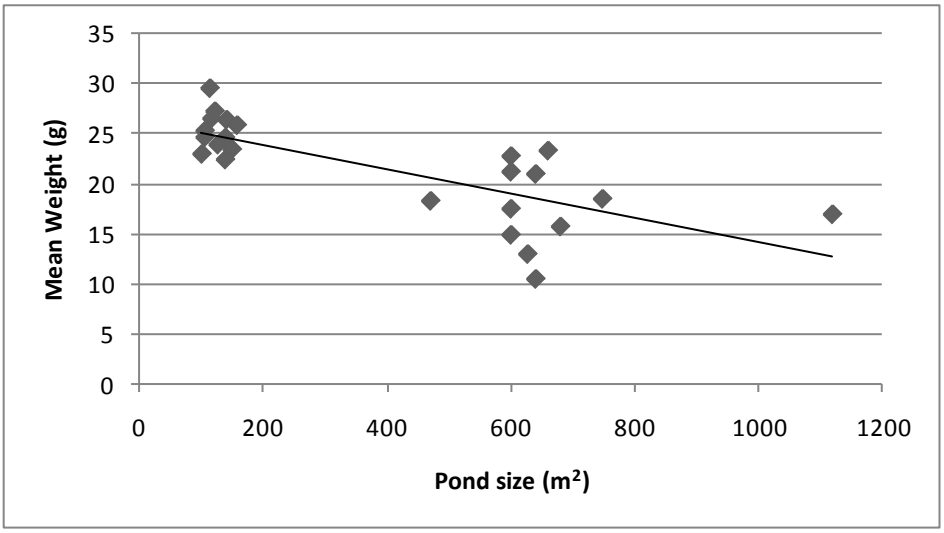

Figure 13. Correlation between mean weight and pond size (including results from both experimental and commercial trials).

7.2 Experimental diet trials for freshwater prawns

7.2.1 Assessment of selected feed ingredients

Results of the ingredient intake experiment that assessed selected local ingredients available in Fiji showed no differences in the intake level for the two batches of selected local ingredients. Experimental intake is shown on Figure 14.

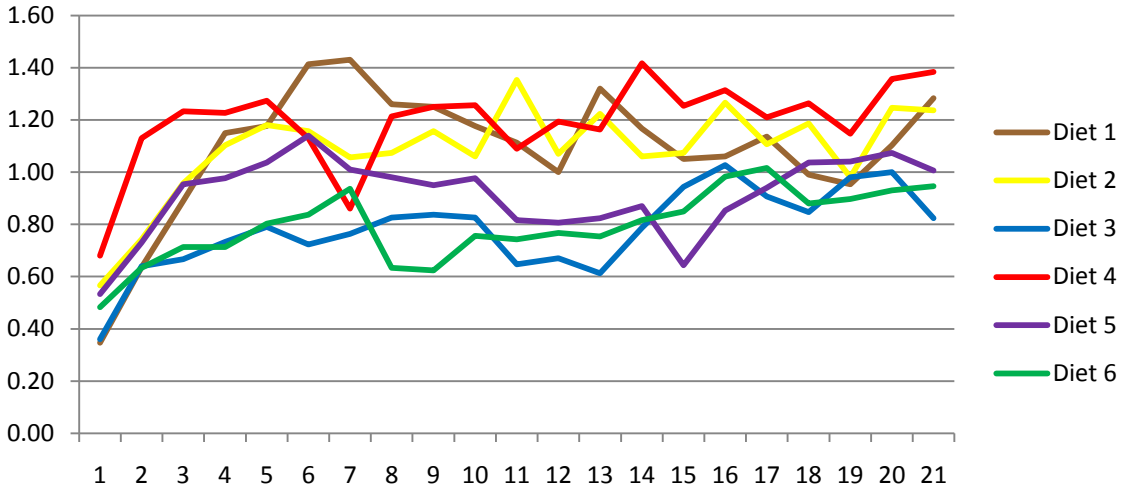

Figure 14. Experimental feed intake of the freshwater prawn

Results of the assessment of selected ingredients locally available in Fiji suggested that inclusion options for feeds in formulation of diets for GFP were very flexible.

7.2.2 Pond Nutrition Trials

Growth parameters recorded in this experiment are summarized in Table 12. Growth performance and survival rates of prawns fed the four experimental diets were not significantly different. Similar outcomes can be explained by high within diet variation for experimental groups. Animals fed with Diet 1 showed the best results for all growth parameters measured, having an average of 33% better weight gain than for Diet 2 (9.28 *vs*. 6.06) and 22% better than Diet 3 (9.28 *vs*. 7.15). Diet 1 and Pacific Feeds showed very similar weight gain results (9.28 and 8.87g).

Different stocking densities used for all diets did not show any difference in either growth performance or survival rates. The average feed conversion ratio (FCR) for the different diets ranged from 0.97 to 1.14. The lowest and best FCR value were obtained for Diet 1 & the Pacific Feed formulation, respectively.

Table 12. Growth parameters

	Diet 1			Diet 2			Crest Feed			Pacific Feeds			Comments
	A	B	C	A	B	C	A	B	C				
Initial weight	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	IBW Initial body weights
Month 1	0.94	1.89	1.42	0.84	1.59	1.40	1.07	1.16	1.76	1.38	1.68	1.56	BW Average body weights
Month 2	3.47	3.30	3.66	1.94	4.00	2.72	2.25	2.63	3.98	3.42	3.93	3.50	
Month 3	5.00	5.54	6.42	2.13	6.25	3.13	2.90	3.96	5.50	4.90	7.17	4.56	
Month 4	8.78	10.17	9.13	5.16	9.09	4.18	5.10	5.77	10.83	8.28	10.24	8.32	FBW Final body weight
Feed intake	6135	7015	8994	3364	6733	6338	3967	5622	9043	5793	9982	8710	Feed intake (g) 124 days
	8.61	9.65	8.61	4.62	10.83	5.37	6.11	5.87	11.45	8.86	9.77	10.18	Feed intake(g)/124 days/animal
Protein intake	2008	2296	2944	1083	2167	2040	905	1282	2063	1752	3020	2635	Protein intake (g) 124 days
	2.82	3.16	2.82	1.49	3.48	1.73	1.39	1.34	2.61	2.68	2.95	3.08	Protein intake(g)/124 days/animal
WG	8.70	10.09	9.05	5.08	9.01	4.09	5.02	5.69	10.75	8.20	10.16	8.24	Weight Gain (g)
SGR	2.19	2.34	2.23	1.66	2.23	1.45	1.65	1.77	2.40	2.13	22.35	2.14	Specific Growth Rate
FCR	0.99	0.96	0.95	0.91	1.20	1.31	1.22	1.03	1.06	1.08	0.96	1.24	Feed Conversion Ratio
PER	3.09	3.20	3.21	3.42	2.59	2.37	3.60	4.25	4.12	3.01	3.44	2.68	Protein Efficiency Ratio
Survival rate	90.14	85.83	84.06	89.66	88.86	87.99	88.30	84.48	80.61	88.98	82.29	77.89	

7.2.3 Experimental Feeds vs. Commercial Feeds

Aqua feeds are the major input cost for most farmers. Consequently, it is very important to get the best performing feed for the most economical price and hence feed conversion ratio (FCR) is one of the most important principles. In this study we stocked an average of 972 animals in each pond with a total weight of 83g. During the 142 days of the experiment a total of 20.42kg of feed was distributed in each pond. Feed intake per animal averaged 8.33 g. We harvested a total of 6.5 kg of prawn on average from each pond, so average feed conversion ratio in this study, was estimated at 1.08kg of feed per kg of prawns produced.

Relative feed conversion rates among diets.

2484 prawns were fed with Diet 1**;** this group of animals had a total initial weight of 206 grams. After 142 days of the experiment using 22.14kg of feed, we harvested 23.16kg. FCR for Diet 1 was 0.97.

A total of 2530 prawns with initial weight 210 grams were fed with *Diet 2.* During 142 days of experiment they consumed 16.44 Kg feed. Harvesting was 14.32kg & FCR for Diet 2 was 1.14.

Diet 3 was tested in 2849 animals with a total biomass of 236 grams. During experimental 142 days the feed consumption was 18.63 Kg. Harvested 17.37kg FCR = 1.10

Diet 4 tested in 3076 animals, 255 grams biomass, consumed 24.49kg feeds and harvested 22.98 kg. FCR was 1.09.

Graphics of these results are presented in Figure 15.

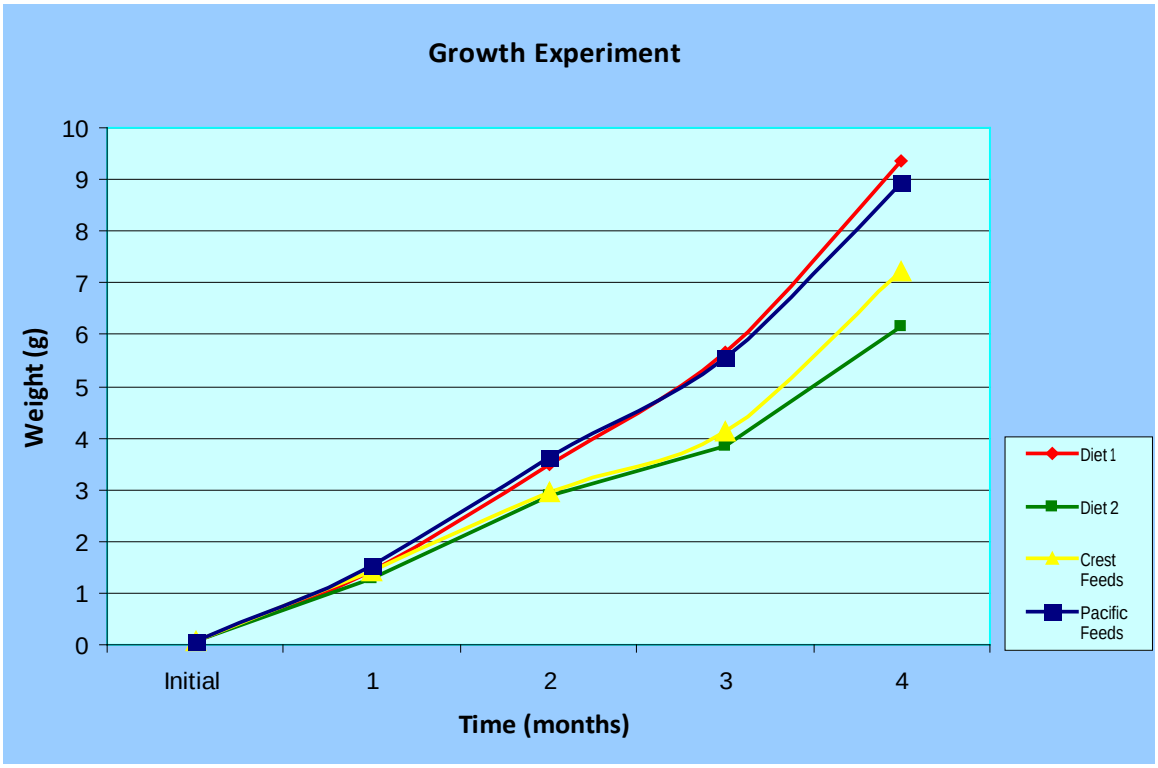

Figure 15. Growth rates during the 4-month experimental period

Our results show that prawns fed Diet 1 or Pacific Feeds diet produced the best growth rates. Growth studies and FCRs vary according to several factors, including the nutritional and physical quality of feeds, environmental variants, such as temperature; the intensity of production (availability of natural feed) and other factors, including genetics. Although the literature is replete with specific FCRs for other aquatic species achieved under experimental conditions, FCRs published for GFP achieved in commercial practice have not been widely reported.

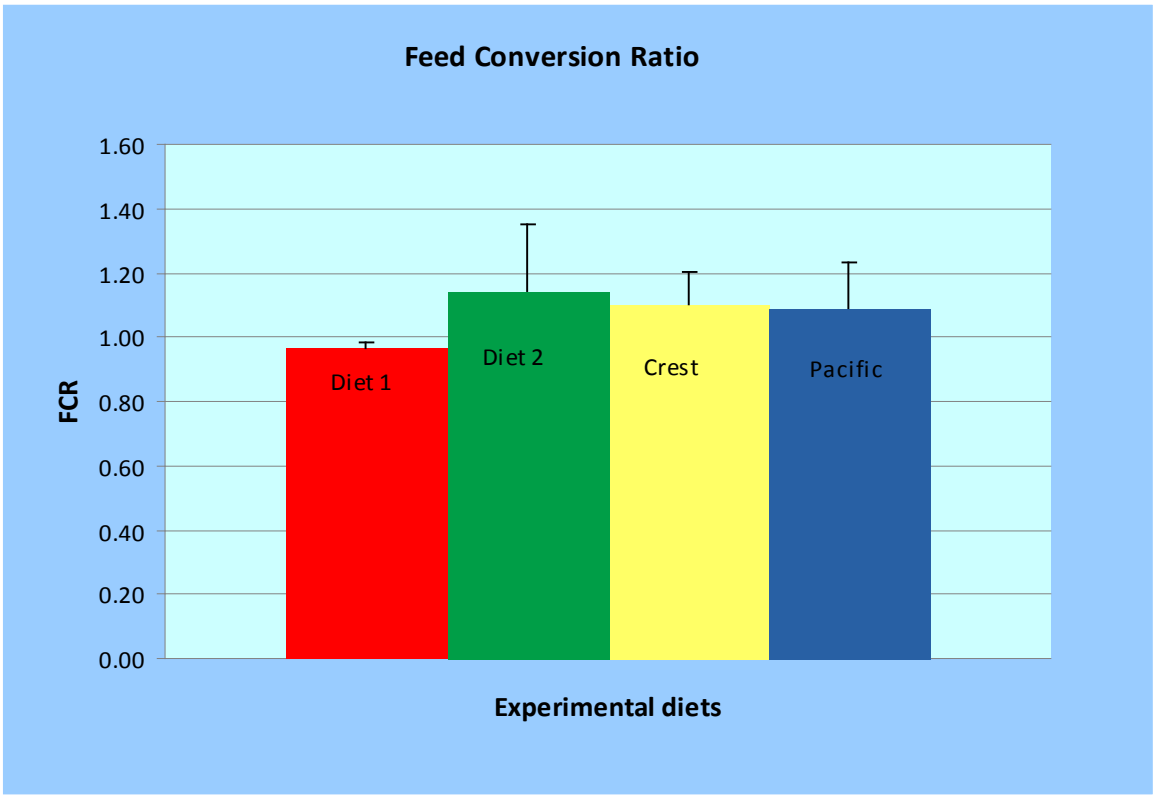

Figure 16. Feed conversion ratios of the experimental diets

A final comparison of cost of individual feeds is presented below.

The cost of feed to produce 1kg of freshwater prawn among the diets were:

- Using Diet 1 – 0.58 AUST$ or 1.08 FJ$
- Using Diet 2 – 0.38 AUST$ or 0.71 FJ$
- Using Crest Feeds – 1.2 AUST$ or 0.64 FJ$
- Using Pacific Feeds – 1.52 AUST$ or 0.81 FJ

These costs do not include feed preparation expenses, (i.e., labour costs) but should be virtually the same among diets.

7.3 Training and capacity building

7.3.1 Training of NRS staff

MFF staff capacity to run and manage experimental evaluation trials was achieved in the project in particular for operation of the prawn hatchery. A close working relationship was established between QUT scientists and MFF staff and other collaborators in the region that enhanced efficiency and expertise in hatchery and grow-out practices.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Now

Considerable benefits have flowed from the current project for the GFP industry in Fiji. The results from the experimental and commercial pond grow-out trials indicated that the Vietnam strain was likely performing best under Fiji conditions. This strain has been recommended to MFF. And with effect from June 2011, PLs of this strain have been made available to farmers by MFF-NRS and private prawn hatcheries. NRS is the only supplier of broodstock to the public and private hatchery sectors and will make this germplasm (Vietnam strain) freely available to farmers.

Assessment of the relative levels of genetic diversity suggest that the Fijian line of GFP had not experienced any greater impact of population bottlenecks after more than 20 years in captivity compared with the Vietnam and Indonesia lines that were introduced in December 2008.The Malaysia line in contrast showed significant effects of loss of diversity compared with other lines.

Pond nutrition trials suggest that it is possible to formulate a diet using local feed ingredients that performs better, that is cheaper and is higher in crude protein content compared with other locally available formulated diets. This experimental diet produced the best growth performance and is significantly cheaper (AUST$0.58/kg-produced using NRS feed making facilities) compared with AUST$0.81/kg for a commercial prawn diet. The formulation of this diet has been recommended to MFF.

During the four years taken to implement this project, we kept our collaborating partners (MFF, SPC and USP) and private sector operators informed of progress and results obtained in trials via written reports, presentations during visits to NRS by project scientists, and MFF quarterly meetings, and discussions with visiting company and overseas scientists. These covered topics such as the pond grow-out trials and problems associated with it, and the likely benefits of these for prawn producers relying on prawn as one of their main source of income.

In five years

1. NRS staff will have improved knowledge about managing genetic resources
2. NRS staff will be better able to evaluate new germplasm and to work closely with farmers to help them test new lines under specific field conditions.
3. NRS and regional staff can provide better extension support to farmers and practice improved adaptive research.

8.2 Capacity impacts – now and in 5 years

Now

NRS staff involved in the project have both new and enhanced skills in managing and maintaining genetic health and productivity of the best performing GFP strain identified in the project.

PL quarantine practices (not available before this project) were developed and protocols formalised to handle future introductions. NRS staff had been trained to carry out simple quarantine protocols for new introductions of fish and crustaceans and a draft of 'Import

Health Standard and Transitional Facility for Freshwater Prawns ' has been prepared with support from MFF and FQIS.

NRS staff were trained to collect and preserve feed ingredient samples and their skills in a range of areas including design of new ponds, preparation of ponds for stocking, water quality monitoring and data recording have been enhanced.

Project staff successfully trained 7 local government staff at NRS and Galoa in hatchery operation i.e., to produce PLs on demand over shorter hatchery cycle times and using higher larval densities than in the past. More than one million PLs were produced from the new and existing Fijian strain as part of this training. Improvement in PL production revived the supply of PLs and thus many farmers have commenced stocking derelict/empty ponds and surplus PLs from the experiment work were sold to a commercial farm (DDF).

NRS staff members, Ms. Shalini Singh and Ms.Temalesi Koroi were awarded fellowships under an ACIAR-USP scholarship scheme to undertake post graduate studies (MSc.) on genetic and nutritional aspects respectively of freshwater prawn culture through USP. Ms. Singh commenced her studies in March 2009 and has completed her study successfully and she will graduate in April 2012. She is now employed as a fulltime government staff member at NRS. Ms. Koroi has completed all field studies and is currently writing her MSc thesis.

GFP production will be improved by production of the best performing strain (Vietnam strain) of GFP with a cheaper diet using mainly local available ingredients. The production of GFP and profit should increase over time for fish farmers in Fiji. In the meantime, more PLs and more prawns are expected to be distributed and also sold by NRS thus improving the delivery of extension services to farmers. The basic knowledge of raising prawns in ponds will be shared with the community in rural areas.

In parallel to project activities, assistance was also provided to NRS staff to improve management of broodstock of tilapia used for fingerling production. Staff at NRS are now implementing the new management practices for NRS tilapia stocks.

In five years

For capacity building, the main emphasis was on developing the abilities of NRS staff to manage the genetic health and productivity of the GFP strain used for PL supply. Experience in the project, will strengthen current stock management practices at NRS and improve prawn farming technologies. Results of this project can improve the returns to farmers by contributing to higher yields over a larger area of Fiji, particularly in the Western and Northern regions of the country. When NRS staff disseminate the new strain of prawn to the western and northern divisions, these divisions can then supply local farmers.

Training received by NRS and regional staff in hatchery operations will improve the way they assist local farmers. This will facilitate a faster uptake of new prawn production technologies and on a wider scale across the country.

Experience of NRS staff in the current project has enhanced their familiarity with research and this knowledge can be applied to other culture species (e.g., tilapia and carps) produced routinely at the NRS station.

8.3 Community impacts – now and in 5 years

There is large interest in freshwater prawn farming in Fiji but limitations on consistent PL supply and a productive local culture strain that can grow well on locally produced feeds has hindered industry development. Many of these issues have been addressed in the current project and this should expand interest in prawn culture in Fiji.

8.3.1 Economic impacts

Now

The project has created awareness among NRS staff and local prawn farmers of the need to maintain the quality of the stocks since modest declines in growth rate may render many economically marginal farms, unprofitable.

The lack of consistent supply of PLs has been a major problem hindering further expansion of the industry (valued approximately F$0.8M in 2008). PLs can now be produced on demand following training provided to NRS staff.

Farmers who were supplied from excess PLs produced for the project trials and who followed advice provided by project staff increased their farms yield by 10 to 50%. Income increased by $15,000 /cycle after farmers were supplied with better PLs. Prawns farmers currently receive $F25-30 per kg of prawns, equating to over $F10,000 per pond (3,000 m^2) per annum. Reports indicate that apart from free supply of PLs to farmers as part of an MFF subsidy, efforts are underway to also sell PLs from the new strain to commercial farms. This development can generate much needed income for government hatcheries and provide additional employment opportunities in a range of services.

In five years

The new strain of prawn will be distributed across the country and more widely across the region. This will most likely facilitate the adoption of GFP farming technologies at a wider scale and eventually contribute to industry growth, better livelihood for farmers and a sustainable, productive local culture industry.

8.3.2 Social impacts

Now

A major outcome since commencement of the current project is that NRS staff have recognised the need to actively manage the genetic quality of prawn stocks and to provide appropriate quality feeds to maintain their productivity.

Meetings conducted with NRS staff to plan for the pond trials led to the revival of weekly Monday morning meetings to plan for weekly work schedules and actions. This also led to the implementation of larger monthly MFF meetings, where aquaculture staff are often invited to attend to coordinate activities.

Information received from the project officer indicates that efforts are already underway to revive the Fiji Aquaculture Council that will assist new farmers to enter the industry in Fiji.

In five years

Improvement seen in the social interactions and communication among MFF staff and the regional aquaculture staff will likely result in better up take of prawn farming technologies. The NRS staff with their new skills in prawn hatchery, grow-out pond operations could contribute significantly to higher farmer productivity.

8.3.3 Environmental impacts

Now

NRS staff were trained in basic quarantine requirements and how to implement them to manage imported live prawns into Fiji. This resulted in almost 100% survival of all PLs that were under quarantine for 21 days at NRS. At the end of the quarantine period no symptoms or signs of disease were observed in the introduced strains and thus there was no risk of spread of diseases. This experience provides a foundation for handling future introductions of GFP and other aquatic species.

Currently there are no import health standards and no formal requirements in Fiji for risk assessment to be undertaken for introduction of any aquatic species. However, a simple quarantine protocol was developed and has been applied at NRS in collaboration with Fiji's FQIS that can be used in future.

In five years

There are no anticipated changes to the environmental status of rural prawn production in Fiji. Prawn farmers who have established ponds use local available feeds and poultry manure as fertilizers. The use of local feed sources will not impact on the environment although more land may be utilized for growing prawns, fish and other crops.

8.4 Communication and dissemination activities

Communication activities raised the awareness of the research findings. The project generated findings relating to: 1) identifying a productive strain and 2) nutritional requirements of artificial diets for GFP. Both findings were disseminated and communicated using project reports and aquaculture conferences/workshops. Some of these include:

Communication with policy makers

Project staff presented key findings from the project and likely paths of diffusion to key officials of MFF, Ministry of Regional Development, Ministry of Finance, SPC and AusAID on several occasions in 2010 and 2011.

The Fijian Minister of Fisheries and Forests and Permanent Secretary of MFF visited the project site of the pond grow-out and pond nutrition trials. The minister was briefed by local project officer.

The final project workshop and meeting in Suva and NRS, on 9-14th June 2011. Project leader and scientists presented the summary and highlights of accomplishments of the project to the key staff of MFF and regional fisheries officers.

Communication with the scientific community

We have started to present the results of this research at professional meetings in Fiji, and internationally, and are drafting journal articles to be published in international refereed journals and in targeted regional newsletters such as NACA and SPC Fisheries Newsletter. For example, results of the growth evaluation trials (from the 105 days sampling) were presented at the World Aquaculture Society conference held in Hobart, May 2010 by Dr David Hurwood. A manuscript entitled 'Experimental evaluation of the culture performance of three exotic and a 'local' giant freshwater Prawn culture strain in Fiji' is currently in preparation for submission to *Aquaculture Research*.

This publications will continue to be complimented by presentations at regional meetings (including the meetings of SPC aquaculture section)at which we can provide public and private –sector breeding programmes with status reports on progress in on genetic improvement on GFP carried out elsewhere (for example Vietnam), including the availability of broodstocks from NRS and on recommendations on feed formulations.

Communication with media

Participants and project scientists were interviewed on their experiences and feedback about the project. The interviews were aired on the news program of Fiji TV on June 9, 10 13 and 14 and also reported in the local newspapers.

An article 'Giant Freshwater prawns for Fiji' was published by *Fiji Sun* on 16th June 2011, The article was supplied by Fiji's ministry of Information. This article was also published by Ministry of Information as part of their media release, see Appendix 3.

High-level media coverage occurred during the final project meeting on 14-15th June at Holiday Inn, Suva. Key officials of MFF, the ACIAR Country Program Manager, Project Leader from QUT were interviewed and how it can help farmers increase their productivity and its contribution to the achievement of the national government's target to increase prawn production. Dr Richard Markham was interviewed by Ms. Serelisoni Moceira with the article titled 'call for extra sources of income' published in the Fiji Times. See Appendix 4.

An article titled 'Forum talks of prawns, tilapia was featured in Fiji Times of June 13, 2011. See Appendix 5.

An article titled 'Aquaculture farming boosts food supply' was featured in Fiji Times on June 14, 2011. See Appendix 6.

An article titled 'Push for more aquaculture experts' was published by Fiji Times on June 15 2011. See Appendix 7.

Project Leader (Prof. Peter Mather) was interviewed by reporter Geraldine Coutts of radio Australia on 4th July 2011. Interview entitled 'Vietnam prawn revitalises Fiji's giant prawn industry' at : http://www.radioaustralia.net.au/pacbeat/stories/201107/s3259989.htm

Interactions with regional staff

The following list of participants attended the workshop:

Fiji MFF: Mrs. Penina Cirikiyasawa, Mr. Sanaila Naqali, Ms. Tavenisa Vereivalu, Ms. Mere Lakeba, Mr. Maleli Dawai, Mr. Jone Vasuca, Mr. Alivereti Senikau, Mr. Samuel Mario; **ACIAR**: Dr. Richard Markham; **QUT**: Prof. Peter Mather, Dr. David Hurwood, Dr. Carmen Gonzales, Dr. Satya Nandlal; **USP**: Ms. Cherie Whippy Morris, Ms. Shirlene Bala, Mr. Avinash Singh, Mr Jone Marawa, Dr William Camargo, Mr. Monal Lal; **SPC**: Mr. Robert Jimmy, Dr. Tim Pickering; **Cook Islands**: Mr. Richard Story, Mr Ngereteina George; **Samoa**: Ms. Ferila Fiti-Samuelu, Mr. Tauvae Sua; **Solomon Islands**: Mr. Alex Meloty, Mr. James Nqwaerobo; **Vanuatu**: Mr Glen Alo, Mr. Lency Dick**; PNG**: Mr. Havini Vira, Mr. Wally Solato, Mr. Gideon Pama; **Nauru**: Mr. David Uera, Mr. Monte Daupune and Dr Subha Bhassu of University of **Malaysia.**

Interactions with international organizations

The following staff from international organizations attended the workshop.

Mr. Robert Jimmy, Dr Tim Pickering from SPC, Noumea

Dr Subha Bhassu from University Malaya, Malaysia.

Engagement with farmers and the general public.

Training and extension services to MFF staff, regional aquaculture staff including prawn farmers in Fiji has been achieved mainly through direct communication, emails and through linkages with USP, SPC and the project coordinator in Fiji. The project has created awareness for the need to maintain quality of the stocks since modest declines in growth rate may render many economically marginal farms, unprofitable. In addition, lack of regular supply of PLs had been a major hindrance to sustainability of existing farms and development of new farms. NRS staff now produce PLs on demand and since the

commencement of this project, they now recognise the need to actively manage the genetic quality of prawn stocks and to provide appropriate quality and quantity of feeds to maintain their productivity.

The following farmers were visited during the workshop and farm owners served as resource persons:

1. Mr. Setoki Qauqau, Prawn and Tilapia farmer, Waila, Sawani.
2. Mr. Vula Prawn farmer, Waidra, Baulevu.
3. Mr. Raghuwaiya, Prawn farmer, Navua.
4. Montfort Fish farm, Veisari, Suva.
5. Dairy Fish Farm, (Commercial Prawn farm), Navua.
6. Galoa Government Brackishwater Hatchery, Navua.
7. Mr. Abdul Sadiq, Tilapia Integrated Fish Farm, Waidra, Baulevu.

9 Conclusions and recommendations

9.1 Conclusions

The project successfully sourced divergent culture lines of GFP from Indonesia, Malaysia and Vietnam and introduced them to Fiji leading to successful establishment of new inbred culture lines. In parallel, NRS staff and MFF improved infrastructure and other facilities to implement the project activities at NRS. The key outcomes of this project include:

1. Successful transhipment and introduction of live culture exotic strains (in consultation with AQIS, FQIS and ground staff at various airports) to establish new GFP germplasm for the local culture industry. This was facilitated by engaging FQIS and MFF staff and completing successful quarantine of the prawns at NRS.
2. The data from the pond grow-out trial in combination with commercial pond trials confirmed Vietnam strain to be the strain of choice when both relative survival and growth rates were considered together. Vietnam strain performed consistently well. Overall the results indicate that pond productivity is better with the Vietnamese strain.
3. Quality broodstock from the Vietnam strain of GFP were handed over to senior MFF staff in a ceremony in Suva on 14th June 2011 and now are used to supply PL's to the local industry.
4. Project staff at NRS and other MFF staff were trained to operate hatcheries efficiently, to produce quality PLs and to conduct pond grow-out trials. The hatchery operations conducted at Galoa hatchery and pond trials at NRS and DDF further developed their skills to lead other extension staff from other divisions in training prawn farmers for the national program of the MFF.
5. After the completion of the pond grow-out trials, NRS staff and farmers began integrating at least two project technologies into their prawn production practices, which has led to higher yield and income. Records of harvests and reports from NRS indicate productivity improvements in PL production and farm outputs from farmers supplied with the Vietnam strain. They generated on average F$15,000/cycle/ha more than had been achieved in the past.
6. The project workshop conducted at the end of the project led to implementation of improved maintenance of broodstock and better health/hygiene management of hatchery and implementation of disease management actions.
7. A pathway to scale out and scale up GFP technologies was discussed to fast-track adoption by farmers in other districts and potentially in other regions.

9.2 Recommendations

The project activities were mainly based at NRS and evaluated the Fiji strain of GFP against 3 productive strains found in Asia. The researchers selected stocks from 3 countries: Indonesia, Malaysia and Vietnam for comparison and developed and applied techniques for strain evaluation using the research ponds and facilities at NRS. This work ensured that all the strains were properly assessed for their ability to meet Fiji's requirements prior to making a recommendation of the best performing strain for Fiji conditions to government authorities.

The project also conducted experiments to test feed formulations specifically for GFP and training to ensure effective dissemination of knowledge about the best strain and its requirements. The project documented the levels and patterns of genetic variation in the four strains of GFP to serve as a baseline for future management.

At the final meeting of the project at Suva on 13-14/6/2011 suggestions were made regarding future directions and issues to be addressed to enhance GFP culture in Fiji and the region. This would follow on from the current project "Freshwater prawn aquaculture in the Pacific: Improving culture stock quality and nutrition in Fiji". The project established a unique collaboration between partners, built on prawn and tilapia genetic improvement and feed formulation research at NRS.

Specific Project recommendations from the final workshop include:

- Vietnam (V1) and Fiji GFP strains should be maintained at NRS for production by industry and the Malaysia and Indonesia strains be culled or kept only for research purposes.

- The environmental factors that contributed to large among-pond performance in the trials require detailed investigation and include: pond size, pond shape, substrate, depth, shelter availability, feeding regime, aeration etc. to optimise stock performance as pond environmental conditions have a large impact on relative culture performance and need optimisation.

- There is an urgent need to identify optimum parameters that support best growth and survival rates for both small-scale and commercial scale productions systems. These conditions may not be the same given the impact that pond size had on individual growth rate (small ponds provided better growth rates).

- Nutritional requirements of artificial diets for GFP are flexible and so many different feed ingredients can be trialled in low cost formulations that are unlikely to compromise growth performance. Effective formulated feed trials are needed to optimise formulations and feeding rate and efficiency.

- Artificial feeds in each PIN should be developed and trialled that incorporate locally available feed components.

- Need to separate broodstock management and supply from the PL production process in hatcheries because the goals of the two processes are different and not always compatible.

- Investigate polyculture options for growing GFP with tilapia and grass carp in Fiji to expand financial returns from pond culture.

- There is a need to provide training for staff in experimental design approaches for identifying best production environments including provision of accurate and realistic information to the policy makers, general public and consumers. This is because as aquaculture in Fiji and the region develops, its success will depend, in part, on a supply of well-educated and well-trained employees to perform the technically challenging tasks required for prawn culture systems. A request was made by MFF, Fiji for a practical, hands-on training on nursery systems, pond grow-out, post-harvest handling and marketing of GFP.

- At present, survival from pond grow-out operations at most farms is poor, averaging around 40%. In a wider context, project results suggest that significant variation exists in stock performance due to pond size, pond shape, substrate, depth, shelter availability, feeding regime, aeration etc., and we propose that this variation should be considered in on-farm trials of the improved strain by NRS-MFF to optimise stock performance as pond environmental conditions have a large impact on relative culture performance. Farmers need to be informed of the best strategies to be employed to maximise both growth and survival rates in different production environments.

10 References

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10.2 List of publications produced by project

Hurwood, D.A., Singh, S., Dammannogoda, S., Nandlal, S. and Mather, P.B. (in prep). Experimental evaluation of the culture performance of three exotic and a 'local' Giant Freshwater Prawn (*Macrobrachium rosenbergii*) culture strain in Fiji . *Aquaculture Research.*

11 Appendixes

11.1 Appendix 1: Protocol for importing freshwater prawns to Fiji

A simple protocol for satisfying for Import Health Standard and a transitional facility for introducing freshwater prawns from Indonesia, Malaysia and Vietnam to Fiji.

1.0 Introduction

Live *Macrobrachium rosenbergii* post larvae (PL) will be imported from Indonesia, Malaysia and Vietnam into Fiji as part of the above project. PLs will be held in quarantine on their arrival in Fiji to minimize the risk of introducing infectious agents and transferring them to susceptible species in Fiji

Post larvae will be sourced from aquaculture establishments that are officially registered in exporting countries (under government control), and shall meet the following conditions;

1. Hatcheries used to produce PLs are subject to health surveillance according to local standards in the respective countries, and are certified that establishments are free from disease.
2. Prior to export, PLs are subject to testing for serious disease using appropriate and acceptable methods.

Prior to export, a quarantine examination will be carried out by a competent authority in the exporting country of origin. They will certify that the PLs are healthy and show no sign of disease. PLs will be transported in accordance with acceptable standards of packaging, transportation and disinfection. Consignments will be accompanied by an original copy of the aquatic animal health certificate issued by a competent authority in the exporting country. The certificate shall state the following:

1. Identification: species, age, size and number.
2. Place of production: exporting country, hatchery name and address.
3. Destination: Fiji Islands. Mr. Maciu Lagibalavu, Principal Aquaculture Officer. C/- Ministry of Fisheries and Forests, Fisheries Department. P.O Box 358, Lami, Suva, Fiji Islands.
4. Results of quarantine examinations.

At Nadi international airport, the Fiji Project coordinator will inspect the seals before the containers/boxes are opened to observe the condition of the PLs including that the species and approximate numbers of PLs within the consignment are as recorded on accompanying documentation. If discrepancies are recorded for the consignment and any non-approved species identified. The consignment will be destroyed under Fiji Quarantine Department supervision.

Operating requirements for Fiji Project officer and the quarantine facility are given below in 2 parts:

Part one:

This note specifies the operating requirements for holding freshwater prawn post larvae on arrival in Fiji to a transitional (quarantine) facility (Naduruloulou Quarantine Facility) as a requirement of import health standards.

The secondary purpose is to prevent introduction of freshwater prawn species that have not been approved for importation.

Part two:

This note specifies the requirements for the supplier of supervision of transitional facilities for freshwater prawn post larvae to ensure that operators are in compliance with Part one of this standard.

2.0 Approval of quarantine facility and an Operator

2.1 Approval of facility

The Naduruloulou Aquaculture Quarantine facility has been approved as adequate for the purposes of providing quarantine for FW prawn post larvae. It will have an approved operator (to be appointed by Fijis' MFF) and operated in accordance with this note (standard).

[A tour of the facility in May 2008, by the ACIAR Project leaders in Australia and the Fijian counterpart reported that the facility complied with minimum basic requirements for quarantine and also for the Fiji Quarantine and Inspection Services and Ministry of Fisheries and Forests.]

2.2 Approval of the Operator

The operator is responsible for operation of the facility and for ensuring that mechanisms are in place for resourcing the facility.

The operator of the facility shall be the **Project Officer** of the present project. The Fijian MFF authorities /Fiji Project Leader shall appoint an operator for the facility.

The operator shall satisfy the leader that s/he has the technical and financial resources in place to maintain the facility in good order.

3.0 Structural and Operational Requirements

3.1 General requirements

The quarantine facility shall be operated in a manner that shall maintain the imported PLs in isolation.

During unloading and after transfer of PLs to holding tanks, water in the containers shall be treated with a chlorine based disinfectant. Any plant or animal species apart from *Macrobrachium rosenbergii* and the containers themselves are to be incinerated or similarly treated with chlorine based disinfectant.

PLs must be held isolated in the facility for a quarantine period of not less than 3 weeks. The Fiji Project coordinator (PC) reserves the right to remove samples at any time for such tests as may be required. PLs must be made available for inspection by the Project coordinator or any other Fiji Quarantine official. If any exotic disease or pathogenic disease agent is observed the PC may direct any or all the PLs to be detained in quarantine for further testing, or order their destruction.

All disease testing shall be conducted at Naduruloulou Fish Laboratory or at an alternate laboratory at the direction of PC (e.g. USP).

Based on clinical and prawn management history and the samples provided by the operator, the 'biologist' at the laboratory shall select the laboratory examinations that are appropriate. The specific disease agents of interest include:

Diseases caused by protozoa. Protozoa that cause diseases of prawns are *Zoothamnium* sp., *Epistylis* sp., *Vorticella* sp. and *Acineta* sp. However other unknown diseases and parasites may be detected. (Treatment for bacterial and fungal infection-use formula: C1V1 =C2V2.

See sections for making a diagnosis, methods of control, how to treat a diseased PL

During the quarantine period:

- The operator shall ensure that no PL, equipment, or materials are removed from the facility without approval of the Fiji Project Coordinator (PC). The PC shall use a system (record system) and the conditions of removal shall address the risk of removing unwanted organisms from the facility.

- The facility shall not be used for any other purpose other than the quarantine of imported PLs although locally produced PLs may be kept in the tanks for control purposes.

3.2 Structure of the present facility

The PLs will be held at Naduruloulou Quarantine Facility that complies with Fiji MFF standards. The facility is fully enclosed and provides access for people and the holding of PLs and other aquatic animals.

Floor, walls, ceiling, shelves, and all other fixtures are constructed of permanent materials and can be effectively cleaned and disinfected. Floor surfaces are smooth and impervious. Free water does not lie on the surface.

PLs from each country will be held in equal numbers in 2 separate tanks. The tanks shall be kept clean and there will be sufficient lightening to allow clear observation of their contents. The tanks shall be permanently identified so that record of PLs can be correlated with each tank.

Tanks must be fitted with lids (or approved equivalent) to prevent prawns from jumping out of the tanks.

3.3 Security of the facility

A prominent sign will be displayed at the entrance to the facility to show that it is a quarantine facility and that unauthorized entry is prohibited.

Procedures shall be adopted to prevent unauthorized access to the facility.

The entrances to the facility shall be kept locked, except when in active use.

3.4 Access to the facility

Access to the facility will be limited to those people identified by PC or representative of the project Officer.

Any visitor shall be authorized by the PC. The project officer shall record the name and address of visitors and visit date in a logbook held near the entrance.

Visitors shall adhere to access procedures and be accompanied by the Project Officer. The instructions of the Project Officer are to be followed at all times.

The Project Officer shall provide protective clothing and footwear for visitors to use in the facility. This shall remain in the facility and always be kept separate.

The Project Officer shall develop procedures for the movement of people to and from the facility that prevent potential transfer of pathogenic agents from quarantined PLs to non-quarantined prawns. These procedures shall address the risk of transfer via the hands, arms, footwear and clothing. Procedures shall include the requirement for people who make contact with fish, prawns or water to wash their hands and forearms with soap and water before exit from the facility.

3.5 Shared Quarantine

Each import shipment of PLs shall be physically isolated from others, and kept separately in tanks. Isolation includes all equipment associated with the feeding and handling of PLs and water supply. Procedures shall address the risk of transfer of pathogenic agents from one shipment to another via hands, arms, footwear and clothing. Procedures shall include the requirement for people who make contact with PLs or water to wash their hands and

forearms with soap and water before exit from the facility or alternatively to wear new surgical gloves while attending to each set of PLs at all times inside the facility during the quarantine period.

3.6 Identification of FW prawn

The operator shall be responsible for the identification of the imported PLs

3.7 Progeny of Imported Broodstock (PLs)

A component of the imported PLs and their progeny may be shifted to another facility after all quarantine conditions have been satisfied.

3.8 Removal of Material from the facility

Nothing may be removed from the facility without the approval of PC. The conditions of removal shall address the risk of removing pathogens and PLs from the facility.

Equipment taken into the quarantine building shall be removed unless cleaned and disinfected.

3.9 Water disposal and treatment

Provision is made to contain all water used for exchange or discharged water. All wastewater from the quarantine facility shall enter directly into an approved sump.

3.9.1 Treatment of waste water

All wastewater must pass through a filter capable of removing suspended organic material prior treatment according to MFF standards.

3.10 Cleaning and disinfection

Facilities shall be available for adequate disinfection of all equipment, filters, tanks etc. that comes in contact with in quarantine waters.

3.11 Disease surveillance and treatment

The operator shall observe PLs for signs of illness and abnormal behaviour periodically throughout the day.

PLs shall be available for inspection by the PC who reserves the right to take specimens at any time for disease testing.

The operator shall notify the PC within 24 hours of any deaths or changes in behaviour by PLs where more than 30% of a tank is affected over a 5-day period. Dead PLs shall be removed from tanks as soon as possible and kept under refrigeration, or otherwise as directed, until the PC has examined them. The operator shall have a system to identify the tank of origin of PLs.

The cause of death shall be established, where possible. In addition, the operator shall provide materials for packaging of samples for further examination.

Dead PLs may be taken for incineration by the PC or they may, with approval, be held preserved in 10% formaldehyde.

Treatments or prophylactic measures shall not interfere with disease surveillance and shall be recorded.

3.11.1 Occurrence of an exotic disease/disease control

If an exotic disease is diagnosed the PC shall be notified within 24 hours.

The PC may direct the management of disease control and extend the period of quarantine or order the destruction of PLs. If the PC orders destruction of a shipment, all shipments in the facility may be destroyed if there is some doubt about the isolation of shipments.

If the PLs are to be destroyed and the facility requires decontamination the following procedures are likely to be authorized:

- The PLs shall be destroyed
- All dead PLs be removed from the facility for incineration.
- The interior of the facility, tanks and equipment etc. shall be thoroughly cleaned and disinfected
- The water shall be treated with chlorine.
- Approval shall be sought from the PC before the facility can be used again.

3.12 Contingency Plans

Contingency plans shall be in place to take account of any breakdown during transport, quarantine, flooding or any other emergency. If an outbreak of exotic disease occurs provision shall be made to treat all water. Resources shall be identified and accessible for the contingency. The PC shall be advised of the emergency as soon as is possible.

3.13 Costs

The PC is required to pay all costs associated with the operation of the facility.

3.14 Biosecurity clearance

At the end of the quarantine period, the consignment may, subject to sections … of Fisheries Act 1958, be given a biosecurity clearance pursuant to section … of the, providing documentation meets all requirements noted under 'documentation accompanying the consignment' and the in the MFF.. or any other.. or to the satisfaction of the Director of Fisheries.

Consignments that do not meet Fiji's import requirements will remain in quarantine control, be re-exported or destroyed.

3.15 Audit

The Project Officer shall provide the PC or any other representative, access to the facility, records and documents for inspection and audit. The Project Officer shall be available to assist and ensure that all relevant procedures and records are made available to the PC.

The PC will conduct inspections and on-site audits as required. Additional audits will be conducted as required, especially if non-compliance is found.

3.16 Records

The Project Officer is required to demonstrate compliance with this standard by keeping records as required for quality assurance. The project Officer shall, for auditing purposes, maintain for one year the following records filed with each shipment.

- Overseas supplier, country of origin, dates of arrival and release date
- Number of PLs in each tank
- Details of clinical signs of disease, number affected in a tank and treatment
- Details of PL mortality by tank
- Details of management changes, such as food changes, and power and aeration failures
- Biosecurity clearances
- Records of internal audits and corrective actions
- Records of external audits and corrective actions.

11.2 Appendix 2: Closing workshop agenda, 13–14 June 2011

Closing Workshop on projects: 'Freshwater prawn aquaculture in the Pacific: improving culture stock quality and nutrition in Fiji' and 'An assessment of the extent of genetic introgression in exotic culture stocks of tilapia in the Pacific', 13-14 June 2011, Holiday Inn, Suva.

AGENDA

DAY 1 Monday 13th June

Time	Topic	Presenter
9.00-9.10	Welcome	USP
9.10-9.30	Opening Address	Fiji's MFF
9.30-9.50	Opening address	Dr Richard Markham
9.50-10.15	Introduction by Participants	USP
10.15-10.45	Morning tea	
10.45--11.00	The progress of GFP culture in Fiji	Dr Satya Nandlal
11.00-11.30	ACIR GFP stock improvement project-objectives & methodologies	Prof. Peter Mather
11.30-12.00	GFP growth trial results	Dr David Hurwood
12.00-12.30	GFP feed trials	Dr Carmen Gonzales
12.30-2.00	Lunch	
2.00-2.15	University of Malaya	Dr Subha Bhassu
2.15- 3.15	General discussion & regional issues	
3.15- 3.45	Afternoon tea	
3.45-4.00	Project recommendations	Prof. Peter Mather
DAY 2 Tuesday 14 June		
8.45-9.00	ACIAR – tilapia for food security in the region	Dr Richard Markham
9.00-9.10	Progress of tilapia culture in Fiji	Dr Satya Nandlal
9.10-9.20	Tilapia culture in Cook islands	Mr Ngereteina George
9.20-9.30	Tilapia culture in Fiji	Mr A.Senikau
9.30-9.50	Tilapia culture in PNG	Mr Havina Vira,
9.50-10.00	Tilapia culture in Samoa	Mr Tauvae Sua
10.00-10.10	Tilapia culture in Nauru	Mr David uera
10.10 -10.20	Tilapia culture in Solomon islands	Mr Alex Meloty
10.20-10.30	Tilapia culture in Vanuatu	Lency Dick
10.30- 11.00	Morning tea	
11.00- 11.30	ACIAR tilapia project objectives &methodologies	Prof. Peter Mather

11.30-12.30	Tilapia project results	Dr David Hurwood
12.30- 2.00	Lunch	
2.00- 3.30	General discussion and project recommendations	Prof. Peter Mather
3.30- 4.00	Afternoon tea	
4.00-....	Closing ceremony	

11.3 Appendix 3: Giant freshwater prawns for Fiji

The Australian Centre for International Agricultural Research (ACIAR) handed over a strain of giant freshwater prawns to the Department of Fisheries at Holiday Inn while closing a five-day workshop on 'Freshwater Prawn Aquaculture in the Pacific' today. These giant prawns, originally from Vietnam, were identified as the best performance stock for Fiji, which suited the local environment for future aquaculture industry. A total of 15,000 prawn strains were handed over to the department. Professor Peter Mather of ACIAR said they conducted research over three years on both tilapia and freshwater prawns and found the stock decreasing. "There is evidence which showed productivity in ponds declining due to genetic reasons or due to ways of handling and managing ponds," he said. "We addressed the first part of the issue which was to identify good genetic line and brought tilapia fish from Philippines which had 25 per cent faster growth rate and moved to freshwater prawns." The research was done at the Naduruloulou Research Station on three strains of prawns in Fiji from Indonesia, Malaysia and Vietnam. It was found that the Vietnamese strain of prawns grows faster and the Department of Fisheries is planning to introduce these strains to boost production and meet the local demand. When opening the second part of the workshop, the Ministry of Fisheries and Forests deputy secretary Mrs Penina Cirikiyasawa said the workshop focused on improving culture stock quality and nutrition in Fiji and assessment of the extent of genetic introgression in exotic culture stocks of tilapia in the Pacific. "Fiji is importing huge supplies of prawns and shrimps from overseas to meet its local demands and the Government is presently advocating import substitution strategies to boost local production and supplies," Mrs Cirikiyasawa said. She said the Department of Fisheries has been promoting and advocating the development of aquaculture in Fiji in areas of prawns and tilapia farming through free supplies of prawn post larvae and tilapia fingerlings for stocking by farmers as well as technical advisory services. The workshop was organised and sponsored by ACIAR and University of the South Pacific where regional fisheries stakeholders participated.

11.4 Appendix 4: Call for extra sources of income

Serelisoni Moceica
Wednesday, June 15, 2011

THERE is a need to create additional sources of income as a strategy to address food security, says a participant of the Freshwater Prawn Aquaculture in the Pacific workshop yesterday.

Dr Richard Markham, a Suva-based program manager for Australian Centre for International Agricultural Research (ACIAR), said subsistence living was irrelevant in today's economy as people struggled to put food on the table.

"The idea of subsistence farming is almost an illusion in the present day and many farmers produced in economically rational ways," Dr Markham said.

Dr Markham said that many factors, including the increasing population, was causing an increasing priority on a culture of low value fish and food security.

The researcher also said that aquaculture was still unfamiliar technology in the region and this was one of the issues faced by the sector. He also added that a medium scale enterprise can provide employment from which workers are able to purchase food. Dr Subha Bhassu, University of Malaya project leader, said the products developed should be of commercial value and relevant to the needs of the community.

The five-day workshop which began at Naduruloulou Research Station ended yesterday at Suva's Holiday Inn.

11.5 Appendix 5: Forum talks of prawns, tilapia

Monika Singh
Monday, June 13, 2011

A THREE-DAY workshop aimed at helping Fiji and its neighbouring islands learn more about freshwater prawn and Tilapia farming has been organised by the Department of Fisheries and the University of the South Pacific at the Naduruloulou Aquaculture Research Station in Nausori.

Workshop facilitator and Research Fellow in aquaculture and applied ecology at the Queensland University of Technology, Dr Satya Nandlal said freshwater prawns and Tilapia had the potential to become very successful but it depended on government.

He said aquaculture in Fiji failed because of the lack of knowledge and funding.

He said presently freshwater prawns were very expensive in Fiji with a kilogram being sold for $30. "This is not something that the poor can afford and that is where Tilapia comes in and we are working on improving the taste of Tilapia fish because we believe that it can be afforded by the poor because it is known as the poor man's fish," he said.

Dr Nandlal said they were working with Macrobrachium rosenbergii (freshwater prawn) species which is in Fiji and could be good for Fiji's aquaculture. The Fisheries Department operates a large freshwater aquaculture centre and prawn hatchery at Naduruloulou Research Station outside Nausori and is responsible for overseeing the development of this sector.

11.6 Appendix 6: Aquaculture farming boosts food supply

Serelisoni Moceica
Tuesday, June 14, 2011

 + Enlarge this image

Havini Vira of Papua New Guinea, holds a prawn during a prawn and Tilapia workshop at the Naduruloulou Agriculture Station in Tailevu last Thursday. Picture: ELIKI NUKUTABU

AQUACULTURE boosts much needed nutritional requirements for the poorest section of our community, says Ministry of Primary Industries deputy secretary Benina Cirikiyasawa.

Mrs Cirikiyasawa made the comment at the five-day workshop on Freshwater Prawn Aquaculture in the Pacific in Suva.

The last two sessions of the workshop were held at the Holiday Inn and organised by the Ministry of Fisheries and Forests.

The session featured representatives from Pacific island countries, research institutions, non-government and government agencies.

Mrs Cirikiyasawa said the workshop convened at a time when there was growing recognition of the contribution of aquaculture to food supply.

She said research conducted into aquaculture would be used for the improvement of aquaculture farming in the Pacific.

"It is noted that ACIAR (Australian Centre for International Agricultural Research) and USP have been doing intensive collaborative research work with the Department of Fisheries in past years," she said.

"I am sure during the course of these research works, they have identified problems as well as find appropriate solutions for further improvement."

The workshop, facilitated by Dr Satya Nandlal of Queensland University of Technology, ends today.

11.7 Appendix 7: Push for more aquaculture experts

Serelisoni Moceica
Wednesday, June 15, 2011

Deputy Secretary for Fisheries and Forests, Penina Cirikiyasawa receives a giant prawn from Professor Peter Mather of the Queensland University at the Holiday Inn in Suva. Picture: ELIKI NUKUTABU.

THERE is a need for an upgrade of the skills of personnel involved in the development of aquaculture in the country, according to fisheries officer, Alifereti Senikau.

Mr Senikau raised the issue at the aquaculture workshop yesterday and said the lack of expertise in the area would cause inconsistency in development.

"We need upskilled field officers as they are in touch with farmers, knowledgeable in the aquaculture sector and would establish a consistent relationship with everyone out there in the field," he said.

Deputy permanent secretary Penina Cirikiyasawa said the fisheries department supplied free prawn post larvae and tilapia fingerlings for farmers and provided technical services.

Mr Senikau said Freshwater Aquaculture Plan which was under the Aquaculture Development Plan for 2011-2014 was also being reviewed.

"There is also the recent establishment of the Interim Tilapia Farmers Association where farmers can raise issues related to their work," Mr Senikau said.

The officer also raised the issue of seed supply to all the three divisions in the country participating in aquaculture development. Mr Senikau said the draft aquaculture decree would be submitted once completed.