

**Final report for Mini-project MS0603:**

**Eradication of Mozambique tilapia (*Oreochromis mossambicus*), restocking of Nile tilapia (*O. niloticus*) and improved aquaculture pond management in Nauru**



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## 1.0 Introduction

Nauru is a single, raised coral limestone island (land area 21 sq. km and length of coastline 24 km), encircled by a fringing coral reef which is exposed at low tide. The ground rises from a narrow sandy beach forming a 100-300 meters wide fertile belt around the island. Inland, coral cliffs rise up to 30-40 meters above sea level, merging into a central plateau which reaches 60-70 meters in some places.

Nauru had a very unique tradition of milkfish (*Chanos chanos*) farming dating back hundreds of years. The juvenile milkfish were collected from the inter-tidal reefs and reared in the island's main 'lake', the Buada Lagoon and other ponds. Most of these ponds are bomb-craters as a result of bombing in World War II. Some ponds were constructed for milkfish farming. These ponds are spread around the island, mainly along the coast, 3-10 meters above sea level, covering a total area of about 2-5 hectares with a holding capacity of approx. 20,000 cubic meters of water. Milkfish (locally known as 'ibia') was harvested regularly from these ponds and formed a very important source of food especially during unfavourable weather conditions when fishermen were not able to go out fishing on the reefs. Some reports indicate that milkfish was harvested for special occasions and was also used for ornamental purposes, for example, women would adorn themselves with its scales and other body parts for special dancing occasions.

In 1961, *Oreochromis mossambicus* (Mozambique tilapia) was introduced into Buada Lagoon and ponds to control mosquito larvae. This tilapia, being a prolific breeder and active competitor for food and space, made it very difficult for people to raise milkfish in the lagoon. Since tilapia had become part of the lagoon fish fauna, the milkfish produced were very small in size and not acceptable by the people for food. In addition, the *O. mossambicus* had spread to almost all the ponds with the result that milkfish harvested were of small size, i.e. <20 cm, and not appreciated by the pond owners. As a result many farmers abandoned their traditional practice of raising milkfish, resulting in a gradual decrease in this form of aquaculture over the years.

Since fishing is limited by the fact that there is very narrow fringing reef and very few boats suitable

for deepwater or pelagic fisheries, people have resorted to catching tilapia from the lagoon and ponds using gill nets and hook and lines. It has become a source of protein for some of the communities.

In 1981, Food and Agriculture Organization (FAO) initiated an aquaculture program, commencing with an eradication program for *O. mossambicus*. The eradication of *O. mossambicus* was not successful. Later, several other attempts were made by FAO and other agencies to demonstrate culture of milkfish, tilapia etc. For example, a Taiwanese government funded project was able to achieve faster growth rates of imported milkfish fry [from Kiribati] using intensive culture methods but the costs were too high and prohibitive for local conditions. Also, in 1998, FAO introduced tilapia (*O. niloticus*) from Fiji for farming but culture of this species did not develop because it was out-competed by *O. mossambicus*. In addition, FAO in collaboration with Nauru Fisheries and Marine Resources Authority (NFMRA) carried out tilapia taste trials through import of freshly chilled Nile tilapia from Fiji. It was preferred by the people.

Recently milkfish fingerlings were imported by NFMRA, on behalf of the farmers, from Kiribati and stocked in Buada Lagoon and some ponds. Further support for aquaculture projects came in 2004 with the purchase of aquaculture equipment under an aid program.

At present Nauru is going through a period of economic hardship and efforts are directed at increasing availability of fish protein through aquaculture that could reduce the reliance on marine fishes that are reportedly becoming over-exploited. Under the present situation of food shortage, there is focus towards production of tilapia in backyard ponds for subsistence as it now forms a very important source of protein for the people in Nauru. Small quantities of undersize tilapia are harvested using fishing lines from the ponds. Recently the NFMRA provided advice to private individuals wishing to establish tilapia pond culture. However, there has been limited success due mainly to constraints of:

- Lack of expertise and skills in eradicating unwanted fishes in the ponds before tilapia (*O. niloticus*) can be stocked;
- Lack of general tilapia farming/husbandry techniques;

- lack of appropriate equipment for fish farming;
- lack of locally available fish feed and fertilizers.

In 2004, the NFMRA requested SPC to address the above constraints. Although the complete eradication of Mozambique tilapia is unlikely to be achieved in the short-term, improving the condition of small ponds and stocking with remnant stocks of Nile tilapia will increase production of much-needed protein at low cost. It will also be a simple test of whether the eradication of unwanted fishes can be achieved in small ponds. If such small scale eradication trials are successful, then farming of Nile tilapia and milkfish may become viable again in cleared ponds. Farmers will also be trained to gain skills that will lay the foundation for rejuvenating traditional milkfish aquaculture.

The objectives of this study were to:

1. develop and trial protocols for eradication of unwanted fishes, primarily *O. mossambicus*, in two derelict freshwater ponds;
2. evaluate growth and production of *O. niloticus* stocked into ponds;
3. improve capacity of farmers and government aquaculture staffs in pond restoration, restocking, feed production and fish husbandry skills.

The proposed research forms an integral part of a larger aquaculture initiative within the region which seeks to address the problem of degradation caused by Mozambique tilapia and food security concerns. The project does not involve any introduction or transshipment of new species, potential legal disputes or controversial issues.

## 2.0 Materials and method

Mr Satya Nandlal (SPC) made two visits to Nauru. The first was from 5-20 May 2006, to carry out consultations with NFMRA staff, initiate the study (site selection, preparation, eradication of unwanted fishes and stocking) including training of fisheries officers and local farmers. The second visit was from 7-21 September to supervise the final sampling and harvest of fish and to conduct a workshop to present results of the study.

### 2.1 Site selection

Consultations were carried out with Nauruan communities to identify sites for the grow-out trials

on May 5 2006 followed by detailed surveys at several locations identified by NFMRA. Three potential sites were identified:

- (1) an earthen pond belonging to Junita of Menen (Pond 1);
- (2) an earthen pond belonging to Jovani of Nibok (Pond 2); and
- (3) a cement tank, Ivon's swimming pool (Pond 3).

The main selection criteria for the earthen ponds were: located close to residence of owners (i.e., security for the ponds), good pond features and soil quality. Furthermore, pond owners were eager and willing to participate in the research. The pond belonging to Junita had been constructed for milkfish culture in the 1970s but was abandoned due to the presence of *O. mossambicus* in the pond. Pond owners at other locations were not willing to farm tilapia as they were more interested in raising mullet, a project proposed by other donor agencies in Nauru. Ivon's swimming pool, was chosen at the recommendation of NFMRA. It is located on the hills at Nauru Phosphate Corporation and had been used for tilapia culture over the last 5 years.

Although substantial preparatory work was carried out on Jovani's pond (Pond 2), it was eventually not stocked due to problems between the Nibok community and the pond owner.

### 2.2 Eradication of unwanted fish

Eradication of unwanted fish in the pond was imperative to ensure optimum growth of the stocked fingerlings, i.e., to meet the first objective of this project. One of the methods to achieve this was to drain the pond and allow the pond to dry for about two weeks until the pond bottom cracks. The topography of the pond site was such that it was not possible to drain the ponds by gravity as ponds did not have outlets. Ponds are filled by ground water, thus there were also no inlets. It was not possible to drain and dry the ponds. The method chosen was to empty the pond water using a pump, apply piscicide such tea seed cake or rotenone or cyanide and thereafter de-silt the ponds.

Tea seed cake was used since it is cheap, effective and not harmful to humans. It is a residue of the fruit of plants from the Camellia family after the oil is extracted and contains the toxin, saponin. Tea seed cake for the study was imported from Taiwan.

Ponds at both sites were cleared of all bushes, debris and rubbish. The ponds were infested with *O. mossambicus* and *Gambusia* spp. The ponds were emptied until it was not possible to pump out the water using water pumps i.e., to about 2 cm water depth. A solution of tea seed cake [2 kg in 10 liters of water] was prepared in a bucket and broadcast all over the water. Dead fish were seen floating 40 minutes after application of tea seed cake solution.

*Note: best results are obtained when tea seed cake solution is applied with minimal water in the pond. The dosage is based on the volume of water in the pond, i.e., dose for 1000 m<sup>3</sup> of water (10 cm of water in 1 ha) use 15-20 kg of tea seed cake powder.*

### 2.3 Pond preparation

#### Junita's earthen pond (Pond 1):

A day after application of tea seed cake solution, the pond was de-silted and its design (shape and size) improved by an excavator. The sides were sloped and the pond bottom deepened to about a meter by removing the silt. Removing the silt also ensured that all fish fry and eggs were removed. Soon after de-siltation, the pond started to fill with ground water. The pond dimensions were length 32 m, width 26 m and water depth 1.0 m [range 0.8-1.2 m] giving a total surface area of 832 m<sup>2</sup> and capacity to hold over 850 tonnes of water. Water level in the pond was kept at 80-100 cm deep to maintain the water volume at all the times.

#### Ivon's cement tank (Pond 3):

The swimming pool at this site already contained *O. niloticus* brought from NFMRA at an earlier time. The tank water was transferred with aid of a water pump into a neighbour's swimming pool. The fish were seined and held in a container which had an air stone to aerate the water. The tank was cleared of all rubbish and sludge removed by buckets. The tank was refilled and fingerlings stocked. The tank was supplied with rain water from nearby building guttering whenever it rained. The tank dimensions were length 7 m, width 3.5 m and depth of 1.5 m, providing a surface area of 24.5 m<sup>2</sup> and capacity to hold about 35 tonnes of water at a water depth of 1.4 m.

*Note that the earthen pond was not limed because lime was unavailable in Nauru. Treating the*

*pond bottom with lime is a recommended practice to condition the pond bottom in order to buffer fluctuations in pond water pH and also kill any organisms present in the pond. Another important aspect of pond preparation is to fertilize the ponds (it is a recommended practice to fertilize ponds with organic or inorganic fertilizers- normally a week is sufficient for the water to turn green after which time fish can be stocked). There were no fertilizers available in Nauru, thus the pond and tank were not fertilized.*

### 2.4 Fingerlings for stocking

According to NFMRA staff, *Oreochromis niloticus* fingerlings imported from Fiji in 1998 had been stocked in cement tanks behind the office building. The tanks received water from the building water runoff. Later the tanks were stocked with milkfish fry imported from Kiribati. Milkfish grow-out trials were conducted in these tanks and the tilapia fingerlings were given to farmers. Some were taken by Jovani and released into a 2-3 hectare swamp adjacent to his residence in Nibok district.

On May 18, 2006, during Mr Nandlal's visit to initiate the project, a small area of the Nibok swamp, approximately 100 m<sup>2</sup>, was cleared and the water was pumped out. *O. niloticus* fingerlings were collected using a push net. These fingerlings were rinsed clean of mud and stored live in water-filled buckets without aeration, then transported to Junita's pond. Here, the fingerlings were counted as they were released into the pond. Due to lack of equipment, there was no means to weigh or grade the fingerlings. The average fingerling weight was estimated at 5 g and the total number stocked in Junita's pond was 1,300. Care was taken while releasing the fingerlings to ensure that the water temperature in the buckets holding the fingerlings was similar to that of the pond water. The pond water temperature and other water parameters were also not measured as the equipment was not available.

On the night of May, 19, Ivon's tank was cleaned and prepared. A total of 60 fingerlings were selected from this tank to be stocked into Jovani's pond by NFMRA but this stocking was never carried out. Instead, Ivon's cement tank was re-stocked with 160 fingerlings with an estimated average weight of 5 g each (stocking density of 6-10 fish/m<sup>2</sup>).

*Note: Initial stocking density would normally be*



based on the size of the expected yield at harvest. Since no adequate aqua feeds were available (only commercial stock feed- duck starter and pig starter), it was decided to stock at a low density of 1.5 fish per m<sup>2</sup> of water surface area and expect a weight of 150-200 g per fish at harvest time. Low density stocking was also selected because the fingerlings were from a swamp and of unknown (but probably low) quality.

## 2.5 Feed

A grower mash was formulated to contain ~16.5% crude protein from commercial stock feeds: a duck starter diet (crude protein 16%) and pig starter diet (crude protein 17%). These feeds were ground up and mixed in equal portions manually. It was packed in 'flour' bags and stored at the NFMRA office. 5 kg of the mash were given to both Junita and Ivon to feed their fingerlings. Rates for daily feeding were prepared, starting with a ration of 10% of the fish biomass to be fed twice daily (50% in the morning and 50% in the afternoon) for first 21 days and decreasing to 8%, 6% and 4% at 21-day intervals thereafter until the end of the trial period.

## 2.6 Sampling

Sampling of fish (to monitor growth rates and adjust feeding rations) were scheduled to be carried at 21 day intervals throughout the study but due to logistical constraints were only carried out on (need date here) May , 7 July, 8 and 14 September..

## 2.7 Water quality measurements

Water temperature, salinity, pH and DO levels were measured by NMFRA staff. The DO level was not measured for the complete trial period due to equipment failure. Due to unavailability of transport to travel to the sites, staff were not able to monitor water parameters daily, measurements were taken approximately two or three times per week.

## 2.8 Harvesting

The final sampling and harvesting at Junita's pond were carried out on September 14. The pond water level was dropped to a depth of about 5 cm. The majority of the fish was seined by dragging a "shade screen" net over the entire length of the pond. This process was repeated until most of the fish were collected. Thereafter all the water was pumped out and the remaining fish were collected

by hand from low areas in the pond. As the fish were collected, they were rinsed clean of mud and debris. They were counted and group weighed thereafter stored in 500 l tanks with aeration beside Junita's house. Fish were also stored in tanks at the Fisheries office and in hapas installed in an adjacent pond. Fingerlings and fry were also collected, rinsed clean of mud and stored in separate hapas. Individual weight and length of a sample of 250 fish were measured.

Most of the fish stored in holding facilities to purge overnight were found missing the following morning. Thus the planned marketing exercise was not carried out. The fish held in tanks at NFMRA office remained and will be used for displays and as future broodstock.

Harvesting of fish at Ivon's cement tank was carried out on September 15. The water in the tank was pumped to a tank belonging to the neighbour. All the fish were collected with a scoop net, washed and measurements for body weight and length taken.

## 2.9 Training

Mr Nandlal ran a two day workshop in tilapia hatchery and grow-out methods for NFMRA officers, pond owners and members of the local aquaculture association. It was based on the Tilapia Fish Farming in Pacific Island Countries manuals (Nandlal and Pickering 2004), and included hapa, tank and pond hatchery method, eradication of unwanted fishes, pond rehabilitation and pond management techniques. Hands-on training was also provided in seining tilapia fingerlings, holding in containers, manual sexing, transporting, counting, acclimatization and stocking. Simple feed preparation techniques were demonstrated.

# 3.0 Results

## 3.1 Water quality

In Junita's pond, the water temperature ranged from 27- 32°C, salinity was below 5 ppt, pH ranged from 7.85-8.04 and DO levels 1.7- 5.3 mg/l (Figure 1). The average water temperature in Ivon's cement tank was 29.4°C, pH 7.6 and DO 4.4 mg/l.

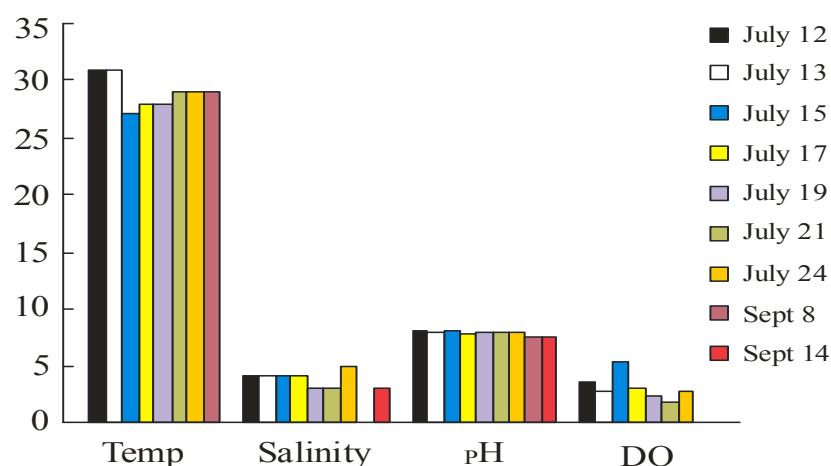


Figure 1 Temperature, salinity, pH and dissolved oxygen level in Junita's pond over the trial period.

### 3.2 Fish data

The average weight of fish in Junita's pond was 41.43 g, compared to 71.5 g in Ivon's tank (Table 1, Figure 2). The total fish biomass in the pond was 54 kg and 18.3 kg in the tank. Survival rate in the pond was over 98%. In the tank there were more fish harvested than stocked [someone added fish without the knowledge of NFMRA staff]. The gross feed conversion ratio is not calculated as there were no records of feed given to the fish. Most of the female fish harvested had spawned. About 20,000 fry and fingerlings were harvested from the earthen pond and about 1,000 fingerlings from the cement tank.

Table 1. Record of number of fingerlings stocked, average weight at stocking and harvest including total fish weight at harvest.

	Pond	Tank
Area (m <sup>2</sup> )	832	25.5
Stocking density (no/ m <sup>2</sup> )	1.5	6.2
Number stocked	1301	160
Mean weight at stocking (g)	5	5
Number harvest	1280	257
Mean weight at harvest (g)	41.43	71.5
Prod./pnd (kg)	54.1	18.3
Prod./ha (kg/ha/cycle)	650	7176.4

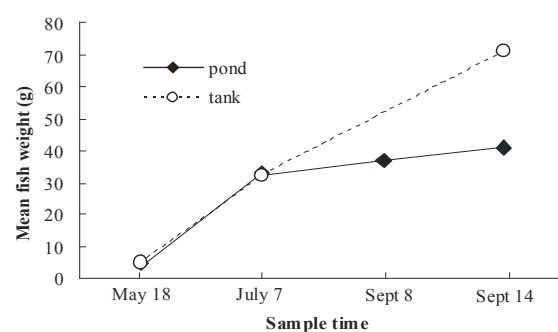


Figure 2. Mean weight of fish at each sampling time from Junita's Pond and Ivon's tank.

The production of fish was 650 kg/ha and 7176 kg/ha from stocking densities of 1 fish/m<sup>2</sup> and 6-10 fish/m<sup>2</sup> respectively (Table 1).

Apart from *O. niloticus*, there were no *O. mossambicus* or other fish seen or harvested in the ponds indicating a successful eradication of unwanted fishes.

During harvest, the fish, including fry and fingerlings were seined, washed and transferred into holding hapas and tanks with almost 100% survival. Marketing of the harvested fish was not carried out as most of the fish went missing overnight from the holding facilities.

Post harvest, the ponds were prepared again, i.e., cleaned and tea seed cake solution applied and then refilled and restocked with fingerlings harvested from the ponds.

## 4.0 Discussion

The results showed that application of tea seed cake and de-silting of the ponds eradicated unwanted fishes, especially *O. mossambicus* and *Gambusia* species. Effective fishpond management requires the elimination of fish competitors or unwanted fishes in ponds as part of pond preparation before stocking with desired fish. In Nauru, imported tea seed cake was used successfully to eradicate unwanted fishes in the ponds without affecting the subsequent crop. Tea seed cake is expensive. There is a native source of fish toxicant in the country that is claimed to be equally effective as tea seed cake according to a staff of NFMRA. However, at present there is no information available on its use or toxicity, therefore it should not be used until proper testing is been carried out.

Although the fish yields were lower than expected, good survival was observed in the two ponds. The growth rate of tilapia was 0.35 g/day in Junita's pond and 0.6 g/day in Ivon's tank, which may have been due to the different stocking densities [Junita's pond at 1.5 fish/m<sup>2</sup> and tank at 6.27 fish/m<sup>2</sup> and at harvest 10 fish/m<sup>2</sup>], feeding protocols, water quality or some unrecorded difference between the two trial ponds.

Results of experiments carried out in Fiji showed significant differences in pond yields from the use experimental tilapia diets with varying protein levels: fish grew better on 32% protein diets than on 20%. The feed used in this trial was prepared from available commercial stock feed in Nauru with a crude protein level of 16.5%. Supplemental feeds with 25-32% protein are generally used for tilapia culture in semi-intensive and intensive systems. At these higher protein levels, expected average fish weight is approximately 180-250 g and total production is near 10 tonnes/ha for a stocking rate of 50,000/ha, with survival of 98%. The small size of the fish obtained in this trial did not discourage NFMRA staff as they were similar to, or bigger than, some of the marine reef species currently caught by spear fishing. Production equivalent to over 7 tonnes/ha in the cement tank was a very encouraging result despite the poor quality of the feed used. Our efforts to develop a better feed will continue so that Nauruan fish farmers can economically produce tilapia at sustainable levels.

In the experiment a mixed-sex population of fingerlings (average weight 5 g and age not known)

was used. The harvest should have been carried before or soon after the fish reached sexual maturity, thereby eliminating or minimizing recruitment and subsequent over-crowding. A restricted culture period limits the size of fish that can be harvested. In addition, in mixed-sex culture, tilapia fingerlings are usually stocked at low rates to reduce competition for food and promote rapid growth. In practice, 1-2 month-old, 3-5 g fingerlings are stocked at 20,000 to 50,000 fish per hectare into grow-out ponds for a 4-5 month culture period (i.e. 2-5 fish/m<sup>2</sup>). Newly raised fingerling should be used because older, stunted fish, such as those used in this study, will reach sexual maturity at a smaller size. If the present source of fingerlings is used, then manual sexing should be carried out. Manual sexing is the process of separating males from females by visual inspection of the external urogenital pores. Secondary sexual characteristics may also be used to help distinguish sex. Reliability of sexing depends on the skill of the workers and the fish size.

The basic fish husbandry and pond management skills necessary to bring about significant improvements in the tilapia yield from existing pond structures have been acquired by NFMRA staff. These include use of tea seed cake in elimination of unwanted fishes, use of pumps, use of excavators for pond improvement, fingerling collection and transportation, pond preparation and pond management, sampling and harvesting, feed preparation and feeding. Other practices such as breeding tilapia in hapas, tanks and ponds, broodstock management etc. would require more resources and increased effort by NFMRA staff. Demonstration farms should be established if the Nauru government desires tilapia culture to develop. Junita's farm could be developed as a demonstration unit.

## 5.0 References

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## **Acknowledgments**

The authors express sincere appreciation to all who contributed to the completion of this project, namely ACIAR and SPC for funding, NFMRA and DPI,-Queensland. We appreciate the opportunity to participate in this project especially on eradication of unwanted fishes in the ponds and extend many thanks to the sponsors. We also thank the pond owners and others for providing the necessary help and facilities during the experiment.