Aquaculture CRSP 21st Annual Technical Report

Survey of Tilapia-Shrimp Polycultures in the Philippines

Tenth Work Plan, New Species/New Systems Research 3E (10NSR3E)
Final Report

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Abstract

A survey of farmers who had adopted some form of shrimp-finfish polyculture was conducted. The respondents included producers from 13 separate provinces in eight regions of the Philippines. Four separate techniques were reported for rearing fish with their shrimp: simultaneous, sequential, rotational, and cages inside ponds. The majority of the respondents stocked tilapia with shrimp, with milkfish being the primary alternative.

Most of the respondents reported that the integration of finfish and shrimp culture lessened disease problems, especially vibriosis. Several on-farm trials have shown that luminous bacterial counts in the water and in the shrimp were below 10 colony forming units (cfu) per ml and below 1,000 cfu per hepatopancreas, respectively. The on-farm trials were conducted in ponds that had previously been used for tilapia culture (rotation) and whose water was previously taken from a tilapia reservoir (sequential), as well as the stocking of tilapia in cages with shrimp (cages) and stocking directly in the ponds (simultaneous). Several of the respondents also reported that the tilapia contributed to "conditioning" the water. Specifically, the density of green algae increased, providing "greenwater."

The Philippines has developed the most wide-ranging forms of integrated tilapia-shrimp farming. The severe impact of diseases on the yield and profitability of shrimp culture provided much of the impetus for this variety. Adoption of polyculture has provided jobs for many people who had lost positions with the loss of shrimp operations and has led to what appears to an apparently more sustainable culture method.

Introduction

Shrimp ponds have been abandoned in many parts of the world due to diseases, poor management, and environmental degradation. Production of tilapia, supplemented with low densities of shrimp may provide an opportunity to develop a sustainable aquaculture system using abandoned shrimp ponds that will support local Filipino inhabitants who have not benefited from the shrimp boom that has occurred in many parts of the world. Polyculture, or crop rotation of shrimp and tilapia, may even be the modern equivalent of the Chinese polyculture of carp. Tilapia production in former shrimp ponds (with and without shrimp) has increased rapidly in Aquaculture CRSP countries, including Thailand, the Philippines, Honduras, Mexico, Peru, and elsewhere, such as the inland desert of Arizona.

The spread of shrimp-tilapia polyculture presents a unique opportunity to take advantage of the strengths of the Aquaculture CRSP's locations and expertise to conduct cross-cutting research and make a contribution to groups who would be most likely to understand and benefit from a sustainable production system. Farmers in several locations around the world appear to have demonstrated that tilapia and shrimp can be grown together.

Shrimp aquaculture has been devastated in many countries due to disease outbreaks or decreasing yields or both. The progression of shrimp aquaculture has followed a familiar pattern throughout the tropics. Initially, farms are constructed in the most appropriate areas. These locations are characterized by good soils with proper pH, appropriate levels of clay, silt, and sand, proper elevation, good access to clean water, and convenient disposal of waste waters to a location that keeps wastes from being cycled back into the farm. These farms, if managed well, tend to be very profitable. This early success leads others to imitate the process as best they can, and hence a "gold rush" attitude exists where excessive numbers of farms are built, often in ecologically fragile areas, particularly mangrove forests. From a practical standpoint, mangrove forests are usually poor sites for shrimp farms. They do not have the proper soils, there is poor access to water and inadequate drainage due to low elevation, and they are especially susceptible to storm damage.

A related phenomenon that causes farm failure is the overstocking of an existing farm. After the initial success of a farm, the managers often assume they can increase yields and profits by stocking more shrimp and feeding more heavily. This may work for one or two crops, encouraging even more stocking, but inevitably the producer overshoots and a disease outbreak occurs because the animals have been overstocked and are stressed beyond the buffering capacity of environmental conditions in the pond.

In most cases the farm managers react by increasing water flow through the farm or by adding mechanical aeration. These do in fact address the problem, but they also increase operating expenses and environmental impacts. Added to this situation is the fact that the ponds must be properly maintained and the pond soils managed between crops. Many farms do not properly maintain their infrastructure or their pond environments. When multiple farms in one area reach this stage, there tends to be an environmental overload. The effluent from one farm becomes the supply water for another, and the receiving environment cannot process the nutrient-rich effluents, leading to eutrophication. Diseases are then spread by water transfers, birds, and other vectors. Excessive pumping of water can lead to saltwater intrusion and depletion of freshwater aquifers. Farms that had been highly profitable with little management can suddenly require more investment and sophisticated management for lower levels of profit. Some farms make the investment to operate in a more sophisticated and sustainable manner; many others just abandon the farm. In many countries, the governmental oversight and environmental regulation and protection have been inadequate to avoid this serious ecological damage.

A related problem has been one of land tenure. Investment groups frequently come in and gain control of coastal lands and hired local inhabitants. The workers are usually happy to have the employment, and they appreciate the infrastructure (roads and electrification) that often accompanies the farm. However when these farms fail, the local inhabitants are left unemployed and with environmental damages that impair their abilities to return to artisanal fishing or small-scale agriculture. Common environmental damage includes salinization of soils, salt-water intrusion, loss of breeding areas for marine species, eutrophication, and changes in the water flow through estuaries.

One technique that has been tested to utilize abandoned shrimp ponds is to convert the pond to tilapia production. There have been several variations of tilapia production, including rearing fish in seawater, brackishwater, and freshwater. Some have attempted polyculture with shrimp, and some are using a crop rotation of tilapia and shrimp (Fitzsimmons, 2001).

In nature, tilapia are omnivores. Young tilapia graze on algal and bacterial films scraping most hard surfaces with their tongues and teeth. As they grow they also become effective filter-feeders of phytoplankton and predators of zooplankton. Larger tilapia are less effective filter-feeders but graze heavily on macrophytic algae and aquatic plants. In extensive farming situations, tilapia feed on algae, prey on zooplankton, and scrape films from any hard surfaces in the pond. In intensive farms most nutrition is derived from pelleted feeds, although fish will continue to spend time scraping algal and bacterial films from all surfaces.

In nature, larval shrimp feed first on phytoplankton and then zooplankton. As juveniles and adults they are omnivores and detritivores. Their natural behavior is to search the bottom substrates for decaying plant and animal material. They also constantly pick up sand grains and pieces of organic matter, graze the algae and bacteria, then drop the grain or particle and go onto the next item. In farm settings, shrimps feed on pellets and products of natural processes in the pond. Research by Samocha et al. (1998) has demonstrated that shrimp can be reared in systems with little water exchange, taking advantage of the natural abilities of shrimp to thrive in conditions with high bacterial loading so long as dissolved oxygen levels and other water quality factors are maintained.

There are several variations of tilapia-shrimp polyculture: simultaneous, sequential, and crop rotation. In the simultaneous method, the fish and shrimp are grown together in a pond or raceway. In the sequential case, the water is moved from one growing unit to another, and crop rotation alternates between tilapia and shrimp. There appear to be distinct advantages to each of these systems.

In a polyculture setting, tilapia and shrimp can utilize different niches. In an extensive farm, tilapia can feed on phytoplankton and zooplankton in the upper water column. Shrimp spend most of the time in the pond bottom, where they graze on bacterial films on the substrate and on the detritus settling from above. This detrital matter consists of dying algae cells and fecal matter from the tilapia. In a more intensive farm receiving pelleted feeds, the tilapia monopolize the feed, especially if it is a floating feed. However, some feed particles always get to the bottom where the shrimp will get it. More importantly, the fecal matter from the tilapia contributes to the detrital rain that supports the shrimp. *Macrobrachium*-tilapia polyculture reduces the yield of prawns compared to monoculture, but increases total yield of fish and prawns (Garcia-Perez et al., 2000).

A similar effect occurs with brackishwater polyculture of tilapia and shrimp (Yap, 2001). Anggawa (1999) reported that yields of shrimp increased when tilapia were stocked into existing shrimp ponds. The suggested stocking rate was 20 to 25 g fish m^{-2} and the fish size at stocking of 50 to 100 g $fish^{-1}$. The use of all-male fish was needed to control reproduction. Fish were stocked when the shrimp biomass was at least 80 g m^{-2} (for 3 to 4 g shrimp) or 150 g m^{-2} (for 5 to 6 g shrimp). Tilapia harvest biomass was 40 to 50 g m^{-2}, and shrimp survival was 70%.

From the disease aspect, tilapia seem to provide advantages in several ways. Growers in Ecuador have reported that tilapia will consume dead or moribund shrimp in polycultured ponds. Cannibalism is one of the primary vectors for transmission of shrimp diseases. Tilapia, which do not appear to be susceptible to or carriers of these viruses, disrupt cannibalism as a mode of transmission. Tilapia also consume small crustaceans in shrimp ponds. These crustaceans are of concern as potential vectors. Having tilapia directly in the ponds or alternating with shrimp in a crop rotation can be effective for reducing crustacean populations. Bacterial infections may also be less virulent with polyculture. Vibrio and most other bacterial pathogens common in shrimp culture are gram-negative, while waters which have been used for fish culture tend to be predominated by gram-positive bacteria. Using water from a fish culture pond seems to reduce the prevalence of luminous Vibrio bacterial infections in shrimp ponds (Yap, 2001). Growers in Asia and South America have provided anecdotal reports that shrimp production increases due to higher survival in some of these polyculture systems. However carefully controlled and replicated trials are needed to better study these systems and

Table 1. Regions and provinces covered by the survey.

Region	Provinces	Number of Respondents
1	Pangasinan	15
3	Pampanga	2
	Bulacan	2
6	Negros Occidental	2
7	Cebu	2
	Bohol	2
	Negros Oriental	1
10	Misamis Occidental	2
11	Sarangani	2
	Davao	1
12	Lanao del Norte	1
13	Agusan del Norte	3
	Surigao del Sur	1
Total		**36**

Table 2. Percent distribution of respondents according to age, sex, and civil status.

Characteristics	Region								
	1	*3*	*6*	*7*	*10*	*11*	*12*	*13*	*Overall*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
AGE									
≤30	0	25	0	0	0	0	0	25	5.55
31-40	13.33	25	50	40	0	0	0	0	25
41-50	66.67	50	50	40	0	50	0	50	44.45
>50	20	0	0	20	100	50	100	25	25
SEX									
Male	100	100	100	100	100	100	100	100	100
Female	0	0	0	0	0	0	0	0	0
CIVIL STATUS									
Single	0	0	0	0	0	0	0	25	2.78
Married	100	100	100	100	100	100	100	75	97.22

Table 3. Tenure status and years engaged in shrimp farming or polyculture.

Characteristics	Region								
	1	*3*	*6*	*7*	*10*	*11*	*12*	*13*	*Overall*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
TENURE STATUS									
Owner	73	0	50	80	100	0	0	75	58.33
Caretaker	27	100	50	20	0	33.33	0	25	33.33
Employee	0	0	0	0	0	66.67	100	0	8.33
YEARS ENGAGED IN SHRIMP FARMING									
<5	0	50	0	0	50	0	0	0	8.33
5-10	20	0	0	20	50	33.33	0	0	16.67
11-15	0	25	50	40	0	66.67	0	50	38.89
>15	13.33	0	50	40	0	0	100	0	16.67
YEARS ENGAGED IN POLYCULTURE									
<5	13.33	50	50	100	100	33.33	100	25	38.89
5-10	60	50	50	0	0	66.67	0	0	41.68
11-15	6.67	0	0	0	0	0	0	50	5.55
>15	13.33	0	0	0	0	0	0	0	5.55

confirm such results.

Physical factors may also improve shrimp survival and growth in polyculture and crop rotations. Tilapia disturb bottom sediments to a greater degree than shrimp, both in foraging and nest building activities. This may be beneficial in several ways. Disturbance of the pond bottom could improve oxidation of the substrate and interrupt life cycles of shrimp pathogens and parasites. It could also release nutrients into the water column that could improve algal blooms. However, it is also possible that these activities may be detrimental. Disturbing bottom sediments could also negatively impact water quality, lowering dissolved oxygen levels, increasing turbidity from sediments, and reducing algal blooms. Sediment disturbance can also hinder a farmer's ability to remove fish and shrimp at harvest, and it would most certainly increase the need to repair pond bottoms between crops.

METHODS AND MATERIALS

This study included 36 respondents from 13 provinces covering eight regions in the Philippines (Table 1). The data and information were collected through personal interviews using a prepared questionnaire during February–July 2002.
The survey questionnaire was divided into several parts as follows:

- Background information, including name, age, length of experience in shrimp-fish polyculture, and motivation for shifting into shrimp-fish polyculture (Table 2);
- Farm profile, which included information about the farm such as land area, source of water, depth of ponds, salinity of the water, sources, and cost of acquiring stocks (Table 3);
- Production technology practiced by the respondents, whether simultaneous , sequential, or rotational culture, or using fish cages in shrimp ponds (Table 4);
- Pond and water management, which included questions on how ponds are prepared and whether chemicals are used;
- Feeds and feeding management;
- Parasites and disease problems;
- Harvesting and marketing;
- Problems encountered; and
- Other pertinent information.

Most sampled respondents were found and interviewed by "chance." In the province of Pangasinan, however, one farmer volunteered to gather other farmers in one place where interviews were facilitated. We also took the opportunity to interview shrimp growers during the National Shrimp Congress held in Bacolod City, Philippines on 1–4 July 2002.

Due to a limited number of respondents, each region was treated as one case study and attempts were made to describe the existing culture practices in each region with respect to fish-shrimp polyculture. Data gathered were collated and tabulated. Analyses of the data were mainly descriptive in nature, such as frequency distribution, percentages, ranges, and mean values.

Shrimp-Fish Production Practices by Region

Region I - Pargasinan

Only the province of Pangasinan was covered in the survey of Region I. Pangasinan is one of the provinces in the northern Luzon. The province is bounded on the north by the Lingayen Gulf and on the west by the South China Sea. It is one of the leading fish producing provinces in Region I with milkfish (*Chanos chanos*) as the major aquaculture species in brackishwater ponds. Most of the farmers do extensive farming in ponds although cage farming of milkfish has developed rapidly. Shrimp and oyster farms also abound in this province. Most of the respondents in Pangasinan were owners of the farms (73%), all were males and married, with an average age of 46 years old (Table 2).

Farm Profile
The average farm area in Pangasinan was 30 ha, with almost all of this area devoted to polyculture of shrimp (*Penaeus monodon*) and milkfish. Shrimp-milkfish integration has a long

Table 4. Culture system used in finfish-shrimp polyculture system.

Culture System	Region								
	1	*3*	*6*	*7*	*10*	*11*	*12*	*13*	*Overall*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Simultaneous	93	100	0	25	0	100	100	100	67.64
Rotational	20	0	0	50	50	66.7	0	0	26.47
Sequential	0	0	100	50	100	66.7	0	0	23.53
Fish Cage in Shrimp Pond	0	0	50	25	0	0	0	0	11.76

*multiple responses

history in Pangasinan. One respondent has been practicing this integration for almost 20 years. The average depth of ponds was 1.1 m. The estuary or tidal river was the primary source of seawater. Freshwater sources included the river, surface run-off and deep well. Most farms had clay type of soil and some had clay-loam soil. The water salinity depends on the season. During rainy season, salinity ranged from 0 to 5 ppt while during the dry season salinity ranged from 20 to 30 ppt.

<u>Stocking Practices</u>
Most of the respondents in Pangasinan were doing milkfish-shrimp polyculture. However, the production system can be regarded as an extensive form of aquaculture. Stocking density for shrimp varied from 1 to 15 pcs m^{-2} with the majority of the respondents stocking at 5 pcs m^{-2} (43%). Milkfish fry were stocked at the rate of 0.5 to 15 pcs m^{-2}. Four respondents stocked tilapia from 1 to 5 pcs m^{-2} in addition to milkfish.

The cost of shrimp postlarvae varied from PHP (Philippine Peso) 0.10 to 0.45 per fry, while milkfish fry cost PHP0.35 to 1.00 each and tilapia fingerlings were purchased at PHP0.35 to 0.45 a piece. The seeds were either purchased directly from hatcheries or through some agents who provide the seeds on credit but at a slightly higher price.

<u>Pond and Water Management</u>
All respondents prepare their ponds by drying. Only two respondents did mechanical removal of mud as well as flushing of mud. Pond dikes were repaired one to three times per year.

Pond fertilization was practiced by 73.3% of the respondents using combined organic and inorganic fertilizers. One respondent used only inorganic fertilizer (13.3%) and another one only organic fertilizer (6.6%). One respondent (6.6%) did occasional application of fertilizer because he was providing commercial feeds. Agricultural lime and teaseed cake were occasionally used. Teaseed cake when used was applied at the rate of 25 to 50 kg ha^{-1}.

Water exchange was practiced every high tide. When necessary, water was discharged into drainage canals or the river. None of the respondents used mechanical aerators. Some were able to monitor salinity but none of the respondents were doing a complete monitoring of water quality.

<u>Feeds and Feeding Management</u>
Feeding practices were variable, including fresh feeds, commercial feeds, or a combination of fresh and commercial feeds. Fresh feeds consist of mollusks, given for the first two weeks if available. Commercial feed was given, but the onset of feeding was variable. Some farmers feed upon stocking while some respondents provided commercial feeds one week after stocking.

Those who provided a combination of fresh and commercial feeds start feeding the stocks two months after stocking. Protein content of commercial feeds varied according to the types of feeds. Most respondents do not use a feeding tray but followed the broadcast method of feeding. Those who used feeding trays check them every five hours to every other day. Feed adjustment is done every two weeks.

<u>Parasites and Disease Problems</u>
In general, the respondents did not experience severe disease problems. However, some disease problems that were encountered included white spot disease (20%), fungal infection (20%), and bacterial disease (14%). Parasite problems were also observed by 36% of the respondents. Shrimp mortality was also attributed to sudden changes in salinity.

Lime and teaseed cake, or sun-drying, were used to eradicate parasites. Also, during parasite or disease outbreaks water was changed without treating it before it is discharging it into the drainage canal.

<u>Harvesting and Yield</u>
The culture period averaged 120 d for the shrimp and tilapia, while milkfish had an average culture period of 80 d. Two harvesting methods were noted in Pangasinan: partial draining to harvest the milkfish and total draining to harvest the shrimp.

Average weight of shrimp at harvest was 120 g, or about 8 pcs kg^{-1}. Shrimp yield was 300 to 400 kg ha^{-1}. Survival rate of shrimp was only 5%, but because shrimp is a high-valued crop, the respondents still found the operation profitable. In contrast, milkfish survival is 99 to 100% and 90% for tilapia. Shrimp were sold from PHP300 to 400 kg^{-1}, milkfish from PHP60 to 75, and tilapia were sold at PHP30 kg^{-1}.

<u>Problems Encountered and Other Information</u>
Problems that were identified by the respondents included the following: unregulated setup of fish pens in the river which impede water flow, high cost of feeds, and marketing problems where middlemen control the price of shrimp. Some support that the respondents would like the government to provide included training on new techniques and feeding strategies.

Region III - Pampanga and Bulacan

Two provinces were included in the survey in Region III: Bulacan, which is in the southeastern part of Central Luzon;

and Pampanga, which is located in the heart of Central Luzon. Farming and fishing are two of the main industries in these provinces. Rivers and fish ponds are used in the production of fish, shrimp, and crabs. Simultaneous culture of shrimp and milkfish was practiced in these two provinces.

Farm Profile

Total farm size in Bulacan was small with a mean area of four ha. Farm sizes in Pampanga were larger, with a mean area of 19 ha. All of the farm areas were used for shrimp-milkfish culture. Soil types were clay and clay loam. Pond depth was maintained at one meter. Seawater came from estuary or tidal influx, while freshwater came from the rivers.

Stocking Practices

Shrimp and milkfish were stocked at 40,000 to 60,000 ha^{-1}. During dry season, the stocking rate was lower at about 20,000 ha^{-1}. Milkfish were stocked at 500 to 1,000 ha^{-1}. In Pampanga, crabs (*Scylla serrata*) were added into the ponds when available and were stocked at 6,000 ha^{-1} during rainy season and 2,000 ha^{-1} during dry season.

Shrimp postlarvae were bought in another province, while milkfish fry were acquired from nearby hatcheries at PHP0.10 and PHP1.80 per piece, respectively. The culture period was 2 to 3 months.

Pond and Water Management

Pond preparation before each cropping was practiced by drying the pond for about two weeks. No other pond preparations were followed. Dikes were repaired as needed. Ponds were not fertilized. Sodium cyanide was used to exterminate unwanted species. Water exchange was done during the culture period, which depended on the tide. Farmers were able to measure salinity occasionally, and it ranged from 5 to 40 ppt. The respondents do not use aerators.

Feeds and Feeding Management

Fresh feeds such as molluscs locally called *sulib* or *gasang* were provided to the shrimp. Trash fish, including small shrimp were also given to shrimp and crabs. Milkfish were fed with floating feeds. Feeding of boiled squash was practiced by one respondent only. This was done during the conditioning process of the post-larvae in net enclosures before they are stocked for grow-out culture. Breads were also given during the first month of culture. Feeding trays were not used, with the amount of feeds being adjusted based on approximation only. Feeding was done by broad casting from a boat.

Parasites and Disease Problems

The respondents could not make effort to observe parasites and diseases because of the extensive nature of their operation. Also, they may have lacked the training or expertise needed to observe parasite and disease problems. One respondent however, was using a pro-biotic NS Series Super SPO (NU-GENES Technologies, Inc.) supposedly to eliminate bacteria.

Harvesting and Yield

The respondents were experiencing a 10% survival rate for the shrimp and from 90 to 100% survival rate for the milkfish. Harvesting of shrimp was done after two months, especially when the farmers observed some mortality.

Problems Encountered and Other Information

A problem encountered by the respondents in Pampanga was the water source. Since the Mt. Pinatubo explosion, water sources have become limited because of siltation of lahar in the rivers.

Table 5. Reasons for the adoption of shrimp polyculture systems.

Reason	Percentage
Profitable Business	44.11
Stable Source of Income	32.35
Reduced Disease Problems	32.35
Low Capital Investment	5.88
Stable Water Quality	2.78
Research	2.78

*multiple responses

Region VI - Negros Occidental

Negros Occidental occupies the northern and western parts of Negros Island, the fourth largest island in the Philippines, located between Panay and Cebu in the Visayas Sea. The province is also known as the "sugar bowl," producing more than half of the country's sugar. Motivated by a growing export market, high economic returns, and improved technology, many of the lands in Negros Occidental were converted into shrimp ponds during the early 1980s. Grow-out operations were intensified following technologies from Taiwan.

Farm Profile

There were only two respondents from Negros Occidental. One farm was 35 ha while the other was 200 ha. All the 35 ha from the first farm were used for shrimp-tilapia polyculture, while 60 ha out of the 200 ha farm were utilized for the shrimp-tilapia integration. Both respondents have long years of experience in shrimp farming, but it is only during the last 3 to 5 years that they have started to engage in shrimp-tilapia polyculture. The main motivation to start with polyculture was to reduce disease problems and also due to the economic viability of the shrimp-tilapia polyculture system (Table 5).

The estuary remained the source of seawater for the farms, and the river and a deep well were the sources of freshwater. Water depth in the ponds was maintained at 1 to 1.5 m. Salinity of the water ranged from 5 to 32 ppt.

Two types of culture system were noted from the province, and these were sequential system and an in-house technology called Tilapia Introduction to Prawn System (TIPS).

Stocking Practices

Species used for the polyculture system were shrimp and tilapia. Shrimp postlarvae were bought from commercial hatcheries. For tilapia, one respondent mentioned that his company developed its own hybrid known as the "Jewel" hybrid. The other respondent acquired tilapia stocks from other hatcheries.

The price of the shrimp post-larvae was from PHP0.25 to 0.34 $piece^{-1}$, while for tilapia it was PHP0.50 to 0.90 $fingerling^{-1}$. Shrimp post-larvae were stocked at the rate of 15 to 25 pcs m^{-2} and tilapia at 3 pcs m^{-2}.

Pond and Water Management

Ponds were prepared after each culture period by drying for 15 to 20 d and up to two months. Mechanical removal of mud and tilling were done every cropping. Dikes were repaired as necessary.

The ponds were fertilized with organic and inorganic fertilizers at the rate of 2,000 kg ha^{-1} and 200 kg ha^{-1}, respectively. Chemicals such as agricultural lime, hydrated lime, and teaseed cake were used at the rates of 100 kg ha^{-1}, 25 kg ha^{-1}, and 20 to 30 ppm, respectively.

Water exchange was practiced as needed to maintain plankton density of 500,000 to 700,000 cells ml^{-1}. Pond water was discharged into drainage canals or into another pond. Water quality parameters measured daily were dissolved oxygen (DO) concentration, salinity, pH, alkalinity, ammonia, and temperature. In addition, plankton and bacterial profiles were monitored every two weeks. Aeration was provided by using a paddle wheel.

Feeds and Feeding Management

The shrimp were fed with a combination of fresh and commercial pelleted feeds. For fresh feeds, the shrimp were given crushed golden apple snails (*Pomacea canaliculata*) daily for shrimp 10 to 25 g in size. The stocks were fed commercial feeds with protein content of 37 to 38% and at feeding rates from 2 to 20% of body weight.

Feeding trays were used and were checked regularly depending on the age of the shrimp. Trays were checked every 1 to 4 hours for younger shrimp and every 45 minutes for older shrimp. The amount of feeds was adjusted depending on the observation on the feeding trays. Feed supplements such as growth and digestive enzymes and vitamin mixes were also used.

Parasites and Disease Problems

Incidence of parasitic infestation was lower in polyculture than in monoculture of shrimp. Protozoan parasites, were eradicated by either an iodine bath or a salinity change.

Disease problems caused by protozoa and bacteria were treated with probiotic and iodine treatment. Neither respondent used any antibiotics since they started doing shrimp-tilapia polyculture. However, on occasions when they had to discharge water during a disease or parasite outbreak, one respondent treated the water before discharging to the drainage canal while the other did not.

Harvesting and Yield

The methods of harvesting for both respondents was total draining. Shrimp yield was from 4,000 to 5,500 kg ha^{-1} at about 30 pcs kg^{-1}. Yield of tilapia was from 2,000 to 3,000 kg ha^{-1} at 2 pcs kg^{-1}. Observed survival rate for shrimp in the polyculture system was from 70 to 90%, and the survival rate for tilapia was 90%. Shrimp were sold from PHP350 to PHP460 kg^{-1} and tilapia were sold at PHP50 to PHP75 kg^{-1}.

Problems Encountered and Other Information

When asked where learned about the polyculture technology, one respondent said that the shrimp-tilapia polyculture (particularly the TIPS) was developed by his company, while the other learned about the technology from other shrimp farmers and from the Negros Prawn Producers Marketing Cooperative, Inc.

One support structure that they reported to need from the government is a post-harvest facility, such as a storage and processing plant to assist the farmers in product development. Also, it was suggested that a gene bank is important to preserve the germplasm of tilapia.

Region VII - Cebu, Bohol, Negros Oriental

Three provinces from Region VII were covered in the survey: Cebu Province, Bohol Province, and Negros Oriental Province. These make up the Central Visayas region. Cebu is in Central Visayas and is more than 200 km long and 40 km across at its widest point. It is the premier corn producing province and is also rich in mineral resources. Cebu is noted for grapes, mangoes, and cut flowers. Bohol is the tenth largest island of the Philippines. It is essentially agricultural. Rice, coconut, and corn are the main products.

Four types of shrimp-finfish integration were practiced by the respondents in this region: simultaneous, sequential, rotational, and cage culture of tilapia in shrimp ponds (Table 4). The motivations for the shift were high economic returns, reduced disease problems, research, and the availability of stocking materials (Table 5).

The respondents had from 12 to 17 years of experience in shrimp farming but have been practicing shrimp-tilapia integration during the last 2 to 4 years.

Farm Profile

Farm size ranged from 3 to 35 ha. Sources of seawater were the estuary and saline ground water. For freshwater, farmers pump from deep wells or from springs and rivers. One respondent from Bohol did not have a source of freshwater.

Pond depth was maintained at 1 to 1.4 m. Soil types were clay loam and backfilled with agricultural limestone. Salinity of the water varied with season: 0 to 10 ppt during the wet season and 25 to 35 ppt during dry the season.

Stocking Practices

All of the respondents were using *P. monodon*, *C. chanos*, and tilapia with unknown identity. One respondent was actually breeding his own tilapia stocks but also used tilapia collected from brackish water ponds that were presumably *Oreochromis mossambicus*. Shrimp were purchased from hatcheries, although one respondent also had his own hatchery.

Shrimp post-larvae cost PHP0.22 to PHP0.27 per piece, while tilapia fingerlings cost from PHP0.45 to PHP0.75 per piece. Milkfish cost PHP0.30 to PHP0.60 per fry. Stocking rates were 12 to 30 pcs m^{-2} for shrimp post-larvae, 3 to 6 pcs of milkfish fry, and 3 to 6 pcs of tilapia fingerlings.

Pond and Water Management

Pond preparation methods included pond drying for 2 to 4 weeks, mechanical removal of mud by using a bulldozer two weeks after drying, flushing of mud done alternately with plowing, and tilling alternately with flushing. Dikes were also repaired as part of the mud removal.

Ponds were fertilized with organic and inorganic fertilizers. Under a rotational system of integration, ponds were fertilized at 5 to 10 kg ha^{-1} for prawn culture and 25 to 50 kg ha^{-1} for milkfish culture. Teaseed cake was used to kill predators and other fish competitors in the pond, and chlorine was used to disinfect the ponds.

Water exchange was done every 7 to 12 days or as needed. Pond water was discharged either to a drainage canal or into another pond. Water quality parameters monitored included DO concentration, temperature and salinity, which were measured twice daily, and pH, which was measured once daily. Alkalinity and ammonia were not monitored regularly but as needed. Other parameters included transparency of the water and color, which were observed twice daily. Plankton density was also measured daily. Paddlewheels were provided for aeration of the water. One respondent was experimenting on different types of aeration systems.

Feeds and Feeding Management

Commercial pelleted feeds were provided for the shrimp. One respondent was producing his own commercial feeds. Fresh feed such as crushed golden apple snail were provided when there was a supply, but otherwise the stocks were not given fresh feeds. Commercial pelleted feeds were provided one day after stocking. Different types of commercial feeds with varying crude protein contents were provided depending on the age of the stocks: starter feeds with 40% CP, grower feeds with 38% CP, and finisher feeds with 36% CP. None of the respondents were using feed supplements.

Feeding trays were used, otherwise feeds were broadcast by hand on a boat. Feeding trays were checked two hours after feeding and feed was adjusted according to monitoring of the trays.

When asked how much money they spent on feeds, one respondent said that at least 55 to 60% of the total production cost was due to feed.

Parasites and Disease Problems

The respondents have not encountered parasite problems with their stocks. One respondent never monitored for the presence of parasites in his stocks. Disease problems were observed to have been presumably caused by bacteria, which they treat by reducing the water salinity. Also, one respondent observed that water change, liming, and the use of green water were successful ways to treat disease. No disease outbreak was reported. The respondents never use antibiotics or chemicals to treat disease.

Harvesting and Yield

Harvesting was done by total draining of the ponds after 150 days of culture. Survival rate of shrimp was from 70 to 75%, and milkfish had 100% survival rates. Average weight was 36 g for shrimp, 240 g for tilapia, and 333 g for milkfish. Shrimps were sold at PHP350 to PHP400 kg^{-1}, tilapia earned PHP60 to PHP70 kg^{-1}, and milkfish earned PHP60 to PHP80 kg^{-1}. Prawns were sold to exporters, while milkfish and tilapia were sold to wholesalers and retailers.

Problems Encountered and Other Information

The respondents learned about the technology of shrimp-finfish polyculture from government extension workers, particularly from the Southeast Asian Fisheries Development Center (SEAFDEC), through trainings and seminars, and from the Negros Prawn Producers and Marketing Cooperative, Inc. in Bacolod City, Negros Occidental.

One problem mentioned by a respondent is the unavailability of saline tolerant strains of tilapia that they can use in the integration system. Inconsistent government policies and a lack of price information for their products were also mentioned as constraints.

Region X - Misamis Occidental

Two respondents from the Misamis Occidental province participated in this survey. Misamis Occidental forms the eastern end of Zamboanga peninsula in northwestern Mindanao. Fishing is the main industry. The province has 131 km of coastline fronting the rich fishing grounds of Panguil and Iligan Bays. Misamis Occidental has the biggest area of brackish water fish ponds in the region.

Farm Profile

Both of the respondents from this province owned and operated their farms. Each farm was a 2 ha farm. One practiced crop rotation while the other practiced a sequential type of integration. Both started to practice integration only in 2000, and they were convinced that such integration would provide them a steady source of livelihood and reduced disease problems. Pond depth was maintained at 1 to 1.5 m with water coming from the sea or from tidal water.

Stocking Practices

Species used were shrimp, tilapia, and milkfish. Both farms got the shrimp post-larvae from shrimp hatcheries and from the wild. Milkfish came from hatcheries as well and also from local gatherers, while tilapia fingerlings (Jewel tilapia) were obtained from the FYD International, Inc. and from so-called "traveling suppliers." Stocking densities were 30,000 to 40,000 ha^{-1} for the shrimp post-larvae, 5,000 ha^{-1} for milkfish fry, and 1,000 to 3,000 ha^{-1} for the tilapia fingerlings. Price of stocks ranged from PHP1.40 for the wild caught and PHP0.72 for the hatchery-bred post-larvae. One operator purchased the shrimp post-larvae for PHP0.22 per piece. Milkfish fry were purchased at PHP0.25, while Jewel tilapia fingerlings were purchased from PHP0.40 to PHP0.75. The culture period lasted from four months.

Pond and Water Management

Pond preparation was done before each culture period, and it varied between farms. One would dry the pond for 1 month while the other for only 1 week. Mechanical removal of mud was also practiced in one farm as well as flushing of mud and repair of dikes. The other farm only practiced pond drying and tilling.

Both farms were applying fertilizers in the ponds, but they had not treated the ponds with any chemicals except for lime and teaseed cake. Water exchange was done twice monthly through the drainage canal. Water quality parameters were not monitored, nor were aeration systems provided for extra oxygen.

Feeds and Feeding Management

Both respondents only provided commercial pelleted feeds. Feed adjustment is based on the consumption of the shrimp from the feeding trays, which were checked every two hours. No other feed supplements were used.

Parasites and Disease Problems
Some parasite problems with their stocks were observed by the respondents. One respondent observed a higher incidence of parasites in shrimp in polyculture than in monoculture. However, these parasites have not been properly diagnosed. Other disease problems are suspected to have been bacterial. To date, these have not been treated and proper control of this disease is needed. Water change during disease incidences was practiced, but the water was not treated before discharge into the drainage canal.

Harvesting and Marketing
Harvesting was conducted by total draining of ponds. Shrimp survival was from 15 to 50%, and the yield obtained was from 100 to 400 kg ha^{-1}. For tilapia, the harvest yield was 300 kg ha^{-1}. One farm has no tilapia harvest yet. Market price for shrimp depends on the size; i.e., for an average body weight of 30 g, the market price can be PHP320 kg^{-1}, or for 7 to 8 pieces kg^{-1}, the price is PHP400. Tilapia price varied from PHP35 to PHP40 kg^{-1} and they are normally sold on cash basis to shrimp exporters.

Problems Encountered and Other Information
Both respondents learned about shrimp-tilapia culture from friends. One respondent believed that shrimp-finfish polyculture can reduce the occurrence of disease in shrimps. However, government support for more specialized technical support, such as water quality analysis and equipment for pond development, were lacking. Also, a properly trained fishery technologist who can ascertain the quality of shrimp fry sold from hatcheries is needed.

Region XI - Saranggani and Danao

Saranggani is at the southern tip of the island of Mindanao. Its capital is Alabel. The main sources of livelihood are farming and fishing. The surrounding waters, particularly the Saranggani Bay, are rich fishing grounds. The primary focus of aquaculture in the province is prawn culture. Prawn ponds are located on the eastern and western shores of the province. Tilapia and milkfish ponds are also found in different parts of the bay.

Farm Profile
One of the leading companies doing aquaculture in Saranggani province is the Alson's Aquaculture Corporation. It has a total farm size of 200 ha, with 40 ha devoted to shrimp monoculture and 150 ha for milkfish-shrimp polyculture. Saline ground water was used with a water depth maintained at 1 to 2 m. Fresh water is obtained from a river. The soil type is clay loam. Salinity ranged from 0 to 30 ppt. The company has been engaged in shrimp-finfish polyculture for the last six years because of the stable water quality and reduced disease problems they encountered.

Stocking Practices
The Alson Aquaculture Company used *P. monodon*, *O. niloticus*, and milkfish. Shrimp post-larvae were sourced out from hatcheries in Cebu and Iloilo. While tilapia came from Luzon and also from Mindanao, their milkfish fry were obtained from a sister company in Saranggani Bay. Shrimp post-larvae were purchased at PHP0.35 per piece, and tilapia sex-reversed fingerlings went for PHP0.30 per piece and milkfish fry for PHP0.45 fry^{-1}.

Pond and Water Management
Pond preparation has been recognized as an important practice before each culture cycle. Pond drying was done for 30 days, while mechanical drying was dependent on the volume of mud in the ponds. Ponds were fertilized with organic fertilizer at 1.5 tons ha^{-1} and with inorganic fertilizer as the need arose. The ponds were treated with lime at 30 tons ha^{-1} and with teaseed cake at 300 kg ha^{-1}.

Water was exchanged weekly into the drainage canal or into treatment ponds. Water quality parameters were closely monitored on a daily basis and bi-weekly for parameters such as alkalinity. Aeration systems such as paddlewheels, were used.

Feeds and Feeding Management
Shrimp were fed immediately after stocking with commercial feeds containing a crude protein level of 40%. Feeding trays were used and checked every two hours. The amount of feed was adjusted based on the demand of the shrimp, and vitamins and unsaturated fatty acids were supplemented in the feeds.

Parasites and Disease Problems
A parasite commonly observed in shrimp was zoothamnium, which was treated by water changing. A disease problem occurred due to bacteria, but no treatment was found successful for any disease problems.

Harvesting and Marketing
Total and partial draining were followed for the harvesting of the stocks. Shrimp attained 200 kg ha^{-1} in polyculture against 5,000 kg ha^{-1} in monoculture. Survival rate for shrimp was also observed to be high in monoculture (about 50%) against a 20% survival rate in polyculture. Shrimp were sold at PHP300 to PHP400 kg^{-1}, tilapia were sold live at PHP50 to PHP60 kg^{-1}, and milkfish were sold at PHP65 to PHP70 kg^{-1}.

Problems Encountered and Other Information
Sustainability of the technology on polyculture seemed to be a problem. Unreliable and undependable supplies of tilapia fingerlings were also problems encountered by the farmers. The respondents particularly wanted to have support on fish health monitoring and marketing. They learned about polyculture technology from government extension workers and also from other shrimp farmers, but they also wanted more information on grow-out technology from the government.

Region XII - Lanoa del Norte

The western Mindanao region makes up Region XII. Lanao del Norte is in northern Mindanao. It is bounded on the north by Iligan Bay and Misamis Oriental, on the east of Bukidnon, and on the west by Panguil Bay and Zamboanga del Sur. Agriculture, fishing, and forestry are the dominant sources of livelihood in this region.

Farm Profile
Only one respondent was interviewed from this region. The farm size was 16 ha. The farmer has mainly farmed shrimp, but in 1999 he started to devote 10 ha for shrimp-tilapia culture to try and reduce disease problems. His farm was properly located in that any salinity range could be available. His main source of seawater was the estuary or tidal river, but he also drew saline ground water. His sources of freshwater were a

deep well and the river. Pond depth was maintained at 150 cm to 200 cm.

Stocking Practice
The Respondent followed the TIPS technology offered by FYD, Inc. He used *P. monodon* and Jewel tilapia, which were acquired from the FYD, Inc. *P. monodon* were stocked at 12 m^{-2}, while the Jewel tilapia were stocked at 30,000 ha^{-1}. The stocking materials were purchased at PHP0.24 and PHP0.32 per piece. The culture period lasted from 120 to 150 d.

Pond and Water Management
Preparation of the ponds involved pond drying for 15 d. The ponds were fertilized with organic fertilizer at the rate of 1 t ha^{-1} and with inorganic fertilizer at 50 kg ha^{-1}. The ponds were not treated with any chemicals except for teaseed cake at 20 to 25 ppt and with lime at 2 t ha^{-1}.

Feeds and Feeding Management
A combination of fresh and commercial feeds were provided to the shrimp. Freshwater snail as fresh feeds were provided when the animal had an "appetite" to eat. With commercial feeds, the farmer used a feeding tray, which was checked five times a day, and the amount of feeds was adjusted based on feeding distribution. No other feed supplement was provided in the diet.

Parasites and Disease Problems
No parasites were observed in the shrimp stocks, but with the Jewel tilapia some leeches were observed and treated with "hot lime." No disease problems were observed in the shrimp following the TIPS technology.

Harvesting and Marketing
Harvesting was done by total draining of the ponds. Shrimp were sold at PHP320 kg^{-1} directly to exporters, while the Jewel tilapia were sold locally at only PHP25 kg^{-1}.

Problems Encountered and Other Information
The respondent said he has lost his fascination with the government. What the government has promised with their business—namely the price of the shrimp—has remained unfulfilled. Although he found the TIPS technology useful because of the easy water culture and the elimination of disease-causing luminous bacteria, he still wanted to have more technical knowledge about shrimp-tilapia polyculture.

Region XIII - Agusan del Norte and Surigao del Sur

The Caraga region makes up Region XIII. Agusan del Norte is in northeastern Mindanao. It is bounded on the north by Butuan and Surigao del Norte, on the east by Surigao del Sur, on the south and southeast by Agusan del Sur, and on the west by Misamis Oriental. Its capital is Butuan City. It is primarily an agricultural province. Agusan del Sur is the leading rice producer in the region.

There were three respondents from Agusan del Norte and one respondent from Surigao del Sur. However, of those from Agusan del Norte, two of them were purely doing monoculture of shrimp and only one respondent was doing a shrimp-tilapia integration, while the respondent from Surigao del Sur was using shrimp-milkfish integration.

Farm Profile
One of the respondents from Agusan del Sur who was doing shrimp-tilapia polyculture operated 300 ha but devoted 7 ha for the simultaneous culture of *P. monodon* and *O. mossambicus* in the province. The average water depth was from 0.5 m to 1.0 m, while the respondent from Surigao del Norte was operating a 100 ha farm that was mainly extensive in nature but simultaneously integrating shrimp and milkfish.

Stocking Practices
In Agusan del Sur, the shrimp post-larvae were sourced from the Cebu, Butuan, and Ormoc hatcheries, while the milkfish fry came from General Santos City . The respondent from Surigao del Norte obtained his shrimp stocks and *O. mossambicus* from hatcheries in the Visayas at PHP0.30 to PHP0.39 per post-larvae and PHP0.80 for the tilapia fingerlings. Stocking density for shrimp ranged from 30,000 to 50,000 ha^{-1}, while milkfish density was 300 to 500 ha^{-1} and tilapia fingerlings were stocked at 300 h^{-1}.

Pond and Water Management
Both farms prepared their ponds before the start of a new culture period by practicing pond drying. However, the farm in Surigao del Norte did not fertilize its pond, whereas the farm in Agusan del Sur used a silica-based organic fertilizer and a phosphate-based inorganic fertilizer. Both farms were using lime and treated the ponds with teaseed cake at the rate of 20 ppm. Both did water exchange every high or spring tide. Monitoring of water quality varied. One was monitoring every week, while the respondent from Surigao del Norte only monitors salinity every month. Aerators were not used in either farm.

Feeds and Feeding Management
A combination of fresh and commercial feeds was used by the respondent in Agusan del Norte. The animals were fed with crushed mollusks for two weeks and started on commercial feeds one month after stocking. Both farms were using feeding trays and would check on them depending on the size of the prawn. One respondent was checking the feed tray six months after feeding the prawn.

Parasites and Disease Problems
No parasite problems were observed by either respondent. However, the respondent from Agusan del Norte observed protozoans and bacteria had caused diseases, and he had not found success in treating them. He has become dependent on the use of probiotics but had reduced the use of antibiotics.

Harvesting and Marketing
A higher survival rate was observed by the respondent in Agusan del Norte when doing polyculture than with shrimp monoculture. The yield was higher in polyculture (800 to 1,000 kg ha^{-1}) versus 600 to 800 kg ha^{-1} with monoculture. Also, the survival rate was observed to be higher in polyculture than in pure shrimp monoculture (75 to 85 % versus 60 to 80%, respectively).

Problems Encountered and Other Information
Financial and infrastructure programs are two of the problems that have not been addressed by the government. Also, the respondent from Agusan del Norte expressed a need for an alternative source of seawater, especially during the rainy season. These problems hinder their productivity. While they

are convinced that finfish-shrimp integration resulted in good quality shrimp, they face a lack of financial and infrastructural support from the government.

Note: At time of writing, exchange rate for Philippine peso to US dollar is 40:1.

Discussion

Most of the respondents saw that the integration of finfish and shrimp lessens the disease problems in the pond, especially that of vibriosis. Several farm trials have been conducted that showed that luminous bacterial counts in the water and in the shrimp were below 10 cfu and below 10^3 cfu per hepatopancreas, respectively. These trials were conducted in ponds which had previously been used for tilapia culture and whose water was previously taken from a tilapia reservoir. Additionally, tilapia were stocked directly in cages, with shrimp outside the cages (Paclibare et al., 2001). The use of "greenwater" was also tried by Corre, et al. (1999), and they found that the growth of luminous bacteria was effectively reduced. Likewise, a stable bloom of phytoplankton was observed in the rearing ponds. They also observed that tilapia produced better greenwater than milkfish, so tilapia was the preferred species.

Shrimp-finfish integration appeared to be widely used in the Visayas and Minadanao regions but not in Central Luzon. One problem was that the certified source of tilapia strain would only tolerate a certain level of water salinity. While Jewel tilapia was more of an in-house saline tolerant hybrid developed by the FYD International Inc., it was made available to other shrimp producers on a very limited scale because the company also used the strain for their own operations. There should be other sources of tilapia that can be made more available to farmers. At present, farmers are scouting throughout the Philippines for the availability of saline or brackishwater stocks of *O. mossambicus*.

Anticipated Benefits

Shrimp-tilapia polyculture has been tested in several of the important shrimp producing regions of the world. The findings here should benefit growers and extension professionals and government officials who advise farmers. By using this style of polyculture, farmers may be able to rear shrimp with fewer disease problems. In addition, they may be able to rear a secondary crop of fish that should increase their sales or at least provide an additional edible product for workers.

Acknowledgments

We would like to thank all the respondents of this survey. Special thanks to Joan Bulacso, Ma. Cristina Falla, and Eddie Boy Jimenez for acting as enumerators for this study. Also we would like to acknowledge the financial support of the Aquaculture CRSP through the USAID grant.

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Cite as: [Author(s), 2004. Title.] In: R. Harris, I. Courter, and H. Egna (Editors), Twenty-First Annual Technical Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, [pp. ___.]