

# MILKFISH CULTURE TECHNIQUES GENERATED AND DEVELOPED BY THE BRACKISHWATER AQUACULTURE CENTER

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This paper reviews the work on milkfish *Chanos chanos* (Forsskal) culture techniques conducted from 1973 to 1983 by the Brackishwater Aquaculture Center, the aquaculture research arm of the College of Fisheries, University of the Philippines in the Visayas at Leganes, Iloilo, Philippines. Significant findings and innovative techniques dealing with milkfish fry collection and fingerling production such as those obtained from survival studies of fry during collection, sorting, handling, acclimation, storage, transport, and rearing in nursery ponds or land-based nurseries are reviewed. Fingerling production utilizing improved methods and techniques is discussed. Results of work on pond culture techniques; the use and application of organic manure and of the different nitrogen-phosphorus ratios in inorganic fertilizers to increase pond productivity; adaptation of milkfish production techniques such as monoculture, polyculture, and integration of milkfish culture with other agricultural activities are presented and discussed. Recommendations for future work and tips on proper utilization of various culture techniques are given.

## INTRODUCTION

The Brackishwater Aquaculture Center (BAC, formerly the Inland Fisheries Project — IFP, Brackishwater Fish Culture Research Station) initiated its milkfish research program at its establishment in 1971. The initial funding support of IFP

came from the Government of the Philippines through the National Science Development Board (NSDB, now the National Science and Technology Authority —NSTA) and the Government of the United States through the U.S. Agency for International Development. The University of the Philippines, through its College of Fisheries, Institute of Fisheries Development and Research, implemented the project in collaboration with Central Luzon State University and other government agencies which carried out the provisions of the Memorandum of Agreement by and between the Philippines and the U.S. Government to help the country in its food production campaign by increasing fish production through the generation of improved aquaculture technologies. Under this agreement, BAC developed its research programs with emphasis on milkfish culture because this fish was and is still considered the primary species for brackishwater fish culture in the country. The key areas of concern in milkfish culture that were identified and pursued from the beginning by BAC are the following:

- Evaluation, improvement, and development of pond culture systems and techniques
- Fry and fingerling survival
- Acid sulphate soils
- Use of agricultural by-products and waste for fish culture

The researchers of BAC pursued research in these areas both individually and collectively. Although other areas of concern were identified later, new technologies and information derived from the pursuit of the identified problems, particularly on milkfish, were generated and verified, and a number of them have been used by local fish farmers and/or introduced to other countries.

This paper reviews the selected technologies for milkfish culture generated by BAC. The main objective is to present in capsule form those techniques that are considered innovations in milkfish culture. Although many of the selected technologies have been utilized by the industry, a number of them still need to be verified before transfer and utilization.

### HISTORICAL CONSIDERATIONS

Until the 1970s, milkfish culture was based on trial and error methods. Most, if not all, of the technologies and practices were expressed in terms of yield. The culture method was nothing more than just growing the *lumut* (filamentous algae, primarily *Spirogyra* sp.), stocking milkfish fingerlings, and then waiting for 4-6 months to harvest and restock again for the next cropping. This practice was done until the *lablab* method or the shallow water method of milkfish culture was introduced into the Philippines from Taiwan in the 1960s by Mr. Yun-an Tang, an FAO consultant, and widely accepted by fish farmers.

In the early 1970s, another method was introduced—the plankton method or the deep water method of milkfish culture. This method was based on the hypothesis that milkfish is primarily a plankton feeder as evidenced by its fine gill structures, particularly the gill rakers. It was also recognized that this method has several advantages concerning the biological requirements of milkfish, e.g., higher dissolved oxygen content of water and no significant fluctuation of temperature as in the

shallow water method. Therefore, stocking density could be increased and decomposition of fishpond organisms, particularly *lablab*, causing oxygen depletion is not likely to occur.

Up to the present, milkfish aquaculture techniques have not been standardized, as there are inconsistencies in their application. Techniques that work successfully in one area do not necessarily work in another. For this reason, BAC continues to work on them in an attempt to answer various questions posed by the industry.

## GROWTH AND SURVIVAL STUDIES IN NURSERY PONDS

### Rate of Growth and Survival in Nursery Ponds

A series of studies conducted by the Center on the rate of growth and survival of milkfish fry in brackishwater nursery ponds was done in the facilities of the Bureau of Fisheries (now Bureau of Fisheries and Aquatic Resources) in 1974 at Molo, Iloilo City. The first study used a stocking density of 16 000 milkfish fry/ha and reared them for 33 days under the *lablab* method. This resulted in a survival of 89.6%, attaining a mean individual weight of 7100 mg from an initial weight of 1.7 mg (IFP 1974a).

In a related study, the rate of growth of milkfish fry in nursery ponds was studied using a higher stocking density of 28.75 fry/m<sup>2</sup> (287 500 fry/ha), cultured under *lablab*, plankton, and a combination of *lablab*-plankton culture methods. The fry were reared for 46 days; mean daily weight increments of 48, 36, and 41 mg for the *lablab*, plankton, and *lablab*-plankton methods, respectively, were attained; and survivals were recorded to be 65%, 80%, and 76%, in the same order. This trial indicated the advantage of the plankton method of culture in rearing milkfish fry to fingerlings (Fortes 1975).

### Rearing of Fry to Fingerlings in Production Ponds

Based on the hypothesis that milkfish fry require considerably less food than and do not compete harmfully with fingerlings, fry and fingerlings were stocked at the same time in the same ponds. This way, at least two croppings of milkfish per year can be expected without interruption.

Fry (mean weight 4-1 mg) were stocked at 4000/ha in some ponds (Treatment A). In another set of ponds the same size of fry were stocked at the rate of 3000/ha (Treatment B). In both treatments, fingerlings with sizes of 41.3-89.5 g were stocked 20 days later. After 153 and 133 days of culture, the stocks were harvested. The production data are shown in Table 1 (IFP 1976a).

It appears from Table 1 that production data were low. It should be noted, however, that during that time the productive capacity of the ponds used was only 300 kg/ha; therefore the method was still promising. One problem that needs to be settled, however, is the type of gear to be used in selectively harvesting the bigger fish because the gill net, although effective, removes some scales of the milkfish. Filipino housewives normally prefer to buy milkfish with intact scales; otherwise the fish commands a lower price.

Another attempt to maximize the utilization of ponds while improving milkfish fingerling, roduction was done by installing *hapas* (fine mesh nets) within the rearing

**Table 1. Production data of mixed culture of milkfish fry and fingerlings (or a culture period of 153 days.**

Treatment	Production (kg/ha)			Survival (%)	
	Marketable size	Fingerlings	Total	Marketable size	Fingerlings
A. 3 000 fingerlings/ha plus 4 000 fry/ha	314	42	356	97	73
B. 3 000 fingerlings/ha plus 8 000 fry/ha	348	77	425	96	65

pond stocked with milkfish fingerlings being grown to marketable size. Three 4000 m<sup>2</sup> ponds were used and seven *hapas* (each 1 m × 1 m × 1 m) were installed in each pond. All treatments (stocking densities) were represented in each pond, viz., 500, 1000, 2000, 4000, and 6000 fry/*hapa*.

After a 1-month culture period, survival was observed to range from 9% (6000/*hapa*) to 71% (500/*hapa*), which indicated that density-dependent factors had started to show effects. It was suspected that the two most important factors that caused high mortality were oxygen deficiency and predation. Based on these results, another run was made using the following stocking rates: 367, 500, 1000, and 2000/*hapa*. After 2 months of rearing, the fry grew from an initial weight of 0.2 g to a final weight of 3.3, 3.1, 4.1, and 2.4 g, respectively, with survival rates of 93.2%, 83%, 86%, and 52.5%, in the same order. These growth and survival rates were attained without any supplemental feeding. In addition, the production of milkfish stocked in the ponds averaged 558 kg/ha in a 4-month period (IFP 1976b).

#### POND CULTURE TECHNIQUES

##### Evaluation of Fertilizing Materials

The most commonly used inorganic fertilizing materials for milkfish production in the Philippines are solophos (0-20-0), monoammonium phosphate (16-20-0), diammonium phosphate (18-46-0), and urea (46-0-0); all are intended for agricultural crops, not for fishfood organisms. The organic materials are chicken manure and rice bran. The Center evaluated these fertilizing materials to develop a fertilizer analysis suitable for fishponds.

In an exploratory trial, the effects of solophos and diammonium phosphate plus chicken manure on the production of fishfood organisms in ponds were determined. The production of fishfood organisms after 32 days was 335 mg/liter and 264 mg/liter, respectively, indicating better response of fishfood organisms to solophos (IFP 1973a). In another study, the effects of various fertilizing materials on the production of fishfood organisms in ponds were studied. The different treatments tested are shown in Table 2.

**Table 2. Effect of various fertilizing materials on the production of fishfood organisms.**

Treatment	Rate of application	Remarks
I 16-20-0	10 g/m <sup>2</sup>	Better <i>lablab</i> formation than IV
II Rice bran plus chicken manure	60 g/m <sup>2</sup> 200 g/m <sup>2</sup>	With reddish brown and oily film on water surface
III Rice bran	60 g/m <sup>2</sup>	With reddish brown and oily film on water surface
IV Chicken manure	200 g/m <sup>2</sup>	Good <i>lablab</i> formation
V 16-20-0	10 g/m <sup>2</sup>	Slightly improved <i>lablab</i> growth
VI 16-20-0 plus rice bran	60 g/m <sup>2</sup>	No <i>lablab</i> production

In a related trial, the effects of chicken manure, 18-46-0, 20-0-0, and fertilizers with various N:P ratios (1:1, 1:2, and 1:4) on *lablab* in 26 days were studied in tanks (IFP 1973b). See Table 3.

Another study was made in pursuit of solutions to the problems encountered in the first two studies mentioned above. This was conducted in newly constructed ponds of the Center which were stocked with milkfish. The various fertilizing materials and their combinations were tested in both the *lablab* and plankton methods of milkfish culture (IFP 1975b). The following were the various treatments:

A. *Lablab*

1. Chicken manure only
2. Chicken manure plus 0-20-0
3. Chicken manure plus 46-0-0
4. Chicken manure plus 16-20-0
5. 16-20-0 only
6. 0-20-0 only
7. 46-0-0 only
8. Unfertilized

B. Plankton (same treatments in A).

**Table 3. Effect of various fertilizing materials on *lablab* production.**

Treatment	Rate of application (g/m <sup>2</sup> )	<i>Lablab</i> (ml/m <sup>2</sup> )
Chicken manure	200	560
18-46-0	2	450
21-0-0	2	150
1:1 (N:P)	1 + 1	250
1:2 (N:P)	1 + 2	500
1:4 (N:P)	1 + 4	340

The effects of the various fertilizing materials on production of fishfood organisms and on fish production appeared not to be correlated. However, the importance of phosphorus, other nutrients, and chicken manure was demonstrated in all the studies. Rice bran had an unfavorable effect on the fishfood organisms, contrary to the claim of fish farmers. It was also surmised that the inconsistent effects of the various fertilizing materials on the growth and production of fishfood organisms and on fish production could be due to inherent differences in the pond soil. Thus it is important to have the soil analyzed first before any fertilizer is applied. Analysis should be made to determine the nutrients that are deficient and to avoid application of unnecessary nutrients.

In a related study, an attempt was made to determine the influence of the various fertilizing materials on the production of fishfood organisms. This was done in miniature habitats that simulated pond conditions and where the effect of single nutrient enrichment on the growth and development of fishfood organisms could be determined. The nutrients tested were N, P, and K. Results of the study showed that, in general, production of plankton was greatest in P-treated units (mean = 306 906 cells/ml), followed by N-treated units (mean = 132 153 cells/ml) and K-treated units (mean = 83 923 cells/ml). The control units yielded 63 923 cells/ml of fishfood organisms (IFP 1976c).

The need to evaluate organic manure application in milkfish ponds was identified. The present practice is to apply 1-2 t/ha of chicken manure every cropping period. Some practitioners apply dried chicken manure during the culture period to serve as feed for milkfish and as fertilizer for the fishfood organisms. An organic matter content of the pond soil higher than 5% produces good growth of *lablab* and therefore of milkfish. Based on these observations, a study was made to compare the production of *lablab* and fish in ponds with two levels of soil organic matter content — 6% and 8%, which were arbitrarily chosen because the initial organic matter content of the pond soil was approximately 5%, which was considered the minimum level. The first set of ponds had an average organic matter content of 5.52%, which was raised to 6% by an additional input equivalent to 6.6 t/ha of chicken manure. The other set of ponds had a mean of 5.54% organic matter content and required 36.6 t/ha of chicken manure to raise it to 8%.

The ponds with higher organic matter content (8%) produced significant growth of *lablab* and other fishfood organisms and yielded an average of 609 kg/ha of milkfish in 90 days at a stocking rate of 3000/ha. The ponds with lower level of organic matter (6%) had significantly lower *lablab* production and yielded a mean of 279 kg/ha of milkfish (IFP 1976d).

A follow-up study was made right after the termination of the first trial, but without addition of chicken manure to both treatments. Thus the residual effect of heavy doses of chicken manure could be determined. Milkfish with an average individual weight of 0.9 g were stocked in both treatments at 2880/ha and cultured for 93 days. It was observed that the ponds with 8% level of soil organic matter (OM) produced much more *lablab* than those with the 6% OM content. Furthermore, the ponds with higher soil OM content produced 504 kg/ha of milkfish while those with lower OM content yielded 473 kg/ha of milkfish (Leary and Laureta 1977). It was

surprising to note, however, that fish production in the 6% OM ponds was higher than in the first trial of the same level, indicating that, while the heavier doses of organic matter had an advantage over the lower doses in terms of the short-term effect on the production of fishfood organisms, in terms of residual effect the lower dose of organic matter would benefit the fish farmers more in the long run.

### **Early Attempts to Improve Milkfish Production with Feeding**

The effect of feeding on the production of milkfish under brackishwater conditions was determined by comparing the performance of milkfish on *lablab*, plankton, and fish pellets (IFP-1) as the main food sources. The feed composition of IFP-1 was 37.4% crude protein, 14% crude ash, 11% fat, and 9.4% crude fiber with 26% NFE. The *lablab* and plankton ponds required fertilizer doses equivalent to 10 kg  $P_2O_5$ /ha per application. The ponds that received feeds were not fertilized. Milkfish production after 181 days from ponds that received feeds only was 814 kg/ha. *Lablab* and plankton ponds had 504 kg/ha and 352 kg/ha, respectively (IFP 1972a). The effect on fish production of fertilized *lablab* ponds (16-20-0) was further compared with that of the ponds supplied with feed. After 82 days of culture, the ponds that received feed only gave the highest milkfish production of 320 kg/ha compared to 217 kg/ha (fertilizer only), 67 kg/ha (fertilizer plus lime), and 262 kg/ha in ponds with feed and lime (IFP 1972b). A follow-up study that tested *lablab*, *lablab* plus feed, and feed only showed highest milkfish production in the feed only treatment (IFP 1972c).

The above observation indicated that milkfish could perform well with pelleted feed. However, a more practical and economical feed needed to be developed. This prompted the researchers of the Center to screen commonly available material such as ipil-ipil (*Leucaena* sp.) leaf meal, which contains a high level of good quality protein (up to 25% dry weight) and has been used successfully as a feed ingredient, at limited levels, for livestock and poultry. Ipil-ipil was used successfully to make up 40% of a feed for *Macrobrachium*. Although ipil-ipil leaf meal contains mimosine, a toxic alkaloid that limits the level of this ingredient that can be added to feeds, its undesirable effect on fish has not yet been established. For this reason, it was tested on milkfish as a supplemental feed given daily at approximately 1600 h at 1% of total fish biomass. This was placed inside a floating enclosure (four hollow bamboo trunks joined at the corners to form a square 2.25 m on a side) to prevent it from being blown to the downwind shore. The daily ration was increased after every fifth feeding day by an increment based on the estimated daily growth increment of the fish. Milkfish fingerlings were stocked at the rate of 3000/ha.

An increase in net production of 23-30% over the control ponds (ponds receiving only 16-20-0 fertilizer at 50 kg/ha every 2 weeks) was attained after 179 days of culture. From an economic standpoint, ipil-ipil leaf meal as a supplemental feed for milkfish looks promising (IFP 1976b). Further studies, however, are needed to determine the optimum level of ipil-ipil leaf meal that will not cause undesirable effects. Studies could also be made on ipil-ipil leaf meal as a source of protein in pelleted or prepared feeds to minimize the use of animal protein for fish feeds, particularly for milkfish, which is considered a primary herbivore.

### Innovations in Milkfish Culture Techniques

The foregoing studies were rather confirmatory and evaluative of existing practices and techniques for milkfish culture. Although some ideas may have been new, the use of fertilizers (organic and inorganic) and feeds and the rearing of milkfish utilizing natural food by encouraging the growth of certain food types (plankton, *lablab*, or *lumut*) by nutrient enrichment had been practised for many years. However, refinements of these practices were needed to make the methods more effective and efficient in producing milkfish, and the Center embarked on the following innovations:

*Use of substrates to increase area of attachment for fishfood organisms.* The introduction of substrates to bluegill (*Lepomis macrochirus* Rafinesque) ponds resulted in higher production of bluegill due to greater production of fishfood organisms that attached to the added substrates (Pardue 1973). This encouraged the Center to evaluate this method for milkfish production based on the fact that *lablab* production or the abundance of natural food is dependent upon the area of the pond bottom. Using nylon screens that were cut into strips (30 × 10 m) and installed vertically like a series of pingpong nets across the ponds along the east-west direction (to avoid obstruction of sunlight) and set about 20 cm above the pond bottom, the following percent increases of surface area were tested: 0% (control), 15%, 30%, and 60%. The ponds were stocked with milkfish fingerlings (average weight 3.9 g) at a stocking density of 3000/ha.

The results indicated that a 30-60% increase in surface area is needed to effect a significant increase in fish production (IFP 19760f).

To lower the cost of increasing the area of attachment for fishfood organisms, locally available materials, particularly agricultural waste products, may be used. The abundance of rice straw in the locality prompted the Center to test its use as the additional substrate. Three methods of placing straw in ponds were tried: broadcasting, staking, and hanging. Initially, a single dose of 800 kg/ha of rice straw was used in all treatments. The hanging method was found to produce 6-8% more milkfish than the other treatments (IFP 1976g). In order to determine the appropriate amount of rice straw, another trial was conducted using the broadcast method based on the ease and practicality of application. The varying amounts of rice straw tested were 1 000, 6 000, and 10 000 kg/ha. It was obvious that the higher amounts (6 000 and 10 000 kg/ha) had ill effects on milkfish production, although the 1 000 kg/ha approximated milkfish production in the control ponds. This indicated that the amount of rice straw used as a substrate for fishfood organisms should be within 1000 and 5000 kg/ha. Moreover, care should be taken for there are indications that residues of pesticides applied to rice are accumulated by rice stalks, which could affect the fish (Fortes et al 1977).

*Stock manipulation.* An attempt was made to modify the stock manipulation technique as practised in Taiwan to suit Philippine conditions. Three 1500 m<sup>2</sup> ponds were each stocked with three size groups of milkfish, viz., half grown, 1500/ha; post-fingerling, 1500/ha; and fry, 3000/ha. One month after stocking, another batch of fingerlings was added to the ponds at the rate of 1500/ha. This was followed by another batch of fingerlings at a stocking rate of 1500/ha. Two months after the initial stocking, 50% of the marketable size fish (stocked as half grown) were



harvested. The other 50% was harvested one month later. On the fourth month after the initial stocking, 50% of the marketable size fish (stocked as the first batch of post-fingerlings) was harvested. One month later, the remaining 50% was harvested. A monthly harvest was thereafter programmed until the last batch of fingerlings was harvested. A gill net with specified mesh size for selective harvesting was used in all harvests.

The results showed a significant difference in milkfish production between stock manipulation ponds and nonstock manipulation ponds. Production in the former ranged from 734 to 961 kg/ha, while in the latter, it was from 613 to 702 kg/ha (IFP 1976h), indicating that stock manipulation can be done in the Philippines with certain modifications to suit prevailing conditions.

#### *Polyculture.*

- The first attempt of the Center to culture milkfish in combination with other species was made in 1973 using *Penaeus indicus*. At a stocking rate of 3 330/ha for milkfish and 28 756/ha for *P. indicus*, production after 85 days was 510 kg/ha and 109 kg/ha, respectively (IFP 1974c).

In another trial, milkfish was stocked at 3 000/ha and *P. indicus* at 30 000/ha. Heavy shrimp mortality occurred in this trial, but the following important information was noted: (IFP 1975c).

1. Use of aeration during handling increased survival and lowered stress of milkfish and shrimp fry;
2. Shortening of the acclimation process for shrimps to 1.5 h significantly increased stress;
3. Adding *lablab* to the holding container of the shrimps reduced cannibalism; and
4. The use of an acclimation pond was found very useful for both the shrimps and the milkfish fry.

- Some years after the introduction of tilapia (*Oreochromis mossambicus*) into the Philippines in 1950, fish farmers started regarding it as a nuisance or pest in milkfish ponds, and the trend was to eradicate it. Tilapia, because of its high reproduction rate, caused overcrowding, resulting in greater competition and undesirable fish size. It was thought that, if a young tilapia population could be controlled, an additional crop in terms of bigger tilapia could be obtained. The Center conducted an experiment wherein milkfish and all-male tilapia were cultured in combination. Tilapia was stocked at 2000 and 4000/ha and milkfish at 3000/ha, and they were raised for 80 and 85 days.

The results of the experiment showed that the daily weight increment of milkfish in monoculture (1.8 g/fish per day) was the same as that attained in polyculture with tilapia. Milkfish in monoculture attained an average yield of 554 kg/ha. In polyculture with tilapia, average milkfish production was 521 kg/ha (with 2000 tilapia/ha) and 467 kg/ha (with 4000 tilapia/ha). In terms of total production, the two milkfish-tilapia ratios produced 680 kg/ha and 800 kg/ha in 85 days, respectively (IFP 1975b). These results show that there is a good promise for polyculture of milkfish and all-male tilapia.

The labor-intensive method of manual sexing of tilapia and the technical constraints in producing all-male tilapia by sex inversion and hybridization posed a

problem in the use of milkfish-all-male tilapia polyculture. Because of this, the use of a predator to control the population of young tilapia was tried. Fortes (1980) established a tarpon (*Megalops cyprinoides*): tilapia ratio of 1:10 as adequate to control the young tilapia population and to allow the original stocks to grow. Using this technique, a milkfish-tilapia-tarpon combination was tested.

The different treatments used were: (1) milkfish (3000/ha); (2) milkiish (3000/ha) + mixed-sex tilapia (2000/ha); (3) milkfish (3000/ha) + mixed-sex tilapia (2000/ha) + tarpon (200/ha). They were cultured for 120, 107, and 90 days, respectively.

To compare the results with those of milkfish and all-male tilapia, another experiment was conducted with the following treatments: (1) milkfish only (3000/ha); (2) mixed-sex tilapia only (1000/ha); (3) mixed-sex tilapia (1000/ha) + tarpon (100/ha); (4) all-male tilapia (1000/ha); (5) all-male tilapia (1000/ha) + milkfish (3000/ha); and (6) mixed-sex tilapia (1000/ha) + milkfish (3000/ha) + tarpon (100/ha).

The results of the first study indicated that tarpon was an effective predator on young tilapia in the presence of milkfish and did not harm the milkfish. Fish production from the various treatments in the first study was as follows:

Treatments	Production (kg/ha)
1. Milkfish only (3000/ha)	533
2. Milkfish (3000/ha) + mixed-sex tilapia (2000/ha)	612
3. Milkfish (3000/ha) + mixed-sex tilapia (2000/ha) + tarpon (200/ha)	574

Production in Treatment 2 consisted of 41% young tilapia, 22% adult tilapia, and 37% milkfish. Treatment 3 consisted of 7% young tilapia, 25% adult tilapia, 66% milkfish, and 2% tarpon.

In the second study, the contribution of young tilapia to total production in treatments with tarpon was minimal (6% in Treatment 3, less than 1% in Treatment 4). Marketable size fish comprised 94% (Treatment 3) and 90% (Treatment 6) of the total production. In the treatment without tarpon (2) young tilapia comprised 64% while large tilapia made up 36%. Milkfish comprised 83% of total production in Treatment 6. This suggested that production of milkfish was favored in the milkfish-mixed-sex tilapia-tarpon combination over the milkfish-all-male tilapia polyculture (Fortes 1983).

- The tri-species culture of milkfish, mullet, and tiger shrimp (*P. monodon*) was tried to determine their effect on each other. In terms of competition index (CI) tiger shrimp had a negative effect on milkfish, but milkfish favored the production of tiger shrimp. Milkfish and mullet had a fairly high competition, but mullet and tiger shrimp favored each other, thus, improving total production (Fortes 1982).

*Integrated system.* The success of fish-pig culture under freshwater conditions has been demonstrated, but reports of its practice in brackish water appear to be lacking. On this basis, milkfish was cultured in combination with all-male tilapia in brackishwater ponds where pigs at 40 head/ha were raised in pens built above each pond. The pens were washed daily using pond water to rinse the manure and uneaten

feed. The pigs were bathed with rainwater, and all washings went directly into the ponds.

The results indicated that in polyculture of milkfish and all-male tilapia (4000/ha and 2000/ha, respectively), piggery wastes could affect the growth and production of milkfish negatively (Fortes et al 1980). However, milkfish production could be improved using fresh pig manure at appropriate dosage, using the following equation (Tamse 1983):

$$\text{OSR} = 24.65 + (176 \pm 158) m + (0.2 \pm 0.1) t$$

Where OSR = oxygen saturation reduction

m = manuring

t = time (number of days)

Regular daily manure application following the above equation prevented oxygen depletion and resulted in higher milkfish production.

### RECOMMENDATIONS

The work at BAC has centered on milkfish seeds collected from the wild. Hence, the following are recommended for consideration for future work, not only for the Center but also for other institutions:

- Although work should continue on fry from the wild, particularly collection, transport, holding, and rearing, more concerted efforts should now be focused on milkfish seeds from hatcheries in the following areas:
  - environmental requirements of hatchery-produced milkfish fry;
  - feed and nutrient requirements of milkfish larvae for maximum survival during larval rearing; and
  - more studies on natural food sources and the nutrients required for their production.
- More systematic and scientific methods of milkfish broodstock development are needed.
- Refinement of existing culture techniques (ponds, pens, etc.) to standardize methods must be done.
- More studies should be directed toward hybridization and genetic work, possibly determining a species that could be used to strengthen the lone species of *Chanos*.
- Evaluation and confirmatory work should continue in support of the needs of the milkfish industry.

### LITERATURE CITED

- Fortes, R. D. 1975. Growth rate and survival of bangus fry and fingerlings in brackishwater ponds. Paper presented at the Third Fisheries Forum, Philippine Council for Agricultural Research, Manila, 29 August 1975.
- Fortes, R. S., C. C. Baylon, and T. U. Abalos. 1977. Use of rice straw as additional substrate for fishfood organisms in brackishwater ponds (Trial II). Pages 63-79 m R. S. Fortes, ed. Inland Fisheries Project Philippines, Tech. Rep. Nos. 11 and 12, CY 1977 (Brackish-

- water Aquaculture Part). Brackishwater Aquaculture Center, U.P. College of Fisheries, Leganes, Iloilo, Philippines.
- Fortes, R. D., 1980. Tarpon as predator to control Java tilapia young in brackishwater ponds. *Fish. Res. J. Philipp.* 5(2):22-35.
- Fortes, R. D., R. C. Aure, R. C. Sanares, and R. V. Unarce. 1980. Effect on fish production of piggery wastes used as feed and fertilizer in brackishwater pond fish culture. Pages 461-470 in Chung Po, ed. *Animal Wastes Treatment and Utilization*, Council for Agricultural Planning and Development, Taipei, Taiwan.
- Fortes, R. D. 1982. Observations on the polyculture of *Penaeus monodon* Fabricus with selected finishes. Paper presented during the PCARRD Fisheries Forum, BFAR-NCR, Arcadia Bldg., Quezon City, Oct. 1982, 17 p.
- Fortes, R. D. 1983. Polyculture of tilapia (*T. mossambica*) and milkfish (*Chanos chanos*) in brackishwater ponds with tarpon (*Megalops cyprinoides*) as predator to control young tilapia population. Paper presented at the International Symposium on Tilapia in Aquaculture, Nazareth, Israel, 8-13 May 1983.
- Inland Fisheries Project. 1972a. Bangus culture in ponds with feed, *lablab*, and plankton. Pages 4- 18 in *Inland Fisheries Project Technical Report No. 1, FY 1971-72*. U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1972b. Bangus culture in ponds with feed and *lablab* with and without lime. Pages 18-26 in *IFP-TR No. 1, FY 1971-1972*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1972c. Bangus culture in ponds with feed and *lablab*. Pages 26-32 in *IFP-TR No. 1, FY 1971-72*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1973a. *Lablab* and bangus production in brackishwater ponds treated with combination of organic and inorganic fertilizers and with phosphate fertilizer only. Pages 31-38 in *IFP-TR No. 2, FY 1972-73*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1973b. Tank experiment with effect of various fertilizer materials on the growth of natural food organisms in brackish water. Pages 38-44 in *IFP-TR No. 2, First Half FY 1972-73*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1974a. Rate of growth and survival of bangus fry in brackishwater ponds. Pages 7-8 in *IFR-TR No. 4, First Half FY 1973-74*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1974b. Bangus transfer from one salinity to another. Pages 70-75 in *IFP-TR No. 4, First Half FY 1973-74*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1974c. Combination bangus-shrimp culture. Pages 9-10 in *IFP-TR No. 4, First Half FY 1973-74*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1975a. Simultaneous culture of bangus fry inside hapas and bangus fingerlings at large in the same ponds. Pages 14-31 in *IFP-TR No. 7, 2nd Half FY 1975*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1975b. Bangus production in newly constructed ponds with plankton and *lablab* for three consecutive cultures using single combination fertilizers. Pages 32-47 in *IFP-TR No. 7, 2nd Half, FY 1975*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1975c. Monoculture and polyculture of bangus and shrimp (*Penaeus* sp.) in brackishwater ponds. Pages 19-22 in *IFP-TR No. 6, First Half FY 1975*, U.P. College of Fisheries, Diliman, Quezon City, Philippines.

- Inland Fisheries Project. 1975d. Monoculture and polyculture of bangus and all-male tilapia in brackishwater ponds. Pages 1-13 in IFP-TR No. 7, 2nd Half FY 1975, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976a. Mixed culture of bangus fry and fingerlings in brackishwater ponds with plankton. Pages 16-24 in IFP-TR No. 9, First Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976b. Simultaneous culture of bangus fry inside hapas and bangus fingerlings loose in same ponds. (Trial II). Pages 51-65 in IFP-TR No. 9, First Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976c. Mass culture of food organisms using different fertilizers and nutrient media. Pages 5-20 in IFP-TR No. 10, 2nd Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976d. Milkfish production at two levels of organic matter control in pond soil. Pages 62-67 in IFP-TR No. 10, 2nd Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976e. The effectiveness of *Leucaena* sp. leaf meal as a supplemental feed for bangus in brackishwater fishponds. In IFP-TR No. 9, First Half FY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976f. Production response of milkfish, *Chanos chanos* (Forsskal) to additional substrates fishfood in brackishwater ponds. Pages 89-94 in IFP-TR No. 10, 2nd Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976g. Preliminary study on the use of rice straw as an additional substrate for fishfood organisms. Pages 1-4 in IFP-TR No. 10, 2nd Half CY 1976, UP College of Fisheries, Diliman, Quezon City, Philippines.
- Inland Fisheries Project. 1976h. The effect of stock manipulation on the growth and production of milkfish in ponds. Pages 21-40 in IFP-TR No. 10, 2nd Half CY 1976, U.P. College of Fisheries, Diliman, Quezon City, Philippines.
- Leary, D.F., and L.V. Laureta, 1977. A comparison of isonitrogenous application of urea or ammonium fertilizer in brackishwater fishponds (Trial II). Pages 1-8 in R.D. Fortes, ed. Inland Fisheries Project Philippines, Tech. Rep. Nos. 11 and 12, CY 1977 (Brackishwater Aquaculture Part). Brackishwater Aquaculture Center, U.P. College of Fisheries, Leganes, Iloilo, Philippines.
- Pardue, G.B. 1973. Production response of the bluegill sunfish *Lepomis macrochirus* Refine-que to added attachment surface for fishfood organisms. Trans. Amer. Fish. Soc. 102(3): 622-626.
- Tamse, A.F. 1983. The regular application of fresh pig manure for milkfish culture in brackishwater ponds. M.S. thesis, College of Fisheries, Univ. of the Phil. Visayas, Iloilo City, 75 p.