MILKFISH RESEARCH IN THE PHILIPPINES

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Development and directions in milkfish research in the Philippines from 1976 to the present are reviewed and analyzed. The problems of milkfish culture are dichotomous: low productivity vis-a-vis seasons of glut and price fluctuations. To intensify fish production, extensive research has been conducted on fertilizer management, reclamation of acid sulfate soils, and pond construction and engineering. Research efforts have also been heavily directed toward increasing fry production through artificial propagation, improvement of fry collecting gear, and increasing fry survival through nutrition, control of parasites, and proper handling. Research on improved icing, packaging, and processing techniques along with market analysis are necessary for maximizing economic returns.

INTRODUCTION

Milkfish, *Chanos chanos* (Forsskal), is the predominant fish cultured in the Philippines. In 1981, 170 431 t of milkfish were harvested from about 195 000 ha of brackishwater ponds, accounting for 90% of the total fishpond production in the country. Milkfish is popular even with Filipino communities abroad, to which most of the 5261 of exported frozen milkfish went in 1981. Philippine exports of canned milkfish have increased steadily in recent years, and there is a growing demand for milkfish juveniles for tuna bait.

Much remains to be done, though, to increase the present annual average milkfish fishpond production of 870 kg/ha. This low yield is related, among other reasons, to an insufficient use of inputs, large tracts of underdeveloped fishpond areas, and irregular supplies of fry. In marketing, seasons of glut, variable price levels, and abnormal market flows are common problems.

The government, the research community, and the private sector are exerting concerted efforts toward increasing milkfish production and stabilizing the industry. Yields of more than 2 t/ha per year from the more progressive fish farms of Bulacan and Iloilo indicate the potential for increased production.

MILKFISH AS A RESEARCH PRIORITY

Aquaculture research in the Philippines accelerated during the 1970s due in part to the establishment and strengthening of better-equipped aquaculture research and training centers. Later, a national research system was developed through the Philippine Council for Agriculture and Resources Research and Development (PCARRD). There has been increased government and international support for fisheries research along with active participation by the private sector in research and extension.

Milkfish culture and related studies are top priority research areas in aquaculture. The lead agencies in milkfish research are the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC-AQD) and the Brackishwater Aquaculture Center at the University of the Philippines in the Visayas. Adaptive trials are carried out by the Bureau of Fisheries and Aquatic Resources and by fishery schools throughout the country.

Within the PCARRD registry, about 80 research studies in milkfish were completed from 1973 to 1982, most of which dealt with pond management techniques. Extensive research was conducted to optimize fertilizer efficiency in the production of *lablab* and plankton as a food base. Field trials were conducted on the reclamation of acid sulfate soils, and a number of experiments on the polyculture of milkfish with tilapia, shrimp, mudcrab, and other nontraditional cultured species were carried out. Breakthroughs were achieved in broodstock development, induced spawning, and sex differentiation of milkfish breeders. Various aspects of the biology and physiology of fry and broodstock were also explored. For postharvest handling and processing, methods and fish formulations were standardized. Ample data were gathered on the economics of the milkfish industry. This paper reviews the research conducted over the past 8 years.

RESEARCH STATUS (1976-1983)

Culture Techniques

Pond engineering. The design and construction of brackishwater milkfish ponds have evolved through years of commercial practice by the private sector. Engineering principles and technologies have recently been applied to these practices. Current pond engineering technology has established the following: (1) criteria concerning site selection; (2) relationship between the size of gate, pond water level, and design tide curve; (3) design elevation for foundation; (4) relationship among the sizes of pond compartments according to their functions; (5) different types of layout schemes; (6) size and proportioning of dikes; (7) control of internal erosion and seepage; (8) methodology of pond construction and repair, including related facilities; and (9) construction tools and machinery (de la Cruz 1979).

Through the progression system of pond culture, it has become possible to raise at least six crops per year. In this system, three adjacent ponds with a 1:2:4 area ratio form a module. Stock is transferred from a smaller to a bigger pond after a 30-day culture period in each compartment. Once a pond is vacated, it is immediately prepared for another stock. The progression system is a continuous program of pond preparation, stocking, transfer, and harvest. Potential production is about 3 t/ha per year.

Fertilization and growing of natural food. Research on optimizing fertilizer use has taken into consideration the types and amounts of elements needed, the nutrient ratios, sources of nutrients, and the frequency, time, and methods of fertilizer application. A series of studies indicated that about 1 ppm of nitrogen and 1.5 ppm of phosphate should be maintained in the pond water for sustained growth of benthic algae. Among traditionally used fertilizers, mono- and diammonium phosphate proved to be superior. Split applications at an interval of 2 weeks in 3 months resulted in higher milkfish production than bulk doses of the same amount (Singh, unpubl.). Applications made on a semisubmerged platform or in solution improved the fertilizer use efficiency and reduced phosphorus losses (Ladja 1983).

The use of artificial substrates is promising in increasing production in brackishwater ponds. Nylon nets are set in the pond bottom to which *lablab* can attach and grow. At 60% of pond area added artificial substrates, it is estimated that a 15-20% increase in fish production is possible compared to the conventional *lablab* method.

Acid sulfate soil. A technology has been generated to reclaim acid sulfate soils common in new brackishwater ponds. This type of soil was found to respond poorly to phosphorus fertilization and to release nearly lethal concentrations of aluminum and iron, leading to low productivity. The reclamation technology involves a repeated sequence of intensive draining, drying, and flooding before the residual acid is neutralized by liming (Singh 1982, Singh and Poernomo 1984).

Nutrition and feed development. Nutrition studies have indicated that 40-50% protein is required in the diet by milkfish fry for maximum growth, efficient feed conversion, and high survival rate. High density rearing of fry to fingerlings in an indoor system seemed feasible using a purified diet with prophylactic treatment (Camacho 1975).

No clear-cut technology on milkfish feed formulation seems to be available. Present practices utilize single-ingredient materials like rice bran, bread crumbs, and corn bran. Addition of Terramycin and Vigofac in these feed materials favored the growth rate of milkfish. Other forms of feed ingredients used are copra meal, hog mash, dried rice straw, broken bones, fish meal, egg yolk in small quantities, *ipil-ipil* (*Leucaena leucocephala*) leaves, and *kangkong* (*Ipomoea reptans*) leaves. For natural food, dried grass, filamentous green algae, particularly phytoflagellates, and *gulaman* (*Gracilaria* sp.) are being used. Feeding techniques, however, need to be standardized.

Parasites and diseases. At present, the extent and kinds of diseases and parasitism in milkfish have not been established. Various parasites and diseases affecting milkfish in different parts of the country have been described (Velasquez 1979). Lio-Po et al (1982) reported the known diseases of economically important fish species in the Philippines including those of milkfish. Bacterial (*Vibrio* sp.) and fungal diseases and parasites (isopods and copepods) of milkfish were described. Prophylactic treatments are known but are only effective and adaptable in small confined areas.

Environmental factors that may cause widespread infestation of fish in the pond are not known. Knowledge of the life cycle of fish parasites is needed to devise successful prophylactic measures.

Polyculture. Polyculture of milkfish with prawn or mudcrab is traditionally practised, as these species enter milkfish ponds with the incoming tide. To systematize the practice, five different stocking combinations of milkfish and prawn (*Penaeus monodon*) were evaluated in brackishwater ponds. The polyculture of 2000 milkfish and 6000 prawns/ha was reported to be economically feasible, with average milkfish and prawn production per 100 days of 388.06 and 75.58 kg/ha, respectively (Pudadera 1980), although the monoculture of prawn (production of 144.30 kg/ha per 100 days) was more profitable. Trials have also been conducted on the polyculture of milkfish with *P. semisulcatus* and with all-male *Oreochromis mossambicus* (IFP 1976a). Milkfish-tilapia trials consistently gave high yields (IFP 1976b).

Freshwater production. Milkfish pen culture has been a profitable enterprise in Laguna de Bay since the technology was successfully demonstrated by the Laguna Lake Development Authority in the early 1970s, with an average production of 5 t/ha per year. The industry is beset by serious problems such as the occurrence of destructive typhoons and high fingerling mortality rates, seasonal off-flavor taste, and occasional fish kills. In studies conducted to improve fishpen design and construction, criteria for site selection and several fishpen models were recommended.

Acclimation methods were also developed to reduce fingerling mortality. It was shown that, with nursery pond-reared fingerlings at 12-15 ppt salinity, mortality can be reduced by 10% if dilution progresses over a 6-hour period (Baguilat 1980). Cages were tested for rearing fry to fingerlings to minimize handling, salinity, and transport stress. One trial showed that the effective cost of rearing fry to fingerlings in freshwater ponds is equal or almost equal to purchasing fingerlings from brackishwater nurseries (Mane 1979). More studies on freshwater nursery techniques are needed, however.

Fry Collection, Storage, and Transport

Fry grounds and seasonal occurrence. Milkfish fry appear throughout the year in one location or another, but have marked peak periods, and the fry supply fluctuates to some degree from year to year. Fry catch for a given level of effort varies from day to day within the month, with peak gathering periods occurring during the monthly high tides associated with the full and the new moon (Librero et al 1976, Smith 1981, Villaluz et al 1982).

Traditional and new fry grounds were reported along with corresponding catching gear being used in these areas and the degree of resource exploitation. Larval net tows showed that Antique Province has one of the most productive fry grounds in the country.

Collecting gear. The design, construction, and area of operation of fry collecting gear are dictated primarily by the topography of the fry ground, the wind direction, the local current system, and tidal fluctuations. Traditional gear and methods of collection are modified for convenience and as the result of availability and cost of materials (Villaluz et al 1982).

The common types of milkfish fry collecting gear used on Panay Island were classified by Kumagai et al (1980) according to mobility as passive filtering or active (dragged or pushed). Experiments were conducted to test the efficiency of modifications of traditional collecting gear using netting materials of various meshes and colors (Kawamura et al 1980, Quinitio and Kawamura 1980, Paler 1981). Efficiency was based on the number and survival of fry gathered compared to those caught by the original gear. Driving effect, ease in handling, and visibility of fry were also considered for every gear tested.

Storage and transport. Fry dealers have developed their own techniques for storing and feeding fry prior to sale or transfer to a nursery. Consequently, different stocking densities during storage are used, no standard feed is given, and the suitable water salinity for storing fry is not known. The fry are commonly stored in water with low salinity and fed with boiled egg yolk. Mortalities range from 3% to 10% in at most 2 weeks of storage.

It is commonly believed that mortality can be reduced when fry are stored in fresh water. A study of the effect of various salinity levels and stocking density manipulation methods on the survival of milkfish fry during storage revealed, however, that it is not necessary to reduce the salinity of the water used. It is more important to provide sufficient food and to maintain good water quality by changing about three-fourths of the water every morning to obtain better survival (Quinitio and Juario 1979). The recommended stocking density for storing milkfish is 150-400 fry/liter in plastic basins and 100-122 fry/liter in earthen jars.

Fry are transported in oxygenated plastic bags. Fingerlings are transported in the same manner but are considered more fragile than the fry, more susceptible to disease, and therefore in need of more careful handling. For the Laguna de Bay fishpens, most of the fingerlings are transported by *petuya,* an open boat with a pump aerator which allows for changes of water.

Artificial Propagation

An analysis of the milkfish fry industry in the Philippines by Smith (1981) indicated that fry resources are sufficient and can meet present demands if they are fully exploited. Nevertheless, a steady supply of artificially produced milkfish fry for culture to marketable size would help stabilize the milkfish culture industry by reducing dependence on the natural fry supply. Several studies were therefore conducted in the past decade to learn more about wild milkfish and to learn how to induce them to spawn in captivity and to rear the resultant larvae to fry. These have been followed by studies on captive broodstock reared in pens and cages at the SEAFDEC-AQD Igang Substation.

Biology. Sex differentiation of milkfish spawners based on discernible anatomical differences in the anal regions of mature fish has been observed (Chaudhuri et al 1976). Milkfish egg collections around Panay Island indicated spawning migration patterns (Senta et al 1976). The eggs occurred in waters of 10-900 m depth. A considerable number were obtained from 200 m-deep waters, although the majority of the eggs were found close to the coast.

The probable transport and movement of milkfish eggs and larvae from the spawning ground to the fry collection ground were discussed by Kumagai and Bagarinao (1979) based on drift card experiments. The results of the experiments suggested that the vertical and horizontal distribution of milkfish eggs and larvae at various developmental stages-, current, and the active movement of the postlarvae are to be considered in determining drift patterns or mechanisms of transport of milkfish eggs and larvae at sea.

Induced spawning. Induced spawning and larval rearing of milkfish were pioneered by SEAFDEC-AQD. Attempts to induce ovulation in *sabalo* (milkfish spawners) using different hormones succeeded as early as 1977. In the following years further studies led to the formulation of an effective spawning dose for the wild and captive stock. After a series of experiments, SEAFDEC-AQD published a guide to induced spawning and larval rearing techniques that recommended the use of a mixture of acetone-dried pituitary gland homogenate of coho salmon (SPH) and human chorionic gonadotropin (HCG) for the female and Durandron Forte "250" (DF), a long-acting androgen, for the male. Careful capture, handling, and transport were also recommended to ensure successful induced spawning (Juario and Duray 1982).

From the experiments on rearing newly-hatched milkfish larvae, the highest survival rate was achieved by giving various feeds from day 1 to day 21, changing one-third of the water whenever necessary, and maintaining the light green color of the water throughout the rearing period. Figure 1 shows the feeding schedule for milkfish larvae during the 21-day period.

Maturation in cages. Following the land-based studies, significant findings were achieved when milkfish matured sexually and spawned spontaneously in floating cages at Igang in August 1980 (SEAFDEC 1980). The fertilization rate of the eggs was 55-65%, the hatching rate 30-50%, and the larval survival rate 50%. Spontaneous spawnings recurred in 1981, 1982, and 1983 (Marte, pers. comm.). More studies are being conducted to determine optimum requirements for gonad maturation.

Economics

The average yield of milkfish ponds is 870 kg/ha per year. Recent studies concluded that this low production is a result of extensive farming techniques in the Philippines. Generally, inputs are not used in sufficient quantities to increase yield substantially. The average stocking rate of fry is too low, while the average stocking rate of fingerlings is too high. Levels of organic and inorganic fertilization need to be increased. Other significant factors that may explain current milkfish yields include age of pond, status of tenure, miscellaneous operating costs, farm size, and climate (Librero et al 1977, Chong et al 1981).

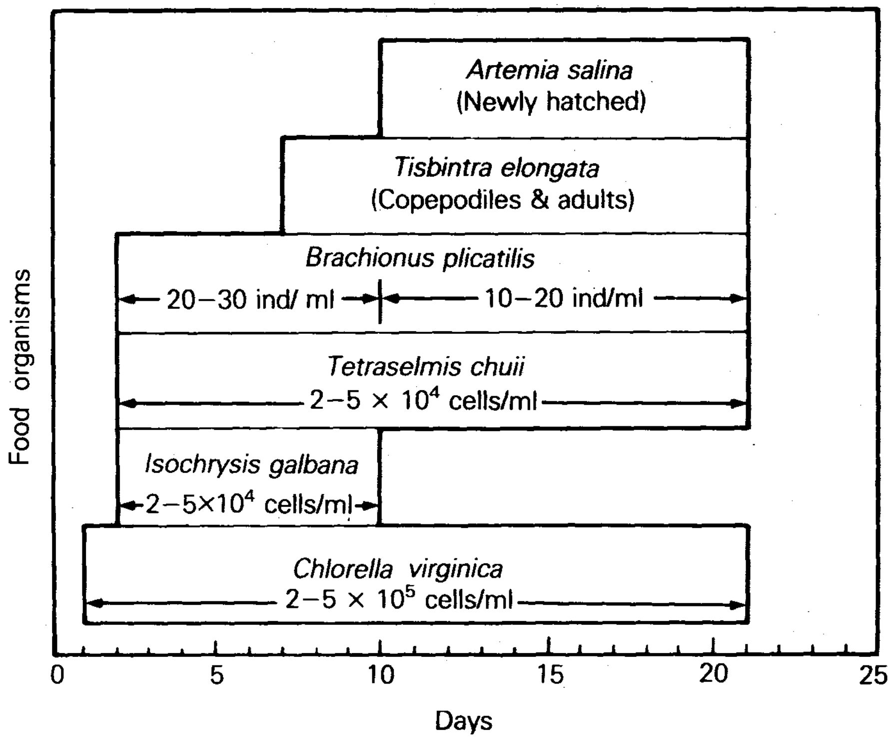

Fig. 1. Feeding schedule for milkfish larvae during the 21-day rearing period (from Juario and Duray 1982).

Larger farms are more efficient than medium and small farms (Chong et al 1981). Milkfish farmers should be encouraged to reorganize and restructure small units of production into large units to make production more efficient and profitable. With group farming, farmers should also be encouraged to apply more yield-increasing and yield-protecting inputs such as fertilizers and, whenever appropriate, to encourage the use of cheaper indigenous materials for fertilization and pesticide application.

Postharvest Handling and Processing

As with other aquatic products, the price of milkfish is dictated by its quality upon reaching the consumer. A portion of the harvested fish can be processed to make them last longer. Postharvest operations and product utilization technologies have been developed for dissemination and commercial application to milkfish (Orejana 1979). A National Science Development Board assisted project dealing with post-harvest fish handling preservation and processing has come up with a publication entitled "Milkfish (*Bangos*) as Food" (NSDB 1978), which includes handling, freezing, canning, other processing methods, and use of the by-products of milkfish processing.

Handling, chilling, and freezing. Dolendo et al (1978) determined the proper handling and icing of milkfish to preserve its quality during transport and storage. Pre-chilling to 4°C immediately after harvest with appropriate ice to fish ratios was found to maintain the quality of the fish. Suitable containers for every mode of transport, blast freezing, proper packaging, and storage methods were recommended after considering economy, length of the trip, and ease of handling.

Processing. Product formulation studies were conducted for canned milkfish prepared in various styles and recipes (Palomares et al 1978). Drying, smoking, fermentation, and pickling were also studied, and procedures for sun-dried milkfish, soft-boned and deboned smoked milkfish, and fermented and pickled milkfish were recommended (Guevara et al 1978).

By-product utilization. Hand in hand with the processing of milkfish, particularly in the canning operation, the utilization of waste has to be considered. Fish meal, fish silage, hydrolysate (*bagoong* and *patis*) and oils, and guanine extracts are some of the more important by-products prepared from milkfish waste. Publications on the canning of milkfish and the preparation of its by-products are now available. Further improvements in keeping the quality of frozen and processed fish, e.g., improved packaging, will be needed. Likewise, quality standards for processed fishery products should be established.

RESEARCH THRUST

The national research system coordinated by PCARRD guides the research activities pursued by various agencies. Research areas have been identified and organized into a framework of activities under general research thrusts. In the aquaculture commodity, the five general research thrusts involve priority research areas on milkfish culture as follows:

- Increased pond production through intensive culture by
  - Improved aquaculture engineering systems
  - Improved pond management
  - Sociological and production economics studies
- Postharvest handling, processing, and marketing
- Production of seedlings
  - Seed production of cultivable species
  - Broodstock development
  - Nutrition and feed development
- Development of integrated agro-fishery systems
- Development of pen/cage culture

CONCLUSIONS/RECOMMENDATIONS

The need for intensification and adoption of appropriate technology in milkfish production has to be pursued more vigorously. The more progressive pond operators have shown that the national average production of 870 kg/ha per year may possibly be raised to 2 t/ha per year.

It is necessary to emphasize the advantages of investing in necessary inputs to increase production. Levels of inputs — including fry, fingerlings, miscellaneous operating costs, and organic and inorganic fertilizers — that were found to be significant determinants of output per hectare can indicate the areas where further research can help improve cultural practices (Chong et al 1981).

Extension and technology dissemination should receive additional support, both from the government and from the private sector. Identification of and solutions to site-specific problems will require a linkage between researchers and extension specialists.

Active government support is equally needed in financing and marketing. With more incentive and liberal credit programs developed, loans for buying supplemental inputs can be made available to operators. Provision can be made for adequate infrastructure support and marketing channels.

Though prawn culture may give higher returns, milkfish will nevertheless still be the primary cultured fish in brackishwater fishponds. This fish has great potential in the processed food industry. The canned milkfish industry is picking up with increased local demand, serviced by both small private entrepreneurs and large canning factories.

It is hoped that the potential demand will encourage milkfish pond operators and other sectors involved in the industry to make Philippine milkfish farms more productive and profitable.

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