Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni

8-11 September 1992
Iloilo, Philippines

Aquaculture Department
Southeast Asian Fisheries Development Center

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FOREWORD

In September 1992, the SEAFDEC Aquaculture Department conducted an aquaculture workshop for its training alumni from three SEAFDEC Member Countries - Malaysia, Thailand, and the Philippines. The workshop aimed to (1) maintain linkage between the Department and its training alumni and among trainees; (2) assess the effectiveness of the training courses of the Department; (3) inform alumni of the recent technologies developed by the Department; and (4) recommend ways to make the training courses more responsive to the needs of the fishfarmers and the aquaculture industry. The Government of Japan was generous enough to fund the workshop.

This volume contains the papers presented by the training alumni at the workshop. The alumni were asked to write about their experiences in relation to five areas of their countries' aquaculture industry: shrimp and marine fish hatchery, grow-out culture, diseases, and nutrition. Their assessments included the status, prospects, and problems, and paid particular attention to manpower needs.

Some industry practitioners from the Philippines also attended the workshop and shared their views. Department scientists briefly reviewed research at AQD during the period 1988-1992. The training and information programs of the Department were also reviewed.

We believe that publication of this volume can help SEAFDEC/AQD realize its goals in technology transfer and information dissemination. We also hope the readers will learn from the experiences of the training alumni.

Efren Ed. C. Flores, D. Fish:
Department Chief

September 1993

WORKSHOP SUMMARY AND RECOMMENDATIONS

Aquaculture Workshop for
SEAFDEC/AQD Training Alumni
8-11 September 1992
Iloilo, Philippines

The SEAFDEC Member Countries - Malaysia, Philippines, Singapore, and Thailand - recognize that training and technology transfer are essential for the continued growth of the region's fisheries and aquaculture. The AQD training alumni identified several problems regarding the capability of the technical staff in aquaculture:

• *Shrimp seed production*

In Malaysia, there is an apparent lack of experienced technicians especially for newly started shrimp hatcheries. Thailand cited the high rate of staff turnover due to more attractive offers from private hatcheries. The present hatchery technicians need further training in eyestalk ablation, *Artemia* preparation and its feeding, and chemical or antibiotic treatment of larval diseases. The Philippines is batting for accreditation and prpfessionalization of hatchery technicians and other aquaculture practitioners.

• *Marine fish seed production*

The Philippines cited the inadequate knowledge of milkfish hatchery technicians especially those connected with the government's National Bangus Breeding Program. Milkfish fry production in government and private hatcheries is yet minimal. There are few technicians who can run marine fish hatcheries. Malaysia is yet to develop its human resources in marine fish hatchery.

• *Grow-out culture*

The Philippines noted the inconsistent technology in the culture of shrimp, and that technicians depend largely on their own experiences. Malaysia's extension services are largely directed to commodities that have only been recently developed, and skilled manpower is generally lacking.

• *Fish diseases*

Malaysia noted the limited manpower skilled in disease diagnosis and treatment in shrimp farms and hatcheries. A lot of information exists but most government fisheries assistants have only very basic knowledge. The country is hoping to develop expertise in disease prevention, diagnosis, and control. Thailand noted that technicians generally lack understanding of proper pond management, a situation that often leads to diseases.

• *Fish nutrition*

Manpower problem is not yet apparent since farmers and technicians generally follow manufacturers' recommendations. On-farm feed formulation is not widespread.

The six major SEAFDEC/AQD training courses partly answer the training needs of Southeast Asia. These are:

- *Shrimp Hatchery/Nursery Operations and Management*
- *Marine Finfish Hatchery/Nursery Operations*
- *Fish Health Management*
- *Fish Nutrition*
- *Culture of Natural Food Organisms* and
- *Aquaculture Management*

The *Workshop* participants considered the AQD courses to be very good in both content and presentation. But deficiencies were noted and the following recommendations were made:

- Training courses must address the effects of aquaculture on the environment, particularly those related to intensification of culture and resulting pollution and diversion of resources.
- More case studies or practicals must be given in the training courses to acquaint technicians with actual field conditions. There is a need to assess the duration of the courses. New technologies and on-going research must be included for trainees to get a picture of the direction of the industry.
- The training alumni must be given opportunity to continuously update themselves other than the internships offered by AQD in some areas (i.e, chemical/proximate analyses, plankton culture, instrumentation, pathology, economics, microtechnique).
- On the management side of the training courses, AQD must refine the requirements for the prospective trainees and accept only those working or will work in the field of training.
- Two more training courses must be developed by AQD: *Mollusc Culture* and *Brackishwater Pond Culture.*

Cesar T. Villegas, Ph.D.
Training and Information Division Head and
Chairperson, Workshop Organizing and
Program Committee

ACKNOWLEDGMENT

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The Editors

COUNTRY REPORTS

SHRIMP AND MARINE FISH SEED PRODUCTION

Five country papers were presented on the status, practices, and problems of shrimp and marine fish seed production.

A summary of the discussion that took place is presented.

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SHRIMP SEED PRODUCTION IN MALAYSIA

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ABSTRACT

The giant freshwater prawn, *Macrobrachium rosenbergii,* and the marine shrimp, *Penaeus monodon, are* now becoming the most important cultured species in Malaysia. The progress in the aquaculture of these species has led to the development of hatcheries in various parts of the country. To date, a total of 50 hatcheries are now in operation.

Fry production technology varies between hatcheries. For M. *rosenbergii,* clear-water, closed system, and green-water larviculture techniques are common. For *P. monodon,* the two-tank and one-tank larviculture systems are used. A range of problems such as lack of skilled hatchery personnel, larval diseases, and lack of financial support hampers hatchery operations. In order to ensure the continued operation of the hatcheries, the Department of Fisheries (Malaysia) is providing the necessary support services and technical assistance.

Shrimp culture (*Penaeus monodon, P. merguiensis,* and *Metapenaeus* spp.) was first practiced in Malaysia in the 1930s whereas, the culture of the giant freshwater prawn (*Macrobachium rosenbergii*) began only in the 1960s.

The artificial propagation of the giant freshwater prawn was first achieved experimentally in the early sixties. This was followed by success in rearing several species of marine penaeid shrimps, with the giant tiger shrimp (*P. monodon*) being successfully propagated at Glugor, Penang for the first time in July 1969.

A research hatchery was first established at the Fisheries Research Institute in Glugor, Penang in 1975, essentially for the mass propagation of the giant freshwater prawn. Later, the station went into hatchery-scale propagation of marine shrimps, particularly the giant tiger shrimp. With the establishment of National Prawn Fry Production and Research Centre (NAPFRE) at Kampung Pulau Sayak, Kedah in February 1987, the Department of Fisheries (Malaysia) has now expanded and concentrated all its research and training programs in one center, especially fry production technology and broodstock maturation.

Shrimp culture is now the fastest growing sector of the aquaculture industry in Malaysia. There has been considerable private/corporate sector involvement in the development and intensification of shrimp culture on a commercial basis with investments totalling millions of ringgit. This resulted in the development of marine shrimp hatcheries all over the country. Most of these hatcheries have small production capacities and serve the requirements of small grow-out farms while some large hatcheries cater to larger farms and the lucrative fry export market.

Status

Presently, there are 50 crustacean hatcheries, five of which are freshwater prawn and the rest are marine shrimp hatcheries. Out of this number, two are government-owned, one in Perak producing mainly freshwater prawn seed while the other (NAPFRE, Kedah) produced both freshwater and marine shrimp seeds. The annual production capacity for freshwater prawn hatchery is between 2-12 million juveniles and for the marine shrimp hatchery, 5-25 million postlarvae.

In 1990, the country's marine shrimp hatcheries produced an estimated 1 billion fry. The giant tiger shrimp is by far the main species cultured, although the banana shrimp (*P. merguiensis*) is also produced to a small extent. The production in the freshwater prawn hatcheries was estimated at 20 million juveniles and the bulk of it, i.e., 16 million, came from the government hatcheries.

The total area of freshwater ponds in Malaysia is about 4,900 ha while 1,550 ha are under marine shrimp culture. It is expected that by the year 2,000 about 21,000 ha of brackishwater ponds and 15,000 ha of freshwater ponds could be developed. Based on these figures, the fry requirement for penaeid shrimp culture will be about 2.1 billion and 51 million for freshwater prawn culture.

Hatchery technology

Hatchery design. The hatchery design commonly used varies considerably depending on the system adopted. Some low-budget projects use a simple shed with just a roof to cover the larval rearing tanks. Most hatcheries, however, are well enclosed to maintain optimum temperature conditions. The use of transparent roof sheets is common to ensure adequate light penetration and to raise the ambient temperature close to the optimum 30°C. Sun-shade screens are normally used to control light intensity and, hence, water temperature. On the other hand, there are some hatcheries that keep the larviculture tanks totally covered and sheltered from light (Taiwanese system).

Hatchery tanks are built of fiberglass, plastic, or concrete; fiberglass are often lined with epoxy polyester paint. The tanks vary in shapes (round, conical, square, and rectangular) and sizes (1-2 to 10-50 t).

The tanks are usually placed on the same level. However, some of the newly constructed marine shrimp hatcheries have adopted a design where the algal tanks are placed slightly higher so that algae-rich water could flow by gravity into the larval rearing tanks and subsequently to the nursery tanks which are, again, placed at a lower level.

Water treatment. The seawater treatment normally follows sedimentation-filtration-storage process before being used in the hatchery. Sedimentation is done for silt precipitation. Filtration is by passive sand filters or pressurized sand filters. Cotton-bag filters or cartridge filters are also used by some hatcheries. Storage facility for water is optional as some hatcheries use the water immediately after filtration. In some hatcheries, water is treated by UV-light irradiation or by chlorination.

Broodstock supply. Most hatcheries are totally dependent on the supply of gravid females caught from the wild which are found in abundance. Only 1 hatchery (NAPFRE) is known to supplement its spawner needs by induced spawning of mature female tiger shrimp using the unilateral eyestalk ablation technique.

The broodstock supply of freshwater prawn is either caught from estuarine areas or obtained from the ponds. Some hatcheries have ponds to raise juveniles to broodstock.

Larval rearing systems

***Marine shrimp* (*P. monodon and P. merguiensis*).** The larviculture systems can be classified as same tank system or different tank system. These systems are briefly described below:

Same tank system

In this system, there is no change of tanks throughout postlarval production activities. Spawning, egg hatching, larval rearing, and nursery maintenance (until PL 5 to 35) are all carried out in the same tank. The tank sizes vary among hatcheries. Gravid females either caught from the wild or eye-stalk ablated are stocked at a rate of 1-1.5 individuals per ton of water. After spawning, the females are removed. The eggs in the tanks are allowed to hatch and larval rearing commences. Prior to this, the tank water is fertilized with agriculture fertilizers to encourage growth of mixed diatoms which are important larval feeds. Some hatcheries culture diatoms (*Chaetoceros* sp., *Skeletonema* sp.) in separate outdoor tanks. Diatom cell densities range from 25,000 to 80,000 cells/ml. Artificial larval pellets are also used. *Artemia salina,* either newly hatched or hatched and frozen, is given from late protozoea 3 to PL 5 stages. After PL 5, a range of larval diets is used until PL 15 to PL 35. Water change for larval rearing may commence during late protozea 3 stage and onwards. The amount of water change is 30-70% during mysis to early postlarval stages. After PL 5, water change may be restricted to 30-50% on alternate days and siphoning of uneaten feed and organic debris is carried out simultaneously.

Harvesting is done by draining the tanks and finally trapping the postlarvae into filter screen boxes or fine-mesh bags (500-1000 μ) submerged in collecting basins. Most hatcheries claim an average survival of 50%.

Separate tank system

Spawning, hatching, larval rearing (PL 1 to 5), and nursery rearing are done in separate tanks of different volumes. Hatchery owners claim better control and programming of hatchery management in this system. For spawning, 0.3-1 t cylindrical tanks with conical or flat bottoms are used. The eggs are allowed to hatch in the same tank after the waste left by spawning is removed by changing the water. A few hatcheries even collect and wash the eggs before hatching them in another tank. After hatching, nauplii population is estimated, and transferred to larval rearing tanks. Feeding of larvae commences at protozoea 1 or at late nauplius (N6) stage. As in the previous system, algal (*Chaetoceros, Skeletonema, Isochrysis*) and artificial larval diets are fed. Algal cell densities vary from 25,000 to 50,000 cells/ml. Algal culture is done separately. *Anemia* nauplii are given as feed at late protozoea 3, mysis stages, and up to postlarvae 1. Water is changed every other day or as required (e.g., daily or after every few days) with simultaneous siphoning of tank wastes at the bottom. PL 2-5 are transferred to nursery tanks (20-50 t) by draining the tanks and trapping the postlarvae in nets. Nursery rearing is up to PL 15-35; thereafter, postlarvae are harvested for distribution to farms.

***Freshwater prawn* (*M. rosenbergii*).** There are several larval culture systems: closed, clear-water, and green-water. Government hatcheries use all three while private hatcheries use the clear water or green water system. These are briefly described below:

<u>Close system</u>

This is usually practiced at small-scale level though it involves a high density (100 larvae/1). This technique uses 2-t cylindrical tanks with conical bottoms. The larval rearing tanks are connected to a highly efficient biological filter system which can remove water pollutants (ammonia, organic wastes) and recirculate water continuously. Larval rearing uses different salinities: 4 ppt on the 1st day, 8 ppt on the 2nd day, and 12 ppt on the 3rd day until the 22nd or 23rd day; thereafter, salinity is reduced to 8-10 ppt to facilitate metamorphosis into postlarvae. Newly hatched *Artemia* nauplii are fed at a rate of 6-50 nauplii per larvae daily. Formulated larval pellets (particle size, 200-400 μ) are fed daily in the morning at a rate of 50-250 mg/1,000 larvae on the 11th day (PL 6-7) and onwards. Daily monitoring of larval activity (feeding, metamorphosis), water quality, diseases, and condition of biological filter is carried out. Water change is done only to adjust salinity levels for the different stages of larvae. Duration of larval culture is 30-35 days. The system can give an average postlarval metamorphosis and survival of 58%.

<u>Clear water system</u>

The stocking density of larvae is 20-100 larvae/1. Rectangular or circular cement, concrete, or fiberglass tanks (2-20 t) are used. Larviculture uses clear brackishwater with initial salinity of 6 ppt which is raised by 2 ppt daily until 12 ppt is reached. Water change (50-80%) is done on alternate days or once in three days. Larval feeds used are *Artemia* nauplii, egg custard, and formulated pellets. Daily monitoring of larval culture involves observation for general activity of larvae and metamorphosis. Duration of culture is usually 30-35 days with larval survival estimated at 50-70%.

Static green water system

This system is carried out by using the green algae, *Chlorella virginica,* culture at a density of 2×10^5 - 1×10^6 cells/ml. Larvae are stocked in this green water culture at 10-50 larvae/1. Some hatcheries even claim a stocking rate of 100 larvae/1. Larval feeding and daily monitoring are generally similar to the clear water system. If the green algae culture collapses in the rearing tank, augmentation of green water from separate *Chlorella* culture tanks is necessary. Duration of culture is 30-35 days. Survival at postlarvae is 19-64%.

Problems of hatcheries

The common problems faced by hatcheries are as follows:

Water quality. Major constraints in the operation of the hatcheries are related to water quality. A number of hatcheries reports variation of salinity (below 25 ppt) levels and turbid water conditions during the monsoon months. Some hatcheries have also complained of runoffs from estates, farm wastes, and heavy metal pollution.

Diseases. Disease is another major problem. Most hatcheries lack the necessary experience in tackling disease problems.

Diseases such as ciliate, fungal, and bacterial infections are commonly encountered as a result of poor management practices, poor hygienic conditions, poor water quality, high stocking densities, and inadequate and unsuitable feeds.

Disease outbreaks cannot be completely eliminated but several measures can be taken to reduce its occurrence. The optimal environmental, nutritional, and culture conditions must be maintained at all times. The use of Treflan, a fungicide, and antibiotics such as Furazolidone and Oxytetracycline in prophylactic doses has helped minimize losses. Usually, a badly infected culture is discarded to prevent the spread of the disease and production of weak postlarvae.

Another common practice is complete dry-out of the hatchery or a break-cycle between several production cycles. This has been found to be very effective in minimizing the occurrence and severity of disease outbreaks.

Plankton culture. Plankton collapse has been faced in some hatcheries. The frequent collapse of algal cultures is due to unfavorable outdoor conditions, mainly climatic and water quality factors.

Broodstock. The inconsistent and seasonal supply of good quality spawners caught from the wild is a problem faced by many hatcheries. High prices (M$180-200) are also common.

Artificial feed. The quality of some imported artificial larval feeds is sometimes questionable. Feeds are also generally expensive.

Nursery operations. The lack of nursery facilities in most shrimp farms results in expensive hatchery space and valuable time is spent in growing the postlarvae to PL 15, PL 20, or PL 25 as most farmers require these ages for stocking their ponds.

Manpower. Generally, the newly started hatcheries face the problem of lack of experienced personnel to manage the hatchery while others complain of high staff turnover due to more attractive offers from other establishments.

Power and freshwater supply. Hatcheries in remote areas still lack electricity and water supply. In addition, operation of power generating units increases cost and causes maintenance problems. Collection of rain water is insufficient, and well water is sometimes high in iron.

Finance. Some hatcheries lack sufficient operating capital due to cash flow problems.

Marketing. The hatcheries also face an inconsistent and unstable market. This results in fluctuation of the price of postlarvae. Exporters are faced with erratic demand, lack of cargo space when needed, and poor coordination of export schedules.

The progress of the shrimp hatcheries in Malaysia has shown that the local hatchery technology is satisfactory. The freshwater prawn and shrimp grow-out industries are becoming more active because of the success of these hatcheries in producing good quality fry and their ability to meet the demand.

Some problems, however, still need to be resolved. These include the various support services provided by the Malaysian Government, particularly the Department of Fisheries, Malaysia. However, the establishment of NAPFRE, which also provides training and extension services, is a testimony to the Government's commitment to develop the shrimp industry.

The author thanks the Director-General of Fisheries, Malaysia, Y. Bhg. Dato Shahrom Bin Haji Abdul Majid, for his kind permission to present this paper at SEAFDEC/AQD in Iloilo, Philippines.

REFERENCES

Annual Fisheries Statistics. 1990. Department of Fisheries, Ministry of Agriculture, Kuala Lumpur, Malaysia.

Chan, H.H. 1988. The status of marine shrimp/prawn seed production in Malaysia. *In:* Marine prawn farming in Malaysia - present problems, future prospects. Tarlochan Singh and Ang Kok Jee (eds.). Malaysian Fisheries Society Occasional Publication No. 1.

Ong, KS., P.C. Liong, and H. Hambal. 1988. Prawn shrimp culture technology in Malaysia. Paper presented at the Seminar on Aquaculture Investment Opportunities in Sabah, Kota Kinabalu, 10-13 Aug. 1988.

Palanisamy, V. 1988. Progress and problems of freshwater prawn/marine shrimp culture with particular reference to small-scale hatcheries in Malaysia. Paper presented at the Expert Consultation On Small-Scale Prawn /Shrimp Hatcheries, Bangkok, Thailand.

Yaakob, Ahmad. 1988. Pembiakan benih udang galah, teknik intensif - sistem tertutup. Proceedings of 'Seminar Penyelidikan', 28-29 June 1988. Institut Penyelidikan Perikanan, Jabatan Perikanan, Glugor, Pulau Pinang, Malaysia.

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SHRIMP HATCHERY AND GROW-OUT OPERATIONS IN THAILAND

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Shrimp farming in Thailand has been practiced since more than 50 years ago. This began with the extensive system (traditional method) where shrimp fry are allowed to enter ponds during the high tide, and then harvested after some time. Production then was low and widely fluctuated. After the Department of Fisheries (DOF) successfully spawned and nursed the shrimp (*Penaeus*), new techniques were developed and this led to more intensive culture systems. Production of shrimp from aquaculture continuously increased - from 991 t in 1972 to 130,000 t in 1991. The estimated production for 1992 is 150,000 t.

The tiger shrimp (*Penaeus monodon*) is the most desired species due to its rapid growth (commonly grows to 30 g in 4 months in ponds) and its high export value. It is also the major species cultured especially in the intensive system. The other species are banana shrimp (*P. merguiensis*), white shrimp (*P. indicus*), and *Metapenaeus ensis.* These are normally grown in extensive and semi-intensive culture systems.

THE HATCHERY INDUSTRY

Status

Seed production techniques of *Penaeus* spp. in hatcheries were developed 15 years ago. Basically, there are two types of hatchery techniques: the big tank system which was originally developed in Japan and the small-tank system which originated from Texas, U.S.A. Both systems have their advantages and disadvantages depending on the environmental condition in each area.

Hatchery techniques normally used in Thailand are the same as the techniques used in other countries. Broodstock are collected from the wild or from ponds and ablated to induce them to spawn in captivity. Seawater used in hatcheries is clear and clean, though some chemicals such as chlorine or formalin are used. Some hatcheries mix the highly saline water from salt or *Artemia* ponds and freshwater to the desired salinity. Feeding techniques are also the same as in other countries. Phytoplankters such as *Chaetoceros* and *Skeletonema* are fed to the nauplius and zoea stages after which *Artemia* and artificial feeds are used. Chemicals and antibiotics are only applied when necessary.

Table 1. Number of private hatcheries and nurseries, by province

	1986	1987	1988
Central region			
1. Bangkok	-	1	1
2. Samut Prakan	6	-	-
3. Samut Sakhon	5	14	18
4. Samut Songkran	6	9	9
5. Phetchaburi	2	5	11
	19	29	39
Eastern region			
1. Chachoengsao	4	415	1,200
2. Chonburi	11	171	200
3. Rayong	4	10	19
4. Chanthaburi	6	3	14
	25	599	1,433
Southern region			
1. Prachuab Khirikhan	1	-	6
2. Surat Thani	1	-	15
3. Nakhon Si Thammarat	3	15	27
4. Songkhla	4	8	11
5. Krabi	-	1	1
6. Phangnga	-	3	6
7. Satun	-	2	2
8. Phuket	8	29	102
	17	58	170
Total	**61**	**686**	**1,642**

The hatcheries in Thailand can be divided into three main groups. The first includes hatcheries that produce only nauplii, located in two main parts of the country where natural broodstock of shrimp can be collected (Phuket in the south and Chonburi in the east). The nauplii are supplied to other hatcheries that nurse them until postlarval stage (PL5). The second group of hatcheries is the big group located throughout the country, especially in central Thailand (Chachengsao, Chonburi, and Supanburi provinces). The third group comprises the nurseries that grow PL 5 up to PL 15-30 or to sizes that farmers order. Most of the shrimp hatcheries are developed for the giant freshwater prawn (*Macrobrachium rosenbergii*), small-scale, and operated by families.

The Department of Fisheries has surveyed the increasing number of shrimp hatcheries: 61 in 1986; 686 in 1987; 1,642 in 1988; and 2,000 in 1992 (Table 1). Seed production is estimated at 8-20 billion postlarvae per year, enough to meet the demand of shrimp farms in the country.

Problems

The most important problems are as follows:

Lack of broodstock. Most of the hatcheries that produce the nauplii of the tiger shrimp, *Penaeus monodon,* use broodstock caught from the wild. The supply can not sometimes meet the demand. In addition, some of the broodstock are exported to other countries, forcing the government to ban export of both broodstock and seed.

Manpower. Since most hatcheries are of the backyard type, they lack technicians knowledgeable in many areas such as eyestalk ablation, hatching of *Artemia* and its application, and chemical and antibiotic application. In response to this problem, the Department of Fisheries is intensively and continuously training and extending technology to farmers. The government has also legislated the registration of all the hatcheries and grow-out ponds in operation.

THE GROW-OUT INDUSTRY

Status

Shrimp production of Thailand comes from two main sources: capture and culture.

	Production (t)		
	Capture	Culture	Total
1978	121,009	6,395	127,404
1980	110,278	8,063	118,341
1985	91,631	15,841	107,472
1990	82,494	118,227	200,721
1991	80,000	130,000	210,000

The production from capture fisheries decreases every year because of the new 200-mile economic zone and overfishing. Production from aquaculture comes mainly from tiger shrimp and banana shrimp (Table 2). In 1990, culture area was about 500,000 rai (80,000 ha) in 22 provinces along the coastline. Culture system can be divided into three:

Extensive system. Culture area is 40% of the total area. Production is low (30-60 kg/yr), and widely fluctuates because it depends on natural conditions.

Semi-intensive. Culture area is 30% of total area. This system is partly controlled like for seed, feed, or water exchange. Production is 80-200 kg/yr.

Intensive system. Culture area is 30% of total area. Most conditions during culture are controlled, and production is high - 1,000-2,000 kg/yr.

The super-intensive system is also practiced in eastern Thailand. In this system, stocking rate is more than 100 postlarvae/m^2, culture period is 4 months, and production is 2,000 t/crop.

Table 2. Shrimp and prawn production

	No. of farms	Culture area (rai)	Production (t)				
			Banana shrimp	School prawn	Tiger shrimp	Other shrimps	Total
1980	3,572	162,727	5,859	1,502	88	614	8,063
1981	3,657	171,619	7,127	2,152	25	1,424	10,728
1982	3,943	192,453	6,346	2,454	96	1,195	10,091
1983	4,327	222,107	7,835	2,417	147	1,527	11,926
1984	4,519	229,949	8,657	2,653	170	1,527	13,007
1985	4,939	254,805	10,397	3,635	106	1,703	15,841
1986	5,534	283,548	11,031	3,672	897	2,286	17,886
1987	7,221	325,929	8,843	2,703	10,544	1,476	23,566
1988	11,838	342,364	9,226	3,557	40,775	2,561	56,119
1989		486,269					90,000
1990		500,000					

Sources : Monthly review - Bangkok Bank, Vol. 30, No.11, November 1989; Thailand in figures 1990, Tera International Co.; Monthly review - Bangkok Bank, Vol. 30, No. 9, September 1989.

Marketing

The main market is Japan, USA, the EEC countries, and Singapore. The volume exported is as follows:

	Quantity (t)	Value (million Baht)
1987	28,729	21,391
1989	74,293	16,056
1990	84,691	20,444
1991	121,203	26,675
1992	110,000	28,000

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MILKFISH BREEDING PROGRAM IN THE PHILIPPINES

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The National Bangus Breeding Project (NBBP) was established in 1981 in compliance with a presidential directive. Breeding and hatchery techniques for milkfish (*Chanos chanos*) developed by the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD) are adopted. The project is a joint undertaking of the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture and SEAFDEC/AQD with the former as the lead implementing agency.

Goals and objectives

<u>Long-range</u>

- To increase milkfish fry supply in selected natural fry grounds, particularly those close to productive fishponds;
- To produce excess fry for export; and,
- To establish hatcheries in fishpond areas far from natural sources of milkfish fry.

<u>Short-range</u>

- To verify the milkfish breeding techniques developed by SEAFDEC;
- To accelerate the development of a simplified technology for propagating milkfish; and
- To test the economic viability of the milkfish breeding technology for commercial application.

Methodology

Milkfish juveniles (3-month old) are stocked and reared in brackishwater ponds or in fish pens. In addition to natural food, fish are fed supplemental feed pellets (35% protein) at 2% of their body weight. Four-year old fish are transferred to 10-m dia. floating net cages and fed crustacean feed pellets (42% protein) at 2% of their body weight. For 5-year old fish, feeding level is raised to 5% per body weight a few months before the onset of the spawning season.

Gonads of milkfish broodstock are regularly sampled. Based on the external and histological morphology of the sampled gonadal tissues, preparations for the natural spawning of the fish are made. A collector and a fine mesh (*hapa*) net cage are set up in the cages. Scale-up of natural food organisms for milkfish larvae is started in the fish hatchery of the project sites.

Naturally spawned milkfish eggs are collected and packed in plastic bags for transport to the hatchery. The total number of eggs collected and rates of fertilization and hatching are calculated. Milkfish eggs are hatched and reared to 21-day old larvae following techniques developed at SEAFDEC.

At the start of the program, 12 experimental stations were established and maintained throughout the country but two sites (Regions 2 and 8) are unsuitable because of extensive damage to cages caused by frequent typhoons. These projects were suspended. The remaining ten stations maintain broodstock that are more than 5 years old. The Aquaculture Division of BFAR with its NBBP Coordinating Team monitors, coordinates, and administers the project.

Due to the increasing cost of maintenance and operation, financial assistance from the International Development Research Centre (IDRC) of Canada was sourced in 1985. In February 1986, the grant for four NBBP sites (Regions I, III, VII, and XI) was approved covering 4 years (1986-1989). With available funding, the following were achieved: (a) rearing of market-sized fish to breeders and (b) spontaneous spawning under varying ecological conditions at different sites. With the spawning of the broodstock, hatcheries in these stations were established.

Status of operation

The status of the NBBP stations throughout the country as of June 1992 follows:

<u>REGION I</u>

Location: NBBP office - Lucap, Alaminos, Pangasinan (300 km north of Manila); maturation cages installed in Hundred Islands (30 min. by motorboat from Lucap)

Date started: 1981

Stock:

Cage	No. of stocks	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	85	9/6	4.5	Mature
2	49	8/8	4	Mature
3	50	8/8	4	Mature
	184			

Reported date of first spawning : March 1986; milkfish broodstock were reported to spontaneously spawn but limited number of milkfish fry were produced.

Hatchery facilities : Hatchery completed in 1987.

Present activities: Maintenance of three maturation cages with approximately 184 broodstock. Assessment of gonadal stage was made by

SEAFDEC/AQD staff in May 1992. Spawning occurred April 1992. Egg collection is ongoing. Hatchery activities underway but fry survival is very low. Hatchery facilities are operational and culture of natural food can be effectively done. The Fisheries Sector Program (FSP) of the Department of Agriculture is partly supporting the project in terms of feed requirement since 1991.

REGION III

Location: Office and maturation cage - Bamban, Masinloc, Zambales
Date started: 1981
Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	44	9/6	3.5	Mature

Reported date of first spawning: March 1986
Hatchery facilities : Hatchery completed in April 1988
Present activities: Forty-four broodstock are being maintained in one cage. The previous stock escaped when the cages were washed away by a typhoon in 1988. Monitoring of spawning activities is ongoing. Hatchery facilities is not fully operational. Some equipment (blower, pumps, etc.) need repair. Feed requirement is being supported by FSP.

REGION IV

Location: Maturation cages - Tiniguiban Cove, Puerto Princesa City
Date started: 1983
Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	18	9/0	5	Mature
2	30	5/0	3	Maturing
3	70	5/0	3	Maturing
4	200	4/0	2 5	Maturing
	318			

Reported date of first spawning: Spawning reported in 1989 but no record of milkfish fry production submitted.
Hatchery facilities: Hatchery completed in 1989.
Present activities : Maintenance of more than 100 mature and 200 maturing stock is ongoing. Aside from milkfish, the station is also engaged in the culture of other fishes (sea bass, siganids, mullet) and mollusc

under a searanching scheme. Hatchery facilities are existing but vital equipment to make it operational is needed.

REGION V

Location: Maturation cages - Damacan, Bacacay, Albay

Date started: 1983

Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	191	5/3	4.5	Mature
2	39	5/3	4.55	Mature
3	100	4/3	2.91	Maturing
4	77	4/3	2.91	Maturing
5	92	4/3	2.91	Maturing
6	139	2/3	1.6	Developing
	638			

Hatchery facilities: None

Present activities: Maintenance of broodstock and cages. The station also undertakes culture of sea bass and siganids, and crab fattening.

REGION VI

Location: Maturation cages - Barangkalan, Caries, Iloilo

Datestarted: November 1989

Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	13	-	4.3	Maturing

Reported date of first spawning: Since its establishment, no spawning activity was reported.

Hatchery facilities: None.

Present activities: The station is presently maintaining 13 milkfish broodstock that came from SEAFDEC/AQD. FSP supports the project for feeds and other materials. In addition to milkfish, mullets are also cultured in a separate cage.

REGION VII

Location: Maturation cage - Pangangan Is., Calape, Bohol

Datestarted: 1981

Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	16	9/10	5.26	Mature
2	17	9/10	5.26	Mature
	33			

Reported date of first spawning: Spontaneous spawning was reported in October 1986.

Hatchery facilities: Hatchery was completed in 1987.

Present activities: Two maturation cages with 33 broodstock are being maintained. Spawning is in progress. Collection of milkfish eggs is relatively high but fry survival is very low. About 1,000 7-day old fry are reared in a 5-t fiberglass tank last May 1992. Hatchery facilities are being shared by NBBP and a shrimp project.

REGION IX

Location: Maturation cages - Sangali, Zamboanga City

Date started: 1981

Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	7	5/5	4.35	Mature
2	108	4/9		Maturing
	115			

Reported date of first spawning: Since its establishment, no spawning activity was reported.

Hatchery facilities: None

Present activities: The station is maintaining two maturation cages with 115 broodstock. Some problems in support services exist. There is also a lack of technical staff.

REGION X

Location: Maturation cages - Punta Miray, Baliangao, Misamis Occidental
Date started: 1981
Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	8	8/7	4.4	Mature
2	90	5/9	3.9	Mature
	98			

Reported date of first spawning: No spawning activity was reported since its establishment.
Hatchery facilities: None.
Present activities: A total of 98 milkfish aged 5- and 8- years old are being reared in two 10-m dia. cages. Some problems in support services.

REGION XI

Location: Maturation cage - Tagabuli, Sta. Cruz, Davao del Sur
Date started: 1981
Stock:

Cage	No. of stock	Age (yr/mo)	Ave. body wt. (kg)	Gonadal stage
1	69	6/8	4	Mature

Date of reported spawning: Spawning has been reported since April 1986.
Hatchery facilities: Hatchery completed in November 1987.
Present activities: Broodstock are maintained in a 10-m dia. cage. Hatchery facilities are not operational.

Region XII

Location: Maturation cages - Parang, Maguindanao
Date started: 1981
Stock: None
Reported date of first spawning: No spawning activity reported
Hatchery facilities: None
Present activities: There is no activity in the station. Maturation cages are partly submerged because of worn-out nets and dilapidated floats. The cages are not covered. Implementation of NBBP in Region XII was greatly hampered when the project was turned over to the Autonomous Region. Several administrative problems exist.

Problems and issues

The reorganization of the Department of Agriculture in 1988 brought changes in the administration of the project. BFAR which used to be a line bureau was reduced to a staff bureau, thereby losing its administrative control over the NBBP stations. All the stations, therefore, were transferred to the respective DA Regional Offices. The set-up greatly hampered the release of funds for the stations' operations. Supplies and equipment badly needed in the stations could hardly be provided, specifically feeds. Regional allotment is often insufficient and released very late. Hatchery facilities and laboratory equipment were neglected. Repairs were not immediately instituted resulting in bigger damages. Generally, the NBBP stations including the broodstock are poorly maintained and managed.

Inspite of the above conditions, the broodstock in all the stations continued to spontaneously spawn. Some fertilized eggs were collected but the insufficient knowledge of the staff assigned in the sites and the poor hatchery facilities resulted in very low larval survival. Sale of fertilized eggs had been resorted to, especially in Region I. Private hatcheries were invited to go into larval rearing with DA, with some promising results. With this success, more private hatchery operators became interested in leasing or buying milkfish spawners.

Plans for the NBBP

The Department of Agriculture recently initiated the privatization of all NBBP stations, and the following recommendations were made by BFAR after the NBBP sites were assessed in April-June 1992:

a) Region I - Since the private sector is interested in collaborating with the regional office on larval rearing, such collaboration should be considered. Outright lease or sale of broodstock should also be allowed.

b) Region III - The primary constraint in the success of implementing the project is insufficient personnel. Lease of hatchery facilities and broodstock or outright sale of breeders is highly recommended.

c) Region IV and V - The project has technically trained and capable staff. Appropriate support from the regional office is given. Most likely, NBBP in Palawan and Albay provinces will prosper. Hatchery facilities in Region IV was established through the initiative of the regional office, though some vital equipment is lacking. Both NBBP stations reported spontaneous spawning, and there are more than 100 mature broodstock. Lease or outright sale of excess broodstock is recommended in both stations.

d) Region XII - Three maturation cages in Parang, Maguindanao are partly submerged underwater. Nets are worn-out and floats are dilapidated. This is due to very limited funding allotted by the regional office. Termination of the project is recommended.

The government through DA-BFAR and SEAFDEC/AQD are finalizing the general guidelines on the privatization of NBBP. With its enactment, prospects of the project for future development are very high.

REFERENCES

Lopez, N.A. 1987. A Progress Report on the National Bangus Breeding Program in the Philippines. I. Maturation and Spawning. Paper presented at the Fish Breeding Workshop; 7-10 April 1987; Singapore.

Lopez, N.A. and J.D. Tan. Bangus Breeding (Philippines) Annual Report (Year I), May 1987.

Lopez, N.A. and L.B. Garcia. Bangus Breeding (Philippines) Annual Report (Year II) and Final Report, May 1988 and May 1989.

Marte, CL., G.F. Quinitio, L. Ma. B., Garcia, and F.J. Lacanilao. 1984. A guide to the establishment and maintenance of milkfish broodstock. Technical Report No. II Aquaculture Department, SEAFDEC, 36 pp.

Marte, C.L. and F.J. Lacanilao. 1986. Spontaneous maturation and spawning of milkfish in floating net cages. Aquaculture 53:115-132.

Marte, CL., J. Toledo, G. Quinitio, and A. Castillo. 1986. Egg collection of naturally spawning milkfish eggs in floating cages. Paper presented at the First Asian Fisheries Forum, 25-31 May 1986; Manila.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

SEED PRODUCTION OF MARINE FISH IN MALAYSIA

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Aquaculture especially brackishwater fish culture in Malaysia has a very high potential for development. It is also a very important source of protein. The three major species cultured in cages are sea bass, grouper, and snapper. They are very popular, especially sea bass which is a highly esteemed delicacy.

Sea bass culture started in the mid-1970. The fry was obtained from the wild or imported from Thailand or Singapore. This industry developed slowly because of inadequate supply of seed. During this period also, the culturist had very little experience in managing the cages.

As an answer to the problems of the industry, the Fisheries Research Institute (FRI) of the Department of Fisheries, Ministry of Agriculture, Glugor, Penang, established a unit responsible for research on hatchery propagation, larval feed development, and cage culture of sea bass. The Brackishwater Unit of FRI situated in Gelang Patah, Johor is responsible for research and development of sea bass grow-out in coastal ponds. The Marine Finfish Production and Research Centre (MFPRC) situated in Tanjung Demong, Terengganu was set up in 1982 for marine fish fry mass production. The Extension Branch of the Department of Fisheries in Kuala Lumpur is responsible for all extension services, including promotion of sea bass aquaculture as well as other species. The Extension Branch also operates the MFPRC and organizes training on coastal aquaculture at the Brackishwater Aquaculture Centre in Johor.

The Fisheries Development Authority of Malaysia (LKIM), a government statutory body formed in 1971 with the objectives of upgrading the socioeconomic status of fishermen and developing the fisheries industry, is also involved in marine fish culture, especially in setting up commercial culture projects involving local fishermen.

In addition to government bodies, some universities in Malaysia also carry out activities related to marine fish culture, especially disease studies.

Status

Sea bass, grouper, and snapper are among the most important marine fishes cultured in Malaysia. The production of sea bass seed has been very successful while the other two are still experimental although some breakthroughs have been achieved in 1990.

Larval propagation of sea bass (based on wild broodstock) was first developed by FRI in Penang in 1982. And the first spawning of sea bass broodstock raised in captivity was achieved in July 1985.

The earlier success in sea bass propagation in Thailand has stimulated research in Malaysia. In July 1982, with the expansion of research hatchery facilities at Glugor, the first hatchery production of sea bass fry in Malaysia was achieved based on broodstock caught from water off Penang. Fry raised from this successful breeding venture are now reared to maturity in cages in Terengganu. Since July 1985, after matured fish were transferred to spawning tanks, several spawnings were obtained and millions of hatchlings and fry has been produced.

So far, three private commercial hatcheries were set up, two in Kedah and one in Johor. These hatcheries obtain their hatchlings from the MFPRC.

The LKIM also has one hatchery which supplies sea bass seed to its cage culture projects throughout the country.

Production method at MFPRC

Spawning. Spawners are usually caught from the wild or raised in cages. For the latter, fingerlings are collected from the wild or selected from a rearing run, nursed, and cultured until they mature. These rearing cages are about 30 km from the MFPRC.

The fingerlings (5-10 cm) are initially stocked in *hapa* nets at 500 pieces per *hapa* (2.5 x 2 x 1.2 m). After one month, the fry reach the size of 12-15 cm. They are then selected and stocked into another nursery cage (3 x 3 x 3 m) at 400 fish per cage for another 60-90 days. At this time, mortality rate is approximately 10%. Again, the fingerlings are transferred to a production cage (3 x 3 x 3 m) for culture to 0.8-1.0 kg size, for about a year. Selection are again made from 50% of these stock. Two years later, another 50% are selected.

The broodstock are ready to spawn at the end of their third year when their body weight reaches 3.5 kg. For male spawners, maturing age is 2-4 years and for females 3-4 years. At maturity, the fish are fed 5-10% of their body weight on alternate days.

A 150-t tank (10-m dia., 2-m deep) is used for spawning. The inside layer is painted with dark-green epoxy paint to increase the tank's resistance to water and for easier cleaning. About 30-40 spawners are selected from cages and transferred to 150-t tanks in the hatchery. The mature fish are paired 1:1 male to female. This is done visually. The males are usually smaller with a slender shape and narrow body depth. The females are bigger with soft round belly and red-pink papilla that extends to the urogenital aperture.

The salinity of water in spawning tanks ranges 28-32 ppt. The water is changed daily, approximately 80% of the total volume is drained out and clean seawater is replaced.

The spawners are fed sardine or other small fishes once a day in the morning at 2% of their body weight. The excess food which settles down at the bottom of the tank is removed by siphoning.

Prevention of diseases is done by incorporating tetracycline in the feed at

20 mg/kg body weight. Bacterial infection normally occurs as secondary infection due to scratches on the body. Formalin is commonly used at 30 ppm for the treatment of external parasites.

Live food culture

Chlorella culture

In the culture of *Chlorella,* cooled boiled seawater and sterile 2-1 flasks are used. Nutrients are provided by the following stock solutions (1-1 each are prepared):

Potassium nitrate, KNO_3	100 g
Sodium biphosphate, $NaHPO_4 .12H_2O$	10 g
Sodium EDTA complex	3 g

One ml of each stock solution is added to 1 l microalgae culture.

In mass culture, the seawater is sterilized overnight with 5 ghypochlorite/ m^3 of water and strongly aerated. Sodium thiosulphate(9g/m^3 of water) is used to neutralize residual chlorine. The following commercial grade chemicals are added to 1 m^3 of culture water as nutrients:

Ammonium sulphate	100 g
Calcium superphosphate	10 g
Urea	10 g

Rotifer culture *(Brachionus plicatilis)*

In the culture of *Brachionus,* a modified partial-harvest system is used. Two methods of culture are done at the MFPRC:

1. *Brachionus* culture using *Chlorella* - Initially, one-third of the culture tank is filled with microalgae and then inoculated with *Brachionus* at 20-30 ind/ ml. After two or three days, the microalgae is consumed and the *Brachionus* population multiplied. Additional microalgae is pumped to the tank. When the microalgae is again consumed and *Brachionus* has multiplied, a portion of the culture water is siphoned through a 60-μ mesh size screen to collect *Brachionus* for feeding to larvae. The culture is continuously maintained by pumping new microalgae to the tank. The procedure is repeated until the tank accumulates wastes at the bottom. Culture is stopped and the tank is washed and disinfected with hypochlorite.

2. *Brachionus* culture using yeast enriched with fish oil, egg yolk, and vitamins - Yeast is enriched with a solution described below before being fed to *Brachionus:*

Fish oil	500 ml
Egg yolk	3/4 pcs
Mixed vitamin	20 g

The ingredients are dissolved in freshwater to fill up 3 l. One liter of solution is used per 1 kg yeast.

One-third of the culture tank is filled with fresh seawater and *Brachionus* is inoculated at 20-30 ind/ml. Yeast is fed daily (at 0.5-1.0 g yeast per 1 million *Brachionus).* After 2 or 3 days when the population of *Brachionus* has multiplied, seawater is added to full tank capacity. When *Brachionus* population is more than 100 ind/ml, a certain portion of the culture water is siphoned through a 60-μ mesh size screen to collect *Brachionus* for feeding. The procedure is repeated until the tank bottom accumulates waste. Culture is then stopped and the tank is washed and disinfected with hypochlorite.

Larviculture

Egg collection

At Tanjung Demong Hatchery, the spawner is allowed to spawn naturally. Spawning occurs between 1900-2300 H continuously for 4-7 days around the 1st and 3rd quarter phases of the lunar cycle. Eggs are pelagic and can be collected by a seine net (mesh size, 400 μ; length, 10 m; depth, 3 m) and are then stocked in larval rearing tanks.

Incubation and hatching

Rectangular cement tanks with capacities of 10-20 t are used for incubation, hatching, and rearing. The eggs are washed with fresh seawater and stocked at 30,000-50,000/t with moderate aeration. Hatching usually occurs at about noon, 12-19 h after fertilization of eggs. Aeration in the tank is suspended for 30 min. to enable unhatched eggs and other detritus to settle on the tank bottom. These are then siphoned out.

Water exchange

The water is changed every day starting on the second day after hatching. The rate of water replacement in the rearing tank depends on the feeding of each larval stage. For instance, only 10-20% of the rearing water is drained out in the period of rotifer feeding to prevent loss of rotifers. During *Artemia* feeding, 50% of water is changed while almost complete change is made when trash fish is fed.

Feeding

The rotifer *Brachionus* is fed to 2-day old larvae until the 15th day at 5-20 ind/ml. *Artemia* nauplii are given from the 10th day until larvae reach 2.0 cm (TL). Larvae, however, are first weaned for five days by feeding small amounts of *Artemia* with *Brachionus.* Problems do not usually occur during adaptation as the large larvae tend to prey on much larger food particles.

Minced trash fish are initially given with *Artemia* nauplii when larvae reach 1.5 cm (TL). Usually, the larvae take one week to adapt to this new type of food. When the larvae totally accept the minced fish as food, feeding with *Artemia* nauplii is stopped.

Grading

Sea bass do not grow uniformly. A few show very fast growth rate and exhibit highly cannibalistic behavior, preying on small larvae. Hence, grading is necessary to reduce cannibalism. The first grading is usually done on day 14 or 15, and the subsequent gradings every 5 days.

Stocking density

The stocking density varies depending on stage or size of larvae. The stocking densities practiced at MFPRC are shown below:

Age	*No. of larvae/t*
1-14	30,000 - 50,000
15-25	5,000 -10,000
26-35	3,000 - 5,000
36-45	2,000 - 3,000

Problems

Hatcheries of marine fishes are new to Malaysia, and a lot of problems have to be solved. These include (1) availability of broodstock; (2) egg quality; (3) availability of larval food of appropriate size; (4) availability of artificial diet for fish larvae; and (5) availability of highly-skilled technicians.

REFERENCES

Ali, A. 1986. Sea bass (*Lates calcarifer*) larvae and fry production in Malaysia. Proceedings of an international workshop held at Darwin, N.T. Australia, 24-30 September 1986. ACIAR Proceedings No. 20.

Ali, A. 1986. Status of sea bass (*Lates calcarifer*) culture in Malaysia. Proceedings of an international workshop held at Darwin, N.T. Australia, 24-30 September 1986. ACIAR Proceedings No. 20.

Ali, A., S. Ramli, and A. Ahmad Fuad. 1985. Pengeluaran Benih Ikan Siakap. Risalah Perikanan Bil. 21. Jabatan Perikanan Kementerian Pertanian, Kuala Lumpur. pp 2-6.

Hussin, M.A. 1986. Sea bass (*Lates calcarifer*) cage culture research in Malaysia. Proceedings of an international workshop held at Darwin, N.T. Australia, 24-30 September 1986. ACIAR Proceedings No. 20.

Hussin, M.A. 1986. Sea bass (*Lates calcarifer*) spawning in tank in Malaysia. Proceedings of an international workshop held at Darwin, N.T. Australia, 24-30 September 1986. ACIAR Proceedings No. 20.

Ong, K.S. 1981. Aquaculture development in Malaysia in the eighties. Fisheries Extension Papers, No. 74, Fisheries Extension Services Branch, Department of Fisheries.

Ong, K.S. 1987. Development and management of aquaculture in Malaysia. Fisheries Extension Papers, No. 128, Fisheries Extension Services Branch, Department of Fisheries.

Rabanal, H.R. and Soesanto. 1982. Introduction to the taxonomy, biology and fishery of the giant seaperch or sea bass (*Lates calcarifer*). Report of training course on sea bass spawning and larval rearing, Songkhla, Thailand, 1-20 June, Manila: SCS/GEN/82/39. p. 2.

Ubaidillah, A.K. 1987. Aquaculture development and strategies and programmes. Fisheries Extension Papers, No. 131, Fisheries Extension Services Branch, Department of Fisheries.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

STATUS AND PROBLEMS OF MARINE FISH SEED PRODUCTION IN THAILAND

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Aquaculture of marine fishes such as sea bass, milkfish, and mullet among others, have been conducted in Thailand for a long time in its provinces along the coast. The fry of these fishes have been collected from natural waters and cultured for the consumption of the family. The traditional method was used in rearing these fishes - flowing seawater into earthen ponds using the bamboo stake trap as the water gate, and culturing trapped fry. Feed was usually the juveniles of other species that come with the water. Needless to say, production was very low.

Rearing marine fish in commercial scale is fairly recent, only in the last 30 years. Seed collection, transport, nursery, grow-out culture, and rearing techniques have been experimented by the Department of Fisheries since 1954 at its Prachuab Fisheries Station. The results were then disseminated to fish farmers. The species which are popularly cultured include sea bass (*Lates calcarifer*), red snapper (*Lutjanus argentimaculatus*), and grouper (*Epinephelus tauvina*).

Status of seed production

Sea bass (*Lates calcarifer*). Culture of sea bass has been initiated in Thailand for a long time by collecting the fry from natural waters particularly in the mouths of rivers, canals, and swamp/mangrove areas. However, sea bass culture at that time could not reach the commercial scale because of the uncertain quantity of fry available. In 1973, the Department of Fisheries succeeded in breeding sea bass, and since then, sea bass culture rapidly advanced. Breeding of sea bass can be conducted in three ways:

<u>Artificial breeding</u>

Normally, artificial breeding can be done during April to September by collecting live broodstock caught by fishermen. Stage of maturity of spawners are determined and the potential spawner with ripe eggs and milt are selected for stripping. Fertilized eggs are transported to the hatchery. This method is no longer popular because spawners can be taken from grow-out ponds or cages.

<u>Natural breeding in the tank</u>

By culturing sea bass fry for three years, 50-cm fish weighing 2.5-3 kg can be obtained and used as spawners. Breeding procedure begins with selection of the healthy broodstock to rear in the spawning tank. Good management of the broodstock is necessary. For example, good water quality should be maintained and food should be fresh and given at 1-2% of body weight. Normally, sea bass spawns between 7-11 p.m. of the first to the fifth day of the full moon and dark moon. About 400,000-800,000 eggs are obtained in each spawning. Fertilized eggs are collected the next morning using scoop nets of fine mesh size, and transferred to another tank to hatch. Rearing is done also in this tank. This method seems to be the most successful that the Department of Fisheries has extended to the private sector.

Induced spawning by hormone injection

The procedure of spawning is the same as the second method except that selection of broodstock to be injected to induce spawning is made. After that, the broodstock is placed in the spawning tank, following the procedure in the second method. Many types of hormone have been used, for instance, HCG (human chorionic gonadotropin), puberogen, and pituitary gland.

Nursery of sea bass fry can be divided into two phases:

Larval rearing

The water quality in the rearing tank needs special attention. Clean water (25-30 ppt) should be replaced after the wastes have been siphoned. The rate of water replacement depends on the feeding period of each stage. During rotifer feeding, only 10-20% of the water has to be changed to prevent loss of rotifers. During *Artemia* and minced fish feeding, 50 and 100% change are needed, respectively. Feeding should be constantly checked; adequate amount of suitable food must be fed to the larvae at each stage. After rearing to day 15-18 when the difference in size of larvae can be distinguished, grading should be done every 3-5 days to prevent cannibalism. Larvae can be harvested when they are 30-45 days old (1-1.5 cm). Generally, the price of this size is 2 Baht/pc.

Nursing of fry

Before transferring sea bass fry to ponds, the fry have to be nursed first until they reach 6-8 cm. This ensures better fry survival. Nylon cage (2 x 1 x 0.9 m; 0.1 mesh size) is generally used; stocking rate is 300-500 ind/cage. The fish are adequately fed finely chopped fresh fish or trash fish 2-3 times a day. To prevent disease infection, antibiotics such as tetracyclin and oxytetracyclin are mixed with the food and fed to fish every three days. Grading of fish is done every 7-10 days. The fry reaches fingerling size within 40-60 days and can now bestocked in ponds.

Grouper (*Epinephelus tauvina*). Grouper cage culture has been initiated at the Songkhla Brackishwater Fisheries Station in 1975. Fry are collected from shallow water areas, mouths of rivers, and canals. Tree branches bound together are used to aggregate 2-3 cm fish. For 100-300 g fish, traps are used. Grouper fry were found distributed in the coastal areas of Pethburi to Narathivas Province of the Gulf of Thailand and throughout the Andaman Coast.

At present, grouper is one of the most important fish cultured in cages because of its fast growth and high survival rate. The price of fish is also high.

Consequently, the area used for cage culture has been expanded especially along the Andaman Coast. Moreover, collection of grouper fry from the wild has become a minor occupation. Fry (1-2 cm) are generally sold for 1-2 Baht/pc while bigger fish (100-300 g) are sold for 30-50 Baht/pc. Market-sized grouper is expensive: 500-530 Baht/fish for 1.2-2.0 kg fish and 380-400 Baht/kg for fish outside the above size range. But the expansion in culture is not without consequences. Grouper fry catch in the wild has reportedly declined rapidly.

Breeding of grouper was first tried in 1984 at the Phuket Brackishwater Fisheries Station. Since then, attempts to improve breeding technique has been intensified to obtain sufficient seed for grow-out culture. But up to the present, the results are largely experimental.

***Red snapper* (*Lutjanus argentimaculatus*).** Red snapper is another highly valued fish. It can be cultured in brackishwater areas. Red snapper is also carnivorous like sea bass and grouper and is priced much higher than the former. As a result, many farmers have shifted to its culture. As with grouper, red snapper fry are collected from the wild and cultured in cages.

In the last ten years, breeding of red snapper has been carried out by the Rayong Marine Fisheries Station mainly to stock depleted fishing areas. The increasing demand of red snapper fry for culture is contributing to the decline of the natural stock. The Department of Fisheries has to improve the breeding technique of this fish to get a production adequate enough to supply the fish farmers and reduce dependence on natural sources.

The method of nursing red snapper fry is the same as that of sea bass and grouper. In Phangnga Marine Fisheries Station where experiments on cage culture in tin mining ponds were conducted, it was recorded that red snapper attains 299.2 to 1,125 g in 7 months. Feed conversion ratio is 4.5:1 and survival rate is 89%. Commercial culture is fairly recent and information on grow-out culture is seldom recorded.

Problems in marine fish culture

Marine fish culture in Thailand encounters problems similar to those of other countries:

Rearing ground. Cage culture has spread out to coastal areas, causing obstruction in navigation. Accidents have been reported. Furthermore, fishfarmers operate cage culture facilities along rivers, canals, bays, or coastal areas which authorities find difficult to control. To solve this problem, the Department of Fisheries began requiring permits to operate cages. The Department aims to closely monitor the areas where cages are present.

Shortage of feeds or seasonal supply of feeds. Trash fish is the most important raw material used in feed formulations. It is also utilized by the fish meal industry, canning industry, and animal feed industry, among others. Price of trash fish is, therefore, high, especially when catch is low. It is expected that the future trash fish supply will no longer be enough. In anticipation of this problem, it is recommended that collaboration between the government and the private sector to produce artificial feeds be carried out.

Water pollution. With the progress of the industrial sector, the expansion of communities along the shoreline, and the use of chemicals and new technology in agriculture, pollution of soil, water, and air has magnified. Water pollution has caused fish losses in farms in addition to those in natural bodies of water. It is recommended that concerned agencies strictly enforce anti-pollution regulations.

Shortage of capital. Capital for materials and equipment essential for cage culture is quite high, especially seeds and feeds. As such, small-scale fishermen have difficulty in sourcing funds. To solve this problem, financial institutions are urged to help fishfarmers by providing soft loans or other easy-term financial arrangements.

Discussion

The technical issues discussed by the workshop participants include:

Shrimp

- Stocking density, size of tank/tank system, feeding, and survival of larvae
- Prophylactic measures for broodstock and eggs
- Problems in nursery operations (i.e., quality of fry, facilities)
- Criteria for fry quality
- Seasonality of broodstock and fry supply
- Pricing of older larvae

Marine fish

- Milkfish spawning and subsequent appearance of fry in shores
- Advances in snapper and grouper spawning
- Species of grouper in Malaysia
- Use of *Artemia* as feed
- Anaesthetic used for milkfish
- Use of raceways for sea bass
- Fishing gears for wild fry collection
- Production of grouper in Thailand

The participants noted the following training gaps:

Shrimp

• Lack of experienced technicians especially for newly started hatcheries in Malaysia and Thailand. Areas for intensive training include eyestalk ablation, production of *Artemia,* and chemical (antibiotic) treatments.

• Thailand's representative cited frequent "piracy," e.g., high staff turnover due to more attractive offers from privately owned hatcheries.

Marine fish

• Inadequate knowledge of milkfish hatchery technicians (NBBP) as cited by the representative from the Philippines. Some NBBP sites do not have technical staff to maintain the project.

• Because hatchery of marine fishes is new in Malaysia, it does not have skilled technicians in seabass hatchery although the industry is growing.

COUNTRY REPORTS

GROW-OUT CULTURE TECHNIQUES

Two country papers were presented on the status, practices, and problems of grow-out culture.

A summary of the discussion that took place follows.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

SHRIMP GROW-OUT CULTURE TECHNIQUES IN THE PHILIPPINES

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The major commercial shrimp species in the Philippines belong to the genus *Penaeus* and *Metapenaeus.* The important penaeid shrimps are: *P. monodon* (giant tiger shrimp or *sugpo*); *P. japonicus* and *P. semisulcatus* (tiger shrimp and *bulik* or *sugpo*); and *P. merguiensis* and *P. indicus* (white shrimp and Indian white shrimp or *putian*). The giant tiger shrimp is the major species cultured in ponds while the others are incidental crops.

There are 210,000 ha of potential and existing brackishwater ponds in the Philippines (Fig. 1). Because most of these are underdeveloped, present technologies are aimed at improving production or encouraging the development of new areas.

Brackishwater fishfarming in the country is primarily centered on milkfish (*Chanos chanos*) (Table 1). Shrimp used to be merely an incidental crop when postlarvae from the wild enter the milkfish ponds. In the last decade, many traditional milkfish growers recognize the market of shrimps, primarily the giant tiger shrimp. Polyculture of milkfish and shrimp was practiced, and the fishfarmers shifted to shrimp monoculture when price of shrimp in the international market went up.

In the mid-70s, SEAFDEC/AQD developed and extended its shrimp hatchery technology, and hatcheries proliferated throughout the country. Seed supply became abundant, encouraging more people to invest in grow-out culture. However, production remained low and inconsistent since the grow-out technology remains largely an art.

When Taiwanese grow-out technology was introduced in the country and research in shrimp was intensified in the Department of Agriculture, University of the Philippines, and SEAFDEC/AQD, new coastal areas were developed particularly in Negros Island where vast tracts of sugarland and rice land were converted to shrimp ponds. Milkfish ponds were also renovated for shrimp culture.

There are four shrimp culture levels in the country, namely: traditional, extensive, semi-intensive, and intensive which vary mainly in pond design, stocking density, feeds and feeding, and water management (Table 2). Only the semi-intensive and intensive culture systems are discussed.

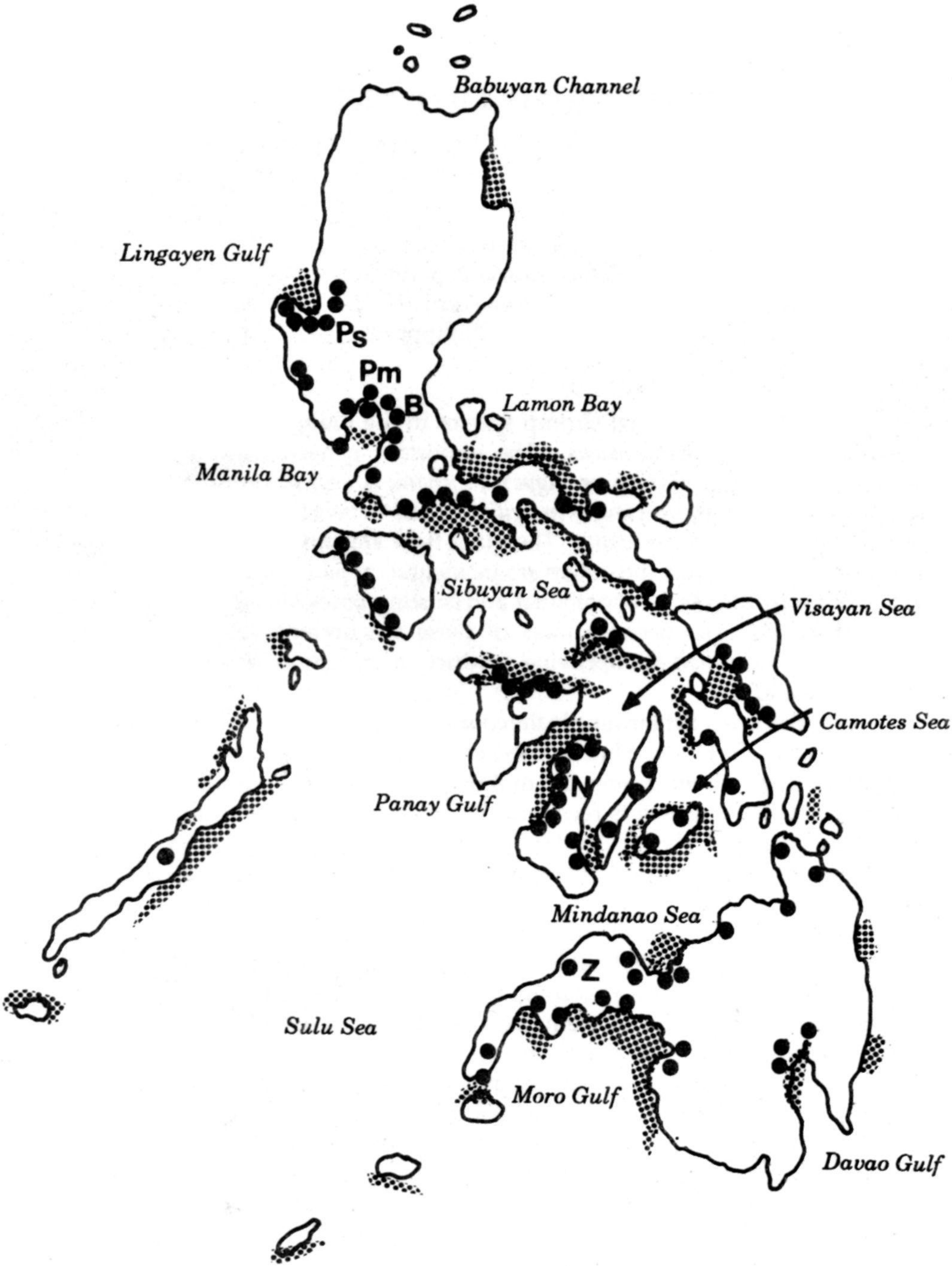

Fig. 1. The Philippines: mangrove areas (▒), fishpond areas (•), and fishing grounds. The eight provinces with the largest fishpond areas are indicated (Ps, Pangasinan; Pm, Pampanga; B, Bulacan; Q, Quezon; C, Capiz; I, Iloilo; N, Negros Occidental; and Z, Zamboanga del Sur) (Camacho and Bagarinao 1986).

Table 1. Brackishwater fishponds in operation

Region	Total area (ha)	Production (M t)*			
		Bangus	*Sugpo*	Others**	Total
NCR	703	503	56	85	644
I	16,658	16,955	3,765	5,806	26,566
II	1,469	680	19	244	943
III	53,465	49,477	12,058	11,717	73,252
IV	23,281	9,062	8,035	1,973	19,070
V	11,028	3,961	1,276	722	5,959
VI	59,074	64,959	15,699	4,143	84,801
VII	7,110	6,771	371	-	7,142
VIII	5,977	2,349	450	112	2,911
IX-A	1,540	1,293	20	53	1,366
IX-B	14,861	12,961	348	1,902	15,211
X	4,326	2,910	156	43	3,109
XI	7,248	6,012	603	1,964	8,579
XII	3,940	3,264	683	80	4,027
TOTAL	210,680	181,197	43,539	28,844	253,580

*Average national yield, 1.2036 Mt/ha/yr. **Tilapia, white shrimp, mudcrab, others. NCR, national capital region.

Table 2. Comparative features of various technology levels of shrimp culture

	Traditional	Extensive	Semi-intensive	Intensive
1. Stocking density (pc/m^2)	0.5-1.5	3.5	6.15	10 and above
2. Maximum pond size (ha)	30	1.5	1.5	0.70
3. Minimum water depth (m)	1.0	1.0	1.1	1.2
4.Aerators (/ha)	None	None	4-8 units at 1 hp	4-8 units at 1 hp
5. Feeds	Fresh diet	Commercial; fresh diets	Commercial feeds	Commercial feeds
6. Water supply	Tidal; brackish-water	Tidal; brackish-water	Pumping; fresh-, sea-brackish-water; river	Pumping; fresh-, sea-water
7. Production (Mt/ha/yr)	0.2 - 0.8	0.8 - 3.0	3.0 - 7.0	7.0 - 10.0

Semi-intensive and intensive culture

Pond preparation. The pond bottom is sun-dried for 15 days or until the pond bottom cracks and the surface turns whitish. The sluice gates are sealed to control water level and to prevent entry of unwanted organisms. Dried ooze is removed from the pond bottom by scrapping.

Ponds are plowed to further dry the pond bottom. Then, 1 t/ha of hydrated lime is applied to obtain a soil pH of 7-7.5. Note that only 50% of the required lime is initially applied, the remaining 50% after the second plowing. The second plowing is made towards the gate where the bottom is more depressed and unwanted species hide. The remaining 50% of the lime required is applied with 21-0-0 to kill crabs and other crustaceans. Teaseed powder is also applied for the same purpose two days before the pond is filled with water.

A water depth of 1 m is maintained. Dikes and gates are checked for leaks and these are immediately repaired. Salinity of incoming pond water is preferably the same as in the source of fry. Floating debris and filamentous algae are removed.

The appropriate number of paddle wheels is installed and positioned parallel to the dikes for 1-ha or bigger ponds or oblique to the dikes for smaller ponds. The number of paddle wheels installed varies with days of culture (DOC), expected survival, and average body weight (ABW):

- if survival is <80% and ABW is <35 g

DOC	*No. of units*
1-90	4
91 to harvest	6

- if survival is >80% and ABW is >35 g

DOC	*No. of units*
1 - 75	4
76 - 120	6
121 to harvest	8

Sampling of stock. Regular sampling is necessary to monitor growth and survival, indices useful in adjusting the amount of feed given to stock. Sampling is scheduled every 15 days preferably early in the morning or late afternoon. The number of shrimps in the feeding trays is an adequate estimate when shrimps are still small but cast net must be used for bigger shrimps. Different parts of the ponds must also be sampled.

Water management. Water quality should be frequently monitored. Change of pond water is usually adequate to maintain good water quality aside from helping introduce new food organisms and stimulating the molting of shrimps. If pond water remains stagnant for long, organic wastes may rapidly decompose, and depletion of oxygen may affect shrimp growth.

Tidal exchange of pond water is normally practiced in traditional shrimp farms. One half of the water is drained during low tide and replenished during rising tide, the exchange done within 5 to 7 days of the spring tide. Refertilization takes place after the last day of water replenishment.

Water pumps are used in semi-intensive and intensive cultures. For semi-intensive culture, the pump is used only during neap tide because tidal water can facilitate exchange during spring tide. About 50% of pond water is changed. For intensive culture, frequent changes are essential to reduce decomposing food and to maintain optimal oxygen level. One-third of pond water can be changed by adopting a flow-through system.

Salinity

The ideal salinity for *P. monodon* is 15-25 ppt although it can tolerate a much wider range. A refractometer is used to determine salinity before, during, and after every water change.

Dissolved oxygen

The ideal DO level for shrimp is 4-8.5 ppm. This is maintained through water replenishment and the use of paddle wheel aerators. When oxygen depletion occurs, paddle wheels are immediately operated and, if necessary, additional units are installed. Water exchange by overflow (10%) is also initiated.

Transparency and color

The ideal water transparency is 30-40 cm and this is monitored by a secchi disc. If transparency goes below 30 cm, water is changed and closely monitored for algal collapse that is usually indicated by a change in the color of water. If the latter occurs, 50% of the water is again changed. Algae, again, is allowed to grow until the later stages of culture. Greenish water though ideal is difficult to maintain, but can be done with frequent replenishment and longer paddle wheel operation.

Temperature

A depth of 1 m ensures that pond water temperature does not fluctuate much. Because the country is tropical, seasonal temperature fluctuation is small though at certain months of the year (November to early March), temperature is too cold for the shrimp (24°C). At this time, feeding is adjusted and rearing period is extended.

pH

The pH is indicative of fertility or potential productivity. Water with pH 7.5-9.0 is suitable for shrimp. Water pH below 5.0 retards shrimp growth; it can be raised by adding lime to neutralize acidity. Likewise, water of excessive alkalinity (pH 9.5) is harmful to shrimp. Ponds with abundant phytoplankton have high pH when temperature is high and low pH when temperature is low. Excessive plankton growth can be corrected by water change.

Predator control. Filters placed in water intake pipes or gates do not prevent all predators from entering the ponds. Small fishes and eggs can go through the filters and drain canals when the gates are opened during pond preparation. Predators and competitors can be seen in feeding trays or along the dikes.

Teaseed cake is the most common chemical used to eliminate fish predators. It is applied at 20-40 ppm (weight by volume) during the 45th to 50th day of culture, coinciding with the first water exchange. Shrimp at this time weighs 5 to 10 g. Teaseed cake is applied in the morning, preferably during a sunny day for best results. About 60% of the pond water is drained before teaseed is applied; the required amount of powder which was dissolved in a container overnight is broadcast around the ponds. The pond is refilled 5 h after application.

Feeds and feeding management. Feed is the largest operational cost in shrimp farming. Great attention should be taken to ensure efficient utilization of feeds, enabling shrimps to attain the desired size at the targetted time frame. It is also necessary to know the feeding habits and behavior, nutritional requirements, and feed conversion ratio of shrimp.

Generally, traditional culture is fully dependent on natural food organisms (*lab-lab, lumut,* phytoplankton, *Najas graminae, Ruppia maritima*). In semi-intensive culture, supplemental feeds (moist/wet feed, dry pelleted feeds, formulated pelletized feed with 40% protein) are given although natural food organisms remain the major source of food. In intensive culture, shrimp is completely dependent on artificial diet (Tables 3-5).

Feeding method. Feeds may be broadcast or placed in feeding trays. If feeds are broadcast in big ponds, a dugout banca is used so that feeds can be given in the middle of the pond. Feeding trays, on the other hand, are placed strategically at different parts of the pond. The trays vary in size (1-10 m^2), and they can be made of bamboo strips and polyethylene screen. Normally, there is one tray per 10 to 100 m^2 of pond area. The trays are located along the sides (usually nine of them) and the middle (six) of the pond. The number of feed monitoring trays depend on the size of the pond. For example:

Pond area	No. of trays
1 ha	6
1-2 ha	8
2-3 ha	10
3 ha	12

During feeding, 1 % of the total amount of ration is placed in each tray. The trays are inspected after every feeding to determine if the feeds have been consumed. Adjustment is then made. Feeding may be adjusted after water change, teaseed application, or when there are abnormal changes in the pond environment. Feeding trays can also be used to determine survival rate and to monitor health of shrimp.

Procurement of fry. One of the factors that ensure the success and profitability of shrimp farming is the supply of good quality postlarvae (PL). Generally, semi-intensive and intensive farming depends on hatchery bred PL while traditional farmers get 80% of their PL from the wild.

Table 3. Recommended feeding rates for *Penaeus monodon* as percent body weight per day

Average body weight (g)	Feeding rate (%)
1.5	blind feeding
1.5 -5	9.0 - 6.5
5-10	7.0 - 5.5
10 - 15	6.0 - 4.5
15 - 20	5.0 - 35
20 - 25	4.0 - 3.0
25-30	3.5 - 2.5
30-35	3.0 - 2.0
35 - up	2.5 - 1.5

Table 4. Recommended feeding frequencies for shrimp

Average body weight (g)	Feeding frequency (%)
1.5	2-3 x
1.5 - 5	4 x
5 - 10	5 x
10 - 15	5 x
15 - 20	5 x
20 - 25	5 x
25 - 30	5 x
30 - 35	5 x
35 - up	5 x

Table 5. Recommended feed ration distribution (%) for shrimp at different feeding frequencies and feeding schedules

Feeding frequency (per day)	Ration distribution (%)					
	6 am	10 am	2 pm	6 pm	10 pm	2 am
2x	40			60		
3x	30			40	30	
4x	25	15		30	30	
6x	25	10	10	10	25	20

The various devices used to collect shrimp fry from the wild are:

1. Twig - small bunches of twigs are suspended close to or placed on the bottom of shallow lagoons, estuaries, and coasts. The fry are collected during low tide by placing the scoop net under each bunch of twigs as it is lifted up.

2. Fry lure - 20-m lure lines are made of saltwater grass. These are usually set along beaches and banks of rivers. Shrimp fry is collected as it is lifted up.

3. Scoop nets - in areas where aquatic weeds are abundant, a scoop net can be used to collect shrimp fry that cling to the weeds.

4. Push or scissor nets - the nets, with or without cod ends, are used along beaches, lagoons, bays near shore, and estuaries. They are operated by hand or boat.

5. Fry trap - this stationary gear consists of a wing and a collecting chamber. The cod end of the collecting chamber is kept afloat by bamboo raft and the wing is fixed with bamboo poles against the incoming water.

6. Sagnet or *bayakos* - this stationary gear consists of a wing and a cod end with a non-return valve. It is usually 20-30 m long.

The shrimp hatchery has become an important source of fry. The advantages of hatchery-bred fry are size uniformity and its availability in bulk. Although wild fry are good for stocking, its supply is inconsistent.

Nursery operations. Generally, shrimp farmers prefer direct delivery of hatchery-bred PL to the farm. In intensive culture, PL are generally stocked directly to grow-out ponds. In traditional (and some intensive) ponds, they are stocked first in nursery ponds or cages and then transferred to grow-out ponds after 45 days.

<u>Nursery pond</u>

The size of nursery pond ranges from 500 to 2,000 m^2 with water depth of 40-70 cm. Ponds are prepared prior to stocking using standard pond preparation techniques, and stocked with 50-150 fry per m^3 depending on size of fry.

<u>Nursery cages</u>

Synthetic cages (0.3 m^3, 0.5-1 mm net mesh) supported by bamboo or wooden frames are installed. Inverted mosquito nets or *hapa* nets may also be used. The cages are kept afloat by raft or synthetic floats and set in rivers, lagoons, or within the pond itself. They are usually stocked with 1,000-2,000 fry per m^3 of water. Feeding screens similar to that used in ponds are also installed in the cages.

<u>Stocking of fry</u>

Shrimp fry are very sensitive to abrupt changes in temperature and salinity. They should be acclimated to pond conditions before being released by gradually mixing the container water with pond water. The container is kept afloat in the pond until water temperature has stabilized, and fry can be slowly released. Optimum stocking density depends on size, natural mortality, pond productivity, and culture system employed. The fry are best stocked during the coldest part of the day, i.e., early in the morning (0700 - 1000 H), late in the evening (2100 - 2400 H), or when there is incoming tide.

Problems

Several environmental and technical problems result from intensiveculture system.

Environmental problems. Less than one-third (110,000 ha) of the original mangroves are left in the country. Many important shrimps, fishes, and molluscs feed and seek shelter in the mangrove ecosystem. Deforestation as a result of mangrove conversion into ponds causes the gradual loss of critical habitats, lowering catch in natural fishing grounds including fry and brood-stock needed for aquaculture. A wide array of economic goods and services including materials for fuel and construction as well as fish and shoreline erosion control is no longer available to coastal communities.

In the 1980s, red tide predominated in some coastal areas in the country and adversely affected the mariculture industry. Demand of fishes and molluscs declined due to cases of paralytic shellfish poisoning.

Accelerated development of shrimp farms in many areas of the country, particularly in Negros Island, led to excessive extraction of ground water. Most intensive ponds mixed the freshwater with seawater to provide good quality water to cultured shrimps. As a result of this excess, the water table lowered, seawater intruded in domestic ground wells, the supply of ground water declined, and land subsided in some areas.

Site selection. The common problems of shrimp farmers regarding site selection are water supply, acid sulfate soils, typhoons and floods, and limited area for expansion. Brackishwater ponds traditionally use tidal fluctuation to supply water in higher areas. Areas reached only by extreme springtides are costly to develop. Low areas, on the other hand, will require formidable dikes. Aside from the tide, shrimp farms in many areas of the country require large volume of clean freshwater. In intensive shrimp farms, freshwater is important especially during a long dry season when salinity becomes very high due to rapid evaporation.

Acid sulfate soils are mostly found in ponds developed along dense mangrove vegetation. This is a problem especially during the first few years of operation. Acid sulfate results from the accumulation of pyrites (iron sulfides) in coastal soil. Since breakdown of pyrites is minimal in submerged soil, ponds often have low productivity and mass kills sometimes occur.

Typhoons and floods are common problems faced by farmers in northern Philippines. Most shrimp farms are in the flood plains and some are constructed within the typhoon belt especially farms in the Pacific side. Frequently flooded shrimp farms bring risk to life and property. Often, this is a result of poor planning and environmental impact assessment. This problem can be minimized with proper site selection.

Shrimp farmers are unable to expand their farms because of government regulation prohibiting conversion of mangrove areas to fishponds. Some areas, however, have underutilized ponds which can be developed.

Design and construction. Most of the existing shrimp farms in the country are converted from milkfish farms. It is difficult to adopt more recent innovations of pond lay out such as those used in Taiwan or other countries due to the high cost of development. Farmlands in Negros (central Philippines) that were converted to shrimp farms (10 ha or more) are difficult to manage. Only a few shrimp ponds continue to operate.

Despite the proliferation of engineering firms, several mistakes are still being committed in pond design. Proper drainage and strict separation of supply and drainage canals are still not given adequate consideration. Also, most fishfarms have their gates built close to the river without provision for strong water current and eventual sedimentation.

Pests and diseases. Intensification faces serious disease and parasite problems because ponds usually create conditions conducive to disease outbreaks. Once an outbreak occurs, treatment maybe too expensive for large-scale application. In shrimp, common diseases are caused by virus, bacteria, fungi, and protozoa. Some are caused by chemical agents.

Others. Some farmers claim that financing is a major constraint in shrimp intensification. Site development, equipment, and other support facilities require major capital investment. Capital is also needed particularly for the purchase of supplemental feeds which comprise about 50-60% of the operational cost. When a lot of capital is involved, the problem is compounded because financing assistance requires high collateral and high interest rate. Government development banks require collaterals and the banking institutions do not grant loans to fish pond lease agreement (FLA) land holders. Shrimp growers also complain of high cost of inputs, like fertilizers, pesticides, chemicals, and feeds which increase more rapidly than the market price of produce.

There are also social problems affecting the shrimp industry. One is the monopoly by big businessmen who often have joint ventures with foreign investors. The difficulty of FLA holders to secure loans breeds discontent. Another is displacement of labor as the daily subsistence of small-scale fishermen and some agricultural workers is endangered by intensification. Since intensive shrimp ponds depend on hatchery-bred fry, only a few benefit from employment. In traditional and extensive farms, many fry gatherers are benefitted. Furthermore, a number of sugarland and overland workers or farmers are being displaced, since the conversion of agricultural lands for shrimp culture now requires only three maintenance workers for every 5 ha in contrast to sugarland farms that need 8-10 laborers.

REFERENCES

Abesamis, G. Jr. 1989. Philippine shrimp grow-out practices. p. 98-101. *In:* Akiyama (ed.). Proceedings of the Southeast Asian Shrimp Farmer Management Workshop; July 26-Aug. 11; Indonesia and Thailand.

Abesamis, S. and N.R. Rabanal. 1987. The shrimp industry in Luzon, Philippines. *In:* Compilation of Conference Papers. Vol. 111. National Conference on Fishery Policy and Planning; 16-20 Mar.; Baguio City, Philippines.

Apud, F.D. 1989. Recent development in prawn pond culture. p. 39-65. SEAFDEC Aquaculture Extension Pamphlet No. 1.

Camacho, A.S. and T. Bagarinao. 1986. Impact of fishpond development on the mangrove ecosystem in the Philippines. In: Mangroves of Asia and the Pacific: status and management. Tech. Rep. UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the Pacific (RAS/79/002).

Cruz, P.S. 1991. Shrimp feeding management: principles and practices. Davao City: Kabukiran Enterprises, Inc. p. 2-19.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

AQUACULTURE DEVELOPMENT IN MALAYSIA IN THE 1990s

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Aquaculture is still at an early stage of development in Malaysia. In 1991, for example, Malaysia's total aquaculture production amounted to only 64,344 t, while the overall fish production for the year totalled 976,272 t.

In recent years, however, there have been significant aquaculture expansion and development in the country. This was fueled not only by the declining catch rates in coastal and inland fisheries but also by the technical advances in aquaculture. There is still considerable potential for further development and production is expected to increase steadily for all the cultured species. With concerted efforts by the public and private sectors, aquaculture could contribute an annual production of more than 200,000 t by year 2000.

Existing aquaculture practices

There are several successful aquaculture systems in the country. These include:

- Cockle culture on coastal mudflats
- Freshwater fish culture in ponds and cages
- Freshwater prawn culture in ponds
- Penaeid or marine shrimp culture in brackishwater ponds
- Crab culture or fattening in brackishwater ponds
- Culture of marine fishes in brackishwater ponds and cages
- Mussel and oyster culture

Cockle culture. Cockle culture started in 1948 and has since developed into the most important aquaculture industry in Malaysia. The culture is, however, only semi-intensive as seed cockles are collected from natural spatfall areas and not hatchery-produced. The Fisheries Research Institute in Glugor, Penang has succeeded in the spawning and larval rearing of the cockle though large-scale (commercial) production of seed is still to be developed. So far, the supply of natural seed has been able to sustain culture operations, and the collection of seed is facilitated by the occurrence of a definite breeding season. Hence, spatfall in certain areas is definite.

Cockle thrive well on coastal mudflats with salinities of 18-30 ppt. They are sedentary and feed directly on the natural food abundant in the intertidal

Table 1. Cockle production and total marine landings

Year	Total marine landings (t)	Cockle production (t)
1991	911,933	46,625
1990	951,307	35,931
1989	882,492	39,346
1988	825,631	34,867

zone, and hence, require very little effort when cultured. The key factors in culture are (1) selection of suitable site (soil and water conditions) and (2) proper sowing and distribution of seed on culture beds. Extensive studies carried out on the growth of cockle have shown that maximum yield is obtained when they are harvested after a 1-yr growing period.

Cockle culture in Malaysia continues to be a viable industry although there has been no significant increase in production in recent years. In fact, there are indications that cockle production has declined with respect to the total marine fish landings (Table 1).

In view of the increasing consumer concern over mollusc sanitation - high faecal coliform counts frequently occur in samples of cockles from some selected localities - and the sanitary standards imposed on bivalve imports by many countries, the Fisheries Research Institute established in 1986 a depuration system for cockle. Purification to the required levels (<20 FC-MPN/g) could be achieved within 36 h even with highly contaminated cockle (1,260 FC-MPN/g).

Freshwater fish culture in ponds. Freshwater fish culture in Malaysia started more than 60 years ago. Progress was, however, slow in the early years, and significant expansion of freshwater fish culture only took place in the 1960s. The total number of freshwater ponds in the country in 1991 was 29,817 with a total area of 4,860 ha (excluding 644 ha of ex-mining pools).

Many species of freshwater fish are being cultured. These include the Chinese carps like the bighead (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*), and common carp (*Cyprinus carpio*); Indonesian carp (*Puntius gonionotus*); rohu (*Labeo rohita*); Nile tilapia (*Oreochromis niloticus*); sultan fish (*Trichogaster pectoralis*); jelawa (*Leptobarbus hoeveni*); patin (*Pangusias sutchi*); ketutu (*Oxyeleotris marmoratus*); and kalui (*Osphronemus goramy*). Although some of the freshwater species (ketutu, patin, and tilapia) are monocultured, most are grown under polyculture, with the ponds stocked with a suitable combination of different fish species which occupy different ecological niches. Polyculture fully utilizes the three-dimensional growing space and the diverse food organisms in the pond.

In a typical polyculture, the fish species stocked usually include the silver carp and the bighead carp which live in the upper and middle layers and feed on the phytoplankton and zooplankton in the pond, respectively; the grass carp and the Indonesian carp which live in the middle layer and feed on larger aquatic plants (macrophytes); and the common carp which lives close to the pond bottom and feeds mainly on bottom-living organisms. Small number of carnivorous fish species can also be included to feed on the small fishes and shrimps that constitute the nekton of the pond ecosystem. However, the majority of the fish stocked in polyculture are plankton-feeders and herbivores. Primary production can be easily boosted by increasing pond fertility, often through organic (animal manure) fertilization. Hence, polyculture is often integrated with animal husbandry as the manure can be used to enrich the pond, and other agriculture crops, e.g., tapioca leaves, can be fed to the grass carp. The pond bottom accumulates rich organic matter which can be excavated and used to fertilize land crops.

The tilapias, very popular fish in some countries, are still not greatly demanded in Malaysia. There is, however, a growing interest in Nile tilapia; this species has a better appearance and market potential than the more common *O. mossambicus.* The main problem with tilapia is that it breeds readily unlike other freshwater fishes. It is also smaller. As a result, small-sized tilapias compete with each other as well as other fishes for food and space. Inclusion of carnivorous fish such as the giant sea perch (*Lates calcarifer*) checks tilapia population and increases harvest value.

Many of the polyculture ponds show very good growth and survival rates, and yields of more than 3 t per ha per year have been reported.

The seed supply of freshwater fish is comparatively easy to obtain as breeding techniques have been developed, although fry of some species are imported. The bighead carp, common carp, Indonesian carp, sepat siam, temakang, and kalui are bred at the Department of Fisheries stations set up in different parts of the country. Their fry are distributed free to fishfarmers. Only the fry of the Chinese major carps, particularly grass carp, are imported. The Freshwater Fisheries Research Centre at Batu Berendam, Malacca has succeeded in spawning the grass carp, rohu, catla, and ikan jelawat. While freshwater fish culture in ponds is predominantly polyculture, monoculture of some fishes, e.g., ikan ketutu, is also practiced but only in small scale. In monoculture, the fish normally do not depend on the pond's natural food. In the case of ikan ketutu, low-grade fish and cockle are fed, and although the feeding cost and labor are quite high, these are offset by its high price in the market. The fish can be artificially bred but because the fry grow slowly, mass propagation is not yet possible. Fry are instead collected from the wild, i.e., old mining pools.

Freshwater fish and prawn culture in ponds. Freshwater ponds that are used for polyculture and without predatory fish (such as snakehead or ikan haruan, catfish or baung dan keli) are suitable for udang galah (giant prawn, *Macrobrachium rosenbergii*) culture. The udang galah has many attributes that make it a very desirable species for culture, primarily its fast growth rate. It is also omnivorous, feeding on vegetable matter or commercially available chicken feeds, among others. It breeds readily in captivity and broodstock is easy to obtain. However, both its larval development and grow-out periods are considerably longer than that of the marine shrimp, and although it has a high market value, its export potential is not as large as shrimp. Male prawn usually grow faster than the females, and in view of the prawn's territorial behavior, it cannot be cultured intensively.

In grow-out culture, udang galah is usually stocked at 5,000-10,000 juveniles per ha in combination with 750-1,000 fish (the plankton feeders, big-head and silver carp; and the herbivores, grass carp and lampan jaya). The bottom-living common carp is excluded as this competes with the prawn. Survival of prawn ranges 50-90%. Polyculture of udang galah with fish has advantages over intensive culture of udang galah like lower feed costs and lower volume of water required. More recently, monoculture of udang galah has been carried out, and stocking densities range 2-15 juveniles/m^2. The prawn are fed commercial formulated feed. Water quality is maintained by regular exchange, i.e., pumping of water, and by the use of paddle wheels. The prawn are partially harvested or culled after 4 months. Average yield is 1 t/ha/ cycle.

Freshwater fish culture in cages. There are many large impoundments or bodies of water where fish pens, enclosures, or cages can be set up. In 1991, about 60% of the freshwater cage farming was carried out in Selangor, Perak, and Malacca. The red tilapia is by far the most important species cultured in cages, accounting for 60% of the total production (573.97 t) in 1991. Other species cultured include the lampam jawa, grass carp, and ikan jelawat. Cage culture of tilapia is also advantageous in that tilapia are prevented from multiplying. In impoundments where phytoplankton and zooplankton are abundant, plankton-feeders like the silver carp, bighead carp, and rohu can be cultured without feeding; the fish filter off the plankton at the same time improving the clarity of the water. Culture of other species such as ikan patin can also be developed as mass fry production has already been achieved in the Freshwater Fisheries Research Centre in Batu Berendam, Malacca. The hatchery technique can be extended to fish breeders.

Penaeid or marine shrimp culture in brackishwater ponds. The culture of marine or penaeid shrimps in ponds built in coastal low-lying areas is mostly carried out in the southern part of Johor. These shrimp ponds are fairly extensive and large sluice gates allow juveniles to enter the ponds with the tidal inflow. Shrimp are fed chicken feed pellets. Market-sized shrimp are harvested in bagnets placed in sluice gates during tidal outflow. Included in the harvest are large shrimps such as *Penaeus merguiensis* and *P. indicus* which fetch very good prices. However, the bulk of the harvest consists of medium-sized, immature shrimps, mainly *Metapenaeus ensis.*

Teaseed cake is occasionally used to selectively kill fish predators and competitors. However, harvest is inconsistent as this system depends solely on natural stocking. The operation is confined to areas where shrimp seeds are abundant.

There has been growing interest in the development of more modern systems of shrimp farming in Malaysia. More hatcheries are set up and more well-designed brackishwater ponds are constructed. At the Fisheries Research Institute at Glugor, Penang several species of marine shrimps, including the giant tiger shrimp (*Penaeus monodon*) and the banana shrimp (*Penaeus merguiensis*), have been reared to sizes suitable for pond culture since 1969. Improvements in hatchery design and operations have been incorporated in the designs of private hatcheries, including that of the National Prawn Fry Production and Research Centre in Kampung Pulau Sayak, Kedah.

Shrimp postlarvae from the Fisheries Research Institute and the National Prawn Fry Production and Research Centre have been used in grow-out research at the Brackishwater Aquaculture Research Centre (of the Fisheries Research Institute, Department of Fisheries, Malaysia) in Gelang Patah, Johor. Recent experiments in pond culture produced approximately 8 t of shrimp per ha every 3-4 months of culture. This considerable experience and other advances have fueled optimism that marine shrimp farming can become a major aquaculture industry in Malaysia. The private sector has been expanding, the price in export markets is good, and the general conditions of shrimp culture in the country is favorable.

Of the many species of marine shrimps, the giant tiger shrimp is preferred as it is hardy, fast-growing, and highly priced. Adults used in hatchery operations are mainly caught by trawlers. The unilateral eyestalk ablation technique in induced spawning has enabled many hatcheries to use even non-gravid adult shrimps. In the future, it is likely that gravid females will be produced from pond-raised broodstock.

Large-scale commercial culture of marine shrimps depends, to a large extent, on suitable and cost-effective feeds, as feeds often constitute more than half of the variable costs in aquaculture production. The Brackishwater Aquaculture Research Centre at Gelang Patah has recently developed several shrimp feeds. Also, many local or imported commercial shrimp feeds are readily available. The steady supply and constantly improving quality contribute to the rapid development of shrimp culture in the country.

Crab culture or fattening in brackishwater ponds. The mangrove swimming-crab or ketam batu (*Scylla serrata*) is very hardy. It can live in a wide range of salinity and even remain out of water for long periods. The crab has a very high market value and supply from the wild has declined due to indiscriminate fishing. The growing interest in crab culture, therefore, is no surprise.

At present, brackishwater ponds in Johor and other places are into the culture or fattening of the mangrove crab. Small to medium-sized and even large but "thin" crabs, which have low market value, are stocked in ponds. The crabs are fed trash or low-grade fish. After two months, the crabs are already marketable with the females having well-developed gonads. They sell at a considerably higher price. Cages are also used for fattening crabs. The crabs must be well fed to reduce cannibalism.

The mangrove crab has been artificially propagated at the Fisheries Research Institute at Glugor, Penang but the production of young crabs was very low, mainly due to cannibalism and lack of hatchery facilities. Further research on crab seed production and culture is being carried out at the National Prawn Fry Production and Research Centre that has better facilities. Sufficient number of young crabs have been produced during the first few months, and this has supplied the pond culture trials which were participated in by fisherfolk. A considerable number of young crabs are also used for coastal ranching. With further improvements in technology, it is likely that hatchery-produced young crabs will provide increasingly large quantities of seedstock for crab farming in the country.

Culture of coastal fishes in brackishwater ponds. Pond culture of coastal fishes is a very recent development in Malaysia. It is carried out in only a few areas (Kedah, Penang, Johor). The species cultured are ikan siakap (giant sea perch, *hates calcarifer*) and ikan kerapu (grouper, *Epinephelus suillus/E. malabaricus/E. tauvina*) based on young fish collected from the wild, though some fry of siakap are imported from Thailand. Both siakap and kerapu are carnivorous, feeding on trash or low-grade fish. Their high market price makes culture profitable. Both fish can withstand low salinities, and siakap can even be raised in freshwater. However, siakap is not as tolerant to handling as kerapu although it is quite hardy and fast growing. Its growth is often uneven among individuals in a single population.

The supply of siakap and kerapu fry, collected from the wild, is inadequate to sustain large-scale culture. Being carnivores, they occupy the top of the food chain and biological pyramid of numbers; hence, it is unlikely that very large numbers of their fry can be collected from the wild. In 1982, the Department of Fisheries began producing siakap fry in their hatcheries and by 1986, the hatchery-raised siakap which were transferred to cages had matured. They provided the broodstock for spawning and breeding of siakap at the Coastal Finfish Hatchery Centre at Terengganu. While larviculture and nursery operations of siakap can still be improved, the Department of Fisheries has already provided training and extension services in siakap culture. The Department of Fisheries also successfully propagated the grouper and the snapper at the Tanjung Demong Coastal Finfish Hatchery Centre. Although spawning has been consistently achieved and larvae produced by the millions, seed supply is still low; further research and development is required before artificial propagation of these species can be carried out on a big scale.

Research on the culture of coastal fishes especially giant sea perch in brackishwater ponds is undertaken at the Brackishwater Aquaculture Research Centre of the Fisheries Research Institute in Gelang Patah, Johor. Suitable artificial feeds have been developed for siakap culture as well as a practical raceway system for nursing the fry.

Culture of coastal fishes in cages. Culture of coastal fishes in cages suspended from floating rafts anchored in sheltered inshore areas is carried out mainly in Penang, Selangor, and Johor. The species cultured are the carnivorous ikan siakap and ikan kerapu. Trash or low-grade fish is fed but suitable pellet feeds are likely to be used in the future.

Cages and floating rafts are not as expensive as brackishwater ponds. Also, the number and relatively small size (approximately 3 x 3 x 2 m) of the cages allow for easy separation and maintenance of fish according to body size. The small size also facilitates maintenance of the cage itself.

***Culture of mussel* (*kupang/suput,Perna viridis*).** The Fisheries Research Institute has successfully conducted research on mussel culture, and the Strait of Johor has been found to have a great potential for mussel culture. An increasing number of fishermen are now going into mussel culture.

Mussel culture can be carried out by setting up rafts in suitable areas and suspending ropes from these rafts. Mussel settle on the ropes and they are harvested once the market size is reached. In areas where the currents are too strong for the raft method, the stake method may be used. Mussel efficiently filter microscopic plants (phytoplankton) from the moving water, and reach marketable size (70 mm) in 5 months. (European mussels are cultured for 2 years.) They are also among the hardiest and most easily gathered organisms, and mussel culture is the most productive form of saltwater aquaculture. Mussel culture is now already well developed in France, Italy, Philippines, and Thailand, and is considered to have very good potential in Malaysia.

The Fisheries Research Institute has recently introduced mussel culture to other parts of Malaysia by transplanting mussel spats collected in Johor Strait to other coastal areas. Various localities including Malacca, Pulau Ketam (Selangor), Lekir/Pangkor (Perak), Batu Maung and Pulau Aman (Penang), and Pulau Langkawi (Kedah) have been found to be suitable for mussel culture.

Oyster culture. Recent advances in oyster culture have further encouraged its development. In the Muar River, shells thrown into the river serve as collectors and growing substrates of spat oyster. This culture system is known as on-bottom culture. In Sabah and Sarawak, attempts were made to develop the raft and rack methods for oyster culture, but while oyster (*Crassostrea belcheri*) culture for food has not taken off, the commercial culture of pearl-oyster (*Pinctada* sp.) for pearl production has become established. The Fisheries Research Institute at Glugor continues to carry out research on oyster culture, testing various types of collectors and culture methods in different parts of the country. Earlier work carried out in Pulau Langkawi has shown that *Ostrea colium* may have culture potential. In 1988, the institute in collaboration with the Bay of Bengal Programme for Fisheries Development succeeded in the spat collection, transplantation, and culture of *Crassostrea iredalei* and *C. belcheri* in several areas, particularly Sungai Mercang and Kuala Setiu (Terengganu), Batu Lintang (Kedah), and Kg. Telaga Nenas and Kg. Telok (Perak). Since both species command a good price at seafood restaurants and leading hotels, the development of oyster culture in Malaysia is receiving increasing attention especially spat production, culture techniques, and marketing. Malaysia also imports some 250 t of dried oysters a year.

Promoting aquaculture development

The Department of Fisheries of the Ministry of Agriculture has two main functions in promoting aquaculture in the country: (1) research and development and (2) extension services. Both are largely directed at overcoming the constraints encountered in aquaculture, particularly the scarcity of fry especially of the species for which controlled breeding techniques have only been recently or are still being developed. The Department also addresses the inadequacy of skilled manpower and lack of facilities especially for fry production, the lack of capital or financing available to the rural and coastal poor, and the threat of aquatic pollution.

Aquaculture research is carried out at the Fisheries Research Institute with its headquarters situated in Glugor, Penang; its branches are located in

Batu Berendam, Malacca (Freshwater Fisheries Research Centre); Gelang Patah, Johor (Brackishwater Aquaculture Research Centre); Kampung Pulau Sayak, Kedah (National Prawn Fry Production and Research Centre); and Tanjung Demong, Terengganu (Marine Finfish Fry Production Centre). Major research findings in Glugor pertain to the biology and culture of the cockle, mussel, oyster, the giant sea perch, the udang galah or giant Malaysia prawn, and the marine shrimps. Research on freshwater aquaculture is carried out at Batu Berendam, Malacca where successful induced breeding techniques have been developed for various freshwater species including bighead carp, jelawat, rohu, catla, tilapia merah, patin, and keli. At Gelang Patah, pond grow-out systems are developed for marine shrimps especially giant tiger shrimp (*Penaeus monodon*), and for coastal fishes, especially siakap. At the Kampung Lulau Sayak Centre, research is focused on shrimp fry production, including studies on captive broodstock and suitable feeds for both hatchery and nursery operations. Training courses on shrimp hatchery technology and coastal aquaculture are held at this center. Research and training in the artificial propagation of coastal fishes (*Lates calcarifer, Epinephelus* spp., and *Lutjanus* spp.) are conducted at the Marine Finfish Production Centre in Tanjung Demong, Terengganu.

The Department of Fisheries extends technology through its Extension and Training Division and the Fisheries Offices in the various states/regions/districts/stations. Extension activities include advisory and information service, demonstration and training, and supply of fry. The advisory and information service facilitates the dissemination of information from research and other sources to the industry, and is achieved through publications, audio-visual aids, and the mobile unit. Demonstrations and training are conducted at the Department's stations and centers as well as established farms. Fish and shrimp fry are being produced at the Breeding Stations situated in various parts of the country especially for distribution to small-scale aquaculturists. Relevant training courses in seed production are given to fishfarmers and private individuals to facilitate the setting up of more private hatcheries/breeding stations and for the production of fish/shrimp fry to help meet increasing demand.

To ensure the smooth development of aquaculture in the country, rules and regulations governing aquaculture have also been made. The law governing fisheries in Malaysia is contained in the Fisheries Act of 1985. Included in this law is the Fisheries (Marine Culture System) Regulation that covers rack and pole culture, raft culture, cage and pen culture, and on-bottom culture systems. Besides these regulations, the Government has also introduced various incentives for the development of aquaculture in the country. These incentives include pioneer status, investment tax credit, and export incentives.

Discussion

The technical issues discussed by the workshop participants include:

- English and common names for some species that can be polycultured with tiger shrimp
- Pollution problem in cockle and oyster culture
- Stocking density of shrimp
- Lack of a standard pond management technique

The representative from Malaysia noted that their extension services are largely directed to commodities that have only been recently developed, and skilled manpower is generally lacking.

COUNTRY REPORTS

FISH DISEASES

Two country papers were presented on the status and problems of fish diseases.

A summary of the discussion that took place follows.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

FISH DISEASES IN MALAYSIA: STATUS AND PROBLEMS

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Aquaculture is still at an early stage of development in Malaysia; however, it has expanded quite rapidly over the past decade or so. Under the National Agriculture Policy, aquaculture development has been given high priority and entrepreneurs are given various incentives and support services.

The technologies of various aquaculture systems in Malaysia are already well developed. Many farms adopt intensive culture system and where inadequate fish seed is a constraint, importation from neighboring countries supports culture. It is in the intensive culture system, both in the hatchery and grow-out phases, that diseases often occur. Diseases have resulted in significant economic loss to fish and shrimp farmers.

The study of fish parasites has been carried out for sometime but it dealt mainly with taxonomy. The systematic study of fish disease and its documentation are comparatively new. At present, three institutions are involved in fish disease research: Fisheries Research Institute under the Department of Fisheries, Agriculture University of Malaysia, and Science University of Malaysia.

Disease prevention and control

Fishes. The major diseases associated with fish culture are protozoan and bacterial diseases. Other pathogens which play important roles in disease outbreaks are fungi and metazoan parasites.

The most prevalent protozoan diseases are caused by *Ichthyophthirius multifilis* in freshwater and *Cryptocaryon irritans* in marine environments (Wong and Leong 1987). From 1985 to 1987, a government freshwater hatchery at Tapah, Perak faced these problems during the rainy season at the end of each year. The protozoans mainly affected the walking catfish, *Puntius gonionotus;* other species remained free of the infection. *C. irritans* was reported to cause high mortality in sea bass hatchery (M. Nawawi, pers. comm.) and occasionally, there were reports of the occurrence of this disease in grow-out ponds and cages.

Trichodinasis is found in both freshwater and marine environments (primarily in groupers) but so far, there is no major outbreak reported. Two common myxosporidians found in freshwater fishes are *Myxobolus* and *Henneguya* sp. (Shariff 1984). *Myxobolus* is more prevalent, causing high mortality. To date, there is no recommended treatment.

Other protozoans which affect fish culture are *Chilodonella* spp., *Ichthyobodo* spp., *Epistylis* spp., *Piscinoodinium* spp., and *Zoothamnium* spp. However, very little or no information is available on the prevalence, intensities, or distribution of these protozoans.

The most common bacterial diseases are caused by *Aeromonas hydrophila, Flexibacter, Pseudomonas,* and *Edwardsiella* sp. for freshwater fishes (Siti Zahrah 1992) and *Vibrio* spp. for marine fishes (Leong 1989; Leongand Wong 1992). Sea bass fry cultured in cages suffer heavily from fin and tail rots. In grouper, vibriosis occurs throughout the hatchery and grow-out phases. Use of antibiotics has been attempted in hatcheries but it has not been tested in ponds.

A fish louse, *Argulus* sp., is found both in marine and freshwater environments. Affected fish are thin with hemorrhagic areas on their bodies. Infection on small fish often causes mortality. Other common parasitic copepods are *Lernaea* spp. in freshwater (Shariff 1984) and *Lenanthropus* spp. in marine environment. Dipterex is effective in treating crustacean diseases (Chong and Chao 1986; Fauzidah and Rajamanikam 1992).

Sea bass fry was reported to be very prone to infection by a monogenean *Diplectanum* sp. *Dactylogyrus* sp. is occasionally seen in marine environment but it was more prevalent in freshwater fishes particularly the fry of Chinese carps that are 10-20 cm. Short baths of formalin (0.1 ppm) are used to treat the infected fish (Chong and Chao 1986; Fauzidah and Rajamanikam 1992).

Marine shrimps. Marine shrimp culture is a fast expanding industry in Malaysia and much effort has been geared towards the improvement of culture and hatchery technology. However, the disease aspects of culture have hardly been given proper attention. Information on shrimp disease is very limited, confined mostly to the work of few government researchers (Department of Fisheries and Agriculture University).

Vibrio spp. are the major cause of bacterial diseases such as necrosis and septicaemia (Anderson 1988; Palanisamy 1990) in hatcheries. In the pond, systematic bacterial condition also occurs in juvenile and adult marine shrimp. Affected ponds have low-level, continuous mortalities which begin as the shrimp approach market size. Liming is carried out routinely before each crop to disinfect ponds.

A non-infectious filamentous bacteria, *Leucothrix mucor,* usually causes secondary infection in *Penaeus monodon* postlarvae affected by *Penaeus monodon* baculovirus. Larvae can die overnight (Anderson 1988). Most hatcheries use antibiotics to control bacterial diseases. *Leucothrix mucor* has also been observed frequently in *Macrobrachium rosenbergii* larvae (Suhairi et al. 1983).

Infestation by ciliates such as *Zoothamnium* spp., *Epistylis* spp., and *Vorticella* spp. is a common problem in Malaysian marine shrimp hatcheries. Some hatcheries have problems with an unidentified ciliate that causes similar symptoms (Anderson 1988). *Vorticella* and *Zoothamnium* have been observed frequently on the larvae of *M. rosenbergii* at NAPFRE, Kedah (NAPFRE, pers. comm.).

Rickettsia (an obligate intracellular parasite) has caused serious disease problem in two Johore shrimp farms (Anderson 1988). Only *P. monodon* was affected with mortalities reaching 90-95%. Chemotherapy and change in pond management had no effect. At present, the only action considered is changing the cultured species.

Fungal diseases encountered in Malaysian marine shrimp hatcheries are mainly caused by *Lagenidium* and *Sirolpidium.* Protozoeal and mysis stages are most susceptible. Fungal diseases have caused serious mortality in several hatcheries (Anderson 1988) including that for *Macrobrachium rosenbergii.* The fungi isolated include *Penicillum* spp., *Pullularia* spp. and *Aspergillus* spp. (Shariff et al. 1978).

Three types of virus have been identified: MBV (monodon baculovirus), IHHNV (infectious hypodermal and haematopoietic necrosis virus), and HPV (hepatopancreatic parvo-like virus). MBV is considered endemic to all Malaysian marine shrimp hatcheries and farms but prevalence and infection intensity are low. HPV lesion or disease has not been observed in marine shrimps but recently, HPV-like hepatopancreatic changes were found in *M. rosenbergii* postlarvae. IHHNV has been observed in *P. monodon* juveniles from farms in Sabah but it is not significant in terms of shrimp health. The actual distribution and importance of IHHNV in Malaysia is still unknown (Anderson 1988).

Many farms in Malaysia have reported the occurrence of soft-shell disease (Anderson 1988; Fauzidah and Rajamanikam 1992). The recommendations for its prevention in ponds include addition of extra calcium in pond water, increasing water exchange, and improvement in feeding levels and quality of feed given.

Molluscs. The main species of molluscs cultured in Malaysia are cockle (*Anadara granosa*), green mussel (*Perna viridis*), and oyster (*Crassostrea belcheri*). The main problem in culture has been bacterial contamination of sewage and animal wastes rather than diseases in culture until the recent outbreak of tubellarian worms in Malacca.

In early 1991, Melaka experienced a very bad drought which lasted for 3 months, and there were reports of mass mortality of mussel. Salinity of the culture area has increased to 34-35 ppt. The mussels were found to be heavily infected (100-200/mussel) by turbellarian worms. Mortality was observed mainly in the water column where salinity was higher; thus, it appeared that the tubellarians favored more saline conditions. To prevent the spread of the infestation, the farmers were advised to transfer the mussel rafts to other areas with lower salinity (Choo 1992).

Problems

Many shrimp farmers and hatchery operators carry out good hygiene practices such as disinfection of hatchery/pond, careful maintenance of water quality, use of breakcycle, and cleaning of tanks, equipment, floor, footwear, etc. Whenever disease is suspected, treatment is usually done using recommended chemicals. In most cases, farmers seek the assistance of the Department of Fisheries when they cannot diagnose the disease. However, they sometimes report the problem when the outbreak is already serious. There are also farmers who are totally ignorant of fish diseases while others simply ignore the problem, hoping that it will disappear with time and will not recur in future production.

Another major constraint is limited skilled manpower in this field, at all levels, in the country. In Malaysia, there are Fisheries Assistants at every district level responsible for giving technical advise to fishfarmers. Most of the assistants have only very basic knowledge. Whenever they encounter disease problems they are not familiar with, they refer these to higher authority or the few institutions which are involved directly in fish diseases. By the time a problem reaches the people concerned, it is usually too late for remedial action. It is also quite difficult for the few people concerned to cover the whole of Malaysia.

Malaysia imports a large number of fish fry without any proper quarantine upon entry to the country. It is well recognized that such importation is a serious source of diseases.

The Department of Fisheries, being the main government body responsible for the development of the aquaculture industry, has taken several measures to overcome fish disease problems. Steps have been taken to improve the skill in fish disease diagnosis, prevention, and control among its technical staff at every level. Training courses on fish diseases have been conducted and many technical staff have also been sent overseas for training. All aquaculture training courses for farmers conducted by the Department include fish health aspects to give them an understanding of fish diseases that could occur in the culture system and factors that trigger them.

A national committee has been set up to undertake fish disease work under the Ministry of Agriculture. A subunit within the Department of Fisheries was launched early this year headed by a Fisheries Officer who coordinates national efforts on fish diseases and pollution. Systematic documentation and follow-up will be done when there are reports on disease outbreaks. This will enable researchers to determine the distribution of various fish diseases in the country and to recommend precautionary measures to reduce fish disease problems.

The government also plan to establish quarantine centers at five major entry points importing live fish. In late 1991, a quarantine center at the International Subang Airport has already started operation. The implementation of quarantine measures for live fish imports can also assist in checking the spread of diseases in the country.

LITERATURE CITED

Anderson, I.G. 1988. Disease problems faced by marine prawn farms and hatcheries. Presented at the Seminar on Marine Prawn Farming in Malaysia - Present Problems, Future Prospects. Universiti Pertanian Malaysia, Serdang.

Chong, Y.C. and T.M. Chao. 1986. Common diseases of marine foodfish. Primary Production Department, University of National Development, Republic of Singapore.

Choo, P.S. 1992. Turbellarian infestation and the mass mortality of the mussel, *Perna viridis,* in Malaysia. Proceedings of the National IRPA (Intensification of Research Priority Areas) Seminar (Agriculture Sector). Vol.11. Kuala Lumpur: Ministry of Science, Technology & Environment, Malaysia. p. 552.

Fauzidah, O. and L.D. Rajamanikam. 1992. Identification of fish and shrimp diseases - their treatment and prevention. Proceedings of the National IRPA Seminar. Vol. II. Kuala Lumpur: Ministry of Science, Technology & Environment, Malaysia. p. 550.

Leong,T.S. 1989. Marine fish diseases: the Malaysian experience. Paper presented at the Forum on New Technologies in Aquaculture; 17 Aug. 1989; Kuala Lumpur. Malaysian Fisheries Society and Ministry of Science, Technology and Environment, Malaysia.

Leong, T.S. and S.Y. Wong. 1992. Control of diseases in cultured marine fishes. Proceedings of the National IRPA Seminar. Vol. II. Kuala Lumpur: Ministry of Science, Technology & Environment, Malaysia. p. 281.

Shariff, M.D. et al. 1978. Parasite impact on fish culture in Peninsular Malaysia - problems and possible preventive measures. Paper presented at the Workshop on Diseases of Fish Cultured for Food in Southeast Asia; 28 Nov-1 Dec 1978; Cisarua, Bogor, Indonesia.

Shariff, M.D. 1984. Introduction, prevention,and treatment of fish disease. Fish. Bull. No. 27. Kuala Lumpur: Ministry of Agriculture, Malaysia. (In Bahasa Malaysia.)

Palanisamy, V. 1990. Luminous bacterial infection of penaeid larviculture at NAPFRE hatchery. Proceedings of the Research Fisheries Officer Seminar, 1988. Kuala Lumpur: Ministry of Agriculture, Malaysia.

Siti Zahrah Abdullah. 1992. Common bacterial diseases of catfish, *Clarias macrocephelus,* cultured in Malacca. Proceedings of National IRPA Seminar. Vol. II. Ministry of Science, Technology & Environment, Malaysia, Kuala Lumpur.

Suhairi et al. 1983. Fish quarantine and fish diseases in Southeast Asia. Report of a workshop held in Jakarta, Indonesia, 1982. Ottawa: IDRC/FAO.

Wong, S.W. and T.S. Leong. 1987. Current fish disease problems in Malaysia. In: Fish quarantine and fish diseases in Southeast Asia (1986 update). Report of Asian Fish Health Network Workshop held in Manila, Philippines, 1986. Asian Fisheries Society in association with IDRC. p. 12.

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FISH DISEASES IN THAILAND: STATUS AND PROBLEMS

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In Thailand, there are several species cultured and systems of freshwater and marine aquaculture. However, improper management and lack of government control on the area and number of ponds contribute to the deterioration of the environment. One consequence of environmental degradation is the occurrence of diseases.

Status and problems

Freshwater fish. The most commonly cultured species include a hybrid of the African catfish (*Clarias gariepinus*) and the native catfish (*C. macrocephalus*); snakehead (*Ophicephalus striatus*); sepat siam (*Trichogaster pectoralis*); Javanese carp (*Puntius gonionotus*); sand goby (*Oxyeleotris marmoratus*); striped catfish (*Pangasius* sp.); Nile tilapia (*Oreochromis niloticus*); grass carp (*Ctenopharyngodon idella*); and freshwater prawn (*Macrobrachium rosenbergii*).

The hybrid catfish, one of the most economically important freshwater fish, was successfully reproduced in 1989. It grows fast and has more resistance to diseases than the local variety. However, rapid expansion and lack of understanding of proper pond management result in disease problems.

Sepat siam is cultured mainly in swampy ponds with a production of 14,240 t from an area of 24,025 ha in 1987. However, this production has been reduced because of the conversion of ponds to industrial and residential areas.

Snakehead culture in the central and eastern parts of the country is rapidly increasing. The culture technique is similar to that of hybrid catfish, with high stocking rates of up to 200 fry (3-5 cm) per m^2. But disease problems are causing losses; snakehead is always infested with external parasites. *Trichodina* infects the skin and gills and appears to be the most damaging to fry. *Epistylis* sp. does not cause direct mortality but causes hyperplasia at the attachment site (Chinabut and Limsuwan 1983). *Epistylis* sp. causes red spots on the skin (Tonguthai 1985). Several pathogenic bacteria were discovered in diseased snakehead during the severe disease outbreaks in 1981-85. *Aeromonas hydrophila* was isolated from all samples of ulcerated fish (Tonguthai 1985).

Sand goby is a highly priced food fish that is exported to Singapore, Hong Kong, and Malaysia. It is produced in cages along river banks in central Thailand, but the production has been greatly reduced since a disease outbreak in 1984. Mortalities in cages are not attributed to parasites but are associated with *A. hydrophila.* Infection is indicated by deep ulcers, and skin and muscle necrosis. *Corynebacterium* sp., *Streptococcus* sp., *Pseudomonas* sp., and *Edwardsiella tarda* are occasionally associated with the ulcers (Supamart et al. 1983). In a rare case, about 1% of cage-cultured sand goby in Nakhornsawan Province develop tumors after stocking for four months (Limsuwan and Chinabut 1984). The cause of the tumor has not been determined.

Striped catfish is also an important species cultured in integrated farms. During the outbreak of the epizootic ulcerative syndrome or EUS, infected walking catfish and snakehead cultures suffer heavy losses but striped catfish reared in adjacent ponds are free of the disease.

Herbivorous fishes do not seem to have many parasites or disease problems. *Aega* sp., an isopod parasite, is a blood feeder which occasionally infects. During 1981-85, sepat siam was one of the major species affected by severe EUS but mortality was not as great as in catfish and snakehead.

Freshwater prawn farming is mainly in the central part of the country. However, production has been reduced because of poor water quality and poor management. *Aeromonas hydrophila* is frequently isolated from shells of diseased prawns in grow-out ponds. Prawns are always weak and sensitive to pathogenic infection because they are raised in high densities under low levels of dissolved oxygen (Ruangpan 1992).

Brackishwater and marine fish. Sea bass (*Lates calcarifer*) and grouper (*Ephinephelus* sp.) are the two most common species in brackishwater culture. But cage and pond culture may be increasing too rapidly that they may succumb to diseases. The most concentrated area of cage culure of both species are in the south, followed by the eastern part of the country. The total production of seabass and grouper in 1987 reached 1,158 t and 343 t, respectively (Fisheries Statistic Sub-Division, 1989). Both species are reared intensively using trash fish as feed.

Protozoa are a major cause of fry mortality, especially at the age of 10-20 days (Ruangpan 1985). Streptococcal infection has been found in cultured sea bass, and isolated from eye, kidney, liver, heart, and brain. Characteristics of the disease include sluggish swimming, darkening of skin, exophthalmia, and hemorrhage at the base of the dorsal fins (Direkbussarakom and Danayadol 1987). Columnaris disease caused by *Flexibacter columnaris* has occured in sea bass cage culture in the outer part of Songkhla Lake in December 1983 through February 1984 (Danayadol et al. 1984). Symptoms of the disease include fin rot, loss of scales, and lesions on the body. Lymphocystis was first reported from sea bass in cages from the Songkhla Lake in 1983. The disease lasted for three months, causing 1% mortality.

Trichodina sp. and *Cryptocaryon* sp. are the major protozoans found infesting the gills and skin of grouper. The monogeaneans are commonly found in 1-in fry to adult grouper (Danayadol and Direkbussarakom 1987).

Crustaceans. Penaeid shrimps and crabs are the two major crustaceans cultured. Marine shrimp farming has expanded rapidly, and the total farming area has reached 67,200 ha with a production of 145,000 t in 1991. The culture system has changed from extensive to semi-intensive and intensive systems.

The commercially cultured species are black tiger shrimp (*Penaeus monodon*) and banana shrimp (*P. merguiensis*). The consequence has been the occurrence of monodon baculovirus (MBV), vibriosis (Sae-Oui et al. 1987), and protozoan diseases. The Veterinary Medical Aquatic Animal Research Center at Chulalongkorn University reports that more than 50% of the diagnostic cases submitted to them by private shrimp farms are infected with MBV (Tangtrongpiroj 1989). In histological samples of captured male and female broodstock obtained from the Andaman Sea, the incidence of individuals with MBV occlusion bodies is approximately 5.7% (Hegel et al. 1990).

Vibrio sp. is found in shrimps with rotten appendages and black spots on their body. Symptoms like black gills and abnormality of body color usually indicate infestation of filamentous bacteria, *Zoothamnium* sp., *Epistylis* sp., and *Acineta* sp. (Boonyaratpalin et al. 1989).

A serious protozoan pathogen often infests the black tiger shrimp, causing the cotton disease. *Thelohania* sp. is isolated from striated muscles, hepatopancreas, and intestine; these organs often degenerate (Prasertpol 1989).

Two species of fungi are reported as an infectious agent in penaeids. *Lagenidium* sp. can cause severe destruction of tissues, particularly in larval stages. *Fusarium* sp. causes black gill disease especially in adults.

Fish health management

Aquaculture and fish health management in Thailand are the mission of the Department of Fisheries of the Ministry of Agriculture as well as the local cooperatives. In addition, there are several universities and private consultancy companies.

Department of Fisheries. Within the Department, several divisions have responsibility over different areas of aquaculture and fish health management. Under the Freshwater Fisheries Division, there are 12 development and research centers and 32 stations. The Coastal Aquaculture Division is a laboratory for brackishwater animal health management that has three biologists working on fish parasitology, mycology, and bacteriology. There are also several centers/stations under this division that have laboratory facilities for disease diagnosis. The National Institute of Coastal Aquaculture or NICA is located in the southern province of Songkhla. The institute serves as a research, training, and extension center for the southern region.

Universities. The Faculty of Fisheries of the Kasetsart University offers fish disease courses for the bachelor and masteral degrees. Laboratories for parasitology, histology, bacteriology, and immunology are available for fish disease research. The Veterinary Medical Aquatic Animal Research Center of the Faculty of Veterinary Science, Chulalongkorn University operates an extension service for shrimp farmers. Two veterinary technicians operate a mobile diagnostic service that is on call for the farmers.

Government rules and regulations. Fish health certificates are issued upon request to the receiving country for live fishery products exported from Thailand. These permits are supplied after examination of the samples by the Coastal Aquaculture Division or National Inland Fisheries Institute. Sanitary quality control of processed fishery product for export is necessary and this is carried out by the Quality Control Section of the Fisheries Technological Development Division, Department of Fisheries. Samples of fishery products being exported are examined for the number of total bacteria (*E. coli, S. aureus, V. cholerae, Salmonella* spp., and *Shigella* spp.) and for its mercury, cadium, and lead contents.

Drugs commonly used for shrimp and fish culture include oxytetracycline, tetracycline hydrochloride, furazolidone, sulfathiazone, sulfadiazine, and trimethoprim. Chemicals commonly used are formalin, benzalkonium chloride, copper chelate, Dipterex, acriflavin and methylene blue. These drugs and chemicals are available in the market without any regulation regarding procurement or use.

Fish diseases are difficult to control in later stages and delayed control may lead to severe episodes. Aquaculture in Thailand involves intensive culture systems with high stocking densities, hence, proper management is essential; otherwise, disease problems will continue. In freshwater fisheries, the causative agent of EUS has not yet been identified and practical measures to alleviate the losses should be implemented. In brackishwater aquaculture, MBV appears to be the most important disease in *Penaeus monodon.*

Serious disease problems affecting shrimp farming are attributed to environmental deterioration in areas along the upper Gulf of Thailand. Shrimp mortality has been so severe that a large number of farms have been abandoned and the industry has been forced to relocate to the southern provinces.

The government should manage and control the area and the number of ponds so as not to contribute to environmental deterioration. Research on the impact of aquaculture on the environment is urgently needed. There is also a need to develop the quarantine and fish health certification in Thailand to prevent disease transmission.

LITERATURE CITED

Boonyaratpalin, S., V. Komvet, and P. Songjinda. 1989. Disease of tiger shrimp (*Penaeus monodon*) reared in circular concrete tank. Tech. Pap. No. 4/1989. Natl. Inst. Coastal Aquacult. Songkhla, Thailand. 17 pp.

Chinabut, S. and C. Limsuwan. 1983. Histopathological changes in some freshwater fishes found during the disease outbreak: 1982-1983. Thai Fish. Gaz. 36:281-289. (In Thai, English Abst.)

Danayadol, Y.S., S. Direkbussaradam, and J. Buranapanidgit. 1984. Columnaris disease in sea bass, *Lates calcarifer.* Tech. Pap. No. 14/1984. Natl. Inst. Coastal Aquacult. Songkhla, Thailand. 9 pp.

Danayadol, Y. and S. Direkbussarakom. 1987. The disease of grouper (*Epinephelus malabaricus,* Bloch & Sehneider) in the east coast of Southern Thailand. Contribution No. 1/1987. Natl. Inst. Coastal Aquacult. Songkhla, Thailand. 8 pp.

Direkbussarakom, S. and Y. Danayado. 1987. Epizootic caused by non-haemolytic

Streptococcus sp. in cultured sea *bass* (*Lates calcarifer*). Tech. Pap. No. 6/1987. Natl. Inst. Coastal Aquacult. Songkhla, Thailand. 12 pp.

Fisheries Statistics Sub-Division. 1989. Fisheries Statistics of Thailand 1987. Pap. No. 3/ 1989. Fisheries Statistics Sub-Division, Fishery Policy and Planning Division. Bangkok, Thailand. 94 pp.

Regel, T.W., D.F. Fegan, S. Sree-urairattana, and M. Vicrut. 1990. The occurrence, development, and histopathology of MBV in southern Thailand. Mahidol Univ., Bangkok. 8 pp.

Limsuwan, C. and S. Chinabut. 1984. Lymphoma in sand goby (*Oxyeleotris marmoratus*). Natl. Inl. Fish. Inst. Tech. Pap. No.33. Dept. Fish. Thailand. 9pp. (In Thai, English Abst.)

Prasertpol, J. 1989. Cotton disease of *Penaeus monodon.* Thai Fisheries Gazette (ISSN0125-6297). Chantaburi Coastal Aquacult. Devl. Cent. Brackishwater Fish. Div. Dept Fish. Thailand. 6 pp.

Ruangpan, L. 1985. Diseases and parasites found in cage cultured sea bass. Brackishwater Fish. Div. Coastal Aquacult. Res. Sect. Tech. Pap. No. 1. Dept. Fish. Thailand. 15 pp. (In Thai.)

Ruangpan, L. 1992. Diseases of giant freshwater prawn: their prevention and control. Brackishwater Fish. Div. Coastal Aquacult. Dept. Fish. Thailand. 5 pp.

Sae-Oui, D., A. Tansutapanich, and L. Ruangpan. 1987. *Vibrio harveyi:* luminous bacteria causing disease in *Penaeus merguiensis.* Tech. Pap. No. 6. Brackishwater Fish. Div. Dept. Fish. Thailand. 11 pp.

Supamart, K., S. Boonyaratpalin, C. Rongchayapoom, and J. Saduakdee. 1983. Effect of water quality on sand goby cultured in cages. Spec. Rep. Fish Disease Outbreak Ad Hoc Committee. Dept. Fish. Thailand. 15 pp. (In Thai.)

Tangtrongpiroj, J. 1989. A virus disease of black tiger prawn. Fisheries News 13 (7): 25-29.

Tonguthai, K. 1985. A preliminary account of ulcerative fish diseases in the Indo-Pacific Region (a comprehensive study based on Thai experiences). FAO/TCP/RAS/ 4508 Project, Govt. Thailand, Min. Agricult., Dept. Fish. Bangkok. 39 pp.

Discussion

The technical issues discussed by the workshop participants include:
- Criteria for fry quality
- Mortalities in grow-out cultures that use MBV-infected fry
- Cotton disease and importation of *Penaeus merguiensis* in the Philippines

The participants noted the following training gaps:
- Fisheries technicians in Malaysia have only very basic knowledge in fish diseases. Malaysia hopes to develop their own expertise in disease diagnosis and prevention.
- Thailand's representative noted that most technicians are not knowledgeable in proper pond management which is closely related to disease problems.

COUNTRY REPORTS

FISH NUTRITION

Two country papers were presented on the status, practices, and problems of fish nutrition.

A summary of the discussion that took place is presented.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

FISH NUTRITION IN MALAYSIA: STATUS AND PROBLEMS

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In aquaculture, nothing is more important than a well-balanced diet and adequate feeding. An undernourished fish is never able to maintain its health and attain its growth potential regardless of the quality of its environment. The production of nutritionally balanced diet for fish requires research, quality control, and biological evaluation.

The Department of Fisheries first acknowledged the importance of formulated feed when it established the Feed Section at the Fisheries Research Institute in Glugor in 1976. With the establishment of the research branch, Brackishwater Aquaculture Research Centre (BARC), in Gelang Patah, Johor in 1979 and the National Prawn Fry Production and Research Centre (NAPFRE) in Pulau Sayak, Kedah in 1987, the feed section has been expanded further to cover pond grow-out feeds for fishes and shrimps and the postlarval stage of shrimps. The feed section in Glugor placed greater emphasis on larval and postlarval feed. In the case of freshwater fishes, research and production of feeds began in 1975 at the Freshwater Fish Research Station, Batu Berendam, Melaka.

The development of formulated feeds is concentrated on fishes and crustaceans.

Status

Crustaceans. There are about 30 marine shrimp hatcheries operating in the country, producing an estimated 400 million fry a year (Ong et al. 1989). The first larval feed is usually in the form of live microalgae and this is introduced into larviculture tanks when the nauplii are about to metamorphose into protozoea. Newly hatched *Artemia* nauplii are next introduced at the late protozoeal stage and this is continued up to PL 5 when formulated feeds are given. There are various types of imported formulated feeds available in the country such as Nippai, President, Yeaster, Frippak, Higashimaru, etc. In most cases, these are used as supplementary feeds. Research has been carried out to evaluate the effectiveness of each feed as a replacement for live food. It was found that artificial feeds could not totally replace live food but the combination of certain types of artificial feeds and live food gave better survival and growth (Utama 1991). Other studies have been done on artificial feeds for nursing postlarvae. NAPFRE was able to formulate artificial feeds which are equally effective as the commercial feeds (Utama 1991).

There are also 563 shrimp farms (Annual Fisheries Statistics 1986) in Peninsular Malaysia, making up a total area of 475.77 ha. Most of the farms culture tiger shrimp (*Penaeus monodon*) and white shrimp (*Penaeus merguiensis*). The estimated feed requirement is 2 t /ha/yr. Before 1985, the local market was dominated by Taiwanese feeds. After that, a few local feedmillers started producing shrimp feeds.

Since 1985, research has been carried out by the Department of Fisheries to develop a suitable feed for grow-out. But it was only in 1987 that BRAC produced a feed comparable, if not superior, to the imported feed (Chua and Nafiah 1988).

In the case of the freshwater prawn (*Macrobrachium rosenbergii*), NAPFRE has succeeded in producing a formulated feed for larval rearing called SUTIMAL (Zainoddin and Yaakob 1992). This feed proved to be good, significantly reducing cost and culture period, and giving higher survival rate. All the raw ingredients are locally available.

Fishes. Sea bass (*Lates calcarifer*) is one of the most important species cultured. It is rapidly expanding and production from ponds and cages in 1990 amounted to 1,953.4 t (Fishery Statistics 1990). This was 38% of the total production of fishes and shrimps from ponds and cages.

Cultured fish are solely fed chopped or minced trash fish. However, total dependence on trash fish has its own disadvantages. Natural marine resources are depleting, and supply is not regular especially during the monsoons. This causes fluctuating prices which increase production cost.

In 1986, BARC introduced its first formulated pellet feed for sea bass nursery and grow-out. BARC has also succeeded in producing a better formulated feed with an FCR of 2.0 (Ismail 1992). Although utilized in small amounts, formulated feeds for freshwater fishes are available in various sizes and form, that is, floating or sinking.

Problems

The development of formulated feeds in Malaysia has been hindered by a number of factors. One is lack of good quality raw ingredients. Raw ingredients have to be imported since local supply is too little or irregular to meet the demand. Quality of local ingredients does not also meet the standard. Price competitiveness is another problem. Fishfarmers have not totally accepted formulated diets, especially those produced locally. Although the aquaculture industry is developed to some extent, trash fish is still the main source of feed. Attempts to introduce formulated diets often fail because of its high cost and the limited exposure of fishfarmers to feed pellets. On the other hand, the importance of formulated feeds in shrimp culture has been realized and the demand for them has increased over the years. But this market is small and scattered, and commercial scale production is not profitable for local feedmillers. If feedmillers export their feeds, they face stiff competition from already established companies.

There are still some 114,000 ha of undeveloped land suitable for aquaculture, and 21,000 ha are anticipated to be developed by year 2000. There is, therefore, a great potential for the development of marine shrimp and fish feeds in Malaysia. Since one constraint in increasing local production of feeds is insufficient supply or non-availability of good quality raw ingredients, local suppliers can take advantage of the demand. At the same time, research by the government and private sectors to find alternatives or substitutes to imported ingredients can help the feed industry.

LITERATURE CITED

Annual Fisheries Statistics. 1986, 1990. Department of Fisheries, Ministry of Agriculture, Malaysia.

Chua, T.T. and Md. Nafiah b. Md. Yasin. 1988. Intensive culture of tiger prawn, *Penaeus monodon,* at the Gelang Patah Brackishwater Aquaculture Research Centre. Fisheries Research Institute Seminar, 1988. Penang.

Ismail, A.H. 1992. Feeding trials on sea bass (*Lates calcarifer*) with formulated diet and trash fish in brackishwater pond. Paper presented at the Malaysian Fisheries Society Seminar, 29 Feb. 1992, Kuala Lumpur.

Ong, K.S., P.C. Liong, and H. Hambal. 1989. Prawn/shrimp culture technology in Malaysia. Risalah Perikanan Bil. 38 Kementerian Pertanian Malaysia, Kuala Lumpur.

Utama, CM. 1991. Kebersanan makanan rumusan yang diproses sendiri (home made) berbanding dengan makanan rumusan komersil untuk asuhan udang harimau *Penaeus monodon.* Seminar Pegawai Penyelidek Perikanan, Penang, 1991.

Zainoddin, J. and A. Yaacob. 1992. Formulated feed for the giant freshwater prawn (*Macrobrachium rosenbergii*) larvae. Proceedings of the National IRPA Seminar (Agriculture Sector). Kuala Lumpur, Malaysia.

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FISH NUTRITION IN THAILAND: STATUS AND CONSTRAINTS

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Aquaculture prior to World War II was limited because marine and freshwater fish catches were still abundant. But shortage of fuel and other necessities led to an increase in food prices including fish. The demand for increased fish production in turn increased the number of people involved in fish farming and the number of species cultured to more than 25. The 13 species most commonly cultured include the walking catfish (*Clarias batrachus*), snakehead (*Channa straitus*), striped catfish (*Pangasius sutchi*), gouramy (*Trichogaster pectoralis*), sand goby (*Oxyeleotris marmoratus*), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypopthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), Nile tilapia (*Oreochromis niloticus*), freshwater prawn (*Macrobrachium rosenbergii*), sea bass (*Lates calcarifer*), grouper (*Epinephelus tauvina*), and tiger shrimp (*Penaeus monodon*).

Thailand is a major producer of agricultural products in Asia. Large quantities of raw feed materials are produced and consumed each year. Although aquaculture has been in existence as long as land-based agriculture, it has not kept up in terms of feed development. The feeding methods of most cultured fishes are still largely traditional and based on experience using trash fish, rice bran, and broken rice. It was only recently that aquaculture began using feeds to increase production. In 1986, shrimp culture began evolving toward the semi-intensive and intensive systems, and the demand for compound feeds greatly increased. Commercial feed factories expanded to include shrimp feeds, further developing the feed industry.

Status

Development of dry feeds to replace trash fish. The mixture of trash fish and rice milling by-products are still widely used for carnivorous species, and so far, there are no attempts to change this. Availability of trash fish is not a problem yet for those near the coasts; however, it hinders fish farming in inland areas because of quality deterioration during transport and other problems. The Department of Fisheries has, thus, convinced fishfarmers to use well-established dry feeds for cultured species. At the same time, the feasibility of using dry feeds for strictly trash fish- dependent species like sand goby, snakehead, sea bass, and grouper is under investigation.

Table 1. The standard characteristics proposed by the Department of Fisheries for fish and shrimp feeds

	Size (cm)	Protein[1] (%)	Fat[2] (%)	Fiber[1] (%)	Ash[1] (%)	Moisture[1] (%)	P (%)	Others (%)
Marine shrimp feed								
Postlarvae (7-20 days)	0.5	40	4	4	16	12	1.4	-
Postlarvae (0.2-1.5 g)	1.8	40	4	4	16	12	1.4	-
Juveniles (1.5-5g)	2.5	40	4	4	16	12	1.4	2
Young shrimp (5-12g)	3.0	38	4	4	18	12	1.4	2
Adult shrimp (12-40g)	-	36	4	4	18	12	1.4	2
Freshwater prawn feed								
Young prawn (5-12g)	3.0	30	3	6	18	12	1.0	2
Adult prawn (12-40g)	-	25	3	6	18	12	1.0	2
Fish feed								
Catfish (4 days-1 month)	-	30	3	8	16	12	1.0	-
Catfish (1 month-3 months)	-	30	3	8	16	12	1.0	-
Catfish (over 3 months)	-	25	3	8	16	12	1.0	-
Other herbivorous fishes	-	18	3	8	16	12	1.0	-

[1]Maximum. [2]Minimum. P, phosphorus.

Development of fish feed using locally available raw materials. Good fish feed formulas are useless if ingredients are not available in the region. Ideally, fish feeds provide adequate nutrition and are developed from locally available raw materials. Also, their preparation must not be very complicated. Agricultural crops grown in the country are the best guides for developing fish feeds. For instance, rice, corn, cassava, soybean, and their products could be used in fish feeds for the northeastern region while oil-palm products could be a potential feed ingredient for the south.

Standard legislation for aquafeeds. Thailand is one of the world leaders in aquaculture production. The total production of marine shrimp alone is valued in 1991 to be 14,000 million baht. Such a big industry consequently increases demand for feeds. At present, 17 aquafeed mills are in operation with an annual production of 240,000 t or a total production value of 7,500 million baht. The Department of Fisheries realizes that uncontrolled and inconsistent feed quality can cause huge losses for the farmers. Therefore, it proposed standard legislation regarding aquafeeds for consumer protection (Table 2). The legislation guarantees quality.

About one-third of aquafeeds produced in the country are for fish, the rest for shrimp. The following feed plants all produce shrimp feeds; plants 1,4,10, 14,15, and 16 produce fish and shrimp feeds.

1. C.P. Animal Feeds
2. Laemthong Aquatech
3. S.T.C. Feeds
4. P. Chareonphan Animal Feeds
5. Aquastar
6. U.K. Feedmills
7. Thailux Enterprise
8. Grobest Corporation
9. Apitune Sea Food
10. Unicord Feeds
11. Lee Patana
12. Centago
13. Bangkok Animal Feeds
14. Na NA Food Products
15. Sahapatanakaset
16. Feed Specialty
17. Cargill

There are three types of feed produced in the country: fish feed, freshwater prawn feed, and marine shrimp feed.

The feed stuffs for aquaculture are almost the same types used for livestock but the composition of feeds is different. Some of the ingredients used in aquaculture and their nutritional values are shown in Table 2.

Because of adequate animal feedstuffs in the country, animal feed milling is one of the fastest growing industries. The (sinking) dry pelleted feed for catfish was introduced about 20 years ago but few used the feed because it was priced higher than the fish in the market. The feed milling industry then introduced the floating-type pelleted feed. However, traditional practices using fresh trash fish detract the farmers from using them even when feed conversion ratio (1.5:1) was claimed to be lower. This situation slowed the development of compound feeds in aquaculture. Just recently, farmers realized the convenience of using complete feeds, increasing consumption of dry and floating pelletized feeds. When the freshwater prawn and marine shrimp cultures expanded because of adequate seed supply, the need for compound feeds rapidly increased, and many feedmills improved or increased quality and quantity of available feeds. New feedmills that cater to aquaculture were established in 1986-1988. The Department of Fisheries is monitoring these feed milling plants.

There are several shrimp feeds formulated for different levels of culture because of the differences in stocking rates, the natural food available, the production expected, and the level of knowledge on nutrient requirements of aquatic animals. Some known formulations are shown in Tables 3 and 4.

Feeds for herbivorous, omnivorous, and carnivorous fishes are not formulated according to nutrient requirements but are based on the price of the product at the end of culture. Some feed formulations are shown in Tables 5 and 6.

Table 2. Common feedstuffs used in diet formulation

Feedstuff	Dry matter (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	NFE (%)	Bath/kg (%)
Broken rice	87.3	10.2	1.9	1.4	1.2	85.3	6.00
Maize	87.8	10.0	4.5	2.8	2.4	80.3	3.00
Sorghum	85.4	11.1	3.7	6.1	4.1	74.8	3.00
Cassava meal	87.7	4.6	1.1	3.8	6.5	84.0	1.75
Rice bran (raw)	90.0	14.0	15.2	12.7	13.5	44.6	3.00
Soybean meal	88.5	54.2	1.2	5.3	7.9	31.4	8.30
Cottonseed meal	91.6	45.4	1.3	14.5	11.4	27.4	6.50
Sesame seed meal	90.1	51.0	1.3	6.8	12.9	28.0	7.00
Ipil-ipil meal	90.1	18.9	2.8	24.6	11.4	42.4	2.70
Fish meal	93.1	57.0	8 5	2.1	25.0	7.4	10.00
Meat meal	93.0	54.3	10.6	2.2	30.5	2.4	NP
Feathermeal	93.0	91.7	3.2	1.3	3.8	0.0	5.0
Shrimp meal	90.0	49.9	3.3	12.5	30.2	4.1	NP
Yeast	93.0	51.5	2.6	2.5	8.6	34.8	NP
Molasses	85.0	5.4	0.3	9.9	10.3	74.0	1.50
Bone meal	97.0	11.5	9.4	1.7	77.4	-	5.00

NFE, nitrogen-free extract; NP, no price obtained.

The feed formulations are also made according to culture system, age of fish, environmental condition, price of the product, cost of feed, and availability of local ingredients.

Table 3. Feed formula for *P. monodon*

Ingredients	%
Fish meal	30
Soybean meal	25
Shrimp head and wastes	10
Squid meal	6
Yeast	2
Broken rice	12
Rice bran	10
Guagum	1
Premix	0.8
Mineral mix	0.2
Vitamins	2.0
Diphosphate	1.0

Table 4. Shrimp feed with trash fish as the major component

Ingredients	%
Trash fish	40
Fish meal	10
Shrimp head and waste	8
Soybean meal	16
Rice bran	12
Broken rice	10
Ipil-ipil	3.3
Vitamin premix	0 5
Vitamin C	2

Table 5. Feed for herbivorous species, e.g., carp and catfish

Ingredients	%
Fish meal	16
Peanut meal	24
Soybean meal	14
Rice bran	30
Broken rice or cassava meal	15
Vitamin and mineral premix	1

Table 6. Feeds formulated for fry of carnivorous species

Ingredients	%
Fish meal	56
Rice bran	12
Soybean meal	12
Alpha starch	14
Vitamins and mineral	1.6
Binder (bass fin)	0.4
Fish oil	4

Problems and constraints

- Most of the efforts to increase aquatic animal production went into seed supply and very limited funds are given to studies on aquatic animal nutrition and fish feed technology.
- Most of the formulations for aquatic animal feeds are based on experience with land animals. Very few fish nutrition studies and fish feed technology exist. The lack of research in this field reflects the slow process of development.
- The subject is complicated and special instruments are required but government budget alone is not enough. The assistance of international agencies to enhance research would promote better development.
- Many species of fish and shrimps need to be studied and the conditions of culture systems need to be standardized.
- The high price of formulated feeds for some species is not economically appropriate for commercial application. Studies on waste products as substitutes to expensive feed ingredients need to be undertaken.

Discussion

The technical issues discussed by the workshop participants include:

- Shortage of quality feed ingredients
- Upgrading of low-quality feeds by several processing techniques
- Formulated feeds are less acceptable in Malaysia than trashfish. Trashfish supply is adequate and it costs lower (R3/kg) than formulated feeds (US$1/kg). Supply, however, is not unlimited and may decrease like in Thailand.
- Survival of farmed species fed locally produced feeds and those fed imported feeds
- Proximate analysis of feeds used in tiger shrimp culture
- Feeding broodstock
- Control measures on feed quality imposed by the Government of Thailand
- Basis for nutritional requirement; lipid requirement for tiger shrimp

PRIVATE SECTOR EXPERIENCE

SHRIMP HATCHERY AND GROW-OUT CULTURE IN THE PHILIPPINES

Two papers were presented on the status, practices, and problems of the shrimp industry in the Philippines.

A summary of the discussion that took place is presented.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

THE SHRIMP HATCHERY INDUSTRY IN THE PHILIPPINES

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Fifteen years after SEAFDEC Aquaculture Department first offered its training course on *Barangay Prawn Hatchery Management,* the giant tiger shrimp industry has grown tremendously. Among the private investors in shrimp (*Penaeus monodon*) hatchery is Jamandre Industries, Inc. But problems (e.g., scarcity of spawners and lack of effective artificial feeds) led the company to explore culture of penaeid shrimps other than tiger shrimp. Although survival of *P. stylilostris* and *P. vannamei* were found to be higher than *P. monodon* in grow-out ponds and in the hatchery, their culture did not take off in the country. For the penaeid shrimps, technology remains largely an art.

The plunge of a major Philippine conglomerate, the San Miguel Corporation, in aquaculture encouraged other big corporations to join the shrimp business, triggering booms in hatchery, farming, feed milling, processing, and other allied industries. Our company expanded in 1982, producing an average of 30 million fry per year. The increasing demand was sustained for five years.

The year 1988 was significant to the shrimp industry in the country. It was when the *1st Congress of the Philippine Prawn Industry* was held, unifying the different industry sectors. It was also the start of the first major crisis faced by the industry for the intensification of pond culture allowed the proliferation of hatcheries throughout the country which in turn caused the decline in the quantity and quality of wild spawners. In addition, broodstock and maturation techniques at that time were not fully perfected yet by hatcheries. These resulted in inconsistent fry supply and widely fluctuating prices.

Due to the failure of hatcheries, younger fry (PL10-15) from the wild are being stocked in ponds, resulting in low survival. The price of wild fry is high because of the middlemen who became necessary since ponds are very dispersed geographically. Nursery operators, most reliable outlet for hatchery-bred fry, limit themselves to certain areas since disposal of juveniles is risky and mortalities are very high. The industry suffered more when disease outbreaks became common. The outbreaks are caused by several factors, but, quality of hatchery fry was blamed the most. Monodon baculovirus (MBV), the most prevalent disease of hatchery-bred fry and pond-cultured *Penaeus monodon,* occurs in 67% of the disease cases. This led the industry to institute a set of criteria for fry quality. However, the different laboratories for shrimp diseases have come out with different criteria (Fig. 1 A-C). But the emphasis was on the

A

Client: ______________________
Specimen: ______________________
Hatchery : ______________________
Broker: ______________________
Date submitted : ______________________
Laboratory result: ______________________
No. of samples : ______________________

		Criteria	*Result*
A.	Well developed muscles	> 80%	______
	Slightly grainy muscles	< 20%	______
	Spreading muscles	= 0	______
	Spreading chromatophores		______
	Gut rot	< 10%	______
	Gut to muscle ratio	> 1:3	______
	1:3		______
	1:3.5		______
	1:4		______
	1:5		______
	Full gut		______
	Partially full gut		______
	Empty gut		______

		Criteria	*Result*
B.	Bacterial necrosis	< 3 N/A	______
	Light *Leucotrix mucor* infestation	< 100%	______
	Moderate *Leucotrix mucor* infestation	= 0	______
	Heavy *Leucotrix mucor* infestation	= 0	______
	Light protozoan infestation	< 100%	______
	Moderate protozoan infestation	= 0	______
	Heavy protozoan infestation	= 0	______
	Endoparasites	= 0	______
C.	Body length	= 12.5 - 13 mm	______
	Rostral spine count	= 4 - 6	______
	4 rostral spines		______
	5 rostral spines		______
	Uropods	Spreading	______
D.	MBV occlusion bodies Negative	100%	______
	Positive	0%	______

Presumptive diagnosis using 0.1 malachite green staining:

____

Noted by: ______

Analyzed by: ______

B

Client: ____________________
Fry stage: ____________________
Date submitted: ______________

Pathology		**HS**	**S**	**LS**
Bacterial necrosis	count/ind	— < 2	— < 2.9	—
Filamentous bacteria	% heavy inf.	— < 10	— < 40	—
Protozoans	count/ind	— < 5	— < 9	—
Endoparasites	count/ind	— < 3	— < 5	—
Nematodes	absence/presence	—		
Fungi	absence/presence	—		
Physical condition				
Empty gut	% affected	— < 60	— < 90	—
White body	% affected	— < 60	— < 90	—
Incomplete molting	% affected	— < 60	— < 90	—
Deformities	% affected	— < 60	— < 90	—

Additional criteria for harvestible fry

Stress test		
MBV diagnosis	(presumptive)	______________
Muscle development	gut : muscle ratio	______________
Rostral spine	no. of spines	______________
Body length	mm	______________
Spreading uropods	% individual	______________

Comments:

Analyzed by: ______________ Noted by: ______________

Legend: HS - highly satisfactory; S - satisfactory; LS - low satisfactory

Fig. 1. Fish health laboratories run by the private sector have different criteria (A, B, and C) in determining quality of fry.

Fry Analysis Summary Report

C

Client: ____________________

Source: __________ Tank no.: __________ Pop.: ______

PL age: __________ Date received: __________

SAMPLES	Hepato-pancreas		BODY LENGTH	GUT			MUSCLES			GILL			ROSTRUM		APPENDAGES						
	MBV															RN+N		FBI		PI	
	D-INF	Rating		SHG	GN	Rating	MN	GMR	Rating	FBI/ PI	N	Rating	RS	RN	N	RN+ N/A	Rating	Degree	Rating	Degree	Rating
TOTAL	= ______		Ave.: ___ A/N = __	= ______			= ______			= ______							= ___		= ___		= _ Ave.: ______
%	x 30%= ___		x20%= __	x 15% = ____			x 10% = ____			x 15% = _____					x 10% = ______						

Legend: D-INF, degree of MBV infection; SHG, swollen hind gut; GN, gut necrosis; MN, muscle necrosis; GMR, gut-to-muscle ratio; FBI, filamentous bacterial infestation; PI, protozoan infestation; N, necrosis; RS, rostral spine; RN, rostral necrosis; N/A, necrosis per animal.

Total body length (tip of rostrum to tip of telson) = (actual body length - 6)/(theoretical body length - 6) x 100

TOTAL SCORE: ______

Remarks: ______

Analyzed: ____ Noted: ____

presence of occlusion bodies as indicator of MBV. MBV-positive fry are hard to sell even at give-away prices. Hatchery operators either exert more effort to produce quality fry or fold up mainly due to lack of financial assistance and technology.

The standardization of fry quality criteria, a major concern, was recently resolved with the adoption of the criteria used by DOLE Philippines and Sarangani Aquaculture Resources, Inc. (Fig. 1C). The fry quality criteria has been correlated to pond performance with 85% success rate.

The slump in the market price of shrimps in 1988-1989, the devastation brought by typhoon Rufing, and the foreign exchange crisis in 1990 reduced the number of growers although others continued but at lower stocking density. Operation on a large-scale basis was not feasible because of marketing problems. Our company survived by limiting production runs from six to three in a year and by constructing small-scale hatcheries.

The Iloilo hatchery operators formed an association known as AHOCI (Association of Hatchery Operators Cooperative of Iloilo), later changed to IFPA (Iloilo Fry Producers Association). Through the *2nd Congress of the Philippine Prawn Industry* in 1991 in Bacolod City, a national organization - SHOP (Shrimp Hatchery Operators of the Philippines) - was formed. The Philippine Government at this time had become a genuine partner in the industry with the creation of the Presidential Coordinating Committee for the Shrimp Industry. The committee includes the representatives of different sectors of the shrimp industry and the Secretaries of the Departments of Agriculture, Finance, and Trade and Industry. Through the committee, the industry hopes to exert significant leverage to avail of government incentives. It can also better coordinate in minimizing the negative effects of unscrupulous business deals. The professionalization of the hatchery industry can be effected and the solution to problems like scarcity of spawners, and larval diseases can be discussed.

Shrimps have become the fastest growing, non-traditional export product of the country. In 1990, earnings reached US$21.8 million. The shrimps also constitute 3% of Philippine exports of US$8.1 billion; and 6% of the total world shrimp market (US$4 billion). The country also ranks fifth as tiger shrimp supplier in Japan. These facts reveal that although the industry is currently in a slump, it has not died yet. There are still other markets to tap and increased production will help the Philippine economy.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

THE SHRIMP FARMING INDUSTRY IN THE PHILIPPINES

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The shrimp farming industry in the Philippines is the culture of shrimp (*Penaeus monodon*) in brackishwater and seawater grow-out farms to marketable size. The industry is highly dependent upon the other sectors/components of the shrimp culture industry, including:

1. the shrimp hatcheries for their supply of fry (PLs);
2. the feed millers for their supply of commercial pelletized feeds, primarily for semi-intensive and intensive shrimp farms;
3. the shrimp processors/exporters for the purchase of their harvests;
4. the financial institutions for their capital and operational costs; and
5. the research institutions and the government for solutions to technical and other problems.

Such dependence makes shrimp farming vulnerable. Other than that, it is also a high risk business. In addition, monsoon rains, typhoons, and floods can significantly affect shrimp farming. Pollution from watershed activities and from self-generated organic load has resulted in slower shrimp growth, higher susceptibility of shrimp to diseases, and mass mortalities. Widely fluctuating export market prices and demands are also major concerns of the industry.

Status

The status of the shrimp farming industry was examined to identify prevailing issues and problems. Field surveys were made in Luzon, Visayas, and Mindanao from August 4 to September 3, 1992. Questionnaires on farming systems were completed through interviews with the farm manager/owner or farm technician. A total of 40 interviews were completed during the survey (Table 1). Two interviews were from traditional farming, six from extensive farming, 29 from semi-intensive, and three from intensive. The distribution of samples in relation to farming systems does not indicate actual distribution of these farming systems in the country. The survey became skewed toward semi-intensive farms because the Bureau of Investments and shrimp growers associations/cooperatives identified and prioritized the farms to be interviewed. Time constraints prevented a more randomized sampling.

Table 1. Distribution of samples in the field survey, by province

Province	No. of samples
Pangasinan	4
Bulacan	1
Pampanga	1
Bataan	1
Batangas	2
Cebu	4
Bohol	2
Negros Occidental	10
Iloilo	3
Capiz	2
South Cotabato	4
Davao del Sur	2
Misamis Occidental	3
Agusan del Norte	1
TOTAL	40

Areas devoted to shrimp farming. The total area of shrimp farms in the country in 1992 was 49,478 ha, of which 47,774 was devoted to the black tiger shrimp; 1,006 to endeavor shrimp (*Metapenaeus ensis* or "hipong suahe"); and 638 to white shrimp (*P. indicus, P. setiferus* or "hipon puti") (Table 2). The total hectarage under shrimp production constitutes 23% of the country's brackish-water fishponds.

Luzon has 20,940 ha (44%) of total shrimp farm area; Visayas has 14,314 ha (30%); and Mindanao, 12,519 ha (26%). Regions VI and III have the greatest areas of shrimp farms in the country, reflecting the suitable resources for development; while far fewer farm areas are found in Regions I, II, VIII, and NCR. The Ilocos regions are expected to have few areas for shrimp farming in view of the rugged terrain and lack of brackishwater areas. The National Capital Region being highly urbanized is not expected to have significant shrimp farms.

Shrimp farming systems. Shrimp farming utilizes a variety of farming systems influenced by variables such as climate (monsoons), capital availability, site location, tidal variations, source of water supply, marketing of harvested products, and availability and cost of farm inputs. As a result, regional differences in farming systems have developed. Existing farming systems are classified on the basis of the field survey (Table 3).

Variations of the different farming systems have been made by shrimp farmers to solve their problems. In extensive shrimp farms, a portion of the stock are transferred from a grow-out pond to another, with the rationale of providing a larger space for the shrimp to grow. This "modular" type of pond transfer also provides the shrimp a much cleaner environment with more abundant natural food. In some instances, a break is made in the dike between two extensive

Table 2. Preliminary estimates of area (in hectares) of black tiger shrimp, endeavor shrimp, and white shrimp, by region and province, 1991

	Black tiger shrimp	Endeavor shrimp	White shrimp
NCR	**317**	-	-
REGION I	**345**	-	-
llocos Sur	32	-	-
La Union	1	-	
Pangasinan	312	-	-
REGION 2	**30**	-	-
Cagayan	30	-	-
REGION 3	**12,363**	-	-
Bataan	1,507	-	-
Bulacan	1,813	-	-
Pampanga	9,019	-	-
Zambales	24	-	-
REGION 4	**2,514**	**244**	**197**
Aurora	26	-	-
Batangas	116	2	2
Cavite	121	-	-
Marinduque	129	-	-
Mindoro Occ.	272	-	-
Mindoro Or.	556	-	-
Palawan	68	2	2
Quezon	1,222	218	190
Romblon	4	22	3
REGION 5	**5,372**	**403**	**134**
Albay	37	-	-
Camarines Norte	582	22	10
Camarines Sur	822	128	-
Catanduanes	57	22	-
Sorsogon	1,011	-	107
Masbate	2,863	231	17
REGION 6	**12,288**	**75**	**98**
Iloilo/Guimaras	818	-	0
Aklan	1,267	-	-
Capiz	6,885	75	91
Antique	25	-	6
Negros Occ.	3,293	-	1
REGION 7	**1,051**	-	-
Bohol	506	-	-
Negros Or.	213	-	-
Cebu	332	-	-

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	Black tiger shrimp	Endeavor shrimp	White shrimp
REGION 8	**977**	**-**	**5**
Leyte	149	-	-
Southern Leyte	3	-	-
Eastern Samar	4	-	-
Northern Samar	190	-	-
Western Samar	631	-	5
REGION 9	**6,710**	**324**	**92**
Basilan	89	-	-
Zamboanga del Norte	297	-	26
Zamboanga del Sur	6,324	324	66
REGION 10	**1,450**	**-**	**7**
Agusan del Norte	516	-	-
Misamis Occ.	425	-	-
Misamis Or.	122	-	5
Surigao del Norte	387	-	2
REGION 11	**1,345**	**20**	
Davao Oriental	21	3	-
Davao del Sur	199	-	-
South Cotabato	352	-	-
Surigao del Sur	773	17	-
REGION 12	**3,014**	**-**	**88**
Lanao del Norte	1,565	-	15
Lanao del Sur	116	-	-
Sultan Kudarat	133	-	73
Maguindanao	1,200	-	-
TOTAL	47,776	1,006	638

Source: Bureau of Agricultural Statistics, Department of Agriculture.

grow-out ponds to allow the shrimp to transfer on their own. The shrimp farmer is able to obtain a more accurate count and biomass of the shrimp (thus supplemental feeding rate is improved), and is able to assess the growth and condition of the shrimp during transfer.

Crops of shrimp are rotated with milkfish in some semi-intensive farms, allowing the milkfish to clean the pond of organic matter. However, since stock densities of milkfish are high (25,000/ha) and the fish are often fed pellets, the purpose of pond cleaning is defeated.

One pond within the farm is often rotated out of production for fallowing and exposure to the air for a crop period.

Limestone is used in semi-intensive and intensive farms, in places where

Table 3. Summary of comparative features of various shrimp farming systems in the Philippines

	Traditional	Extensive	Semi-intensive	Intensive
Stocking density (pc/m^2)	<1	1-5	>5-20	>20
Average farm area (ha)	73	40	14	7
Pond area (ha)				
Smallest	4.50	0.53	0.58	0.34
Largest	9.25	1.90	1.48	0.67
Pond water depth (cm)	30-80	80-100	100-120	120-150
Life support system				
Aerators	None	As needed	Present	Present
Pumps	Present in some	Present	Present	Present
Salinity maintained	Rainfall dependent	Rainfall dependent; 18-25 ppt	18-25 ppt	10-25 ppt
Water supply	Tidal	Tidal with occasional pumping	Tidal with pumping	Pumping only
Type of feed used	Natural food; trash fish; small crustaceans; animal by-products	Trash fish, snails; small crustaceans; mussel meat combined with commercial pellet	Commercial pellet; infrequently fed snails, mussel meat, crustaceans, trash fish, *Artemia* biomass	Commercial pellet; infrequently fed snails, mussel meat, crustaceans, trash fish, *Artemia* biomass
Frequency of feeding/day	1	2-4	3-5	3-5
Method of culture	Transfer from NP-RP	Modular; straight culture	Straight culture	Straight culture
Average survival (%)	30-50	60-80	75-90	80-90
Culture period (days)	100-150	120-220	120-180	140-155
ABW at harvest (g)	40-70	25-61	20-47	26-40
Production (kg/ha/yr)	<220	220-1,840	>1,840-6,800	Above 6,800
No. of crops/year	2-3	1-2	1-3	1-3
Age of fry at stocking	PLs 10-18	PLs 10-20	PLs 12-45	PLs 15-20

ABW, average body weight; NP, nursery pond; RP, rearing pond; PL, postlarvae. Source: Survey results and key industry sources.

it exists and is accessible, for shrimp pond construction and in covering the pond bottom during pond preparation after the black soil has been scraped off. This increases pond soil pH and alkalinity, reduces the liming of ponds, and is seen by the shrimp farmers to have helped in lessening incidence of diseases.

A longer pond preparation (two to three months) is now practiced in semi-intensive and intensive farms. The intention is to fully oxidize and decompose the organic matter resulting from uneaten feeds and shrimp fecal matter. The general trend in pond preparation, regardless of culture system, is to have a longer pond preparation during the dry months than the rainy months (Table 4). More intensive culture systems generally utilize a longer pond preparation time, especially now that the shrimp growers have realized the effect of organic pollution in their farms. The application of hydrated and agricultural lime before and after pond bottom tilling at the rate of 2,000-3,000 kg/ha is a common practice in pond preparation as a prophylactic treatment and to correct soil pH.

Stocks are sampled at intervals to determine growth rate and to estimate feed rate. One traditional shrimp farm conducts stock sampling at 45 day intervals, and the other only prior to harvest. Some extensive farms sample every week throughout the culture period, while others weekly or monthly after the first 30 days of culture. In semi-intensive and intensive systems, most of the shrimp farms sample stock weekly after the first 30 days of culture, while others sample at 10, 15, or 30 days after the first 30 days of culture.

Feed management. Traditional shrimp farms typically use natural food (Table 3). Extensive farms use trash fish, snail ("kuhol"), small crustaceans, and brown mussel meat (combined with commercial shrimp pellet). (The "kuhol" is the golden snail, *Ampullaria* sp., a pest in many rice fields in the country.) On the other hand, semi-intensive and intensive farms use starter, grower, and finisher commercial shrimp pellets. In later part of the culture (or when the shrimp's ABW is about 20-25 g), some semi-intensive and intensive farms supplement pelleted feeds with "wet feed" such as trash fish, brown mussel meat, kuhol, and *Artemia* biomass.

The feeding frequency for traditional farming is only once a day from the start of feeding (after the first 30 days of culture) until harvest (Table 3). In extensive farming, feeding frequency is twice per day during the first 30 days of culture, then increased to 4 times per day from 45 days of culture to harvest. For semi-intensive and intensive systems, feeding frequency is 3 times per day for the first 30 days, then 4-5 times per day for the rest of the culture period. The feeding frequency for semi-intensive and intensive farms comes from recommendations by the feed manufacturers, and is adhered to by most growers.

Feed conversion ratios (FCR) attained by the different culture systems vary considerably (Table 5). Extensive shrimp farms have a wide range of FCR, from 1.2 to 3.0 with an average of 1.88; intensive farms from 1.5 to 2.5 with an average of 1.93; and semi-intensive farms from 1.4 to 3.5 with an average of 2.05. The efficiency of extensive farms is due to the fact that the shrimp utilize natural food grown in the pond as its primary source of nutrition, with commercial feed as a supplement to the natural diet. According to the shrimp growers, their FCRs are affected by pond management, quality of feed, feed management

Table 4. Duration (days) of pond preparation by region

Culture system	Region 1		Region 3		Region 4	Region 6	Region 7		Region 10		Region 11
	Summer	Wet	Summer	Wet			Summer	Wet	Summer	Wet	
Traditional			30	7-14							
Extensive			60	14		30-120			45-60	30-45	
Semi-intensive	21-30	45-60			30-45	30-90	30-60	30-45	30-60	30-45	30-60
Intensive					30-60		60-90	45-60			

Table 5. Feed conversion ratios obtained by shrimp farmers

Culture system	Region 1		Region 4		Region 6		Region 7		Region 10		Region 11		Overall
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	average
Extensive					1.2—3.0	2.1			1.5-1.8	1.65			1.88
Semi-intensive			1.7-1.9	1.8	1.4-2.5	2	1.5-2.5	2	1.5-3.5	2 5	15-2.5	2	2.05
Intensive	1.8-2.2	2	1.5-2	1.75			1.6-2.5	2.05					1.93

(feed consumption monitoring and feeding frequency), water quality, and age of pond.

Incidence of shrimp diseases. Most farmers note incidence of infectious diseases or its clinical symptoms (Table 6). The most common diseases/clinical symptoms are tail rot, black and brown gills, MBV, and the presence of filamentous algae. As one solution, semi-intensive and intensive farmers apply hydrated lime to induce molting of shrimp. The incidence of shrimp diseases in traditional and extensive farms is far less than the more intensive environments. Recently in Negros Occidental and Capiz, Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV) has been identified as an agent causing poor growth and mass mortality.

Growth rate of shrimp. Some shrimp growers furnished growth data. Results show that shrimp grew faster before 1989 (Fig. 1), when the ponds were newly constructed. During this time, the shrimp could be grown to an ABW of 31-35 g in 110-120 days of culture (DOC) even at high stock densities of 15-25/m^2. Larger sizes (41-50 g) could be attained within the same DOC but at lower stock densities of 5-10/m^2. As the shrimp ponds accumulated organic matter in the bottom, slower shrimp growth was experienced. It now takes 150-220 DOC to attain the 31-35 g size (Fig. 1).

Table 6. Infectious diseases and clinical symptoms observed by shrimp farmers in 1992

Disease	Traditional	Extensive	Semi-intensive	Intensive	Total
MBV (Monodon baculovirus)		1	10	1	12
IHHNV (Infectious hyperdermal hematopoietic necrosis virus)			5	1	6
Filamentous bacterial disease			8		8
Chronic soft-shell syndrome	1	1	9		11
Red Disease			6		6
Soft blue shell syndrome			6		6
Black/brown gills	2	1	19	3	25
Bamboo back			11		11
Protozoans		2	6	1	9
Tail rot	2	1	24	3	30
Barnacles			7	2	9
Black spots	1		8	1	10
Black meat			4		4
Elephant ear			6		6
Algal			9	3	12
Gill rot		1	4		5

Dry and wet seasons affect shrimp growth rates (Fig. 2). In most of the Philippines, the wet month period (May to October) is the best time to grow shrimp because of more ideal salinity in the water sources. Salinity gets to be quite high during the dry months, slowing growth and reducing survival. The exception to this pattern is Region I (Pangasinan); better shrimp growth rates are attained during the dry month period (November to March). In this area, the rains bring the water salinity to almost freshwater and makes the water turbid. During the dry months, salinity is optimal (18-25 ppt).

Issues and problems

Environmental. The crowding of shrimp farms in specific areas has overloaded the carrying capacities of drainage systems (river channels or tidal creeks) rendering them incapable of absorbing the organic loads from shrimp ponds and other users of the river. This condition was observed in Regions I, III, VI, X, and XI.

Site selection has been poor; conversions of coconut, sugar and rice lands that have elevations higher than the sea level and quite distant from the water source make the use of tidal variations impossible. Often, these lands are committed to intensive farming of shrimp and the option to shift to lower valued commodities is no longer feasible because of the high cost of energy to pump water.

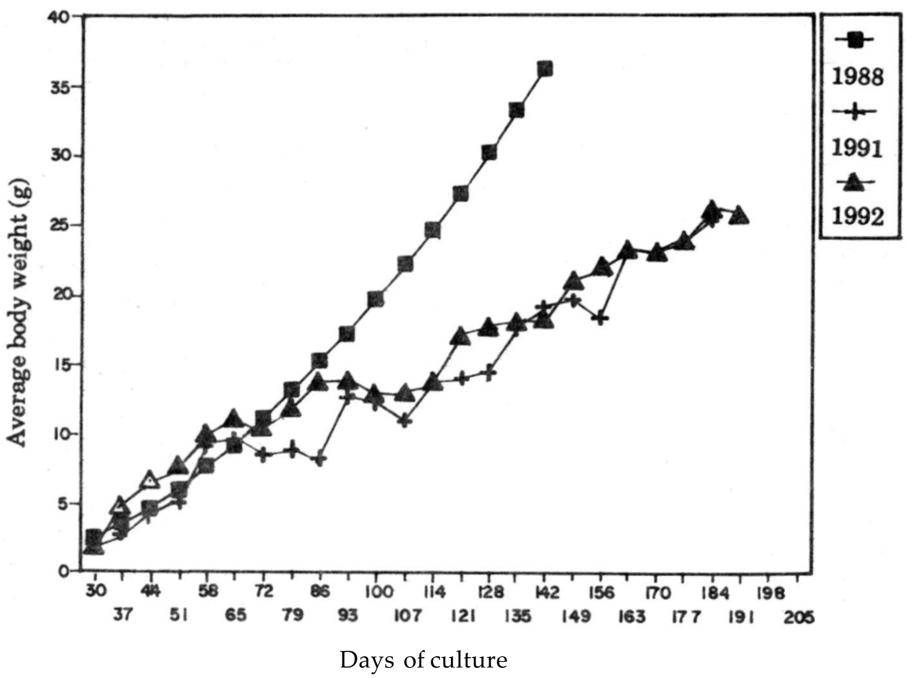

Fig. 1. Comparison of shrimp growth curves in semi-intensive farms for 1988, 1991, and 1992.

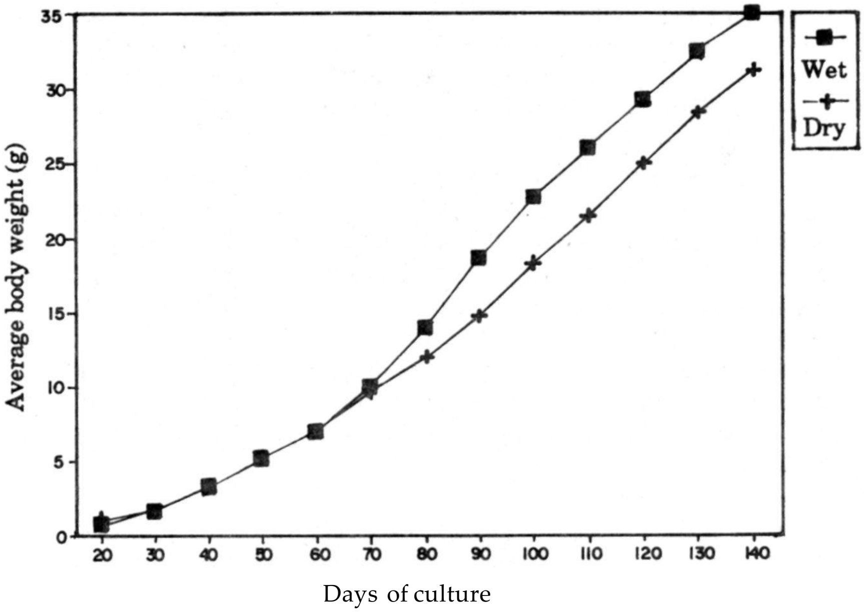

Fig. 2. Comparison of growth curves for semi-intensive shrimp farms in wet and dry seasons, 1992.

Pumping of ground water in semi-intensive and intensive shrimp farms has led to seawater intrusion of groundwater aquifers, and loss of well waters in surrounding communities. This has caused social conflicts (Cebu, Negros Occidental). Conflicts have also developed between multiple uses/users of river channels, including shrimp farms, subsistence fishing (use of fish traps), disposal of effluents and wastes from communities and industries, and agricultural runoff. The ability of rivers to flush themselves of pollution through tidal exchange or discharge has been hampered by siltation at the river mouth (Region VI-Negros,Iloilo,and Capiz; Region X - Panguil Bay and Butuan City). In Regions III, IV, and VI, complaints have been made about the effluents of sugar centrals/mills (molasses and chemicals). Distilleries have also been identified as a point source of pollution.

In view of the environmental (water quality) problems in shrimp farms, many farms now practice longer and more elaborate pond preparation in order to minimize the organic content inside the ponds. However, water quality still remains poor. It is hypothesized that ammonia and nitrite, produced by the deamination of proteins in uneaten feeds and shrimp wastes, become sub-lethal. Significant ammonia concentrations have been found one kilometer offshore from shrimp farm estuaries in Negros Occidental.

The Mt. Pinatubo eruption adversely affected shrimp farm areas in Bataan, Pampanga, and Zambales due to lahar deposition in river channels and shrimp farms. Tidal and water discharge from river channels have been restricted, causing turbid water for shrimp farms. Additional brackishwater farms have been lost due to lahar deposits. In Pangasinan, lahar is carried by rivers supplying shrimp farms, and this is exacerbated by heavy monsoon rains.

There is speculation that El Niño was responsible for a long drought period this past year. The resultant high salinities and temperatures caused poor growth and low survival, and a higher incidence of disease, an observation consistently found in all areas.

Diseases. Shrimp diseases have become more prevalent recently; part of this can be attributed to the drought in 1992, and part to the increasing intensification of farming systems. Poor pond water and soil quality is attributed to the accumulation of uneaten feeds and shrimp feces. The poor environment predisposes the shrimp to infectious processes, resulting in slower growth and poorer survival.

High cost of production. Cost of shrimp production in the country is considered higher than those of other shrimp-producing Asian countries (particularly Thailand and Indonesia). The variable production cost (per kg of shrimp) in the different systems:

	Extensive	*Semi-intensive*	*Intensive*
Variable cost	P88.48	P137.60	P114.69

Major contributors to the variable cost are:

	Extensive	*Semi-intensive*	*Intensive*
Feeds	26%	55%	66%
Fry	24%	13%	9%
Energy	0%	11%	10%
Salaries/wages	14%	9%	7%
Pond preparation	3%	5%	2%
Repair/maintenance	13%	3%	3%
Others	19%	2%	3%

Feeds are by far the greatest variable cost in the semi-intensive and intensive production systems. The high cost for fry in extensive system is due to the low survival rate under this type of management.

Fry quality. Many farmers indicate that there is variability in fry quality. Fry quality criteria have been established to screen fry prior to purchase from hatcheries or fry brokers. The most common complaint is the lack of correlation between the fry quality criteria and the performance of the fry in the pond.

Feed quality. Feed quality has also been blamed by shrimp farmers for the industry-wide poor feed conversion ratio, slow growth and low survival. Feed conversion ratios attained in semi-intensive and intensive farms range from 1.4 to 3.5. Poor feed conversion results in uneaten feed decomposing in the pond bottom, creating a stress on the shrimp by deteriorating the water quality with higher organic content, biological oxygen demand, ammonia, and nitrite.

Comprehensive Agrarian Reform Program. Issues raised by farmers against CARP include (1) the unacceptance of farms by banks as collateral for loans and (2) insufficient compensation vis-a-vis their high capital investment in the construction of the farm.

Incentives of the Board of Investments. BOI-registered shrimp farms note the following difficulties:

1. the extensive documentation required for BOI registration;
2. the time required to get BOI registration, due in part to the highly centralized processing of applications;
3. the long time needed to obtain export certification from shrimp processors/exporters; and
4. the difficulty of obtaining complete "rebates" of tax credits from feed millers.

High cost of money. The high interest rates (24-30%) has made shrimp farming less lucrative, especially when export prices decrease. Some shrimp farmers which had difficulty liquidating loans under guaranty of corporations and advanced credits are now leasing their farms.

The government mandate to all banks to lend 25% of their loan fund for agricultural projects, including shrimp farming, has not been effective. Shrimp farmers have noted that much of the agricultural loan fund are not loaned to agricultural projects but instead invested in treasury bills of the Central Bank.

Shift of shrimp farms to lower stock density and to milkfish farming. Because of the unreliable and inconsistent shrimp market prices and the environmental problems developing in the industry, some shrimp farms have decided to lower their stock densities or to shift to milkfish farming (e.g., Pangasinan). Lower stocking density is a general trend observed in all the areas surveyed. It is, therefore, anticipated that shrimp production will decrease in 1992 simply from a reduction in hectarage devoted to culture. The shift to lower stock density and to milkfish farming is an indication that shrimp growers realize the need to search for alternative solutions to the problems of the farming industry.

Solutions adopted by shrimp farms. The current problems of the shrimp culture industry necessitated alterations in farming systems and management on the part of the private sector. Some of these are:

1. Use of nursery ponds to grow fry to juveniles prior to stocking in grow-out ponds. The fry are tested for growth and survival rates for a 30-day period; poor fry stock are discarded, saving time and money that would have been spent in grow-out culture.
2. Integration of the components of the shrimp culture industry under one management, such as integrating hatchery operations, grow-out operations, processing and exporting as practiced by some large corporations.
3. Research is being done by the industry, such as corporations and-shrimp cooperatives, to solve some of the problems. Research on feed quality is being done by feed millers. The Negros Agri-Aqua Development, Inc. does applied research to solve problems of water quality and to monitor shrimp pond dynamics.

4. Establishment of diagnostic laboratories for fry, soil, and water quality.

5. The establishment of associations/cooperatives within the province or the region in order to solve common problems together. These organizations conduct seminars and workshops to update their scientific knowledge on shrimp farming, open direct marketing conduits to importing countries, monitor shrimp export price fluctuations, and disseminate technical and other information to members through newsletters.

Recommendations

The following recommendations adhere to the general philosophical guidelines on sustainable development of the shrimp culture industry. To achieve this, the industry needs to protect itself and its environment from organic pollution, and allow equitable resource allocation and utilization. Since there is always social accountability and social equity that accompanies an industry, as provided by the Constitution and laws of the land, opportunities also need to be provided for small fishermen/farmers to participate and benefit from the industry.

Crop rotation of shrimp and milkfish. In order to lessen the demands on the watershed, crop rotation of milkfish and shrimp is recommended, with milkfish culture during the dry month period or during the poor shrimp crop season in the area. This crop rotation technique has been applied successfully for three years at the Brackishwater Aquaculture Center, U.P. in the Visayas, Leganes, Iloilo where the Type I climate (two pronounced seasons) exists.

Milkfish (100 g) are stocked at 1500-2000/ha in November-March when salinity is high; fingerlings are grown to the 100-g size in another pond. Milkfish have proven to be effective in reducing the organic load in the pond from the previous shrimp crop that is grown from May to October. The larger milkfish are more efficient in grazing or filtering *lab-lab* or plankton and feeding on organic debris. When harvested, the milkfish are 300 to 500g in size, with a total harvest of about 500-750 kg/ha. Milkfish survival rate is often 95% or more. No feeding is given to milkfish and no fertilizers are introduced. *Lab-lab* or plankton growth is sufficient because of high amounts of organic nutrients in the pond.

Shrimp are stocked after a two-month pond preparation - tilling, washing, drying, and liming the pond bottom. No scraping of black mud is necessary. After water conditioning, PL 13-15 are stocked at 8-15/m^2 and reared to harvestable size using the technology for semi-intensive culture in feeding, tidal and pumping water management (except pumping of freshwater), and aeration. Survival ranges 75-90%. Shrimp are harvested at 31-35 g, producing 2.5-3.5 t /ha in a single crop.

Use of pond reservoirs for water supply and treatment ponds for discharge water. The use of pond reservoirs to settle organic matter from the water source before use in grow-out ponds will assist in cleaning the water supply. In Thailand, these reservoirs are about 30% of the farm area; they have deeper peripheral canals and shallower central portion to allow light penetration and growth of phytoplankton. The pumping of water during high tide obtains better water quality. The pond reservoir can also be used for growing shrimps to broodstock sizes (100 g for male and 70 g for female) at extensive stocking rates (3-5/m^2). Since growing broodstock takes about ten months or more, the stock are transferred to *hapas* while the reservoir is cleaned and prepared between crops. The area of the pond reservoir depends upon the volume needed for pond water management and the frequency of high tides in the area.

A primary treatment pond should accommodate discharge water from ponds, allowing the settling of organic matter prior to disposal in the surrounding environment. The culture of filter organisms like mussel in the settling pond assists in the reduction of organic matter. Algae such as *Gracilaria* and *Caulerpa* should also be cultured on an experimental basis to further clean the water. If these organisms can be cultured in the settling pond, additional financial benefits can be derived.

Use of nursery ponds in shrimp farming. Some shrimp farms use nursery ponds to rear PL 18-20 to juveniles for at least 30 days. Nurseries offer the following advantages:

a. In a month, the farmer can determine the growth and survival of a batch of PL. If the PL performance is poor, the farmer can abort the run and save time and money.

b. During the transfer from nursery to grow-out, the farmer can accurately estimate the biomass of shrimp, leading to more accurate projections of feeding rates in the grow-out phase.

c. Juveniles to be stocked for grow-out can be selected. Smaller juveniles (slower growing) can be culled and more uniformly sized shrimp can be expected during harvest.

Development of shrimp farm estates for small fishermen/farmers. The shrimp farm estate should be under one management with the fisherman/farmer beneficiaries agreeing to management decisions on culture technology, operations, marketing of harvest, and bulk buying of pond inputs (fertilizers, feeds, lime, etc.). The fisherman/farmer beneficiaries own the parcels of land and receive profits generated from the farm estate. However, a professional manager should be hired by the cooperative to handle the estate management. Further vertical integration of a shrimp hatchery and/or feed mill into the estate should be considered.

Expansion of shrimp farm areas. Expansion of shrimp farms is recommended within existing fishponds and marginal lands that are not wetlands. Prior to a final decision to convert these lands into shrimp farms, studies should be made on the carrying capacity of the water source and drainage area (river, bay, sea) to absorb organic and other pollution from the watershed and the planned farm. The size and intensity level of shrimp farm operations should be determined by the study. Regulation of expansion by government agencies protects both the future farms and the communities in these areas from potential environmental problems, and allow the multiple use of the resources. This can eventually lead to the zoning of areas suitable for shrimp farms.

Shrimp pond dynamics: pond soil and water quality research. Research on pond soil and water quality is necessary to determine the effects of intensity levels of farming systems on the quality of the pond soil and water, and to determine the pond preparation necessary to clean the pond bottom of undesirable materials prior to culture of shrimp. Ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen, hydrogen sulfide, organic matter, total phosphorus, acidity, iron, aluminum, and bacteria are parameters which can be monitored in pond soil and water. A vertical profile of these parameters in the pond bottom may be desirable, to a depth of 0.3 to 0.5 m. Preliminary data from the Brackishwater Aquaculture Center, U.P. in the Visayas indicate that organic matter, ammonia-nitrogen, and nitrite-nitrogen are high in the pond soil and water during the latter part of the culture period (4th and 5th month), and are directly correlated to stocking density.

Pond soil and water profiles should be compared for ponds converted from milkfish pond, sugarland, coconut land, riceland, among others. Comparisons should also be made before and after pond preparation, during and after the culture period, and at different stock densities. The results could provide insights for proper pond preparation and stocking densities to be used by shrimp farmers.

This is part of the Final Report: Phil. Prawn Industry Policy Study prepared for the Coordinating Council of the Phil. Assistance Program (CCPAP) and USAID Contract No. DAN-4180-B-00-8009-00 Order #3, January 1993.

Discussion

The technical issues discussed by the workshop participants include:

- Standard quality criteria for shrimp fry; marketing
- Pollution in intensive ponds; accumulation and disposal of black soil in the pond bottom; the use of settling or biological ponds
- Growth of farmed shrimp
- Alternatives to intensive shrimp culture: crop rotation, polyculture, and "rest" cycles
- Standard pond management techniques
- Feeding shrimps
- Professionalization of hatchery technicians through accreditation
- Sourcing of spawners; role of the middlemen
- Shrimp as a value-added product
- Incentives that can be granted by the government investors
- Deformities in hatchery-bred milkfish fry

REVIEW OF SEAFDEC/AQD RESEARCH, TRAINING, AND INFORMATION ACTIVITIES (1988-1991)

Seven papers were presented, including shrimp seed production, marine fish broodstock development and larviculture, fish health, and feed development.

A summary of the discussion that took place is presented.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE SEAFDEC AQUACULTURE DEPARTMENT, 1988-1991

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ABSTRACT

Research studies conducted from 1988 to 1991 focused on breeding, seed production, and farming of thirteen aquaculture species of regional importance. Studies aimed at developing economical feeds, as well as disease prevention and control were undertaken. Guided by the recommendations of ADSEA I (*Seminar-Workshop on Aquaculture Development in Southeast Asia;* 8-12 Sept. 1987; Iloilo City, Philippines), workshops to review the previous years' progress and identify specific studies for implementation were held annually since 1989 with the participation of academic institutions, government and private sectors.

Some 212 studies were implemented. Majority were on tiger shrimp, milkfish, and sea bass. Studies on other species of fishes, crustaceans, molluscs, and seaweeds, as well as larval food organisms, seafarming and economics of hatchery and grow-out culture systems were also undertaken. As of December 1991, 168 studies were completed. Research results were published in 204 scientific journals, proceedings, and other publications. In addition, 27 papers were in press and 63 manuscripts had been submitted.

That research output is gaining recognition in the international scientific community can be gleaned from the number of papers published in refereed journals covered by *Current Contents* (CC). Of the 142 papers published in scientific journals in 1988-1991, 115 (81%) appeared in CC-covered journals. This has increased from 58.8% (124 of 211) in 1976-1987. The active participation of the research staff in scientific meetings is equally evident from the number of publications in proceedings of scientific meetings from 1988-1991 (63).

The *Seminar on Aquaculture Development in Southeast Asia* (ADSEA I) held in 1987 reviewed the status of aquaculture in the region, identified gaps and constraints, and prioritized aquaculture species of regional importance and major areas for research for each species. Areas for collaboration in research and training among SEAFDEC Member Countries were also identified.

Among the 24 species identified were seven marine and brackishwater fishes, five freshwater fishes, five crustaceans, four molluscs, and three seaweed species.

The following were identified as priority areas for research:

Marine and brackishwater fishes (sea bass, grouper, red and golden snapper, mullet, rabbitfish, and milkfish) - (1) development of hatchery and nursery techniques, (2) feed development for nursery and grow-out, and (3) disease prevention and control in nursery and grow-out.

Freshwater fishes (red tilapia and other tilapias, marble goby, carp, and catfish) - (1) selective breeding, (2) refinement of hatchery techniques, (3) feed development for nursery and grow-out, (4) improvement of water management technique for nursery and grow-out, and (5) disease prevention and control.

Crustaceans (*Penaeus monodon, P. merguiensis, P. indicus, Macrobrachium rosenbergii, Scylla serrata, Metapenaeus ensis/M. monoceros*) - (1) development of captive broodstock, (2) development of cost-effective feeds for broodstock, hatchery and grow-out, (3) refinement of hatchery-nursery technology, (4) improvement of water management techniques for grow-out, (5) development of techniques for disease prevention and control, and (6) selective breeding.

Molluscs (*Perna viridis, Crassostrea* sp., *Anadara* sp., *Placuna placenta*) - (1) development of depuration techniques, (2) product development, (3) resource evaluation, (4) site identification and development of spatfall forecasting, (5) evaluation of culture technology, and (6) refinement of grow-out techniques.

Seaweeds (*Gracilaria, Porphyra, Eucheuma*) - (1) biological studies, (2) refinement of culture techniques, (3) screening and characterization of natural products and product utilization, (4) selective breeding, and (5) establishment of seed banks.

Research activities

With the ADSEA I recommendations as framework on which to base the research activities of the Aquaculture Department, a three-year plan of research activities was approved for implementation in 1989-1991 during the 21st meeting of the SEAFDEC Council. Annual workshops to review the previous years' research progress, and identify specific studies for implementation were held annually since 1989 with the participation of representatives from academic institutions, government and private sectors.

In 1986, research activities were centered on ten species, including four marine and brackishwater fishes (sea bass, grouper, rabbitfish, and milkfish), two freshwater fishes (carp and tilapia), two crustaceans (*P. monodon* and *M. rosenbergii),* two molluscs (oyster and mussel). The number of species being investigated has since increased to thirteen with the addition of catfish, *Clarias macrocephalus* (1987), *Gracilaria* (1988), mullet and *P. placenta* (1989),and snapper (1990). Research on *Macrobrachium* was discontinued in 1987, while work on rabbitfish was temporarily suspended in 1991.

The following were the major focus of research undertaken for each species: (1) sea bass - improvement of induced spawning techniques and improvement of hatchery and nursery technologies; (2) grouper, snapper, and mullet - broodstock development; (3) rabbitfish - improvement of seed production techniques; (4) milkfish - improvement of seed production techniques, hormonal induction of off-season sexual maturation, nutritional requirements, and improvement of grow-out culture methods; (5) tilapia - development of methods for strain selection and nutritional requirements of fry and fingerling; (6) carp and catfish - improvement of methods for induced spawning and development of seed production techniques; (7) tiger shrimp - disease prevention and control in hatchery and grow-out, nutritional requirements of broodstock and juveniles, and feed development for various life stages; (8) white shrimp - broodstock nutrition and development of seed production techniques; (9) molluscs - biology and stock assessment of *P. placenta;* and (10) seaweeds - development of methods for management of wild *Gracilaria* stocks and identification of species for culture.

Preliminary studies were undertaken to identify a pilot site for an integrated seafarming and searanching project. Studies to investigate factors associated with the occurrence of epizootic ulcerative syndrome or EUS in freshwater fishes and economic studies to assess cost-effectiveness of developed technologies were also undertaken.

Research accomplishments

The total number of studies implemented in 1988-1991 is 212 (Table 1). As of December 1991, 168 studies were completed (Table 2); the rest were deferred/ cancelled or are continuing.

Research results were published in 204 scientific journals, proceedings, and other publications (Table 3). In addition, 21 papers were in press and 67 manuscripts had been submitted as of December 1991. Significant research findings are discussed in the papers by Estepa, Garcia, Duray, Pitogo, and Millamena in this volume.

Some of the significant results include: (1) natural spawnings of milkfish and grouper in tanks; (2) reliable induced spawning techniques for sea bass, milkfish, catfish and bighead carp; (3) improved hatchery techniques for sea bass and tiger shrimp; (4) development of an experimental and statistical procedure for strain selection of tilapia; (5) determination of nutritional requirements of milkfish and tiger shrimp; (6) development of feed formulations using indigenous feed ingredients for milkfish, tiger shrimp, tilapia, and carp; (7) development of a microbound diet for tiger shrimp larvae; (8) determination of the etiology and route of infection of luminous bacterial disease in tiger shrimp, and development of methods for its prevention; (9) development of a method to reverse the soft-shell disease in tiger shrimp; and (10) screening of suitable *Gracilaria* species for culture, and development of methods for management of wild stocks.

The number of scientists was reduced from 72 in 1987 to 56 in 1990 and non-technical staff by more than half, from 258 in 1987 to 110 in 1990. The research performance of SEAFDEC/AQD scientists, however, has vastly improved. The number of scientific journal publications (142) during the period (1988-1991) exceeded that published in 1981-1987(136). That research output of

Table 1. Research studies by major species, 1988-1991

Commodity	1988	1989	1990	1991	Total
Sea bass	7	11	9	3	30
Grouper	1	6	5	3	15
Snapper			1		1
Mullet		1	1		2
Rabbitfish	4		1		5
Milkfish	9	3	12	2	26
Tilapia	7	5	3	1	16
Catfish	1			1	2
Carp	6	1		1	8
Tiger shrimp	25	13	10	3	51
White shrimp	5	2	2	1	10
Molluscs		3	4	2	9
Seaweeds	4	2	4	1	11
Other studies	12	5	8	1	26
Total	81	52	60	19	212

Table 2. Completed research studies, 1988-1991

Commodity	1988	1989	1990	1991	Total
Sea bass	4	9	6	7	26
Grouper		5	4	3	12
Snapper				1	1
Mullet			1	1	2
Rabbitfish	2	1	1		4
Milkfish	4	5	3	6	18
Tilapia	3	3	4	1	11
Catfish			1		1
Carp	5	1	1		7
Tiger shrimp	17	11	8	6	42
White shrimp	1	3	4		8
Molluscs		1	4	2	7
Seaweeds		2	3	4	9
Other studies	8	4	8		20
Total	44	45	48	31	168

SEAFDEC/AQD is gaining recognition in the scientific community can be gleaned from the number of papers published in journals covered by *Current Contents* (CC) (Table 4). Of the 142 papers published in 1988-1991, 115 (81%) appeared in CC-covered journals, an increase from 67% (98 of 146) in 1981-1987

Table 3. Research publications in scientific journals, proceedings, and other publications, 1988-1991

Commodity	1988	1989	1990	1991	Total
Sea bass	1	4	4	5	14
Grouper		1		2	3
Snapper					0
Mullet					0
Rabbitfish	3	1	2	3	9
Milkfish	16	9	11	10	46
Tilapia	12	1	5	3	21
Catfish				2	2
Carp	2	2	1	4	9
Tiger shrimp	15	15	13	12	55
White shrimp					0
Molluscs	1		1	1	3
Seaweeds		1	1	1	3
Other studies	5	10	15	10	40
Total	55	44	53	53	205

and 40% (26 of 65) in 1976-1980. The participations of research staff in scientific meetings continue to make significant contribution as evident from publications in proceedings during the period (63).

Collaborative projects

Collaboration with local and foreign universities, government agencies, international research institutions, and funding agencies during the period has increased. SEAFDEC/AQD is actively involved in several International Development Research Centre (1DRC) networks such as the Fish Genetics, Fish Microbiology, Fish Nutrition, and the Asian Fisheries Social Sciences Research Network (AFSSRN). Through these networks, research collaborations with the International Center for Living Aquatic Resources Management (ICLARM), Dalhousie University and Simon Fraser University in Canada, and the Universiti Pertanian Malaysia were facilitated.

Other collaborative projects were implemented with the University of Hohenheim, University of Ghent, University of Rhode Island, Food and Agriculture Organization/Network of Aquaculture Centers in Asia (FAO/NACA), and IFREMER. Seven research grants were awarded to AQD researchers by the International Foundation for Science (IFS). Collaborations with the University of the Philippines - Visayas (UPV), Marine Science Institute (UP-MSI), Seafarming Research Development Center (SRDC), Bureau of Aquatic Resources (BFAR), and the Negros Prawn Producers and Marketing Cooperative (NPPMCI) continue. Through the Japan International Cooperative Agency (JICA), five

Table 4. Research publications in scientific journals, 1988-1991

Commodity	1988	1989	1990	1991	Total
Sea bass	1	3	3	5	12
Grouper		1			1
Snapper					0
Mullet					0
Rabbitfish	2	1	2	2	7
Milkfish	13	7	5	8	33
Tilapia	6		2	2	10
Catfish				2	2
Carp	2	1	1	4	8
Tiger shrimp	2	10	10	11	33
White shrimp					0
Molluscs				1	1
Seaweeds		1	1	1	3
Other studies	4	8	10	10	32
Total	30	32	34	46	142
Current Contents-covered	25	25	27	38	115

Japanese experts conducted various studies in the Department. A total of 23 local and foreign graduate students also conducted their thesis research through various collaborative projects.

Research awards

During the period, nine AQD researchers were recipients of eight national and international awards for their research contributions. These include the Elvira O. Tan Memorial Award for Fisheries, Best Paper in Aquaculture (1988 and 1991); the American Institute of Nutrition, Graduate Student Research Award in Abstract Writing Competition (1988); and the Department of Agriculture-Bureau of Agricultural Research Best Paper Award in Fisheries and Aquatic Resources Category (1989, 1991 - first and second prizes), Best Paper in Socioeconomic Category (1990, 1991 - second prize), and Best Paper in Agricultural Engineering Category (1991).

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SHRIMP SEED PRODUCTION AT SEAFDEC/AQD

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Broodstock management and seed production techniques have evolved from laboratory and verification tests that are conducted to increase survival and growth rates of cultured fish species. The present methods of induced maturation and hatchery rearing of shrimp (*Penaeus monodon*) used at the SEAFDEC Aquaculture Department are examples.

Broodstock management

The use of wild or pond-reared adults that are induced to mature in captivity is a timely solution to the declining supply of wild-caught gravid shrimps. Since the successful use of the ablation method by Santiago (1977), induced maturation has been practiced at SEAFDEC. Quite a number of big hatcheries have also adopted the technique but many still prefer wild spawners as nauplii source due to the pond growers' bias against fry from ablated spawners. Eggs from ablated females have been shown to exhibit lower hatching rates (Vogt et al. 1989; Tan-Fermin 1991). Although pond-reared broodstock can be successfully induced to mature (Santiago 1977; Primavera 1978; Millamena 1989), they can not compete yet with ablated wild-caught adults which give a faster turnover, that is, they produce in 4-8 weeks the same number of nauplii that pond broodstock can give in 8-12 weeks (Primavera 1988).

Shrimp that are induced to mature are held in covered maturation tanks. [Tests have shown that good reproductive performance can be attained with green light (Primavera and Caballero 1989).] These maturation tanks are previously disinfected with 150 ppm formalin or detergent and thoroughly rinsed. Tanks are then filled with seawater (30-36 ppt) to a depth of 1 m.

Malesand females(60 g or 100 g, respectively)aredisinfected with 50 ppm formalin for 1 h and acclimated for about a week. Broodstock kept for more than a month without disinfection may acquire viral or bacterial diseases. After 50% have molted, females are ablated through the incision or the heated forcep method (Primavera 1978, 1989). Animals are then stocked at a density of 2-7/ m^2 (Primavera 1989) and at a ratio of 1 male to 1-2 females (Pudadera et al. 1980). Sampling to determine maturation is done 3-4 days after ablation.

Shrimp are fed pellets at 1-3% of body weight per day (Millamena et al. 1986) and mussel, squid, crab meat, or trashfish at 10-15%. Feeds are given separately to avoid selective feeding. Pellets are usually fed in the morning. Marine annelids (*Perenereis*), a good source of fatty acids essential to shrimp maturation, are given once or twice a week.

Water in tanks is totally replaced once weekly. Siphoning of excess feeds is done regularly. Feeding trays are also used to lessen frequency of siphoning.

Hatchery

The hatchery techniques adopted by SEAFDEC are based on the small tank hatchery system (Mock and Murphy 1971) where natural food culture, spawning, and larval rearing are conducted in separate tanks. The community or large tank system (Shigueno 1975) has been tried but high mortalities were encountered due to deterioration of water quality caused by uncontrolled algal blooms.

Hatchery operation begins with proper scheduling of activities, including natural food production and preparation of tanks and facilities. Scale-up production of natural food must be scheduled properly so that phytoplankton will be available when shrimps molt to the first protozoeal stage (Fig. 1). Tanks must be ready; tank preparation includes washing with detergent or hydrochloric acid and rinsing with clean freshwater. Disinfection with 200 ppm chlorine for one hour is also recommended (Po et al. 1989). After washing, tanks are dried under the sun whenever possible. New tanks need to be filled with fresh or seawater for at least a week to avoid mortalities due to toxic effects of chemicals (epoxy paint or even cement) used during construction. Tanks may or may not be placed under a roofed structure (Parado-Estepa et al. 1991).

Wild spawners that are used as sources of nauplii must be carefully selected to obtain high fertilization and hatching rates of eggs. Spawners must be disease-free, hard-shelled, and with spermatophore. It is best to choose shrimp with gonads at stages III or IV (Motoh 1981; Primavera 1988). A reliable method of determining stage would be to measure the ovarian width at the first abdominal segment; an ovarian width of at least 20 mm indicates readiness for spawning (Tan-Fermin and Pudadera 1989). If shrimp with gonads at stage II are chosen, ablation may still be necessary to induce maturation and subsequent spawning.

Spawners are usually disinfected with 200 ppm formalin prior to stocking in tanks (Po et al. 1989). Spawners are separated individually or in small groups to prevent contamination of the whole stock in case one or a few of the spawners are disease carriers. Disease is further prevented by washing the eggs right after spawning or before defecation of spawners. The feces of spawners have been identified as a source of luminescent bacteria (Lavilla-Pitogo et al. 1990a, 1990b).

During stocking and throughout the culture, sudden changes in the condition of the rearing water must be avoided. Stress, and consequently mortality, may occur if larvae or postlarvae are not given time to acclimatize. Temperature and salinity of the rearing water should be similar to the water used during transport or the broodstock source.

Stocking at lower densities is less risky since lower incidences of disease have been experienced. Nauplii are stocked at 50 individuals/1 in the larval tanks and reared until the early postlarval stage (PL1 or PL5). They are harvested and restocked in clean nursery tanks at 10,000-15,000/t. Larval tanks may also be used as nursery tanks.

The nauplius has yolk stored in its body, and it does not require food. Larvae are given phytoplankton (*Skeletonema, Chaetoceros* or *Tetraselmis*) starting on the first protozoeal stage. These phytoplankton are maintained at a density of 20,000 - 50,000 cells/ml in the rearing water. The density is determined with the use of the microscope and hemacytometer.

Dried preserved algal cells of diatoms or *Spirulina* are available commercially and can be used during the protozoeal stages. However, complete substitution of diatoms with these preserved algae must still be tested and evaluated. Algal cells can be preserved using the method described by Millamena et al. (1990).

Eggyolk can be used for feeding of the protozoea and the mysis stages (Quinitio and Reyes 1983). However, this was found to be deficient in some polyunsaturated fatty acids, an important component of larval diet. Artificial diets, called microparticulates because of their small particle size, can be given during the protozoeal stage. SEAFDEC has formulated a carageenan-microbound diet for larval rearing (Bautista et al. 1989; Bautista et al. 1991) but numerous diet formulations are also commercially available.

Animal protein is essential at the mysis stage. Although microparticulate diets contain animal protein, newly hatched *Artemia* nauplii is, so far, still the best food for the mysis and postlarval stages. *Artemia* cysts should be disinfected with hypochlorite (Sorgeloos et al. 1986) as unwashed *Artemia* cyst is a possible source of luminescent bacterial contamination (Lavilla-Pitogo 1990b). A summary of the suggested feeding schedule is given in Fig. 1.

To ensure that metabolites in the water do not exceed tolerable levels, water must be replaced regularly. With lower density rearing, water change can be started when the animals have all metamorphosed to the postlarval stage. This water management and stocking scheme is better than daily water change from the protozoeal stage onwards because it causes lesser stress and lower metabolite levels.

As in stocking, temperature and salinity of the water before and after water change must not differ by more than 1°C or 2 ppt, respectively. Levels of some water parameters recommended are given in Table 1.

Water for rearing is previously treated with 5-10 ppm hypochlorite and neutralized with sodium thiosulfate. As an oxidizing agent, hypochlorite kills or retards the growth of possible harmful microorganisms. It has been shown that chlorine reduces bacterial population by 90% (Baticados and Pitogo 1991). However, chlorine is also toxic to larvae or postlarvae so water must be neutralized before use. Water is also treated with 5-10 ppm EDTA (ethylene diamine tetraacetic acid) to chelate heavy metals (Licop 1988a).

During rearing, fungicide such as Trifluralin is applied every other day to prevent contamination with fungi. The fungicide being photosensitive is usually applied early in the morning or late in the afternoon.

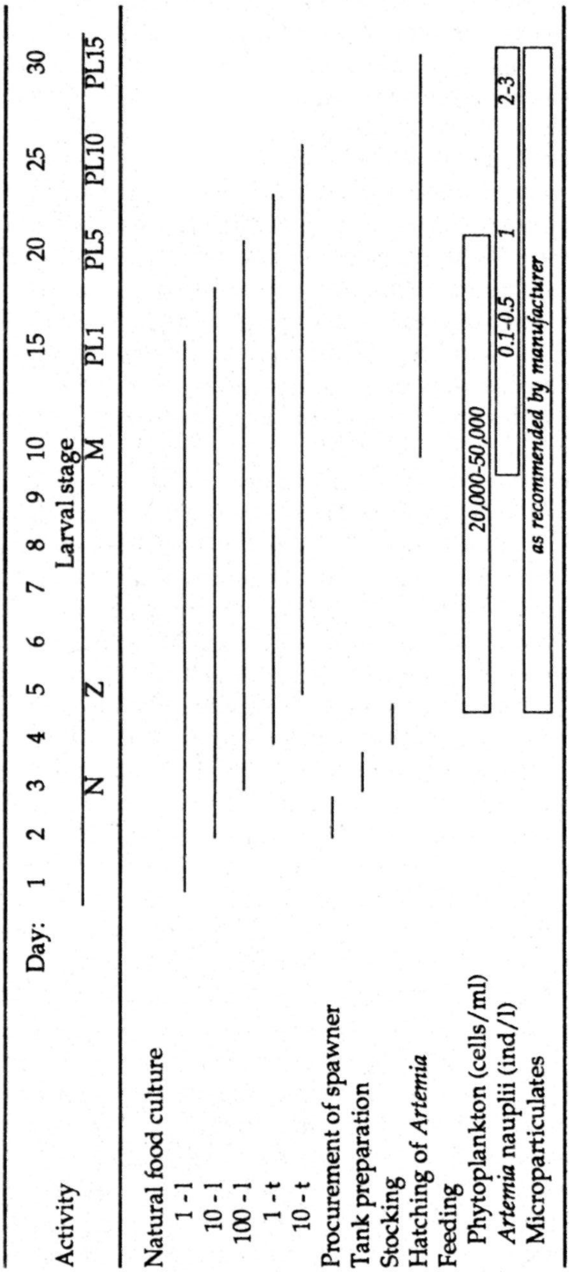

Fig. 1. Larval rearing of shrimp, *Penaeus monodon*.

Table 1. Recommended ranges of some water parameters suitable for a shrimp hatchery

Parameter	Range
Temperature	27-30°C
Salinity	30-36 ppt
pH	7.8-8.5
Dissolved oxygen	>3.5 ppm
Unionized ammonia (NH_3)	<0.1 ppm
NO_2-N	<0.02 ppm

Nursery

The nursery phase consists of rearing the early postlarval stage to older and more hardy and tolerant stage. In the hatchery, nursery rearing usually refers to the period from PL1-5 until PL15-20. Shrimps are harvested at the early postlarval stage, then transferred to other larval or nursery tanks.

Feeds during the nursery phase include Artemia nauplii or adults and formulated diets. Other feeds such as trashfish, squid, or mussel meat are not commonly used due to the resulting pollution in the rearing water.

Substrates are usually installed in the nursery tanks to provide solid surfaces on which the shrimp can cling to, provide shelter and protection from cannibalism during molting, and provide surface area on which food organisms can grow on.

Problems

One of the most pressing problems is the lack of shrimp spawners or adults. Thus, there is a need to give greater emphasis on broodstock development and induced maturation. Research on the refinement of hatchery techniques with emphasis on cost efficiency and disease prevention must continue.

REFERENCES

Baticados, M.C.L., E.R. Cruz-Lacierda, M.C. dela Cruz, R.C. Duremdez-Fernandez, R.Q. Gacutan, C.R. Lavilla-Pitogo, and G.D. Lio-Po. 1990a. Diseases of penaeid shrimps in the Philippines. Aquaculture Extension Manual No. 16. SEAFDEC/ AQD, Tigbauan, Iloilo. 46 p.

Baticados, M.C.L. and C.L. Pitogo. 1991. Chlorination of seawater used for shrimp culture. Israeli J. Aquacult. - Bamidgeh 42: 128-130.

Bautista, M.N., O.M. Millamena, and A. Kanazawa. 1989. Use of kappa-carrageenan microbound diet (C-MBD) as feed for *Penaeus monodon* larvae. Mar. Biol. 103: 169-173.

Bautista, M.N., F.D. Parado-Estepa, O.M. Millamena, and E. Borlongan. 1991. Large scale production of *Penaeus monodon* using natural food and artificial diets. Israeli J. Aquacult. - Bamidgeh 43: 137-144.

Kunvankij, P., L.B. Tiro, B.J. Pudadera Jr., I.O. Potestas, K.G. Corre, E. Borlongan, G.A. Taleon, L.F. Gustilo, E.T. Tech, A. Unggui, and T.E. Chua. 1988. Shrimp hatchery design, operation and management. NACA training manual series no. 1. Tigbauan, Iloilo. NACA Regional Lead Center in the Philippines. 88 p.

Lavilla-Pitogo, C.R., L.J. Albright, M.G. Paner, and N.A. Suñaz. 1990a. Studies on the sources of luminescent *Vibrio harveyi* in *Penaeus monodon* hatcheries. A paper presented at the Symposium on Diseases. Bali, Indonesia. 26-29 November 1990.

Lavilla-Pitogo, C.R., M.C.L. Baticados, E.R. Cruz-Lacierda, and L. de la Peña. 1990b. Occurrence of luminous bacterial disease of *Penaeus monodon* larvae in the Philippines. Aquaculture 91: 1-13.

Licop, M.S.R. 1988a. Sodium EDTA effects on survival and metamorphosis of *Penaeus monodon* larvae. Aquaculture 74: 239-247.

Licop, M.S. R. 1988b. Hatchery operations and management. In: Biology and culture of *Penaeus monodon.* Brackishwater Information System State-of-the-Art series no. 2. SEAFDEC Aquaculture Department. Tigbauan, Iloilo, Philippines. pp. 59-88.

Millamena, O.M, J.H. Primavera, R.A. Pudadera, and R.V. Caballero. 1986. The effect of diet on the reproductive performance of pond-reared *Penaeus monodon* Fabricius broodstock. In: Maclean J.L, L.B. Dizon, and L.V. Hosillos (eds.). The First Asian Fisheries Forum; 1986 May 26-31; Manila, Philippines. Manila: Asian Fisheries Society: 593-596.

Millamena, O.M. 1989. Effect of fatty acid composition of broodstock diet on tissue fatty acid patterns and egg fertilization and hatching in pond-reared *P. monodon.* Asian Fish. Sci. 2: 127-134.

Millamena, O.M., E. Aujero, and I.G. Borlongan. 1990. Techniques in algae harvesting and preservation for use in culture as larval food. Aquacult. Eng. 9: 295-304.

Mock, C.R. and M.A.Murphy. 1971. Techniques for raising penaeid shrimp from egg to postlarvae. First Annual Workshop, World Mariculture Society; proceedings; 1970 February 9-10, Louisiana, USA. 6p.

Motoh, H. 1981. Studies on the fisheries biology of the giant tiger shrimp, *Penaeus monodon,* in the Philippines. Technical Report No. 7. Tigbauan, Iloilo: SEAFDEC Aquaculture Department. 128 p.

Parado-Estepa, F.D. and J.H. Primavera. 1988. Broodstock management and seed production of *Penaeus monodon* (Fabricius). In: Juario, J.V. and L.V. Benitez (eds.). Perspectives in Aquaculture Development in Southeast Asia and Japan; Contributions of the SEAFDEC Aquaculture Department; proceedings; 1987 September 8-12; Iloilo City, Philippines. Iloilo: SEAFDEC Aquaculture Department. pp. 149-168.

Parado-Estepa, F.D., E.T. Quinitio, and E. Borlongan. 1991. Prawn hatchery operations. Aquaculture Extension Manual No. 19. Tigbauan, Iloilo, Philippines: SEAFDEC AQD.

Po, G.D., R.D. Fernandez, E.R.Cruz, M.C.L. Baticados, and A.T. Llobrera. 1989. Recommended practices for disease prevention in prawn and shrimp hatcheries. Aquaculture Extension Pamphlet No. 3. Tigbauan, Iloilo, Philippines. SEAFDEC Aquaculture Department. 17p.

Primavera, J.H. 1989. Broodstock of sugpo (*Penaeus monodon* Fabricius). Aquaculture

Extension Manual No. 5. 4th ed. Tigbauan, Iloilo, Philippines. SEAFDEC Aquaculture Department. 60p.

Primavera, J.H. 1988. Maturation, reproduction, and broodstock technology. *In:* Biology and culture of *Penaeus monodon.* Brackishwater Information System state-of-the-art series no. 2. SEAFDEC Aquaculture Department. Tigbauan, Iloilo, Philippines. pp. 37-57.

Primavera, J.H. and R. Caballero. 1989. Effect of tagging on maturation and survival of ablated *Penaeus monodon* in painted and unpainted tanks. The Philippine Scientist 26: 5-20.

Primavera, J.H. 1978. Induced maturation and spawning in five-month old *Penaeus monodon* by eyestalk ablation. Aquaculture 13: 355-359.

Pudadera, R.A.,J.H. Primavera, and E. Borlongan. 1980. Effect of different sex ratios on maturation, fecundity, and hatching rates of ablated wild stock *Penaeus monodon* Fabricius. Fish. Res. J. Philipp. 5:1-6.

Quinitio, E.T. and E.Reyes. 1983. The effect of different feed combinations using chicken egg yolk in *Penaeus monodon* larval rearing. In: Rogers, G.L., R. Day, and A. Lim (eds.). Proceedings of the first international conference on warm water aquaculture - Crustacea; 1983 Feb. 9-11; Brigham Young University Hawaii Campus. Brigham Young University: 333-336.

Santiago, A.C. Jr. 1977. Successful spawning of cultured *Penaeus monodon* Fabricius after eyestalk ablation. Aquaculture 11: 185-196.

SEAFDEC AQD Working Committee. 1984. Prawn hatchery design and operation (2nd ed.). Aquaculture Ext. Manual No. 9. Tigbauan, Iloilo, Philippines. 50p.

Sorgeloos, P., P. Lavens, P. Leger, W. Tackaert, and D. Versichele. 1986. Manual for the culture and use of brine shrimp *Artemia* in aquaculture. State University of Ghent, Belgium. 319 p.

Shigueno, K. 1975. Shrimp culture in Japan. Association for International and Technical Promotion. Tokyo, Japan. 153 pp.

Tan-Fermin, J.D. 1991. Effects of unilateral eyestalk ablation on ovarian histology and oocyte size freqency of wild and pond-reared *Penaeus monodon* (Fabricius) broodstock. Aquaculture 93: 77-86.

Tan-Fermin, J.D. and R. Pudadera. 1989. Ovarian maturation stages of the wild tiger prawn, *Penaeus monodon* Fabricius. Aquaculture 77: 229-242.

Vogt, G., E.T. Quinitio, and FP. Pascual. 1989. Interaction of the midgut gland and the ovary in vitellogenesis and conseqences for the breeding success: a comparison of unablated and ablated spawners of *Penaeus monodon.* p. 581-592. In: de Pauw N., E. Jaspers, H. Ackefors, and N. Wilkins (eds). European Aquac. Soc. Bredene, Belgium.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

MARINE FISH BROODSTOCK DEVELOPMENT AT SEAFDEC/AQD: STATUS AND ADVANCES

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The success of a fish culture operation depends, in part, on adequate supply of seed for hatchery and grow-out. The culture and husbandry of many of Southeast Asia's marine fish species are constrained by the unreliability of seed supply which are seasonally gathered from coastal areas. To augment the natural seed supply and decrease the dependence on wild catch, SEAFDEC/AQD has undertaken studies to develop a captive source of breeders for some of the economically important marine fish species in the region.

This paper presents a brief update of the status and recent advances in marine fish broodstock development undertaken by SEAFDEC/AQD.

Grouper (*Epinephelus* spp.)

Initial work on broodstock development of grouper at SEAFDEC/AQD began in 1986. Spawning of mature *E. salmoides* following two injections of luteinizing hormone-releasing hormone analogue (LHRHa) or human chorionic gonadotropin (HCG) and carp pituitary extract has been reported (Kungvankij et al. 1986). The treatment protocol was not, however, further duplicated nor improved in recent years due to lack of captive spawners. Subsequent efforts, therefore, concentrated on obtaining wild spawners, which were then reared in concrete tanks or sea cages.

Since grouper is a protogynous hermaphrodite, captive young juvenile groupers reared until the onset of gonadal maturation are most likely females, which invert into males at an unknown age. Wild spawners were usually females and very rarely were male grouper caught. Methods to control sex inversion in this species was, therefore, initiated in 1989. Two synthetic androgens, methyltestosterone (MT) and mibolerone, were used. MT in silastic capsules failed to induce sex inversion in adult female grouper (3-9 kg body weight) after 7 monthly implantations (SEAFDEC/AQD 1989). However, 3 months after termination of biweekly MT injections (0.5-5 mg/kg), histological signs of sex inversion in the gonads were noted (Tan-Fermin et al. 1989). Fish weighing more than 1.2 kg underwent spermatogenesis, but fish receiving MT and the hormone produced milt. Similarly, results indicate that juvenile grouper fed a moist diet enriched with mibolerone did not invert sex (SEAFDEC/

AQD 1989,1990). Intra-specific interaction of juvenile grouper of varying sizes held in communal tanks did not effectively invert sex of the largest individual in the group (SEAFDEC/AQD 1990). Only about 4% of the females possessed a transitional ovotestis 11 weeks after social interaction commenced.

The first spontaneous spawning of adult *E. suillus* broodstock in the Philippines was achieved in 1990 among fish reared in 50-t concrete tanks (6 females to 4 males) and in sea cages (1 female to 2 males). Tank-reared broodstock spawned year-round from 6 to 14 times monthly (SEAFDEC/AQD 1990). Cage-reared broodstock, however, spawn only from July to October, coinciding with the known breeding season of grouper in the Philippines.

Milkfish (*Chanos chanos*)

Initial research on milkfish focused on the biology of wild adults *(sabalo)* in Panay Island. Ecological studies to determine the age, spawning sites, migration patterns, and external sex markers of adult milkfish were conducted (Juario et al. 1983). This information was critical in the effort to use wild adults as source of seed for hatchery production of milkfish fry.

The availability of wild milkfish adults caught by fish traps during their annual spawning migration along the Panay coastline provided material to test the effectiveness of hypophysation to induce spawning. Following the success of semi-purified salmon gonadotropin (SG-G100) to induce ovulation in milkfish (SEAFDEC/AQD 1976), the use of a salmon pituitary homogenate (SPH) and HCG was further standardized to determine the optimum hormone dose, injection, intervals, and initial egg size required to trigger spawning. About 20 mg SPH and 3000 IU HCG per kg administered in 2 injections at 12-24 h intervals were required to induce spawning in fish with an initial egg diameter of 0.66 mm (Juario et al. 1984). Vitamin B was also injected to "counteract captive- and handling-related stress" of *sabalo* (Liao et al. 1979). About 5000 IU HCG and a long-acting testosterone formulation maintained milt production for a week in contrast to only 3 days when HCG alone was used (Juario et al. 1980).

In addition to hypophysation, LHRHa was also tested in mature milkfish. Initial results of LHRHa combined with HCG injection either failed to induce spawning when the initial egg size was 0.99 mm (SEAFDEC/AQD 1983) or fish underwent ovarian hydration to complete release of eggs (SEAFDEC/AQD 1986). Subsequent results, however, indicated that LHRHa administered by injection or pellet implantation to promote chronic release of the incorporated hormone can induce spawning of milkfish 18-36 h after administration (Marte et al. 1987). LHRHa contained in an osmotic pump was less effective than either pellet-implantation or injection.

Attempts to initiate and advance gonadal development of sexually immature adult milkfish and rematuration of spent *sabalo* by SPH, LHRHa, and estrogen failed (SEAFDEC/AQD 1980, 1981, 1982), in part, because "gonadotropin" remained in circulation for 1-2 days only (Marte and Crim 1983). However, hormone-implanted milkfish were sexually mature in a cage several months after termination of the hormone therapy (SEAFDEC/AQD 1980). Testosterone implantation of 3- and 4-year old fish resulted only in males becoming mature (SEAFDEC/AQD 1984). Tank-reared 4-year old milkfish were mature after chronic administration of LHRHa and testosterone (SEAFDEC/AQD 1986; Marte et al. 1988). These variable results suggest that milkfish may have different hormonal requirements for maturation, re-maturation, and spawning.

Cryopreservation of gametes becomes an alternative when the supply of wild broodstock is depleted or when gametes which are not synchronously released are required for artificial fertilization. Milkfish serum remains as the best extender for cryopreservation of milkfish milt (SEAFDEC/AQD 1981; Hara et al. 1982). When used to fertilize eggs, frozen milt in glycerine had higher fertilization rates than milt with dimethyl sulphoxide as cryoprotectant.

Spontaneous maturation and spawning of cage-reared broodstock was first achieved in 1980 and has since been repeated yearly during the breeding season of milkfish in Panay and elsewhere in the Philippines (Marte and Lacanilao 1986; DA-BFAR 1989). Collection of naturally spawned eggs in sea cages has also been markedly improved by the development of an egg sweeper and a fine mesh *hapa* net to retain eggs inside the maturation cage (Garcia et al. 1988; Marte 1988). Likewise, adult milkfish reared in concrete tanks have also undergone spontaneous maturation and spawning since 1990 (Emata and Marte 1990). Breaking all previous records, a combined total of more than 70 million eggs from more than 50 spawnings by milkfish breeders in Igang and Tigbauan have been collected in 1992. Nutritional studies to improve the quality of milkfish seed suggest that a lipid-enriched diet may advance spawning or enhance egg production by cage-reared broodstock (SEAFDEC/AQD 1987).

Further, morphological and physiological changes occurring during sexual maturation of milkfish have been characterized. Although blood parameters appeared variable during maturation, pituitary cells showed distinct morphological changes during the annual gonadal cycle (Tan 1985). A female-specific protein (vitellogenin) characterized in milkfish plasma may be used to distinguish sexes (SEAFDEC/AQD 1989).

Snapper (*Lutjanus* spp.)

Wild snappers of unknown species caught in coastal waters off Panay Island are only recently being domesticated in sea cages and in concrete tanks. Fish have spontaneously matured in these holding structures, but failed to spawn naturally. Recently, mature snapper in circular concrete tanks have been induced to spawn 27 h after an injection of 1500 IU HCG/kg (ADN 1992). Eggs collected by air-lift and manual seining totalled about 1.3 million, of which 95% were fertilized.

Sea bass (*Lates calcarifer*)

Like milkfish, research on sea bass breeding was initiated by the successful spawning of hypophysed mature broodstock (SEAFDEC/AQD 1983). Several analogues of LHRHa administered in various ways (injection, cholesterol pellet, osmotic pump, and silastic-based implants) were also successful in inducing single or consecutive spawnings at 24 h intervals over 4-5 days (Nacario and Sherwood 1986; Almendras et al. 1988).

Further improvement of the use of LHRHa was also achieved by defining the optimum dose required to induce single or consecutive spawnings. Implantation of pelleted LHRHa within the range 4.75-75 µg/kg stimulated a dose-dependent spawning response while higher dosages (150-300 µg/kg) resulted in significantly fewer spawnings (Toledo et al. 1991). Fertilization rates were low after implantation of the highest pelleted LHRHa dose (300 µg/kg), but hatching rates were not significantly different after induction of consecutive spawnings by various LHRHa dosages. Egg production peaked on the first day of consecutive spawnings, but declined on subsequent days. Similarly, single or consecutive spawnings by mature sea bass may be triggered by various amounts of injected LHRHa (Garcia 1989b). A single injection of 5 µg LHRHa/kg or less resulted in at least one spawning every 4 days. Higher dosages of LHRHa (10 µg/kg and above) stimulated more than one spawning in 4 days. Egg production, fertilization and hatching rates were not significantly influenced by various amounts (1-10 µg/kg) of the injected hormone.

To further refine the LHRHa spawning protocol, a technique was developed to obtain intra-ovarian oocytes for a more reliable means of determining the initial ovarian condition of fish prior to hormone treatment (Garcia 1989c). Eggs can be routinely sampled with a polyethylene tubing inserted into the genital pore of sea bass and then fixed in 5% buffered formalin for egg diameter measurement. The spawning response of sea bass to LHRHa can be better predicted if the initial egg size of recipient fish becomes known. Hence, mature sea bass with an initial egg diameter of 0.40-0.49 mm spawned after an injection of 100 µg LHRHa/kg, but fish with an initial egg size of less than 0.40 mm did not (Garcia 1989b). Fish having an initial egg diameter of 0.50-0.55 mm may spawn spontaneously with or without exogenous LHRHa. Also, the time of hormone injection can be manipulated to maximize the number of eggs spawned by LHRHa-treated sea bass (Garcia 1990a). Egg production was greater among LHRHa-injected fish which spawned at dawn than during the day. Sea bass spawn at dawn when LHRHa was administered during daytime.

One of the major objectives of fish breeding is to manipulate gonadal cycles to be independent of the annual or diurnal periodicities, so that gametes for seed production become available on demand. Chronic implantation of pelleted LHRHa and MT to cage-reared sea bass broodstock has partly achieved this objective. A hormonal therapy consisting of regular implantation of LHRHa alone or in combination with MT during the off-season months of February until March advanced gonadal maturation and spawning in May, which is earlier than the peak spawning months of July and August (Garcia 1990b). Attempts on off-season maturation of sea bass by hormonal and photoperiodic cues are in progress (SEAFDEC/AQD 1990). During the breeding season, spontaneous spawning of cage-reared sea bass coincide with the declining spring tides of quarter moons (Garcia 1992; Toledo et al. 1991). LHRHa treatment, however, can effectively override the lunar- and tide-synchronized spawning rhythm.

Although further studies are required, the milt response of sea bass to both LHRHa and MT suggests a potential role of this particular spawning protocol in the improvement of sperm production and milt dilution, and enhancement of spontaneous milt release (Garcia 1992). In addition, the maintenance of the biological potency of LHRHa can be improved by proper handling, preparation, and storage of the hormone. Hence, sea bass spawned after an injection of solubilized LHRHa stored for less than 90 days in a refrigerator (4-10°C) or 30 days at room temperature (28-30°C) (SEAFDEC/AQD 1990). Also, pelleted LHRHa stored for 120 days at room temperature retained its potency.

Rabbitfish (*Siganus guttatus*)

Earlier studies on breeding rabbitfish involved multiple injections of an anti-estrogenic compound (clomiphene citrate) in combination with HCG (SEAFDEC/AQD 1982). Later studies proved the effectiveness of HCG alone to induce spawning of mature rabbitfish (Juario et al. 1985) although fish with an initial egg diameter of at least 0.46 mm and greater did not require hormone treatment (Ayson 1991). Fish with an initial egg size of <0.45 mm require multiple HCG injections (2 IU/g) (Juario et al. 1985). Handling-associated stress also enhanced spawning of rabbitfish comparable with HCG-injected fish (Ayson 1989). In addition to HCG, silastic-based LHRHa implantation advanced spawning of female rabbitfish 1-2 days earlier than sham controls (Harvey et al. 1985). LHRHa also stimulated milt production and milt dilution a day after hormone injection (Garcia 1991).

Rabbitfish broodstock may spawn year-round without exogenous hormone intervention. Female rabbitfish fed a cod liver oil-rich diet spawned repeatedly for at least 4 consecutive months between the first quarter and full moon periods (Hara et al. 1986). Similarly, mature oocytes were present for 5 consecutive months among rabbitfish fed a lipid-enriched diet (SEAFDEC/AQD 1990).

Mullet (*Mugil* spp. and *Valmugil* spp.)

Mullet mature but do not spawn spontaneously in captivity. The hypophysation protocol of mullet has already been developed and established elsewhere, but trials using LHRHa require further work. Hypophysation using HCG and SPH induced ovulation in fish having an initial egg size of 0.6 mm (SEAFDEC/AQD 1980). However, mullet with an initial egg diameter of 0.89 mm were stimulated to spawn by a single injection of 1000 IU HCG/kg (SEAFDEC/AQD 1981). Ovulated eggs were normally stripped and artificially fertilized with fresh or cryopreserved milt (SEAFDEC/AQD 1982).

Conclusion and prospects

Marine fish broodstock development continues to be a major research effort at SEAFDEC/AQD, although much has been achieved over the years. The breeding of captive milkfish, sea bass, and rabbitfish is already a fairly routine achievement which is ready for adoption by trained fish farmers. Off-season spawning of milkfish and sea bass broodstock has to be assured to produce seed year-round. Improvements on the present broodstock diet is necessary to produce quality seed stock.

The development of grouper and snapper broodstock, however, requires further research prior to being considered an established technology. Specifically, sex inversion among hermaphroditic fish species must be controlled to maintain an adequate sex ratio among broodstock.

The lack of a keen interest in Southeast Asia for producing mullet seed from broodstock is apparent due, in part, to its relatively low popularity as food fish in many areas of the region. Nonetheless, the improvement of hatchery techniques will continue until production will significantly augment supply from natural sources. The development of broodstock of other marine fish species with culture potential in Southeast Asia will also continue.

REFERENCES

Almendras, J.M., CE. Dueñas, J. Nacario, N.M. Sherwood, and L.W. Crim. 1988. Aquaculture 74:97-111.

Aqua Dep't News (ADN). 1992. 7:1.

Ayson, F.G. 1989. Aquaculture 80:241-246.

Ayson, F.G. 1991. Aquaculture 95:133-137.

Department of Agriculture - Bureau of Fisheries and Aquatic Resources (DA-BFAR). 1989. Bangus Breeding (Philippines), Final Report. 36 pp.

Emata, A.C. and C.L. Marte. 1990. SEAFDEC Asian Aquaculture 12:1-3.

Garcia, G.H. 1992. MSc Thesis. University of the Philippines in the Visayas. 51 pp.

Garcia, L.Ma.B. 1991. Aquaculture 97:291-299.

Garcia, L.Ma.B. 1992. J. Fish Biol. 40:359-370.

Garcia, L.Ma.B. 1990a. J. Applied Ichthyol. 6:167-172.

Garcia, L.Ma.B. 1990b. Aquaculture 86:333-345.

Garcia, L.Ma.B. 1989a. Aquaculture 77:85-96.

Garcia, L.Ma.B. 1989b. J. Applied Ichthyol. 5:177-184.

Garcia, L.Ma.B. 1989c. Aquaculture 77:97-102.

Garcia, L.Ma.B., C.L. Marte, and V.3. Traviña. 1988. Aquaculture 68:83-86.

Hara, S., M.N. Duray, M. Parazo, and Y. Taki. 1986. Aquaculture 59:259-272.

Hara, S., J.T. Canto Jr., and J.M.E. Almendras . 1982. Aquaculture 28:339-346.

Harvey, B., J. Nacario, L.W. Crim, J.V. Juario, and C.L. Marte. 1985. Aquaculture 47:53-59.

Juario, J.V., M.N. Duray, V.M. Duray, J.F. Nacario, and J.M.E. Almendras. 1985. Aquaculture 44:91-101.

Juario, J.V., M.N. Duray, V.M. Duray, J.F. Nacario, and J.M.E. Almendras. 1984. Aquaculture 36:61-70.

Juario, J.V., R.P. Ferraris, and L.V. Benitez (eds.). 1983. Advances in Milkfish Biology and Culture. Island Publishing House, Inc., SEAFDEC/AQD and IDRC. 244 pp.

Juario, J.V., G.F. Quinitio, J.E. Banno, and M. Natividad. 1980. Kalikasan, Phil. J. Biol. 9:321-326.

Kungvankij, P., L.B. Tiro, B.P. Pudadera, and I.O. Potestas. 1986. In: Maclean J.L., L.B. Dizon, and L.V. Hosillos (eds.). The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines. pp. 663-666.

Liao, I.C., J.V. Juario, S. Kumagai, H. Nakajima, M. Natividad, and P. Buri. 1979. Aquaculture 18:75-93.

Marte, C.L. 1988. Aquaculture 71:387-392.

Marte, C.L., L.W. Crim, and N.M. Sherwood. 1988. Aquaculture 74:131-145.

Marte, C.L., N.M. Sherwood, L.W. Crim, and B. Harvey. 1987. Aquaculture 60:303-310.

Marte, C.L. and F. Lacanilao. 1986. Aquaculture 53:115-132.

Marte, C.L. and L.W. Crim. 1983. Kalikasan, Phil. J. Biol. 12:100-106.

Nacario, J.F. and N.M. Sherwood. 1986. In: Maclean J.L., L.B. Dizon, and L.V. Hosillos (eds.). The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philip pines; p. 13.

SEAFDEC/AQD Annual Report(s). 1976, 1980, 1981, 1982, 1983, 1984, 1986, 1987, 1989, 1990.

Tan-Fermin, J.D., L.Ma.B. Garcia, and A.R. Castillo Jr. 1989. In: Chan, D.K.O. (ed.). Hormones and the Environment. Society for the Study of Endocrinology, Metabolism and Reproduction, Department of Medicine, University of Hong Kong; pp. 19-20.

Tan, J.D. 1985. J. Fish Biol. 26:657-668.

Toledo, J.D, C.L. Marte, and A.R.Castillo Jr. 1991. J. Applied Ichthyol. 7:217-222.

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LARVICULTURE OF MARINE FISHES AT SEAFDEC/AQD

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The recent glut in the world market for shrimp dealt a heavy blow to the aquaculture industry. It is thus apparent that fish farmers should not depend on only a single species for culture. The popularity and market demand for grouper, sea bass, and snapper make them obvious choices as alternative culture species. On the other hand, milkfish and rabbitfish are cheaper sources of protein and they already contribute substantially to fish production from aquaculture--56.2% from milkfish for example (Rabanal 1988). However, culture and production of marine fishes are hindered by the unpredictable and seasonal seed supply. Research on larviculture at SEAFDEC/AQD are geared towards hatchery production of fry to augment supply from the wild.

Status

There are five marine fish species being cultured at AQD, namely: grouper (*Epinephelus suillns*), sea bass (*Lates calcarifer*), milkfish (*Chanos chanos*), rabbitfish (*Siganus guttatus*), and most recently the snapper (*Lutjanus argentimaculatus*). Although larviculture of milkfish was first tried in 1977, it was only after spontaneous spawning occurred that larval rearing techniques rapidly developed. At present, this hatchery technology (Gapasin and Marte 1990) is verified in selected private hatcheries in Antique, Capiz, and Iloilo of Panay Island with very promising results. The seed production technique for sea bass developed in Thailand has been modified to suit local conditions. This in turn has already been adopted by some private hatcheries. Although larval rearing techniques for the rabbitfish are available, these techniques have yet to be tried in commercial scale. Larviculture of grouper and snapper are still under experimentation.

Larviculture

Spawning. Naturally spawned eggs are commonly used in larval rearing trials. These come from mature fish induced to spawn by hormonal injection or pellet implantation. *E. suillus* spawn from 1600 to 1800 H within four days before or after the last quarter moon phase (Toledo et al. 1990). Sea bass usually spawn in the evening (Garcia 1988) between 1900 and 2300 H four days before or after the first quarter moon and within five days before or three days after the last quarter (Toledo et al. 1991).

Egg collection and transport. Except for the rabbitfish whose eggs are adhesive and demersal, the pelagic eggs of other species are collected by manual seining or by draining the water in the tank into an egg concentrator seine. SEAFDEC/AQD has designed a manually operated "egg sweeper" for milkfish (Garcia et al. 1988). For *S. guttatus,* an egg collector or a substrate is placed at the bottom of the tank prior to spawning. This substrate can be transferred to incubation or rearing tanks.

Eggs are transported from Igang Marine Substation to the hatchery at Tigbauan Main Station in double-layered oxygenated plastic bags inside *pandan* bags. Packing densities vary from 90,000 to 300,000 in 8-101 of water depending on the species.

Incubation. Eggs are incubated in 400- or 500-1 tanks or directly stocked in 3- or 5-t larval rearing tanks at stocking densities ranging from 100 to 400 egg/1. Dead eggs are removed and incubation water is partially changed by allowing the water to flow through for no less than 30 min. Moderate aeration is provided to each tank. Incubation period is about 17-18 h for the grouper, 12-17 h for sea bass, 26-32 h for milkfish, 18-20 h for rabbitfish, and 17-18 h for the red snapper.

Larval rearing

Food and feeding

Rotifers are still essential in the initial stage of rearing the various marine fish larvae because of their size and ease of culture. Most marine fish larvae are fed rotifers on day 2 at 10-15 rotifers/ml. Newly hatched brine shrimp nauplii are usually given on day 15 starting at ≤ 1 ind/ml. This rate is gradually increased as larvae grow. Gradual weaning from one prey type to another is practiced (Fig. 1-3).

Growth and survival are significantly better if sea bass larvae are given ≥ 6 ind/ml *Artemia* nauplii four times a day (Duray 1990). To optimize the use of *Artemia* on sea bass larvae, mouth width development is monitored. Dhert et al. (1990) suggested the use of newly hatched San Francisco Bay type of *Artemia* (430 μm) from days 8 to 10, Great Salt Lake *Artemia* (500 μm) from day 11 and onwards. HUFA-enriched Great Salt Lake metanauplii (800 μm) can be given starting day 14. Metamorphosis has been enhanced with the use of HUFA enrichment, and larvae, in turn, show strong resistance to salinity stress.

In milkfish, a combination of microparticulate feed and rotifer can result in significantly bigger larvae than those solely fed rotifer or microparticulate feed (Marte and Duray 1991). Likewise, a significant increase in growth and survival of the larvae is observed when larvae are fed HUFA-enriched rotifers compared to *Chlorella*-fed ones (Duray, unpubl.). This result is similar for those larvae given microparticulate feed and rotifer. Milkfish are also observed to be more robust and to have slightly higher survival rates when reared in open outdoor tanks. The verification runs in private hatcheries use open outdoor tanks in rearing milkfish larvae.

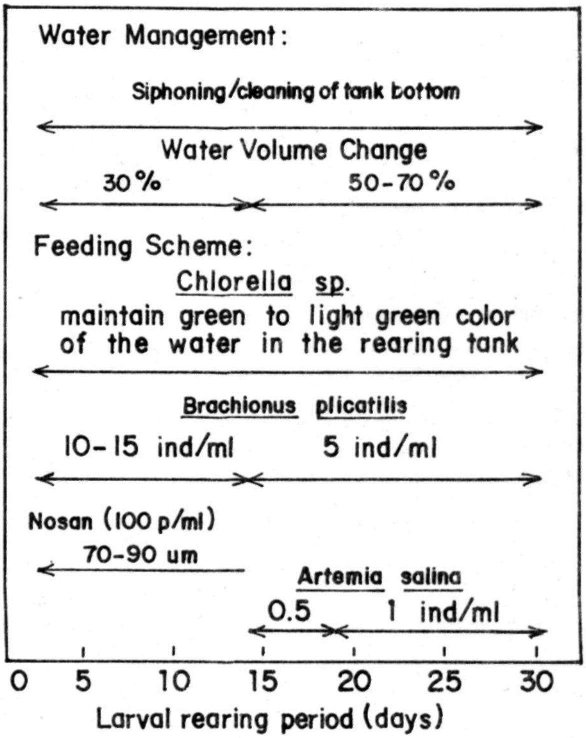

Fig. 1. Water management and feeding scheme for rearing milkfish larvae (Juario and Duray in Marte 1988; Marte and Duray 1991).

Since both siganid and grouper larvae have small mouths, screened rotifer (< 90 µm) can be used during initial feeding in the absence of SS-rotifer strain. If *Artemia* is fed starting day 21 rather than day 14, mortality for grouper larvae is lower.

Water management

Compared to other species, siganid and grouper larvae are reared initially in static water system for 5 to 7 days; otherwise, partial water changes from 30-50% during the rotifer feeding days and 50-75% on brine shrimp feeding period are followed. Larviculture of milkfish in open outdoor tanks requires greater volume of water to be changed; if not feasible, a flowthrough system is allowed for 1-2 h until the water becomes clear of diatom bloom.

Stocking rate

The initial stocking density used for most of these fish species is 30 larvae/1. For grouper, a stocking rate of 10-20 larvae/1 is optimum. For sea bass, from an initial stocking rate of 30 larvae/1, the density is reduced by half every ten days. Grading of the stock is done before restocking sea bass in freshly cleaned tanks.

Diseases and their control

Common disease problems encountered in the hatchery are related to viral or bacterial infection. Vibriosis associated with the appearance of red spots

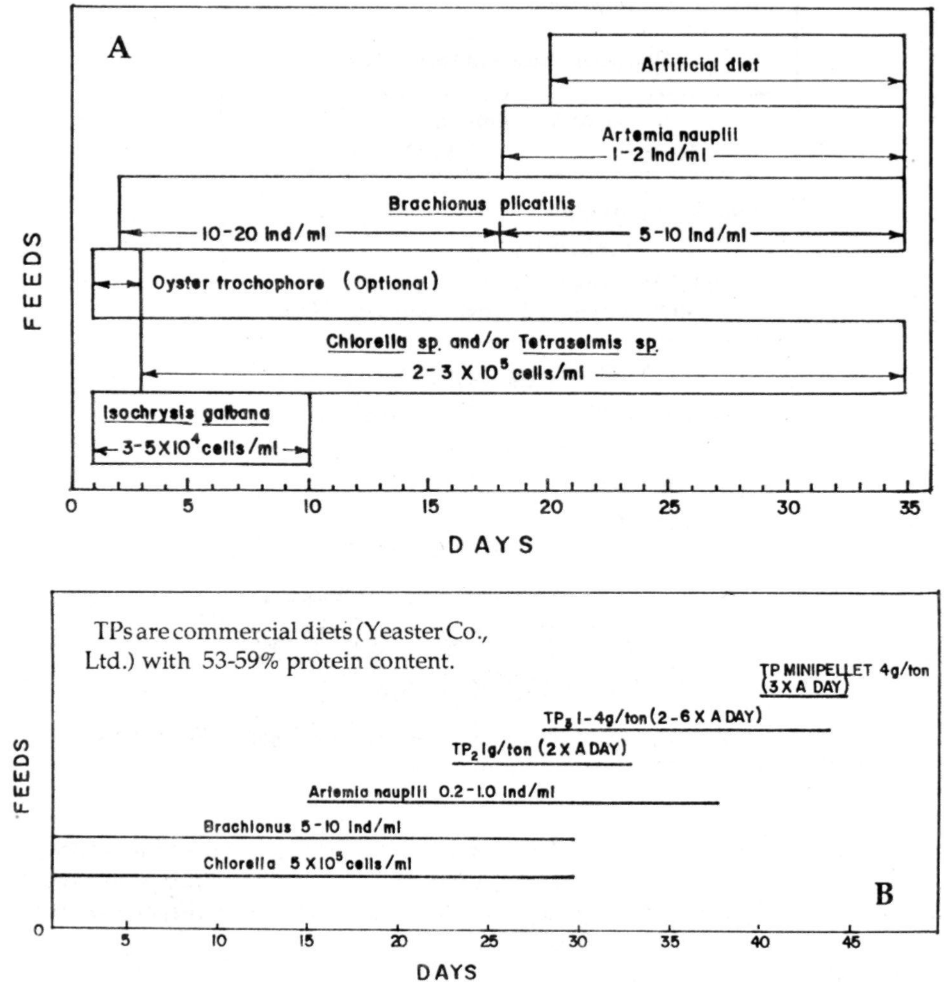

Fig. 2. *Siganus guttatus:* feeding schedule for larvae. A, *after* Juario et al. 1985; B, illustrated based on data in Hara et al. 1986.

in the tank bottom and sides is common. Application of freshwater directly to the infected area effectively controls the infection after two to three days (Duray and Juario 1988).

Swimbladder stress syndrome (SBSS), often mistaken as gas bubble disease, is observed. This is due to environmental stress. High stocking density accompanied by high levels of ammonia-nitrogen and other stress-inducing factors may contribute to SBSS occurrence. Some preventive measures include the maintenance of good water quality, adequate nutrition, and reduction of other environmental stress like low dissolved oxygen, extreme temperatures, and build-up of wastes.

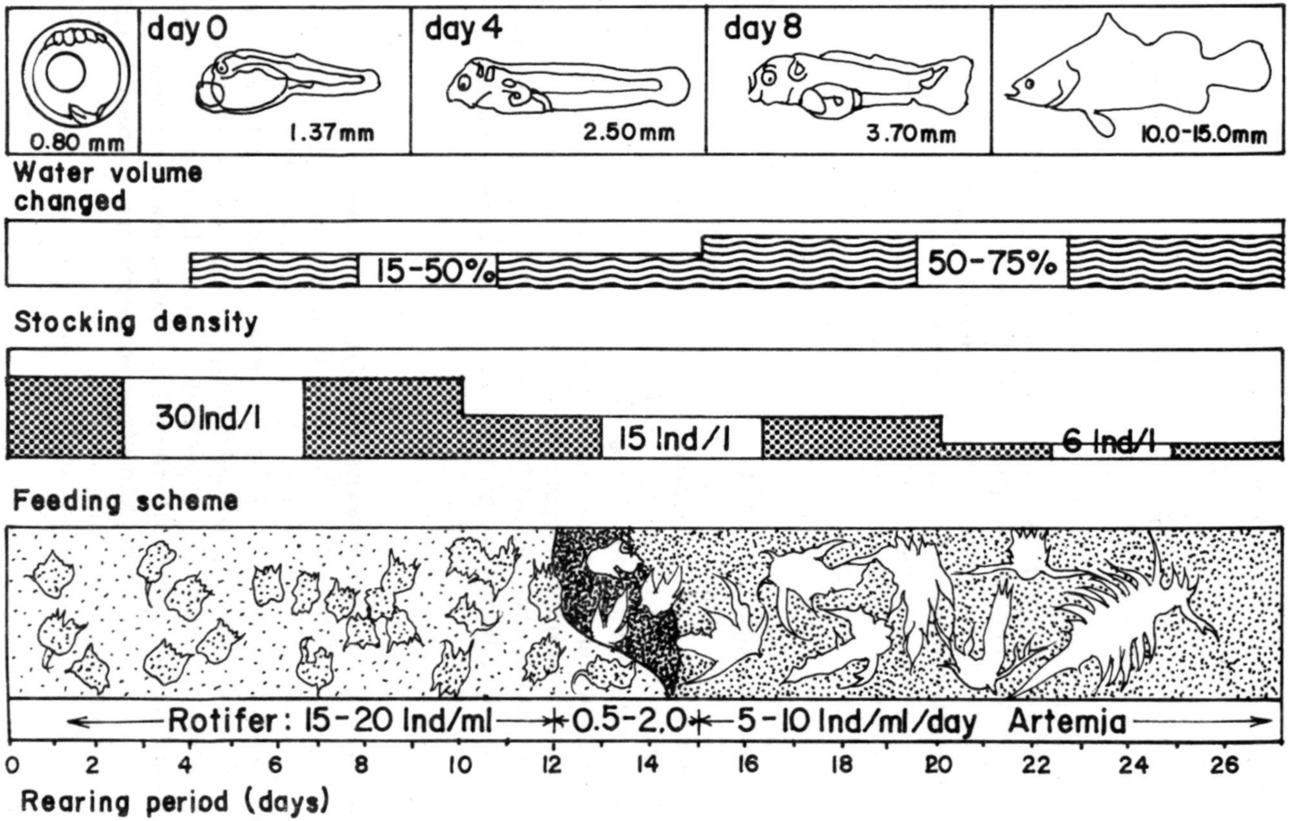

Fig. 3. Larval rearing of sea bass (*After* Parazo et al. 1990).

Live food production. Intensive larviculture of marine fish species depends on adequate supply of rotifers grown on microalgae. Most large-scale algal production are unialgal semi-continuous or batch culture. Both methods are used at SEAFDEC/AQD although the latter is more common. Of the three species (*Chlorella* sp., *Tetraselmis chuii,* and *Isochrysis galbana)* grown in the hatchery, *Chlorella* is preferred in spite of its low n-3 fatty acid profile. *Chlorella* is easier to mass produce compared to the other two.

Chlorella production

For *Chlorella* propagation in large-scale, a ratio of 4:1 filtered seawater and algal starter is used. Commercial fertilizer mix (100 g of 21-0-0; 20 g of 16-20-0; and 20 g of 46-0-0/t of seawater) is applied and strong aeration is provided. Peak bloom is attained within 4-5 days. At this time, a portion is transferred to another tank to serve as a starter and to the rest, rotifers are inoculated. "Culture crashes" sometimes occur either due to the failure of the algae to multiply or due to algal death. Color of the algae and pH of the culture are often the guides to the condition of the algal culture.

Rotifer production

When *Chlorella* culture peaks, rotifers are added at densities ranging from 10 to 50 ind/ml depending on availability. A density of 120-200 rotifers/ml is reached within 4 days. They are then harvested and concentrated using a 48-μm plankton net bag, then fed to larvae. From the harvested stock, a portion is reserved as a starter for the other *Chlorella* tank.

Diatom contamination sometimes occurs. If contamination is severe, the culture is usually discarded. If algal culture "crashes," rotifers are harvested using a 63-μm plankton bag and fed Baker's yeast at 0.5-1.0 g/million rotifers. Rotifers are fed algae at least overnight prior to feeding them to the larvae.

Production constraints

For milkfish, extraneous species (shrimps, other fishes) that come with the eggs are difficult to separate, and, most of the time, they compete for food or prey on milkfish larvae. For *S. guttatus* fry, a lot of work has to be done before artificial propagation can be carried out routinely. Survival rates are still variable. Development of larval rearing techniques for grouper is hampered by poor egg quality resulting in low hatching rates. Suitable food for the different developmental stages has to be determined as well as the environmental requirements of the larvae. Larviculture of the red snapper has just been started so a great deal still needs to be done.

REFERENCES

Dhert, P., M. Duray, P. Lavens, and P. Sorgeloos. 1990. Optimized feeding strategies in the larviculture of the Asian sea bass, *Lates calcarifer.* *In:* Hirano, R and I. Hanyu. (eds.). The Second Asian Fisheries Forum. 991 p. Asian Fisheries Society, Manila, Philippines.

Duray, M.N. and J.V.Juario. 1988. Broodstock management and seed production of the rabbitfish, *Siganus guttatus* (Bloch), and the sea bass, *Lates calcarifer* (Bloch). *In:* Juario, J.V. and L.V. Benitez (eds.). Perspectives in Aquaculture Development in Southeast Asia and Japan: Proceedings of a seminar held in Iloilo City, Philippines; 1987 September 8-12, Tigbauan, Iloilo: SEAFDEC Aquaculture Department.

Duray, M.N. 1990. Level and frequency of feeding of sea bass larvae with *Artemia.* Asian Aquaculture 12(1): 8-9.

Gapasin, R.S.J, and C.L. Marte. 1990. Milkfish hatchery operations. Aquaculture Extension Manual No. 17. SEAFDEC Aquacult. Dept. Iloilo, Phil. 25 pp.

Garcia, L.Ma.B. 1988. Induced breeding in sea bass. Asian Aquaculture 10(3): 1-4.

Garcia, L.Ma.B., C.L. Marte, and V.S. Traviña. 1988. A collecting gear for naturally-spawned milkfish (*Chanos chanos* Forsskal) eggs in circular floating net cages. Aquaculture 68:83-86.

Hara, S., M.N. Duray, M. Parazo, and Y. Taki. 1986. Year-round spawning and seed production of the rabbitfish, *Siganus guttatus.* Aquaculture 59:259-272.

Juario, J.V., M.N. Duray, J.L. Nacario, and J.M.E. Almendras. 1985. Breeding and larval rearing of the rabbitfish *Siganus guttatus* (Bloch). Aquaculture 44:99-101.

Marte, C.L. 1988. Broodstock management and seed production of milkfish. *In:* Juario, J.V. and L.V. Benitez (eds.). Perspectives in Aquaculture Development in Southeast Asia and Japan: Proceedings of a seminar held in Iloilo City, Philippines; 1987 September 8-12; Tigbauan, Iloilo: SEAFDEC Aquaculture Department.

Marte, C.L. and M.N. Duray. 1991. Microbound larval feed as supplement to live food for milkfish (*Chanos chanos* Forsskal) larvae. *In :* Lavens, P., P. Sorgeloos, P. Jasper, and F. Ollevier (eds.). Larvi '91 - Fish and Crustacean Larviculture Symposium. European Aquaculture Society, Special Publ. No. 15.

Parazo, M.M., L.Ma. B. Garcia, F.G. Ayson, A.C. Fermin, J.M.E. Almendras, D.M. Reyes Jr., and E.M. Avila. 1990. Sea bass hatchery operation. Aquaculture Extension Manual No. 18. SEAFDEC Aquacult. Dept. Iloilo, Phil. 38 p.

Rabanal, H. 1988. Development of the aquaculture industry in Southeast Asia: An Overview. *In:* Perspectives in Aquaculture Development in Southeast Asia and Japan: Proceedings of a seminar held in Iloilo City, Philippines; 1987 September 8-12; Tigbauan, Iloilo: SEAFDEC Aquaculture Department.

Toledo, J.D., A. Nagai, D. Javellana, and J.D. Tan-Fermin. 1990. Successive spawning of grouper, *Epinephelus malabaricus (=suillus),* in tank and floating net cage. SEAFDEC Asian Aquaculture 12(4): 8-10.

Toledo, J.D., C.L. Marte, and A.R. Castillo. 1991. Spontaneous maturation and spawning of sea bass, *Lates calcarifer,* in floating net cages. J. Appl. Ichthyol. 7:217-222.

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FISH HEALTH RESEARCH AT SEAFDEC/AQD

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Fish pathology as a discipline was of relatively minor importance in the early years of SEAFDEC/AQD because technologies for producing aquaculture commodities were still being developed and high-density fish rearing activities were minimal. With fast adaptation of technologies developed locally and elsewhere and their modification to suit industry needs, disease problems started to occur. Disease develops through the interaction of three important factors: the host, the pathogen or disease agent, and the environment. In most high-density aquaculture rearing units, the environment exerts pressure on the host and favors the pathogen. When the host's defenses are overwhelmed, a disease condition is created which may result in death. Mortalities are often equated to economic losses, and research in fish diseases then becomes significant. Research has the ultimate aim of preventing disease occurrence.

Background of fish health activities

A summary of studies concerning fish diseases at SEAFDEC/AQD can be gleaned from the List of Publications on Fish Health (p. 138-142). The earliest research dealt with studies that determine the tolerance of *Penaeus monodon* larval stages to chemicals such as furanace (Gacutan and Llobrera 1977) and malachite green (Lio-Po et al. 1978). The results were aimed at gathering data on the levels that can be used when epizootics occur. In an effort to find control measures against the fungal species affecting shrimp and crab eggs, Lio-Po et al. (1982, 1985) studied the effects of fungicides on the hyphae and spores of *Lagenidium* spp. and *Haliphthoros philippinensis.*

Studies on the characteristics and biology of various infectious agents like *Caligus* sp. (Laviña 1978), the fungi *Lagenidium* (Gacutan and Baticados 1979; Bian et al. 1979) and *Haliphthoros* (Hatai et al. 1980), and the "cotton shrimp"-causing microsporidian in *Penaeus merguiensis* (Gacutan et al. 1979; Enriquez et al. 1980) were also conducted. Further investigations to describe the developmental stages and histopathology of the parasitic microsporidia were done by Baticados and Enriquez (1982a, b). Baticados and Quinitio (1984) also reported the occurrence and pathology of *Amyloodinium-like* protozoan affecting the gills of captive mullet, *Mugil cephalus.* Palisoc (1987) studied the host-parasite relationship of the bopyrid *Epipenaeon ingens* and *Penaeus semisulcatus.*

Since the 1970s, bacterial disease problems have been identified for various commodities. Muroga et al. (1984) identified a *Vibrio* associated with eye lesions in milkfish. Studies on the characteristics and pathogenicity of *Pseudomonas fluorescens* associated with tilapia fry mortalities were done by Duremdez and Lio-Po (1985) and Lio-Po and Sanvictores (1987). Secondary localized infection due to bacteria in hormone-implanted sites of milkfish broodstock was studied by Lio-Po et al. (1986). Disease investigation of transported milkfish stocked in Laguna Lake revealed that the internal organs of these fish had significantly higher bacterial counts (Lio-Po et al. 1986). The virulence of the associated bacteria on healthy milkfish fingerlings was tested by Lio-Po and Duremdez-Fernandez (1986).

A few studies on the post-harvest quality of mollusc were done (Llobrera et al. 1986; Gacutan et al. 1986), as well as studies on the occurrence of paralytic shellfish poisoning in the Philippines (Gacutan et al. 1984; 1985).

Some poorly understood syndromes in both fish and crustacean culture facilities were also studied. In sea bass hatcheries, swimbladder stress syndrome affecting larval stages was reported by Bagarinao and Kungvankij (1986). In *Penaeus monodon,* the various aspects of chronic soft shell syndrome were studied by Baticados et al. (1986; 1987) and Bautista and Baticados (1990).

Research work on the effects of ammonia on the gill structure of milkfish was done by Cruz and Enriquez (1982). Further, studies on the tolerance of various species to chemotherapeutants were done (Cruz and Pitogo 1989; Cruz and Tamse 1989), as well as the effects of pesticides on tilapia (Cruz et al. 1988), shrimp (Baticados and Tendencia 1991), and milkfish (Cruz-Lacierda 1992).

Highlights of activities (1989 to present)

Since 1989, a concerted effort has been devoted to study the occurrence of epizootic ulcerative syndrome (EUS) in freshwater fish, and the various infectious diseases of *Penaeus monodon* such as luminescent vibriosis and monodon baculovirus. In addition, the Diagnostic Service component of the Fish Health Section continues its service to farmers and AQD researchers. The service has provided the Section with an excellent source of information for gauging the problems besetting the aquaculture industry. It has also served as an effective guide in determining priority areas for future research.

Epizootic ulcerative syndrome. Between early December 1985 and early February 1986, a fish disease characterized by lesions and open necrotic ulcers was observed in seven species of fish in Laguna de Bay, the largest and most productive lake in the Philippines. The occurrence was reported by Llobrera and Gacutan (1987). In 1987-1990, the Network of Aquaculture Centers in Asia funded a research on the predisposing environmental factors of EUS in Laguna de Bay. With a grant from the International Development Research Centre (IDRC) of Canada, a study on this regional problem was started in June 1989 with the specific objective of determining the disease-causing factor or combination of factors. Emphasis is on viral, bacterial, parasitic, and environmental factors, including agricultural and industrial contaminants. A study on the histopathology of the disease in naturally infected fish is also being conducted and results will be related to the pathogenesis of the disease. The results of the different studies will then determine the ways of protecting susceptible fish stocks.

Important highlights of the study include the establishment of fish cell lines for viral isolation, and characterization and determination of the role of bacteria in the occurrence of EUS (Lio-Po et al. 1992).

Bacterial diseases in shrimps. Common bacterial diseases observed in penaeids include luminous bacterial disease due to *Vibrio harveyi* (Lavilla-Pitogo et al. 1990), shell disease (Lio-Po and Lavilla-Pitogo 1990), and filamentous bacterial infestation (Baticados et al. 1990). Of these, luminescent *Vibrio* and filamentous bacteria are most frequently encountered by hatchery operators. *Vibrio harveyi* may cause larval mortalities of up to nearly 100% of affected populations. Epizootics occur year-round and may destroy hatchery productivity for extended periods. Baticados et al. (1990) studied the efficacy of various antibiotics against *V. harveyi* and found that none among the tested drugs can be used to effectively control the disease due to the limited tolerance of the larvae to the drugs. In 1989, IDRC funded a 3-year study to determine the mechanisms of vertical and horizontal transfer mechanisms of the bacteria. An investigation on the sources of luminescent *Vibrio harveyi* in hatcheries showed that the greatest source of bacteria is the fecal matter shed into the water when the shrimp spawn (Lavilla-Pitogo et al. 1992). Other sources of V. *harveyi* are nearshore seawater and unwashed *Artemia* nauplii. Diatoms like *Skeletonema costatum* and *Chaetoceros calcitrans* have no associated *V. harveyi* population. The major aim of this study is to find ways of minimizing, if not completely eliminating, the luminous bacterial disease problem in *P. monodon* hatcheries.

Monodon baculovirus infection. The occurrence and pathology of monodon baculovirus (MBV) was studied by Baticados et al. (1991). This study showed that MBV was diagnosed in 43% of postlarval samples obtained from various hatcheries in 1989. The records in the Diagnostic Service show an even higher percentage of infection. In grow-out ponds, MBV has been associated with retarded growth and low survival of stocks. Since there is no effective therapy for crustacean viral infections, farmers try to prevent the occurrence of MBV by submitting fry for examination and stocking only the fry not diagnosed with MBV. This practice, however, has created problems for hatchery operators who fail to find markets for infected fry. AQD's Diagnostic Laboratory, as well as a few privately owned ones, detects MBV infection by using the presumptive malachite green method. The more accurate methods of diagnosis, i.e., histology or fluorescence microscopy, are not routinely employed by most laboratories because of lack of equipment and the long time involved before results are obtained.

1992 research studies. In addition to ongoing research on EUS and luminescent vibriosis, there are studies on the role of vibrios in the development of red disease syndrome in *Penaeus monodon,* the effect of the antibiotic Ektecin on bacteria affecting sea bass juveniles, and investigation on the diseases of groupers. Collaborative studies with the Nutrition and Feed Development Section on quality assessment of shrimp feeds is being done. The study focuses on the effects of aflatoxin, thiobarbituric acid value, and urease activity on the growth of shrimp. The role of Vitamin C in the wound healing process of *P. monodon* juveniles is also being investigated as part of a study on the use of L-ascorbyl-2-phosphate Mg as Vitamin C source for shrimp.

Important diseases/syndromes observed in 1992 and problems for future research

Based on the samples that were submitted for diagnosis, the following are important problems which need to be investigated:

<u>Fish</u>
Swimbladder stress syndrome in hatchery-reared sea bass larvae
Gas bubble disease in milkfish larvae and tilapia fry
Parasitic infestations in various stages of groupers

<u>Penaeid shrimp</u>
Microbial infection due to viruses, rickettsia, bacteria, and other microorganisms
"Loose shell" syndrome in pond-reared sub-adults
Swollen hindgut syndrome in hatchery-reared postlarvae
Development of a simple but reliable criteria for gauging fry quality

In addition, the three-year plan of AQD states that fish health studies on snapper and bighead carp should also be conducted.

Training and extension activities

As part of the Section's commitment to the extension and dissemination of information to shrimp farmers, a pamphlet on the *Recommended Practices for Disease Prevention in Prawn and Shrimp Hatcheries* (Lio-Po et al. 1989) and a manual on *Diseases of Penaeid Shrimps in the Philippines* (Baticados et al. 1990) were put together. Upon the request of both government and private entities, Fish Health researchers also conduct short trainings or lectures for technicians. Also, SEAFDEC/AQD training programs have fish health lectures and practical sessions as part of the courses.

The most comprehensive program that the Section offers to technicians from both the government and private sectors is the *Fish Health Management Training Course.* First offered in November 1987 for Department of Agriculture technicians, the training has been conducted yearly and has about 80 alumni now. In addition to this structured training course, the Section also accommodates internships for technicians and on-the-job training for students.

RESEARCH PUBLICATIONS OF THE FISH HEALTH SECTION

Journals

Gacutan, R.Q. and A.T. Llobrera. 1977. Effects of furanace on the zoea and mysis of *Penaeus monodon.* Kalikasan, Philipp. J. Biol. 6:263-268.

Laviña, E.M. 1978. A study on certain aspects of the biology and control of *Caligus* sp., an ectoparasite of the adult milkfish *Chanos chanos* (Forsskal). Fish. Res. J. Philipp. 3:11-24.

Lio-Po G.D., C.R. Lavilla, and A. Tillo-Llobrera. 1978. Toxicity of malachite green to the larvae of *Penaeus monodon.* Kalikasan, Philipp. J. Biol. 7:238-246.

Bian, B.Z., K. Hatai, G.L. Po, and S. Egusa. 1979. Studies on the fungal diseases in crustaceans: I. *Lagenidium scyllae* sp. nov. isolated from cultivated ova and larvae of the mangrove crab *(Scylla serrata).* Trans. Mycol. Soc. Jap. 20:115-124.

Gacutan, R. and M.C. Baticados. 1979. Notes on *Lagenidium* from larvae of *Penaeus monodon* Fabricius. I. Isolation and culture in artificial media. Fish. Res. J. Philipp. 6:64-81.

Enriquez, G.L., M.C.L. Baticados, and R.Q. Gacutan. 1980. Microsporidian parasite of the white prawn *Penaeus merguiensis* de Man: a preliminary report. Nat. Appl. Sci. Bull. 32:319-325.

Hatai, K., B.Z. Bian, M.C.L. Baticados, and S. Egusa. 1980. Studies on the fungal diseases in crustaceans. II. *Haliphthoros philippinensis* sp. nov. isolated from cultivated larvae of the jumbo tiger prawn (*Penaeus monodon*). Trans. Mycol. Soc. Jap. 21:47-55.

Cruz, E.R.. 1981. Acute toxicity of un-ionized ammonia to milkfish (*Chanos chanos*) fingerlings. Fish. Res. J. Philipp. 6:33-38.

Baticados, M.C.L. and G.L. Enriquez. 1982a. Histopathology of microsporidian infection in white prawn, *Penaeus merguiensis* de Man, 1988. Nat. Appl. Sci. Bull. 34:299-313.

Baticados, M.C.L. and G.L. Enriquez. 1982b. Developmental stages of microsporidian parasite of the white prawn, *Penaeus merguiensis* de Man, 1888. Nat. Appl. Sci. Bull. 34:255-270.

Cruz, E.R. and G.L. Enriquez. 1982. Gill lesions associated with acute exposure to ammonia. Nat. Appl. Sci. Bull. 34:1-13.

Lio-Po, G.D., M.E.G. Sanvictores, M.C.L. Baticados, and C.R. Lavilla. 1982. *In vitro* effect of fungicide on hyphal growth and sporogenesis of *Lagenidium* spp. isolated from *Penaeus monodon* larvae and *Scylla serrata* eggs. J. Fish Dis. 5:97-112.

Tamse, C.T., F. Piedad-Pascual, and M.C. de la Cruz. 1983. Some histological observations on the opaque eyes of milkfish *Chanos chanos* Forsskal. Fish. Res. J. Philipp. 8:69-72.

Baticados, M.C.L. and G.F. Quinitio. 1984. Occurrence and pathology of an *Amyloodinium*-like protozoan parasite on gills of grey mullet, *Mugil cephalus.* Helgolander Meeresunters 37:595-601.

Muroga, K., G. Lio-Po, C. Pitogo, and R. Imada. 1984. *Vibrio* sp. isolated from milkfish (*Chanos chanos*) with opaque eyes. Fish. Pathol. 19:81-87.

Cruz, E.R. and K. Muroga. 1985. Studies on the tolerance of Japanese eel *(Anguilla japonica)* to zinc sulfate. Fish. Pathol. 20:459-461.

Duremdez, R.C. and G.D. Lio-Po. 1985. Studies on the causative organism of *Sarotherodon niloticus* (Linnaeus) fry mortalities. 2. Identification and characterization of the physiological properties of *Pseudomonas fluorescens.* Fish. Pathol. 20:115-123.

Gacutan, R.Q., M.Y. Tabbu, E.J. Aujero, and F. Icatlo, Jr. 1985. Paralytic shellfish poisoning due to *Pyrodinium bahamense* var. *compressa* in Mati, Davao Oriental, Philippines. Mar. Biol. 87:223-227.

Lio-Po, G.D., M.C.L. Baticados, C.R. Lavilla, and M.E.G. Sanvictores. 1985. *In vitro* effects of fungicides on *Haliphthoros philippinensis.* J. Fish Dis. 8:359-365.

Bagarinao, T. and P. Kunvankij. 1986. An incidence of swimbladder stress syndrome in hatchery-reared sea bass (*Lates calcarifer*) larvae. Aquaculture 51:181-188.

Baticados, M.C.L., R.M. Coloso, and R.C. Duremdez. 1986. Studies on the chronic soft-shell syndrome in the tiger prawn, *Penaeus monodon* Fabricius, from brackishwater ponds. Aquaculture 56:271-285.

Cruz, E.R. and C.T. Tamse. 1986. Histopathological response of milkfish, *Chanos chanos* Forsskal, fingerlings to potassium permanganate. Fish Pathol. 21:151-159.

Lio-Po, G.D., C. Pitogo, and C.L. Marte. 1986. Bacteria associated with infection at hormone-implantation sites among milkfish, *Chanos chanos* (Forsskal), adults. J. Fish Dis. 9:337-343.

Lio-Po, G.D. and E.G. Sanvictores. 1986. Tolerance of *Penaeus monodon* eggs and larvae to fungicides against *Lagenidium* sp. and *Haliphthoros philippinensis.* Aquaculture 51:161-168.

Lio-Po, G.D. and H. Wakabayashi. 1986. Immuno-response in tilapia *Sarotherodon niloticus* vaccinated with *Edwardsiella tarda* by hyperosmotic infiltration method. J. Vet. Immunol. Immunopathol. 12:351-357.

Baticados, M.C.L., R.M. Coloso,andR.C. Duremdez. 1987. Histopathology of the chronic soft-shell syndrome in the tiger prawn, *Penaeus monodon.* Dis. Aquat. Org. 3:13-28.

Lio-Po, G. and E. Sanvictores. 1987. Studies on the causative organism of *Oreochromis niloticus* (Linnaeus) fry mortalities: I. Primary isolation and pathogenicity experiments. J. Aqua. Trop. 7:25-30.

Llobrera, A.T. and R.Q. Gacutan. 1987. *Aeromonas hydrophila* associated with ulcerative disease epizootic in Laguna de Bay, Philippines. Aquaculture 67:273-278.

Muroga, K. and M.C. de la Cruz. 1987. Fate and location of *Vibrio anguillarum* in tissues of artificially infected ayu *(Plecoglossus altivelis).* Fish Pathol. 22:99-103.

Nakai, T., T. Kanno, E.R. Cruz, and K. Muroga. 1987. The effects of iron compounds on the virulence of *Vibrio anguillarum* in Japanese eels and ayu. Fish Pathol. 22:185-189.

Palisoc, F.P. 1987. Observations on the host-parasite relationship of *Epipenaeon ingens nobili* (Epicarde:Bopyridae) and *Penaeus semisulcatus* de Haan. Philipp. J. Sci. 116:281-293.

Cruz, E.R. and C.L. Pitogo. 1989. Tolerance level and histopathological response of milkfish (*Chanos chanos*) fingerlings to formalin. Aquaculture 78:135-145.

Cruz, E.R. and C.T. Tamse. 1989. Acute toxicity of potassium permanganate to milkfish fingerlings, *Chanos chanos.* Bull. Environ. Contam. Toxicol. 43:785-788.

de la Cruz, M.C, G. Erazo, and M.N. Bautista. 1989. Effect of storage temperature on the quality of diets for the prawn, *Penaeus monodon* Fabricius. Aquaculture 80:87-95.

de la Cruz, M.C. and K. Muroga. 1989. The effects of *Vibrio anguillarum* extracellular products on Japanese eels. Aquaculture 80:201-210.

Baticados, M.C.L., C.L. Lavilla-Pitogo, E.R. Cruz-Lacierda, L.D. de la Peña, and N.A. Suñaz. 1990. Studies on the chemical control of luminous bacteria *Vibrio harveyi* and V. *splendidus* isolated from disease *Penaeus monodon* larvae and rearing water. Dis. Aquat. Org. 9:133-139.

Baticados, M.C.L. and C.L. Pitogo. 1990. Chlorination of seawater used for shrimp culture. Israeli J. Aquacult. -Bamidgeh 42:128-130.

Lavilla-Pitogo, C.R., M.C.L. Baticados, E.R. Cruz-Lacierda, and L.D. de la Peña. 1990. Occurrence of luminous bacterial disease of *Penaeus monodon* larvae in the Philippines. Aquaculture 91:1-13.

Baticados, M.C.L. and E. A. Tendencia. 1991. Effects of Gusathion A on the survival and shell quality of juvenile *Penaeus monodon.* Aquaculture 93:9-19.

Baticados, M.C., C.L. Pitogo, M.G. Paner, L.D. de la Peña, and N.A. Suñaz. 1991. Occurrence and pathology of *Penaeus monodon* baculovirus infection in hatcheries and ponds in the Philippines. Israeli J. of Aquacult. - Bamidgeh 43:35-41.

Lavilla-Pitogo, CR. 1992. Agar-digesting bacteria associated with "rotten-thallus" syndrome of *Gracilaria* sp. Aquaculture 102:1-7.

Proceedings

Gacutan, R.Q., A.T. Llobrera, C.B. Santiago, P.J. Guttierez, and G.L. Po. 1979. A suctorean parasite of *Penaeus monodon* larvae. Lewis, D.H., Leong,J.K., compilers. Proceedings of the Second Biennial Crustacean Health Workshop; 1977 April 20-22; Galveston, Texas. College Station, Texas: Sea Grant Program/Texas A&M University; 201-213.

Gacutan R.Q., A.T. Llobrera, and M.C.L. Baticados. 1979. Effects of furanace on the development of larval stages of *Penaeus monodon* Fabricius. Lewis, D.H., Leong, J.K., compilers. Proceedings of the Second Biennial Crustacean Health Workshop; 1977 April 20-22; Galvestone, Texas. College Station, Texas: Sea Grant Program/Texas A&M University; 231-244.

Lio-Po, G.D., J.P. Pascual, and J.G. Santos. 1983. Country report on fish quarantine and diseases in the Philippines. In: Davy, F.B. and A. Chouinard (eds.). Fish Quarantine and Fish Diseases in Southeast Asia. Report of a Workshop, 1982 December 7-10, Jakarta, Indonesia. Ottawa, Canada: International Development Research Centre; Manila, Philippines: UNDP/FAO South China Sea Fisheries Development and Coordinating Program; 35-46.

Gacutan, R.W., M.Y. Tabbu, T. de Castro, A.B. Gallego, M. Bulalacao, L. Arafiles, and F. Icatlo, Jr. 1984. Detoxification of *Pyrodinium*-generated paralytic shellfish poisoning toxin in *Perna viridis* from Western Samar, Philippines. In: White, A.W., M. Anraku, K.K. Hooi (eds.). Toxic Red Tides and Shellfish Toxicity in Southeast Asia. Proceedings of a consultative meeting; 1984Septemberll-14;Changi Point, Singapore. SEAFDEC/MFRD; Ottawa, Canada: International Development Research Centre; 80-85.

Lio-Po, G.D. 1984. Diseases of milkfish. Juario, J.V., R.P. Ferraris, L.V. Benitez (eds.). Advances in Milkfish Biology and Culture: Proceedings of the Second International Milkfish Aquaculture Conference, 1983 October 4-8, Iloilo City, Philippines. Tigbauan, Iloilo, Philippines: SEAFDEC/AQD; Manila, Philippines: Island Publishing House, Inc.; Ottawa, Canada: IDRC; 145-153.

Gacutan, R.Q., M.L. Bulalacao, and H.L. Baranda, Jr. 1986. Bacterial depuration of grossly-contaminated oysters, *Crassostrea iredalei.* In: Maclean, J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 429-432.

Gacutan, R.Q. 1986. Effects of coconut milk and brown sugar on crude toxins from mussels exposed to *Pyrodinium bahamense* var. *compressa.* In: Maclean, J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum: Proceedings of the First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 311-313.

Lio-Po, G. and R. Duremdez-Fernandez. 1986. The pathogenicity of bacteria associated with transport-stressed *Chanos chanos* fingerlings. In: Maclean, J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum: Proceedings of the First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 223-226.

Lio-Po, G., R. Duremdez-Fernandez, and A. Villaluz. 1986. Disease investigation of transported *Chanos chanos* stocked in Laguna Lake, Philippines. In: Maclean,J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum: Proceedings of the First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 227-230.

Llobrera, A.T., M.L.Bulalacao, and N. Suñaz. 1986. Effects of storage on the microbial quality of slipper oysters, *Crassostrea iredalei.* In: Maclean, J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum: Proceedings of the First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 437-442.

Llobrera, A.T. and D.H. Lewis. 1986. Antibiotic uptake of the giant freshwater prawn *Macrobrachium rosenbergii* by the osmotic infiltration technique. In: Maclean, J.L., L.B. Dizon, L.V. Hosillos (eds.). The First Asian Fisheries Forum: Proceedings of the First Asian Fisheries Forum. 1986 May 26-31, Manila, Philippines. Asian Fisheries Society; 333-336.

Baticados, M.C.L. 1988. Problems of diseases in prawn projects. In: Prawn Farming in the Philippines: Problems and Solutions. Proceedings of the National Seminar on Problems of the Prawn Farming Industry and Suggested Solutions. 1987 October 23-24, Makati, Philippines. Fishfarmers Technical Assistance Foundation, Inc.; 58-68.

Baticados, M.C.L. 1988. Typical prawn disease - causes, prevention and treatment. In: Chiu, Y.N., L.M. Santos, R.O. Juliano (eds.). Technical Considerations for the Management of Intensive Prawn Farms, 1987 November 16-20, Iloilo City, Philippines. U.P. Aquaculture Society, 134-143.

Cruz, E.R., M.C. de la Cruz, and N.A. Suñaz. 1988. Hematological and histological changes in *Oreochromis niloticus* after exposure to molluscicides Aquatin and Brestan. In: Pullin, R.S.V., T. Bhukaswan, K. Tonguthai, J.L. Maclean (eds.). The Second International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings No. 15, 1987 March 16-20, Bangkok, Thailand, 99-110.

Lio-Po, G. 1988. Prawn health in aquaculture. In: Chiu, Y.N., L.M. Santos, R.O. Juliano (eds.). Technical Considerations for the Management of Intensive Prawn Farms, 1987 November 16-20, Iloilo City, Philippines. U.P. Aquaculture Society, 130-133.

Llobrera A.T. 1987. Current fish disease problems in the Philippines and their economic impact. Arthur, J.R. (ed). Fish Quarantine and Fish Diseases in South and Southeast Asia. Update: Report of the Asian Fish Health Network Workshop, 1986 May 30, Asian Fisheries Society, Manila, Philippines, 22-28.

Bautista, M.N. and M.C.L. Baticados. 1990. Dietary manipulation to control the chronic soft-shell syndrome in tiger prawn, *Penaeus monodon* Fabricius. Hirano, R. and I. Hanyu (eds.). Proceedings of the Second Asian Fisheries Forum, 1989 April 17-22, Tokyo, Japan. Asian Fisheries Society, Manila, Philippines, 341-344.

Lio-Po, G.D. and C.R. Lavilla-Pitogo. 1990. Bacterial exoskeletal lesions of the tiger prawn *Penaeus monodon.* Hirano, R. and I. Hanyu (eds.). Proceedings of the Second Asian Fisheries Forum, 1989 April 17-22, Tokyo, Japan. Asian Fisheries Society, Manila, Philippines, 701-705.

Baticados, M.C.L. and J.O. Paclibare. 1992. The use of chemotherapeutic agents in aquaculture in the Philippines. In: Sharif, M., R.P. Subasinghe, and J.R. Arthur (eds.). Diseases in Asian Aquaculture I. pp. 531-546. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Cruz-Lacierda, E.R. 1992. Toxicity of rotenone to milkfish, *Chanos chanos,* and tilapia, *Oreochromic mossambicus.* In: Shariff, M., R.P. Subasinghe, and J.R. Arthur (eds.). Diseases in Asian Aquaculture I. pp.419-423. Fish Health Section, Asian Fisheries

Society, Manila, Philippines.

Lavilla-Pitogo, CR., L.J. Albright, M.G. Paner, and N.A. Suñaz. 1992. Studies on the sources of luminescent *Vibrio harveyi* in *Penaeus monodon* hatcheries. In: Shariff, M., R.P. Subasinghe, and J.R. Arthur (eds.). Diseases in Asian Aquaculture I. pp. 157-164. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Lavilla-Pitogo, G.D., L.J. Albright, and E.V. Alapide-Tendencia. 1992. *Aeromonas hydrophila* in the epizootic ulcerative syndrome (EUS) of snakehead, *Ophicephalus striatus,* and catish, *Clarias batrachus:* quantitative estimation in natural infection and experimental induction of dermomuscular necrotic lesion. In: Shariff, N., Subasinghe, R.P., and Arthur J.R. (eds.). Diseases in Asian Aquaculture I. pp. 461-474. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Extension pamphlet and manual

Lio-Po ,G.D., R.D. Fernandez, E.R. Cruz, M.C.L. Baticados, and A.T. Llobrera. 1989. Recommended Practices for Disease Prevention in Prawn and Shrimp Hatcheries. Aquaculture Extension Pamphlet No. 3. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Baticados, M.C.L., E.R. Cruz-Lacierda, M.C. de la Cruz, R.C. Duremdez-Fernandez, R.Q. Gacutan, C.R. Lavilla-Pitogo, and G.D. Lio-Po. 1990. Diseases of Penaeid Shrimps in the Philippines. Aquaculture Extension Manual No. 16. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

RESEARCH ON NUTRITION AND FEED DEVELOPMENT AT SEAFDEC/AQD

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ABSTRACT

The Feed Development Section at SEAFDEC/AQD conducts research on the nutritional requirements and the development of cost-effective practical diets for regionally important fishes (milkfish, tilapia, carp, and sea bass) and shrimp (*Penaeus monodon*).

Macronutrient requirements for protein, lipid, carbohydrate, energy, and optimum dietary protein to energy ratio have been defined. Essential fatty acids required by each species have been identified. Requirement levels for the ten essential amino acids in milkfish and tilapia have been established. In shrimp, requirements for other essential nutrients like phospholipid and cholesterol are known. Dietary calcium and phosphorous requirements of shrimp have been determined. Requirement for water-soluble vitamins and bioavailability of stable forms of vitamin C are being evaluated. However, much work remains to be done on the vitamin and mineral requirements of cultured species.

The major digestive enzymes, proteases, carbohydrases, and lipases in milkfish have been studied. Further, the apparent digestibility of commonly used feedstuffs were determined *in-vivo* and *in-vitro* for milkfish, and presently, for shrimp and sea bass.

In diet development, the formulation of supplemental grow-out feeds from inexpensive indigenous materials has been emphasized. Likewise, artificial diets for larvae and broodstock are being developed. Effects of feed additives like chemo-attractants and antioxidants were studied. In addition, studies on feed and feedstuff quality control and application of proper processing techniques are being pursued. At present, there are supplemental grow-out diets for the fishes that are commercially viable. Diets for all life stages (grow-out, larval, and broodstock) of shrimp are available. Improvement of these diets will continue as more information on the nutrient requirements are known.

Feed is considered a major input in semi-intensive and intensive pond culture systems because it represents 50% or more of the total production cost. The availability of a cost-effective feed is essential to the success of fish farming. However, feed development in developing countries is hindered by the lack of necessary expertise to formulate and test appropriate feeds to demonstrate their nutritional and economic values. Commercial feeds are available but these require ingredients that are not found locally or are too expensive for the fish farmer. Thus, the need for formulations based on locally available inexpensive ingredients is widely recognized.

The thrust of the SEAFDEC Aquaculture Department's Feed Development Section is to develop cost-effective fish and shrimp diets for the industry. To achieve this goal, research studies on nutrient requirements and nutrient interrelationships are conducted to provide baseline data for practical diet development and refinement. Considerable effort has been made to determine the nutrient requirements of important fishes (milkfish, tilapia, carp, sea bass) and shrimp (*Penaeus monodon*). In diet development and improvement of a traditional diet, the primary concern is nutritionally balanced and low-cost feed that takes advantage of inexpensive, indigenous feed ingredients. Meanwhile, studies to improve feeding techniques and practices to minimize feeding costs are conducted.

Diets developed are continuously refined and improved. Effective diets are tested on-farm for technical and economic feasibility prior to dissemination to end users. The goal is to transfer feeding technology to fish farmers who may want to formulate and prepare his own feeds.

Highlights of recent work on nutrition and feed development conducted at SEAFDEC/AQD are reviewed.

Milkfish

Nutrient requirements. Milkfish (*Chanos chanos* Forsskal) juveniles require 30-40% protein, 7-10% lipid, 25% carbohydrate, and digestible energy of 2,500-3,500 kcal/kg diet. A protein to energy ratio of 44% was found to be optimal for milkfish (Table 1).

Studies on milkfish requirement for the ten essential amino acids have been completed. The requirement levels (Table 2) correlate well with the tissue pattern except for lysine, leucine, tryptophan, and valine wherein the levels required are lower than those found in fish tissues. In diet formulation, caution should be exercised when using the tissue amino acid pattern because this might result in disproportionate amounts of dietary lysine, leucine, tryptophan, and valine, causing sub-optimal growth rates.

Studies on essential fatty acid requirements have shown that fish grown in seawater require n-3 fatty acids. Both linolenic acid (18:3n3) and n-3 highly unsaturated fatty acids (HUFA) gave good growth and survival. Linoleic acid (18:2n6) is less important in milkfish adapted to seawater compared with n-3 fatty acids.

Digestive enzymes and digestibility. Milkfish have substantial activities of the major digestive enzymes: carbohydrases, proteases, and lipases; however, cellulase activity is absent. Since milkfish reared in ponds rely mostly on filamentous algae and cellulosic plant materials for food, its cellulase activity is probably derived from the gut microflora.

Milkfish digestive enzymes have two well-defined pH optima, one at

Table 1. Summary of nutrient requirements of milkfish, sea bass, tilapia, and shrimp

Nutrient	Requirement	Reference
Milkfish, *Chanos chanos* Forsskal		
Protein	30-40%, juveniles	Pascual 1989
	44% protein: energy	Coloso et al. 1988
Essential amino acids	See Table 2	
Lipid	7-10%	Pascual 1989
Essential fatty acids	n-3, 1-1.5%	Borlongan 1992
Carbohydrate	25%	Pascual 1989
Digestible energy	2,500-3,500 Kcal/kg	
Sea bass. *Lates calcarifer* Bloch		
Protein	43%, juveniles	Alava, unpubl.
	50% protein: energy	Catacutan, unpubl.
Essential amino acids		
Methionine	2.4% of protein	Coloso et al. unpubl.
Lysine	4.7%	
Lipid	10%	Catacutan, unpubl.
Essential fatty acids	n-3, 0.5%; n-6, 0.5%	Borlongan and Parazo 1991
	n3/n6 ratio, 1.0	
Carbohydrate	20-25%	Catacutan, unpubl.
Tilapia. *Oreochromis niloticus*		
Protein	25%, fingerlings	Santiago et al. 1982
Essential amino acids	See Table 2	
Shrimp. *Penaeus monodon* Fabricius		
Protein	40%, juveniles	Alava and Lim 1983
	50%, larvae	Bautista et al. 1989
	53%, broodstock	Millamena et al. 1986
Essential amino acids		
Arginine	5.8% of protein	Pascual, unpubl.
Threonine	3.1%	Millamena, unpubl.
Lipid	8-12%, juveniles	Catacutan 1991
	12-15%, larvae	Bautista et al. 1989
	12-15%, broodstock	Millamena et al. 1986
Essential fatty acids	20:4n-6, 20:5n-3	Millamena 1990
	22:6n-3	
	n-3 HUFA, 2.6%	Catacutan 1991
	18:2 n-6, < 5%	
Cholesterol	1.0%	Nalzaro 1982
Lecithin	1-2%	Pascual 1989
Carbohydrate	20%	Bautista 1986
Digestible energy	2,850-3,700 Kcal/kg	
Vitamin C (phosphated)	100 mg/kg diet	Catacutan, unpubl.
Ca/P ratio	1.0	Bautista and Baticados 1990

Table 2. Amino acid requirements of milkfish and tilapia

Amino acid	Percentage of protein	
	Milkfish[a]	Tilapia[b]
Arg	5.2	4.2
His	2.0	1.7
Ile	4.0	3.1
Leu	5.1	3.4
Lys	4.0	5.1
Met[c] (cys, 0.5)	2.5	3.2 (0.8)
Phe[d] (tyr, 1.8)	4.2	5.5 (1.0)
Thr	4.5	3.8
Trp	0.6	1.0
Val	3.6	2.8

[a]Borlongan and Coloso, in press. [b]Santiago and Lovell 1988.
[c]Methionine + cystine. [d]Phenylalanine + tyrosine.

slightly acidic and the other at alkaline pH. The optimum pH values of the various digestive enzymes are pH 6.2 to 7.2 and pH 8 to 9, and optimum temperature is 45-60°C. Thus, increased water temperature (30-34°C) during the dry season is favorable for growth of milkfish because of more active digestive enzymes.

Studies on diurnal variations of amylase activity in milkfish and feeding habits reveal a high correlation between amylase activity and feeding index. Peak enzyme activity occurs at noon time (1230 H) when feeding activity is maximal. This confirms earlier observations that milkfish is a daytime feeder.

Apparent protein digestibility values of commonly used feed ingredients for milkfish have been determined (Table 3). The digestibility of gelatin in milkfish is 90-98% while casein, defatted soybean meal, and fish meal are moderately digestible (50-90%). Ipil-ipil leaf meal is the least digestible at 10-40%.

Table 3. Apparent protein digestibility coefficients (%) of some feedstuffs for milkfish

	Freshwater fish (g)			Seawater fish (g)		
Feedstuff	2	60	175	2	60	175
Casein	58	83	87	73	49	65
Fish meal	45	65	73	71	62	71
Gelatin	94	94	94	96.5	98.5	97.5
Ipil-ipil	47	41	41.6	60.5	30.5	-10
Soybean meal (defatted)	53	62	94.3	74	54	60

Source: Ferraris et al. 1986.

Practical diet. Supplementary feeding for milkfish (27% protein) has been tried in brackishwater ponds with encouraging results. Undoubtedly, productivity in milkfish culture can be increased further with the use of supplementary feeds. At present, practical diet development using alternative protein sources are being undertaken. Leaf meals (kangkong, camote, cassava, ipil-ipil, and papaya) and legumes (cowpea, mungbean, and soybean) have been used to replace part (15-20%) of fish meal in the diet.

An artificial diet for milkfish fry reared in sea water with crude protein of 40.8% has been developed. Results showed that soybean meal can replace corn gluten meal and meat and bone meal can substitute for shrimp head meal up to 8% of the crude protein in the diet.

Sea bass

Nutrient requirements. Sea bass (*Lates calcarifer* Bloch) juveniles require 43% protein, 10% lipid, and 20-25% carbohydrate (Table 1). Optimum protein to energy ratio is about 50%.

Studies on the quantitative essential amino acid and fatty acid requirements of sea bass are ongoing. Initial results show the following requirements for essential amino acids (expressed as percentage of protein): methionine, 2.4% and lysine, 4.7%. Sea bass require both n-3 and n-6 highly unsaturated fatty acids (HUFA) at 0.5% in the diet or an n3/n6 ratio of 1.0.

Apparent digestibility. Studies on the apparent digestibility of commonly used feedstuffs for sea bass are currently being undertaken.

Practical diet. A formulated diet for sea bass grow-out has been tested under laboratory conditions with excellent results. The formulation will be verified in ponds.

Soybean meal (SBM), shrimp head meal (SHM), and meat and bone meal (MBM) have been shown to partially substitute fish meal protein in sea bass juveniles diet. SBM, SHM, and MBM can replace up to 10, 20, and 20%, respectively, of the 40% protein diet.

Dietary lipid sources - soybean oil (SBO), cod liver oil (CLO), and coconut oil (CO) - singly or in (1:1) combination have been evaluated for their effects on growth, survival, and fatty acid composition of sea bass fry. Fry fatty acid profile reflects that of the dietary lipid. Growth and survival of fry fed a diet with 1:1 CLO and SBO are highest, followed by those fed CLO or SBO alone, and lowest in those fed the CO diet. Thus, savings in feed cost can be achieved if soybean oil is partly substituted for fish oil as dietary lipid source.

Tilapia

Nutrient requirements. Nile tilapia (*Oreochromis niloticus*) fingerlings require 25% dietary protein. For the red tilapia (a hybrid of Nile tilapia and one or more related species), diets with 35 to 40% protein with a protein to energy ratio of 111 mg/kcal gave the highest growth. The quantitative requirements of the fry for ten essential amino acids have been established (Table 2).

Practical diet. Practical diets for Nile tilapia fingerlings have been formulated and evaluated in feeding trials. Diets contain 20, 25, or 30% protein. Significant differences in weight gain are observed at each protein level and diets with higher protein content do not necessarily produce better growth. As to protein source, diets with 18% or more fish meal gave higher weight gain than diets with 5% or 0% fish meal. Those with copra meal or ipil-ipil leaf meal as major protein source gave the lowest growth. The results indicate that protein quality influence the growth of Nile tilapia fingerlings.

The effects of various inclusion levels of feedstuffs not commonly used in tilapia diets have also been studied. Ipil-ipil leaf meal alone or mixed with rice bran at two levels is found to be effective when used as supplemental feed of tilapia fingerlings in cages. However, ipil-ipil leaf meal exceeding 40% of the complete diet causes weight loss and cessation of reproduction among female broodstock, and drastic reduction in fry production.

The effect of dietary protein levels on the reproductive performance of Nile tilapia broodstock has been determined. Under laboratory conditions, the spawning frequency and number of eggs per spawning of broodstock fed diets containing 20-50% protein do not differ significantly. However, tilapia broodstock in cages and tanks have the best growth and fry production when fed a 40% crude protein diet.

Experiments on the influence of feeding rate and diet form on Nile tilapia fry have been conducted. Fry fed at 30% of the fish biomass daily grow fast and have efficient feed conversion rates. Between pellet crumbles and non-pelleted form of the same diet, the pellet crumbles slightly enhances growth and feed conversion ratio and significantly increases survival rates.

Fresh *Azolla pinnata* as supplemental feed can positively enhance the growth of Nile tilapia fingerlings in cages while dried *Azolla* is a suitable component of complete diets for the fry. Growth and feed conversion ratio improve as the level of *Azolla* meal increased from 8.5 to 42.5% of the diet. Survival rates are not affected by the levels of *Azolla* in the diets.

Bighead carp

Nutrient requirements. Bighead carp (*Aristichthys nobilis*) fry require 30% protein, 7-10% lipid, and 3,130 kcal metabolizable energy per kg diet. A dietary protein to energy ratio of 92 mg per kcal is required.

Practical diet. Bighead carp fry have been shown to attain high growth and survival when fed once daily at 30% of the fish biomass. However, higher feeding rates have to be tested. Fry grow best when fed a combination of natural food and artificial diet, particularly *Moina* or *Brachionus* and a 40% protein diet.

The benefit of giving supplemental diet to bighead carp broodstock in cages has been demonstrated. Although growth, fertilization, and hatching rates are not significantly increased by feeding, fecundity and fry quality (based on the ability to withstand starvation) are enhanced significantly. Fish fed the 40% protein diet have the highest fecundity, total weight of eggs per female, number of eggs per kg body weight, and number of 3-day old fry. Fish fed the 20% protein diet have the intermediate values while the control fish the lowest values for the same parameters.

Shrimp

Nutrient requirements. Shrimp, *Penaeus monodon* Fabricius, juveniles require 40% protein, 8-12% lipid, 20% carbohydrate, and 2,850-3,700 kcal digestible energy per kg diet. A protein to energy ratio of around 56% is required (Table 1). An amino acid test diet containing casein, gelatin, and amino acid mixture as protein sources promotes good growth and survival in shrimp juveniles. The formulation has been used in recent experiments to determine arginine, lysine, and threonine requirements of *P. monodon. A* study on the amino acid composition of *P. monodon* females during the reproductive cycle shows similar amino acid levels in tissues at different maturation stages.

Studies on essential fatty acid requirement show that about 2.6% dietary HUFA enhances growth while levels of 18:2n6 greater than 5% have negative effect on growth of shrimp juveniles. Phospholipid requirement using soy lecithin as dietary source is 1-2% while cholesterol is required at 0.5-1.0%.

Tissues (hepatopancreas, muscle, gonad) of wild *P. monodon* broodstock have been analyzed for lipid and fatty acid composition. Profiles of fatty acid consistently show the following highly unsaturated fatty acids (HUFA): arachidonic (20:4n6), eicosapentanoic (20:5n3), and docosahexanoic (22:6n3) acids. High levels of HUFA in the phospholipid fraction of maturing ovaries suggest that HUFA is significant to ovarian maturation. Likewise, fatty acid composition during larval development of *P. monodon* shows that levels of monoenoic fatty acids decreased with corresponding increase in HUFA, 20:5n3, and 22:6n3; this suggests the importance of the latter as dietary components.

Water-soluble vitamin-deficient diets have been tested in *P. monodon* juveniles. Results show that vitamin-free, choline-free, and inositol-free diets significantly suppress growth with severe changes in the histological structure of the hepatopancreas. This indicates that choline and inositol are indispensable in shrimp juvenile diet. Niacin-free and pyridoxine-free diets provide similar growth as a diet with all vitamins present but with slight changes in the histology of the hepatopancreas. Bioavailability of phosphated form of Vitamin C has also been tested. Results show that *P. monodon* can utilize the phosphated form as Vitamin C source. Shrimp without Vitamin C supplement develop blackened exoskeleton. Survival rate is significantly lower compared with those given the Vitamin-C supplemented diets.

Dietary manipulation of Ca and P is important in the management of soft-shelled shrimps. A dietary Ca to P ratio of 1:1 is effective in hardening the exoskeleton and preventing soft-shelled disease in *P. monodon.*

Apparent digestibility. The protein digestibility coefficients of commonly used feedstuffs for *P. monodon* juveniles have been determined (Table 4). Purified forms of protein (casein and gelatin) are 98-99% digestible, while soybean meal is more digestible (88%) compared to Peruvian fish meal (61%). Dietary carbohydrate levels of 5-35% do not affect protein digestibility. Further, the apparent protein digestibility of whole and dehulled rice and cowpea has been compared. The dehulling process significantly increases the apparent protein digestibility of rice but not of cowpea. This is attributed to the removal of anti-nutritional factors like tannin and other poly-phenols present in rice hull.

Table 4. Apparent protein digestibility coefficients (APDC) of some feedstuffs for tiger shrimp

Feedstuff	APDC (%)
Pure protein source	
Casein	98.9
Gelatin	99.0
Animal protein source	
Fish meal (Peruvian)	60.8
Fish meal (white)	72.0
Meat and bone meal	73.8
Shrimp head meal	89.1
Shrimp meal *(Acetes* sp.)	95.4
Squid meal	96.0
Testis meal	93.4
Plant protein source	
Bean starch	84.7
Copra meal	75.2
Corn starch	72.0
Flour	69.0
Peanut cake	84.4
Rice bran	48.3
Soybean meal	88.1
Tapioca starch	32.1
Wheat germ meal	91.9
Yeast	86.8
Yeast (*Candida*)	93.0

Source: Catacutan, unpubl.

Feed additives. The addition of 1.5% chemoattractant, betaine/amino acid, to a diet with 38% plant protein (soybean meal) and 24% animal protein (fish meal and shrimp head meal) results in improved performance (growth, specific growth rate, and survival) of juvenile shrimps. This information could open new avenues on the use of plant protein sources in feed formulation.

Newly processed and properly stored feeds do not need antioxidants if used within 1-2 months. The antioxidants tested include: butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), ethoxyquin (ETHQ), and propyl gallate (PG); these have been added at 0.05%. BHA and BHT give significantly higher weight gain and show minimal lesion in the hepatopancreas of *P. monodon* compared with ETHQ and PG.

Practical diet. A refinement of supplemental grow-out diet for *P. monodon* significantly improves total yield in brackishwater ponds. The formulation is recommended at stocking densities of 5-10 shrimp per sq m.

Practical diets (53% protein) supplemented with various sources of lipids (cod liver oil, soybean lecithin, or their 1:1 combination) have been compared for their effects on reproductive performance of pond-reared *P. monodon.* Reproductive performance (number of spawnings, eggs and nauplii production, larval quality) is best with cod liver oil-supplemented followed by lecithin-supplemented diet. The combination of both lipids gives the lowest response but is better than the control (all-natural food diet).

The performance of kappa-carrageenan microbound larval diet (C-MBD) on *P. monodon* larvae has been assessed. Feeding C-MBD in combination with natural food results in highest % survival but this is not significantly different from those obtained with natural food alone or C-MBD alone. Large-scale hatchery production of *P. monodon* larvae using C-MBD in combination with natural food is feasible.

Alternative ingredient *sources.* Dehulled cowpea and rice are used as partial replacement (15.6%) of total animal protein in diets for *P. monodon* juveniles. Growth rates of shrimp given dehulled cowpea and rice are comparable with those given defatted soybean meal (the control).

Animal lipids (cod liver oil, pork lard, and beef tallow) and plant lipids (soybean oil, coconut oil, and corn oil) are used as lipid sources for shrimp juveniles. Weight gain and specific growth rate of shrimp fed 12% cod liver oil are significantly higher compared with those of other treatments. Pork lard, beef tallow, and coconut oil are poor lipid sources for *P. monodon.*

Feed/feedstuff evaluation. The presence of anti-nutritional factors such as aflatoxin may lessen the nutritional quality of feeds and may result in huge losses to the feed industry.

Tolerance of *P. monodon* to various levels of aflatoxin present in feeds have been determined. Based on growth performance, pre-adult shrimp are able to tolerate aflatoxin ($AFLB_1$) levels of up to 50 ppb although histopathological changes are already evident in the tissues of shrimp given diets with 25 ppb $AFLB_1$ Survey of aflatoxin level in commercial shrimp feeds shows that 92% contained 40 ppb and below, indicating acceptable but narrow margin of safety for the shrimp. Methods for removal or reduction of tannin and anti-tryptic factor in leaf meals by soaking and blanching are currently being evaluated.

Some local fish meals derived from herring, slipmouth, and tuna are found to be comparable with imported ones based on their essential amino acid index (EAAI). EAAI of local fish meals are 0.92-0.95 while those of white and Peruvian fish meals are 0.96 and 0.92, respectively.

Locally grown seaweeds (*Gracilaria* and *Eucheuma*) are found to have comparable water stability and higher apparent dry matter digestibility compared with common binders like agar, bread flour, corn starch, and wheat gluten. Inclusion at 3-5% in the diet of *P. monodon* juveniles is recommended.

REFERENCES

Alava, V.R. 1989. Terminal report submitted to SEAFDEC Aquacult. Dept.

Alava, V.R. and M.C.de la Cruz. 1983. Quantitative dietary fat requirements of *Chanos chanos* fingerlings in a controlled environment. *In:* Second Int'l Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4-8, 1983. p. 32.

Alava, V.R. and C. Lim. 1983. The quantitative dietary protein requirement of *Penaeus monodon* juveniles in a controlled environment. Aquaculture 30:53-61.

Bautista, M.N. and M.C.L. Baticados. 1990. Dietary manipulation to control the chronic soft-shell syndrome in tiger prawn, *Penaeus monodon* Fabricius. *In:* Hirano, R. and I. Hanyu (eds.).The Second Asian Fisheries Forum. Tokyo, Japan: Asian Fisheries Society. pp. 341-344.

Bautista, M.N., P.F. Subosa, and C.R. Lavilla-Pitogo. 1992. Effects of antioxidants on feed quality and growth of *Penaeus monodon* juveniles. J. Sci. Food & Agriculture 58. In press.

Bautista, M.N., F. Parado-Estepa, O.M. Millamena, and E.L. Borlongan. 1991. Large scale hatchery production of *Penaeus monodon* using natural food and artificial diets. The Israeli Journal of Aquaculture-Bamidgeh 43(4): 137-144.

Bautista, M.N., O.M. Millamena, and A. Kanazawa. 1989. Use of kappa-carrageenan microbound diet (C-MBD) as feed for *Penaeus monodon* larvae. Mar. Biol. 103(2): 169-174.

Bautista, M.N. 1986. The response of *Penaeus monodon* juveniles to varying protein/ energy ratios in test diets. Aquaculture 53:229-242.

Benitez, L.V. and L.B. Tiro. 1982. Studies on the digestive proteases of milkfish *Chanos chanos.* Mar. Biol. 71:309-315.

Borlongan, I.G. 1992. Essential fatty acid requirements of milkfish (*Chanos chanos* Forsskal) juveniles. Fish Physiology and Biochemistry 9(5-6): 401-407.

Borlongan, I.G. 1992. Dietary requirement of milkfish (*Chanos chanos* Forsskal) juveniles for total aromatic amino acids. Aquaculture 102:309-317.

Borlongan, I.G. and M.M. Parazo. 1991. Effect of dietary lipid sources on growth, survival, and fatty acid composition of sea bass (*Lates calcarifer* Bloch) fry. Bamidgeh - Israeli J. Aquacult. 43:95-102.

Borlongan, I.G. 1990. Studies on the digestive lipases of milkfish, *Chanos chanos.* Aquaculture 89:315-325.

Borlongan, I.G. and L.V. Benitez. 1990. Quantitative lysine requirement of milkfish (*Chanos chanos* Forsskal) juveniles. Aquaculture 87:341-347.

Borlongan, I.G. and R.M. Coloso. Requirements of milkfish (*Chanos chanos* Forsskal) juveniles for essential amino acids. J. Nutr. (In press).

Catacutan, M.R. 1991. Growth and fatty acid composition of *Penaeus monodon* juveniles fed various lipids. Bamidgeh-Israeli J. Aquacult. 43:47-56.

Catacutan, M.R. 1991. Apparent digestibility of diets with various carbohydrate levels and the growth response of *Penaeus monodon.* Aquaculture 95:89-96.

Chiu, Y.N. and L.V. Benitez. 1981. Studies on the carbohydrases in the digestive tract of the milkfish, *Chanos chanos.* Mar. Biol. 61:247-254.

Coloso, R.M., L.V. Benitez, and L.B. Tiro. 1988. The effects of dietary protein-energy levels on growth and metabolism of milkfish (*Chanos chanos* Forsskal). Comp. Biochem. Physiol. 89 A:11-17.

Eusebio, P.S. 1990. Effect of dehulling on the nutritive value of some leguminous seeds as protein sources for tiger prawn, *Penaeus monodon* juveniles. Aquaculture 99:297-308.

Ferraris, R.P, M.R. Catacutan, R.L. Mabelin, and A.P. Jazul. 1986. Digestibility in milkfish, *Chanos chanos* (Forsskal): Effects of protein source, fish size and salinity. Aquaculture 59:93-105.

Lim, C, S. Sukhawongs, and R.P. Pascual. 1979. A preliminary study on the protein requirements of *Chanos chanos* (Forsskal) fry in a controlled environment. Aquaculture 17:195-201.

Millamena, O.M. and P. F. Pascual. 1990. Tissue lipid content and fatty acid composition of *Penaeus monodon* Fabricius broodstock from the wild. J. World Maricult. Soc. (21) 2: 116-121.

Millamena, O.M. 1989. Effect of fatty acid composition of broodstock diet on tissue fatty acid patterns and egg fertilization and hatching in pond-reared *Penaeus monodon.* Asian Fisheries Science 2:127-134.

Millamena, O.M.J.H.Primavera, R.A.Pudadera, and R.V. Caballero. 1986. Effect of diet on the reproductive performance of pond-reared *Penaeus monodon* Fabricius broodstock. pp.593-596. *In:* J.L.Maclean,L.B.Dizon,and L.V.Hosillos(eds.). The First Asian Fisheries Forum. Manila, Philippines: Asian Fisheries Society.

Millamena, O.M. and E.T. Quinitio. 1986. Lipids and fatty acids in the nutrition of *Penaeus monodon* larvae. *In:* Y. Taki,J.H. Primavera, and J.A. Llobrera (eds.). Proc. First Int'l Conf. on the Culture of *Penaeus* Shrimps. SEAFDEC Aquaculture Department. Iloilo, Philippines.

Nalzaro, G.G. 1982. Quantitative dietary cholesterol requirement of *Penaeus monodon* juveniles. M.S. Thesis, Univ. of the Philippines in the Visayas. 47 pp.

Pascual, F.P. 1989. The effect of various levels of protein, fat, carbohydrates, and energy on growth, survival and body composition of *Chanos chanos* fingerlings. *In:* E.A. Huisman, N. Zonneveld, and A.H.M. Bouwman (eds.). Proc. Asian Sem. on Aquaculture by the International Foundation for Science (IFS); Malang, Indonesia. 1988 14-18 Nov. 1988. Wageningen: Pudoc. 228-236.

Peñaflorida, V.D. 1989. An evaluation of indigenous protein sources as potential component in the diet formulation for tiger prawn, *Penaeus monodon,* using essential amino acid index (EAAI). Aquaculture 83:319-330.

Peñaflorida, V.D. and O.M. Millamena. 1990. Variation in the biochemical composition of *Penaeus monodon* tissues during the reproductive cycle. The Israeli Journal of Aquaculture - Bamidgeh 42(3): 84-90.

Santiago, C.B., A.S. Camacho, and M.A.Laron. 1991. Growth and reproductive performance of bighead carp (*Aristichthys nobilis*) reared with or without feeding in floating cages. Aquaculture 96:109-117.

Santiago, C.B. and R.T. Lovell. 1988. Amino acid requirements for growth of Nile tilapia. J. Nutr. 118: 1540-1546.

Santiago, C.B., M.B. Aldaba, M.A. Laron, and OS. Reyes. 1988. Reproductive performance and growth of Nile tilapia (*Oreochromis niloticus*) broodstock fed diets containing *Leucaena leucocephala* leaf meal. Aquaculture 70:53-61.

Santiago, C.B., M.B. Aldaba, and O.S. Reyes. 1987. Influence of feeding rate and diet form on growth and survival of Nile tilapia (*Oreochromis niloticus*) fry. Aquaculture 64:277-282.

Santiago, C.B., M.B. Aldaba, O.S. Reyes, and M.A. Laron. 1987. Response of young Nile tilapia to diets containing *Azolla* meal. *In:* Second International Symposium on Tilapia in Aquaculture. 1987 March 16-20; Bangkok, Thailand.

Santiago, C.B., O.S. Reyes, M.B. Aldaba, and M.A. Laron. 1986. An evaluation of formulated diets for Nile tilapia fingerlings. Fish. Res. J. Philipp. 11(1 & 2): 5-12.

Santiago, C.B, M.B. Aldaba, and M.A. Laron. 1982. Dietary crude protein required for

Tilapia nilotica fry. Kalikasan, Philipp. J. Biol. 11:255-265.
Sumagaysay, N.S., F.E. Marquez, and Y.N. Chiu-Chern. 1991. Evaluation of different supplemental feeds for milkfish *Chanos chanos* reared in brackishwater ponds. Aquaculture 93:177-189.

Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni; 8-11 September 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. 1993. 173 pp.

TRAINING AND INFORMATION ACTIVITIES AND ACCOMPLISHMENTS OF THE SEAFDEC AQUACULTURE DEPARTMENT, 1988-1991

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One of the mandates of the SEAFDEC Aquaculture Department is the development of human resources and dissemination and exchange of information in aquaculture to promote the aquaculture industry in Southeast Asia. The Department receives trainees from SEAFDEC Member Countries (Thailand, Malaysia, Singapore) and other countries for short-term training programs. AQD also disseminates and exchanges information on aquaculture research and technology through symposia, seminars, workshops, video programs, and publications.

Training programs

The training activities of SEAFDEC/AQD consist of degree and non-degree programs (Table 1). The collaboration with UNDP/FAO Network of Aquaculture Centres in Asia and the Pacific Region (NACA) and the University of the Philippines - Visayas (UPV) has graduated 18 participants in the one-year *Senior Aquaculturists Training Course.* The participants were granted the degree Master of Aquaculture by UPV.

The short-term (4-7 weeks) training courses regularly offered at present are: (1) Fish Nutrition, (2) Marine Fish Hatchery, (3) Fish Health Management, (4) Aquaculture Management, (5) Culture of Natural Food Organisms, and (6) Shrimp Hatchery/Nursery Operations. These courses are 80-90% practical or laboratory work and 10-20% lectures. A total of 429 government workers and aquaculture technicians [386 from Member Countries (Philippines, 287) and 43 from other countries] completed the 29 sessions of training courses offered by SEAFDEC/AQD from 1988 to 1991 (Table 1). This number includes those who trained in courses previously offered by the Department (Brackishwater Pond Culture, Freshwater Aquaculture, and *Artemia* Culture).

Beginning 1989, the training program of SEAFDEC/AQD focused on the priority courses identified at the *Seminar on Training Requirements in Fisheries and Aquaculture* held in Thailand in 1988. Also, the demand for training shifted from shrimp hatchery /culture to marine fish hatchery, fish health management, and fish nutrition. This was gauged from the number of training course

Table 1. Number of participants in training courses and seminars conducted by SEAFDEC/AQD in 1988-1991*

Program	1988	1989	1990	1991	Total
NACA training		18			18
Short-term courses	144	116	83	86	429
Individual training					
Internship	59	43	17	21	140
Student Practicum	49	45	42	48	184
Seminars/workshops					
International	23			188	211
National	1,309	600	-	616	2,525
TOTAL	1,584	847	193	986	3,610

* See Annex 1 for details

applications and industry feedback. The shift was partly caused by the collapse of the shrimp industry in 1988, renewing interest in fish culture and subsequently, hatchery production of fry. Shrimp hatchery operators in the Philippines requested SEAFDEC/AQD through the Regional Agricultural and Fishery Council (RAFC) Region VI to conduct training on milkfish fry production. In response, two training sessions on milkfish larval rearing were conducted in 1990 with funding support from the International Development Research Centre (IDRC) of Canada. This was attended by 17 participants: private shrimp hatchery operators and technicians (13) and Department of Agriculture extension workers (4).

The Department has been offering individual training (internship and student practicum). Internships in nutrition and feed development, chemical/ proximate analyses, disease diagnosis, plankton culture, instrumentation, and other laboratory work are arranged for individuals or groups from SEAFDEC Member Countries. Practicum training is designed for graduating students in fisheries and related fields to satisfy the 400 hours requirement. It aims to provide students practical knowledge in aquaculture to supplement their theoretical orientation in school by assisting in ongoing research and verification studies at AQD. A total of 135 trainees from the national government and private sectors, and five from other countries underwent internship training at AQD. Also, 184 graduating students in fisheries and related fields from various schools took their practicum at AQD (Table 1).

Pursuant to the directive of the Philippine President to formulate a program for out-of-school youth to engage in productive endeavors during summer, 103 trainees availed of the Summer Youth Training Program implemented by AQD.

The International Seminar/Workshop on Teaching Strategies and Curriculum Development for Adult Learners funded by IDRC of Canada and the

Aquaculture Development in Southeast Asia (ADSEA '91) sponsored by SEAFDEC/AQD and the Government of Japan have been conducted by the Department. In addition, AQD conducts extension activities in the form of outreach/on-site seminars; a total of 2,525 local aquaculturists, technicians, and fish farmers have attended these seminars.

Table 2 shows the number of trainees from Member Countries and other countries and supporting agencies. SEAFDEC fellowship fund contributions from the Government of Japan have been granted to 150 participants from SEAFDEC Member Countries. Of the other supporting agencies, the Government of Netherlands supports the most number of participants from SEAFDEC Member Countries.

Library, documentation, and publications

Library holdings as of 31 December 1991 consisted of 10,158 monographic volumes, 5,042 pamphlets, 2,359 SEAFDEC publications, and 3,634 journal volumes, which were accumulated from gifts and exchanges, purchases, and paid subscriptions. Readership at the Library averages eight readers per hour, mostly students, researchers, faculty members, and practitioners from other institutions.

The Brackishwater Aquaculture Information System (BRA1S) Project which started in 1984 with funding from IDRC of Canada was completed in 1989. Total database entries include over 5,000 bibliographic entries with abstracts on brackishwater aquaculture and related subjects, 47 institutions registry, and 202 scientists registry. The BRAIS networking activities include acquisitions of 4,308 materials from national centers in Indonesia, Malaysia, Thailand, and the Philippines.

The Southeast Asian Fisheries Information System (SEAFIS) Project of the SEAFDEC Secretariat has implemented some of its activities at AQD. These

Table 2. Number of participants in SEAFDEC/AQD short-term training courses by country of origin and sponsors (1988-1991)

Sponsors	MAL	PHIL	THAI	SING	Other*** countries	TOTAL
SEAFDEC*	40	72	46			158
IDRC	-	-	-	-	4	4
FAO	-	-	-	-	14	14
Netherlands	1	3	1	-	1	6
Other agencies**	-	2	4	-	9	15
Gov't/private inst.	4	212	-	1	15	232
Total	45	289	51	1	43	429

* Fellowship fund contribution of the Government of Japan. ** USAID, CIDA, BADC, ADB, and World Bank. *** See Annex 2 for details.

Table 3. SEAFDEC/AQD in-house publications (1988-1991)*

	1988	1989	1990	1991	Total
Regular publications					
Asian Aquaculture (quarterly)	2	6	3	3	14
Aqua Farm News (bimonthly)	7	6	5	5	23
Aqua Dep't News (fortnightly)	21	25	24	21	91
BRA1S Newsletter**	3	2	-	-	5
Information Alert**	5	-	-	-	5
Annual Report	2		2	1	5
SUBTOTAL	40	39	34	30	143
Extension manuals***	-	10	3	1	14
Extension pamphlets and leaflets	-	3	14	1	18
Monograph	-	-	2	1	3
Abstracts	3	4	1	-	8
Proceedings and compilations	3	-	1	-	4
Others					
Brochures and directories***	6	8	4	7	25
Video tapes	4	-	-	-	4
Posters	I	1	1	1	4
SUBTOTAL	11	9	7	9	36
TOTAL	57	65	60	41	223

*List of 1988-1991 publications appears in Annex 3. ** Discontinued in 1989.
***Includes reprinting.

REFERENCES

Southeast Asian Fisheries Development Center. Aquaculture Department. Annual Reports (1988-1990). Tigbauan, Iloilo.

Southeast Asian Fisheries Development Center. The Secretariat. 1988. Training Requirements in Fisheries and Aquaculture in Southeast Asia. Report of the Seminar Held in Hua Hin, Thailand, 29-30 March 1988. Bangkok. (SEC/RM/53)

Annex 1. Number of participants in training courses and seminars, 1988-1991

	1988	1989	1990	1991	TOTAL
Degree program					
UNDP/FAO/NACA-UPV-SEAFDEC/AQD Senior Aquaculturists Training Course (Masters in Aquaculture)	-	18(1)*	-	-	18(1)*
Short-term training courses					
Brackishwater Pond Culture	45(2)	14(1)	-	-	59(3)
Freshwater Aquaculture	10(1)	-	-	-	10(1)
Prawn Hatchery	55(3)	41(2)	10(1)	17(1)	123(7)
Marine Finfish Hatchery	11(1)	18(1)	14(1)	16(1)	59(4)
Fish Health Management	8(1)	17(1)	17(1)	14(1)	56(4)
Fish Nutrition	-	14(1)	12(1)	12(1)	38(2)
Aquaculture Management	-	-	13(1)	14(1)	27(2)
Artemia Culture	15(1)	-	-	-	15(1)
Culture of Natural Food Organisms	-	12(1)	-	13(1)	25(2)
Milkfish Hatchery	-	-	17(2)	-	17(2)
T O T A L	144(9)	116(7)	83(7)	86(6)	429(29)
Other training programs					
Internship Training	59	43	17	21	140
Summer Youth Training	-	25	51	27	103
Practicum Training for Fisheries Students	49	45	42	48	184
Seminars					
1. International					
Workshop on Teaching Strategies and Curriculum Development for Adult Learners	23(1)				23(1)
Aquaculture Development in Southeast Asia (ADSEA)				188	188(1)
2. National Outreach Seminars					
Pond Culture and Management	35(1)				35(1)
Prawn Hatchery Operation and Management	50(1)		–	–	50(1)
Feed Development and Fish Nutrition				16(1)	16(1)
Freshwater Aquaculture	8(1)	-	-	-	8(1)
Outreach Seminars for local small-scale fish farmers	1200(28)	600(9)		616(10)	2416(47)
Artemia Workshop	16(1)	-	-	-	16(1)

* Figures in parentheses indicate number of training courses and seminars conducted.

Annex 2. Number of participants in SEAFDEC/AQD short-term training courses by country of origin and sponsors, 1988-1991

	SEAF-DEC*	IDRC of Canada	FAO	Nether-lands	Other funding agencies	Other govern-ments or private org.	TOTAL
Member Countries							
Malaysia	40	-	-	1	-	4	45
Philippines	72	-	-	3	2	212	289
Thailand	46	-	-	1	4	-	51
Singapore	-	-	-	-	-	1	1
Other Countries							
Vietnam	-	-	6	-	-	-	6
Indonesia	-	1	3	1	2	-	7
India	-	-	-	-	2	1	3
Sri Lanka	-	2	-	-	3	6	11
Uganda	-	-	-	-	-	1	1
Nigeria	-	-	-	-	-	3	3
Tonga	-	-	2	-	-	-	2
Kiribati	-	-	1	-	-	-	1
Kenya	-	1	-	-	-	-	1
Papua New Guinea	-	-	2	-	-	-	2
United Arab Emirates		-	-	-	-	1	1
China	-	-	-	-	2	-	2
Mauritus	-	-	-	-	-	1	1
Yap State	-	-	-	-	-	1	1
Iran	-	-	-	-	-	1	1
TOTAL	158	4	14	6	15	232	429

*Fellowship fund contribution of the Government of Japan.

Table 1. Number of private hatcheries and nurseries, by province

	1986	1987	1988
Central region			
1. Bangkok	-	1	1
2. Samut Prakan	6	-	-
3. Samut Sakhon	5	14	18
4. Samut Songkran	6	9	9
5. Phetchaburi	2	5	11
	19	29	39
Eastern region			
1. Chachoengsao	4	415	1,200
2. Chonburi	11	171	200
3. Rayong	4	10	19
4. Chanthaburi	6	3	14
	25	599	1,433
Southern region			
1. Prachuab Khirikhan	1	-	6
2. Surat Thani	1	-	15
3. Nakhon Si Thammarat	3	15	27
4. Songkhla	4	8	11
5. Krabi	-	1	1
6. Phangnga	-	3	6
7. Satun	-	2	2
8. Phuket	8	29	102
	17	58	170
Total	**61**	**686**	**1,642**

The hatcheries in Thailand can be divided into three main groups. The first includes hatcheries that produce only nauplii, located in two main parts of the country where natural broodstock of shrimp can be collected (Phuket in the south and Chonburi in the east). The nauplii are supplied to other hatcheries that nurse them until postlarval stage (PL5). The second group of hatcheries is the big group located throughout the country, especially in central Thailand (Chachengsao, Chonburi, and Supanburi provinces). The third group comprises the nurseries that grow PL 5 up to PL 15-30 or to sizes that farmers order. Most of the shrimp hatcheries are developed for the giant freshwater prawn (*Macrobrachium rosenbergii*), small-scale, and operated by families.

The Department of Fisheries has surveyed the increasing number of shrimp hatcheries: 61 in 1986; 686 in 1987; 1,642 in 1988; and 2,000 in 1992 (Table 1). Seed production is estimated at 8-20 billion postlarvae per year, enough to meet the demand of shrimp farms in the country.

6. Proceedings and Compilations of AQD Research Publications (5)
   - 6.1 *Perspectives in Aquaculture Development in Southeast Asia and Japan* (1988)
   - 6.2 *Culture and Use of Algae in Southeast Asia* (1990)
   - 6.3 *Collected Reprints: Research Publications (1976-1986) Vol. 1A Finfishes; Vol. 1B Crustaceans and Bivalves* (2nd edition 1988)
   - 6.4 *Collected Reprints: Research Publications (1986-1991)*

Posters (4)**
   - 7.1 *Important Penaeid Prawns/Shrimps of the Philippines* (Poster No. 1, reprinted 1988)
   - 7.2 *Life Cycle of Prawn* (Poster No. 2, revised 1989)
   - 7.3 *Anatomy of Adult Penaeid Prawns/Shrimps* (1990)

8. Video Tapes (5)
   - 8.1 *Biology and Ecology of Penaeus monodon* (revised 1988)
   - 8.2 *Hatchery Production of Nursery Prawn Fry* (revised 1988)
   - 8.3 *Prawn Feed Preparation* (revised 1988)
   - 8.4 *Prawn Processing* (revised 1988)
   - 8.5 *Caring for Milkfish Larvae* (1992)

9. Brochures (25)**
   - 9.1 *AQD Information Brochure*
   - 9.2 *SEAFDEC Brochure*
   - 9.3 *Aquaculture Training Program*
   - 9.4 *List of AQD Research Publications*
   - 9.5 *List of AQD Senior Staff*
   - 9.6 *Publication Catalogue*
   - 9.7 *Brochure on Business Opportunities in Aquaculture*
   - 9.8 *List of Publications and Video Tapes*
   - 9.9 *Personnel Profile*

10. Directories (2)
   - 10.1 *Directory of Brackishwater Aquaculture Scientists*
   - 10.2 *Directory of Brackishwater Aquaculture Institutions*

11. Monographs (4)
   - 11.1 *Biology and Culture of Siganids*
   - 11.2 *Biology and Culture of Penaeus monodon*
   - 11.3 *Biology of Milkfish (Chanos chanos)*
   - 11.4 *Seaweeds of Panay*

*Discontinued in 1989. **Includes reprinting.

Discussion

The technical issues discussed by the workshop participants include:

- Fish eggs: disposal program of AQD, monitoring survival
- Performance of pond-reared as against wild shrimp broodstock: nauplii production and size, spawning period
- Philippine Government support to NBBP
- Feeding trials for grow-out culture of shrimp; performance and cost of AQD formulated feeds as against commercial feeds
- Possibility of AQD commercially marketing and producing its feed formula. Constraints include limited AQD facilities and technical knowledge of small-scale fishermen, and bias towards large-scale feed millers. Organizing fishfarmers into cooperatives to produce their own feeds has been suggested.
- Soft-shelling in shrimp; blue shrimp
- Status and direction of AQD's seafarming project
- Need for more research for the development of fish broodstock: sex ratio; stocking density; number of eggs and spawning per season
- AQD's research on fry criteria: physiology or disease and survival correlation
- Research on locally-available feed ingredients: constancy in supply, possibility of tapping other government and non-government agencies
- Stocking density of shrimp in hatchery

Training gap noted:

- Technicians skilled in disease diagnosis

<u>APPENDICES</u>

WORKSHOP PROGRAMME
THE PARTICIPANTS AND OBSERVERS

WORKSHOP PROGRAMME

September 7

Arrival and billeting of participants

September 8

Registration, Opening Ceremony, Reception

9:00	Registration	
11:00	Opening Ceremony	
12:00	Lunch Break	

Country Reports: Shrimp and Marine Fish Production

Shrimp

1:30	Philippines	[1]Ms. Ma. Salvacion Ferrer
1:50	Malaysia	Mr. Mohd Hatta Mahmud
2:20	Thailand	[1,2]Mr. Tharaphand Wattanamahard
2:40	General Discussion	
3:20	Coffee Break	

Marine Fish

3:30	Philippines	Mr. Nemencio Arevalo
3:50	Malaysia	Mr. Mohd Zaidi Mohammad
4:10	Thailand	Mr. Jate Pimoljinda
4:30	General Discussion	
6:30	Reception	

September 9

Country Reports: Grow-out Culture Techniques

8:30	Philippines	Mr. Apolinario Gicos
8:50	Malaysia	Ms. Shahima Ab. Hamid
9:10	Thailand	[1]Mr. Rewat Prempiyawat
9:30	General Discussion	
10:15	Coffee Break	

Country Reports: Fish Diseases

10:30	Philippines	[1]Ms. Simeona Regidor
10:50	Malaysia	Ms. Safiah Sayuthi
11:10	Thailand	Mr. Wasan Sreevatana
11:30	General Discussion	
12:00	Lunch Break	

Country Reports: Fish Nutrition

1:30	Philippines	[1]Ms. Alma Mendoza
1:50	Malaysia	Mr. Zulkifli Talib
2:10	Thailand	Mr. Vitaya Havanont
2:30	General Discussion	
3:15	Coffee Break	

Private Sector Experience

3:30	Seed Production	Ms. Elizabeth Lamera
4:10	Grow-out Culture	Prof. Valeriano Corre, Jr.
4:30	General Discussion	

September 10

Review of SEAFDEC/AQD Research, Training and Information Activities (1988-1991)

8:30	Overview: Research	Dr. Clarissa Marte
8:45	Shrimp Seed Production	Ms. Fe Estepa
9:00	Marine Fish Broodstock	Mr. Luis Ma. Garcia
9:15	Marine Fish Seed Production	Ms. Marietta Duray
9:30	Fish Diseases	Ms. Celia Pitogo
9:45	Fish Nutrition	Ms. Oseni Millamena
10:00	Coffee Break	
10:15	Overview: Training and Information	Dr. Cesar Villegas
10:30	General Discussion	
12:00	Lunch Break	

Workshop, Closing Ceremony

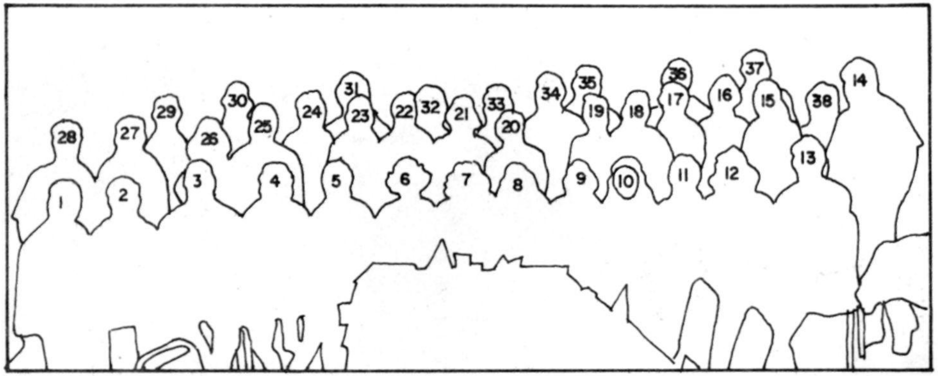
1:30	Course Assessment/ Training Needs	Mr. Rodrigo Lacierda
3:30	Break	
6:30	Closing Ceremony Dinner Party	

September 11

Tour: Igang Marine Substation and U.P. in the Visayas

Unable to attend due to unforseen circumstances. [2]Paper read by co-participant.

THE PARTICIPANTS AND OBSERVERS



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The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in 1967. Its Member-Countries are Japan, Malaysia, the Philippines, Singapore, and Thailand.

Created to develop fishery potentials in the region in response to the global food crisis, SEAFDEC undertakes research on appropriate technologies, trains fisheries and aquaculture technicians, and collects, analyzes, and disseminates fisheries and aquaculture information. To pursue these objectives, the Center established four key departments - Marine Fisheries Training Department (Thailand), Marine Fisheries Research Department (Singapore), Aquaculture Department (Philippines), and Marine Fishery Resources Development and Management (Malaysia).

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