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Catfish Aquaculture

by
Josef D. Tan-Fermin, PhD
SEAFDEC Aquaculture Department
5021 Tigbauan, Iloilo, Philippines
Email: jtfermin@aqd.seafdec.org.ph

The Philippines is the fourth biggest catfish-producing country in Southeast Asia in 1997 to 2001. Next to tilapia, catfish is the second highest freshwater fish produced in fishponds in 2001. In Asia and the Pacific, highest production comes from *Clarias* spp. of the family Clariidae. Of great importance in fisheries and aquaculture and the most well-studied species among the clariids are the Asian catfish *Clarias macrocephalus* and *C. batrachus*, and the African catfish *C. gariepinus* (*C. lazera*).

Because of its tender and delicious meat, the native catfish or 'hito' or *C. macrocephalus* (picture this page) is one of the favorite freshwater food fishes in the Philippines. Before the early seventies, it is abundantly found in the rice fields and other natural habitats in the Philippines. At present however, *C. macrocephalus* is scarcely found in rice fields or any of its natural environment. Some observers hypothesized that the fast disappearance of *C. macrocephalus* is due to its interbreeding with *C. batrachus*, a closely related, faster-growing species introduced from Thailand in the 1970's. In Thailand, there is almost the same number of *C. macrocephalus* and *C. batrachus*, while in Vietnam, there is a more abundant supply of *C. macrocephalus* than *C. batrachus*.

C. macrocephalus and *C. batrachus* are almost similar in size and appearance. *C. macrocephalus* can be distinguished from the Thai catfish *C. batrachus* by the shape of the occipital process, blunt or rounded in the former

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Getting IRAP started in Vietnam

Excerpted from the travel report of WG Yap and VT Sulit. For more information, email: wgyap@aqd.seafdec.org.ph

The importance given by Vietnam to SEAFDEC's integrated regional aquaculture program (IRAP) was evident in the fact that two ranking officials of the Ministry of Fisheries flew to Hue from Hanoi to meet the IRAP staff from SEAFDEC/AQD (Mr. Wilfredo Yap, Ms. Virgilia Sulit, and Ms. Marietta Duray). The two were Dr. Vu Van Trieu, Director General, International Cooperation Department; and Dr. Tran Van Quynh, Director, National Fisheries Extension Center. With them was Tran Van Chuong, Vice Director, Fishery Promotion Center of Hue province.

At the Hue provincial fishery office, the AQD staff was briefed on the itinerary (July 29 to August 4, 2003) and the Vietnamese counterparts' expectations of IRAP. Afterwards, the group went to Phu Tuan commune to visit a prawn hatchery, which is intended to be converted into a rabbitfish hatchery. A private nursery, which uses rabbitfish fry caught from the Pha Tam Giang, was also visited.

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2004 training courses at SEAFDEC/AQD, page 19

European Union and SEAFDEC/AQD on mudcrab *Scylla* p 20

Wanna know what concerns fishfarmers? Share in their frequently asked questions, p 11

Catfish feeding experiment. p 4

Part 2 of 2 of *Business opportunities in aquaculture* will appear next issue. Our apologies.

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To spawn the native catfish, a choice of hormones can be injected to female catfish while the male catfish is sacrificed for its milt

and pointed in the latter, and presence of white spots along the sides of the body in *C. macrocephalus*.

SEAFDEC Aquaculture Department at Tigbauan, Iloilo, central Philippines, embarked on research on the artificial propagation of *C. macrocephalus* since the late 1980s to provide the seeds and probably restock natural population. This article will deal with the biology, broodstock management, seed production techniques and grow-out culture practices in *C. macrocephalus*.

Biology and broodstock management

In the Philippines, catfish can be found in Bicol region, Palawan, and some areas in Mindanao. These can be collected from lakes, rivers, tributaries by hand or indigenous fish trap. After collection, the fish can be transported in any container made of styrofoam, plastic, metal and the like, with pond or riverine water just enough to cover the bodies of the fish, without aeration.

Broodfish can be reared in concrete tanks with 10 cm mud overlay or in earthen ponds. Before stocking the fish, 1.0-1.5 ton per ha agricultural or 0.5-1.0 ton per ha hydrated lime is applied to disinfect and eradicate predators, while 50-100 ppm formalin is used to prevent the growth of filamentous algae.

In the wild, catfish fry feed on small crustaceans, protozoans, and phytoplankton, and on worms, insects, crustaceans, and benthic organisms as they grow bigger. Catfish are carnivores, but can feed on kitchen refuse, fish meal with broken rice or rice bran, or formulated feeds. SEAFDEC-formulated broodstock diet containing 439c protein resulted in comparable reproductive and larval performance as when the fish were fed fish by-catch or trash fish. The composition (% dry weight) of this diet is as follows: fish meal, 15; soybean meal, 35; ricebran, 15.61; corn starch, 2; vitamin mix, 3.55; soybean oil, 3; meat and bone meal, 22.4; and copra meal, 3.44.

Sexes can be distinguished externally by the presence of elongated, urogenital papillae in the males, and a round opening in the females at the lower, ventral side of the body. Regardless of size, *C. macrocephalus* are generally mature at 6 - 8 months of age.

The natural breeding months in catfish vary from place to place. However, the common factor in these places is the onset of the rainy season. The final stimulus to spawn in Clariid catfishes seems to be associated with a rise in water level and flooding of marginal areas.

Breeding

While natural spawning of catfish occurs in the wild, *C. macrocephalus* may not spawn in confined waters: hence, use of hormones to induce its spawning is necessary. The absence of spawning is correlated with the lack of a surge in gonadotropin (GTH), a hormone secreted by the pituitary gland with gonad (ovary or testis) as target organ. Most of the hormonal treatments either stimulate or artificially induce the endogenous release of GTH.

For induced spawning, it is better to choose bigger females since fecundity is positively correlated with size. Success in induced spawning depends largely on knowledge of the optimum dose of the hormones to be used and the resulting latency period, the time between hormone administration and stripping of eggs. The optimum dose and latency period using the different hormones is summarized below:

Inject females with	strip after
pituitary gland (1 per 100 g body weight. BW)	13-14 hours
hCG or human chorionic gonadotropin (4 IUs or international units per g BW)	13-18 h
LHRH or luteinizing hormone-releasing hormone (0.05 µg) + 1 µg of PIM per g BW	16-20 h
Ovaprim (0.05 µl per g BW)	16-20 h
Ovatide (0.20-0.50 µl per g BW)	16-20 h

About 16-20 hours after hormone injection, females are checked of their readiness to release eggs. If eggs ooze out upon gentle pressure on the abdomen, male catfish are then sacrificed, the reproductive tract dissected and macerated to obtain the milt, a hydrated suspension of sperm. Male catfish are sacrificed because milt cannot be stripped from the abdomen. Milt is mixed with 0.6% sodium chloride (NaCl), placed in a small beaker, and poured into same container where eggs are stripped. Eggs and milt are then mixed with a feather for about one minute, transferred to a small scoop net and wash in gentle, running, tap water before fertilized egg mass is transferred to the incubation container. Speed is important in doing these procedures since sperm are motile for a few minutes only, and stripped eggs are viable for about 1-2 minutes due to closure of the micropyle. (Sperm enter the egg through an opening on the egg surface called micropyle.)

Catfish possess demersal, spherical or slightly oval-shaped eggs that measure 1.2-1.6 mm, and become sticky upon contact with water.

Hatchery

Simple facilities are used in running a catfish hatchery. Basically, facilities include incubation containers where fertilized egg mass are hatched and yolk sac larvae maintained, and tanks for rearing the larvae for about two weeks.

An incubation container can be in the form of a rectangular, wooden trough or plastic basin, but should have a flow-through water supply during incubation and until hatching of the larvae, which is about 24 - 30 h at water temperature of 26 - 30°C. Eggs can be stocked at 4000 per liter, and are usually spread as a monolayer on a rectangular screen net on a wooden frame. Good water exchange is necessary, hence having a recirculating water system using rain water during incubation of catfish eggs is advisable. The newly hatched larvae are easily dropped into the bottom of the trough by slowly moving the framed screen net, leaving only the dead eggs on it.

The newly hatched catfish larvae contain yolk, which serve as food. It takes about 4-5 days for the yolk to be totally resorbed. Thereafter, natural food organisms such as newly hatched nauplii of the brine shrimp *Artemia* are given to the larvae for 3 days, and the cladoceran *Moina* for another 4 days. Thereafter, catfish larvae are fed artificial feed containing 40% protein with particle size of 150-200µ in three rations daily at 50% of the body weight. The composition (% dry weight) of the SEAFDEC diet: soybean meal, 25; Peruvian fish meal, 35; rice bran, 19.5; bread flour, 10; cod liver oil, 3; soybean oil, 3; vitamin mix, 3; and mineral mix, 1.5.

Nursery

Bigger rearing facilities are needed for the production of catfish fingerlings in the nursery. Ten days before stocking, growth of natural food organisms should be promoted by suspending about 20 kg cow dung placed in a sack in the middle of the tank or pond and introducing *Moina* or *Daphnia* starters. Although the 15-day old fry or even the 3-day old first feeding larvae can be stocked directly into the tank or pond, it is advisable to rear the larvae inside a net cage with a mesh size of 0.5-1.0 mm, especially if fry are reared in ponds. Rearing in net cages suspended in either tanks or ponds was observed to improve survival of the fry.

The same formulated feed given to the fry in the hatchery phase can be fed during the nursery phase. Feeding is given in three rations daily at 20% BW during the first week, 15% BW on the second week, and 10% thereafter.

As in the hatchery, rearing of the fry to the fingerling stage in the nursery is also done in a static water system. Water change can be done weekly. In tanks, 50% of the rearing water is replenished, while replenishment of water in the ponds is done when necessary to maintain a depth of 70 cm.

Fifteen-day old *C. macrocephalus* fry can be stocked initially at 200-800 per square meter in tanks, and up to 1200 per m² in net cages that are suspended in ponds or tanks. After 28 days of rearing, fry grown in tanks can reach the size of 0.2-0.4 g and 3-4 cm, and 0.4-1.4 g, 4-5 cm when reared under pond conditions.

Grow-out

Catfish are usually cultured in earthen ponds or pens, either in monoculture or polyculture with other fishes, especially tilapia.

Preparation of ponds include drying the pond bottom for 7-10 days until the soil cracks, and application of hydrated lime and chicken manure at 1 ton per ha. Before stocking of the fish, 60% of the rearing water is changed, and increased to a depth of 60 cm upon stocking of juvenile catfish. Uniform-sized and healthy fingerlings are selected for stocking. Swamp cabbage and water hyacinth are grown at 20-30% of the pond area to serve as shelter for the fish.

When used for intensive culture, catfish juveniles are fed with artificial feeds containing at least 40% crude protein. However, commercial pellets with 30-32% crude protein or a combination of blanched chicken entrails and rice bran at a ratio of 9:1 are acceptable to catfish when given as supplemental feed. As catfish grow bigger, decreasing feeding rates of 5 to 3% of the body weight is recommended.

Stocking density for grow-out culture depends on the initial size of the fingerlings. Catfish juveniles, with mean total length of 3-4 cm can be stocked at 80-100 ind per m², 5-6 cm at 60-80 ind per m², or 7-10 cm at 40-60 ind per m². With proper management, culture of *C. macrocephalus* takes about 4 - 5 months.

Diseases caused by bacteria or ectoparasites can affect the culture of catfish. Lime and salt at 1 kg per 40m² are applied two weeks before the cold season, and at 0.5 kg per 40m² every two weeks. Diseased fish should be isolated from the rest of the stock and disposed of properly.

Economic analyses

Investment costs per run for broodstock and hatchery, nursery and grow-out operations in catfish is about P142 700, P83 000, and P178 500, respectively (below).

Summary of financial investment analysis of catfish seed production and grow-out operations for 10 years

	Hatchery	Nursery	Grow-out
Gross revenue	P 8,432,167	11,222,833	23,184,500
Investment costs	142,700	83,000	178,500
Total cost	3,156,744	6,202,838	13,981,901
Net income	5,132,722	4,936,995	9,024,099
Payback period (yr)	0.25	0.15	0.19
Net present value at 12%	2,530,192	2,456,970	4,467,056
Internal rate of return (%)	387	666	526

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Growth and yield of Asian catfish *Clarias macrocephalus* (Gunther) fed different grow-out diets

Eliseo B. Coniza, *Researcher I*; Mae R. Catacutan, *Scientist II*; and Josefa D. Tan-Fermin, *Scientist II*
SEAFDEC/AQD, Iloilo, Philippines
<econiza@aqd.seafdec.org.ph>

In the Philippines, catfish farming is a growing industry and one of the species being cultured is *Clarias macrocephalus*, a highly esteemed food fish because of its meat. Many studies have been done on breeding, hatchery and nursery of *C. macrocephalus*, but information on its culture is limited.

Previously, *C. macrocephalus* culture in the Philippines did not prosper due to lack of efficient diet. Catfish are carnivores and catfish growers commonly use pelleted diet, chicken entrails, fish by-catch, rice bran or any combination of these. However, the supply of chicken entrails and trash fish are limited and seasonal.

The study was undertaken to evaluate the efficiency on growth, survival, feed conversion ratio (FCR) and production of Asian catfish fed four grow-out diets.

The experiment was conducted in a freshwater fishpond in Dumangas, Iloilo, Philippines. Twelve pens were installed in a 440 m² pond. The pond was prepared by sun-drying the pond bottom for five days until the soil cracked. Hydrated lime [Ca(OH)₂] and chicken manure were then applied at 1 ton per ha each. The pond was then filled with water to an initial depth of 10 cm. After seven days, the water depth was increased by 5 cm every two days until it reached 30 cm. Next, urea (45-0-0) was applied at 25 kg and ammonium phosphate (16-20-0) at 50 kg per ha and the water level was raised to 60 cm. The pens were installed in two parallel rows, 1 m apart. Each pen was created by enclosing a 5 x 5 m area with B-net (2 mm mesh) held in place by a bamboo framework and round ipil-ipil wood (10 cm diameter). The bottoms of the net were buried 30 cm into the pond bottom. To prevent leaching and mixing of feed, the walls were lined with plastic sheet (gauge #2.6). A bamboo catwalk was constructed between the rows for ease of feeding and management.

Two days before stocking, 2 kg (wet weight) of swamp cabbage *Ipomea aquatica* (locally known as "kangkong") and four kg of water hyacinth *Eichornia crassipes* were put into each pen to serve as shelter for catfish. The plants were limited to 20-30% of the pen area throughout the experiment to allow space for feed input.

Hatchery-bred *C. macrocephalus* fingerlings with initial weight of 3.6 g and total length 78.0 mm were stocked at 10 fish per m². Four diets (Table 1) were tested in a completely randomized design (CRD) with three replicates per treatment for 120 days. Diets 1, 2 and 3 were given at 5.0, 4.5, 4.0, and 3.5% of the fish biomass per day for four months, respectively. They were fed in crumble

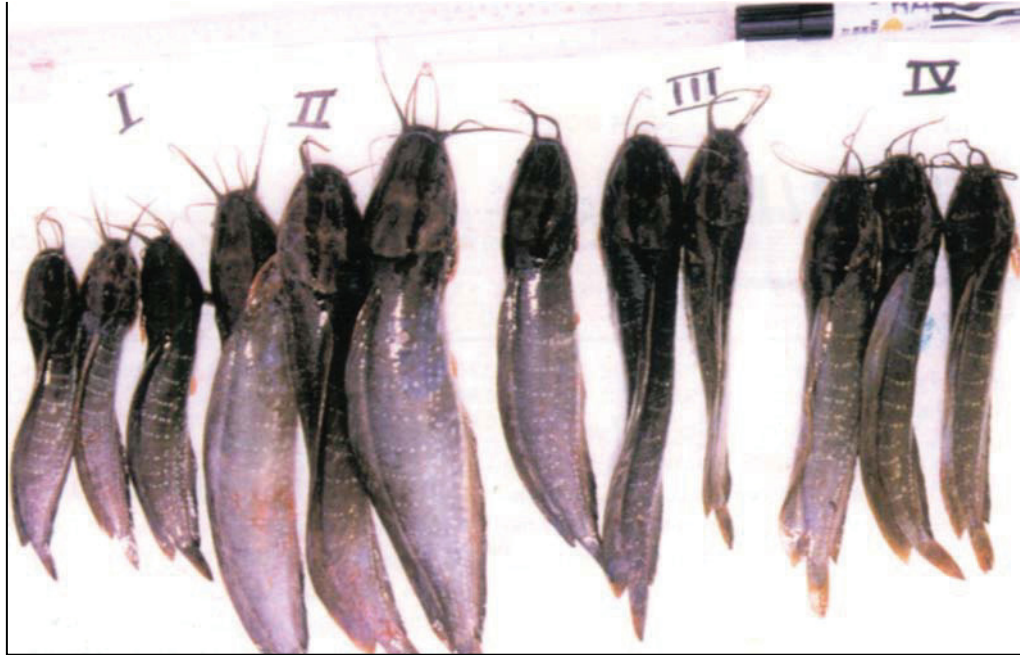
TABLE 1 **Composition (%) and proximate analysis (% dry matter basis) of experimental diets for *Clarias macrocephalus* juveniles**

	Diet 1 ^a	Diet 2 ^a	Diet 3 ^b	Diet 4
Composition				
Chilean fish meal	6	20		-
Soybean meal	5	30		-
Rice bran	70	31		20
Bread flour	9	9		-
Soybean oil	5	5		-
Mineral mix ^c	1	1		-
V-22 ^c	1	1		-
Dicalcium phosphate	3	3		-
Chicken entrails	-	-		80
Proximate analysis				
Moisture	10.4	8.5	8.8	72.7
Crude protein	19.0	34.2	28.9	31.7
Crude fat	12.8	9.5	11.1	29.7
Nitrogen-free extract	53.0	36.4	48.4	4.6
Crude fiber	5.8	5.8	4.7	7.2
Ash	9.4	14.2	8.4	6.8
Gross ME (kcal kg ⁻¹) ^d	4032	3679	4091	4910
Protein to energy ratio (P/E) ^e	47	93	71	64

Analysis was done according to AOAC (1990): ^aSEAFDEC/AQD-formulated diets. ^bCommercial feed pellet. ^cCommercial pre-mix. ^dMetabolizable energy values (kcal·kg⁻¹): protein, 4; fat, 9; nitrogen-free extracts, 4. ^eP/E = mg protein/kcal

form for the first two months and in pellet form (2.5 mm diameter) in the third and fourth. Diet 4 was a combination of chicken entrails (80%) and rice bran (20%) and fed to catfish following industry practice: 10% of the fish biomass per day during the first two months and then 8% thereafter. Chicken entrails were blanched in a nylon screen bag in boiling water for a few seconds, then chopped finely and mixed with rice bran (sieved through a 1-mm mesh). Feeds were given twice daily at 8 AM and 4 PM.

The water level was maintained at 60 cm for the first 15 days of culture and raised to 90-105 cm for the remainder of the experiment. During the first two months, 30-40% of the pond water volume was drained, and replenished by pumping water from the reservoir pond once a week. From the third month, the same amount of water was exchanged twice weekly.



Size differences in native catfish fed different diets. Roman numerals refer to type of diet

TABLE 2 Growth, survival, feed conversion ratio (FCR), condition factor, production, ALR and PER of *Clarias macrocephalus* fed four diets for 120 days. Initial body weight 3.6±0.1 g, and total length 78.0±0.1 mm. Values are mean of three replicate pens, ± SEM

	Diet 1	Diet 2	Diet 3	Diet 4
MBW (g)	30.2 ± 0.9 ^c	108.9 ± 2.7 ^a	58.3 ± 2.7 ^b	67.4 ± 2.4 ^c
MTL (mm)	154.3 ± 0.0 ^c	232.8 ± 0.7 ^a	190.8 ± 0.6 ^b	203.2 ± 0.3 ^b
SGR (% day ⁻¹) ¹	1.8 ± 0.0 ^c	2.9 ± 0.1 ^a	2.3 ± 0.1 ^b	2.4 ± 0.1 ^b
Daily weight gain (g day ⁻¹) ²	0.2 ± 0.0 ^c	0.9 ± 0.1 ^a	0.5 ± 0.1 ^b	0.5 ± 0.1 ^b
FCR: As fed	3.4 ± 0.3 ^b	2.5 ± 0.3 ^a	2.3 ± 0.1 ^a	5.0 ± 0.3 ^c
Survival (%) ³	73.1 ± 3.1 ^a	67.7 ± 8.4 ^a	81.2 ± 4.0 ^a	72.4 ± 6.3 ^a
Condition factor (K) ⁴	0.8 ± 0.0 ^{ab}	0.9 ± 0.0 ^a	0.8 ± 0.0 ^{ab}	0.8 ± 0.0 ^b
ALR (%) ⁵	78.0 ± 6.4 ^b	131.7 ± 14.5 ^a	95.0 ± 4.3 ^b	89.6 ± 5.3 ^b
PER ⁶	1.7 ± 0.2 ^a	1.3 ± 0.2 ^a	1.6 ± 0.1 ^a	2.4 ± 0.1 ^b
Production (kg 25 m ⁻² pen)	5.5 ± 0.3 ^c	18.4 ± 1.1 ^a	11.8 ± 1.1 ^b	12.2 ± 0.3 ^b

Means within a row with different superscripts are significantly different (P>0.05)

¹Specific growth rate (% day⁻¹) = ln (final wt) - ln (initial wt)/days fed × 100

²Daily weight gain = mean weight gain/days fed

³Arcsin transformed

⁴Condition factor = weight (g)/length (cm)³ × 100

⁵Apparent lipid retention = final body lipid - initial body lipid/total lipid fed × 100

⁶Protein efficiency ratio = weight gain (g)/protein fed (g)

Soil samples from the pond bottom were collected before and after the experiment to analyze the levels of organic matter (OM), pH, available iron, phosphate and sulfate. The water quality parameters were monitored twice weekly. Water temperature and dissolved oxygen (DO), turbidity, pH, nitrite-nitrogen (NO₂-N) and ammonia-nitrogen (NH₃-N) were determined between 8-9 AM.

Twenty-five fish were sampled for weight using a seine net every 15 days to monitor growth and adjust the feed ration. During sampling, fish were anaesthetized with 400-500 ppm (4 to 5 ml per 10 liters water) ethylene glycol monophenyl ether. Catfish after harvest were sampled and graded according to size in terms of the body weight.

The proximate composition of experimental diets and fish carcasses were determined before and after the experiment. Taste test was conducted on odor, flavor and general appearance or tex-

ture of steamed, salt-less fish samples taken from each replicate and pooled for each treatment. The fish samples were held in 60 l fiberglass tank with aeration for about 36 hours and then cleaned and steamed for 15 minutes before the taste test.

After 120 days of culture, the mean weight, total length, daily weight gain, specific growth rate, condition factor and production of fish fed Diet 2 were significantly higher than fish fed Diets 1,3 or 4 (Table 2). The FCR of Diet 3 was better but not significantly different from Diet 2. Survival rates were similar in all treatments. Catfish fed Diet 2 had highest apparent lipid retention but their protein efficiency ratio did not differ from those of fish fed with Diets 1 and 3.

Catfish fed Diet 1 weigh less than 80 g (Fig. 1). In catfish fed Diet 2, 93 % of the fish weighed above 80 g. In catfish fed Diet 3, 92% weighed less than 81 g and in catfish fed Diet 4, 82% were below 81 g.

Crude protein level in fish fed Diets 2 and 3 were higher than in fish fed Diets 1 or 4 (Table 3). Catfish in all treatments became fatty at the end of the experiment: crude fat was highest in fish fed Diet 4 and lowest in Diet

3. Ash content was highest in fish fed Diets 1 and 2. and nitrogen-free extract was highest in fish fed Diet 3.

Soil quality after harvest did not differ among treatments. pH was 7.5, organic matter was 0.74%, available phosphate was 481 ppm, available iron was 0.02 ppm and available sulfate was 0.28 ppm. Compared to the initial values, the organic matter and available phosphate increased, while available iron and sulfate decreased. The increase in organic matter and phosphate in the soil after harvest maybe due to increased organic loading of pens caused by the feeding. The decrease in the available mineral components such as iron and sulfate may be due to assimilation by *E. crassipes*, *I. aquatica* or other algae, or by trapping in the pond sediment.

The pond water quality varied little throughout the experiment in all treatments and within the optimum ranges. The lowest

AQD holds training on viral diseases

The second and final hands-on training on important viral diseases of shrimps and marine fishes started on November 5 and ended November 21. There were 11 participants from Bangladesh, Cambodia, China, India, Indonesia, Kenya, Mozambique, Pakistan, Philippines, and Tanzania. Lecturers came from AQD and Japan.

Fish Disease Expert Dr. Kazuya Nagasawa serves as leader of the regional fish disease project at AQD, funded by the Government of Japan. He emphasized the importance of a networking scheme for disease diagnosis and control in the region. AQD Chief Dr. Rolando Platon, on the other hand, highlighted the importance of the training and the role of participants in sustainable aquaculture development in the region.

The viral diseases course is an offshoot of the seminar-workshop "Disease Control in Fish and Shrimp Aquaculture

in Southeast Asia - Diagnosis and Husbandry Techniques"* convened in Iloilo City from December 4 to 6, 2001. It is conducted by AQD in collaboration with the Government of Japan, Office International des Epizooties (OIE), and Network of Aquaculture Centers in Asia-Pacific (NACA).



The Malaysians at AQD

Malaysia seeks collaboration with AQD

Three officials of the Malaysian Ministry of Agriculture visited AQD from October 16 to 17 to discuss collaboration in national skills training for aquaculture in Malaysia.

The visitors were Haji Mohd Yunus bin Aminuddin, Director, National Agriculture Training Center (NATC of the Malaysian Ministry of Agriculture); Dr. Muhamad Sopian bin Johar, also of NATC; and Haji Yaakob, Head, Aquaculture Training Center (photos at left).

The Malaysian government identified agriculture as the third engine of growth by 2010. The country aims to boost agriculture and aquaculture production and reverse its negative balance of trade in 2002 to a surplus of half a billion US dollars by 2010.

"We would like to gain insights into the training philosophy and the methodology of organizing an aquaculture training program, and explore possibilities of collaboration," explained Haji Yunus in a meeting with AQD officials and scientists.

The visitors requested AQD's assistance in organizing a training course for Malaysian trainees, developing training modules and materials, providing experts, and evaluating training courses to ensure quality.

"We express our willingness to collaborate with Malaysia which is a member of the SEAFDEC family," says research head Dr. Clarissa Marte.

The visitors were briefed on the SEAFDEC/ASEAN mangrove friendly shrimp culture project in Malaysia. This project has pilot demonstration sites in the Philippines, Thailand, Vietnam, and Myanmar.

▼ *International trainees pose with (seated, L-R) Fish Disease Expert Dr. Kazuya Nagasawa, AQD Chief Dr. Rolando Platon, and Training-Information Head Engr. Pastor Torres Jr*





Training on mangrove-friendly shrimp culture; site survey in Cambodia

The training course on *Mangrove-friendly shrimp aquaculture* was conducted October 23 to November by SEAFDEC/AQD. This third session provided knowledge of the mangrove ecosystem and skills in environment-friendly shrimp culture to nine participants from SEAFDEC member countries: Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam.

The technology disseminated through the course was developed through the Mangrove-Friendly Shrimp Culture (MFSC) project, a collaborative undertaking of the Association of South-east Asian Nations (ASEAN), SEAFDEC, and the Government of Japan.

In related development, a site survey for the MFSC project in Cambodia was conducted from September 15 to 22 by Mr. Dan Baliao of SEAFDEC/AQD and Mr. Leap Haing of the Department of Fisheries Cambodia. Suitable technology demonstration sites were found in the provinces of Kumpot (Kbalromeas Farm, Tropaing Saingke Commune) and Khoh Kong (Porn Marina Farm, Mondelsyma).

The Kbalromeas Farm was stocked with shrimp at 15 postlarvae per m² in late November. One hectare of ponds was designated for grow-out, another ha for reservoir. AQD sent a senior technician to the site in October. Harvest is expected in April 2004. DOF Cambodia and AQD share the expenses and income.

AQD trains Filipinos on crab seed production

Four Filipino participants joined the training course on *Crab seed production* that started September 23 and ended November 6. They were Mustapha Ibad, Carmelo Lazatin, Jesus Tangub, and Peter Gurion, Ibad and Gurion are Vice-Chairman and Consultant, respectively, of Shariff Kabunsuan Multipurpose Cooperative in Cotabato City in central Mindanao.

The lectures and practicals covered biology of *Scylla serrata*, broodstock management, culture of natural food organisms, and larval and nursery rearing.

The training provided participants with technical knowledge and skills so that they can establish or operate a mudcrab hatchery.

The crab training course was officially all-Filipino, but an intern from Canada's Marine Institute International attended as observer

IRAP training on freshwater fishes; site survey in Vietnam

SEAFDEC/AQD conducted a training on breeding tilapia and carp with observation tours on grow-out farms, from September 30 to October 19, in central Luzon. The participants were three officers of the Department of Fisheries in Cambodia and Department of Livestock and Fisheries in Lao PDR, and a farmer from Lao PDR.

The training is part of the Integrated Regional Aquaculture Program (IRAP), the flagship component of the ASEAN-SEAFDEC Special Five-Year Program, IRAP promotes sustainable aquaculture technologies in rural areas.

Meanwhile, the IRAP project in Vietnam (see also cover story) aims to diversify aquaculture which is now mostly shrimp culture.

Vietnam will send a trainee to AQD to learn about rabbitfish hatchery, and AQD will send a breeding expert and a technician to Hue Province to assist in starting up a hatchery. AQD will also train technicians from Binh Dinh Province in marine fish breeding and nursery, particularly of milkfish, but also other species. AQD will also assist in a milkfish fry survey in the Dam De Gi area.

Memorial University and AQD discuss collaboration

Officials of the Marine Institute (MI) of Memorial University of Newfoundland, Canada visited AQD from October 6 to 7 to discuss collaboration in electronic learning (e-learning) and aquaculture research. The MI officials were Bill Chislett, Director; Nigel Allen, Director for Aquaculture; and Robert Wells, Director for Learning Technologies. They were accompanied by Bundit Chokesanguan, Information Head of SEAFDEC's Training Department (TD) in Bangkok.

"We are happy to offer a visitation grant to the AQD Chief," said Chislett, to enable Dr. Rolando Platon to learn more about MI's program in aquaculture research and training.

MI and TD are current collaborators, developing a program on fisheries reporting and a Learning Management Software (LMS) as e-learning platform. The success of the collaboration prompted both to explore other SEAFDEC departments such as AQD.



AQD to train researchers from Cavite State

SEAFDEC/AQD and the Cavite State University (CSV) have agreed to collaborate on a three-year researcher training program.

"We recognize AQD as having an excellent core of scientists who can take our university faculty under its wings," says CSV's Naic campus superintendent Dr. Hernando Robles upon signing the agreement on October 23 with AQD Chief Dr. Rolando Platon.

Both institutions will participate in the recruitment of faculty-scholars. CSV will fund their scholars' research studies while AQD is expected to manage the scholarship fund, supervise, provide learning opportunities (including visits to private farms, email and library services) and monitor the scholars.

23 AQD papers win awards

The Bureau of Agricultural Research of the Department of Agriculture (DA-BAR) in the Philippines gave awards to 23 AQD papers during its 15th National Research Symposium on October 9.

The annual symposium recognizes significant accomplishments in research and provides incentives for publication. This year, DA-BAR recognized 94 papers out of a total 159 submitted from around the country.

Winners of the DA Secretary Award

- (1) Bautista-Teruel MN, AC Fermin, S Koshio. 2003. Diet development and evaluation for juvenile abalone, *Haliotis asinina*: animal and plant protein sources. *Aquaculture* 219: 645-653
- (2) Bautista-Teruel MN, PS Eusebio, T Welsh. 2003. Utilization of feed pea, *Pisum sativum*, meal as a protein source in practical diets for juvenile tiger shrimp, *Penaeus monodon*. *Aquaculture* 225: 121-131
- (3) Bombo RF, AC Fermin, JD Tan-Fermin. 2002. Nursery rearing of the Asian catfish, *Clarias macrocephalus*, at different stocking densities in cages suspended in tanks and ponds. *Aquaculture Research* 33: 1031-1036
- (4) Borlongan IG, PS Eusebio, T Welsh. 2003. Potential of feed pea (*Pisum sativum*) meal as protein source in practical diets for milkfish (*Chanos chanos* Forsskal). *Aquaculture* 225: 89-98
- (5) Catacutan MR, PS Eusebio, S Teshima. 2003. Apparent digestibility of selected feedstuffs by mud crab, *Scylla serrata*. *Aquaculture* 216: 253-261
- (6) Coniza EB, MR Catacutan, JD Tan-Fermin. 2003. Growth and yield of Asian catfish *Clarias macrocephalus* fed different grow-out diets. *Israeli Journal of Aquaculture - Bamidgheh* 55: 53-60
- (7) Cuvin-Aralar ML, J Fastner, U Focken, K Becker, EV Aralar. 2002. Microcystins in natural blooms and laboratory cultured *Microcystis aeruginosa* from Laguna de Bay, Philippines. *System. Appl. Microbiol.* 25: 179-182
- (8) Estudillo CB, MN Duray. 2003. Transport of hatchery-reared and wild grouper larvae, *Epinephelus* sp. *Aquaculture* 219: 279-290
- (9) Eusebio PS, RM Coloso. 2002. Proteolytic enzyme activity of juvenile Asian sea bass *Lates calcarifer* is increased with protein intake. *Aquaculture Research* 33: 569-574
- (10) Fermin AC. 2002. Effects of alternate starvation and refeeding cycles on food consumption and compensatory growth of abalone, *Haliotis asinina*. *Aquaculture Research* 33: 197-202
- (11) Fermin AC, SM Buen. 2002. Grow-out culture of tropical abalone, *Haliotis asinina* (Linnaeus) in suspended mesh cages with different shelter surface areas. *Aquaculture International* 9: 499-508
- (12) Hurtado AQ, DP Cheney. 2003. Propagule production of *Eucheuma denticulatum* by tissue culture. *Botanica Marina* 46: 338-341
- (13) Madrones-Ladja JA. 2002. Salinity effect on the embryonic development, larval growth and survival at metamorphosis of *Placuna placenta*. *Aquaculture* 214: 411-418
- (14) Peñaflores VD. 2002. Evaluation of plant proteins as partial replacement for animal proteins in diets for *Penaeus indicus* and *P. merguensis juveniles*. *Israeli Journal of Aquaculture - Bamidgheh* 54: 116-124
- (15) Rodriguez EM, AT Triño, M Minagawa. 2003. Diet and harvesting regimen for the production of mud crab *Scylla olivacea* in brackishwater ponds. *Fisheries Science* 69: 37-42

- (16) Sumagaysay-Chavoso NS, MLSD McGlone. 2003. Water quality and holding capacity of intensive and semi-intensive milkfish (*Chanos chanos*) ponds. *Aquaculture* 219: 413-429
- (17) Sumagaysay-Chavoso NS. 2003. Nitrogen and phosphorus digestibility and excretion of different-sized groups of milkfish fed formulated and natural food-based diets. *Aquaculture Research* 34: 407-418
- (18) Tendencia EA, LD dela Peña. 2002. Level and percentage recovery of resistance to oxytetracycline and oxolinic acid of bacteria from shrimp ponds. *Aquaculture* 213: 1-13
- (19) Tendencia E, M dela Peña. 2003. Investigation of some components of the greenwater system which makes it effective in the initial control of luminous bacteria. *Aquaculture* 218: 115-119
- (20) Triño AT, EM Rodriguez. 2002. Pen culture of mud crab *Scylla serrata* in tidal flats reforested with mangrove trees. *Aquaculture* 211: 125-134

Winners of AFMA R&D Paper Award

- (21) Leбата MJH, JH Primavera, J Altamirano, EF Doyola, L Gustilo. Induced spawning and larval development of the mangrove clam *Anodonta edentula*
- (22) Luhan MR. Growth and agar quality of *Gracilaria heteroclada* grown in a filter tank of the finfish broodstock tank
- (23) Tan-Fermin J, LMB Garcia, GF Quinitio, and JD Toledo. Reproductive biology, embryonic development, larval morphology, and larval rearing trials in the blue tang *Paracanthurus hepatus* (L.)

In related development, AQD scientist Dr. Neila Sumagaysay-Chavoso was named one of the awardees in the "Search for the 2003 PCASTRD Outstanding Thesis/Dissertation Awards in Advanced Science and Technology."

PCASTRD is the government body Philippine Council for Advanced Science and Technology Research and Development under the Department of Science and Technology. Dr. Sumagaysay-Chavoso was conferred the award on December 12 in Manila. She won for her dissertation "Nutrient loading and effluents of intensive and semi-intensive milkfish ponds, and the environmental capacity of receiving water" at the University of the Philippines' Marine Science Institute. ###



AQD Research Publications

Reprints of papers listed here may be requested directly from SEAFDEC/AQD authors

[names of AQD researchers in boldface] or from the AQD Library

Compiled by the **AQD LIBRARY** <library@aqd.seafdec.org.ph>

Emata AC. 2003. Reproductive performance in induced and spontaneous spawning of the mangrove red snapper, *Lutjanus argentimaculatus*: a potential candidate species for sustainable aquaculture. *Aquaculture Research* 34 (10):849-857

Abstract. A reliable breeding technique was developed for the mangrove red snapper, *Lutjanus argentimaculatus* (Forsskal 1775), to help sustain the aquaculture of this immensely popular species in Southeast Asia. Using standardized indices of female maturity (based on mean oocyte diameter of greater than or equal to 0.40 mm), time of injection (1000-1130) and sex ratio (one female to two males), a single injection of 100 $\mu\text{g kg}^{-1}$ luteinizing hormone-releasing hormone analogue (LHRHa) (n=16 fish), but not 50 $\mu\text{g kg}^{-1}$ (n = five fish), successfully induced egg (62.5% success rate) and larval (43.8%) production. Human chorionic gonadotropin (hCG) at 500 IU kg^{-1} (n = five fish) also failed to induce spawning, but doses of 1000 (n = 22 fish) and 1500 IU kg^{-1} (n = 15 fish) gave spawning (77.3% and 80.0% respectively) and hatching success rates (72.7% and 60.0% respectively) that were not significantly different from those of 100 $\mu\text{g kg}^{-1}$ LHRHa. No spawning was observed in saline-injected controls (n =7 fish). While mean spawning latency, egg diameter, egg production per spawn, percent egg viability, hatching rate, percent of normal larvae and cumulative survival of eggs to normal larvae did not differ significantly among the effective hormones and doses, 1000 IU kg^{-1} hCG had a higher percentage (76.5%) of total spawns with egg production per spawn in excess of one million than those of 1500 IU kg^{-1} hCG (50.0%) and 100 $\mu\text{g kg}^{-1}$ LHRHa (40.0%). Mangrove red snapper spontaneously spawned from March-April to November-December with a peak of egg collection and spawning in May-June. Egg collection per spawn ranged from 0.05 to 6.35 million. Spontaneous spawning of mangrove red snapper exhibited lunar periodicity with spawns mostly occurring 3 days before or after the last quarter and new moon phases and occurred consistently between 02:00 and 04:00 hours. High fecundity and good egg quality, coupled with the ability to respond to induce spawning or natural spawning in captivity, provide a sound basis for improving the sustainability of red snapper aquaculture in Southeast Asia.

Gallardo WG, Bautista-Teruel MN, Fermin AC, Marte CL.

2003. Shell marking by artificial feeding of the tropical abalone *Haliotis asinina* Linne juveniles for sea ranching and stock enhancement. *Aquaculture Research* 34 (10): 839-842

Abstract. A method of marking abalone (*Haliotis asinina* Linne) for sea ranching and stock enhancement purposes was developed. Three-month-old abalone juveniles (11.8-mm shell length, 0.28 g) were fed artificial diets for 1, 2, or 3 weeks. The width of the bluish-green shell band produced by abalone juveniles was 1.7, 2.6, and 4.2 mm after 1, 2, or 3 weeks of feeding respectively. The growth and survival of juveniles fed artificial diets did not differ from that of juveniles fed the seaweed *Gracilariopsis bailinae* (control). Feeding the diet-fed juveniles with the seaweed thereafter produced the natural brownish shell, thus forming a

sandwiched bluish-green band. An experimental release in outdoor tanks with natural growth of seaweeds and diatoms, and in a marine reserve showed that the shell band remained clear and distinct, indicating the usefulness of this shell marking method in sea ranching and stock enhancement of abalone.

Kimura S, Dunlap PV, Peristiwady T, Lavilla-Pitogo CR. 2003. The *Leiognathus aureus* complex (Perciformes : Leiognathidae) with the description of a new species. *Ichthyological Research* 50 (3): 221-232

Abstract. Taxonomic analysis of a group of morphologically similar ponyfishes (Perciformes: Leiognathidae) establishes a complex comprising three valid species: *Leiognathus aureus* Abe and Haneda 1972, widely distributed in the western Pacific Ocean (Taiwan, Philippines, Thailand, Singapore, Indonesia, and northern Australia); *L. hataii* Abe and Haneda 1972, currently known only from Ambon, Indonesia; and *L. panayensis* sp. nov. Kimura and Dunlap, currently known only from Panay Island, the Philippines. The *L. aureus* complex can be defined by the following combination of characters: mouth protruding forward, not downward; small but sharp conical teeth uniserially on jaws, a black line between lower margin of eye and lower jaw articulation; and lateral line incomplete, ending below posterior part of dorsal fin base or on anterior caudal peduncle. *Leiognathus hataii* differs from both *L. aureus* and *L. panayensis* in having a large dark blotch below the spinous dorsal fin base and fewer counts of scales (lateral line scales 50-58 vs. 64-85 in the latter two species; scales above lateral line 7-10 vs. 12-18; scales below lateral line 22-26 vs. 30-41). *Leiognathus panayensis* is distinguished from *L. aureus* in having a deeper body (41-51 % SL vs. 35-45% SL in the latter), long posterior limb of maxilla (21-25% HL vs. 15-23% HL), wholly scaled belly (vs. naked along preanal median keel), and a dark blotch on nape (vs. absent).

Lückstädt C, Focken U, Coloso R, Becker K. 2000. Survey on the use of natural food and supplemental feed in commercial milkfish farms on Panay, Philippines, p 229-230. In: International Agricultural Research - A Contribution to Crisis Prevention, Book of Abstracts; Deutscher Tropentag; Hohenheim, Germany [Also on CD-ROM, p 1-10 and the website www.wfish.de]

Abstract. This study evaluated the feed intake of the milkfish (*Chanos chanos* Forsskal) in commercial brackishwater ponds under different management regimes. Feed intake and growth were compared between a rather intensive culture management in a fish farm of 1 ha pond size and a semi-intensive one, with a total pond area of 30 ha. The data suggested a direct consumption of only 12% of the supplemental feed in the intensive farm, leading to a wastage of high quality fish feed and a significantly lower specific and metabolic growth rate ($P < 0.001$) than in the semi-intensive

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system without any supplementation and only relying on abundant natural food through fertilization. These results suggest that a heavy reduction in, or even the abandonment of the use of, supplemental feed for milkfish culture would be more cost-effective.

Primavera Y. 2002. The coral reef fisheries of Malalison Island, west central Philippines two years after fish sanctuary protection. *UPV J. Nat. Sci.* 7 (1&2): 120-132

Abstract. Fish landings in Malalison Island, west central Philippines were monitored from June 1995 to January 1997 to determine species composition of catch, catch per unit effort (CPUE) and yield from the fishing areas. A total of 596 fishing operations were recorded from the five fishing areas namely Nablag, Balabago, and Salangan patch reefs and North and South fringing reefs. CPUE (kg fisher⁻¹ hr⁻¹ was 0.71 for hook and line, 1.6 for speargun, 2.80 for hookah (speargun with compressor), 1.29 for set gill net, 1.30 for drive-in gill net and 2.23 for drift gill net. Total fish yield was estimated to be 26.4 t km⁻² yr⁻¹. Reef and reef-associated fish species comprised about 85% of the total yield and was dominated by caesionids (33%) and acanthurids (28%) caught by hookah and set gill net. Hookah contributed highest yield from Nablag patch reef. Reef and reef-associated fish yield was estimated to be 22.44 t km⁻² yr⁻¹. This is almost four times the 1992 estimate of 5.8 t km⁻² yr⁻¹ when com-

munity-based management efforts were initiated by the SEAFDEC Aquaculture Department to sustain the coral reef fisheries in Malalison Island.

Siar SV. 2003. Change in Aplaya: resource use and responses to changing markets among fisherfolk in Honda Bay, Palawan. *Philippine Quarterly of Culture and Society* 31: 226-239

Tendencia EA. 2003. Iodine disinfection of grouper *Epinephelus coioides* eggs. *Bulletin of the European Association of Fish Pathologists* 23 (4): 191-196

Abstract. In this study, the developmental stage, iodine concentration and exposure time that will reduce the bacterial load without decreasing the hatching rate for the disinfection of grouper (*Epinephelus coioides*) egg were established. Results of the study showed that the best stage to disinfect grouper egg is at late neurula stage where the embryo shows twitching movement. The effective and safe concentration that will reduce bacterial load but will not decrease hatching rate for the disinfection of grouper egg is 7.5 ppm free iodine for 10 min. Total bacterial count of eggs disinfected with 7.5 ppm free iodine for 10 min (8.99×10^2 cfu/20 eggs) is significantly lower than the unrinsed/undisinfected eggs (1.99×10^7 cfu/20 eggs).

IRAP VIETNAM ... FROM PAGE 1

Pha Tam Giang has an area of 22,000 hectares. The elongated lagoon is actually a shallow part of the sea that has been separated from the open waters by a sand bar. Seawater comes in and goes out through both ends but the area is sheltered from strong winds and waves and has been found ideal for fish cages and pens. Fishponds have also been built along the shore. It is difficult to determine where the fishpond ends and where the fishpen begins. From a distance the two systems form a continuum with no sharp demarcation. *Penaeus monodon* is the major species farmed but mudcrabs and siganids are increasingly produced as well.

Going south to Binh Dinh

Binh Dinh province, mid-way between Hue and Ho Chi Minh City, was the next stop. At Cac Mon were the milkfish ponds of Mr. Nguyen Duong and Mr. Le Duong. The latter operates a nursery for milkfish fry caught from the lagoon.

Milkfish fry are found in the lagoons and collected by fish farmers using stationary filter nets set across river mouths. Le Duong said that his father already practised milkfish culture. The common belief is that the milkfish spawn only in Philippine waters and the fry are carried by ocean currents. (Vietnam faces the South China Sea).

There are three separate lagoons in Binh Dinh, Dam De Gi with 1,600 ha, Dam Tra O with 1,200 ha, and Dam Thi Nai, the biggest, with 5,600 ha. There are 2,500 ha of shrimp farms in the province and 40% are under the intensive system. There are also some 600 ha of ponds stocked with milkfish mostly in polyculture

with *P. monodon*. Mrs. Chau owns and operates an intensive shrimp farm; her husband builds fishing boats on order and also operates some of them.

Next visited was a shrimp hatchery which had been turned over to the Binh Dinh Provincial Fishery Office by the national government. It is a large hatchery complex consisting of a building for spawning and four buildings containing 84 circular 3-ton larval rearing tanks. This shrimp hatchery will be converted into a milkfish hatchery.

A meeting was arranged at this venue to discuss the findings and the future activities of the project. Present were all the AQD alumni - six of them, including Mr. Ha and Mr. Tam, plus one who trained at SEAFDEC's Training Department in Thailand.

On to Hanoi

The IRAP staff had dinner with the new Philippine ambassador to Vietnam, Victorino Licaros, who had just arrived four days earlier. The next day, the Ambassador and his staff were briefed about IRAP and the activities that will involve Filipino experts coming into Vietnam, and Vietnamese going to the Philippines for conferences, workshops and training.

The last stop was the RIA-1 (Research Institute for Aquaculture) to meet with Dr. Le Thanh Luu. Dr. Luu briefed the IRAP staff on the status of aquaculture development in Vietnam, present research thrust and plans. He was happy about the future of cobia that he introduced to Vietnam.

The IRAP staff dropped by a restaurant specializing in cobia prepared in many ways -- sashimi cobia, steamed cobia and grilled cobia -- before catching the flight back to Manila. #####



AROUND THE WORLD

with frequently asked questions

[www.seafdec.org.ph/aquafarmer's corner](http://www.seafdec.org.ph/aquafarmer's%20corner)

Needing solutions to your fish disease problems, wanting books to read, or just voicing out ideas before you try them? You might find help through SEAFDEC/AQD's lively discussion board at <http://www.seafdec.org.ph> participated in by fishfarmers, aquaculturists, teachers and students from different parts of the globe. The Aquafarmers' Corner is now a year old, conceptualized and moderated by no less than AQD's head of training and information Engr. Pastor Torres Jr.

AQD's 50 experts working on breeding, hatchery/nursery, feed development, fish health, farming systems/ecology, and socioeconomics, answer queries too.

Here's a sampling of the Q&A ...

What are the remedial measures for swollen hindgut (SHG) syndrome disease?

Swollen hindgut syndrome was studied at SEAFDEC/AQD. Although we were not able to zero in on the main cause of the disease, transfer of affected animals to clean water with clean food reversed the condition.

Our ponds have low salinity, 2-8 ppt. If luminous bacteria thrive in high saline water, how come shrimps still experience the "mid-culture" mortality?

There may be factors other than bacteria that caused "mid-culture" mortality in your stocks. Accurate diagnosis of the disease can only be done if samples of affected shrimps are examined in the laboratory.

For assistance on monitoring bacteria, you may contact AQD's Fish Health Section or a Bureau of Fisheries and Aquatic Resources (BFAR) station nearest your farm. AQD can also train your staff to do bacterial counts on site.

You can also go to AQD website (www.seafdec.org.ph) and open the page on

disease diagnostic services (<http://www.seafdec.org.ph/stories/story04-diagnostic-services.html>) for sufficient information.

We are looking for more information in larval rearing of siganid, *Siganus lineatus* or closely related species. Where are the most successful siganid (rabbitfish) hatcheries in the Philippines?

In the Philippines there are no hatcheries producing solely rabbitfish because siganid grow-out is not yet a common enterprise. However, breeding of siganid (*Siganus gutatus*) is routinely included in the training course on marine fish hatchery at AQD with satisfactory results. For more information, please contact: Dr Felix Ayson fayson@aqd.seafdec.org.ph.

Do you have any extension manuals for culture of tilapia, shrimp, mud crab, grouper, and other relevant publications? Training courses?

Yes, we do. Please go to AQD website's (www.seafdec.org.ph) and open the page on publications and videos (<http://www.seafdec.org.ph/information/publication.html>). The page contains all AQD's publications, and downloadable order and request forms.

For sufficient information on training courses offered by AQD, open the page on training program (<http://www.seafdec.org.ph/trainingpage.html>).

Are golden snails effective feed for mud crab?

Golden apple snail's meat is a useful source of protein (protein content, 54%) but snails alone will not support good crab growth. A mixed diet of 75% of golden apple snail flesh and 25% fresh or frozen trash fish or brown mussel meat is recommended. The snails must come from a

safe source (not from an area sprayed with molluscicides).

The mixed diet is effective for grow-out as well as for the fattening of mud crab. In grow-out, the crabs are fed the mixed diet at the rate of 10% of the crab biomass per day when the mean carapace width is < 6 cm. or at 5% when > 6 cm. About 40% of the daily feed ration is given at 0730 and 60% given at 1700h. Crabs to be fattened are fed the mixed diet at 10% of the crab biomass per day for 15-30 days.

What are the critical factors in zoea rearing?

Mud crab zoea is very sensitive to various factors like diseases (fungal, viral and bacterial infection), fluctuations in water temperature, poor water quality and nutritional deficiency.

In rearing zoea, do we expect to use different tanks for the larval stages? Or can we use one tank?

Zoea undergoes 5 stages but only zoeae from the same 'mother' crab should be stocked together in one tank (at 50-80 ind per li). Rotifers *Brachionus* are fed to zoea 1 to 5. Brine shrimp *Artemia* nauplii are given in addition to rotifers to zoea 3 to 5.

Techniques for the production of natural food and larval rearing are discussed in AQD's manual "Biology and hatchery of mud crabs *Scylla* spp." by ET Quintinio and FD Estepa. To order a copy, please write to sales@aqd.seafdec.org.ph

I have gone through the extension manual that was published by your organization regarding hatchery of mud crab. I would appreciate if you could brief me for a trial run at what scale. What is the best way to start-up?

It is prudent that you undergo hands-on training on mud crab hatchery and visit other hatchery facilities to see the actual operations before you go into crab hatch-

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ery. Experience/technical knowledge on shrimp or fish hatchery is very important. This will save you a costly trial-and-error process. AQD can arrange a hands-on training for you. Write to training@aqd.seafdec.org.ph

We harvest milkfish in 45 to 60 days of culture. If we mix milkfish with tiger shrimp, how long before we can harvest both?

Time of harvest depends on your target sizes. Growth of both species depends on stocking density, water quality, and food and feeding management. If you raise tiger shrimp for 2.5 months in deep brackishwater ponds, and transfer your pre-market sized milkfish to that tiger shrimp pond, then you can harvest both, almost simultaneously, within 30 to 60 days.

The culture of tiger shrimp will not be economically profitable if the pond is shallow, and the water is fully saline.

Will mangroves inside the pond die when submerged longer in the water during mud crab culture?

Yes, mangroves will die if their roots are submerged in water for more than seven days. Just drain the pond for three consecutive days after every 7 days to expose roots of mangroves. Be sure, however, that there is no problem with supplying water to the ponds even at neap tide.

Another alternative is to dig a peripheral canal. Soil from the excavation can then be used as peripheral dike. Then, install a water control gate. During low tide, the pond can be drained and the mangrove roots exposed. Meanwhile, crabs may take refuge in the peripheral canal that still has water.

Is there hatchery or grow-out operation on white shrimp in the Philippines?

There is no commercial white shrimp (*Penaeus indicus*) hatchery or grow-out in the country because the market is weak. However, the technologies for both hatchery and grow-out of white shrimp are widely known in the country. Before starting white shrimp aquaculture, first find a market for white shrimp fry.

What instruments are required for a primitive type of fish health laboratory and standard procedures required for diseases diagnosis?

The following are needed for a basic fish health laboratory: good compound and stereo microscopes for observation even of microspecimens, and autoclave, incubator, refrigerator, oven, etc. for microbiological work.

For standard procedures for disease diagnosis, please refer to any book on fish diseases. "Health management in aquaculture," published by SEAFDEC/AQD, is available from sales@aqd.seafdec.org.ph. The manual "Husbandry and health management of grouper" is available from Dr. Erlinda Cruz-Lacierda eclacier@aqd.seafdec.org.ph.

What could be a simple but good in-house monitoring of feed quality?

There are four methods of evaluating feed quality: physical, chemical, microbiological and biological. Physical method involves senses of smell, taste, or sight to detect the presence of adulterants in feedstuffs and feeds. Chemical method quantifies the amount of a given compound present in the feed. Microbiological method involves the use of microorganisms in the evaluation of nutrient content of feeds. Biological method involves actual feeding experiment; this method is more tedious and expensive than the first three but gives the most accurate estimate of feed quality.

The simplest method is physical, i.e., the use of senses. Rancidity and off-odors in feeds can be detected by the sense of smell. Off-flavors of the main ingredients contained in the ration can be detected by sense of taste. The presence of extraneous materials like small stones, scrap metal, dirt, pieces of wood, and seeds that are added to increase the weight of the product, as well as presence of insects and molds can be detected by sight. Finally, the wetness, dryness, or hardness of a feed can be detected by touch.

Feeds of acceptable quality must be dry, free-flowing, and uniform in appearance.

philippines: call for action

By the association of marine scientists in the country

Mangroves, seagrasses and other marine ecosystems are vital to the livelihood and well-being of Philippine society, especially to coastal communities. Foremost among their products are fish, prawns, shrimps, mollusks, and other invertebrates that provide the most available and relatively inexpensive form of protein in the national diet. Other goods from both fisheries and forestry include timber/wood/nipa (fuel and construction), food, medicines and dyes. Ecologically, mangrove forests provide protection from typhoons and storm surges, prevent soil erosion and regulate flooding. Seagrasses provide food to siganids, dugongs and other marine organisms, serve as silt filters and other increase marine productivity. In light of such ecological and socioeconomic benefits, we commend the efforts of the Department of Environment and Natural Resources (DENR) and other government agencies in rehabilitating mangrove ecosystems.

However, we note that such efforts involve the planting of mangroves in existing seagrass beds. Both these ecosystems recycle nutrients, act as nurseries for commercial fish and crustacean species, and provide habitat for wildlife. Therefore, why plant mangroves on seagrass beds when it is not only unnecessary but also costly? In addition, mangrove plantations are generally monocultures of bakaw of *Rhizophora apiculata*, *R. mucronata*, and *R. stylosa* (although natural monospecific stands of mangroves do occur such as of *R. apiculata* in more protected portions of bays, e.g., Ulugan Bay, Palawan). Monocultures reduce biodiversity and therefore productivity, and make the system susceptible to pests and diseases. These decade-long practices are widespread - note Murcielagos Bay in Misamis Occidental and Zamboanga del Norte, and Tubajon, Laguindingan, Misamis Oriental in Mindanao; Carles, Iloilo, and Molocaboc, Sagay, Negros Occidental in the Visayas; and Sorsogon in Luzon.

We the officers and members of the Philippine Association of Marine Science,

Inc. (PAMS), a society of scientists and students from more than 40 schools, universities, nongovernmental organizations and other institutions, therefore call on the DENR and other government agencies to reconsider the practice of monoculture and stop the planting of mangroves on seagrass beds. Instead, we recommend:

- (a) the planting of locally adapted and existing mangrove species in a given area, such as piapi or bungalow (*Avicennia marina*) and pagatpat (*Sonneratia alba*) in seaward zones, and bakhaw (*Rhizophora* species) in more sheltered areas;
- (b) the implementation of the mangrove buffer zone or greenbelt requirement as mandated by the Revised Forestry Code (P.D. 705), DENR A.O.#76, and other legislation; and
- (c) the preservation and sustainable management of seagrass beds.

For the first two, we propose the establishment of multispecies mangrove nurseries for the production of planting materials of bungalow/piapi, pagatpat and other species from both seeds and germinated wildlings. Pagatpat (*S. alba*) reproduces year-round while seeds and wildlings of the widely distributed bungalow/piapi (*A. marina*) are available from August to October.

We further encourage the World Bank, Asian Development Bank, Japan Bank for International Cooperation and other external development agencies to continue funding support for mangrove planting programs, provided they follow ecologically sound criteria. *Cagayan de Oro City, 24 October 2003*

australia: study on toxin

Toxin from a marine bacterium

A doctorate student from the University of New South Wales has found that the marine bacterium *Pseudoalteromonas tunicata* produces antibacterial protein that kills other bacteria in the surroundings. However, the bacterium also produces toxins against itself, and an "antidote" molecule.

The study has implications for the maritime as well as for aquaculture industries since it deals with marine biofouling and bio-innovation.

The student researcher in Sydney, Australia is Doralyn Dalisay-Saludes whose area of specialization is marine microbiology after earning a BS Pharmacy degree from the University of San Agustin, and a MSc in Biology from the University of the Philippines in the Visayas, both in Iloilo.

tilapia symposium

Sixth International Symposium on
Tilapia in Aquaculture
September 12-16, 2004
Manila, Philippines

Hosted by
Bureau of Fisheries and Aquatic Resources
Department of Agriculture - Philippines
Sponsored by
Aquaculture CRSP, World Aquaculture Society, Schering-Plough Aquaculture, Global Aquaculture Alliance, Phil. Council for Marine and Aquatic Research and Devl, FYD International

The focus of the meeting will be the exploding trade in tilapia products and the role of Asia, and especially the Philippines, as a center of advancement in technology as well as production for the international markets. There will be technical presentations, producer workshops, industry trade show and farm tours.

<http://ag.arizona.edu/azaqua>

<rbolivar@mozcom.com>
<kevfitz@ag.arizona.edu>

barcelona : biotech

Aquaculture Europe 2004

Barcelona, Spain

"Biotechnologies for quality"
October 20-23, 2004
"Challenges in Mediterranean aquaculture products"
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Organized by
European Aquaculture Society
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ASIAN FISHERIES SOCIETY

7th Asian Fisheries Forum

November 30 - December 4, 2004
Penang, Malaysia

Organized by
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Ministry of Agriculture-Malaysia
Department of Fisheries-Malaysia
Fisheries Development Authority-Malaysia
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<http://www.usm.my/7AFF2004>

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RESEARCH UPDATE: MUDCRAB ... FROM PAGE 20

Disease problems in mudcrab larval rearing include severe fouling of eggs and larvae with filamentous bacteria and protozoans, and sporadic fungal infection in egg mass (see photos). These may result in poor hatching. Mortality of larvae in the hatchery is mainly due to systemic bacterial infection and occasionally, fungal infection. Monitoring of various larval rearing runs revealed the following main sources of bacterial pathogens in the hatchery: developing eggs, untreated water supply, and natural food, mainly *Brachionus* and *Artemia*. Although the water supply can be effectively rid of bacterial pathogens by chlorination (minimum of 10 ppm active chlorine), such technique does not remove pathogenic bacteria from the other sources.

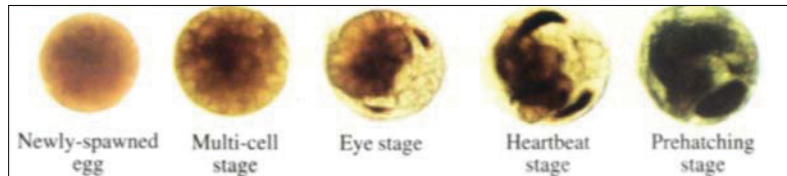
Fungi isolated from eggs and larvae of *Scylla* spp. are either vesicle-formers or non-vesicle-formers. The first are *Lagenidium*-like while the latter are *Sirolopidium*-like. In both fungal types, spore formation and release were inhibited by 10 ppm formalin bath for 24-40 h, but the fungi remained viable and grew when replanted on peptone yeast extract agar. Fungal hyphae exposed to 50 and 100 ppm formalin for the same period did not produce nor release spores and were not viable after exposure.

Nursery

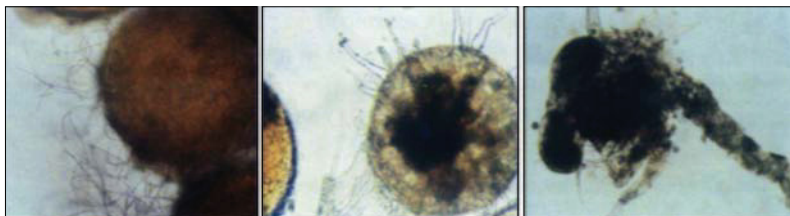
Juveniles produced from rearing megalopae for a month in net cages ('hapa') may have to be grown to a bigger size to meet preference of most growers. Thus, a method for extension of nursery rearing has to be developed. A comparison was made among stocking densities and between net cages and ponds as rearing systems for growing small juveniles to the preferred size. The hapa



Net cages for rearing megalopae to juveniles



Some of the embryonic stages of mudcrab



Egg infected with filamentous algae

Egg and larva (right) infected with fungi

net rearing system, regardless of stocking density, resulted in a higher mean survival (78%) than the pond system (46%). However, juveniles harvested from the hapa nets were smaller (3-7 g body weight) than those grown in ponds (10-16 g). Stocking densities did not significantly influence survival in either nets or ponds.

S. serrata seems to prefer more saline waters than *S. tranquebarica* and *S. olivacea* and may have different responses to salinities with respect to growth. The effect of salinity on molting was investigated in crab instar (<0.5 cm carapace width) and juveniles (1.5 to 2.5 cm). In *S. olivacea* crab instar 1, the survival was similar in salinities of 12, 16, 20, 24, and 32 ppt. The mean body weight after 1.5 months was highest in 12 and 16 ppt and lowest at 32 ppt. Crabs at 32 ppt had a mean of four molts while those in other test salinities had undergone five. Tests on *S. serrata* and *S. tranquebarica* are ongoing.

Juveniles previously reared for at least a week in 32 ppt were transferred abruptly to salinities of 8, 16, 20, 24, and 32 ppt. Among *S. serrata*, survival after third molt (2.5 months after stocking) and the molt intervals were similar in all salinities. Among *S. olivacea*, lowest survival was obtained at 8 ppt (23%) and highest at 16 (76%). At 32 ppt, survival was 48%.

Cannibalism is a common problem in mudcrab juveniles. The agonistic behavior of juveniles was studied to develop strategies to minimize cannibalism.

Aquasilviculture

Grow-out mangrove pen systems suitable for coastal communities have been developed by SEAFDEC/AQD over the years. Dependence on "trash fish" or fish biomass, used as food by low income groups, remains a problem in farming mudcrabs. To reduce if not completely eliminate such dependence, the project is currently testing a low cost, incomplete pellet on crabs reared inside mangrove pen systems. The first run gave generally low crab survival and production because wild juveniles of *S. olivacea* - a species that is relatively aggressive and does not grow fast - were stocked. The ongoing run uses hatchery/nursery-reared juveniles of *S. serrata* and *S. tranquebarica*.



GROWTH AND YIELD OF ASIAN CATFISH ... FROM PAGE 5

TABLE 3 Proximate whole body composition* (% on dry matter basis \pm SEM) of *C. macrocephalus* fed four diets for 120 days (means of three replicates)

	Initial value	At harvest			
		Diet 1	Diet 2	Diet 3	Diet 4
Crude protein	65.4	51.8 \pm 1.0 ^b	54.5 \pm 0.6 ^a	56.1 \pm 0.4 ^a	49.8 \pm 1.5 ^b
Crude fat	9.7	27.8 \pm 0.5 ^b	28.3 \pm 0.3 ^b	22.0 \pm 0.2 ^c	34.5 \pm 1.5 ^a
NFE	10.0	5.8 \pm 0.9 ^b	3.0 \pm 1.2 ^b	9.4 \pm 0.6 ^a	5.1 \pm 1.2 ^b
Moisture	91.1	70.9 \pm 0.9 ^a	71.0 \pm 0.5 ^a	73.7 \pm 0.5 ^a	60.7 \pm 1.5 ^b
Ash	14.7	14.5 \pm 0.2 ^a	14.2 \pm 0.3 ^a	12.4 \pm 0.1 ^b	10.6 \pm 0.3 ^c

Means within a row with different superscripts are significantly different ($p < 0.05$).

*Crude fiber was 0.14% at the start of the experiment; levels were lower than 0.05% in all treatments at the end

D.O. recorded was 1.3 ppm, but *Clariid* catfishes have arborescent organ for breathing air that could increase tolerance to adverse D.O. conditions.

Taste test analysis showed that odor, flavor and appearance were "slightly like" by the panel, and were not significantly different among treatments.

C. macrocephalus fed a diet of 34.2% crude protein attained the best growth and yield with 93.3% of the harvested catfish weighing more than 80 g. Average body weight of catfish fed Diet 2 was 72%, 46% and 38% higher than catfish fed Diets 1, 3 and 4, respectively. Catfish harvest is usually 5 to 6 months of culture, but using Diet 2 can shorten the culture period with the same average weight and therefore beneficial to farmers.

The significantly higher growth of catfish fed Diet 2 may be attributed to the composition of Diet 2 that could have approximated the nutritional requirement of *C. macrocephalus* juveniles. Among the treatments. Diet 2 had the highest amount of crude protein, the lowest amount of energy and the highest P/E ratio. The P/E in Diet 2 could have explained the good growth and feed efficiency in catfish fed this diet. Catfish are carnivorous and require great amount of protein for growth. Furthermore, survival rate of 68-81% is not influenced by the diets used. One way to increase survival of catfish is to select bigger and uniform-sized fingerlings to minimize cannibalism.

MUDCRAB ... FROM PREVIOUS PAGE

Fisheries and population dynamics

In addition to crab culture in pens or ponds, stock enhancement has been proposed to compensate for declining wild catches. However, baseline information on crab population dynamics is needed before interventions can be implemented. Wild populations in natural (Ibajay, Aklan) and planted (Kalibo) mangroves were monitored monthly using catch data from two native gears - crab dip net ('bintol') and bamboo trap ('tapangan'). Consisting predominantly of *S. olivacea* in both places, crab populations showed smaller sizes but greater numbers in Kalibo compared to Ibajay. *S. tranquebarica* and *S. serrata* were rare inside the

Diet 1 was formulated as a protein supplement to the natural food in the pond. The amount of natural food in the pond may not have been enough to compensate for the protein deficiency in Diet 1 that had resulted in slow growth and low yield.

The catfish fed commercial fish pellets (Diet 3) had similar growth to those fed chicken entrails and rice bran (Diet 4) but catfish fed Diet 4 contained the higher amount of crude fat and yielded fatter fish. Fattiness in catfish has been identified as a major problem in commercial catfish industry. An increased in fat content is responsible for the poor keeping quality and decreased yield of processed products. Using chicken entrails as feed has many disadvantages such as. storage and availability, difficulty in preparation and blanching may not sufficient to eliminate bacteria. Although the taste test showed no off-flavor

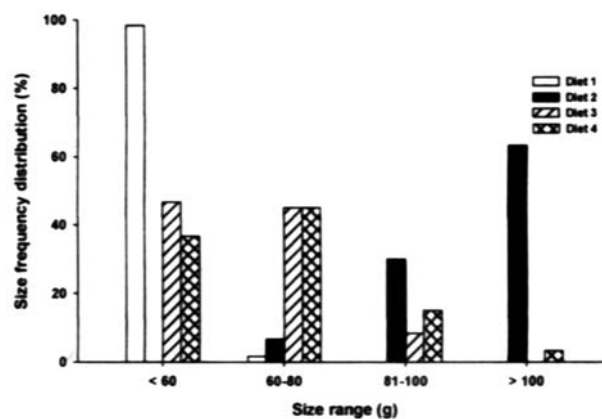


FIGURE 1 Size distribution of Asian catfish *Clarias macrocephalus* fed four different diets for 120 days

in fish fed Diet 4. or in any diet, the use of chicken entrails maybe practical for a backyard fishpond operation but not in intensive commercial culture. Under experimental conditions, a diet of about 34% crude protein resulted in the best growth and yield of *C. macrocephalus* in a relatively shorter period. #####

mangroves but *S. tranquebarica* comprised 5-65% in a channel draining the Kalibo mangroves. Females with attached egg mass and small crabs (1-3 cm CW) were caught mainly in Ibajay starting September and later in November, respectively. #####

For more information, please contact any one of the research team:

Jurgenne Primavera <jhprima@aqd.seafdec.org.ph>

Emilia Quintio <etquinit@aqd.seafdec.org.ph>

Fe Parado-Esteva <fpesteva@aqd.seafdec.org.ph>

Celia Lavilia Torres <celiap@aqd.seafdec.org.ph>

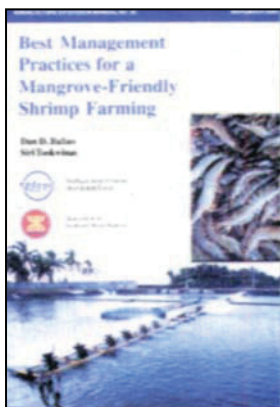
Veronica Alava <vralava@aqd.seafdec.org.ph>

Junemie Lebata <jlebata@aqd.seafdec.org.ph>

Eduard Rodriguez <emr@aqd.seafdec.org.ph>

Books, websites, training courses EXTENSION MATERIALS

NEW!



Best management practices for a mangrove-friendly shrimp farming, a 50-page manual written by Dan Baliao of SEAFDEC/AQD and Siri Tookwinas of the Department of Fisheries Thailand. It describes improved pond systems: pond layout, reservoir with biomanipulators and greenwater, settling pond with baffles and biofilters, sludge collectors, power supply, aeration systems, water pumps, and filter boxes.

For a copy, email: tvs-tvcd@aqd.seafdec.org.ph



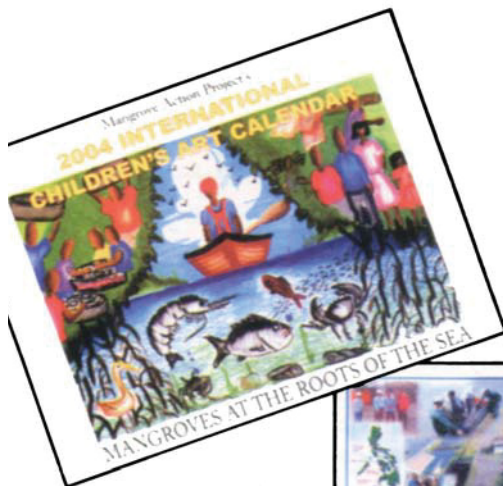
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Check out SEAFDEC/AQD's discussion board - *Aquafarmers' Comer*. This is your site for exchanging and sharing ideas and issues to further aquaculture development in the region. Our vast pool of experts, through *Aquafarmers' Corner*, hopes to answer your queries on aquaculture technology at the farm level. We would like to hear about your experiences too, so that we may build on it. Come, visit us!

Website for networking with fish health professionals in Southeast Asia and elsewhere

<http://afs-fhs.seafdec.org.ph>

Home of Fish Health Section of the Asian Fisheries Society or AFS which has membership of about 3,000 fisheries professionals from 75 countries and territories. AFS-Fish Health Section's secretariat is presently hosted by AQD.



NEW!

**2004
calendars**

2004 International Children's Art Calendar, by the Mangrove Action Project. It features young artists from China, Cuba, Egypt, Guatemala, Indonesia, Kenya, Malaysia, Nigeria, Philippines, Thailand, Turks & Caicos, and Virgin Islands. For more information, visit www.earthisland.org/map



Calendar of the ASEAN-SEAFDEC Special Five-Year Program on the Contribution of Sustainable Fisheries to Food Security in the ASEAN Region. Photos of project sites. Email: secretariat@seafdec.org

Some of SEAFDEC/AQD numbers are new!

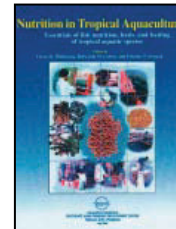
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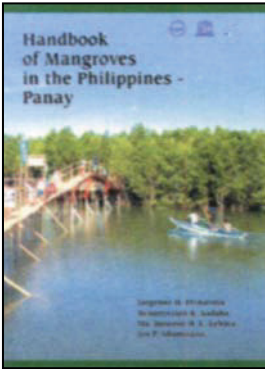


Disease Control in Fish and Shrimp Aquaculture in SEA - Diagnosis and Husbandry Techniques. 215 pages, edited by Yasuo Inui and Erlinda Cruz-Lacierda. Email [eclacier@ aqd.seafdec.org.ph](mailto:eclacier@aqd.seafdec.org.ph) or fax (63-33) 5118709, 3351008.



Nutrition in Tropical Aquaculture is edited by SEAFDEC/AQD scientists Dr. Oseni Millamena, Dr. Relicardo Coloso, and Dr. Felicitas Pascual. sales@aqd.seafdec.org.ph

NEW!



Handbook of mangroves in the Philippines - Panay, 120 pages with full color illustrations. A user-friendly guide for local communities. NGOs, students, teachers and researchers. With it, you can identify 35 species of Philippine mangroves based on plant morphology, biology and ecology. Written by JH Primavera, RB Sadaba, MJHL Leбата, and JP Altamirano, experts from SEAFDEC/AQD and University of the Philippines in the Visayas.

For a copy, email:
sales@aqd.seafdec.org.ph

NEW!

Aquafarm tip: living with white spot, a 2-page flyer given free to interested fishfarmers, aquaculturists and students of aquaculture. Email sales@aqd.seafdec.org.ph



Mud crab hatchery technology

"Biology and hatchery of mud crabs *Scylla* spp." all of 42 pages with colored photos and step-by-step methods written by researchers Dr. Emilia Quintio and Dr. Fe Dolores Parado-Estepa. Contents include biology of *Scylla*, hatchery and nursery operations, common problems and solutions, economics, and a list of references.

For a copy of the manual, contact [sales @aqd.seafdec.org.ph](mailto:sales@aqd.seafdec.org.ph)



Annual report

"2002 Highlights" reports SEAFDEC/AQD's accomplishments in four research areas - managing broodstock and improving seed quality, developing responsible and sustainable aquaculture techniques, screening new species for aquaculture, and developing strategies for stock enhancement. Progress is tracked for three regional programs (implemented in Southeast Asia): mangrove-friendly shrimp culture technology, aquaculture disease management, and integrated regional aquaculture program (ASEAN-SEAFDEC). For a copy, write sales@aqd.seafdec.org.ph



Joint mission for accelerated nationwide technology transfer program (JMANTTP): 2002 highlights. 20 pages.

Reports the accomplishment of SEAFDEC/AQD and the Bureau of Fisheries and Aquatic Resources in environment-friendly schemes in shrimp farming and mariculture parks. The project sites include Batangas, Palawan, Iloilo, Guimaras, Bohol, Lanao del Norte and Davao. For a copy, email aqdchief@aqd.seafdec.org.ph



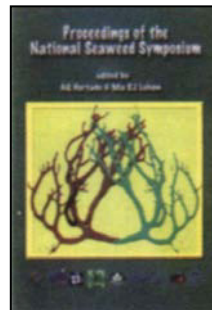
Report of the Seminar-Workshop on Integrated Regional Aquaculture Program (IRAP) is now available from the SEAFDEC Secretariat (www.seafdec.org). It may also be requested from SEAFDEC/AQD. email aqdchief@aqd.seafdec.org.ph

IRAP is part of the aquaculture component of the ASEAN-SEAFDEC special 5-year program on the contribution of sustainable fisheries to food security in the ASEAN region.



Research Output of the Fisheries Sector Program (FSP) Vol. 1 Articles published in scientific journals

The volume contains 34 papers on coastal resources management and rehabilitation, aquaculture, and utilization of aquatic products. These are studies funded by FSP, a landmark national initiative which addresses issues in the fisheries sector. FSP's research agenda was coordinated by the Bureau of Agricultural Research. This report was compiled with the assistance of SEAFDEC/AQD. Email rd@bar.gov.ph



The Proceedings of the National Seaweed Symposium is published by the Seaweed industry association of the Philippines (SIAP). The 109-page book is edited by SEAFDEC/AQD researchers Dr. AQ Hurtado and Ms. Ma. RJ Luhan.

It contains industry cluster situationers; global overview including developments in Chile; and programs of LandBank, Quedancor, Department of Trade and Industry, Department of Agriculture, Department of Science and Technology, University of the Philippines, and SEAFDEC/AQD.

The proceedings is available from SIAP Rm 203 Jose R. Martinez Jr. Bldg. Osmeña Boulevard. 600 Cebu City, Philippines. Tel. (63-32) 253 7433. Fax (63-32) 254 8780. Email siap@digitelone.com

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- Cage culture of fish. 7 days in July
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Grouper handbook

The 94-page fully illustrated, full color book entitled "**Husbandry and health management of grouper**" is available in English, Bahasa, Thai, Mandarin, Filipino, and Vietnamese. Contact Dr Erlinda Cruz-Lacierda at eclacier@aqd.seafdec.org.ph or fax (63-33) 5118709, 3351008



The Southeast Asian Fisheries Development Center (**SEAFDEC**) is a regional treaty organization established in December 1967 for the purpose of promoting fisheries development in Southeast Asia. Its Member Countries are Japan, Malaysia, the Philippines, Singapore, Thailand, Brunei Darussalam, the Socialist Republic of Viet Nam, Union of Myanmar, and Indonesia.

Four departments were established in the Member Countries; one of them, the Aquaculture Department (**AQD**) located in the Philippines, pursues aquaculture research and development

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Editorial offices are located at the: Training and Information Division SEAFDEC Aquaculture Department, Tigbauan 5021, Iloilo, Philippines *tel.* 63 (33) 511 9171, 336 2965, 336 2937, 511 9050, 511 9172 *fax* 63 (33) 5118709, 3351008. *e-mail* devcom@aqd.seafdec.org.ph

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Contributions

We accept articles that focus on issues, developments, and information on all phases of sustainable aquaculture for publication in this newsletter. Photographs and line drawings must be camera-ready, glossy B&W prints or colored slides. The newsletter editor reserves the right to edit contributed articles for brevity and style.

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Nota bene Mention of trade names in this publication is not an endorsement.

European Union's special project on mudcrab

By SEAFDEC/AQD/AQD's mudcrab R&D team

The European Union through the European Commission is funding a project on the "Culture and Management of *Scylla* Species." which is being undertaken by four institutions worldwide—University of Wales (Bangor) in the United Kingdom, Artemia Reference Center of the University of Ghent in Belgium, Can Tho University in Vietnam, and SEAFDEC/AQD in the Philippines.

The overall aim is to improve the reliability and economic viability of mudcrab hatchery and nursery production for mangrove-pond aquasilviculture production systems and stock enhancement. The project will run for three years beginning January 2002 with funding from the European Union. It is divided into six work packages: improvement of broodstock and larval quality, bacterial disease control in the hatchery, technical identification of larvae of four crab species, nursery and aquasilviculture, crab fisheries and population dynamics, and stock enhancement.

Broodstock and larval quality

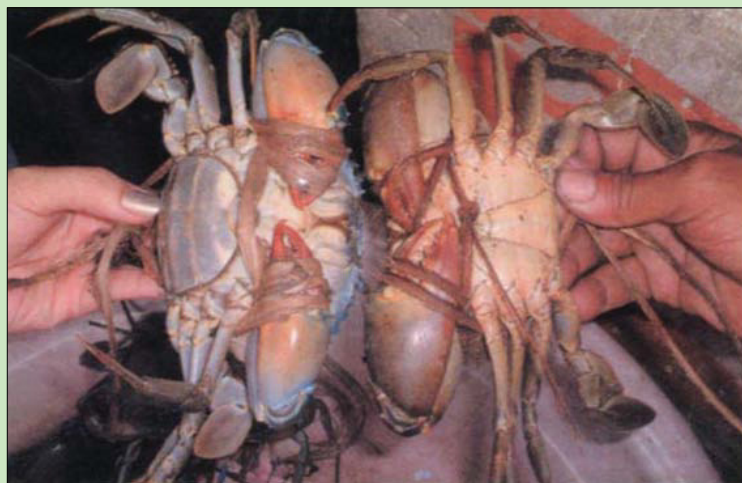
Ovarian maturation of wild and pond-sourced *S. serrata* was classified into 6 stages (immature to spent) based on external and histological descriptions of the ovary. During maturation, protein, lipids, minerals and ascorbic acid were accumulated in the ovaries indicating the importance of these nutrients in the reproductive process. Of the ten essential amino acids in wild-sourced crabs, arginine, isoleucine, leucine, methionine and valine increased in mature ovaries: triglycerides and phosphatidylcholine were accumulated, and 22:6n-3 (docosahexaenoic acid, 20:5n-3 (eicosapentanoic) and 20:4n-6 (arachidonic acid) levels were high. In pond-sourced crabs, lipids in newly spawned eggs and the more advanced eye stage were comparable. However, lipids in the heart-beat stage to newly hatched zoea significantly decreased indicating utilization.

Rotifers are routinely used as feed for crab larvae and as an alternative; the efficacy of oyster (*Crassostrea iredalei*) trocophores was evaluated. Trocophores were acceptable as food but survival and growth were better in larvae fed rotifers alone or trocophores in combination with *Artemia*.

Body measurements, development of the external sexual characters and gonad were determined in hatchery-reared *S. serrata*, *S. tranquebarica* and *S. olivacea* grown to maturity. There is an increase in the abdominal width per unit increase in carapace width (ICW) in females in the three species. Mating readiness of *S. olivacea* occurs at smaller body sizes (7.9 cm ICW female, 7.8 cm male) than in *S. tranquebarica* (9.1 cm female ICW, 8.7 cm male) and *S. serrata* (9.9 cm ICW female, 9.4 cm male).



Mudcrab fishers in Kalibo. Aklan tying their crabs collected by bamboo traps (tapangan) in preparation for sale in local markets



The color morph "sinaw" of *Scylla olivacea*, preferred for culture or fattening to other *S. olivacea* morphs



Stocking of mud crab juveniles inside mangrove pens for comparison of growth on fish biomass vs low-cost pellets

Diseases

Disease problems in broodstock after they were held for 3 months in tanks include shell disease due to a combination of fouling organisms and chitinolytic bacteria. Shell disease first manifests as off-white and black patches on the shell, progressing to become perforations through which nematodes and other saprophytic organisms gain entry. The fouling problems that affect the integrity of the shell are considered to reduce the life span and reproductive potential of broodstock under tank conditions.