

acid composition and total lipid content of the diets and of *P. monodon* fed with these diets were assessed.

Reproductive performance was evaluated in terms of number of spawnings, fecundity, egg and nauplii production and hatching rate of eggs. Broodstock response was best in Diet 1 and comparable with the control, followed by Diets 3 and 4, and was poorest in Diet 2.

Broodstock performance appeared to be related to the fatty acid pattern of the diet. All pelleted diets contained similar levels of total lipids. However, there were differences in amounts of important polyunsaturated fatty acids (PUFA): 20:4 ω 6 (arachidonic), 20:5 ω 3 (eicosapentaenoic) and 22:6 ω 3 (docosahexaenoic) acids. The fatty acid profiles of Diets 1 and 3 more closely resemble the profile of maturing ovaries of wild *P. monodon*; the PUFA content of these diets and ω 3/ ω 6 ratios were higher compared to Diets 2 and 4. Diet 2, showing the poorest profile among the diets, was low in ω 3/ ω 6 ratio and contained minimal levels of PUFA.

Study on the Larval Rearing of *Penaeus merguensis*

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Nursing postlarvae of *Penaeus merguensis* in the same tank as rearing always results in low survival rates, around 30%. One reason is that stocking density for P₁ is too high for postlarvae grown to P₂₀ size. Another reason may be that it is impossible to sufficiently clean a tank containing culture stock. In order to overcome the first constraint and to test whether the second is valid, rearing of nauplii to early postlarval stage was done in one tank, then early postlarvae were moved to another tank for nursing to P₂₀.

Rearing was done in rectangular, concrete tanks (5 m \times 5 m \times 2m) of 50 ton capacity, with an initial stocking density of 20-40 nauplii/l. *Chaetoceros* sp. at a density of 3-4 \times 10⁴ cell/ml, or *Tetraselmis* sp. at 1-3 \times 10⁴ cell/ml were fed to zoea stage, then rotifer was given when the larvae metamorphosed to mysis stage. Within 8-10 days, when all of the larvae metamorphosed to postlarval stage, they were transferred to the nursing tank. Postlarval nursing was done in rectangular, concrete tanks with a capacity of 12 or 30 tons. The stocking rate was 12 postlarvae/l in the 12-ton tanks and 8 postlarvae/l in the 30-ton tanks. The early postlarvae were fed constantly with brine shrimp, and the older postlarvae were fed 4-5 times daily with squid meat. Fifty to seventy percent of seawater was exchanged, and siphoning of food remnants was done daily. The postlarvae grew to an intermediate size (1.0-2.5 cm total length) for stocking in grow-out ponds within 12 to 20 days.

The results of rearing in 50-ton tanks with an initial stocking density of 20-25 postlarvae/l, 25-30 postlarvae/l and 30-40 postlarvae/l produced survival rates of 74.3%, 63.6% and 47.6%, respectively. The survival rate for nursing in 12-ton

tanks, with stocking density of 12 postlarvae/l was 85.0% and for 30-ton tanks with stocking density of 8 postlarvae/l was 61.7%. These results seem to indicate that the rearing and nursing of shrimp would be more efficient if carried out in separate tanks.

Characterization of Ovarian Maturation Stages in Wild Unablated *Penaeus monodon*

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At least five wild-caught *Penaeus monodon* from various maturation stages (initially classified *in vivo* as 0, I, II, III, IV, V) were measured, weighed and dissected for histological and histochemical studies. The anterior and posterior parts of the thoracic and abdominal regions of the ovary were sampled and stained with Mallory trichrome, alcian blue-periodic acid-Schiff (AB-PAS) and Sudan black.

Results showed that the ovary is composed of the ovarian wall and its extensions, zone of proliferation, follicle cell layer and oocytes. The proliferating cells are less than 10 μ m, have thin rims of cytoplasm, and increase in size as maturation proceeds. Based on histology, the stages were finally classified into groups (1) previtellogenic (stage 0), (2) vitellogenic (stages I and II), (3) cortical rod (stages III and IV), and (4) spent (stage V). The previtellogenic group consists only of perinucleolar oocytes (46-72 μ m) which are stained negatively with AB-PAS and Sudan black. Oocytes bigger than 55 μ m are enveloped by a single layer of follicle cells. The vitellogenic group is composed mostly of yolky oocytes (121-211 μ m) with the following cytoplasmic inclusions: small granules of glycoproteins, medium-size globules of lipoglycoproteins, and few large lipid droplets. The cortical rod group consists mostly of yolky oocytes (288-408 μ m) with additional rod-like bodies which contain acid and basic mucopolysaccharides but no lipid. The presence of cortical rods is a characteristic feature of mature penaeid ovaries. The spent group is similar to the previtellogenic group but contains some yolky oocytes, thicker follicle cell layers, or irregularly shaped perinucleolar oocytes. The GSI ranges of the four groups are 0.899-1.937, 3.099-7.598, 5.631-12.000 and 1.848-2.919, respectively.

The Use of Haptophyceae in Rearing Experiments on Larval *Penaeus orientalis*

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The food value of five clones of Haptophyceae, *Coccolithus pelagicus*, *Dicrateria zhanjiangensis*, *Isochrysis galbana*,

Tahitian *Isochrysis* aff. *galbana*, and *Pseudoisochrysis paradoxa* were tested for larval *Penaeus orientalis*. The algae were semi-continuously cultured in 5,000 ml carboys with 4,000 ml of Guillard f/2 medium, under 2,000 lux continuous light and under aeration. The algal density was up to 1×10^7 cell/ml. Rearing experiments were conducted in round tanks with diameter of 45 cm. Algal density was controlled at 1×10^5 cell/ml in the course of the experiments. The larval density was 18 individual/100 ml; water temperature, 21-24°C; pH, 7.5-7.7; and sea water specific gravity, 1.019.

The results showed that of five clones used, Tahitian *I.* aff. *galbana* and *D. zhangjiangensis* proved to be the best. It took 9-11 days for nauplius I to develop into mysis I with survival rate of 73.5% and 73.4%, respectively.

The Tolerance of *Penaeus monodon* Eggs and Larvae to Fungicides against *Lagenidium* sp. and *Haliphthoros philippinensis*

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The *in vivo* effect of mycostatic levels of fungicides against the fungi *Lagenidium* sp. and *Haliphthoros* sp. were tested on *Penaeus monodon* eggs and larvae. Hatching rate and survival of nauplii, zoeae, mysis and postlarvae exposed to 10 mg/l Benzalkonium chloride, 1 mg/l Clotrimazole, 1 mg/l Crystal Violet, 10 mg/l 2,4-D, 10 mg/l Daconil, 20 mg/l laundry detergent, 1 mg/l Econazole nitrate, 10 mg/l Resiguard, 0.2 mg/l and 10 mg/l Treflan-R, 0.01 mg/l and 0.2 mg/l Trifluralin were monitored daily for 96 hr in a static bioassay in glass aquaria. Results showed that all test chemicals had no inhibitory effect on hatching rate but survival rate of hatched nauplii was significantly reduced in most treatments except that of 0.2 mg/l Treflan-R. Tests with zoeae, mysis and postlarvae indicated that 0.2 mg/l Treflan-R and 0.01 mg/l and 0.2 mg/l Trifluralin did not adversely affect survival. In addition, Benzalkonium chloride caused no significant mortalities among exposed mysis.

Growth and Survival of *Penaeus monodon* Postlarvae with Different Feeding Regimes and Stocking Densities in Earthen Brackishwater Nursery Ponds

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The effect of different stocking densities (50, 100 and 150/m²) and two feeding regimes (natural food, consisting

mainly of lablab, and natural food plus artificial diet) on the growth and survival of *Penaeus monodon* postlarvae (PL₄ to PL₅) were evaluated in eighteen 40 m² earthen brackishwater nursery ponds using tidal water exchange for a period of 45 days.

Results of the experiment indicated that the effect of different stocking densities was highly significant ($P < 0.01$) on growth but not on survival for the two feeding regimes. Likewise, no interaction effect was discerned. Shrimps given artificial feed (Treatments II, IV and VI) obtained higher mean weight gains of 1.55, 1.17 and 1.05 g, respectively, than those that were not given artificial feed (I-1.44 g, III-0.92 g, and V-0.66 g). Similarly, those reared with artificial feed attained better survival of 41.62% (II), 67.44% (V) and 52.14% (VI) compared to shrimp that were not given artificial feed (I-42.53%, III-54.61% and V-46.90%).

An exploratory economic study showed that the nursery operation gave promising results in all treatments. High rate of investment (ROI) was obtained to give a safe margin for the risk involved in this kind of business. Among all treatments, treatment V had the highest ROI of 693% and shortest payback period of 0.19 years.

Intermediate Culture of Chinese Prawn Without Feeding in Nursery Ponds

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The aim of the experiments is to find a new way to accomplish intermediate culture of the penaeid prawn in nursery ponds. Experiments have been carried out in prawn farms in Haiyang County, Shandong Province. Prawn fry were stocked at high density in a nursery pond. Commercial fertilizer was added to the nursery pond to fertilize the pond water as nutrients for the planktonic and benthic organisms. The prawn fry in the pond fed only on the available natural food organisms without any special feed supply and grew normally. The survival and growth rate of the prawn fry are discussed.

Survival, Growth and Production of White Shrimp *Penaeus indicus* in Brackishwater Ponds

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This study was conducted in 4 one-ha ponds, 70-100 cm deep and 2 two-ha ponds, 40-70 cm deep to evaluate the survival, growth and production of white shrimp, *Penaeus indicus* stocked at 50,000/ha and cultured within a period of 90 days with supplementary feeding.