showed ontogenetic development of thermal resistance. Moulting of larvae was hindered at temperatures (37.2°C for nauplius when TA=25°C) well below lhLT50 (38.1°C for nauplius when TA=25°C). The embryonic stages were more susceptible to thermal stress than the larval stages. The salinity effects were also significant. Nauplius and protozoea stages showed their highest CTM values at the salinity in which they were spawned.

When compared with another penaeid *M. macleayi* (offshore breeder), *M. bennettae* (estuarine breeder) was found to have higher thermal resistance, but was less adaptive to changes in acclimation temperature.

Growth and Productivity of Juvenile Banana Prawns, *Penaeus merguiensis* in Natural and Laboratory Systems

Derek J. Staples, David J. Vance
and **Donald S. Heales**
CSIRO Marine Laboratories
P.O. Box 120, Cleveland, Qld. 4163
Australia

Growth and survival of *Penaeus merguiensis* juveniles were measured over four years in the Norman River estuary, south-eastern Gulf of Carpentaria. Growth in carapace length for the first 8-9 weeks after settlement was essentially linear and averaged 1.2 mm/week in summer at 29.5°C and 0.45 mm/week in winter at 19.5°C. A comparison of different cohorts under varying temperatures and salinities indicated that growth was temperature- but not salinity-dependent. Survival of newly settled postlarvae varied seasonally and was highest in spring (October-November).

In the laboratory, a study of moulting rate and moult increment at 15, 20, 25, 30 and 35°C demonstrated that the optimal temperature for growth was 25-30°C. Survival of juveniles was also highest at intermediate temperatures. Effects of salinity and food ration amounts are discussed.

Water Quality Criteria for Farming the Grass Shrimp, *Penaeus monodon*

Hon-Cheng Chen
Department of Zoology and
Institute of Fishery Biology
National Taiwan University
Taipei, Taiwan

Physiological and growth effects of pH, salinity, temperature, heavy metals, pesticides and others on juvenile grass shrimp *Penaeus monodon* have been investigated to determine the biologically safe concentrations. Optimal pH, salinity and temperature are found to be in the range of 8.0-8.5, 15-25 ppt, and 28-33°C, respectively. A dissolved oxygen concentration of 3.7 ppm seems to be the critical oxygen pressure to support the normal life of grass shrimp. To avoid poor survival and retarded growth, the recommended level for each pollutant are: heavy metals, 0.0025 ppm Hg, 0.1 ppm Cu, 0.15 ppm Cd, 0.25 ppm Zn; pesticides, 0.0004 ppb parathion, 0.001 ppb malathion, 0.008 ppb rotenone, 0.01 ppb Azodrin, 0.033 ppb Saturn, 0.01 ppb paraquat, 0.01 ppb Endosulfan, 1 ppb Butachlor; surfactants, 0.1 ppm Dunall OSE, 0.2 ppm BP 1100, 0.5 ppm Seagreen 805; and others, 0.033 ppm H_2S, 0.1 ppm NH_3.

Genetic Changes During Development of Penaeid Shrimp

L. James Lester
University of Houston
Clear Lake, 2700 Bay Area Blvd.
Houston, Texas 77058, U.S.A.

As penaeid shrimp grow from the earliest naupliar stages, through protozoeal and mysis stages, to postlarvae, they develop greater morphological and behavioral resemblance to the adults. Electrophoretic analysis of cytoplasmic enzymes from nauplii, protozoea, mysis, postlarvae, and adults show that each stage has a unique pattern of gene activity. Thirteen enzyme stains and a general protein stain have been used on larval samples from *Penaeus stylirostris, P. vannamei* and *P. aztecus.* Some enzymes, such as phosphoglucose isomerase, are produced in the same isozymic form during all of the stages. Other enzymes exhibit changes in the number and position of isozymic bands during development, e.g. glutamate dehydrogenase. Some of these differences among developmental stages can only be explained by changes in the number and/or identity of the genes that are active at each stage. This finding suggests larval and adult responses to selection may be relatively independent.

Osmotic, Total Protein and Chloride Regulation in *Penaeus monodon*

Ronaldo P. Ferraris, Fe Dolores P. Estepa
Jocelyn M. Ladja and Evelyn Grace de Jesus
Aquaculture Department
Southeast Asian Fisheries Development Center
P.O. Box 256, Iloilo City, Philippines

The osmotic, total protein and chloride ion regulation in two size groups (10 and 30 g) of *Penaeus monodon* Fabricius was investigated. Preliminary experiments showed that osmolality, total protein and chloride concentrations tend to

become stable 24 to 36 hours after molting. Thus, hemolymph values 36 to 240 hours after sampling were not significantly different from each other. Based on these results, only 36 hours (or more) postmolt animals were sampled after transfer from control (32 ppt) to five test salinities (8, 16, 24, 32 and 40 ppt). Hemolymph samples were then taken 1, 2, 3, 5, 7 and 10 days after transfer. Results showed that in general, osmolality, total protein and chloride concentrations in the hemolymph did not vary with time within the same salinity.

Both sizes exhibited hyperosmotic and hyperionic regulation in lower salinities and hypoosmotic and hypoionic regulation in higher salinities. The isosmotic values obtained were approximately 676 to 720 mOsm (24 to 28.8 ppt) for the 10 g, and 724 to 792 mOsm (26 to 28.5 ppt) for the 30 g size group. For chloride, the isoionic values ranged from 324 to 339 mM in 10 g prawns. Slopes of the regression lines of hemolymph osmolality versus salinity in 10 g prawns were not significantly different from slopes of similar regression lines in 30 g prawns. These results suggest that the ability to regulate osmotic and total protein concentration in the hemolymph is similar in the two size groups.

Induced Ovarian Maturation and Rematuration by Eyestalk Ablation of *Penaeus monodon* Collected from Indian Ocean (Phuket Province) and Songkhla Lake

Niwes Ruangpanit, Sujin Maneewongsa Thanan Tattanon and **Prakit Kraisingdeja**
National Institute of Coastal Aquaculture
Kaoseng, Songkhla, Thailand

Because of the difficulty involved in maintaining a supply of sexually mature female shrimp for larval production in hatcheries, experiments on induced ovarian maturation in tiger shrimp, *Penaeus monodon* by eyestalk ablation were carried out from March to August, 1983. These shrimps were collected from two areas of Thailand: Phuket on the Indian Ocean and Songkhla Lake with entry to the Gulf of Thailand. Every female had one eyestalk pinched before being stocked together with males in various female-male ratios in 50-ton cement tanks with continuous water flow. The shrimp were fed 10% of their body weight daily with a diet of 90% green mussel (*Mytilus edulis*) and 10% cow liver.

Results show that of those female shrimps collected in the Phuket area which is a natural spawning ground, 51% became gravid. However, of those collected in Songkhla Lake which is not a spawning area, only 19.51% became gravid. There was also a large difference in the number of days between eyestalk ablation and first spawning: 4-5 days for the Phuket samples and 20-30 days for those from Songkhla Lake. The survival rate of the larvae until P_{20} averaged 8.5% (total 732, 259) for the Phuket samples and 4.0% (total 300,000) for the Songkhla Lake samples. Results show mass mortality during the nauplius and mysis stages of shrimp from both locations which may indicate a greater susceptibility to bacterial and fungal infections in larvae produced from artificially matured females.

Further studies should be undertaken to determine the proper nutritional diet for maximum production of gravid females, and to discover methods to increase sperm production in males from areas other than natural spawning grounds.

Variation in Tissue Lipid Content and Fatty Acid Composition During Ovarian Maturation of Unablated and Ablated *Penaeus monodon* Broodstock

Oseni M. Millamena, Rosario Pudadera and **Mae R. Catacutan**
Aquaculture Department
Southeast Asian Fisheries Development Center
P.O. Box 256, Iloilo City, Philippines

The tissue lipid content and fatty acid composition in the hepatopancreas, tail muscle and gonad of unablated and ablated *Penaeus monodon* were determined. Females at various stages of maturity were collected from offshore spawning grounds in Tigbauan and Guimbal, Iloilo, Philippines. Ablated females were reared in captivity.

The hepatopancreas showed the highest lipid content at 15.72 to 25.20% in unablated females and 22.47 to 34.90% in ablated females. Fresh lipid levels averaged 2.60% with no marked variation throughout the maturation period. Ovarian lipid increased from 5.80% (unablated) and 7.50% (ablated) in Immature Ovaries to more than two-fold in Early Maturing Ovaries coupled with a drop in hepatopancreatic lipid suggesting lipid mobilization to the ovaries. In ablated females, ovarian lipid progressively increased to a maximum of 21.90% in Fully Mature Ovaries with a corresponding rise in hepatopancreatic lipid. Both the ovarian and hepatopancreatic lipids declined in spent females. Fatty acid profiles of the tissues consistently showed the presence of polyunsaturated fatty acids (PUFA) 20:4ω6, 20:5ω3 and 22:6ω3. These fatty acids were reflected in the spawned egg. The lipid level in the hepatopancreas appeared to be inversely related to the total PUFA concentration in the ovaries. Lipid accumulation in ablated females was significantly higher than in unablated females.

The findings suggest storage and subsequent utilization of lipids for maturation and spawning processes. The type of polyunsaturates present in the maturing ovaries is indicative of their metabolic and physiological importance in the reproductive process.