Carbohydrate Requirements of *Penaeus monodon* Juveniles

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Penaeus monodon juveniles (initial mean weight=0.62 g) were fed semi-purified diets containing 10, 20 and 30% trehalose, sucrose or glucose for eight weeks. Results showed that shrimps fed 20% trehalose gave the highest growth rate. Of the three types of sugars tested, trehalose promoted the best growth rates, followed by sucrose and glucose. When the level of sugar was considered, 20% gave the best growth rate and 30%, the lowest. The type as well as level of sugar greatly affected the body crude protein and body lipid ($P < 0.01$), while survival was mainly affected by type of sugar alone ($P < 0.01$). Trehalose and sucrose diets promoted better survival than glucose diets. A negative linear correlation ($r = -0.70$) between the body crude protein and body lipid was obtained.

Earthworm, Marine Annelids and Squid as Feed Ingredients in Formulated Diets for Juvenile *Penaeus monodon*

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Earthworm and annelids were incorporated in diets for *Penaeus monodon* juveniles (mean weight 0.54 g) either in wet or dry form. These protein sources were added in amounts needed to replace 10% of the animal source of protein. Other sources of protein in the diet were shrimp head meal, fish meal, and defatted soybean meal. Diets were computed such that two-thirds of total protein came from animal sources and one-third from vegetable sources. Other components of the diet were rice bran, sago palm starch, cod liver oil and a vitamin-mineral mixture. Another diet, used as maintenance diet, served as control. Postlarvae were randomly stocked at 6 individuals/tank in a flowthrough system with 5 replicates/treatment. Each of the oval fiberglass tanks had three 10-cm diameter PVC pipes for shelter. The prawns were fed 10% of biomass twice daily.

Although treatment means for percent weight gain were not significantly different, the diet that contained dried earthworm or annelid meal gave higher weight gain than diets containing the wet form. The earthworm diet gave higher weight gain than diets containing annelids. Survival rate also followed a similar pattern as that of weight gain. Shrimp fed earthworm (wet or dried) gave survival rates numerically higher than those fed marine annelids. Shrimp fed the control diet had survival rates lower than those fed earthworm-containing diets but higher than those fed the wet annelid diet.

In another experiment, earthworm or squid was incorporated in the diet. Survival rates of shrimp with earthworm or squid in the diet were significantly higher than those fed the control. Weight gains were not significantly different from each other. Food conversion was generally low. The drawback in the use of earthworm, annelids and squid is that they are relatively expensive compared to fish meal and shrimp head meal.

Effects of Some Water-Soluble Vitamins on the Growth of *Penaeus monodon* Juveniles

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The response of *Penaeus monodon* juveniles (ave. wt.= 0.076 g) in terms of survival and growth rates to vitamin test diets was observed in a 35-day feeding experiment. The prawns were reared in 60-ℓ oval tanks containing filtered seawater in a flowthrough system of ambient temperature and salinity. The treatments consisted of a control (complete vitamin mix), a vitamin-free diet and nine other diets, each lacking one of the vitamins in the mixture. At the end of the feeding trial, the survival rates in all treatments ranged from 80 to 100%, while weight gain ranged from 74 to 40%. Significantly lower weight gains were obtained from choline chloride-free diet ($P<0.05$) and vitamin-free and inositol-free diets ($P<0.01$) than from control.

Ruppia maritima and *Najas graminea* as Natural Foods for *Penaeus monodon* Juveniles

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Ruppia maritima (*kusay-kusay*, Hiligaynon) and *Najas graminea* (*digman*, Hiligaynon) are macrophytes growing in local brackishwater ponds believed to provide food and shelter to prawns and fishes. Their effect on growth and sur-

vival of *Penaeus monodon* juveniles (PL_{50}; carapace length, 4.01 mm; body weight, 0.053 g) were studied in 80-ℓ glass aquaria. The treatments were: (a) a commercial pellet (40% protein); (b) *live Ruppia;* (c) decaying *Ruppia*; (d) live *Najas*; and (e) decaying *Najas.* The pellet was offered to satiety (approx. 100% of body weight) twice daily. Live *Ruppia* and *Najas* were transplanted in the aquaria using pond soil a week prior to the experiment. Decaying *Ruppia* and *Najas* were transferred from ponds. Salinity was maintained at 15 ppt and 50% of the water was changed regularly.

Highly significant differences ($P < 0.01$) in mean carapace length (CL) and mean body weight (BW) on the 10th, 20th and 30th days were observed among treatments. Increase in CL was fastest with decaying *Najas* and slowest in live *Ruppia* (14% vs. 17% after 30 days). Growth with decaying *Ruppia* was comparable to pellets on the 10th and 20th days but was faster after 30 days. Body weight on all sampling days was highest in decaying *Najas* and lowest in live *Ruppia.* Percentage increases were 122, 273 and 565% on the 10th, 20th and 30th days, respectively, with decaying *Najas.* Those given live *Ruppia* registered increases of 11, 67 and 94%, respectively. The rapid growth rate of animals on decaying *Najas* was compensated negatively by a low survival rate (31%), significantly lower than on live *Najas* (100%). Other survival percentages were: decaying *Ruppia,* 59% and pellet, 53%.

Hepatopancreas Cells as Monitor Cells for the Nutritional Value of Prawn Diets in Aquaculture

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The hepatopancreas is considered to be the central organ of metabolism in decapod Crustacea. It is a system of blind tubules consisting of four cell types. The E-cells at the summits of the tubules develop into R-cells (for resorption of nutrients), F-cells (for production of digestive enzymes) and B-cells (function unknown).

The ultrastructure of *Penaeus monodon* R-cells changes largely after starvation and feeding different diets. B-cells show slight reactions, while F- and E-cells are rather constant. Thirteen day-starvation results in a large decrease of the cell size and in a significant reduction of all cell organelles. After seven days starvation and four days refeeding with various extreme diets, the R-cells develop completely different food-specific ultrastructures. A distinct proliferation of the endoplasmic reticulum is characteristic of protein diets. Large fat drops are the main feature after refeeding with cod liver oil. Sucrose feeding results in "empty" cells with only few organelles. The most diversified ultrastructure with fat droplets and a high amount of all cell organelles is obtained by feeding a mixed diet.

The study indicates that R-cells are very sensitive to the application of different diets. They could be used as monitor cells for the nutritional value and the availability of a diet for prawns. Particularly poor or badly formulated feed could be detected early by electron microscopy. This method may be very helpful for the development of artificial prawn diets in aquaculture, especially if natural sources will be used as food components.

Effect of Cholesterol in Artificial Diets for Mediterranean Prawns

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Mediterranean prawn (*Penaeus kerathurus* Forsskal) postlarvae (2 months old) were fed *ad libitum* with previously tested artificial diet (41% D.W., mainly of vegetal origin) supplemented with different percentages of cholesterol (0, 0.1, 0.5, 1.0 and 3.0%) and fresh bivalve mussel. Growth and survival rates were determined twice.

Considering supplemented formulas only, data show that: (a) individual weights were higher with 0.1% cholesterol in the diet; (b) survival sharply dropped in the last week of the experiment, in particular with 0.1 and 3.0% cholesterol diets; and (c) with 1.0% cholesterol, mortality and growth counterbalanced giving over-all better results.

No artificial feed can compete with the natural diet, either for survival rate or for individual growth.

Evaluation of Artificial Feeds for Shrimp (*Penaeus monodon*) Production in Brackishwater Ponds

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The experiment was conducted in fifteen 500-m^2 brackishwater ponds to determine the response of *Penaeus monodon* juveniles fed with various artificial diets. Five treatments with three replicates each were: two commercial feeds containing 45% and 40% crude protein (treatments I and II), two experimental diets formulated to contain 35% crude protein (treatments III and IV) and control, without