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Nutrition and Feeding of Penaeus monodon

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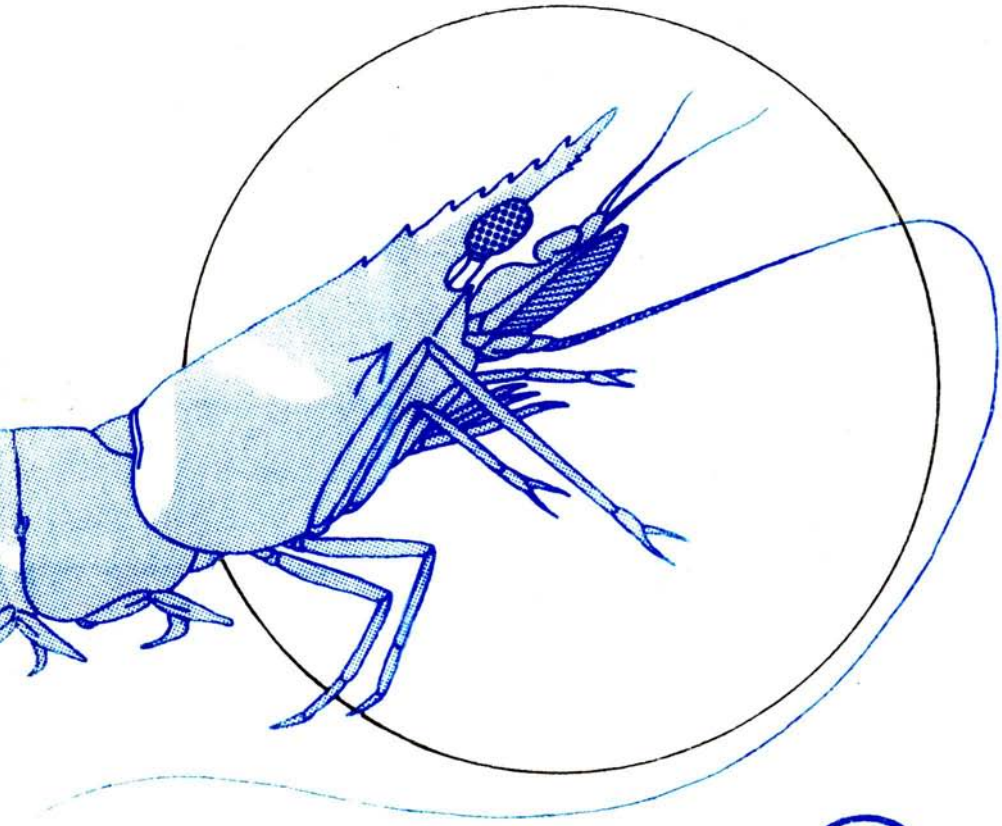

AQUACULTURE DEPARTMENT
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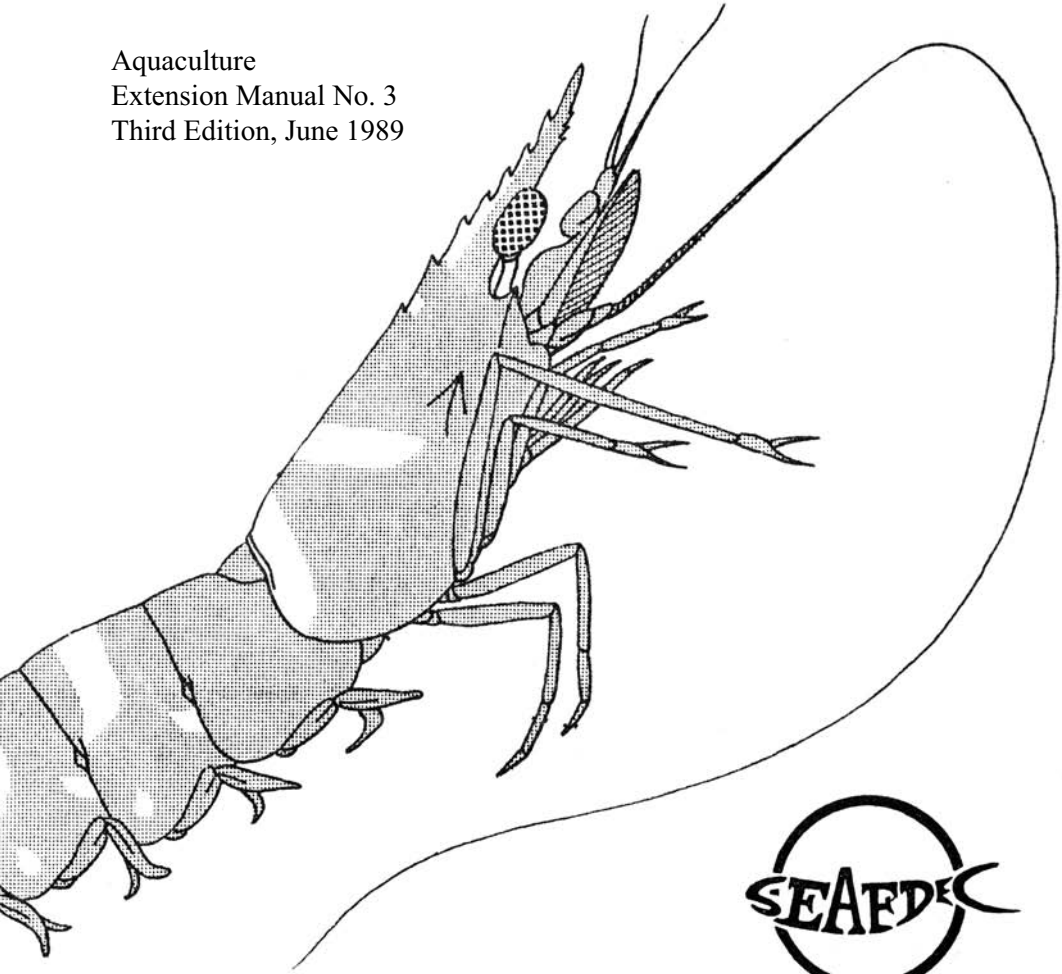

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FEEDING AND NUTRITION OF PENAEUS MONODON
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PREFACE

Penaeus monodon Fabricius is a highly priced aquaculture species in Taiwan, Thailand, Indonesia, and the Philippines. Its culture at the semi-intensive and intensive levels was introduced only recently. Prawns cultured using the extensive method depend on the natural food organisms in ponds. With the development of semi-intensive and intensive culture systems it became necessary to introduce artificial feeds to bolster the growth of prawns. It is important, therefore, to know the nutrient requirements, feeding methods, and the right kind of low-cost but efficient feed for prawns.

Not all of the nutrient needs of *sugpo* are known but there are already some feed formulations which can increase culture production. It is therefore recommended that the suggested formulated diets on pages 11 and 12 be tested in 0.5- or 1.0-hectare areas to determine which one would suit a particular culture system. These serve as a tool or a guide for the innovative prawn farmer who might find it challenging to formulate his own feed. Tables 1 and 2 are compilations of chemical compositions of available local feedstuffs analyzed at the SEAFDEC Aquaculture Department (AQD) Centralized Analytical Laboratory.

This revised edition includes recent findings on the nutrient requirements of prawns, feed preparation, improved diet formulations, feeds composition table, procedure for computing daily feed ration, and suggested feeding schemes.

This guide is a product of eleven years of experimentation at SEAFDEC AQD with partial support from the American Soybean Association, International Foundation for Science, Japan International Cooperation Agency, and the cooperation of numerous farmers who gladly shared their results from experimental trials in their ponds. The cooperation and help extended by the Crustacean Feed Development Team, the Centralized Analytical Laboratory, the Publications Review Committee, and Information Division of SEAFDEC AQD is gratefully appeciated.

Comments, suggestions, and corrections coming from users in all sectors will be most appreciated.

F.P. Pascual

SEAFDEC AQD, Tigbauan, Iloilo
5 June 1989

NUTRITION AND FEEDING OF PENAEUS MONODON

CONTENTS

INTRODUCTION

The need to increase production to meet the ever-growing demand for protein food has led to the search for better ways of producing fish and shellfish.

The success in broodstock and larval production of *Penaeus monodon* Fabricius, locally known as *sugpo* or tiger prawn, and the growing interest in its culture point to the need for supplementary or complete formulated feeds that are economically viable for use in pond culture. The traditional method of rearing prawns with natural food and organisms present in the pond and supplementing these with frog or dog meat, chicken entrails, carabao hide, trash fish, mussel, and the like might suffice in the extensive culture system.

Successful rearing of *sugpo* depends on many factors. These are correct pond preparation, availability of healthy fry, optimum stocking density and proper stocking procedures, feeds and feeding system, water management, and proper pesticide and fertilizer application. High production through intensive culture is possible if prawns are provided with good nutrition. One way of attaining good nutrition is to feed the fish with either natural or artificial feed.

Feed is one of the major inputs in the intensive production of *P. monodon* and it represents a sizeable percentage of the total cost of prawn production. Thus, nutritious and economical diets are a worthy investment. With supplemental feeding a stocking density of 3/sq m or more can be used compared to 1/sq m when prawns depend on natural food alone. Moreover, prawns with supplemental feeding would reach marketable size a month earlier than those depending only on natural food. Thus, more harvests per year and bigger-sized prawns that command a higher price in the market are possible.

Although many formulations or rations are claimed to boost growth of prawns, these diets are either too expensive, because some are imported, or impractical, because they are unsuitable to use under Philippine conditions. In many instances, the feed ingredients are not available in the local market.

The difficulty in procuring and storing live and fresh food has led to the development of artificial diets. Fresh food easily deteriorates resulting in the reduction of its nutritive value. Also, when spoilage sets in due to poor storage, the feed may cause mass mortality. Refrigeration of wet feed is, however, too expensive for most fishpond operators. Dry feed, therefore, is a good choice for the postlarvae.

Feeding provides proper nutrition for the prawn such that, with optimum environmental conditions, the prawn will attain marketable size in the shortest time and at the least cost in order to obtain the largest margin of profit. It is then necessary that an adequate diet is formulated to ensure rapid growth of prawns, prevent nutritional diseases, develop and maintain their resistance to infection, and provide for an attractive and palatable product.

FOOD AND FEEDING HABITS

Information on dietary requirements of the prawn can be gathered from studies on food intake in the natural habitat. At the zoeal stage, prawns are herbivorous. They prefer phytoplanktons such as *Chaetoceros* and *Skeletonema.* Later, at the mysis stage (5-7 days after hatching), they become carnivorous. Their choice shifts to *Brachionus* and other zooplanktons, and the brine shrimp, *Artemia.* At the postlarval stage they ingest small crustaceans like crabs and shrimps and molluscs, fish, polychaetes, ophiuroids, and even debris, sand and silt. Both plants and animals are eaten but prawns when starved will eat any food offered to them. Crustaceans appear to be their staple food although molluscs are also eaten in large amounts. In the wild, they prefer small shrimps and fishes. During the months of March, April, June, August, and December, molluscs are found more frequently than crustaceans in the guts of prawns. Fish remains are more evident in prawns in January, March, and August compared to other months. In one study, it was found that the peak seasons of *P. monodon* spawners occur in April, August, and November. This suggests that prawns feed on molluscs and fish for their gonad development.

Unlike fish, prawns are nibblers, hence slow eaters. They take food with their pincers, bring this to their mouth, and slowly chew on the food. If the feed is small enough they would throw the whole piece into the mouth. Although they have been found to eat all day, prawns seem to eat more at night than at daytime. They increase their feeding activity before low tide. They have a tendency to become cannibalistic when the food is of poor quality and insufficient. Healthy prawns attack and feed on the weak ones like those that have just molted.

NUTRIENT REQUIREMENTS

Little is known about the nutrient requirements of *P.monodon.* Like any other organism, however, prawns need nutrients or substances that will provide for normal growth, regulate body processes, and increase resistance to diseases.

There are five major categories of nutrients needed by. prawns: protein, fats, carbohydrates, vitamins, and minerals.

5 Major nutrients needed by the prawn

- **35~45% Protein**
- **25% Carbohydrates**
- **10% Fats**
- **Vitamins**
- **Minerals**

Protein and Amino Acids

Protein is necessary primarily for growth. When there is not enough fat and carbohydrates in the diet, protein is used first for energy requirements instead of for growth. It is the amount and quality of protein in the diet that must be considered.

Amino acids are building blocks for protein formation. When one amino acid is lacking or insufficient in the diet, protein formation can be stopped or decreased. This will result in a diminished utilization and efficiency of the diet. A diet with an amino acid profile similar to that of prawns will provide for good growth.

There are around eighteen amino acids needed for protein formation. Ten are *essential*, that is, they can not be synthesized by the animal and therefore, have to be included in the diet. These are arginine,

histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan, threonine, and valine. The other amino acids can be formed or synthesized in the body, hence they are called *non-essential* amino acids. These are aspartic acid, serine, glutamic acid, proline, glycine, alanine, cystine, and tyrosine. The amount for each of the ten essential amino acids required by prawns has not been determined. However, several prawn nutrition experts (researchers) have shown that the closer the essential amino acid pattern of the diet to that of the species being studied, the better is the diet.

The quantity of protein in the diet is as important as its quality. Studies at SEAFDEC AQD indicate a need for 40% protein in the diet of *P. monodon* grow-out. It is therefore suggested that 35-45% protein be used in the diets of prawns in grow-out ponds.

Lipids and Fatty Acids

Fats or lipids are necessary for prawns not only for their energy value but also for the presence of essential fatty acids and fat-soluble vitamins A, D, E, and K. They also act as carriers of these vitamins. Like protein, it is not only the quantity of fat that is important in the diet but also the quality as influenced by the presence of essential fatty acids.

The fatty acid composition of *P. monodon* is related to the fatty acid pattern of the diets. In wild *P. monodon* broodstock, the fatty acid profiles of the ovaries, hepatopancreas, and tail muscle show that there is a preponderance of long chain polyunsaturated fatty acids such as arachidic, eicosapentaenoic, and docosahexaenoic acids.

Cholesterol is another lipid required by *P. monodon* at about 0.5-1% in the diet. Likewise, about 34% lecithin, a fat-containing phospholipid, is required by prawns for good health.

The type of fat in the diet also affects survival of prawns. Around 5-10% lipid is needed of which about 5% should come from marine sources.

Carbohydrates

Carbohydrates are used mainly for their energy value and to spare protein from being used for energy. Hence, both fats and carbohy-

drates are known as protein sparers, Dissacharides, trehalose, and sucrose are heat for prawns. Starches provide energy and also are useful for their binding properties in the diet. Around 25% nitrogen-free extract or carbohydrates excluding fiber is suggested in the diet of *P.* monodon juveniles.

There are indications that prawn juveniles need from 3100 to 3300 kcal/kg of diet. When there is not enough calories or when the food energy supply does not meet the requirements, prawns will not grow well. The protein in their diets will be used for energy rather than for growth.

Vitamins and Minerals

Vitamins and minerals are important in regulating body processes. The B vitamins are necessary for proper utilization of proteins, carbohydrates, and fats. Vitamins A and C are important in building resistance to diseases. Vitamin D, together with minerals like calcium and phosphorus, is necessary for the formation of exoskeleton or shell. All of these nutrients are so interrelated that they have to be incorporated in proper amounts in the diet to be efficiently utilized by the prawn.

Calcium and phosphorus (1:1) are needed to prevent "softshelling" in prawns.

For lack of information on vitamin-mineral requirements, published data for other shrimps may be used. Commercially available vitamin-mineral mixes may also be used. Suggested vitamin and mineral mixes are appended under Table 4 on page 13,

Under extensive or semi-intensive pond culture, the vitamins like Vitamin C present in natural foods (phytoplankton, *lablab, digman, kusay-kusay*) may suffice.

DIET DEVELOPMENT

There are two categories of protein sources: animal and plant. Since prawns tend to be carnivorous, it is suggested that two-thirds of total protein come from animal sources and one-third from plant sources.

Likewise, there are two sources of lipids: animal and plant. Of the animal fats, those from marine sources like fish liver oils are preferable.

Aside from the nutritional requirements, there are other factors to be considered in developing a diet. These are availability and cost of ingredients, acceptability and attractiveness of the diet to the prawn, and effectiveness of the diet in promoting growth.

A survey of the available feed ingredients and their cost should be made before attempting to prepare the diet. Protein sources like fish meal, shrimp meal, etc. are often the most expensive items in the diet. Commercially produced pellets may be more expensive than home-mixed diets. Financial factors, as well as equipment and manpower resources should also be considered if one is to prepare his own prawn diets.

A pelletized artificial diet might be easy to prepare but whether or not the food is attractive and acceptable to the prawn is another problem to consider. Unlike fish that gulps on or swallows its food, *P. monodon* is a nibbler and hence requires a pellet that is stable in water for six or more hours.

A diet that is stable in water and attractive and acceptable to prawns is still not good unless it results in rapid growth, high survival, and a palatable and colorful prawn. Astaxanthin in shrimp meal gives prawns its bright attractive color. The consumer palate has to be satisfied. What good is a big prawn if it does not have the color and delicate flavor that the consumer is accustomed to?

The effectiveness of a prepared diet is usually expressed in terras of food conversion ratio (FCR) or feed efficiency. This is the amount of dry feed that will produce a unit of wet weight gain. For example, if two kilograms of feed produce one kilo of live prawn, then we say, we have a FCR of two. The lower the FCR, the better it is because less feed is required per unit weight gain.

A diet is generally composed of:

— Protein sources
— Lipid sources
— Carbohydrate sources
— Binder
—Attractant
— Vitamins

— Minerals
— Additives such as antioxidants, antibiotics, fungicides, hormones, etc.

Many of the available feed ingredients are used in poultry and swine feeds. Feedstuffs considered as protein sources usually contain more than 20% protein when dry.

Some protein sources are:

— Fish meal (both white and brown)
— Shrimp meal
— Shrimp head meal
— Earthworm meal
— Squid meal
— Chicken entrails
— Mussel meat
— Meat and bone meal
— Chicken egg (whole)
— Toads
— Snails
— Yeast
— Soybean meal (defatted or full-fat)
— Cottonseed meal
— Peanut meal

Shrimp, earthworm, squid and mussel meals are excellent protein sources. They also provide the attractant and some essential fatty acids. Shrimp and other crustacean meals contain astaxanthin that gives the bright color to prawns when cooked. Generally, a combination of two or more protein sources is better than just one source.

Soybean meal should not be given raw. It should be heat-treated at 170°C for 10 minutes to destroy the trypsin inhibitor which prevents the efficient utilization of protein. When full-fat soybean meal is used, adjustments in the amounts of fat and carbohydrates should be made.

Ipil-ipil meal contains mimosine, a toxic substance which can be removed by soaking the leaves for 24 hours in freshwater. The giant Hawaiian variety contains less mimosine than the short local variety.

Some lipid sources are:

— Cod liver oil and other fish liver oils
— Squid oil
— Beef tallow

— Purified soybean oil
— Soybean oil (crude, degummed)
— Peanut oil
— Corn oil
— Sunflower oil
— Oil palm oil

Cod liver oil and other fish liver oils contain the highly unsaturated fatty acids predominant in *P. monodon.* Around 5% of total lipid should therefore come from marine sources and the rest from plant sources, preferably soybean oil. A 1:1 ratio of cod liver oil and soybean oil (preferably crude, degummed soya oil, if available) is suggested.

Some carbohydrate sources are:

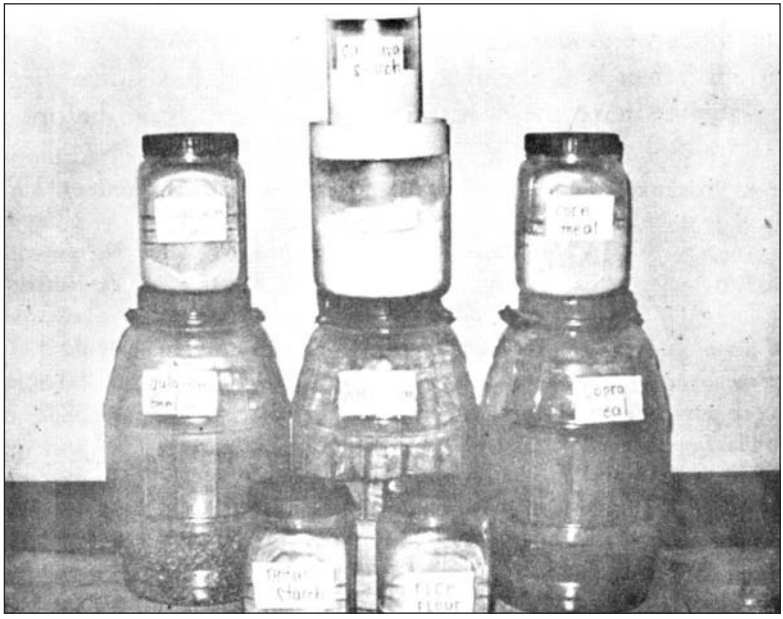
— Wheat flour (bread flour)
— Rice flour
— Cassava flour
— Potato starch
— *Sago* palm starch
— Rice bran (*tiki-tiki* or the very fine type)
— Corn meal

Sweet potato starch is an energy source but its presence in the diets causes rapid growth of molds especially when the feed is not properly stored. Aside from providing energy, carbohydrate sources also act as binders. Among the starches that are good binders are bread flour, *sago* palm starch, potato starch, and corn starch. Other good binders are wheat gluten, carhoxymethyl cellulose, carrageenin, agar (*gulaman*), and alginates.

While rice bran, corn meal, and corn gluten meal have considerably high fiber content, they also contribute protein, fat and carbohydrate to the compounded diet. Although these feedstuffs are poor sources of protein, the total amino acid pattern is usually improved when they are mixed with fish meal and shrimp head meal. Corn meal and rice bran, etc. should not be rancid and moldy to avoid mass mortality of prawns due to aflatoxin, a carcinogen.

The vitamin-mineral premix for poultry may not be the best combination but it can be utilized in the absence of concrete findings on the vitamin-mineral requirement of prawns under tropical conditions. The premix should contain Vitamin C which is good for prawn. The

other vitamins needed in the mix are A, D, E, K, B_1, B_2, B_6, B_{12}, pantothenic acid, choline, inositol, and folic acid. The minerals calcium, phosphorus, potassium, iron, magnesium, iodine, cobalt, copper, zinc, and manganese should also be added.



Carbohydrate sources available locally. These serve primarily as energy sources but are important in the diet formulations also for their binding property.

At present, there is no single formula that can be considered the "best" or perfect. One can plan or formulate a diet to meet his needs.

Assuming that other factors such as cost and availability of feedstuffs have been considered, one should list down the feedstuffs that will provide the essential nutrients for prawns. First, protein sources should be listed. Two or more sources are better than one. Second, carbohydrates and lipid sources, as well as vitamins and minerals should also be considered. Finally, a binder to make the pellet stable should be added. Antioxidants such as butylhydroxy toluene (BHT) and anti-molds like propionic acid should be used only if the diet is to be prepared and stored long before use. Prepared diets should be stored in covered containers.

Tables 1 and 2 serve as a guide in determining the nutrients needed by prawns and in computing for the amounts of total protein, lipid, and carbohydrate in a diet. It is advisable to have all feedstuffs chemically analyzed. However, if chemical analysis is not possible, a feed composition table is an alternative guide. Seasonality of feedstuffs, environmental factors such as soil and water characteristics, methods of processing feedstuffs, length of storage, and storage conditions affect the chemical composition of feedstuffs; hence, it is advisable to have the feedstuffs chemically analyzed before use.

Table 1. Proximate analysis of feedstuffs (% dry weight): plant sources.

	Moisture	Crude protein	Crude fat	Crude fiber	N-free extract	Ash
Bread flour	12.44	13.34	1.03	0.44	84.61	0.58
Copra meal	6.22	21.43	8.24	19.86	37.53	12.94
Flour (all-purpose)	14.10	13.04	0.30	1.36	84.87	0.43
Ipil-ipil leaf meal (giant)[a]	10.44	28.69	.7.11	8.74	47.40	8.06
Ipil-ipfl leaf meal (local)[b]	11.54	31.07	7.02	7.47	44.49	9.48
Kussy-kusay (*Ruppia* sp.)	4.76	15.38	3.70	17.20	49.48	14.24
Rice bran	9.89	13.73	13.23	7.54	54.46	11.04
Rice bran (defatted)	10.29	21.36	1.42	9.32	55.26	12.64
Rice hull	5.69	2.80	0.84	43.28	32.26	20.83
Soybean meal (defatted)	6.98	39.08	1.64	6.44	43.61	9.23
Wheat flour[c]	10.95	15.83	1.98	1.38	79.71	1.10
Yeast (Brewers)	1.40	56.10	2.14	0.33	31.58	9.85

[a,b] Mimosine content(%): 2.29 and 2.44, respectively.

[c] Calcium and phosphorus content(%): 0.04 and 0.24.

Table 3 gives an example of a formulated diet and the calculated and true values of each ingredient based on chemical analysis.

Table 4 shows four suggested formulated diets with the amounts of ingredients needed in each type of diet.

- *Diet 1* is the simplest formulation which can be used to supplement the natural food present in die pond. Note, however, that no vitamins and minerals are added. This diet it recommended for extensive culture in place of chicken entrails, trash fish, frog sneat, and other fresh

Table 2. Proximate analysis of feedstufts: animal sources.

	Moisture	Crude protein	Crude fat	Crude fiber	N-free extract	Ash
Ascetes sp.	6.94	64.42	3.86	4.18	10.75	16.79
Earthworm (*Nereis* sp.)	3.20	46.98	25.22	0.58	20.61	6.61
Earthworm (*Eosinea foetida*)	3.76	55.98	17.09	0.71	21.82	4.40
Earthworm (*Eudrinus eugineae*)	7.98	52.40	3.66	5.94	22.41	15.59
Fish meal						
Local	6.54	66.89	7.92	0.74	0.89	17.56
Peruvian	7.74	67.40	5.72	0.89	0.87	17.12
Tuna	7.29	57.99	9.70	0.42	6.99	24.90
Salmonete	10.46	72.57	3.42	1.35	0.59	22.07
Meat & bone meal[a]	5.02	45.14	8.39	1.56	5.36	39.55
Mussel meat[b]	5.74	61.14	11.26	3.05	14.15	10.40
Prawn head meal (*sugpo*)	6.05	52.70	4.75	13.31	2.59	26.65
Shrimp meal	6.06	73.76	4.10	3.36	4.11	14.67
Shrimp head meal	8.69	25.17	1.14	7.54	7.16	58.99
Squid meal	7.18	77.14	5.89	4.59	1.06	5.32
Trash fish	6.60	72.74	10.00	0.23	5.59	11.44

[a,b]Calcium and phosphorus content(%): 9.97 and 3.80, 0.71 and 0.85.

food. A harvest of about 75-100 kg of prawns is expected using this diet formulation.

— *Diet 2* contains a poultry vitamin-mineral mix and a 1:1 ratio of fish liver oil to soybean oil. A stocking density of 1/sq m is recommended. About 200-300 kg can be harvested, assuming 70% survival.

— *Diet 3* is more complete but more expensive than Diets 1 and 2. It is recommended for a stocking density of 2.5/sq m. About 500-600 kg of prawns can be harvested per hectare per crop.

— *Diet 4* contains less fish meal and bread flour than Diet 3. Furthermore, it contains more soybean meal and cod liver oil. It has no added lecithin. It is recommended for a stocking density of 10/sq m. Around 2,000 kg of prawns can be harvested.

Table 3. Proximate composition of a formulated diet Figures are analyzed (calculated) values in percentages.

	Amount (%)	Protein	Fat	NFE	Moisture	Crude Fiber	Ash
Fish meal	32.0	64.99 (20.80)	3.06 (0.98)	0.52 (0.17)	10.46 (3.35)	1.21 (0.39)	19.76 (6.32)
Shrimp head meal	15.0	49.51 (7.43)	4.46 (0.67)	2.43 (0.36)	6.05 (0.91)	12.50 (1.87)	25.05 (3.75)
Soybean meal	15.0	36.35 (5.45)	1.52 (0.23)	40.57 (6.08)	6.98 (1.05)	6.00 (0.90)	8.58 (1.29)
Rice bran	14.8	19.18 (2.84)	1.27 (0.19)	49.57 (7.33)	10.29 (1.52)	8.36 (1.24)	11.33 (1.68)
Wheat flour	14.0	14.10 (1.97)	1.76 (0.25)	70.98 (9.94)	10.95 (1.53)	1.23 (0.17)	0.98 (0.14)
Cod liver oil	3.0		100 (3.0)				
Lecithin	2.0		100 (2.0)				
Vit. mix	1.5						
Min. mix	1.5						
Binder	1.0						
B.H.T.	0.2						

Calculated values:	(38.49) x 4	(7.32) x 9	(23.88) x 4	(8.36)	(4.57)	(13.18)
(kilocalories/100 g diet):	153.96	65.88	95.52	Total:	315.36 kcal	

Table 4. Suggested formulated diets. Ingredients in percentage.

Ingredients	Diets			
	1	2	3	4
Fish meal	30	30	32	16
Shrimp head meal or shrimp meal	30	15	15	15
Soybean meal (defatted)	15	15	15	35
Rice bran	15	15	13.3	15
Bread flour	5	15	14	4.8
Sago palm or cornstarch	-	5	-	-
Potato starch	5	-	-	6.0
Binder	-	-	2.5	-
Lecithin	-	2.0	2.0	-
Cod liver oil	-	2.0	3.0	5.0
Soya bean oil	-	2.0	-	-
Vitamin mix	-	0.95[a] 0.05[b]	1.5[c]	1.5[c]
Mineral mix	-		1.5[d]	1.5[d]
BHT (Butylhydroxy toluene)	-	-	0.2	0.2
Water (enough to make a dough)	150	200	200	200

[a] Poultry vitamin-mineral mix.

[b] Vit. C.

[c] Thiamine-HCl, 015; riboflavin, 0.50; pyridoxine-HGl, 0.15; nicotinic acid, 2.0;Ca-panthothenate,0.75; inositol, 10.0; biotin, 0.15; folic acid, 0.0375;p-amino-benzoic acid, 1.0; choline chloride, 20.0; ascorbic acid, 25.0; alpha-tocopherol, 1.0; menadione, 0.10; B-carotene, 0.10; calciferol, 0.015; cyanocobalamine, 0.001; cellulose, 39.181. Amounts in grams per 100 grams of mix. (*After* Deshimaru, 1981)

[d] K_2 HPO_4, 10.0; $NaH_2HPO_4.H_2O$, 21.5; $Ca(H_2PO_4).H_2O$, 26.5; $CaCO_3$, 10.5; Ca-lactate, 16.5; KCl, 2.8; $MgSO_4.7H_2O$, 10.0; Fe citrate, 1.20; cellulose, 13.08; trace metals, 1.0 ($AlCl_3.6H_2O$, 0.024; $ZnSO_4.7H_2O$, 0.476; $MnSO_4.6H_2O$, 0.107; CuCl, 0.015; KI, 0.023; $CoCl_2.6H_2O$, 0.14); cellulose, 0.125. Amounts in grams per 100 grams of mix. (*After* Deshimaru, 1981.)

When Diet 3 is used, do not give it soon after stocking of prawns in the pond if there is enough natural food. Feeding may start one month after stocking. A complete diet is necessary when rearing prawns using the semi-intensive and intensive culture systems. Diet 4. is given soon after the prawns have been stocked.

In an extensive prawn culture where stocking density is less than one postlarva per square meter, it is usually not necessary to use a mixed diet. Fertilization and proper water management may suffice. Water management is fully dependent on tidal fluctuation. However, one may give trash fish, chicken entrails, frog meat, mussels, or shrimp heads at Certain periods, perhaps after one or two months or toward the last month of culture period at around 15 to 20% of total biomass of the prawn.

Good water management is important when feed is given to the prawn. Aside from depending on tidal fluctuations, a water pump is needed during neap tide or during an emergency when dissolved oxygen is lower than 4 ppm and salinity is more than 40 ppt. Anaerobic water at the bottom of the pond, especially when pellets are fed, has to be removed by changing water from under rather than from the surface of the ponds.

FEEDING REGIMES

Artificial feeding could start immediately after stocking when natural food is lacking in the pond or when the pond is highly stocked (50,000 and above) as in intensive farming. When feeding, the suggested amount of feed is 10% of body weight. The following computation shows how to determine the daily feeding ration (DFR).

DFR (kg) = ABW (g) x No. of stock x % Survival x R

where: ABW (g) = average body weight of stock sample during a particular period,
% Survival = estimated percentage of survivors during that particular period,
R = feeding rate as percentage of the estimated total weight of all prawns during that particular period.

Example:

Given: No. of prawns in 1 ha pond = 25,000 pcs
ABW (g) after 45 days = 5.0 g
Estimated survival (%) = 92.0 %
Feeding rate based on total wt. = 6.0%

Calculate: a) daily feeding ration (DFR) (kg)
b) total feed requirement (TFR) for 15 days

Solutions:

a) DFR (kg) = 5 g x 25,000 x 0.92 x 0.06 = 6.9 kg

b) TFR (15 days) = 6.9 kg/day x 15 days = 103.3 kg

The suggested feeding schemes and schedules at a stocking density of 25,000/ha are shown in Table 5.

If one decides to feed soon after stocking as in the case of the intensive culture, a suggested sliding rule is:

1 — 30 days = 10% of body weight
31 — 60 days = 8% of body weight
61 — 90 days = 6% of body weight
91 — 120 days = 4% of body weight

The use of 6-8 feeding trays ($1 m^2$) placed around the pond is advantageous because feeding can be observed. The amount of feed can be adjusted or increased when there is little or none left in the trays. Since prawns eat more and forage at night, it is better to give more of the daily allowance in the afternoon. Around 30% of total feed for the day could be given in the morning and 70% in the late afternoon. Furthermore, around 30% of the total feed for the period can be placed in the feeding trays and the rest broadcasted in the middle of the pond with the use of a flat boat.

At present, there are several commercial feeds in the market for intensive culture of prawns. Each company has its own feeding scheme. It is, therefore, suggested that the instructions given by the feed manufacturer be fallowed and some feeding experiments be tried by comparing different feeds in the market or making substitutions as one gets a feel of the culture of prawns.

DIET PREPARATION

In the absence of locally produced, stable crustacean pellets, home mixing might be more practical.

Ingredients

Feedstuffs readily available in the locality should be tried. See list on pages 6-8.

Table 5. Suggested feeding scheme at initial stocking density of 25,000 fry/ha.

Age	ABW	Expected survival rate (%)	No. of prawns	%BW	Amount of feed per day	Amount of feed per 15 days
0	0.5-1.5	100	25,000			
1-30	2.6	96	24,000	-	-	-
31- 45	5.0	92	23,000	6	6.9	103.5
46- 60	9.5	89	22,250	6	12.4	186.2
61- 75	14.2	85	21,250	5	15.1	226.3
76- 90	19.0	82	20,500	5	20.3	304.4
91-105	25.3	78	19,500	4	19.7	296.0
106-120	30.5	75	18,750	4	22.9	343.1
					TOTAL	1,459.5

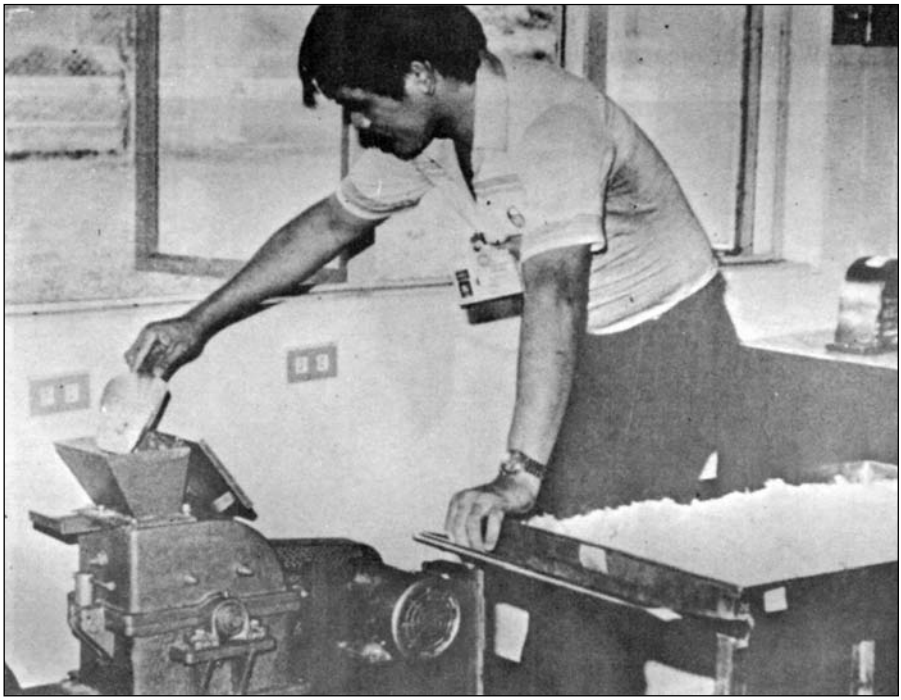
Feeding Schedules

I	II	III
8:00 AM - 30% of daily feed ration	8:00 AM - 30% of daily feed ration	8:00 AM - 25% of daily feed ration
1:00 PM - 20% of daily feed ration	4:00 PM - 70% of daily feed ration	2:00 PM - 25% of daily feed ration
6:00 PM - 50% of daily feed ration		6:00 PM - 25% of daily feed ration
		10:00 PM - 25% of daily feed ration

Equipment

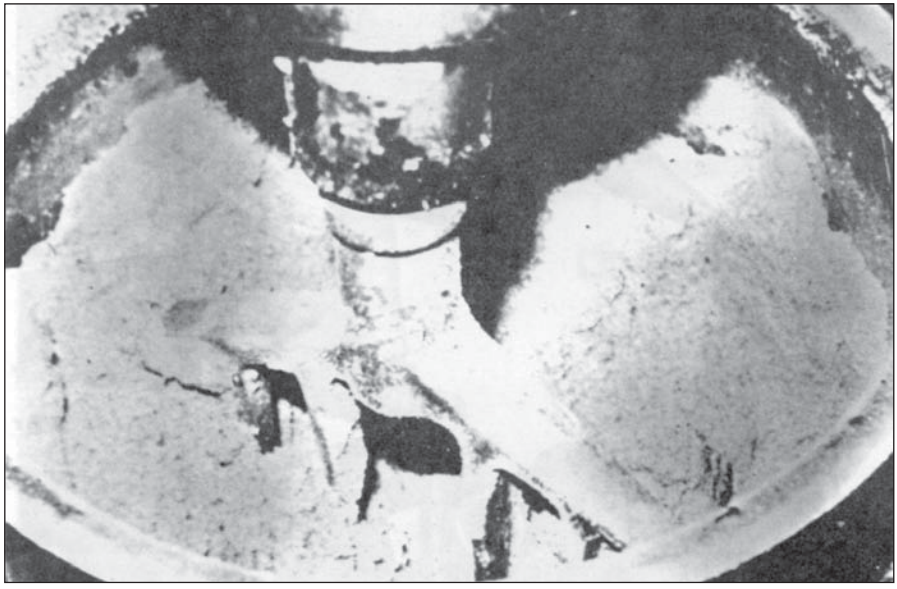
— Weighing scale or balance
— Tyler sieve, No. 40
— Mixer (5-10-kg capacity)
— Meat or food grinder (pelletizer)
— Corn mill
— Steamer or a big cauldron with cover
— Bamboo basket
— Saucepan
— Drier or oven
— Wooden laddie
— Plastic bucket with cover

Procedure

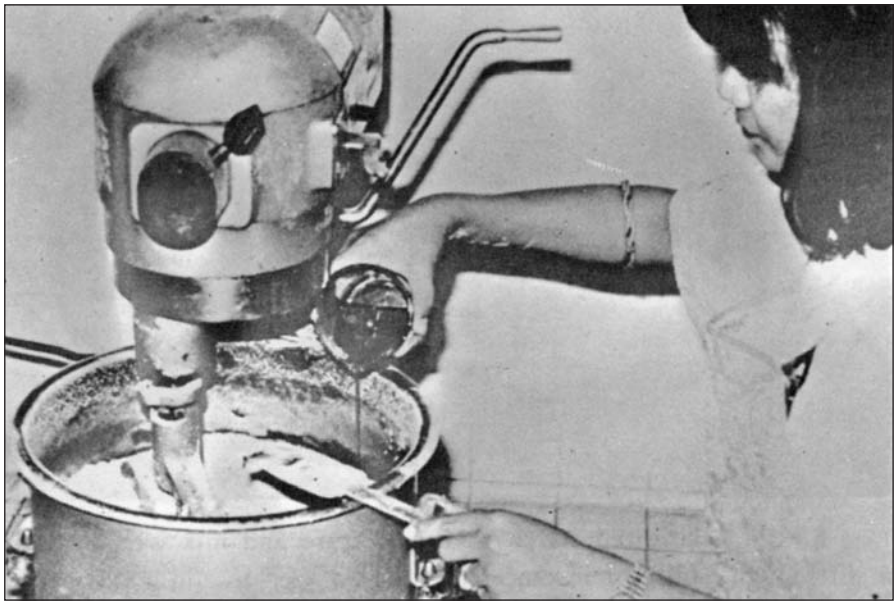


1. Finely grind ingredients until particles are of similar size. If possible, ingredients should pass through a No. 40 sieve, a nylon mesh of 420 microns to one sq cm. Dissimilar sizes result in unstable pellets.

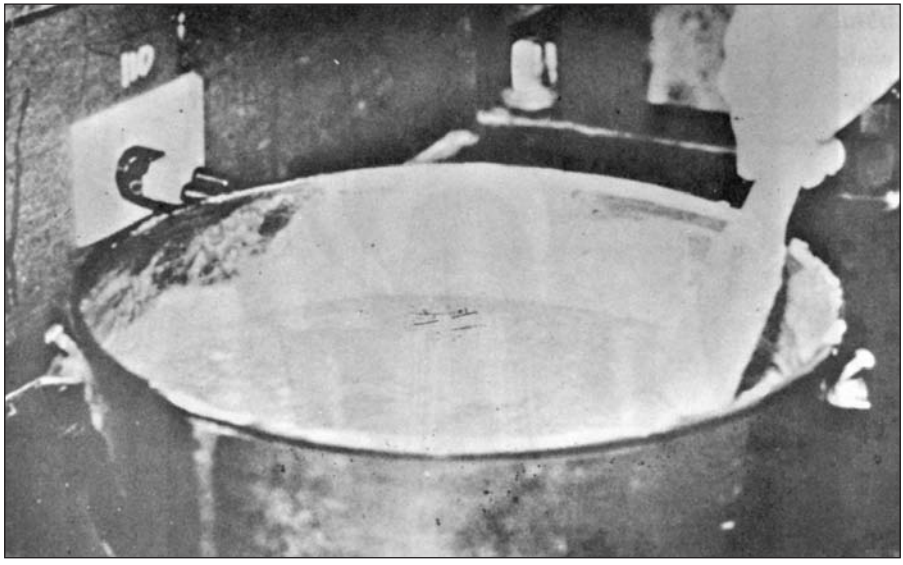
2. Weigh or measure all ingredients.



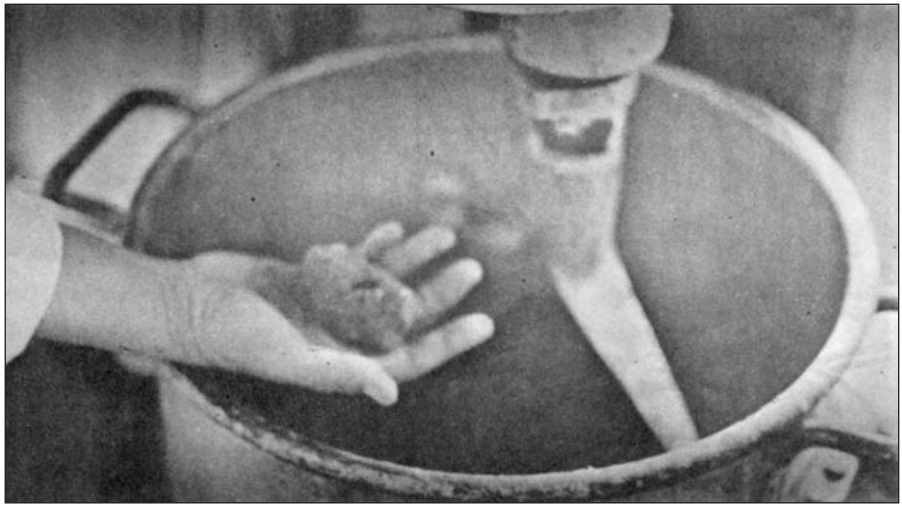
3. Mix all dry ingredients thoroughly. If large batches are to be prepared, the dry ingredients can be mixed in a large cake mixer or a cement mixer.



4. Add oil and mix for at least another five minutes.



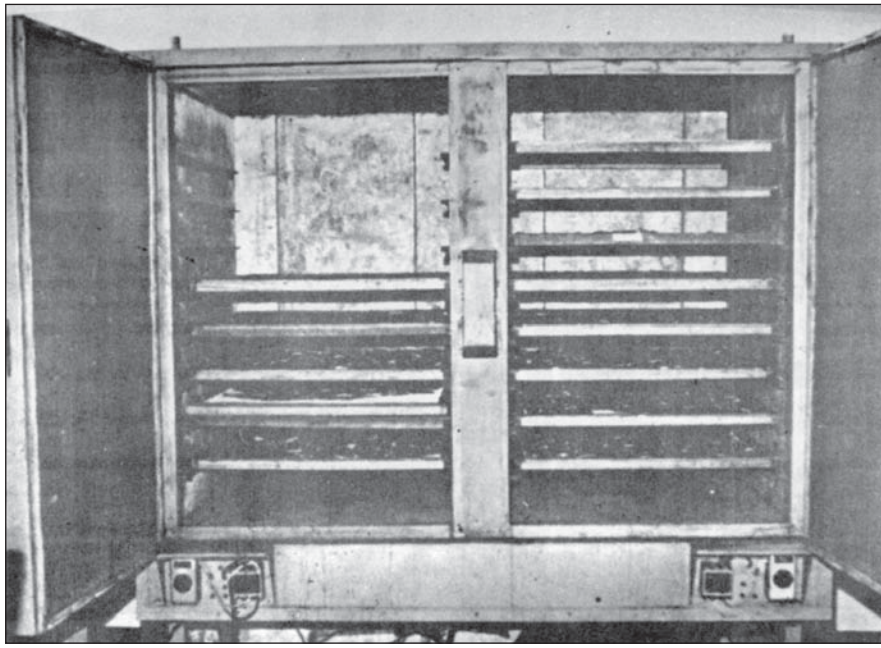
5. Cook cornstarch to gelatin consistency similar to the way it is cooked for starching clothes. In a saucepan, put one part starch in four parts of water (50 g in 200 cc water) for one kilogram of feed. Suspend starch in water before gelatinizing the binder.



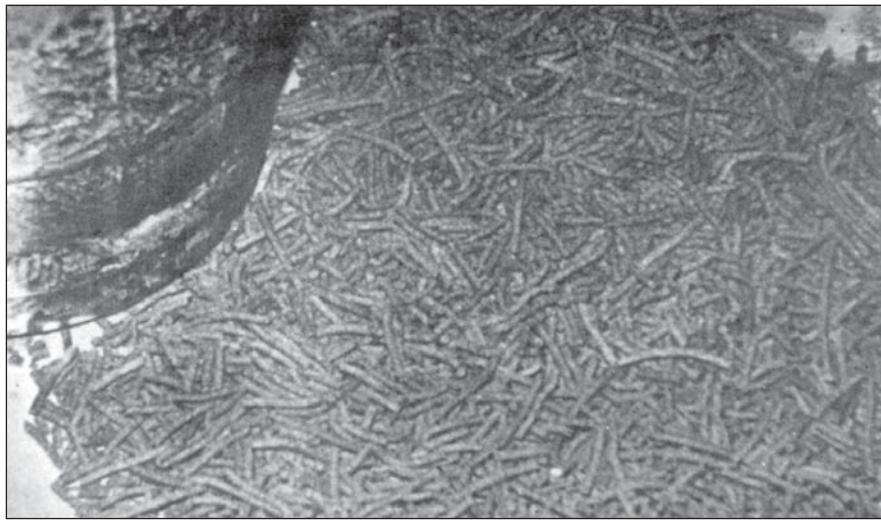
6. Add gelatinized starch to the mixture and mix well to make a stiff dough. In most instances there is no need to add water. However, if the dough falls apart after a ball is formed, some more water may be added, usually about 1/2 to 1 cup.

8. Cut the extrusions (which look like noodles) into 0.5-cm long pellets and steam for five minutes. Steaming makes the pellets more stable. Unsteamed pellets break up within thirty minutes but steamed pellets are stable up to more than six hours. Since the prawn is a slow eater and may not be able to find its food soon enough, it is preferable to steam the pellets.

7. Pass the dough through a meat grinder with a 1-, 2- to 3-mm diameter (dia.) die, depending on the size of the prawn to be fed. For the juveniles weighing around 0.35 g, use 1-mm dia. die; 2-mm dia. die for 2 g; 2.5- to 3-mm dia. die for 10 g or more.



9. Dry the steamed product in an oven overnight (8-12 hours at 60°C). Sun-drying will destroy some of the vitamins.



10. Place pellets in covered plastic buckets and store in a cool, dry place. Pellets can be made once a week or every day depending upon the availability of storage space.

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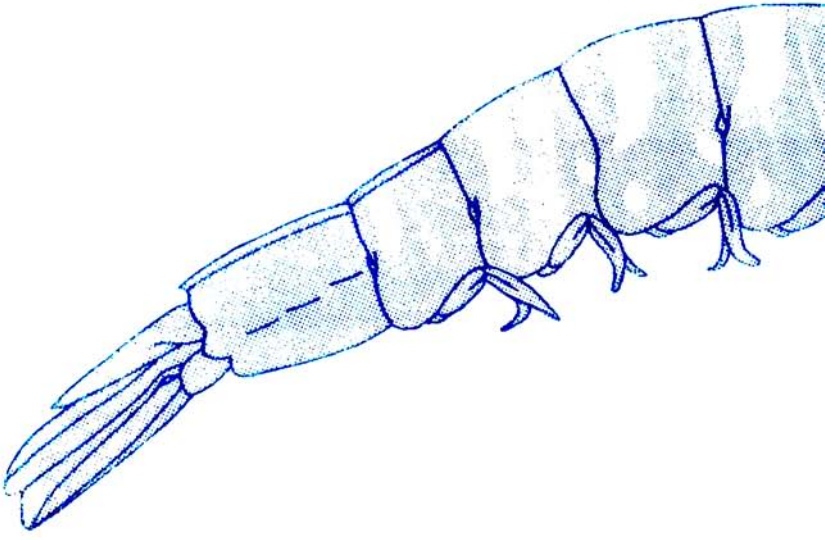

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