NUTRITIONAL REQUIREMENTS OF SUGPO IN HATCHERY AND IN PONDS

by

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INTRODUCTION

The increasing world demand for protein ushers a widespread and intensive search for new sources. Recently, the aquaculture ventures of many countries, particularly in shrimp and prawn[1/] culture, are given serious consideration. In the Philippines the promise of the new industry as a new source of food protein supply and additional income to its teeming population, has stimulated in-depth research on the culture and cultivation of its native species, sugpo, spearheaded by two research institutions- the MSU Institute of Fisheries Research and Development and the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC).

NUTRITION OF SUGPO UNDER NATURAL CONDITIONS

The gut of sugpo is composed of a mouth with a short esophagus which leads into a large capacious cardiac and pyloric stomach which is equipped with a gastric mill and hepatopancreas (Fig. 1). The esophagus, cardiac stomach and the interior half of the pyloric stomach with the gastric mill

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[1/] See differences between shrimp and prawn in Table 1 or median teeth are parts of the foregut. The midgut is limited to the posterior half of the pyloric stomach. The hindgut refers to a long intestine extending from the pyloric stomach through the abdomen and opens to the exterior on the ventral side of the telson.

Little is known concerning the actual nutrition of sugpo. Under natural conditions they feed on the bottom epiflora (plants) and epifauna (animals) of the mud substrata and as such, they are described as "omnivorous scavengus" or "detritus feeders". Findings on gut analyses show the presence of indigestible remains (chitin fragments, annelid jaws and setae, etc.), organic detritus, algal material, small organism contained in the mud, and sand.

During digestion, digestive juices are produced almost entirely by cells of the hepatopancreas. Since sugpo does not chew their food effectively with the mouthparts, food chewing or grinding is the function of the gastric mill. Intensity of food ingestion is correlated with the degree of fullness of the gastric mill. Based on observations, within several minutes after a starved sugpo is given abundant blended food, the anterior chamber of the proventriculus fills to capacity. Ingestion ceases until some food has passed through the gastric mill. Defecation may begin in an hour after feeding and reaches a peak in 4 to 6 hours.

CRITERIA OF GOOD NATURAL AND SUPPLEMENTARY FOOD IN COMMERCIAL SUGPO PRODUCTION AND CULTIVATION

There are certain criteria to be observed in the selection of food to be given to sugpo at different larval stages and to adult. The following are:

A. Quality

A.1 Good Nutritional Value

In considering sugpo nutrition one must recognize the various developmental stages (nauplius, zoea, mysis, post larvae, juvenile and adult) because each stage requires certain environmental conditions related to the physiological condition of the animal as well as to its feeding characteristics.

Sound nutrition determines growth, maturation, and reproduction. Nutritional requirements for growth and metabolism consist of different classes of nutrients. These nutrients are the food elements which are the end products of digestion such as:

(1.1) AA (amino acid): The building block of Protein.

Protein is a body builder. Sugpo is made up of protoplasm which in turn is composed of nitrogenous compounds. Protein is the only food element containing nitrogen and is therefore essential to sugpo diet. Protein is composed of AA (amino acid) which is necessary in almost every metabolic processes (growth, replacement and repair of tissue cells). It is in the form of amino acids that protein is absorbed through the intestinal wall and into the blood.

In the formulation of feeds it has been found that the amount of required crude protein ranges from 40-60% for fishes. In the search of shrimp crude protein requirement, researches in Japan revealed that the value was generally proportional to the protein content ranging from 60 to 75%. With this finding, it is known that shrimps require higher amount of protein. In this connection, in the evaluation of nutritive value of a given shrimp feed, it should be made as a standard to find out whether or not the amino acid components in the feed approximate the requirements of the shrimp (Table 2). In the selection then of materials for the formulation of feeds, their amino acids content is the primary consideration. Table 3 shows amino acid analysis on common shrimp feeds. From this data, it is highly significant to find that amino acids composition held by the feeds of higher efficiencies is approximated to that found in the shrimp. The best among the tested feeds are short-necked clam and squid meal. These contain amino acids that are very close to that of the shrimp.

Next in rank is vegetable soy-bean protein of whose amino acids approximate that of the shrimp than the crustacean brine shrimp. Whale meal, on the other hand, is rich in the amount of amino acids but the composition is different from that of the shrimp. The same is true with fish meal which is short in the content of basic amino acids essential for shrimp growth like phenylalanine, lysine, histidine and arginine. Lack of these elements is found to lower the food efficiencies of fish meal, as evidenced in the feeding experiment done by Shigeno in Japan. Other identified amino acids necessary for shrimp growth are threonine, valine, methionine, isoleucine, leucine and triptophane.

(1.2) Simple Sugars

It is in this form where carbohydrates (CHO) is being absorbed in the blood. Carbohydrates are utilized by the tissue cells for energy or carried to the muscles where they are stored for future use. Table 3 shows certain percentage of CHO in some feeds used for shrimps.

(1.3) Fats

These are the richest source of energy. Weight for Weight basis, they yield more than twice as many energy units of either CHO or protein. Fats are utilized by the body in metabolism their original form or as fatty acids of which all fats are composed. Stored fats serve as a reserve supply of energy and to a certain extent as insulation in the body. Table 3 also shows fats content on tested shrimp feeds.

(1.4) Vitamins

Vitamins are chemical substances manufactured in plants and found deposited in animal tissues. They are essential to life and good health. In extremely small amounts they govern and regulate many important functions of the body such as metabolism. Example of vitamins used with sugpo feeds are thiamine, riboflavin, nicotinic acid, biotin, folic acid, choline chloride, menadione, ascorbic acid and cyanobalamin. Table 4 gives the composition of vitamin mixture in mg % in shrimp diet.

(1.5) Minerals

These are chemical substances for building and repairing tissue cells and regulating body processes. Important minerals are Ca, O, Fe, I, Na, K. Mn, Cl, - Mg Common mineral salts used with shrimp feeds are K_2HPO_4 (10%) $Ca_2 (PO_4)_4$ (15%) and Ca-lactate (75%).

To further evaluate good nutrition for sugpo is to use growth factor as an index. Growth is a process which involves increase in the number and size of cells composing the organism.

Growth as effected by food can be measured by calculating gross feed conversion efficiency (Eg) by the formula adapted from Brett, et a. (FAO publication 1970):

$$Eg = \frac{G}{I} \times 100\%$$

where:

G = growth

I = food intake

ex: $\frac{\text{2 kg (growth of shrimp in terms of weight)}}{\text{4 kg (food given in terms of weight)}} \times 100\% = 50\%$

Then:

food conversion ratio = 2.4

food conversion effieiency = 50%

Another way of solving growth is by adapting the Shigeno formula as presented below:

$$\text{daily growth rate \%} = a = \left(\sqrt[t]{\frac{W}{W_o}} - 1\right) \times 100$$

rate of daily feed intake % = b

$$b = \frac{F \times 100}{\frac{n_o + n}{2} W_o \left(1 + (1 + a) + (1 + a)^2 + \ldots + (1+a)^t\right)}$$

$$\text{feed efficiency \%} = e = \frac{(W + D) - W_o}{F} \times 100$$

Where:

W_o = initial body weight (average) in grams

W = final average body weight in grams

n_o = initial number at the start

n = final number at harvest

t = duration of rearing experiment in days

F = total amount of feed-intake in grams

D = total body weight of dead shrimp in grams

The first conversion efficiency formula is simple than the second. Whichever is applied provides an extremely useful measure of the growth phenomenon for it indicates both the circumstances under which the animal is most efficient and the criterion for most economical use of the feed.

A.2 <u>Food preference and utilization efficiency</u>.

Limited knowledge exists on both food preference and utilization effiency. Certain species characteristically show changes in food preferences and feeding habits. Food preferences and utilization efficiency are due to the impact of different feeds or individual nutrient components on the flavour or organoleptic quality of shrimp. Organoleptic quality of shrimp has something to do with the attrativeness, odor, and taste of the food given. Texture, size and shape would be other factors to consider which has effects on the ingestion and digestion or morphological structure offeeding adaptation of sugpo.

B. Comparative Low Cost Feeds

In sugpo farming cheaper cost of production would depend on pond productivity andpond carrying capacity. Pond productivity is a result of the interplay of many factors, such as the depth of the water in the pond, the quality of the water, the quantity of fresh water allowed into it, the temperature of the water and its surrounding, the composition of the fish population and the type of pond soil.

The degree of productivity varies even in between two adjacent ponds. This is a result of the ability to produce more natural feed as "lab-lab" which houses plankton and bottom animals. The rate of increase of these small unicellular plants is markedly controlled by the intensity of the prevailing light and to a lesser extent by the ambient temperature. To produce and maintain a large population, adequate nutrients in the form of inorganic nitrogen and phosphorous compounds, minor nutrients and dissolved CO_2 must be made available. And this is being done by fertilization.

Pond productivity does not apply to the production of weeds in ponds. A weed is a plant that grows in a location where it is not wanted. Aquatic weeds in ponds divert the flow of the basic nutrients (N-P-K), CO_2, and solar energy from the desired form of plant life to an undésirable one.

The ideal food chain in growing sugpo is:

Basic substances ------→phytoplankton/bacteria --→zooplankton--→ sugpo
(fertilizer)

In ponds where supplemental feeding is being done, weeds interfere with feeding of the sugpo. Further, where large amounts of weeds are present during periods of cloudy weather, the needs of D.O. may exceed the photosynthesis input, causing sugpo losses from reduced O_2 in ponds. Example of these weeds are filamentous algae (lumut), hydrodictyon, pithophora, and potamogeton.

Pond carrying capacity is a term used to denote maximal attainable yield for a given season, taking into consideration of optimal increase in daily growth. It was found out that higher temperature reduce carrying capacity because of a greater demand for O_2 by the cultured species and by microoorganisms (algal growths, protozoa, and bacteria) that commonly accompany it. The criterion which limits the carrying capacity in this case is the reduction of oxygen level to 6 ppm. The O_2 supply must be sufficient to maintain normal growth (7-9 ppm).

Weeds can reduce the capacity of a given pond by inhibiting later development of phytoplankton to support the desired fish population throughout the growing season.

Control of the growth of weeds may be done by employing manual labor, introducing herbivorous fish and using of copper sulfate or lime.

C. Readily Available Feeds

For sugpo food to be categorized as readily available it must be obtained locally at any given time if the needs for it arises. And since shrimps have a high metabolic rate when active or when its food reserve is low, the food supply is extremely important to the growth of the animal.

FOODS UTILIZED IN EXTENSIVE AND INTENSIVE CULTURES OF SUGPO AND NUTRITIONAL PROBLEMS

A. Food Used in Production and Cultivation of Sugpo

Extensive culture involves the use of natural bodies of water with minimal control of the environment, competition and predation. Sugpo fry come from natural sources and feed on natural food in the water which may be added with minimal artificial food. It is a low-density culture method which usually involves low capital investment, and thus, profits can be low and variable. Intensive culture on the other hand, is expensive as it may necessitate the construction of hatcheries, raceways and ponds. Culture is high density and thus requires full control over hatchery supply of sugpo fry. Artificial food is used, supplemented by naturally-developed food.

In intensive sugpo fry production types of food given in Table 5 prove to be good in attaining higher survival rates.

TABLE 5: FOOD USED IN SUGPO FRY PRODUCTION

FOOD	Stages		
	Zoea	Mysis	Postlarvae
Diatoms	+	+	+
Single Cell	+	+	+
Protein(Bread yeast, fodder yeast, bacteria flock)	+	+	+
Juice (Eelgrass, filamentous algae sargassum)	+	+	
Cake (soya bean, mongo bean	+		
Brachionus/chlorella		+	+
Artemia nauplii		+	+
Minced clam		+	+
Shrimp meal			+
Formula feed (pelleted squid meal plus other ingredients)			+

Sugpo cultivation feeds could be enumerated as follows:

1. lab-lab (diatoms + blue greens + zooplankton)
2. "lumut" (filentous algae + diatoms + zooplankton)
3. skin of cow or carabao
4. bia (bagtis)
5. minced fish (tilapia)
6. clam meat (amahong)
7. Shrimp
8. concentrated algal frozen foods
9. dried shrimp heads and waste left after processing and mixed with rice bran

The ability of sugpo postlarvae to accept non-living food makes it better suited for intensive cultivation. However, with increase in size of the maturing animal, the size of the food particles should be proportionally increased. Percentage survival of P. monodon post-larvae on various foods is given in Table 6. While minced clam has been used as the main bulk of sugpo food, researches to be undertaken are geared to the development of "artificial" or synthetic diets. Feeding dosage of the supplementary food is still to be determined, so that the effects of decomposition of un-utilized food in the growing ponds will cease to be a serious problem.

Table 6. Survival Rate % of Advance Stage of P. Monodon Post Larvae Fed with Various foods (MSU-IFRD), 1973-1974)

Food	P_4--------P_{15}	P_7---P_{26}	P_{10}-----P_{33}
Benthic (Bottom) Diatoms	√	√	√
Planktonic (floating) Diatoms	√	√	√
Copepod	√		
Brachionus	√		√
Artemia	√	√	√
Minced Clam	√	√	√
Bread Yeast	√	√	√
Dinoflagellate	√	√	√
Protozoans	√	√	√
Count at Nauplius Stage	288,000 1,072,138	332,640	423,360
Count at harvest	195,000 530,000	60,000	60,000
Persentage Survival at harvest	67.71 46.64	18.04	14.17

B. Problems in Shrimp Nutrition

The following are of important consideration in the nutrition of shrimp:

1. Determination of an Optimal Feeding Environment. To determine the environmental factors that enhance feeding efficiency , it is necessary to experiment on temperature and salinity requirements, effects of aeration; effective removal of waters/sedimentation, as well as the effects of possible contaminants in the water.

2. The inherent variability in the animal. Differences in growth rates among individual shrimp seem to be greater than those observed in some other animals. This inherent variability makes interpretation of data more difficult especially in the comparison of groups of 10-20 individuals. A mean from this population growth will be markedly affected by the presence of one rapid or one slow growing shrimp. Although attempts have been to made to choose animals of a uniform age and size with a known feeding history, variability is still an important factor to be considered by investigators.

3. The selection of the form of food in its ingredients. Food for shrimp should retain its form and consistency for a number of hours in water. It must also be attractive and available to the stage to which it is presented. The food form whether a flake in the water column or a pellet on the

bottom, should be determined based on the behaviours of a given stage. For example, the tendency of sugpo P_1 - P_5 to spend much of their time in the water column may account the success of live brachionus sp., copepod or brine shrimp nauplii as food. These food organisms are frequently encountered and thus ingested, since they swim actively in the water column.

4. The presentation of the data in a form useful to other investigations and to the commercial mariculturist. Because our data must eventually be of use to the commercial aquaculturist, the use of simple, direct presentation of data is more desirable. For example, growth presented as percent increase either in mean weight or biomass is complicated when comparison between groups of animals of different initial weight is taken for percent increase is inversely related to initial weight. To have simplier data presentation on growth, growth should be taken as a function of time. Thus graphing of the data may be understood better with mean weight on the Y-axis and elapsed time on the x-axis.

CONSIDERATION IN DEVELOPMENT OF "ARTIFICIAL OR SYNTHETIC DIET RATION FOR SUGPO

The food supply for the larval and postlarval stages of sugpo is a challenging problem. In this regard, the encapsulation and pelleted food ration may offer the great possibility of the development of a completely chemically-defined food.

The techniques of micro-encapsulation and pelleting consists of enclosing substrates (single or mixed materials, i.e. squid meat and vitamins and mineral salts) within a develpped binder or wall (starch, gulaman or agar-agar), Selection and combination of a typical binder can control flexibility or permeability of the wall to effect controlled release of the nucleus. This slow leaching of nutrients will attract shrimp and stimulate their feeding response . Density of the capsule or pellet should also be noted. This has something to do with the neutral bouyancy of the fed in sea water or its rapid sinking to the bottom. If these processing techniques will be fully developed it might be the excellent vehicles for the introduction of hormones and other chemical regulatory substances that will influence the behavior and growth of sugpo larvae, post larvae and adults.

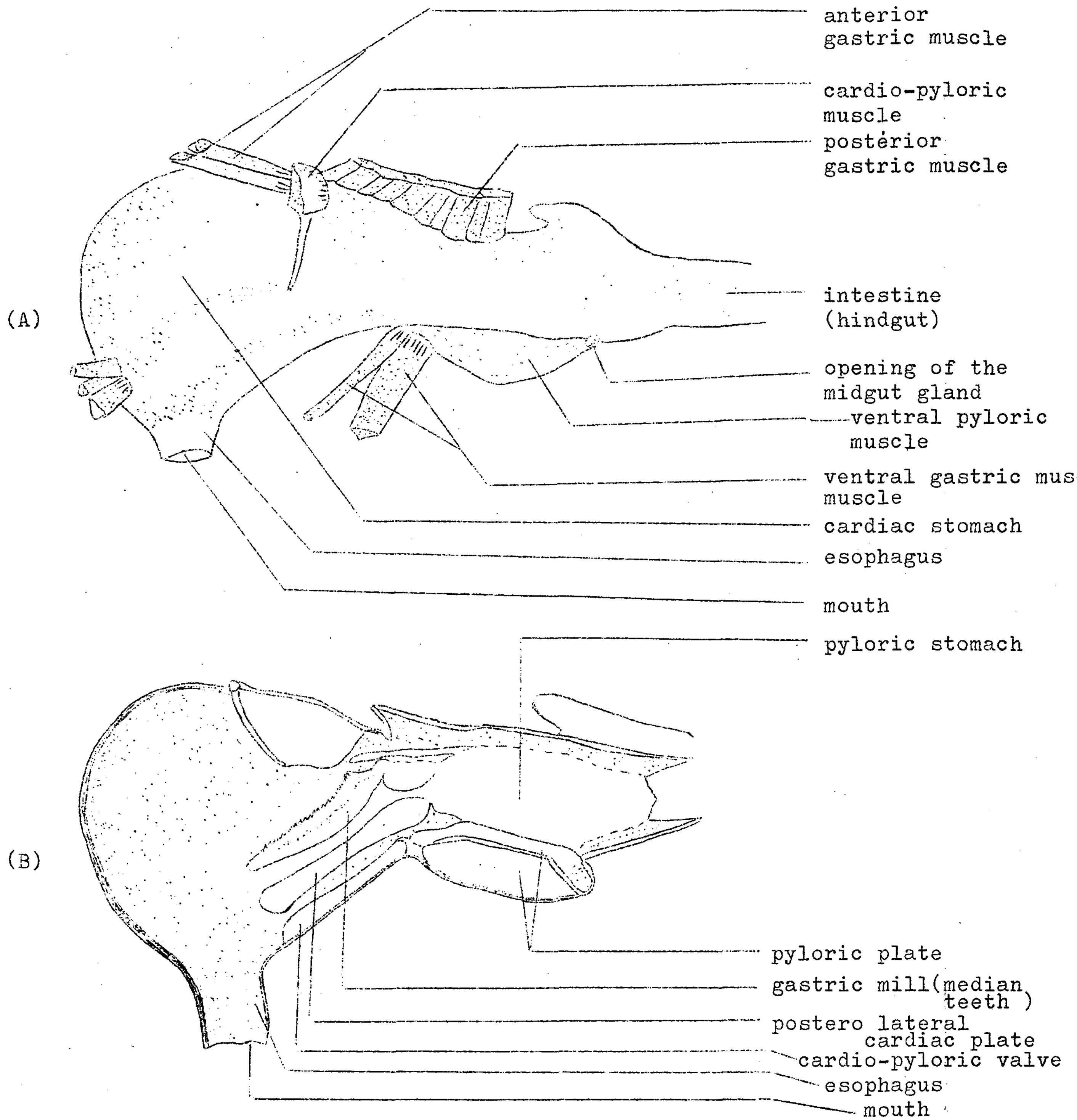


FIGURE 1. Stomach of Penaeus monodon (Fabricius). (A) Lateral View, (B) Sagital section.

Table I

Differences between shrimp and prawn

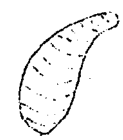
FACTORS	SHRIMP	PRAWN
1. Family	Penaeidae	Palaemonidae
2. Gills	Dendrobranchiate 	phyllobranchiate 
3. Characteristics abdominal pleura of 2nd segment	do not overlap with first abdominal pleura	overlaps with first abdominal pleura
4. Example	Penaeus monodon	Macrobrachium rosenbergii

Table 2. Amino-acid Analysis of Whole - Body of 4 Penaeid Shrimps (Dry Matter), Jan., 1973

(Shigeno)

Species and Locality	*P. merguiensis* (Thailand)		*P. monodon* (Thailand)		*M. monoceros* (Thailand)		*P. japonicus* (Japan, Fished)		*P. japonicus* (Japan, Cultured)	
	AA %	Composition %	AA %	Composition %	AA %	Composition %	AA %	Composition %	AA %	Composition %
Aspartic acid	5.99	11.80	5.47	10.62	5.74	15.25	5.38	11.38	5.03	12.18
Threonine	2.13	4.20	2.09	4.06	1.48	3.93	2.23	4.72	1.81	4.38
Serine	2.18	4.29	2.08	4.04	1.44	3.83	1.87	3.96	1.71	4.14
Glutamic acid	8.39	16.53	8.53	16.56	6.08	16.16	7.71	16.31	6.76	16.37
Proline	1.84	3.62	2.25	4.37	1.28	3.40	1.62	3.43	1.70	4.12
Glycine	2.47	4.87	2.79	5.42	1.73	4.60	2.35	4.97	2.27	5.50
Alanine	2.97	5.85	2.88	5.59	2.09	5.55	2.64	5.58	2.29	5.55
Cystine	0.43	0.85	0.52	1.01	Tr.		0.54	1.14		
Valine	2.79	5.50	2.84	5.51	1.93	5.13	2.84	6.01	2.04	4.94
Methionine	1.37	2.74	1.32	2.56	1.04	2.76	1.28	2.71	0.92	2.23
Isoleucine	2.29	4.51	2.57	4.99	1.86	4.94	2.27	4.80	2.13	5.16
Leucine	3.88	7.64	3.83	7.43	2.86	7.60	3.97	8.40	3.35	8.11
Tyrosine	1.84	3.62	1.97	3.82	1.42	3.77	1.79	3.79	1.57	3.80
Phenylalanine	2.27	4.47	2.41	4.68	1.67	4.44	2.12	4.48	2.05	4.97
Lysine	4.18	8.23	4.00	7.76	2.92	7.76	3.55	7.51	3.03	7.34
Histidine	1.13	2.23	1.23	2.39	0.88	2.34	1.10	2.33	1.04	2.52
NH_3	0.89	1.75	0.93	1.77	0.60	1.59	0.77	1.63	0.67	1.62
Arginine	3.71	7.31	3.83	7.43	2.61	6.95	3.24	6.85	2.91	7.05
	50.77		51.52		37.63		47.27		41.28	

Table 3

Chemical composition of shrimp feeds (Shigeno & Deshimaru (1972)

Feeds	Percentage on dry basis		
	Crude Protein	Fat	Carbohydrate
Squid meal	81.38	9.63	5.33
Shrimp meal	76.05	2.72	5.57
Brine Shrim meal	54.44	4.92	21.48
Marine Yeast	25.63	2.69	63.50
Petroleum Yeast	61.22	2.10	26.24
Fish Meal	70.47	7.69	1.74
Sperm Whale Meal	78.97	3.83	7.36
Fin-back Whale Meal	82.34	3.49	8.82
Soyben-protein	50.39	1.17	41.92
Short-necked clam	84.20	-	-

Table 4

Composition of vitamin mixture used in shrimp feeds (Shigeno, 1972)

Vitamins	mg % in diet
Thiamine -hydrochloride	5
Riboflavin	40
Pyridoxine - hydrochloride	10
Cyanacobalamin	0.01
Nicotinic acid	75
Ca-oantothenate	50
Biotin	1
Inositol	200
Folic Acid	3
Choline chloride	250
p-Aminobenzoic acid	40
Menadione	2.5
Ascorbic acid (Ca-salt	500
Cholesterol	1250