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# Fish nutrition

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# FISH NUTRITION

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## 5 Major nutrients

- Protein
- Carbohydrates
- Fats
- Vitamins
- Minerals



Given its genetical constitution and environment, rapid growth in fish, as in man, is ensured by a balanced diet. In aquaculture, this hinges on proper feed and feeding techniques. The farmer's dilemma therefore is whether to supplement the natural food or to completely control the diet of the fish. Be it a supplemental feed or a complete diet, the feed preferences, feeding habits and nutrient requirements of the cultured fish, and feed development techniques based on basic nutrition concepts have to be known before a feeding scheme can be successful (Item One).

In feed development, one needs to be acquainted with the terms in the feed formulation recipe (Item Two). The ingredients are sourced from both plants and animals (Item Three), and the procedure follows a pre-determined pattern for all feed recipes (Item Four). The resultant feed should be visually appealing to the fish (Items Five & Six).

Feeding techniques are patterned after the feeding behavior of fry (Item Seven) and broodstock (Item Eight). Grow-out feeding techniques are also discussed (Item Nine), as is the mechanism for a successful feeding management (Item Ten).

### Item One: General Information on Feeds and Feeding

#### What to know about fish or shrimp to be able to increase production through proper feeding

1. Biology of the species to be cultured.
2. Nutrient requirements.
3. Feeding habits of the fish, what food it prefers, how it takes in food, what time of the day it eats, what parts of the body are involved in the ingestion of food.
4. Proper pond management.

#### Ways of developing feeds

1. Imitation of natural diets which is possible when stocking density is low.
2. Trial and error with existing cheap diets. This is attractive because development costs may be less.
3. Controlled feeding with nutritionally defined diets. This method appears costly, time-consuming, and likely to lead to many problems. However, it is the best approach. Experience with other animals such as chicken and swine has shown that formulating cheap reliable feed is not possible until the nutrient requirements of the species and the interaction of these nutrients are known for the various life stages.

To achieve increased production through proper feeding, one has to:

- o Study nutritional requirements;
- o Understand the digestive processes;
- o Evaluate feedstuffs;
- o Develop feeds;
- o Determine good feeding techniques or feeding management schemes. Studies can be done simultaneously if human and budgetary resources are available.

To be able to formulate diets, one has to know the proximate analysis of the feedstuffs either by actually performing the chemical analysis or by relying on feed composition tables.

#### Some basic concepts in nutrition

- o Adequate nutrition is essential to good health.
- o Nutrients in the body are in dynamic equilibrium, hence, a deficiency or over supply of one will affect the others.
- o Dietary intake and nutrient needs should be known.
- o Nutrient needs vary because of factors such as age, physical activity, body size, state of health, physiological processes like growth, reproduction, and pathological disorders.
- o Nutrient content of food varies and diet preparations should aim to preserve the nutrient in the natural food.
- o Nutrient requirements are known for some nutrients only and may differ from species to species, thus, requirements and allowances will have to be revised as new knowledge is obtained.
- o A variety of feedstuffs is better than one source.
- o The study of nutrition is interrelated with allied arts and sciences. Nutrition is also an art because there is no single approach to meeting the needs of the animal.

Source: Lecture notes of Dr. Felicitas P. Pascual, Scientist, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

### Item Two: Glossary of Terms in Feed Formulation

Important terms in feed formulation need to be understood as defined hereunder:

**Standard Reference Diet (SRD)** - a precisely defined and reproducible test diet satisfying the nutritional needs of fish for use in feeding studies to facilitate comparisons between various experiments, species, locations, researchers, and other factors.

**Reference Diet (RD)** - a diet with which to compare response to experimental design and dietary treatments.

**Control Diet (CD)** - a negative or positive reference diet used to compare dietary treatment responses. It can be SRD or RD.

**Practical diet** - one that is formulated from natural ingredients such as cereal grains, oil seed meals, fish meals, and meat by-products.

**Purified diet** - a feed made out of refined ingredients with precisely defined composition.

**Semi-purified diet** - contains some natural ingredients in a relatively pure form in combination with purified ingredients. For example, corn oil or cod liver oil may be used as lipid or fat sources in such a semi-purified diet because both are nearly 100% pure fat.

**Balanced diet** - contains nutrients in amounts and proportions that fulfill the physiological needs of animals as specified by recognized authorities in animal nutrition.

**Complete feed** - a nutritionally adequate feed for a specific animal in a specific physiological state. It is compounded to be fed as a sole diet and is capable of maintaining life or promoting production (or both) without the consumption of any additional substance except water.

**Supplemental feed** - a feed used with another to improve nutritive balance or performance.

**Nutrient** - substance which provides nourishment (food). In discussing feeds, this word is often used to refer to dietary components such as lipids, fatty acids, proteins, amino acids, carbohydrates, vitamins and minerals.

**Isocaloric** - having the same calorie or energy level.

**Isonitrogenous** - having the same protein level.

**Isolipidic** - having the same lipid level.

**Casein** - the protein precipitate that results from treating skim milk with acid or rennet.

**Gelatin** - animal protein obtained by boiling skin, tendons, ligaments and bones with water.

**Zein** - protein present in corn. It is extracted from gluten meal.

Source: Lecture notes of Ilda G. Borlongan, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

### Item Three: Feed Sources Based on Nutrient Content

**Animal protein sources.** Proteins may come from animal or plant sources. Feedstuffs of animal origin have high protein content ranging from 34 to 82%. Proteins from animal sources contribute a mixture of amino acids different from that of proteins from plant sources. Some examples of animal protein sources are: (1) fish meal - most common protein source; (2) trash fish - no fixed nutrient composition due to variation in the types of fish it includes; (3) shrimp meal - excellent source; (4) squid meal - excellent source but expensive; (5) mussel meal - contains growth-promoting factors and attractants; (6) poultry by-products; (7) milk and milk by-products - essential amino acid content is close to chicken egg protein, the "ideal food;" (8) meat and bone meal; and (9) toad or frog meat.

**Plant protein sources.** The common plant protein sources are legumes and oil-bearing seeds. Legumes are potentially valuable as aquaculture feed source in the tropics because of their abundance. Their leaves are also rich in protein and minerals.

Oil-bearing seeds and oil cakes which are by-products of the vegetable and oil industry are also plant protein sources. They are high in protein and low in carbohydrate. Terms used with these types of feedstuffs are cake or oilcake and meal or oil meal. Some examples of plant sources are: (1) soybean meal - high protein, potential partial replacement of fish meal; (2) peanut meal - subject to aflatoxin contamination; (3) sunflower meal - has no known toxins; (4) cottonseed meal; (5) copra meal - lower protein compared with other plant sources; (6) sesame; (7) safflower; (8) castor oil meal; (9) linseed oil meal; and (10) corn gluten meal.

**Non-conventional protein sources.** There are sources that can be used for fish and shrimp feed formulations but are not yet fully utilized at present. These are called non-conventional protein sources. Some of these sources are: (1) SCP - algae, fungi (yeasts) and bacteria; (2) algae (*Skeletonema*, *Chaetoceros*, *Scenedesmus*, *Chlorella*, *Spirulina*) - may be too expensive as feedstuff; (3) seaweeds - good sources of trace minerals and Vitamin A; (4) *Ipil-ipil* leaf meal - low digestibility and contains toxic mimosine, thus level of incorporation is limited; (5) earthworm meal - should be dried to inactivate toxin; (6) snails - should be cooked and dried; (7) krill; (8) silkworm pupae; and (9) fly larvae.

**Lipid or fat sources.** Lipid or fat sources may also come from animals or plants. Some terms associated with this nutrient group are animal tallows, lards, and oils. Some examples of lipid sources are: (1) animal sources - cod liver oil, squid oil, other fish liver oils, beef tallow; and (2) plant sources - soybean oil, sunflower oil, peanut oil, corn oil, and linseed oil.

**Carbohydrate sources.** Carbohydrates include starches, sugars, and celluloses and are usually the cheapest source of energy for fish and shrimp. Starch content helps to increase the water stability of the feed especially when heating is included in the processing. Carbohydrates may come from cereals or rootcrops. Cereals are important components in aquaculture diets despite their high carbohydrate content. They are the cheapest raw material and are sources of B vitamins (bran). Rootcrops

are also excellent sources of energy, being rich in carbohydrate. Their value as ingredients for aquaculture feeds is limited because of their use as human food. Besides, most aquatic species cannot digest carbohydrate well. Examples of good carbohydrate sources are: (1) cereal grains and by-products, rice bran and other rice by-products, corn, barley, millet, wheat, rye, oats, sorghum; and (2) roots and tubers - potato starch, cassava starch, sago palm starch.

**Vitamin and mineral sources.** Vitamins and minerals are required in trace amounts for normal growth, reproduction, health, and general metabolism. Deficiency symptoms usually occur in intensive system where natural food is not sufficient. Major natural sources of vitamins are as follows: fish oils, vegetable oils, leaf meals, brans, yeasts, milk and milk products, soybean, cereals, citrus fruits, wheat germ, liver, fish meal and viscera, slaughterhouse wastes, fresh fish tissue, insects, and animal offal.

Source: Lecture notes of Veronica D. Peñaflorida, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

#### **Item Four: Criteria in Selecting Aquaculture Feeds**

Considering the nutritional requirements of prawns, the feed should meet the following criteria:

1. It should be made cheap enough, yet meet the nutritional needs for prawn growth at various stages.
2. It should contain the necessary components that will make it an attractive food for the prawn.
3. It should be made in suitable size and form that can be easily consumed by the prawn at various growth stages.
4. It should have the necessary water stability and should not disintegrate before it is consumed by the prawn; otherwise, it can contribute to the pollution of the pond water.
5. It can be manufactured at acceptable processing cost and necessary skills.
6. It should have a satisfactory shelf-life to avoid undue loss in nutritional value, and reduction of pellet integrity and general quality under simple packing, normal storage, and handling.

#### **Manufacture of feed**

The manufacture of the regular type or grade of prawn feed involves the following basic steps:

1. Grinding and reducing to uniform size the various feed components.
2. Screening and grading of the components to obtain uniform particle size.
3. Formulation (usually on weight basis) of the ground and screened feed components.
4. Batch mixing of the formulation.

5. Conditioning of the meal with the introduction of suitable dosing liquids to improve pellet quality.
6. Pelleting or extrusion of the conditioned meal.
7. Pellet cooling and cleaning.
8. Pellet crumbling, if necessary, to attain the desired feed size not attainable by pelleting.
9. Screening and sizing of pellets to eliminate the crumbles.
10. Special feed screening, if necessary, such as by coating, glazing, etc. to improve the quality, physical structure and strength of the feed pellets.
11. Feed packing (expiry date essential).
12. Feed storage which should not exceed the period necessary for the projected feed quality/stability. (See "Feed Handling in Aquaculture," *Aqua Farm News*, Vol. VII, No. 1, January-February 1989.)

Certain variations in the foregoing manufacturing process may be considered, depending on the conditions of the feed components as received or are made available at the feed mill. Some manufacturers may find it better to purchase their feed components semi-processed or finished. Some plants may be equipped to handle feed components in very raw form such as the more expensive feed components, the protein-rich materials like fish meal, shrimp or squid meals, etc. It may be more economical if these components were to come from locally available raw materials instead of buying such materials from outside sources. (See "How to Prepare Prawn Diets," *Aqua Farm News*, Vol. V, No. 10, November-December 1987.)

Source: "Feed Milling Process and Equipment" by Engr. Felix F. Bermejo, guest lecturer, Fish Nutrition Course of the Training Division, SEAFDEC/AQD.

#### **Item Five: Physical Characteristics of a Feed**

Aside from the statement of the major nutrients present in a feed-stuff or feed, information is also required on the physical characteristics of the product including color, texture, odor, particle size, pelletability, bulk density, water stability, and attractability.

**Water stability.** One physical property that is necessary in a feed is its water stability. A water-stable diet provides maximum available food to the fish and minimum leaching out of vitamins and other nutrients.

Poor water stability can also impair water quality. Crustaceans such as shrimps, lobsters and crabs grasp their food with the chelae, carry it to the mouth, and tear it into smaller fragments before swallowing. They need relatively more stable pellets than do the finfish. Thus, binders and processing techniques like steaming and extrusion are done to ensure water stability.

Water stability tests are usually done on pellets intended for slow feeders. One gross way of determining the stability of the pellet in the water is by crumbling it or by just feeling the rough edge of the pellet.

**Particle size.** Pellets with ingredients that are not finely or uniformly ground tend to be less stable than pellets with uniformly ground ingredients. Hence, ingredients should be finely ground and sieved to uniform particle size before incorporation in the diet.

The size and shape of feeds should be designed to accommodate and conform to the anatomical organs of the crop animal for seizing, engulfing, or ingesting food. Food particle size in particular is an important parameter in the feeding of cultured species whose mouthparts vary greatly.

**Texture.** Also an important aspect of a diet is texture - hard, soft, moist, dry, rough, or smooth. Some species appear to avoid hard pellets. Those that tear their food may have to be provided with feed of a texture different from that given to those species that swallow or nibble off small pieces of the food.

**Color.** Various species of aquatic animals are able to see colors. Color contrast between the feed and the culture tank may provide greater ease for the fish to capture their food.

**Density.** As ground feed ingredients are received in the feed mill, bulk density measurement can be done to check on the amount of adulterants present. Bulk density of the ingredient sample should be determined and compared with the bulk density of pure feedstuffs. If contaminants or adulterants are present, bulk density will change. It is a good practice to go back to the sample for closer look by paying particular attention to adulterants. In general, adulterants are ground extra fine to escape detection.

**Pelletability.** Depending on their nature, feed ingredients may be of low, medium, or high pelletability. Usually, the finer the particle size, the higher is the pelletability of the ingredient.

**Attractability.** Both attractability and palatability are critical factors in formulation of diets. An otherwise nutritionally balanced diet may be less effective or marginal in performance due to the absence or minimal concentration of ingredients that stimulate gustatory response in the species. The practical importance of feed attractants and diet palatability is particularly critical during the weaning of marine fish larvae from natural food to artificial diet. In addition, attractants or feed stimulants can reduce the period of time the feed remains uneaten in the water, thus minimizing leaching of nutrients.

Source: Lecture notes of Ilda G. Borlongan, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

#### **Item Six: Visual Stimuli of Food**

The stimuli that food provides and to which fish responds include size, movement, shape, color, and contrast of the food particle.

**Size.** For fish heavily dependent on vision for location and identification of food, there are upper and lower limits to the size of food items they would respond to positively. The lower limit often depends on visual ability and the upper limit depends on better identification of the



item as food. Often there is a specific size range that evolves a positive response. The size range is inherent in the ability of the fish to capture and ingest the food.

**Movement.** Movement is important in the identification of food items. Water does not transmit light as effectively as air does; hence, underwater vision can be greatly impaired. It is only at closer distance when vision becomes accurate that the perception of movement helps in the identification of a food item. For some species, movement is an essential stimulus, while in others only stationary food items are attacked. Some fish react only to fast moving objects while others to slow or intermediate ones. The type of motion is also important. Certain species respond to oscillatory movement, while others to rotatory motion. In goldfish, a unidirectional motion is a powerful stimulus.

**Shape.** Most fishes are capable of identifying a wide range of shapes. In the piranha, this ability is important in recognizing a potential food item versus another of the same species. Piranhas have egg-shaped bodies and often will attack only other fishes which do not have this characteristic shape.

**Color and contrast.** Identification of food items is enhanced further by color and contrast. Laboratory tests show that fish approaches objects of specific colors. For example, a type of bass is attracted to red and yellow but not to black. The rainbow trout is attracted to blue but not to green.

Where food items are largely of dull colors, contrast becomes important in identification. Fishes are far more effective in identifying high contrast as opposed to low contrast in food items. For planktonic food organisms, those that are highly transparent (low contrast) are often not eaten. Those that are darkly pigmented and less transparent are preferred to a greater degree.

### **Feeding process**

After identification of the food item, feeding is completed after a three-stage process of approach, pursuit, and attack. The feeding process in larval fish is far easier to document and record. The attack position is characterized by a specific body conformation termed the S-strike position.

Source: Lecture notes of Ilda G. Borlongan, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

## **Item Seven: Food and Feeding Behavior of Selected Cultured Species**

### **Finfishes**

1. Snappers (*Lutjanus sanguines* and *Lutjanus sebae*) are demersal. They feed on almost all kinds of organisms inhabiting the bottom. Stomach contents are mostly made up of fish, crabs, stomatopods, molluscs, and other crustaceans.

2. Sea bass (*Lates calcarifer*) and groupers (*Epinephelus* spp.) are piscivores. Specially during the juvenile phase, cannibalistic tendencies are observed under culture conditions.

3. Siganids (**Siganus** spp.) are herbivorous in their natural habitat but they readily become omnivorous under culture conditions, eating a wide variety of items, e.g., trash fish, pellets, rice bran, **lumut**, **lablab**, and other vegetable matters.

4. Common carp (**Aristichthys**) is a benthic feeder whereas silver, big-head and Indian carps are planktivores.

5. Mulletts (**Mugil cephalus**) subsist largely on organic matter and small algal cells. They possess a very long intestine and a gizzard-like stomach to grind ingested items.

6. The adult milkfish (**Chanos chanos**) are pelagic swimmers with small toothless mouth. They feed mostly on planktonic algae, although they are said to frequent coastal areas to feed on benthic algae in addition to their plankton diet. Juvenile milkfish are found in swamps, lagoons, and estuaries. At this stage, they become benthic filter feeders with detritus forming the bulk of their diet. Milkfish fry feed mostly on zooplankton and resuspended bottom materials. Milkfish fry seem to be tolerant of food deprivation and may be stocked for several days in basins with minimal feeding.

### Shrimps

After hatching, shrimp nauplii do not feed but rely only on yolk for energy requirements. Upon molting into the zoea stage, the mouth and anus become functional, and they begin to feed on plankton such as **Skeletonema**, **Nitzschia**, marine yeasts, green algae, or fertilized eggs and larvae of oysters. At this stage, shrimp larvae feed only in the water column. They are also photosensitive, thus light attraction could be employed for nighttime feeding.

From the mysis up to the early postlarval stages, the food preference shifts to bigger organisms like rotifers, copepods, and **Artemia**. From PL 5, shrimps become benthic and start to feed on bivalves or smaller shrimps. Under culture conditions, they may also eat trash fish or egg custard. Juvenile shrimps prefer small crabs and other shrimps, molluscs, fish, polychaetes, and ophiuroids. Sand and silt are also found in the stomach although these may only be accidentally ingested.

Adult shrimps usually live in shallow waters (up to 200 m). They feed mostly on slow-moving benthic macroinvertebrates. They are considered omnivores with 85% of their diet made up of small crabs and shrimps and 15% with fish, polychaetes, ophiuroids, debris, and some algal matter. When feeding, they hold the food particle with their pincers, bring this to the mouth, and slowly nibble it.

The feeding behavior of shrimps are affected by other factors. At certain stages in their molt cycle, shrimps do not feed actively. Eye ablation causes increased feeding activity of the shrimp. Being nocturnal in nature, shrimps feed actively at night, although they may also feed during daytime. Feeding is also more active during ebb tide when small crustaceans come out from their hiding places to feed on nutrient matters drawn by the outgoing tide. It appears that there is a seasonal variation in the feeding activity of shrimps; however, this remains to be verified.

Source: Lecture notes of Monina M. Parazo, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

**Item Eight: Prawn Broodstock Feeds and Feeding**

**Natural food.** Prawn broodstock should be fed a variety of live or fresh food including marine annelids (*Nereis* sp.), squid, brown mussel (*Modiolus metcalfei*), and other molluscs. A composite diet is better than a single-item diet. These food items are recommended because they are rich in polyunsaturated fatty acids which are predominantly found in mature ovaries and testes of penaeids, suggesting their role in reproduction.

Although ideal for penaeid maturation, it may be impractical to feed live food items if the amounts required are great. One alternative is to procure the food live and store it in a freezer at  $-8^{\circ}\text{C}$  or lower, and the amount needed each day should be thawed.

**Feeding regimes.** The standard feeding regime for *P. monodon* broodstock used at SEAFDEC/AQD consists of a mix diet (fresh food + pellet). Food is distributed twice a day. Fresh or frozen food is given alternately at 8-9 A.M. at 10-20% (wet weight) of biomass and pellets at 4-5 P.M. at 2-3% (dry weight) of biomass.

Before feeding, brown mussel meat is removed from the shell and squid is chopped into small pieces. Marine annelids are preferably fed while in the fresh state. Natural food is fed by broadcasting inside the maturation tank. Artificial diets in the form of sinking pellets 3-10 x 3 mm are provided by the use of feeding trays.

Tables below show some nutrient sources and feeding regimes.

**Nutrient sources for prawn broodstock diet**

<u>Protein</u>	<u>Lipid</u>	<u>Carbohydrate</u>
Fish meal	Cod liver oil	Wheat flour
Squid meal	Squid oil	Wheat gluten
Prawn head meal	Pollack liver oil	Sago palm starch
Alamang ( <i>Aschetes indicus</i> )	Soybean oil	Corn starch
Mussel meat	Corn oil	Gelatin
Marine yeast		Rice bran
<i>Artemia</i> biomass		

**Feeding regimes for prawn broodstock**

<u>DAY</u>	<u>A.M.</u>	<u>P.M.</u>
1	Squid	pellet
2	Brown mussel	"
3	Marine annelids	"
4	Squid	"
5	Brown mussel	"
6	Marine annelids	"

**Pelleted diet.** Artificial diets are necessary since live or frozen food may not provide the large quantities required by broodstock. Studies on pond-reared *P. monodon* broodstock have shown that reproduction performance was markedly improved when feeding was with a mix diet (natural food + pellet). Most of the females that were given natural food alone resorbed their ovaries and failed to spawn.

**Diet formulation.** Protein sources are chosen from among the following locally available feedstuffs that closely approximate the amino acid profile of *P. monodon* spawner: squid meal, brine shrimp, marine yeasts, and fish meal. Results are excellent with squid meal.

Another group of protein-rich feedstuffs which can be considered for use in prawn rations is that of single-cell proteins like yeasts and algae. The brine shrimp, *Artemia*, is reported to be a source of hormones needed for shrimp maturation.

Practical diets for *P. monodon* broodstock have already been developed and these can be used with reasonable degree of assurance. However, additional information is still needed for a more effective broodstock diet.

Source: Lecture notes of Oseni M. Millamena, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

## Item Nine: Feeding Strategies and Pond Fertilization

### Feeding strategies

There are four feeding strategies for grow-out: (1) no fertilization, (2) fertilization, (3) supplementary feeding, and (4) complete diet feeding.

**No fertilizer or feed input.** Fish are totally dependent for their food on the live food organisms and plants present in the water. Growth of these organisms is in turn dependent on the natural fertility of the water and soil. This feeding strategy is practiced in extensive culture system with low stocking density.

**Fertilization.** Chemical and organic fertilizers are applied to increase production of live food organisms and plants. Fertilizer use is typical of extensive and semi-intensive farming systems.

**Supplementary feeding.** This is added when natural productivity of the water resulting from fertilization cannot adequately maintain maximum growth of the cultured fish at high stocking density. Dietary requirement of the fish is supplied by a combination of natural live food organisms and supplemental diets. Higher stocking density and production are attained with this practice which is typical of a semi-intensive farming system.

**Complete diet feeding.** This involves the external provision of a nutritionally complete, high-quality diet. Complete diets may consist of a single food item of high nutrient value (e.g., trash fish, *Artemia* nauplii), or a combination of different feed ingredients. Dietary requirement of cultured fish is totally supplied by the diet, typical of an intensive culture system.

### Pond fertilization

The natural productivity of a body of water can be increased by chemical and organic fertilization.

**Chemical fertilization.** Chemical fertilizers directly stimulate phytoplankton production. They also indirectly increase the production of grazing zooplankton and benthic organisms since these organisms can ingest primary producers.

**Method and frequency of application.** To ensure the uptake of mineral nutrients by phytoplankton in all parts of the pond, and to prevent nutrient loss by precipitation or release into the atmosphere, fertilizers should be distributed in the water as evenly as possible. Granular and powdered phosphate fertilizers, when allowed to come in direct contact with the pond bottom, are rapidly adsorbed by the soil particles. To overcome this, phosphate fertilizers should either be dissolved in water prior to distribution or placed in floating perforated cannisters, or perforated sacks suspended on underwater platforms. For maintenance of the pond's primary productivity, fertilizers should be applied preferably at weekly or bi-weekly intervals throughout the culture cycle. The residual effect of an applied fertilizer dosage lasts only for two to four weeks depending on the water management employed.

**Organic fertilization.** The most common fertilizers used are animal or farmyard manures (chicken, pig or cow dung, etc., with or without urine and bedding material). Readily available and inexpensive manures represent a nutrient-packed resource containing sizeable amounts of the nitrogen as well as phosphorus originally fed to the animal. However, the nutrient composition of animal manure is highly variable depending on the diet, age, and species of the animal, the type and proportion of bedding material present, and the handling and treatment of the manure prior to usage.

**Effect on pond productivity and fish production.** Organic fertilizers supply organic matter and detritus to the pond ecosystem. The manure serves as a substrate for the growth of bacteria and protozoa, which in turn serve as food for zooplankton and even for the cultured fish. The smaller the particles of organic matter, the faster is the colonization and decomposition by bacteria and protozoa. Intense organic and chemical fertilization of aquaculture ponds has resulted in fish and shrimp yield as high as 5-10 tons per hectare per year or 15-32 kg per hectare per day with no supplementary feeding.

**Manuring through straight manual application.** The major limitation in the amount of manure that can be used is its effect on oxygen concentration. The decomposition of organic matter by bacteria uses large amounts of oxygen. Thus manure should be applied to the ponds during mid-morning when oxygen levels are rising rapidly due to photosynthesis. Since the dietary food requirement of the fish biomass increases with the standing crop, the amount of manure should also increase until it reaches the maximum which may be safely added. Chicken manure added daily at 2-4% of biomass (dry organic matter) is adequate. In all cases, daily manure added to the pond should not exceed 75-100 kg dry organic matter content per hectare regardless of fish biomass.

**Manuring through composting and fermentation.** Composting and fermentation speed up the natural decomposition process and reduce the time lag between fertilizer applications. Such processes also increase the value of agricultural wastes (coffee pulp, sugar cane waste, rice straw,

palm oil waste), facilitate the destruction of potentially hazardous pathogens and parasites which may be present in the raw waste material, reduce the bulk weight of the original waste material, and also reduce the oxygen demand of the stabilized waste when applied to the water.

Source: Lecture notes of Neila S. Sumagaysay, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

### **Item Ten: Keeping Records**

Accurate records will enable a fish farmer to assess feeding efficiency in relation to the previous growing cycle in different ponds. Records are the key to obtaining highest production at minimum cost.

#### **Feed record**

All feeds bought-in should be identified. A file index for each batch of feed delivered must bear the following information: (1) date delivered, (2) manufacturer's name, (3) product name, (4) batch number of bags, (5) amount delivered, (6) cost per unit weight, and (7) notes (any special notes on condition of feed upon receipt, etc.).

For feed made on farm site, the following should be recorded: (1) formulation used in feed manufacture with its own reference number, (2) the feed formulation number, date and time made, name of foreman responsible for manufacture, and source of ingredient used (compound feed containers should be clearly labelled with the feed number and batch date), and (3) changes of ingredient prices for calculating the cost of feeds at certain dates.

Ideally, information on the chemical analysis of each batch of ingredients and feeds made must also be maintained.

#### **General management record**

The following are some of the important parameters needed before the effects of a feeding program can be judged: (1) pond or cage or tank number, (2) water exchange rate, (3) salinity records, (4) water temperature data, (5) dissolved oxygen data, (6) weather conditions during growing cycle, (7) species stocked, (8) source of stock, (9) date(s) stocked, (10) number(s) stocked, (11) size of animal stocked, (12) any special results (e.g., pump failure, predation, mortalities, pond overflow), and (13) date, type and amount of chemicals used.

#### **Feeding records**

The following details which are mainly related to feeding practices must be recorded: (1) type of fertilizer used, (2) quality of fertilizer applied, (3) date of fertilizer application, (4) type of feed(s) used, (5) date(s) each feed type given, (6) feeding frequency, (7) feeding time, (8) feeding rate, (9) growth rate, (10) survival rate, (11) quantity harvested, (12) average weight of animals, (13) size distribution of harvested animals, and (14) any special event.

These records will determine the efficiency of a feeding program and will interpret for the fish farmer his success or failure.

Source: Lecture notes of Neila S. Sumagaysay, Research Associate, SEAFDEC Aquaculture Department, Tigbauan, Iloilo.

**SEAFDEC/AQD 1990 TRAINING COURSES**  
(Tentative Schedule)

Courses <sup>a/</sup>	Dates <sup>b/</sup>	Training Fee <sup>c/</sup>
FISH HEALTH MANAGEMENT	21 Feb - 27 Mar	₱ 5,900
AQUACULTURE MANAGEMENT	18 Apr - 23 May	5,500
PRAWN HATCHERY & NURSERY OPERATIONS	08 May - 27 Jun	8,350
HATCHERY/NURSERY OF MARINE FINFISHES	29 Aug - 18 Oct	8,350
FISH NUTRITION	13 Jun - 01 Aug	7,700
	03 Oct - 13 Nov	6,900

a/ A course session may be cancelled due to lack of qualified applicants.

b/ Allow another 5 days for post-training tour (optional).

c/ Basic training fee covers lodging (electricity and amenities billed separately; extended stay requires additional lodging fee) at SEAFDEC stations, cost of registration, training materials, field trips, honoraria for resource persons, accident insurance and medical consultation. Other fees include a refundable breakage fee of P500 (for training courses with laboratory practicum). Average cafeteria meals cost P20-35. All fees must be paid in full on or before the start of the training course, otherwise admission will be cancelled. Payment should be made in demand draft, manager's check, cashier's check, or telegraphic transfer payable to SEAFDEC Aquaculture Department, or in cash.

For requests for application forms and further information, please contact: Training Division, SEAFDEC Aquaculture Department, P.O. Box 256, Iloilo City.

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