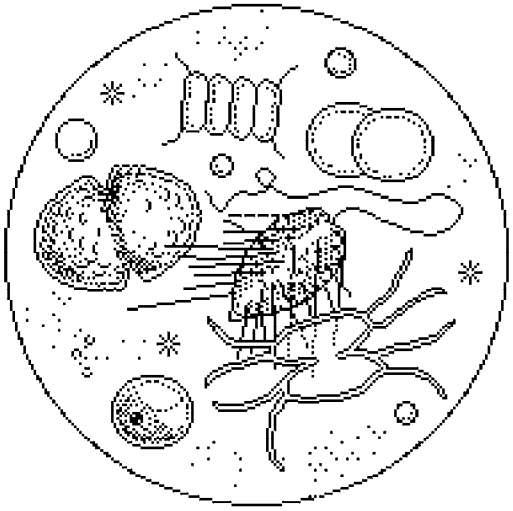
WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

FEEDING YOUR FISH

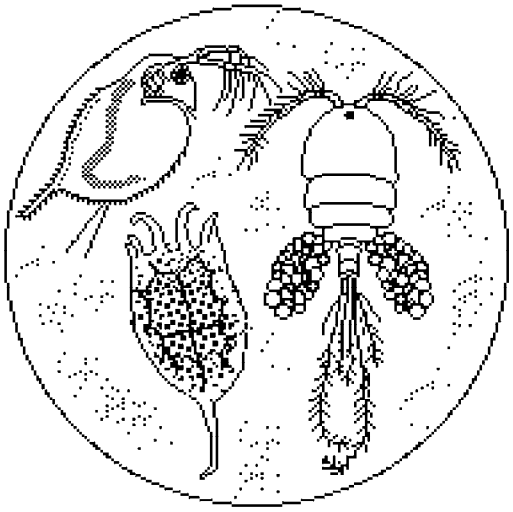
INTERNATIONAL CENTER FOR AQUACULTURE
AND AQUATIC ENVIRONMENTS
AUBURN UNIVERSITY

INTRODUCTION

Fish grow fast and stay healthy if they have enough nutritious food to eat. Living organisms are natural fish foods and are produced in the water where the fish live. Phytoplankton (microscopic plants), zooplankton (microscopic animals), insects and certain other plants are all examples of natural foods (Figure 1). Fertilization increases their abundance.



Phytoplankton



Zooplankton

Figure 1: Natural fish foods can supply the complete nutritional requirements for fish.

When natural foods are not available in sufficient quantity to provide adequate nutrition for fish growth, feeds that are manufactured or grown outside of the fish pond may be fed at regular intervals (daily, weekly, etc.). These feeds supplement natural foods. They are not nutritionally complete, and will not adequately support fish growth in the absence of natural foods. Natural food organisms in the water will provide essential nutrients. Some examples of supplementary fish feeds are commercially produced rations for chickens and pigs, rice bran, manioc leaves, kitchen refuse, oil seed cakes, or other agricultural products and by-products.

In the absence of natural foods, nutritionally complete manufactured feeds that contain all essential nutrients and vitamins must be fed to fish. These feeds are used in high technology, intensive culture systems that are normally inappropriate for rural development applications and will not be discussed here.

PREPARATION OF SUPPLEMENTARY FEEDS FOR FISH

Manufactured supplementary fish feeds may be available in some developing countries. The local economy determines if it is profitable to use them. Other less costly feeds may be used by farmers. Table 1 provides a list of supplementary feed ingredients that can be used alone or in combination. Several guidelines for using items listed in Table 1 should be followed (Figure 2).

1) Use ground ingredients when possible. Leaf meals should be sun or oven-dried before grinding.
2) Measured ingredients should be mixed thoroughly in desired proportions.
3) Dry rations, such as rice bran, ground corn and leaf meals, may be stored in a cool, dry place for several weeks. Portions may be taken as needed to feed fish.
4) Moist rations are prepared daily by adding about 350 ml of water per kg of ingredients to form a dough-like mixture. This ration may be stored in plastic bags or containers and divided for morning and afternoon feedings. The mix is broken apart and small pieces are dropped into the water for the fish.

Figure 2: Grinding and storing feed ingredients.

Table 1: Ingredients that can be used as supplemental feeds, their percent crude protein content and expected conversion ratio of feed to fish.

Ingredient	Percent Dry Matter	Percent Crude Protein	Conversion Ratio
Agricultural By-Products			
coconut, (copra) meal	91	21	-
coffee pulp meal	87	12	46
cotton seed meal	91	41	4
dehydrated sugarcane molasses	94	10	-
dried, salted fish waste	-	36	-
dry poultry manure with litter	89	22	-
fresh blood (coagulated)	-	12	-
fresh livestock offal	-	12	6
rice bran	91	10	5
wheat bran	89	15	5
Animal Meal			
blood meal	92	80	2
crab meal	92	-	-
ground fish meal	92	65	2
Commercial Feeds			
chicken starter feed	-	25	4
Fresh Leaves			
banana leaves	-	-	25
cassava leaves	-	6	15
cocoyam leaves	-	2	20
sweet potato leaves	-	2	20
Oil Seed Cake			
palm kernel press cake	-	19	8
On-Farm Products			
alfalfa leaf meal	92	17	-
cassava flour	88	2	18
cocoyam meal	-	3	-
crushed beans and field peas	-	24	2
dry roasted soybean seeds	90	48	-
fresh termites	-	15	7
green banana/plantain meal	-	6	-
ground dried potato	91	8	-
ground corn	88	9	5
ground millet	90	12	5
ground paddy rice	89	8	-
ground sorghum	88	11	5
Lucaena leaf meal	92	27	-
peanut meal extract	93	48	5
soybean meal cake	90	45	4
sweet potato meal	-	1	-
wheat flour (white)	88	12	7
yellow yam meal	-	3	-
Yeast			
brewers waste (dry)	93	44	10

The conversion ratio in Table 1 represents the dry weight of feed needed to produce one unit wet weight of fish. A low conversion ratio means that fish will convert the feed into flesh more efficiently. High ratios indicate less efficient conversion. For example: it takes about 4 to 6 kg of ground corn, but 10 to 20 kg of fresh cassava leaves to produce 1 kg of fish flesh.

CHOOSING FEEDSTUFFS

Single feed ingredients may be fed to fish to supplement available natural food in a pond. Better quality supplemental feed may be made by combining ingredients. Fish should grow well on a feed containing 20 to 30% crude protein, of which 7 to 10 % of the protein is from animal sources. When natural food is abundant and fish are stocked at low densities, a 20 to 25% protein content is suitable. A 30% or higher crude protein content is more suitable for commercial operations where fish are stocked at higher densities.

Choose ingredients from Table 1 when preparing a supplemental feed, so that a feed mixture having the desired crude protein content is obtained. Inquire from poultry and livestock dealers and farmers what ingredients are locally available. Two simple methods can be used to determine how much of a selected ingredient should be used for making a fish feed with a desired crude protein content. The trial and error and Pearson's square methods are described below.

Method 1: Trial and error method

1) Choose a combination of ingredients from Table 1 that will provide a feed containing 25 to 30% crude protein.

Ingredient	Amount of Ingredient (kg)		% Crude Protein		Crude Protein In Feed (kg)
rice bran	47	X	10	=	4.7
copra meal	10	X	21	=	2.1
Lucaena leaf meal	7	X	27	=	1.9
soybean oil meal	28	X	45	=	13.4
fish meal	8	X	65	=	5.2
Totals	100				27.3

This feed would contain 27.3 kg of crude protein if 100 kg of the listed ingredients were combined as indicated. This would make a feed containing approximately 27 % crude protein by weight since (27.3 kg / 100) x 100 kg = 27.3 % protein content.

Method 2: Pearson's Square

This method may be used for two or more feed ingredients and is preferable to the trial and error method. Examples of feed formulations with two and more ingredients are shown.

Example 1: - two ingredients

Find the proportions of rice bran and fish meal required to make a feed containing 30 % crude protein.

1) Draw a square (See diagram on the following page).

2) Place the desired protein level at the center of the square. In this case, 30 %.

3) Place the two ingredients on the two left corners of the square along with the protein content of each.

4) Calculate the difference in crude protein content of the two ingredients (65 and 11) and record this number (54) near the lower left corner of the square.

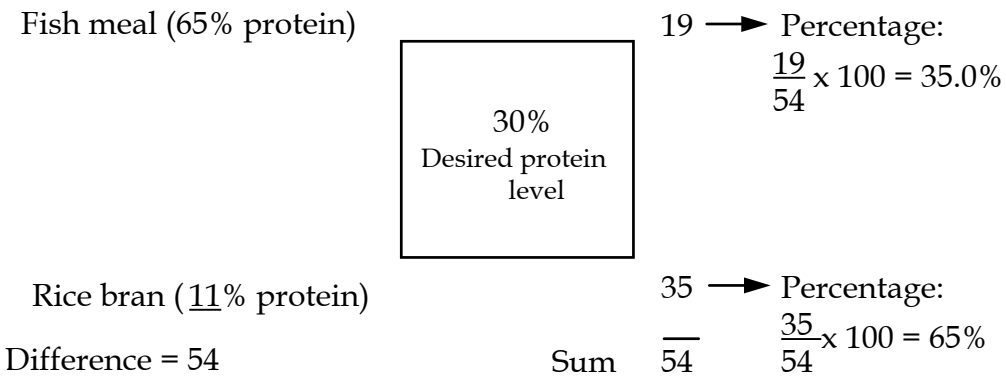
5) Subtract the desired protein level (30 %) of the feed from the protein content of each ingredient and place the answer in the corner diagonally opposite from each ingredient. Ignore positive or negative signs. The difference between percentages of protein in rice bran and in the feed (19) represents the amount of fish meal needed. The difference between fish meal and the feed (35) represents the amount of rice bran needed.

6) Add the differences obtained at the right corners of the square (19 and 35) and record their sum (54) near the bottom right corner. The sum in the right corner should equal the difference in crude protein content recorded near the lower left corner of the square.

7) Divide the sum obtained in step 6, which was 54, into each difference obtained in step 6, which were 19 and 35. Then multiply each by 100 to obtain the percentage of each ingredient needed for the feed.

Thus, 35 kg of fish meal and 65 kg of rice bran are combined to make 100 kg of fish feed containing 30% crude protein. The feed can also be described as being composed of 35% fish meal and 65% rice bran.

Pearson's Square 1



Example 2: - three or more ingredients

In this example, find the proportions of soybean meal cake, fish meal, ground corn and cassava flour needed to make a fish feed with a 30% crude protein content.

1) Draw a square and place the desired protein level (30%) at the center of the square. (See diagram on the following page).

2) Group the ingredients into energy sources (crude protein less than 20%) and protein supplements (crude protein greater than 20%).

3) Calculate an average for the crude protein (CP) contents of each group of ingredients (Table 1).

Protein supplements:	Fish meal		65 % CP
		=	
	Soybean meal cake		45 % CP
		=	
	Total		110 % CP
		=	
	Average: 110 ÷ 2		55 % CP
		=	
Energy Sources:	Ground corn		9 % CP
		=	

Cassava flour		2 % CP
	=	
Total		11 % CP
	=	
Average: 11 ÷ 2		5.5 % CP
	=	

4) Place the averages obtained above at the left corners of the square.

5) Calculate the difference in crude protein content between the protein supplements and energy sources and record this near the lower left corner of the square. The answer in this case is 49.5.

6) Subtract the desired protein level (30 %) of the feed from the combined protein content of the protein supplements and energy sources and place the difference in the opposite diagonal corners. Ignore positive or negative signs. Results are 25 and 24.5, respectively for the protein supplements and energy sources.

7) Add these differences and record the sum near the lower right corner of the square. In this case, the answer is 49.5 on the left side and 49.5 on the right side.

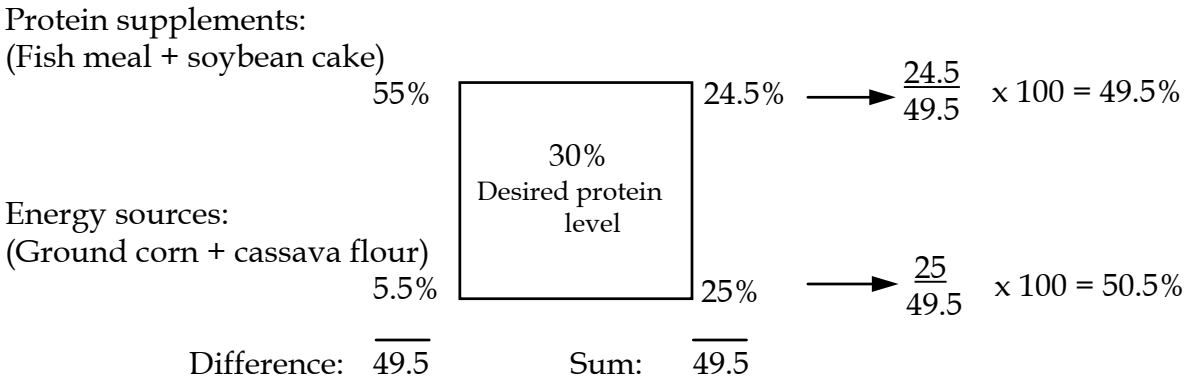
8) Divide the left side sum (49.5) into each difference obtained in step 6 (24.5 and 25) and multiply by 100 to calculate the percentage of protein supplement and energy source needed for the feed. The respective answers are 49.5 % and 50.5 %.

9) One half of the protein supplement (24.75 %) is provided by fish meal and one half is provided by soybean oil cake. One half of the energy source (25.25 %) is provided by ground corn and one half is provided by cassava meal.

Thus, to make 100 kg of fish feed containing 30% crude protein from a combination of ingredients including fish meal, soybean meal cake, ground corn and cassava meal the following proportions would be mixed.

fish meal	24.75 kg
soybean meal cake	24.75 kg
ground corn	25.25 kg
cassava flour	25.25 kg

Pearson's Square 2

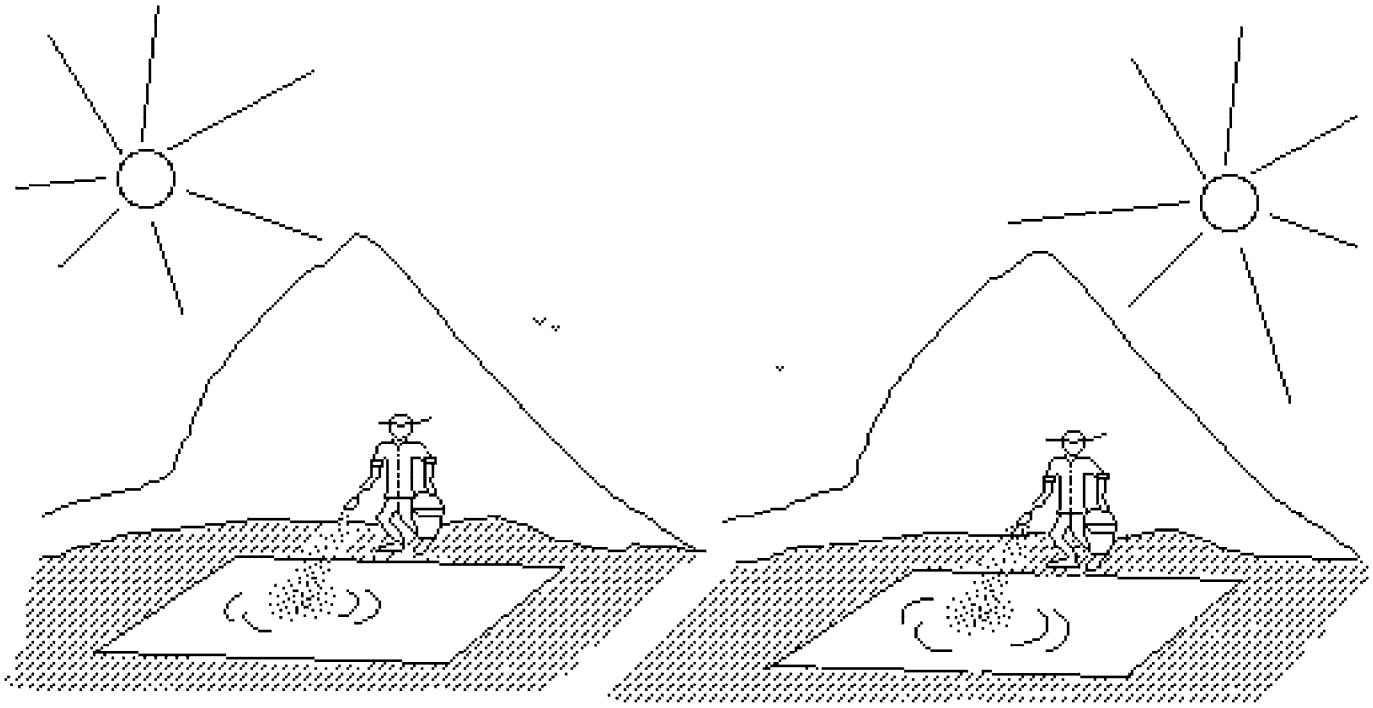


HOW TO FEED YOUR FISH

Feeds are provided to increase fish yields, and are especially beneficial: 1) when fertilization is not practiced; 2) when a pond does not respond well to fertilization; 3) when fish are stocked at high density in a pond; 4) when fish are confined in a cage, pen or other structure; 5) when fish are held in tanks. The following general rules should be followed when providing supplemental feed.

RULE 1: Always feed fish at the same time and place

Fish become trained and learn when and where they are fed. Two feedings per day are normal (Figure 3). Half of the daily amount is given about mid-morning and half in the early afternoon.



Morning Feeding Afternoon Feeding

Figure 3: Feeding is done twice a day.

RULE 2: Never overfeed the fish

Give only as much feed as the fish will consume in 20 minutes or less. Uneaten feed will pollute the water and increase the cost of raising your fish. When accumulated uneaten feed decomposes water may become low in dissolved oxygen. In such ponds, fish will usually be seen at the pond surface in the predawn hours gulping air. They will die if the oxygen concentration in the water becomes too low (Figure 4). Steps must be taken to exchange or aerate the pond water. Feeding should be temporarily suspended when dissolved oxygen is low to improve water quality. Signs of overfeeding are listed below.

1) An obvious inability of the fish to consume all of the feed offered within a 20-minute period. A farmer can walk into the feeding area of his pond 20 minutes after feeding and feel the pond bottom. If a large amount of feed is stirred up, too much feed is being offered. Feed may also be placed on trays or platforms which are lowered into the water. These platforms can then be pulled up after feeding to determine the quantity of feed consumed.

2) A foul smell in the water when the bottom sediments are disturbed. A handful of bottom sediment picked up from the feeding area should not be black and foul smelling.

3) An overabundance of phytoplankton. Overfeeding can make plankton become so abundant that a submerged object can only be seen at depths less than 25 cm. This should be a warning sign to farmers that indicates possible overfeeding.

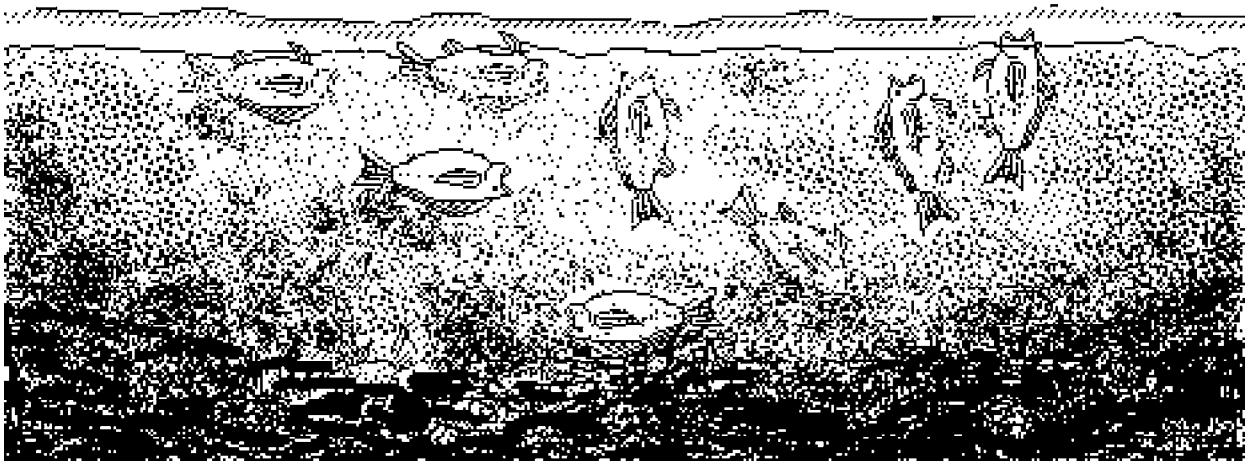


Figure 4: Overfeeding can kill fish.

RULE 3: Do not feed on harvest day

Stop feeding fish 24 to 48 hours before they are harvested (Figure 5). This allows them to clean their intestines and makes them better able to survive the stress of handling and transportation. It will also save feed.

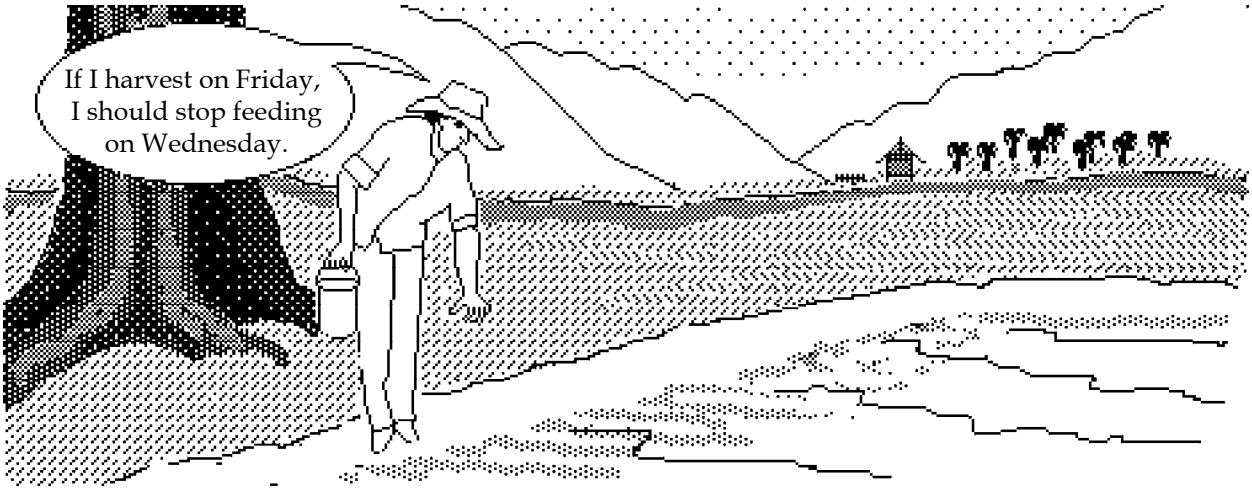


Figure 5: Plan when to stop feeding before harvest.

HOW MUCH TO FEED

Feeding rates may be adjusted on a monthly basis by estimating the fish biomass in the pond. There are several ways to determine the fish biomass. The most accurate is to catch a small number of fish and weigh them. The average weight of fish in the sample is multiplied by the number of fish stocked to calculate fish biomass in the pond. This method requires a farmer to have accurate scales and to maintain good records of fish weight and number.

Another way to adjust feeding rates is to assume a growth rate for the fish based on previous experience. Growth rates will differ depending on the amount of natural food in the pond, the type and amount of supplementary feed given, fish species and size, the stocking rate and the water temperature.

Table 2 presents a chart showing what percentage of body weight should be fed to tilapia of a certain size. This chart may be used as a rough guide to determine feeding rates. The following example illustrates this.

Example of feeding rate determination using Table 2:

A farmer samples his fish pond with a net and determines the average length of his fish to be about 15.5 cm. The average individual weight would be approximately 85 g (from Table 2). If the farmer has 350 fish in his pond, and feeds them at 4.0% of their body weight per day, he would feed about 1.2 kg of feed.

Calculation:

(350 fish X 85 g per fish) X 0.04 of body weight/day = 1190 g of feed or about 1.2 kg/day.

Table 2: Approximate length/weight relationships for tilapia and appropriate feeding rates.

Fish Size (cm)	Average Individual Fish Weight (g)	Percent of Body Weight Fed Daily
2.0	1	----------
3.0	5	
7.5	10	
9.5	20	5%
11.0	30	
12.0	40	
13.0	50	----------
14.0	60	
14.5	70	
15.0	80	4%
16.0	90	
16.5	100	----------
17.0	110	
17.5	120	
18.0	130	
18.5	140	
19.0	150	3%
19.5	160	
20.0	175	
20.5	185	
21.0	200	----------

GLOSSARY

fish biomass - total weight of fish in a pond.

crude protein - total amount of nitrogen present in the feed.

conversion ratio - dry weight of feed required to produce one unit wet weight of fish.

complete feed - a feed which completely satisfies all the nutrient requirements of the fish.

supplemental feeds - feeds which supplement natural food available in the pond by adding to available nutrients, but which alone do not completely satisfy nutritional requirements of the fish.

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