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The Asia-Pacific Marine Finfish Aquaculture Network (APMFAN) was established in 1998 at a meeting of regional grouper aquaculture specialists in Bangkok, Thailand. APMFAN seeks to promote collaborative research, development and extension activities in the field of tropical marine finfish aquaculture to support the development of sustainable marine finfish aquaculture in the Asia-Pacific region.

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1. Introduction

Farming of groupers (members of the Serranidae, subfamily Epinephelinae) is widely practised in Asia, particularly in the tropical East (China, Hong Kong SAR, Taiwan Province of China) and Southeast Asia (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam). Most grouper species bring high prices in local or export markets, and thus are an attractive culture proposition for coastal aquaculture farmers.

Groupers are carnivorous and consequently prefer feeds high in fish protein. Most farms in Asia still rely on what is commonly termed 'trash fish'. The term trash fish is inaccurate in that these fish species would not necessarily otherwise be wasted, and alternative uses include protein sources for other agricultural commodities (such as pigs and poultry) or even human food, consumed directly or as fish sauce. In some cases, so-called trash fish may even be valuable juveniles that have potential as adults to contribute to a productive fishery.

Despite the apparent abundance and availability of trash fish in many areas, there are several major issues and problems related to its use in fish farming:

Floating marine fish cages at Kedah, Malaysia.

Floating marine fish cages at Satun, southern Thailand.

- Trash fish has a very short storage life. Without refrigeration, trash fish will quickly become rancid, especially in the tropics. Even with refrigeration, the nutritional quality of trash fish will decline within a few weeks. Unless there is a very good trash fish supply chain, farmers will need to have freezer for trash fish storage to avoid rapid spoilage.
- The availability of trash fish supply is often highly variable and seasonal. For example, during the monsoon season the supply of trash fish on the west coast of southern Thailand is often limited and therefore the price increases. Many farmers try to compensate for this by storing trash fish captured in the pre-monsoon season, but the stored trash fish deteriorates rapidly.
- Trash fish readily break up into small pieces when eaten, particularly when fed to large-mouthed species such as groupers. Consequently, as much as 30 to 50% of the trash fish fed to fish can be lost during the feeding process. Feeding losses from trash fish are 2 to 4 times higher than for pelleted feeds.
- The small pieces of trash fish that are lost during feeding may decompose on the bottom of the cage or pond, or on the substrate beneath

the cage. This leads to localized pollution and water quality degradation.

- Feeding trash fish may assist in the transmission of parasites and diseases. Freezing may kill some parasites but most bacteria and viruses that cause diseases in fish will be preserved in the frozen trash fish and can potentially infect the cultured fish. Also, carp and many freshwater species and some marine fish (pilchard, herring and anchovy) contain an enzyme (thiaminase) that destroys the B vitamin, thiamin. Removing the viscera from trash fish will ensure the removal of most of the thiaminase.
- Using fish as feed for farming of carnivorous fish species is giving rise to increasing international concern regarding the sustainability of this practice. There is also concern that some species used as trash fish would be better left to mature in the wild, being more valuable when contributing to capture fisheries. Such concerns will increase in future, and may possibly lead to trade barriers for fish produced using unsustainable practices.

To provide farmers with a viable alternative to feeding trash fish to grouper, the Australian Centre for International Agricultural Research (ACIAR) supported project FIS/97/73 Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region from 1999 to 2002, with one component to develop formulated feed for grouper aquaculture. The experiences of the project have been synthesized into this Practical Guide to Feeds and Feed Management for Cultured Groupers to:

- promote the use of formulated feeds,
- promote reduction in the use of trash fish in grouper aquaculture,
- assist farmers in making more efficient use of feeds and feed resources.

Floating cage farms at CatBa, Vietnam, are supplied with fresh trash fish daily.

2. Traditional method – feeding trash fish

Traditionally, grouper farming has used trash fish as the single feed source for grouper grow-out. Trash fish can be divided into three grades: good, average and poor, using the following criteria:

- Good: Fresh and shiny appearance
- Average: Poor colouration but still intact
- Poor: Decayed, bad smell

Only good quality trash fish should be fed to groupers.

Cost of trash fish

The costs of trash fish vary from country to country and depend heavily on seasonality and species. The following provides some guideline for trash fish cost in various countries:

- Indonesia: US$ 0.35 – 0.59/kg
- Thailand: US$ 0.20 – 0.28/kg
- Vietnam: US$ 0.19 – 0.45/kg

These costs are for reference only. In many cases, grouper farmers are also fishermen and in these cases capture of trash fish may be only an opportunity cost.

The use of trash fish should be reduced, if formulated feeds are available. However, in many farming areas in Asian region, formulated feeds are still not easily accessible and trash fish is the only feed source available to many grouper farmers. Feeding trash fish to grouper will require some basic processing, such as removing the gut and head of the trash fish and cleaning off all the waste. When groupers are small, there is a need to cut/chop the trash fish into smaller pieces to suit their mouth size.

Good quality trash fish used for grouper culture.

Average quality trash fish.

Poor quality trash fish.

Overfeeding with trash fish results in wastage, as seen here, which contributes to water and sediment pollution.

Heads and guts should be removed from trash fish before they are fed to groupers.

Farmer cutting trash fish to smaller sizes before feeding to groupers in floating cages.

Good quality trash fish after being cleaned and gutted for feeding to grouper.

Trash fish that has been cut and is ready to be fed to groupers in cages.

Cleaned and cut trash fish ready to be fed to smaller groupers.

3. New and better practices – use of formulated feed

In response to the limitations and problems associated with trash fish usage for grouper aquaculture, new and better practices are being developed. Foremost amongst these is the use of formulated feeds instead of trash fish.

Formulated feeds are of two types:

1. 'Moist' feeds, that can be produced on the farm; and
2. Commercially produced pellets that must be purchased from a feed manufacturer.

Benefits of using formulated feed

Economic advantages

Although most formulated feeds appear to be expensive in comparison with trash fish, many farmers are misled by comparing costs directly, in terms of cost per kilogram of the feed. Since fresh trash fish contains about 75% moisture whereas a formulated dry pelleted feed contains less than 10% moisture, pelleted feed has almost four times more dry matter than trash fish. The only way of correctly comparing the two feed types is to calculate the amount and cost of the feed that is required to produce the same weight gain in the cultured fish, i.e. food conversion ratio (FCR).

The FCR for groupers conditioned to eating formulated dry pelleted feed should be less than 2:1. That is, the fish eat between 1.5 and 2 kg of pellets for every 1 kg increase in their weight. In comparison, much greater quantities of trash fish are required to produce 1 kg of food fish. Even with good quality trash fish, the FCR will typically be 6:1 or higher.

The economics of using formulated feeds versus trash fish are examined in more detail in Section 6 of this guide, Assessment of feed performance. Economic advantages will vary between different farms, particularly depending on the relative costs of formulated feeds and trash fish, but often it is more cost-effective to feed formulated feeds.

In the long term, as the grouper grow-out industry develops further, the cost of formulated feeds is expected to decrease, further improving the economics of feeding formulated feeds.

A secondary economic benefit of using formulated feeds is that fish grow faster and are healthier in comparison to fish fed trash fish because formulated feeds provide a nutritionally complete diet. For example, ACIAR-funded research at the Research Institute for Mariculture, Gondol, Indonesia, showed that grouper grew 75% faster when fed formulated pelleted feed compared with grouper fed trash fish.

Commercial dry pellet feed used for grouper juveniles at nursery stage.

Environmental benefits

Formulated feeds also generate less pollution as water stability is better and less of the feed is wasted. In turn, this provides a better environment for the fish leading to a reduction in disease problems.

Moist feeds

Farmers in some Asian countries make farm-based moist feeds for marine finfish. Moist feeds generally follow a prescribed formula, originally developed from fisheries or aquaculture research and development authorities in the country, and modified by the farmers according to requirements, farming situation and availability of ingredients. Moist feeds can be in various forms, pellet, ball, etc. Moist pellets offer improved water stability over other forms of moist feeds, and can be fed to groupers by broadcasting into the cage or pond. For moist feeds in other forms, such as a ball, it is best to utilise a feeding tray to reduce wastage during feeding.

Moist pellet feed for groupers can be made on farm, using a mincer such as the one shown here.

An example of ingredient composition of feed for humpback grouper developed during the ACIAR project is listed below. This formula can be used as a reference for farmers who wish to develop farm made moist feed for groupers.

Feeding tray being used for moist feed in pond culture of green grouper (Epinephelus coioides). The tray also allows farmers to monitor whether the fish are feeding well.

Ingredient	kg
Trash fish[1]	60
Soybean meal[2]	15
Rice bran (cooked)[3]	15
Vitamin premix	1
Vitamin C	0.02
Trace mineral premix[4]	0.5
Fish/squid oil	2
Water	0–10
Total	**~100**

[1] Can be replaced with 20 kg of good quality fishmeal (65% crude protein) and extra water added to form a dough.
[2] Cooked / fat-extracted.
[3] Dry weight prior to boiling.
[4] Preferred but not essential.

The above formula provides the following nutritional composition for the moist feed.

Nutritional Composition	(%)
Dry matter	≤ 40
Crude protein	18.9
Digestible protein	16.2
Gross energy	8.8
Digestible energy	6.1
Lipid	4.8
Ash	4.4

The following two tables show the recommended active amounts of vitamins and trace minerals that should be provided by the vitamin and mineral premixes used for the moist feed.

Vitamin	Amount(mg/kg diet)[1]
Retinol (A)	0.45 (1500 IU)
Thiamine (B_1)	7.5
Riboflavine (B_2)	10
Nicotinic acid (B_3)	30
Choline (B_4)	200[2]
Pantothenic acid (B_5)	15
Pyridoxine (B_6)	5
Cyanocobalamin (B_{12})	0.02
Ascorbic acid (C)	50
Cholecalciferol (D_3)	0.015 (600 IU)
DL-α -Tocopherol (E)	30 (30 IU)
Biotin (H)	0.2
Menadione (K_3)	2.5
Folic acid	2.5

[1] This is the amount of the vitamin that should be present in 1 kg of the moist diet (containing about 40% dry matter).
[2] Only if feeding broodstock fish.

Trace mineral[1]	Form	Amount (mg/kg diet)[2]
Cobalt	$CoCl_2$	0.25
Copper	$CuSO_4$	2.5
Iron	$FeSO_4$	20
Manganese	$MnSO_4$	10
Selenium	$NaSeO_3$	0.05
Zinc	$ZnSO_4$	20

[1] Trace mineral premix is not necessary if trash fish is used in the formulation.
[2] Amount of the active mineral that should be present in 1 kg of moist diet (40% dry matter).

Equipment for farm-made feeds

The type of equipment needed for making farm-made feeds will depend on the volume of feed to be prepared. There are essentially three steps: Reducing the size of the materials to enable effective mixing; blending or mixing of the ingredients into a uniform dough; and forming of the dough into a size and shape to suit the fish to which the feed will be fed.

- Size reduction – use a hand operated or electric meat mincer for wet, soft ingredients such as trash fish. These may be a stand alone kitchen or industrial appliance or often purchased as an attachment for a dough mixer. Dry ingredients can be reduced in size using any convenient grinding equipment – a mortar and pestle for small amounts or engine or electrical hammer mills and gristers.
- Blending – small quantities can be manually mixed by hand or shovel. Larger quantities are best mixed using the planetary bowl-type dough mixers that are used widely in the commercial baking industry. Many of these mixers also have a meat grinder attachment, which is useful for mincing wet foods.
- Forming – again, depending on volume and need, the dough can be formed into a suitable size and shape manually or passed through a meat mincer and die plate to produce spaghetti-like strands of a desired diameter. These strands can then be reduced in length according to the size of fish being fed.

Dry pellets

Dry pellets are now being produced commercially in many parts of Southeast Asia by feed manufacturers. Dry pellets provide the same benefits as moist pellets, but some additional advantages of using dry pellets are:

- Reliable supply: Commercial dry pellets are available year-round and farmers can obtain them more easily and reliably.
- Longer shelf life: Commercial dry pellets can be stored for longer periods than trash fish or moist pellets without rancidity. However, a well-ventilated, dry and cool storage place is very important to maintain freshness of the feed (refer to Chapter 4 of this guide).
- More environmentally sound: Dry pellets usually have very high water stability so nutrients do not easily dissolve in the water body. Therefore pelleted feed causes less pollution at feeding.

However, dry pellets have several disadvantages over other feed types:

- Pellets may not readily be available in more remote regions, and the cost of transport to remote farms may substantially add to their cost.
- Groupers, like other marine finfish, must be 'weaned' to feed on pellets. Once fish are weaned to a pellet diet, they should not be fed trash fish since it will require additional time to wean them back to a pellet diet. During the weaning period (perhaps as long as several weeks), feeding activity may decline and growth is reduced.

Using formulated feeds

Although formulated feeds have many advantages over trash fish, many farmers have experienced some problems in their use. Some of the most important problems in making farm made moist feeds or selecting dry pelleted feeds, and how they can be overcome, are discussed below.

Key points in formulating good farm made moist feeds:

- Use a formulation that has been recommended by an appropriate authority for the particular species and size/age of fish being fed. Do not make major changes to the amount or type of ingredients used in the formulation without first getting appropriate advice. Avoid using more than the recommended amount of trash fish or fish meal in the formulation; more does not necessarily mean better fish performance but instead will increase feed costs and cause greater pollution
- If trash fish is to be used for moist diets, ensure that only the freshest and best quality trash fish is used and that it is properly cleaned and gutted.
- Moist feeds should be held in a cool place and used on the same day of preparation unless some form of refrigerated storage is available. Even refrigerated, moist feeds should be fed out as quickly as possible (within 5 days of preparation).
- It is important to recognize that a moist feed formulation that is ideal for one species of fish may be completely inadequate or over specified for another species. Similarly, formulations may need to be varied for different age/size of fish being fed. Juvenile fish generally require higher protein feed compared with adult fish. Again, seek advice from appropriate authorities.
- One of the most frequent problems experienced by farmers using formulated feeds (moist or dry) is feed rejection by the cultured fish. This most often occurs when the cultured fish are switched from trash fish to formulated feed. This is a particular problem when trash fish becomes expensive or in short supply. It is best to condition fish from an early age to formulated feed and then to continue to use formulated feed until the fish are harvested. Switching from trash fish to formulated feed without appropriate conditioning of the fish will lead to severe feed rejection and lost fish productivity.

Key points in selecting good dry pelleted feeds:

- Buy from a reliable feed manufacturer and buy only feed that has been formulated for the particular species and age/size of fish that is being cultured.
- Feed quality – nutrient content, ingredient make-up and freshness is far more important than buying simply on price per kg.
- Know where and when the feed was manufactured and check how the feed was handled since manufacture and delivered to the farm. Even dry pelleted feed should be fed within 1–2 months of manufacture and must be stored in a dry and cool place until it is fed to the fish.
- Any feed that shows signs of water/rain damage (discoloured bags, clumping of the pellets, off smells etc.) should be rejected and never fed to the fish.
- Reject dry pellets that are crumbled or crushed. This indicates a high ash content in the pellet, or that the pellets have been damaged during transport and storage.

Making moist pellets with a small-scale feed machine.

Good commercial dry pellet feed used for grouper grow-out.

A poor quality commercial pellet feed that has high ash content. Note the high 'dust' component due to crumbling.

4. Feed storage and quality control

Proper feed storage is essential for all grouper farms. Poor feed storage facilities will lead to deterioration of feed quality, which in turn will result in poor growth, malnutrition, health problems and possible high mortality of the fish. All of these will decrease farm profitability.

What are the characteristics for good feed storage facilities?

- Shelter from direct sunlight and rain
- Properly ventilated and cool
- Dry and low humidity
- Protected from vermin (rats/mice) and insect pests
- Feed stored off the ground to prevent ground condensation and mould spoilage
- Feed should be stored away from chemicals and drugs

Poor storage will reduce the shelf life of the feed through loss of critical nutrients such as vitamins, essential fatty acids and anti-oxidants. This will lead to reduced growth and higher mortalities due to poor fish health. Feed subjected to wet storage conditions may become mouldy. In extreme cases, the use of mouldy feeds may lead to mass mortalities through poisoning of the fish.

Even with a good feed storage system, feed should only be stored for a short period, ideally for less than two months from the date of the feed being manufactured. Cutting down storage time ensures that the feed is turned over faster, reducing the inventory cost of the feed and providing the grouper with the freshest and best quality feed. Finally, there is no point in having the best possible feed storage conditions on your farm if the manufacturer and transport distributor have not carefully handled the feed prior to its arrival at the farm. Always check the date of feed manufacture and how the feed has been handled.

Commercial dry pellets stored in a well-sheltered feed storage area. Polystyrene foam has been used to prevent the feed from dampness.

5. Feeding management

Feeding regimen

To attain maximum farm profitability, fish should be grown to market size as quickly as possible. Therefore, it is best to adopt a feeding practice that maximizes feed intake to achieve the best possible growth rate of the fish. Care should be taken not to feed to excess, which results in feed being wasted and causes water pollution problems that may lead to disease.

Several commercial feed companies and researchers have developed a feeding regimen based on their own experience. It is important that farmers use such a feeding regimen only as a guide when developing their own feeding practices. One needs to be aware that different farming conditions such as water quality, weather, environment and farming systems can influence how best to feed the fish. Feeding regimens may also vary between different fish species. Therefore a regimen used in one area, or on one farm, may not be directly applicable to another.

Two feeding regimens recently developed for feeding groupers on either trash fish or dry pellets can be used as a guide in the absence of specific local knowledge or experience. These feeding regimens are listed below based on Sutarmat et al. (2003).

Feeding regimen for feeding trash fish to groupers.

Fish size (g)	Daily feeding rate (%ABW[1])	Number of feeds/day
5–10	15–20	3–4
10–50	10–15	2–3
50–150	8–10	1–2
150–300	6–8	1
300–600	4–6	1

[1] Average body weight (ABW).

Feeding regimen of dry pellets to groupers.

Fish size (g)	Daily feeding rate (%ABW[1])	Number of feeds/day
1–5	4.0–10.0	3–5
5–20	2.0–4.0	2–3
20–100	1.5–2.0	2
100–200	1.2–1.5	1–2
200–300	1.0–1.2	1
>300	0.8–1.0	1

[1] *Average body weight (ABW)*

Timing of feeding and removal of uneaten feed

Grouper fingerlings of less than 5–10 g body weight generally need to be fed more than three times daily to achieve high feed intake and rapid growth. As fish grow in size, the frequency of feeding can be reduced without markedly affecting growth rate.

If fish are to be fed twice each day, feeding should be done as early (dawn) and as late (dusk) in the day as is practical. For fish being fed once per day, it is best to feed the fish late in the afternoon before sunset. Noon and early afternoon are less favourable feeding times, as the sunlight is strong. At these times, groupers tend to rest on the bottom and generally feed less actively.

If farmers adopt satiation feeding and take care to distribute the feed evenly, this will avoid grouper feeding aggression, there will be little feed that settles to the bottom and wastage will be minimized. An undesirable practice is to simply 'dump' a quantity of trash fish or pellets into the cage without observing the feeding behaviour of the groupers. As a result, a lot of the feed may pass though the cage bottom to be wasted and pollute the surrounding water.

Uneaten food should be removed from the cage (pond) as soon as possible to prevent water pollution and nutrient load in the nearby water body.

Overfeeding of formulated dry floating pellets at a fish pond lead to wastage, high feed cost and water pollution.

How to calculate feeding quantity based on biomass?

Use the following formula:

Feed quantity = (number of fish in cage × average body weight of fish) × % daily feeding rate.

For example, for 1,000 fish in a cage with an average body weight (ABW) of 5 g, then the daily feeding rate of dry feed pellets is about 4% based on the previous table. Therefore the total amount of feed (in grams) to be fed each day to that cage is calculated as:

= (1,000 × 5) × 4%
= 5,000 × 0.04
= 200 g

If the fish are to be fed three times a day, the total daily amount of 200 g should be divided approximately equally between each feeding. Thus approximately 67 g of feed would be fed each time, added slowly to enable all fish to eat to satiation. The same method of feeding applies when using trash fish.

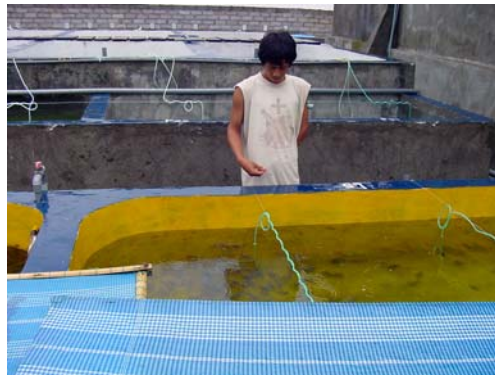
Methods of feeding

The commercial dry pellets used for grouper farming are generally slow sinking pellets that give fish more time to get food. It is very common to spread the feed widely in the cage area to allow for better access to the feed by all the fish in the cage. However, groupers quickly become accustomed to feeding times and they will often aggregate close to where the feed is first added. This reduces the need to spread the feed over all of the cage area. The rule always is to add the feed slowly and ensure that all fish in the cage (or pond) have good access to the feed.

If the groupers stop actively feeding before all of the intended feed has been fed, feeding should immediately stop as satiation has been reached. Adding more feed will simply result in feed wastage and cause water quality problems.

Weaning grouper from raw feed to formulated feed

Hatchery-produced grouper fingerlings may have no problem in accepting formulated feed if they have been fed with formulated feed during the hatchery and nursery periods. However, farmers who have obtained fingerlings or juveniles from the wild may experience difficulties in converting



Dry pellets being fed to juvenile mouse grouper at a commercial nursery. The pellets are fed slowly, in small quantities to ensure that little feed is wasted. Although this is an efficient use of feed, the process is relatively labour-intensive.

to formulated feed. The best weaning strategy is to feed them a mix of trash fish and formulated feed. Trash fish should initially comprise a large portion of the mixed feed. The proportion of formulated feed is slowly increased in the mix until trash fish is totally eliminated.

An alternative approach is to starve the fish for 2–3 days, and then feed only formulated feed. However, care should be taken not to starve or underfeed the fish for too long which may cause the fish to lose condition, leading to health problems.

Check list for better feed management practices

- The first basic rule – feed to satiation but avoid overfeeding. When fish stop taking feed, feeding should stop.
- Feeding should be based on the biomass of fish in the cage or pond and feeding tables used, but only as a guide.
- Feed should not be 'dumped' into the cage or pond but rather added slowly and distributed to where the fish are present.
- Usage of aquatic health products such as antibiotic in feeds should be avoided. If they have to be used, proper dosage and advice should be sought from local or national fisheries authorities. The use of medicated feeds should cease as soon as the fish health problem is resolved.
- Feed should be given according to the size of the fish and the size of the pellet should increase as the fish grow in size. Feed companies can usually advise the preferred pellet size for various fish sizes.

Spreading trash fish into grouper cages – the preferred method of efficient feeding.

6. Assessment of feed performance

This section illustrates how to calculate feed performance at farm level. In order to assess feed performance, it is important to know the biomass in the culture system and the total feed consumed. Based on biomass, total feed consumed together with feed cost, one can calculate the performance of the feed used. The following section provides a comparison of formulated feed and trash fish.

Calculation of grouper biomass in the culture system

Calculation of production is based on the number of fish that you originally stocked in your cage (pond), the likely survival rate during the culture period (based on daily observation and calculation) and the size of the fish when you harvest and sell them. Therefore:

$$\text{Production} = (N_i \times SR_e) \times ABW$$

Where:

N_i = initial number of fish stocked
SR_e = estimated survival rate
ABW = average body weight

Example – calculation of production:

= (1,000 fish × 70%) × 0.6 kg
= 700 fish × 0.6 kg
= 420 kg

Food conversion ratio

The food conversion ratio (FCR) is calculated as the mass of food consumed divided by the increase in mass of animal(s) produced.

$$\text{FCR} = \frac{\text{Total feed consumed}}{\text{Total fish weight gain}}$$

Example of FCR calculation for formulated feed

The total amount of formulated feed used to produce 420 kg of groupers is 700 kg, the FCR is:

$$\text{FCR} = \frac{700 \text{ kg}}{420 \text{ kg}}$$

FCR = 1.67 (formulated feed)

Examples of FCR calculation for trash fish

The total amount of trash fish used to produce 420 kg of groupers is 2,520 kg the FCR is:

$$\text{FCR} = \frac{2{,}520 \text{ kg}}{420 \text{ kg}}$$

FCR = 6.0 (trash fish)

Comparison of feed performance based on cost

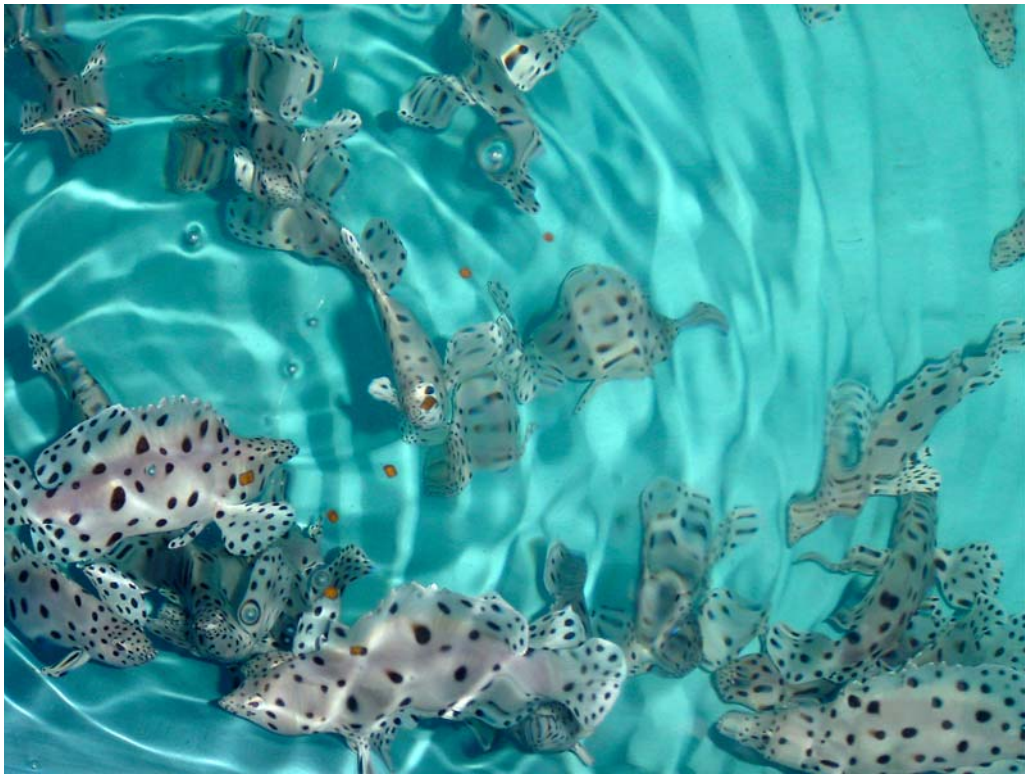
FCR values, as well as the cost of the feed, need to be taken into account in determining the relative value of different feed types.

Example – cost comparison of formulated feed and trash fish

The lowest prices of formulated feed and trash fish in Indonesia have been used in this example. All values are in US$.

	Formulated feed	Trash fish
Cost per kg	$1.20	$0.35
FCR	1.67:1	6:1
Feed cost per kg production	($1.20 x 1.67) = $2.00	($0.35 x 6) = $2.10

Based on this example, the formulated feed provides a saving of US$ 0.10/kg on feed costs. In addition to this direct saving, the use of a formulated diet also increases the growth rate of groupers, therefore shortening the culture period, allowing more rapid return on investment and reducing financial and culture risks. It is also important to note that formulated feed generally delivers higher survival rate, a more healthy environment, less disease problems, and the fish produced are usually of superior quality and more tolerant of transport.



Mouse grouper juveniles gather to feed on dry pellets at a regular feeding time.

Glossary

ABW: Average Body Weight. The mean weight of a population of fish (in a tank, cage or pond)

Broodstock: Adult fish kept in tanks or in sea cages to produce eggs for rearing in the hatchery.

FCR: Food Conversion Ratio. A commonly-used measure of how efficiently feed is converted to fish flesh, FCR is the amount of feed required to produce 1 kg of fish. FCR's for trash fish usually range from 6:1 to 10:1; FCR's for compounded pellets should be in the range 1:1 to 2:1.

Feeding tray: A shallow tray, usually made from fine mesh net, suspended on the bottom of a pond. Feed is placed on the tray and the tray is retrieved regularly through the day to ascertain the level of feeding by the fish in the pond.

Formulated feeds: Feeds containing a range of ingredients to ensure proper nutrition for the target species.

Formulation: Different fish species have different nutritional requirements. Farmers should ensure that they use a feed specifically formulated for the species that they are culturing.

Grister: A type of mill that uses two plates or discs to grind material very finely.

Grouper: Fish belonging to the Subfamily Epinephelinae, Family Serranidae. Known as cod (estuary cod, flowery cod, etc.) in Australia.

Mincer: Hand or electric operated machine for mincing meat products. Commonly used in aquaculture to break down fish flesh into smaller pieces.

Mixer: Electric mixers are used to combine the ingredients for moist diets. Dough mixers or similar are suitable.

Moist feeds: Feeds made on-farm using moist ingredients. Moist feeds have a very short shelf life compared with pellet feeds.

Pellet feeds: Commercially produced feeds sold in bulk in the form of pellets. Different pellet sizes are available for different sizes of fish.

Premix: Premixes contain a range of vitamins and trace minerals. They are added to formulated diets to ensure that adequate levels of vitamins and trace minerals are incorporated in the diet.

Rancidity: Degradation of fats in trash fish or feeds stored improperly. Using rancid feeds will cause nutritional deficiencies in the cultured fish, leading to increased prevalence of disease, and may directly kill fish.

Satiation: When the fish have had enough to eat, they are satiated (i.e. their appetite is suppressed). Satiation is signalled by a dramatic lessening of feeding activity.

Trash fish: Small fish that may be targeted by fishers or caught as incidental bycatch. Commonly used as a feed source for aquaculture in Asia. Alternative uses include human consumption or as a protein source for other agricultural feeds (chicken or pig feed).

Trace minerals: Very small quantities of specific minerals are added to formulated feeds to ensure that the feed meets the specific nutritional needs of the target species.

Thiaminase: An enzyme found in fish, thiaminase can degrade Vitamin B in trash fish or formulated feeds, resulting in nutritional deficiencies in the cultured fish. Thiaminase activity can be reduced by removing the guts of trash fish.

Vitamins: An essential nutritional component, vitamins may degrade due to poor storage of feeds. Vitamin deficiencies may present as a range of fish health problems, including skeletal deformities, lethargy, increased prevalence of disease, and increased mortality in the cultured fish.

Weaning: The process of converting fish from one food type to another. In hatcheries and nurseries this usually refers to the conversion of fish from a diet of live food to compounded feeds. In grow-out, it may also refer to the process of converting fish from a diet of trash fish to moist feed or compounded pellets.

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