Aquaculture

Feeding Practices for Recirculating Aquaculture

Selecting the proper feeds and feeding methods is an important aspect of fish growth. Feed considerations are therefore a fundamental part of indoor recirculating aquaculture. Unlike pond culture, the only source of nutrition for aquaculture fish is in the feed they are given. Complete fish feed pellets, which contain all necessary nutrition, are essential. Feed ingredients are chosen for their digestibility of protein, fat, and carbohydrate components, as well as their buoyancy characteristics and price and accessibility for feed mills. Most of these complete feeds contain fish meal, which provides the proper amino acid profile and healthy omega-3 fatty acids needed for fish nutrition. Sustainability of aquaculture, however, will require feeds that reduce the fish meal needed, decreasing ocean fishing pressure in the name of aquaculture. Replacing fish meal with other proteins can negatively change the fatty acid profile from heart-healthy omega-3 fatty acids to saturated fats and trans fats, making fish products less healthy for human consumption. Thus feed ingredients must be carefully selected.

Hand feeding tilapia

FEED OPTIONS

Floating *v.* Sinking Feeds – Floating feed is commonly used in the production of finfish in order to monitor feeding behavior. The uneaten pellets can be easily netted out of the water. Shellfish species like shrimp and crayfish need a sinking feed because they spend the majority of their time on the bottom. It is much more difficult to gauge whether or not the shellfish are consuming the feed rationed to them, and over- or under-feeding is common. For sinking feeds, feeding behavior can be monitored to some extent by designating a feeding area in the tank and netting the bottom in that area approximately 15 minutes after feeding to gauge the amount of uneaten feed. Semi-floating or slow-sinking feeds can be used for finfish that are shy feeders, or fish that won't feed from the surface, which is particularly useful in species like bluegill.

Carnivorous *v.* Omnivorous Diets – Fish that are carnivorous require more fish meal and a higher percentage of protein in their diets than herbivorous fish that can directly feed on vegetative matter. Omnivorous fish, such as tilapia and channel catfish, can grow well on both animal and plant protein.

Medicated Feed – When fish get a bacterial infection, one of the most effective treatment options is to provide medicated feed so that antibiotics get inside the fish's body. Because sick fish do not eat, it can be difficult to administer medicated feeds.

FA 0002A December 2014

Iowa State University
Extension and Outreach

Garlic oil is a commonly used feed attractant that can be used to topcoat the feed and improve fish uptake. Medicated feed should be stored in a separate location from other feeds, and it is typically refrigerated to prolong its life.

Medications for food fish are strictly controlled and a farmer must work with an aquatic veterinarian to obtain a prescription to purchase and use medicated feed. The prescription will include an application rate, amount to be fed, and duration to be fed. The prescription should be strictly adhered to, preventing further harm to the fish or the biofilter. Approved aquaculture drug additives for feed include Terramycin, Romet, Aquaflor, and others.

A withdrawal period (i.e., time between the end of the treatment and harvest of the fish), is required for food fish to ensure that the antibiotics do not transfer to humans. This period varies depending on the drug used.

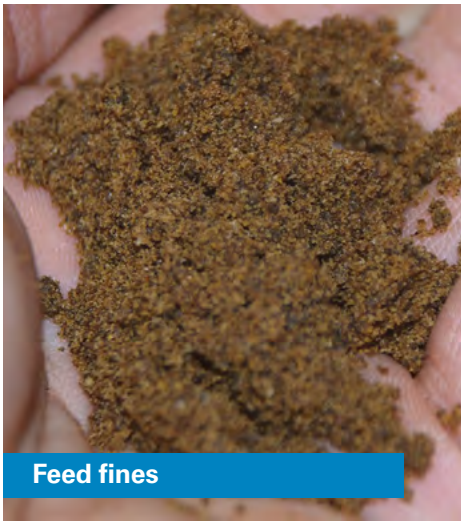
Feed Quality – Fish feeds range in terms of their ability to provide adequate nutrition for the fish. Less expensive feeds that may be a byproduct of another agricultural process can be useful as a supplemental feed but will not contain all the nutrition fish need to grow optimally. Complete feeds are those that contain all the vitamins, minerals, amino acids, fatty acids, and other components required by the fish to grow. Complete feeds may be used exclusively, but these feeds are typically more expensive.

The feed production process and ingredients used determine the structural stability and nutritional quality of the feed. Pellet mills compress feeds into a dense pellet that will sink and may be more prone to crumbling, which creates more fine particles that the fish cannot eat. This could cause water quality issues. Extruded feeds can be produced under heat and steam that cause starches to expand, creating a structurally sound feed that will float. Feeds that are small in diameter or have low carbohydrate (starch) content will tend to sink.

FEEDING PRACTICES

Fish should not be fed if the water quality in the system is not adequate or if fish are sick and stressed. Fish will not eat when they are stressed and extra feed in the water can cause water quality issues. Feeding should be avoided when dissolved oxygen is low or ammonia levels are high. Sick and stressed fish, recognizable by symptoms such as skin lesions or erratic swimming behavior, will not eat feed. Withholding feed will help avoid water quality issues and mortalities.

2.5 mm floating feed



Feed fines

Feeding Response – The feeding response is the amount of vigor that fish display in consuming feed. If fish are slow to eat and leave feed floating on the surface of the water, feeding should cease and the uneaten feed should be removed from the water.

If the fish are feeding very aggressively and consume the feed quickly, more feed should be added. Feeding should continue until the fish cease eating and leave a small amount of feed floating. Excess feed should still be removed.

Feeding to Satiation – Satiation is the point at which fish are full and do not desire to eat anything more. The typical method for gauging satiation in fish is to feed the fish as much feed as they will consume in 15 minutes. Feeding should start in small increments to determine how aggressively the fish are feeding. If they are feeding vigorously, then more feed should be added until the feeding behavior slows. Cease feeding if feed is left uneaten, and remove excess feed after the 15-minute feeding period. The amount of feed fed and the feeding response should be recorded to help predict the amount of feed the fish will require in the future.

FEED CALCULATIONS

Feeding Schedules – A feeding schedule is a prediction of the amount of feed that should be fed to the fish at any given point during the growth cycle. It is based on a percentage of the total biomass, or the combined weight of all fish in the system. Smaller fish require a higher percentage of their biomass in feed on a daily basis than larger fish. A typical feed schedule


Juvenile tilapia

may call for a feed ration that equals 40% of the fish biomass on a daily basis as fry or juveniles, then 10% of biomass as fingerlings, then 2% - 3% of the fish biomass as adults. A daily growth increment should additionally be considered in the biomass estimate between samplings. Depending on the species, fish generally add more weight per day as they grow. For example, a fish may grow by 0.1 g (larval) to 2.0 g (fingerling) to 10.0 g (adult) per day if optimal water conditions are met. The daily feed ration should be split into multiple feedings per day to avoid water quality issues and to improve feeding efficiency; 3 to 5 feedings per day is common.

Feed Conversion Ratio – Feed conversion ratio (FCR) is a common term in aquaculture that provides a standard to compare the feeding efficiency of different species, feeds, and systems. Feed conversion ratio refers to the weight of feed fed per fish weight increase throughout the growth cycle. Aquaculture is the most efficient of all livestock production forms, meaning it has the lowest FCR. A realistic FCR for a novice farmer is about 1.5 to 3.0, but experienced aquaculturists can achieve an FCR of 0.8 to 1.0 depending on the fish species, age, and the feed used. Accurate feed records and fish weight data must be collected to calculate FCR. These values are important for gauging production efficiency and improving production practices over time among species, cohorts, and systems. Since feed costs are a considerable portion of production costs (40% - 60%), even a slight improvement in feeding efficiency can yield large changes in profitability.

IMPLICATIONS OF FEEDING

Feed Effects on Water Quality – Feed contains protein utilized by fish to build muscle, but the protein also creates nitrogen waste in the form of ammonia excreted through fish gills and feces. Ammonia (NH_3 or NH_4^+) can be extremely toxic to fish and it must be removed from the system as quickly as possible. One method to do this is bacterial processing to nitrite (NO_2^-), which also can be toxic, but is eventually processed to relatively non-toxic nitrate (NO_3^-). The amount of ammonia produced is directly proportional to the amount of feed added to the water. More feed results in more ammonia, and also increases stress on the biological filter. Ideally, all feed will be consumed by the fish. However, broken feed particles entering the water can actually break down into ammonia without providing any benefit to the fish. Small feed particles, the fines, will also not be consumed by fish and will create water quality issues. Fines stain the water dark colors and contribute to high biological and chemical oxygen demands. Good quality feed that holds together in the bag and in water will cause fewer issues with water chemistry because the fish can more easily consume the feed and feed particles can more easily be netted or filtered out of the system.

It is important to purchase high quality feed from a reputable supplier. Choosing a high quality, water-stable feed that is free of fines, easily digestible, and nutritious is important. It is then helpful to feed in small amounts on a frequent basis (3- to 5-times per day) and utilizing the correct size of feed as well as a feed delivery system that removes fines from the system before they can enter the water.

Effects on Population Growth Rate – Feeding smaller rations and feeding more frequently can reduce the ammonia and oxygen stress on the system. However, providing enough feed in a single feeding to ensure that all the fish have access to feed is critical for even fish growth. Finding a balance between these strategies will optimize feeding efficiency.

Aggressive fish can consume more feed and grow at a faster rate than other fish. They may become so large that they can eat the less aggressive fish. It is important to grade the fish on a regular basis depending on fish size to prevent cannibalism. Similar sized fish are easier to sell at market or to a fish processor. Generally, there is a market accepted size for each fish species between 1.5 and 2 pounds. Growing all fish in a cohort to that target size is much more desirable than having fish of varying sizes.


Hand delivery


Belt feeder


Auger feeder

FEED DELIVERY TECHNOLOGY

There are many methods of getting feed to aquaculture fish. Some of them are more labor intensive, some are gentler on feed, while others are designed to reduce malfunction and over/under feeding. Regardless of the feed delivery system, it is important to visually inspect the system for fish feeding behavior, equipment clogging and malfunctions.

Hand Delivery – Feeding by hand is the most labor intensive method, but allows the farmer to monitor feeding behavior and have more control over the feed inputs. This type of feeding is ideal for small facilities and for operator observation and management of stressed or diseased fish.

Belt Feeders – Belt feeders allow farmers to meter out feeding over time with a simple timed delivery device. One advantage to this system is the simplicity of operation. Some disadvantages are that the systems must be re-wound daily, there is some risk of mechanical malfunction, and humidity can cause feed to stick to the belt where it becomes wet. This can cause feed to buildup and decay. Fungus and toxins may also accumulate and inadequate feeding can occur, especially with smaller diameter larval feeds.

Pneumatic Feeders – Pneumatic feeders use the power of compressed air to force feed into the culture tank. These systems can be convenient for moving feed quickly from a central source. However, the pellet velocity can actually cause fracturing when the feed comes in contact with a hard surface, leading to reduced feeding efficiency and fine particles in the water that rapidly degrade water quality.

Auger Feeders – Auger feeders use a screw to move feed along the length of a tube. Although effective, this method may break the pellets, leading to reduced feeding efficiency and fine particles in the water that rapidly degrade water quality. Additionally, depending on the system, the electric motor may be in a humid environment, which will increase its risk of failure.


Cable delivery system

Cable Delivery System – A cable delivery system utilizes a series of equally spaced disks strung along a cable that slide through a tube, carrying feed along the tube to one of many feed delivery locations along the line. These delivery locations will dump their load into the culture container simultaneously at pre-determined feeding intervals. This system tends to be gentler on the feed, causing less pellet fracturing and fines, which increases feeding efficiency and water quality.

FEED MANAGEMENT

Because feed represents such a large component of the variable costs in an aquaculture operation and because it has such drastic effects on the growth rate and survival of fish, it is very important to invest in an optimal feed and manage the feed to ensure only good quality is provided to the fish.

Feed Preservation – Fish feed has an expiration date because of its organic components. It must be stored and managed properly to get the maximum value. Feed quality degrades quickly in hot, humid environments, so feeds should be stored in a cool, dry place. The average shelf life of feed is about 6 months, but it can be lengthened by placing feed in refrigeration units or freezers. Rodents and insects will be attracted to feeds, so they should be stored in a sealed container and spilled feed should be swept up frequently.

Toxins – In humid environments, like aquaculture production units, mold can become an issue in feeds. Some fungi will emit toxins called mycotoxins that can stress or kill the fish. It is important to regularly inspect the feed distribution units and sanitize where necessary.

Quality and Inventory Control – Record keeping is very important to tracking incoming and outgoing feed to ensure that it is the correct feed (size, nutritional content, floating *vs.* sinking) being fed to the correct fish (size and species) in the correct tanks (prevent over- or under-feeding) at the correct time (feeding frequency and use of degraded feeds).

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