North Central Regional
Aquaculture Center

In cooperation with USDA

Feeding Tilapia in Intensive Recirculating Systems

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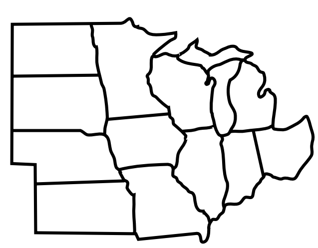
Benefits of Culturing Tilapia in Recirculating Systems

There are many species of tilapia, but only a few are widely cultured around the world. In the United States the most commonly cultured species of tilapia are the Nile (*nilotica*), Blue (*aurea*), Mozambique (*mossambicus*), Hornorum (*hornorum*), and hybrids such as the Taiwanese and Florida red. Choosing a species to culture depends largely on customer preference, legal status, growth rate and cold tolerance.

Tilapia are well suited for culturing in ponds, cages, tanks, or raceways. Using ponds is the most popular method in the southern United States due to longer growing seasons. In the southern most parts of Texas and in Florida water temperatures can remain warm enough for year-round growth. In the cooler, temperate regions of the North and Midwest, tank culture is favored. Tank culture has the added benefit of reducing time and labor required for harvesting and feeding. Indoor tank culture is the preferred method when sufficient warm water is not available due to climatic conditions.

There are two types of systems used for tank culture; flow-through systems, and recirculating systems. Flow-through systems are only practical if geothermal water or waste heat are available. Indoor recirculating systems offer the advantages of reduced land requirements, less water use, and environmental control for year-round growth. Recirculating systems can recycle as much as 99 percent of the culture water daily, although 90 percent recirculation is the preferred target. To make these systems cost effective the fish are generally reared intensively. Intensive recirculating tank culture can produce high yields on small plots of land with little water use. However, recirculating systems tend to be energy intensive and require high capital investments. Therefore, to make them profitable it is important to increase efficiency through feeding management.



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Feed Requirements of Tilapia in Recirculating Systems

Most wild tilapia are omnivorous, meaning they will eat a variety of things, including both plants and animals. This is in contrast to many other fish that are more specialized. However, like other animals, tilapia have specific requirements for nutrients such as amino acids from protein, fats, minerals and vitamins.

Fish reared in intensive recirculating systems have different nutritional requirements than those in the wild. Wild tilapia graze on blue-green algae and bacteria. This type of feeding requires a lot of energy due to finding and digesting this type of food. To meet the energy required for feeding and growth, they must consume more food relative to farm raised fish. In intensive tank culture natural food is limited. Therefore, all nutrients must be supplied in a complete pelleted diet. An advantage to feeding a pelleted diet is the higher quality and consistency of the diet.

Table 1. Suggested standard pellet sizes used for feeding tilapia from hatching to market size.

Size of fish (grams)	Standard Feed Size
0–3	# 00, or # 0
3–10	# 1
10–25	# 2
25–40	# 3
40–100	3⁄32"
larger than 100	1⁄8"

Requirements for each nutrient are dependent on a number of factors. Some of these factors are biological such as the size, age, condition, and reproductive state of the fish. Environmental factors such as temperature, dissolved oxygen, water quality, and photoperiod also affect requirements. Feeding management including the amount, and frequency of feeding, are also factors. Finally, the diet itself, including the amount and quality of protein, energy, and the method of processing will affect the requirements.

How to Feed Tilapia in Recirculating Systems

The optimum feeding method depends on the physiology of the species, and economics of the production unit. Historically culturists have emphasized maximizing intake in the hopes of maximizing growth. Evidence suggests this may not be the most effective for fish production. Maximizing intake can lead to uneaten feed, lower feed efficiency, and result in more expensive production. Uneaten feed also reduces water quality, fish health, and performance. This is especially true in recirculating systems that use low water exchange.

Types and size of feeds

Newly hatched fry are given a complete diet of powdered feed. The feed should be high in protein (about 50 percent) and energy to meet the demands of the fast growing fry. Feed size is gradually increased in relation to growth. A good rule to follow is, "small fish, small feed; large fish, large feed". However, tilapia prefer smaller size feed than other commonly cultured species, such as salmon, trout or catfish.

The size should be increased through various sizes of crumbles for fingerlings 5 to 40 grams (Table 1). Fish larger than 40 grams should be fed pellets. The most common pellet sizes for tilapia are 3⁄32 inch–1⁄8 inch. Floating pellets are the preferred type because they allow culturists to observe feeding responses. Additionally, the processing method used in making floating pellets increases the amount of energy available to tilapia.

Recommended protein levels for tilapia diets range from 32 to 36 percent in fingerling feed, and 28 to 32 percent in feed for fish larger than 40 grams. The amount of energy provided from fat is generally restricted to 4 to 8 percent of the diet. The higher fat content is fed to small fish and is gradually decreased with increasing size.

Feed selection and storage is important when feeding fish in an intensive recirculating system. A high quality feed with few fine dust-like particles should be used to reduce waste production and minimize the load on the biofiltration and oxygen systems. Feed should be kept in a dry, cool place to ensure maximum quality and avoid mold formation.

Feed rates

Feeding rates will vary with fish size and water temperature. The appropriate amount is measured as a percent of the average body weight. As the fish weight increases, the percent body weight fed decreases (Table 2). The daily feed ration must be adjusted to compensate for growth.

Fry grow rapidly and will gain close to 50 percent in body weight every 3 days. The feed rations should be adjusted accordingly. Daily feed rations should be adjusted weekly between the range of 5–30 grams, and once every two weeks beyond 30 grams.

Because of their rapid growth, high energy requirements, and small stomachs, fry require frequent feeding. Fry should be fed as many

Table 2. Example of daily feeding allowances for different sizes of tilapias at 28°C (82°F). Source: National Research Council. 1993. Nutrient Requirements of Fish. National Academy Press, Washington, D.C.

Size of fish (grams)	Amount of daily feed (% of fish weight)
0–1	30–10
1–5	10–6
5–20	6–4
20–100	4–3
larger than 100	3–1.5

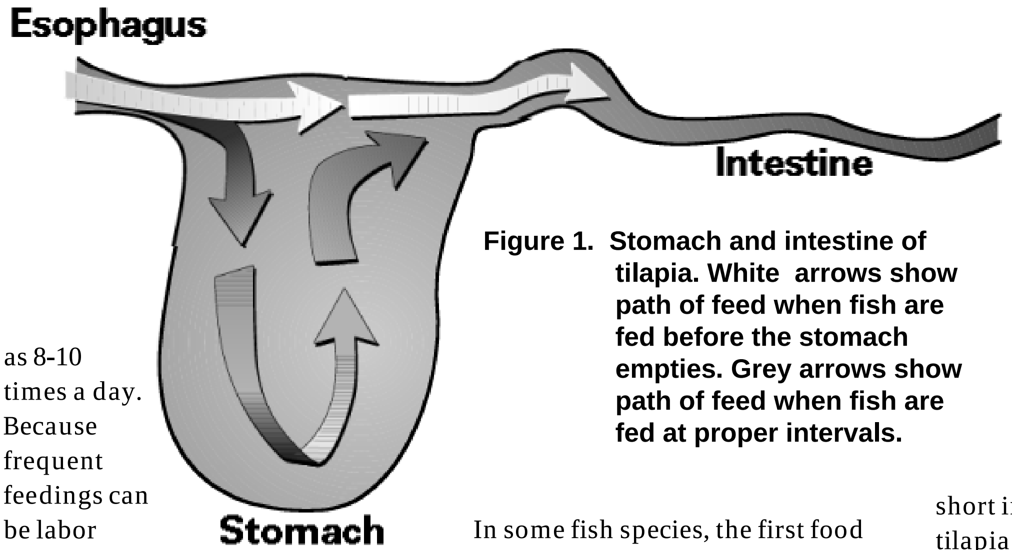

Figure 1. Stomach and intestine of tilapia. White arrows show path of feed when fish are fed before the stomach empties. Grey arrows show path of feed when fish are fed at proper intervals.

as 8-10 times a day. Because frequent feedings can be labor intensive, an alternative is to feed fry continuously throughout the day with automatic feeders. Automatic feeders should be checked frequently and adjusted if necessary to avoid over feeding which can foul water quality.

Fingerlings also grow fast and should be fed at least four times a day. Fish should be fed less when water temperature decreases.

Feeding Frequency

The interval between feedings may be more important than the total number of feedings. Feeding strategies for tilapia have traditionally been to feed a little bit of feed at frequent intervals. This strategy comes from early work on wild tilapia that eat algae. However, the higher quality and consistency of pelleted diets eliminate the need for many frequent feedings.

The optimal interval between feedings will depend on the return of appetite. Fish eat available food depending on stomach fullness, and at intervals determined by the time it takes to empty the stomach. The speed the stomach empties depends on temperature, fish weight, meal size, feed composition, and feeding frequency.

In some fish species, the first food entering the stomach is the first food to leave. However, food eaten by tilapia can move past the stomach and enter directly into the intestine (Figure 1). Fish fed at 2–3 hour intervals eat more feed than their stomachs can hold (Figure 2). The extra feed eaten passes over the stomach and is considered wasted. The result is an increased cost of production and lower profits. Fish fed at 4–5 hour intervals eat nearly the same amount of feed needed to refill their stomachs. This suggests the optimal interval between feedings is 4–5 hours, depending on the energy and composition of the diet.

Increased feeding frequencies decrease aggressive behavior in some fish species. This results in faster growth and less size variation. However, there is a limit to the frequency that will result in benefits. There are many fish species that are less efficient when fed at short intervals. Evidence suggests tilapia fed too frequently utilize feed less efficiently.

Water quality concerns

Fish are sensitive to water quality. Feeding should be reduced or stopped if water quality falls below certain levels. Shortly after feeding, dissolved oxygen levels decline rapidly. Dissolved oxygen levels should be maintained above 5.0 ppm for best growth. At dissolved oxygen levels between 3.0–5.0 ppm feeding should be reduced, and feeding should be stopped at dissolved oxygen levels below 3.0 ppm.

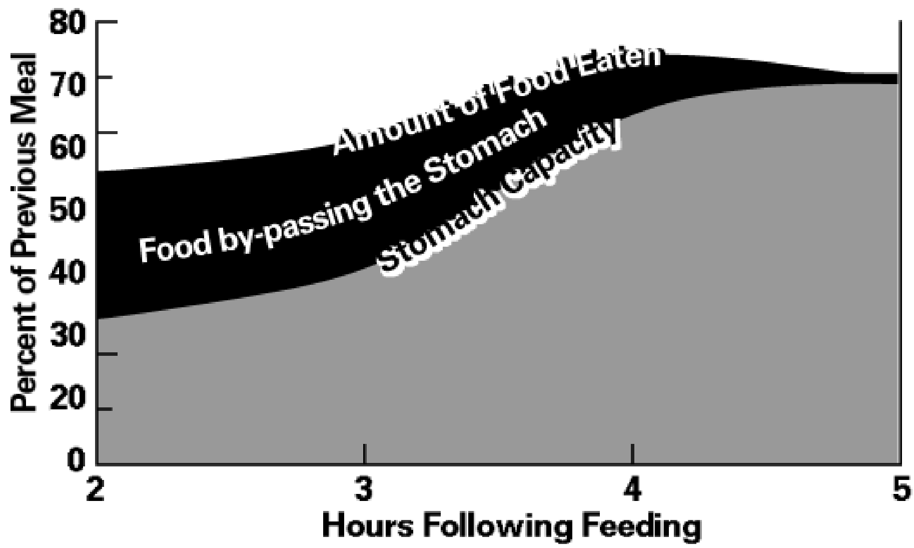

Figure 2. Amount of food eaten at different time intervals between meals. The stomach capacity is the amount of room in the stomach before eating again. The shaded area is the amount of food eaten that by-passes the stomach because of lack of room.

Ammonia and nitrite are a concern in intensive recirculating systems and should be monitored regularly. Ammonia production is directly related to feeding and depends on the quality of feed, feeding rate, fish size, and temperature. Following feeding activity ammonia levels begin to rise. In most species of fish, ammonia production peaks 4–6 hours following feedings.

In water, ammonia exists in two forms, ammonia (NH_3, or unionized ammonia) and ammonium (NH_4^+, or ionized ammonia). The form that is most toxic to fish is NH_3. Both forms are present at all times in the water, but the percentage of each depends on temperature and pH of the system. Warmer water and higher pH in the system favors the more toxic NH_3.

Unfortunately the term ammonia is often used to refer to both the toxic NH_3 (given as mg / L NH_3-N) and the two forms ($NH_3 + NH_4^+$) added together. This often leads to confusion, therefore culturists often refer to ($NH_3 + NH_4^+$) as the total ammonia nitrogen (given as mg / L-TAN). When measuring or discussing ammonia concentrations it is important to be clear which term is being used.

The lethal ammonia concentration for most warmwater fish is between 0.6–2.0 mg / L NH_3-N (1 mg / L = 1 ppm). Tilapia begin to die when unionized ammonia concentrations are higher than 2.0 mg / L NH_3-N. However, unionized ammonia concentrations as low as 1.0 mg / L NH_3-N will decrease growth and performance in tilapia.

Generally smaller fish are more sensitive to the toxic effects of ammonia. Low dissolved oxygen also increases the toxicity of ammonia and lowers the concentration that affects fish. When ammonia concentrations remain elevated, or fish show signs of stress, feeding should be reduced or stopped.

Conclusion

Tilapia are well suited for aquaculture. Tilapia grow rapidly and are fairly resistant to stress and disease. However, due to climatic conditions, the culture of tilapia in most of the United States requires the use of intensive recirculating systems and formulated diets. Recirculating systems can be expensive to build and operate therefore it is important to maximize production efficiency.

To maximize production efficiency and minimize costs, tilapia should be fed:

- Nutritionally complete diets formulated to meet their dietary requirements;
- Optimum crumble or pellet size;
- Optimum feeding rate (% of fish body weight);
- Optimum time intervals (4 – 5 hours depending on the energy and composition of the diet); based on the size of the fish and the culture conditions.

Additional Reading

Many extension articles on tilapia and their culture can be downloaded from the AquaNIC web site: http: / / aquanic.org—Check out **Tilapia and Recycle** under the **Beginner** drop down menus for **Species and Systems**, respectively.

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