

## **FIS 307: FISH ECOLOGY (2 UNITS)**

### **Food and Feeding Habits in Fish**

There are four basic eating groups among fish: carnivores, herbivores, omnivores and limnivores. Each group of fish needs to be fed in a particular way.

Carnivores are meat-eating fish. Whilst they will never damage your plant life, you will be lucky if you do not find any of the smaller fish disappearing mysteriously. If there are smaller fish in the aquarium with a carnivore, sooner or later the smaller fish will end up in the carnivore's stomach. Carnivores need at least 45% of protein in their food, without which they become severely malnourished. Although many of the prepared foods are spiked with extra protein to help such fish, carnivores are happiest when they are fed live food like worms. An added benefit is that chasing their prey seems to whet their appetite even further. Recommended food for the carnivores would be:

- Earthworms, Red worms, Tubifex worms and Daphnia.
- Larvae of mosquitoes or fruit flies.
- Oysters, shrimps, clams and other fish. If these are kept frozen, they need to be thawed and then sliced into slivers.
- Lean chicken, turkey and salmon. These should be cooked, but never fried.
- Supplements in the form of flakes or granules and pellets for added nutrition.

Herbivorous fish are those that will eat only plants. These fish need to graze very often, and whether they are fed regularly or not, they will nip at your plant life. Many aquarists who like herbivores keep plastic plants in their aquarium. If real plants are used, the aquarium runs a risk of having a badly mauled garden. It is a good idea to feed these fish with fresh veggies. Planting leafy vegetables like spinach into the substrate is a good trick. The fish will keep nipping at these. Care should be taken to remove the frayed plants before they start decaying and rotting in the water.

Recommended foods for this variety are:

- Cucumber, peas and potatoes. These can be kept frozen and be chopped into tiny pieces at mealtime.
- Vegetable flakes come in a variety of flavors.
- Algal flakes will also be a favorite among this kind of fish.

Omnivore fish will eat pretty much anything, and that makes them dangerous to plants as well as to other smaller creatures in your aquarium. They are also voracious eaters and aquarists can sometimes mistake their eating frenzy for hunger. It is a common tendency to overfeed these species, and they do tend to pile on the fat very quickly if overfed.

Limnivores are also known as mud-eaters. Limnivore fish feed mainly on algae and on the microorganisms in your aquarium. These kinds of fish are constantly eating, and can be given

pellets and algae based foods.

Proper feeding practices are a matter of habit. They require some amount of patience, observation and consideration. Understanding your fish and appreciating the differences between the different species help a lot when you feed them. The type of food, the culture conditions and the individual fish will all affect the quantity of food you should provide. In nature, there may be times when an adult fish starves for a day or two, or even for longer periods of time. The younger fish need more frequent feedings than the older ones. The fry have their own feeding needs.

Most feeding problems arise due to overfeeding. More food also means more waste. The excess food will putrefy and degrade the water quality. Under gravel filters can get clogged with uneaten food wastes. Frequent water changes along with cleaning of decorations, rearranging of plants etc will help to control the debris collection in the aquarium. Loaches, catfish and other common bottom-feeding fish will help keep the aquarium clean.

Deficiencies in vitamins can cause stunted growth, loss of appetite, cloudy eyes, weakness or tumors in fish. For this reason it is advisable to give your fish vitamin supplements from time to time. No supplement should be left too long in your water. Adding any unnatural substance into your aquarium should be followed up by a water change in a day or two. This will keep the fish as well as the beneficial bacterial colony thriving.

## NICHE CONCEPT

Every organism has a place to live in nature, a functional role in that place, and a complex set of adaptations for reproducing its kind. On the surface, this observation might seem to be obvious, even trivial. However, in order to understand our biological world—the biosphere, how it operates and ultimately how to protect it—we need to understand at a deep level how organisms interact with each other and with their physical environment.

In this chapter we will examine further some of the concepts that ecologists use to organize their thoughts about the ways in which organisms use their environment, relate to each other, and assemble into communities or ecosystems. The most fundamental and perhaps most difficult of these concepts is that of the **ecological niche**. A niche refers to the way in which an organism fits into an ecological community or ecosystem. Through the process of natural selection, a niche is the evolutionary result of a species' morphological (morphology refers to an organism's physical structure), physiological, and behavioral adaptations to its surroundings. A **habitat** is the actual location in the environment where an organism lives and consists of all the physical and biological resources available to a species. The collection of all the habitat areas of a species constitutes its **geographic range**. We will examine each of these concepts in turn using a historical approach where appropriate and discuss how these ideas can help us to understand the issues of modern conservation biology.

## GEOGRAPHICAL RANGES

One of the first things that people noticed as they started to study and write about the world was that when they visited different parts of the earth they found different species. In fact, most

species have limited distributions. Giraffes, for example, are found only in Africa, koalas only in Australia, and lemurs only in Madagascar. If we choose a particular species, plot a point on a map of the world for every place in which it is found, and then draw a line surrounding all of the points, we will have delimited its geographical range. Figure 7.1 is a range map for three species found in the United States. Some species, such as the Devil's Hole pupfish that only lives in one particular desert spring, have a geographical range of just a few square meters; others (e.g., human beings) range over most of the land area of the earth. Most species, though, have intermediate-sized distributions, as does the bighorn sheep.

## Food Chains and Food Webs

"What's for dinner?"

### Sample Food Chains

Every organism needs to obtain energy in order to live. For example, plants get energy from the sun, some animals eat plants, and some animals eat other animals.

A food chain is the sequence of who eats whom in a biological community (an ecosystem) to obtain nutrition. A food chain starts with the primary energy source, usually the sun or boiling-hot

deep sea vents. The next link in the chain is an organism that make its own food from the primary energy source -- an example is photosynthetic plants that make their own food from sunlight (using a process called **photosynthesis**) and chemosynthetic bacteria that make their food energy from chemicals in hydrothermal vents. These are called **autotrophs** or **primary producers**.

Next come organisms that eat the autotrophs; these organisms are called **herbivores** or **primary consumers** -- an example is a rabbit that eats grass.

Trophic Level	Grassland Biome	Pond Biome	Ocean Biome
Primary Producer	grass ↓	algae ↓	phytoplankton ↓
Primary Consumer	grasshopper ↓	mosquito larva ↓	zooplankton ↓
Secondary Consumer	rat ↓	dragonfly larva ↓	fish ↓
Tertiary Consumer	snake ↓	fish ↓	seal ↓
Quaternary Consumer	hawk	raccoon	white shark

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The next link in the chain is animals that eat herbivores - these are called **secondary consumers** -- an example is a snake that eat rabbits.

In turn, these animals are eaten by larger predators -- an example is an owl that eats snakes.

The tertiary consumers are are eaten by **quaternary consumers** -- an example is a hawk that eats owls. Each food chain end with a **top predator**, and animal with no natural enemies (like an alligator, hawk, or polar bear).

The arrows in a food chain show the flow of **energy**, from the sun or hydrothermal vent to a top predator. As the energy flows from organism to organism, energy is lost at each step. A network of many **food chains** is called a **food web**.

### **Trophic Levels:**

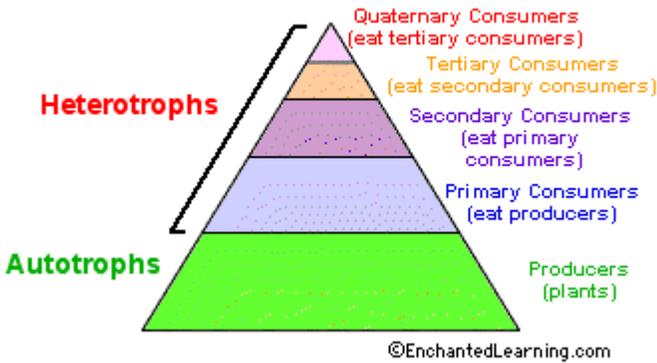
The trophic level of an organism is the position it holds in a food chain.

1. **Primary producers** (organisms that make their own food from sunlight and/or chemical energy from deep sea vents) are the base of every food chain - these organisms are called **autotrophs**.
2. **Primary consumers** are animals that eat primary producers; they are also called **herbivores** (plant-eaters).
3. **Secondary consumers** eat primary consumers. They are **carnivores** (meat-eaters) and **omnivores** (animals that eat both animals and plants).
4. **Tertiary consumers** eat secondary consumers.
5. **Quaternary consumers** eat tertiary consumers.
6. Food chains "end" with top predators, animals that have little or no natural enemies.

When any organism dies, it is eventually eaten by **detritivores** (like vultures, worms and crabs) and broken down by **decomposers** (mostly bacteria and fungi), and the exchange of energy continues.

Some organisms' position in the food chain can vary as their diet differs. For example, when a bear eats berries, the bear is functioning as a primary consumer. When a bear eats a plant-eating rodent, the bear is functioning as a secondary consumer. When the bear eats salmon, the bear is functioning as a tertiary consumer (this is because salmon is a secondary consumer, since salmon eat herring that eat zooplankton that eat phytoplankton, that make their own energy from sunlight). Think about how people's place in the food chain varies - often within a single meal.

## The Food Web



### Numbers of Organisms:

In any food web, energy is lost each time one organism eats another. Because of this, there have to be many more plants than there are plant-eaters.

There are more autotrophs than heterotrophs, and more plant-eaters than meat-eaters.

Although there is intense competition between animals,

there is also an interdependence. When one species goes extinct, it can affect an entire chain of other species and have unpredictable consequences. herbivores, decreasing the herbivore population. It then becomes harder and harder for the carnivores to find herbivores to eat, and the population of carnivores decreases. In this way, the carnivores and herbivores stay in a relatively stable equilibrium, each limiting the other's population. A similar equilibrium exists between plants and plant-eaters.

## Reproductive Behaviour and Life Cycle of Nile Tilapia

### Nile Tilapia: Life History and Biology

The Nile tilapia (*O. niloticus*) was one of the first fish species cultured. Illustrations from Egyptian tombs suggest that Nile tilapia were cultured more than 3,000 years ago. Tilapia have been called "Saint Peter's fish" in reference to biblical passages about the fish fed to the multitudes. The Nile tilapia is still the most widely cultured species of tilapia in Africa.

Positive aquacultural characteristics of tilapia are their tolerance to poor water quality and the fact that they eat a wide range of natural food organisms. Biological constraints to the development of commercial tilapia farming are their inability to withstand sustained water temperatures below 50 to 52°F and early sexual maturity that results in spawning before fish reach market size. Following is a discussion of the characteristics and culture of nonhybrid tilapia.

### Taxonomy

"Tilapia" is the generic name of a group of cichlids endemic to Africa. The group consists of three aquaculturally important genera – *Oreochromis*, *Sarotherodon* and *Tilapia*. Several characteristics distinguish these three genera, but possibly the most critical relates to reproductive behavior. All tilapia species are nest builders; fertilized

eggs are guarded in the nest by a brood parent. Species of both *Sarotherodon* and *Oreochromis* are mouth brooders; eggs are fertilized in the nest but parents immediately pick up the eggs in their mouths and hold them through incubation and for several days after hatching. In *Oreochromis* species only females practice mouth brooding, while in *Sarotherodon* species either the male or both male and female are mouth brooders.

During the last half century fish farmers throughout the tropical and semi-tropical world have begun farming tilapia. Today, all commercially important tilapia outside of Africa belong to the genus *Oreochromis*, and more than 90 percent of all commercially farmed tilapia outside of Africa are Nile tilapia. Less commonly farmed species are Blue tilapia (*O. aureus*), Mozambique tilapia (*O. Mossambicus*) and the Zanzibar tilapia (*O. urolepis hornorum*). The scientific names of tilapia species have been revised a lot in the last 30 years, creating some confusion. The scientific name of the Nile tilapia has been given as *Tilapia nilotica*, *Sarotherodon niloticus*, and currently as *Oreochromis niloticus*.

### ***Physical characteristics***

Tilapia are shaped much like sunfish or crappie but can be easily identified by an interrupted lateral line characteristic of the Cichlid family of fishes. They are laterally compressed and deep-bodied with long dorsal fins. The forward portion of the dorsal fin is heavily spined. Spines are also found in the pelvis and anal fins. There are usually wide vertical bars down the sides of fry, fingerlings, and sometimes adults.

### ***Banding Patterns and Coloration***

The main cultured species of tilapia usually can be distinguished by different banding patterns on the caudal fin. Nile tilapia have strong vertical bands, Blue tilapia have interrupted bands, and Mozambique tilapia have weak or no bands on the caudal fin. Male Mozambique tilapia also have upturned snouts. Color patterns on the body and fins also may distinguish species. Mature male Nile tilapia have gray or pink pigmentation in the throat region, while Mozambique tilapia have a more yellow coloration. However, coloration is often an unreliable method of distinguishing tilapia species because environment, state of sexual maturity, and food source greatly influence color intensity.

The red tilapia has become increasingly popular because its similar appearance to the marine red snapper gives it higher market value. The original red tilapias were genetic mutants. The first red tilapia, produced in Taiwan in the late 1960s, was a cross between a mutant reddish- orange female Mozambique tilapia and a normal male Nile tilapia. It was called the Taiwanese red tilapia. Another red strain of tilapia was developed in Florida in the 1970s by crossing a normal colored female Zanzibar tilapia with a red-gold Mozambique tilapia.

A third strain of red tilapia was developed in Israel from a mutant pink Nile tilapia crossed with wild Blue tilapia. All three original strains have been crossed with other red tilapia of unreported origin or with wild *Oreochromis* species. Consequently, most red

tilapia in the Americas are mosaics of uncertain origin. The confused and rapidly changing genetic composition of red tilapia, as well as the lack of head-to-head growth comparisons between the different lines, make it difficult for a producer to identify a best red strain. Other strains of tilapia selected for color include true breeding gold and yellow Mozambique lines and a Rocky Mountain white tilapia (a true breeding line originating from an aberrant Blue tilapia, subsequently crossed with Nile tilapia). Most strains selected for color do not grow well enough for food fish culture.

Identifying the species of an individual fish is further complicated by natural crossbreeding that has occurred between species. Electrophoresis is often used to determine the species composition of a group of tilapia.

### ***Reproduction***

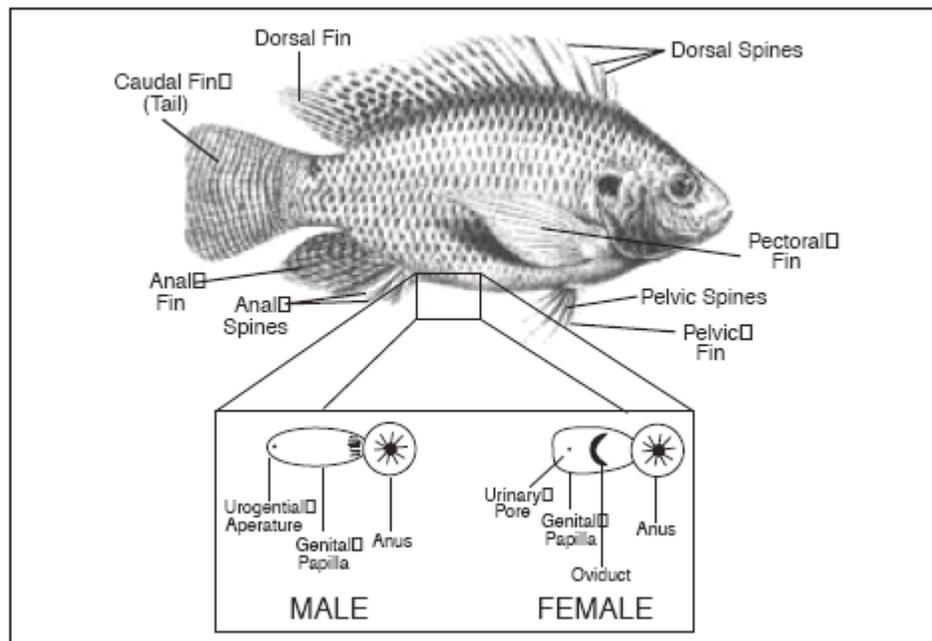
In all *Oreochromis* species the male excavates a nest in the pond bottom (generally in water shallower than 3 feet) and mates with several females. After a short mating ritual the female spawns in the nest (about two to four eggs per gram of brood female), the male fertilizes the eggs, and she then holds and incubates the eggs in her mouth (buccal cavity) until they hatch. Fry remain in the female's mouth through yolk sac absorption and often seek refuge in her mouth for several days after they begin to feed.

Sexual maturity in tilapia is a function of age, size and environmental conditions. The Mozambique tilapia reaches sexual maturity at a smaller size and younger age than the Nile and Blue tilapias. Tilapia populations in large lakes mature at a later age and larger size than the same species raised in small farm ponds. For example, the Nile tilapia matures at about 10 to 12 months and 3/4 to 1 pound (350 to 500 grams) in several East African lakes. Under good growth conditions this same species will reach sexual maturity in farm ponds at an age of 5 to 6 months and 5 to 7 ounces (150 to 200 grams). When growth is slow, sexual maturity in Nile tilapia is delayed a month or two but stunted fish may spawn at a weight of less than 1 ounce (20 grams). Under good growing conditions in ponds, the Mozambique tilapia may reach sexual maturity in as little as 3 months of age, when they seldom weigh more than 2 to 4 ounces (60 to 100 grams). In poorly fertilized ponds sexually mature Mozambique tilapia may be as small as 1/2 ounce (15 grams).

Fish farming strategies that prevent overcrowding and stunting include: 1) cage farming where eggs fall through the mesh to the pond bottom before the female can collect them for brooding; 2) polyculture with a predator fish, such as fingerling largemouth bass, at 400 per acre; and 3) culture of only males (monosex). All-male culture is desirable in ponds not only to prevent overpopulation and stunting but also because males grow about twice as fast as females. Methods of obtaining predominately male fish include: 1) manually separating the sexes based on visual examination of the genital papilla of juvenile fish (hand-sexing); 2) hybridizing between two selected species that produce all-male offspring (for example, Nile or Mozambique females crossed with Blue or Zanzibar males); 3) feeding a male hormone-treated feed to newly hatched fry for 3 to 4 weeks to produce reproductively functional males (sex reversal); or 4) YY male

technology (currently under development and not yet a commercial option).

The sex of a 1-ounce (25-gram) tilapia fingerling can be determined by examining the genital papilla located immediately behind the anus (Fig. 1). In males the genital papilla has only one opening (the urinary pore of the ureter) through which both milt and urine pass. In females the eggs exit through a separate oviduct and only urine passes through the urinary pore. Placing a drop of dye (methylene blue or food coloring) on the genital region helps to highlight the papilla and its openings.



*Figure 1. Fins and genital papilla of the Nile Tilapia.*