

## Soil Biology

### The Soil Biology Primer

#### Chapter 5: SOIL PROTOZOA

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#### THE LIVING SOIL: PROTOZOA

Protozoa are single-celled animals that feed primarily on bacteria, but also eat other protozoa, soluble organic matter, and sometimes fungi. They are several times larger than bacteria – ranging from 1/5000 to 1/50 of an inch (5 to 500  $\mu\text{m}$ ) in diameter. As they eat bacteria, protozoa release excess nitrogen that can then be used by plants and other members of the food web.

Protozoa are classified into three groups based on their shape: *Ciliates* are the largest and move by means of hair-like cilia. They eat the other two types of protozoa, as well as bacteria. *Amoebae* also can be quite large and move by means of a temporary foot or “pseudopod.” Amoebae are further divided into *testate amoebae* (which make a shell-like covering) and *naked amoebae* (without a covering). *Flagellates* are the smallest of the protozoa and use a few whip-like flagella to move.



Figure 1: Protozoa play an important role in nutrient cycling by feeding intensively on bacteria. Notice the size of the speck-like bacteria next to the oval protozoa and large, angular sand particle.

**Credit:** Elaine R. Ingham



Figure 3: Flagellates have one or two flagella which they use to propel or pull their way through soil. A flagellum can be seen extending from the protozoan on the left. The tiny specks are bacteria.

**Credit:** Elaine R. Ingham



Figure 2: Bacteria ingested by an amoeba.

**Credit:** No. 35 from Soil Microbiology and Biochemistry Slide Set. 1976. J.P. Martin, et al., eds. SSSA, Madison, WI

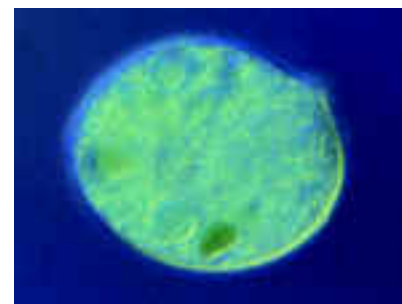


Figure 6: Ciliates are the largest of the protozoa and the least numerous. They consume up to ten thousand bacteria per day, and release plant available nitrogen. Ciliates use the fine cilia along their bodies like oars to move rapidly through soil.

**Credit:** Elaine R. Ingham

#### WHAT DO PROTOZOA DO?

Protozoa play an important role in mineralizing nutrients, making them available for use by plants and other soil organisms. Protozoa (and nematodes) have a lower concentration of nitrogen in their cells than the bacteria they eat. (The ratio of carbon to nitrogen for protozoa is 10:1 or much more and 3:1 to 10:1 for bacteria.) Bacteria eaten by protozoa contain too much nitrogen for the amount of carbon protozoa need. They release the excess nitrogen in the form of ammonium ( $\text{NH}_4^+$ ). This usually occurs near the root system of a plant. Bacteria and other organisms rapidly take up most of the ammonium, but some is used by the plant. (See figure for explanation of mineralization and immobilization.)



Another role that protozoa play is in regulating bacteria populations. When they graze on bacteria, protozoa stimulate growth of the bacterial population (and, in turn, decomposition rates and soil aggregation.) Exactly why this happens is under some debate, but grazing can be thought of like pruning a tree – a small amount enhances growth, too much reduces growth or will modify the mix of species in the bacterial community.

Protozoa are also an important food source for other soil organisms and help to suppress disease by competing with or feeding on pathogens.

## WHERE ARE PROTOZOA?

Protozoa need bacteria to eat and water in which to move, so moisture plays a big role in determining which types of protozoa will be present and active. Like bacteria, protozoa are particularly active in the rhizosphere next to roots.

Typical numbers of protozoa in soil vary widely – from a thousand per teaspoon in low fertility soils to a million per teaspoon in some highly fertile soils. Fungal-dominated soils (e.g. forests) tend to have more testate amoebae and ciliates than other types. In bacterial-dominated soils, flagellates and naked amoebae predominate. In general, high clay-content soils contain a higher number of smaller protozoa (flagellates and naked amoebae), while coarser textured soils contain more large flagellates, amoebae of both varieties, and ciliates.

## NEMATODES AND PROTOZOA

Protozoa and bacterial-feeding nematodes compete for their common food resource: bacteria. Some soils have high numbers of either nematodes or protozoa, but not both. The significance of this difference to plants is not known. Both groups consume bacteria and release  $\text{NH}_4^+$ .

### BUG BIOGRAPHY: Soil Dwelling Vampires

Most protozoa eat bacteria, but one group of amoebae, the vampyrellids, eat fungi. The perfectly round holes drilled through the fungal cell wall, much like the purported puncture marks on the neck of a vampire's victim, are evidence of the presence of vampyrellid amoebae. The amoebae attach to the surface of fungal hyphae and generate enzymes that eat through the fungal cell wall. The amoeba then sucks dry or engulfs the cytoplasm inside the fungal cell before moving on to its next victim.

Vampyrellids attack many fungi including root pathogens, such as *Gaeumannomyces graminis*, shown in the photo. This fungus attacks wheat roots and causes take-all disease.

