Notes from the Underground[1]

1. Invertebrates beneath the canopy

All sorts of invertebrates make their home in the soil: springtails, mites, fly larvae, beetle larvae, millipedes, centipedes, earthworms and many others. Some of these organisms number millions per acre and constitute a considerable biomass. The total weight of earthworms may equal the weight of livestock that can be supported on the land. Some of the organisms, like wireworms and leatherjackets, feed directly on living plant material, but most consume dead organic matter or other soil invertebrates. The soil fauna is important in cycling energy, nitrogen and other nutrients among the various components in the system, including the microorganisms and forage crops.

Manure increases invertebrate populations in forage fields. A trial at PARC (Agassiz) showed that repeated applications of manure increased populations of voracious soil-dwelling insects called 'carabid ground beetles' (Fig. 1 and 2).

Several species of carabid were found. Fig. 1 shows the relative size of some of the beetles, from 0.3-2.5 cm (0.1-1 in). They are generalist predators that will feed on anything they can handle! Some examples:

- *Bembidion* species—insect eggs;
- *Calathus fuscipes*—caterpillars, aphids, weevils;
- *Pterostichus melanarius*—caterpillars, aphids, weevils;
- *Carabus* species—insects and earthworms;
- *Carabus granulatus*—insects, earthworms and slugs.
- *P. melanarius*—appears to be the dominant species in the Agassiz trial. This beetle can eat more than three times its own weight per day. No correlation has yet been made between available food and the carabid populations. In principle, increased carabid populations should reduce the numbers of important pests of forage crops, such as wireworms and leatherjackets, but the overall effect has yet to be determined.

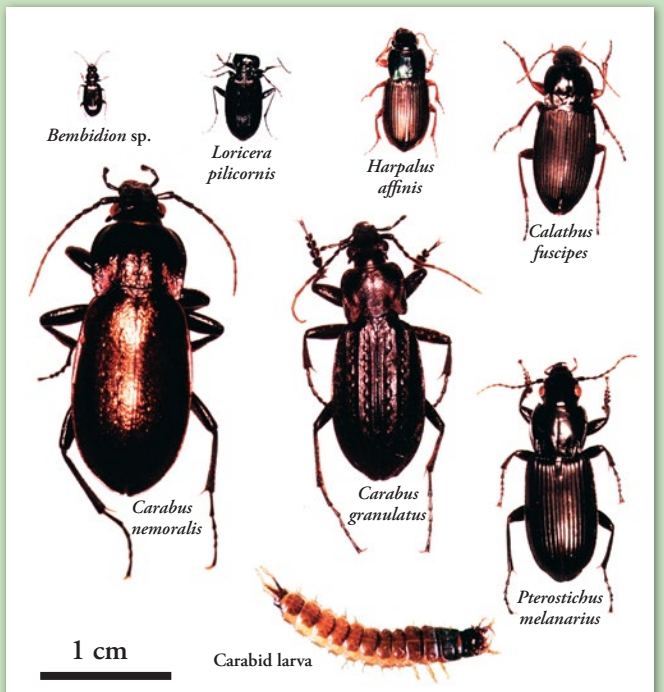

Figure 1. Carabid beetles found in a forage-manure trial at Agassiz, BC. (Photo by J.Troubridge and M.Knott, AAFC)

Dave Raworth Agriculture and Agri-Food Canada, Agassiz, BC, Canada (retired)

2. Microscopic creatures of the underworld

Manure contains various 'foodstuffs' (carbohydrates, fatty acids, amino acids, peptides) that provide energy for growth of bacteria and fungi. Therefore, the addition of manure to soil promotes growth of soil microorganisms.

The growing microbes have a great appetite for available nitrogen, from the manure or soil, which they consume and incorporate into their bodies. This nitrogen is 'immobilized' as it is made unavailable for plants or other microbes. The speed of immobilization by microbes is affected by the makeup of the biological community and the conditions in the soil.

Addition of nitrogen fertilizer to nitrogen-deficient soils promotes microbial growth, which temporarily immobilizes some of the fertilizer. Adding manure or other soil additives with high carbon:nitrogen ratios helps to immobilize the nitrogen in the soil.

1. Originally published in *Advanced Forage Management,* Bittman et al. 1999.

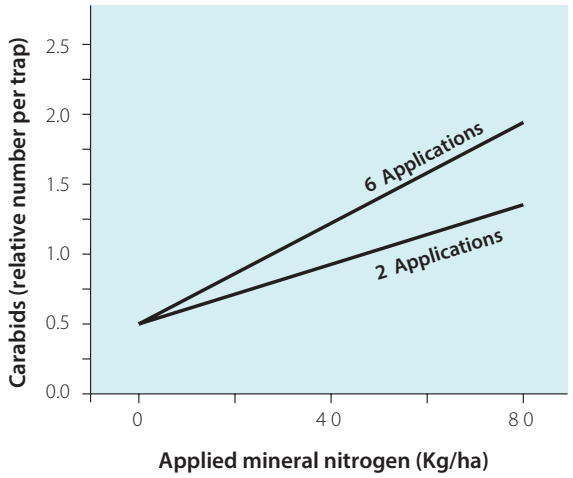

Figure 2. Carabid beetle populations in soil planted to tall fescue are affected by repeated manure and fertilizer application at PARC (Agassiz), BC.

Two kinds of microscopic animals (microfauna) in the soil graze on the bacteria and fungi that immobilize nitrogen. These are single-cell 'protozoa' and miniature roundworms called 'nematodes'. Although these animals make up less than 10% of the living microorganisms in the soil, they control the populations of bacteria and fungi.

As they feed on microbes and grow, the 'micro-animals' excrete ammonium back into the soil. They also stimulate turnover of the remaining microbial biomass and promote activity of enzymes involved in breaking down nitrogen-containing molecules such as proteins. Release of nitrogen from the living and non-living organic material in the soil is called *mineralization*.

It is evident that soil 'micro-animals' affect plant growth. In controlled environment studies, plants grown in soil with both microbes and protozoa were able to take up 40-75% more nitrogen than plants grown in soil without the protozoa. Unfortunately, it is difficult to quantify the contribution of the 'micro-animals' to mineralization of nitrogen even when their population is known. Even without protozoa and nematodes, nitrogen in the microbial cells is gradually released as energy sources are depleted and microbes die.

A study at PARC (Agassiz) compared the effects of repeated applications of manure and fertilizer on soil microorganisms under a grass stand. Immediately after the manure was applied, bacteria populations doubled (see Fig. 3). The bacterial growth probably stimulated the short-lived peak of protozoa. The repeated manured plots sustained high populations of bacteria-eating nematodes.

In contrast to manure, nitrogen fertilizer slightly depressed bacteria populations and had no effect on nematodes. In fact, populations of bacteria-feeding nematodes and protozoa were several times greater in manured than in fertilized plots. Interestingly, both manure and fertilizer reduced soil fungi compared to the control.

This study shows that applying manure causes massive unseen changes in soil microbes. The rising bacteria population captures some of the nitrogen that would be available to plants, immobilizing this nitrogen. But the surge of protozoa and the resident populations of bacteria-eating nematodes help to release (mineralize) some of the nitrogen back into the soil. Soils with a history of manure application have a more dynamic response to addition of nutrients than soils that receive only fertilizer. Understanding soil microbes is necessary to predict the fate of nitrogen and other nutrients in the soil.

Tom Forge Agriculture and Agri-Food Canada, Agassiz, BC, Canada | tom.forge@agr.gc.ca

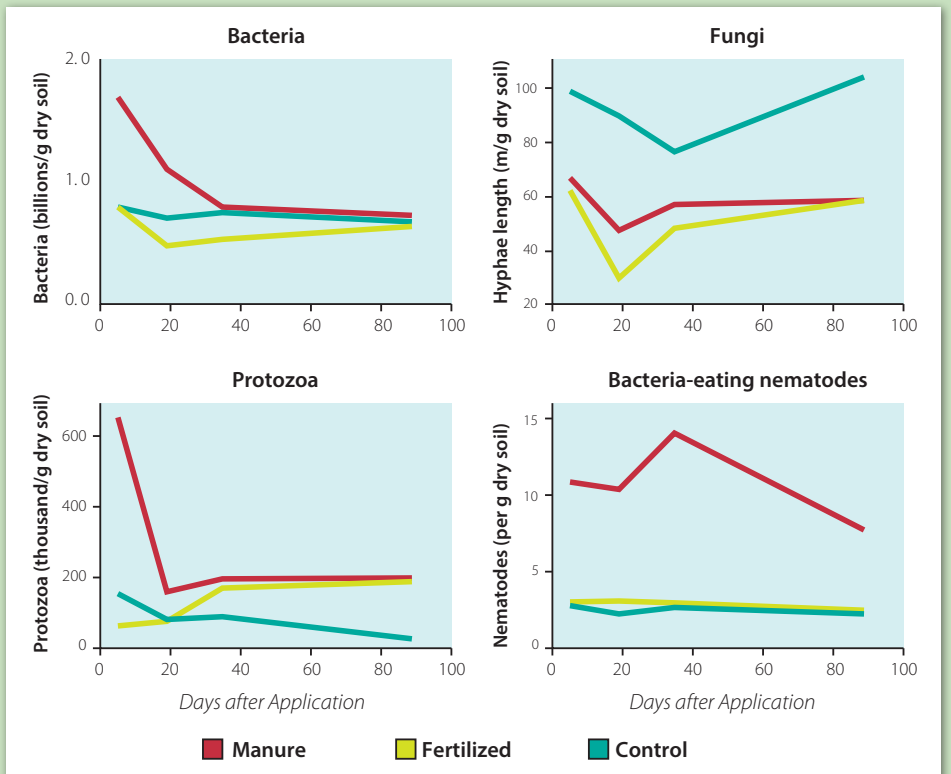

Figure 3. Microscopic creatures of the underworld: application of manure and fertilizer produce different effects on populations of soil microbes.