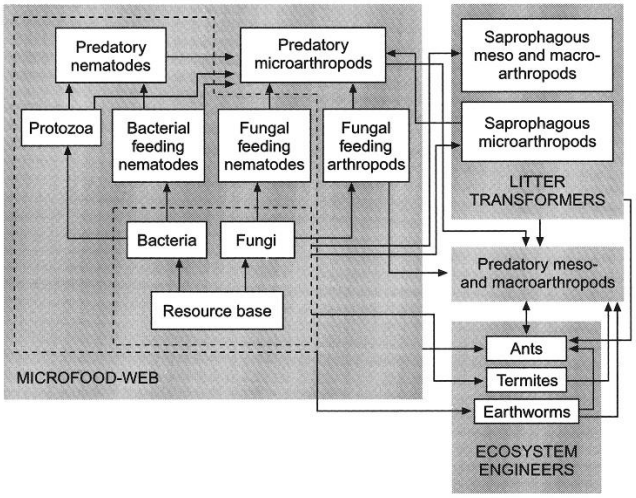
PLANT AND SOIL NEMATODES

ECOSYSTEM SERVICES PROVIDED BY SOIL ARTHROPODS PLAY A KEY ROLE IN KEEPING SOILS HEALTHY

All terrestrial ecosystems consist of a producer subsystem and a decomposer subsystem. The producers (primarily plants) contribute carbon, the energy source that drives the system while the decomposers break down the carbon and release and cycle the nutrients it contains. Arthropods are an important component of the decomposer food web and their roles in keeping plants and soil healthy are discussed below.

The decomposer food web

Bacteria and fungi begin the process of decomposing the organic materials in soil by breaking down cellulose and lignin, two polymers that account for most of the dry matter in leaves and wood. The soil fauna then become involved, and the end result is a soil food web with three functional roles (see diagram below). The **'microfood-web'** consists of the bacteria and fungi that decompose organic matter and the nematodes, protozoa and other animals that directly feed on them and each other. The **'litter transformers'** (arthropods, earthworms and enchytraeids) either shred organic matter into fragments or consume plant debris and egest it as faecal pellets. Since shredding increases the surface area available to decomposers and faecal pellets are highly favourable for microbial growth, the activities of litter transformers increase decomposition rates. The **'ecosystem engineers'** create physical structures that provide a modified habitat for the soil microflora and other soil fauna. Earthworms, for example, stimulate the microflora by improving aeration and moisture conditions, secreting mucous and shredding litter.



The structure of the detritus food web, showing the major groups of organisms and the linkages between them (From Wardle, 2002).

Functional roles of arthropods in the microfood web

Oribatid mites are the most diverse and abundant microarthropods in most soils, often being found at densities of 10^5 – 10^6 individuals/m^2. Springtails are also extremely abundant, often reaching densities of 10^4 – 10^5 individuals/m^2. Both groups are the dominant microarthropods in the microfood web because they feed on decaying plant material and the fungi involved in the decomposition process. Their role is to breakdown organic debris that has already been decomposed to some extent by bacteria and fungi.

As shown in the diagram above, predatory microarthropods also have a place in the microfood web. These mites belong to the Order Mesostigmata and are considered to be specialised predators of nematodes and other members of the micro- and meso-fauna. Studies of one of these mesostigmatid mites (*Protogamasellus mica*) showed that individuals had the capacity to consume huge numbers of free-living and plant-parasitic nematodes, which indicates that their role is to regulate populations of their prey (Stirling et al. 2017).

Examples of Australian mesostigmatid mites that are known to prey on nematodes. From left to right and top to bottom: *Athiasiella* sp. (Ologamasidae); *Asca* sp. (Ascidae); *Rhodacarus* sp. (Rhodacaridae); *Macrocheles* sp. (Macrochelidae); *Stratiolaelaps* sp. (Laelapidae); *Gamasellodes* sp. (Ascidae).
Photographs provided by Dr David Walter.

Main functional roles of litter transformers

Litter transformers break up plant debris into minute fragments, thereby increasing the surface area that can be colonised by microorganisms. These microorganisms, together with the microarthropods fragmenting the debris, temporarily store the nutrients in their bodies until they are eventually consumed by a predator. During the feeding process, nutrients such as nitrogen, which are in an organic form as amino acids, are converted to ammonium (NH_4^+) and ultimately to nitrate (NO_3^-). This process, which occurs with all nutrients, is known as mineralisation, and it means that nutrients are constantly being released from detritus and made available for plant uptake. All soil organisms contribute to this process but oribatid mites and springtails play a major role. Microarthropods also influence the distribution of soil microbial populations by transporting their propagules to other locations.

Main functional roles of ecosystem engineers

The larger arthropods (ants and termites) produce a subterranean network of tunnels and galleries that play an important role in enhancing aeration and water infiltration. A field experiment in Western Australia showed that this is very important in warm, dry habitats, because the presence of ants and termites increased wheat yield by 36% (Evans et al. 2011). The reason for the effect was that the tunnels produced by these arthropods allowed rainwater to infiltrate deeper into the soil, reducing evaporation losses from the soil surface and allowing the plants better access to the available water.

Conclusion

Arthropods improve soil and plant health in several ways

- Predatory microarthropods prey on plant-parasitic nematodes
- Litter transformers fragment plant litter and foster the growth of microorganisms that decompose the litter. The organic nutrients in the litter are then mineralised and released in a controlled and continuous manner for uptake by plants.
- Ecosystem engineers bring substantial amounts of subsoil to the surface, while their tunnelling and burrowing activities improves soil porosity, increases aeration, enhances water-holding capacity, facilitates root penetration, and reduces surface crusting and erosion of topsoil

Further reading and literature cited

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