Soil fauna and its role

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The soil under our feet breathes! But living beings under the earth, and their immense number are not known to many people. However, soil provides life, and is an indispensable resource for life. Biodiversity and coexistence of organisms in the soil, as well as their ecosystem services for human beings as well as for soil development are important.

Soil organisms consists of animals (soil fauna) and plants (soil flora). They are essential components of any soil. This article will provide all information about the animal component of the soil or about the soil fauna.

Soil fauna is categorized into four main groups according to their body size, that is, either length or width of the body. They are the microfauna, mesofauna, macrofauna and megafauna (Wallwork 1970). Figure 1 shows the classification based on body length.

Microfauna are organisms with body size between 20 µm and 200 µm. All animals of protozoa belong to microfauna. Apart from that, small mites, nematodes, rotifers, and tardigrades (water bears or moss piglets) also belong to this category.

Mesofauna are the organisms of body size between 200 µm and 2 mm. Mites and springtails are the main representatives of this group. This group also includes some nematodes, rotifers, tardigrades, small spiders, pseudoscorpions, opiliones, insect larvae, small isopods and myriapods (molluscs).

Organisms whose body size is between 2 mm and 20 mm are categorized as macrofauna. This category includes certain earthworms, millipedes, centipedes, snails and slugs, isopods, some small spiders and most insects.

Soil megafauna are usually classified as the invertebrates in the soil with a body length over 20 mm. This category includes large soil invertebrates such as earthworms and snails.

The value of soil fauna is rarely taken into consideration. One main reason for this situation is that many of us are not aware of their contribution to our food production system. It is very important to know why these fauna are important as a sustainable earth resource. For a better understanding, it is necessary to learn about the functions of these different organisms.

Soil animals are important in soil formation, maintenance of soil structure, decomposition and nutrient release. Some of the many

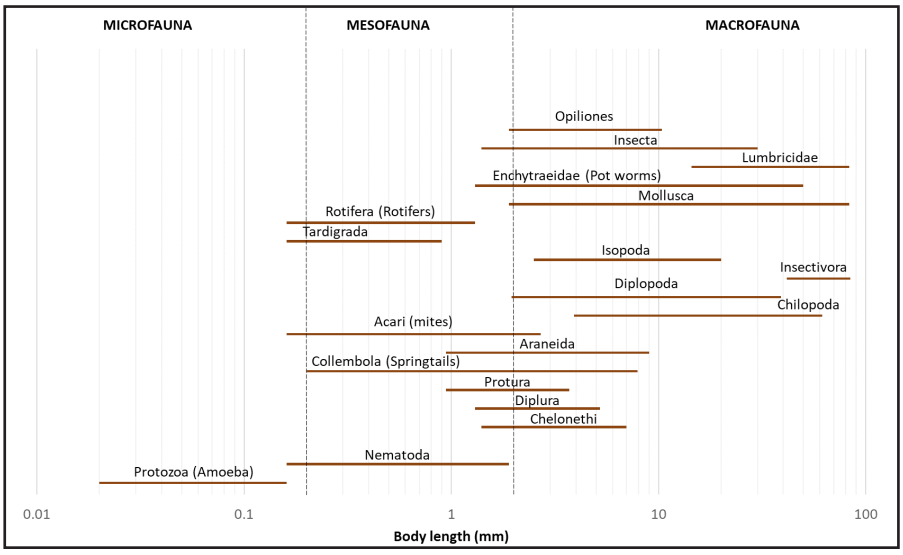

Fig 1: General classification of soil fauna based on body length

Fig 2 : Giant Gippsland earthworm

functions affected by soil organisms include decomposition, nutrient cycling, carbon sequestration, degradation of pollutants, plant protection (through predation of pests) and soil aeration. Thus the food of these organisms is either organic matter and/ or other organisms.
Soil fauna directly and indirectly affect the transport of organic and inorganic materials within the soil systems. Feeding and burrowing activities of larger soil invertebrates, such as earth worms and termites, mix organic matter and mineral particles and modify the physical properties of soil.

Earthworms can be called as engineers in our ecosystem, because they are like human engineers, making tunnels in soil both in horizontal and vertical directions. These tunnels are useful in gas exchange within the soil and to transport water. They also breakdown organic matter into small pieces, which enable bacteria and fungi to feed on it to release nutrients back to the soil. This process is known as decomposition. Earthworms also leave their casts (faeces) in the soil during decomposition, which is a good soil fertilizer. Earthworms are sometimes physically introduced into soils for their beneficial effects on soil structure. They also mix organic matter and soil among different soil profile layers. Because of this reason, Charles Darwin named the earthworms as 'nature's ploughs'. They are in addition a source of food for many other animals such as birds, mammals (mice), amphibians (frogs) and reptiles. Where many earthworms are found in soil, it is common to find more bacterial and fungal activity. There are approximately 6000 earthworm species found worldwide with different body lengths. A good example is the giant Gippsland earthworms (Megascolides australis) found in Australia, which is shown in Figure 2. Some of these are around 3 m in length. Earthworms are the dominant contributors to soil formation in temperate countries.

Fig 3 : Termites

However, in tropical countries like Sri Lanka, ants and termites play a major role in nutrient recycling and transportation of soil material.

It is well known that termites can cause much damage if they invade residences. Nevertheless, there are many advantageous of termites, because they can decompose dead trees and recycle the resulting material back into soil, helping forests to regenerate faster. Their food sources are decaying plant materials, dead foliage, woody materials, roots, seeds and the faeces of higher animals. They also help to aerate the soil so that water and nutrients can easily reach the plant roots. Termites are social insects that live in colonies. They have a queen, as well as workers and soldiers in their colony. The termite nests or mounds are built in different locations such as within the wood of a dead or living tree, above soil surface, or on tree's which are known as arboreal nests. They make arboreal nests to protect from floods, and are made of wood and faecal matter to be light in weight. It is interesting to note that the world's largest termite mounds are as old as pyramids, and could be seen even via satellite images. Such termite mounds are present

Fig 4 : Termite workers inside a termite tunnel

in north-eastern Brazil, which has the land area of Great Britain. They are built in a regularly spaced array as can be see in Figure 5. This is one of the most exciting engineering works done by a single species of termites. Inside these termite mounds many vertical and horizontal tunnels can be seen. These tunnels help to protect termites from predators and from dry environments.

Anthills, similar to termite mounds is another example of a modification of the soil by ants

Fig 6 : A top view of an anthill

(see Figure 6). An anthill consists of chambers which are connected by many tunnels. These chambers provide space for the fungi to grow. These tunnels help to circulate air and water inside the ant hill. In addition, these chambers provide space for rearing larvae and laying eggs. In the process of creating ant hills, fine soil particles are transported to the soil surface, which are more mineral in nature.

Fig 7 : A snail in a moist environment

Other types of megafauna include molluscs such as slugs and snails, which secrete a mucous (glue like liquid) that has a cementing effect on the soil particles, and thereby assisting the stability and structure of the soil to prevent soil erosion. Hence, snails and slugs are also important for our ecosystem (see Figures 7 & 8).

Mesofauna particularly mites and collembola, help to disperse, and to control fungal growth by feeding on them. Mesofauna usually have no ability to change the soil structure because of their smaller body size. Therefore, they usually use the pore spaces already available in the soil to move within the soil. Their activities are high when the soil is moist. If soil is too dry, their body gets dehydrated. A high mesofauna population and a high population diversity is observed when the soil is more porous, and contain more organic matter. They have different feeding behaviours such as plant feeding, microbial feeding, predators or omnivores. Micro- and mesofauna contribute directly to decomposition of organic matte and nutrient recycling. Bacteria, fungi, protozoa and algae are the primary decomposers of organic matter. They are also involved in humus production, cycling of energy, and some metabolic activities in the soil which facilitates the formation of important chemical components that are important in soil aggregate formation.

Pseudoscorpions or false scorpions are good example for mesofauna.

Fig 5 : Areal view of huge termite mounds in Brazil

They are usually less than 5 mm in length (see Figure 9). They spend most of their lives under mulch, wood and leaf litter, stones and tree bark, and such other places which are hard to see. Unlike scorpions, pseudoscorpions are not harmful. However, they are important in the soil ecosystem as they hunt caterpillars, flies, ants, beetle larvae and nematodes.

Similar to pseudscorpions, Opiliones also act as predators in soil (see Figure 10). Opiliones are also known as daddy-long-legs or harvestmen. They are not harmful to human beings. Presence of them is a good indication of an undisturbed environment.

Fig 8 : Black colour Slug (Arion ater) found in a garden of a European country

Protozoa which belongs to microfauna have some main functions in the soil. They are responsible for regulating the bacterial and fungal populations because they feed mainly on bacteria. As they eat bacteria, protozoa get more nitrogen and this excess nitrogen is then released in the form of ammonium. This is a good source of nitrogen for plants and other members of the food web. This usually occur near the root system of a plant.
They also suppress pathogenic microbes present in soils. At the same time, they serve as an important food source for other soil organisms such as nematodes. Protozoa feed mainly on bacteria, but they also eat other protozoa and fungi. Protozoa are classified into three groups based on their shape. They are the Ciliates, Amoebae and Flagellates. 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 which is called a 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 (see Figure 11), which use a few whip-like flagella to move. Protozoa eat bacteria and need water in which they move. Like bacteria, protozoa are mainly active in the root zone. As observed in the above examples, diversity in shape and in function among the soil animals, has an important overall influence on ecosystem functions. There are many methods such as density and species richness to describe the diversity of these organisms. Here a small experiment can be carried out to get an idea about the diversity of soil fauna. First on extract can be made to identify live soil micro and mesofauna from a soil sample using heat.

Fig 9 : A Pseudoscorpion

Fig 10 : Goniosoma longipes is a colorful Opilion

What is needed is a collecting container, a 1.5 litre plastic bottle, a mesh, two pieces of gauze of same size and a table lamp with a light bulb of 40 or 60 Watts. These can be found at home.

Then a funnel can be made by cutting the bottle into two parts as shown in Figure 12. Place the funnel on top of the other half of the bottle. Now place the mesh over the funnel. Any type of mesh which could hold the soil sample inside the funnel can be used. Then spread the two layers of the gauze over the mesh. With this set-up, the soil animals can fall through the gauze and the mesh, but the soil remains in the funnel.

Next a container has to be prepared to collect the soil fauna. We will collect the live animals, so we can use a media to collect them using a mixture of plaster of Paris and activated charcoal. The recipe to make this mixture is as follows.

Take one tablespoon of plaster of Paris (8 parts), a half a table spoon of activated charcoal (4 parts) and enough water to mix to a soupy consistency (6 parts). First mix the plaster of Paris and charcoal without adding water. Then add enough water to bring this mixture to a soup like liquid. Pour this mixture into a small plastic or a glass container to a depth of 1cm. Tap the container on a table to make a smooth surface and leave it to dry for several days. Once water is added again, the mixture will re-wet and excess water can be removed. As a different media, 70% ethanol can be used to preserve the animals. Periodically add a couple of drops of water to the containers to keep the organisms alive and moist during the extraction. Next step is to place this collecting container inside the bottle as shown in Figure 12. Now a soil sample can be taken from a forest or any other place and fill it to the funnel.
Switch on the table lamp directly over the funnel and adjust the

distance between lamp and the funnel to be 5 cm to 7 cm apart approximately. The soil temperature should reach about 30-35°C. The temperature can be checked using a thermometer. When heat is applied in this way, soil fauna is highly sensitive to desiccation, and consequently try to escape from the direction of the lamp thereby enabling the collection of them from the bottom of the funnel. Apply heat and light for 2 to 10 days, and check periodically for soil fauna in the collection jar.
Now remove the collection jar and

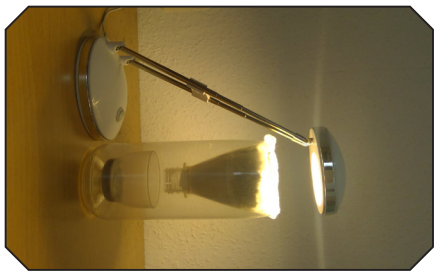

Fig 12 : Experimental set-up to collect the soil fauna

observe it using a light microscope or a hand lens. It is possible to get a small drop of sample and place in a microscope slide and observe. Try to identify the fauna and record the total number of species present and number of fauna present in each species.

It is also possible to take the same amount (volume or weight) of a soil sample from different places such as a paddy field or an agricultural land and to repeat the experiment. This will show the differences that exists among soil faunae in different environments. Higher the number of species found in a soil per unit soil volume, is regarded as a soil rich in species, or in other words, high species richness.

Presence of different soil organisms is important for the maintenance of a productive soil. Reduction in soil biodiversity such as loss of species with unique functions in soil leads to soil degradation and loss of agricultural productive capacity. Every day a part of fertile soil is lost by different ways, mainly due to intensive agriculture. Therefore, it is necessary to take greater care for the soil and its living beings to facilitate a higher species richness. Human activities such as deforestation, large scale pollution, urbanization, as well as agricultural practices such as soil tillage, plant pest management, and fertilisation have negative impacts on biodiversity and the activity of soil fauna. Tropical soils are also exposed to compaction and soil erosion. Heavy metals in soil can have lethal effects on soil fauna. Therefore low-till agriculture, return of organic matter to soil and utilizing diverse cropping systems, as well as avoiding the application of toxic substances can have positive effect on soil fauna.
The multiple roles of soil fauna are often unseen and disregarded. Soils or soil fauna work silently to make our lives better. Therefore, every one of us have a role to play to keep our soil and its life healthy. It could be a very small change in our life style or in habits that would have a great effect on the entire planet. This could be something simple like in the use of personal care products such as soap or cream which does not include harmful chemicals, or the careful use of pharmaceuticals which could affect the microbial functionality or their biodiversity when disposed to the soil. When these substances

Fig 11 : Flagellate Bodo saltans ingesting a bacterium

are added to the soil it could be toxic to soil fauna which is known as ecotoxicity. Many countries in the world conduct research on ecotoxicity as it has already become a threat to our soils.

The International Union of Soil Sciences (IUSS) in 2002 proposed 5th of December as the World Soil Day to celebrate the importance of soil as a critical component of the natural system, and as a vital contributor to human well-being (United Nations, 2019). Soil is a non-renewable resource, therefore whatever harm that is done to soil and its organisms, will have adverse reflections an the people. Thus even as individuals, a small contribution towards the health and well being of the soil on this important day, could be a great step forward towards ensuring the sustainable use of earth's resources to serve the mother planet.

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