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A Short Review on the Role of Insects in Increasing Soil Fertility

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INTRODUCTION

According to the U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS), soil health is the "ability for soil to function as a vibrant living ecosystem that supports plants, animals and even humans". Healthy soil must incorporate a great diversity of organisms to support a multifunctional ecosystem. Through the biotic and abiotic interactions of diverse soil-dwelling organisms, the soil affects the structure and functioning of arable ecosystems. Insects play a major role in promoting biodiversity among various groups of organisms.

Among the animal kingdom, the Insecta is the largest class. They have invaded every niche, except the oceanic benthic zone calculated that arthropods constitute 65% of the total known biodiversity. Thus, from a modest beginning some 400 mya, insects have become the dominant component of the known diversity on Earth, with 100 million species having ever lived**.** Insects are important because of their diversity, ecological role, and influence on agriculture, human health, and natural resources. Insects play a crucial role in maintaining soil biodiversity, due to their abundance and wide range of species. Insects are involved in critical processes that release and immobilize nutrients from soil organic matter (SOM), improve soil structure, and stimulate plant growth. Ecological processes rely on these activities. The biodiversity of insects has been studied extensively in climate change issues, developmental biology, ecology, biomechanics, evolution, genetics, paleolimnology, and physiology. Because of their many roles, they are familiar to the general public. Their conservation, however, is a challenge. An immense perception barrier to their conservation is the human indifference to insects along with general disdain for them.

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Ecological Role of Insects

Insects create the biological foundation for all terrestrial ecosystems. They cycle nutrients, pollinate plants, disperse seeds, maintain soil structure and fertility, control populations of other organisms, and provide a major food source for other taxa. Soil insects are essential for the maintenance of healthy and productive agricultural ecosystems. Almost any depiction of a food web in a terrestrial or freshwater ecosystem will show insects as a key component, although food-web architectures in these two ecosystems are quite different.

Insects are of great importance as a source of food for diverse predators. For example, Aquatic insect larvae serve as food for fishes, many stream fish seem to be limited by the availability or abundance of such prey, at least on a seasonal basis. Myriads of adult mayflies are devoured at the season of their emergence by trout, and this phenomenon forms the basis of the fly fishing sport. Insects are an important supplementary source of calories and protein for humans in many regions of the world and some 500 species in more than 260 genera and 70 families of insects are known to be consumed. In the future, insects may prove especially relevant to food security.

Miller (1993) has categorized how insects interact with other organisms as providers, eliminators, and facilitators. Insects serve as providers in communities and ecosystems by serving as food or as hosts for carnivorous plants, parasites, and predatory animals. They also produce byproducts such as honeydew, frass, and cadavers that sustain other species. As eliminators, insects remove waste products and dead organisms (decomposers and detritivores), consume and recycle live plant material (herbivores), and eat other animals (carnivores).

Bioturbation and Microbial Community

The process of bioturbation is the displacement and mixing of sediment particles by animals or plants. It increases soil aeration and water porosity, affecting soil biota and plant productivity. Biologically active soil is subject to bioturbation. As invertebrates move through the soil (e.g., earthworms, beetle larvae, mites, and nematodes), they push particles aside as they wedge into the interstices. A few organisms physically alter the soil bioturbation, while a few consume the organic matter affecting the soil structure and biochemistry. They may have significant influences on the soil by making burrows and excavating soil.

The examples of different insects contributing to bioturbation are discussed below:

a) Ants

An ant is a social insect that can live in colonies. They can dig deep burrows into the ground to survive and eventually they contribute to the bioturbation process. In the underground, ant burrows form a complex network of macropores. It is only possible for ants to move about within the grain-sized soils. In turn, this increases soil grain size heterogeneity. Ants generally reduce soil bulk density.

The activity of ant bioturbation can be seen in the mounds of soil that are deposited during nest construction. Ant mounds have a significant impact on soil infiltration. Due to their stability, bio pores probably play a significant role in soil infiltration and water distribution in the profile, even when the nest is abandoned. Moreover, ants alter soil chemistry by bringing dead plant or animal material to the nest area to decompose, which alters the chemical nature of the soil in the long run. Meat ants (*Iridomyrmex greensladei*) were found to be responsible for the mounds.

b) Termites

The effects of termites on soil are similar to those of ants. The termite transports soil from depth to the surface to build its termitaria. They excavate large holes below ground for their colonies. Occasionally, they indurate soil towers above ground. As a result of construction and erosion, sediments are transported upward on a conveyor belt. Termites move 1 g to 106 g of soil per ha per

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year, with surface accumulations between 0.0125 and 2 mm per year. Thus, termites play an active role in bioturbation. Although they are very small, they exert an influence on organic matter dynamics. The total biomass of soil fauna can be greatly influenced by termites.

c) Paracoprid Dung Beetles

Paracoid dung beetles play a significant role in the bioturbation of soil. Their tunneling strategies involve transporting deep soil from the ground to the surface. During the feeding process, the larvae and adults of dung beetles manipulate feces in order to influence a variety of ecosystem functions. Major functions include nutrient cycling, bioturbation, soil fertilization, plant growth enhancement, secondary seed dispersal, biological pest control, etc.

Paracoprid dung beetles play a critical role in removing dung from soil surfaces. Despite likely having a critical role to play in soil environments, dung plays an understudied role in nutrient cycling. The dung beetle aerates and mixes the soil by burrowing, and burying dung makes the soil more organic. As a result, the soil can hold more water and provide more nutrients, which is beneficial to plants. They allow the soil to recirculate nutrients by breaking down and recycling dung into the soil. These dung beetles add organic matter to soil by feeding and nesting in different ways.

d) Burrowing Wolf Spider

The vertical burrow of the wolf spider (Geolycosa sp; Lycosidae family; Araneae order) is found on the dunes and interdunes. Burrows are usually found in areas with little to no vegetation. Silk web collars as long as 10cm in length is spun by spiders to stabilize the walls of the burrow in the dry layers. The spider secretes a substance that forms a hard smooth finish to the lower portion of the burrow so that as it runs in and out, no sand is displaced.

Aeolian Deposits Affected By Bioturbation Caused By Insects

Bioturbation of aeolian deposits by invertebrates is geographically significant. Animals within the phylum Arthropoda are particularly important to aeolian bioturbation studies for several reasons. First, many anthropods have a long-range in the geologic record, and revolutionary changes have been relatively minor in some groups.

1. **Sand Wasp-** The subfamily Nyssoninae of the family Sphecidae (digger wasp) includes almost 1000 known species of wasps that burrow in sand and sandy soil. It has been observed that *Microbembex monoonta* and several species of the genus Sand wasp burrows lead into the slope, obliquely crossing the internal stratification of the dune, and have mounds of excavated sand at the burrow mouths. The wasps are very selective about the texture and cohesiveness of the sand and may test many sites by digging shallow burrows before selecting a suitable location. The larval wasp also agglutinates sand to form a protective cocoon. The architecture of the burrow (cell position, length of the burrow, and other features) is usually species or genus-specific.
2. **Sand Treader Camel Crickets-** They are particularly well adapted to burrowing in loose sand, having spines on their hind legs to throw sand backward out of their burrows. The largest known species *Daihinibaenetes giganteus*, is very common in all relatively unvegetated parts of Great Sand Dunes, Colorado. Burrows are typically straight and are oriented obliquely into the shape. The size and length of the burrow relate in part to the size of the cricket (ranging from 2cm according to the age of the cricket), the dampness and the texture of the sand.
3. **Ants -** Certain species of ants of different sizes burrow in dune sand, most commonly in interdunes and vegetative areas. They obliterate sedimentary structures within

clearly defined areas ranging in size from a few hundred cubic centimeters for an isolated colony to disturbance of an entire dune.

4. **Termites-** They are observed to bury sticks of wood in slip faces of dunes to escape high surface temperatureTermites then consume the stick, leaving secretions of saliva which agglutinates the sand in the long rods, tubes, or plates.The termite's traces were observed both high on dune slip faces and in interdunes: they strongly resemble root molds.
5. **Collembola** is an important component of soil communities in all terrestrial ecosystems. Collembola is abundant and ubiquitous microarthropods that are found in terrestrial ecosystems. They can affect the amount of biomass and the activity of microbial communities, either directly through selectively feeding on fungi and bacteria, or indirectly by dissemination of microbial propagules, and the alteration of nutrient availability. Collembola in the soil plays a major role as comminutors (cf. earthworms) break up plant residues and vastly increase the surface area accessible to microbial attack. This increased nitrogen flux shows that the presence of Collembola in soil can affect its nutrient concentration.

Observation of the burrowing behavior of various species has allowed differentiating and interpreting some burrows.

Insects' role in the nutrient cycle and soil fertility

Insects can be considered as one of the most important and largest of all contributors to species richness. Insects play an important role in the enhancement of soil fertility as well as in nutrient recycling.

The insect frass or fecal matter has been reported to be an excellent source of soil fertility enhancer. They have been extensively used as an organic amendment for increasing soil fertility. For example, the frass of Black Soldier Fly (*Hermetia ilucens*), Gypsy moth frass, mealworm frass, etc., has been proved to be beneficial in increasing soil fertility.

Around 90% of the net terrestrial primary production has been estimated to be entering into the detritus food webs, in which they are decomposed and recycled in the course **[21]**. Plant litter is basically a mixture of certain unstable as well as stable substrates. The litter has to be initially weathered making it easy for the various soil microflora and fauna to act upon it and degrade. Later, the insects affect the decomposition directly by feeding on the litter and adhering to microflora, thus converting the energy embedded therein into the production of biomass and respiration, and indirectly, through conversion of litter into feces and the re-ingestion of fecal material, the disintegration of litter, mixing of litter with soil, and regulation of the microflora through feeding and the dissemination of microbial inoculum.

Benefits of Conservation of Biological habitats

Conservation of the habitats for the wild species can be considered as one of the major issues that the environment is facing currently. The incessant destructive human activities have led to the loss of biodiversities, species extinction, severe deforestation, different forms of erosions, etc. So, there is a strong need for the conservation of biological habitat.

The benefits gained from the conservation of biological habitats can be pointed out as follows:

- Conservation of the biological habitats will eventually lead to the protection of the plants, animals, genetic and microbial for the production of food, functions involved in agricultural ecosystems like recycling of nutrients, pollination of plants or crops, pests and diseases regulation, erosion control, soil fertilization management, etc.
- Biodiversity conservation will also help in poverty alleviation and boosting

economic growth. It has been reported that around 1.6 billion people depend on forests and their valuable products as a source of income and subsistence. Around 2.6 billion people from developing countries depend on fisheries and other related sea products for their livelihood.

- The effects of climatic changes can be altered to a great extent with the conservation of biodiversities. For example, the percentage of carbon dioxide released into the atmosphere, carbon sequestration can be checked; impacts of natural disasters like floods and storms can also be reduced effectively.

CONCLUSION

With the help of scientific and technical knowledge, it is possible to utilize insects in different commercial processes leading to the soil fertility enhancement. Since, agriculture is greatly embracing the concept of sustainability. Insects can be an effective tool to achieve this goal. Additionally, they can be used to reduce negative environmental impacts such as bio-waste management, with the proper utilization and management. Entomocompost, in particular, reduces feed imports, fertilizer use, and energy loss. Insect-driven sustainable development schemes are more efficient and effective in achieving sustainability in agriculture. They are also cost-effective. Numerous schemes have attempted to use insects as part of sustainable agriculture approaches. Nevertheless, more results are expected with further research on discovering new insect species and their genetic improvement for utilization in sustainable agriculture.

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