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A Review on Soil Arthropods Contributing to the Cropping Systems

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Abstract: ***Arthropods are considered Farmer's Friends because they perform an important part in the long-term development of soil. The arthropod community characterizes soil quality and aids in bio-monitoring fertility for efficient land use. The current article presented a review of soil health with respect to diverse arthropod communities that are available. The number and diversity of organisms in the soil will reflect the human impact on the ecosystem and environment. The research on distinct arthropod groupings in the soil also reveals whether the arthropod community's merits may be used as a monitoring method. The lack of a basic understanding of variety and abundance patterns highlights prospects for further research in the agricultural and non-agricultural systems, as increased crop output necessitates improved soil quality, which is currently of global interest. Arthropod abundance and diversity, in particular, reflect the health of the soil and have evolved into a cost-effective component of the agro-natural system.***

Keywords: Arthropods, Soil, Collembola, Acari, Soil Processes

1. Introduction

Pedogenesis is a soil-improvement method that includes a game plan that includes physical, creation, and biotic systems. Soil is ringed by a series of actions that combine the organic movement approach with the improvement of biotic systems (H. Jenny, 1980). Soil improvement begins with fundamental movement, which includes the physical endurance of the stones, creating breaks and gaps, and fractionating them into smaller particle difficulties (Culliney, 2013).

Soil is home to a diverse range of species that relies on its presence. Biodiversity has an important role in maintaining the structure and elements of the environment that the soil controls (D. O. Agwunobi et al., 2012).

Arthropods are mostly the soil meso-and macrofauna, with body lengths ranging from around 16 centimeters to 200 meters or more (Culliney, 2013). Among all the soil arthropods, the class Insecta is considered the most powerful. This class is noted for having more variety than the average and is sensitive to changes in soil conditions, making it a bio-pointer gathering class (Nsengimana et al., 2018). The soil arthropods are a group of arthropods that includes Acarina, Collembola, Myriapoda, and a variety of Insecta configurations that play important roles in soil conditions (Ogedegbe and Egwuonwu, 2014). Acari and Collembola are the most common and diverse operators of soil arthropod organizations, and they can be found in a wide range of agroecosystems (Hendrix et al., 1986; Crossley, et al., 1992; Culliney, 2013).

The acarine taxa oribatid, Prostigmata, and mesostigmata, as well as the types of collembola, make up microarthropods (Culliney, 2013).

2. Soil Arthropods

2.1 Acari

Acarine are cosmopolitan in that they can be found at any height and in the soil, as well as in freshwater and marine water. Arachnida life forms can endure cutoff points like acidic or key conditions, and even in less favorable conditions, they can make due at a depth of roughly 10 meters inside the soil. Mesostigmata, Prostigmata, and Oribatida are the three groups of soil parasites (Behan-Pelletier, 2002).

Oribatids are the best soil arthropods out of 9000 species belonging to 172 families, which include dwellers of both the earth and litter structure (Norton et al., 2009). Acari life forms have shallow absorption, a predictable course of events, a postponed life cycle with constant population densities, and a low birth rate. Parthenogenesis is a common practice in some households. Ordinarily, oribatids who live in calm have a future of one to two years, whereas residents in colder regions have a future of three to five years (Culliney, 2013).

Prostigmata is a suborder with a delicate body and a combination of management characteristics, such as benefiting from algae, small living things, plants, and parasites. In the Shortgrass field and Fescue knoll, these are common suborders (Clapperton et al., 2002).

Suborder stigmata eat nematodes, collembolan, and even sensitive-bodied vermin. They went to examine how nature is responding to the increasing number of prey in the area (Behan-Pelletier, 2002).

2.2 Collembola

Hexapods were once categorized as apterygote insects, however, they were later found as having a close relationship to insects but not being insects (Giribet et al., 2012). Major soil organisms have body sizes ranging from

0.5 to 3 mm and rely on decomposing materials and microbes for nutrition (Behan-Pelletier, 2002).

Collembolans are extremely sensitive to changes in soil health and are considered the most important component of the soil ecosystem. Collembolan variety and abundance are seen as indicators of soil contamination (F. Michelle et al., 2004).

Collembolans have been found to have a vital role in decomposition, nutrient cycling, and soil formation, as well as influencing fungal activity. When compared to oribatids, even collembolans are thought to react quickly to any changes in the habitat (Moore et al., 1984; Behan-Pelletier, 2002).

2.3 Myriapoda

Within the soil, Myriapoda is divided into two major groups: Diplopoda and Symphyla. In calcareous soils, habitats with greater moisture, and especially in the upper layers of soil, these groupings are found to be more numerous and diverse in terms of their types. The majority of these creatures feed on dead and decaying stuff, primarily leaf litter and wood, while some also eat fungal mycelia. These have been identified as being more diverse and numerous in temperate and tropical climates. They are extremely reliant on moisture to survive (Hoffman et al., 1990; Culliney, 2013).

2.4 Isopoda

These insects, which belong to the oniscidea suborder, are known as woodlice or sowbugs. They are not well suited to the terrestrial environment, despite their diversity. Changes in some structures, like the porous cuticle and gills, indicate that these creatures are sensitive to water balance, as indicated by behavioral changes. They eat moisture-rich dead and decaying detritus, such as wood and leaves, as well as their own feces, which aids in the recycling of vital nutrients like inorganic copper. When there are enough food supplies available, they enjoy going through a breeding phase that varies by species (Zimmer et al., 2003; Culliney, 2013).

2.5 Termites

These are acknowledged as overwhelming arthropods populating the soil of North American deserts such as Chihuahuan and Sonoran, in addition to obtaining larger plenitude and a good variety of them in tropical locations. Based on their feeding habits, they are divided into two groups: one that lives in tropical rain forests and feeds on humus, and another that is more common in savannas and feeds on wood and litter (Schuurman et al., 2012; Bignell et al., 2000).

2.6 Ants

These arthropods, which are classed as Formicidae and require Hymenoptera, are abundant in almost all earthbound locations. They are effective arthropods, and their ability to scavenge in a pleasant manner is most likely the key to their success. Even as fungivores, they play an important role as predators and foragers. They create their states, which are primarily made up of females, one of whom is the sovereign, who is in charge of multiplication, while the rest of the infertile females rank completes various tasks, whereas men have only one obligation: the giving of sperms during marital flights. Numerous studies have recently discovered that these arthropods are both physiologically important and beneficial to the ecosystem (Hölldobler et al., 1990; Culliney, 2013; Del Toro et al., 2012).

Table 1: Differentiation of soil arthropods on the basis of their body size, broadly categorized into two kinds micro and macro-arthropods

Arthropods	Examples	References
Microarthropods (0.2-10mm)	Collembola, mites, pseudoscorpions	Yadav R. S. *et al.*, 2018
Macroarthropods (10mm and more)	Termites, centipedes, millipedes, mole crickets, etc.	Yadav R. S. *et al.*, 2018

Table 2: On the basis of functional roles, soil arthropods are majorly classified into four categories i. e., shredders, one which feeds upon coarse particulate organic material such as leaves; predators, which prey upon other organisms; herbivores, which feed upon roots of plants and mycophilic, which feeds upon fungi

Functional roles	Examples	References
Shredders	Millipedes, snow bugs, termites, and certain mites	Yadav R. S. *et al.*, 2018 and Culliney, 2013
Predators	Centipedes, spiders, ground beetle, scorpion, tiger beetle, etc.	Yadav R. S. *et al.*, 2018 and Culliney, 2013
Herbivores	Symphylans, mole crickets, etc.	Yadav R. S. *et al.*, 2018 and Culliney, 2013
Mycophilic	Collembola, mites, etc.	Yadav R. S. *et al.*, 2018 and Culliney, 2013

Table 3: Classification of soil arthropods on the basis of their inhabitation inside the soil

Soil habitat	Examples	References
Euedaphon (lowest soil layer)	Protura, diplura, and symphyla as well as oribatid mites	http: //what-when-how. com/insects/soil-habitats-insects/
Hemiedaphon (represent a transitory form of life)	Earwigs, field crickets, and mole crickets, tiger beetles and white grubs	http: //what-when-how. com/insects/soil-habitats-insects/
Epedaphons (live on the soil surface and leaf litter)	Oribatids, springtails, several crickets and beetles including rove beetles and ground beetles	http: //what-when-how. com/insects/soil-habitats-insects/

Table 4: Ecologically soil arthropods interact with each other and on the basis of that, they are categorized into different trophic levels

Trophic levels	Examples	References
First trophic level	Primary producers like plant debris, humus, etc.	Yadav R. S. *et al.*, 2018
Second trophic level	Collembola, diplura, protura, thysanura, symphyla, parapoda, diplopoda, termites, betles etc.	Yadav R. S. *et al.*, 2018
Third trophic level	Collembola, mites, beetles, Chilopoda, etc.	Yadav R. S. *et al.*, 2018

Fourth trophic level	Ground beetles, rove beetles, ants, pseudoscorpion, mites, chilopods, etc.	Yadav R. S. *et al.*, 2018

3. Arthropods as Bioindicators

Bio-sign can be estimated as biomedical and physiological factors in living creatures or their physiological yield, which gives data to alterations in two angles: positive or negative, according to a few studies. There are four different types of bioindicators: (1) general pressure pointers of genuine impacts, (2) sensitive general pressure markers, (3) explicit markers of genuine impacts, and (4) delicate explicit pointers (Straalen N., 1996). According to one of the studies done by Hogervorst et al., 1993, non-horticultural grounds have shifted in their suitability for smaller-scale arthropods to live in, and this suitability can be evaluated by the wealth of the life forms in the network.

The natural and physical elements of soil layers vary from one to the next, eventually establishing a purpose for vertical administration of fauna found in the soil (Sheik A. A. et al., 2016). People of large-scale faunal groups have been established as indicators of soil wellness, which is widely acknowledged, as a result of several workouts such as soil totals arrangement, supplement cycling, and so on (Siqueira G. M et al., 2014). Arthropods are noted for their enormous decent diversity among the soil faunal diverse variety and act as litter transformers or biological system engineers, changing, maintaining, and structuring the living area and directing the assets to make it accessible to different species. The soil arthropod's variety grows as the natural issue substance of the soil expands, and this arthropod acceptable variation reveals occasional diversity. It explains whether the benefits of the arthropod network may be used as a soil health monitoring system (Meitiyani et al., 2018).

Soil quality refers to the physical and chemical boundaries of the soil, whereas soil wellness refers to the organic components of the soil, which provide information about the health of nature through edaphic parameters (Curell et al., 2012). The health of the soil is maintained by a number of factors, including the types of soil, the faunal networks in the soil, and the number of supplements available in the soil. Changes in the soil faunal network provide information about the soil wellbeing status in response to specific changes in natural conditions, as the soil biotic network, primarily the arthropods, have a unique ability to detect any changes in the current condition because they are sensitive to it, and because of this unique characteristic, arthropods are an effective bioindicator of soil wellbeing and direct it (Nicole R. et al., 2019).

For all intents and purposes, acari and collembolan, the two most common and improved solicitations of soil arthropods, are the two most commonly present in all farming and non-agricultural soil systems (Crossley et al., 1992). A few soil arthropod packs serve as associations with advanced lifestyles, anticipating roles as predators and prey, and they can even rot soil features and improve cycles, managing earth structure and plant development, as well as yield creation (Bradford et al., 2007; Nicole R. et al., 2019).

4. Functional roles of arthropods to the soil system

4.1 Role of arthropods in maintaining soil fertility:

The repercussions of the mixing of physical and organic boundaries have finally fashioned the decay of the natural issue. Above all, the disintegration procedure necessitates the physical enduring of the soil, which is largely accomplished by organisms, and makes them accessible to soil faunal networks for natural enduring and causes them to become the structure in which they can be utilized and shape biomass. When this physically demanding procedure is completed, it slows down until the arthropods, along with the microflora, profit from the litter and create biomass and breathe by converting the energy available thereby properly delivering the fecal problem after benefiting from the litter, then making the fecal issue reusable by blending soil with litter and maintaining the microflora by the act of caring for and spreading microbial inoculum (Culliney, 2013).

4.2 Role of arthropods in nutrient cycling

Because they are not useful to plants at all structures, the improvements accessible in the earth must first be converted into an inorganic structure before they can be taken up by the roots. The breath process, in which the breakdown of starches and amino acids results in the formation of ammonium ($NH4+$), which is then subjected to additional procedures and structures to form nitrates ($NO3+$), is a procedure that also includes the catabolism procedure, in which natural supplements are converted to inorganic supplements with the help of a decomposers network and free $CO2$. Arthropods improve the degradation process and boost supplement accessibility in the soil by the process of plant litter handling by the arthropod network, whether consciously or unconsciously. Arthropods brush the microflora, preventing unwelcome organism development and allowing the minerals to be mineralized and absorbed by the roots. Under the conditions, minerals are formed with as little direction as possible (Kautz et al., 2000; Reichle et al., 1977).

4.3 Role of arthropods in the formation of soil aggregates

Because the cohesive force is the major factor working among the fecal pellets and incorporates the endurance, the arrangement of Collembolan fecal pellets results in the creation of hydro-stable aggregates. The most important percentage of humus involved in the production of sand dunes is collembolan and other microarthropod excrements, which form the aggregation of larger sand particles, resulting in larger aggregates and also contributing to the control and stabilization of dunes. In weakly developed soils such as arctic and alpine, collembolan fecal pellets have been established as a central part of the process involved in the formation and regulation of soil microstructure, whereas termites that feed on the soil also contribute to the formation of soil aggregates by their fecal pellets in tropical soils (Van vliet et al., 2003; Garnier – sillam et al., 1995; Culliney, 2013).

4.4 Role of arthropods in litter feeding

The arthropod network completes soil decay and humus arrangement by breaking down plant flotsam and jetsam, which is a physical discontinuity that includes the annihilation of leaf fingernail skin and all the substance of the cell, while increasing the porosity of the soil with an increase in the soil's water-holding limit, allowing supplements or water to move effectively all through the soil layers, whether it is toward or upward. Plant litter is consumed by saprophagous living organisms, which are broken down and undergo numerous catabolic reactions in the stomach, with the undigested materials expelled as a fecal issue. Which are different in size and arrangement from the treated materials. The surface zone for smaller scale living beings to attack expands as plant materials become a fecal concern (Blower J. G, 1985; Zimmer M, 2002; Culliney, 2013).

4.5 Roles of arthropods in the formation of soil structure

By spatially arranging the soil particles, keeping the pore size of the soil, and maintaining the union of the particles framing their totals, and balancing them out, science has a significant impact on soil structure. Root infiltration is simply because of the supplement holding limit, porosity, and water maintenance limit, which prevent soil disintegration of the soil layer. The soil disintegration of the soil layer is completely shielded by an optimum soil structure. Arthropods have a variety of effects on soil fundamental qualities, such as the transit of soil molecule size within the subsurface, which is strikingly guided by the activities of ants and termites (Oades J. M, 1993; Wilkinson et al., 2009).

4.6 Role of arthropods in mineralization of nutrient elements

Mineralization is a process that involves catabolic reactions of natural components into inorganic ones, such as carbon dioxide breaking down into ammonium and subsequently nitrates with the help of decomposers, to make the components available for the taking-up process by plant roots. Microbial biomass stores soil structure, which is mostly made up of supplements, until it is released into dung and onto passing animals, particularly microarthropods (Ausmus et al., 1976; McBrayer et al., 1974).

Grazing activity of micro and microarthropods, as well as fungi and bacteria, increases carbon mineralization through comminution of litter; however, as grazing pressure increases, microbial respiration becomes hampered. By transferring their own microbes or propagules, arthropods in the soil modify the microbial population (Henlon and Anderson, 1979; 1980). Termite foraging and other actions such as collecting litter while creating conditions that allow in the growth of microbial communities and the mineralization of organic materials are frequent in drier and warmer parts of the world.

Table 5: Some soil arthropods have an important functional role like nutrient mineralization by breaking the nutrients and making them available for the uptake of roots and on the basis of that, a few examples are:

Arthropods	Minerals	References
Collembola	N and Ca	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Isopoda	C, N, $P_2O_5^-$- P, K^+, Mg^{2+} and Ca^{2+}	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Termite	N and C	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Acari	N and C	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013

Table 6: As arthropods vary in their feed hence their biomass is composed of different components like some are rich in nitrogen whether some are rich in sulfur depending upon their feed constituents and make the nutrients available for the soil system, based on that some examples are:

Arthropods	Nutrients	References
Collembola	NO_3^-	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Millipede	NH_3	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Termites	N and C	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013
Isopoda	S	Culliney, 2013; Behan-Pelletier V. M, 2013 and Ashford O. S. *et al.*, 2013

5. Conclusion

The cornerstone of the biological system is soil, which is kept healthy by the activities of the biota that reside there. Arthropods make up a significant component of the meso- and macrofauna, and they play a role in processes such as building decay, predation, and illness.

Collembolan, acari, Myriapoda, Isopoda, and Insecta are the five categories of living things that dwell in or on the soil. The most abundant and improved of the five are acari and collembolan. The remaining three have no effect on soil processes at all.

Microarthropods belonging to the genera Oribatid, Prostigmata, and Mesostigmata are known as acari. Microarthropoda is the essential linkage in food networks, allowing vitality to pass from soil microflora to higher trophic level microflora, and finally to macroflora on higher trophic levels. The most frequent acari taxon is Oribatida, which plays a role in degrading forms.

Some of the most essential helpful activities of arthropods in sustaining soil productivity are supplement cycling, litter management, mineralization of supplement components, soil structure maintenance, soil blending and improvement of pores and voids, and soil totals arrangement. In any case, given the goal of this study is to highlight the many vital practical roles that arthropods play in soil health, such memories are unlikely to be included in open awareness.

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