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ECOLOGICAL ROLE OF DETRITIVOROUS INSECTS: IMPACTS AND CHALLENGES IN CLIMATE CHANGE SCENARIOS

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Abstract
Detritivorous insects are an important part of the ecosystem. They aid in the decomposition of organic matter, the recycling of nutrients, and the sustainability of soil fertility. These insects are beetles, termites, springtails, cockroaches, and dipteran larvae, which decompose plant and animal litter into smaller particles, promoting microbial degradation and the nutrient mineralization process. Detritivores also enhance soil aeration and soil water retention through their feeding and burrowing behaviors. Besides that, they have a significant role in detritus-related food webs by transporting energy from dead organic matter to higher trophic levels, including birds, amphibians, reptiles, and predatory arthropods. Nevertheless, the current climate change is a major threat to the existence of detritivore communities and the ecological process. Elevated temperature, changes in precipitation, drought, can influence their metabolic rate, feeding habits, survival, and distribution. These environmental shifts can interfere with the decomposition processes, change the nutrient cycling, and affect the soil health and trophic interactions. Shifts in species distributions and phenology due to climate could also cause a lack of fit between detritivore activity and organic substrate availability and could have a negative impact on ecosystem performance. Although detritivorous insects are ecologically important, they are still under-researched, with much of the research conducted in limited regions and methodological limitations, in addition to problems with predictive ecological modeling. The future research ought to be directed into the areas of long-term ecological monitoring, better taxonomic identification using a molecular tool, and the development of integrative models that would consider various environmental stressors.

INTRODUCTION

The insects that are capable of decomposing the dead organic matter of plants and animals, contributing to the nutrient cycling and reduction of wastes, are known as detritivorous insects (J. Louzada & L. Nichols, 2012). These insects are diverse and are largely distributed in areas with dead matter, from normal soil to rich forest soil. Insects like dung beetles, wood lice, termites, rove beetles, and springtails contribute to nutrient cycling by feeding on dead organic matter (Collins, 1981; De Smedt et al., 2016; J. Louzada & L. Nichols, 2012). They convert organic matter into small particles, which increases the rate of recycling of macronutrients such as nitrogen and phosphorus (Potapov et al., 2022;

Thanuja et al., 2025). They also promote soil formation and increased fertility through burrowing and fecal production activities, which support microbial growth and keep the soil healthy, which is crucial to healthy plant growth (Wissinger et al., 2018).

The initial ecological models defined that the degradation of organic matter is not only a passive process of decay but a process of active energy transfer. Lindeman (1942) was the first to introduce the concept of a trophic-dynamic system, incorporating decomposers into a formal hierarchy of energy flow. He stated that this bioconversion system, including the detritivore and microbe system, is essential to ecosystem stability (Lindeman, 1942). By the 1960s, scientists argued that the majority of the energy in most ecosystems was transferred through the detritus pathways instead of the grazing pathways. Odum and de la Cruz (1963) pointed out that detritus-based food webs, which are highly mediated by specialized insects, are a major component of ecosystem function, not only a by-product of ecosystem functionality (Odum & de la Cruz, 1963). In the second half of the 20th century, the shift was focused on the physical and chemical effects of soil fauna on soil. Now, the historical emphasis on local nutrient cycling has been extended worldwide. This highlights the importance of saprophagous insects as an important ecosystem engineer. They determined the soil's capacity to hold carbon. According to Lavelle et al. (1997) and subsequent meta-analyses by Kampichler and Bruckner (2009), the capability of soil to act as a carbon sink or source is determined by the functional diversity of detritivorous insects, a discovery that now forms the core of the predictive capacity of ecosystems to climate change (Kampichler & Bruckner, 2009; Lavelle et al., 1997). But these insects are highly vulnerable to climate change.

The anthropogenic climate change presents a synergistic stress trap to detritivorous insects, mostly due to the increase in temperature, disrupting their metabolic and thermal limits, causing low rates of survival and reproduction (Sukkar et al., 2025). This heat stress is often worsened by changed precipitation and moisture regimes, with drying out of soil, and brings about enormous changes in the decomposition pace (Torsekar et al., 2024). Habitat fragmentation does not allow these species to migrate to more favorable climates. As a result, insect is no longer consistent with the seasonal presence of leaf litter (Satpathy et al., 2022). The combination of these problems places stable soil carbon sinks at risk of becoming sources of carbon dioxide in the atmosphere as the productivity of the brown food web fails (Torsekar et al., 2024). Therefore, this review aims to identify the key climate change factors affecting the activity of these valuable insects and how their reduced variety disrupts the whole ecosystem balance.

Taxonomy and Functional Groups of Detritivorous Insects

In food-web research of soils, detritivores are considered as functional groups since they carry out common ecological functions, but with great taxonomic diversity. This common grouping is used in ecological modeling to determine the ecosystem response to environmental change (Heděnec, 2022).

I. Major Orders and Families

The detritivorous beetles belonging to the order Coleoptera include a number of families, such as Scarabaeidae, Silphidae, Tenebrionidae, Dermestidae, and Geotrupidae. These communities have developed independently and are adapted to feed on the rotting organic matter of terrestrial systems (J. Louzada & E. S. Nichols, 2012). They are functionally divided into coprophages, necrophages, saprophages, and keratophages. The groups have various ecological niches and specialize in diverse detritus types. Dung beetles release nutrients and enhance soil structure by burying, and carrion beetles increase the speed of a carcass decomposition. Saprophagous species shred leaf litter and decompose, including keratin (McKenna et al., 2019).

Isoptera members are large detritivores, predominantly able to feed on cellulose in dead wood, leaf litter, and soil organic material. They use symbiotic gut microorganisms to decompose the cellulose, and it is essential in the ecological carbon cycle, soil development, and decomposition in tropical and subtropical ecosystems (Gbenonsi & Higley, 2025).

Collembola are small arthropods that live in soil and feed on decaying vegetation, fungi, and microbial biofilms. They assist in the fragmentation of litter, control populations of microorganisms, and increase soil fertility through the promotion of nutrient turnover (Asad et al., 2025).

Order Blattodea, which includes cockroaches, are critical detritivores that recycle nutrients, especially in tropical and subtropical forests. Cockroaches increase the rate at which organic material decomposes, consequently fertilizing the soil and promoting plant growth. These insects enhance soil structure and help to recycle nutrients back to the soil system by feeding on the decomposing matter and by moving through the soil. The Blattodea species depend on an intricate intestinal microbiota, such as Blattabacterium, to digest the cellulose and recycle nitrogenous waste into useful nutrients for their hosts (Lopes, 2018).

Dipteran larvae and other microarthropods are other detritivores that feed on the decaying organic matter of different habitats.

Together, these groups play a major role in determining the decomposition processes, breakdown of organic matter, soil composition, and the general productivity of the ecosystems in the terrestrial environments (Geburzi & Zimmer, 2025).

II. Functional Roles

Detritivores are categorized into a number of functional groups according to feeding modes, size, and the kind of detritus that they feed on, especially in the terrestrial and aquatic ecosystems. Depending upon their place of feeding, detritivorous insects can be subdivided into: Detritus Shredders organisms have chewing mouth parts, and they can shred large fragments of organic matter into smaller fragments, making them more accessible to colonization by microbes. They include millipedes, woodlice, and some beetle larvae (Schowalter, 2022). Detritus Grazers are insects that consume the bacteria and fungi that grow on the decaying organic matter, but not on the substrate. These are, such as springtails and oribatid mites. Bioturbators are insects that mix, ingest, and defecate soil and litter, and this helps in decomposition and cycling of nutrients. A significant example on Earth is the termites. Necrophages are insects that feed on animal carcasses, such as blow flies, house flies, and carrion beetles (Litt et al., 2024). Xylophages insects eat dead wood, helped by symbiotic microorganisms in their gut, which digest cellulose, like termites and the larvae of long-horned beetles (Schowalter, 2022).

Ecological Functions and Ecosystem Services

Detritivorous insects play an important role in terrestrial and freshwater ecosystems, as they carry out processes that lead to a direct contribution to ecosystem health and resilience. They provide supporting and regulating ecosystem services, particularly in decomposition, nutrient cycling, soil formation, and organic waste regulation (Barragán-Fonseca et al., 2025).

I. Decomposition and Nutrient Recycling

Detritivorous insects play an important role in nutrient cycling and decomposition. They can break and eat the dead organic materials, enhancing the decay of litter and woody debris, which otherwise would be retained and restrict the flow of nutrients (Nichols et al., 2008). Decomposition of organic matter by detritivores involves mechanical fragmentation and chemical digestion, which also enhances surface area for microbial colonization. This results in a close association of these insects with microbes, as bacteria and fungi further break down complex organic components, helping in the conversion of organic matter into simpler forms (Hättenschwiler et al., 2005). Detritivores are also involved in the mineralization and recycling of nutrients, through which they can help release vital nutrients into the soil, such as nitrogen, phosphorus, and carbon, which promote plant productivity and keep the ecosystem productive. Such insects include earthworms, termites, beetle larvae, and springtails, all of which play different roles in litter breakdown, as they have different feeding habits and microhabits (Moore et al., 2004). Beside decomposition and nutrient cycling, insect frass also has greater amounts of soluble nitrogen and phosphorus, which encourages the growth of microorganisms and increases the speed of the cycling of nutrients (Haettenschweiler, 2005).

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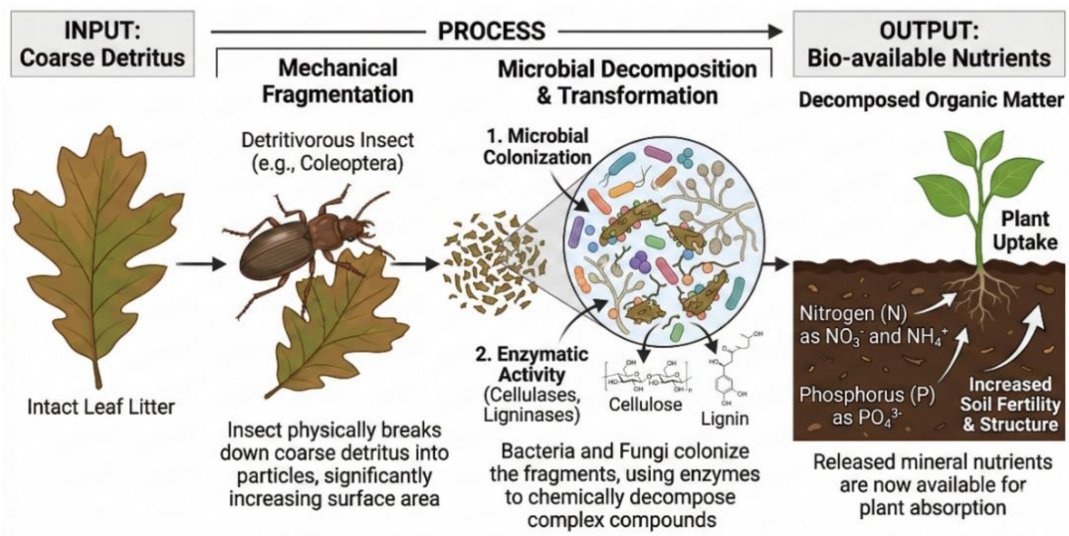

Figure 01. Insect-Microbe engine in Soil systems

II. Soil Structure and Fertility Enhancement

The presence of detritivore insects, such as beetles, termites, and other arthropods living in the soil, which feed, burrow, and decompose soil, has a great impact on the soil structure and fertility (Shehzad, 2024).

Bioturbation is defined as the movement and mixing of soil materials. This process is essential to soil fertility. Detritivore insects, particularly larger insects such as termites and certain beetles, help in the distribution and creation of aggregates in the soil due to their digging and tunneling activities. This process moves organic material and mineral grains across various horizons of the soil that can enhance the development of the soil and alter the soil fertility trend in the long run. This biotic pedoturbation stimulates the degraded micro-aggregates and creates pore spaces, which help to promote structural heterogeneity and also stabilize the soil aggregates, which is necessary in resisting soil erosion and stabilizing the soil porosity (Culliney, 2013).

Detritivore insects move around, and as a result of their physical activities, a web of macrospores and channels is formed, which enhances aeration of the soil. These pore structures enhance oxygen diffusion that is crucial in root respiration and anaerobic microbial functions. Better aeration also aids in the preservation of favorable redox conditions, and microbial activities take place in support of soil fertility (Shehzad, 2024). Moreover, the increased porosity enables the soil to hold water better, which buffers the soil against drought stress and reduces surface runoff, which is especially useful during changed precipitation conditions due to climate change (Culliney, 2013).

Even the frass of a large number of detritivores also adds organic food in the soil matrix, increasing the water retention and promoting the ability of the soil to host plant and microbial communities in the dry season (Staczek, 2025).

III. Trophic Interactions and Food Web Support

Detritivore insects are the foundation of detritus-based food webs, which originate with dead organic matter, unlike the traditional grazing food chains, which begin with the biomass of live plants. These insects decompose detritus into forms that can be utilized by other components and therefore bring energy and nutrients to higher trophic levels (Yang, 2014).

These insects are important prey species for a large variety of vertebrate and invertebrate consumers. A variety of detritivore insect taxa in the terrestrial and aquatic ecosystems are preyed upon by birds, fish, amphibians, reptiles, and predatory arthropods, so they move energy from the detrital sources into higher trophic levels. An example of this is aquatic detritivore insect larvae, which are the primary prey of fish and amphibians (Hui, 2012).

Terrestrially, beetle detritivores are an important part of the diet of small carnivores and omnivores, and thus present examples of how detritus-based energy resources can support many different populations of consumers. The presence of these predatory insects regulates the detritivore communities, reinforcing the trophic interdependence of the soil and litter layers (Wyckhuys, 2021).

IV. Contribution to Ecosystem Resilience

The ecological benefits of detritivorous insects include resilience of an ecosystem by buffering nutrient loss and recovery of an ecosystem upon disturbance. They decompose and mineralize the dead organic matter, thereby enhancing the rate of decomposition and mineralization of important substances such as nitrogen, phosphorus, and carbon that remain in the soil and are available to plants and other microbes. Moreover, heterogeneous communities of detritivores guarantee the continuation of decomposition under unsteady conditions, which contributes to the ecosystem resisting climatic stresses and allowing long-term functional stability (Odum & de la Cruz, 1963).

Impact of Climate Change on Detritivore Insects

Climate change is having comprehensive effects on the structure and functioning of detritus-based ecosystems by impacting detritivore insects. An increase in temperature, changes in the pattern of precipitation, and an increase in the frequency of extreme climatic events all have direct impacts on the feeding behavior, distribution, and decomposition processes of detritivore insects (Yin et al., 2026). A meta-analysis conducted across the whole world revealed that environmental stressors decrease the feeding of soil detritivores by approximately 47.8 % and climate change alone by approximately 59.8 %. Droughts specifically are more detrimental, as they inhibit feeding rates more than warming alone, as illustrated in Figure 02 (Wu et al., 2021).

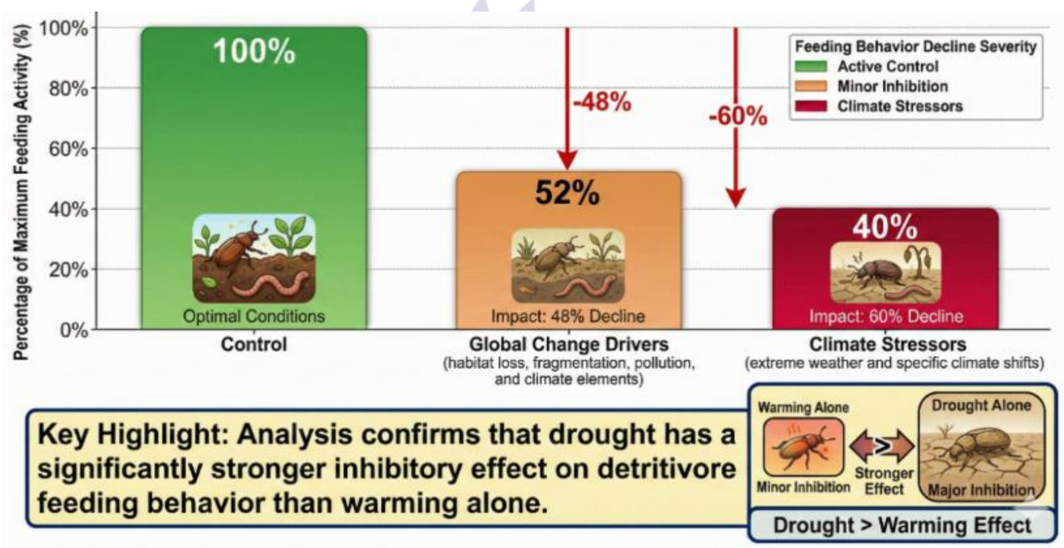

Figure 02. Environment changes and effects on Detritivores feeding activity

I. Temperature Stress

Temperature stress causes serious physiological limitations to detritivore insects because it influences metabolic functioning, oxidative balance, water regulation, and reproductive capability (Parmesan 2006). Climate change has the potential to change the rate and association of detritivores with microbial decomposers. The warming occurring all over the world decreases the activity of detritivores, decelerating the decomposition and nutrient recycling process (Yin et al., 2026).

Detritivore insects have behavioral adaptation and thermal tolerance, as well as resilience to climate change. But behavioral thermoregulation and physiological plasticity only offer short-term buffering against high and low temperatures, and they are not effective enough at long-term warming and habitat degradation. Therefore, surpassing thermal tolerance limits can result in a decrease in feeding, a change in the structure of communities, and a decrease in decomposition in both terrestrial and aquatic environments (Sunday et al., 2019).

II. Moisture and Drought Effects

Losses in litter moisture also impact the water balance and physiology of detritivores. The majority of litter-dwelling insects have permeable cuticles and low-desiccation-resistance, so they are extremely sensitive to the loss of water. A decrease in the moisture level leads to a rise in the evaporative stress that results in dehydration and makes insects either slow down or go to deeper soil layers. This kind of behavior change usually leads to less litter fragmentation and a slower decomposition process (Blankinship et al., 2011).

The moisture-sensitive species include soft-bodied larvae and microarthropods, which are likely to be reduced in the presence of extended dry weather conditions, whereas the species that tolerate drought conditions may survive. The changes in species composition may frequently decrease the functional diversity and alter the pathways of decomposition, which may cause a decrease in ecosystem resilience (Wall et al., 2015).

III. Altered Distribution and Phenology

Environmental stressors not only affect the functioning of detritivore insects but also alter their distribution. Cold-adapted detritivores are confined to narrow thermal niches, so they are particularly susceptible to losing habitat due to global warming. The dispersal of soil-dwelling and litter-dwelling species is limited, relative to their reproductive potential. As a result, local extinctions of these species can occur when appropriate microhabitats are lost (Sunday et al., 2014). Conversely, thermophile detritivore species can increase their geographic ranges in the case of warming. The poleward expansion of the termites has been observed in various locations as minimum winter temperatures rise. This may change the rates of decomposition and the dynamics of carbon cycling in recently occupied locations by termites. These expansions have the capacity of altering the community makeup, competition, and nutrient circulation patterns (Eggleton, 2000).

Another significant impact of climate change is the changes in phenology that is the timing of the biological events. Insects tend to emerge in warmer temperatures, develop at a quicker rate, and stay active longer. In the case of detritivore insects, early spring activity might enhance temporary rates of decomposition (Eggleton, 2000). However, decomposition efficacy can be reduced when there are mismatches between peak detritivore activity and peak litter fall or the optimum microbial activity (Parmesan & Yohe, 2003).Disturbed phenology may also affect the population dynamics. High temperatures can decrease the duration of the generation time and can increase the population growth rate of certain species (Eggleton, 2000).

Alterations in the seasonal rainfall patterns also affect the cycle of activities. The occurrence of drought during the important feeding periods is capable of overriding seasonal maxima in detritivore activity, despite good temperatures. On the other hand, the severe rainfall events can cause short-term activity due to high moisture levels of litter, or disruption of the habitats due to flooding or soil erosion. (Mbabazize et al., 2025)

In addition, seasonal shifts in detritivore-action may cause the alteration of the release of carbon and nutrients, which may disproportionately match the needs of plants and modify the energy flux in food webs. These time discrepancies may minimize the stability of an ecosystem in the face of sustained climatic change (Eggleton, 2000).

IV. Interaction with Invasive Species

Climate warming tends to increase the occurrence of invasive detritivores by increasing their habitat and minimizing their climatic barriers. Most invasive species have expanded thermal tolerance intervals, increased phenotypic plasticity, and faster rates of reproduction than native species. These characteristics allow them to become more competitive than indigenous detritivores, especially in disturbed or warming habitats. Consequently, invasive detritivores can control the pathways of decomposition in new colonies (Liu et al., 2025).

The competition between the native and invasive detritivores usually happens in terms of the utilization of the resources. The leaf litter and detrital substrates are finite resources, and the higher the density of the detritivores, the higher the competition can be. Invasive detritivores tend to have elevated rates of feeding and competitive foraging behavior, which enables them to monopolize on detrital resources (Eggleton, 2000). For example, invasive termites and isopods have been observed to eat litter faster and replace native fauna of the decomposers in certain ecosystems. This competitive displacement can decrease indigenous biodiversity and interfere with ecological connections, which have developed over the long term (Duquesne & Fournier, 2024). Invasive species tend to be more tolerant of changes in temperature and drought than native species and can continue functioning even during stressful environments. Such an imbalance gives a competitive edge to invasive detritivores in drying and warming conditions (Bellard et al., 2016).

Predation pressure can also be determined by invasive detritivores themselves. When invasive detritivores are abundant, they can be an alternative prey and therefore may cause a decrease in predation pressure on native detritivores. On the other hand, invasive prey can also cause population growth of predators by supplying them with more food resources, which, in turn, leads to apparent competition and enhances the predation of native species. These indirect interactions are capable of disrupting the trophic relationships. These interactions are also modified by climate warming, which raises predator metabolic demand. The increase in temperature generally increases the rate at which predators feed, a factor that increases the effect of an invasive predator on the population of detritivores. Simultaneously, indigenous detritivores who are already stressed by thermal and humidity constraints might possess less response to escape or defensive ability and therefore become easier prey (Simberloff et al., 2013).

Feedbacks to Ecosystem Processes under Climate Change

Detritivore insects control the speed at which organic substances are transformed into bioavailable nutrients, while climate change affects the process of decomposition to a considerable extent. The alteration of temperature, precipitation patterns, and extreme weather conditions has a great impact on their metabolic activity, feeding habits and reproductive rate (Simberloff et al., 2013). Increasing temperature tends to increase the metabolism of detritivore insects. Enhanced feeding activity increases litter fragmentation, which increases the surface area in which microbial colonization and enzyme degradation occur. Detritivores and microbes synergistically increase mineralization of important nutrients like nitrogen, phosphorus, and potassium, leading to accelerated nutrient cycling (Bardgett & Van Der Putten, 2014).These climatic variations in the activity of detritivores affect many important ecosystem processes, especially the dynamics of decomposition, soil health, and trophic interactions, as explained in the subsequent sections.

I. Altered Decomposition Rates

Climatic variations may change the activity of detritivores and have a major impact on the rate of decomposition in temperate or tropical ecosystems. Warming in tropical systems can augment nutrient losses in volatilization or leaching, diminishing soil fertility, and hastening carbon cycling, soil respiration, and carbon dioxide release, and this may become a positive feedbacks that amplify atmospheric greenhouse gases (Bardgett & Van Der Putten, 2014).

Nevertheless, the efficiency of detritivores may be decreased by climate stress, land-use change, habitat degradation, and invasive species, and thus, decreases the potential of the ecosystem to store and regulate carbon in a more efficient way (Schimel, 2018).

II. Soil Health Implications

The detritivore insects play a vital role in ensuring that soil remains fertile by increasing the rate of organic matter decomposition and recycling nutrients. Their activity decomposes complex residues into smaller particles, which in turn are decomposed by soil microbes, thereby releasing nitrogen, phosphorus, and potassium. The stressors associated with climate change can decline the abundance and activity of detritivores, subsequently causing soil infertility (Gilman, 2010). The decrease in soil fertility because of low detritivore action may lead to a cascade effect on the functioning of the ecosystem. A reduction in the nutrient level can decrease plant growth, change the species makeup, and decrease carbon fixation. This can require the use of more fertilizers in farm systems, which has an additional effect on nutrient balances and greenhouse gas emissions (Schimel, 2018). Drought and heatwaves further reduce soil fertility. Drought decreases the availability of moisture in litter and soil, and has a direct effect of limiting detritivores' feeding as well as microbial activity. Heat stress may lower the survival rates of detritivore insects. All these stressors combine to impair the nutrient cycling and lower the soil fertility that may lead to decreased ecosystem productivity and resilience (Wardle, 2004).

III. Effects on Trophic Networks

The detritivore insects play a crucial role in trophic webs as they have a direct connection between the detritus-based energy and the higher trophic levels. They are both decomposers and prey, passing on the energy contained in dead organic matter to predators, including birds, amphibians, reptiles, and predatory arthropods. Climate change may interfere with such interactions by changing the abundance, phenology, and spatial distribution of detritivores, which impacts predator-prey interactions, decomposition rates, and food web stability. Bardgett, 2014). The high functional diversity of detritivores offers a redundant effect in the decomposition of organic matter, which increases the resilience levels in an ecosystem, but the loss of sensitive species may decrease the effectiveness of nutrient cycles, decelerate plant growth, and propagate a cascading effect with increased trophic diversity. All together, the disruption of detritivore communities may upset the food webs, which underscores their importance in the stability of ecosystems in terms of structure and functioning (Moore, 2004; Gilman, 2010).

Challenges in Studying Detritivore Insects

Although detritivorous insects play a key ecological role in decomposition and nutrient cycling, studying them is difficult due to methodological issues, lack of data, and modeling limitations.

I. Methodological Limitations

Sampling detritivorous insects is not easy, as many species live in cryptic microhabitats like soil pores, leaf litter, and decaying wood. Various sampling methods, such as pitfalls, litter picking, and soil cores, tend to capture varying elements of the community, and hence, there may be bias in estimated abundance and diversity. Also, several detritivorous insects are morphologically similar, so that species-level identification is challenging without molecular methods, e.g., DNA barcoding (Lavelle & Spain, 2001).

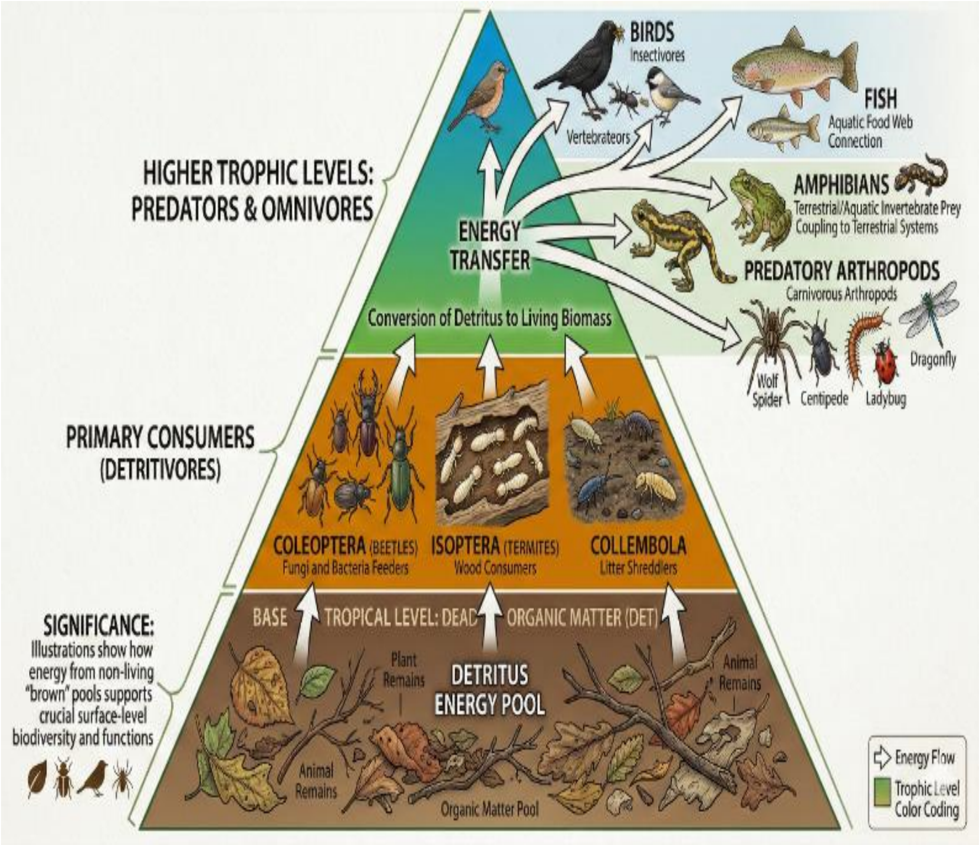

Figure 03. Energy Flows from Detritus to Supporting Surface-Level Biodiversity

II. Knowledge Gaps

Despite the ecological significance of detritivore insects, there are great knowledge gaps in the study of detritivore ecology. The studies on decomposition and soil fauna responses to climate change are short-term and geographically localized. There is limited data on long-term monitoring, and it is hard to determine the response of detritivore communities to the gradual environmental change. Moreover, research activities are also clumped in temperate regions, and tropical areas are underrepresented, although most tropical areas are highly biodiverse (Bardgett & Van Der Putten, 2014; Lavelle & Spain, 2001).

III. Predictive Modeling Challenges

It is still complex to predict the response of detritivore communities to environmental change due to the interaction of stressors affecting ecosystems, including climate change, land-use change, and invasive species. The ecological models typically fail to combine such factors and to connect the species-level responses with the ecosystem-level processes, including decomposition and nutrient cycles. Subsequently, forecasting future ecosystem operation under altered environmental conditions is a significant issue in soil ecology(Bardgett & Van Der Putten, 2014; Gilman et al., 2010).

Conclusion and Future Directions

Detritivorous insects are a key component of ecosystem processes, as they contribute to decomposition, mineralization of nutrients, and energy transfer of the detritus-based food webs. The organisms enhance microbial decomposition by their feeding, litter fragmentation, and soil-burrowing activity, which leads to improved soil structure and fertility. Moreover, detritivores link the detrital pool with higher trophic levels, thereby benefiting predators like birds, amphibians, reptiles, and predatory arthropods. Due to these roles, detritivorous insects become fundamental in nutrient cycling, maintaining soil conditions, and ecosystem stability (Bardgett & Van Der Putten, 2014; Lavelle & Spain, 2001).

However, climate change has multi-facets effects on detritivore communities. Different environmental stressors like global warming, changed precipitation patterns, and drought can alter the functionality and physiology of detritivore insects. The ecosystem resilience can be influenced by these changes through the sequestration of carbon, soil fertility, and food web stability. Specifically, the alterations in the abundance and activity of detritivores can lead to mismatches between decomposition processes and nutrient availability, which will eventually influence the productivity of plants and the functioning of the ecosystem.

Although such insects are ecologically important, very few ecological studies have focused on them as compared to other functional ecological groups. Their biodiversity, community structure, and mechanisms of responding to environmental change are poorly understood, especially in tropical and developing areas. Methodological issues, such as sampling biases and the inability to discover cryptic species, further limit the knowledge about the ecology of detritivores and their role in ecosystem processes.

There are various areas that future research should address. It is necessary to conduct long-term ecological studies to get a greater idea of how climate change affects the diversity of detritivores, their activity patterns, and decomposition processes over time. Cryptic species can be discovered more efficiently with the help of innovations in molecular methods and technologies. In addition to these, integrative ecosystem models, which contain a number of environmental stressors like climate change, land-use change, and biological invasion, are needed to predict future ecosystem responses at a higher level. Finally, more efforts are required to consider understudied areas and environments, especially tropical ones, where detritivore diversity and ecological significance would be highest.

On the whole, it is important to understand the ecological functions of detritivorous insects and integrate them into ecological management and climate studies. Conserving the diversity of detritivores will support the decomposition process, nutrient cycling, and maintain ecosystem resilience when the global environmental change continues to take place.

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