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Original Article

Leaf cutter ant and their interactions with ecosystem

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Abstract:

Leaf-cutter ants are a prominent feature in Neotropical ecosystems, but a comprehensive assessment of their effects on ecosystem functions is lacking. We reviewed the literature and used our own recent findings to identify knowledge gaps and develop a framework to quantify the effects of leaf-cutter ants on ecosystem processes.
Leaf-cutter ants account for about 25% of all herbivory in Neotropical forest ecosystems, moving 10%–15% of leaves in their foraging range to their nests. Fungal symbionts transform the fresh, nutrient-rich vegetative material to produce hyphal nodules to feed the ants. Organic material from roots and Arbuscular mycorrhizal fungi enhances carbon and nutrient turnover in nest soils and creates Biogeochemical hot spots. Breakdown of Organic matter, Microbial and Ant respiration, and Nest waste material decomposition result in increased CO2, CH4, and N2O production, but the build-up of gases and heat within the nest is mitigated by the tunnel network ventilation system.
Leaf-cutter ants are dominant herbivores that disturb the soil and create biogeochemical hot spots. We studied how leaf-cutter ant *Atta cephalotes* impacts soil CO2 dynamics in a wet Neotropical forest. Estimated total nest-soil CO2 emissions were 15 to 60% more than in nonnest soils, contributing 0.2 to 0.7% to ecosystem-scale soil emissions.

Keywords: Neotropical ecosystems, Herbivory, Arbuscular mycorrhizal fungi, Biogeochemical.

Description

Ants have a crucial role in ecosystems, which is widely acknowledged. Ants are crucial for predation, nutrient flow, the structure of herbaceous vegetation, and soil development. When they affect tremendously large populations, their consequences are astounding. Ant populations are frequently very consistent throughout the course of seasons and years. Ants are one of the most significant groups of insects in ecosystems due to their number and stability. The almost 250 New World-only species of fungus-farming ants (Formicidae: Myrmicinae: Attini: Attina) give a well-known illustration of Mutualism. The ants have an obligate symbiosis with the grown fungi that they consume, and in exchange the ants give the fungi food, a way to spread to new areas, protection from parasites, and an environment free from competition.
Except for Atta and Cardiocondyla, two genera of fungus farming ants that are referred to be leaf-cutting ants, the majority of genera do not cut leaves. Between leaf-cutter and non-leaf cutter fungus farming ants, the genera Trachymyrmex and Sericomyrmex are thought to be transitional, and their cultured substrates include fresh fallen plant material as well as arthropod frass and carcasses.

Leaf cutter ant entomology

Leaf cutter ants are fascinating creatures that belong to the family Formicidae and are known for their ability to cut and carry large pieces of leaves, which they use as a substrate to grow their fungus gardens.
The leaf cutter ants have a highly organized social structure. They live in colonies that can have millions of individuals, with each individual having a specific role to play in the colony. There are four main castes in a leaf cutter ant colony: Queens, Males, Workers, and Soldiers.
The Queen is the largest member of the colony and is responsible for laying eggs. She can live for over 20 years and can lay up to 150 million eggs in her lifetime. Males, on the other hand, are smaller and have wings. Their sole purpose is to mate with the queen, after which they die.

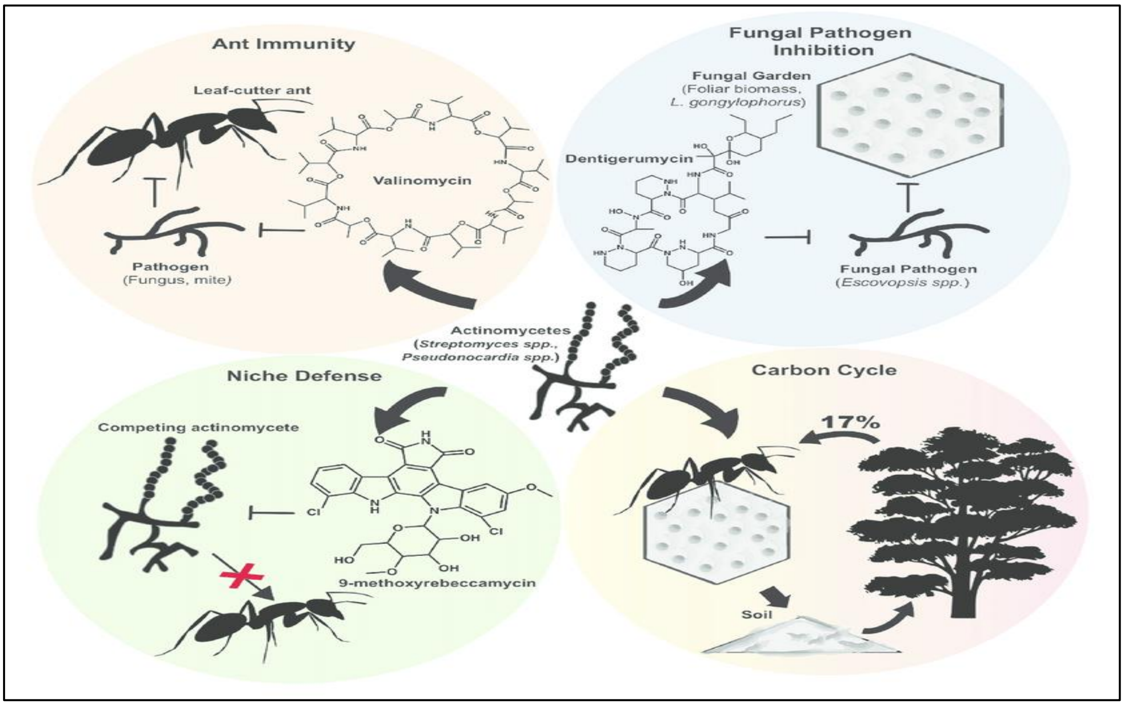

FIG. 1: Leaf-Cutter Ant Ecosystem

Leaf cutter ant interactions with ecosystem

The workers are the smallest members of the colony, and they are responsible for the day-to-day tasks of the colony. These tasks include foraging for food, caring for the young, and tending to the fungus gardens. The workers are also the ones responsible for cutting and transporting the leaves. Soldiers are larger and stronger than the workers and have a specific role in protecting the colony. They have large mandibles that they use to defend the colony from predators.

One of the most remarkable things about leaf cutter ants is their ability to cut and transport leaves that are up to 50 times their body weight. The ants use their sharp mandibles to cut pieces of leaves, which they then carry back to the colony. Once back at the colony, the workers chew up the leaves and mix them with their saliva to create a pulp. This pulp is then used as a substrate to grow the fungus gardens.

Several survey of the literature identified the following knowledge gaps that are important to address in order to determine the effects of leaf-cutter ants on ecosystem processes:

1. *Nest attributes and physical alterations*—What are the relationships among nest architecture, nest alterations (e.g., translocation of soil material), and biogeochemical processes?
2. *Nest inputs*—What is the influence of organic nest inputs, including roots and Arbuscular mycorrhizal fungi, on nest carbon and nutrient dynamics?
3. *Carbon and nutrient transformation*—How do nutrient transformations in fungal and refuse chambers affect carbon and nutrient concentrations and fluxes?
4. *Nest outputs*—How do soil physical characteristics influence gas movement throughout leaf-cutter nests?
5. *Transport of dissolved organic matter*—What is the quantity and quality of dissolved organic matter? How are organic molecules transported from fungal and refuse chambers out of the nest?
6. *Spatial and temporal heterogeneity in nest dynamics*—How do spatial and temporal dynamics of leaf-cutter ant nests, including nest inception, migration, turnover, and mortality, influence rates and heterogeneity in nutrient cycling? What is their influence on ecosystem processes?

Effects of leaf-cutter ants on soil biogeochemical processes

The effects of leaf-cutter ants on net soil biogeochemical processes can be estimated by taking into account direct organic matter inputs and ant-mediated changes in soil properties inside nests. These impacts can be scaled up to estimate resulting ecosystem carbon dynamics by quantifying net density.

Leaf-cutter ants are dominant herbivores in Neotropical forest ecosystems, where they account for approximately 25% of all herbivory on a daily basis. Individual nests can span more than 50m², with ants harvesting up to 200m beyond the nest , and can reach up to 8 m below the soil surface. They remove 1–2 tons of fresh plant material annually.

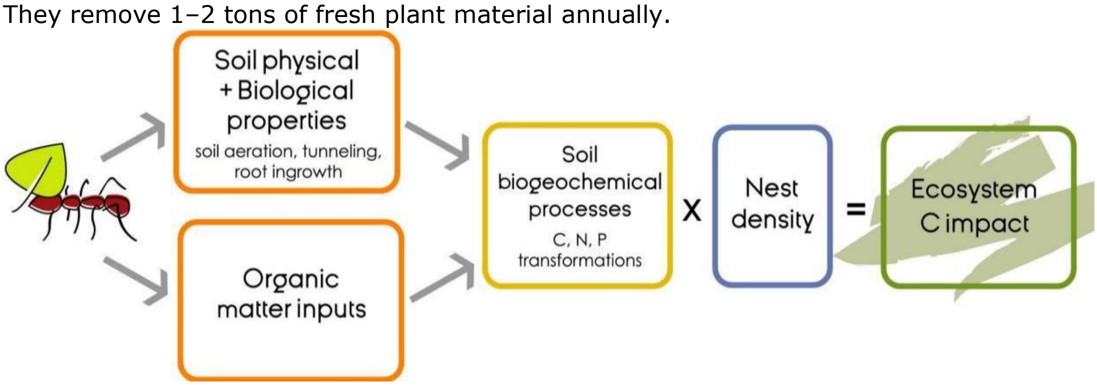

FIG. 2: Effect Of Leaf-Cutter Ants On Biogeochemical Processes

The harvested material is quickly decomposed in the nest by the fungal symbionts to produce hyphal nodules that are the main source of food for the ants. Ant-mediated soil disturbance and the rapid decomposition of the fresh organic material create biogeochemical hot spots. Leaf-cutter ants, along with termites and earthworms, are considered ecosystem engineers because they alter physical, chemical and biological conditions and affect resource and habitat availability of other species.

Effect of leaf-cutter ant nests on soil co2 concentrations and emissions

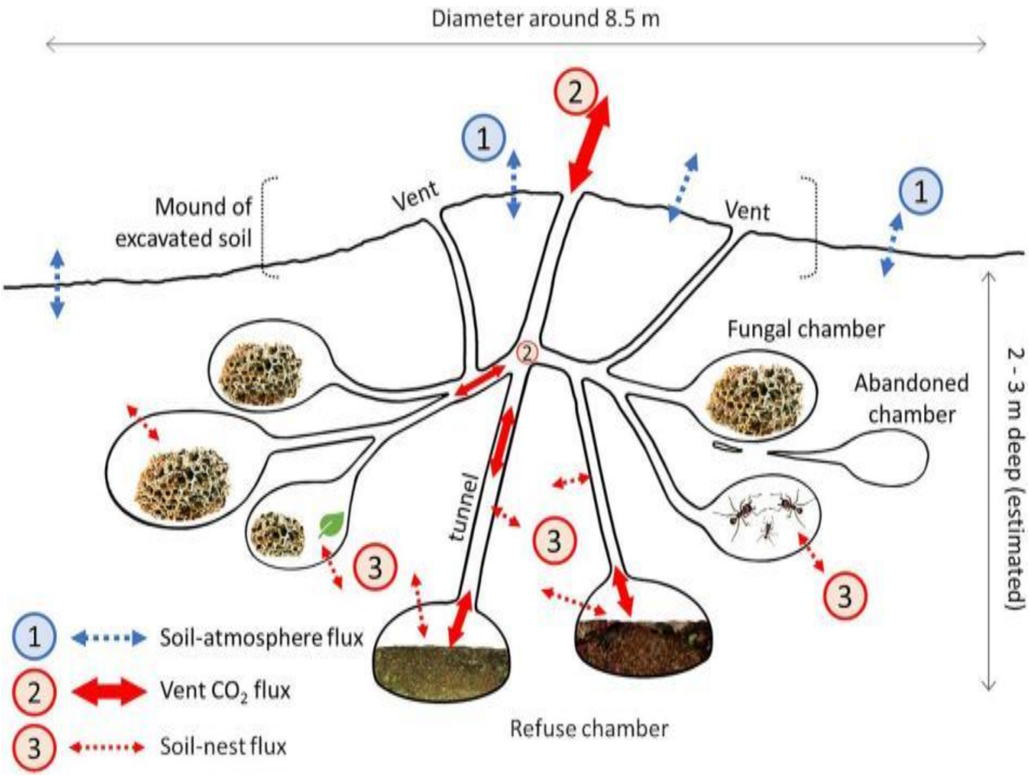

FIG. 3: Conceptual diagram of CO2 exchange and transport pathways in *Atta cephalotes* nests, including (1) Soil surface CO2 efflux; (2) Nest vent CO2 flux (convection and diffusion), where vent CO2 stems from nest production (primarily fungal activity and refuse decay); and (3) Soil-nest efflux.

The effect of leaf-cutter ant nests on soil CO2 concentrations and emissions is not well understood. As nutrient hot spots, it is reasonable to propose that nest soils emit more CO2 than nonnest soils, especially given that CO2 concentrations in nest tunnels are higher than atmospheric levels and can exceed 5% (by volume) in vents connected to fungal and refuse chambers. Leaf-cutter ant colonies constantly excavate their nest ventilation network to maintain adequate CO2 and O2 concentrations . For instance, grassland species *Atta vollenweideri* extend their vent openings by creating turrets above ground level to allow wind forced convection to drive ventilation. For most leaf-cutter ant species, vent CO_2 emission rates have not been well characterized, nor has the potential connection between the nest air and the surrounding nest soils. If the air in the nest has lower CO_2 concentration than the surrounding soil, given the large surface of nest walls and tunnels, the CO_2 emissions from the soil matrix to the nest air can be significant. If the opposite gradient occurs, it can be a relevant ventilation pathway for the nest.

The complex behavioral and metabolic processes in leaf-cutter ant nests, coupled with their intricate architecture, lead to soil CO_2 efflux regimes that combine diffusive and convective gas transport and are challenging to quantify. For instance, forced convection (pressure-driven flux) is caused by windy conditions in *A. vollenweideri* nests. Free convection, caused by significant gas density differences resulting from non-uniform temperature and vapor moisture content, has not been studied in leaf-cutter ant nests. It may play an important role in *A. cephalotes* nests built under dense canopies at times when the temperature and water vapor levels differ between the nest chambers and the atmosphere. Soil temperature and moisture content can significantly affect both soil gas diffusion and CO_2 production rates, and their relative contributions to soil CO_2 efflux can be difficult to separate. Within the soil matrix, diffusion from higher to lower concentrations is typically the dominant soil gas transport process, although instances of nondiffusive transport (convection) have been noted in soil respiration studies. Soil fauna can also affect soil properties pertinent to gas transport.

Conclusion

In conclusion, leaf cutter ants are fascinating creatures that have evolved to live in highly organized societies. Their ability to cut and transport large pieces of leaves, as well as their cultivation of fungus gardens, is a testament to their ingenuity and adaptability. By studying these ants, we can gain a greater understanding of the intricate social behaviors of animals and the delicate balance of ecosystems.

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