STM JOURNALS

International Journal of
Insects

Volume 1, Issue 2, 2024
July–December
DOI (Journal): 10.37591/IJI

https://journals.stmjournals.com/iji

Review IJI

Ants in Ecosystems and Agriculture: A Comprehensive Review

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Abstract

Nearly 60% of the world's habitats are underutilized. And current agricultural practices are blamed for contributing to soil carbon depletion and biodiversity loss. Climate change, habitat fragmentation, and other challenges hinder species development, leading to projected shifts in species distribution. This calls for alternative management strategies. The organizational structure of social insects, especially ants, offers a model for improved ants account for half of all insect biomass. It plays an important role in agricultural management superorganism. This article describes harvester ants and leafcutter ants, primarily the genus Lasius, and details their social structure. These ants collect plant sap with carbon-to-nitrogen (C/N) ratios of around 40 for their own sustenance and leaves with C/N ratios of 100 for fungus gardens and brood food. Their colony activities, such as burrowing, enhance soil aeration and drainage, while their fungus cultivation supports food preservation, disease control, and waste management. Ant colonies operate far from thermodynamic equilibrium, with physical, chemical, and biological gradients influencing nutrient cycling and biomass production. Leaf-cutter ants import 85–470 kg of plant material annually, primarily rich in carbon but low in nitrogen, facilitating nitrogen fixation and nitrate reduction. In nitrogen-deficient environments, ants rely on N_2-fixing microorganisms to meet nitrogen demands. As a result, harvester, leaf cutter and honeysuckle ants are managed with low nitrogen ants present a sustainable agricultural approach, reducing soil carbon degradation and preventing increases in N_2O emissions.

Keywords: Social insect organization, harvester ants, leaf-cutter ants, sustainable agriculture, nitrogen fixation, soil carbon management, fungus cultivation, biodiversity conservation

INTRODUCTION

Cooperative energy of organisms with creatures and plants and flexibility to fluctuating ecological conditions make them fundamental for better working of climate. Their association and flexibility to negative natural conditions are fundamental for their relationship with climate [1]. Ants has a place with family Formicidae of request Hymenoptera and are differentiated, social bugs assessed around 25,000 species. But Antarctica, ants can be seen in any mainland of the world. In an insect province, they can be not many to millions in number living inside little cavities/burrows occurring normally or developed by them [2]. An insect province comprises of one or not many sovereigns (rich females) and fruitful guys known as robots [3]. State additionally comprises of a position of apterous sterile females known as laborer and warrior ants [3, 4]. Ants positively affect physically just as substance properties of soil [5]. Ants are discovered to be compelling scroungers and hunters in their size range [6, 7]. Ants are acceptable soil blenders, supplement transport and help in better soil air circulation which makes them significant than night crawlers [8, 9]. They additionally assume

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Received Date: October 23, 2024
Accepted Date: October 25, 2024
Published Date: October 28, 2024

Citation: Soumik Dey Roy, Sourav Singh. Ants in Ecosystems and Agriculture: A Comprehensive Review. International Journal of Insects. 2024; 1(2): 15–22p.

applicable part as they help in seed dispersal and occasionally go about as pollinators [10]. There are a few animal types which go about as nuisance as they harm structures, for example, craftsman ants (*Camponotus* spp.). A few animal varieties penetrate our homes or harm the plants wellbeing in a roundabout way by shielding aphids from regular foes to gather honeydew emitted by them [5, 11].

EFFECT OF ANTS ON SOIL AND PLANTS

Ants assume huge function in soil activation in development and upkeep of their homes. They produce a lot of natural issues which are kept in exceptional offices of their home. By this natural issue creation, they leave an impact on physical just as substance properties of soil making them more useful for vegetation [2, 12]. Ants' homes influence soil fruitfulness in valuable manner by expanding supplements and cation level without adjusting the pH. These impacts rely upon taking care of propensities for ants. The home territory is so much ripe that it expands the supplements fundamental for plant development [13].

POTENTIAL OF ANTS AS BIOLOGICAL CONTROL AGENT

Ants are generally foragers as they chase for little animals or their eggs [14]. Wheeler's overview pronounced that the cornfield insect, *Lasius alienus* (Foerster) are accounted for to strike and wrecking the settlements termites *Reticulitermes flavipes* (Kollar) [15]. As per his examination, there are different ants known as the criminal insect, *Solenopsis molesta* (State), which takes and gobbles up termite brood. Some researchers also noted predation of *Aphaenogaster tennesseensis* Mayr and *A. fulva* Roger on termites [16, 17]. In another exploration, Adams noticed that *Formica sclllufussi* Mayr and *Formica exectoides* Forel removed the termites and devoured them. Chinese individuals used to put insect settlements in their citrus plantations for checking the nuisance populace [18]. There is a notable hunter known as Weaver subterranean insect, *Oecophyll smaragdina,* which is utilized against numerous farming nuisances to control their populace [14, 19, 20]. Besides, the little red insect, *Formica rufa* (Linnaeus), goes about as hunter of various defoliating bugs in Europe [21].

Genuine exploration about savage conduct of *Solenopsis geminata* has been done in certain harvests [22]. In the examination, plainly *S. geminata* can go about as a compelling natural control some against rice bugs (Table 1). In the examination alongside *S. geminata, Tapinoma. indicum and Paratrechina longicornis* (Latreille) were seen originating before on *N. lugens. S. geminata* likewise assaults eggs, hatchlings of rice leaf-folder *Cnaphalocrocis medinalis* (Guenée) (Lepidoptera: Pyralidae) inside the leaf folds. Ants are seen slithering into the collapsed leaves, nibbles, and upset the hatchlings and individual specialist incapacitates them (by stinging) and diverts to the home [20]. *Formica aquilonia* and *Formica rufa* are found exceptionally compelling against certain creepy crawlies and are being utilized to control the backwoods bugs in Europe [23, 24].

Table 1. Plant species which experimentally received ants' support in pest management.

S.N.	Crop	Ant Species	Pests Controlled	Highlights	Reference
1	Cauliflower	*Pheidole* sp.	Diamondback moth larvae, black cutworm larvae.	Decreased leaf damage by black cutworm larvae.	[25]
2	Cashew	*Oecophylla smaragdina*	Tea mosquito bug, fruit-spotting bug, mango tip-borer, leafroller.	Pests controlled, higher quality nuts produced.	[26, 27, 28]
3	Citrus	*Azteca* spp.	*Atta cephalotes*.	Presence prevents Defoliation.	[29]
4	Cocoa	*Wasmannia auropunctata*	Cocoa mirids.	Noted control of pest.	[30]
		Anoplolepis longipes	*Pantorhytes* sp., *Pseudodoniella Laensis*.	Reduced pest Numbers.	[31]

CONTRIBUTION OF ANTS IN POLLINATION

Specialist ants can be seen gathering nectar from flower portions of the plants. In any case, there is an astounding truth that fertilization by ants is exceptionally less revealed [32]. As we realize that a large portion of the fertilization is finished by bugs, just 30 reports are still for fertilization by ants [33, 34]. It is a suspicion about ants that because of their more modest size, they can undoubtedly get the nectar without contacting the conceptive pieces of the bloom and in this manner called nectar criminals. Besides, they have smooth fingernail skin which forestalls the dust to get connected to their body (Table 2) [35]. As indicated by some researchers, there are a few detailed ants which convey dust. Guys (males) of *Myrmecia urens* helps in pollinating *Leporella fimbriata* [33, 36].

Table 2. Plant species which experimentally received ants' support as pollinators.

Plant Species	**Reference**
Bordera pyrenaica (Dioscoreaceae)	[37]
Hormathophylla spinosa (Brassicaceae)	[38]
Blandfordia grandiflora (Lilliaceae)	[39]
Epipactis thunbergii (Orchidaceae)	[40]
Paronychia pulvinata (Caryophyllaceae)	[41]
Fragaria virginiana (Rosaceae)	[42]
Epipactis palustris (Orchidaceae)	[43]

ROLE OF ANTS IN SEED DISPERSAL

Plants take the assistance of creatures for far reaching of their seeds. It incorporates the strategy for staying of seeds with mammalian hairs and quills of feathered creatures. Seed dispersal additionally happens when creatures ingest natural product seeds and store them to somewhere else by spewing forth or discharge. However, among vertebrates, ants likewise assume significant function in seed dispersal. Ants scatter seeds in each landmass other than Antarctica. There are at least 60 families containing around 3000 blossom species which are disseminated by ants and in future, more can be found. Seed dispersal by ants is seen essentially two systems. First system if there should arise an occurrence of reaper ants wherein, they assemble seeds in bigger number and convey them to their home to burn-through later. At the same time, a few seeds are lost by them in the manner to home which under reasonable conditions, gets sprouted. Be that as it may, this instrument is stronger to subterranean insect endurance rather than seed endurance [44]. The other instrument is referred to as Myrmecochory which includes elaisomes as subterranean insect attractant [45]. Ants transport diaspores (seed having elaisome) into their home, feed on the elaisome, and dispose of the seed close to the home [46]. Elaisomes are variable in shading, size, and shape. They are meaty and consumable to ants [47].

In myrmecochorous dispersal, seed is scattered to new region with less rivalry which builds the fruitful dispersal and germination of seed [48]. *Aphaenogaster* sp. and *Pheidole* sp. of ants were observed shipping the seed into their home. *Pheidole grayi* were seen to scatter the most elevated number of seeds followed by *Aphaenogaster beccarrii* and while *S. geminata* eliminated the elaisome from the seed without moving it from its place [49].

ANTS AS PHORESY

The wonder of a living being to append itself on host's body with the end goal of transportation is called Phoresy [50]. Parasites are generally plentiful because of their little size, capacity to utilize the microhabitats in natural reach. Bugs can be found in earthly, sea-going just as marine living space moreover. They can undoubtedly connect to a collection of creepy crawlies, flying creatures, vertebrates, or creatures [51, 52].

Considering the kind of parasite, there are exceptional advancement stages with the end goal of phoresy. If there should arise an occurrence of vermin from infraorder Astigmata, second nymphal instar is changed into deutonymphs which have teardrop like shape, short legs and substandard gut [53]. Suborder Mesostigmata comprises of the biggest kind of bugs found in subterranean insect homes. They basically hold their phoretic have by tarsal hooks [54]. Suborder Uropodina have created diverse strategies for phoresy by gnawing to body hairs of their host, emission of paste to stay with have body for effective transportation [55]. There are various arthropods living in relationships with fire ants inside their homes. Collins and Markin have announced at least 50 creepy crawly species from homes of *Solenopsis* spp. [56].

There is little data with respect to parasites from *S. Invicta* home though a few vermin are seen in phoretic association with both winged and wingless structures [57, 58]. *Histiostoma blomquisti* is typically discovered connected to both winged and wingless structures. Yet, some scientists have found that these vermin favor the wingless structures more than winged structures [59].

ANTS AS PESTS OF STORED GRAIN PESTS

By searching on planted seeds, collected and put away grains, ants cause incredible harm all through the entire season [60, 61]. *Messor galla* Forel (Hymenoptera: Formicidae), additionally called reaper insect, is pest of developed little grains of oats in Nigeria [62]. Sorghum, millet, rice, and wheat go under significant staple nourishments in Nigeria, and furthermore utilized in bread shops and fermenting ventures [63]. Another research uncovered that the rummaging inclinations for oat grains by *M. galla* was subject to grain weight and the haulage limit of the specialist sizes [64]. Warburg saw that *M. arenarius* favors broken seeds of wheat over healthy wheat seeds [65].

ANTS AS FARMERS/PLANT GROWERS

Cultivating mutualism is a wonder wherein a creature underpins the other living being to develop so later they can get food from it. If there should be an occurrence of ants, mutualism with plants has been created. Ants are additionally in relationship with epiphytes when they develop plants in container settles and give it the sustenance to develop. For instance, *Philidris nagasau* (Dolichoderinae) are subterranean insect species that are in epiphytic relationship with *Squamellaria* sp. (Rubiaceae) where they involve the domatia, sow it and give sustenance basic to its development. Ants involve more than 70–80 percent of the domatia of *Squamellaria* sp. and scatter it close by to develop the plants [66]. A few types of *Squamellaria* including *S. grayi, S. huxleyana, S. thekii,* and *S. wilsonii* developed by ants rewards them with wholesome sugar mixes in return of their administration [67]. Gatherer ants, *Pogonomyrmex badius* makes exhibitions 40–100 cm subterranean and store seeds in them which can weigh up to 1 kg containing around 3,00,000 seeds [68, 69].

Seeds gathered by gatherer ants are put away in sodden, underground storehouses, which, in instance of *P. badius,* are for the most part between 40 cm and 100 cm subterranean. Absolute stores in this species may surpass a large portion of a kilogram and incorporate more than 300,000 seeds. MacKay detailed that over the yearly cycle, seed stockpiling in *P. rugosus* went from 10 to 70 mg of seeds for every laborer, with for the most part a lot of lower rates in *P. subnitidus,* and none in *P. montanus* [70, 71].

Huge states of *P. occidentalis* gather around 30 seeds for every dynamic hour, and house an expected 58,000 seeds in the home, 78% of which are from grass species alone. *Pogonomyrmex occidentalis* has been accounted for not to overwinter with seeds, suggesting that seeds in certain species might be gotten to or disposed of inside the range of a solitary yearly cycle [72]. Be that as it may, this is negated by Lavigne whose unearth of *P. occidentalis* recouped seeds consistently [73]. Little is thought about the living arrangement season of seeds in subterranean insect homes or if specific seed species are utilized specially. The general proportions of seeds entering and debris leaving can be checked, yet no endeavors have been made to screen the destiny of individual seeds or to gauge relative seeds on home occasions.

CONCLUSIONS

Ants play a crucial role in both the ecosystem and agriculture, serving as soil enhancers, biological control agents, seed dispersers, and even pollinators in some rare cases. Their ability to build extensive colonies, scavenge, and predate on pests makes them valuable in pest management. Their activities, such as soil aeration, organic matter deposition, and nutrient transport, improve soil fertility, and promote plant growth. Ants like *Oecophyll smaragdina*, *S. geminata*, and *Formica rufa* have shown remarkable efficiency in controlling pest populations in agricultural settings, proving their potential as cost-effective biological control agents. Additionally, ants contribute to seed dispersal, promoting plant diversity, and regeneration through myrmecochory. Certain ant species engage in farming mutualism, growing plants to provide themselves with food, illustrating the complex and beneficial relationship between ants and their environment. However, in certain cases, ants can become pests, particularly in stored grains, causing significant damage to crop and food supplies. Despite these downsides, the overall contribution of ants to ecological balance and sustainable agricultural practices is immense, highlighting their importance in both natural and managed ecosystems.

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