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ANTS IN AGRO ECOSYSTEMS: UNSUNG ALLIES OR HIDDEN FOES?

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Abstract

Ants (Formicidae) play a vital role in various terrestrial ecosystems, including agricultural landscapes. With more than 14,000 species identified worldwide, ants contribute substantially to invertebrate biomass and ecological processes (Hölldobler & Wilson, 1990). Their diverse behaviors, from predation to mutualism, have significant implications for crop health and pest regulation (Lach et al., 2010). In agricultural systems, ants often emerge as ecologically influential organisms, engaging in a range of interactions. Their role as predators can help suppress pest populations naturally; however, their tendency to form mutualistic associations with honeydew-producing insects may enhance pest infestations. This functional duality raises important questions about their net impact on farm productivity. Additionally, ants alter soil characteristics through nesting and foraging, which can affect nutrient dynamics and plant growth. Research has highlighted both beneficial contributions, such as improved nutrient cycling and pest control, and detrimental effects like seed damage and yield reduction due to pest facilitation. These outcomes are shaped by the specific ant species involved, local environmental conditions, and farming practices.

1. Introduction

Ants represent one of the most ecologically dominant and adaptable insect taxa, inhabiting a vast range of terrestrial ecosystems worldwide. Within agro-ecosystems, they are both prevalent and ecologically significant, often functioning as keystone organisms due to their interactions with multiple trophic levels. Their ecological plasticity and behavioral diversity allow them to thrive under various farming conditions and influence both biotic and abiotic components of agricultural environments. Despite being frequently encountered by farmers, the ecological roles of ants are often underappreciated or misunderstood. While many species contribute positively by preying on agricultural pests, others may promote pest outbreaks by defending honeydew-producing insects, thereby complicating pest management strategies. The distinction between beneficial and detrimental species is highly context-dependent, varying with species composition, environmental factors, and crop systems. With growing interest in sustainable agriculture and ecological intensification, ants are being re-examined for their potential role in reducing chemical inputs and enhancing ecosystem services. Emerging research highlights the need for a nuanced understanding of ant behavior in farming contexts. This review critically examines the diverse ecological functions of ants in agriculture, emphasizing their dual nature and implications for integrated pest and soil health management.

2. Ants as Beneficial Agents in Agro-ecosystems

2.1 Biological Pest Control

Numerous ant species serve as effective natural enemies of agricultural pests by preying on herbivorous insects that threaten crop productivity. A well-documented example is *Oecophylla smaragdina* (weaver ants), which have been employed in citrus and cashew orchards for biological pest suppression (Peng & Christian, 2004). These ants not only engage in direct predation but also interfere with pest establishment and behavior, thereby reducing infestation risks (Way & Khoo, 1992). Through their active foraging and territorial patrols, predatory ants create a deterrent effect that limits pest activity—a phenomenon often described as establishing a "landscape of fear." This continuous presence on plant surfaces can lower feeding rates and inhibit egg-laying by pest species. Field studies have shown that excluding ants from cropping areas often leads to a surge in pest populations and a corresponding decline in yields. In regions of Africa and Southeast Asia, ants have been integrated into pest management programs as part of ecosystem-based strategies. When not involved in mutualisms with honeydew-producing insects, these ants can act synergistically with other biological control agents such as parasitoids and predatory insects. Their impact on pest populations is frequently influenced by prey density and ant foraging dynamics. Promoting predatory ants in agro-ecosystems thus presents a low-input, ecologically sound alternative to synthetic pesticides.

2.2 Soil Aeration and Nutrient Cycling

Ants play a crucial role in shaping soil structure and fertility through their nesting and foraging behaviors. The excavation of tunnels by ants increases soil porosity, which enhances both aeration and water infiltration (Folgarait, 1998). These physical modifications improve conditions for root growth and microbial colonization. As they move and mix soil particles, ants help redistribute organic material and essential nutrients, thereby enhancing soil structure and nutrient availability. Many ant nests act as localized nutrient reservoirs, often enriched with nitrogen and phosphorus, which can benefit nearby plant roots, especially when nests are located within the rhizosphere. Additionally, certain ant species participate in seed dispersal (myrmecochory), contributing to plant regeneration and the maintenance of agroforestry systems. Ants also aid in organic matter decomposition by fragmenting litter and incorporating it into the soil, promoting microbial activity and enzymatic processes. Studies have recorded increased microbial biomass and biochemical activity in soils modified by ants, indicating improved soil biological health. These soil-engineering effects are particularly valuable in low-input or degraded agricultural lands, where external nutrient inputs are limited. Through these mechanisms, ants indirectly support crop productivity and sustainability in farming systems.

2.3 Mutualisms with Plants

Certain ant species establish mutualistic relationships with plants, particularly those offering extrafloral nectaries or food rewards. In exchange for these resources, ants often provide protection against herbivorous insects, forming a defense-based mutualism (Heil & McKey, 2003). Many crops and agroforestry species have evolved to attract ants through such traits, benefiting from reduced herbivore pressure. For instance, crops like cotton and pigeon pea with extrafloral nectaries can attract predatory ants that contribute to pest suppression in the field. Similarly, in coffee and cacao plantations, specific ant species are known to defend trees from herbivores, leading to improved plant health and yield stability. However, the effectiveness of these associations largely depends on the compatibility between ant species and host plants, as not all interactions result in positive outcomes. In some cases, ants may deter pollinators or interfere with reproductive processes. Management practices such as maintaining vegetative ground cover, conserving nectar sources, and minimizing pesticide applications can help sustain beneficial ant populations. Enhancing floral diversity and avoiding chemical disturbances are key strategies to promote these mutualisms. When appropriately managed, ant–plant partnerships can be integrated into ecological pest management systems to enhance crop resilience and reduce reliance on synthetic inputs.

3. Ants as Agricultural Pests or Pest Facilitators

3.1 Tending of Sap-Sucking Insects

One of the major ecological drawbacks of ants in agricultural systems is their mutualistic association with honeydew-producing pests such as aphids, mealybugs, whiteflies, and scale insects. In exchange for the sugary secretions known as honeydew, ants provide protection to these sap-feeding insects, defending them from natural enemies like parasitoids and predatory beetles (Styrsky & Eubanks, 2007). This protective behavior often results in increased pest survival and reproduction, ultimately exacerbating crop damage. Such interactions can undermine natural biological control efforts, as ants may actively attack beneficial insects including parasitoid wasps that regulate pest populations. Moreover, ant-tended pest infestations are linked to the spread of certain plant pathogens, further intensifying crop health issues. In organic and low-input farming systems, where chemical control is limited, these mutualisms may lead to unintended pest outbreaks. Research from cotton, tea, and citrus cultivation has consistently demonstrated the detrimental impact of these interactions. Effective pest management thus requires breaking the ant–pest partnership. Physical barriers like sticky bands on tree trunks and the use of repellent or barrier plants have shown promise in limiting ant access and reducing pest protection. Addressing these mutualisms is essential for maintaining ecological balance in agro-ecosystems and ensuring the success of integrated pest management strategies.

3.2 Direct Crop Damage

While most ant species are not herbivorous, certain ants can inflict direct damage to agricultural crops. For example, *Solenopsis invicta* (red imported fire ant) has been observed damaging germinating seeds and young seedlings, leading to poor crop establishment and reduced stand density. Under conditions of environmental stress, such as drought, ants may feed on sugar-rich plant tissues or harvest developing fruits, particularly in fruit orchards and vegetable plots. In stored grain systems, some ant species contaminate produce by nesting in storage bags or silos, compromising food quality and hygiene. Damage has also been recorded in crops like groundnut, maize, and sunflower, where ants either feed on seeds or interfere with flowering and fruit setting. Seed-harvesting ants, such as species from the genus *Pheidole*, may remove and relocate seeds, disrupting sowing patterns and germination uniformity. In some instances, ant-related damage can be confused with that caused by rodents or beetles, potentially leading to inappropriate management responses. Additionally, ant nests or trails may obstruct farm operations, interfering with machinery or clogging drip irrigation systems. Though less common than indirect effects, these direct damages by ants can pose economic risks and warrant monitoring in vulnerable cropping systems.

3.3 Competition with Other Beneficial's

Ants can negatively influence agro-ecosystem services by displacing or preying on other beneficial insects, including pollinators and natural enemies such as parasitoids (Lach, 2007). Their competitive and often aggressive behavior can disrupt the ecological balance necessary for effective biological control and pollination. For instance, *Linepithema humile* (Argentine ant) is notorious for outcompeting native arthropod communities, including key predators and pollinators. In citrus orchards, the presence of dominant ant species has been shown to interfere with the activity of parasitoids that target scale insects, thereby diminishing the effectiveness of biological control efforts. Ants also monopolize floral resources, deterring pollinators such as bees from accessing nectar or pollen, which can reduce pollination success and subsequent fruit set. This is particularly problematic in intensively managed or monoculture systems where floral diversity is limited. Studies have documented a decline in honeybee foraging behavior in areas heavily populated by aggressive ant species. The dominance of such ants can shift insect community dynamics, lowering the functional diversity and resilience of agro-ecosystems. To minimize these disruptions, managing both the abundance and species composition of ants is essential, ensuring that their presence does not compromise key ecosystem services.

4. Factors Determining Ant Roles

The role of ants in agro-ecosystems—whether beneficial or detrimental—is shaped by a complex interplay of ecological, environmental, and management-related factors. Species identity is a primary determinant, as some ant species are predominantly predatory and contribute to pest control, while others engage in mutualistic relationships with herbivorous pests, leading to increased crop damage. The size of the colony and specific foraging patterns further influence the magnitude and direction of their ecological effects. Agro-ecosystem structure, including crop diversity and landscape heterogeneity, affects resource availability and niche differentiation. Organic and diversified farming systems tend to promote beneficial ant communities that enhance ecosystem services, whereas monoculture systems and heavy pesticide usage often support pest-associated ant species. Ant behavior is also sensitive to abiotic conditions, such as drought, temperature fluctuations, and soil compaction, which can modify their foraging range and interactions. Agronomic practices like tillage, irrigation, and fertilization influence ant habitat suitability and activity levels. Additionally, crop species and developmental stage can affect the nature of ant interactions with pests and pollinators. Broader landscape features—such as hedgerows, woodlots, and water bodies—serve as corridors or barriers for ant dispersal and colony establishment. A nuanced understanding of these interconnected factors is crucial for developing ant-inclusive management strategies that optimize their beneficial roles while minimizing negative impacts.

5. Ant Management Strategies in Sustainable Agriculture

Effective management of ants in agricultural systems requires species-specific and context-based approaches to enhance their beneficial roles while minimizing negative impacts. Promoting native, predatory ant species can be achieved by enhancing habitat complexity through practices like intercropping, maintaining ground cover, and limiting chemical pesticide applications. Physical barriers such as sticky traps or exclusion bands can be used to restrict ant movement, particularly when trying to prevent them from tending honeydew-producing pests. Biological regulation through the introduction of natural ant enemies—such as phorid flies—or through competitive ant species, has shown potential in managing problematic ant populations. In some orchard systems, relocating nests of beneficial ants has also been explored as a strategy to optimize pest suppression. Farmer education is essential for distinguishing between harmful and helpful ant species, which supports better decision-making at the field level. At the landscape scale, conserving natural vegetation and ecological corridors can improve ant-mediated ecosystem services. Additionally, attractants and repellents derived from natural substances can influence ant foraging patterns, steering them away from sensitive crop areas. Regular monitoring of ant activity using bait stations or visual surveys helps guide timely and targeted interventions. These techniques should be integrated within a broader framework of sustainable pest and soil health management.

6. Research Gaps and Future Directions

Despite growing recognition of ants as important ecological agents in agriculture, several critical knowledge gaps persist. A majority of existing studies are short-term and geographically limited, often focusing on a single crop or region, which restricts the generalizability of findings. There is a pressing need for long-term, multi-crop field studies that evaluate both ecological functions and economic trade-offs of ant activity in diverse farming systems. The roles of ants in on-farm pollination and seed dispersal processes remain relatively understudied, particularly in tropical and subtropical agro-ecosystems. Advances in molecular biology offer opportunities to unravel complex species interactions and trophic relationships involving ants. Furthermore, the microbial communities associated with ants—their microbiomes—and their potential contributions to pest regulation and plant health are largely unexplored. Climate change adds another layer of complexity, yet little is known about how shifting environmental conditions will alter ant behavior, distribution, and ecosystem functions. From an economic perspective, cost-benefit analyses of ant-inclusive management strategies are limited, impeding broader adoption. Additionally, social dimensions—such as farmers' perceptions, cultural beliefs, and local knowledge about ants—warrant systematic investigation to inform effective communication and adoption strategies. Incorporating ant ecology into agricultural extension frameworks and fostering interdisciplinary collaboration among ecologists, agronomists, and farming communities are vital steps toward closing these research and application gaps.

7. Conclusion

Ants fulfill diverse and context-dependent roles within agro-ecosystems, functioning both as valuable allies and, at times, as agricultural antagonists. Their overall influence on crop productivity hinges on a complex interplay of species-specific traits, environmental variables, and farm management practices. Leveraging the ecological services ants provide—such as natural pest regulation and soil enhancement—demands carefully tailored, site-specific approaches. Simultaneously, their potential to foster pest outbreaks through mutualisms with honeydew-producing insects must be strategically controlled. The ecological versatility of ants poses both obstacles and opportunities in the pursuit of sustainable farming. With greater ecological insight and adaptive, integrated management, ants can serve as natural allies that reduce reliance on synthetic inputs and bolster system resilience. Going forward, it is essential to develop holistic ant management frameworks that combine ecological understanding with agronomic practicality and socio-economic viability. In the context of accelerating climate change and the urgent need for sustainable food systems, optimizing the functional role of ants in agriculture is both relevant and imperative. When appropriately managed, ants can emerge not as hidden threats, but as indispensable partners in agro-ecological transformation.

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