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Influence of Invasive Plant Species on Pollinator Networks and Crop Pollination Services: A Comprehensive Review

[1]Manshi Yadav, [2]Avshesh Kumar

[1,2,3]Department Of Botany ,T .D .P .G . College ,Jaunpur Affiliated To VBSP University ,Jaunpur (U.P.)222002.

ABSTRACT

The majority of blooming plants and numerous agricultural crops depend on pollinators for reproduction, which is crucial for preserving biodiversity and ensuring global food security. However, pollinator diversity and plant-pollinator interactions are seriously threatened by the fast spread of invasive alien plant species (IAPS). Invasive species frequently decrease native plant variety and pollination efficiency by changing the availability of floral resources, pollinator foraging behavior, and ecological networks. Pollinator visiting patterns, interaction frequency, and network stability have been observed to be altered by species like Lantana camara, Parthenium hysterophorus, Ageratina adenophora, Impatiens glandulifera, and Prosopis juliflora. By decreasing pollinator variety and interfering with migratory migration between wild and farmed habitats, these modifications may have a detrimental impact on crop pollination services.

The intensity of the invasion, the features of the ecosystem, and the makeup of the pollinator community all affect how big these effects are. The consequences of invasive plant species on pollinator communities, the structure of the plant-pollinator network, and crop pollination services are summarized in this article. Major ecological mechanisms, case studies from India and around the world, research gaps, and management techniques for pollinator conservation and ecosystem resilience restoration are also highlighted.

KEYWORDS
Pollinators, plant-pollinator networks, invasive alien plant species, biodiversity, ecosystem services, agriculture, and crop productivity.

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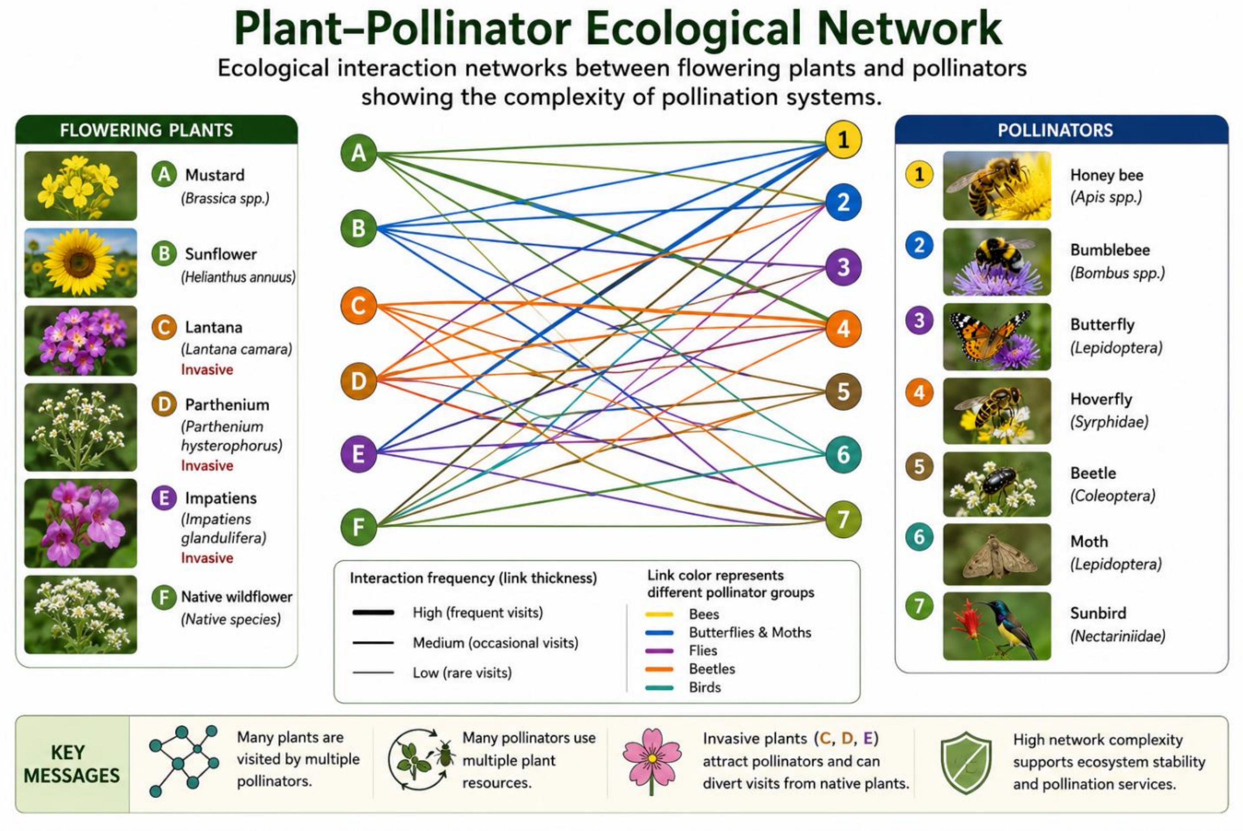
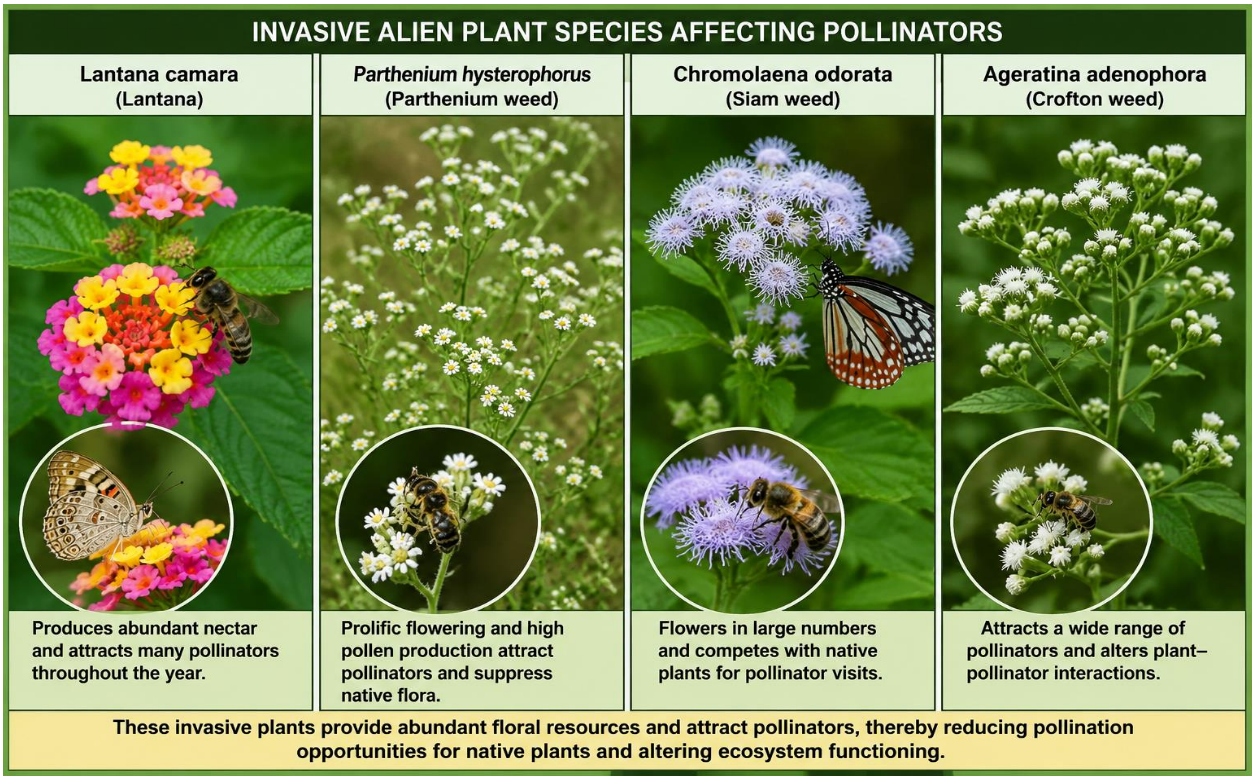
1. Introduction

Along with pollution, habitat loss, climate change, and overuse of natural resources, biological invasions are one of the main causes of environmental change worldwide. According to Pyšek et al. (2020), invasive alien plant species (IAPS) are non-native plants that spread quickly and have a detrimental impact on native ecosystems by changing species relationships, biodiversity, and ecosystem processes. Globalization, international trade, urbanization, and human disturbances have all increased their global expansion (Seebens et al., 2017). According to Vilà et al. (2011), these invasive plants alter soil microbial communities, vegetation structure, nutrient cycling, and ecological interactions, including those between plants and pollinators. As a result, it is now crucial to comprehend how they affect pollination services in order to conserve biodiversity and promote sustainable agriculture (IPBES, 2016).

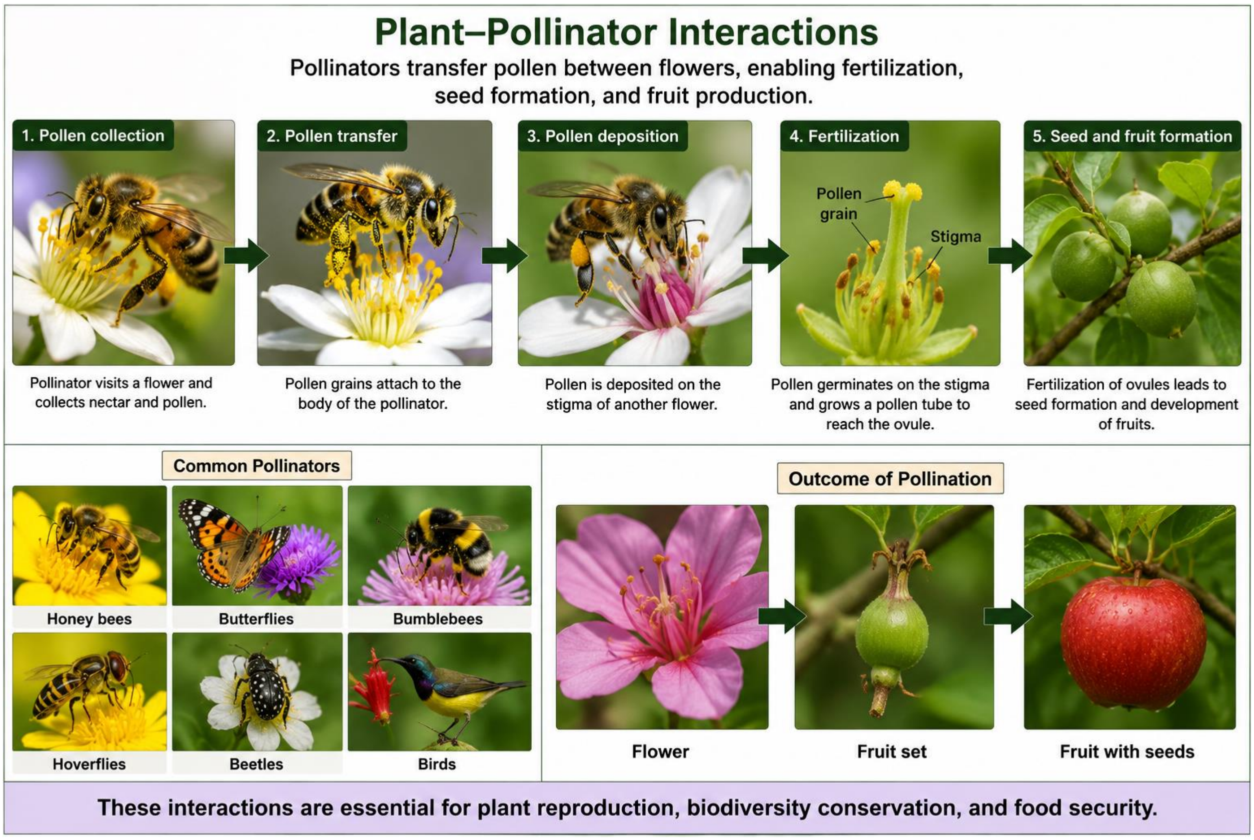


Approximately 87.5% of blooming plants and nearly 75% of globally significant food crops depend on pollination, which is one of the most significant ecological services (Klein et al., 2007). By moving pollen from blossom to flower, pollinators including bees, butterflies, moths, flies, beetles, birds, and bats ensure seed generation, fruit development, and plant reproduction (Ollerton et al., 2011). Pollination not only preserves biodiversity but also significantly increases agricultural production and global food security, with an estimated annual economic value of hundreds of billions of dollars (Potts et al., 2016). Pollinator populations are decreasing globally despite their ecological significance as a result of illnesses, biological invasions, agricultural intensification, habitat destruction, pesticide use, and climate change (Goulson et al., 2015). Invasive alien plants primarily affect pollinators indirectly by changing the variety, quantity, and seasonal availability of floral supplies, in contrast to many environmental stressors that directly lower pollinator populations (Stout & Morales, 2009). Pollinator foraging behavior, species composition, and interactions with native plants are all impacted by these changes, which eventually impair ecosystem functioning.



Plant reproduction and ecosystem stability depend on the intricate ecological networks that are created by interactions between plants and pollinators (Bascompte & Jordano, 2007). However, by displacing native vegetation or drawing pollinators with their profusion of flowers, extended flowering times, and high nectar production, invasive species frequently upset these networks (Morales & Traveset, 2009). Native species experience decreased pollen transmission, decreased seed generation, and decreased reproductive success as pollinators visit invading plants more frequently. During times of floral scarcity, certain invasive species, such as Impatiens glandulifera and Lantana camara, may momentarily supply copious amounts of nectar and pollen, sustaining pollinator populations (Lopezaraiza-Mikel et al., 2007). However, long-term declines in native floral diversity and ecological resilience frequently surpass these immediate advantages (Traveset & Richardson, 2014).

One of the main ways that invasive plants impact pollinator groups is through competition for floral resources. Their high nectar production, long flowering times, and dense floral displays draw a significant number of pollinator visits, which lowers the success of native plant species' pollination (Bjerknes et al., 2007). By changing floral characteristics including color, fragrance, nectar content, and flowering phenology, invasive plants also influence pollinator behavior. According to Bartomeus et al. (2008) and Morales & Traveset (2008), these alterations often result in decreased visitation to native plants and greater heterospecific pollen transfer, which lowers reproductive success and modifies the dynamics of plant communities. Additionally, ecological research shows that invasive plants reduce specialization while increasing network connectance, which makes pollination networks less stable and more susceptible to environmental disruptions (Aizen et al., 2008; Valdovinos et al., 2016).



Agriculture is directly impacted by disturbed pollination networks. For maximum yield and quality, insect pollination is crucial for many commercially significant crops, such as mustard, sunflower, apple, mango, tomato, cucumber, coffee, and almond (Klein et al., 2007). Pollinators may preferentially feed on invasive flowers rather than crop blossoms when invasive species predominate nearby habitats, which affects pollination efficiency and agricultural productivity (Potts et al., 2016). Invasive alien plant species like Lantana camara, Parthenium hysterophorus, Chromolaena odorata, Ageratina adenophora, Prosopis juliflora, and Mikania micrantha have taken over forests, grasslands, and agricultural landscapes in India, causing changes in pollinator communities and a loss of biodiversity (Reddy, 2008). As changes in flowering phenology and pollinator activity further disturb plant-pollinator interactions, these effects are predicted to worsen under climate change (Bellard et al., 2018).

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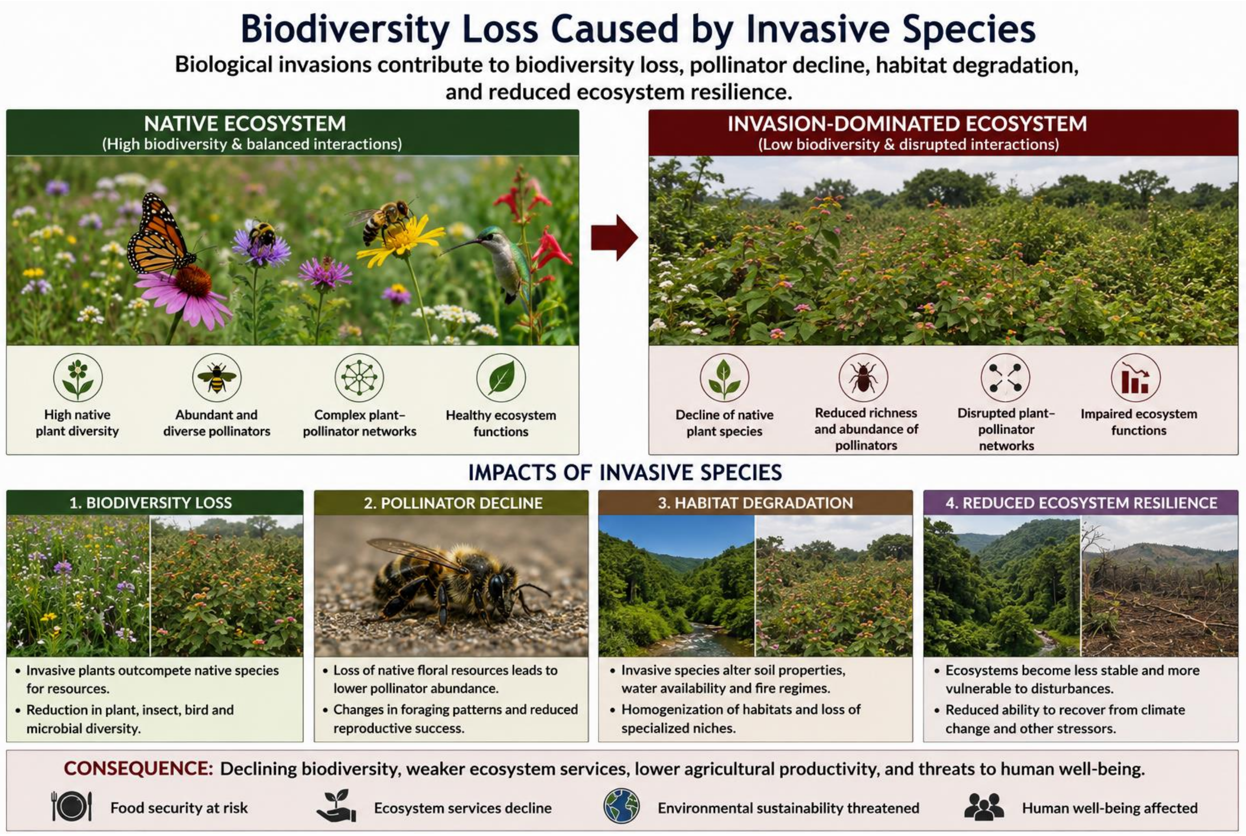

Comprehensive studies integrating invasive species, pollinator networks, and crop pollination services are still rare, especially in tropical locations, despite the fact that a significant amount of research has looked at invasive plants and pollinators independently. Thus, this review highlights ecological mechanisms, research gaps, and management strategies for pollinator conservation and sustainable agriculture while summarizing current knowledge on the impact of invasive alien plant species on pollinator diversity, ecological network structure, and crop pollination services.

Conclusion

One of the main causes of ecological change is invasive alien plant species, which have a substantial impact on pollinator communities, biodiversity, and ecosystem functioning. This research demonstrates how invasive species affect plant-pollinator interactions, change the availability of floral resources, and alter pollinator behavior—all of which are critical for preserving ecosystem stability and agricultural output.By drawing generalist pollinators and decreasing visits to native plant species, flowering plant invasions frequently alter the composition of plant-pollinator networks. These modifications weaken ecosystem resilience, simplify ecological networks, and diminish native plant reproduction. During times of floral scarcity, certain invasive species may momentarily supply nectar and pollen, but these short-term advantages are typically balanced by long-term reductions in native floral variety and pollination efficiency.

The review also emphasizes how invasive plants have a detrimental impact on crop pollination services by interfering with pollinator travel, competing for pollinators, and decreasing pollination success in many economically significant crops. Long-term infestations may therefore result in decreased fruit and seed quality, poorer agricultural yields, and financial losses for producers. These effects show that biological invasions pose a threat to food security and sustainable agriculture in addition to biodiversity.Native vegetation, pollinator habitats, and ecosystem services are at risk in India due to the widespread spread of invasive species like Lantana camara, Parthenium hysterophorus, Chromolaena odorata, Ageratina adenophora, Prosopis juliflora, and Mikania micrantha. Nevertheless, there are still few thorough studies that connect invasive plants, pollinator networks, and crop productivity, underscoring the need for more investigation.

To better understand invasion patterns and facilitate efficient management, future research should concentrate on long-term monitoring, ecological network analysis, remote sensing, molecular tools, and sophisticated modeling methodologies. To preserve pollination services and guarantee long-term ecosystem resilience, native flowering plant conservation, habitat restoration, invasive species control, and pollinator-friendly farming practices are crucial. In order to enhance biodiversity conservation and sustainable agricultural growth while reducing the ecological and economic effects of invasive plant species, cooperation between researchers, legislators, land managers, and local populations will be essential.

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