Introduction

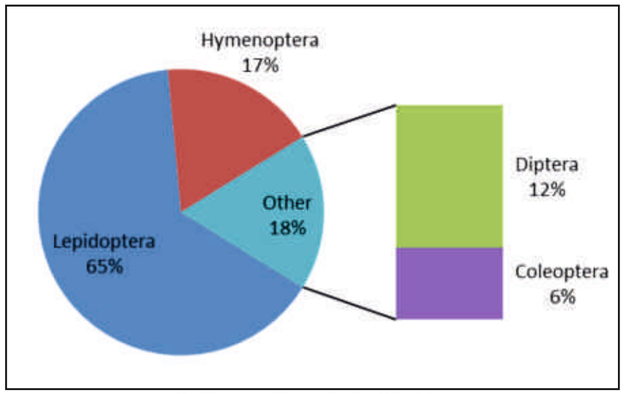
Biotic pollination is a crucial biodiversity dependent ecosystem service that contributes to crop & fruit yield, supports food security and provides other ecosystem services. Insect pollinators including bees, butterflies, beetles, flies, wasps and ants are fundamental to the functioning of forest ecosystems and agricultural systems worldwide. Pollination is a biological process in which pollen grains are transferred from the male reproductive structures of flowers to the female structures, resulting in fertilization and development of fruits and seeds. This process forms the foundation of plant reproduction and ecosystem continuity.

Alongside managed pollinators, rich and diverse communities of wild pollinators play a crucial role in the successful reproduction of pollinator dependent plants. Their presence enhances crop & fruit productivity by increasing yields and improving the quality of fruits and seeds. Pollination significantly enhances agricultural productivity and plays a critical role in ensuring food and nutritional security, conserving biological diversity, protecting environmental integrity and maintaining ecosystem. Beyond agriculture, insect pollinators support forest & natural vegetation, maintain ecological interactions and sustain ecosystem services. Forest ecosystems, in particular, rely heavily on pollinators for natural regeneration and long-term resilience. As the cultivation of pollinator dependent crops has expanded globally, human reliance on pollination services has also increased substantially. However, growing evidence indicates that 20–40% of pollinator populations and species diversity are declining globally, largely due to anthropogenic pressures. Immediate conservation action is therefore essential to safeguard pollinators and ensure sustainable ecosystems and food systems.

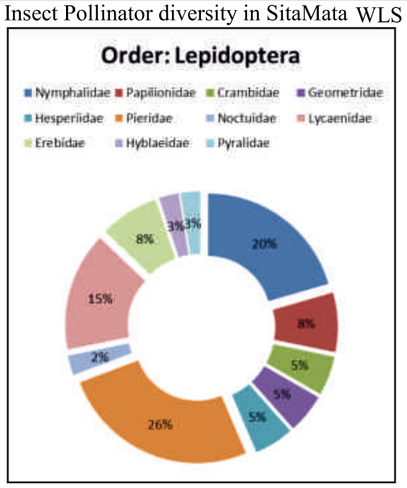
Insect pollinators serve as bio-indicators of forest health

Workdone by ICFRE-AFRI, Jodhpur

ICFRE–AFRI, under a CAMPA-funded project, conducted studies in Sitamata Wildlife Sanctuary, Rajasthan, situated in the southern Aravalli hills of India. The sanctuary spans 422.95 km² across the Chittorgarh and Udaipur districts (24°04′–24°23′N, 74°25′–74°40′E), comprising 359.60 km² of Reserved Forest and 63.35 km² of Protected Forest. With its unique flora and fauna, the sanctuary plays a crucial role in maintaining the ecological balance of the region. Insect pollinators are among the most important contributors to the health of this ecosystem, being essential for the reproduction of numerous plant species and the overall functioning of the sanctuary. This study aimed to assess the diversity of insect pollinators and establish long-term monitoring to understand their role in sustaining the sanctuary's ecological balance. The research focused on flowering plants and their insect visitors, documenting species from the orders Lepidoptera, Hymenoptera, Diptera and Coleoptera, with Lepidoptera recorded as the most species-rich group. These pollinators play a vital role in sustaining plant reproduction, maintaining genetic diversity and supporting the overall ecological health of the area.



Insect Pollinator diversity in SitaMata WLS



Richness of Lepidopteran insect di-versity in SitaMata WLS

Role of Insect Pollinators in Forest Ecosystem Conservation

Plant Reproduction

Insect pollinators are indispensable for the sexual reproduction of most flowering plant species in forest ecosystems. More than 80% of flowering plants worldwide rely partially or entirely on animal pollination. In forests, effective pollination ensures fruit and seed production, which is vital for natural regeneration and forest succession. Declines in pollinator populations can reduce seed set, impair seed viability and ultimately hinder forest recovery and expansion.

Maintenance of Genetic Diversity

Pollinators facilitate gene flow between spatially separated plant populations by promoting cross-pollination. This genetic exchange enhances population-level genetic diversity, which improves plant adaptability to environmental stressors such as pests, diseases and climate variability. In fragmented forest landscapes, mobile pollinators play a critical role in maintaining genetic connectivity among isolated plant populations.

Biodiversity support

By enabling fruit and seed production, pollinators indirectly sustain a wide range of forest-dwelling organisms, including birds, mammals, reptiles and other insects. The loss of pollinators can disrupt trophic interactions, leading to cascading ecological effects and reductions in overall forest biodiversity.

Ecosystem stability

Healthy pollinator populations contribute to ecosystem services that regulate climate and environmental processes. Therefore, conserving pollinators is closely connected to climate change mitigation and strengthening ecosystem resilience. Pollinators enhance ecosystem stability by supporting plant diversity and productivity. When pollinator communities are abundant and diverse, they promote effective pollination and seed production, ensuring plant reproduction and long-term survival. Greater plant diversity reduces the likelihood that disturbances such as disease, drought or climate change will eliminate entire plant communities, thereby creating more stable and adaptable ecosystems. In addition, by enabling fertilization and seed formation, pollinators boost plant productivity, sustain food webs and improve an ecosystem's capacity to recover from disturbances.

Contribution of Insect Pollinators to Crop Production

Globally, insect pollinators are vital to food production and economic stability. Approximately 35% of total crop production by volume depends on pollinators. Pollinator-dependent crops provide up to 40% of key dietary nutrients. More than 75% of the world's leading food crops benefit from animal pollination, particularly fruits, vegetables, nuts, oilseeds and spices.

India's agriculture, forestry and biodiversity are closely interconnected with insect pollination. More than 51% of cultivated crops in the country show some degree of dependence on animal pollination and more than half of cultivated plant species depend on pollinators for successful fruit and seed set.

Drivers of Pollinator Decline

Pollinators are declining not only in agricultural landscapes but also in forest areas, traditionally considered biodiversity refuges. Factors such as habitat fragmentation, invasive species, and climate stress are weakening forests' capacity to support healthy pollinator communities, thereby jeopardizing long-term forest sustainability. The major drivers of pollinator decline include:

Pathogens and Parasites: Pollinators are increasingly affected by infectious diseases, parasites and predators. In managed honey bees, parasites such as *Varroa destructor* and pathogens like *Nosema* spp. weaken immune defenses, reduce foraging efficiency and increase mortality.

Pesticide Exposure: The intensive use of agrochemicals, particularly systemic insecticides, poses a major threat to pollinators. These substances can cause direct mortality or induce sub-lethal effects such as impaired navigation, reduced learning capacity and lower reproductive success, ultimately destabilizing populations.

Habitat Loss and Fragmentation: Conversion of natural habitats into agricultural land, urban areas and infrastructure reduces floral diversity and nesting opportunities. Fragmented habitats force pollinators to travel greater distances, increasing energy expenditure and vulnerability to predators.

Climate Change: Altered temperature and precipitation patterns disrupt the synchronization between pollinators and flowering plants. Mismatches in emergence and flowering periods can lead to inadequate or failed pollination and a decline in insect pollinator populations.

Light Pollution: Artificial illumination interferes with the natural behavior of nocturnal pollinators, affecting navigation, feeding and reproduction and increasing exposure to predators.

Air Pollution: Air pollutants degrade floral scent molecules, reducing the distance over which scent cues travel. This hampers pollinators' ability to locate flowers and decreases foraging efficiency.

Invasive Species: Non-native pollinators, including managed honey bees in some regions, native pollinator populations.

Competition for Resources: As habitats shrink, competition for food and nesting sites intensifies both within and among species, placing additional stress on pollinator communities.

Agricultural Intensification: Monoculture farming systems and market-driven land use reduce plant diversity and eliminate continuous floral resources needed throughout pollinators' life cycles.

Consequences of Pollinator Decline

- Reduced plant yields
- Poor fruit & seed quality
- Loss of plant diversity
- Disrupted food webs
- Threats to Food Security
- Ecosystem imbalance

Strategies for Insect Pollinator Conservation

Strategy	Key Actions
Habitat Conservation	Protect forests, grasslands and wildflower corridors
Pollinator-friendly Farming	Reduce pesticide use; adopt integrated pest management
Agroforestry	Integrate native flowering trees and shrubs
Community Engagement	Educate farmers and local communities
Policy Support	Promote sustainable land-use and conservation policies

Published by

Dr. Ashutush Kumar Tirpathi

Director

ICFRE-Arid Forest Research Institute

Post-Krishi Upaj Mandi, New Pali Road, Jodhpur

Web: http://afri.icfre.org email:dir_afri@icfre.org

Phone : +91-0291-2722549

Prepared by

Dr. Shiwani Bhatnagar, Scientist-E & HOD

Forest Protection Division

Funded by : CAMPA Extension 2025-26

Designed by : Kusum Lata Parihar, ACTO Ext. Div.

Insect Pollinators: Key to Conserving Forest and Ecosystem Health

"By mediating cross-pollination, insect pollinators sustain plant reproduction and maintain biodiversity"

ICFRE-ARID FOREST RESEARCH INSTITUTE (AFRI) JODHPUR

INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN

(AN AUTONOMOUS BODY OF MOEF & CC, GOVT. OF INDIA)