International Journal of Engineering and Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 14 Issue 10 October 2025 || PP 52-58

A Study of Insects and Their Role in the Ecosystem

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Abstract
Insects represent one of the most diverse and ecologically significant groups of organisms, playing a vital role in sustaining ecosystem structure and functionality. This study explores the various ecological roles performed by insects and highlights their importance in maintaining environmental balance. Insects contribute extensively to key ecosystem processes such as pollination, nutrient recycling, soil formation, population regulation, and the stabilization of food chains and food webs. Through these functions, they support plant reproduction, enhance soil fertility, and ensure energy transfer across trophic levels.
The study is based on an in-depth review of existing scientific literature, including ecological research articles, environmental reports, and biodiversity assessments. It emphasizes how insects act as primary drivers of biodiversity and ecosystem resilience, often serving as indicator species for environmental health. In addition, the paper examines the growing threats faced by insect populations worldwide, including habitat loss, climate change, excessive pesticide use, pollution, and rapid urbanization. Evidence from previous studies suggests that the decline in insect populations can lead to serious ecological consequences, such as reduced pollination efficiency, disruption of food chains, and weakened ecosystem stability. These changes not only affect natural ecosystems but also have direct implications for agriculture, food security, and human well-being.
By synthesizing current research findings, this study underlines the urgent need for effective insect conservation strategies and sustainable environmental practices. Understanding the role of insects in ecosystems is essential for preserving biodiversity and ensuring long-term ecological sustainability. The paper aims to contribute to ecological awareness and provide a scientific foundation for future research and conservation efforts.
Keywords- *Insects, Ecosystem**,** Biodiversity**,** Pollination**,** Food Web**,** Decomposition etc.*

I. Introduction

Insects are among the most diverse and widespread organisms on Earth, comprising more than half of all known living species. They inhabit almost every terrestrial and freshwater ecosystem, ranging from forests and grasslands to agricultural fields and urban environments. Due to their vast diversity, abundance, and adaptability, insects play a central role in shaping ecosystem structure and maintaining ecological balance. Ecologists have long recognized insects as essential components of natural systems, contributing significantly to ecosystem functioning and resilience (Wilson, 1987; Stork, 2018).

One of the most critical contributions of insects lies in their involvement in fundamental ecological processes. Insects act as pollinators, decomposers, predators, prey, and ecosystem engineers, thereby facilitating nutrient cycling, energy transfer, and population regulation across trophic levels (Losey & Vaughan, 2006). Pollinating insects, such as bees, butterflies, and flies, are particularly important for plant reproduction and agricultural productivity, as a substantial proportion of flowering plants depend on insects for successful pollination (Ollerton et al., 2011). Similarly, decomposer insects aid in the breakdown of organic matter, accelerating nutrient recycling and improving soil fertility. Despite their ecological importance, insect populations are facing unprecedented declines in many parts of the world. Recent studies have reported significant reductions in insect abundance and diversity, raising serious concerns about ecosystem stability and sustainability (Hallmann et al., 2017; Sánchez-Bayo & Wyckhuys, 2019). Factors such as habitat destruction, climate change, intensive agriculture, pesticide use, and pollution are widely identified as major drivers of this decline. The loss of insects not only threatens biodiversity but also undermines ecosystem services that are vital for human survival and economic development.

In this context, the present study aims to examine the role of insects in ecosystems and to highlight their ecological, environmental, and socio-economic significance. By synthesizing existing scientific literature, the paper seeks to provide a comprehensive understanding of insect–ecosystem interactions and to emphasize the need for conservation-oriented approaches to ensure long-term ecological sustainability.

II. Concept of Ecosystem and Insect Diversity

An ecosystem can be defined as a functional unit of nature in which living organisms interact with one another and with their physical environment, including air, water, soil, and climatic factors. These interactions involve the flow of energy and the cycling of nutrients, which together sustain life on Earth. Ecosystems may vary in scale, ranging from small habitats such as ponds or grasslands to large systems like forests, deserts, and oceans. Within these systems, biotic components such as plants, animals, and microorganisms are interconnected through complex ecological relationships (Odum & Barrett, 2005).

Insects form a major part of the biotic component of ecosystems and represent the most diverse group of animals on the planet. It is estimated that insects account for nearly 70–80% of all described animal species, with millions of species still remaining undiscovered (Chapman, 2009). Their extraordinary diversity is reflected not only in species richness but also in their wide range of ecological functions. Insects occupy almost every ecological niche and are present at multiple trophic levels, functioning as herbivores, carnivores, decomposers, pollinators, and parasites.

The diversity of insects is closely linked to ecosystem complexity and stability. High insect diversity often indicates a healthy and resilient ecosystem, as different species perform complementary ecological roles. For example, while some insects specialize in pollination, others contribute to decomposition or act as natural predators controlling pest populations. This functional diversity ensures that ecosystem processes continue even if certain species decline, thereby enhancing ecosystem resilience (Tilman et al., 2014).

Moreover, insects exhibit remarkable adaptability to environmental conditions, allowing them to thrive in diverse habitats. Their short life cycles and rapid reproductive rates enable quick responses to environmental changes, making them important indicators of ecosystem health. Consequently, understanding insect diversity is essential for comprehending ecosystem functioning and for developing effective biodiversity conservation strategies.

III. Ecological Roles of Insects

Insects perform a wide range of ecological functions that are essential for the maintenance and stability of ecosystems. Their roles extend across multiple trophic levels and influence both biotic and abiotic components of the environment. Due to their abundance, diversity, and functional specialization, insects act as key drivers of several ecosystem processes. The major ecological roles of insects are discussed below.

3.1 Pollination and Plant Reproduction

One of the most significant ecological roles of insects is pollination. A large proportion of flowering plants rely on insects such as bees, butterflies, moths, beetles, and flies for the transfer of pollen. Insect-mediated pollination enhances plant reproductive success, genetic diversity, and seed production. It is estimated that nearly 75% of global food crops depend, at least partially, on animal pollinators, with insects being the dominant contributors (Klein et al., 2007). The decline of pollinating insects therefore poses a serious threat to both natural ecosystems and agricultural productivity.

3.2 Role in Food Chains and Food Webs

Insects form a crucial link in food chains and food webs. They serve as primary consumers by feeding on plants and as secondary consumers by preying on other insects. Additionally, insects are an important food source for birds, reptiles, amphibians, mammals, and fish. The removal or decline of insect populations can disrupt trophic interactions, leading to imbalances within ecosystems (Begon et al., 2006).

3.3 Decomposition and Nutrient Cycling

Many insects, such as beetles, ants, and termites, play a vital role in decomposition by breaking down dead plants, animals, and organic waste. This process accelerates nutrient cycling and returns essential elements like nitrogen and phosphorus to the soil, thereby enhancing soil fertility and supporting plant growth (Lavelle et al., 2006).

3.4 Soil Formation and Aeration

Soil-dwelling insects contribute to soil formation and structure through burrowing and organic matter processing. Their activities improve soil aeration, water infiltration, and microbial activity, which are critical for healthy ecosystems.

3.5 Population Regulation and Biological Control

Predatory and parasitic insects help regulate populations of other organisms, including agricultural pests. This natural biological control reduces the need for chemical pesticides and supports sustainable ecosystem management (Losey & Vaughan, 2006).

IV. Insects and Biodiversity Conservation

Insects play a crucial role in biodiversity conservation by supporting ecosystem stability, species interactions, and ecological resilience. Due to their high species richness and functional diversity, insects contribute significantly to the maintenance of biological diversity across ecosystems. They interact closely with plants, microorganisms, and vertebrates, forming complex ecological networks that sustain ecosystem processes (Cardinale et al., 2012).

One of the key reasons insects are vital to biodiversity conservation is their role as **indicator species**. Changes in insect diversity, abundance, or behavior often reflect alterations in environmental conditions such as habitat quality, climate variation, and pollution levels. For instance, declines in butterfly and dragonfly populations have been widely used to assess habitat degradation and climate change impacts, as these insects are highly sensitive to environmental disturbances (Thomas, 2005).Insects also function as **keystone species** in many ecosystems. Certain pollinators, such as wild bees, are essential for the reproduction of specific plant species. The loss of such insects can lead to cascading effects, resulting in plant population declines and subsequent impacts on herbivores and higher trophic levels. Similarly, decomposer insects like termites and dung beetles play an indispensable role in nutrient recycling, and their absence can significantly slow decomposition processes and reduce soil productivity (Nichols et al., 2008).

Furthermore, insect diversity enhances **ecosystem resilience**, enabling ecosystems to withstand and recover from disturbances such as droughts, fires, and invasive species. Functional redundancy among insect species ensures that if one species declines, others can partially compensate for its ecological role. This redundancy is critical for maintaining ecosystem services under changing environmental conditions (Tilman et al., 2014).Conserving insect biodiversity therefore has direct implications for broader biodiversity conservation goals. Protecting insect habitats, promoting landscape heterogeneity, and reducing anthropogenic pressures are essential strategies for sustaining insect populations. Effective insect conservation not only preserves individual species but also safeguards ecosystem integrity and long-term ecological sustainability.

V. Economic and Environmental Importance of Insects

Insects provide a wide range of economic and environmental benefits through the ecosystem services they offer. These services contribute directly and indirectly to human well-being, agricultural productivity, and environmental sustainability. Despite their small size, insects have a disproportionately large impact on global ecological and economic systems. One of the most economically significant contributions of insects is **pollination**. Insect pollinators support the reproduction of wild plants as well as major agricultural crops such as fruits, vegetables, nuts, and oilseeds. Studies estimate that pollination services provided by insects contribute hundreds of billions of dollars annually to the global economy. For example, global crop production reliant on animal pollination is valued at approximately USD 235–577 billion per year (IPBES, 2016). The absence of insect pollinators would lead to reduced crop yields, increased food prices, and threats to food security.

Insects also play a critical role in **biological pest control**, reducing the economic losses caused by agricultural pests. Predatory and parasitic insects such as ladybird beetles, parasitoid wasps, and dragonflies naturally regulate pest populations, decreasing the need for chemical pesticides. This not only lowers production costs for farmers but also minimizes environmental pollution and health risks associated with excessive pesticide use (Van Lenteren et al., 2018).

From an environmental perspective, insects contribute significantly to **nutrient cycling and waste decomposition**. Decomposer insects, including dung beetles and termites, break down organic matter such as dead plants, animal remains, and animal waste. This process accelerates nutrient recycling, improves soil structure, and enhances soil fertility. In grazing ecosystems, dung beetles alone have been shown to save millions of dollars annually by improving pasture quality and reducing livestock parasites (Nichols et al., 2008).Insects also have applications in **medicine and scientific research**. Compounds derived from insects are used in pharmaceuticals, while insect models such as fruit flies have played a vital role in genetic and biomedical research. Additionally, insects contribute to cultural, aesthetic, and educational values, strengthening human connections with nature.

Overall, the economic and environmental importance of insects underscores the need to recognize and conserve them as indispensable components of sustainable ecosystems.

VI. Threats to Insect Populations

In recent decades, insect populations across the globe have experienced alarming declines in both abundance and diversity. This phenomenon, often referred to as the “insect decline” or “insect apocalypse,” has raised serious ecological concerns among scientists and conservationists. Multiple studies indicate that insect populations are declining at unprecedented rates due to a combination of anthropogenic and environmental factors (Sánchez-Bayo & Wyckhuys, 2019).One of the most significant threats to insects is **habitat loss and fragmentation**. The conversion of natural habitats into agricultural land, urban areas, and infrastructure has reduced the availability of suitable environments for many insect species. Forest clearing, wetland drainage, and grassland degradation eliminate nesting sites, food sources, and breeding grounds, leading to population declines. Agricultural intensification, in particular, has simplified landscapes, reducing floral diversity and negatively affecting pollinator communities (Potts et al., 2010).

Pesticide use is another major driver of insect decline. The widespread application of chemical pesticides, especially neonicotinoids, has been linked to reduced survival, reproduction, and navigation abilities in insects. These chemicals not only target pest species but also harm non-target beneficial insects such as bees, butterflies, and natural predators. Several studies have demonstrated that chronic exposure to low pesticide concentrations can weaken insect immune systems and increase mortality rates (Goulson et al., 2015).**Climate change** poses an additional and growing threat to insect populations. Rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events disrupt insect life cycles, distribution, and seasonal activity. Many insect species are highly sensitive to temperature changes, and shifts in climate can lead to mismatches between insects and their host plants or prey species. Such disruptions can destabilize ecological interactions and reduce ecosystem resilience (Deutsch et al., 2018).

Furthermore, **pollution and invasive species** contribute to insect declines. Air, soil, and water pollution degrade habitats, while invasive species compete with native insects for resources or act as predators and pathogens. The combined impact of these threats has resulted in significant insect losses. For instance, long-term studies in Europe have reported declines of over 70% in flying insect biomass within protected areas (Hallmann et al., 2017).Addressing these threats is critical, as continued insect declines could have severe consequences for ecosystem functioning, biodiversity, and human well-being.

VII. Impact of Declining Insect Populations on Ecosystems

The decline in insect populations has far-reaching consequences for ecosystem structure, functioning, and stability. Since insects are integral to numerous ecological processes, their reduction can trigger cascading effects across multiple trophic levels. These impacts are not limited to natural ecosystems but also extend to agricultural systems and human societies that depend heavily on ecosystem services provided by insects.

One of the most immediate consequences of insect decline is the **disruption of pollination services**. A reduction in pollinator populations leads to decreased plant reproductive success, lower seed and fruit production, and reduced genetic diversity in plant communities. This can result in declining plant populations, particularly for insect-dependent species, ultimately altering vegetation composition and ecosystem dynamics (Ollerton et al., 2011). In agricultural ecosystems, pollinator loss directly affects crop yields and food security, increasing dependence on artificial pollination or less sustainable farming practices. Insect decline also significantly affects **food chains and food webs**. Insects serve as a primary food source for many birds, amphibians, reptiles, fish, and small mammals. A reduction in insect availability can lead to population declines in insectivorous species, disrupting predator–prey relationships. Studies have shown that declining insect biomass is closely associated with reductions in bird populations, particularly in agricultural landscapes (Bowler et al., 2019). Such trophic imbalances can destabilize entire ecosystems.

Another major impact is on **nutrient cycling and soil health**. Decomposer insects play a vital role in breaking down organic matter and facilitating nutrient recycling. Their decline slows decomposition processes, leading to the accumulation of organic waste and reduced nutrient availability in soils. This negatively affects soil fertility, plant growth, and overall ecosystem productivity (Lavelle et al., 2006).Furthermore, the loss of insects weakens **ecosystem resilience**, reducing the ability of ecosystems to recover from disturbances such as climate extremes, invasive species, and habitat degradation. Insects contribute to functional redundancy and stability; their decline makes ecosystems more vulnerable to environmental change. Collectively, these impacts highlight the critical importance of conserving insect populations to maintain ecosystem integrity and long-term ecological sustainability.

VIII. Conservation Strategies and Sustainable Practices

Given the critical ecological and economic importance of insects, the conservation of insect populations has become an urgent global priority. Effective conservation strategies must address the multiple drivers of insect decline while promoting sustainable interactions between human activities and natural ecosystems. A combination of habitat-based, policy-driven, and community-level approaches is essential for ensuring long-term insect survival and ecosystem stability. One of the most effective strategies for insect conservation is **habitat protection and restoration**. Preserving natural habitats such as forests, wetlands, grasslands, and hedgerows provides insects with essential resources, including food, nesting sites, and breeding areas. Habitat restoration efforts, such as reforestation and the creation of pollinator-friendly landscapes, have been shown to significantly improve insect abundance and diversity. For example, maintaining floral diversity in agricultural landscapes supports pollinators and other beneficial insects by ensuring continuous food availability throughout the year (Potts et al., 2010).

Sustainable agricultural practices play a crucial role in reducing insect decline. Integrated Pest Management (IPM) promotes the use of biological control, crop rotation, and selective pesticide application to minimize harm to non-target insect species. Reducing dependence on chemical pesticides not only protects beneficial insects but also enhances soil health and ecosystem resilience. Studies indicate that farms adopting IPM and organic practices often support higher insect diversity compared to conventionally managed farms (Van Lenteren et al., 2018).Policy interventions and environmental regulations are equally important. Implementing restrictions on harmful pesticides, protecting critical habitats through legislation, and incorporating insect conservation into land-use planning can significantly reduce anthropogenic pressures. International initiatives and biodiversity frameworks have increasingly recognized insects as essential components of ecosystem services, emphasizing their inclusion in conservation policies (IPBES, 2016).

Public awareness and community participation also contribute to successful conservation outcomes. Educational programs, citizen science initiatives, and urban greening projects encourage public engagement and promote insect-friendly practices at local levels. By integrating scientific research, policy measures, and societal involvement, insect conservation strategies can effectively support ecosystem sustainability and biodiversity preservation.

IX. Research Methodology

The present study adopts a qualitative and descriptive research approach based on an extensive review of existing scientific literature. The objective of this methodology is to synthesize current knowledge on insects and their ecological roles, identify key trends related to insect population dynamics, and examine the implications of insect decline for ecosystem functioning.

9.1 Research Design

This research is designed as a **systematic literature-based study**, focusing on secondary data sources. The study does not involve field experiments or primary data collection; instead, it relies on previously published peer-reviewed research to ensure scientific accuracy and reliability. Such a design is appropriate for understanding broad ecological patterns and developing theoretical insights into insect–ecosystem interactions.

9.2 Data Sources

Data for the study were collected from a wide range of credible sources, including:

- Peer-reviewed journals in ecology, entomology, and environmental science
- Academic books and edited volumes
- Reports published by international organizations such as environmental and biodiversity assessment bodies
- Conference papers and review articles related to insect ecology and conservation

Databases such as Google Scholar, ScienceDirect, SpringerLink, and JSTOR were consulted to access relevant and up-to-date literature.

9.3 Data Analysis

The collected literature was carefully reviewed and analyzed using a thematic approach. Key themes such as ecological roles of insects, ecosystem services, biodiversity conservation, threats to insect populations, and conservation strategies were identified and systematically examined. Findings from different studies were compared to identify common patterns, gaps in research, and areas of scientific consensus.

9.4 Limitations of the Study

As the study is based on secondary data, it is limited by the scope and availability of existing literature. Regional variations and species-specific dynamics may not be fully captured. However, by drawing from a diverse range of studies, the research provides a comprehensive overview of the role of insects in ecosystems.

X. Discussion

The findings of this study clearly demonstrate that insects are indispensable components of ecosystems, contributing to ecological stability, biodiversity maintenance, and the delivery of essential ecosystem services. By synthesizing evidence from a wide range of ecological studies, the discussion highlights how insect-mediated processes such as pollination, decomposition, biological control, and nutrient cycling are interconnected and mutually reinforcing. The reviewed literature strongly supports the view that insect diversity enhances ecosystem resilience. Ecosystems with a high diversity of insect species tend to be more stable and better able to withstand environmental disturbances such as climate variability, habitat alteration, and biological invasions. Functional diversity among insects ensures that key ecological processes continue even when certain species decline, thereby reducing the risk of ecosystem collapse. This aligns with broader ecological theories suggesting that biodiversity acts as a buffer against environmental change.

The discussion also reveals that the decline in insect populations poses a serious threat to ecosystem functioning. Reduced pollinator abundance directly affects plant reproduction and agricultural productivity, while losses in decomposer insects impair nutrient cycling and soil fertility. Furthermore, the disruption of food webs caused by insect decline has cascading effects on insectivorous species, ultimately affecting higher trophic levels and overall ecosystem balance. These findings highlight the interconnected nature of ecological systems and demonstrate how the loss of a single group can destabilize entire ecosystems. Another important insight emerging from this study is the strong link between human activities and insect decline. Agricultural intensification, pesticide use, habitat destruction, and climate change collectively exert pressure on insect populations. This suggests that conservation efforts must move beyond species-specific approaches and adopt integrated, landscape-level strategies that address multiple stressors simultaneously.

Overall, the discussion underscores the urgent need to incorporate insect conservation into broader environmental management and policy frameworks. Protecting insect populations is not only an ecological necessity but also a prerequisite for sustaining ecosystem services that support human well-being and economic stability.

XI. Conclusion

Insects play an indispensable role in maintaining the structure, functioning, and stability of ecosystems. This study highlights that insects are not merely abundant organisms but are fundamental drivers of key ecological processes such as pollination, nutrient cycling, decomposition, biological control, and energy transfer across trophic levels. Through these functions, insects support biodiversity, enhance ecosystem resilience, and contribute significantly to environmental sustainability. The review of existing literature clearly indicates that the ongoing decline in insect populations poses serious risks to ecosystem health. Reduced insect abundance can disrupt pollination services, weaken food webs, impair soil fertility, and decrease the capacity of ecosystems to adapt to environmental changes. These ecological consequences have direct and indirect implications for agriculture, food security, economic stability, and human well-being. The findings emphasize that insect decline is not an isolated environmental issue but a broader ecological challenge with long-term global consequences.

The study also underscores the role of human activities—such as habitat destruction, intensive agriculture, pesticide use, pollution, and climate change—as major drivers of insect population decline. Addressing these challenges requires a shift toward sustainable land-use practices, environmentally responsible agricultural systems, and effective conservation policies. Protecting insect habitats, promoting biodiversity-friendly farming, and raising public awareness are essential steps toward mitigating insect losses. In conclusion, conserving insect populations is crucial for preserving ecosystem integrity and ensuring long-term ecological sustainability. Greater scientific attention, policy support, and community involvement are needed to safeguard insects and the vital ecosystem services they provide. Future research should focus on region-specific studies, long-term monitoring, and the development of innovative conservation strategies to better understand and protect insect diversity in a rapidly changing world.

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