International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 15-06-2026, Accepted: 15-07-2026, Published: 30-07-2026
Volume 11, Issue 3, 2026, Page No. 193-196

Pollination potential and conservation challenges of *Apis florea*

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DOI: https://doi.org/10.66856/ijer.2026.11.3.11259

Abstract

Apis florea is an important pollinator widely distributed in tropical and subtropical regions.It is also called as dwarf honey bee. It plays a significant role in the pollination of numerous cultivated crops as well as wild plant species, thereby supporting ecosystem stability and agricultural productivity. Due to its efficient foraging activity and adaptability to diverse environmental conditions, this species contributes greatly to plant reproduction and biodiversity maintenance.

In recent years, however, populations of *Apis florea* have shown signs of decline due to several environmental and anthropogenic pressures. Factors such as habitat degradation, indiscriminate use of chemical pesticides, changing climatic conditions, and infestation by pathogens and parasites including *Nosema* species and *Varroa* mites have negatively impacted its survival and pollination performance. The reduction in pollinator populations can have serious consequences, including decreased crop productivity, disruption of ecological interactions, and potential threats to food security.

This study emphasizes the ecological and agricultural significance of Apis florea and discusses the potential impacts of its declining populations on ecosystem functioning. It also highlights the importance of adopting sustainable management approaches, such as minimizing pesticide usage, conserving natural habitats, and encouraging the growth of native flowering plants. Improving our understanding of the biology and ecological requirements of *Apis florea* will be essential for developing effective conservation and management strategies aimed at protecting this valuable pollinator.

Keywords: *Apis florea*, pollination, conservation, management, apiculture

Introduction

Pollination is essential for maintaining ecosystem balance and is crucial for crop production. It links agriculture with the natural cycle of life, enhancing both the quality and quantity of crops produced. Pollination is defined as the transfer of pollen from male anthers to female stigmata, which can occur within the same flower (self-pollination) or between different plants (cross-pollination). Bees are highlighted as key vectors in this process, particularly in cross-pollination, which is vital for many crops [13]. Insect pollination is a cost-effective and eco-friendly way to boost agricultural yield, with one-third of the global food supply relying on it [17].

Pollinators, particularly insects, play a crucial role in enhancing the quantity and quality of crops, making them essential to farmers worldwide. As the human population grows, agricultural systems must produce more food sustainably, and pollinators will continue to be vital to these systems. Insects, especially bees, are the most important group of pollinating insects, with over 200,000 species thought to act as pollinators. The relationships between pollinators and plants vary, ranging from generalist to highly specialized, and can change depending on the region and time of year. Different pollinators are used for different crops, such as honey bees for mangoes in Brazil and bumble bees and flies in Israel [9].

Honey bees play a crucial role in crop production and preserving wild habitats through their coevolution with native flora. Their diverse nesting strategies and specific relationships with host plant biochemicals make them ideal for monitoring environmental processes [8]. Honeybees play a crucial role in human prosperity and ecosystem functioning, contributing to pollination, biodiversity, and the economy. They are the primary producers of honey, pollen, bio-wax, and royal jelly. In India, there are several species of honeybees, including the Indian bee, Italian bee, Rock bee, little bee, and Stingless bee. The Little bee (*Apis florea*) is a wild species that has been partially domesticated and is known for its high medicinal value honey [17].

There is a growing concern of pollinator decline due to various factors such as pesticides, climate change, and habitat loss. This decline poses a significant threat to food security and ecosystem services. Honeybees play a crucial role in crop pollination and food production. It is estimated that around 1.5 billion colonies are needed annually to meet the global pollination demand, but the current number of managed honeybee colonies is insufficient. There is a need to conserve both managed and unmanaged pollinator populations, including wild and feral populations, to ensure ecosystem services and food security. The conservation of both populations is essential, particularly in regions where they coexist, such as Africa where bee-keeping depends on swarms trapped from the wild [7]. Organizations like the Convention on Biological Diversity and the Food and Agricultural Organization of the United Nations are increasingly focusing on this issue due to the perceived jeopardy of pollination systems [1].

The conservation of wild honeybees is crucial due to their vulnerability to habitat loss, human influence, and exploitation. Factors influencing the conservation of dwarf honeybees include seasonal variations, swarming and migration, destruction of habitat, and the impact of chemical insecticides. For the management of dwarf bee colonies, methods such as the use of smoke, handling the queen, and hiving the colonies is undertaken [10].

Importance

Bees are the primary pollinators in agricultural systems, with over 20,000 species worldwide, of which 50 are managed by humans for various purposes, including crop pollination. The Western Honey Bee (*Apis mellifera*) is one of the most widely used species. However, the diversity of wild bee species varies greatly across the world, with the highest numbers found in warmer temperate areas. Only a small number of common species, such as bumble bees and carpenter bees, are important for agriculture, with 80% of crop pollination provided by just 2% of bee species [9].

The economic value of global pollination was estimated at EUR 153 billion, representing 9.5% of the world's agricultural production of human food in 2005. Insect-pollinated crops, especially vegetables and fruits, contribute significantly to this value, with each category generating around EUR 50 billion. A stark contrast is noted in the economic value of crops dependent on insect pollination versus those that are not. For instance, crops reliant on pollinators are valued at an average of EUR 761 per ton, compared to EUR 151 for those that do not depend on insect pollination [12].

Prior research has highlighted the importance of pollinators in agricultural productivity and biodiversity. Studies have shown that bees, including *Apis florea*, contribute significantly to the pollination of many crops and wild plants, which is crucial for maintaining ecosystem balance and food security [3]. Insect pollination, primarily by honey bees, contributes to 75% of global crop pollination, with honey bees accounting for 70-80% of this. The decline in honey bee populations can severely impact biodiversity and agricultural productivity [8].

The significance of pollinators is highlighted by studies showing that their presence can increase both the volume and quality of crops. For instance, a project in India demonstrated that farmers who utilized honey bees for pollination saw substantial increases in their onion seed and pomegranate yields, by 17% and 35% respectively. This increase in yield also translated to higher incomes for farmers, with onion farmers seeing a 19% rise and pomegranate farmers a remarkable 42% increase in profits [9].

Carrot is a cross-pollinating crop that relies heavily on insects for seed production. As it is protandrous, self-pollination is not possible, requiring the assistance of cross-pollinating insects. Honeybees are the most efficient pollinators of carrots due to their affinity for pollen and nectar. Research has shown that insect pollination improves the quality and quantity of carrot seeds. The results of a study showed that 21 species of insects from 13 families, 17 genera, and 4 orders visited carrot flowers. The dwarf honeybee, *Apis florea*, was the most common visitor, making up over 94% of the flower visitors [4].

Factors and Consequences of Population Decline

The red dwarf honey bee is a crucial pollinator in India's northwestern region, known for its abundance and significance in pollinating around 35 crops, especially those that require cross-pollination. It plays a vital role in pollinating crops with specific needs like self-incompatibility, protandry, protogyny, or unisexual flowers, particularly during the summer months when other pollinators are less active. The loss of foraging populations of *Apis florea* in this region would result in a significant reduction in available pollination services for crop growers. The crops in this region depend heavily on the pollination services provided by this honey bee for successful fruit or seed production. The decline in the colony numbers and foraging populations of the red dwarf honey bee poses a serious threat to crop pollination in the northwestern region of India [13].

The effects of habitat fragmentation on bee populations were studied, noting that while some species may thrive, others may decline. This variability underscores the importance of species-specific traits in understanding population dynamics. There is a gap in understanding how indirect factors, such as land management practices, relate to direct factors like food resource availability. It calls for more manipulative experiments to clarify these relationships and their implications for bee conservation [6].

A study highlighted the risks of disease and pest transmission between managed and wild pollinators, particularly in areas with high colony densities, such as apiaries. They note that the introduction of non-native species, such as the Western honeybee (*Apis mellifera*), has led to the spread of diseases and parasites, including the Varroa mite, which has devastated honeybee populations in Europe and North America. In contrast, African honeybees have shown resilience to Varroa infestation, likely due to their genetic diversity and interactions with wild populations. The study also discusses the risks of host shifts and disease transmission between managed and wild bumblebees, citing examples of parasites and diseases that have been introduced through commercial transportation of bumblebee colonies [7].

Different insecticides pose varying risks to dwarf honey bees. Emamectin benzoate was identified as the most toxic, with a low LC50 value of 1.02 g/mL after 48 hours. This is consistent with previous studies, which have shown that emamectin benzoate is highly toxic to bees due to its low detoxification during metabolism and high absorption coefficient. In contrast, fipronil was found to be less toxic, with a higher LC50 value of 3.52 mg/mL after 72 hours. It was also found that imidacloprid had a long half-life, with an LT50 value of 11.21 hours at 40 ug/mL [14].

An economic model was presented to measure the impacts of pollinator deficits on traded commodities. The findings suggested that consumers may face higher prices and reduced availability of affected commodities, while producers might experience mixed outcomes-potentially higher prices despite crop declines [1].

Management Strategies

Bees play a crucial role in agriculture, contributing an average of $3,251 per hectare to crop production worldwide, similar to managed honey bees. However, conserving pollinator diversity is essential beyond the key pollinator species, as it provides insurance against future changes and makes agricultural systems more resilient. Protecting pollinator diversity also ensures that specific relationships between crops and pollinators are maintained, as the disappearance of one pollinator does not guarantee the presence of another. This diversity can be protected by integrating conservation measures with sustainable agricultural practices, which can increase crop yields and protect bees and other pollinators. Research shows that introducing occupied carpenter bee nests can increase pollination and improve crop yields. The effectiveness of pollinators varies depending on factors such as their abundance, ability to reach individual plants, and pollen transfer efficiency. Both wild and managed bees contribute to pollination, but managed bees are more reliable and versatile, although they have limitations, such as a mismatch between body size and flower size. The introduction of managed bees can also have negative ecological effects, such as competition with wild pollinators, and careful consideration is needed when introducing them to an ecosystem [9].

There is no one-size-fits-all approach to conserving pollinators, as different species have varying preferences for food sources and nesting sites. Research is ongoing to identify effective conservation measures for different regions, crops, and pollinator species. One such example are the apple orchards in south-west Germany, where the creation of hedges is being tested as a way to support pollinators and improve pollination services. A better understanding of pollinators and their needs will lead to more effective conservation and management measures, ultimately benefiting farmers, consumers, and nature [9].

The commencement and cessation of foraging activities of *Apis florea*, a species of honey bee, were found to be influenced by various environmental factors. The bees started foraging between 08:00 and 08:50 hours in the morning, with activity levels increasing as the temperature, light intensity, and solar radiation increased. The bees ceased foraging when the light intensity and solar radiation declined. The diurnal activity pattern of *A. florea* showed a peak in activity between 12:00 and 14:00 hours, with the highest number of bees observed during this period. The bees were found to be more active in clear weather conditions, with temperature, light intensity, and solar radiation being the most important factors influencing their activity. The presence of nectar sugar concentration also had a positive effect on bee activity, although its direct effect was small. The analysis of the correlation matrix and path coefficients revealed that temperature, light intensity, and solar radiation were the most important factors influencing bee activity, while relative humidity had a negative effect [5].

A. florea plays a crucial role in pollination and biodiversity preservation, especially in tropical and subtropical climates. Its contribution to agricultural production and ecosystem services is significant in India, high lighting the need for understanding its population dynamics and health. Research involving field surveys and laboratory analyses to assess the health and behaviour of *Apis florea* were done. Observations were made in different plots during specific months to evaluate pollinator activity and the overall health of the colonies. The study found that the number of pollinators, including *Apis florea*, varied significantly across different months and times of the day. For instance, higher pollinator activity was recorded in February compared to January, with specific plots showing greater concentrations of pollinators [16].

In a study done in Egypt, it was found that the environmental parameters of the study area were suitable for the Asian giant honey bee (*A. florea*). The area's diverse topography, climate, and vegetation provide a range of habitats for the species. The analysis of the random forest model showed that temperature-related parameters are the most influential features in the model and precipitation-related parameters also play a significant role. The study's findings are consistent with previous research, which suggests that *A. florea* can tolerate high temperatures and is adaptable to various environmental conditions. The results also indicate that the species prefers areas with a moderate to high percentage of tree cover and non-tree vegetation. The study's findings have implications for conservation efforts, particularly in identifying and prioritizing areas with high habitat stability [18].

Effective management practices are crucial for enhancing bee productivity, for example the use of clipping methods to protect brood and hygienic honey extraction techniques. Additionally, the introduction of the millennium hive has been highlighted as a significant advancement in maintaining colony health and productivity. Several regions in India have high potential for beekeeping, including Jammu and Kashmir, the northeastern region, and various states with unique flora that serve as excellent forage sources for bees. Specific plants like sandalwood, litchi, and mustard are noted for their significance in honey production [2].

Ecological Niche Models (ENMs) are essential for understanding species' responses to environmental changes and for predicting suitable habitats. Studies note that the reliability of ENMs is contingent on the quality of presence data and model parameters, which is crucial for assessing the impacts of climate change on species distribution [11]. Research emphasizes the importance of public awareness regarding the presence of *A. florea* and the need for management strategies to control its spread. This aspect is crucial for addressing the challenges posed by invasive species in urban environments [15].

Conclusion

The decline in colonies and foraging populations by about 25% over 27 years in India raises concerns about potential extinction. Factors contributing to the decline remain unknown, with a positive correlation between colony and forager numbers indicating fewer colonies as a possible cause. Despite no major diseases or pests impacting this honey bee, the indiscriminate use of insecticides on cotton and rice crops is believed to be the primary reason for the decline. Loss of nesting areas and floral dearth were deemed unlikely causes, as ample nesting sites and year-round bee flora were available. The toxic effects of insecticides, especially on bees visiting treated crops, have led to significant mortality and colony losses, threatening the honey bee’s survival in the region. Immediate conservation efforts are crucial to prevent total extirpation, emphasizing the need for long-term strategies like integrated pest management to safeguard this important pollinator and its services.

There is a need for caution when transporting pollinator species out of their native range, citing the risks of introducing non-native species that can harm local ecosystems. There is a concern about the potential for the Varroa mite problem to spread to bumblebees in new regions, and the impact of large-scale beekeeping on native pollinator biodiversity. Managing bees in a way that prioritizes regionally endemic species and avoids transporting insects across ecological borders or continents is essential, in order to safeguard pollinator populations and maintain ecosystem services that support human life and food security.

Honey bees (Apis species) were the most abundant pollinators, making up 44.36% of total visits. Their abundance was significantly higher in summer months (March to May) and lower in winter months (November to January), likely due to the availability of foraging resources. There is also a positive relationship between bee abundance and floral resources, but a negative relationship with relative humidity. Knowledge of honeybee flora is crucial for apiculture and commercial crop pollination, and adequate forage resources are essential for honeybee colony health and profitability.

Studies warn of potential serious problems for global food supply and trade if current trends in pollinator decline are not addressed. It suggests that various crops and cropping systems could serve as starting points for further economic studies on this topic. There is an urgent need for economic assessments of pollinator declines, highlighting both the challenges and the potential areas for future research. The findings aim to inform policymakers and stakeholders about the economic ramifications of pollinator shortages in agriculture.

The findings underscore the urgent need for conservation strategies and sustainable management practices to enhance the resilience of *Apis florea* populations in the face of environmental changes and biological constraints.

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