Strategies and Outcomes in Bee Conservation: Evaluating Impact on Pollination Ecosystems

Abstract:

Pollination stands as a crucial process vital for ecosystem maintenance, with pollinators serving as pivotal vectors. Approximately 80% of pollination relies on insects, with bees emerging as primary contributors. Their significant role in ecosystem services and economic value cannot be overstated, given that approximately 30% of food sources directly or indirectly rely on honeybee pollination. Additionally, honeybees provide essential products such as honey, propolis, beeswax, and venom. However, the alarming decline in honeybee populations due to various threats, including habitat loss from land use intensification, pesticides, climate change, pathogens, parasites, diseases, invasive species, and nutritional deficiencies, poses a grave concern. To ensure the conservation of honeybees and sustain pollination for future generations, a multifaceted approach is imperative. Key strategies include promoting beekeeping in urban areas to provide alternative habitats, implementing pesticide bans to mitigate harmful effects, fostering genetic resistance to combat diseases, establishing wildflower strips to enhance foraging resources, employing biocontrol agents for pest management, ensuring proper nutrition through diverse floral resources, and implementing effective sterilization techniques. Evaluating the impact of these conservation efforts on pollination ecosystems is paramount for assessing their efficacy and guiding future conservation initiatives.

Keywords: Pollinator, honeybees, Urban beekeeping.

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INTRODUCTION

The survival of ecosystems, human agriculture, and various plant species relies heavily on the indispensable ecosystem service of pollination, where pollinators facilitate the transfer of pollen from the male stamen to the female stigma of plants. This intricate process not only sustains wild plant networks but also enhances farming efficiency (Garibaldi *et al.*, 2013). Approximately 80% of wild plant species and 75% of crop types crucial for human consumption depend on insect pollination (Klein *et al.*, 2007). Among the diverse pollinators, bees contribute significantly to this vital ecological function. Bees, encompassing a reported 17,553 species globally, with 633 species in India alone, play a pivotal role in ensuring effective pollination of both native and cultivated crops (Lermen *et al.*, 2016; Chandra *et al.*, 2019). Honey bees, constituting a substantial portion of the bee population, are not only economically valuable for honey and wax production but are also essential pollinators for a myriad of crops, including almonds, apples, cherries, and more (Pannure *et al.*, 2016). Studies indicate that bee pollination can boost crop production by up to 50% (Krishnan *et al.*, 2012).

Despite their crucial role, there is a concerning decline in pollinator populations globally. Factors such as habitat loss, agricultural intensification, pesticide use, and the introduction of alien species contribute to this decline, posing a threat to both pollinators and the plants reliant on them (Vanburge *et al.*, 2013; Gill *et al.*, 2016). Rapid urbanization and deforestation further exacerbate the challenges faced by pollinators (Sodhi *et al.*, 2004).

Conservation efforts are imperative to address this decline in pollinator populations. Strategies include habitat creation, urban beekeeping, protection of non-floral resources, and banning harmful pesticides (Egerer *et al.*, 2020; Requier *et al.*, 2020; Vanbergen *et al.*, 2013). The importance of conserving bees extends beyond their role in pollination – it also influences floral growth, providing shelter and sustenance for various animals, insects, and birds. The origin and global distribution of honey bees, recognizing their significance as pollinators, identifying major crops dependent on bee pollination, and implementing conservation measures are crucial steps in safeguarding these essential contributors to our ecosystems. Failure to address the decline in honey bee populations could result in a significant impact on global crop production and nutrition. Therefore, urgent and concerted efforts are needed to ensure the conservation of bees for the well-being of both ecosystems and humanity (Kamala *et al.*, 2021).

What are pollinators?

A pollinator refers to biotic agents, creatures, or vectors that transfer pollen from the anthers to the stigma of a flower. Insects and various other animal pollinators play a crucial role in ensuring the development of robust crops for food, fibers, edible oils, medicines, and other essential products. The contribution of pollinators is immense in the production of a wide range of fruits, vegetables, and field crops. Numerous reports highlight insect pollination as a pivotal ecosystem service supporting agricultural food production at both local and global levels (Das *et al.*, 2018).

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Honey bees are particularly significant for crop pollination, but other insects such as wasps and butterflies also play a vital role in pollinating numerous economically and ecologically important plant species. Additionally, pollinating birds, including humming birds and roosting birds, as well as flies, rodents, monkeys, snails, and slugs, are effective contributors to the pollination process. Achieving enhanced pollination in crops is essential for sustainable food production as it reduces the time between flowering and fruit setting, resulting in better-shaped fruits. A majority of these pollinators belong to the dipteral and hymenoptera categories (Sharma *et al.*, 2021). Contribution of the pollinators are given below:

S. No	Crops	Pollinator/Visitors
1.	Tomato, Watermelon, cole crop, pumpkin and squash, lettuce, okra, onion.	Honey bees
2.	Lima beans, beans, beet, bitter gourd	Thrips
3.	Field been, Carrot, Scarlet runner bean	Bumble bees
4.	Parsnip, peppers, brinjal	Beetles
5.	Fig	Female fig wasps
6.	Carrot, Chilli	Solitary bees
7.	Okra, Radish	Flies
8.	Banana, Guava	Bats
9.	Papaya	Moths
10.	Vanilla	Birds
		Panure *et al.*, 2016 and Sharma *et al.*, 2021

Crops benefitted by honey bee pollination:

Honeybees are important pollinator to many horticultural crops and also, they are important for the sustainability of many of the cultivated and wild plants (Guzman *et al.*,2016). Approximately 30% of the food crops around the world directly or indirectly pollinated by honey bees (Greenleaf *et al.*, 2006).The following table shows the various crops that are benefitted by honey bee pollination.

Table 1. Crops benefitted by honey bee pollination					
S. No	**crop**	**Scientific name**	**Family**	**Mode of pollination**	**Benefit**
1.	Kiwi	*Actinidia deliciosa*	Actinidiaceae	Cross pollination	Fruit set and yield of the

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					fruit increase
2.	Pear	*Pysrus*	Rosaceae	Cross pollination	Increase in the yield by 10to 15%and fruit size by 7%
3.	Citrus	*Citrus*	Rutaceae	Self-pollination or cross pollination	Increase in fruit set and weight by 24% and 35% resp.
4.	Apple	*Malus domestica*	Rosaceae	Cross pollination	Fruit set increase by 10%. Also increase in fruit sugar and seed set.
5.	Water melon	*Citrullus lanatus*	Cucurbitaceae	Cross pollination	As no. of honey bee visits increase the fruit No., fruit set and weight increase linearly
6.	Avocado	*Persea americana*	Lauraceae	Cross pollination	Increase the production and improves fruit weight.
Vegetables					
7.	Pumpkin	*Cucurbita maxima*	Cucurbitaceae	Cross pollination	Linear increase in fruit size, set and weight and no. of seeds as the number of visits increase.
8.	Cucumber	*Cucumis sativus*	Cucurbitaceae	Self-pollination	Increase in production by 10%
Other Plants					
9.	Soya beam	*Glysine max*	Fabaceae	Self-pollination	Increase yield by 18.09% and seed no.
10.	Cotton	*Gossypium hirsutum*	Meliaceae	Self-pollination	Increased production for fiber weight and seed no. by 12%and 17% resp.
					Joshi *et al.*,2021 and Khalifa *et al.*,2021

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Threats to Honeybees:

Honey bees are important pollinators in ecosystem and agriculture; however, their numbers have significantly declined. Declines insect population are thought to result multiple factors together with habitat loss, temperature change, exaggerated vulnerability to diseases and parasites and chemical use.

Climate change:

The impacts of climate change on honey bees and pollination are not completely obvious for some time. Climate change the nature of flower and can increment or lessen colony harvesting limit and advancement and impact the life cycle of honeybees (Field *et al.*, 2014). Le Conte *et al.* (2008) observed that the change in climate can have a variety of effects on honey bees and other pollinators. It has the ability to change the quality of environment of flora. Also the climate change has the ability to have a direct impact on the behaviour of pollinators and their physiology. Any type of change in climate and migration of pollinators, especially honey bees race from one region to another is likely to have noticeable impacts. It can result in the emergence of new pathogens and parasites which are harmful for the pollinators.

The following graph shows % age winter loss of honey bee population in different countries (2018-2019) missing

Pathogen and parasites:

Honey bees face a myriad of challenges from a diverse array of pathogens and parasites, as highlighted in studies by Potts *et al.* (2010) and Genersch *et al.* (2010). Genersch *et al.* (2010) identified several pathogens including viruses (ABPV, DWV, IAPV), bacteria (*Melissococcus plutonius*), fungi (*Nosema cerenae*), and the parasitic mite Varroa destructor, all implicated in colony losses across various regions globally. Core *et al.* (2012) investigated the impact of the phorid fly *Apocephalus borealis* on honey bees, noting its association with hive abandonment behavior and subsequent death of parasitized bees, with phorid larvae emerging from the deceased bees. Microarray analysis revealed the presence of twisted wing virus and *Nosema cerenae* in infected hives. Flores *et al.* (2021) explored the role of Varroa and other microorganisms in honey bee health, particularly in *A. miberiensis* subspecies used in Spanish apiculture. Their findings underscored the critical link between Varroa infestation

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and viral diseases such as deformed wing virus and acute paralysis virus, emphasizing the urgent need for effective Varroa control to mitigate colony losses.

Pesticide:

The risk posed by pesticides to honeybees encompasses both toxicity and exposure levels, influenced by various factors such as chemical composition, land management practices, interaction with other stressors, and landscape features (Park *et al.,* 2015). Herbicides, employed for weed control, indirectly threaten honeybees by reducing the abundance and diversity of flowering plants that provide essential pollen and nectar (Gabriel *et al.,* 2007). Studies have demonstrated the sublethal effects of pesticide exposure on honeybee behavior, with Teeters *et al.* (2012) showing that exposure to imidacloprid led to increased energy expenditure during foraging activities. Video tracking methods revealed these subtle behavioral changes, underscoring the importance of such techniques in assessing pesticide impacts. Furthermore, Tackenberg *et al.* (2020) investigated the effects of neonicotinoids on honeybee circadian rhythms and critical behaviors, finding that exposure disrupted circadian clocks and led to alterations in time memory, sleep patterns, and social communication. These disruptions in clock neurons suggest potential impairments in navigation and learning processes critical for honeybee survival.

Nutrition deficit:

Honeybees rely on floral resources for essential nutrition, with nectar providing honey, warmth, and energy, while pollen supplies protein, vitamins, fatty substances, and other nutrients. Insufficient quality or quantity of nutrition renders honeybees vulnerable to certain diseases (Dolezal *et al*., 2018). Hendriksma *et al.* (2016) emphasize the importance of diverse floral resources, encompassing varied sugar content, nectar, and pollen species, for successful brood rearing in honeybee colonies. A balanced intake of carbohydrates, proteins, lipids, vitamins, minerals, and water from multiple floral sources is crucial for bee nutrition. Dependence on a single floral source can lead to nutritional deficiencies, resulting in undernourishment and population decline, particularly during reproduction and overwintering periods, especially under stress conditions.

Land use intensification:

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Land use changes, including habitat destruction and agricultural intensification, have led to a decline in pollination services and honeybee populations (Baude et al., 2016; Kennedy *et al.*, 2013). Pollinator species, particularly bees, are heavily impacted by habitat loss and degradation due to urbanization and intensified agriculture, resulting in local and regional declines (Vanbergen *et al*., 2016). The extensive use of pesticides in intensive crop management further exacerbates this decline by damaging pollinator populations (Vanbergen *et al*., 2016). Urbanization poses a significant threat to honeybee health, affecting food store quality and colony strength, with urban areas showing positive effects on colony strength but rural areas exhibiting lower performance, as found by Samuelson *et al*. (2020).

Electromagnetic radiations:

Taye *et al.* (2017) investigated the impact of cell phone tower electromagnetic radiation on honey bee foraging behaviour from December to May over two years. Five treatments at varying distances from the tower showed that worker bees' foraging behaviour was highest at 500m, followed by 1000m, 300m, and 200m, with the minimum at 100m. The study suggests that honey bees near the tower experienced adverse effects, leading to a decline in their population.

Alien species:

The presence of invasive species like Vespa velutina poses significant environmental threats to honeybees and pollination ecosystems. Traveset *et al*. (2014) highlight how invasive predators can disrupt native honeybee populations, leading to changes in pollination frameworks. Leza *et al*. (2019) found that *Vespa velutina* presence correlates with increased oxidative stress in honeybee workers, emphasizing the negative impact on honeybee health. These findings underscore the urgent need for conservation efforts amidst multiple threats like climate change, pesticides, pathogens, electromagnetic radiation, and land intensification.

Need to conserve:

In conservation efforts, understanding the tangible benefits of species is crucial for prioritization and funding allocation. While the significant value of crops pollinated by western honey bees (*Apis mellifera*) is well-documented, assessments for Asian regions are lacking (Oldroyd *et al.*, 2009). Deforestation contributes to honeybee decline, impacting ecosystems reliant on pollination. Hence, halting deforestation is imperative. Conservation strategies must align with both philosophy and sound science, focusing on achievable goals with tangible benefits (Oldroyd *et al*., 2009).

Importance in the environment:

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Honey bees are cornerstone species, if honey bees vanish it will end most life. In nature different creatures depend on honey bees for endurance in light of the fact that their food sources-nuts, berries, seed and organic products-depends on insect pollination. Pollination, likewise permits botanical development, which gives living spaces for creatures, including different bugs and birds. Finally honey bees themselves and the honey they produce are well Fig. 4. Spring of nourishment for some creatures (Dietemann *et al.*, 2009).

Environment Services:

While honey bee populace proceeds to decline, the development of food harvests will diminish also, as honeybee pollination is essential for a very long-time crop. Honey bees are answerable for pollinating 35% of rural creation and very nearly 90 different monetarily developed food crops (Aslan *et al.*, 2014).

Economic Contribution:

The worth of honey bee pollination to overall horticulture has been assessed to be around 215 billion dollars. Other than their job as pollinators of numerous plant, vegetable and field crop as well as wild blossoms, honey bees are the wellspring of honey and different honey hives items, for example, propolis , regal jam, toxin and beeswax. The overall creation of honey sums north of 1,000,000 tons, yielding a trade market worth over 1 billion (Tesfay *et al.*,2014).

Plant Pollination:

Pollinators unequivocally impact the environmental connections, biological system protection and solidness of the hereditary variety in plant networks. More than 35% of harvests and significant 60 to 80% of wild plant species that depend on the movement of pollinators, honey bees are among the major pollinating insects that assume a significant part in ensuring yield and quality for various plant, field and vegetable harvests. They are likewise the most financially significant pollinators of yield monocultures around the world. Without the movement of these insects, yield of few natural products, seed and nuts harvests would diminish, by more than 90%. Undoubtly, clear any decrease in the pollinator populace will think twice about creation and thusly the economy (Breeze *et al.*, 2011).

Conservation of Honeybees:

Honeybees are significant pollinators of many natural products, nuts, vegetables and field crops. Honeybees additionally pollinate different wild blooming plants and assist with keeping up with the biological systems. Right now, these honeybees are confronting various dangers including pesticides, habitat loss and many other. As a result of the decrease in their

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number,there is an extraordinary loss of environmental administrations which impacts the world economy (Paudel *et al*., 2015).

So, in order to decrease the decline in honeybee population various conservation methods are used.

Beekeeping in urban area:

Urban beekeeping offers advantages due to reduced exposure to pesticides, but public concerns for health necessitate the implementation of barriers (Fitch *et al*., 2019; Ropars *et al*., 2019). Matsuzawa *et al*. (2021) studied honeybee flight patterns with barriers at varying distances and heights, finding that barriers were effective in increasing flight height, especially when placed closer to the hives. Urban beekeeping contributes to biodiversity and community building.

Bio control Agents:

Breeding biocontrol agents present a promising and environmentally friendly approach for managing honeybee parasitic and harmful pests by leveraging beneficial microorganisms and natural products (Arbia *et al*., 2011). Ugras *et al*. (2017) demonstrated an eco-friendly biocontrol method by conserving honeybees through their own microbiota, showcasing the potential of supporting honeybee health against infections. Various bacteria found in healthy honeybees and their products exhibit significant inhibitory activity against the American foulbrood agent *P. larvae*. Additionally, Allipi *et al.* (2007) suggested the use of antibiotic treatment, specifically oxytetracycline hypochloride, as a means to control American foulbrood disease in honeybees, providing a method to mask infection signs in hives for an extended period.

Chemical:

Ritter *et al*. (2006) proposed the use of antibacterial sodium sulfathiazole to reduce bacterial diseases in honeybee hives rapidly. Fumagillin antibiotics at 25 mg/1L of sugar syrup can decrease Nosema disease during extended precipitation seasons. To control *Varroa destructor* and its damage, various substances such as essential oils, organic acids, amitraz, oxalic acid, lactic acid, flumethrin, and formic acid are employed. Pettis *et al.* (2017) highlighted the global use of various products for mite management, noting the adverse environmental effects of chemical pesticides. Formic acid and Mite-Away quick strips were found to be commercially available products that effectively reduce mite populations within about 2 months, with no observed negative impact on honeybees. Sulfur-containing compounds, like sulfur and Hopguard, were also used to reduce mite populations but had effects on adult bees in developing colonies.

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Genetic resistance:

Honey bees exhibit genetic resistance to certain pathogens and parasites, as documented by Meixner *et al*. (2010). Glinski *et al*. (2001) proposed that waxes and unsaturated fatty acids in honeybee cuticles possess antifungal properties, breaking down primary physical barriers in invading organisms. Glinski et al. (2003) and Govind *et al*. (2008) demonstrated that invasive organisms trigger various physiological immune responses, including cell and humoral immune reactions, with phagocytosis and encapsulation being common defense mechanisms against entomopathogenic organisms. Davis *et al*. (2008) found that the midgut's biochemical environment provides protection against food-borne parasites, while septic injuries prompt the activation of clotting cascades and melanin production, which release reactive oxygen species with cytotoxic antimicrobial properties, preventing further infection.

Proper Sterilization techniques:

Baggio *et al.* (2005) suggested that the gamma irradiation with a cobalt-60 source used to disinfect polluted beekeeping instrumentation. It is accomplished after the honey bee wax and honey are irradiated. At the ideal degree of irradiation, it had no adverse consequences on the wax constitution, aside from chemical science adjustments of honey like diminishing of its enzymatic exercises and changing of shading. Sabramanian *et al.* (2007) suggested that microwave heating diminishes the quick development of yeast. In any case, Infrared heating isn't as quick as microwave heating to accomplish the outcome. Layer handling is a thermal interaction which is more successful for the total expulsion of the yeast cell from honey.

Proper nutrition:

The availability of assorted floral resources and its species regarding nectar, sugar content and pollen square measure important for brood rearing. Honeybee should be accessing the adequate sources of carbohydrates, proteins, lipids, vitamins Minerals and water that collect from the nectar pollen, honey reserves and different water supplements (Hendrikshma *et al.*, 2016). Nectar could be a supply of honey, heat and energy for honeybees whereas pollen prove macromolecule, vitamins, fatty substances and alternative nutrients (Pasquale *et al.*, 2016).

Conclusion:

In summary, diverse pollinators contribute to the vital process of pollination, with bees playing a predominant role at 73%. Honey bee pollination positively impacts various crops,

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including those in the Cucurbitaceae family. Global variations in winter honey bee population losses were observed in 2018-19. The decline in pollinator populations has led to significant crop losses, particularly in stimulant crops. The Brassicaceae family stands out as a major source of pollen and nectar for a variety of plants.

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