Bee Conservation: A Critical Analysis of Strategies and Impacts on Pollination

Abstract:

Pollination is a necessary process in order to maintain the ecosystem and the vectors that help in the important ecosystem services of pollination are called pollinators. Around 80% of pollination is dependent upon insects. Bees are known to be the best contributor in the pollination process. They play a major role in ecosystem services and economic contribution as there are around 30% of food that are directly or indirectly pollinated by honeybees and also we get honey and other honey hives items like propolis, beewax and toxins from honeybees. But now honeybees are considered as endangered due to various possible threats to honeybees that includes land use intensification leading to habitat loss, pesticides, climate change, pathogen and parasites, diseases, invasion of alien species and nutrition deficit. So in order to conserve them for the future their are various steps to be considered for conservation that includes beekeeping in urban area, pesticide ban, genetic resistance, growing wildflower strips, use of biocontrol agents for pests, proper nutrition and proper sterilization technique.

Keywords: Pollinator, honeybees,Urban beekeeping.

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 (Chandra *et al.*, 2019; Lermen*et al.*, 2016). 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 (Gill *et al.*, 2016; Vanburge*et al.*, 2013). 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 (Vanbergen *et al.*, 2013; Egerer *et al.*, 2020; Requier*et al.*, 2020). 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).

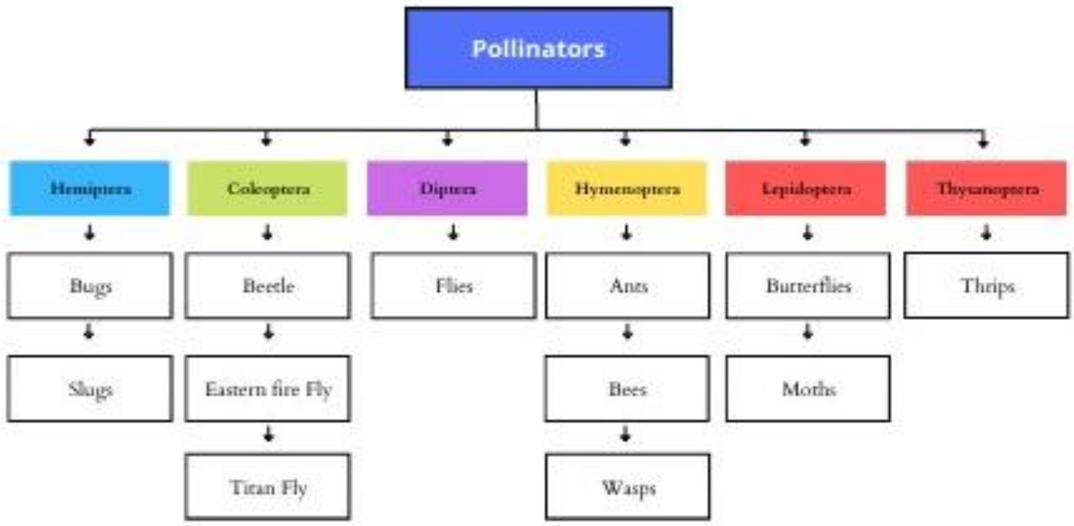
What are pollinators?

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).

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 hummingbirds 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).

Role of different pollinators in pollination:

Pollinators are basic providers of plant multiplication, environment wellbeing, and farming creation. Generally 78% of mild and over 90% of tropical plant species rely upon creature fertilization to some degree benefits that are given by blossom visiting, the most important pollinators are honey bee because of their large numbers and single



gathering**(Iwaski*et al.*, 2021).**

Fig. 1. Different pollinators in pollination

Pollinators are essential within side the functioning of just about all terrestrial ecosystems including those overwhelmed by horticulture due to fact they are within sidethe front line of sustainable productivity through plant reproduction **(Panure*et al.*, 2016)**

Ants

Ants, belonging to the order Hymenoptera, are social insects known for their affinity towards nectars. These industrious insects are often observed diligently visiting flowers to collect energy-rich nectar. Despite being wingless, ants navigate into each blossom to access their prize, primarily extracting nectar without actively participating in cross-pollination. Certain tropical plants have intricate floral structures that pose challenges for honeybees and other pollinators to reach inner nectar. Consequently, ants find it tempting to penetrate flowers from the outside, particularly those that release nectar externally, while their leaves serve as a protective barrier preventing other insects from pilfering the nectar (Junker *et al.*, 2007).

Bats

Bats belong to order Therapsid. They are found to be vital pollinators in tropical and desert environments. Most gloom visiting bats are found in Africa, South East Asia and the pacific islands. Two species of nectar feeding bats, the lesser long-nosed bat and the Mexican long tongue bat, relocate north thousand mile or more every spring from Mexico into Arizona, New Mexico and Texas. Bats feed on the insects in the blossoms as well as nectar and bloom parts, example calabash, wiener tree, Areca palm, Kapok tree, Bannana. More then three hundred types of organic product rely upon bats for pollination. The fruits that are pollinated by bats include guava, mangoes, bananas **(Zalipah*et al.*,2016).**

Beetle

Beetles belong to the order Coleoptera which constitutes the immense order of animal. Beetle's size vary from species that are scarcely noticeable to enormous exotic species that are the size of a human hand **(McKenna *et al.*,2009).**Beetles pollinate numerous industrially useful plants which includes palms, sugar and custard apples and also providing pollination in ecological ecosystems. There are around 184 species of angiosperms that are pollinated by beetles, with atleast another 100 beetles and with other animal fertilized the flower **(Sayers *et al.*,2019).**

Birds

Birds are vital pollinators of wild flowers all through the world. In the mainland United States, Humming birds are key in wildflower pollination. In different regions, honey creepers and honey eaters are significant pollinators. Also, brush tongued parrots and sun birds fill in as tropical pollen vectors. Around 2000 bird species feed on nectar, the insects, and the spiders related with nectar bearing blossoms. Humming birds have excellent eyes and are very drawn to red. They push their very long thin bills profound into blossoms nectar pulling out face tidied in pollen **(Lehmann *et al.*,2019).**

Butterflies

Butterflies belong to the order Lepidoptera and are also known as nectar thieves. This diverse insect is found in various tones and sizes. Globally, there are over 28,000 types of butterflies, with around 80% of them found in tropical areas. Butterflies require food in liquid form (Larson *et al.,* 2001). The survival of butterflies relies on the nectar produced in flowers and ripe fruits. Butterflies play a pivotal role in ecosystems as pollinators, a source of food, and indicators of ecosystem health. Despite being highly active during the day and visiting various wildflowers, butterflies are less efficient pollinators compared to bees. Due to their long, slender legs and specific structures, butterflies do not collect as much pollen on their bodies. They typically favor flat, clustered flowers that provide a suitable landing pad and abundant rewards. **(Stokl*et al.*,2011).**

Moth

Moths, belonging to the order Lepidoptera, lead a crepuscular or nocturnal lifestyle and are recognized as major pollinators across diverse natural settings worldwide (Macgregor *et al.*, 2015). They are frequent plant visitors, displaying various interactions with different plant species. Moths contribute to the pollination of approximately 40% of plant species in rural landscapes. In agricultural environments, their role is often attributed to the pollination of non-crop plants, enhancing biodiversity in agro-ecosystems and providing a widely appreciated ecological function (Power *et al.*, 2010).

Fly

Flies, belonging to the order Diptera, are a highly diverse group present in almost all natural environments and biomes. While they have been studied less than bees, flies are shown to be as effective, or even better, than bees in pollinating certain crops (Cook *et* *al.*, 2020). This two-winged insect group includes flies, gnats, and mosquitoes, and some species are excellent pollinators despite lacking the hairiness of bees. Flies, such as syrphids, can mimic bees and wasps, but a keen eye can distinguish them. Unlike bees and wasps, flies have only a single set of wings (Giroux *et al.*, 2010).

Wasps

Wasps, belonging to the family Vespidae, play a crucial role in the pollination of Ficus species. Agaonid wasps, specific to certain fig varieties, pollinate within the enclosed inflorescence called figs. The pollination behavior of these wasps can be either active or passive. In active pollination, the wasps collect pollen from the anther inside their native fig, storing it in specialized structures called pollen pockets. When reaching an open fig, the wasp deposits an egg and transfers pollen from the pockets onto the stigmas. In passive pollination, agaonid wasps do not display such behavior; instead, figs produce stamens that release pollen as the wasps emerge, coating them with pollen as they leave their native fig (Cook *et al.*, 2003; Jousselin*et al.*, 2003).

Bees

Bees as any insect play vital function in crop pollination along different animal pollinator consisting of bats, birds, whips, butterflies etc. Bees make contributions to the worldwide meals deliver through pollinating a huge variety of crops including fruits and vegetables **(Khalifa *et al.*,2021).**

Bumble bees

Bumble bees are fundamental pollinators for agrarian and wild plants around the world, there pollination upholds food security **(Crowther *et al.*,2019).**The solid transformation to various environments and territories of bumble bee make sense of their capacity to keep scavenging even in high and low temperatures **(Peat *et al.*,2005).** Bumble bees have added to the crop pollination by means of the extended and improving the nature of organic products. Natural products cultivators gain

many advantages from pollination by bumble bees which are great pollinators of few yields for example kiwi fruit, sweet pepper and red clover **(Fijen*et al.*,2018).**

Stingless bees

Stingless bees, a diverse group of eusocial bees, are excellent pollinators known for their small to medium size and minimal stings (Quezeda*et al.*, 2018). Their varied body sizes, often large and smooth, with long hairs, assist in carrying pollen and other items to the colony (Meléndez *et al.*, 2018). Stingless bees have physiological adaptations for efficient flower pollination, including structures for collecting pollen and nectar. Their lack of a strong stinging behavior makes them easier to handle compared to larger bees. Some species, like those in the Melipona genus, exhibit vibration behavior to extract pollen, particularly useful for crops with poricidal anthers such as tomatoes and peppers (De *et al.*, 2013).

Carpenter bees

Carpenter bees enjoy various benefits in crop pollination, as they feed on expansive scope of plant species during their long movement season. They likewise can buzz fertilize blossoms, making them significantly more different crop pollinators**(Somanathan *et al.*,2019).**It has been seen that blossoms visited by carpenter bees produce nectar that is odoriferous, so it is conceivable that these bees utilize this scent as prompt to visit the right blossom **(Raju *et al.*,2006).**

Solitary bees

Solitary bees involve most of bee species on the planet. Solitary bee species represent 85% of all bee species. The greater part of solitary bees are polylectic while a more modest number are oligolectic and not very many are solid. Solitary bees are found to be more efficient then honey bees for few crops that relly upon pollinators for their fertilization (**Kleijn *et al.*,2015).**

Honey bees

Honey bees are crucial pollinators, playing a vital role in crop productivity and contributing to about one-third of the human diet. Their importance in climate and food production underscores the significance of their health (Ullah *et al.*, 2021). In India, the beekeeping industry is growing due to the demand for natural food and skincare products, providing employment opportunities. Raw honey, with its health benefits, has been a traditional medicine for centuries, making beekeeping economically viable (Vasukidevi*et al.*, 2021).

Table 1. Contribution of the pollinators

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
		Sharma *et al.*, 2021 and Panure*et al.*, 2016

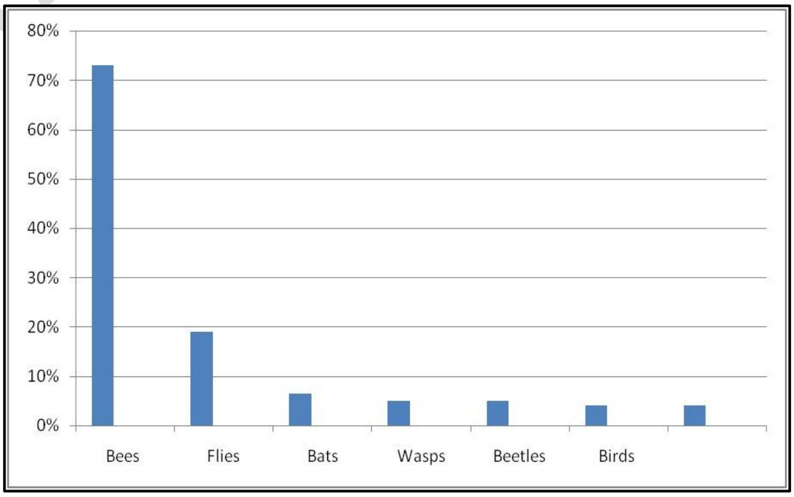


Fig. 2. Contribution of different pollinators in pollination

(Abrol*et al.,* 2009)

Honey bees play a pivotal role in crop pollination, contributing to about 33% of the world's yield dependent on pollination. Their managed and wild populations contribute significantly to commercial crops, valued at $235 to $577 billion annually. Honey bees also serve as vital environmental bioindicators, responding sensitively to environmental changes. Using honey bees as bioindicators can offer valuable insights into understanding environmental stress and change (Quigley et al., 2019).

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 2. 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 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

Threats to Honeybees:

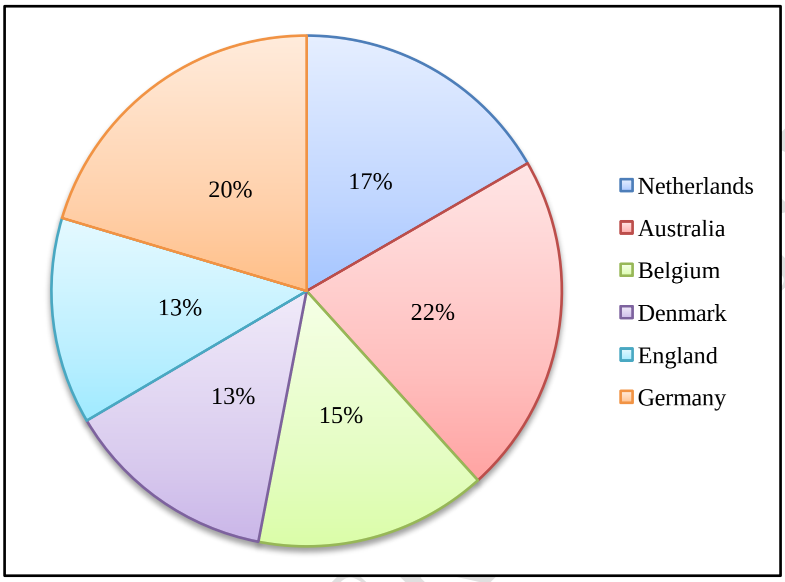
Honey bees are important pollinators in ecosystem and agriculture;however, their numbers have significantly declined. Declines insect population are thought to result multiple factors together with habitat loss, temperature change, exaggerated vulnerability to diseases and parasites and chemical use.

Climate change:

The impacts of climate change on honey bees and pollination are not completely obvious for sometime.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.*, 2008observed 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 andmigration 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)

Fig. 3. Percentage age winter loss of honey bee population

(Source:Gray *et al.*,2020)

Pathogen and parasites:

Honey bees experience the ill effects of a wide range of parasite, bacterial and viral microbes and protozoan and invertebrate parasites**(Potts *et al.*,2010)Genersch*et al.*, 2010** selected honey bee pathogen and parasite which have been demonstrated in colony losses in different regions which have been exhibited to be associated with settlement misfortunes in various locations of the world and which, therefore, are considered current danger to honey bees and bee keeping. In this study they have shown different pathogens which includes Virus(ABPV,DWV,IAPV), Bacteria (*Melissococcusplutonius*), Fungi (*Nosema cerenae*), Metazone parasites (Varroa destructor) that are involved in several colony losses in different regions (Germany, USA, Switzerland, Spain, Cannada) of the world and from this data they found that even within Europe, different pathogens are involved in the assumed mysterious colony losses.

Core *et al.*, 2012 studied the impact of phorid fly *Apocephalus borealis* on honey bees. They have noticed that parasitized honey bees show hive abundment behavior, leaving their hives at night and dying shortly thereafter. On average, after seven days upto thirteen phorid hatchlings rise up out of every dead honey bees and puppete away from the honey bee using DNA barcoding, they confirm that phorid that rose up out of honey bee and bumble bee were from the same species. Further they have done microarray investigation of honey bees from infected hives which shows that these honey bees are frequently contaminated with twisted wing infection and *Nosema cerrenae.*

Flores *et al.*,2021 investigated role of verroa and other microorganisms and their regards to the reasonability to the honey bee states. They have done this during one bee keeping season, including sub-species *A.mibieriensis* that is commonly used in apiculture industry of Spain further they have shown a critical connection between the presence of varroa destructor and viral disease by disfigured wing infection and intense honey bee loss of motion infection. They have also explored a potentially naturally occurring subset of peptides, which are liable for humerol insusceptibility of the honey bees. The outcome showed the significance or Varroa as driver of other pathologies affecting honey bee; obviously with experimental proof of the sign of diseases through transmission of DWVE, as well concerning ABVP and CBPV, about which lesses known. These discoveries feature the need of accomplishing sufficient control of the varroa insect to keep away from the misfortune of the bee colony.

Pesticide:

The risk of pesticides to honeybees is through a mix of poisonousness and level of openness. The pesticides effect the honeybees as per their biology,between chemical compounds, with the sort and size of land management, communication with other stressors and with scene biological infrastructure**(Park *et al.*,2015).** Herbicides that are used to control weeds represent a roundabout risk as they lessen the overflow and variety of blossoming plants giving pollen and nectars to honeybees **(Gabriel *et al.*,2007)**. Exposure to 50 and 500 ppb imidacloprid significantly increased honey bee energy expenditure near food sources compared to controls. The study, using video tracking (Etho Vision XT), highlights the sublethal effects of pesticides on honey bee foraging behavior, supporting the efficacy of this method for assessing such impacts. **(Teeters *et al.*, 2012)**

Tackenberg*et al.*, 2020The study investigated the impact of neonicotinoids on honey bee circadian clocks and critical behaviors. Exposure to neonicotinoids disrupted circadian rhythms, leading to accumulations in the bee brain. This disturbance resulted in altered time memory, sleep patterns, and social communication. Neonicotinoid effects on clock neurons suggest potential impairments in honey bee navigation and learning processes.

Nutrition deficit:

Honeybees depend upon floral resources for getting proper nutrition i.e pollen and nectar.Nectar could be a supply of honey, heat and energy for honeybees whereas pollen prove macromolecule, vitamins, fatty substances and alternative nutrients. The improper quality and quantity of nutrition makes the honeybees susceptible to certain diseases **(Dolezal *et al.*,2018).**

Hendriksma*et al.*,2016The study suggests that the availability of diverse floral resources, considering sugar content, nectar, and pollen species, is crucial for successful brood rearing in honeybee colonies. Adequate sources of carbohydrates, proteins, lipids, vitamins, minerals, and water, collected from various floral resources, are essential for the bee's nutrition. Overreliance on a single floral source can result in nutritional imbalances, leading to undernourishment and population decline in honeybee colonies, particularly during reproduction and overwintering under stress conditions.

Land use intensification:

Pollination services and honeybee population are declining via land use changes including the demolition, dissolution and degradation of semi arid natural surroundings or the transformation of differentiated cultivating frameworks into traditional escalated horticulture**(Baude *et al.*,2016)**. Such land use changes and board escalation can diminish or alter the flower supply and nesting resources to honeybees that is frequently leading to decline in honey bee population**(Kennedy *et al.*,2013)**

According to **Vanbergen *et al.*, 2016**, pollinator species are the ones that are most affected by the habitat change. Many natural habitats that bees rely on for foraging and breeding have been lost or degraded as a result of urbanization and growing agricultural intensification . The change in land use can frequently result in the extension of pollinators at local and regional levels. Pesticides that can damage pollinators are frequently used in intensive crop management. The abundance of wild bees, butterflies and other pollinators have been observed to be less where there is immense use of pesticides.

Samuelson et al. (2020) found that urbanization, a rapidly expanding driver of land use change, poses two significant threats to honey bees. Their study investigated the impact of urbanization on food store quality and colony health. Testing 51 hives across urban, suburban, open, and wooded areas in spring and pre-winter, they observed positive effects of urban land use on colony strength and richness of stored pollen morphotypes. However, honey bee colonies exhibited lower performance and strength in rural areas, highlighting the potential negative impact of modern rural landscapes on insect pollinator habitats.

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.

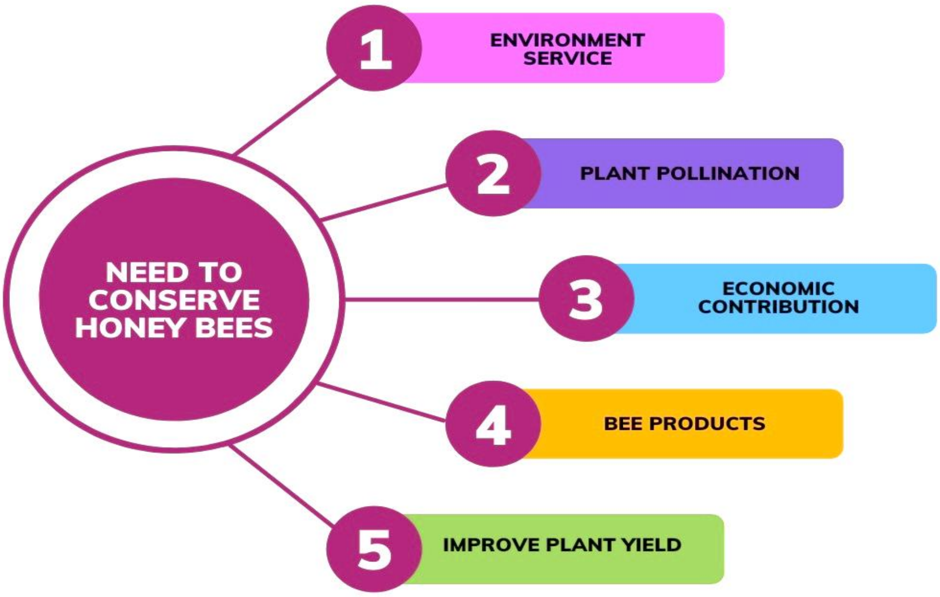
Alien species:

The environmental impacts of alien spices on honeybees and pollination are complicated, yet can be significant under certain natural and bio geographical conditions. Obstructive alien predators can change biological systems by consuming local honeybees leading to shift to an invasive dominant pollination framework **(Travesete*et al.*, 2014).**

Leza et al. (2019) analyzed the impact of the invasive species Vespa velutina on honey bee workers' oxidative stress parameters. Positive and negative apiaries were selected, with 233 samples collected from six hives each in spring, summer, and autumn. The presence of Vespa velutina correlated with increased expression of oxidative stress-related genes, enzyme activity, and protein peroxidation in honey bees. This study highlights the negative impact of Vespa velutina on honeybee health, adding to the various threats like climate change, pesticides, pathogens, alien species, electromagnetic radiation, and land intensification, emphasizing the urgent need for honeybee conservation.

Need to conserve:

In spite of the fact that we would content that honey bees have inborn worth, it is frequently helpful in the conservation to be equipped with the unmistakable advantages of a species type so they might be given higher need for conservation strategy and perhaps funding. The worth of crops pollinated by western honey bees *A. mellifera* is amazingly huge, however tragically no appraisals are accessible for the worth of honey bees pollination for Asian regions or Asia in total. It is unquestionable that forest cleaning adds to honey bee decline, and the reason of honey bee add to the tune of plants and creatures that are likewise burdened. Getting free of old growth forest on this planet ought to just be halted. Regardless, conservation system should be established in logic as well as great science, so we ought to



likewise zero in on those issues where something can reasonably accomplished in the more limited term, and that will be likewise be valueable**(Oldroyd *et al.*, 2009).**

Importance in the environment:

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 1,000,000tons, 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 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 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 (Ropars et al., 2019; Fitch 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.

Genetic resistance:

Honey bees shows genetic resistance to certain pathogens and parasites **(Meixner *et al.*, 2010).Glinski *et al.*,2001** suggested that the waxes and unsaturated greasy acids that are the chemical element in the cuticle of the honeybees have a antifungal potent activityagainst pathogenic organisms that contaminate insects by breaking their primary physical barriers that are peritrophic membranes and cuticle.

Glinski *et al.*,2003 and Govind *et al.*,2008 demonstrated that when the external actual obstructions are penetrated , the invasive organisms experience an assortment of physiological insusceptible safeguards by initiation of cell and humoral insusceptible responses. Cell insusceptible reactions start following an intrusion is recognized in the haemolymph, While antimicrobial peptides commonly show up in the haemolympha few hours after disease. Phagocytosis and epitome are the most normal safeguard mechanism in honeybees against entomopathogenic organisms.

Davis *et al.*,2008 found that the biochemical atmosphere of the midgut gives some protection against parasitic food-borne microorganisms . On the opposite hand, septic injury quickly sets off enactment of chemical process cascades at the site of injury that prompts limited blood coagulation also, the development of melanin coagulation thereby prevent the loss of homolymph through the injury.The result of melanin creation is an arrival of receptive oxygen species that have cytotoxic antimicrobial properties.

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, 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.

References:

1. Arbia, A., &Babbay, B. (2011). Management strategies of honey bee diseases. *Journal of Entomology*, *8*(1), 1-15. https://doi.org/10.3923/je.2011.1.15
2. Aslan, C. E., Liang, C. T., Galindo, B., Kimberly, H., & Topete, W. (2016). The role of honey bees as pollinators in natural areas. *Natural Areas Journal*, 36(4), 478-488. https://doi.org/10.3375/043.036.0413
3. Baggio, A., Gallina, A., Benetti, C., &Mutinelli, F. (2009). Residues of antibacterial drugs in honey from the Italian market. Food Additives and Contaminants: Part B, 2(1), 52-58.
4. Baude, M., Kunin, W. E., Boatman, N. D., Conyers, S., Davies, N., Gillespie, M. A., Morton, R. D., Smart, S. M., & Memmott, J. (2016). Historical nectar assessment reveals the fall and rise of floral resources in Britain. Nature, 530(7588), 85-88. https://doi.org/10.1038/nature16532
5. Breeze, T. D., Bailey, A. P., Balcombe, K. G., & Potts, S. G. (2011). Pollination services in the UK: how important are honeybees?. *Agriculture, Ecosystems & Environment*, *142*(3-4), 137-143
6. Campbell, J. W., Stanley-Stahr, C., Bammer, M., Daniels, J. C., & Ellis, J. D. (2019). Contribution of bees and other pollinators to watermelon (*Citrullus lanatus*Thunb.) pollination. *Journal of Apicultural Research*, *58*(4), 597-603. https://doi.org/10.1080/00218839.2019.1614271
7. Chandra, K., Saini, J., & Gupta, D. (2019). Insecta: Hymenoptera: Apoidea (Bees). Fauna of Punjab, State Fauna Series, 23, 1-486.
8. Cook, D. F., Voss, S. C., Finch, J. T., Rader, R. C., Cook, J. M., & Spurr, C. J. (2020). The role of flies as pollinators of horticultural crops: An Australian case study with worldwide relevance. *Insects*, *11*(6), 341.https://doi.org/10.3390/insects11060341
9. Cook, J. M., &Rasplus, J. Y. (2003). Mutualists with attitude: coevolving fig wasps and figs. *Trends in Ecology & Evolution*, *18* (5), 241-248.https://doi.org/10.1016/S0169-5347(03)00062-4
10. Crowther, L. P., Wright, D. J., Richardson, D. S., Carvell, C., & Bourke, A. F. (2019). Spatial ecology of a range- expanding bumble bee pollinator. *Ecology and evolution*, *9*(3), 986-997.https://doi.org/10.1002/ece3.4722
11. Das, A., Sau, S., Pandit, M. K., & Saha, K. (2018). A review on: Importance of pollinators in fruit and vegetable production and their collateral jeopardy from agro-chemicals. *Journal of Entomology and Zoology Studies*, *6*(4), 1586-1591.

12. Davis, R. B., Baldauf, S. L., & Mayhew, P. J. (2010). The origins of species richness in the Hymenoptera: insights from a family-level supertree. *BMC evolutionary biology*, *10*(1), 1-16.https://doi.org/10.1186/1471-2148-10-109
13. Pasquale, G. D., Salignon, M., Conte, Y. L., Belzunces, L. P., Decourtye, A., Kretzschmar, A., Suchail, S., Brunet, L., &Alaux, C. (2013). Influence of Pollen Nutrition on Honey Bee Health: Do Pollen Quality and Diversity Matter? PLOS ONE, 8(8), e72016. https://doi.org/10.1371/journal.pone.0072016
14. Dietemann, V., Pirk, C. W. W., & Crewe, R. (2009). Is there a need for conservation of honeybees in Africa?.*Apidologie*, 40(3), 285-295. https://doi.org/10.1051/apido/2009013
15. Dolezal, A. G., & Toth, A. L. (2018). Feedbacks between nutrition and disease in honey bee health. *Current opinion in insect science*, *26*, 114-119. https://doi.org/10.1016/j.cois.2018.02.006
16. Dymond, K., Celis- Diez, J. L., Potts, S. G., Howlett, B. G., Willcox, B. K., & Garratt, M. P. (2021). The role of insect pollinators in avocado production: A global review. *Journal of Applied Entomology*, *145*(5), 369-383. https://doi.org/10.1111/jen.12869
17. Egerer, M., &Kowarik, I. (2020). Confronting the modern Gordian Knot of urban beekeeping. *Trends in Ecology & Evolution*, *35*(11), 956-959.https://doi.org/10.1016/j.tree.2020.07.012
18. Field, C. B., & Barros, V. R. (Eds.). (2014). *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press.
19. Fijen, T. P., Scheper, J. A., Boom, T. M., Janssen, N., Raemakers, I., & Kleijn, D. (2018). Insect pollination is at least as important for marketable crop yield as plant quality in a seed crop. *Ecology letters*, *21*(11), 1704-1713.https://doi.org/10.1111/ele.13150
20. Fitch, G., Wilson, C. J., Glaum, P., Vaidya, C., Simao, M. C., & Jamieson, M. A. (2019). Does urbanization favour exotic bee species? Implications for the conservation of native bees in cities. *Biology Letters*, *15*(12), 20190574.https://doi.org/10.1098/rsbl.2019.0574
21. Flores, J. M., Gámiz, V., Jiménez-Marín, Á., Flores-Cortés, A., Gil-Lebrero, S., Garrido, J. J., & Hernando, M. D. (2021). Impact of Varroa destructor and associated pathologies on the colony collapse disorder affecting honey bees. *Research in veterinary science*, *135*, 85-95. https://doi.org/10.1016/j.rvsc.2021.01.001
22. Gabriel, D., &Tscharntke, T. (2007). Insect pollinated plants benefit from organic farming. *Agriculture, Ecosystems & Environment*, *118*(1-4), 43-48.https://doi.org/10.1016/j.agee.2006.04.005
23. Gallai, N., Salles, J. M., Settele, J., &Vaissière, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological economics*, *68*(3), 810-821. https://doi.org/10.1016/j.ecolecon.2008.06.014

24. Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., & Klein, A. M. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *science, 339*(6127), 1608-1611.
25. Genersch, E. (2010). Honey bee pathology: current threats to honey bees and beekeeping. *Applied microbiology and biotechnology*, *87*(1), 87-97. https://doi.org/10.1007/s00253-010-2573-8
26. Gill, R. J., Baldock, K. C., Brown, M. J., Cresswell, J. E., Dicks, L. V., Fountain, M. T., ... & Potts, S. G. (2016). Protecting an ecosystem service: approaches to understanding and mitigating threats to wild insect pollinators. In *Advances in ecological research* 54, 135-206. https://doi.org/10.1016/bs.aecr.2015.10.007
27. Giroux, M., Pape, T., & Wheeler, T. A. (2010). Towards a phylogeny of the flesh flies (Diptera: Sarcophagidae): morphology and phylogenetic implications of the acrophallus in the subfamily Sarcophaginae. *Zoological Journal of the Linnean Society*, 158(4), 740-778. https://doi.org/10.1111/j.1096-3642.2009.00561.x
28. Gliński, Z., & Buczek, K. (2003). Response of the Apoidea to fungal infections. *Apiacta*, *38*, 183-189
29. Glinski, Z., & Jarosz, J. (2001). Infection and immunity in the honey bee Apis mellifera. *Apiacta*, *36*(1), 12-24.
30. Govind, S. (2008). Innate immunity in Drosophila: Pathogens and pathways. *Insect science*, *15*(1), 29-43. https://doi.org/10.1111/j.1744-7917.2008.00185.x.
31. Greenleaf, S. S., & Kremen, C. (2006). Wild bees enhance honey bees' pollination of hybrid sunflower. *Proceedings of the National Academy of Sciences*, *103*(37), 13890-13895.https://doi.org/10.1073/pnas.0600929103
32. Guzman-Novoa, E., Cork, S., Hall, D. C., &Liljebjelke, K. (2016). Colony collapse disorder and other threats to honey bees. *One health case studies: addressing complex problems in a changing world*, 204-216.
33. Hendriksma, H. P., & Shafir, S. (2016). Honey bee foragers balance colony nutritional deficiencies. *Behavioral Ecology and Sociobiology*, *70*(4), 509-517.https://doi.org/10.1007/s00265-016-2067-5
34. Joshi, U., Kothiyal, K., Kumar, Y., & Bhatt, R. (2021). Role of honeybees in horticultural crop productivity enhancement. International Journal Agricultural Science, 17, 314-320. DOI:10.15740/HAS/IJAS/17-AAEBSSD/314-320
35. Breeze, T., Bailey, A., Balcombe, K., & Potts, S. (2011). Pollination services in the UK: How important are honeybees? Agriculture, Ecosystems & Environment, 142(3-4), 137-143. https://doi.org/10.1016/j.agee.2011.03.020

36. Jousselin, E., Hossaert-McKey, M., Herre, E. A., & Kjellberg, F. (2003). Why do fig wasps actively pollinate monoecious figs?.Oecologia, 134(3), 381-387. https://doi.org/10.1007/s00442-002-1116-0

37. Junker, R., Chung, A. Y., & Blüthgen, N. (2007). Interaction between flowers, ants and pollinators: additional evidence for floral repellence against ants. Ecological Research, 22(4), 665-670. https://doi.org/10.1007/s11284-006-0306-3

38. Kamala, I. M., & Devanand, I. I. (2021). Pollination and Ecological Intensification: A Way Towards Green Revolution. In *Ecological Intensification of Natural Resources for Sustainable Agriculture* , 381-427. https://doi.org/10.1007/978-981-33-4203-3_11

39. Kennedy, C. M., Lonsdorf, E., Neel, M. C., Williams, N. M., Ricketts, T. H., Winfree, R., ... & Kremen, C. (2013). A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecology letters*, *16*(5), 584-599. https://doi.org/10.1111/ele.12082

40. Khalifa, S. A., Elshafiey, E. H., Shetaia, A. A., El-Wahed, A. A. A., Algethami, A. F., Musharraf, S. G., ... & El-Seedi, H. R. (2021). Overview of bee pollination and its economic value for crop production. *Insects*, *12*(8), 688.https://doi.org/10.3390/insects12080688

41. Kleijn, D., Winfree, R., Bartomeus, I., Carvalheiro, L. G., Henry, M., Isaacs, R., ... & Potts, S. G. (2015). Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. *Nature communications*, *6*(1), 1-9.https://doi.org/10.1038/ncomms8414

42. Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the royal society B: biological sciences*, *274*(1608), 303-313. https://doi.org/10.1098/rspb.2006. 3721.

43. Krishnan, S., Kushalappa, C. G., Shaanker, R. U., & Ghazoul, J. (2012). Status of pollinators and their efficiency in coffee fruit set in a fragmented landscape mosaic in South India. *Basic and Applied Ecology*, *13*(3), 277-285.https://doi.org/10.1016/j.baae.2012.03.007

44. Larson, B. M. H., Kevan, P. G., & Inouye, D. W. (2001). Flies and flowers: taxonomic diversity of anthophiles and pollinators. *The Canadian Entomologist*, *133*(4), 439-465.https://doi.org/10.4039/Ent133439-4

45. Lehmann, L. J., Maruyama, P. K., Joaquim Bergamo, P., Maglianesi, M. A., Rahbek, C., & Dalsgaard, B. (2019). Relative effectiveness of insects versus hummingbirds as pollinators of Rubiaceae plants across elevation in Dominica, Caribbean. Plant Biology, 21(4), 738-744. https://doi.org/10.1111/plb.12976

46. Leza, M., Herrera, C., Marques, A., Roca, P., Sastre-Serra, J., *et al.*, (2019). The impact of the invasive species Vespa velutina on honeybees: A new approach based on oxidative stress. *Science of The Total Environment*, 689, 709-715. https://doi.org/10.1016/j.scitotenv.2019.06.511
47. MacGregor, C. J., Pocock, M. J., Fox, R., & Evans, D. M. (2015). Pollination by nocturnal L epidoptera, and the effects of light pollution: a review. *Ecological entomology*, *40*(3), 187-198. https://doi.org/10.1111/een.12174
48. Matsuzawa, T., &Kohsaka, R. (2021). Preliminary experimental trial of effects of lattice fence installation on honey bee flight height as implications for urban beekeeping regulations. *Land*, *11*(1), 19.https://doi.org/10.3390/land11010019
49. Mazzilli, S. R., Abbate, S., Silva, H., & Mendoza, Y. (2020). Apis mellifera visitation enhances productivity in rapeseed. *Journal of Apicultural Research*, 1-9.
50. McKenna, D. D., & Farrell, B. D. (2009). Beetles (Coleoptera). The timetree of life, 278, 289.
51. Meléndez Ramírez, V., Ayala, R., & Delfín González, H. (2018). Crop pollination by stingless bees. In *Pot-pollen in stingless bee melittology*, 139-153. https://doi.org/10.1007/978-3-319-61839-5_11
52. Oldroyd, B. P., &Nanork, P. (2009). Conservation of Asian honey bees. *Apidologie*, *40*(3), 296-312.https://doi.org/10.1051/apido/2009021
53. Pannure, A. (2016). Bee pollinators decline: perspectives from India. *International Research Journal of Natural and Applied Sciences*, *3*(5), 1-10.
54. Park, M. G., Blitzer, E. J., Gibbs, J., Losey, J. E., & Danforth, B. N. (2015). Negative effects of pesticides on wild bee communities can be buffered by landscape context. *Proceedings of the Royal Society B: Biological Sciences*, *282*(1809), 20150299. https://doi.org/10.1098/rspb.2015.0299
55. Paudel, Y. P., Mackereth, R., Hanley, R., & Qin, W. (2015). Honey bees (*Apis mellifera* L.) and pollination issues: current status, impacts, and potential drivers of decline. *Journal of Agricultural Science*, *7*(6), 93. http://dx.doi.org/10.5539/jas.v7n6p93
56. Peat, J., Darvill, B., Ellis, J., &Goulson, D. (2005). Effects of climate on intra- and interspecific size variation in bumble- bees. *Functional Ecology*, *19*(1), 145-151.https://doi.org/10.1111/j.0269-8463.2005.00946.x
57. Pena, J. F., & Carabali, A. (2018). Effect of Honey Bee (*Apis mellifera* L.) Density on Pollination and Fruit Set of Avocado (*Persea americana* Mill.) Cv. Hass. *Journal of Apicultural Science*, *62*(1), 5.
58. Pettis, J. S., Rose, R., &Chaimanee, V. (2017). Chemical and cultural control of Tropilaelapsmercedesae mites in honeybee (Apis mellifera) colonies in Northern Thailand. *PloS one*, *12*(11), e0188063. https://doi.org/10.1371/journal.pone.0188063

59. Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in ecology & evolution*, *25*(6), 345-353. https://doi.org/10.1016/j.tree.2010.01.007
60. Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical transactions of the royal society B: biological sciences*, *365*(1554), 2959-2971. https://doi.org/10.1098/rstb.2010.0143
61. Quigley, T. P., Amdam, G. V., & Harwood, G. H. (2019). Honey bees as bioindicators of changing global agricultural landscapes. *Current opinion in insect science*, *35*, 132-137.https://doi.org/10.1016/j.cois.2019.08.012
62. Raju, A. S., & Rao, S. P. (2006). Nesting habits, floral resources and foraging ecology of large carpenter bees (Xylocopa latipes and Xylocopa pubescens) in India. *Current science*, 90(9), 1210-1217.
63. Requier, F., & Leonhardt, S. D. (2020). Beyond flowers: including non-floral resources in bee conservation schemes. *Journal of Insect Conservation*, *24*(1), 5-16. https://doi.org/10.1007/s10841-019-00206-1
64. Ritter, W., &Akratanakul, P. (2006). Honey bee diseases and pests: a practical guide.
65. Ropars, L., Dajoz, I., Fontaine, C., Muratet, A., & Geslin, B. (2019). Wild pollinator activity negatively related to honey bee colony densities in urban context. *PloS one*, *14*(9), e0222316. https://doi.org/10.1371/journal.pone.0222316
66. Sayers, T. D., Steinbauer, M. J., & Miller, R. E. (2019). Visitor or vector? The extent of rove beetle (Coleoptera: Staphylinidae) pollination and floral interactions. *Arthropod-Plant Interactions*, *13*(5), 685-701. https://doi.org/10.1007/s11829-019-09698-9
67. Sharma, A., & Banerjee, J. (2021). Pollinator Management-A Realistic Way To Improve Yield of Vegetables and Spices, 1(10), 1-8.
68. Sodhi, N. S., Koh, L. P., Brook, B. W., & Ng, P. K. (2004). Southeast Asian biodiversity: an impending disaster. *Trends in ecology & evolution*, *19*(12), 654-660.https://doi.org/10.1016/j.tree.2004.09.006
69. Somanathan, H., Saryan, P., & Balamurali, G. S. (2019). Foraging strategies and physiological adaptations in large carpenter bees. *Journal of Comparative Physiology A*, *205*(3), 387-398. https://doi.org/10.1007/s00359-019-01323-7
70. Sushil, S. N., Stanley, J., Hedau, N. K., & Bhatt, J. C. (2013). Enhancing seed production of three Brassica vegetables by honey bee pollination in north-western Himalayas of India. *Universal Journal of Agricultural Research*, *1*(3), 49-53.
71. Tackenberg, M. C., Giannoni-Guzmán, M. A., Sanchez-Perez, E., Doll, C. A., Agosto-Rivera, J. L., Broadie, K., ... & McMahon, D. G. (2020). Neonicotinoids disrupt circadian rhythms

and sleep in honey bees. *Scientific reports*, 10(1), 1-10. https://doi.org/10.1038/s41598-020-72041-3

72. Taye, R. R., Deka, M. K., Rahman, A., & Bathari, M. (2017). Effect of electromagnetic radiation of cell phone tower on foraging behaviour of Asiatic honey bee, *Apis cerana*F.(Hymenoptera: Apidae). *J EntomolZool Stud*, *5*, 1527-1529. www.entomolijournal.com
73. Traveset, A., & Richardson, D. M. (2014). Mutualistic interactions and biological invasions. *Annual Review of Ecology, Evolution, and Systematics*, *45*, 89-113. https://doi.org/10.1146/annurev-ecolsys-120213-091857
74. Ugras, S., Dursun, H., Dulger, G., & Kekecoglu, M. (2017). POTENTIAL USE OF FIRSTLY ISOLATED BACTERIA FROM YIGILCA HONEYBEES (*APIS MELLIFERA* L.) AND PRODUCTS AGAINST THE PATHOGENS. *Fresenius Environmental Bulletin*, *26*(11), 6825-6834.
75. Ullah, A., Gajger, I. T., Majoros, A., Dar, S. A., Khan, S., Shah, A. H., ...&Anjum, S. I. (2021). Viral impacts on honey bee populations: A review. *Saudi Journal of Biological Sciences*, *28*(1), 523-530. https://doi.org/10.1016/j.sjbs.2020.10.037
76. Vanbergen, A. J., & Initiative, T. I. P. (2013). Threats to an ecosystem service: pressures on pollinators. *Frontiers in Ecology and the Environment*, *11*(5), 251-259.https://doi.org/10.1890/120126
77. Walters, S. A. (2005). Honey bee pollination requirements for triploid watermelon. *HortScience*, *40*(5), 1268-1270. https://doi.org/10.21273/HORTSCI.40.5.1268
78. Zalipah, M. N., Anuar, M. S. S., & Jones, G. (2016). The potential significance of nectar-feeding bats as pollinators in mangrove habitats of Peninsular Malaysia. Biotropica, 48(4), 425-428.