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Role of honey bees as beneficial insects: Significance and challenges

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Abstract

Insects play a vital role in both nature and human culture, and can either be hazardous or beneficial to society. The agricultural sector faces systematic annual losses due to harmful insect pests and in India total losses caused by insects are estimated to be 26%. The challenge to food security posed by invasive and evolving pests, which has caused a considerable rise in crop costs and posed a harm to the ecology, is one of the biggest problems facing humanity. Considerable increase in use of chemicals as crop protectants poses the beneficial insects to as serious threat in crop ecosystem resulting as decrease in crop production day by day. In this context, protecting beneficial insects may help the farming community's economic well-being and crop output. Beneficial insects are such that perform valued services in our ecosystem and thus benefited us. The honey bee is one of such beneficial insects that take part in global food security and ecosystem sustainability through their ever-known free service i.e., pollination. Even better, farmers can benefit from the priceless products produced by bee colonies and improve their capacity for economic viability. The present article concern about the importance of honey bee as a beneficial insect in rural agricultural economic development as well threats imposed to their population.

Keywords: Beneficial and harmful insects, food security, ecosystem sustainability, pollination, honey bees, rural agriculture

Introduction

Honey bees are social hymenopteran insects belonging to the genus *Apis*, characterized by the production and storage of honey and other substances potentially useful to humans. Honey is the main bee hive product having high nutritional value, much often also employed in both human and veterinary medicine (Subbarao & Joseph *et al.*, 2007) ^[45]. Aside from honey, other bee products include royal jelly, propolis, bee venom, and bee wax, all of which have significant economic value. Another significant fact is that they are essential to the pollination of many different fruits and crops around the planet. Over 80% of total pollination activities are conducted by insects, while bees provide nearly 80% of total insect pollination, making them the top pollinators (Robinson and Morse, 1989) ^[39]. Not only the cultivated crops, but also pollinate different wild flowering plants and help to maintain the ecosystems. According to Gallai *et al.* (2009) ^[19], the yearly economic value of insect pollination was estimated to be €153 billion. Even, their pollination is believed to be worth more than 15 times the value of all hive products combined, while quantifying their value is much more challenging (EARO, 2000) ^[13]. In spite of having all these beneficial functions, currently, these pollinators are facing a number of threats leading their declination and thus their apparent decline is of importance for humans and biodiversity. The main aims of this review, therefore, are to highlight the importance of honeybees in our society, their potential threats for decline and possible intervention measures for future improvements.

Honey bees and their diversity

Bees are the aculeate hymenopterans representing 7 families, namely Andrenidae, Apidae, Colletidae, Halictidae, Megachilidae, Melittidae and Stenotritidae under superfamily Apoidea, represent a great diversity estimated more than 20,000 species worldwide (Michener, 2007) ^[34]. The term honey bees or true honey bees referred those bees belong to

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the only genus *Apis* of the family- Apidae, subfamily- Apinae and tribe- Apini, on the contrary, the term 'wild bee' or 'pollen bee' is used commonly for all bees except honey bees (and/or stingless bee of Meliponini). In general, solitary bees (wild bees) make up two thirds of the bee population (Michener, 1965; Linsley, 1958; Batra, 1977) [33, 31, 7].

Continuous debate prevalent regarding the existence of species diversity of true honey bees (genus *Apis*), most recent being 10 or 11 species (Lo *et al.* 2010) [32]. Among them, four well-known species recognized as: Giant or Rock bee, *Apis dorsata* F., Little or Dwarf Honey bee, *A. florea* F., Eastern Honey bee or Asian Bee or Oriental Honeybee, *A. cerana* and Western Honeybee or European or Italian Honeybee, *A. mellifera* L. Of these four types (even among all the types), only *Apis cerana* & *Apis mellifera* are manageable and used commercial beekeeping.

Rock bee, *Apis dorsata* constructed open nests on tall tree branches and rocky out crops, as a single, enormous comb. It is wild nature and large bee in among four, produce 30-35 kg honey per year. Little bee, *Apis florea* smallest among four, made up open nesting in single small comb in branches of bushes, hedges etc. and is wild type. European bee, *Apis mellifera* constructs several parallel combs in hollowed-out tree trunks, rock holes, and other crevices. It can produce honey 25-40 kg/year. Asian bee, *Apis cerana*, similar in habits to *Apis mellifera* having builds parallel combs and can produce about 3-5 kg of honey.

Honey bees are social insects, reside in colonies and in a colony three castes (queen, drone and worker) of bees are found. Queen bee only single in number and the only function is egg laying, having of life span 3-5 years. Drone are few hundreds in number (in active season), and function is only mate with queen. Worker bees are thousands in number in a single colony and do all the works in hive from rearing to foraging.

Importance of honey bees as compared to others

Human civilizations benefit greatly from a variety of natural ecological activities known as ecosystem services. One such ecosystem service that controls a variety of direct and indirect benefits to human societies is insect mediated pollination, which is the movement of pollen within or

between flowers by insect vectors (Fisher *et al.*, 2009) [17]. 75% of globally significant crop species are expected to benefit from insect pollination, which also contributes to an estimated 35% of worldwide agricultural production (Klein *et al.*, 2007) [25]. The nature and extent of these benefits varies by crop, and can range from boosting the amount and quality of fruit or seed produced in order to accelerate crop growth and increase genetic diversity within crop species (Free, 1993; Shipp *et al.*, 1994; Hajjar *et al.*, 2008) [18, 41, 22]. In our society, many types of pollinator present (honeybees, leafcutter bees, other wild bees, butterflies, moths and other) which are beneficial to us, and among them honey bee is most important for not only a good pollinator but also improve rural economic development through production different types of high-quality hive products (honey, pollen, bee wax, royal jelly, bee venom and propolis). The body of the bee is covered with feathery hairs, and it has another structural change that allows it to carry and transfer pollen from one blossom to another. As the bee drops her head inside the flower to drink the sweet nectar deep within the blossom, its hairy body rubs against the pollen-carrying anthers. When she travels to the next flower, pollen from her body falls on the stigma, effecting pollination (Abrol, 2007) [1].

Roll of honey bee in pollination: Pollination establishes a link between agriculture and the life cycle because it is both the foundation of agricultural productivity and essential for preserving ecological equilibrium. As a result of the increased quality and quantity, pollination plays a preface in the economic sector (Khalifa *et al.*, 2021) [24]. Pollination is described as the movement of pollen from male anthers to female stigmata within the same flower (self-pollination) or across plants (cross-pollination). Pollinators are important participants in crop production because plants rely exclusively on vectors to deliver pollen during cross-pollination. For instance, incorporating both wild and managed bee species in a region could enhance cross-pollination. The frequency of visits and the cumulative impacts of various bee species affect not only the amount but also the quality of crops produced, which is particularly significant from an economic aspect (Table 1). Figure 1 also shows the importance of bees as pollinating insects.

Table 1: Percent increase in yield due to bee pollination

Sl. No.	Crops	Scientific name	Percentage increase in yield
Oilseeds			
1.	Linseed	<i>Linum usitatissimum L.</i>	22 to 38
2.	Mustard	<i>Brassica spp.</i>	43
3.	Niger	<i>Guizotia abyssinica Cass.</i>	199
4.	Safflower	<i>Carthamus tinctorius L.</i>	23 to 28
5.	Sesame	<i>Sesamum indicum L.</i>	32
6.	Sunflower	<i>Helianthus annuus L.</i>	32 to 48
Fibre			
7.	Cotton	<i>Gossypium spp.</i>	17 to 19
Fodder			
8.	Berseem	<i>Trifolium alexandrinum L.</i>	3497
9.	Lucerne	<i>Medicago sativa L.</i>	112
Vegetables			
10.	Cucumber	<i>Cucumis sativus L.</i>	66
11.	Onion	<i>Allium cepa L.</i>	93
12.	Tomato	<i>Solanum lycopersicum</i>	160
13.	Radish	<i>Raphanus sativus L.</i>	700
14.	Watermelon	<i>Citrullus vulgaris Schrad</i>	52
Fruits			

15.	Apple	<i>Pyrus malus L.</i>	44
16.	Grape	<i>Vitis vinifera L.</i>	37
17.	Lime	<i>Citrus spp.</i>	1533
18.	Litchi	<i>Nephelium litchi Camb.</i>	150 to 170
19.	Plums	<i>Prunus sp.</i>	15
Condiments and Spices			
20.	Cardamom	<i>Elettaria cardamom Maton</i>	21 to 37
21.	Coriander	<i>Coriandrum sativum corniculata L.</i>	30
22.	Kasuri methi	<i>Trigonella L.</i>	80
23.	Saunf	<i>Foeniculum vulgare Miller</i>	81
Plantation			
24.	Coffee	<i>Coffea arabica L.</i>	83

Source: CBRTI, KVIC

Additionally, according to the United States Department of Agriculture (USDA), honey bees help pollinate a variety of food crops, including almonds, apples, grapefruits, soybeans, strawberries, and grapes (Del Moral and Standley, 1979; Williams, 1994) [12, 49]. In North America, the value of agricultural commodities, fruits, and vegetables that are pollinated by bees is \$20 billion annually (Klein *et al.*, 2007; Morse and Calderone, 2000) [25, 35]. The worth of honey bee pollination to Canadian agriculture has been estimated by

researchers to be between 443 million and 1.2 billion Canadian dollars annually (~ USD 413 million-1.12 billion; Winston and Scott, 1984). The annual benefits in Australia totalled AUD 156 million (~ USD 147 million; Gill, 1990), while advantages in the US were pegged at USD 1.6 to 40 billion (Morse and Calderone, 2000; Southwick and Southwick, 1992) [35, 43]. In India, the value of bee pollinated crops estimated to be Rs. 410 094.77 crores representing 31.76% of total value of agricultural output.

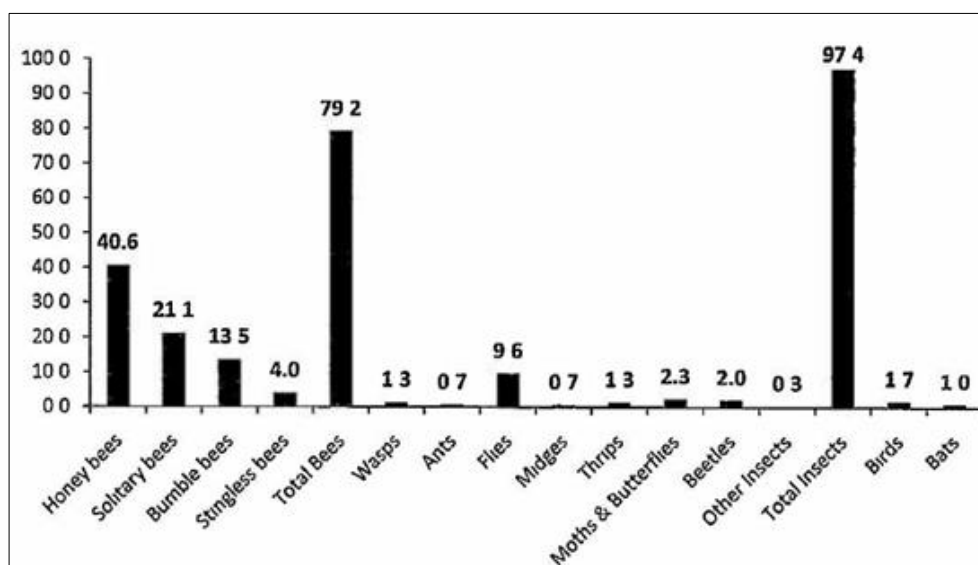


Fig 1: Frequency of floral visitors recorded as pollinating agents in different crops. (Chaudhary, 2019)

Role of honey bee in rural economy development/boost up: Rural development aims to help people manage their lives more successfully by making better use of available resources. By enabling people to utilize their skills without compromising the eco-services provided by their environment, it increases their social and economic power (Ahmad *et al.*, 2007) [3]. Honey production through bee keeping has grown in popularity among small-scale farmers in recent years and this is due to farmers' diversification of revenue sources (Famuyide *et al.*, 2014) [15]. Beekeeping can assist economically challenged communities in achieving financial stability. Aside from direct income from bee products, beekeeping creates off farm job opportunities in a variety of fields, including hive construction, honey trade, renting and hiring bee colonies for pollination, and bee-based micro-enterprises (Ahmad *et al.*, 2007) [3].

Honey

Foraging bees gather floral nectar, which they then digest and regurgitate repeatedly to generate honey. The

supersaturated aqueous solution that results from the stomach's acidic pH and the enzymatic activity of invertase, diastase, and amylase contains 80% sugars, primarily fructose and glucose, with tiny amounts of sucrose, maltose, and other complex sugars (Cornara *et al.*, 2017) [11]. Honey has a pH level that is of 3.9 due to the presence of approximately 0.57% organic acids, the majority of which are gluconic acid generated from glucose oxidase activity and citric acid. There are also trace amounts of vitamins, including vitamin B complex as well as ascorbic acid. Mineral levels range from 0.04 to 0.2%, according to the mineral richness of the soils where source plants flourish. The most prevalent element is the mineral potassium, which accounts for more than a third of the total mineral composition (Ramanauskiene *et al.*, 2012) [38]. Honey has been demonstrated to suppress the development of some microbes (Allen *et al.*, 1991) [5]. Honey has its value as a food, medicine and also as a cash crop for domestic and international markets. It is an integral component of various cultural traditions (Edwards and Heath., 1964) [14].

Royal jelly: When the glands are completely functioning, between six and twelve day old nursing bees exude royal jelly. It is a very healthy diet that is supplied to the young worker larvae as well as the queen's larva and adult. The color of a royal jelly is milk or light pale. Royal jelly is a substance that has been utilized in conventional medicine since the dawn of time. It is now employed in the cosmetics and pharmaceutical sectors, as well as being promoted as an over-the-counter nutritious food. In addition to having characteristics against bacteria, fungi, and viruses, royal jelly has also been shown in a number of studies to have hypotensive, anticancer, anti-hypercholesterolemia, and anti-inflammatory effects in animal models (Ramadan and Al-Ghamdi., 2012) [37].

Propolis: Bees collect propolis from a tree's resinous exudates. Propolis is used in bee colonies to adhere frames and fill in fractures and gaps. However, it contaminates comb wax. We get propolis by scrapping from frames. Propolis is frequently used to treat diabetes, a condition cold sore, and oral swelling. There isn't any solid scientific proof to back up its usage for illnesses like genital herpes, wounds or sores caused by canker (Wagh, 2013) [48].

Bee venom: A worker bee's stinger is connected to a venomous sac that contains poison. A newly hatched bee is unable to sting since its stinger cannot be implanted because its chitin has not fully developed. A bee's poison sac contains its most potent amount of venom around two weeks old. Live bee stings are used in bee venom treatment to treat a variety of syndromes' symptoms, including pain, lack of

coordination, and muscular weakness. Stings may occur everywhere on the body, and they appear to have various effects depending on where they exist (Ali, 2010) [4].

Bee pollen: Foraging bees bring pollen back to the hive where it is packed into pellets and stored. During this process, the pollen mixed with nectar and bee salivary secretions becomes the "bee bread," representing a main food reserve for the hive colony (Almeida-Muradian *et al.*, 2005) [6]. The primary chemical components of bee pollen include carbohydrates, protein and amino acids, as well as lipids and fatty acids, as well as phenolics, enzyme and coenzymes, vitamins, and minerals (Komosinska-Vassev, *et al.*, 2015) [27]. Bee pollen is an energy source that people utilize as a diet supplement and for athlete training. In alternative healthcare, bee pollen is utilized to treat high altitude illness syndrome, gastric ulcers, infectious illnesses, and prostatitis (Linskens and Jorde., 1997) [30].

Beeswax

The substance that bees utilize to construct their nests is beeswax. Young honeybees create it by secreting a liquid from unique wax glands. When they are 14 to 18 days old, worker bees begin to secrete wax. When wax comes into touch with air, it solidifies and creates scales, which are visible as tiny wax flakes on the underside of the bee. Nutrition, flames, and skincare are just a few examples of the commercial goods and techniques that use beeswax as a component. It functions as a thickener, binder, drug carrier, and release inhibitor in medicinal formulations (Cornara *et al.*, 2017) [11].

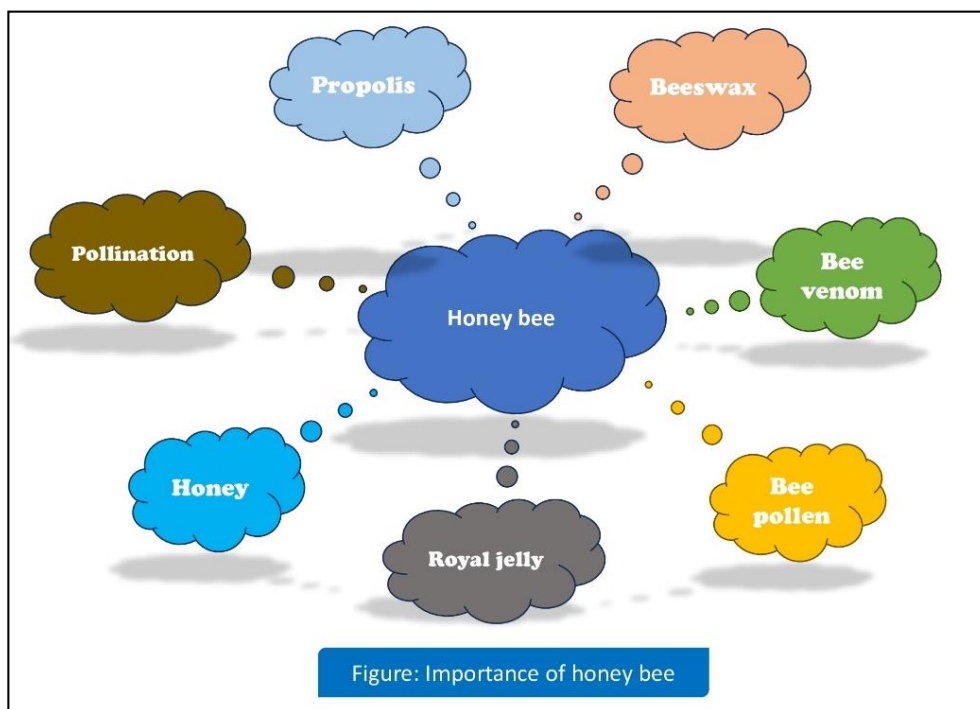


Fig 2: Importance of honey bees compared to others

Threats of honey bees

Honey bee populations are declining, indicating a potential future pollination scarcity (Bauer and Wing, 2010) [8]. Honey bees are threatened by a variety of factors, many of which are brought on by human activity, including habitat destruction and fragmentation, irresponsible honey harvesting, biological incursions, and excessive chemical

and herbicides usage (Vanbergen and the Insect Pollinators Initiative, 2013) [47].

Climate change

The link between the honey bees and plants might go out of sync as a result of climatic disasters including floods, droughts, and increasing temperatures worldwide. This

would affect honey bee food production and pollination activities (Valk H., 2011) ^[46].

Colony loss: Diseases, pests, lack of food supply, and residual pesticides are only a few of the causes of colony loss (Hellerstein *et al.*, 2017) ^[23]. According to the Control of Honey Bee Community Losses (COLOSS), there were losses of 16.4 percent of the colonies of honey bees during the 2017 and 2018 winter, ranging from a 2.0 to 32.8% of the globally (Gray *et al.*, 2019) ^[21].

Food crisis: With less pollen and nectar available, honey bee malnutrition can be a hard issue. Climate changes and extremes, the accessibility of food savings, and the presence of brood are only a few of the variables that affect how quickly food is depleted from storage. Honey overharvesting can also lead to a lack of food for bees (Leonard, 2011) ^[29].

Pathogens and parasites: The diseases and parasites that affect honeybees are many. Mites, bacteria, fungus, and

viruses are a few of them. Pests like the wax moth, *Galleria mellonella*, and the Varro mite, *Varroa* spp. cause stress in honeybee colonies. Pathogen like *Nosema* cause impairs in bee's digestive system.

Agriculture pesticide

The incidence and severity of pesticide exposure are affected by cropping practices, how pesticides are applied, their properties, and their appeal to honey bees. The main factor affecting risk is the timing of pesticide applications in relation to crop blooming or other agricultural activity. To destroy certain pests of insects during farming operations, a chemical called pesticide is applied on the plant's surface (Ferrier *et al.*, 2018) ^[16].

Deforestation

Deforestation is the one of most important causes to reduce honey bee day. Bee populations are primarily impacted by the loss/change of floral supplies and nesting locations when natural vegetation is removed.

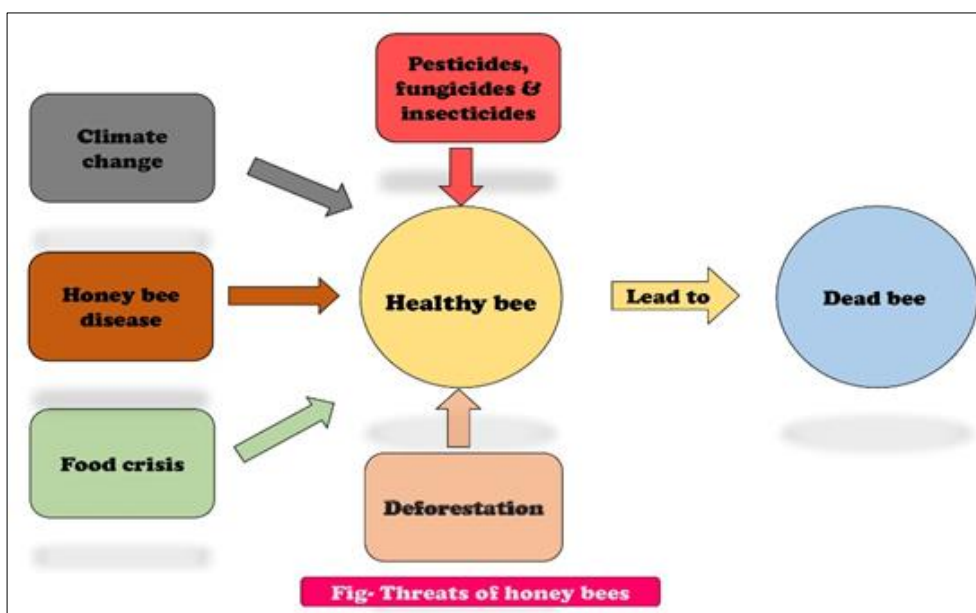


Fig 3: Potential threats of honey bees

Protection measures

Pollinator protection can improve global food security by assuring zero hunger, feeding the world's rising population, and reducing poverty by increasing agricultural productivity. Bee conservation also promotes biodiversity. A twenty-five percent rise in crop yield may be achieved via effective pollination and pollinator control (Silva, 2018) ^[42].

Discourage use of pesticides and insecticides: Although they are insects, bees are the most significant pollinators for us. To reduce the usage of pesticides, choose organic products. It is now obvious that pesticides as a whole pose a serious threat to bee populations. Because they are designed to kill certain insects, insecticides are more dangerous to bees. The use of artificial and industrially produced chemicals should be avoided in agriculture by using organic farming techniques. Purchasing food that has been grown organically supports this startup company and discourages the use of pesticides on farmlands. Creating bee-friendly environments also benefits from avoiding harmful pesticides and fertilizers (Goulson *et al.*, 2015) ^[20].

Adopt a beehive: Through a group, adopt a beehive. It aids neighborhood beekeeping initiatives. Several honey bees are lost each year. The person who keeps bees becomes more aware of the requirements of the honey bee colonies they have adopted after adopting a beehive. In the process, the beekeeper makes money, and you get to assist in saving bees (Adgaba *et al.*, 2014) ^[2].

Plant trees: Establish trees in vacant areas whenever you can. Trees give bees a lot of honey and pollen to collect. Honey bees may visit hundreds of flowers on one tree in a short period of time. Bees receive resin from trees in addition to nectar and pollen from them. Bees utilize the resins to plug holes, fissures, and microscopic fractures in their hive. In order to keep the beehive clean, it is also used to mummify dead bees, insects, and animals (Koch and Stevenson, 2017) ^[26].

Protect bee habitats: Where bee habitat is threatened, protect it. Urban environments don't have enough green spaces to support insect and bee life. To help counteract this

habitat loss, little green areas might be promoted and offered. It is possible to create a habitat corridor or a bee garden. Bee-friendly blossoms with high nectar-producing abilities can be used. These flowers may be grown on balconies, in intersections, and along the sides of roadways (Kremen *et al.*, 2002) ^[28].

Support local beekeepers

Purchase local honey and items made from beehives to support beekeeping. Nearby bee conservation efforts typically involve local beekeepers. Additionally, they are paying greater attention to their methods of production than commercial honey producers do. Beekeepers work very hard to maintain the health of honeybee colonies. They add to the regional genetic diversity of the bee population in your region. When you require local honey and hive products, purchasing them indirectly benefits beekeepers. Through regional clubs and organizations dedicated to beekeeping, you may also donate money or provide your services (Sponsler and Bratman, 2021) ^[44].

Become a beekeeper

When you first begin beekeeping, local beekeeping organizations and clubs are excellent venues to meet other beekeepers. The organizations provide training to assist novice beekeepers in locating the required supplies and tools. Through study, practice, and a dedication to being a part of the answer to preserve bees, you may start out as a beekeeping hobbyist and advance to become a master beekeeper (Sammataro and Avitabile, 1998) ^[40].

Create a bee bath

Bees become thirsty when searching for and gathering nectar. Fresh water should be poured into a small dish or birdbath, and then stones and pebbles should be placed within to break up the surface of the water. Bees will settle on the rocks and pebbles to take lengthy, cool drinks (Buxton, 2006) ^[9].

Conclusion

As beneficial insects, honey bees are essential to our ecosystems and agricultural landscapes. Their importance goes far beyond honey production, including crucial pollination functions that sustain the world's food supply chain and boost biodiversity in the environment. Without their hard labour, many of our favourite nuts, fruits, and vegetables would become scarce, causing a shortage of food and rising food prices. However, honey bees encounter a variety of difficulties in the contemporary environment. Their populations are at risk from pesticides, habitat loss, climate change, and illnesses. Not only do these issues affect honey bees, but they also have significant effects on the world's food supply and ecological health. A multifaceted strategy is needed to overcome these obstacles. It includes managing pesticide usage through sustainable farming methods, preserving and restoring bee-friendly habitats, and doing ongoing research on the health and disease of honey bees. The protection of honey bees and their essential function also depends on public involvement and awareness. Work to increase awareness of the value of honey bees among people, communities, and policymakers can result in positive change and encourage appropriate stewardship of these priceless creatures.

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