*Original Research Article*

# FARMERS' PERCEPTION ON INSECT POLLINATORS DECLINE AND CONSERVATION METHODS IN HIMACHAL HIMALAYA, INDIA


**ABSTRACT**

Insect pollinators are required for the sustainability of agriculture and natural ecosystems. Many insects like bees, flies, butterflies, beetles, wasps, moths, and midges are important pollinators of many crops. The climate of Himachal Himalaya is suitable for growing various kinds of fruit crops but in the recent years, yield and quality of fruit crops is diminishing due to insufficient pollination. This study was conducted to assess the pollinator declining factors and farmers' perception in respect of conservation and management of pollinators in Himachal Himalaya. The number, abundance and biodiversity of insect pollinators is decreasing due to various threatening factors pollinators observed in Himachal Himalaya are: - loss of habitat; introduced species; mono-cropping; grazing and mowing; Forest fires; Honey hunting; Exotic bees; Pesticides; Diseases and parasites; Cell phone radiations; Environment pollution, and Climate change.

The farmers here practiced beekeeping as a part time or whole time job while there were different types of constraints such as non-availability of bee flora throughout the year, heavy snowfall, shortage of labour, absconding of bees and poor knowledge about medicines. Most of the farmers wanted to have financial support for different horticultural practices, management technology and training purposes. The farmers had knowledge about different aspects of honey production, processing and marketing i.e. constituents of honey, nutritional value, different type of honey containers used for honey storage, honey processing, marketing problems etc. But only some farmers were acquainted with different pests, predators and diseases of honeybees and their remedial measures. To minimize the pesticides effect, majority of farmers sprayed them in the morning and during nonflowering session.



**KEY WORDS:** - Himachal Himalaya, Pollinators decline, Bee Pollination, Threatening factors, Farmer's Perception, Climate change, Bee Management


## INTRODUCTION

The services of insect pollinators are very important for the sustainability of agricultural/ horticultural and natural ecosystems. The diversities of insects are important for stabilizing plant pollination and its yield. It has been estimated that over 80% of all flowering plants depend on animal pollinators, especially bees. Among insects, bees, flies, beetles, butterflies, midges, moths, and wasps are important pollinators of many crops (Raj et al. 2012). Most crops would produce no fruit or seed without the pollination of their flowers. Poor pollination often results in reduced crop yields and deformed fruits. In the recent years the diversity and distribution of insect pollinators is declining. There are many factors responsible for the decline of insect pollinators, including the loss, degradation and fragmentation of habitat; introduced species; habitat disruption from grazing, mowing and fire; the use of pesticides; diseases and parasites, climate change and mono-cropping (Raj and Mattu, 2016). The decline of pollinators caused the lowering of yield of pollinator-dependent crops and referred to as pollination crisis and subjected to different sciences like politics and economy (Jung, 2014). Many fruit crops grown in Himachal Himalaya are apples, almonds, peaches, plums, pears, cherries, walnuts, and pine nuts in the mountains and citrus fruit, mangoes, litchis, guavas, and loquat in the foothills and in the plains. But apple is the main cash crop accounting for 42% of the total area under fruit cultivation and about 88% of total fruit production (Raj et al. 2012).

Insect pollinators mainly belong to the orders of Hymenoptera (bees), Lepidoptera (butterflies), and Diptera (syrphid fly). There are also vertebrate pollinators like birds, bats, monkeys, etc. but honeybee (*Apis sp*.) is dominant pollinators of crops (Klein et al., 2007). There are many abiotic and biotic factors that weaken honeybee-keeping and its values. Among the abiotic factors, climate change is a major factor (Langowska et al., 2016). Global warming due to climate change may have a substantial negative impact on the production of honey (Langowska et al., 2016). Birhan et al. (2015) reported that lack of honeybee forage, shortage of rainfalls, agrochemical poisons, pests, absconds, and lack of honey storage facilities affected honeybee production and productivity negatively. In addition to climate change, higher pathogen prevalence (Furst et al., 2014) and competition between native and invasive species (Goulson, 2003) has brought the instabilities in pollinator population, and plant diversity.

Lack of honeybee professionals and trained bee labours allows poor management of colonies. The transport costs are also high in migratory beekeeping (Sharma et al. 2014). Many commercial beekeepers face problems

including interference of police and octroi people during the migration of their bee colonies. Indiscriminate use of pesticides poses a major threat to honeybees (Shinde and Phadke1995). Producer price for honey and other products from beekeeping is very low compared to retailer price, and this always irritates the beekeepers (Singh 2000). Many beekeepers report that the cost of the equipments is too high and this will also discourage the entrepreneurs in this field. Most of the commercial beekeepers are troubled by the international standards for exporting honey as the beekeepers have poor knowledge of these standards (Sharma et al. 2014).

## MATERIALS AND METHODS

A field survey was conducted at different localities in Himachal Pradesh**.** The data prepared for the present study is primary as well as of secondary nature. Primary data was collected from farmers with the help of a questionnaire prepared for the purpose. Farmers were asked about the various types of bee management practices. They were also asked about different hive products, honey bee diseases & pests and pollinator declining factors. The farmers were also questioned about different problems they faced in beekeeping and getting institutional support. The secondary data was collected from different agencies like Directorate of Horticulture and Directorate of Industries Govt. of Himachal Pradesh, Khadi and Village Industries Commission (KVIC) and Central Bee Research and Training Institute (CBRTI), Pune. Elaborate interactions were made with the district and state level officials of beekeeping department of Govt. of Himachal Pradesh.

## RESULTS AND DISCUSSION

In recent years, pollination services are being hampered by a decline in the number, abundance, and diversity of pollinator populations throughout the Himalayan region. The inadequate pollination in fruit orchards is largely attributed to decline of natural pollinators such as honey bees. This is forcing farmers to find different ways for conservation and management of insect pollinators in their orchards.

### I. POLLINATOR DECLINING FACTORS

Human activities and practices are primary factors for the loss of habitats of pollinators leading to a decrease in their food supplies, nectar, and pollen. Other major factors contributing to pollinator decline include an increase in monoculture-dominated agriculture, forest fires, use of pesticides and climate change. Some of the possible factors for pollinator decline in context of Himachal Himalaya are observed as under: -

**1. Loss of habitat :-** Farmers in the high mountain regions of Himachal Himalaya are planting apples in their pasture lands. Himachal Pradesh has observed an increase of 135% in apple orchards. The ongoing increase in agricultural and horticultural area at the cost of forests and grasslands is apparently leading to the loss of nesting sites and food sources of pollinators. About the impacts of human disturbances on bees, Winfree et al. (2009) identified habitat loss and fragmentation as the most significant factor in declines of abundance and species richness of bees. Factors causing habitat loss and fragmentation include increasing urbanization, expansion of intensive agriculture, invasive plants, and climate change. These reduce, degrade, and/or eliminate pollinator habitat.

**2. Pests, predators and diseases :-** There are many types of pests, predators and diseases affecting the bee pollination in Himachal Himalaya. Only some of the farmers (42.10%) had knowledge about pests and diseases of honey bee, and a few persons (34.50%) used medicines for the cure of bees (Table 1). Mostly there occur attacks of pests on bees.

**Table 1: Disease of honey bees**

| | | **% of responses** |
|---|---|---|
| **a.** | **Knowledge about diseases of honey bees** | |
| | Yes | 42.10 |
| | No | 55.20 |
| | DNK | 2.70 |
| **b.** | **Knowledge about medicines for cure of bees** | |
| | Yes | 34.50 |
| | No | 29.10 |
| | DNK | 6.40 |
| **c.** | **Types of diseases and attacks** | |
| | Wasps | 36 |
| | Viral | 24 |
| | Acarine | 11 |
| | Mites | 26 |
| | Wax moths | 3 |

**3. Pesticides:-** Apple farmers spray different pesticides (including insecticides) as many as 10 times in a season, and in Himachal Pradesh almost 31% of farmers spray during the flowering period (Table-2). Agricultural pesticides kill not only the foraging insects, but also *Apis dorsata* and *Apis florea* colonies in adjoining areas.

**Table 2: Number and time of spray of pesticides on apple crop in H.P.**

| | | **% age of responses** |
|---|---|---|
| **a.** | **Number of pesticide spray per season** | |
| | 3-4 | 10 |
| | 4-5 | 8 |
| | 6-7 | 15 |
| | 9-10 | 67 |
| **b.** | **Period of spray** | |
| | Non-flowering | 61.10 |
| | Flowering | 30.90 |
| | Both | 8.00 |
| **c.** | **Time of spray** | |
| | Morning | 52.20 |
| | Afternoon | 29.80 |
| | Evening | 18.00 |
| **d.** | **Commonly used pesticides** | Metacid, metasystox, diethane M-45, thiodan, monocrotophos, fenitrothion, malathion |

The use of pesticides, including insecticides and herbicides, is detrimental to a healthy community of pollinators. Pollinator larvae are also harmed by consuming food contaminated with pesticides (Abbott et al. 2008). Herbicides may kill plants that pollinators depend on when crops are not in bloom, thus reducing the amount of foraging and egg-laying resources available (Tscharntke et al. 2005). In the eve of cash crop farming, farmers use insecticides and pesticides indiscriminately, contributing to the decline in natural insect pollinators.

4. **Cell phone radiations :-** Electro-magnetic radiations of cell phones affect the behavior of honeybees. They are dyeing due to losing the location of their colonies or behavioural disorders. Sharma and Kumar (2010) have compared the performance of exposed and unexposed honey bee colonies in cell phone radiation. A significant decline in colony strength and in the egg laying rate of the queen was observed. The behaviour of exposed foragers was negatively influenced by the exposure. There was neither honey nor pollen in the colony at the end of the experiment. Radiation from the cell phone influences the behavior and physiology of adult workers of *Apis mellifera* L (Kumar et al, 2011). There was reduced motor activity of the worker bees on the comb initially, followed by mass migration and movement toward "talk mode" cell phone.

**5. Environment pollution :-** Pollutants in the air, water and land always affect the physiology and behavior of the insects. Changes in the carbon-nutrient balance in plant tissues as a result of increases in carbon dioxide will reduce the nutritional quality of plant tissues and alter production of secondary compounds. Predicted effects for insect herbivores with chewing mouth parts, include increased first-instar mortality, increased development time and consumption, and decreased digestive efficiency and performance. Lower development rates may also increase herbivore mortality from natural enemies and result in asynchronous plant–insect life cycles (Bale et al. 2002). Fuentes (2008) observed that air pollution from automobiles and power plants has been inhibiting the ability of pollinators such as bees and butterflies to find the fragrances of flowers.

**6. Climate change :-** Climate change is one of the major forms of environmental change impacting biodiversity of insects. The effects of climate change on insects will differ between species depending on their biology, current environment, and geographical distribution. As a result, some species are likely to be more susceptible to climate change than others. Water availability is one of the most important determinants of the distribution and abundance of insects. Because of their small body size, insects are particularly vulnerable to water loss, and water loss rates are positively related to precipitation levels (Chown and Nicolson, 2004). Increased frequency of extreme events, such as floods, droughts, and fires, will increase mortality and may result in extinction of restricted-range species**.**

**7. Impact of introduced species :-** Biological invasion is recognized as one of the major threats to biodiversity worldwide, along with habitat loss and climate change. The accidental or sometimes deliberate introduction of alien species, including plants, microbes, vertebrates, and other invertebrates, is also of major concern to insect conservation. Alien invasive plants may impact negatively on insect biodiversity by changing habitat quality, outcompeting native host plants, and interrupting vital ecological interactions (Moller, 1996). Introduced nonnative plants compete with native plants for resources as well as alter habitat composition, and some cause significant

reductions in the abundance and diversity of pollinators and other herbivorous insects. There is also evidence that native pollinator insects prefer native plants (Hopwood, 2008).

**8. Increase in mono-cropping**

Although, mono-cropping or monoculture provides ample forage for pollinators over a limited flowering period, yet practically available forage before and after the main flowering period, may not commensurate with the requirements of pollinating agents. The replacement of natural plant communities by monoculture, is also a declining factor since most monocultures are not capable of sustaining pollinator populations (Raj and Mattu, 2016). In the past, mountain farmers grew a variety of crops which bloomed at different times of the year and provided food for a number of natural insect pollinators. The transformation of agriculture from traditional mixed crop farming to high value cash crop farming in recent years has led to an increase in monocrop agriculture, reducing the food sources for natural insect pollinators. Now the farmers are switching on a large scale to the cultivation of cash fruit crops and off-seasonal vegetables.

**9. Grazing and mowing :-** The grazing and mowing cattle is practiced in Himachal Pradesh. It can have damaging impacts on pollinators but when carefully managed, they can be beneficial. Livestock grazing can greatly alter the structure, growth, and diversity of the vegetation community, which in turn can affect the associated insect community (Kruess & Tscharntke, 2002). Ways that grazing can harm pollinator habitat include: destruction of potential nest sites, destruction of existing nests and contents, direct trampling of adult bees, and removal of food resources (Sugden 1985). Like grazing, mowing can alter grassland succession and species composition by suppressing growth of woody vegetation (Forrester et al. 2005). Mowing can have a significant impact on insects through direct mortality, particularly for egg and larval stages that cannot avoid the mower (Di Giulio et al. 2001).

**10. Forest fires :-** Forest fires in summer, largely engineered by farmers for fresh growth of grass on forest floors, is a key factor affecting pollinator populations in some areas. Forest fires not only destroy the nesting places and food sources of pollinators but also kill pollinators hibernating or nesting in the area. The large-scale pine plantations in the mid hills of the Himachal Himalaya pose a fire hazard in summer because of the falling of dried pine needles. Forests provide food sources, and habitats for nesting and hibernation for a variety of pollinator species. Studies have revealed that there are more insect pollinators in apple orchards situated near forests than those that are far from forests (Sharma and Gupta, 2010). Therefore, a decline in forest area due forest fires has a negative impact on pollinator abundance. It is common practice for farmers in the Himalayan region to use fire in the fields and grasslands to control weeds and to improve the quality of grass the following year. The removal of weeds reduces the diversity of food sources available to pollinating insects. Afraid of being stung, farmers also burn and poison *Apis dorsata* colonies and other pollinators in India (Partap et al. 2012).

**11. Honey hunting :-** An increase in honey hunting of wild honeybees by burning, smoking and cutting hive full of larvae is contributing to the decline in the population of indigenous honeybees. In the past, honey hunting formed a part of the culture and tradition of honey-hunting communities and provided them with a source of income. It is now being commercialized and exploited by big contractors and companies.

**12. Exotic honey bees :-** The introduction of exotic honey bee species can adversely affect populations of native bee species. This may be because of competition for food, the transfer of pests and diseases from one species to another, or economic preference for exotic species. The introduction of *Apis mellifera* to increase honey production has led to a decline in beekeeping with indigenous *Apis cerana* in mountain region (Partap and Partap, 1997).

Thus, the habitat deterioration by deforestation, forest fire, agrochemicals and honeybee diseases and insects and other pests are reducing honeybee colonies across the globe at an alarming rate. The decline of honeybee populations threatens not only honeybee products but also global agriculture and the world biodiversity (Wakgari and Yigezu, 2021).

## II. FARMERS PERCEPTION REGARDING CONSERVATION OF INSECT POLLINATORS

Despite of overall success in promoting honeybees as pollinators, the survey indicated that about a quarter of farmers had still not understood the potential role of honeybee pollination in enhancing fruit yield. Most of the fruit growers in Himachal Himalaya were aware that introduction of both native *Apis cerana* and exotic *Apis mellifera* colonies in orchards at the time of flowering can help in fruit set and yield. In Himachal Himalaya, many farmers were aware about the local bee flora and they agreed that they had sufficient availability of honey plant resources like mustard, pear, apple, plum, peach, almond, rose, bottle brush etc. in their regions. The data collected from farmers/orchardists through questionnaire on various parameters is tabulated and described as below:-

**1. Farmers' Perception of Pesticide Use and Its Impact on Insect Pollinators**

More than two third (68 %) of the farmers used some type of pesticides in their orchards. They commonly used fungicides, insecticides and other pesticides obtained from government stores. Less than half of the farmers knew that pesticides kill insects. Most of them used wettable powder (Table 3).

**Table 3: Farmers' perception regarding the use of pesticides in orchards**

| | | % age of responses |
|---|---|---|
| **a.** | **Pesticides used in orchard** | |
| | Yes | 68 |
| | No | 25 |
| | DNK | 7 |
| **b.** | **Do pesticides kill pollinators** | |
| | Yes | 49 |
| | No | 32 |
| | DNK | 19 |
| **c.** | **Type of pesticide formulation used** | |
| | Dust | 8.60 |
| | Spray | 27.20 |
| | Wettable powder | 56.10 |
| | DNK | 8.10 |
| **d.** | **Type of pesticide used** | |
| | Fungicides | 46 |
| | Insecticides | 24 |
| | Others | 30 |

2. **Farmers' Knowledge Regarding Bee Management Practices**

Less than half of the farmers know about the bee management practices to be taken (Table 4). Most of the farmers (65.10%) handled the bees by themselves while some (34.90%) of them employed some extra employees. Most (49.50%) of the farmers got the nucleus stock from the horticulture department. Most of the farmers (84.30%) multiply the bees only once and (75%) used smokers for handling bees.

**Table 4: Farmers' knowledge regarding Bee Management Practices**

| | | %age of responses |
|---|---|---|
| **a.** | **Farmers understanding about bee management practices** | |
| | Yes | 56.40 |
| | No | 40.60 |
| | DNK | 3.00 |
| **b.** | **Handling of bees** | |
| | Themselves | 65.10 |
| | Extra hand | 34.90 |
| **c.** | **Source from where nucleus stock is obtained** | |
| | Forest Department | 36.10 |
| | Horticulture Department | 49.50 |
| | Grew Themselves | 14.40 |
| **d.** | **Multiplication of colonies** | |
| | Once | 84.30 |
| | Twice | 14.20 |
| | DNK | 1.50 |
| **e.** | **Equipments used for handling bees** | |
| | Smoker | 75.00 |
| | Bee veil | 16.00 |
| | Gloves | 6.00 |
| | Bee bush | 3.00 |

**3. Migration of Bee Colonies**

Most of the farmers migrated the bee colonies and were satisfied with their migration. Farmers used different types of mode of transportation and faced many types of problems during migration (Table 5).

**Table 5: Migration of Bee Colonies**

| | | % age of responses |
|---|---|---|
| **a.** | **Do the farmers migrate the colonies** | |
| | Yes | 64.10 |
| | No | 30.20 |
| | DNK | 5.70 |
| **b.** | **Mode of transportation** | |
| | Mini Trucks | 51.40 |
| | Maxi Cabs | 22.50 |
| | Trucks | 11.20 |
| | Medium Vehicles | 14.90 |
| **c.** | **Problems in migration** | |
| | Bees fly during migration | 14.30 |
| | Bees die during migration | 31.50 |
| | Money and man power needed | 9.10 |
| | Transportation problem | 22.50 |
| | Difficult terrain | 22.60 |

**4. Marketing of Honey**

Collection of honey was made available at different intervals. Most of the persons (61.40%) were satisfied with the collection interval. Most of the farmers (66.30%) were not satisfied with the transport arrangements in their regions. Most of them (79.90%) faced marketing problems of different kind.

**5. Institutional Support**

Only some of the farmers (38.30%) got financial assistance from the department of beekeeping. Around a quarter reported that they had already received some form of awareness or training support from NGOs and Govt. agencies. Most of them (83%) wanted training in orchards management and improved methods of beekeeping. About half (61%) wanted to have support from the government and technical knowledge about pollination. About 49% of farmers wanted financial support to buy orchard equipments and honeybees (Table 6).

**Table 6: Institutional Support**

| **a.** | **Financial assistance from the government** | **% of responses** | **Remarks** |
|---|---|---|---|
| | Yes | 38.30 | |
| | No | 58.50 | |
| | DNK | 3.20 | |
| **b.** | **Sources from where financial assistance obtained** | | |
| | Department of Khadi Village and Industry | 15.20 | |
| | Department of Horticulture | 23.40 | |
| | Beekeeping farm | 17.70 | |
| | DNK | 43.70 | |
| **c.** | **Desired institutional support** | | |
| | Training in orchards management and beekeeping | 83 | Training in orchards management, improved methods of beekeeping and pollination management using honey bees |
| | Financial support | 49 | To buy farm equipments and for planting materials |

| | | | |
|---|---|---|---|
| | Increasing awareness | 61 | Support towards increases awareness of technical aspects of pollination including honey bee pollination |

**6. Constraints in Beekeeping**

There were different constraints encountered by farmers of Himachal Pradesh in practicing apiculture which are shown in (Table 7).

**Table 7: Major constraints**

| | **% of responses** |
|---|---|
| Non-availability of flora throughout the year | 29.30 |
| Heavy snow fall | 22.60 |
| Lack of latest knowledge | 16.50 |
| Lack of labour | 14.90 |
| Habit of bee to leave the hive | 11.00 |
| No knowledge about medicine | 4.70 |

Most of the surveyed farmers knew that insecticides could kill honeybees and other useful insect pollinators but even than they were making excessive and indiscriminate use of pesticides on cash crops. Insecticides have affected both the diversity and abundance of pollinating insects which was clearly reflected in farmers' perception because they observed that in the past there were large number of insects like honeybees, butterflies and wild bees during the flowering season of temperate fruit crops. But now there is decrease in their population which is affecting the crop productivity.

**CONCLUSIONS**

In spite of suitable climate and soil conditions for growing different fruit crops in Himachal Himalaya, and adequate agronomic inputs and intensive efforts of orchardists, the yield and quality of fruit crops is decreasing, due to insufficient pollination. In recent years, number, abundance and biodiversity of insect pollinators is decreasing due to hazardous human activities. Many threatening factors to the biodiversity of insect pollinators observed in Himachal Himalaya are: - Loss of habitat; Impact of Introduced species; Increase in monoculture; Grazing and mowing; Forest fires; Honey hunting; Exotic honeybees and local honeybees; Pesticides; Pests, predators & diseases; Cell phone radiations; Environment pollution; and Climate change. These factors are imposing a serious threat to crop production and the maintenance of biodiversity. Several farmers getting disappointed with the very low yield and quality of apples, have destroyed their apple trees.

The farmers of Himachal Pradesh practiced beekeeping as a part time or whole time job and were engaged in this venture for the past many years. Most of the farmers also earned extra income from honey and other bee products besides using them for pollination purposes. But only a few farmers were aware about with different pests, predators and diseases of honeybees and their remedial measures. Regarding the institutional support, only some of the farmers got financial assistance from Government agencies like Department of Horticulture and most of them did not know resources from where to get the financial support. Most of the farmers wanted to have financial support for different horticultural practices and training purposes. They preferred to be trained in orchard management technology and beekeeping practices. There were different types of constraints faced by beekeepers regarding the beekeeping practices which included non-availability of bee flora throughout the year, heavy snowfall, shortage of labour, habit of absconding of bees and poor knowledge about medicines. So we need more research to find out new methods, plans and policies for conservation and management of insect pollinators not only in Himachal Himalaya, but a global concern.

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