



Decline of Bees, a Major Pollinator – A Review

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Abstract: Bees are the most significant and potent pollinator group of flowers, fruits, vegetables and crops. Recently worldwide decline of bee population is raising serious concern for crop pollination and biodiversity sustainability. According to a report, (from 2018 April-2019 April) the bee population decreased by 40.7% in U.S. and as well as similar trend is noted throughout the globe. There are several factors that are the foundation for bee declining includes habitat loss, climate change, use of insecticide and pesticide, environmental stressor disease. Large areas of concrete, cemented roads, buildings allow very less space for flowers and fewer sufficient places for bees to build their hive which significantly causing habitat loss. Global warming and Extreme heat waves at the coastal area cause decline of this organism. A group of widely used insecticides, Neonicotinoids are absorbed by plants and can be present in pollen and nectar, making them toxic to bees by killing them. It is also observed that Neonicotinoids could have adverse effect on navigation, immunity and reproductive physiology of bee community. The contrary, after exposure of several environmental stressors young bees start foraging before the usual age which can cause physical alterations to the brain that may reduce their ability to remembering things that needed for proper foraging. Perhaps an invasive mite *Varroa* (a pest of honeybees) sometimes triggers colony collapse disorder (disappearance of majority of worker bees in a colony). ARNA virus Israeli causes acute paralysis to the members of bee colony and a gut parasite *Nosema* is also associated with loss of colony members. Therefore, to control the declining trend of bee population, native and bee friendly flowering plants should be planted into the farm land, reduction of the usage of pesticides and insecticides should be practiced. Moreover, motivation of the farmers for organic food (that is grown without the use of pesticides, fungicides, herbicides.) and improvement of management approaches in urban green spaces and highly urbanized area should be prioritized. On the other hand, EPA (Environmental Protection Agency) tries to develop a policy of pesticides use and also directs the farmers to use a pesticide that is less toxic to pollinator. Thus, protection of pollinator health by preserving wild habitat of bee will restore ecological agriculture.

Keywords: *Pollinator, Bee, pesticide, habitat loss, cognition, environmental stress.*

I INTRODUCTION

A pollinator is an animal that moves pollen from the male anther of a flower to the female stigma of same or another flower. Approximately 35% of the food and fibre crops depend upon pollinator for reproduction (Kelin et al. 2007). There are variety of animals serve as pollinator like Butterflies, Bees, Moths, wasps and other insects, vertebrate mammals like

bats, monkeys, rodent, squirrels, Birds like hummingbirds, sunbirds, honeycreepers. Hymenopteran are the most important groups of pollinating insects.

Pollinators participate in the sexual reproduction of many plants by ensuring cross-pollination, essential for some species and a major factor in ensuring genetic diversity for others. Bee is a major pollinator because most of their life spent collecting pollen, a source of protein that they feed to their developing offspring. The bees not only attracted to flowers by their colours pattern and scent but also the hair all over the bees' body attracts pollen grains through electrostatic force. (Zakon, H. 2016) (Sutton, G.P., Clarke, D., Morley, E.L. and Robert, D. 2016) (Clarke, D., Whitney, H., Sutton, G. and Robert, D. 2013, Callier, V. 2016). For carrying pollen majority of bees possess a specific apparatus scopa which comprises a very dense mass of elongated branched hairs (Setae). Honey bees and bumble bees possess a pollen basket instead of scopa which is an alteration of the hind limbs.

Although there is no evidence that pollinator decline exists, a number of possible reasons for the theoretical concept have been proposed, such as exposure to pathogens, parasites, and pesticides; habitat destruction; climate change; market forces; intra- and interspecific competition with native and invasive species; and genetic alterations.



Figure-1: European Honey Bee (Apis mellifera) extracts nectar from an Aster flower using its proboscis. Tiny hairs covering the bee's body maintain a slight electrostatic charge, causing pollen from the flower's anthers to stick to the bee, allowing for pollination when it move on to another flower. (Zakon, H. 2016)

II IMPORTANCE OF BEE IN ECOLOGY

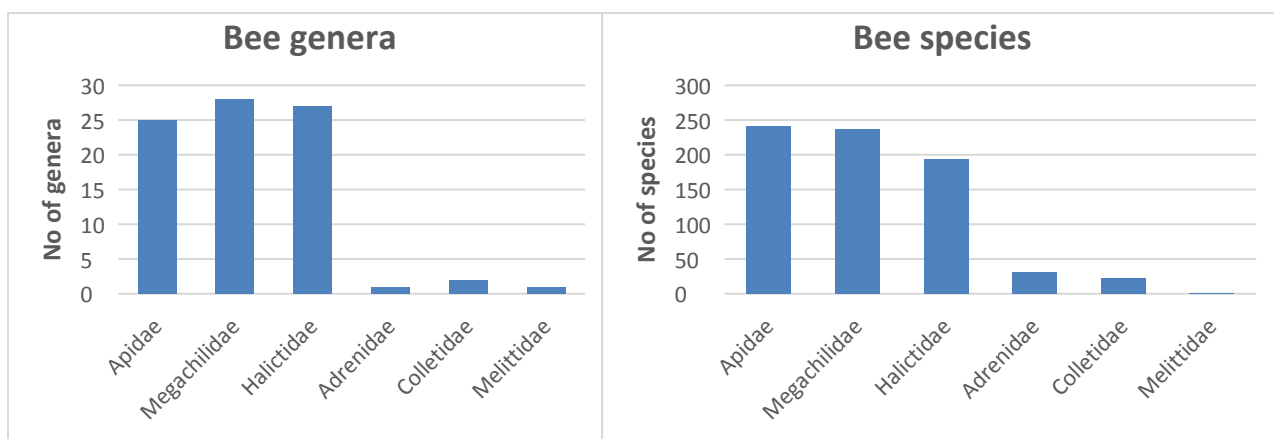
Bees are essential for maintaining the integrity, productivity, sustainability of many types of ecosystems including natural areas, pasture fields, meadows, roadsides, many agricultural crops, fruits, orchards, backyard vegetables and flower gardens (Kevan et al. 2007) without bees many flowering plants would eventually extinct. Many fruits and seed eating birds and some mammals including people would have a less varied and less healthy diet. It is estimated by **Food and Agriculture Organisations (FAO)** of the U.N that more than 100 crop which provide 90% of the food supplies for 146 countries, 71 are bee pollinated (mainly wild bee). For many crops, wild bees are better pollinators than honeybees. (Garibaldi et al.2013; Woodcock et al. 2013).

Crops pollinated by bees in India

Bees are the main pollinator for successful pollination in India. A list of crops pollinated by bees are fruits and nuts like Almond, apple, Apricots, peach, strawberry, lichi and vegetables seed crops like cabbage, cauliflower, carrots, onion, oil seed crops like mustard, sunflower, safflower, forage seed crops like Lucerne, clover.

Taxonomic diversity of bee

Worldwide there are around 25,000 different types of bee species (Michener, 2007) and this huge no is divided into over 40000 genera of bees, which further subdivided in to nine families (Aguiar et.al,2013) where the most well-known family is Apidae family. Honey bee, carpenter bee, Bumble bee are the member of this Apidae family .out of nine bee families 6 families are present in India. Andrenidae, Colletidae, Melittidae are very rare bee families in Indian population. However, most of the people are unaware about non Apis bees and their important role in crop pollination.



Series 1 .Number of genera and species in six families of bees in India (Source: Ascher and Pickering, 2010; Gupta, 2010; Saini and Rathor, 2012)

Decline of bees

Bees are the most significant and potent pollinator group of flowers, fruits, vegetables and crops. Recently worldwide decline of bee population (Potts, S.G. et al. 2010) (Rundlöf, M. et al. 2015) (Ollerton, J. et al. 2014) (Woodcock, B.A. et al. 2016) is raising serious concern for crop pollination (Holden, C. 2006) and biodiversity sustainability.

According to a report, (from 2018 April-2019 April) the bee population decreased by 40.7% in U.S. and as well as similar trend is noted throughout the globe. According to are port (Gallietal.,2009) more than 40 % of honey bees have been disappeared during last 25 years in India. In addition, the International Union for Conservation of Nature (IUCN) lists 16 species of bees as vulnerable, 18 as endangered and 9 as critically endangered globally.

Causes of this decline of bees

There are several factors that are the foundation for bee declining includes habitat loss (Cane et al., 2006), climate change (Hegland et al., 2009), use of insecticide and pesticide, (Kevan, 1999), environmental stressor disease.

Habitat loss and habitat fragmentation

Changes in our land use, including insensitive urban development (Kearns and Oliveras, 2009) and intensive farming (Bjorklund et al., 1999; Kerman et al., 2002) have caused significant loss of bee friendly habitat, resulting in the loss of diverse food source they needed. Large areas of concrete, cemented roads, building sallow very less space for flowers,

grasslands and fewer sufficient places for bees to build their hive which significantly causing habitat loss. Habitat fragmentation is the cause of bee decline. It disrupts the bee from finding mates, building hives and reduces the gene flow in bee population.



Figure-2: Habitat fragmentation in Indiana Dunes National Lakeshore. (Source: Kearns and Oliveras, 2009) Fragmentation of park land by urban areas, such as this highway, can create islands of natural ecosystems and can disrupt the natural movement of plants and animals.

Climate change

Climate change poses increasing threats to bees. Global warming and extreme heat waves in the coastal area causes decline of this organisms. According to a report European bee species *Bombus distinguendus* and *Bombus sylvarum* were declined (Williams, P.H., Araujo, M.B. and Rasmont, P. 2007).

Not only extreme heat weather but also events such as storms, floods, drought are predicted to increase as these have major impact on local bee community. Example – Flooding is likely to harm for many bee species that nest underground. An extremely dry climate can reduce pollen production and pollen diet is very important for rearing the future workers (Conte, Y.L. and Navajas, M. 2008). A pollen shortage induced by drought can weakening the immune system and making them more susceptible to pathogens.



Figure-3: Lavender-honey harvesting is unpredictable. Drought often curbs the production of nectar by lavender flowers (Reference: Climate change: impact of honey bee populations and disease Y. le conte and M. Navajas. 2008)

Neonicotinoids

It is a systematic agricultural insecticide resembling to nicotine. Neonicotinoids are absorbed by plants and can be present in pollen and nectar making them toxic to bees and strongly associated with bee decline (Dr. Goulson et al.2013). It can affect their nervous system (M. Tomizawa, J. E. Casida, 2005). It is also observed that neonicotinoids could have adverse effects on navigation, immunity, feeding behaviour and reproductive physiology of bee community. According to a study Clothianidin, Imidacloprid, Thiamethoxam, Dinotefuran are highly toxic to honey bees, bumblebees and Clothianidin, Imidacloprid are toxic for solitary bees.

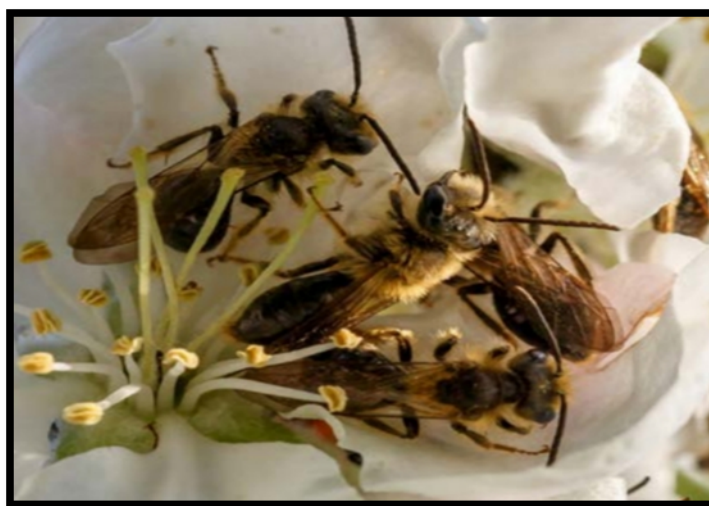


Figure-4: A sleeping cluster of male sweat bees on apple blossom. Neonicotinoids can be applied to apple trees in backyards at rates between 12 and 120 times greater than allowed in commercial orchards. (Photo: TomPotterfield /Flickr.com.)

Environmental stress

Individual bees can be exposed to the environmental stressors (Goulson, D. et al. 2015) at different ages. If bees cannot bear the stress both the hive bee and forager bee populations will decrease. Decreasing the forager bee population triggers young bees start foraging before the usual age which can cause physical alterations to the brain that may reduce their ability to remembering things (Arien, Y. et al. 2015) that needed for proper foraging leading to disorientation and less efficient food gathering. This ultimately leads to Colony collapse.

Diseases

Numerous pests, parasites, pathogens (protozoa, bacteria, viruses) prey upon honeybees and sometimes triggers colony collapse disorder (disappearance of majority of worker bees in a colony).



Figure-5: Colony collapse disorder, death of worker bees. (Reference: *pollinator decline-an ecological calamity in the making? By Christopher J.Rhodes*)

Varroa mite

Varroamite (pest of the honey bees) attaches the body of the bee and weakens the bee by sucking fatbodies. It weakens the bee's immune system and encourages viral growth. It is linked with the death of around 27% of the hives during the winter (Guzmán-Novoa, E., Eccles, L., Calvete, Yi., et al. 2010). A RNA virus Israeli Acute Paralysis Virus can cause acute paralysis to the members of Varroa mite infested colony. Varroa mite is the vector of *this virus*.



Figure-6: *Varroa destructor* mite on a honey bee host. (Guzmán-Novoa, E., Eccles, L., Calvete, Yi. Et al., 2010)

Gut parasite Nosema

Gut parasite *Nosema* infection impairs midgut integrity and alters the energy demands in honeybees. The infection also significantly suppress the bee immune response and modify pheromone production in worker and queen honey bees leading to precious foraging. *N.Apis* has well known to the bee community but *N.Cranea* is recently widespread in western honeybee colonies which can kill bees faster than *N.Apis*. *Nosema cranea* is associated with sharply honey bee declining in Spain (Higes M., Martin R. & Meana A. 2006).

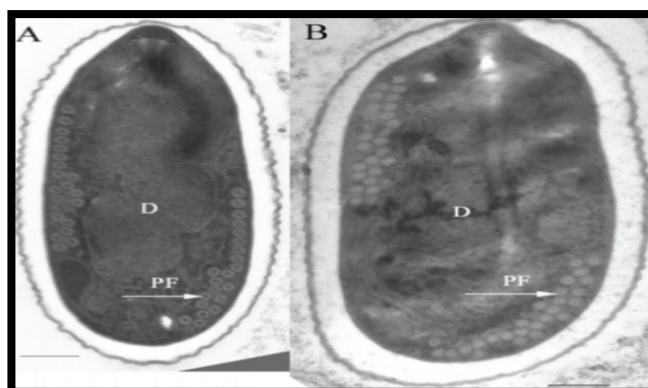


Figure-7: Transmission electron micrographs of spores of (A) Nosema ceranae and (B) Nosema apis. D: diplokarya; PF with arrows: coils of the polar filament. The scale bar is 0.5 μm. (Photos: Ingemar Fries). (Reference: Does infection by Nosema cranea cause “Colony Collapse Disorder” in honey bees (Apis mellifera), Robert Paxton.)

Bacteria

The bacteria which are pathogenic to honeybees attack the brood. American foulbrood is caused by Bacillus larvae occur across the globe. (Jean-Prost P. & Le Conte Y. 2005) European foulbrood is caused by Melissicoccus pluton.

III EFFECTS OF BEE DECLINE

Declining of bee population pose a threat to global agriculture as it is the most important pollinator for agricultural crop (Nabhan and Buchman, 1997). One of every three bites of food eaten worldwide depends on pollinator specially bees. Without bee's seed eating birds, some mammals including people would have a less varied and less healthy diet and food prices will also be increased. Bees are essential for maintaining the integrity, productivity, and sustainability of many types of ecosystems including natural areas, pasture field, meadows, agricultural crops, fruits, backyard vegetable and flower garden. Decline of wild bees highly effects on wild plant system (Nabhan and Buchman, 1997). Also, cannot get non consumable products of bees like wax, candles, cosmetics and pharmaceutical products.

Steps to control bee decline

To control bee decline we have to take some major steps. Flower rich field among or near farm land can increase bee species (L. A. Garibaldi et al., 2014). We should plant native and bee friendly plants mainly flower plants in our garden which also contribute to pollinator conservation (D. Goulson, 2010). We should reduce the usage of pesticides in our lawn and farmland. Motivation of the farmers for organic food (that is grown without the use of pesticides, fungicides, herbicides) and improvement approaches in urban green spaces and highly urbanised area should be prioritized. Deliberate introductions of non-native bee species, parasites and pathogens should of course be prevented.

Steps of EPA

Environmental Protection Agency (EPA) has been working aggressively to protect bees and other pollinators from pesticide exposure. They work on creating a pesticide that is less toxic to pollinator. They created a policy to keep bees away from dust applicants and pesticides.

Steps of European Commission

In 2018, the European Commission banned the outdoor use of three pesticides -Clothianidin, Imidacloprid, Thiamethoxam outdoor crops (Butler, D. 2018) as they are highly toxic to bees.

IV CONCLUSION

Bees are the most significant and potent pollinator group of flowers, fruits, vegetables and crops. Recently bees are suffering from the consequences of chronic exposure to a range of stressors (Goulson, D., Nicholls, E., Botías, C. and Rotheray, E.L. 2015) and they are declining worldwide so to prevent the bee decline we have to take some major steps. Thus, protection of pollinator health by preserving wild habitat of bee will restore ecological agriculture.

Through conservation and socio-economic development of local communities are complementary and equally important tasks, stress has been laid on achieving conservation through legal enforcement. If the development interests of local people are marginalized for a long period of time, they might adopt actions detrimental to the goal of conservation.

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