

Robobees

Way to future or avoiding nature

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Pollination is the basic pillar of our food production, and in this respect, different hymenopteran bees play a crucial role. However, with technological advancements, our world is moving towards a situation that is inviting an enforced 'bee decline' or more broadly 'pollinator crisis'. There are many reasons responsible for this phenomenon, like heavy use of chemicals, habitat loss, infestation of parasites and diseases, urbanization, etc. To tackle this situation, roboticists from different corners of the world are coming with a solution, i.e., robobees in place of natural bees. These robobees are micro robots imitating the buzz pollination of bees. However, robotic crop pollination is technologically and economically a non-viable solution to naturally occurring bee pollination. There are arguments regarding its efficiency as compared to natural bees, its ecological and economical constraints, its impact on biodiversity as well as on ecosystem services, etc. In simple words, these robobees are not the answer to 'bee decline'.

Keywords: Bee decline, Bee pollination, Robobees

IN the last few decades due to rapid growth in global population, we have crossed the milestone of 8 billion people. This massive growth in population raises concerns regarding our food security and prices of food commodities. As per the report of the World Food Program (WFP), every night approximately 828 million people sleep with an empty stomach. In 2050, the world population may reach 9.7 billion and to meet that global requirement we may need 70% more food. In this respect, pollination is a service that can ensure our food security and bees perform the most important role in this aspect by providing highly valued pollination services to majority of our food crops. Bees are also an important contributor to the ecosystem and maintain the diversity of several wild flora by pollinating them. However, with technological advancements our world is moving towards a situation that is inviting an enforced 'pollinator crisis'. As the threat is much higher on bees

that's why 'bee decline' is becoming a serious concern that ultimately returning as a boomerang to us in the form of 'food crisis' due to lack of pollination.

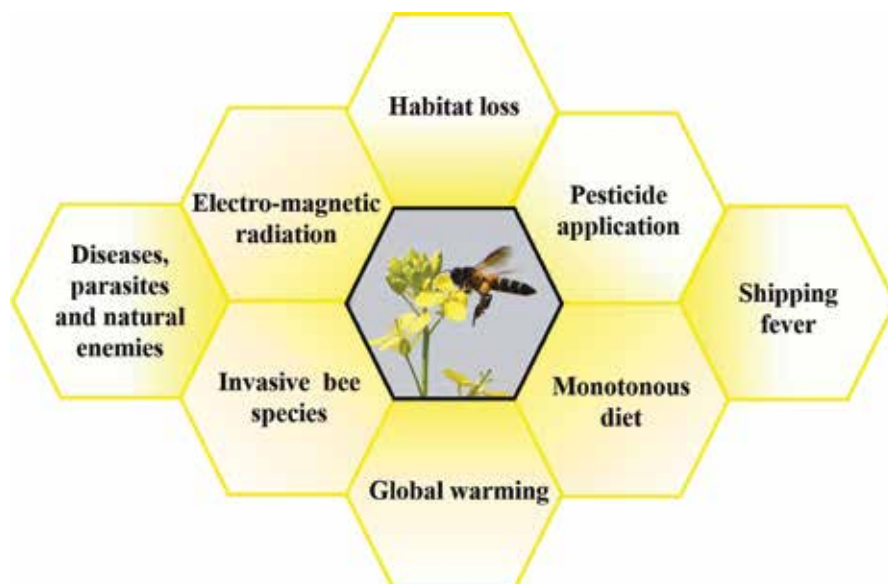
Bee decline: An invited threat

Bee decline is the reduction in the diversity and abundance of bees in the natural ecosystem. There is not a single factor responsible for bee decline, rather a nexus of various factors are responsible for this phenomenon. Among those

stressors, heavy use of chemical pesticides (particularly insecticides and herbicides) and loss of natural and semi-natural habitats are the most important factors. Different other stressors like infestation of parasites and diseases, incidence of different insect pests and natural enemies of bees, monotonous feeding, adoption of mono-cropping practice, urbanization and intensive animal husbandry, occurrence of unfavourable weather conditions, electro-magnetic radiation from



Different insect pollinators pollinating various flora



Factors responsible for bee decline

mentioned some evidence of bee decline occurring in different parts of the world.

Robobees

To address the situation of declining trend in bee diversity and abundance, roboticists from various laboratories around different corners of the world is coming up with ideas to supplement the pollinator activities with autonomous vehicles like ground based mobile vehicles, large aerial drones and micro-unmanned-aerial-vehicles which is also termed as 'robobees'. In our current article we are focusing on the practical implementation of this robobees.



A model of robobee
(Source: wyss.harvard.edu/technology/robobees-autonomous-flying-microrobots)

Robobees are micro robots, having a dimension of a few centimeters and weight up to 10 grams. These bees are designed to transfer pollen between flowers and also simulate the buzzing of bees. These robobees use real time triangulation technology to determine which area of the field needs to be pollinated. A team of researchers from Harvard University developed robobee with the purpose of bringing together the fields of biomimetic science and miniature robotics to solve the increasing pollinator crisis. During March 2018, Walmart first patented autonomous robot bees. The developers of robobees are claiming that it will be able to assure crop pollination in near future. However, different organizations, environmental activists and researchers are not in support of robobees in place of natural bee pollinators. Though presently this

mobile towers, shipping fever, invasion of different exotic bee species and ultimately the global climate change also responsible for huge loss in bee diversity. Among these stressors, the manmade ones are most prominent, indicating that we humans are inviters of this

threat.

Presently bee decline is a phenomenon that is occurring in every corner of the world. The threat on bees is getting higher and higher resulting in different bee species becoming extinct from the face of the Earth. In Table 1 we have

Table 1. Cases of occurrence of bee decline in different corners of the world

Location	Records of bee decline
Europe	Approximately 37–65% of bee species under serious conservation concern
Central Europe	About 25% loss in bee colonies from 1985 to 2005
North America	About 59% decline in bee colonies from 1947 to 2005
	From late 1990s onwards severe decline in <i>Bombus terricola</i> and <i>Bombus occidentalis</i> population
USA	About 39% loss of managed honey bee colonies from 2021 to 2022
Northern California	Extinction of <i>Bombus franklini</i> as it has not been recorded since 2006
Illinois	Substantial declines in bumblebee species diversity from 1940–1960 and extirpation of four species during 20 th century
Chili	Invasion of <i>Bombus terrestris</i> causing decline in native <i>Bombus dahlbomii</i>
India	Disappearance of about 40% of honey bees



Scenario of bee decline in UBKV campus (Left: mass of dead *Apis mellifera* honey bees lying in the field; Right: *Apis dorsata* comb with less population density of worker bees)

robobees are not that much capable of providing crop pollination service in a global scale. But if this technology is developed sufficiently in near future then still there will be a question, "Is it really required?" as the economical, ecological and social constraints did not allow to go for this route. Here we are going to discuss our view regarding why this robobees could not be an efficient solution of future crop pollination and bee decline.

Why are robobees not an efficient solution?

The belief is that these robobees will solve the increasing concerns regarding pollinator crisis and crop pollination. However, both economically and ecologically the robobees cannot match the efficiency of natural pollinators. There are several reasons for not considering robobees as a solution of the pollinator crisis and they are described hereunder.

Not efficient like natural pollinators: In the world there are more than 350,000 species of flowering plants having uniqueness in their interaction with different animal pollinators in terms of pollination. For pollination in some flowers very specific foraging behaviour, morphological and physiological traits of the pollinators are required. So, the question is 'Could robobees pollinate all of

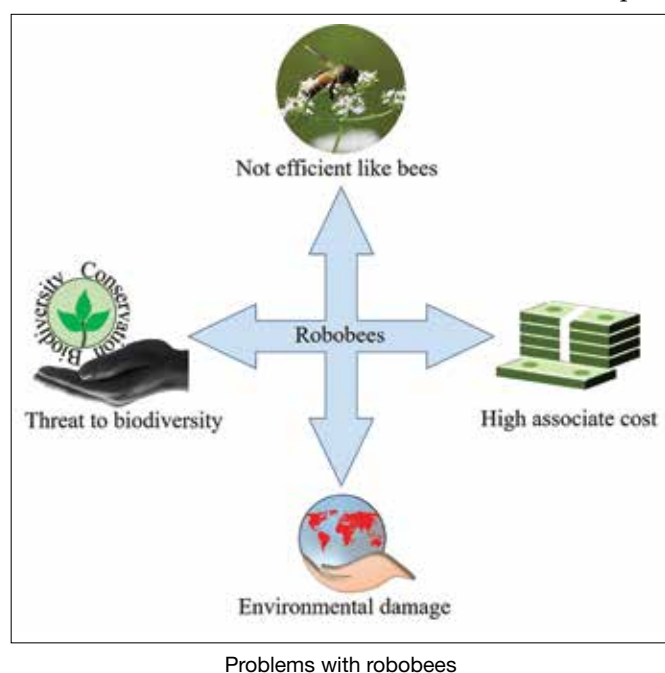
those?' Another thing is, to pollinate that huge number of flowering plants, a larger number of pollinators are present in nature. According to Prof. Jeff Ollerton, every year at least 22 trillion pollinators visit coffee plantations to pollinate the coffee flowers and sustain the global coffee production. That is only for one crop. Now imagine how many pollinators are required to perform the entire pollination service. Now take a look at the bee pollinators. As per a report in 2016, there were over 4.5×10^8 of managed honey bee hives worldwide and considering an average size of 35,000 individuals per colony, the total number can be of nearly 16 trillion managed honey bees. This is the number of only managed honey bees, whereas there are also a huge number of unmanaged honeybee hives along with 20,000+ native bee species. So, could the robobees be able to take the position of that much pollinators and what will be the capacity of robobee manufacturers. That's why it makes no sense how robobees could match the natural pollinators in terms of efficiency.

Not an economical solution: Pollination service provided by the natural pollinators is completely free of cost. Addressing the decline in natural bees with robobees will never be a solution as it demands for a high cost. Manufacturing of robobees require metals, electronic

condition like hail, storm and snowfall will destroy the robobees and will cause huge economical loss. As most of the farmers in developing countries are small and marginal, so the entire cost can't be conveyed by a farmer and even by a group of farmers. Instead of bearing such costs it will be much easier and cost effective to protect the natural pollinators by protecting their habitats and by reducing the use of chemicals.

High environmental costs: The environmental costs associated with robobees are also very high. There would be a huge requirement of energy, carbon and water that need to be exploited from the environment. In addition to that, mining of lithium and other rare metals from the earth will also increase environmental and social concerns. Ultimately it is a machine that after the end of its working life or when it get damaged or broken will cause e-waste problems. That will be hazardous to the environment and recycling of these e-wastes will also be difficult and expensive. After destruction, leaching out battery content will pollute the water sources, ground and air. There is also the possibility of entering these e-wastes into food chain. These robobees may also serve as a source of electro-magnetic radiation that can cause environmental damage. Even if the robobees will release in greenhouse condition to avoid the environmental loss, then crops grown in the field and wild floras will be neglected. These things make the robobees an environmentally nonviable solution.

Eroding the values of ecosystem: In natural ecosystems, a number of pollinators exist. But introduction of robobees in the ecosystem will act as species invasion for the existing pollinators. The interference of these robobees with the foraging activity of natural pollinators will cause local/regional extinctions of native pollinators, disrupt species interaction networks and also ecosystem functions and services. Flowers once pollinated by robobees may halt pollen and



parts, plastics, lithium batteries, composites which are of high cost. Not only that, there will also be costs regarding maintenance, repair, command and control infrastructure. Even controlling them may require expert persons. On the other hand, sudden occurrence of any extreme unfavourable climatic

nectar production and signal the pollinators not to visit further. That will deprive the natural pollinators from food. Further relying on a single pollinator has high risk for crop pollination and it is also against the rules of the ecosystem.

Threat to biodiversity: These robobees may also come up as a threat to biodiversity. Based on human interest, it will only use to pollinate the commercial crops. Then different wild flora that rely on the natural pollinators for pollination will become extinct without pollination. Not only that there are several species for which these pollinating insects are an important component of their food chain. Without these insects their diversity will also come under a threatening situation. On the other hand, as they mimic bees, then if they are consumed by birds, amphibians or reptiles then it will be hazardous to their health. In this case robobee cannot be a supplement of its biological counterparts.

Against human interest: Different natural pollinators also have social, cultural and aesthetic values to human society that cannot be fulfilled by robobees. Even it is not sure but also possible that robobees may cause hazard to crop-duster, aircraft engine, even to human pilot resulting in catastrophic failure.

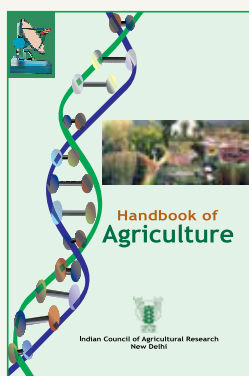
SUMMARY

Now the question is, “Do we really need those things? when we already have nature’s beautiful creation i.e., bees”. Considering the above mentioned reasons robobees are found to be a highly expensive solution when compared to its biological counterparts and far from being able to replace bees to pollinate crops. Biological bees are reliable, resilient, biodegradable, self-constructed, self-organising, self-renewing, self-maintaining, autonomous pollinators. Not only that, honey bees produce honey that is consumed by humans and other animals and also a source

of earning for many groups of people in the society. Even different other organisms also depend on them to maintain their diversity. The thing we only need to do is to protect them. We need technology but we can’t allow technology to replace nature. No matter how much progress we can make in the technology sector, we still need to take care of each and every gift of Mother Nature to protect ourselves. Considering this, organic farming is coming as an excellent alternative to conventional farming. Now, it is need of the society not to think only for food production, rather we need to find the best routes of creating eco-friendly strategies to promote our food production in connection with societal benefits. From the above perspective it is fair to say, ‘Protecting bees means protecting human community from extinction’.

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