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Colony Collapse Disorder, Neonicotinoids, CO_2, Climate Change, and the Four Spheres

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Abstract

This analysis focuses on what effects the decline of both domestic and wild bee populations has on the environment. It will analyze the 21st century-coined phenomenon known as "Colony Collapse Disorder," and will investigate research methods that have improved numbers within bee populations over the last two decades. Within this study, the impacts and interactions between the Colony Collapse Disorder phenomenon and various environmental factors will be discussed, as well as the interactions between the four main spheres of the Earth (*i.e.*, the biosphere, lithosphere, atmosphere, and hydrosphere). In so doing, this study will evidence how and why bee populations are declining, why that decline affects each Earth sphere, as well as how this condition could create both loophole and contagion effects. Finally, this analysis will also briefly touch upon NASA's increasing involvement with replenishing the world's bee populations, the agency's monitoring of CO_2 levels, various ecosystems, and other such relevant and ongoing research.

Keywords

Bees, Extinction, Pollination, Pesticides, Climate Change, Agriculture, Colony Collapse Disorder

1. Introduction

The world's bee populations are in serious decline, and their demise, due to a multitude of factors, has had contagion effects throughout the world. Scientists and researchers have long been aware of decreasing bee populations. Just in North America alone, bees are almost 50% less common than they were nearly 50 years ago, with several species having succumbed to complete extinction [1]. Being the most vital of pollinators, bee losses have been blamed on everything

from changes in global temperatures to multiple man-made causes. One thing is known, however, the decreases within the world's bee populations will inevitably lead to dire consequences and circumstances for humans. Since bees are some of the most prolific pollen spreaders, they become crucial to the survival of various floras, as well as the very agricultural crops humans survive upon. It goes without saying that bees not only play a critical role in our food production systems, but also in the very survival of humanity and every living thing on this planet [1] [2] [3].

2. Climate Change and Decreasing Populations

Recent findings show that dwindling bee populations are due to climate change and that locations on the planet that have risen or had anomalous temperatures have experienced the greatest losses. Moreover, if a species is forced to exist in extreme or even subtle temperature changes, they will either move elsewhere or die. Bees, for example, adapt better to living in cooler climates rather than warmer [2]. They, in particular, are designed to regulate and generate heat while in flight, and this is usually why they are the very first species noticeably out in the early spring months [3].

2.1. Temperature and the Earth Spheres

Studies have implied that bees have limitations within their ability to adapt to changing temperatures. Bees, as a species, can easily overheat, and their death from overheating has loophole effects on wild flora and agriculture, leaving the bees starving [4]. According to the National Oceanic and Atmospheric Administration, which has been tracking global heat, the past 5 years have been the planet's warmest in over a century [5]. With a bee lifespan being only about a year, and with colony queens spending the winter months in decomposing ground leafage, they become more vulnerable to temperature changes, especially unusually out-of-season colder temperatures [6].

Bee extinctions are detrimental for every sphere of the planet, since their pollination of vital flora is necessary for flowering plant populations to reproduce. All pollinators are needed for the production and support of healthy ecosystems within the lithosphere, since they allow and contribute to clean air, soil stability, plus stabilize vial food sources. Since these plants are needed by all other living organisms within the biosphere, bee extinctions lead to devastating ecological effects and cause biodiversity losses as well as severe implications for the economy. It has been estimated that bees contribute to over 15 billion dollars just to the US economy alone through affecting agricultural output, and that over 100 million US crops are reliant on bees, with an added revenue to crop production from pollinators estimated at $18 billion as of 2021 [7].

2.2. Neonicotinoids

Harmful pesticides, in addition to just climate change, have been also to blame

for the bees' demise. Neonicotinoids, which are powerfully toxic pesticides, have proven extremely harmful to insects. More potent than most other pesticides previously used, neonicotinoids have been known to kill off large populations of bees within extremely short time periods [8]. Other human factors contributing to bee population decreases can be attributed to habitat loss through land development projects, as well as the conversion of forests and other natural land locations into agricultural areas. Other, and perhaps lesser-known, culprits are the spread of dangerous pathogens, as well as the purposeful release of non-indigenous bee populations for commercial pollination for better crop and plant production desired by humans [9].

3. Stressors and the Human Element

Scientists know that while many bee populations are able to live with one of these stress factors, they cannot survive when combinations of them exist together. In order to eliminate the multiple issues, researchers argue that tackling only one of the problems is the wrong approach and it ignores the multiple causes of bee decline, as well as the problems created when they occur in conjunction. Instead, conservationists say there are small things humans can do to help. For one, people can plant more flowers that are indigenous to the areas where they live, flora that local bees can feed upon. Secondly, inhabitants can stop using neonicotinoids as pesticides and find natural and/or alternative methods for keeping pests away from gardens, crops, and lawns. Moreover, humans can begin making flower gardens that are in bloom longer during the year, or even year-round, if possible, and they can also delay removing fallen, old, and drying leaves from yards, or at least wait until the spring has arrived, since bees need them for denning purposes [10].

3.1. Colony Collapse Disorder

The phenomenon known as "Colony Collapse Disorder" has been studied since the early 2000s. Colony Collapse Disorder occurs when a majority of worker bees within a bee colony die off, leaving behind the queen, a large supply of food, and only a few nurse bees to take care of the young. Research has found that this decline was attributed to pests, disease, pesticides, toxins, pollutants, nutritional deficits, habitat loss, climate change, agricultural production increases, reduced species, genetic diversity, and changing crop management systems and practices. To fix the situation, researchers and environmentalists are focusing predominately on pollinator health. Within the last few years, the United States has an estimated 2.8 million beehives with no reported incidences of Colony Collapse Disorder. In order to continue this upward trend though, continued research promoting and focusing on bee health is needed [11] [12].

3.2. NASA

NASA's largest research projects pertaining to bee research have been conducted

from their large network of satellites that observe the hydrosphere, lithosphere, and atmosphere, and collect various forms of relevant data about how each of these spheres interacts with each other. From obtaining images to collecting the metrics unseen on Earth's surface, researchers can now detect and better predict thermal radiation, precipitation, infrared, and other non-visible light sources, and how these might affect bee populations in certain areas of the globe. Within the biosphere, for example, scientists are looking at plant biodiversity, and from analyzing the bees' produce, researchers are able to better understand a colony's surrounding environment and its floral diversity, hence helping to better preserve and stabilize the insects' living habitats. Scientists are also able to analyze the presence of invasive species in certain locations by just looking at the components of an area's agricultural produce, and in turn, this enables researchers to become better informed about any restoration efforts following natural disasters, climate anomalies, or other environmental changes.

NASA's ongoing efforts are also exploring weather and meteorological changes pertaining to their effects on bee populations throughout the world. Scientists now know that as the Earth's climate changes, so does the bee population. By using NASA's Geographic Information Systems to map and research the areas where bees tend to live longer and thrive, they can better identify the environmental factors that contribute to better bee survival in various conditions. In certain locations, however, NASA researchers have discovered that bees have been susceptible to various forms of disease, and the COVID-19 situation has been no exception.

One important discovery that researchers are still grappling with is the complexity of the relationship between bee populations and their established habitats, making it necessary for scientists and conservationists to use NASA's various satellite images and data to piece together a better idea of what is happening within bee enclaves causing their demise. For example, NASA's "Develop" Project, which is aimed at providing end-users with a possibility to visualize some of the many factors associated with bee health from space, has provided scientists with the hypothesis that the bees' habitats are largely to blame, and that nutrition plays a key role in beehive productivity and longevity. Likewise, through NASA's Honey DNA research, scientists are measuring bee nutrition, and from this, they are now better informed about the forestation that surrounds hives. From measuring plant environments, scientists can then measure an ecosystem, even utilizing advanced genomic research back in the labs to better look into plant DNA. From understanding where bees forage, scientists also learn which surrounding plants provide bees with the best nutrition and can even work to replant crucial vegetation within specific locations, thus helping keep the bees alive [12] [13].

4. The Four Spheres

Although the biosphere might be the most arguably affected by bee extinction,

the corresponding lithosphere would also experience massive vegetation die-off from bee extinctions, although, arguably, new vegetation that is not reliant on bee pollination would certainly grow in its place if that were to happen. With the plant die-off from the lithosphere, however, the atmosphere would certainly be affected by the lack of oxygen, which would directly cause a completely different composition and make-up of carbon dioxide in the atmosphere, too. The hydrosphere, no doubt, would also be directly affected since when the bees and land plants die off, there would be new ocean life evolving and developing due to the lack of oxygen while existing aquatic life that is more reliant on oxygen would inevitably become extinct or evolve into more adaptive forms.

Concerning drought conditions, bees need water to cool their hives as well as dilute the food resources they give to their young. When water resources diminish through droughts caused by climate change, bee colonies die. On the converse of that though, NASA scientists discovered that drought conditions and bee populations have actually produced some positive effects. For example, studies confirmed that drought conditions heavily-reduced mite populations by decreasing the parasites' reproductive rates. The bee's worst foe, the parasitic varroa mite, which has killed off large populations of bees over the last two decades, likewise diminished during times of drought, so unusually dry conditions can actually have a positive effect on bee populations in this regard [13] [14].

From their studies, NASA scientists have also found that many bees are actually finicky feeding specialists and will only use one species or genus of a plant to feed on. At first glance, scientists thought this made bee survival even more delicate. However, whenever drought conditions occurred, affecting a certain or specific plant species, researchers soon discovered that many bees were heartier and had actually developed a form of survival mechanism, or diapauses, where they were able to suspend their development through delicate environmental cues. In other words, the bees instinctively knew or were signaled that their food resources were affected by drought conditions, and the diapause mechanism existent within their bodies aided in their survival [14] [15].

5. Summary

More needs to be done to promote government programs advancing the survival and health of bee populations. However, there are small steps each individual can take to aid in the preservation of bee populations. Ceasing the use of toxic pesticides would be one. Downsizing lawns that encroach on valuable, natural flora and take up plant space would be another. Planting more natural meadows and wildflowers, which improves the bees' habitat, would also prove helpful. In short, if bees disappear from the planet, so will plants, and inevitably, humans and animals. Understanding how plants, climate, weather, humans, and animals interact with each other is the first crucial step in solving this issue, and through NASA's ongoing programs to provide help for the world's ailing bee populations, hopefully, this situation can one day be resolved.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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