The health, life and activities of honey bee *Apis mellifera* have influenced human societies for centuries. Managed honey bee colonies, known as Apiaries, are a major component of world agriculture as they provide pollination to diverse crops besides being an important ‘cash crop’ of their own through honey, wax, and other hive products. Honey bees and other pollinating insects also shape natural ecosystems by facilitating gene flow for the angiosperms, the most successful and diverse plant taxon.

Historical records indicate that over the years, existing bee colonies in apiaries succumb to a variety of factors including starvation, queen loss, and an array of pathogens/parasites. However, few events disrupt the apiaries more than the sudden collapse of mature colonies across a wide area, even more so when this collapse takes place in the absence of known pathologies or environmental triggers.

This sudden disappearance or silence of the bees’ activity by mass deaths of the world’s primary pollinator is known as colony collapse disorder (CCD). This began a few years ago in the U.S.A. and is now prevalent in Europe and Asia too. CCD is distinct from other bee-loss events in being a relatively sudden disappearance of the majority of adult worker bees (taking place over days or weeks) from an otherwise healthy hive with a queen and brood.

A colony that has collapsed from CCD is generally characterized by all or many conditions occurring simultaneously. Primary symptoms that are observed before the final collapse are insufficient workforce to maintain the present brood, work force made up of adult bees and refusal of existing colony members to consume artificially provided feed, such as sugar syrup and protein supplements.

The final collapse is marked by three characteristic symptoms such as presence of capped brood in abandoned colonies as normally bees do not abandon a hive until the capped brood have all hatched, presence of stored food (both honey and bee pollen) and presence of the queen bee. Usually, if the queen is not present, the hive dies because it is queen-less which is not the case in case of CCD.

While such disappearances have occurred throughout the history of apiculture, the term colony collapse disorder was first applied to a drastic rise in the number of disappearances of western honey bee colonies in North America in late 2006. Colony collapse is a significant loss not just for honey lovers.
but also for the global agricultural market as worldwide many agricultural crops such as apples, soybeans, mango, cocoa and almonds rely on bee pollination. With human population increasing fast, observers worry that bee decline will deepen a global crisis unfolding from limited crops and soaring food prices.

Since the initial description of CCD in 2006, annual colony losses in the United States have exceeded 30%. Over the last five years, approximately one quarter of beekeepers reported CCD symptoms in more than 60% of their annual colony losses. Since CCD continues to be associated with colony loss, attempts to identify the cause or combination of causes that result in CCD have not been successful.

CCD is patchy in appearance, occurs in different time periods and neither corresponds to any pathology in brood/workers nor a tight correlation with levels of parasitic insects. Queens often survive the event, albeit surrounded by a small cluster of worker bees. Although initial efforts focused on identifying a single pathogen, a consensus has recently emerged that multiple pathogens including exposure to novel pathogenic microbes in concert with anthropogenic chemicals, poor nutrition, and increasing environmental stressors are likely to be the driving factors. After initial successes of identifying unusual viral profiles in some CCD colonies, a consensus emerged that CCD is complex and probably cannot be ascribed to any one agent. Instead, bee colonies appear to be resilient to most individual onslaughts of microbes/pathogens/parasites/environmental stressors, but are vulnerable to the cumulative effects of microbes and other stress factors.

Researchers have identified some probable causes of colony collapse disorder (CCD), including blood-feeding parasites, bee viruses, fungi, pesticide exposure and decreased plant diversity causing poor nutrition for honeybees. It seems to be a complex interaction of several different factors that are causing bees to die, resulting in quick colony decline.

The threat to bees seems to be international. England lost more than half its hives in the last two decades, and baffling bee losses are occurring in Asia, South America and the Middle East. A single solution to end this problem is still out of reach. But recent discoveries are shedding light on possible answers to the puzzle.

Some scientists blame commercial agricultural pesticides such as clothianidin, which has been linked to millions of bee deaths near farming areas in different countries. Clothianidin is commonly used in USA on crops such as corn, wheat and soy. A recent discovery found that small levels of a widely used class of pesticide called neonicotinoids fed to the bees over their lifespan, causing poor nutrition for honeybees.

Currently, scientists and beekeepers are especially tuned to bee health, in part due to development of new tools and in part because of an unsolved decline in bees with enigmatic syndrome of colony-collapse disorder.

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Featured Article

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all collapsed colonies in USA. The viral-fungal duo is speculated to destroy bees’ memory or navigation functions and contribute to colony collapse.

Another bee threat is parasites such as the varroa destructor, which clings to a bee as it feeds on hemolymph, or bee’s “blood,” and spreads dangerous viruses. Major infestations of varroa typically wipe out beehives.

Honey bees carry nearly twenty RNA viruses identified as chronic bee virus. Recently, iridovirus was identified to be ubiquitous associated with CCD. Bee viruses affect the morphology, physiology, and behaviour of bees and have been widely associated with weak and dying colonies. Similarly, two bacterial strains Paenibacillus larvae and Melissococcus plutonius are the infective agents of bacterial diseases of honey bee larvae. These are among the primary honey bee threats leading to colony losses and expensive treatment and quarantine regimes. Adult honey bees are parasitized by species bacteria that breach the gut barrier and invade the hemolymph, causing a systemic infection that can ultimately lead to fatal disease in the bee.

Dwindling of bee colonies is also linked with dysentery symptoms in adult bees and the tendency of infected bees to ‘disappear inexplicably’ from the hive. These bees are found to be infected by amoeba that enters by ingestion. The infecting amoeba invade the unique niche of digestive system of bees by feeding upon the epithelial lining of the digestive lumen, degrade the tissue and inhibit metabolic waste excretion followed by ‘amoebiasis disease’ that ultimately weakens and kills bees. As the amoebae reproduce inside the bees, they pack the lumen and bees die by stopping feeding.

Many times environmental and anthropogenic factors also pre-dispose the bees to diseases. One of the most stressful times for honey bee colonies is when foraging opportunities are absent due to unavailability/lack of crops. Honey bee colonies buffer themselves against this stress by storing nectar and pollen when food is available. However, protein levels and physiological health of individual bees decrease due to low protein availability leading to decreased immune-compotence and greater susceptibility to viruses.

Exposures to anthropogenic pesticides and fungicides used on crops and bee parasites have non-target consequences on bees. Bees collect a diverse set of such chemicals leading to long-term effects on immune function that accrues from combined effects with microbial infections. To minimize chemical management of bee pests, breeders are working toward resistant bee lines (predominately Varroa-resistant) by allowing their apiaries to go untreated during disease outbreaks. Colonies that survive are selectively adapted for resistance to the parasite and would reduce dependence on chemical therapeutics. Another scenario involves use of honey bee hybrids that are known for their resilience against varroa mites.

It has also been suggested that it may be due to a combination of many factors and that no single factor is the cause of CCD. The USA department of agriculture (USDA) report states that analysis of collected bee samples (CCD- and non-CCD affected) revealed high number of viruses and other pathogens, pesticides, and parasites present in CCD colonies, and lower levels in non-CCD colonies. This suggests that a combination of environmental stressors may set off a cascade of events and contribute to a colony where weakened worker bees are more susceptible to pests and pathogens.

Thus, in the changing climatic and environmental scenario honey bees face a diverse pathosphere. However, their ability to resist these threats depends upon commensals, nutritional status, accumulation of quantity of toxic compounds, and genetically based resistance and tolerance mechanisms. Although honey bee pathology has been a...
field of study since ancient Greece, many questions remain regarding the impacts of microbes upon bee health.

Discovery of new tools has helped study infection and disease in honey bees and has provided a new appreciation of bee defences against diseases. Genome sequences are now available for the primary honey bee pathogens and sophisticated new tools for quantifying these threats are changing the models used to explore honey bee host–pathogen relationships. Tools, including stable cell cultures, heterologous infection systems, and improved microscopy enable more precise experiments involving honey bee disease, and mitigate the drawbacks of working with an organism for which genetic lineages are difficult to generate and maintain.

Currently, scientists and beekeepers are especially tuned to bee health, in part due to development of new tools and in part because of an unsolved decline in bees with enigmatic syndrome of colony-collapse disorder. Although a clear understanding of what causes CCD has yet to emerge, these efforts have led to new microbial discoveries and avenues to improve our understanding of bees and the challenges they face.

Although CCD affects commercial apiculture severely, similar loss is encountered in agricultural communities. For example, birds do it, fleas do it but when bees do it, it costs billions to the world economy. That’s why scientists are seeking a way to get rid of this problem soon. Detailed studies of honey bee–pathogen dynamics will help efforts to keep this important pollinator healthy and will give general insights into both beneficial and harmful microbes confronting insect colonies.

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Dying population of worker honey bees due to Colony Collapse Disorder (above)
Unhatched (capped) brood in CCD (left)

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