Honey bee colony loss in the US linked to mites, extreme weather, pesticides

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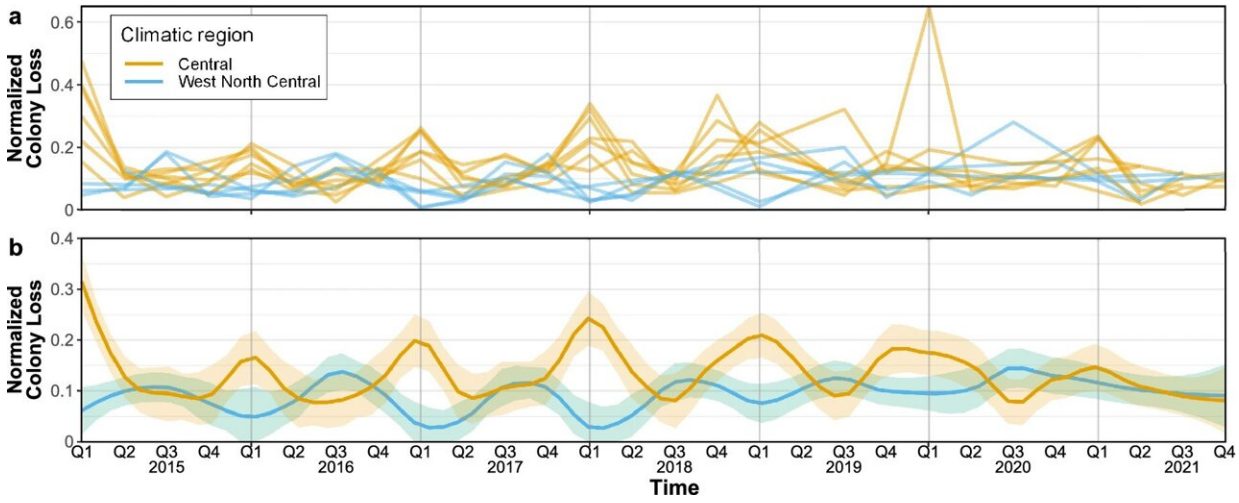

Comparison of normalized honey bee (Apis mellifera) colony loss (number of lost colonies over the maximum number of colonies) between Central and West North Central climatic regions for each quarter of 2015–2021 (the first quarter being January-March). (a) Trajectory of each state belonging to Central (yellow) and West North Central (blue) climatic regions. (b) Smoothed conditional means for each of the two sets of curves based on a locally weighted running line smoother where the width of the sliding window is equal to 0.2 and corresponding standard error bands are based on a 0.95 confidence level. Credit: *Scientific Reports* (2023). DOI: 10.1038/s41598-023-28374-w

About one-third of the food eaten by Americans comes from crops pollinated by honey bees, yet the insect is dying off at alarming rates. In

one year alone, between April of 2019 and April of 2020, one study reported a 43% colony loss in honey bees across the United States.

A new study led by Penn State researchers provides preliminary insight on the potential effects of several variables, including some linked to climate change, on honey bees. Their findings show that honey bee colony loss in the U.S. over the last five years is primarily related to the presence of parasitic mites, extreme weather events, nearby pesticides, as well as challenges with overwintering, according to a new study led by Penn State researchers.

The study took advantage of novel statistical methods and is the first to concurrently consider a variety of potential honey bee stressors at a national scale. The study, published online in the journal *Scientific Reports,* suggests several areas of concern to prioritize in beekeeping practices.

"Honey bees are vital pollinators for more than 100 species of crops in the United States, and the widespread loss of honey bee colonies is increasingly concerning," said Luca Insolia, first author of the study, a visiting graduate student in the Department of Statistics at Penn State at the time of the research, and currently a postdoctoral researcher at the University of Geneva in Switzerland.

"Some previous studies have explored several potential stressors related to colony loss in a detailed way but are limited to narrow, regional areas. The one study that we know of at the national level in the United States explored only a single potential stressor. For this study, we integrated many large datasets at different spatial and temporal resolutions and used new, sophisticated statistical methods to assess several potential stressors associated with colony collapse across the U.S."

The research team, composed of statisticians, geographers, and

entomologists, gathered publicly available data about honey bee colonies, land use, weather, and other potential stressors from the years 2015 to 2021. Because these data came from a variety of sources, they varied in resolution over both space and time. The weather data, for example, contained daily data points for areas only few square miles in size, but data on honey bee colonies was at the state level for a several-month period.

"In order to analyze the data all together, we had to come up with a technique to match the resolution of the various data sources," said Martina Calovi, corresponding author of the study, a postdoctoral researcher in the Department of Ecosystem Science and Management at Penn State at the time of the research, and currently an associate professor of geography at the Norwegian University of Science and Technology.

"We could have just taken an average of all the weather measurements we had within a state, but that boils all the information we have into one number and loses a lot of information, especially about any extreme values. In addition to averaging weather data, we used an 'upscaling' technique to summarize the data in several different ways, which allowed us to retain more information, including about the frequency of extreme temperature and precipitation events."

The researchers used the resulting integrated resolution-matched dataset—which they have made available for use by other researchers—alongside sophisticated statistical modeling techniques that they developed to assess the large number of potential stressors at the same time.

The research team found that several stressors impacted honey bee colony loss at the national level, including the presence of nearby pesticides, frequent extreme weather events, and weather instability.

Colony loss was also related to the presence of parasitic mites, Varroa destructor, which reproduce in honey bee colonies, weaken the bees, and potentially expose them to viruses.

The researchers also found that losses typically occurred between January and March, likely related to challenges with overwintering, but that some states do not follow this pattern.

"Our results largely reinforce what regional studies have observed and confirm that regional patterns around these stressors are actually more widespread," said Insolia, a beekeeper himself.

"These results also inform actions that beekeepers could take to help circumvent these stressors and protect their colonies, including treatments for the Varroa mite' especially in areas of weather instability. Beekeepers could also consider strategies to move their colonies to areas with high food availability or away from nearby pesticides or to provide supplementary food during certain seasons or months with frequent extreme weather events."

The researchers note that having data about beekeeping practices and colony loss at a finer resolution would allow validation of their results and a more nuanced look at honey bee stressors.

"It would be incredibly beneficial to explore beekeeping practices at a finer scale than the state level," said Calovi.

"In many cases, beekeeping associations and other organizations collect this data, but it is not made available to researchers. We hope our study will help motivate more detailed data collection as well as efforts to share that data—including from smaller organizations such as regional beekeeper associations."

The research team also found a strong relationship between colony loss and a broad category of beekeeping practices noted on a USDA survey as "other," which contained everything from hives being destroyed to food scarcity to queen failure. They noted that collecting this data in more detail and breaking up this catch-all type variable would improve their ability to connect particular stressors to colony collapse.

"A changing climate and high-profile extreme weather events like Hurricane Ian—which threatened about 15% of the nation's bees that were in its path as well as their food sources—are important reminders that we urgently need to better understand the stressors that are driving honey bee colony collapse and to develop strategies to mitigate them," said Francesca Chiaromonte, professor of statistics and the holder of the Lloyd and Dorothy Foehr Huck Chair in Statistics for the Life Sciences at Penn State and a senior member of the research team.

"Our results highlight the role of parasitic mites, pesticide exposure, extreme weather events, and overwintering in bee colony collapse. We hope that they will help inform improved beekeeping practices and direct future data collection efforts that allow us to understand the problem at finer and finer resolutions."

More information: Luca Insolia et al, Author Correction: Honey bee colony loss linked to parasites, pesticides and extreme weather across the United States, *Scientific Reports* (2023). DOI: 10.1038/s41598-023-28374-w

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