Bee by Bee

By Jonathan David Farley

PASADENA, Calif.

IN the closing months of 2006, thousands of American bee hives were found to be almost entirely devoid of bees, victims of a mysterious phenomenon now known as colony collapse disorder. A study of 150,000 managed bee colonies in 15 states, commissioned by the Apiary Inspectors of America, found that from September 2006 to March 2007, roughly one-third of the colonies were lost.

Bee keepers have suffered similar unexplained losses in the past, and not all of the hives in the survey were lost to whatever is causing colony collapse. But people are understandably worried that the disorder may threaten all three million managed bee colonies in the United States, a $14.6 billion commercial pollination business. So it is urgent that scientists figure out what is causing the colonies to disappear and how many more colonies stand to vanish.

Better math will help solve the mystery of colony collapse.

Many scientists have suggested that some kind of virus or bacterium — or some combination of infectious agents, possibly carried by parasites like mites — is killing the bees. One way to find out if the culprit really is a contagion (as opposed to an environmental threat like pesticides or some other unknown factor), and to gauge its potential strength, is to look closer at the information we have by using a mathematical model, similar to those used to assess human epidemics.

For example, there is a model that was used in 2003 to figure out whether severe acute respiratory syndrome could be brought under control. Marc Lipsitch, an epidemiologist at Harvard's School of Public Health, used a statistical method to determine the "reproductive ratio," the expected number of people the average sick person would infect. If this number is larger than one, the illness will spread.

Professor Lipsitch found that each person with SARS would infect, on average, three other people. So in order to force the reproductive ratio below one, at least two-thirds of these infections needed to be blocked — mainly by isolating people who had been in contact with SARS victims.

A similar model can perhaps be used to study colony collapse disorder. Using the data from the inspectors' survey, we can assume that one-third of 150,000 colonies die off over the course of six months. Supposing that during the same time the number of infected but not yet collapsed colonies declines (as it would if the most destructive phase of the problem is behind us), then using standard equations that govern epidemics we can conclude that we must have started with at least 10,000 infected (but not yet collapsed) colonies.

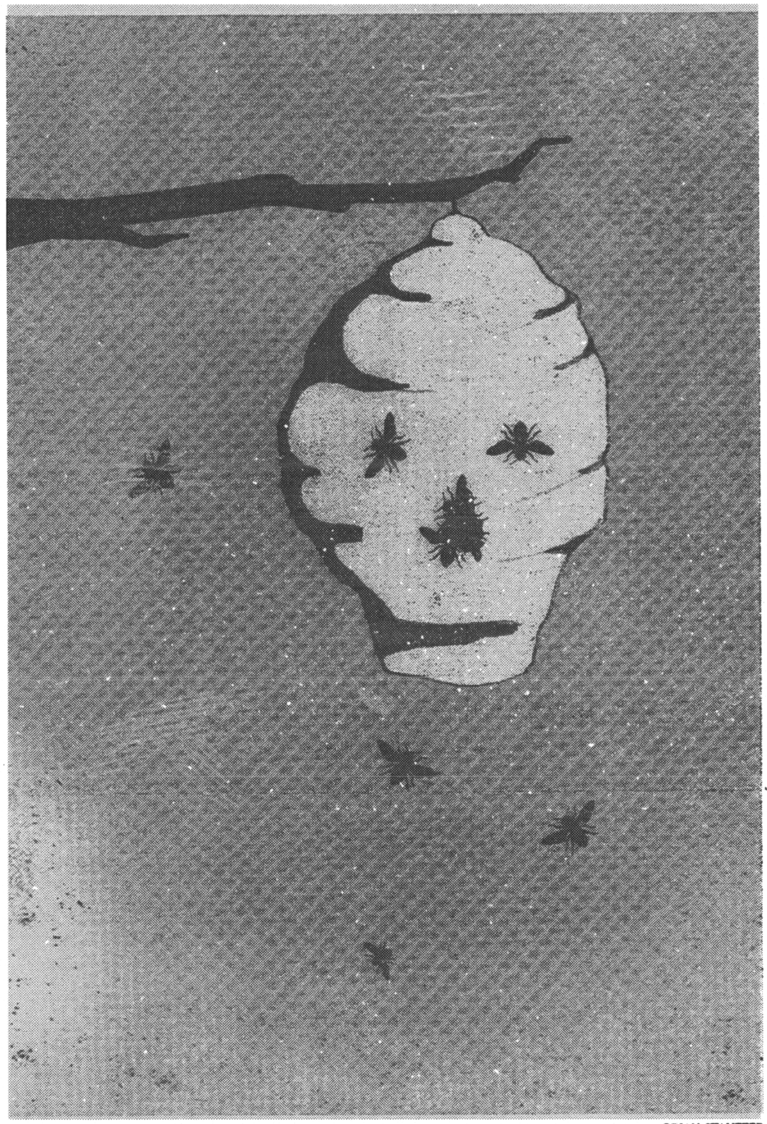
If we knew the true number of healthy colonies at the beginning of the six months, as well as the probabilities that an exposed colony will become sick and that a sick colony will die in a given amount of time, we could also calculate the number expected to die in the future. Since we don't know those quantities, we must do the calculation for every possible set of values.

What we find is that of the original 150,000 colonies, the number of those that will eventually succumb to colony collapse is never higher than 110,000. So if colony collapse is in fact caused by some sort of contagion, a significant proportion of colonies will survive the outbreak. If it turns out that far more colonies are lost, it will be evidence that something is wrong with our model: perhaps it is too crude, perhaps we need better data, or perhaps a contagion is not responsible for colony collapse disorder after all.

Our mathematical model could make more accurate predictions if it could take into account interactions between different colonies. More detailed information about the location and movements of individual colonies would enable us to use more sophisticated modeling to get a clearer picture of how colony collapse takes its toll. We might be able to work out the rate of transmission, the probability that an infected colony will die, when the outbreak actually began and when it might end.

The more accurate our predictions, the more clearly we will be able to see the task ahead. Scientists may be able to zero in on the possible contagious cause of colony collapse. Bee experts could then assess quarantine strategies.

Our first priority should be to gather more accurate information about the bees' disappearance. The war against colony collapse is about numbers. □



BRIAN STAUFFER

Jonathan David Farley is a professor of mathematics at the California Institute of Technology.