California as a Sample Site: How Localized Honeybees Can Help Make Predictions of Nationwide Populations

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Through many years of intense labor, California has become one of the more productive agricultural areas in the world. The more prominent agricultural exports from the state include almonds, strawberries and decorative flowers, which represented a total value of $6.8 billion in 2011 (Tolomeo, 2012). While these crops grow successfully on their own, the quantity and quality of their yield is dramatically improved with the addition of pollinators (Yang, 2006). While there are a number of feasible pollinators, one of the more popular is *Apis mellifera*, the western honeybee.

Why do certain crops need pollinators? Pollination is the process plants use to reproduce. A plant is pollinated when pollen from one plant is placed on the carpel of another. Some plants can self-pollinate, while others use wind and gravity to move their pollen around (Green, 2012). When pollination depends on wind, gravity or self-pollination methods, pollen grains are usually restricted to a relatively small area to which they can travel. By introducing pollinating insects, pollen grains can travel over much larger distances and pollinate plants farther away. This process of mixing helps promote genetic diversity in plants – a trait that is extremely desirable. Increasing the genetic diversity in a population of plants increases the size of fruit and leads to higher levels of resistance to diseases (Booy et al, 2000).

Honeybees and other pollinating insects contribute to pollination by flying in to flowers in search for nectar – a sweet liquid produced by plants for the sole purpose of attracting pollinators. When honeybees land on the flower of a plant to gather nectar, they brush up against strategically placed reproductive organs like stamens. Stamens are tiny branch-like structures with pollen grains on the tips. Once the bee has gathered its fix of nectar, it flies to another flower to gather more. On this next flower, the bee rubs up against more reproductive organs, this time transferring pollen to the stigma, where it eventually fertilizes an egg and creates a seed for a new plant (Green, 2012).

Trouble with Honeybees

While honeybees are considered beneficial and their presence is welcomed, there are other organisms that are not greeted with such open arms. Many of the insects that visit a plant are predatory or herbivorous in nature, and cause more harm than good to the plant. Some plants have evolved their own self-defense mechanisms, while others are left exposed to threats. For this reason growers use synthetic pesticides, many of which are designed to be generalized killers. The number of different species that can pose a threat to a plant at any given time is astronomical, so growers can have a hard time identifying exactly which pest is causing their ailments. A simple way to guarantee the elimination of all insect pests is to attack a feature that all insects possess – the central nervous system (Vijverberg, van der Zalm, & van den Bercken, 1982). By using pesticides specifically designed to attack and over-stimulate the nervous system, growers can ensure that their insect pests are being controlled. While this system seems like a great solution, problems may arise when pollination season comes around. Pollinators (including honeybees) may come in contact with pesticides or their residues, which can lead to death. While there are application timing systems in existence to help prevent the death of vital pollinators, these systems may not be used by small-level growers, or may be used incorrectly (*UC IPM* pest management guidelines: Almond, 2012).

For many years, honeybee colonies have been decreasing in size and richness. There are a large number of factors that may contribute to honeybee deaths, including cell phone radiation, disease, global warming, and accidental pesticide exposure. While it is true that pesticides definitely do play a role, they cannot take full blame for the deaths of millions of bees across the country. Finding a correlation between honeybee deaths and use of pesticides can help to serve as a starting point in saving the pollination and honey industry in the United States.

Using California as a Model for Nationwide Population

On a nationwide level, the number of honeybee colonies used in honey production was 2.6 million for 2012 (United States Department of Agriculture, 2013). Huge proportions of these colonies are migratory, and are transferred all around the country as the seasons vary. Tracking exposure of these bees to different threats as they spend their time in various locations can be mind numbing. Rather than examine the entire population, California's honeybees can be used as a sample to make inferences about the entire nation's population of bees. Why use California's honeybee populations? As of March 2013, California is home to the second largest number of honey-producing honeybee colonies, second only to North Dakota (United States Department of Agriculture, 2013). Because of this large share of the nation's honeybees, it can be predicted that California's populations will accurately represent those of the entire nation. Another reason California is ideal for investigating pesticide usage effects is the high level of regulation and legislation around pesticide use in the state. Any correlations or information gathered by analyzing trends in California can be extrapolated to the national level since federal regulations affect all states, and California places more stringent levels of regulation on pesticide use than other states. Because California's lawmakers have strong environmental interests, online databases have been created that can generate detailed reports on specific applications of pesticides. Using California's detailed records, correlations can be determined within the state, and then extrapolated to the country as a whole.

Methods: How Should It Be Done?

Because the research project at hand has multiple parts and dimensions, it will require large amounts of numerical data from several different sources. To begin, data will need to be gathered on population sizes of honeybee colonies that are native to California. These will then be compared to data on population sizes of honeybee colonies nationwide. If California's population and the nationwide population follow a similar trend, then it can be determined that California can be used as a sample for analysis, and the results will accurately reflect nationwide trends.

Numerical data on population sizes can be gathered from *Honey*, a publication by the National Agricultural Statistics Service. *Honey* is published annually at the beginning of the calendar year, from 1976 to present day. All publications are archived and available online. Within these publications is data on number of honey-producing colonies, yield per colony, and production in pounds. The data is broken down by state and offered as a nationwide statistic. For purposes of the study, only the number of honey-producing colonies will be needed. Data would be analyzed on a graph, with year along the x-axis and number of colonies along the y-axis. California colonies and national totals would be plotted as separate lines on the same graph, and similarities between the lines would be examined to determine whether or not the two datasets fit each other. Statistical analysis using Analysis of Variance (ANOVA) could similarly be used to search for a relationship between the two sets of data, by comparing a trait such as annual percent change in size.

Once is has been determined that California's honeybees are representative of nationwide populations, statistical analysis can begin between colony numbers and usage of specific pesticides. Using databases created by the California Department of Pesticide Regulation, numerical data can easily be gathered about the usage of the most popular pesticides in modern agriculture. Because each chemical has differing properties and levels of application, it can be predicted that some pesticides will show higher levels of relationship than others. Once each pesticide's use within the state has been individually analyzed for a relationship with California's bees, a relationship can be inferred on a nationwide level. Where exactly is all this pesticide data coming from? Thanks to the large level of legislation in California pertaining to pesticide use, data on each pesticide group can be readily gathered from CALPIP, a database service hosted by the California Department of Pesticide Regulation. CALPIP (California Pesticide Information Portal) contains data from the years 1990-2011, and can be sorted into agricultural or non-agricultural applications. The portal also allows for filtration by location of application and what crop the pesticide was applied to. Data will be screened to provide datasets for only agricultural applications of the specified pesticide on high-value crops, throughout the entire state. Once the data has been gathered, pesticides can be compared to find which one fits best with population trends, and therefore has the largest effect on California's honeybee population. Once a relationship is established between pesticides and California's honeybees, inferences can be made about the effects of pesticide use on a nationwide scale.

Beyond statistical likeliness between California and the United States, individual state legislatures regarding the use and/or regulation of pesticides should be examined. While it is being generally assumed that California pesticide regulation is stricter than other states, thorough examination of individual state laws needs to be performed. Furthermore, federal laws should be examined, to determine an absolute baseline level of restriction that can be imposed on those states that do not implement their own individual laws.

How Sampling Is Useful

The evidence of statistical likeness between California and the whole nation can also open new shortcuts to fast examination of colony health. Patterns of honey quality can be compared with patterns of survival rates to determine whether honey is a bio-indicator of bee health. If a correlation is found using California's immense datasets, then studies can be carried out quickly in other parts of the country under the same general assumption that honey quality indicates overall colony quality. A simple examination of honey quality from an individual colony could be used as a starting point for inferring the health status of the aforementioned colony.

Concluding Thoughts

Why so much concern over honeybees? Even though it may seem like a menial and pointless question, it is one that affects almost every citizen in the United States. Around 250,000 flowering plants rely on bees for their pollination, and many crops see their yields increased by the presence of honeybee pollination (Benjamin, 2008). Although modern genetic science and GMO corporations are working on creating species of plants that do not require pollinators, a collapse of honeybee populations in the near future would spell disaster for human food supplies, as well as many animals that feed on fruits and nuts in the wild. Monitoring patterns and correlations between pesticide usage and honeybee populations in California could help to lay ground rules for new legislation and guidelines on pesticide usage nationwide, and slow the downfall of honeybee populations all over the country. By avoiding meltdown of the honeybee community, we could save the food supply, as well as one of the most amazing organisms on earth, *Apis mellifera*.

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