Summer weather predicts overwintering survival in the European honey bee (Apis mellifera) in Pennsylvania

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May 5, 2020

Abstract

The European honey bee (Apis mellifera) is both a crucial pollinator for agricultural and natural ecosystems, and an agricultural commodity in its own right. However, honey bees are experiencing heavy mortality in North America and Europe due to a complex suite of factors. Weather affects both the bees themselves and the plants that support them. Surrounding land use, particularly proportion of agricultural and urban areas, determines forage resource abundance and pesticide exposure risk. Finally, management decisions, including treatment to control parasitic Varroa destructor mites, contribute to colony success and failure. We used three years of data from a survey of Pennsylvania beekeepers to assess the importance of weather, topography, land use, and management factors on overwintering mortality of managed honey bee colonies at both apiary and colony levels. A Random Forest model for mite-treated apiaries predicted overwintering survival with 73.3% accuracy for colonies and 65.7% for apiaries, as determined by cross-validation. Growing degree days was the most important predictor at both levels. Neither topographic nor management variables were important predictors. A weather-only model was used to predict colony survival probability across Pennsylvania for the three years of the study, and to create a composite map of survival probability for 1981-2019 (long-term probability mean value of 59.5%). Although three years of data were not enough to adequately capture the range of possible climatic conditions, the model nonetheless performed well within its constraints. The Random Forest approach is suited to understanding complex nonlinear drivers of survival, and to predicting outcomes given current conditions or projected climate changes.

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