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Allee effects and colony collapse disorder in honey bees.

We propose a mathematical model to quantify the hypothesis that a major ultimate cause of Colony Collapse Disorder (CCD) in honey bees is the presence of an Allee effect in the growth dynamics of honey bee colonies. In the model, both recruitment of adult bees as well as mortality of adult bees have substantial social components, with recruitment enhanced and mortality reduced by additional adult bee numbers. The result is an Allee effect, a net per-individual rate of hive increase that increases as a function of adult bee numbers. The Allee effect creates a lower critical size in adult bee numbers below which mortality is greater than recruitment, with ensuing loss of viability of the hive. Under ordinary and favorable environmental circumstances, the critical size is low, and hives remain large, sending off viably-sized swarms (naturally or through beekeeping management) when hive numbers approach an upper stable equilibrium size. However, both the critical size and the upper stable size depend on many parameters related to demographic rates their and enhancement by bee sociality. The model suggests that multiple proximal causes, among them pesticides, mites, pathogens, and climate change, working singly or in combinations, could trigger CCD by exacerbating the Allee effect. (Received September 11, 2014)