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On honeybees, varroa destructor and deadly diseases: a mathematical approach

The western honeybee is in trouble. In recent years beekeepers all over Europe and North America reported drastic, unprecedented losses of colonies. Among the many stressors that were proposed, parasitic varroa mites have been identified as one of the main culprits. These mites, in addition to being harmful to the bees themselves, are also the vector for several bee viruses.

We present a simple model of the honeybee-varroa mite-acute bee paralysis virus complex. This is a system of four ordinary differential equations, the coefficients of which change with the seasons, i.e. are periodic functions of time. We study this model with a mix of analytical and numerical techniques. This will be broken down into first studying the model without mites and viruses, then the model with mites only but without viruses, and finally the complete model. We find that the bee colony is never able to fight off mites. As long as the mites are virus free we can find (realistic) conditions under which a mite infested colony can function as a seemingly healthy colony. On the other hand, if viruses are introduced, the colony will eventually vanish. An interesting observation is that although this collapse is rapid, it might occur years after the virus was originally introduced, which is consistent with beekeeper reports. We also are able to find a conditions on the model parameters under which the bee colony is able to fight off the virus. The range of parameters needed for this, however, is not necessarily realistic.