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Mathematical modeling of the spatio-temporal dynamics of aphid-paraistoid-plant-virus interactions

Aphids cause considerable damage to agricultural crops, mainly due to their ability to transmit a variety of plant viruses. Understanding the underlying processes that contribute to plant disease dynamics and how to contain the spread of disease requires a combination of biological and theoretical study. The theoretical undertaking requires not only an analysis of the temporal dynamics of the system, which has been the focus of previous work, but also an analysis of the spatial dynamics. Environmental stochasticity operates both spatially and temporally and is likely to influence aphid population processes. As a result, disease transmission by aphids might be influenced by factors acting in addition to density-dependent processes.

To construct a realistic model of an aphid-natural enemy-plant-virus system, we are developing a spatial individual-based model of the aphid *Macrosiphum euphorbiae* on potato plants. Focus is on the dynamics of the summer asexual aphid populations since aphid outbreaks occur when plant material becomes abundant. Individuals move randomly and/or via chemotaxis on a 2-dimensional domain representing one or more plants. We take into account both parasitoid wasp (e.g. *Aphidius ervi*) and predator (e.g. syrphid larvae, coccinellids) natural enemies. Environmental stochasticity is incorporated into the model by changing variables such as patch quality, temperature and light intensity. Parameter estimates for the model are obtained from experimental quantification of population processes in aphids that harbour particular secondary bacteria or that are free of secondary symbionts. A number of aphid clones have been established in culture and their secondary bacteria status confirmed using diagnostic PCR. The individual-based model is used to assess how secondary endosymbionts affect aphid population dynamics, vector capacity and trophic interactions. Previous work on host-parasitoid models (Preedy et al. 2007; Pearce et al. 2006; Schofield et al. 2005) suggests that a broad-range of dynamics including spatio-temporal heterogeneity and chaos can emerge from these systems and similar results are observed in our model.

References

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