Bifurcation Structures in Low-Dimensional Models of Ant–Coffee Berry Borer Dynamics

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Abstract

Ant communities play a key role in the natural regulation of agricultural pests, acting through collective behavior and non-linear feedback at the ecosystem level. In coffee agroecosystems, interactions between ant populations and the Coffee Berry Borer (CBB) provide a paradigmatic example of biologically mediated pest suppression driven by low-dimensional dynamics rather than large-scale complexity. In this talk, we present a class of minimal dynamical systems that describe ant–CBB interactions, focusing on the qualitative structure of the models. Using piecewise-smooth systems of ordinary differential equations, we analyze equilibrium configurations, stability properties, and bifurcation structures in response to changes in key ecological parameters. Our results reveal multiple dynamical regimes, including pest persistence, effective biological control, and bistability between controlled and outbreak states. Transitions between these regimes are governed by bifurcations that provide a mechanistic explanation for changes in pest pressure observed in managed coffee systems. The analysis highlights how collective ant behavior can induce nonlinear threshold effects leading to robust pest suppression. This work illustrates how low-dimensional dynamical models can capture essential features of complex agroecosystems and provides a theoretical framework for understanding biologically driven control strategies from a mathematical biology perspective [1–5].

References

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