Density Dependence in Vectors Influences Coinfection in Plant Pathogens

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Interactions among pathogen species within a host, resulting in cross protective immunity, synergistic mortality, or alterations of host infectivity or transmission can alter the dynamics of both host and pathogen populations. Whereas most coinfection models assume a constant vector population, many vectors experience density-dependent population regulation. Here we develop and parameterize a model based on a well-studied multi-pathogen, multi-vector system, barley and cereal yellow dwarf viruses (B/CYDV). Our model, a system of nonlinear ordinary differential equations, describes a single host, two pathogen strains, and n vector species with a single parameter describing pathogen relatedness. We examine basic and type reproductive numbers, linear stability, parameter sensitivity, and the relative importance of pathogen similarity and vector population regulation on pathogen prevalence and coinfection. We demonstrate numerically that the basic reproduction number describes the disease-free equilibrium stability, whereas type reproduction numbers better describe coinfection dynamics. A sensitivity analysis for two different vector growth functions indicates that infection equilibria of both formulations are sensitive to disease transmission rates, but vector birth and death rates are important only for the logistic formulation. Cross protection is influential only for the constant vector formulation. Thus, empirical determination of the degree and form of vector density dependence is critical for effective predictions about coinfection in natural host populations.

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