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Determining the Effects of Wind-Aided Midge Movement on the Probability of Coexistence of Multiple Bluetongue Virus Serotypes in Patchy Environments

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Abstract : Bluetongue virus (BTV) has 27 serotypes, with some of them coexisting in patchy (different) environments, which make its control difficult. Wind-aided midge movement is a known mechanism in the spread of BTV. However, its effects on the probability of coexistence of multiple BTV serotypes are not clear. Deterministic and stochastic models for r BTV serotypes in n discrete patches connected by midge and/or cattle movement are formulated and analyzed. For the deterministic model without midge and cattle movement, using the comparison principle, it is shown that if the patch reproduction number R0 < 1, i=1,2,...,n, j=1,2,...,r, all serotypes go extinct. If R^j_i0>1, competitive exclusion takes place. Using numerical simulations, it is shown that when the n patches are connected by midge movement, coexistence takes place. To account for demographic and movement variability, the deterministic model is transformed into a continuous-time Markov chain stochastic model. Utilizing a multitype branching process, it is shown that the midge movement can have a large effect on the probability of coexistence of multiple BTV serotypes. The probability of coexistence can be brought to zero when the control interventions that directly kill the adult midges are applied. These results indicate the significance of wind-aided midge movement and vector control interventions on the coexistence and control of multiple BTV serotypes in patchy environments.

Keywords : bluetongue virus, coexistence, multiple serotypes, midge movement, branching process
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