Modeling Tick-Borne Diseases

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Vector-borne diseases account for more than 18% percent of all infectious diseases. Ticks rank second worldwide to mosquitoes as vectors of human disease, and are responsible for more than 100,000 cases of human illness globally. In this project, two models of tick-borne diseases were developed. Areas endemic with *Borrelia burgdorferi* (agent of Lyme disease) and *Babesia microti* (agent of Human Babesiosis) have seen an increased prevalence of *B. microti.* In co-infection, an immune trade-off might be at play where *B. burgdorferi* promotes transmission of *B. microti* due to opposite immune responses incited to each pathogen. The first model tests how an immune-mediated response to *B. microti* and *B. burgdorferi* co-infection in wild-host *Peromyscus leucopus* affects R_0. R_0 measures the likelihood of pathogen establishment in a host population, where $R_0 \geq 1$ indicates possible disease outbreak. Host immune response was represented by a Th2:Th1 ratio, where the response to *B. burgdorferi* is Th2-dominant (anti-inflammatory) and to *B. microti* is Th1-dominant (pro-inflammatory). This model projected simplified experimental outcomes, uniquely characterizing a within-host process. R_0 was found to increase with increasing Th2:Th1 ratio, indicating that a more Th2-dominant (*B. burgdorferi*) infection yields a higher R_0 value for *B. microti*, or increased chance of disease outbreak. Ticks are sensitive to rising temperatures and decreasing humidity that accompany climate change. The second model tests how temperature change affects uninfected and infected tick densities at each instar for *Ixodes scapularis,* the main tick vector in North America. Tick activity level was found to be sensitive to temperature change and incorporated in the tick density functions based on a previous model. Based on previous data, I predicted that larger temperature increases would lead to lower activity levels and subsequently lower tick densities. Currently the model is simplified because tick activity level is not constant at a temperature change and increased tick activity does not necessarily lead to increased infection rate as tick and host seasonality must also be considered. Thus it is important to incorporate tick phenology in future climate-dependent modeling to more accurately project scenarios of future climate and habitat changes. The long term goal for this project is to use both tick and host focused modeling to lay out the infection dynamics of abundant tick-borne pathogens.