How within-host priority effects between specialist and generalist pathogens affect disease risk

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Abstract:

When an individual host is co-infected by multiple pathogens, pathogen fitness within a host can depend on the order of infection. Previous studies demonstrated that this priority effect at the individual level can scale up to influence population-level disease dynamics. Here, we use epidemiological models to explore how priority effects mediate the interactions between generalist and specialist pathogens. Specifically, we analyze a two-host-two-pathogen SI-type model where (i) the pathogens are environmentally transmitted (e.g., spore-based transmission), (ii) the focal host can be infected by a specialist pathogen and a generalist pathogen, and (iii) an alternative host can only be infected by the generalist pathogen. Our analysis focuses on how changes in the density of the alternative host alters the focal host's risk of infection by the specialist pathogen (measured as the density of infectious propagules), and how those effects are mediated by within-host priority effects. A motivating example is how the establishment of an invasive host affects a native host's risk of being infected by a specialist pathogen when both the native and invasive hosts can be infected by a generalist pathogen.

We found that: (i) In the absence of priority effects, there is a positive (negative) relationship between alternative host density and the focal host's risk of being infected by a specialist pathogen when the specialist pathogen has higher (lower) fitness in co-infected hosts. (ii) In the presence of a priority effect wherein the specialist pathogen has higher fitness when it is the second to infect a focal host, there is a positive relationship between alternative host density and the risk of being infected by the specialist pathogen. (iii) In the presence of a priority effect wherein the specialist has lower fitness when it is the second to infect a focal host, there is a negative relationship between alternative host density and the risk of being infected by a specialist pathogen. (iv) The priority effect, combined with pathogen infectivity, could lead to unimodal relationships between alternative host and the risk of being infected by the specialist pathogen. These findings help provide a better understanding of how priority effect via coinfection affect disease risk in multiple-host-multiple-pathogen systems and highlights the importance of coinfection in disease control.