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Within-host parasite cooperation and the evolution of virulence

Infections by multiple genotypes are common in nature and are known to select for higher levels of virulence in some pathogens. It has been argued that for parasites whose virulence is determined by the production of public goods, such co-infections can select for lower levels of virulence. However, this prediction is rooted in a perspective that neglects epidemiological feedbacks. Here, we analyse the case of parasites producing a public good, for example siderophore-producing bacteria, using a nested model that ties together within-host and epidemiological processes. Making the epidemiology explicit with an SI model reveals that the current prediction that co-infection should select for less virulent strains for public-goods producing parasites is only valid if both parasite transmission and virulence are a linear function of parasite density. If there is a trade-off relationship such that virulence increases more rapidly than transmission, or if virulence also depends on the total amount of public goods produced, then co-infections should select for more virulent strains. This suggests that theoretical or empirical studies that seek to determine optimal virulence within a single host may not be representative of the selection pressures faced by parasites at the population level. At the same time, it underlines the importance of including epidemiological processes when studying the evolution of infectious diseases.