BALANCING SELECTION, REINFECTION AND HOST REPLACEMENT IN A HIERARCHICAL HOST-PARASITE MODEL

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We analyze a model for a population of hosts, each of them infected by a large number of parasites that come in two different types and reproduce randomly (and quickly) within hosts. The model has elements of a 2-level Moran dynamics: whenever a host dies it is replaced by a host that is infected by a single parasite type. The resulting decrease in diversity is counteracted by reinfections between hosts, together with a moderately strong balancing selection that attracts towards an equilibrium frequency of the two parasite types within hosts.

Using a graphical representation for the random genealogy we obtain a limit law for the process of parasite type frequencies within hosts as the number of parasites becomes large, and a mean field limit for the host states if the number of hosts becomes large as well. We identify the deterministic dynamical system that governs the frequencies of host states in this limit, and find a parameter regime for which even a very small mutation rate keeps a large, finite population of parasites for most of the time in a state where both parasite types are present in substantial frequencies.

Our model is motivated by patterns found in DNA data of the human cytomegalovirus, an old herpesvirus that is carried by a substantial fraction of mankind and manages to maintain a high diversity in its coding regions.

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