Red Queen dynamics in multi-host and multi-parasite coevolution

（課程博士・様式 7）（Doctoral qualification by Coursework, Form 7）

学位論文草稿の要旨

Abstract of Draft Doctoral Thesis

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論文要旨：

Abstract：

Antagonistic interactions have been hypothesized to cause winnerless coevolution, called Red Queen dynamics. In host-parasite systems, dominant host types are expected to be eventually replaced by other host types due to the elevated potency of their specific parasites through negative frequency-dependent selection. This leads to changes in the abundance of all hosts and parasites exhibiting cycles of alternating dominance, referred to as the canonical Red Queen dynamics. Host-parasite models with less than three host and parasite types have been demonstrated to exhibit canonical Red Queen cycles, but natural host-parasite interactions typically involve many host and parasite types resulting in an intractable system with many parameters. Here we present numerical simulations of canonical Red Queen dynamics with type-II functional response and with more than ten types of hosts and specialist parasites under the condition of no super-host nor super-parasite. The parameter region where the canonical Red Queen cycles arise contracts as the number of interacting host and parasite types increases. The interplay between inter-host competition and parasite infectivity influences the condition for the canonical Red Queen dynamics. Relatively large host carrying capacity and intermediate rates of parasite mortality result in never-ending cycles of dominant types.

The canonical Red Queen dynamics assume that the abundance of all interacting types of hosts and parasites undergo perpetual cycles of alternating dominance, which means that any type could become frequent at some stage. This prediction cannot explain why many rare types stay rare in natural host-parasite systems. To investigate this, we simulate a high-dimensional mathematical model of host-parasite interaction with type-III functional response involving multi-host and multi-parasite types. In a deterministic and controlled environment, Red Queen dynamics exhibiting cyclic dominance occur between selected two types only, while the rest of the types remain subordinate for long periods of time in phase-locked, synchronized dynamics with low amplitude. We refer to these dynamics as Red

Queen binary oscillations. Moreover, the introduction of stochastic physical-environmental noise can allow the subordinate cyclic host and parasite types to replace dominant cyclic types as new players in the Red Queen dynamics. Our models can for the first time explain the Red Queen dynamics with persistent rare, hardly cycling types in populations of multi-hosts and multi-parasites undergoing coevolution.

The coevolutionary switching between host/parasite types are due to Red Queen cycles or due to abiotic physical-environmental random noise. The factors that influence such evolutionary switching are inter-host competition, carrying capacity, mortality and specificity of parasites, functional response, and degree of physical-environmental variability. Our theory contributes new insights to the fields of biomedical parasitology, epidemiology, evolutionary biology and parasite ecology, especially in investigating antagonistic interaction of multi-type species in marine microbial communities (e.g., bacteriophage predation) and invertebrate-parasite systems (e.g., infection of *Daphnia magna* by *Pasteuria ramosa*).