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SHORT COMMUNICATION

Evolution of situation-dependent mutualism

Shin Fukui^{a*} and Atsushi Yamauchi^{a,b}

^aCenter for Ecological Research, Kyoto University, Hirano, Otsu, Japan; ^bPRESTO, Japan Science and Technology Agency, Honcho, Kawaguchi, Japan

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In nature, we can find an organism plays a mutualistic role on its partner species in a particular situation even though it is parasite in essence. What condition realizes such a flexible symbiotic system? To answer this question, we conducted the simulation using dual-lattice model.

Keywords: evolution; parasitism; mutualism; dual-lattice model

Symbiosis is ubiquitous in natural ecosystems and it plays a fundamental role in all ecosystems. The relationship includes from parasitism to mutualism continuously, and there are some cases that the relation can not determine clearly as parasitism or as mutualism. The secondary endosymbiont of aphid, *Serratia symbiotica*, which has negative effects on host fitness at ordinary time, is one of good example. The endosymbiont can keep its host alive some generations when the host aphid loses its primary endosymbiont *Buchnera*, obligate mutualist, whereas the secondary symbiont usually reduces the offspring number and hinders the growth of host aphid (Koga et al. 2003). Such relation shift holds true with the plant–endophyte symbiosis. Endophytes are well known for increasing plant performance as resistance to herbivory and pathogens. However, they exploit the resource from host plant, so that it decreases host fitness under the condition that there is no harm to host (Faeth and Sullivan 2003).

This study focused on the case that an organism has a positive (mutualistic) effect on its partner species in a particular situation even though it affects negatively (parasite) in essence. We investigated the cost/benefit balance and environmental condition that can establish the situation-dependent mutualism (SDM) using dual-lattice model (Doebeli and Knowlton 1998; Yamamura et al. 2004; Travis et al. 2006, see Figure 1). We assumed host species and its symbiont, and two types of symbiont; one is just parasite and the other is the situation dependent mutualist. Symbionts benefit from being in the presence of its host. Conversely, host is forced to take a cost to interact with its symbiont. We also assume that host species is sensitive to the environmental condition, so that the mortality rate decreases proportional to the environmental severity. However, the damage from the environment can ease off by being in the presence of a mutualistic symbiont

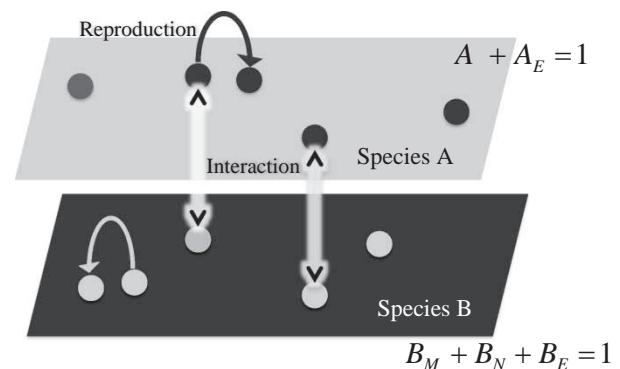


Figure 1. The basic concept of dual-lattice model. Two different species inhibit on each lattice and interact each other at the same position. The offspring can disperse the nearest four sites by its parent site (Von Neumann neighborhood) and establishes when the site is currently unoccupied by that species. Here we use A represent the frequency of host species, and B_M and B_N to represent the frequencies of situation-dependent mutualists and non-mutualists (only parasite) of symbiont species. A_E and B_E are the frequencies of empty sites for host and symbiont on each lattice, respectively.

by taking a cost for it. We investigated the invisibility of mutant SDM against parasite population by simulation. We extend the simulation model described by Yamamura et al. (2004) by introducing the environmental effect, i.e. the stochastic temporal change on each site.

As a result, SDM cannot establish for any parameter values when the environmental condition is fixed because parasite can always invade into SDM population under the condition that SDM can invade into parasite population. However, the temporal variation in a habitat environment, i.e. the environmental severity changes stochastically, allows SDM to evolve. Considering the case that mutualistic

*Corresponding author. Email: fshin3@ecology.kyoto-u.ac.jp

symbiont gives resistance to infectious disease to its host, mutualism can not establish even under the pathogens take hold the host habitat but SDM can emerge from parasitism under a circumstance that the epidemic occurs periodically, for example.

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