Local effect for biodiversity in cyclic competition games

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ABSTRACT
In this talk, we present the role of a local effect in the coexistence of mobile populations whose interactions are governed by a rock-paper-scissors game in spatially extended ecosystems. With different values of relative parameter between migration and local habitat suitability on large sizes, we do some simulations and find that coexistence is broken near the critical mobility $M_c$, but is occurred again for high mobility $M > M_c$. From these results, we found that species react sensitively depending on their environment.

INTRODUCTION
Evolutionary game theory [1,2,17] originated as an application of the mathematical theory of games to biological contexts, arising from the realization that frequency dependent fitness introduces a strategic aspect to evolution. Biodiversity and coexistence are important on a large number of interacting individuals. Many models and experimental results have seen that species can survive and coexist under nonhierarchical cyclic competitions [15]. Cyclic competition species can be described based on the rock-paper-scissors games and lots of researches have been contributed to understand many social and ecological phenomena [5–14]. From the ecological point of view, the influence of the habitat on certain species behaviors has been considered in detailed from various conditions such as water, food, shelter, and so on. The lack of these conditions are deemed to be the reason for species to move. The use of Habitat Suitability(HS) models to assess habitat quality for a spectrum of wildlife species is widespread [3,4].

MODEL AND SIMULATIONS
General rock-paper-scissors game stands for interactions among three species under cyclic competition. In the real ecosystem, species undergoes not only an interspecific competition but also another behaviors, reproduction and migration, depending on their habitat condition. Three interactions, predation, reproduction and migration, occur among nearest neighboring individuals as follows:

$$AB \xrightarrow{\sigma} A \emptyset, \quad BC \xrightarrow{\sigma} B \emptyset, \quad CA \xrightarrow{\sigma} C \emptyset,$$

(1)
where three populations $A$, $B$, and $C$ cyclically dominate each other, $\emptyset$ represents empty sites. Relation (1) represents predation, i.e., one species preys on a less-predominant species in the cycle and leaves the invaded site empty, which occurs at the rate $\sigma$. Relation (2) and (3) define reproduction and migration that occur at the rates $\mu$ and $\epsilon$, respectively.

Species’ different behavior can be influenced by the habitat condition. With considering the inevitable effect of habitat conditions to species behaviors, we introduce the notion of a local effect for mobile individuals in the spatial rock-paper-scissors game model, and investigate how the agent’s response to their local surroundings affects the pattern of species behavior, and further the biodiversity. The three interactions, interspecific competition, reproduction, and migration occur among nearest neighboring individuals. Due to agents responses to their local effects, the aforesaid three types of interactions take place with the rate $\sigma$, $\mu$ and $\epsilon$ depending on a local effect. At each simulation step, a randomly chosen individual interacts with one of its nearest neighbors at random. For the pair of selected nodes, three interactions occur in the same way in [10–12] if the interaction is allowed.

We do Monte-Carlo(MC) simulations for a typical waiting time $T(T \propto N)$ [7,8] on the square lattice with periodic boundary condition.

![Typical snapshots of spatial patterns for different relative parameter $\alpha$ under same initial mobility $M_0 = 3 \times 10^{-5}$(top) and $M_0 = 5.0 \times 10^{-3}$(bottom) from the direct game for $\beta = 2.0$: $\alpha = 0.0$ for (a), $\alpha = 1.0$ for (b), $\alpha = 2.0$ for (c), and $\alpha = 3.0$ for (d), with the lattice size $L = 400 \times 400$ using same initial state.

**CONCLUSIONS**

We observe an influence of local effect into the migration on the emergence of biodiversity in spatially extended systems. In this talk, we find that the local effect promotes the coexistence of mobile populations. Furthermore, we may approach to several real problems using these concepts.
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REFERENCES


