A Novel Self-Regulation Model Consisting of Resource Circulation and Biota Selection (A BIR model).

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Introduction

In most of the biota-involved self-regulatory models so far reported, regulated conditions have been the concentration of resources to the biota (referred to as the dependent regulation). For instances, the concentration of atmospheric carbon dioxide is regulated by the biota who consumes carbon dioxide as its resource. When a phenotype emerges who has an ability of changing an environmental condition, and when the environmental condition is not a resource for the phenotype (referred to as independent regulation), conventional ecology has failed to present a mechanism to select or suppress the phenotype. To discuss the possibility of biota-involved regulation of a condition, which is not a resource (e.g. temperature), it is useful to investigate independent regulation systems. An attempt has been made to find a mechanism to generate the selective or suppressive pressure through an independent regulation mechanism (Biotic Independent Regulation: BIR).

The reason for the theoretical difficulty to select a favorable species, which change a condition toward a favorable way to the biota, is that other species can equally receive the advantage brought by the favorable species. Watson & Lovelock circumvented this difficulty by introducing a local effect to their Daisyworld model. In the model, white/black daisies decreases/increases the temperature of themselves. Geological or biological equivalents of the daisies have never been successfully proposed. According to their writing, geologists and biologists have been dubious about the usefulness and effectiveness of the model, although some of them have admitted the figurative implication of the model.

In this brief paper, we propose a simple abstract model, which select a favorable species (or suppress an unfavorable species) without employing local effects (Akagi, in press).

Model

Two producers (P1 and P2) compete for a resource circulating in open and closed systems. In the open system the resource is introduced at a certain rate, whereas the resource is reproduced via a consumer (C) in the closed system. P1 and P2 respond identically to temperature, but one of the two has acquired the ability to cool down and the other has not. A fluctuation was introduced to bias the growth rate of P1 and P2 in different timings.

The reason that two systems are considered is that any natural systems are geochemically intermediate between the open and closed systems. Phytoplankton generally competes for more than three resources and the population of each species oscillates in natural systems. It looks as if the growth rate against a resource oscillates in a different timing for each species.

Results

The system selected a favorable species (who changes the condition towards the optimum temperature for P1 and P2) and, by doing so, the temperature condition of the system was regulated to the direction of the optimum temperature. The system showed robustness with respect to the parameters applied. The scrutiny of the system reveals that the system loses the regulatory effect when growth equations other than those for producers were employed and that the adoption of more realistic growth equations with a half-saturation rate enhanced the regulatory effect. The effect was not influenced by the growth equation of the consumer, implying that it plays only a subordinate role in the systems.

Implication of the simulation

The results imply that the biosphere on the earth possesses the homeostatic ability through the selection of biota and circulation of resources. By analogy to Set and Akagi (in press), a trade-off was introduced to the system, which would make the model biologically much more realistic. The results of the preliminary calculations seem to solve some biologically interesting problems.

Akagi, T., Artificial Life, in press.
Seto, M, and Akagi, T., Jour. Theol. Biol., in press.
Watson, A. J., Lovelock, J. E., Tellus 35B, 284-289 (1983).