A Seed Size/Number trade-off Daisyworld model.

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(Introduction)

What is life for the earth? Most organisms seem to shift their physical environment away from static equilibrium and moreover to stabilize the system to dynamical equilibrium. However, the regulatory mechanism by biota has not been clearly demonstrated. We reexamined a Daisyworld model (Watoson & Lovelock, 1983) from a traditional view of competition theory and present 'A Seed Size/Number trade-off Daisyworld model (Seto & Akagi, in press)' as one of Biotic Independent Regulation model (BIR Model).

(Daisyworld model)

The first attempt to simulate the emergence of planetary scale self-regulation from environment-altering organisms was the Daisyworld model (Watson & Lovelock, 1983). In Daisyworld, the regulation of global temperature (a representative of environmental conditions) automatically emerges from a feedback between daisies (representatives of life) and temperature if daisies that alter the temperature in a beneficial way to both daisies. However, Darwinian adaptation for daisies that act on the environment in a beneficial way needs an unrealistic 'local' effect, where the white daisies are always warmer and white daisies are always cooler than bare ground. (i.e. the different responses of two daisies against temperature are a key property of the self-regulation).

(A Seed Size/Number trade-off Daisyworld model (ASSN Daisyworld model))

Our ASSN Daisyworld model is based on the original version, but the black and white daisies in this model have (i)the same growth rate against temperature and (ii)different growth rates against bare ground area (a representative for a resource). Unlike the original model, white and black daisies in our model incorporate a seed size/number trade-off. Two strategies of daisies, 'steady seeders' and 'spreading seeders', differ in the germination rate of daisies depending on the bare ground area. Similar variations between growth and resource are commonly seen various experiments and has been parameterized in models (Glover, 1997).

As a result of simulations, the population of the white and black daisies converged to an attractor, in which two daisies can coexist, and thus regulated the planet at a constant temperature. This conclusion implies that biotic environmental feedback can be maintained by the competitive coexistence of species incorporating a trade-off in resource utilization. Traditional competition theory predicts that, at equilibrium, two competing species cannot coexist on one resource (Stewart & Levin, 1973). In our model, however, we found a new mechanism which allows coexistence of two competing species.

(Conclusion)

The ASSN Daisyworld model implies that biotic environmental regulation emerges from the interaction between species and resource ('the independent regulation') without assuming the unrealistic 'local' effect. Like the Akagi's model (Akagi, im press), which first attempts to model such indirect regulation, our ASSN Daisyworld model is one of Biotic Independent Regulation (BIR) models.

(References)

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