Nonconsumable resources facilitate complex evolution

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Open ended evolution (OEE) is a problem closely related to the "arrow of complexity", that is, the temporal emergence of complex and complicated structures and organisms in a progressive, never-ending fashion. A straightforward, and biologically proven means to approach this is to integrate organisms in complex environments, and to make them parts of an evolving food web where various aspects of complexity may increase. Our recent work, reported in a series of papers, addresses OEE via the emergence of food webs and niche differentiation in a simple agent based population that starts from a seed such as a single species of producers (consuming nonreplicating resources and forming the basic trophic level of an ecosystem).

A notorious problem of such systems (as exeplified by recent work like DOVE, Webworld, etc) is the questionable ecological stability of the evolving trophic structure. To stabilize even a 3-species system by parameter tuning is an egregious task, let alone in systems of higher complexity and with the frequent introduction of newer species. A typical problem is that either a newly evolved consumer cannot grow (thus cannot become part of the system) or depletes the resources until both die out. Consequently, few systems currently can handle this problem. To breed restraint e.g. by selecting for moderate predators is a slow process which already presupposes the coexistence of species in a food web. But how do we get there?

Density dependent feedback (such as functional response) could be a viable solution at this point, but that typically requires complicated agents or an alien hand. An additional mechanism is to consider genotype-phenotype maps with tradeoffs in consumption, replication, and other items of life history. This is a road we have reported in another paper submitted to this conference.

Here we introduce and study a different idea, that of nonconsumable resources (NCRs), an idea which is usually underestimated in the evolutionary modeling of food webs and OEE. NCRs are factors required for the life history but not destroyed by the agents; NCRs can range from space to nesting ground to other abiotic factors to sexual partners to environmentally inherited properties to other species entering mutualism or (mild) parasitism with the given species. In natural systems NCRs are found everywhere and they pose important, yet little understood feedbacks on otherwise destabilizing dynamics. Using our agent ecosystem we show that phenotype to phenotype interactions in a consistently agent based ("fully embedded") system naturally introduce NCRs dynamically. This, in turn, helps stabilizing the emerging ecosystems and permits complexification steps otherwise impossible due to kinetic instabilities.

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