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Evolutionary behaviour in single-species discrete-time models: the importance of trade-offs, the underlying population dynamics and density dependence

We study a class of discrete-time single-species models typified by the logistic, Hassell and Ricker forms. These have been used to assess the population behaviour of ecological systems as, despite their relative simplicity, they can produce a wide variety of dynamics from stable equilibria and cycles to chaos. Here, we investigate the evolutionary behaviour of these models which has received much less attention. We use adaptive dynamics (supported by simulations) and assume there are two evolving parameters linked by a trade-off. We show that, for equilibrium underlying population dynamics, the evolutionary behaviour is restricted to an evolutionary attractor or an evolutionary repellor depending on the shape of the trade-off; branching cannot be exhibited. We further show that, in contrast to recent studies, this restriction in evolutionary behaviour is maintained in the standard Hassell model, and models which have a similar separable form, when the underlying population dynamics are cyclic. To gain a broader range of evolutionary behaviour requires considering models in which density-dependence operates differently on reproduction and survival. Such models can additionally for some trade-off shapes exhibit evolutionary branching or Garden of Eden evolutionary behaviour when the underlying population dynamics are non-equilibrium. Fundamental to such outcomes are discontinuous changes in the boundary for convergence stability (with respect to a measure of trade-off shape) across transitions (induced by parameter variation) between different types of underlying population dynamics. Trade-off shape and the nature of the underlying population dynamics can both have a marked effect on the evolutionary behaviour of ecological systems