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Cyclically competing species: deterministic trajectories and stochastic evolution[1]

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Generalizing the cyclically competing three-species model (often referred to as the rock-paper-scissors game), we consider a simple system of population dynamics that involves four species. We discuss both well-mixed systems, i.e. without spatial structure, and spatial systems on one- and two-dimensional regular lattices. Unlike the three-species model, the four species form alliance pairs which resemble partnership in the game of Bridge. In a finite system with discrete stochastic dynamics, all but four of the absorbing states consist of coexistence of a partner-pair. For the system without spatial structure mean-field theory predicts complex time dependence of the system and that the surviving partner-pair is the one with the larger product of their strengths (rates of consumption). Beyond mean-field much richer behavior is revealed, including complicated extinction probabilities and non-trivial distributions of the population ratio in the surviving pair. For the lattice systems, we discuss the growth of domains and the related extinction events, thereby confronting our results with those obtained for the three-species case.

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