Cyclic dominance in asymmetric predator-prey games

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In order to increase their rate of success, predators may attack their prey using a myriad of strategies. Among them, prey may be overcome in a cooperative, coordinated way, with the actions being correlated in space and time. Examples include hawks, crocodiles, lions, spiders, etc., but despite these mounting evidences, much less attention has been dedicated to model such behavior. The problem of coordinate hunting has been considered within a game theoretical framework in which the abundances of prey and predators were assumed constant and only the fraction of those populations using either an individual or collective strategy evolves [1]. The model takes into account some of the advantages and disadvantages for both prey and predators choosing a grouping strategy. More specifically, it is assumed that grouping lowers the risk of predation at the cost of increasing the competition for resources, while predators have a greater probability of success at the expense of having to share the prey with others, sometimes referred to as the “many-eyes, many mouths” trade off. Preys and predators are modeled by assuming that the interactions are independent of distance, a mean field approach, and the temporal evolution of both densities is described by Lotka-Volterra type equations.

A complementary approach, based on a less coarse grained description, locates individuals or groups in space and considers that no interaction occurs beyond a certain distance from the focus individual. These local interactions introduce spatial correlations that may translate into spatial organization favoring either grouping or isolated strategies. Besides its richer behavior in the presence of spatial organization, we also show that the coexistence phase in which collective and individual strategies for each group are present is stable because of an effective, cyclic dominance mechanism [2,3] similar to a well-studied generalization of the Rock-Paper-Scissors game with four species [4], a further exemple of how ubiquitous this coexistence mechanism is.