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Nonlinearities in prey growth, size-dependent predation risk, and functional responses: Understanding the effects of multiple predators on a shared prey using agent-based models

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Nonlinearities in prey growth, size-dependent predation risk, and functional responses: Understanding the effects of multiple predators on a shared prey using agent-based models

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Abstract Predicting the effects of predator loss or introduction on an ecological system is challenging; one predator species can change the deadliness of another predator species through both direct and indirect mechanisms, and often in counterintuitive or nonlinear ways. For example, the per-capita mortality risk prey experience from even a single predator species is often a nonlinear function of prey density, and of prey size, and can vary dynamically through time as prey grow. Agent-based models (ABM) offer a tractable modeling approach to understanding complex interactions among multiple predators and shared prey. In agent-based models, individuals are represented explicitly in space, given simple behavioral rules, and allowed to interact. The results at a population level emerge from the actions of the individual agents. As compared with traditional equation-based modeling, ABMs offer greater extensibility and the ability to consider biological situations more mechanistically. We first replicated published equation-based simulations of multiple-predator effects on a common prey, validating our model structure. Then we extended our model to include prey size, prey growth, and size-dependent predation risk, and consider prey mortality when faced with predators having various attack rates, handling times, and prey size preferences. Ultimately, our model will be used to predict outcomes of lab experiments and explain field survey results from a real multiple predator shared prey system found in the riverine rock pool communities in the James River near Richmond, VA.