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Fluctuation-induced patterns and rapid evolution in predator-prey ecosystems

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Predator-prey ecosystems exhibit noisy, persistent cycles that cannot be described by intuitive population-level differential equations such as the Lotka-Volterra equations. Traditionally this paradox has been met by including additional nonlinearities such as predator satiation to force limit cycle behavior. Over the last few years, it has been realized that individual-level descriptions, combined with systematic perturbation techniques can reproduce the key features of such systems in a minimal way, without requiring many additional assumptions or fine tunings. Here I review work in this area that uses these techniques to treat spatial patterns and the phenomenon of rapidly evolving prey sub-populations. In the latter case, I show how stochastic individual-level models reproduce the key features observed in chemostats and in the wild, including anomalous phase shifts between predator and prey species, evolutionary cycles and cryptic cycles. This work shows that stochastic individual-level models naturally describe systems where evolutionary time scales surprisingly match ecosystem time scales.