New means of predicting populations more accurately accounts for random influences

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By studying the ways of little jar-bound cannibals — tiny flour beetles who like to eat their young — scientists at Rockefeller University have created techniques they believe are the best yet to capture how random "noise" affects the dynamics of a biological population.

To understand how randomness affects population fluctuations, most researchers now use approximate methods from physics that cannot incorporate the highly complex and random events that occur in population biology, the researchers say in a new paper in *Proceedings of the National Academy of Sciences*.

"We are coming up with ways to understand better the details of interactions between random effects and the inherent biology of a system, with the hope that our techniques can be applied to natural populations that we might want to manage or understand," says the study's first author, Daniel C. Reuman, Ph.D., a research associate in Rockefeller's Laboratory of Populations, headed by senior author Joel E. Cohen.

The researchers sought to understand how stochasticity — random influences such as changes in weather or resources — create novel patterns in the dynamics of population change. To do this, they studied a contained population of flour beetles, an insect that has long been used to study population dynamics. These beetles are peculiar cannibals; adult beetles will eat eggs or pupae, but not larvae, and larvae will also eat eggs. "Cannibalism causes wacky and interesting population dynamics, but over time, the population does not go extinct, making it a great opportunity for understanding the way random events and population dynamics interact," said Reuman.

The researchers counted the numbers of larvae, pupae and adults in jars every two weeks. From these data, they derived "power spectra" that represented mathematically how inherent density-dependent processes in the system (births, deaths and cannibalism) interacted with random events (such as times when more eggs were eaten by chance, resulting in fewer adults). They then used the power spectra to compare the accuracy of predictions about the beetle population generated by their model with the accuracy of predictions generated using the linear methods from physics, a more traditional means of understanding noisy populations. In most cases, predictions of their model were far more successful in describing the experimental data.

According to Reuman, power spectra are usually not used to study populations because they require observations over longer intervals than are typically available. The researchers' new methods help circumvent this limitation of power spectra in some cases by using biological knowledge encapsulated in a well-tested model. "As a result, the intellectual power of power spectra can be more widely applied to give new insights into population dynamics," says Cohen, who is the Abby Rockefeller Mauzé Professor at Rockefeller.

To illustrate the difference their power spectral methods brought to light, the researchers use an example of what might happen to a seesaw, which represents regular fluctuations of populations, undergoing an earthquake (random noise). If the earthquake is really strong, they found that "population seesawing" slows down, but if the earthquake is milder, seesawing speeds up. Linearization theory used previously would show no change in the frequency of seesawing. Reuman says, "Our experiments point out an unexpected way that real noise can interact with biological characteristics of the system to produce a new effect."

The paper is the result of a collaboration between Reuman and Cohen with graduate fellow Omar S. Ahmad in the Laboratory of Sensory Neuroscience at Rockefeller and experimentalists Robert A. Desharnais, a former Rockefeller postdoc who now is a professor at California State University Los Angeles, and Robert F. Costantino at the University of Arizona.

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