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Bacteria develop restraint for survival in a rock-paper-scissors community

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It is a common perception that bigger, stronger, faster organisms have a distinct advantage for long-term survival when competing with other organisms in a given community.

But new research from the University of Washington shows that in some structured communities, organisms increase their chances of survival if they evolve some level of restraint that allows competitors to survive as well, a sort of "survival of the weakest."

The phenomenon was observed in a community of three "nontransitive" competitors, meaning their relationship to each other is circular as in the children's game rock-paper-scissors in which scissors always defeats paper, paper always defeats rock and rock always defeats scissors.

In this case, the researchers created nontransitive communities of three strains of Escherichia coli bacteria, one that produces two antibiotics, one that is resistant to both antibiotics and one that is sensitive to both. The sensitive strain outgrows the resistant strain, which outgrows the producer, which kills the sensitive strain.

In communities in which the resistant strain curbed its pursuit of the producer, the resistant strain thrived. With no restraint, the resistant strain greatly reduced the population of the producer. But then the resistant strain was forced into greater competition with the strain sensitive to the antibiotics and the resistant strain's short-term gain meant its long-term demise.

"By becoming a better competitor in a well-mixed system, it could actually drive itself to extinction," said Joshua Nahum, a University of Washington graduate student in biology. "By growing faster, it actually can hurt its abundance."

Nahum is the lead author of a paper describing the work published online the week of June 22 in the Proceedings of the National Academy of Sciences. Co-authors are Brittany Harding, a UW biology undergraduate, and Benjamin Kerr, a UW associate professor of biology and the paper's corresponding author.

The researchers created 192 pools in which the bacteria could grow and interact. The bacteria could migrate among pools, and when migration occurred among neighboring pools the three strains formed multi-pool patches.

"The restrained patches, the ones that grew slower, seemed to last longer and the unrestrained patches, the ones that grew faster, burned themselves out faster," Nahum said.

To understand the process, imagine a community of three strains, Rock, Paper and Scissors, and then imagine the emergence of an unrestrained supercompetitor, Rock* (rock star), that is able to displace Scissors even faster than regular Rock can. But that also makes Rock* a better competitor against Rock, the researchers said. Eventually Rock* will be a victim of its own success, being preyed upon by Paper.

The irony, Kerr said, is that "by chasing your victim faster you actually help out the guy who's chasing you." Restraining exploitive behavior is beneficial to the patch in the long run, he said, and is a realistic embodiment of the proverb "The enemy of my enemy is my friend."

"In patches with faster growth, members of the unrestrained patch burn through their victims and then are left to face their victims' victims, their own enemies," he said.

The observed effect only applies to structured communities with limited migration, the researchers said. In an unstructured community with greater migration and mixing, a species that curbed its aggressiveness would not reduce its chances of being engulfed by its enemy.

The findings have potential implications for other ecological systems, including mating systems of certain lizards that could have analogs among some reptiles, fish, birds and insects.

Provided by University of Washington

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