Importance of rare microbial species is much greater than you think

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The rare bacterial species in a microbial community—species that each make up rarely more than one tenth of one percent of the entire population—play a very important role in ecosystem health and stability. The research is published March 3 in *Applied and Environmental Microbiology*, a journal of the American Society for Microbiology.

"The work aims to provide a fundamental understanding of how biodiversity contributes to ecosystem functioning," said corresponding author Kostas Konstantinidis, PhD.

Despite the small population of each rare species in a microbial community, such species may number as much as several hundred within a community, such that the so-called "rare biosphere" may account for roughly 20-30 percent of individual bacteria within an aquatic community.

As the authors showed in the study, the sheer numbers of rare species resulted in the rare biosphere containing a large reservoir of genes that can degrade important organic pollutants, and that could help the entire microbial community maintain stability in the face of changing conditions, possibly including climate change.

To investigate this issue, the authors, a team from Georgia Institute of Technology, Atlanta, established "mesocosms"—indoor experimental systems—containing 20 liters of water, each. They inoculated these with water samples from the nearby freshwater Lake Lanier.

Konstantinidis said that they then dribbled three frequently used organic chemicals into the mesocosms. By design, these chemicals were not present in the mesocosms at the time of sampling, said Konstantinidis, who is the Carlton S. Wilder Associate Professor in the School of Civil & Environmental Engineering at Georgia Tech. The reason for that is that compounds that are common in a lake are commonly metabolized by abundant members of the microbial community, and so would not have shed light on the rare biosphere. "Also, the important environmental pollutants are generally at low concentration in most natural environments, similar to the organic compounds used here—except during major events such as oil spills" said Konstantinidis. (image: indoor mesocosm in a greenhouse. Wikimedia Commons)

The assayed compounds included 2,4-dichlorophenoxyacetic acid (2,4-D), a widely used herbicide that is an endocrine disrupter and a "possible human carcinogen," according to the International Agency for Research on Cancer (IARC); caffeine (1,3,7-trimethyluric acid); and 4-nitrophenol (4-NP), a precursor of several fungicides and a decomposition product of pesticides.

"We chose these compounds because their biodegradation pathways and the underlying genes are known, which facilitated tracking which microbial populations encoded the proteins for the biodegradation of these organic compounds," said Konstantinidis.

The researchers then repeatedly sampled the mesocosms to determine which bacterial species multiplied, or became depleted in response to the chemicals. "The results allowed us to rigorously test the hypothesis that low abundance species, as opposed to common species, provided the metabolic diversity that enabled the community to respond to the added compounds and the changing conditions," said Konstantinidis.

The motivation for the study was to be able to better predict how microbial communities will respond to future perturbations such as pesticides, oil spills, and even climate change, said Konstantinidis. Questions it might help answer include that of how valuable microbial diversity is for ecosystem functioning, including for maintaining resilience to human-caused pollution. The results of this and future studies might also help enable predicting the consequences of loss of biodiversity, for example, in the wake of massive pollutant spills or climate change.

Provided by American Society for Microbiology

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