Study Reveals Role of Competition in Disturbed Ecosystems

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Hurricanes, wildfires and influxes of pollutants create disturbances that can put ecological systems under extreme stress. Ecologists had believed that at times like these, competition between species becomes less important as all struggle to survive.

But a new laboratory study of microscopic organisms subjected to varying degrees of acoustic disturbance now challenges that assumption -- and could lead ecologists to reconsider how organisms compete during challenging times.

"The consistent role of competition at all levels of disturbance found in our study underscores the need for ecologists to examine competitive interactions and their consequences even in highly disturbed habitats," said Lin Jiang, an assistant professor in the Georgia Tech School of Biology.

Sponsored by the National Science Foundation, the research was reported June 28, 2010, in the early online edition of the journal *Proceedings of the National Academy of Sciences*. The study is believed to be the first to show experimentally that competition could be a factor in regulating ecological communities regardless of the intensity or frequency of disturbance.

Jiang and his team -- Cyrille Violle, formerly a postdoctoral fellow at Georgia Tech currently at the University of Arizona, and Georgia Tech biology graduate student Zhichao Pu -- conducted experiments with freshwater bacterivorous protists in artificial, simplified ecosystems called microcosms.

"A key advantage of this microcosm system is that the rapid reproduction of the microorganisms allowed us to examine multigenerational community dynamics, including competitive exclusion and stable coexistence, in a period of a few weeks," said Jiang.

The researchers assessed the ability of different species of single-celled eukaryotes called protozoa to cope with disturbance in the absence of competition, the competitive ability of species in the absence of disturbance, and the role of competition between species under disturbance. Disturbance was imposed by the application of sound energy to the small ecosystems at 11 different levels, ranging from weak disturbances that had little effect on most species to strong disturbances that caused the direct extinction of most species.

First, the researchers placed all of the protist species in separate microcosms for one month and measured each species' change in population density to assess the ability of each to cope with disturbance. Next, the researchers assessed the competitive ability of species by compelling pairs of species to battle for resources for 10 weeks in the absence of disturbance.

The final set of experiments subjected groups of protist species to both disturbance and competition. The population densities of 11 species -- including three Paramecium species -- in each of 55 microcosms were recorded for five months. The results of the multi-species experiment showed that the number of species decreased with increased disturbance and that most species were no longer present across most levels of disturbance.

"One might think that the observed decline of species diversity with disturbance was because high levels of disturbances directly eliminated most or all species. But this idea was not supported by our first set of experiments, which showed that several species were able to sustain viable populations even at the highest disturbance intensities -- when they were not with other species," explained Jiang.

Instead, the species extinctions that occurred through different levels of disturbance could be partly attributed to competition between species. And the rate of extinctions attributable to competition was greater at higher levels of disturbance.

The findings contradict the intermediate disturbance hypothesis, which suggests that at high levels of disturbance, the species that survive will be those that are hardy under disturbed conditions. At low disturbance, the hypothesis suggests that the ecosystem will be dominated by species that are good competitors. At some intermediate disturbance level, the good competitors will have an opportunity to gain a foothold without being destroyed by disturbance, but will not be able to out-compete the hardier species or exclude less-fit species.

In this study, the 11 species differed markedly in their competitive ability and in their ability to tolerate disturbance. When considered together, there was a strong tradeoff between the two traits, according to Jiang.

"Each species was most vulnerable to inter-species competition at its upper disturbance limit, which is when its population density was the most severely reduced," noted Jiang.

While this study provided unique experimental evidence that competition can consistently regulate species extinction and community richness over broad disturbance gradients, three characteristics of this experiment may influence the applicability of these results to other systems, according to Jiang.

First, since the protist species in these experiments competed for shared food resources and affected each other by reducing the availability of those resources, these findings may not apply to communities competing in other ways, such as those physically or chemically fighting with each other. Second, there was no outside immigration into the experimental microcosms, unlike natural communities in which other organisms can join the competition.

Finally, given the size of the microcosms, disturbance in the experiments could be considered "global," which contrasts with the more common situation in nature where disturbance is heterogeneous over an area.

In the future, more attention should be focused on examining other mechanisms that may potentially contribute to intermediate disturbance hypothesis patterns, says Jiang.

"Our results challenge conventional thinking and have important implications for understanding relevant ecological issues, such as those related to biodiversity, community assembly and conservation," he added.

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