Climate change may affect ecological interactions among species

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Predator-prey equilibria are being disrupted by climate change, according to a study led by Brazilian researchers and published in *Nature Climate Change* .

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With herbivores, omnivores, carnivores, insectivores, frugivores, scavengers and decomposers, Earth's ecosystems function within a vast web of interactions among plants, animals, insects, fungi and microorganisms. A fundamental part of this web resides in the equilibrium of the food chain that links predators to herbivores and regulates plant production on our planet.

Equilibria between predators and plant-feeding prey may be disrupted by future climate change, according to a study published in *Nature Climate Change*. "The study describes the causes of this disruption and shows it can be explained by the components of climate that will change in future, especially temperature," said Gustavo Quevedo Romero, a professor at the University of Campinas's Biology Institute (IB-UNICAMP) in São Paulo State, Brazil, and lead author of the article.

The study concluded that climate change can redistribute the strength of ecological interactions between predator and prey species. The results show that higher temperatures and a more stable climate with less seasonal variability lead to more intense predation pressure.

However, the increased climate instability that accompanies ongoing climate change, especially in tropical regions, will lead to an overall decline in predation pressure in the tropics. In contrast, predation pressure will rise in some temperate regions. "This reorganization of the forces of species interactions could have disastrous consequences for terrestrial ecosystems and for the ecosystem services they provide, such as biological control and nutrient cycling," Romero said.

For example, many organic farmers in the tropics depend on biological

control by natural enemies of crop pests, and projected changes in climate may weaken the effectiveness of predators in controlling these pests.

The new study was based on data collected for a previous study, published in 2017 in the journal *Science*and led by Roslin. In the previous study, researchers measured bites or other feeding marks on artificial caterpillars to show that the higher an ecosystem's latitude (from the equator to temperate and polar regions), the lower the probability of herbivore predation.

The researchers measured predation risk for 2,879 model caterpillars made of green plasticine and monitored at 31 sites around the world along a latitudinal gradient from 30.4 degrees south (a parallel spanning Rio Grande do Sul in southern Brazil, South Africa, and Central Australia) to 74.3 degrees north (spanning the Canadian Arctic, Greenland and the far north of Siberia). The elevation gradient for the 31 sites ranged from zero (Denmark) to 2,100 meters above sea level (Ecuador). In comparison, it is worth noting that Mexico City is 2,240 m above sea level.

The plasticine caterpillars were glued to the upper side of undamaged leaves of plants with at most a height of one meter. Based on their analysis of predator attack marks made by teeth, beaks, radulae or mandibles and preserved in the modeling clay, the researchers identified attacks by six predator groups: birds, lizards, mammals, arthropods and gastropods (snails or slugs).

Climate adjustment

In the *Science* article, the authors confirmed the hypothesis that biotic interaction strength increases toward the equator and decreases toward the poles. In the study now published in *Nature Climate Change*, they

compared the caterpillar predation and location data with present and future bioclimatic data based on several climate models that predict climate change from carbon dioxide emissions.

"All the existing research on the role of global climate change with respect to biotic interactions has been theoretical, as far as I know. Our study is the first to investigate the link between biotic interactions and climate change at a global scale on the basis of empirical data," Romero said. "Furthermore, it's the first time anyone has used niche modeling to study biotic interactions, as this method was developed to predict species distributions."

For the new study, the authors extracted a set of bioclimatic variables from WorldClim 2, a database of 19 bioclimatic variables applied globally to a 1 km^2 resolution grid.

Next, they used the structural equation modeling method to determine the relative significance of the direct and indirect effects of absolute latitude, elevation and the underlying local climate (including precipitation and temperature) on predation pressure.

According to Romero, the models showed that the predation data were best explained by temperature variations.

Future projections

The researchers were able to predict the redistribution of predation pressure at a global scale for a 2070 climate scenario. "Generally, we found that by 2070, predation pressure may be significantly affected by temperature changes but may not be affected by precipitation changes," Romero said.

Predation pressure will be affected both by the increase in temperature

forecasted for 2070 and by temperature variability, that is, the phenomenon of sharp increases and decreases in temperature in certain ecosystems. "Temperature instability rather than warmer temperatures will reduce predation pressure," he said. "This impact will be exacerbated in tropical regions, where the climate is projected to become more unstable."

The findings suggest that as temperatures rise, predation pressure will intensify moderately in temperate regions ranging from North America to Asia. In Scandinavia, the increase in predation pressure will be greatest among arthropods.

Predation pressure will decrease in equatorial regions, where the most biodiverse ecosystems are located, including equatorial Africa, Southeast Asia, tropical South America, Central America, and the Caribbean.

Brazil and Colombia will be particularly affected. Brazil may be the most affected country of all owing to its position in the tropics and the vastness of the Amazon rainforest.

"The most important consequence is simple. If the current climate affects current predation pressure, then we can expect climate change to lead to a change in predation pressure. Climate change is reflected by not only changes in species distributions but also changes in the interactions among species," Romero said.

"A decrease in predation pressure in the tropics could affect tropical crop yields, and in turn, this affect would increase risks to food security owing to a reduction in the efficiency of biological control in areas that are already more vulnerable due to climate change."

More information: Gustavo Q. Romero et al, Global predation pressure redistribution under future climate change, *Nature Climate*

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