Challenge to Classical Theories in Ecology: Seasonal and Daily Climate Variation Inversely Influence Species Distribution

A pressing issue in biology—in this era of climate change—is to understand how the evolutionary history of animals influences their chances of survival in a world altered by climate change. Classic ecological hypotheses have all predicted that greater seasonal climatic variability will result in wider geographic distribution. However, the fact that species simultaneously experience climatic variability on different temporal scales—diurnal and seasonal—has rarely been addressed. A research team led by Dr. Sheng-Feng Shen, an Associate Research Fellow at the Biodiversity Research Center, Academia Sinica, tested the classical hypothesis for the elevational range sizes of more than 16,500 terrestrial vertebrates on 180 montane gradients. They demonstrate that counter-intuitively, elevational range size of species is negatively correlated with diurnal temperature range, contradicting all existing hypotheses on the relationship between climatic variability and species range size. The research will be published in the journal Science on March 25, 2016.

The climatic variability hypothesis states that greater variability, which selects for organisms with broader tolerances, induces their wider geographic ranges. According to this logic, tropical mountain species have been considered more vulnerable to climate change than temperate mountain species, because tropical species are adapted to a relatively stable climate and, therefore, have narrower elevational range sizes. However, species simultaneously experience diurnal and seasonal climatic variability, and the influence of climatic variability on different temporal scales on species distributions has rarely been addressed.

To reexamine this hypothesis, researchers from the team led by Dr. Shen applied structural equation modeling to analyze the relationships among climatic factors from high-resolution datasets and species elevational range size, including 16,592 species of rodents, bats, birds, lizards, snakes, salamanders, and frogs on 180 montane gradients. With the robust support of a mathematical model,

they generalize these empirical findings to propose a novel macroecological pattern—species elevational range sizes are inversely influenced by diurnal and seasonal climatic variability in opposite ways.

Dr. Shen, the leader of the research team, said: “Species range size and factors limiting species distribution are fundamental to understanding ecological, conservation and economic issues as diverse as invasive species, climate-driven range shifts of species, distribution of vector-borne diseases, and areas suitable for food production. Our new findings and proposed novel hypothesis on the relationship between climatic variability and species range size will likely be of great interest not only to biologists but also to climatologists, public health scientists, and economists.” The first author Mr. Wei-Ping Chan added that mean annual precipitation gradients play a stronger role than latitude (with its complex climate gradients) in influencing the relative importance of daily temperature range and seasonal temperature range in driving the evolution of thermal limits, and thus the range sizes of species. “Climate change has triggered species range shifts. The key to explaining this phenomenon is to understand the underlying physiological adaptations, and our research may provide a possible mechanism for explaining species range shifts”, according to the co-first author Dr. I-Ching Chen.

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The article entitled “Seasonal and daily climate variability have opposite influences on the distribution of species across elevational gradients” is available at the Science website at: http://science.sciencemag.org/content/351/6280/1437