Climate and Topography: Explaining Range Sizes of Terrestrial Vertebrates

There is an enormous variation in the sizes of geographic ranges of individual species. Some large-range species can occupy habitats with area of more than 100 million km^2, while some small-range species only occur in area of less than 100 m^2. Understanding factors that influence geographic range sizes of species not only can provide important insights into the mechanisms for the distribution of biodiversity, but also is crucial for predicting shifts in species ranges in response to climate change.

It is widely recognized that current climates (e.g. intra-annual climate variability and climate extremes) control species range size. Species that experience large magnitudes of climate variability or climate extremes would occupy larger range size. Other factors, such as long-term climate change velocity, topographic heterogeneity, land area, and species traits like physiological thermal limits, dispersal ability, fecundity and body size, have been shown to influence range size. Species able to cope with long-term climate change would occupy large range size. High topographic heterogeneity (e.g. mountains or coasts) will exert barriers to dispersal of species, thus limit the range size. Larger habitat area (e.g. continent area for terrestrial species) may harbor higher proportions of large-range species. Broader range of physiological thermal limits (e.g. upper and lower thermal tolerance) would result in a larger geographic range size. Species with high dispersal ability or large body size would also be more likely to occupy larger range size. However, few studies have

examined the generality of each of these factors among different taxa, or have simultaneously evaluated the strength of relationships between range size and these factors at a global scale.

A group led by Prof. LI Yiming from the Institute of Zoology, Chinese Academy of Sciences quantified the contributions of these factors to range sizes of terrestrial vertebrates (three taxa: reptiles, mammals and birds) at a global scale. They found that range sizes of birds are larger than mammals and reptiles. Consistent determinants of range size for the three taxa include monthly extremes of maximum or minimum temperature within species' ranges, long-term climate velocity since the Last Glacial Maximum, topographic heterogeneity and precipitation seasonality. A species would have large range size if it experiences greater monthly extremes of maximum or minimum temperature within their ranges, or it occurs in areas with higher long-term climate velocity and lower topographic heterogeneity or lower precipitation seasonality. Flight ability and body mass or continent width are important only for particular taxa. Weak evidence was detected for the effect of temperature seasonality, physiological thermal limits and clutch/litter size on range sizes. Larger range sizes for birds than for mammals or reptiles might be partly because birds experience lower minimum temperature than mammals or experience higher maximum temperature, and occur in areas with higher long-term climate velocity than reptiles. This study highlighted the dominant effects of climate and topography in shaping range sizes of terrestrial vertebrates.

The results suggested that conservation efforts should be focused on small-range species that experience lower temperature extremes or occur in regions with increased precipitation variability under climate change.

This study, a collaboration effort between Chinese and Danish scientists, has been published online in *Nature Climate Change*. Their work was funded by the National Natural Science Foundation of China and the Ministry of Science and Technology of China.