Georgia Tech Mathematician Enhances the Predictive Power of a Biodiversity Index

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Biodiversity refers to the variation of life forms in all levels of ecological organization; from the biomes comprised of numerous ecosystems that harbor a rich variety species and communities to the entire biosphere of planet Earth. Biodiversity, though traditionally a topic of interest solely for ecologists and environmentalists, has recently gained mainstream momentum as information about global warming and conservation efforts flood into the public realm. Numerous organizations such as the World Wildlife Fund (WWF) are spearheading efforts to protect wildlife and preserve this rich biological heritage of Earth.

Amidst this demand for curbing the effects of global warming is the central concern about the erosion of biodiversity. As multitudes of organisms succumb to pressures of global warming and become endangered, there is a perpetual need to assess the impact of global warming on specific ecological communities by quantifying their biodiversity. Diversity indices are used for this endeavor as they mathematically elucidate both the diversity and abundance of a species within a given community by incorporating two important parameters: species richness, m, and evenness. Species richness represents the number of different species inhabiting a particular community, whereas evenness, or equitability, delineates the relative abundance of each species in that community.

The Berger-Parker index, d, is a commonly used biodiversity index, notable for its simplicity in delineating the proportion of the most abundant species. In the formula, $X(m)$ represents the number of individuals in the most abundant species and n represents the total number of individuals sampled. Hence, the index delineates the proportion of the most prevalent species: lower the value of the Berger-Parker index, the more evenly distributed and diverse the community. However, for a community with a growing number of individuals and species, the typical method of calculating the Berger-Parker index directly is no longer accurate, becoming a barrier for making accurate biodiversity measurements, which is where the important contributions of a Georgia Tech mathematician come into light.

$$d = \frac{X(m)}{n}$$

Dr. Huy Huynh, a recent graduate from the School of Mathematics and present faculty member at the University of Notre Dame has developed statistical tools to estimate the Berger-Parker index as the number of individuals and species grow without bound. While collaborating with his advisors, Dr. Christian Houdre and Dr. Liang Peng, he introduced an estimator for the Berger-Parker index called the multinomial maximum, through which he obtained a limiting distribution of the estimator as the number of individuals and species simultaneously grew without bound. Next, he constructed 95% confidence intervals for the maximum proportion, which immensely helped to improve the comparison of the Berger-Parker index among communities. Hence, Dr. Huynh's research paves the way for enhancing the power of biodiversity measurements and has sound implications for the future.

"Descibing biodeversity phenomena rigorously through mathematics can help scientists further elucidate underlying biology"

For instance, Dr. Huynh seeks to apply these estimation methodologies to bacterial colonies, constituting millions of bacteria. In particular, he would like to estimate the diversity of bacteria populations residing on human skin. The findings from his future studies have the potential to help doctors and scientists better understand why some people are more prone to skin conditions like eczema and psoriasis while others with similar genetic backgrounds are not, which could be invaluable for better prognosis and diagnosis. Finding the appropriate data for undertaking this endeavor is his current challenge. Nonetheless, describing biodiversity phenomena rigorously through the language of mathematics can help scientists further elucidate the underlying biology, and contribute to possible ecological and medical applications.