

## 最大熵原理及其在生态学研究中的应用

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## The principle of maximum entropy and its applications in ecology

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摘要

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**摘要** 最大熵原理(the principle of maximum entropy)起源于信息论和统计力学, 是基于有限的已知信息对未知分布进行无偏推断的一种数学方法。这一方法在很多领域都有成功应用, 但只是近几年才被应用到生态学研究, 并且还存在着很多争论。我们从基本概念和方法出发, 用掷骰子的例子阐明了最大熵原理的概念, 并提出运用最大熵原理解决问题需要遵从的步骤。最大熵原理在生态学中的应用主要包括以下方面: (1)用群落水平功能性状的平均值作为约束条件来预测群落物种相对多度的模型; (2)基于气候、海拔、植被等环境因子构建物种地理分布的生态位模型; (3)对物种多度分布、种-面积关系等宏生态学格局的推断; (4)对物种相互作用的推断; (5)对食物网度分布的研究等等。最后我们综合分析了最大熵原理在生态学应用中所存在的争议, 包括相应模型的有效性、可靠性等方面, 介绍了一些对最大熵原理预测能力及其局限性的检验结果, 强调了生态学家应用最大熵原理需要注意的问题, 比如先验分布的选择、约束条件的设置等等。在物种相互作用、宏生态学格局等方面对最大熵原理更广泛的讨论与应用可能会给生态学带来新的发展机会。

**关键词:** 最大熵方法 贝叶斯统计 植物性状 物种地理分布 宏生态学 物种相互作用 度分布 中性理论

**Abstract:** The principle of maximum entropy (MaxEnt) was originally studied in information theory and statistical mechanics, and was widely employed in a variety of contexts. MaxEnt provides a statistical inference of unknown distributions on the basis of partial knowledge without taking into any unknown information. Recently there has been growing interest in the use of MaxEnt in ecology. In this review, to provide an intuitive understanding of this principle, we firstly employ an example of dice throwing to demonstrate the underlying basis of MaxEnt, and list the steps one should take when applying this principle. Then we focus on its applications in some fields of ecology and biodiversity, including the predicting of species relative abundances using community aggregated traits (CATs), the MaxEnt niche model of biogeography based on environmental factors, the studying of macroecology patterns such as species abundance distribution (SAD) and species-area relationship (SAR), inferences of species interactions using species abundance matrix or merely occurrence (presence/absence) data, and the predicting of food web degree distributions. We also highlight the main debates about these applications and some recent tests of these models' strengths and limitations. We conclude with the discussion of some matters of attention ecologists should keep in mind when using MaxEnt.

**Keywords:** MaxEnt Bayesian statistics plant traits species geographic distribution macroecology species interactions degree distributions neutral theory

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