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Continuous coexistence or discrete species? A new review of an old question

György Barabás[1], Simone Pigolotti[2], Mats Gyllenberg[3], Ulf Dieckmann[4] and Géza Meszéna[5]

[1]*Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, Michigan, USA,* [2]*Department of Physics and Nuclear Engineering, Polytechnic University of Catalonia, Barcelona, Spain,* [3]*Department of Mathematics and Statistics, University of Helsinki, Helsinki, Finland,* [4]*International Institute for Applied Systems Analysis, Evolution and Ecology Program, Laxenburg, Austria and* [5]*Department of Biological Physics, Eötvös Loránd University, Budapest, Hungary*

ABSTRACT

Question: Is the coexistence of a continuum of species or ecological types possible in real-world communities? Or should one expect distinctly different species?

Mathematical methods: We study whether the coexistence of species in a continuum of ecological types is (a) dynamically stable (against changes in population densities) and (b) structurally robust (against changes in population dynamics). Since most of the reviewed investigations are based on Lotka-Volterra models, we carefully explain which of the presented conclusions are model-independent.

Mathematical conclusions: Seemingly plausible models with dynamically stable continuous-coexistence solutions do exist. However, these models either depend on biologically unrealistic mathematical assumptions (e.g. non-differentiable ingredient functions) or are structurally unstable (i.e. destroyable by arbitrarily small modifications to those ingredient functions). The dynamical stability of a continuous-coexistence solution, if it exists, requires positive definiteness of the model's competition kernel.

Biological conclusions: While the classical expectation of fixed limits to similarity is mathematically naive, the fundamental discreteness of species is a natural consequence of the basic structure of ecological interactions.

Keywords: competition kernel, dynamical stability, kinked kernel, limiting similarity, Lotka-Volterra models, niche axis, structural robustness, structural stability.

1. INTRODUCTION

It is an elementary fact of biology that species are – by and large – discrete entities. Why is this so? The question has both an ecological and a genetic aspect (Maynard Smith and Szathmáry, 1995). Here we are interested in the ecological one: does ecology dictate the discreteness of

Correspondence: G. Barabás, Department of Ecology and Evolutionary Biology, University of Michigan, 830 North University, Ann Arbor, MI 48109-1048, USA. e-mail: dysordys@umich.edu

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