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Degree of intervality of food webs: from body-size data to models.

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Abstract

In food webs, the degree of intervality of consumers' diets is an indicator of the number of dimensions that are necessary to determine the niche of a species. Previous studies modeling food-web structure have shown that real networks are compatible with a high degree of diet contiguity. However, current models are also compatible with the opposite, namely that species' diets have relatively low contiguity. This is particularly true when one takes species' body size as a proxy for niche value, in which case the indeterminacy of diet contiguities provided by current models can be large. We propose a model that enables us to narrow down the range of possible values of diet contiguity. According to this model, we find that diet contiguity not only can be high, but must be high when species are ranked in ascending order of body size.

Keywords: Diet contiguity, ecological networks, food-web structure, niche dimension, species size

1. Introduction

Food webs are networks that describe trophic (consumer-resource) interactions in communities (Cohen et al., 1990), and regularities in their structural properties are among the most prevalent in ecosystems (Camacho et al., 2002; Dunne et al., 2002; Cattin et al., 2004; Camacho and Arenas, 2005; Stouffer et al., 2005; Pascual and Dunne, 2006; Allesina et al., 2008). The existence of systematic patterns in food webs of very different origin and nature has encouraged researchers to propose models for their structure, with the aim of reproducing the observed patterns from simple food web assembly rules (Cohen and Newman, 1985; Williams and Martinez, 2000; Cattin et al., 2004; Stouffer et al., 2006; Allesina et al., 2008; Capitan et al., 2009; Capitan and Cuesta, 2011; Capitan et al., 2011). The design and evaluation of theoretical models for food-web structure is crucial to understand the persistence of ecological communities and their fragility against external perturbations (Stouffer et al., 2008; Capitan and Cuesta, 2010; Stouffer and Bascompte, 2011; Stouffer et al., 2012).

Theoretical models of food webs often rely on the concept of ecological niche. A species' niche was initially conceived as the set of relevant traits that determine the trophic position of a species in the network of trophic interactions (Hutchinson, 1957). The question of how many "niche dimensions" are relevant to represent species in their communities has given rise to a long debate in ecology (Cohen, 1977). It has been argued (Stouffer et al., 2006) that the structure of empirical food webs can be fairly well explained reducing the number of traits to simply one. If a single trait were enough to characterize the network of feeding interactions, species could be ordered in a way that each consumer had a contiguous diet, that is, each species would prey upon a set of consecutive resources. Hence consumer's diets could be represented as intervals in a one-dimensional niche space. A food web in which all consumers' diets form continuous intervals along a single niche dimension is known as a perfectly interval food web. Non-interval webs, however, are networks such that no species ordering is possible for consumers' diets to be perfectly contiguous. The quasi-interval nature of real food webs has inspired the majority of recent models for food-web structure (Williams and Martinez, 2000; Stouffer et al., 2005; Allesina et al., 2008), but some researchers have pointed out that real networks are not perfectly interval and that models that generate perfectly interval food webs are therefore inappropriate (Cattin et al., 2004). Stouffer et al. (2006) solved the puzzle by demonstrating quantitatively that a small degree of diet non-contiguity is enough to generate networks whose intervality is compatible with that of empirical food webs. The small deviation from complete intervality suggests that a single trait or a small set of them are enough to capture the structure of feeding interactions and species' niches. Other studies have proven recently that the number of niche dimensions in food webs is low (Eklof et al., 2013) —see, however, the work by Rossberg et al. (2010) regarding the dimensionality of the niche space.

Several candidates for the trait corresponding to the niche dimension were proposed in the past, most prominently body size (Lawton and Warren, 1988). Based on this correspondence

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