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Characterization of topological keystone species Local, global and "meso-scale" centralities in food webs

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ABSTRACT

An important question in the network representation of ecological systems is to determine how direct and indirect interactions between species determine the positional importance of species in the ecosystem. Here we present a quantitative analysis of the similarities and differences of six different topological centrality measures as indicators of keystone species in 17 food webs. These indicators account for local, global and "meso-scale" – intermediate between local and global – topological information about species in the food webs. Using factor analysis we shown that most of these centrality indices share a great deal of topological information, which range from 75% to 96%. A generalized keystone indicator is then proposed by considering the factor loadings of the six centrality measures, which contains most of the information encoded by these indices. However, the individual ordering of species according to these criteria display significant differences in most food webs. We simulate the effects of species extinction by removing species ranked according to a local and a "meso-scale" centrality indicator. The differences observed on three network characteristics – size, average distance and clustering coefficient of the largest component – after the removal of the most central nodes indicate that the consideration of these indices have different scopes for the ranking of species with conservational/biology purposes. The "meso-scale" indicator appears to play an important role in determining the relative importance of species in epidemic spread and parasitism rates.

1. Introduction

Food webs are complex networks representing the trophic relationships of species in a natural ecosystem (Pimm, 1982; Pascual et al., 2005; Jordán and Scheuring, 2004). In these networks species are represented by nodes and trophic relationships are represented by network links. It has been believed for long time that all species are not equally important in an ecosystem. In fact, there are some species "whose impact on its community or ecosystem is large, and disproportionately large relative to its abundance" (Power et al., 1996). These species receive the denomination of keystones, and their extinction can lead to community collapses which make their investigation of great importance in conservation ecology (Paine, 1969; Estes and Palmisano, 1974; Mills et al., 1993; Menge et al., 1994; Power et al., 1996; Springer et al., 2003). The identification of keystone species in a food web is both an important and elusive task for ecologists. Consequently, several measures for a priori identification of keystones have been proposed (Power et al., 1996; Christianou and Ebenman, 2005; Jordán et al., 1999, 2006; Jordán and Scheuring, 2002).

In recent years there have been important discoveries of certain network topological properties which are common to complex systems in a wide range of disciplines ranging from

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