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MEASURING ASYMMETRY IN INSECT-PLANT NETWORKS

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Community and ecosystems ecology use networks to visualize food webs ever since [1]. In the last two decades scientists show a growing interest in networks in order to study other ecological interactions such as pollination, parasitism, seed dispersion or detrivory. All these community ecology systems can be also described by interaction matrices. Recently most studies in community ecology networks are describing mainly mutualistic matrices such as pollination and seed dispersion ones [2]. One can easily represent such interactions in a bipartite graph. In pollinator networks, the two functional groups: pollinators and flowering plants are the vertices of the bipartite network and observed interactions are drawn as links. In this context a species (pollinator or plant) that interacts with many species is called a generalist, while a species that has few or exclusive interactions is called a specialist.

An important aspect in community ecology and by consequence in evolutionary biology [3] is the asymmetry of interaction matrices. The asymmetry is relevant in the study of community stability as well as to understand species coevolution [3, 4]. The matrix asymmetry is put in several frameworks. First of all, it is considered as the asymmetry among generalists and specialists: a symmetric matrix would be characterized by generalists interacting with generalists and specialists with specialists [5]. In a second point of view, asymmetry is thought as a difference in interactions strength. This approach is applied to quantitative bipartite networks (which is not the case of our study) [4]. The third approach is to search for asymmetry in the degree distribution of animals and plants [6].

The objective of this paper is to explore the asymmetry of the interaction matrix using a new tool. Instead of driving our attention to the interaction matrix itself we focus the analysis on the two networks derived from the bipartite network: the animal network, N_A, and the plant network, N_P . These networks are built in the standard way in network analysis [7]. We construct N_A in the following way: two animal species are linked once they share the same plant. In a similar way we build N_P . We search for asymmetry comparing network statistics of N_A and N_P . The ecological interpretation of the N_A is the network of animals sharing a common resource.

We select a set of 23 plant-insect matrices of herbivorous insects and its host plants, characterized as antagonist interactions. All the analyzed matrices consist of insects observed feeding on vegetal tissues of host plants. We used this data set by convenience, but the same study conducted here could be performed with mutualistic interactions, as well as with other antagonist interactions. To explore the asymmetry between N_P and N_A we test for all networks: the difference in size, average connectivity $\langle k \rangle$, clustering coefficient C and normalized clustering coefficient C/C_{rand}. We used a nonparametric statistical test to check for the differences in size L, $\langle k \rangle$ and C. The signal test was applied to compare the number of positive against negative differences. For a significance level of 10% we verified assymetry for L ($L_A > L_P$), $\langle k \rangle$ ($\langle k \rangle A < \langle k \rangle_P$) and C ($C_A < C_P$), but not for C/C_{rand}. The asymmetry in size is already known in the literature of mutualistic networks [8], although in mutualistic studies the proportion of animals per plants is much higher than found here. The asymmetry in $\langle k \rangle$ is related with size asymmetry, smaller L_P implies in larger $\langle k \rangle_P \propto 1/L_P$. However, the asymmetry in the clustering coefficient is a new result we report in this work. Correlation analysis taken for C against L and $\langle k \rangle$ showed negative results. The asymmetry of C is not correlated with size or connectivity.

In a future work we will explore other network indexes in the search for asymmetry in community networks. Indeed, there are other indexes to test that we have not explored, for instance, a centrality index. We also have not explored the networks degree distribution P(k). There is an important study on the subject that shows that P(k) of animals and plants in mutualistic interaction networks follow power-law distributions, or truncated power-law [9]. This result was criticized by [10] that remark that P(k) of interaction networks are not easily classified into a single distribution class. The question we pose, otherwise, is other, since we are not interested in P(k) values of the interaction network, but of animal and plant networks, which is not the same. By construction the networks N_P and N_A present much higher <k> values than the interaction matrices, a fact that has deep consequences on P(k). Finally, the road to achieve a good index to quantify asymmetry in interaction networks is only in its beginning. What is clear in this project is that to understand the role of asymmetry in mutualistic and antagonistic networks is a major challenge in community ecology and evolutionary biology.

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