Scaling Asymmetry in Competition: from Monopolization to Uniformization thorugh Competitive Displacement

Julio A. Camargo[1] .

Since Gause's famous experiments with Paramecium species, ecologists generally recognize that monopolization of limited resources by superior competing species is a primary factor for competitive displacement of one or more inferior competing species. Resource monopolization necessarily implies asymmetry in the acquisition of resources among competing species, and competitive displacement necessarily implies asymmetry in relative abundances of competing species (i.e., species dominance). Furthermore, because competitive displacement of competing species inevitably causes a reduction in species diversity, and because species diversity may be inversely related to species uniformity, it should be evident that the process of monopolization can ultimately lead to the process of uniformization in communities with competing species.

I developed the following statistics to quantify asymmetry in the acquisition of resources (M), absolute monopolization (M_{abs}), and relative monopolization (M_{rel}):

$$M = \sum_{s=1}^{k} \left(\frac{x_s}{m} - \frac{1}{n} \right); \quad M_{abs} = M \cdot m; \quad M_{rel} = \frac{M_{abs}}{m - \frac{m}{n}}$$

where k is the number of superior competitors (superior competing species in our case), x_s is the resource acquisition of each superior competitor, m is the total number of food items (or the total food weight), and n is the total number of competitors. A competitor (i) is superior if its relative

[1]Departamento de Ecología, Edificio de Ciencias, Universidad de Alcalá, 28871 Alcalá de Henares (Madrid), Spain. (e-mail: julio.camargo@uah.es).

resource acquisition $\frac{x_i}{m} > \frac{1}{n}$, and inferior if $\frac{x_i}{m} < \frac{1}{n}$. I also proposed M_{rel} as a statistic to assess the opportunity or potential for selection.

I developed, on the other hand, the following statistics to quantify asymmetry in relative abundances of competing species (i.e., species dominance; d), species diversity (D), and species uniformity (U):

$$d = \sum_{d=1}^{L} \left(p_d - \frac{1}{S} \right); \quad D = S - (S \cdot d); \quad U = \frac{1}{D},$$

where L is the number of dominant species, p_d is the relative abundance of each dominant species, and S is the number of competing species. A competing species (i) is dominant if its relative abundance $(p_i) > \frac{1}{S}$, and subordinate if $(p_i) < \frac{1}{S}$

Simulations using data of hypothetical communities with competing species show that, in the case of limited resources, resource monopolization by a superior competing species (M, M_{abs} and $M_{rel} > 0$) induces competitive displacement of inferior competing species ($d > 0$), increasing the value of species uniformity (U). The final outcome of this uniformization process results in $U = D = S = 1$ and $d = M = M_{abs} = M_{rel} = 0$. In contrast, if the availability of resources is increased, resource monopolization does not induce necessarily neither competitive displacement nor increasing species uniformity, allowing the coexistence of superior and inferior competing species. Moreover, in this case, M_{abs} values may be higher, and M_{rel} values may be lower, than in the case of limited resources.