SPECIES ABUNDANCE DISTRIBUTIONS, THE SPECIES-AREA RELATIONSHIPS AND THE ZIPF'S LAW

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In many complex systems such as a human social system, an economic system, a linguistic system, an ecosystem, a metabolic system, an immune system, etc, common *general community structures* have been widely observed. A mechanism to generate such patterns, e.g. abundance distributions of components, is not only a main topic in each discipline but also have aroused controversy independently. In my talk, I aim to explore a uniform view and methodology for the patterns by theoretically approaching to complex systems essentially containing diverse components, e.g. currencies, products or companies in a economic system, genes in a cell, species in an ecosystem, words in a book, etc. First, some examples of the general community structure will be presented: species abundance distributions (SAD) and the species-area relationships (SAR) in ecology [1], and the Zipf's law [2] in linguistics and social sciences. Second, I relate SAD and SAR to the Zipf's law which may be best known as the power distribution $p(f) \sim f^{-(1+a)}$ of word frequency (f). Its characteristic exponent $(a \sim 1)$ is ubiquitously observed in many other distributions of property in an economic system, benthos population, population of cities, names in a population, proteins or mRNAs in a cell, etc. Various mechanisms of the Zipf's law have been suggested in each discipline, while there is few discussions on the general principle to generate such a ubiquitous exponent. Reconsidering the relations between SAD and SAR, I present a scenario for the origin of the Zipf's law in connection with the *generalized island biogeography* which can be applied to products, words, populations, molecules, etc. In particular, it is suggested that the exponent $(a \sim 1)$ is due to a self-organized critical state at which some function of species richness is maximized, and therefore, the Zipf's law can be explained by a general mechanism which is independent from the details of the characteristics of each system. Some parts of the present study have been conducted in collaboration with Haruyuki Irie (Hiroshima University).

Keywords
evolutionary dynamics, species abundance distribution, complex systems

References

[1] R. M. May, "Patterns of species abundance and diversity", In *Ecology and Evolution of Communities*, Ed. M. L. Cody and J. M. Diamond, Belknap, Cambridge, p. 81-120, 1975.
[2] G. K. Zipf, "Human Behavior and the Principle of Least Effort", Addison-Wesley, Cambridge, 1949.