RNA Viruses Evolution with Frequency-Dependent Selection

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Short abstract **- During 40 years, quasi-species theory has become a standard conceptual frame to study the RNA viruses evolution[1-3]. However, one of problems with this theory is its lack of frequency-dependent selection (fds), i.e. the fitness of a particular phenotype is a constant value independently of the other competing agents [4]. This can be solved by using the replicator-mutator equation [5-7]. We proposed a modified quasi-species model to take the fds into account [8]. We studied the Shannon entropy, the existence of error-catastrophe (a second-order phase transition), and the emergence of cooperation, we interpret the results in terms of this more biologically realistic scheme.**

Keywords **— Quasispecies theory, RNA virus, Frequency-Dependent Selection, Phase Transitions.**

RNA viruses show rapid adaptation both in laboratory and natural environments. The enormous diversity generated by the extremely high error rates is generally considered to be at the root of such adaptive potential. High mutation rates provide increased variation for responding to strong selective pressures, hence accounting for the rapid emergence of drug-resistant viruses, for instance HIV, hepatitis C, polio and influenza.

*E*volution theory has as its cornerstone the concept of fitness. Fitness is usually defined as the relative reproductive success of a genotype as measured by survival, fecundity, number of descendants, seeds, etc. However, this definition is unsatisfactory, when it is confronted with real biological situations. In general, the fitness is considered a quantity constant. This can be solved by proposing that fitness depends linearly on the relative abundance of the species. This modification predicts the appearance of cooperative effects, which has been previously reported in Polio virus [9].

References

[1] Eigen M (1971) Molecular self-organization and the early stage of evolution, Q. Rev. Biophys , Cambridge University Press.

[2] Eigen M, Schuster P (1977) A principle of natural self-organization, Naturwissenschaften, Springer-Verlag.

[3] Eigen M, McKaskill J ,Schuster P, (1988) Molecular Quasispecies, J. Phys. Chem., 92(24)pp 6881-6891.

[4] Elena F, Miralles R, Moya A, (1997) Frequency-dependent selection in a mammalian RNA virus, Evolution 51(3), pp 984-987.

[5] Nowak M, Sigmund K (204), Evolutionary dynamics in biological games, Science 303(5659): 793-799.

[6] Hofbauer, J., Sigmund K (2003) *Evolutionary game dynamics* Bull. Am. Math. Soc. 40, 479-519

[7] Nowak M, (2006) *Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press.

[8] Alvarez-Martinez R, Martinez-Mekler G. (2012) RNA viruses evolution with frequency-dependent selection. In preparation.

[9] Vignuzzi M et al. (2006) Quasispecies diversity determines pathogenesis through cooperative interactions in a viral population. *Nature* **439**, 344-348

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