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On Chaos and Multifractality in a Three-Species Food Chain System

Das, S.* and Bhardwaj, R.

University School of Basic Sciences, Guru Gobind Singh Indrapastha University Dwarka, India

E-mail: saureeshdas@gmail.com
**Corresponding author*

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Abstract

The complexity of temporal dynamics in the three species food web model involving Holling type-II functional response has been investigated analytically and numerically by varying the kill rate parameter of the super predator. In this work, the system is shown to possess co-existing stable equilibrium population over a certain range of kill rate parameter of the super predator. The transition from stable equilibrium point of coexistence to limit cycle behavior is also observed, at a critical value of the kill rate parameter, as result of Hopf bifurcation. Power spectrum and the bifurcation diagram of the food web system have been used to investigate the transition of the system dynamics from regular to quasi-periodic and chaotic regime for increasing value of the kill rate. Numerical computation of Lyapunov characteristic exponents for specific values of the kill rates provides evidence of chaotic system dynamics or an strange attractor. The chaos in such a system is shown to exhibit scale invariance characteristics as indicated by its fractal dimension. The multi-fractal behavior is further revealed in the temporal evolution of the system through the existence of power law and other measures of the multi-fractal detrended fluctuation analysis for different values of the kill rates of the super predator.

Keywords: functional response; food web; Hopf bifurcation; chaos; power spectrum; bifurcation diagram; multi-fractal analysis; power law.