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Reconsidering Taylor's Law with Chaotic Population Dynamical Systems

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Abstract : The exponents of Taylor's law in deterministic chaotic systems are computed, and their meanings are intensively discussed. Taylor's law is the scaling relationship between the mean and variance (in both space and time) of population abundance, and this law is known to hold in a variety of ecological time series. The exponents found in the temporal Taylor's law are different from those of the spatial Taylor's law. The temporal Taylor's law is calculated on the time series from the same locations (or the same initial states) of different temporal phases. However, with the spatial Taylor's law, the mean and variance are calculated from the same temporal phase sampled from different places. Most previous studies were done with stochastic models, but we computed the temporal and spatial Taylor's law in deterministic systems. The temporal Taylor's law evaluated using the same initial state, and the spatial Taylor's law was evaluated using the ensemble average and variance. There were two main discoveries from this work. First, it is often stated that deterministic systems tend to have the value two for Taylor's exponent. However, most of the calculated exponents here were not two. Second, we investigated the relationships between chaotic features measured by the Lyapunov exponent, the correlation dimension, and other indexes with Taylor's exponents. No strong correlations were found; however, there is some relationship in the same model, but with different parameter values, and we will discuss the meaning of those results at the end of this paper.

Keywords : chaos, density effect, population dynamics, Taylor's law
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