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APPLICATION OF THE PHASE SPACE RECONSTRUCTION IN ECOLOGY

Yuzhi Wang [1], Bo Li [1], Renqing Wang [1], Jing Su [2], Xiaoxia Rong [*2, 3]

[1] Institute of Ecology and Biodiversity, School of Life Sciences, Shandong University, Jinan 250100, China
[2] School of Mathematics, Shandong University, Jinan 250100, China
[3] School of Management, Tianjin University, Tianjin 300072, China
Corresponding Author: Xiao-Xia Rong
E-mail: wangyuzhi@sdu.edu.cn (Y.Z. Wang)

Abstract- A brief introduction to phase space reconstruction in ecology is given, and the application of the method to rodent populations is illustrated. Results show that phase space reconstruction is highly convenient and effective when utilized in short-term predictions in natural population.

Keywords- Phase Space Reconstruction, Prediction

1. METHOD

The nonlinear prediction approach was used within a period of 20 years based on the theory of phase space reconstruction. For time series data, the first step was to embed it in a phase space. Following the approach introduced by Farmer, a phase vector x (t) was created by assigning coordinates $x_1(t) = x(t)$, $x_2(t) = x(t+\tau)$ and $x_d(t) = x(t+(d-1)\tau)$, in which τ represented the delay time. The next step was to assume a functional relationship between the current state x(t) and the future state x(t+T), which satisfied $x(t+T) = f_T(x(t))$. This was done to find a predictor F_T, which can approximate f_T. If the obtained data were chaotic, then f_T was considered necessarily nonlinear.

The local approximation is a more effective approach for chaotic time series [1,2], using only nearby states to make predictions. Assuming the vector at time t was $X(t) = \{x(t), x(t+\tau), \cdots, x[t+(m-1)\tau]\}$, and a metric on the phase space was given, we found the k nearest neighbors $X(t_1), X(t_2), \cdots, X(t_K)$ of X(t). We then constructed a local predictor according to $X(t+1) = \frac{1}{N}\sum_{i=1}^{K} X(t_i+1)$. The cases of zeroth-order and first-order approximations were often used.

2. RESULTS

We conducted short-term predictions in two rodent populations with phase space reconstruction. The results are presented below.

2.1. Apodemus agrarius

Figs. 1 and 2 represent the zeroth-order predictions of the original and clean data, respectively. Figs. 3 and 4 represent the first-order prediction maps of the original and clean data, respectively. In both cases, the solid lines represent real data, and the dotted linea represent prediction data.

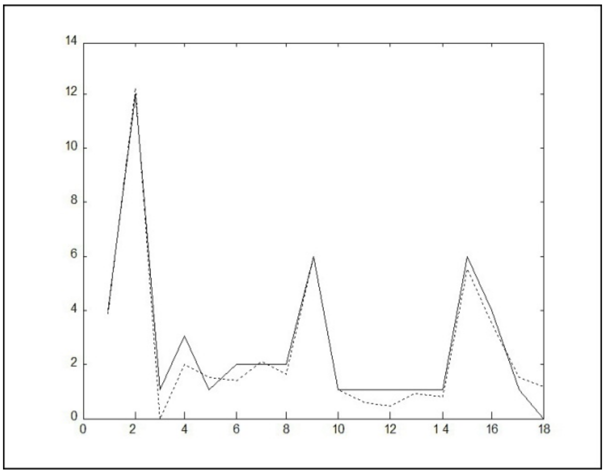

Fig. 1 Zeroth-order prediction of the original data

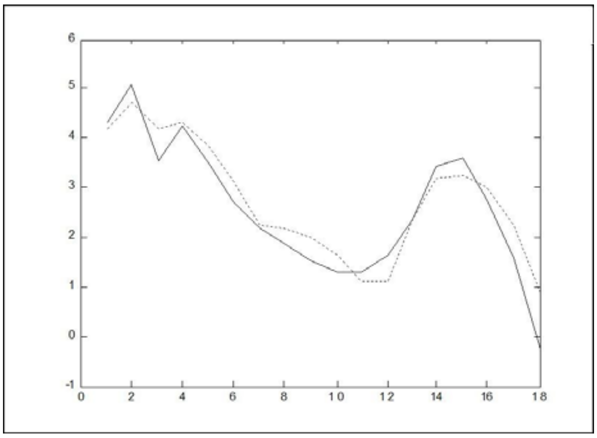

Fig. 2 Zeroth-order prediction of the clean data

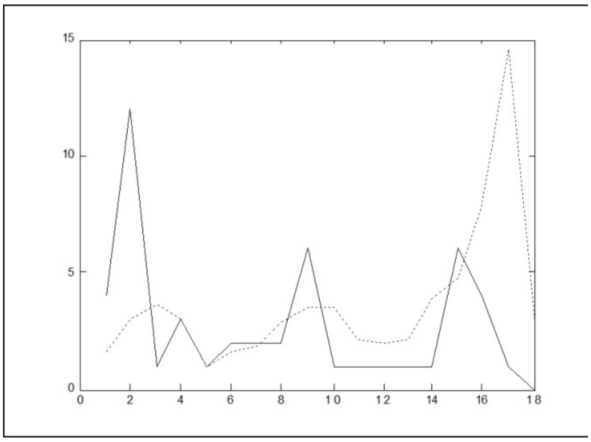

Fig. 3 First-order prediction of the original data

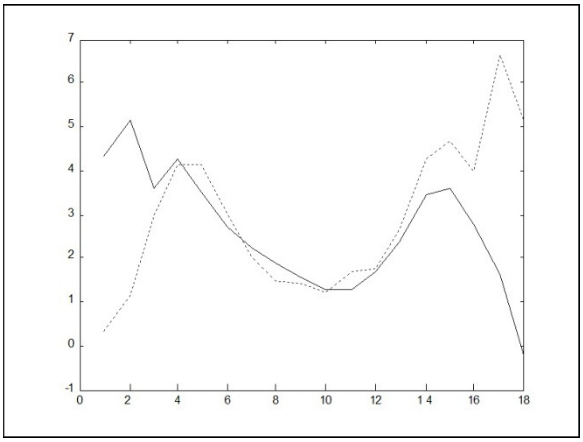

Fig. 4 First-order prediction of the clean data

2.2. Tscherskia triton

Based on the data collected from the period 1982—2001, we tested our model by applying it in the prediction of the capture rate for 2002 and 2003. Fig. 5 shows the zeroth-order prediction of real and prediction data, and Fig. 6 shows the first-order prediction map of real and prediction data. In both cases, the solid lines indicate real data, and the dashed lines indicate prediction data. In Fig. 5, a close similarity of the experimentally collected data can be seen when compared with the computed data. In Fig. 6, such similarity could not be observed. A difference obviously exists between reality and prediction. Nonetheless, this prediction may provide us with some useful information.

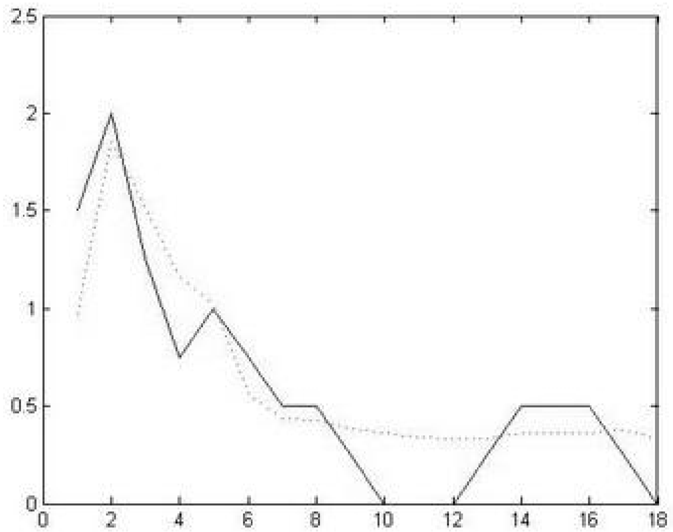

Fig. 5 Zeroth-order prediction of the original data (x-axis: time series; y-axis: capture rate)

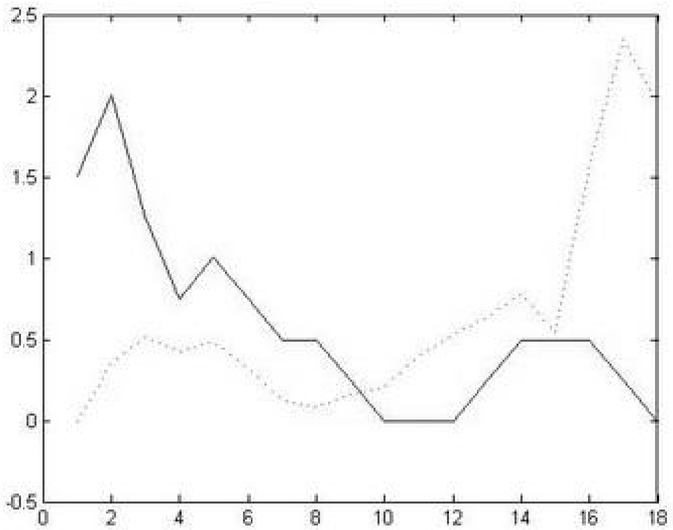

Fig. 6 First-order prediction of the original data (x-axis: time series; y-axis: capture rate)

3. DISCUSSION

Short-term prediction made it possible to predict the dynamic of field animal populations. The simulations performed in this study indicate that zeroth-order prediction can result in accurate estimation, while first-order predictions tend to result in larger errors. Currently, predicting the precise data of the population size of a future population is particularly difficult and even unnecessary. Pursuing an even more accurate prediction model based on more experimental data is, thus, a worthwhile endeavor.

4. REFERENCES

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