

Available online at www.sciencedirect.com



Applied Mathematics Letters

Applied Mathematics Letters 20 (2007) 951-957

www.elsevier.com/locate/aml

Observability and observers in a food web

I. López^{a,*}, M. Gámez^a, S. Molnár^b

^a Department of Statistics and Applied Mathematics, University of Almería, La Cañada de San Urbano sn. 04120-Almería, Spain ^b Institute of Mathematics and Informatics, Szent István University, Gödöllő, Hungary

Received 19 September 2006; accepted 19 September 2006

Abstract

The problem of the possibility of recovering the time-dependent state of a whole population system from the observation of certain components has been studied in earlier publications, in terms of the observability concept of mathematical systems theory. In the present note a method is proposed for effectively calculating the state process. For an illustration an observer system for a simple food web is numerically constructed.

© 2007 Elsevier Ltd. All rights reserved.

Keywords: Lotka-Volterra systems; Observability of nonlinear systems; Observers

1. Introduction

In population ecology and conservation biology we often face the problem of planning an appropriate control of a population system into a desired state. However, before any human intervention we have to know the actual state of the system. In many cases, for technical or/and economical reason we observe (measure) only certain components of the state vector. Then, in a dynamical setting, from the observed components we have to recover the whole state process. The concept of observability of mathematical systems theory can guarantee at a theoretical level that the state process can be determined from the observation in a unique way. However, the corresponding results do not give a constructive method for calculating the state process. In this note we propose the application of a so-called observer system (or for short, observer), which makes it possible to effectively calculate the whole state process, on the basis of the observed (indicator) species, at least asymptotically, near the equilibrium.

A general sufficient condition for the local observability of nonlinear dynamical systems with invariant manifold was developed and applied by [1]. Later, this result became a useful tool in the analysis of different frequency-dependent models of population genetics, evolutionary theory [2–4] and reaction kinetics [5,6]. Observability problems for particular Lotka–Volterra models were considered in [7]. In [8] sufficient conditions to guarantee local observability of a simple trophic chain were obtained.

The design of observers for nonlinear observation systems is a widely studied area of mathematical systems theory, motivated mainly by problems of control engineering. In this note we apply the recent results of [9] to design a local exponential observer for a five-species food web. A numerical illustration is also presented.

* Corresponding author. Tel.: +34 950 015775; fax: +34 950 015167.

E-mail addresses: milopez@ual.es (I. López), mgamez@ual.es (M. Gámez), Molnar.Sandor@gek.szie.hu (S. Molnár).

^{0893-9659/\$ -} see front matter © 2007 Elsevier Ltd. All rights reserved. doi:10.1016/j.aml.2006.09.007