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Feedback control has no influence on the persistent property of a single species discrete model with time delays

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ABSTRACT

By developing some new analysis technique, we show that the following discrete single species model with feedback control and time delays is permanent.

$$\begin{cases} N(n+1) = N(n)\exp\left\{r(n)\left[1 - \dfrac{N^2(n-m)}{k^2(n)} - c(n)u(n-\eta)\right]\right\}, \\ \Delta u(n) = -a(n)u(n) + b(n)N(n-\sigma), \end{cases}$$

where $N(n)$ is the density of species, $u(n)$ is the control variable, Δ is the first-order forward difference operator $\Delta u(n) = u(n+1) - u(n)$. m, σ, η are all nonnegative integers and $r(n), a(n), k(n), c(n), b(n), d(n)$ are bounded nonnegative sequences. Our result shows that feedback control has no influence on the persistent property of the system.

1. Introduction

Gopalsamy [1] considered the following feedback single species system of differential equations with delays

$$\begin{cases} \dfrac{dN(t)}{dt} = rN(t)\left[1 - \dfrac{N^2(t-\tau)}{k^2} - cu(t)\right], \\ \dfrac{du(t)}{dt} = -au(t) + bN(t-\tau), \end{cases} \tag{1.1}$$

where $r, k, a, b, c \in (0, +\infty)$. In the theory of mathematical biology, system (1.1) is a famous feedback control model. K. Gopalsamy thought it was valuable to derive sufficient conditions for the global asymptotic stability of the equilibrium of system (1.1).

Fan et al. [2] generalized the above system to the nonautonomous periodic case, that is, they considered the following periodic feedback single species system of differential equations with delays:

$$\begin{cases} \dfrac{dN(t)}{dt} = r(t)N(t)\left[1 - \dfrac{N^2(t-\tau(t))}{k^2(t)} - c(t)u(t-\delta(t))\right], \\ \dfrac{du(t)}{dt} = -a(t)u(t) + b(t)N(t-\tau(t)), \end{cases} \tag{1.2}$$

where $\tau, \delta, a, b, c, r, k \in C(R, (0, +\infty))$ are ω-periodic functions. The assumption of periodicity of the parameters $a(t), b(t), c(t), k(t), r(t)$ is a way of incorporating the periodicity of the environment (e.g. seasonal effects of weather

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