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# Different delays-induced regime shifts in a stochastic insect outbreak dynamics

Jiakui Zeng[1], Chunhua Zeng[1,2]*, Qingshuang Xie[1], Lin Guan[1], Xiaohui Dong[1], and Fengzao Yang[1]

[1] Faculty of Science, Kunming University of Science and Technology, Kunming 650500, Yunnan, P.R. China

[2] State Key Laboratory of Complex Nonferrous Metal Resources Clean Utilization, Kunming University of Science and Technology, Kunming 650093, Yunnan, P.R. China

**Abstract:** Considering time delays in the deterministic and stochastic forces, we construct stochastic delayed differential equations to investigate the regime shifts in an insect ecosystem. The stationary probability distribution (SPD) and mean first passage time (MFPT) are obtained, respectively. Our main results show: (i) The multiplicative noise, positive cross-correlation noise between two noises and time delays can induce the regime shifts from the boom outbreak state to the bust one, but the additive noise and negative cross-correlation can induce the regime shifts from the bust outbreak state to the boom one; (ii) For the negative cross-correlation, the MFPT as a function of noise strengths exhibits one maximum , at which shows the characteristic of the noise-delayed switching for the boom outbreak state, but for the no cross-correlation or positive cross-correlation, the MFPT decreases with the noise strengths; (iii) Two different types of time delays play same roles on the maximal MFPT with additive noise, and play opposite roles on the maximal MFPT with multiplicative noise. The mechanisms for noises-and delays-induced regime shifts between two states can be explained physically through the effective potential of ecological model.

**Key words:** noises; time delays; SPD; MFPT; insect outbreak dynamics

*e-mail: zchh2009@126.com