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Social behavior-induced multistability in minimal competitive ecosystems

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Abstract

Mimimal models of coordinated behavior of populations living in the same environment are introduced for the cases when they either both gain by mutual interactions, or one hunts the other one, or finally when they compete with each other. The equilibria of the systems are analysed, showing that in some cases the populations may both disappear. Coexistence leads to global asymptotic stability for symbiotic populations, or to Hopf bifurcations for predator-prey systems. Finally, a new very interesting phenomenon is discovered in the competition case: tristability may be achieved showing that the principle of competitive exclusion fails in this case. Indeed either one of the competing populations may thrive, but also the case of populations coexistence is allowed, for the same set of parameter values.

Keywords: predator-prey; symbiosis; competitive exclusion; group gathering; tristability; ecosystems.
AMS subject classification: 92D25, 92D40

1 Introduction

In the almost one-century-long history of mathematical modeling of population interactions, mostly their individualistic behavior has been taken into account. Only relatively recently the effect of group defense has been explicitly modeled, [15]. A slightly different concept is herd behavior, introduced in [1]. In this paper we extend it to encompass more general situations. We consider minimal models for two populations whose intermingling may be beneficial to both of them, beneficial for one and detrimental for the other one, or harmful for both of them. The classical models always assume individualistic behavior of each population, see e.g. Part I of [24]. Here, we remove this assumption by rather using the recently introduced concepts for mimicking the herd

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