

Bifurcation analysis to identify the emergence of the Parrondo paradox in the predator-prey dynamical system

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ABSTRACT

We study the possibility of the Parrondo paradox of a predator-prey continuous dynamic system with two types of predators and one type of prey. In the predator-prey interaction, the first predator is harmed by two things: the struggle for food by the second predator against the first predator and the hunting by humans against the first predator. Both factors lead to fewer first predators. Therefore, we combined the two factors detrimental to the first predator so that the number of first predators can still dominate compared to the number of second predators through bifurcation analysis.

The competition between the two types of predators for prey can be seen as a game with both types of predators as players. If the number of predators is getting smaller or leading to extinction due to this competition, the predator is said to lose the game. On the other hand, the number of predators that dominate is displayed to win the game. In game theory, a paradox known as the Parrondo paradox is an incident where we only apply one type of strategy out of several existing methods and then get a loss. But, when these strategies are combined, then we get the win. Through bifurcation analysis, the two parameters that state two things detrimental to the first predator will be varied. Thus, the equilibrium point of the predator-prey system, which is interpreted as a situation where one experience defeats a predator, changes its dynamic (stable to unstable or unstable to stable).

The results indicate that the Parrondo paradox can occur in a predator-prey continuous dynamic system with two types of predators and one type of prey. Both things that are detrimental and can cause the defeat of the first predator can be combined so that victory can be obtained by the first predator. Success is received by the first predator when two things detrimental to the first predator are maintained in the area of $\lambda > 1$ the first positive eigenvalue. Thus, the equilibrium point, interpreted as a situation where the first predator loses, is unstable.

Kata Kunci: Parrondo paradox, predator-prey, bifurcation, continuous dynamic system