

Accepted Manuscript

Predation promotes cooperation in Prisoner's dilemma games

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PII: S0378-4371(18)31186-5
DOI: <https://doi.org/10.1016/j.physa.2018.09.054>
Reference: PHYSA 20115

To appear in: *Physica A*

Received date: 23 July 2017
Revised date: 2 November 2017

Please cite this article as: X. Yang, et al., Predation promotes cooperation in Prisoner's dilemma games, *Physica A* (2018), <https://doi.org/10.1016/j.physa.2018.09.054>

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1 **Predation promotes cooperation in Prisoner's Dilemma Games**

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7 8 **HIGHLIGHTS**

- 9 ◆ We present a model which is added the predation stress in the PDG.
- 10 ◆ Moderate predation stress lead to the increase of the cooperation.
- 11 ◆ Cooperation decreases monotonously with the increasing of the cost-to-benefit ratio.

12

13 **ABSTRACT**

14 The emergence and maintenance of cooperation among selfish individuals is still a fundamental
15 problem in evolutionary biology and social science, and Prisoner's Dilemma game (PDG) is an
16 important metaphor to study the evolution of cooperation. In this paper, we propose a
17 three-dimensional model based on the PDG in which the harsh ecological environment (indicated by
18 predation stress) is considered. Our results show that proper predation stress is a positive factor for
19 the evolution of cooperation. Moderate predation stress lead to the increase of cooperators, but too
20 large predation stress result in the extinction of cooperators. Moreover, we find that the fraction of
21 cooperators decreases monotonously with the increasing of the cost-to-benefit ratio, but increases
22 monotonously with the increasing of encounter probability. These results indicate that our model
23 represents a step towards understanding how the harsh ecological environment can affect the
24 evolution of cooperation.

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26 **Keywords:** Cooperation; Predation stress; Prisoner's dilemma games

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