Project title: Joining or opting out of a dynamic multi-seasonal predator-prey game: Game theoretical analysis of physiologically structured models

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Function: Assistant professor

Collaborators: prof. Frank Thuijsman, prof. dr. ir. Ralf Peeters, dr. Arne Janssen (Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam), prof. Joel S. Brown (Department of Biological Sciences, University of Illinois at Chicago, US), dr. Tom Groot (Koppert Biological Systems)

Proposal: Arthropod predator-prey systems go through seasons differing in the opportunities to survive and reproduce and they usually have a metapopulation structure. Understanding such systems is essential for effective chemical and natural pest control, which is necessary for protecting our plants and trees, by both natural and chemical means. Predator and prey in these systems have two ways to opt out of their interaction: (1) dispersal in space to establish/enter a population elsewhere; (2) dispersal in time (e.g. diapause) to overcome a period of food/prey scarcity or harsh environmental conditions. These decisions cause the individual predator/prey to have no access to food and to temporarily give up reproduction and/or to face a risk of death.

In this proposal we will extend existing models capturing local predator-prey interactions in seasonal environments to allow predator/prey to opt out or join the interaction and experience the consequences for energy expenditure. We will analyze mathematically which decisions are best for the predator and for the prey. We will determine these optimal decisions at all the levels of natural selection, thereby gaining insight into how hierarchical selection levels affect the strategies. Subsequently, we will specify the conditions under which specific strategies are favored by natural selection. These predictions will then serve as hypotheses to be tested against observations in natural arthropod predator-prey systems (from the Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam and from Koppert Biological Systems). In this way, we will develop a rigorous methodology for studying multi-seasonal predator-prey interactions from the perspective of different selection levels and to study the dynamics of inter-seasonal predator-prey systems.

This research will extend the theory of predator-prey metapopulation dynamics in a multi-seasonal setting and will yield a rigorous methodology for studying these predator-prey interactions by taking multiple selection levels into account. Understanding the pests of our plants and trees and their natural enemies will help with designing effective pest control.

Requirements candidate: Highly motivated student with good English communication skills and proactive and resolute attitude, with a master degree in (applied) mathematics (preferably game theory, optimal control or optimization). Knowledge of programming in Matlab and/or Java is an asset.

Keywords: Dynamic noncooperative game theory, optimal control, predator-prey systems, mathematical biology, adaptive dynamics

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Top 5 selected publications:

1. K. Staňková, A. Abate, and M.W. Sabelis, "Irreversible prey diapause as an optimal strategy of a physiologically extended Lotka-Volterra model", in *Journal of Mathematical Biology*, vol. 66, no. 4-5, pp. 767-794, 2013

2. K. Staňková, A. Abate, and M.W. Sabelis, "Intra-seasonal strategies based on energy budgets in a dynamic predator-prey game", in *Annals of International Society of Dynamic Games, Advances in Dynamic Games*, vol. 13, pp. 204-222, Springer, 2013

3. K. Staňková, A. Abate, M.W. Sabelis, J. Buša, and L. You, "Joining or opting out of a Lotka-Volterra game between predators and prey: Does the best strategy depend on modeling energy lost and gained?", in *Interface Focus* (Theme issue of the *Royal Society Interface*), vol. 6, no. 3, 12 pp., 2013

4. K. Staňková, J.A.J. Metz, and J. Johansson, "The adaptive dynamics of life histories: From fitness-returns to selection gradients and Pontryagin's maximum principle", in *Journal of Mathematical Biology*, vol. 72, no. 4, pp. 1125-1152, 2016

5. J.S. Brown and K. Staňková, "Game theory as a conceptual framework for managing insect pests", in *Current Opinion on Insect Science*, vol. 21, pp. 26-32, 2017