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Pattern formation of a predator-prey model with the cost of anti-predator behaviors

We propose and analyse a reaction-diffusion-advection predator-prey model in which we assume that predators move randomly but prey avoid predation by perceiving a repulsion along predator density gradient. Based on recent experimental evidence that anti-predator behaviors alone lead to a 40% reduction on prey reproduction rate, we also incorporate the cost of anti-predator responses into the local reaction terms in the model. Sufficient and necessary conditions of spatial pattern formation are obtained for various functional responses between prey and predators. By mathematical and numerical analyses, we find that small prey sensitivity to predation risk may lead to pattern formation if the Holling type II functional response or the Beddington-DeAngelis functional response is adopted while large cost of anti-predator behaviors homogenises the system by excluding pattern formation. However, the ratio-dependent functional response gives an opposite result where large predator-taxis may lead to pattern formation but small cost of anti-predator behaviors inhibits the emergence of spatial heterogeneous solutions.