An Individual-Based Model to investigate mechanisms underlying functional responses of predators

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An individual-based model that describes predator-prey interactions taking into account both spatial behaviour and demography was built and numerically investigated. The model is based on extremely simple and plausible rules that determine its dynamics. We consider a closed rectangular habitat. The space is continuous and time is discrete. Both prey and predators can move randomly and both are capable of directional movement. For example, being attracted by prey odour, predators can exhibit prey-taxis with taxis velocity being $\mathbf{v}_{t+1} = \kappa\nabla S_t + \nu\mathbf{v}_t$. Here κ is the taxis coefficient of predators, $\nu \in [0; 1]$ is the inertia coefficient, $S_{N,t}$ is the prey odour concentration and ∇S_t is the odour gradient at the position of moving predator. We suppose that the odour of each prey individual is distributed normally. Non-zero ν allows taking account of inertial movement of individuals. Prey also can move directionally avoiding places of predator aggregation. Individuals of both species reproduce and die with fixed probabilities. A prey situated near a predator closer than the radius of individual activity will be eaten with fixed probability. A predator whose average rate of prey consumption is lower than some threshold value cannot reproduce. Hence the model accounts for species extinction due to demographic stochasticity and starvation. Since the model explicitly describes the spatial movement of animals, it can be used for studying the influence of species spatial behaviour on the functional response. We are able to keep track of each individual and of all its characters. In particular, we calculate the predation rate of each individual and assess the averaged value of the predation rate over the whole population (i.e. the functional response of the predator population). We show how different assumptions about individual movements of predators and prey lead to the emergence of various kinds of functional response at the population level.

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