Model description

Here we give a brief description of the event-based simulation program (written in C++, see this repository), that was used to produce figure 1 of our comment to DiNuzzo and Griffen (2020, Proc. R. Soc. B 287: 20201095.). As described in our comment, the purpose of this model is to produce an event-based implementation of the DiNuzzo and Griffen model, which avoids problems associated with the discrete time structure of their model. The model determines how fast populations that differ in their composition of active and inactive individuals reach an ideal and free distribution across patches of different resource abundance, such that the intake rate of all individuals is optimized.

We consider a number of M patches, where each patch holds a resource value that remains constant throughout a simulation run. Resource values are drawn from a uniform distribution ranging from 1.0 – 9.0. As the values are drawn from a continuous distribution, each patch is assigned a unique value, in contrast to the original implementation of DiNuzzo and Griffen which only considers discrete resource values from 1 to 9. The intake rate is modeled in accordance with a standard implementation (type 1 functional response), where individual intake rate on a patch is given by the resource value divided by the number of individuals present.

Individuals are characterized by their current location (the patch that they are on) and their activity level. The activity level describes the rate at which individuals scan the environment and subsequently move to the patch offering them the highest intake rate. Individuals are ideal and free in the sense that they can accurately assess their potential intake rates on all patches and move without constraints to the patch providing the highest intake rate.

We distinguish between active individuals with an activity level a >= 0.5, and inactive individuals with a low activity level b <= 0.5. The population of N individuals is composed of active and inactive individuals in the proportions p and 1 – p, respectively.

The model is event-based. An event corresponds to one movement decision by an individual. We use the Gillespie algorithm (Gillespie 1976) to determine when the next event occurs and which individual makes a movement. An individual is selected for movement with a probability that is based on its activity level compared to the total population. During an event, the chosen individual compares its current intake rate with the potential intake rates it could achieve elsewhere. If its intake rate can be improved, it moves immediately to the optimal patch. Movement ceases when all individuals are optimally distributed.

The simulation stops when all individuals are optimally distributed and the ideal free distribution is reached. We check whether the ideal free distribution (IFD) has been reached every 0.1 time units. For each set of parameters, we run 300 replicates with a randomly initialized landscape and population of individuals.