Genotype pinning in a periodic environment

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Coinvasion in a heterogeneous landscape

What causes invasion pinning (halting) when there is no obvious obstacle (e.g. treeline)?
Competition between preexisting populations can pin, but what about simultaneous invasions?
We modeled a simultaneous coinvasion by competing asexual populations in a spatially periodic environment.
We found competition in coinvasions can pin one population; solo invasion speeds don't predict the "winner".

Model

Deterministic spatiotemporal competition model (Beverton-Holt type)
Two habitat types: 1 and 2
Alternating one-dimensional strings of ℓ_1 type-1 and ℓ_2 type-2 stepping stones
Asexual, diallelic, single locus : A and a confer fitnesses w_{A1}, w_{A2}, w_{a1}, w_{a2} in the two habitats
Both A and a diffuse with same root-mean-squared dispersal length σ

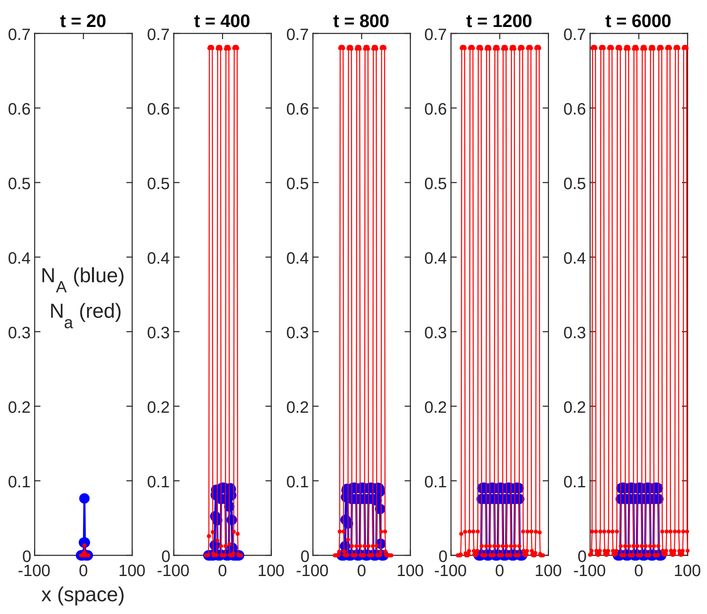
Simulation methods

Start both types in same patch; advance by diffusion alternating with reproduction
Classify outcome for each type as extinction, pinning, or unlimited invasion
Most runs with spacing 1 unit between stepping stones; some with denser grid

Results

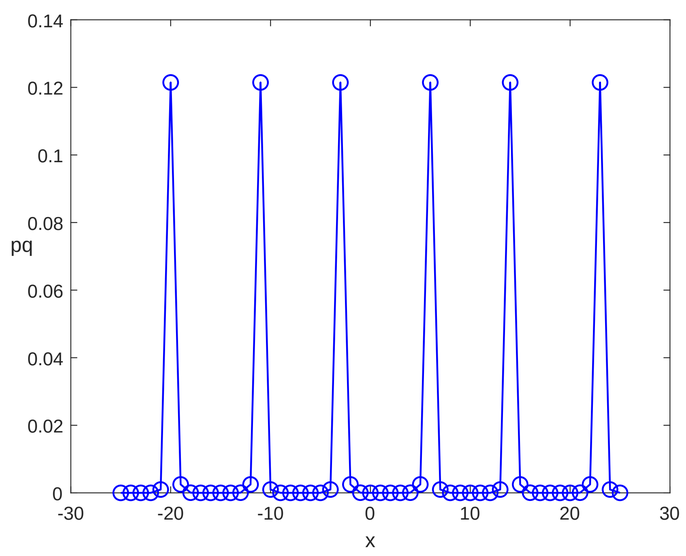
All possible outcome combinations can occur
Local polymorphism can occur with pinning
When one allele is pinned, it can be either the faster or the slower invader in absence of competitor
Pinned allele may spread across multiple strings of stepping stones of different habitat types before stalling
Pinning becomes rarer as the spacing between stepping stones is decreased

Range pinning via competition



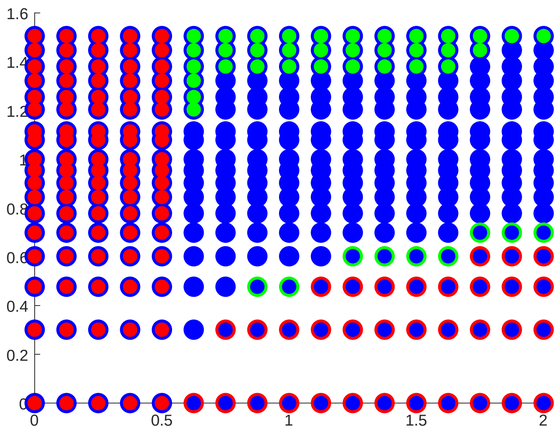
Population densities of A and a individuals after t generations vs. distance from point of introduction. A is pinned.

Polymorphism with pinning



Product $p_A p_a$ near range center once A is pinned and both p_A and p_a have equilibrated.

Paired outcomes



Outcomes for A and a subpopulations vs. intrinsic growth rate of type a in habitat 2 (horizontal axis, log scale) and length of patches of habitat type 1 (vertical axis, log scale) with other parameters fixed. Colors of the outer rings at each point encode outcomes for type A; colors of the inner dot encodes the outcome for type a. Red = extinction; blue = unlimited invasion; green = range pinning.

Conclusions

Competition plus habitat fragmentation gives range pinning in absence of factors (e.g. Allee effect) already known to facilitate pinning.

Local coexistence is compatible with pinning.

Invasion speeds in isolation are poor predictors of the "winner" in a coinvasion.

Degree of fragmentation matters, which points to the need for careful convergence studies before concluding from discretized simulations that a continuous-space model supports pinning.

References

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