Effects of current and historical geography on island biodiversity revealed by an agent-based computer simulation

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Abstract

Oceanic islands continue to pose intriguing study questions, and tools from computer science allow us to approach these classical systems in a novel way. Mechanistic simulations enable researchers to experiment and test theories at large spatial and temporal scale, and thus, can greatly help us to understand the processes behind island biodiversity patterns. We have developed an agent-based computer simulation to study the effects of habitat diversity, archipelago configuration and geological history of Hawaii, Galapagos, Canary Islands, Cape Verde and Azores. Our simulation is spatially explicit, non-neutral and emulates real-world archipelagos, which is a rare combination in island models. We used simplified archipelago maps as a simulation arena and implemented immigration, dispersal, establishment, competition, evolution and disturbance on autonomous agents, which represented populations of different species. We tested how habitat diversity and spatial configuration of archipelagos affected the correlations between simulated and observed plant diversity. We also tested for effects of the geologic history of Hawaii, Galapagos and the Canary Islandson plant, bird and insect biotas. We ran three scenarios for each archipelago: with a static present-day map, with a static Last Glacial Maximum map and with a dynamic map in which island properties changed, mimicking island growth and erosion. We found habitat diversity to be an important factor to achieve realistic simulation results in all five archipelagos, whereas archipelago configuration was important only in the archipelagos with more linear configuration (i.e. Hawaii and Azores). Results also suggest that Last Glacial Maximum geography and geologic history have had a strong effect on plant and insect biodiversity in Hawaii and Galapagos, but less so in the Canary Islands. For birds, we found a universal trend across all archipelagos: present-day geography led to the most realistic simulation results, suggesting that birds as a very dispersive group have already adjusted to the present archipelago geography. The emergent patterns from our simulations suggest that both current and historical geography affect the biodiversity of oceanic archipelagos and that the effects differ among archipelagos and taxonomic groups. We suggest that agent-based simulations are an effective yet underexplored tool for gaining mechanistic knowledge of island biodiversity.

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