

Periodical Cicada Brood Borders are Maintained by Competition and Allee Dynamics

Andrew LIEBHOLD

USDA Forest Service, 180 Canfield St., Morgantown, WV 26505, USA

Richard KARBAN

Department of Entomology, University of California, Davis, Davis, CA 95616, USA

Abstract Periodical cicadas, *Magicicada* spp., exhibit a multitude of remarkable traits. One generation requires either 13 or 17 years for completion. Most of this time is spent in nymphal stages which feed underground on tree roots. Emergence of adults at any one location is synchronized; geographically adjacent populations (referred to as a 'brood') emerge on a single year. While the geographical distribution of broods has been documented on a large scale (county-level records), little is known about their distributions at finer spatial scales. In particular, little is known about the extent to which broods overlap. We conducted a detailed survey at the adjacent margins of brood V (emerged in 1999) and brood VIII (emerged in 2002) in southwestern Pennsylvania. This survey indicated that over most of the area the broods did not overlap, though there was a small area where both broods were sympatric and a larger area where neither brood existed. We used a simulation model to explore the processes that contribute to brood boundary stability. The model combined the inverse density-dependent mortality caused by birds preying on adults and positive density dependent mortality of nymphs caused by competition. The model was parameterized using previously published field data. Simulations indicated that predation caused an Allee effect in which sparse populations always go extinct. Furthermore this Allee effect interacted with the competitive interaction in a way such that the least abundant of any sympatric broods always went extinct. This phenomenon resulted in a type of boundary 'pinning' to reinforce brood boundaries.