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Permanence induced by life-cycle resonances: the periodical cicada problem

Periodical cicadas (*Magicicada* spp.) are known for their unusually long life cycle for insects and their prime periodicity of either 13 or 17 years. One of the explanations for the prime periodicity is that the prime periods are selected to prevent cicadas from resonating with predators with submultiple periods (e.g., see [1,2]). Based on this idea, Webb [3] constructed mathematical models and gave a numerical example that periodically oscillating predators with 2- or 3-year period eliminate nonprime number periodical cicadas. However, in Webb's model, the interaction between well-timed cicada-cohorts and their predators is ignored. In our study, we construct an age-structured model for dynamically interacting predator and prey populations and consider the problem of the predator-resonance hypothesis. Our main result shows that preys are not necessarily eliminated by predators with submultiple periods since invasion of preys is always facilitated by their well-timed cohorts. It is also shown that synchronized life-cycles between predator and prey populations can produce a permanent system, in which no cohorts are missing in both populations. This contrasts with the result that systems with asynchronous life-cycles cannot be permanent. These results suggest that resonances with predators are not always deleterious to their preys.

References

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[3] G. F. Webb: The prime number periodical cicada problem, *Discrete Contin. Dyn. Syst. Ser. B*, (2001), **1**, pp.387–399.