Spatio-Temporal Dynamics

in Synchronized Calling Behavior of Frogs

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Synchronization has been observed in various biological systems; for example, flashing of a firefly swarm and calling of crickets. Moreover, mechanisms to realize such cooperative behavior are mathematically studied, including a phase-oscillator model where each element is assumed to behave periodically and interact with the others.

In this presentation, we focus on talk about frustration phenomena experimentally observed in synchronized advertisement-calls of Japanese tree frogs (Hyla japonica) and its plausible mathematical modeling. While the single male frogs call nearly periodically, they can hear sounds through their eardrums. Therefore, the males can interact by producing and hearing sounds, and calling behavior of several males is understood as a system of coupled phase-oscillators [1, 2, 3].

First, we recorded calling behavior of two male Japanese tree frogs with two microphones, separated sound signals of each frog by independent component analysis (ICA), and confirmed robust call-alternation or almost anti-phase synchronization [1]. Second, we proposed mathematical model with two coupled phase oscillators representing experimental results of call-alternation by two frogs, extended the model to a system of three frogs, and theoretically predicted the occurrence of various synchronization phenomena, such as 1:2 anti-phase synchronization and tri-phase synchronization [2]. Note that calling behavior of three male Japanese tree frogs is frustrated: namely, while almost perfect anti-phase synchronization is robustly observed in a system of two males, three frogs cannot synchronize in anti-phase. Finally, we experimentally investigated spontaneous calling behavior of three frogs and observed various types of synchronized behavior [3].