A Tree Cricket's Tale: Modeling the Evolution of ARTs Using a Continuous Trait-Based Approach

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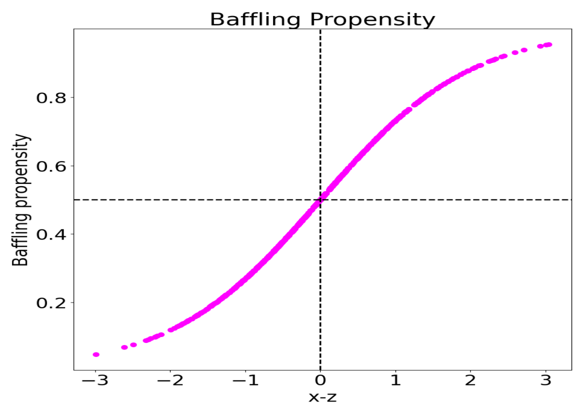
Introduction

Males of the tree cricket species *Oecanthus henryi* produce acoustic mating signals in the form of calls produced by stridulation. Their female counterparts respond to this by performing phonotaxis. Previous work on this model system shows that females preferentially mate for longer duration with louder callers. Interestingly, the males of *Oecanthus henryi* and many other tree cricket species are known to engage in a tool use behavior termed "baffling" in which they call from within self-made holes in leaves. Baffling is known to increase the call SPL by around 10-12dB, essentially allowing the male to appear more attractive and reach a wider audience. We want to look at the evolution of this behavior using a continuous, trait-based approach. We hypothesize the existence of an intrinsic *"baffling threshold (x)"* for *O.henryi* males such that baffling propensity is a function of this intrinsic threshold and the non baffling SPL (z).



Theoretical framework

The Euler-Lotka Equation

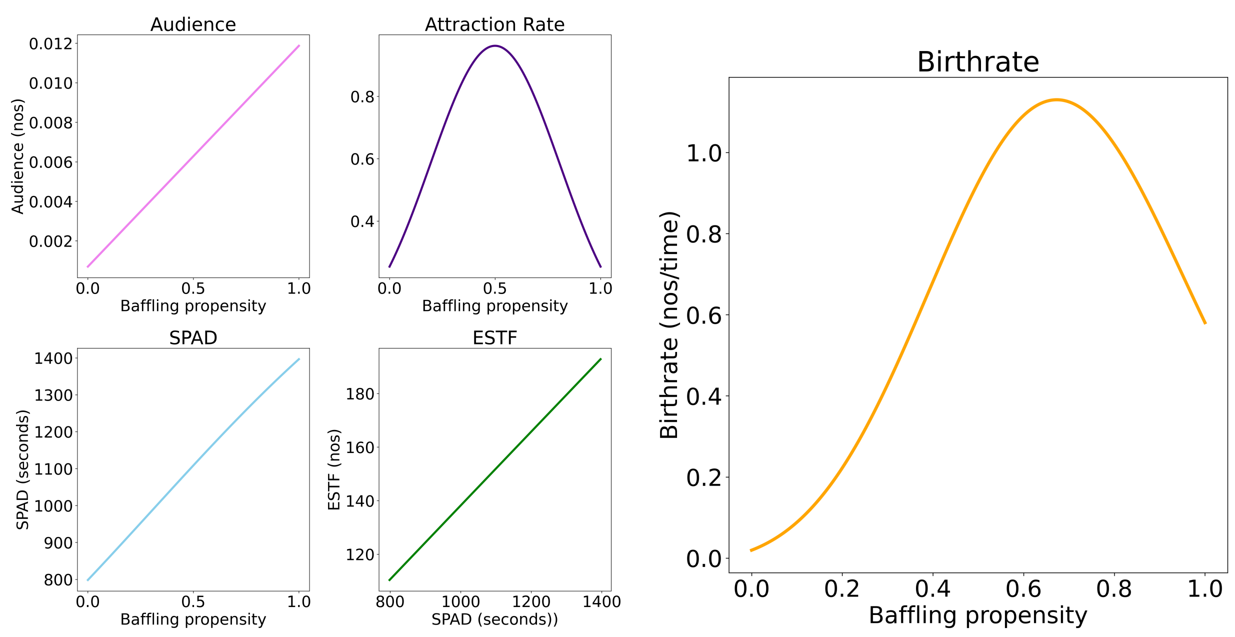
$$1 = \int_0^t e^{-ra} l_a b_a \, da$$

Where b_a and l_a denote the age dependent birthrate and survivorship respectively. Assuming an exponential decay for the survivorship function with the decay rate being a function of baffling propensity, we have;

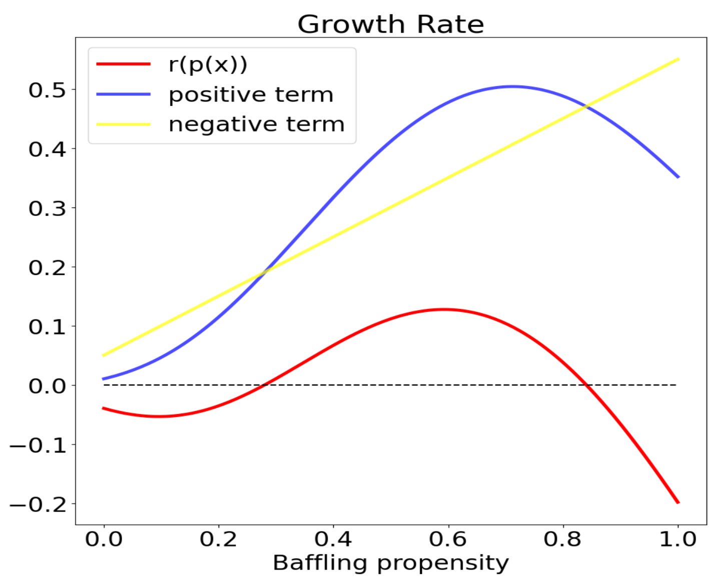
$$r(p(x)) = -d(p(x)) + \frac{1}{\alpha} W\left(\alpha b(p(x)) e^{\alpha(d(p(x)) - \bar{d})}\right)$$

where $p(x)$ denotes the baffling propensity.

Birthrate as a function of baffling propensity



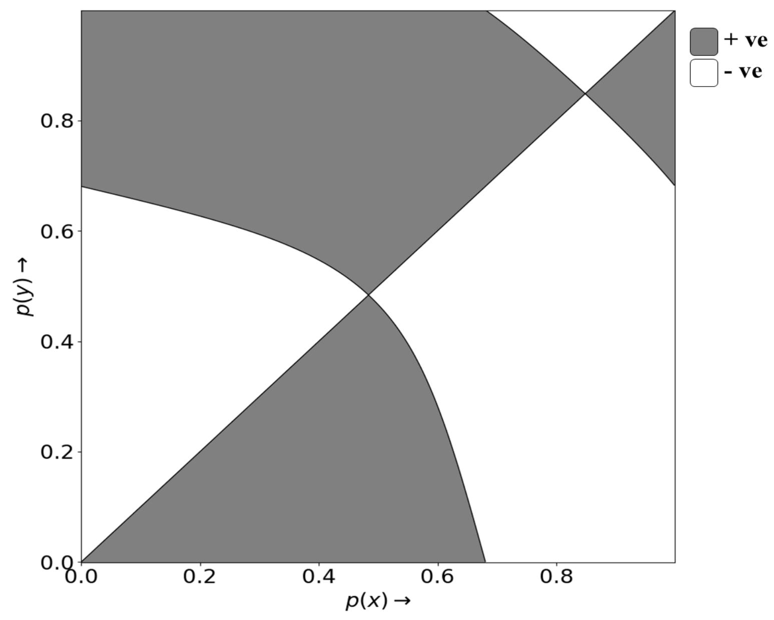
Growth rate and invasion fitness



Invasion fitness of a rare mutant;

$$s_x(y) = r(p(y)) - r(p(x))$$

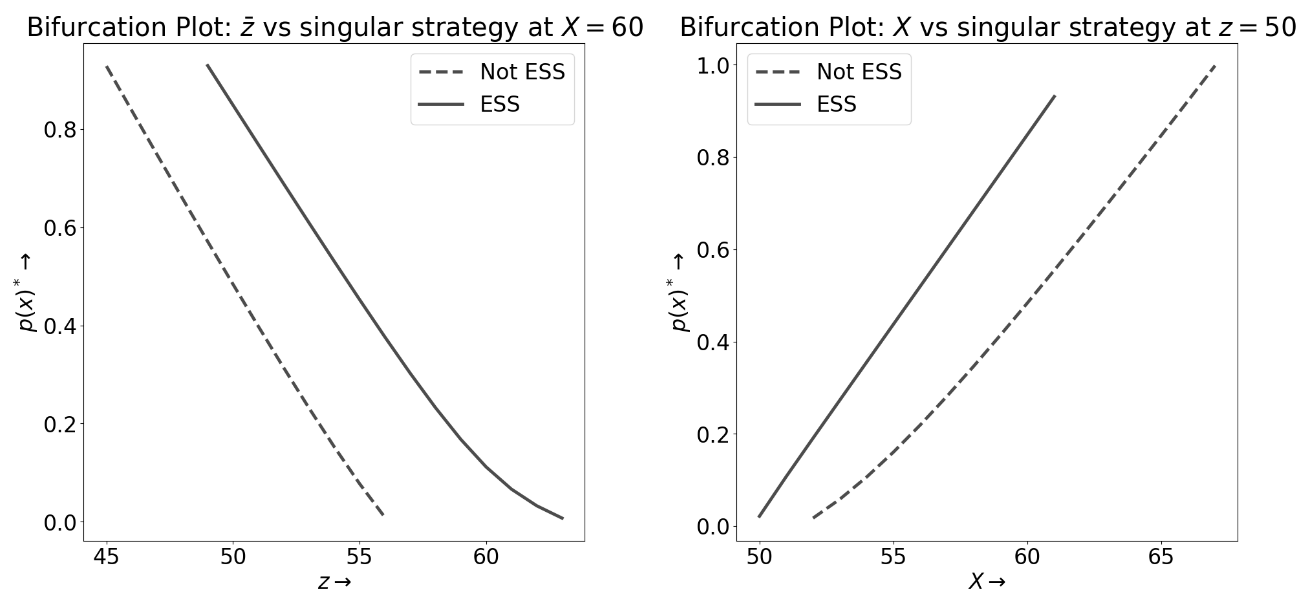
Analysis of fixed points using PIPs



At an ESS singular strategy $p(x)^*$;

$$\left.\frac{\partial s_x(y)}{\partial p(y)}\right|_{p(x)=p(x)^*} = 0 \quad \text{and} \quad \left.\frac{\partial^2 s_x(y)}{\partial p(y)^2}\right|_{p(x)=p(x)^*} < 0$$

Bifurcation diagrams, branching and sympatry



Experiments

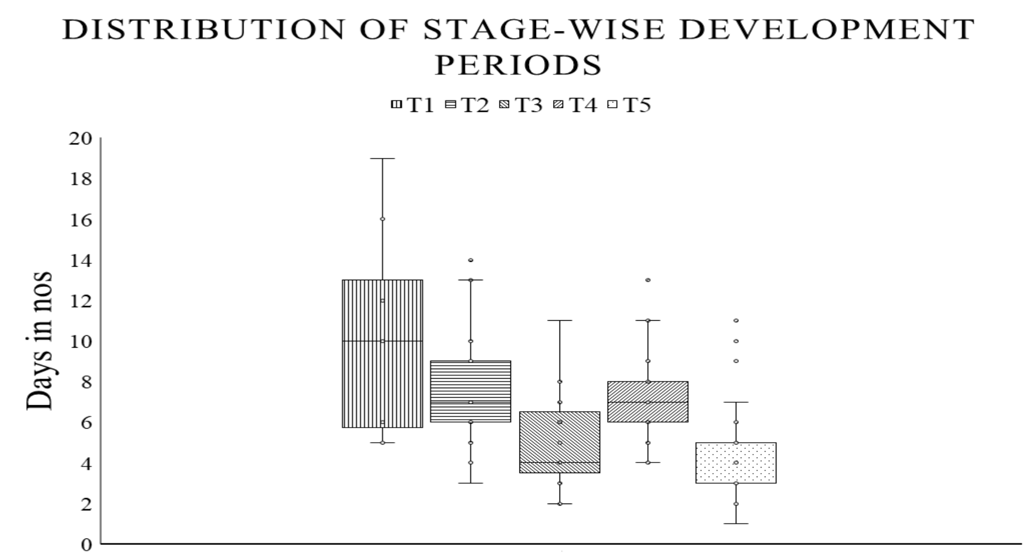


Figure 4. $\bar{T1}$ = 9.9, $\bar{T2}$ = 7.9, $\bar{T3}$ = 4.9, $\bar{T4}$ = 7.1 and $\bar{T5}$ = 4. Where each Ti denotes the time period for transition from $i-1^{th}$ stage to i^{th} stage. Total development time = 33.87 days

Future plans and scope

1. Experimentally obtain female auditory response curve for *O.henryi* and *O.indicus* females and compare. Test model predictions.
2. Derive a better approximation for the fitness function
3. Incorporate a simple population genetics model into the framework

Glossary

Baffling propensity ($p(x)$)	Proportion of baffle making events out of total number of calling events
Baffling threshold (x)	The hypothetical SPL value, such that if $z > x$, $p(x) < 0.5$ $z < x$, $p(x) > 0.5$. If $z = x$, $p(x) = 0.5$
Non-baffling SPL (z)	The natural loudness of a male cricket
SPAD	Spermatophore Attachment Duration
ESTF	Effective Sperm Transfer Function
X	SPL value where the *Attraction rate* peak occurs