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


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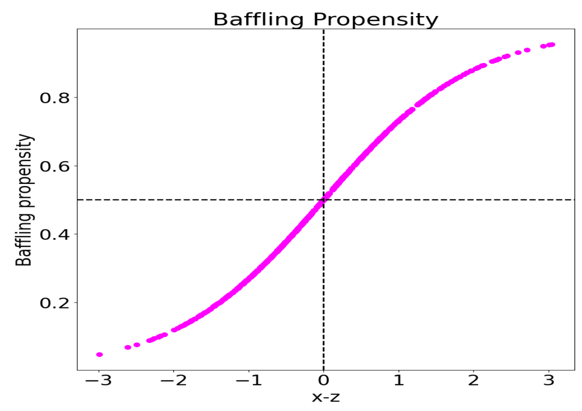
## Introduction

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 [1]. Previous work on this model system shows that females preferentially mate for longer duration with louder callers [2]. 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 15dB, 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 [3, 4]. 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

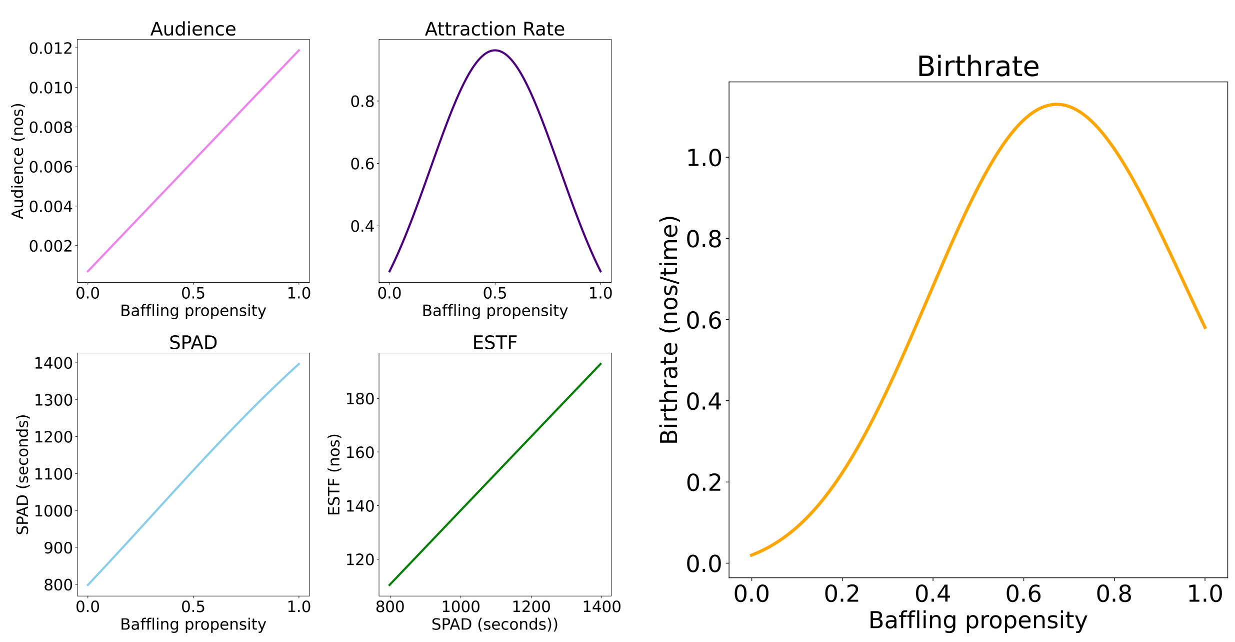
$$1 = \int_0^t e^{-ra} l_a b_a \, da$$

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;

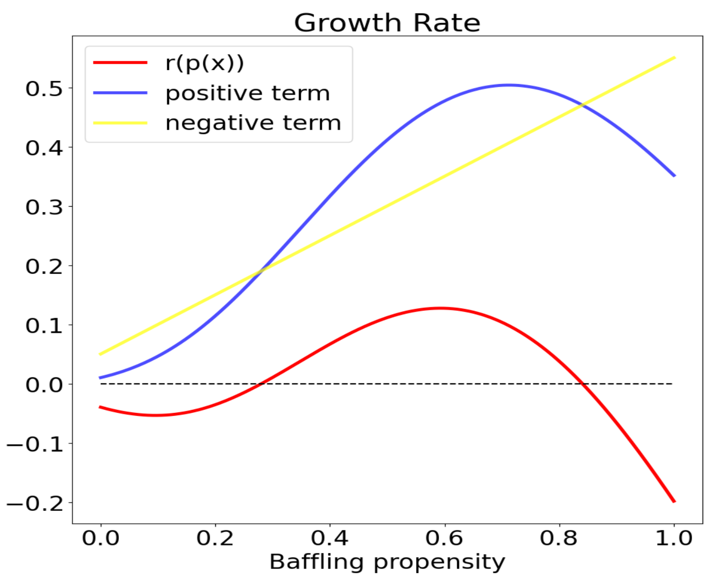
$$r(p(x)) = -d(p(x)) + \frac{1}{\alpha} W\left(\alpha b(p(x)) e^{\alpha(d(p(x)) - \bar{d})}\right)$$

where $p(x)$ denotes the baffling propensity [5].

## Birthrate as a function of baffling propensity



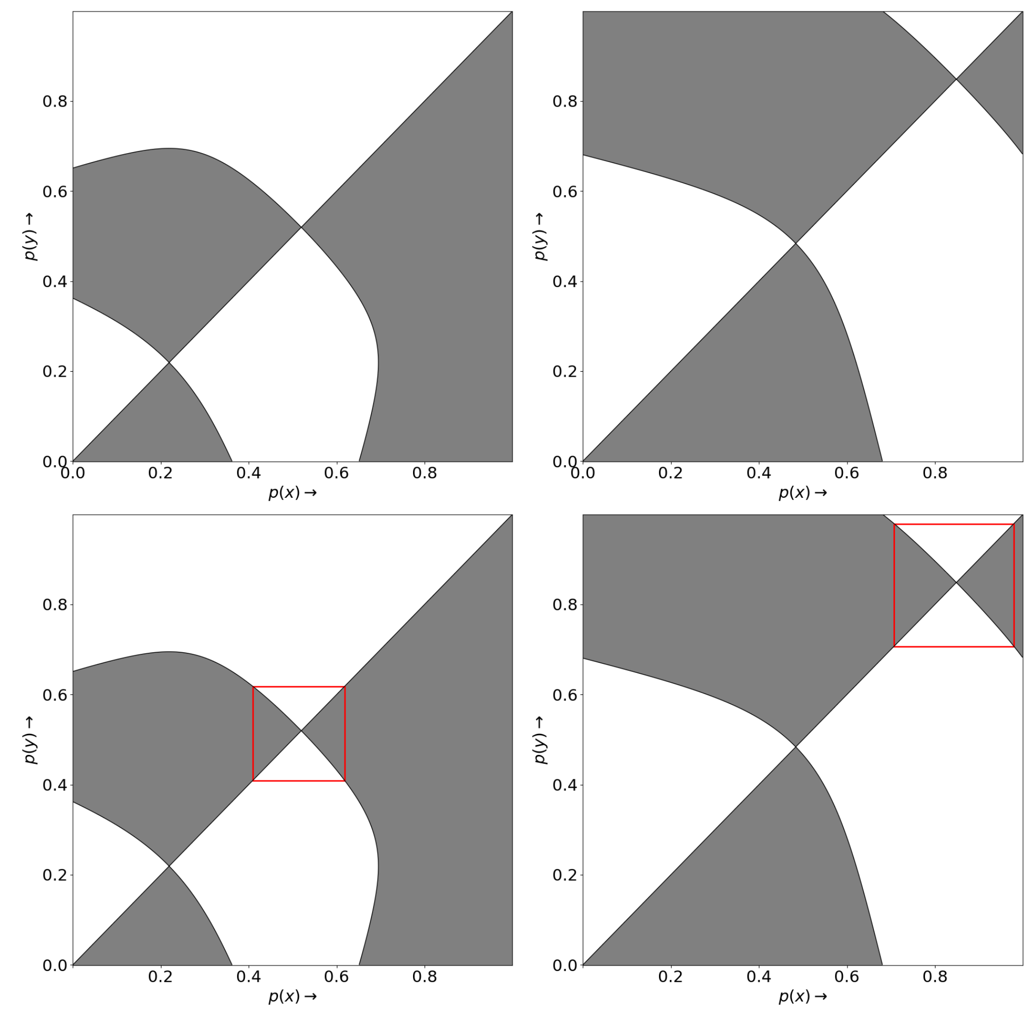

## Growth rate and invasion fitness




Invasion fitness of a rare mutant;

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

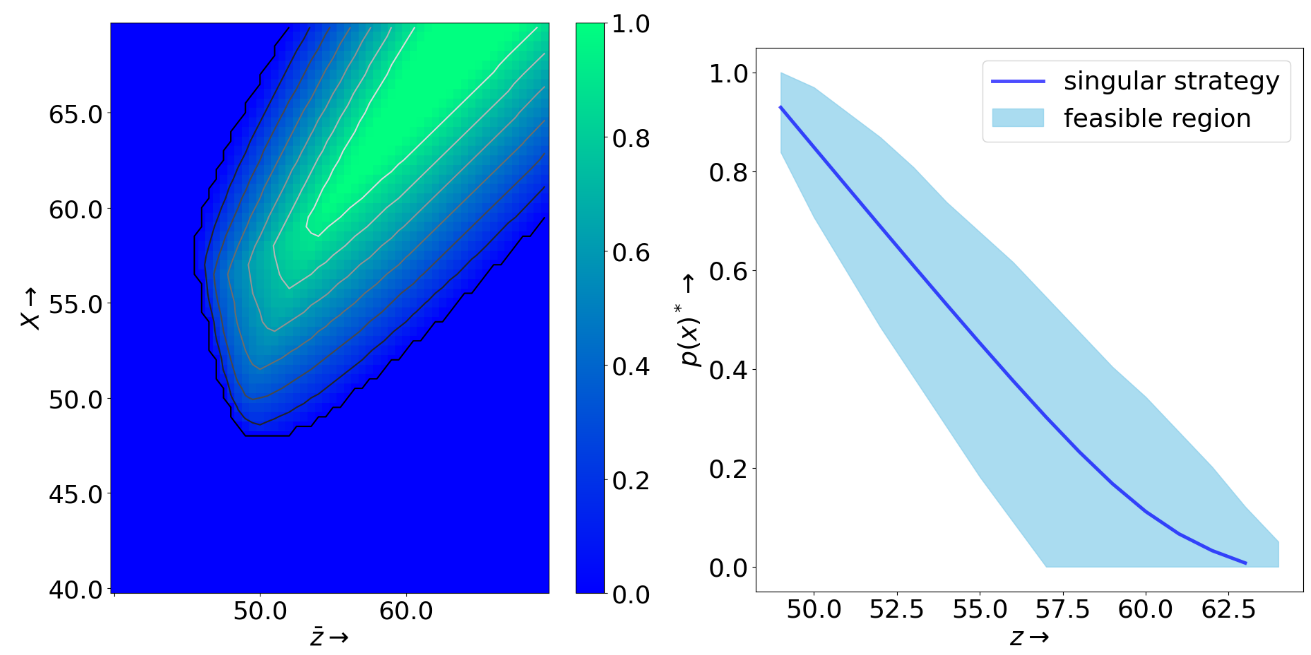
## Analysis of fixed points using PIPs [6]




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

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

## Feasible regions and singular strategies




## Future plans and scope

1. Experimentally validate/obtain or parameterize the baffling propensity, mortality, attraction and sperm transfer functions.
2. Perform non-linear averaging over the distribution of $z$ values to obtain the average growth rate for a population of males (if not possible, obtain a better approximation).
3. Analyze how the evolutionary dynamics changes as we change the class of function describing the mortality rate increment due to baffling.

## Glossary

| | |
|---|---|
| Baffling propensity | Proportion of baffle making events out of total number of calling events |
| Baffling threshold | The hypothetical SPL value, such that a non-baffling SPL above it predisposes a male to baffle with a probability greater than random chance (0.5) |
| SPAD | Spermatophore Attachment Duration |
| ESTF | Effective Sperm Transfer Function |
| $X$ | SPL value where the *Attraction rate* peak occurs |

## References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