A Tree Cricket's Tale: Modelling Alternative Reproductive Tactics as Evolutionarily Stable Strategies in a Communication Game

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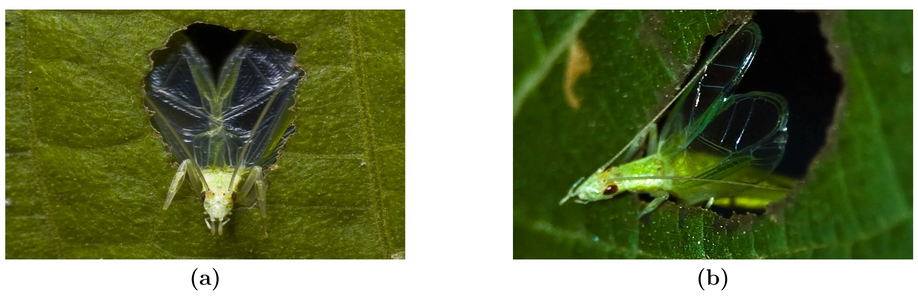
Introduction

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 (moving towards the sound source) [1]. Previous work on this model system shows that females preferentially mate for longer duration with louder callers [2]. We hypothesize that females are using call SPL (the signal) as a proxy for the males physiological energy state; since calling is a very energy expensive process for crickets.

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 (figure 1).



(a) (b)

Figure 1: Baffling *O.henryi* males. *(Photo credits: - (a) Natasha Mhatre, University of Bristol & (b) Rittik Deb, NISER)*

Baffling is known to increase the call SPL by around 15dB, essentially advertising a false, artificially enhanced signal to the surrounding females. **We want to look at this behavior as a cheating strategy in the context of a communication game [3] between males and females.**

What we know and hypothesize

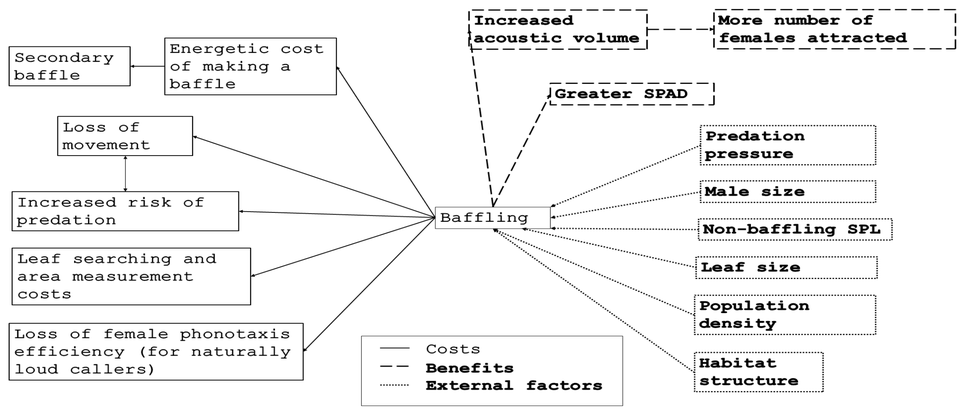
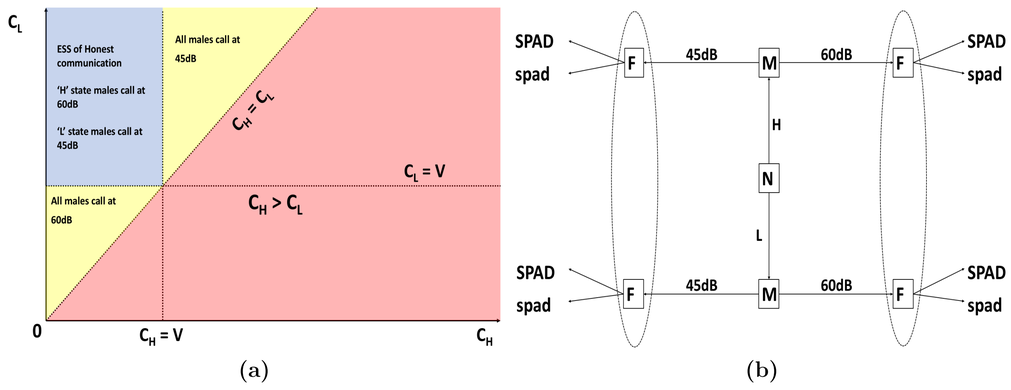


Figure 2: Some of the costs, benefits and external factors that are known/hypothesized to affect baffling behavior in *O.henryi*

An Honest World

Under conditions where baffling as a strategy is not present, modeling of the communication between males and females as a simple discrete game (adapted from [4]) shows the expected ESS of honest signaling.

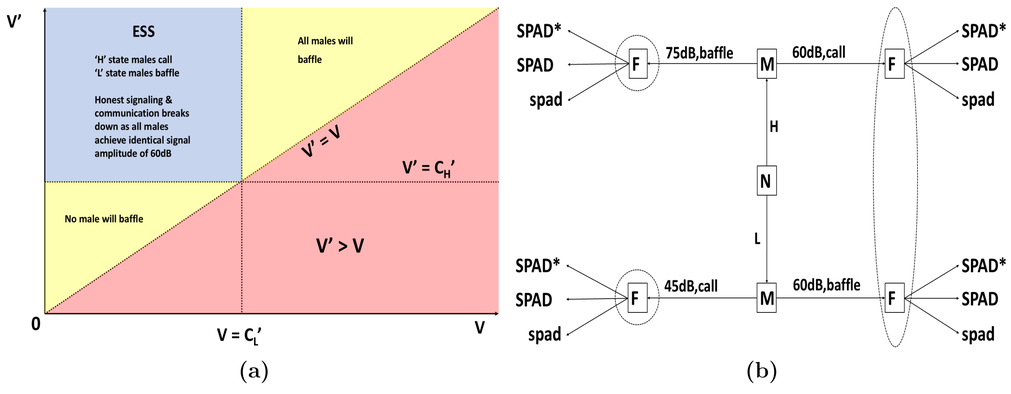


(a) (b)

Figure 3: (a) A 2D phase plot showing the different states of the game as a function of marginal costs C_H and C_L, (b) The game in its extensive form [4].

The ART of Baffling as a cheating tactic: Case I

In the presence of baffling as an alternative, cheating tactic, and under the assumption $C'_H > C_H$ and $C'_L < C_L$, we find an ESS state where naturally loud callers edge call, whereas soft callers baffle.

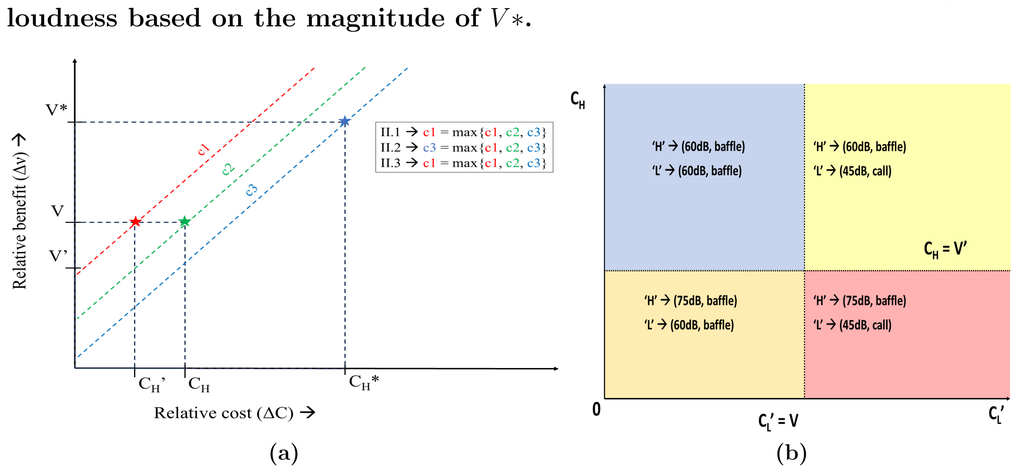


(a) (b)

Figure 4: (a) A 2D phase plot showing the different states of the game as a function of marginal benefits V and V' and marginal costs C'_H and C'_L, (b) The game in its extensive form [4].

The ART of Baffling as a cheating tactic: Case II

Under the assumption that $C'_H < C_H$ and $C'_L < C_L$, we find that the ESS for loud and small callers is to baffle. Loud callers will choose to baffle at a higher or lower loudness based on the magnitude of $V*$.

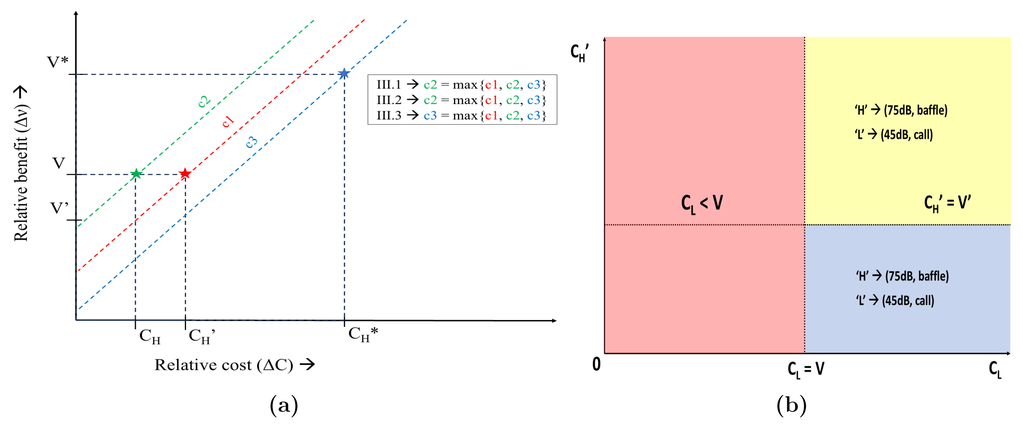


(a) (b)

Figure 5: (a)Plot showing the cost vs benefit slopes for the various possible strategies available to high energy males. Legend on the top right indicates the y-intercept value of the 45^o line incident on the ESS strategy for the separate sub-cases, (b) Phase plot depicting the states of the game as a function of the marginal costs C_H and C'_L and marginal benefits V and V'.

The ART of Baffling as a cheating tactic: Case III

Under the assumption that $C'_H > C_H$ and $C'_L > C_L$, we find either an ESS of honest signaling or exclusive baffling by loud callers.



(a) (b)

Figure 6: (a)Plot showing the cost vs benefit slopes for the various possible strategies available to high energy males. Legend on the top right indicates the y-intercept value of the 45^o line incident on the ESS strategy for the separate sub-cases. (b) Phase plot depicting the states of the game as a function of the marginal costs C'_H and C_L and marginal benefits V and V'.

A Sequential Game

Modeling this interaction as a sequential game between males-nature-females, we find dependence of the ESS on the density of females in the environment.

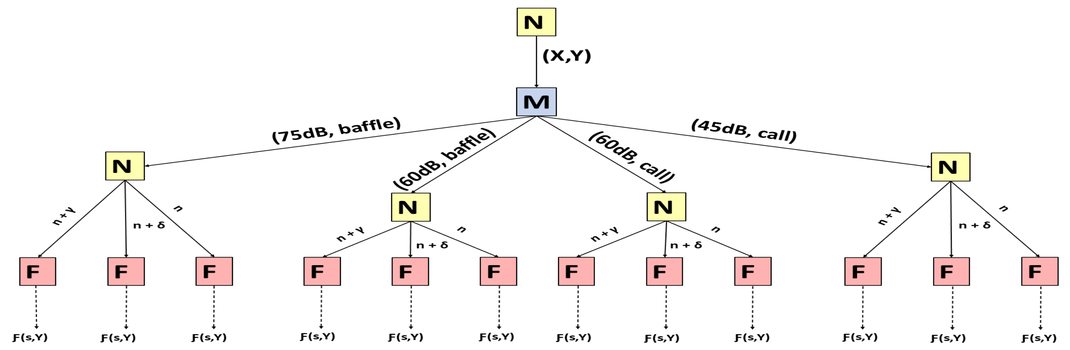


Figure 7: Schematic depicting a general branch of the extensive form of a sequential game between males, nature and females.

z	45dB, call	60dB, call	60dB, baffle	75dB, baffle
(H,X)	—	$d < \frac{C'_H}{denom(H,X)}$, $C'_H > C_H$	$d < \frac{C_H}{denom(H,X)}$, $C'_H < C_H$	$d > \max\left\{\frac{C'_H}{denom(H,X)}, \frac{C_H}{denom(H,X)}\right\}$
(L,X)	$d < \frac{C'_L}{denom(L,X)}$	—	$d > \frac{C'_L}{denom(L,X)}$	—

$$denom(H,X) = V_{45}\{f((SPAD*,X)) - f((SPAD,X))\} + \Delta V_2 f((SPAD*,X)) - \Delta V_1 f((SPAD,X))$$

$$denom(L,X) = f((SPAD,X)) - f((spad,X))\} + \Delta V_1 f((SPAD,B))$$

References

[1] T. G. Forrest, "Acoustic Communication and Baffling Behaviors of Crickets," *The Florida Entomologist*, vol. 65, no. 1, p. 33, Mar. 1982.

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