Predicting the response of *Cirsium pitcheri*, an endangered thistle, to insect seed predation using evolutionary game theory

Helena Puche and Joel S. Brown
Department of Biological Sciences, University of Illinois at Chicago, Illinois

METHODS: GAME THEORY IN ACTION

Following Brown and Venable’s (1991) approach to modeling seed predation as a game, we let annual fitness or expected number of seed progeny (S) be the product of seed production (S) and seed survival from predation (m). We let seed-size (u) be an evolutionary strategy where both thistle species can be viewed as existing on a continuum of seed-size strategies. In particular, using a fitness generating function (G (u, v, s)) we let the seed size of the focal individual (v) influence both seed set, S (u, y, v), and survival from predation, m (v), and let the seed size of other plants influence the focal plant’s seed set via seedling competition.

\[
G = C_v \cdot R \cdot m
\]

Ecological model \rightarrow \text{Evolutionary Game}

\[
G(u, v) = \frac{C_v}{R} \cdot m(v)
\]

Let u be seed size, \( u = (u_1, ..., u_n) \)

v be seed size of a focal individual.

b(u) be seedling size based on \( u, b(u) = u - 0.08 \)

\( C_v \) be seedling size of a focal individual.

b(v) = v - 0.08

C(v) = a rate (1/v) of converting the used portion of R, an available resource, into \( S(u, v), seed set \).

n = number of competitive species.

x_i = number of competitive species.

m(v) = fraction of seeds that survived predation.

We tested (see Fig. 1) safety in size: \( m(v) = \gamma (1 + \gamma - 1 - e^{\gamma - 0.08}) \)

danger in size: \( m(v) = 0.08 \gamma \)

where \( \gamma \) was minimum survival, \( \gamma = 0.08 \)

RESULTS

An evolutionary stable strategy (ESS): i.e., that strategy that allows a species to resist invasion, occurs when fitness is maximized by the focal individual (v) using the seed size of others in the population. These strategies are shown as adaptive landscapes (Fig. 2). The higher on the adaptive landscape, the higher invasive potential.

CONCLUSIONS

A. When NO predation occurs, native outcompetes the invasive.

B. When predation occurs,

- If it is safe to have a big seed (red), native outcompetes the invasive; no strong selection for a particular seed size; seed sizes drift over a wide range with similar seed sets.

- If it is dangerous to have a big seed (green), the small seeded invasive: 1) if at its ESS peak, outcompetes the native. 2) if same seed set, coexists with native. 3) if environmental pressure selects for bigger seeds, invasive outcompetes native but seed set will decrease due to high intra- and inter-specific competition.

FUTURE STUDIES ...

- Parameterize the model using empirical data.
- Apply this model to other plant systems.

LITERATURE CITED


CONTACT INFORMATION

Biological Sciences, University of Illinois