Are the prey- and ratio-dependent functional responses really extremes along a continuum of predator interference?

\[ f(N) \rightarrow f(N/P) \]

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What is Predator Interference?

• Reduction in the per capita consumption rate as predator abundance increases

• Potential mechanisms:
  – Time lost bumping into and “handling” other predators
  – Resource “sharing” over longer intervals of feeding reduces overall consumption rate
Holling Type II: Per Capita Consumption Rate of Predators vs. Prey Abundance
Holling Type II:

Per Capita Consumption Rate of Predators

Predator Abundance
Predator Interference is Real

(Salt 1974)
Competing Functional Responses

Where $N$ is prey density and $P$ is predator density

$f(N)$

Holling Type II
“prey dependent”

increasing predator interference

$f(N/P)$

Arditi-Ginzburg
“ratio dependent”

Where $N$ is prey density and $P$ is predator density
Where \( N \) is prey density and \( P \) is predator density

\[
f(N)
\]
Holling Type II
“prey dependent”

\[
f(N/P^m)
\]
Hassell-Varley-Holling
“predator dependent”

\[
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Where $N$ is prey density and $P$ is predator density

$f(N)$
Holling Type II
“prey dependent”

$f(N, iP)$
Beddington-DeAngelis
“predator dependent”

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Where $N$ is prey density and $P$ is predator density
Does it matter which form of predator interference is used?
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\[ f \left( \frac{N}{P^m} \right) \]

Hassell-Varley-Holling Functional Response for constant prey, increasing predator at various interference.
Does it matter which form of predator interference is used?

\[ f \left( \frac{N}{P^m} \right) \quad f \left( N, iP \right) \]

Beddington-DeAngelis Functional Response for constant prey, increasing predator

Hassell-Varley-Holling Functional Response for constant prey, increasing predator
### Stability Properties of the Extreme Models:

<table>
<thead>
<tr>
<th>Change in Parameter</th>
<th>Prey-Dependent Outcome</th>
<th>Ratio-Dependent Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a \uparrow$ (searching efficiency)</td>
<td>Prey Extinction</td>
<td>Prey Extinction</td>
</tr>
<tr>
<td>$K \uparrow$ (carrying capacity)</td>
<td>Prey Extinction</td>
<td><em>no change</em></td>
</tr>
<tr>
<td>$r \uparrow$ (prey growth rate)</td>
<td><em>no change</em></td>
<td>Prey Persistence</td>
</tr>
<tr>
<td>$d \uparrow$ (pred. death rate)</td>
<td>Prey Persistence</td>
<td>Prey Persistence</td>
</tr>
<tr>
<td>$e \uparrow$ (conversion eff.)</td>
<td>Prey Extinction</td>
<td>Prey Extinction</td>
</tr>
<tr>
<td>$h \uparrow$ (handling time)</td>
<td>Prey Persistence</td>
<td>Prey Persistence</td>
</tr>
</tbody>
</table>
The Simulations:

1. Numerical approximations of differential equations using Populus Software
2. Designed to mimic behaviors of *Didinium-Paramecium* system (parameter values from Harrison 1995)
3. Qualitative outcomes explored over a range of *r/K* values (as planned for my experiments)
4. Parameters $r$ and $K$ linked
5. Non-deterministic criterion for extinction employed
Hassell-Varley-Holling: \( f \left( \frac{N}{P^m} \right) \)
Beddington-DeAngelis: $f(N, iP)$
Beddington-DeAngelis: \( f(N, iP) \)
Competing Functional Responses

Where $N$ is prey density and $P$ is predator density

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The *Paramecium-Didinium* system:

- *Paramecium caudatum*
- *Didinium nasutum*

Meets major assumptions of simple predator-prey models:
- Closed system
- Can be maintained without heterogeneities/refugia
- Single prey/single obligate predator
- Prey food can be delivered as semi-continuous input
Answers via Experiment:

• What is the magnitude of predator interference?
  – Direct measurement of consumption rate over a range of predator densities
  – Curve fitting to HVH and BD models

• Which model should be used?
  – Microcosm experiments designed to explore the $r/K$ continuum
  – Detection of characteristic extinction events: low $r$, high $K$
Acknowledgements:

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Non-deterministic Predator Extinction
Non-deterministic Dual Extinction
Non-deterministic Extinction Criterion:

- $P$ and $N$ values represent densities of prey per volume.
- In a finite system, a fraction of an individual cannot exist. Threshold extinction density is 1 individual per system.
- Threshold extinction as individuals per volume:

\[
\frac{\text{Individuals}}{\text{Volume}} = \frac{\text{Individuals}}{\text{System}} \cdot \frac{\text{System}}{\text{Volume}}
\]