Indirect effects affects ecosystem dynamics

The effect of non-lethal effects in planktonic community

Alessandra Lütz; Garcia Guillerme, Maikol Rodriguez, Thiago Couto, Caio Graciani, Angel Segura
Biodiversity
Energy flow

Ecosystem functioning
Energy fluxes
Trophic models

The interaction between predation and competition

Peter Chesson & Jessica J. Kuang
Vol 456 13 November 2008 doi:10.1038/nature07248
Energy flow

Being eaten (predation)
Change in prey abundance and traits
Modify community dynamics

The interaction between predation and competition

Peter Chesson & Jessica J. Kuang
Vol 456 | 13 November 2008 | doi:10.1038/nature07248
Non Consumable Effects (NCE)

Trait-mediated indirect effects (TMI)

Do not imply **biomass** removal

Trait variation: Phenotypic (size), behaviour (diel migration), etc
NCE effects

Inducible defenses

Predators

Focal species

Resources

TMI
Non Consumable Effects (NCE)

Trait-mediated indirect effects (TMI)
Not new (Science 1971)

Allelochemics: Chemical Interactions between Species

Chemical agents are of major significance in the adaptation of species and organization of communities.

R. H. Whittaker and P. P. Feeny
How relevant are NCEs to community dynamics?
NCE are relevant for predator-prey dynamics

Small experimental systems

Relevant (Significative change)

Planktonic

Chemical cues induce consumer-specific defenses in a bloom-forming marine phytoplankton

Jeremy D. Long*†, Gabriela W. Smalley*‡, Todd Barsby*§, Jon T. Anderson*¶, and Mark E. Hay*‖
Plankton dynamics

Microbial primary producers
Cells or colonies
Hundreds of species
Carbon sinking

Fast generation time (days)
Easy to handle
Large size range
Plankton dynamics

Toxic blooms
Ecosystems integrity
Biodiversity loss
Human
NCE in plankton
Widely recognized

The effect of substances from different zooplankton species and fish on the induction of defensive morphology in the green alga *Scenedesmus obliquus*

MIQUEL LÜRLING*
JOURNAL OF PLANKTON RESEARCH | VOLUME 25 | NUMBER 1
Seldomly taken into account

Few models include explicitly its effects

Long term dynamics of this effect unexplored
Are NCE effects important for community dynamics?
Hypothesis: Inducible defenses modify community dynamics because of changes in biomass fluxes mediated by NCE.

Objective
Analyze community dynamics when species shown inducible defenses behavior.
Planktonic systems

Lots of information on basic physiology

Morphology based functional groups

Nutrient (P limited)
Planktonic systems

Lots of information on basic physiology
Morphology based functional groups
Nutrient (P limited)

Kruk et al., 2010
How to ensemble the “system”?

Predator- “Daphnia”
Limiting resource- Phosporus
Competing species
How to ensemble the “system”? 

Predator- “Daphnia”
Limiting resource- *Phosporus*
Competing species
Explicit competition
How to ensamble the “system”?

Predator- “Daphnia”
Limiting resource- Phosphorus
Competing species
Explicit competition
What if NCE?

Change for I to VII in the presence of Daphnia
Lets put some maths!

Change for I to VII in the presence of Daphnia (m)

\[
\begin{align*}
\dot{G} &= a_g GP - u_g GZ + mCZ \\
\dot{C} &= a_c CP - u_c CZ - mCZ \\
\dot{Z} &= - eZ + u_g GZ - u_c CZ \\
\dot{P} &= eZ - a_g GP - a_c CP
\end{align*}
\]
How does system behaves?

Change for I to VII in the presence of Daphnia (m)

\[
\dot{G} = a_g GP - u_g GZ + mCZ \\
\dot{C} = a_c CP - u_c CZ - mCZ \\
\dot{Z} = -eZ + u_g GZ - u_c CZ \\
\dot{P} = eZ - a_g GP - a_c CP
\]
Changes in the fixed points

$M=0$ (Exclusion)  
$C$ or $G > 0$

$m=0.4$ (Coexistence)  
$C, G, Z, P > 0$
Sustained oscillations
Implications for biodiversity

m=0 (Exclusion G)  m=0.4 (Coexistence)
What about nature?

Coexistence-peaks

What about nature?

Coexistence-peaks
NCEs are important

Non trivial effect (Peacor et al 2012)

Influence dominance and coexistence

Explored in a mechanistic models based on physiological principles (first time)
NCEs are important

No data to compare with model output

Design of experiments for model evaluation and biological parameters

Mathemathical tools (topological aspects)
\[ \dot{G} = G \left[ \frac{a_g PQ_p}{p + \delta} - u_g \frac{wZq_z}{b + wG + (1 - w)C} + mCZ \right] \]

\[ \dot{C} = C \left[ \frac{a_c PQ_p}{p + \delta} - u_c \frac{(1 - w)q_z Z}{b + wG + (1 - w)C} - mZ \right] \]

\[ \dot{Z} = Z \left[ \frac{u_c (1 - w)C + U_g WG}{b + wG + (1 - w)C} - e \right] \]

\[ \dot{P} = eZ - \frac{PQ_p}{p + \delta} \left[ a_c C + a_g G \right] \]
$m > 0$
Similar behaviour

Similar patterns in simple and complex model

Similar model behaviour (needs more formal analysis)

Other competing groups? More predators?
HOPF BIFURCATION IN HIGHER DIMENSIONAL DIFFERENTIAL SYSTEMS VIA THE AVERAGING METHOD

JAUME LLIBRE\(^1\) AND XIANG ZHANG\(^2\)

\[
\begin{align*}
\dot{x} &= \varepsilon ax - by + \sum_{i+j+k+l=2} a_{ijkl} x^i y^j z^k w^l + \mathcal{A}, \\
\dot{y} &= bx + \varepsilon ay + \sum_{i+j+k+l=2} b_{ijkl} x^i y^j z^k w^l + \mathcal{B}, \\
\dot{z} &= \varepsilon cz + \sum_{i+j+k+l=2} c_{ijkl} x^i y^j z^k w^l + \mathcal{C}, \\
\dot{w} &= \varepsilon dw + \sum_{i+j+k+l=2} d_{ijkl} x^i y^j z^k w^l + \mathcal{D},
\end{align*}
\]
HOPF BIFURCATION IN HIGHER DIMENSIONAL DIFFERENTIAL SYSTEMS VIA THE AVERAGING METHOD

JAUME LLIBRE\textsuperscript{1} AND XIANG ZHANG\textsuperscript{2}