Community resistance to biological invasions : role of diversity and network structure

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COREIDS

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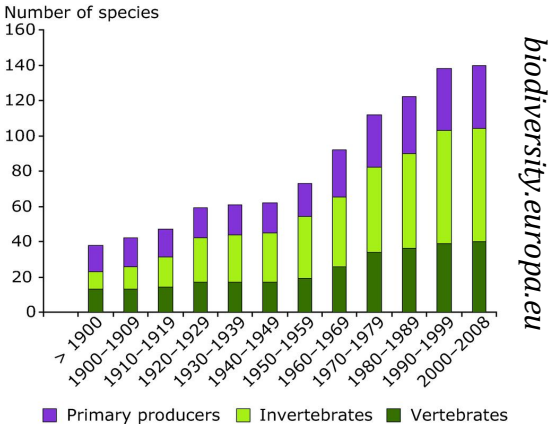
Biological invasions

Zebra mussels
(Dreissena polymorpha)

Water lilies
(Eicchornia crassipes)



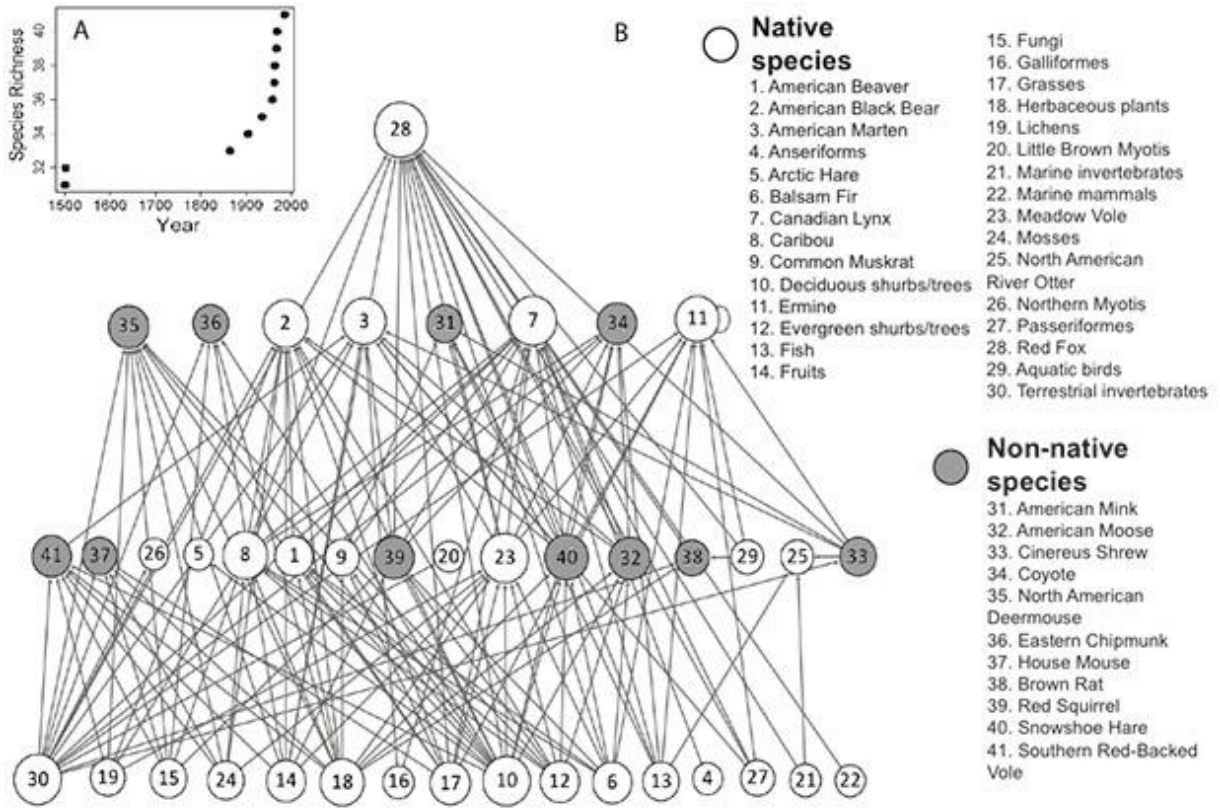
- A worlwide revolution in ecosystems and a major component of global change
- Concerns all kinds of organisms and habitats
- Large impacts on biodiversity but largely unpredictable

Rabbits
(Orycolagus cuniculus)

Nile perchs
Lates niloticus

Networks of species interactions

- Impacts of invasions depend on interactions with resident species
- Interactions are organized in networks (eg food webs)
- What properties of networks make them sensitive to invasion ?



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The COREIDS group

- A group of scientists working on invasions and/or networks in France, Canada, New Zealand
- Field biologists, experimental biologists, statisticians, theoreticians
- Synthesis, Meta-analysis, modelling

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Four types of local impacts of invaders on food webs

1. Top-down

Invasive predator

Resident prey

Euglandina rosea (predatory « wolf » snail)

(Moorea island)

Endemic *Partula spp* (tree snails)

- Direct predation is responsible for most species extinctions following invasions

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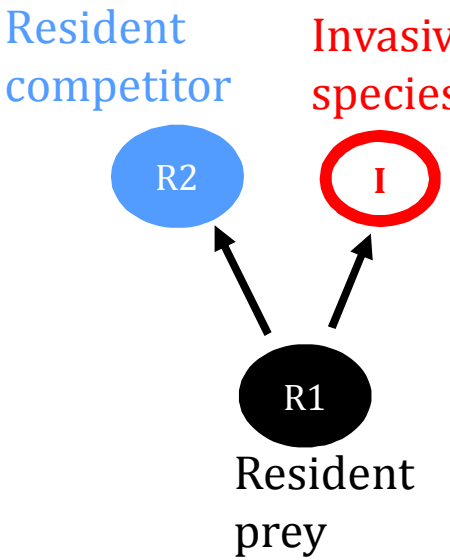
Four types of local impacts of invaders on food webs

2. Exploitative competition

(La Réunion island)



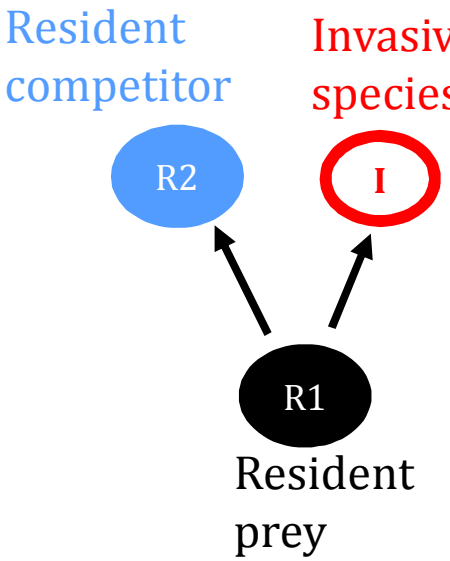
Endemic
Ceratitis catoirii

C. Capitata
Introd 1939

Locally cultivated fruit

Four types of local impacts of invaders on food webs

2. Exploitative competition



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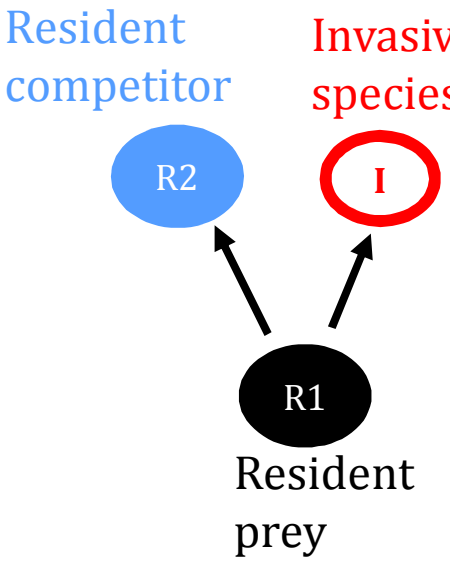

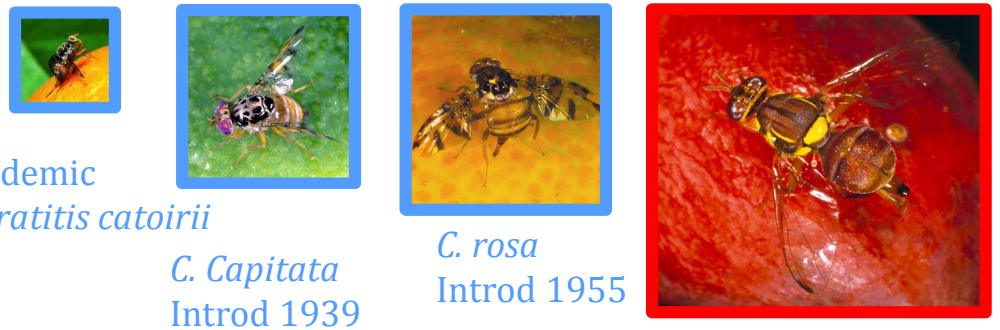

Endemic *Ceratitis catoirii*

C. Capitata Introd 1939

C. rosa Introd 1955

Bactrocera zonata Introd 1991

Locally cultivated fruit

- Invasive competitors often arrive in successive series
- Resident species are reduced or displaced more often than they go extinct

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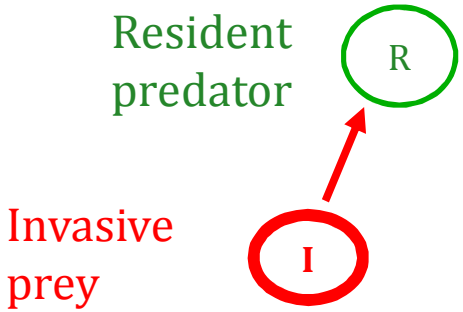
Four types of local impacts of invaders on food webs

3. Bottom-up



Invasive Gobies (Neogobius melanostomus)

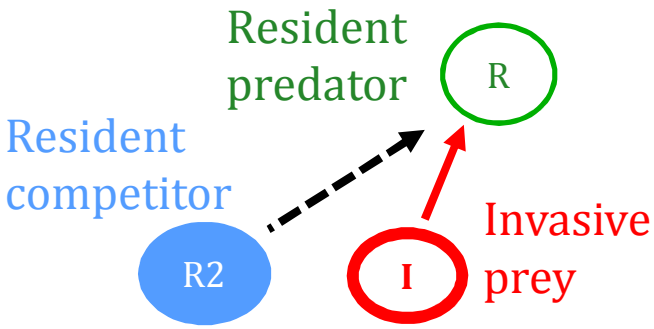
Endemic water snake (Nerodia sipedon insularum)

(Lake Erie)

- Resident predators may limit populations of invasive species (biotic resistance)
- Invasive species usually have positive effects on their predators

Four types of local impacts of invaders on food webs

3. Bottom-up



Horned Lizard
Phrynosoma coronatum

Argentine ant
Linepithema humile

(California)

Native ant
Crematogaster californica

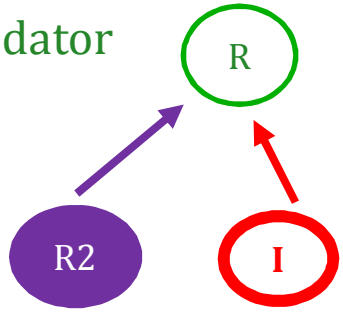
- Invasive species usually have positive effects on their predators
- … but these benefits are sometimes outweighed by competition with more profitable resident prey
- This situation is common with invasive plants eg *Caulerpa taxifolia, Rubus alceifolius >> herbivore diversity decreases*

Four types of local impacts of invaders on food webs

4. Apparent competition

(California channel islands)

Resident predator



Resident prey

Invasive prey

Golden eagle
Aquila chrysaetos

Island fox
Urocyon littoralis

Feral pig
Sus scrofa

- Invasive species may benefit local generalist predators and indirectly affect local species

The filter hypothesis

- ASYMMETRY : Invaders tend to have more impact (often strong) on natives than natives have on invaders; they are fiercer predators, better defended prey, and stronger competitors

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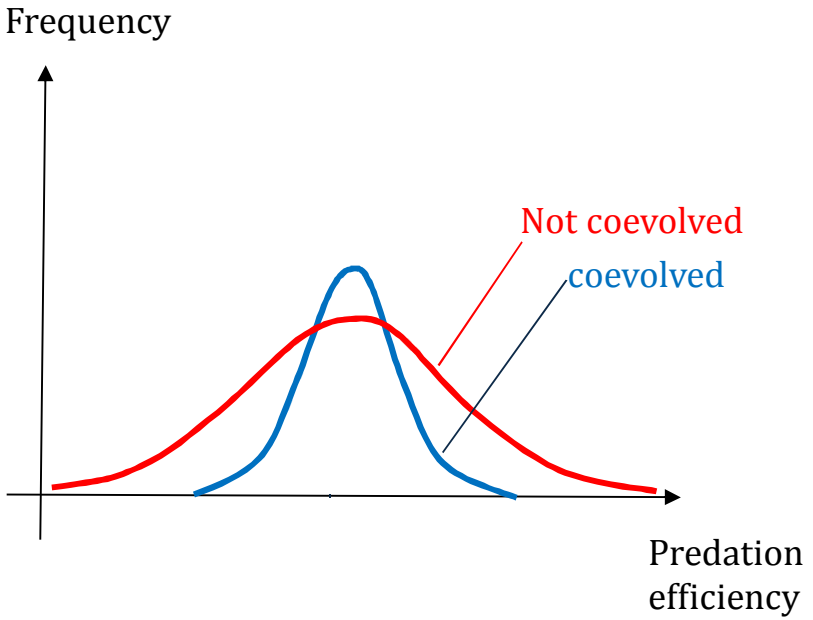
Example of predator introduction



- Major outcomes

The filter hypothesis

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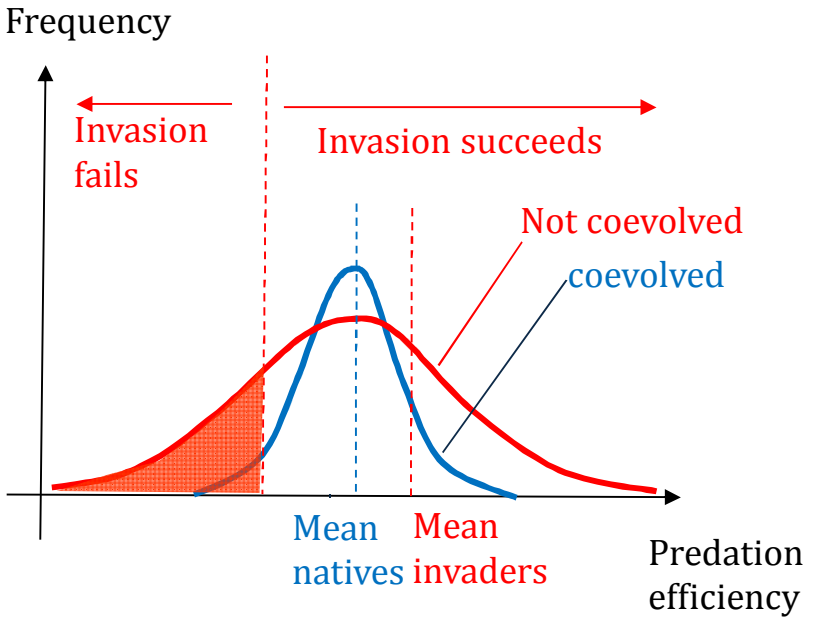
- LACK OF COEVOLUTION : Invaders and residents are evolutionary naive to each other : their interactions may often be extreme

- FILTER : Only species that happen to be tolerant to resident species successfully invade

Example of predator introduction



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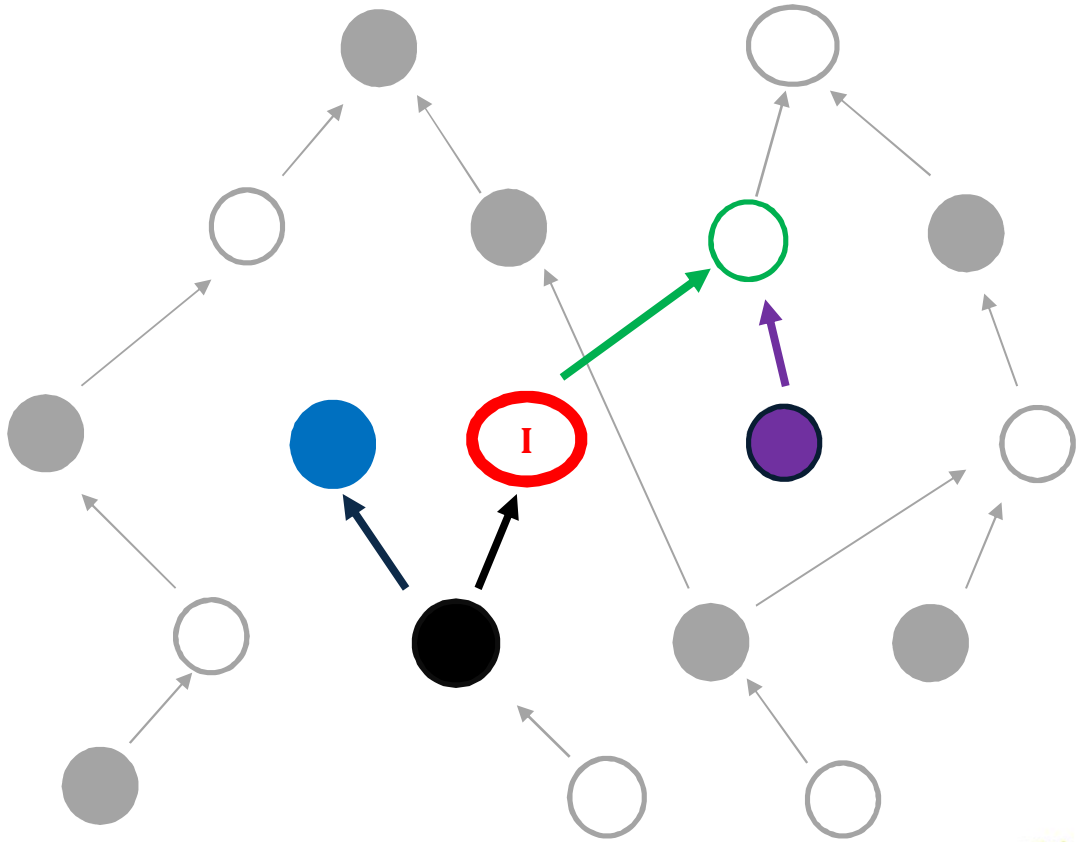
- Major outcomes

Propagation of effects in the recipient network : attenuation or amplification ?



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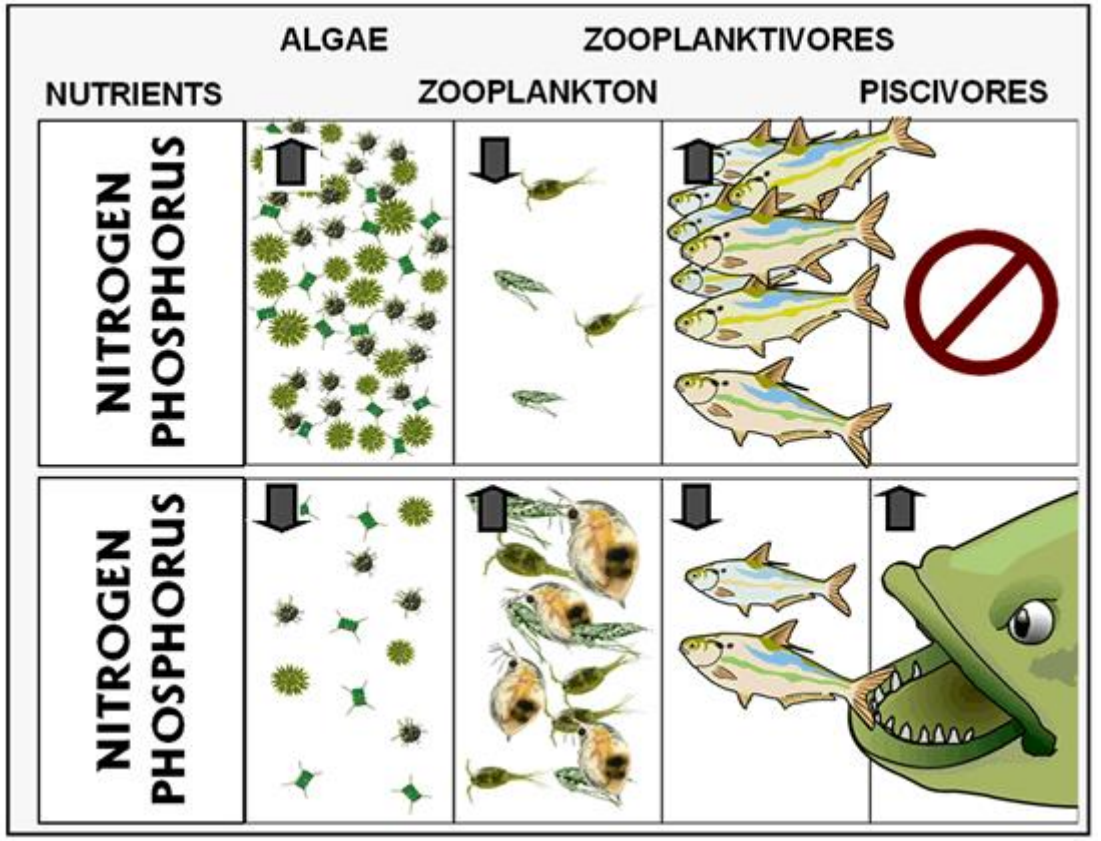
Theoretical predictions

- Theoretical models : construction of model food webs by addition of species and evolution of trophic traits (eg body size)
- Introduce virtual invaders, measure probability of success and impact
- Diversity >> filling of niche space >> less invasions and smaller impacts
- Connectance : no clear effect

Empirical data : Three cases of far-reaching impact of species introduction

1) Trophic cascades in lakes

Favored by the relatively low diversity and high efficiency of primary consumption of phytoplankton
(unlike in many plant-based terrestrial ecosystems)



http://www.lmvp.org

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2) Disequilibrium

- Recent human modification : eutrophication, elimination of top predators, replacement of native forest by agriculture or secondary habitat >> low diversity, lots of unexploited resource

- Evolutionary immaturity : remote islands lacking particular groups >> idem

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3) Ecosystem engineering

- Large modification of habitat: sessile filter-feeders : water clarification, creation of habitats

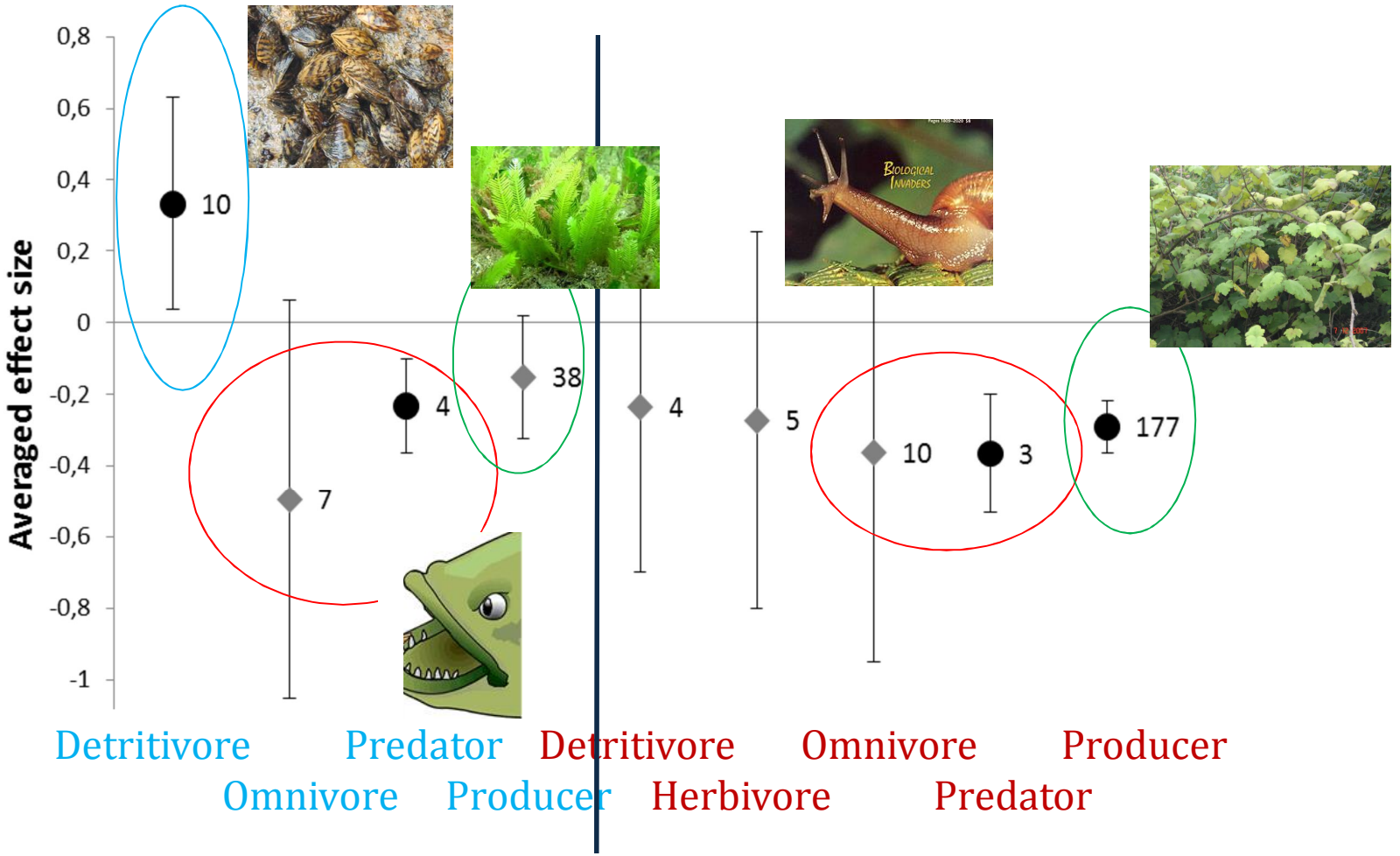
- Attracts many new species, limits many others, deeply reorganizes energy and matter fluxes in lake ecosystem (pelagic >> benthic)

http://ian.umces.edu

Increases

Effect on diversity

decreases



Meta-analysis

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Lessons for ecosystem conservation

- Fight against causes of invasions rather than invasions themselves : pollution, perturbation, predator removal
- Islands are hypersensitive due to past isolation : prevent introductions, especially of generalist predators
- Eradication is usually costly and ineffective; resident communities often change ecologically and evolutionarily after invasions, there is often no way back. Look for mitigation rather than eradication.

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Thanks for your attention

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