Invasive species in marine food webs: their key to success?

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Source area → Environmental barrier → Recipient area (invaded ecosystem)

- External propagule source
- Entering a pathway
- Transportation
- Expansion
- Arrival
- Establishment
- Secondary spread

Source: S. Olenin
Forecasting invasion **success** remains a fundamental challenge in invasion biology.

**Primary factors:**
- Invasiveness of the new area
- Introduction success
- Ecology of the invasive species

**Secondary factors:**
- Biological interactions (predation, competition...)

Success?
Effects of native diversity manipulations on invasion success

Stachowicz et al. 2002 Ecology 83(9): 2575–2590
### Levels of Genetic Structure vs. Range in Hawai‘i

<table>
<thead>
<tr>
<th>Levels of Genetic Structure</th>
<th>Range in Hawai‘i</th>
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</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td>2500 km</td>
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<tr>
<td>Very low levels of genetic structure across 20,000 km</td>
<td></td>
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<tr>
<td><em>Lutjanus kasmira</em></td>
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<tr>
<td><strong>Moderate</strong></td>
<td>1200 km</td>
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<tr>
<td>No genetic structure in the Pacific or Western Indian Oceans but high levels of structure between oceans</td>
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<tr>
<td><em>Cephalopholis argus</em></td>
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<tr>
<td><strong>High</strong></td>
<td>600 km</td>
</tr>
<tr>
<td>High levels of genetic structure at all geographical scales</td>
<td></td>
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<tr>
<td><em>Lutjanus fulvus</em></td>
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</tbody>
</table>

**Success?**
Population genetic structure ($F_{ST}$) versus continuous extent of spread (CES)

Native predators versus invasive species

Study of ecosystem impacts of invasive species:

from evaluation of invasive species impacts on particular processes → analysis of their overall effects on ecosystem functioning

→ an integrative ecosystem-based approach to the analysis of invasive species impacts

two general kinds of biotic mediation:

direct and indirect

Direct effects:
when the presence and/or activities of the invasive species *per se* alters ecosystem process rates → good field observations

Indirect effects:
the invasive species impacts biotic and abiotic intermediaries that, in turn, affect ecosystem process rates → difficult to observe/quantify

two general mechanisms of invasive species impact:

(1) assimilatory/dissimilatory: uptake/release of energy and materials

two general mechanisms of invasive species impact:

1. assimilatory/dissimilatory: uptake/release of energy and materials

2. physical ecosystem engineering: physical environmental modification by organisms

+ additional intermediaries?

→ Complexity increases

to integrate distinctive impacts into general mechanistic representations that link ecosystem processes with changes in biotic and abiotic states (changes in structure, composition, amount, process rates, etc.).

generate predictions about the interplay of invasive species and other drivers of ecosystem processes

of particular relevance to ecosystems where invasive species co-occur with other anthropogenic impacts!

Community ecology

- Sp. 1
- Sp. 2
- Sp. 3
- Sp. 4
- Sp. 5
- Sp. 6
- Sp. 7

Abiotic factors

Ecosystem ecology

- Predators
- Primary consumers
- Primary producers

Abiotic factors

Thompson et al. 2012, TREE 27
Food web ecology

Towards an integrative approach...

Thompson et al 2012, TREE 27
HNF = small Protozoa (heterotrophic nanoflagellates)

Figure 5. Main pathways of the energy flow to the primary carnivore trophic levels under different nutrient scenarios; food web topography as in Figure 1.
Fig. 18: Time lapse pictures of *M. leidyi* digesting copepods (*Acartia* sp.).

True assimilation? -- > trophic markers

Time lapse pictures of *M. leidyi* digesting copepods (*Acartia* sp.).

Vanhove B, Vansteenbrugge, L., Hostens, K., Vincx, M. & De Troch, M. (unpubl.)
Biomarkers

General definition:
A biochemical substance indicating a process, condition or identity of a biological system or organism.

Use in ecological studies:

to assess the **diet** of an organism by comparing its biochemical composition with that of its putative prey (‘you are what you eat’ principle)

e.g.
- stable isotopes
- fatty acids
The perfect trophic marker is a compound

- whose origin can be uniquely and easily identified
- inert and nonharmful to the organisms
- not selectively processed during food uptake and incorporation
- metabolically stable
- transferred from one trophic level to the next in a qualitative and quantitative manner

Habitat use patterns of the invasive red lionfish

Lionfish are opportunistic forages with little movement across habitats.

Distinct isotopic niches

Pieminto et al al. (2013) Marine Ecology
Mnemiopsis leidyi
Beroe gracilis
Pleurobrachia pileus

to

zooplankton

Beroe gracilis
Mnemiopsis leidyi
Pleurobrachia pileus

Spatial variation in stable isotope signatures

Interspecific variability in FA profiles
Species-specific food uptake? Resource partitioning?

FA composition for three ctenophores species

Beroe gracilis
Mnemiopsis leidyi
Pleurobrachia pileus

Lipid- poor species
No reserves

Vanhove B, Vansteenbrugge, L., Hostens, K., Vincx, M. & De Troch, M. (unpubl.)
Tracer experiments: assimilation efficiency?

Treatment 1: $^{13}$C diatoms + *M. leidyi*

Treatment 2: $^{13}$C copepods + *M. leidyi*

Treatment 3: $^{13}$C diatoms + $^{13}$C copepods + *M. leidyi*

Diatoms: *Phaeodactylum tricornutum*

Copepods: *Acartia* sp.

2 time intervals: 3h and 6h

Specific uptake by *M. leidyi* in the different treatments
*M. leidy* can quickly react and obtain energy → opportunistic feeding strategy

lipid-poor species → rapid growth during high food periods

fast digestion times of *M. leidy* → $^{13}$C tracer experiments showed to be a very helpful tool

A plea for the use of trophic markers but also caution!