Is salinity an obstacle for biological invasions?

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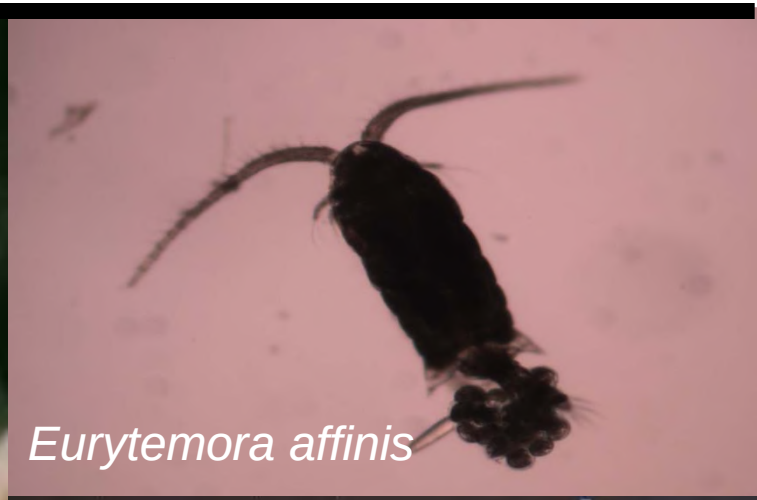
Importance of geographic origin for invasion success

Marine and brackish species in freshwater habitats


Cordylophora caspia


Eurytemora affinis


Dreissena polymorpha

Objectives

1. To explore origin and taxonomic composition of NIS in Northern Europe and the Great Lakes-St. Lawrence River region to determine whether Ponto-Caspian region is the major donor region for these systems

2. to determine if Ponto-Caspian taxa have inherent advantages over other species in colonizing new areas

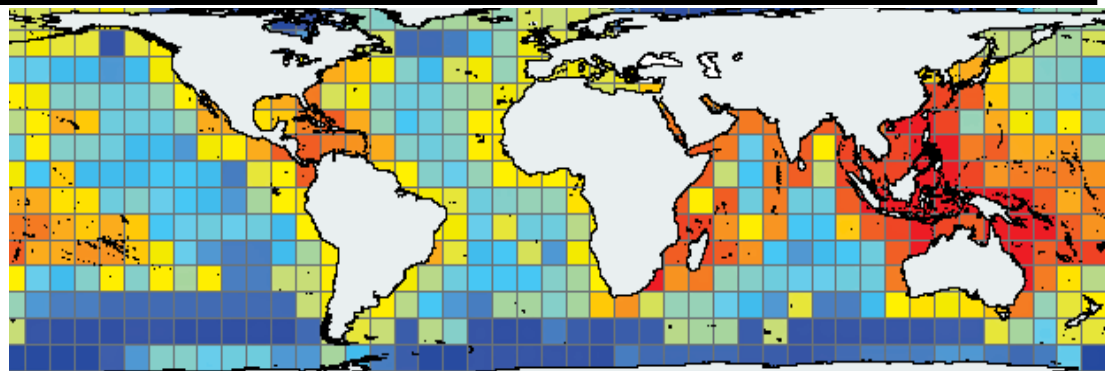
Established NIS in Northern Europe and the Great Lakes-St. Lawrence River

Taxon	Species	Invaded areas	Origin
Animalia			
Acanthocephala			
Eoacanthocephala	*Paratenuisentis ambiguus*	BS	NE Pacific, NW Atlantic
Annelida			
Clitellata	*Branchiura sowerbyi**	NS, BS	Eurasia
	Limnodrilus cervix	BS	N America
	Paranais botniensis	NS	unknown
	Paranais frici	BS	Ponto-Caspian
	*Potamothrix bedoti**	BS	Ponto-Caspian
	Potamothrix heuscheri	BS	Ponto-Caspian
	*Potamothrix vejdovskyi**	BS	Ponto-Caspian
	Tubificoides pseudogaster	BS	North Sea
	Alitta succinea	BS	NE Atlantic
	Boccardia proboscidea	NS	NE Pacific
	Boccardiella ligerica	NS, BS	unknown
	Clymenella torquata	NS	NW Atlantic
	Ficopomatus enigmaticus	NS, BS	Indo-Pacific
	Hydroides dianthus	NS	NW Atlantic

Casties *et al*. 2016

Established NIS in Northern Europe and the Great Lakes-St. Lawrence River

- Number of species from donor region - average spp. per 880 km grid



Tittensor *et al.* (2010)

- Frequency of shipping transit

- Environmental match between donor and recipient regions

Seebens *et al*. (2013)

$$P_{ij}(Non\text{-}indigenous) = (1 + \frac{\gamma}{d_{ij}})^{-\beta}$$

$$P_r(Intro) = \left(1 - e^{-\lambda B_r}\right)e^{-\mu \Delta t_r}$$

$$P_{ij}(Estab) = \alpha e^{-\frac{1}{2}\left[\left(\frac{\Delta T_{ij}}{\sigma_T}\right)^2 + \left(\frac{\Delta S_{ij}}{\sigma_S}\right)^2\right]}$$

Experimental studies of taxa from three regions

Three regions:

- Northern Europe
- Ponto-Caspian region
- The Great Lakes-St. Lawrence River

Salinity tolerance:

- 22 population of 8 species originating from different salinities
- conducted in 4 countries
- Each 2 days salinity increased/ decreased for 2 ppt – until 0 and 40 ppt


Gammarus tigrinus


Filipa Paiva


Andrea Barco

Experimental selection of *Pontogammarus maeoticus*

Caspian Sea, Iran, 10 ppt, 18°C

Selection

Salinity stress

Low 4 ppt

Ambient 10 ppt

High 16 ppt

Low

Control

High

Salinity decrease
0 ppt

Selection salinity

Salinity increase
40 ppt

Literature search of salinity of P-C invaders in native and non-native regions

Taxon	Species	Invaded areas	Origin
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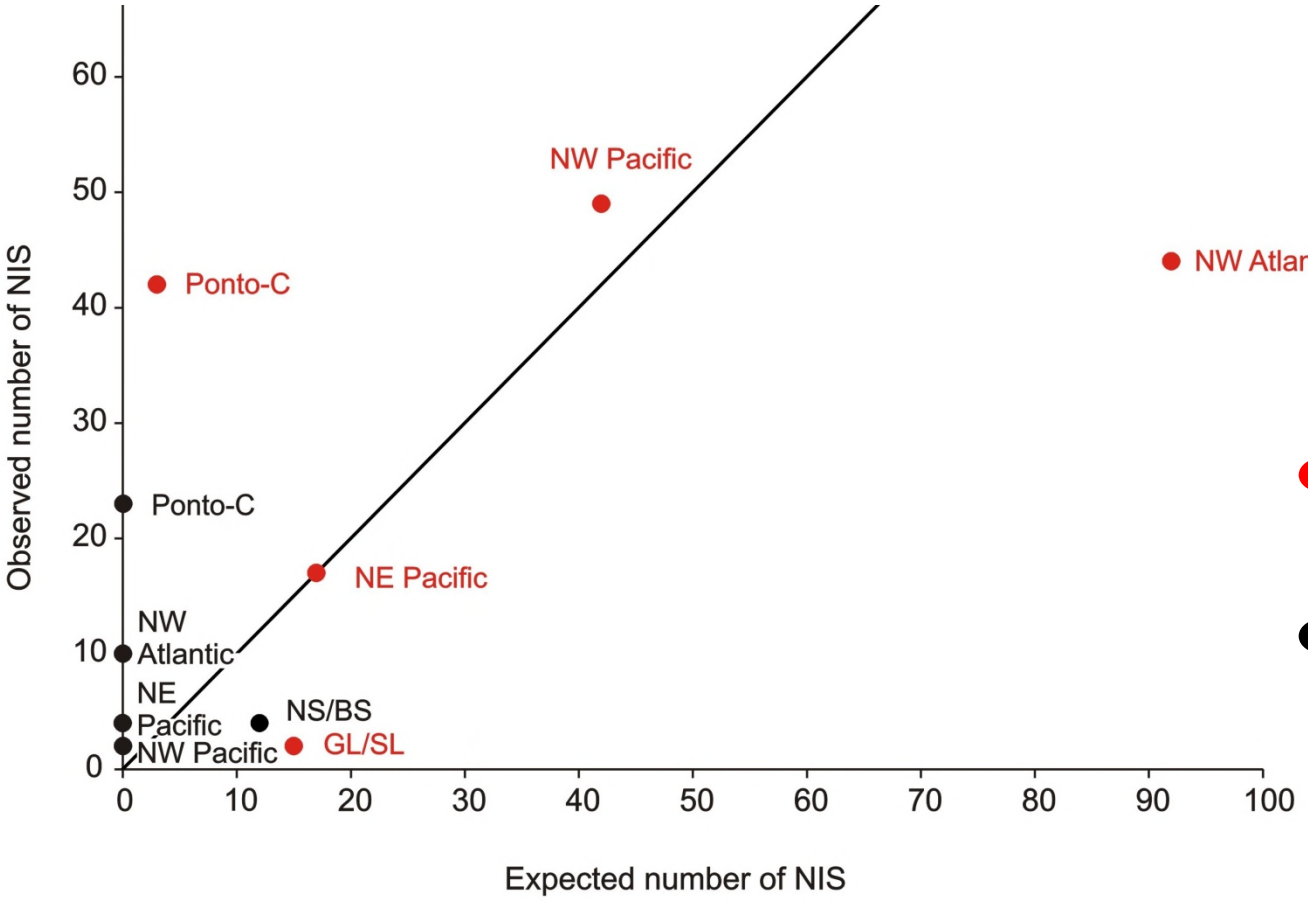
Nora Pauli

Casties *et al*. 2016

Expected *vs*. observed number of NIS

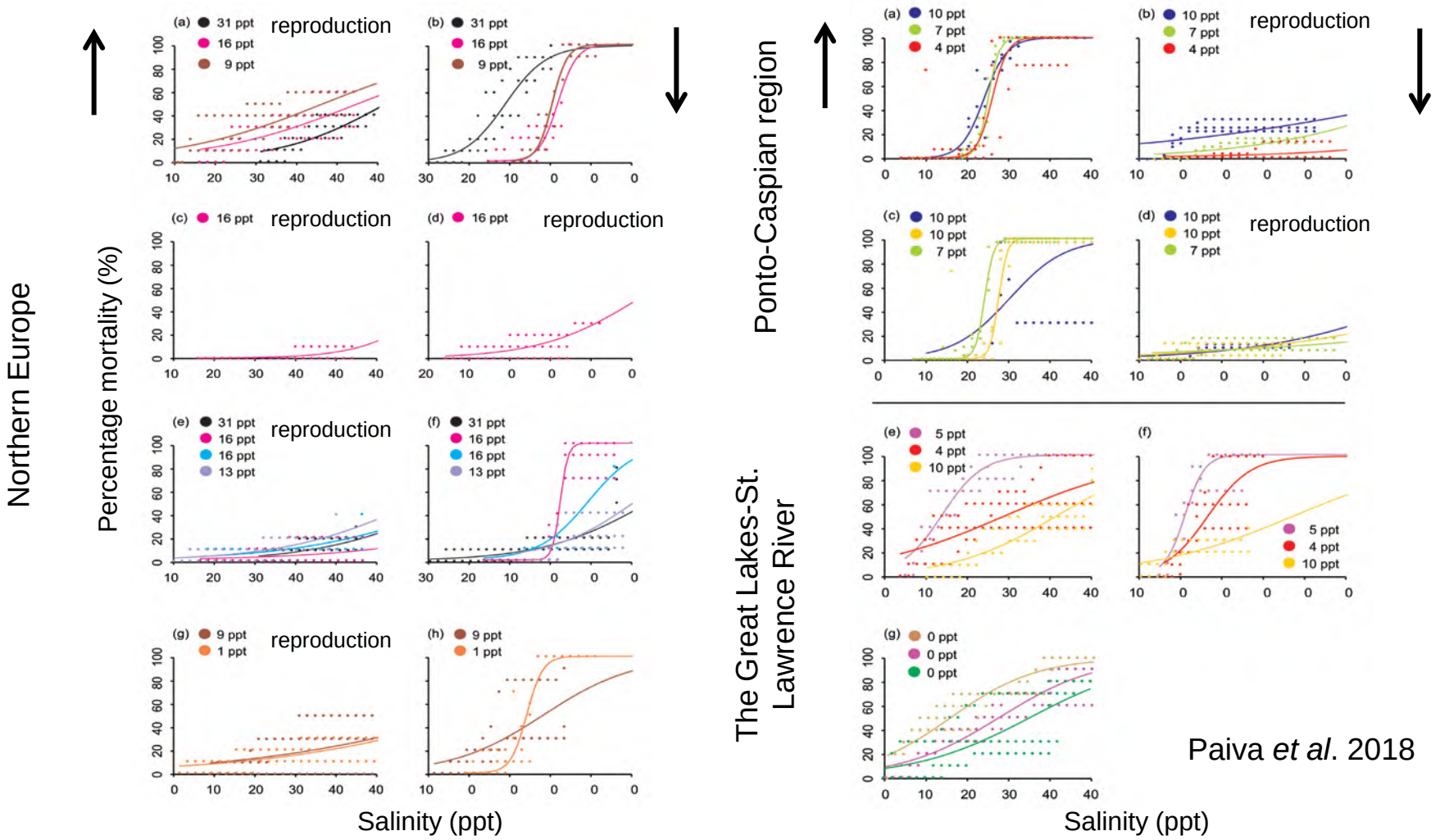


The North and Baltic Seas as recipient region

Great Lakes-St. Lawrence River as recipient region

Casties *et al*. 2016

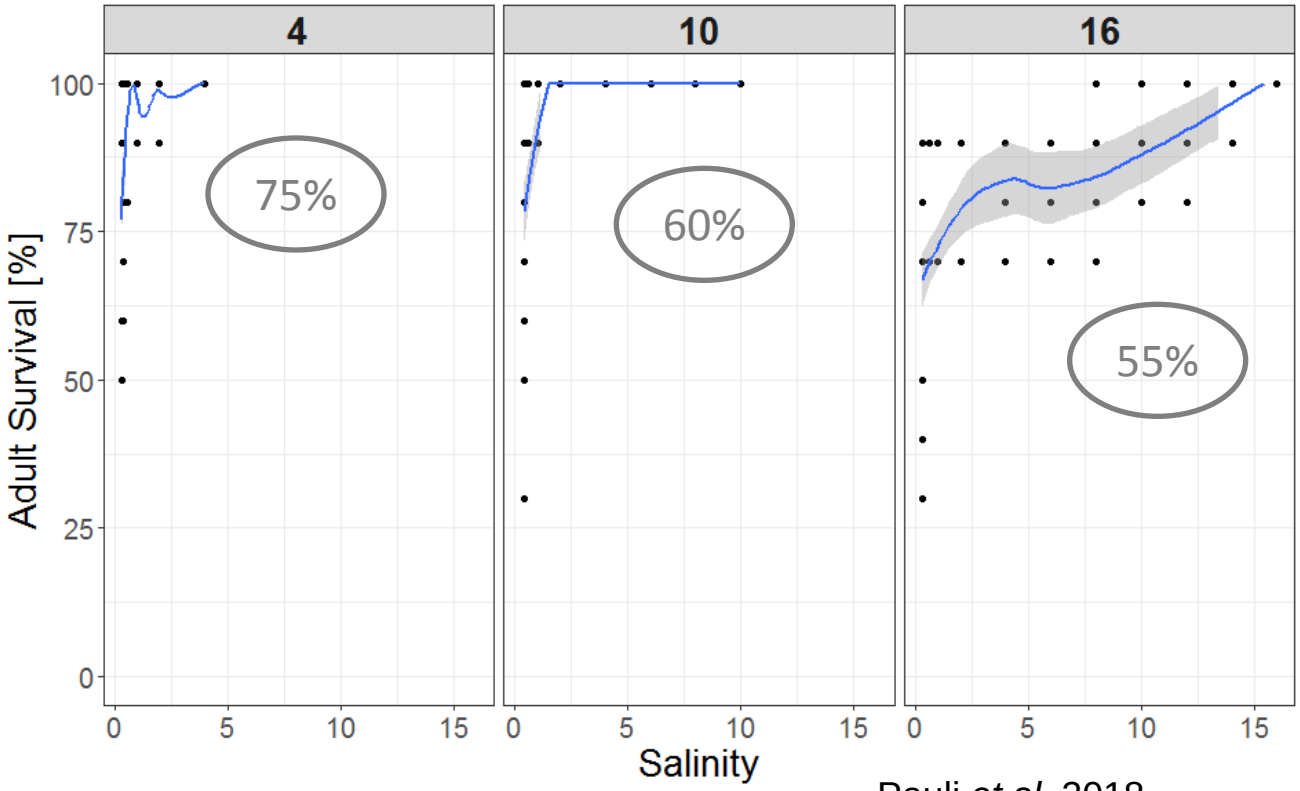
Salinity tolerance of species from three regions



Paiva *et al*. 2018

Selection of Ponto-Caspian sp. – survival of adults

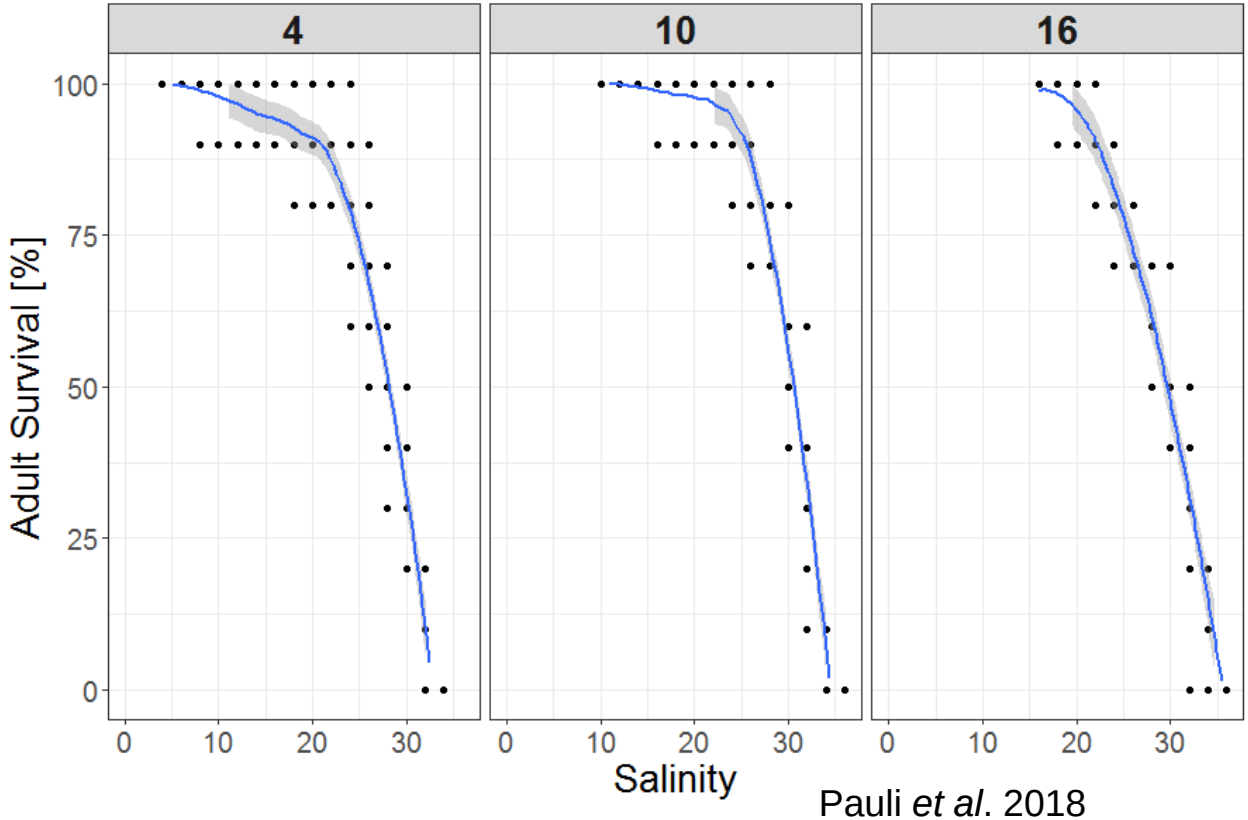
Low salinity stress - highest survival in low selected population



Pauli *et al*. 2018

Selection of Ponto-Caspian sp. – survival of adults

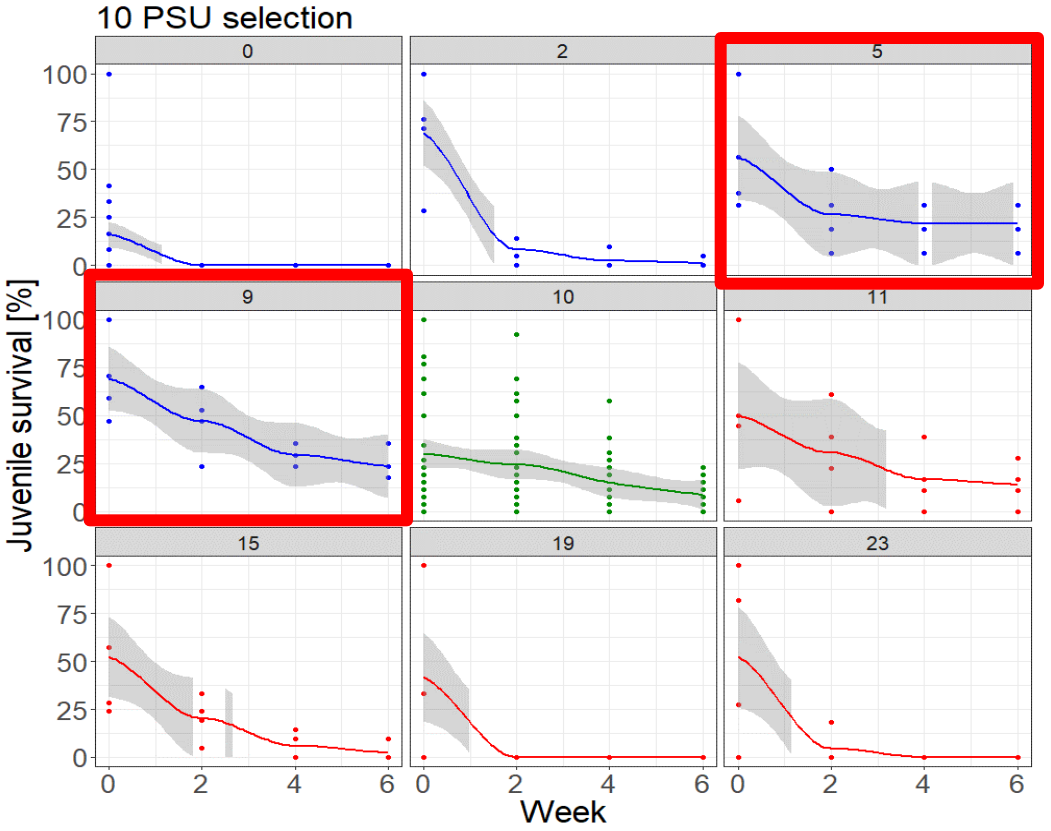
High salinity stress - no survival above 34 ppt in any of populations



Pauli *et al*. 2018

Selection of Ponto-Caspian sp.– survival of offspring control

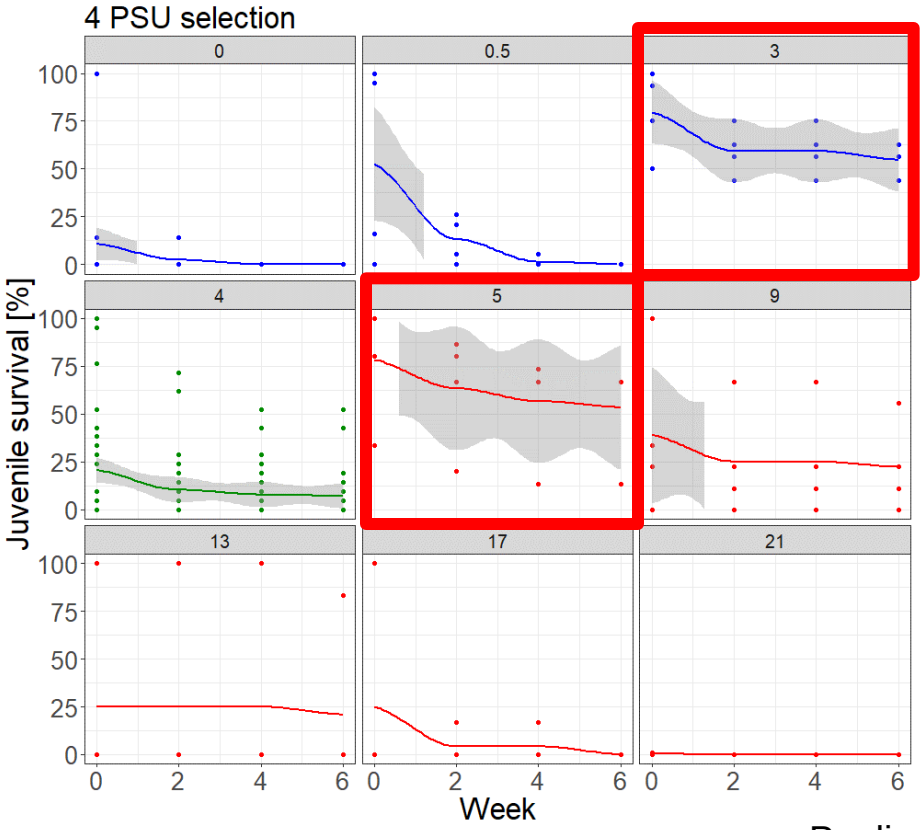
Highest survival in 9 and 5 ppt



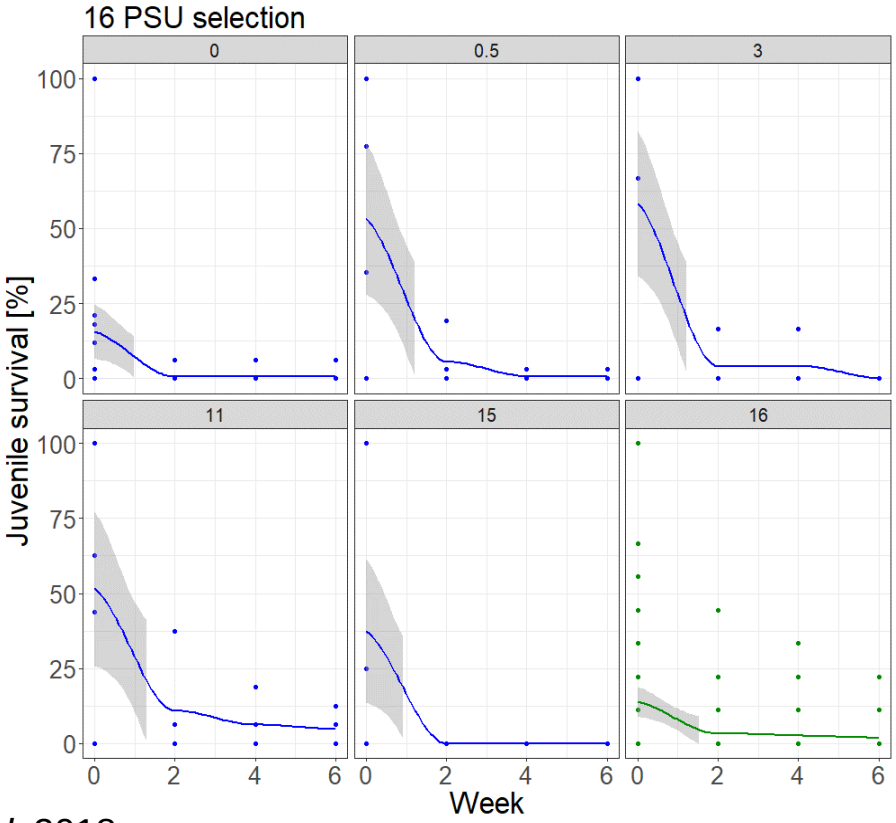
Pauli *et al*. 2018

Selection of Ponto-Caspian sp.– survival of offspring selected to 4 and 16 ppt

- highest survival in 5 and 3 ppt



- no survival in any salinity



Pauli *et al*. 2018

Selection of Ponto-Caspian sp.– survival of offspring selected to 4 and 16 ppt

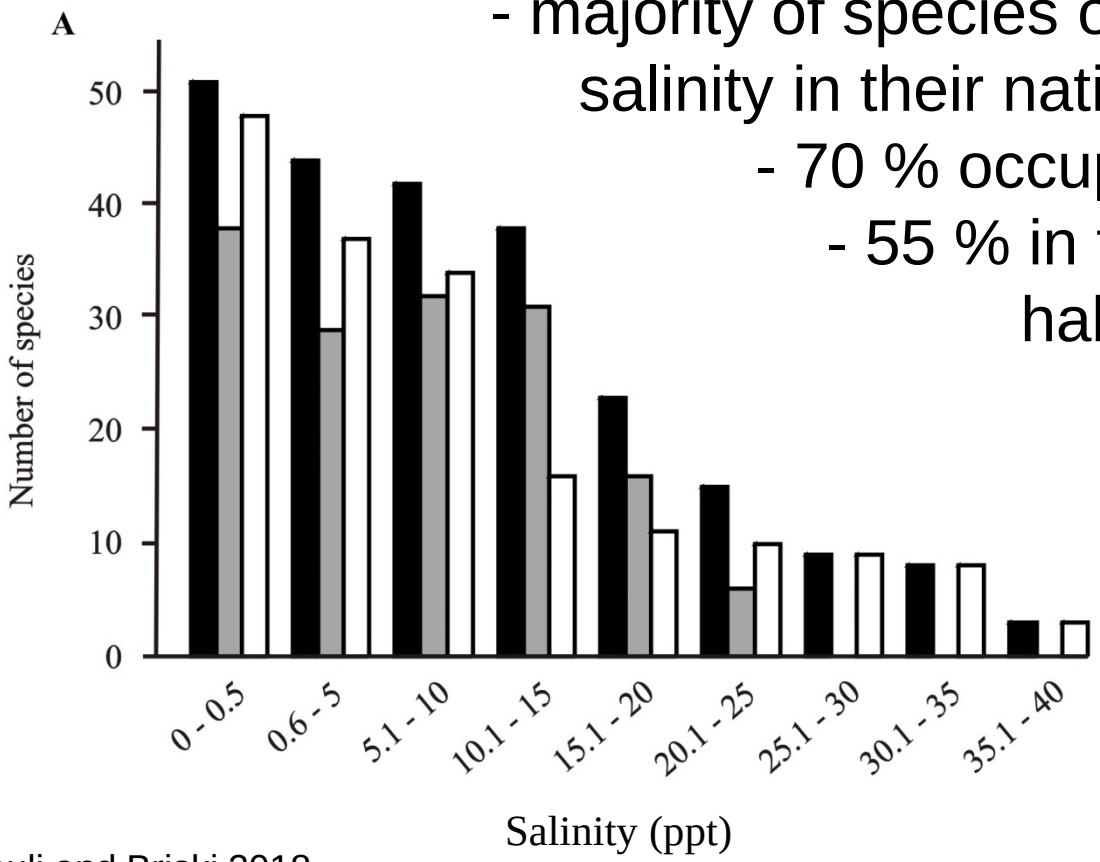
- highest survival in 5 and 3 ppt

- no survival in any salinity

Currently, we have selected population to 1 ppt

Pauli *et al*. 2018

Literature search – salinity of P-C invaders in native and non-native regions



- majority of species occupied wide range of salinity in their native habitats.
  - 70 % occupied freshwater habitats
  - 55 % in freshwater and brackish habitats below 15 ppt.

- 47 % invaded habitats with narrower salinity range than that in their native region

Pauli and Briski 2018

Conclusions

Propagule pressure (*i.e.*, number of introduced individuals or introduction effort) is of great importance for establishment success of NIS - however in our study, either shipping vector or environmental match between regions did not clarify the high numbers of Ponto-Caspian taxa in our study areas

Northern European species performed better in higher salinities, while Ponto-Caspian ones in lower salinity and freshwater conditions

Conclusions

Selection experiments of a Ponto-Caspian gammarid demonstrated possible selection to lower, but not to higher salinity, indicating that the species contains enough standing genetic variation for possible freshwater adaptation, but lacks necessary genetic background for adaptation to fully marine conditions

70 % of Ponto-Caspian invaders occupy freshwater habitats in their native region, while 55 % of them freshwater and brackish habitats below 15 ppt

Freshwater tolerance of P-C species and geological history of the region

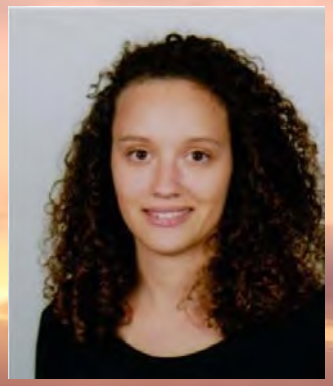
Are Ponto-Caspian invaders of freshwater origin?

If Ponto-Caspian species are evolutionary freshwater species

- not be inherently better colonizers

- simply their inherent advantage may lie in the fact that areas with biggest introduction frequency of NIS are environmentally variable habitats which often include freshwater conditions unable to be tolerated by euryhaline evolutionary marine taxa

Acknowledgements: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