Experimental evaluation of microhabitat preferences by Ponto-Caspian gammarids

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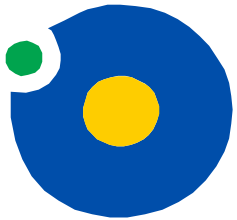

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Experimental evaluation of microhabitat preferences by Ponto-Caspian gammarids

- Several Ponto-Caspian species invaded central and western Europe in the second half of the 20th century
- They mostly occupy large rivers, leaving small affluents as refuges for native species

Dikerogammarus villosus

the „killer shrimp”

- the strongest competitor/predator
- lives on hard substrata in flowing waters
- the most invasive of them all

Pontogammarus robustoides

- occupies a variety of substrata, common on sand and macrophytes
- lives in lentic, often shallow sites

Experimental evaluation of microhabitat preferences by Ponto-Caspian gammarids

- Habitat preferences known mainly from field observations and correlational studies
- We tested their selectivity for several environmental factors to better understand their spreading potential and conditions facilitating invasions

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- Habitat preferences known mainly from field observations and correlational studies
- We tested their selectivity for several environmental factors to better understand their spreading potential and conditions facilitating invasions:

  - Substratum
  - Salinity (conductivity)
  - Water flow
  - Temperature
  - Water depth
  - Impact of both species on each other
  - Impact of fish predators on gammarid habitat preferences

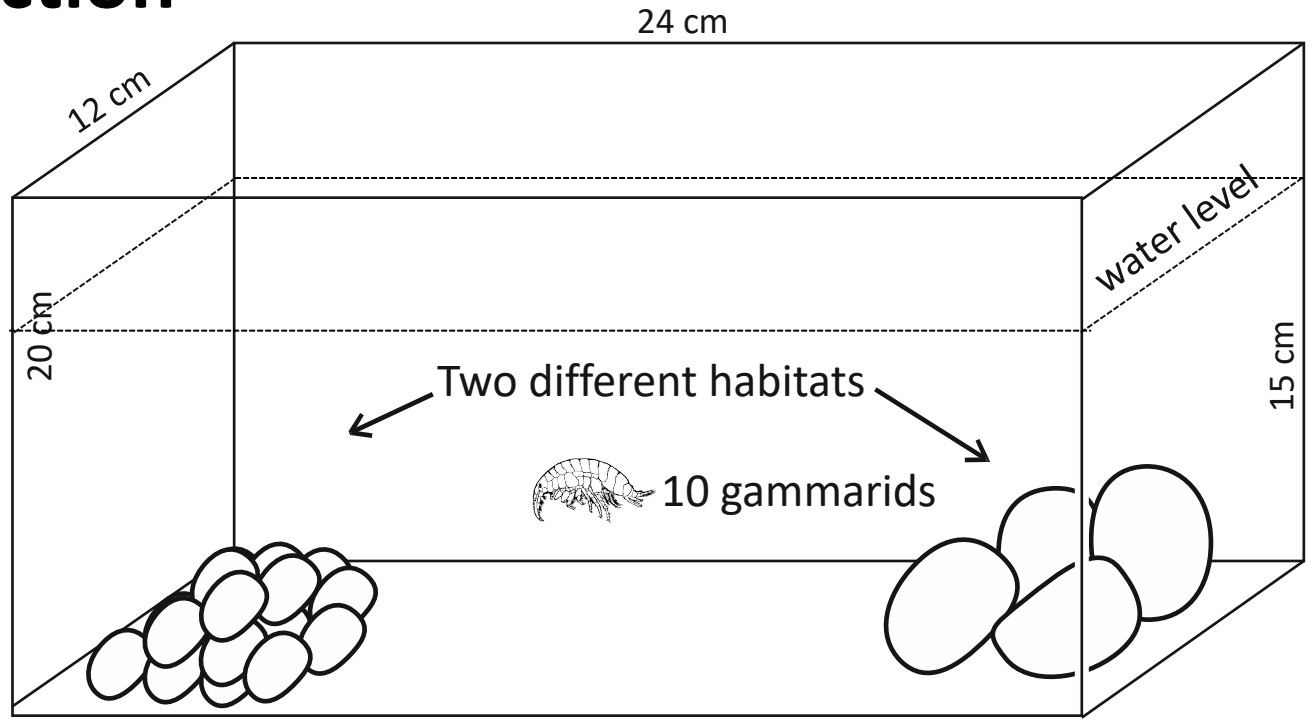
Substratum selection

- In the field, *P. robustoides* occupies a variety of substrata (sand, macrophytes, roots, etc.), whereas *D. villosus* is associated with hard substrata
- Do they differ in their preferences or displace each other by interference competition?

- Kobak J, Jermacz Ł, Dzierżyńska-Białończyk A 2015. Substratum preferences of the invasive killer shrimp *D. villosus*. J. Zool. 297: 66-76
- Jermacz Ł, Dzierżyńska A, Poznańska M, Kobak J 2015. Experimental evaluation of preferences of an invasive Ponto-Caspian gammarid *P. robustoides* for mineral and plant substrata. Hydrobiologia 746: 209-221
- Jermacz Ł, Dzierżyńska A, Kakareko T, Poznańska M, Kobak J 2015. The art of choice: predation risk changes interspecific competition between freshwater amphipods. Beh. Ecol. 26: 656-664

Substratum selection

- 10 gammarids per tank
- Duration: 24 h
- Substrata: gravel and stones of various grain sizes: 0.3-150 mm
- Natural and artificial macrophytes of various architecture



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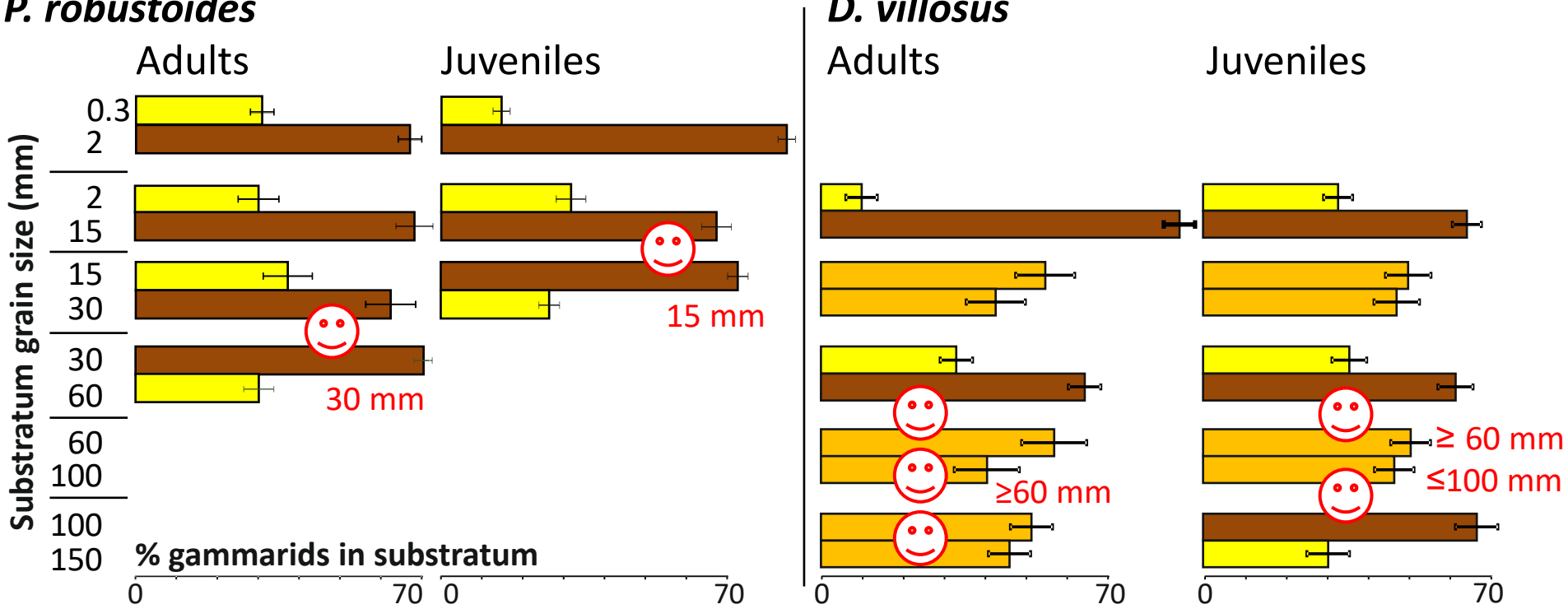
Substratum selection



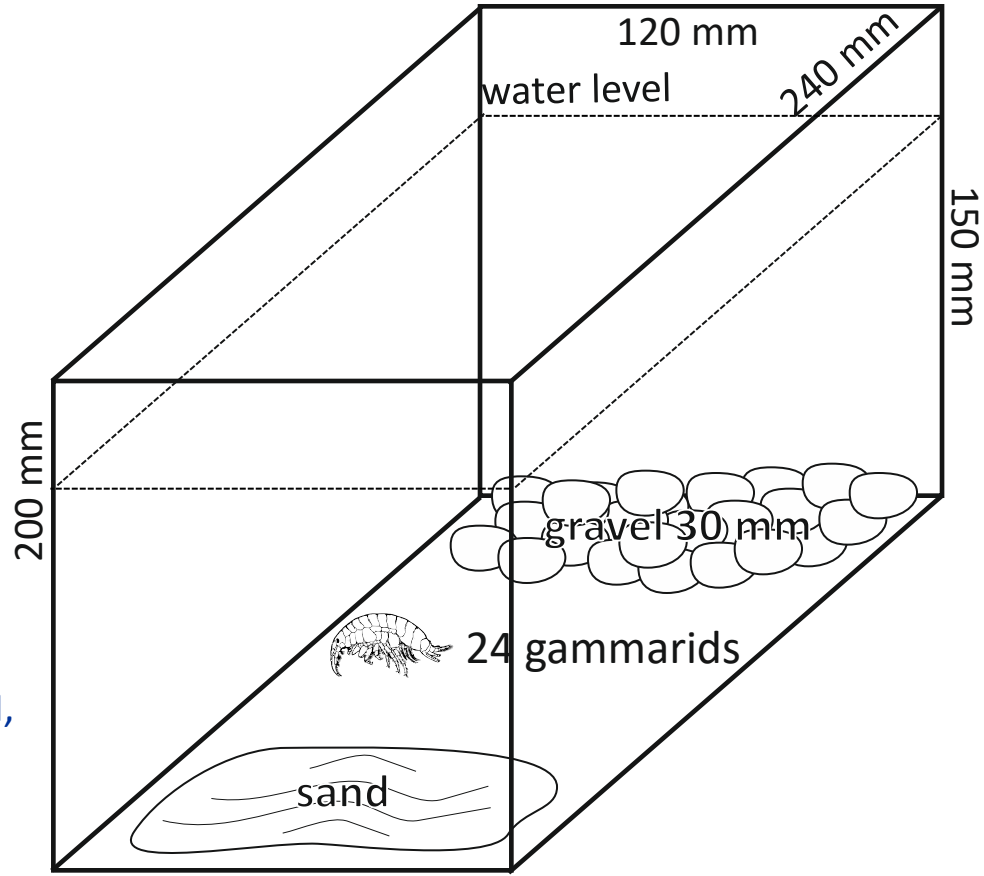
- Both species select gravel/stones, avoiding smallest fractions
- *D. villosus* selects larger particles than *P. robustoides*
- Adults select larger particles than juveniles

Substratum selection

So, why is P. robustoides found so often on sandy bottom in the field?

Test of interspecific interactions

- Substrata: sand (poor) and gravel (preferred by both species)
- 24 individuals of single species or 12 + 12 of both species
- Duration: 24 h



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Substratum selection

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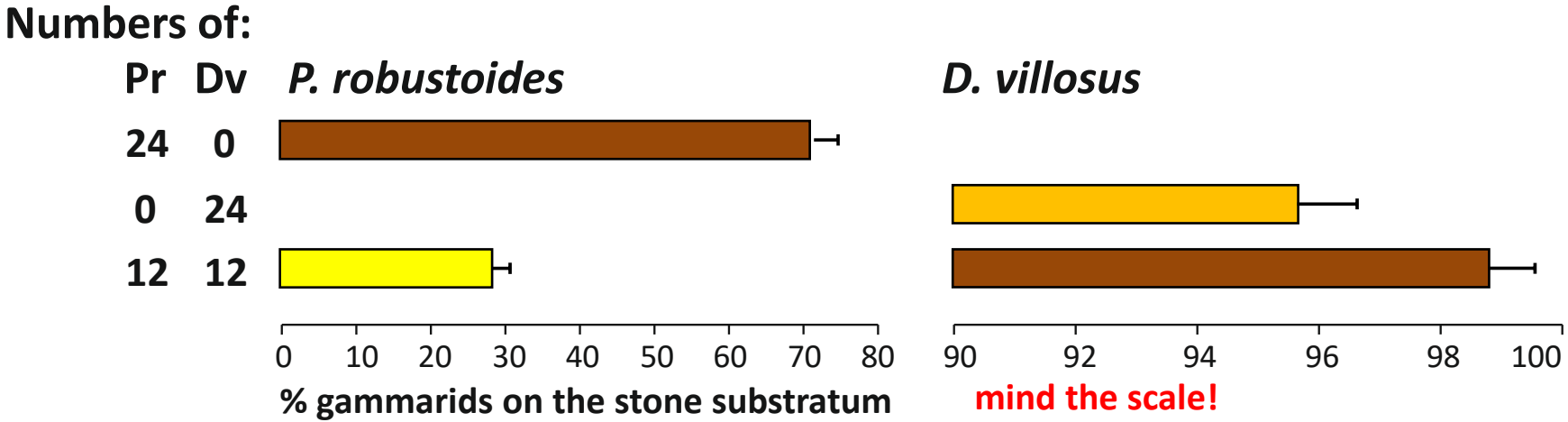
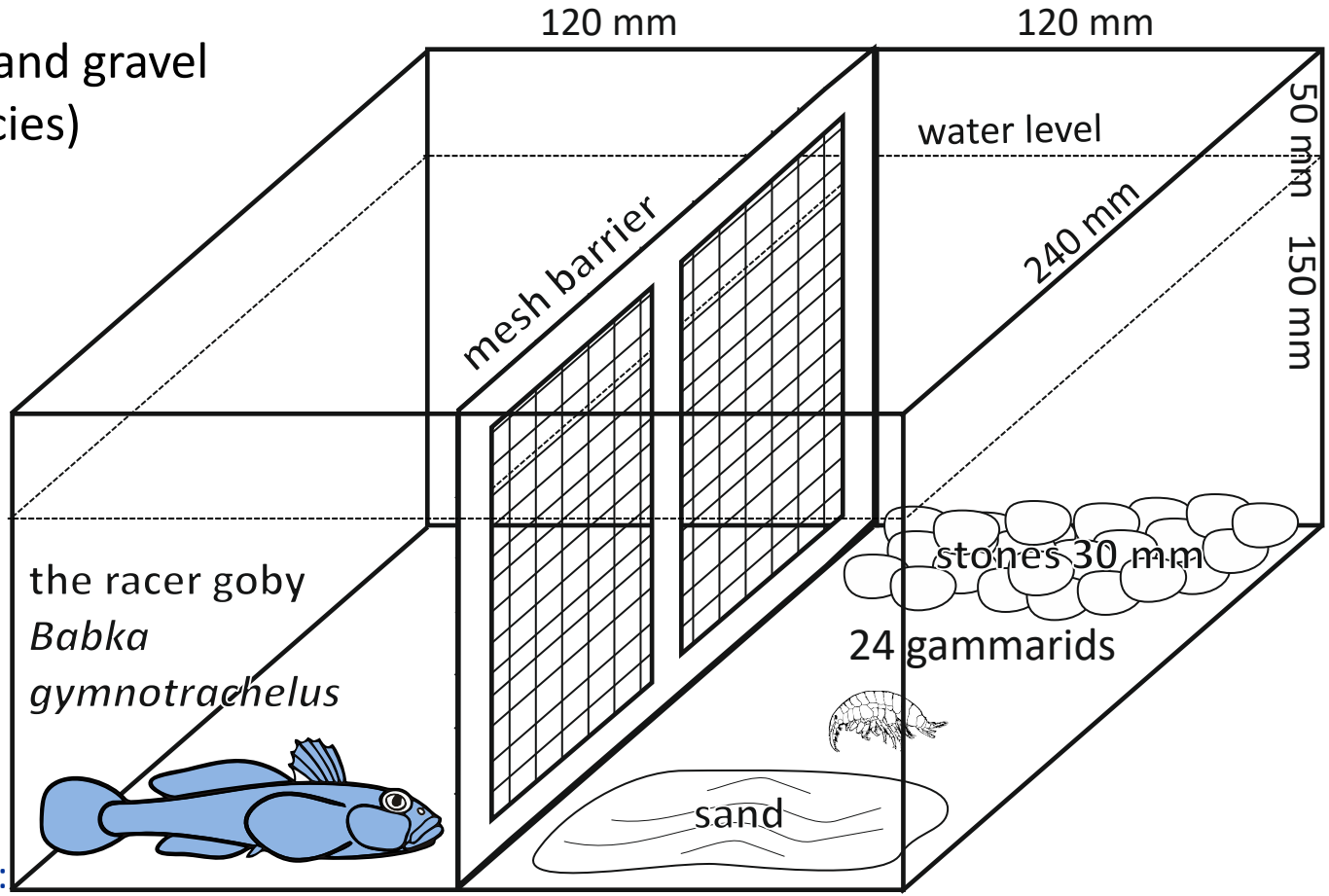


- *P. robustoides* retreats to the worse substratum in the presence of *D. villosus*
- *D. villosus* stays in the better substratum more often in the presence of *P. robustoides*
- No displacement takes place in single species treatments

Substratum selection

- Substrata: sand (poor) and gravel (preferred by both species)
- 24 individuals of single species or 12 + 12 of both species
- Duration: 24 h
- **Additional factor: the signal from a top predator**



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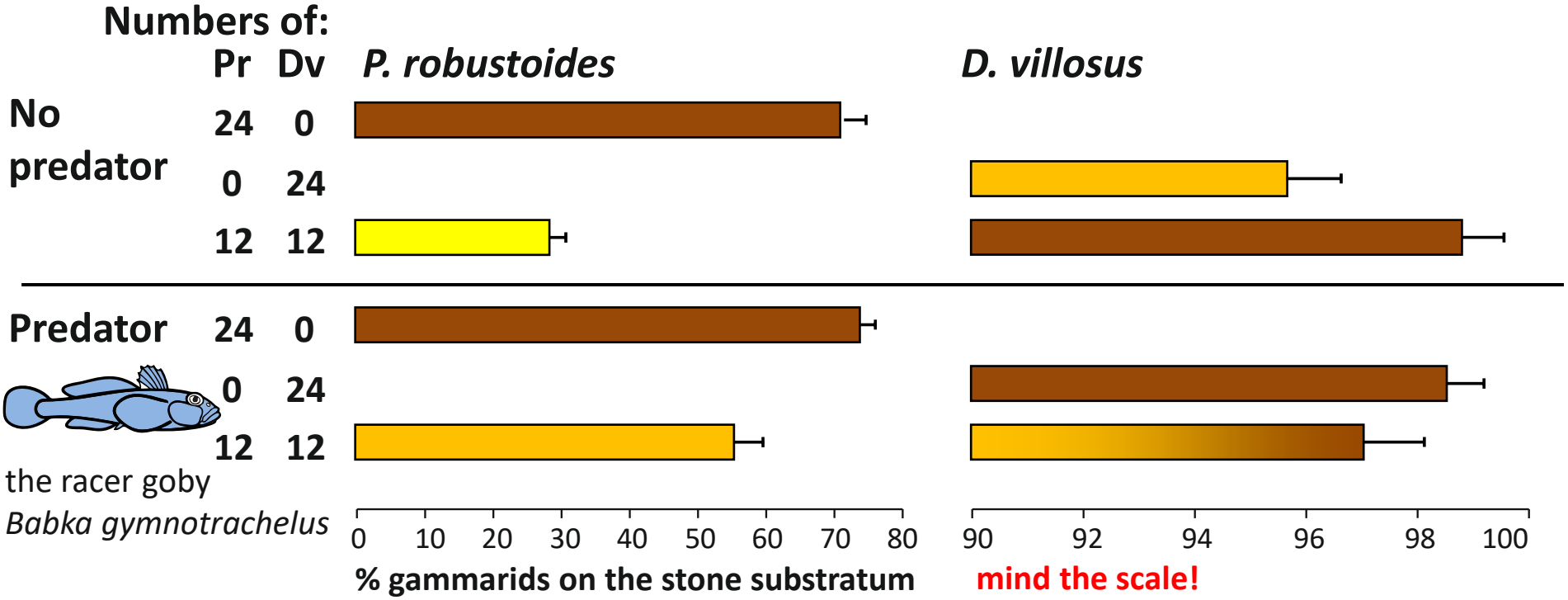
Substratum selection



- *P. robustoides* returns (partly) to the stones in the presence of fish
- **A top predator reduces the pressure of *D. villosus* on its competitor**

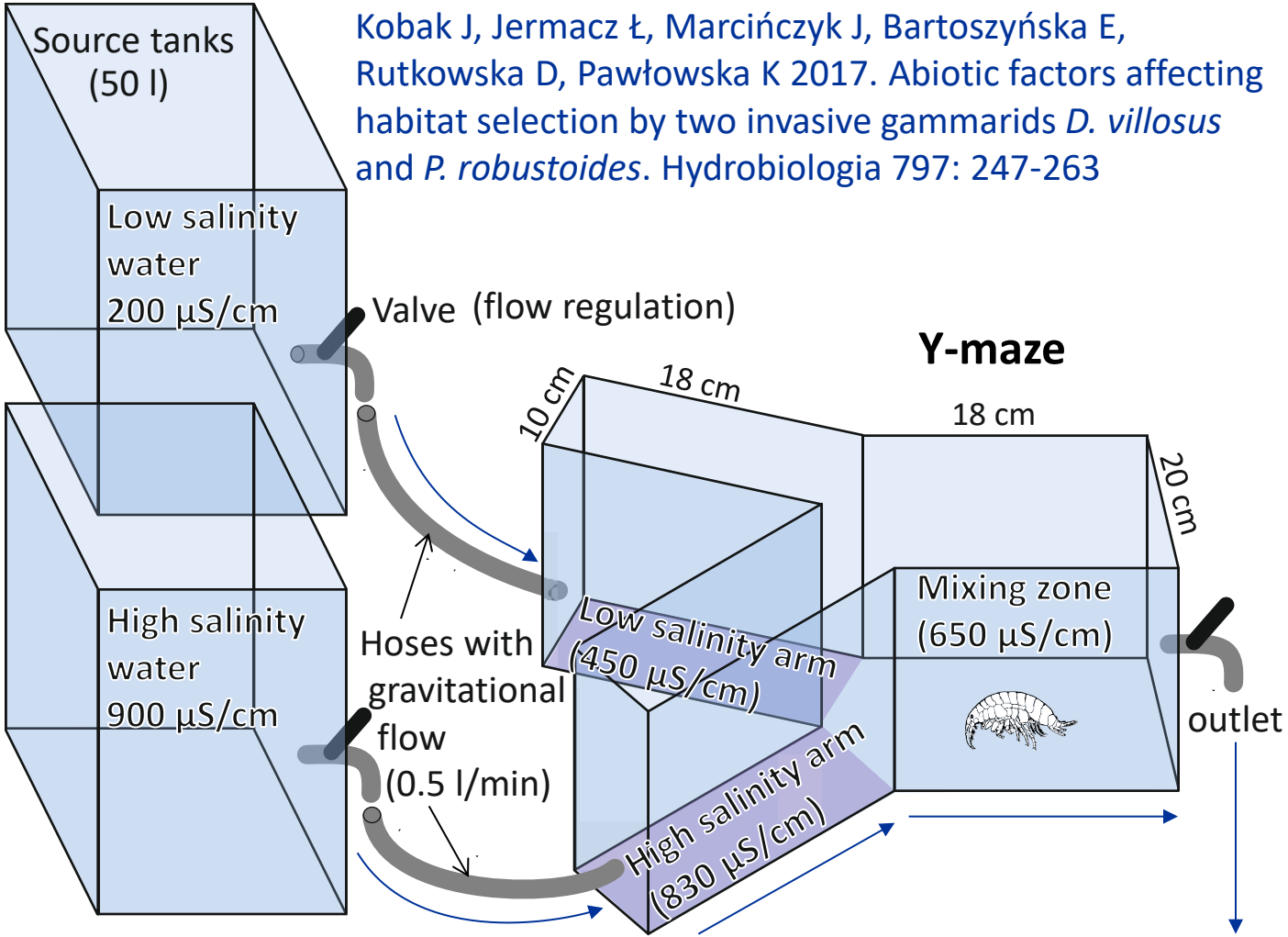
Salinity

- Ponto-Caspian gammarids occupy large European rivers, small affluents are free of invaders
- Lower salinity is often considered as a barrier for the Ponto-Caspian invaders, preventing them from entering small affluents

Kobak J, Jermacz Ł, Marcińczyk J, Bartoszyńska E, Rutkowska D, Pawłowska K 2017. Abiotic factors affecting habitat selection by two invasive gammarids *D. villosus* and *P. robustoides*. Hydrobiologia 797: 247-263

Salinity

- RO & Red Sea Salt
- Two groups adapted to low or high salinity for 3 weeks
- 10 gammarids in the maze
- Duration: 5 + 20 min
- Video recording and analysis of time spent in the zones (Noldus Ethovision XT 10.1)



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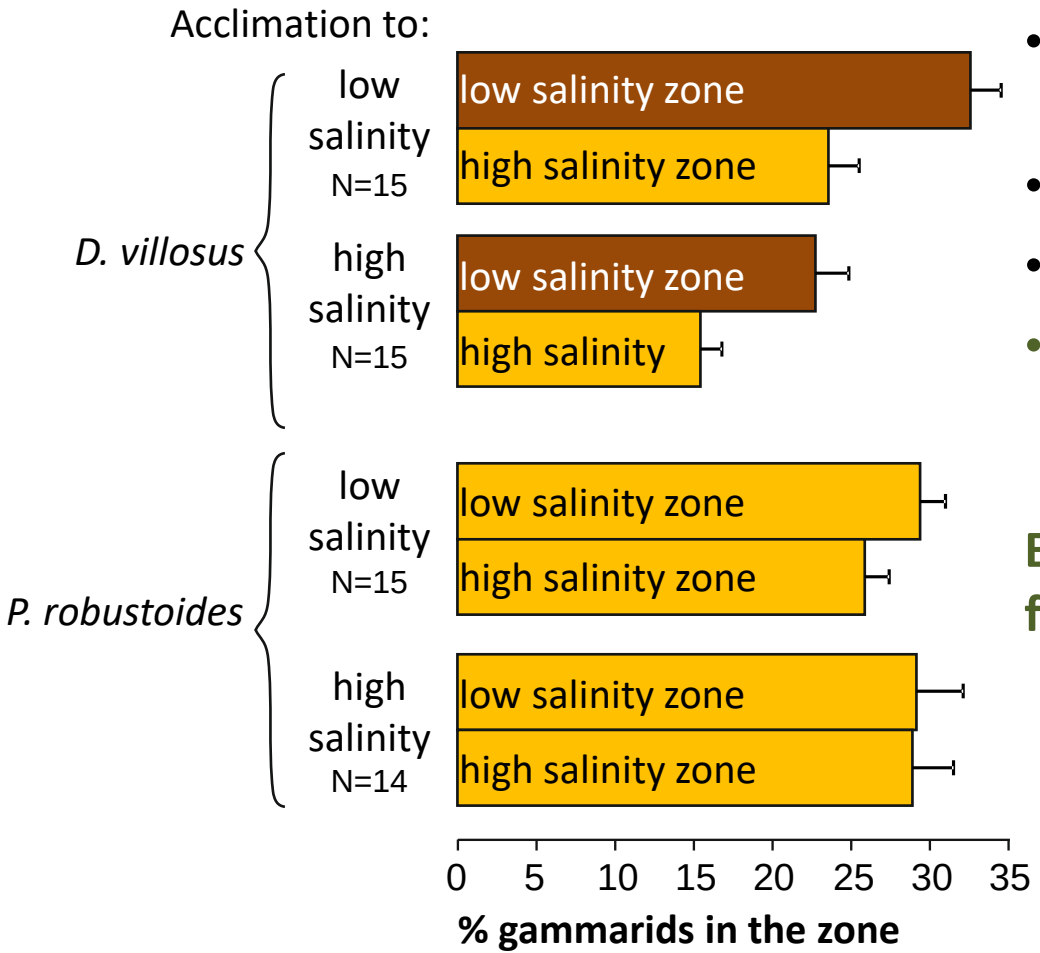
Salinity

450 vs. 830 µS/cm



- No preferences for high salinity detected
- *P. robustoides* shows no selectivity
- *D. villosus* prefers low salinity water
- **In the field: avoidance of high salinity areas in estuaries?**

But then, what keeps them away from small rivers?

Flow speed

- *P. robustoides* is considered as a lentic water species, whereas *D. villosus* lives in slowly flowing water

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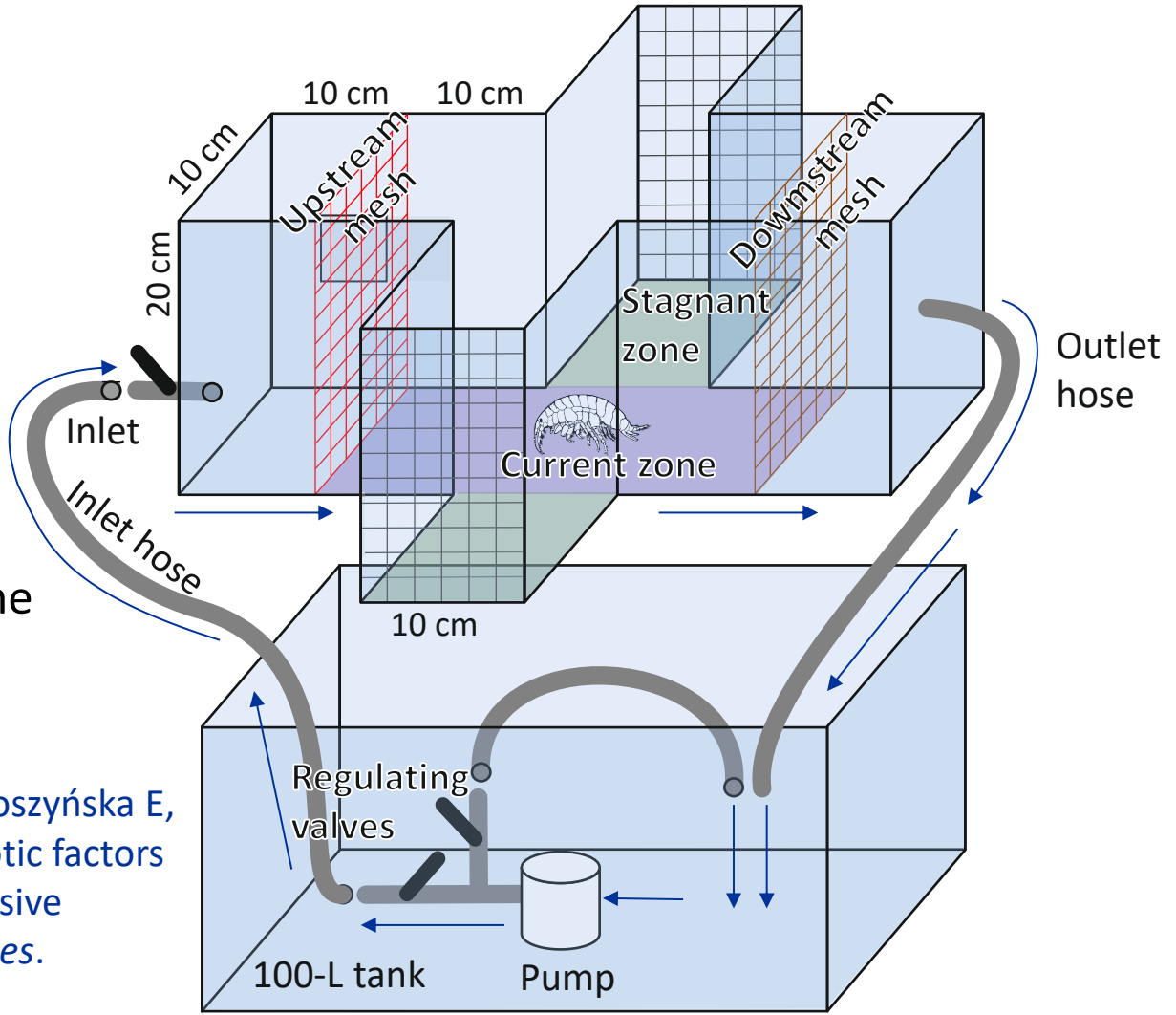
Flow speed

- Flow speeds:
  0, 5, 10, 15 and 30 cm/s
  (a range at the location of gammarid sampling)
- 5 gammarids per the tank
- Duration: 30 min
- Recording and analysis of time spent in the zones (Noldus Ethovision XT 10.1)



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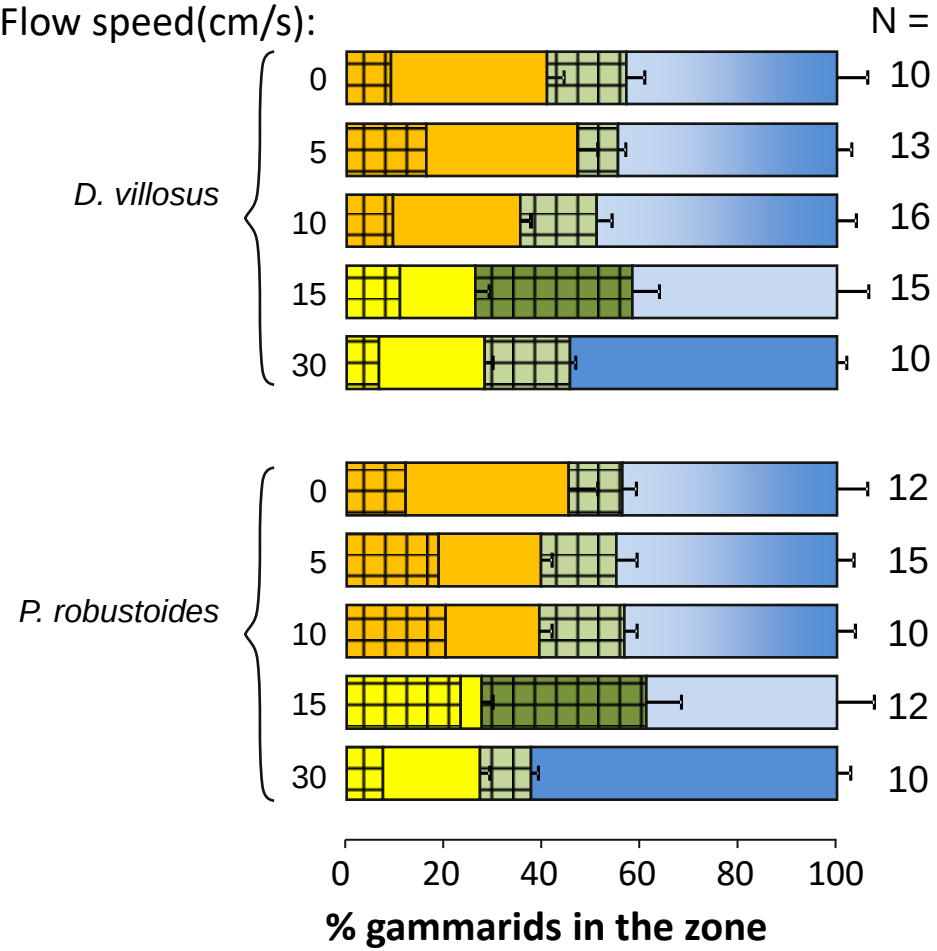
Flow speed



Upstream mesh
Current zone
} Preference for flow (if > the control)

Downstream mesh - Passive drift

Stagnant zone - Avoidance of flow (if > the control)

- No preferences for flowing water
- Avoidance of flows ≥ 15 cm/s
  - At 15 cm/s gammarids stay on the downstream mesh
  - At 30 cm/s they move to stagnant refuges
  - Thus, they are still capable of movement at this flow rate
  - **A reason for avoidance of small rivers?**

Temperature

- Ponto-Caspian species can potentially select warmer areas due to their origin
- They can find colder and warmer microhabitats due to variable shadowing, sediment quality or presence of river outlets, particularly in shallow water

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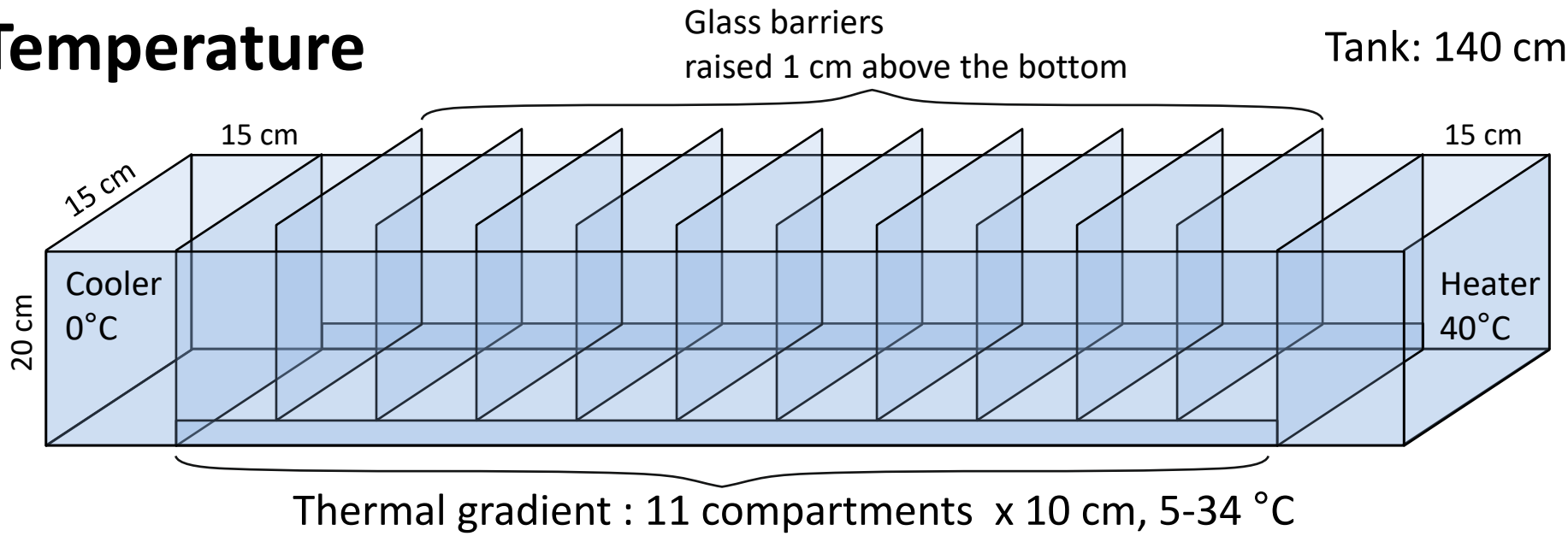
Temperature



- Gammarids collected and tested in summer and in autumn
- In each season, 2 groups: acclimated to 10 or 20 °C
- Duration: 1 h
- Counting individuals in zones of particular temperatures

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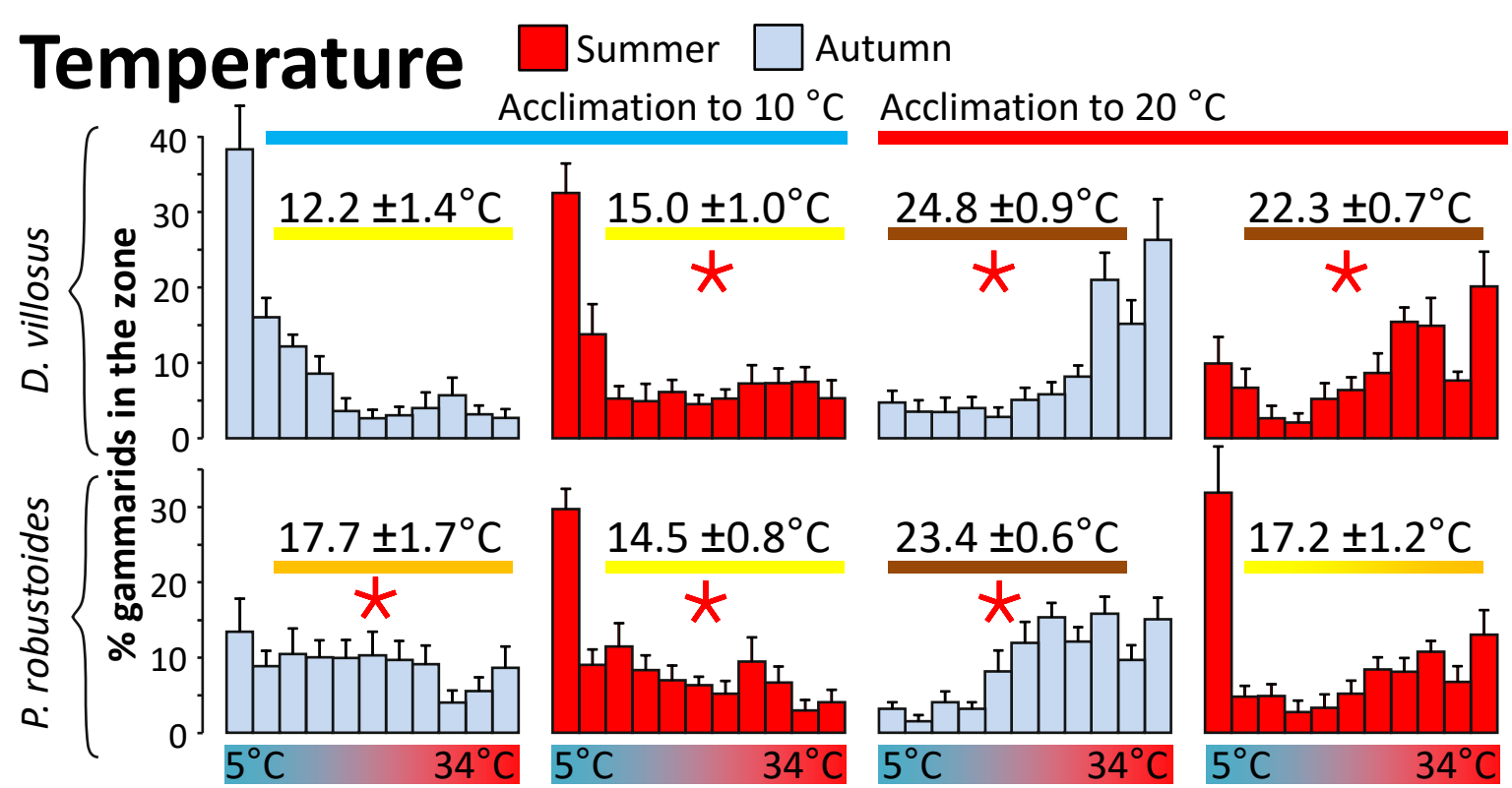


Mean selected temperature:

$\Sigma(N_i * T_i)/\Sigma N_i$

N_i - Number of ind. in zone i

T_i - Temperature in zone i

- Usually they select warm water *

- The choice of *D. villosus* depends on acclimation temp.
- Some *D. villosus* like it hot...

- *P. robustoides* depends more on season
- But it selects colder sites in summer than in autumn
- **A kind of behavioural regulation?**

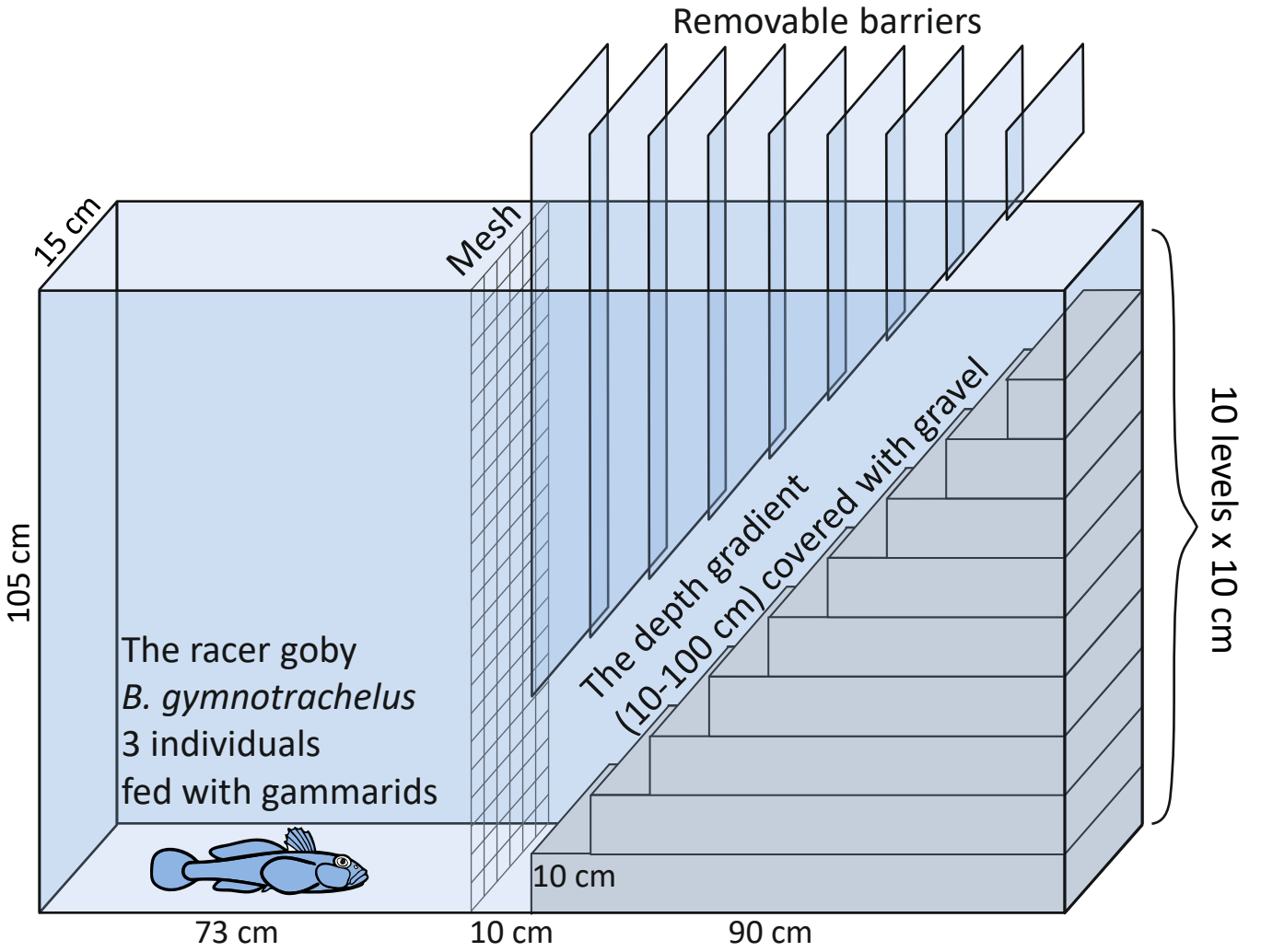
Depth

- In the field, *P. robustoides* is often found in shallow sandy areas, whereas *D. villosus* occupies deeper sites and/or hard substrata
- We already know this is not a matter of substratum quality
- Do they displace each other to shallower/deeper water or have different depth preferences?

Kobak J, Jermacz Ł, Rutkowska D, Pawłowska K, Witkowska L, Poznańska M 2017. Impact of predators and competitors on the depth selection by two invasive gammarids. J. Zool. 301:174-183

Depth

- 40 gammarids of single species or 20+20 of both species
- Duration: 24 h
- Couting gammarids in particular zones
- Darkness



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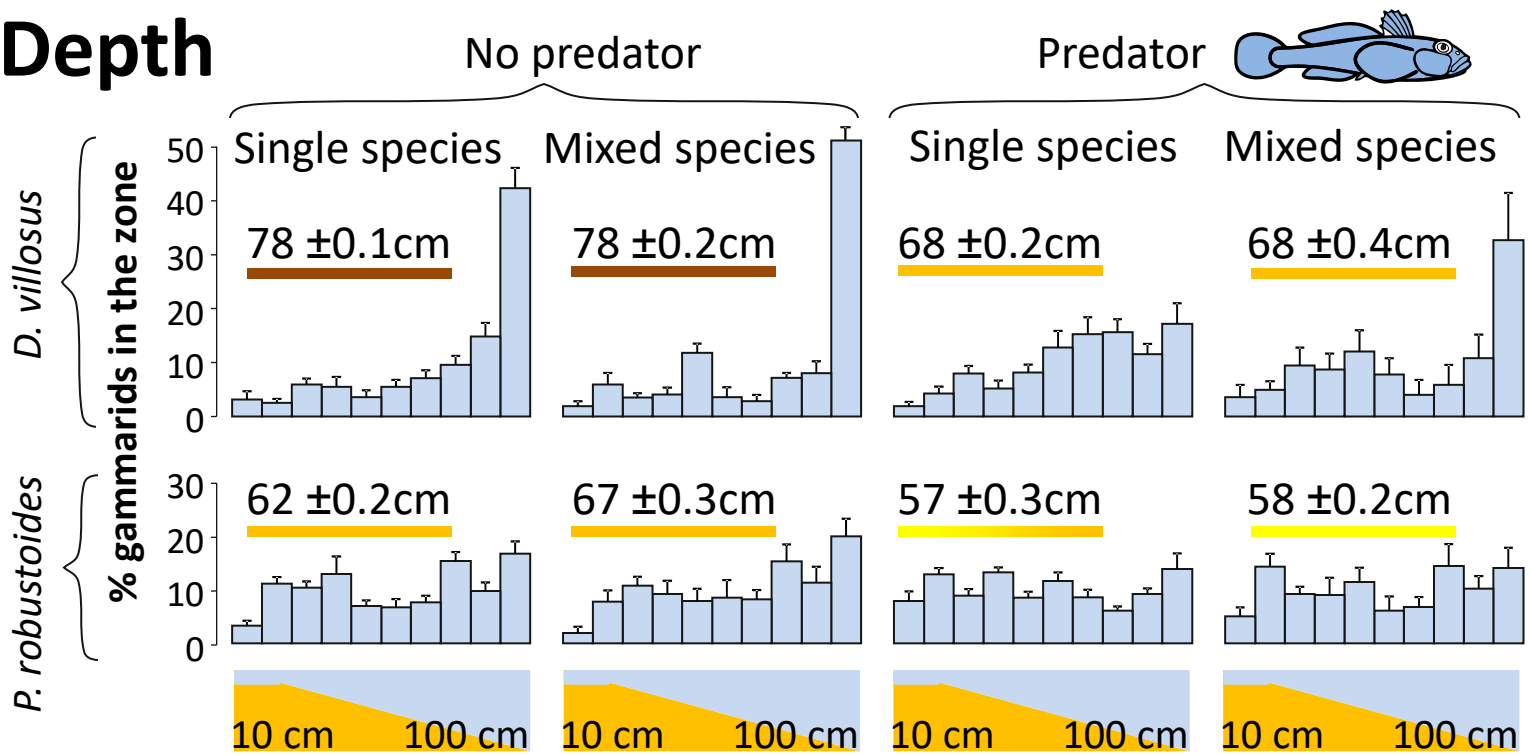

Mean selected depth:

$\Sigma(N_i * D_i)/\Sigma N_i$

N_i - Number of ind. in zone i

D_i - Depth of zone i

- *P. robustoides* occupies shallower water than *D. villosus*
- No effect of species on each other
- **Habitat partitioning?**
- *D.villosus* escapes from predators to shallower water
- Weak effect of predators on *P. robustoides*

Summary

- *D. villosus* and *P. robustoides* have overlapping substratum preferences.
- *D. villosus* displaces the weaker competitor to less suitable areas.
- Their negative interactions are decreased by the impact of top predators and different depth preferences of both species.
- Neither species selects high salinity water. Thus, their absence in small European rivers may be rather caused by their thermal and flow preferences.
- Both species will generally select warm and stagnant/slowly flowing waters with hard substratum.

Thank you for your attention

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