Behaviour and dispersal potential in invasive fish populations

… are we creating superfish?

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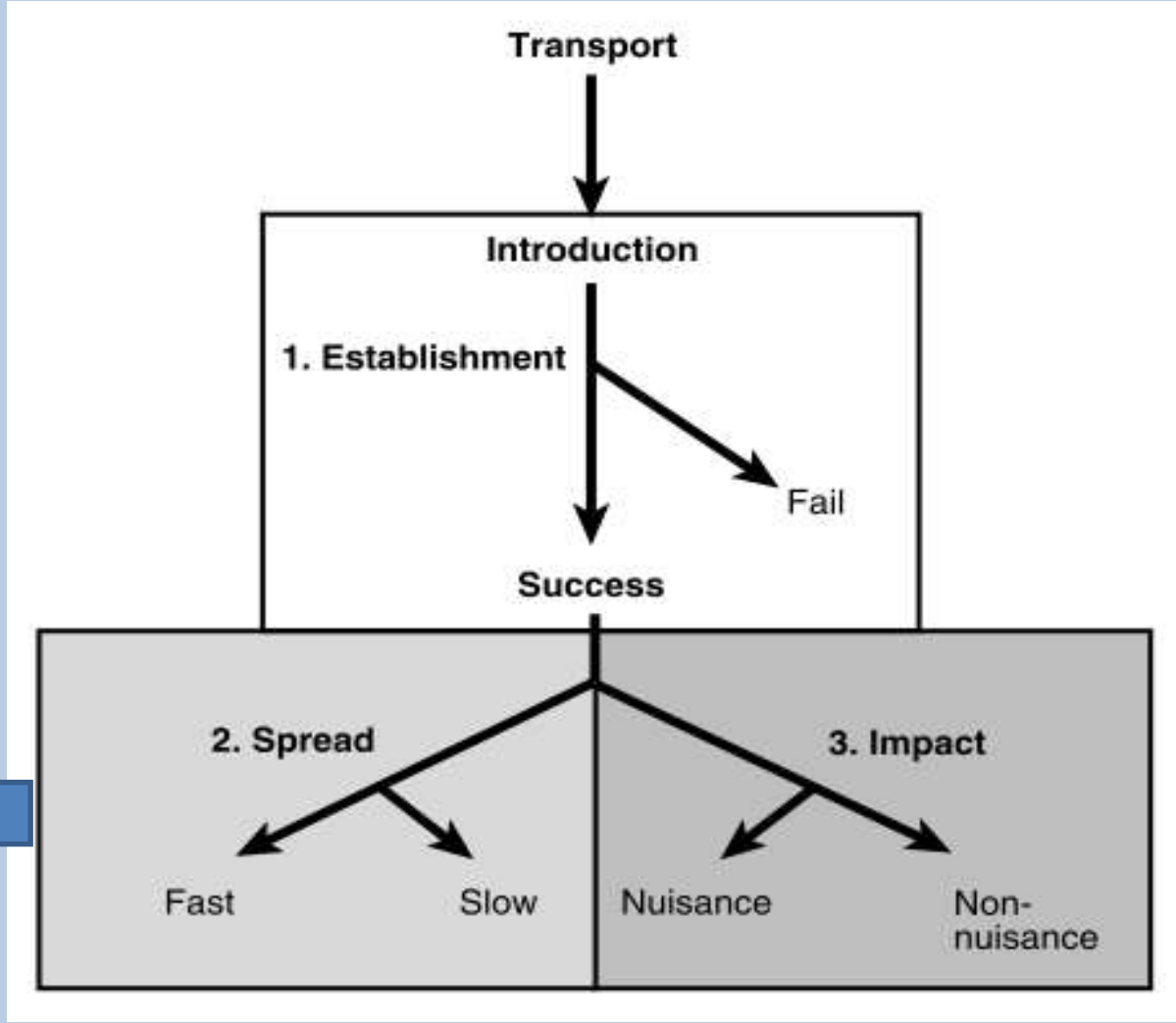
Steps in successful invasion (and prediction of success)

"Invasion by alien species is a process consisting of several transitions, each with an independent probability of failure, and cumulative failure rates are high."

Kolar & Lodge (2002): *Ecological predictions and risk assessment for alien fishes in North America*.

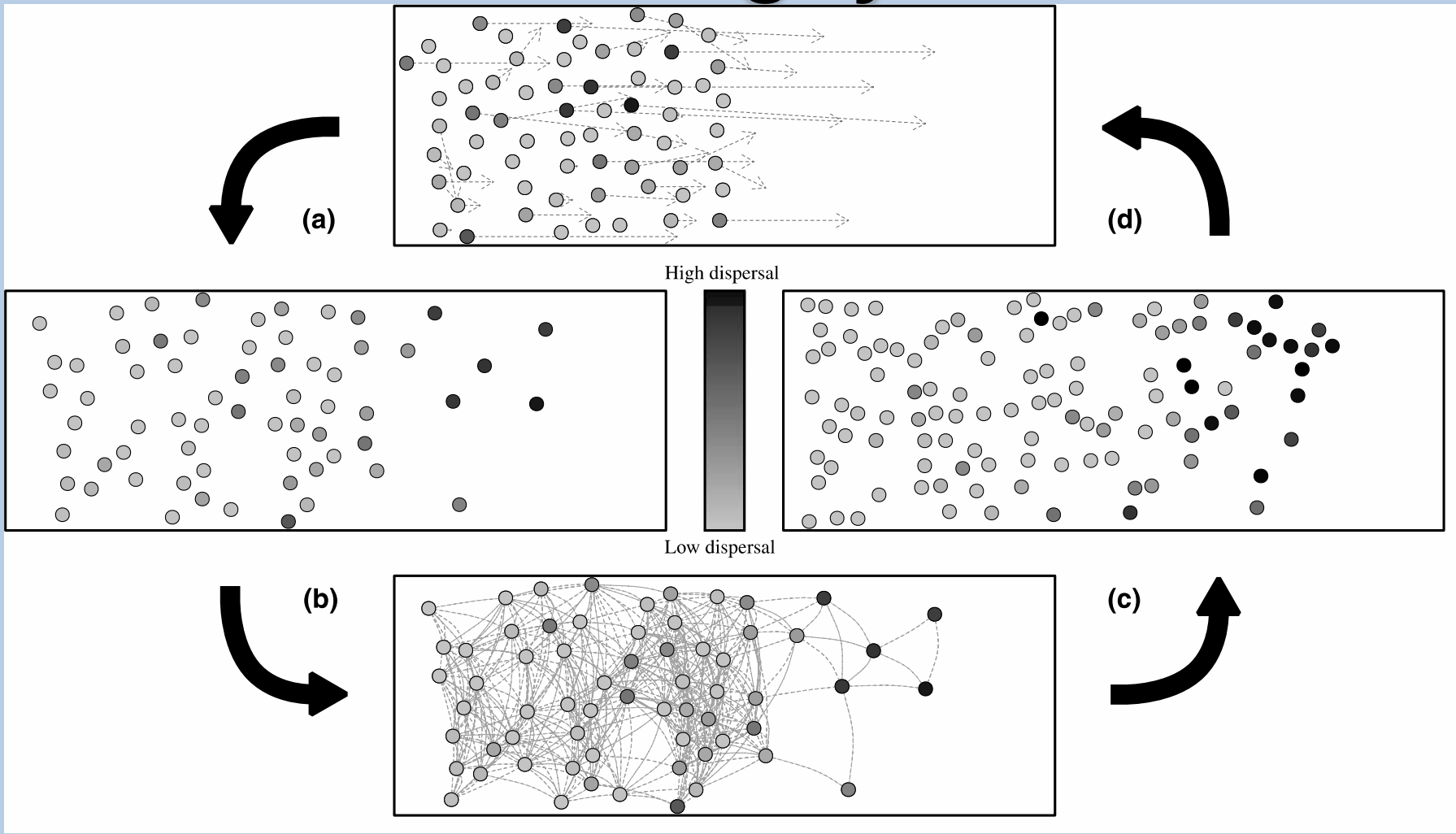
Invasion fronts are the boundaries from which spread occurs



Invasion front dynamics: who are those guys?

Spatial sorting & the Olympic Village effect

(*Phillips et al. 2008, 2010*)



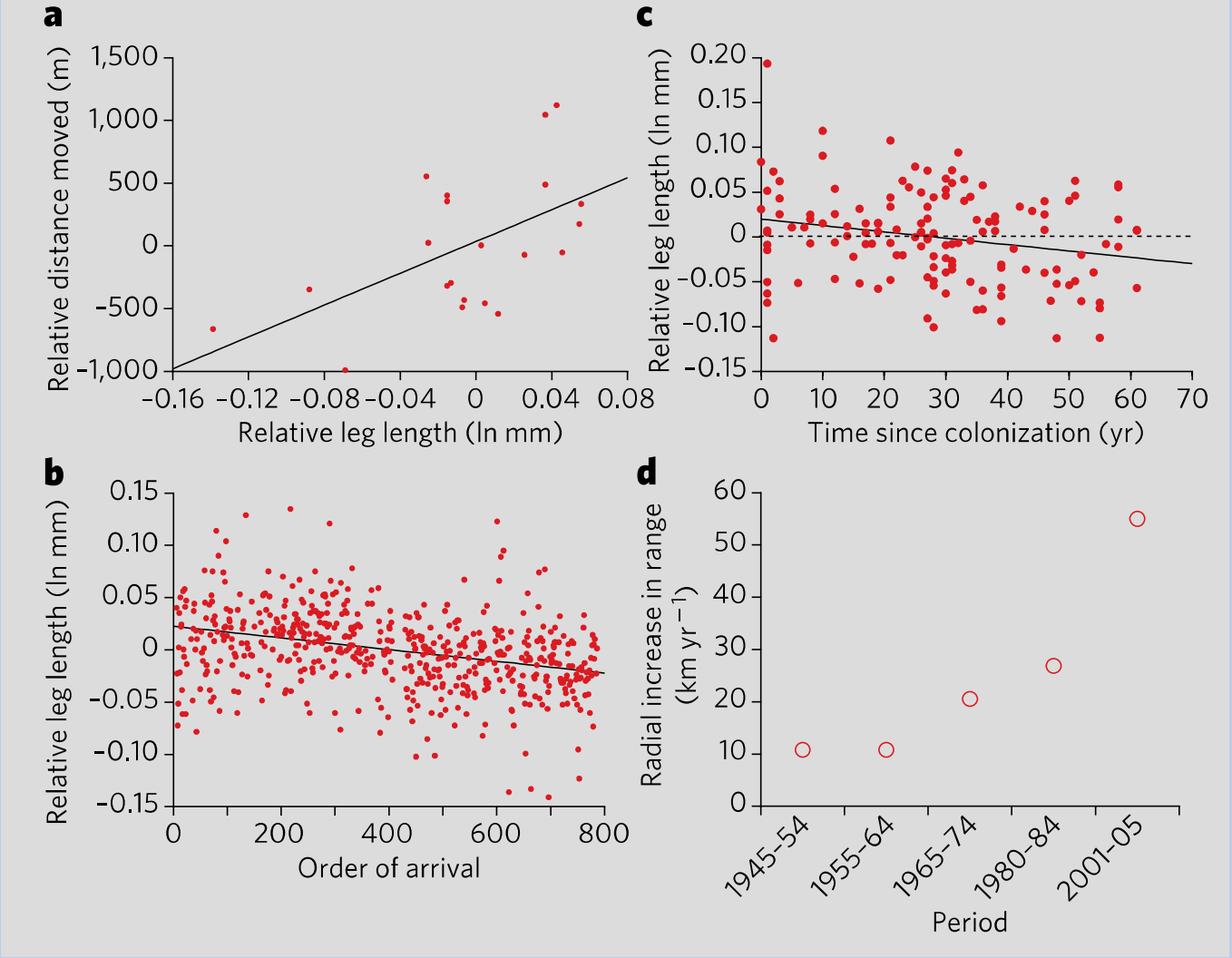
(*Chuang & Peterson 2016*)

Invasion front dynamics:
evidence for spatial selection on dispersal ability

Morphological shifts as cane toads invade

- toads with longer hind limbs move further
- longer hind limbs at the new front

(*Phillips et al. 2006*)

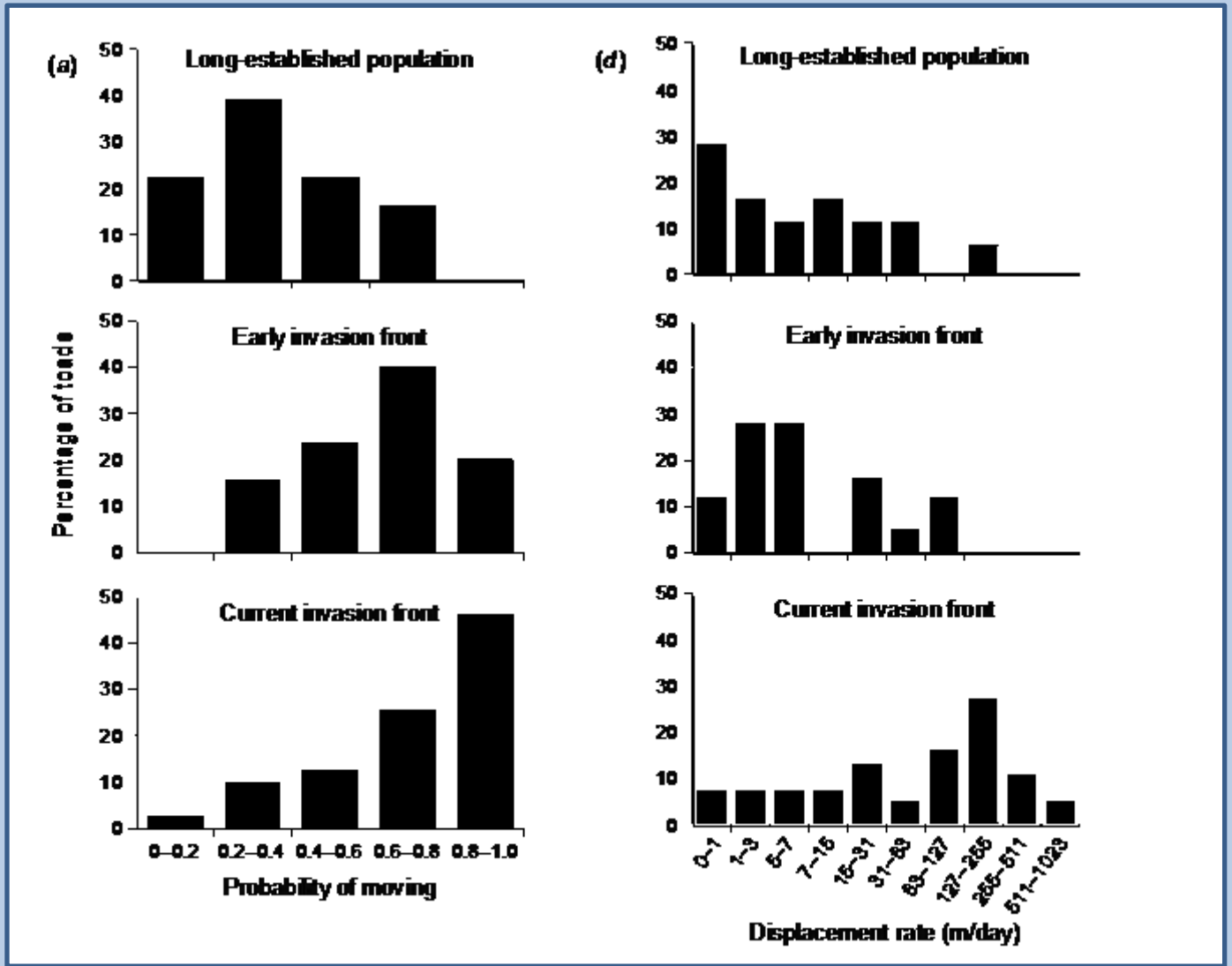


Invasion front dynamics: evolution of super-dispersers?

Toads at the invasion front show:

- higher probability of moving
- greater movement distance

Alford et al. (2009)



Role of personality in invasion dynamics

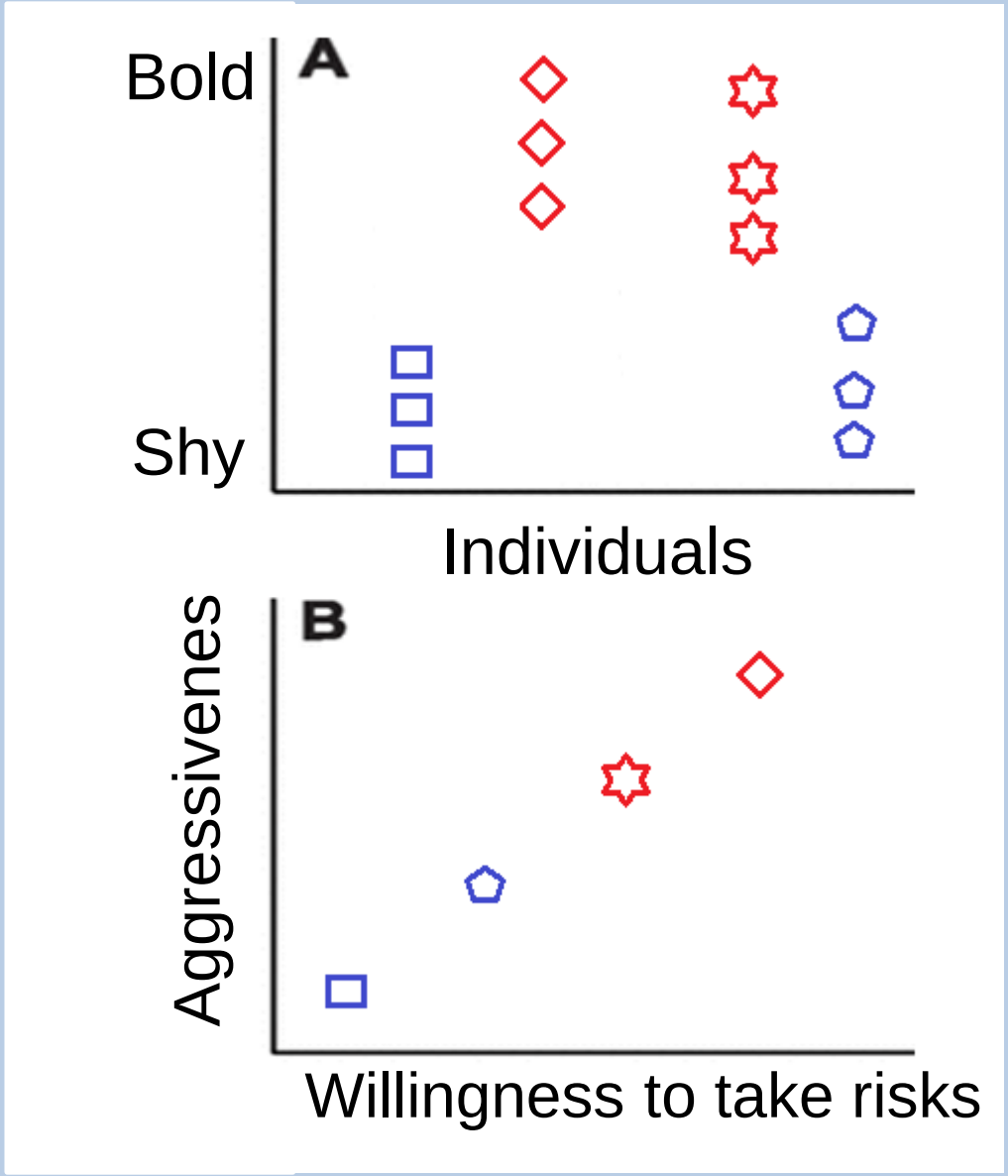
Shy

- timid
- unaggressive
- does not explore novel environments

Bold

- courageous
- aggressive
- explores novel environments

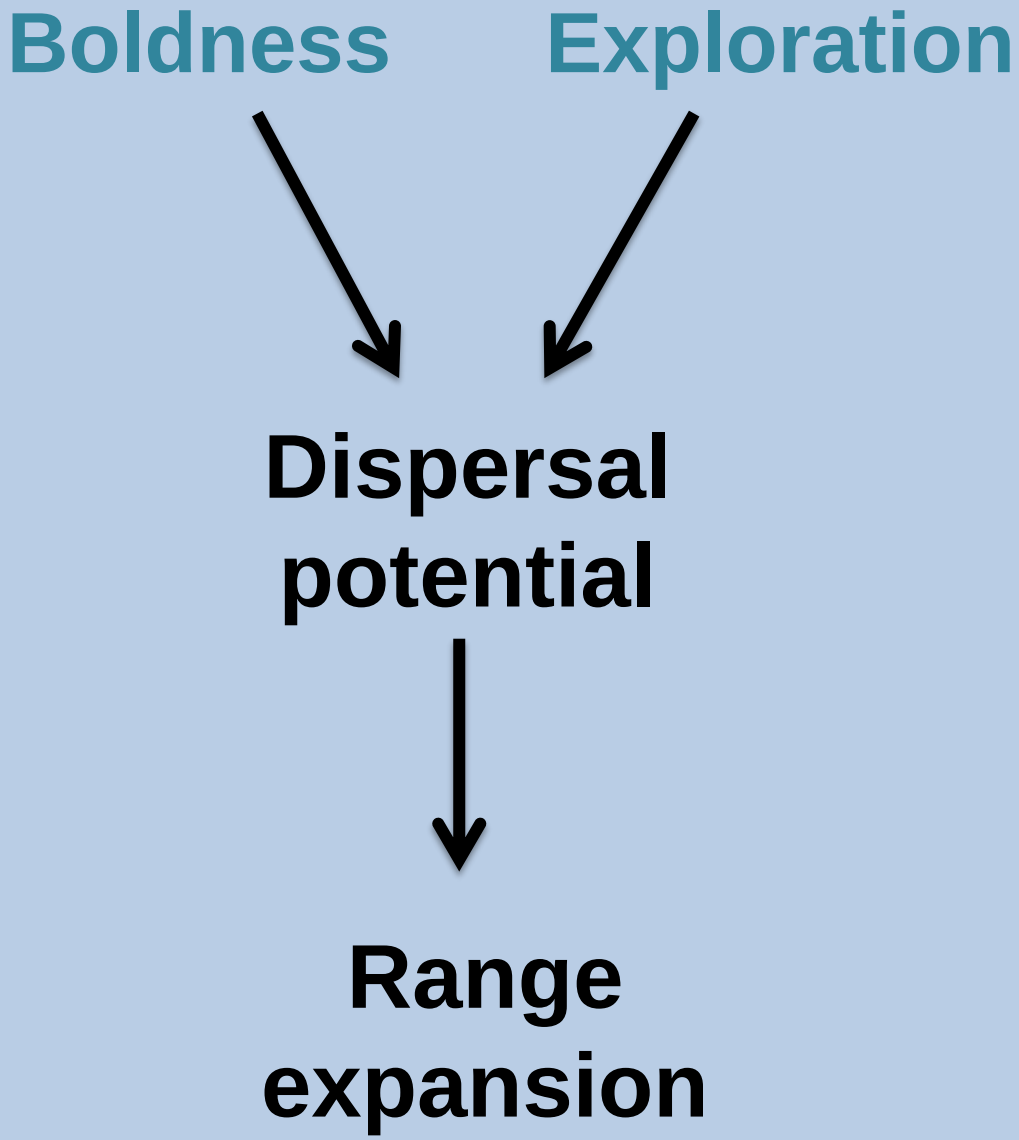
Behavioural Syndromes



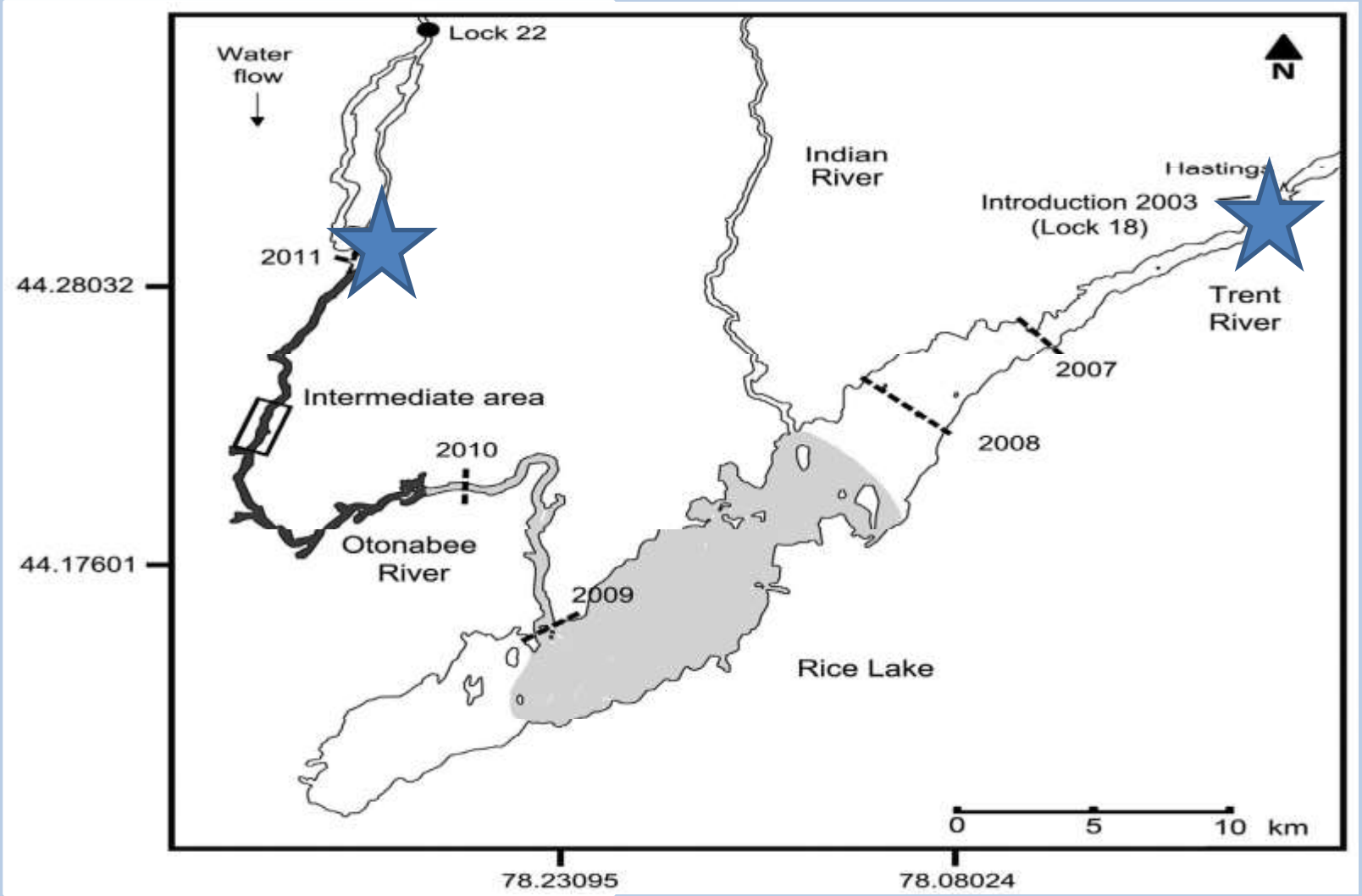
Individuals show consistent behavioural scores across different times and contexts

Correlations among traits

Poulin (2013) Parasite manipulation of host personality & behavioural syndromes. J Exp Biol


Boldness
Exploration
Dispersal potential
Range expansion

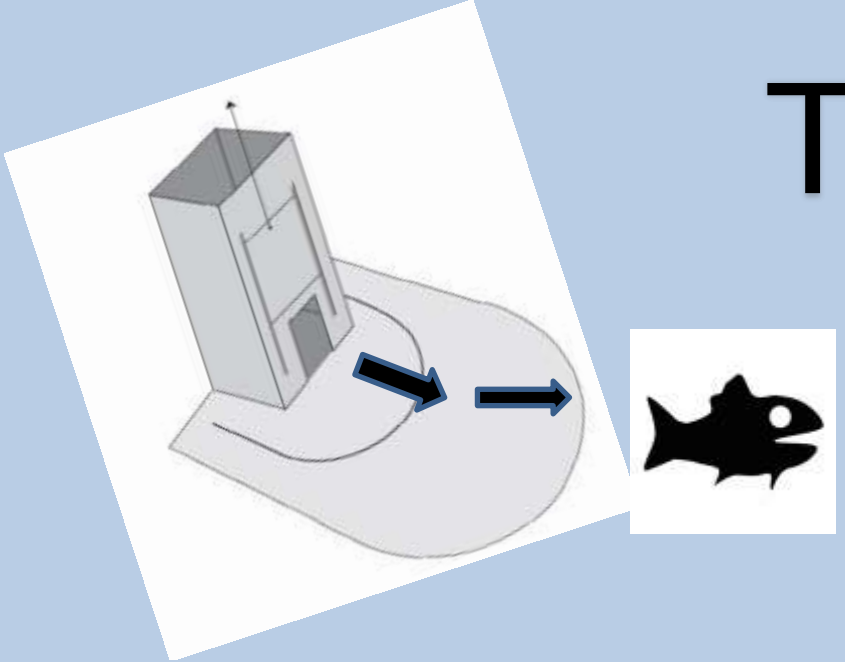
Round goby



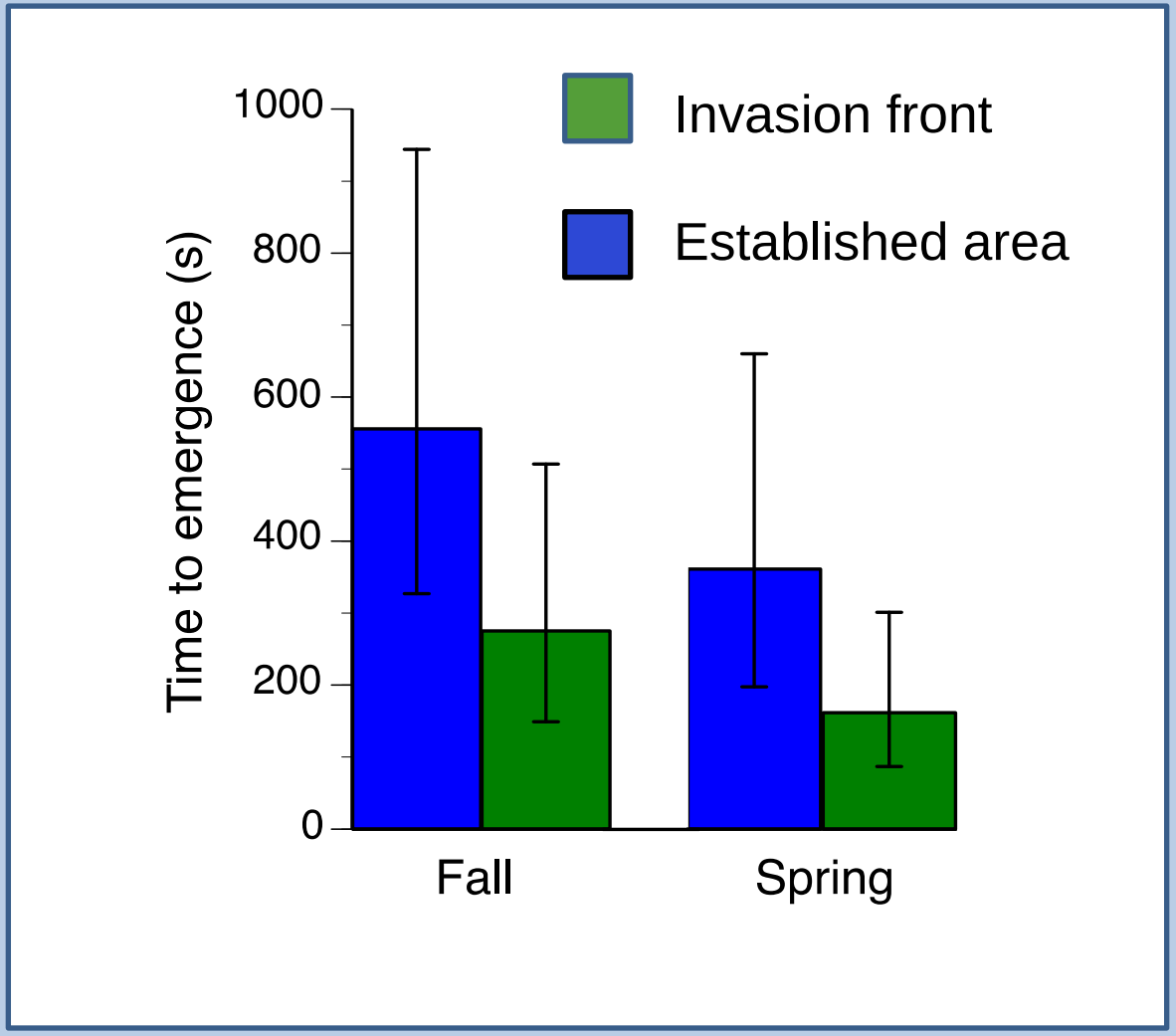
Brownscombe et al. (2012)

Behaviour & dispersal trials

Time to Emerge

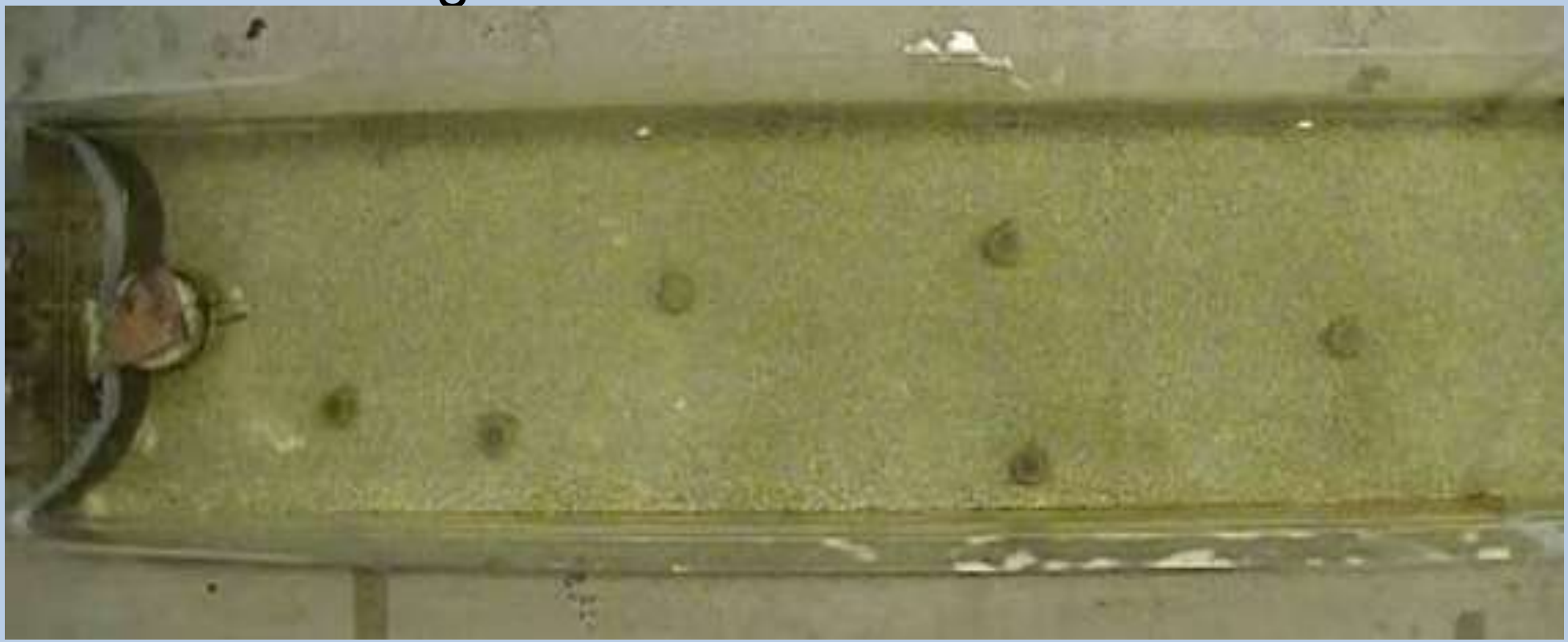


Adapted from Brown et al. (2005)



Behaviour & dispersal potential trials

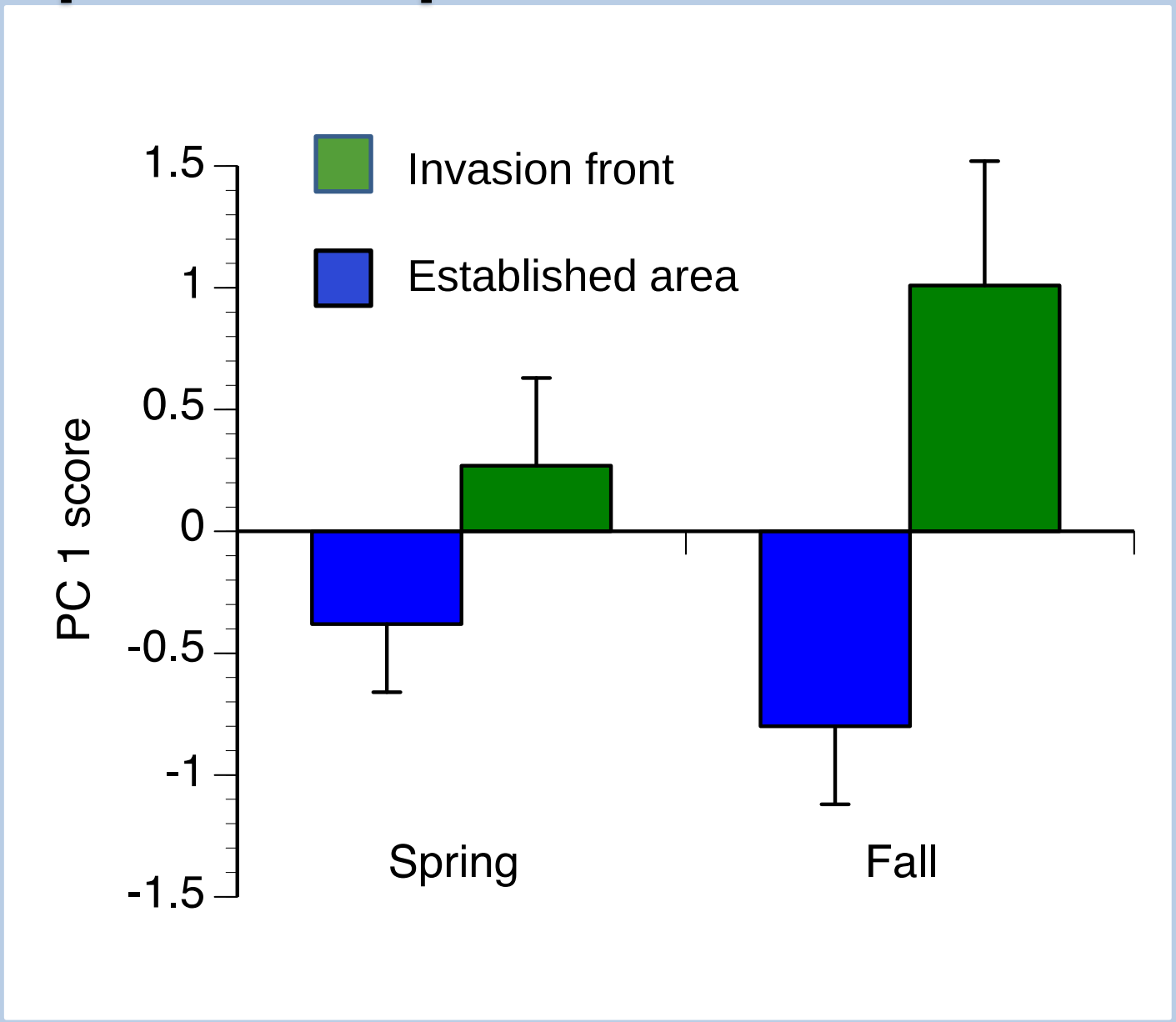
- goby from invasion front (time lapse)
- time to emergence 100 sec



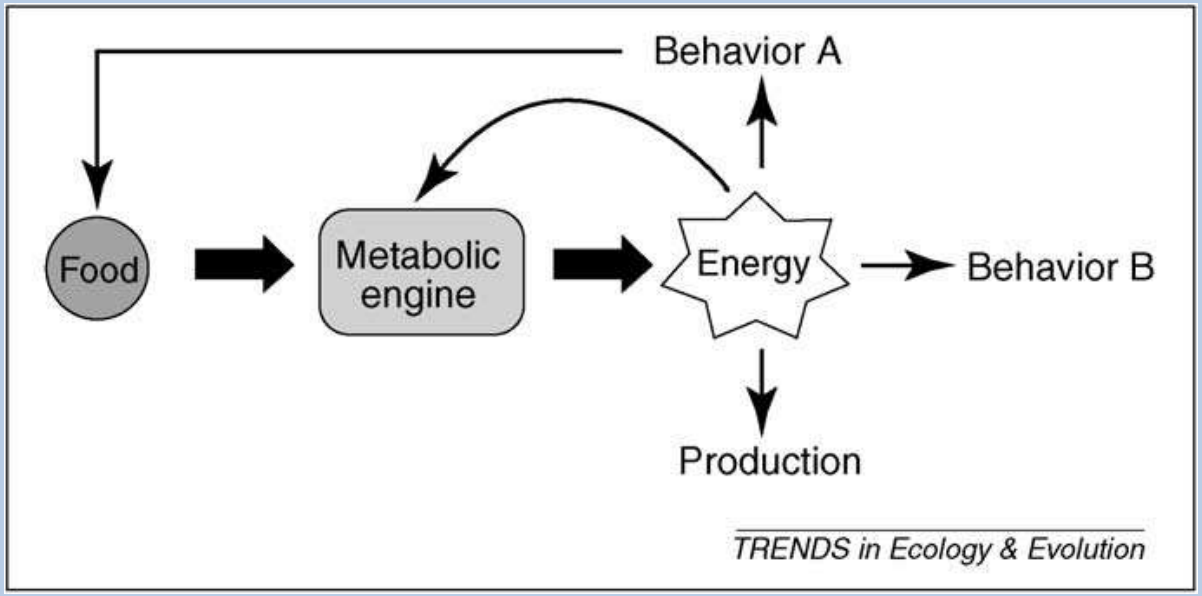
Dispersal potential

PC1 (66% of variation) highly correlated with:

- total distance travelled (0.97)
- mean velocity (0.95)
- amount of time in motion (0.90)

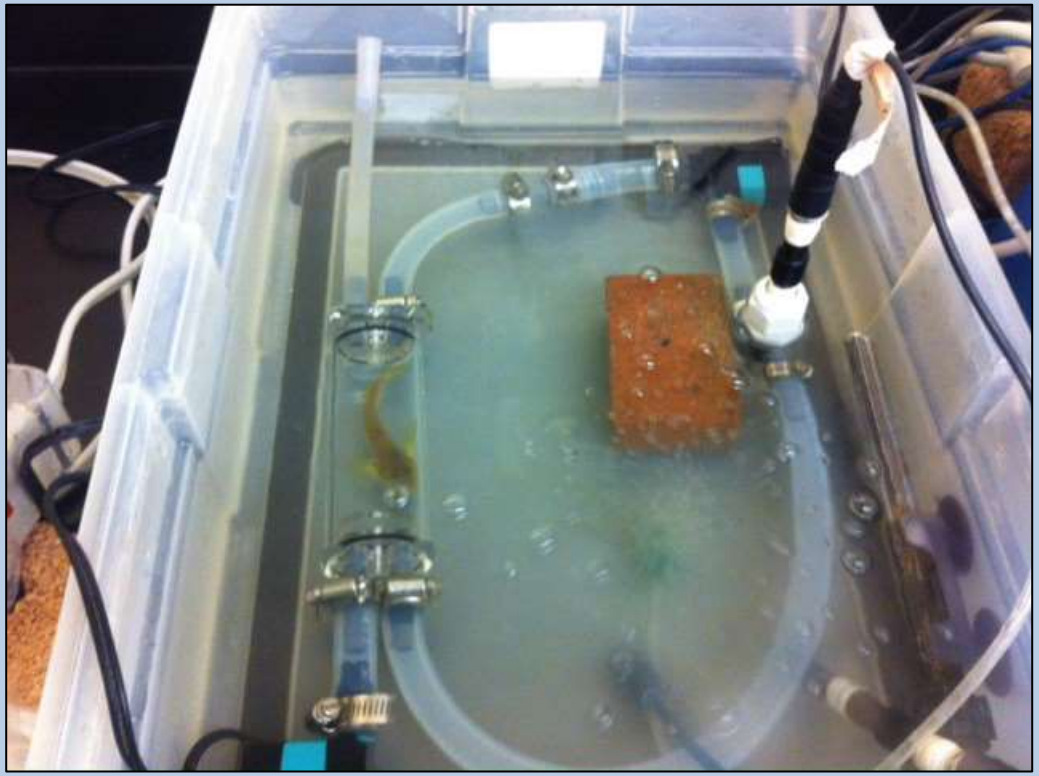


Metabolism

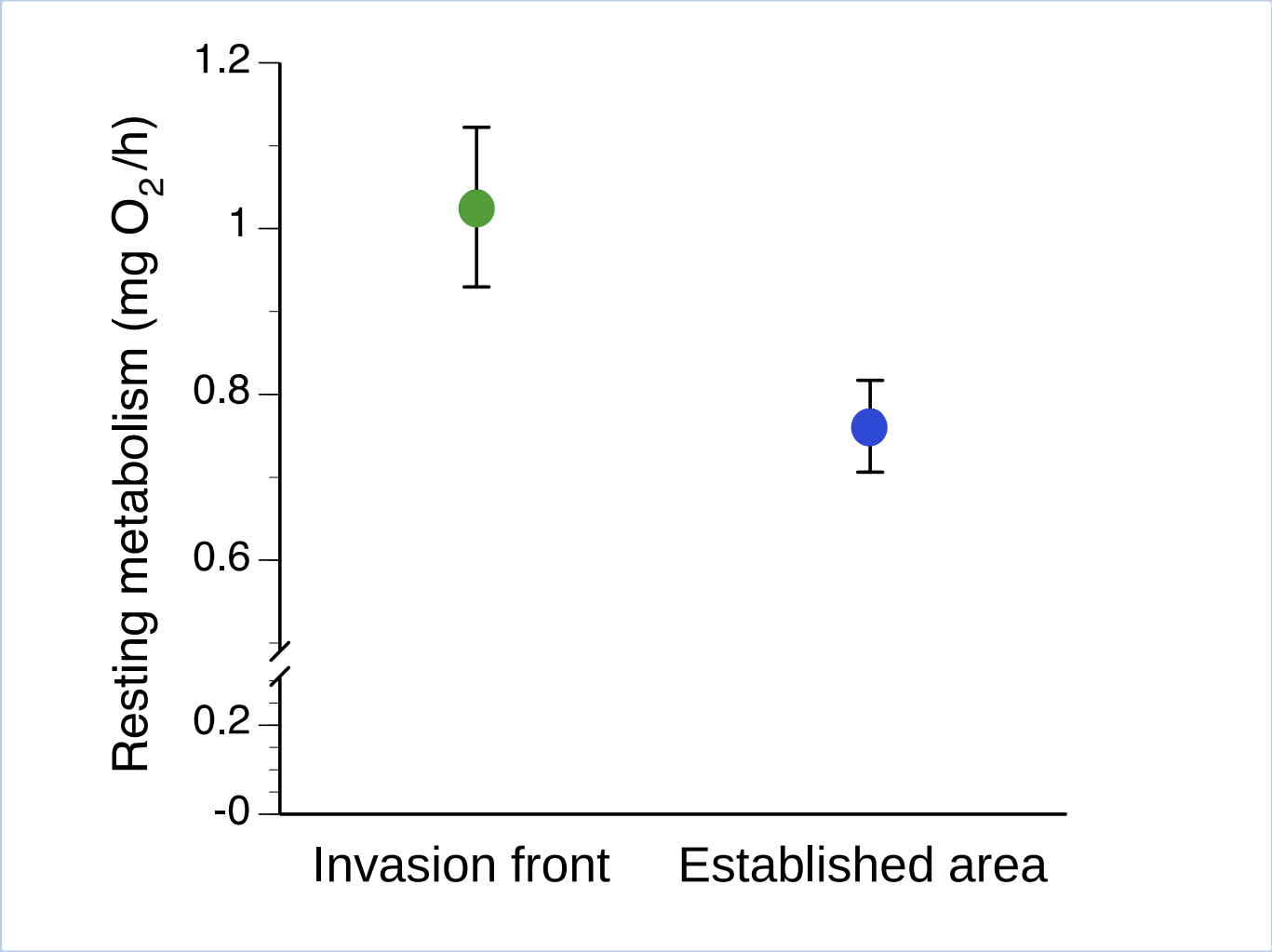


Hypothesized link between metabolism and behaviour

Biro & Stamps (2010)



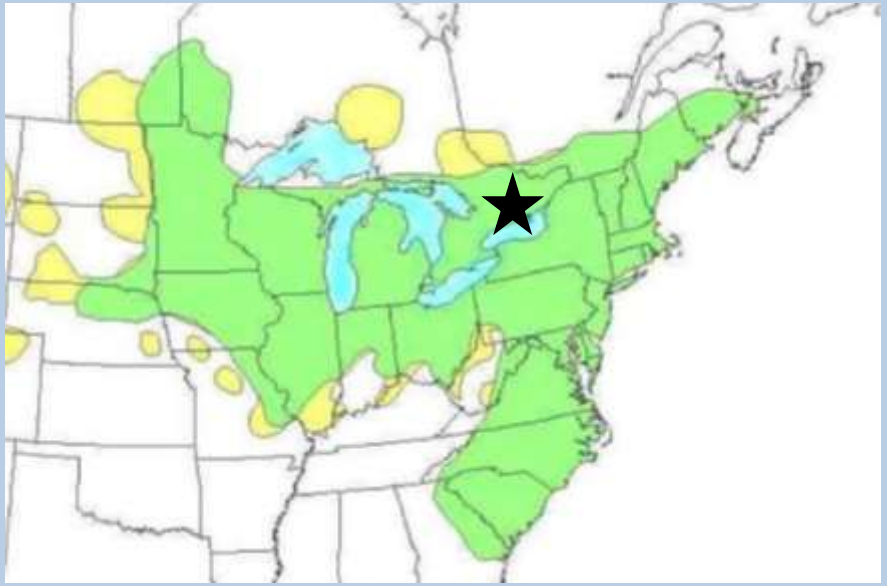
Metabolic rate



Summary

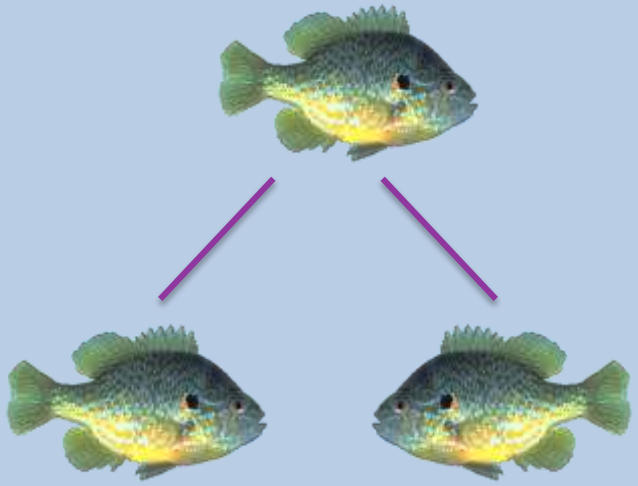
	Established area	Front
Behaviour	Shy	Bold
Dispersal potential	Low	High
Metabolism	Low	High

Are disperser traits elevated in invasive populations?



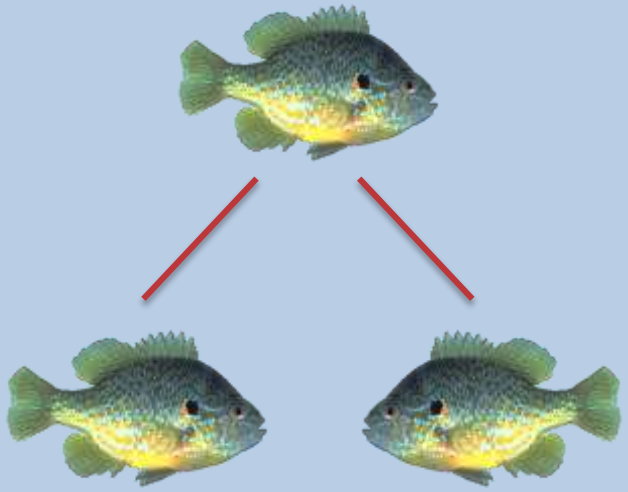
Native range

Introduced range



Otonabee River

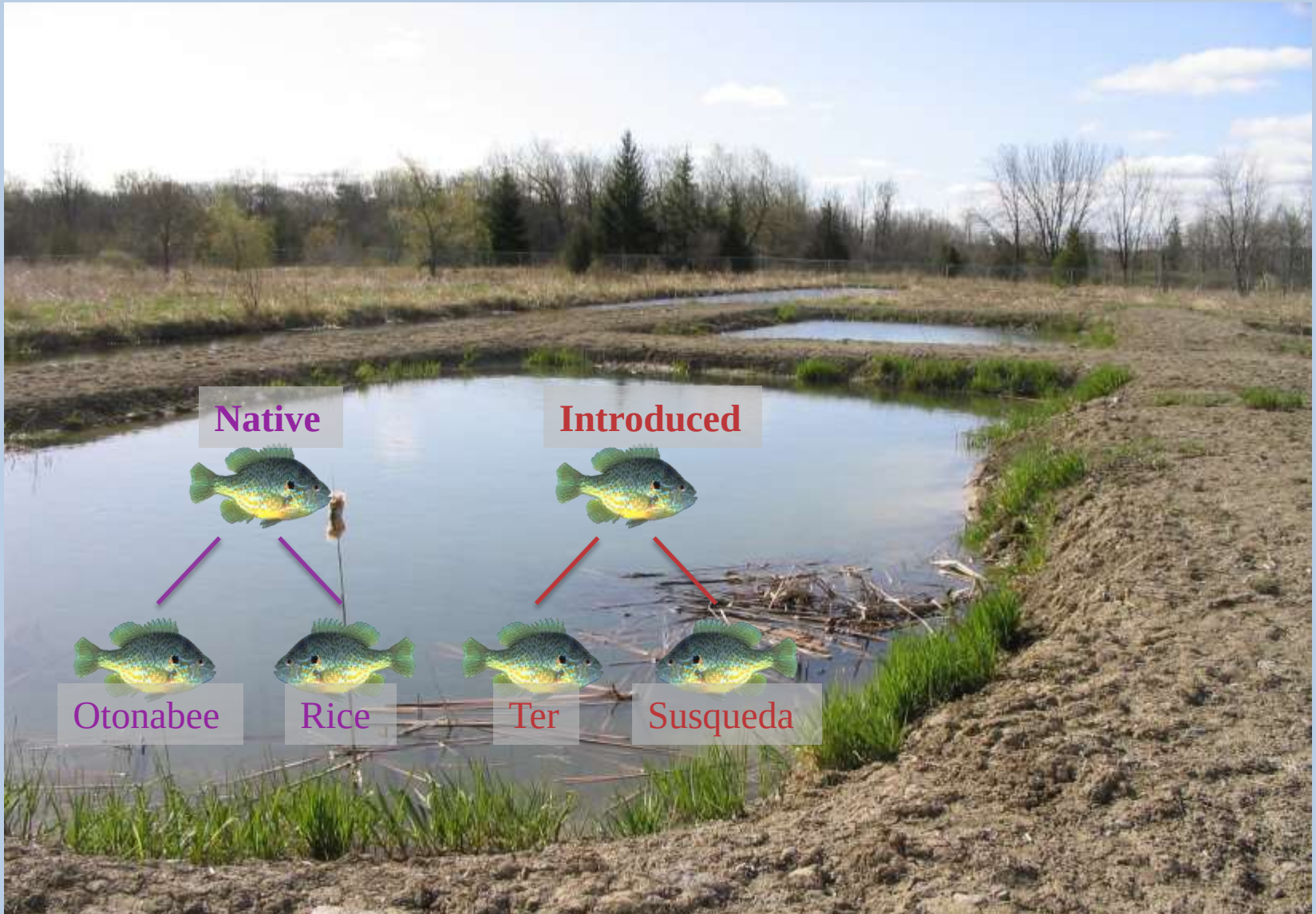
Rice Lake

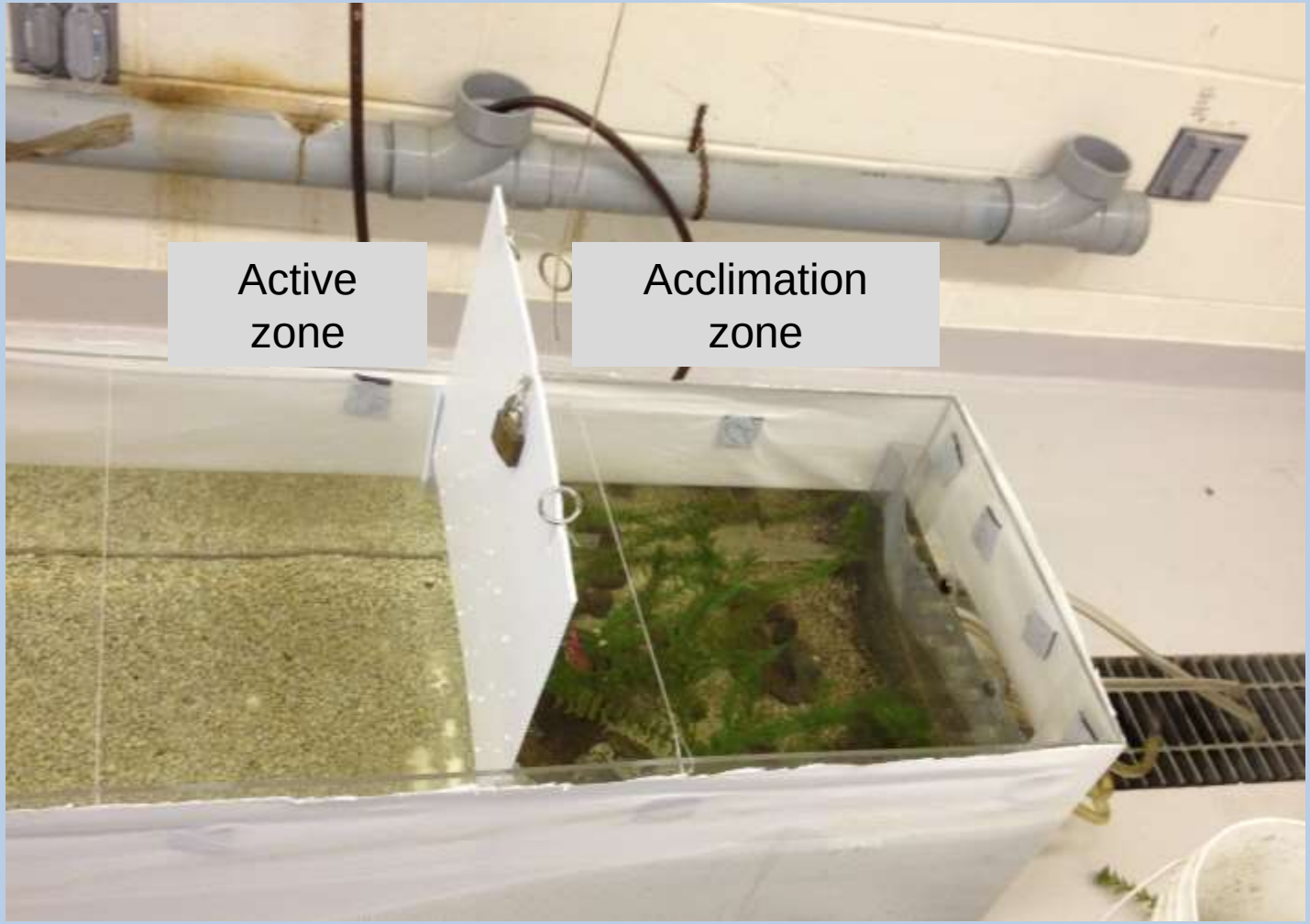


Ter River

Susqueda Reservoir

Pond colonies
(established in 2007)





- 4 m arena
- one fish tested at a time
- 30 min acclimation period
- 30 min trial period
- 2 aerial view cameras

Measures and analysis

Independent variables:

- Total length of body
- Sex

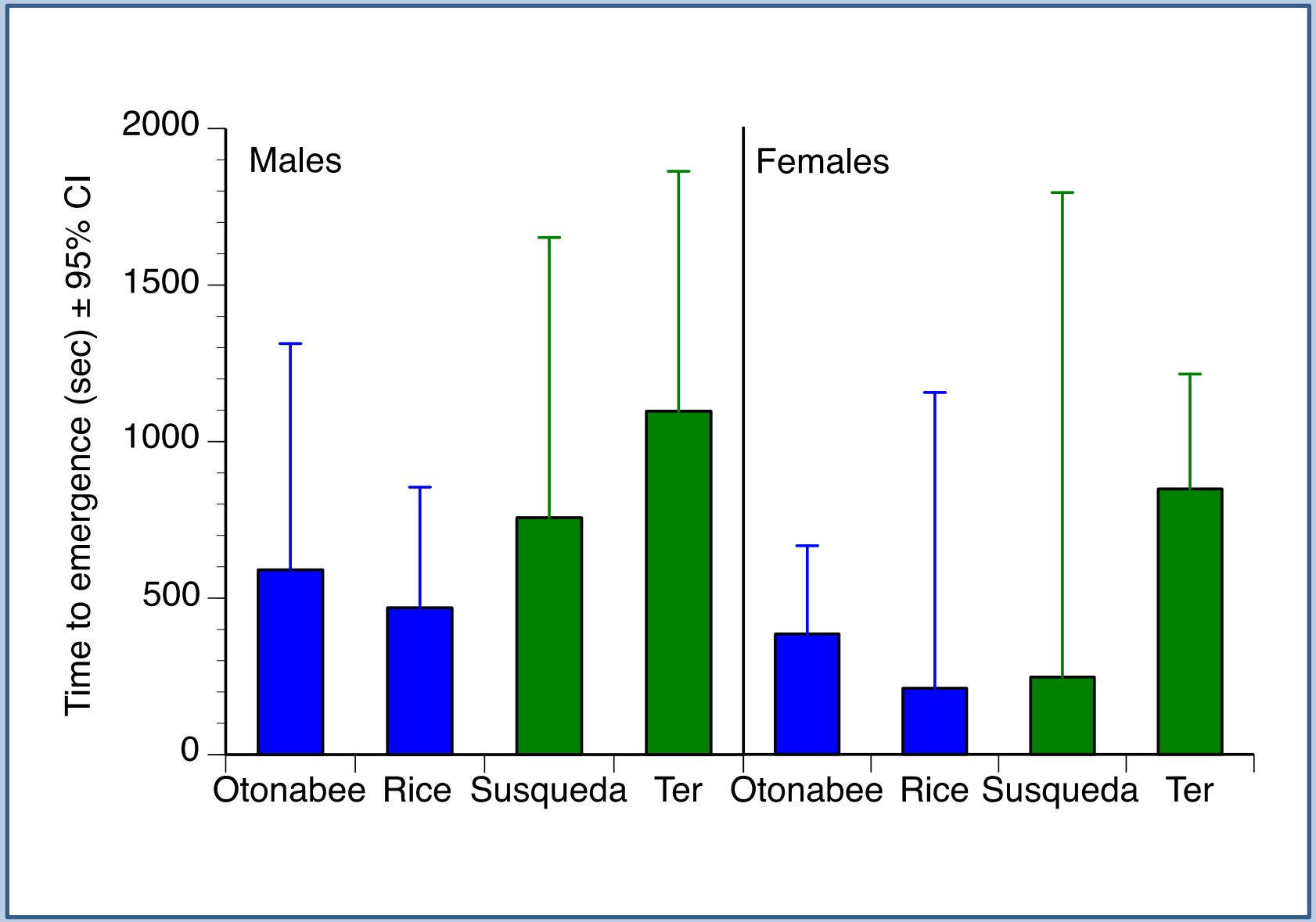
Boldness:

- Time to emerge

Dispersal potential:

- Total distance traveled
- Average velocity (overall & while in motion)
- Time spent moving
- Furthest distance traveled

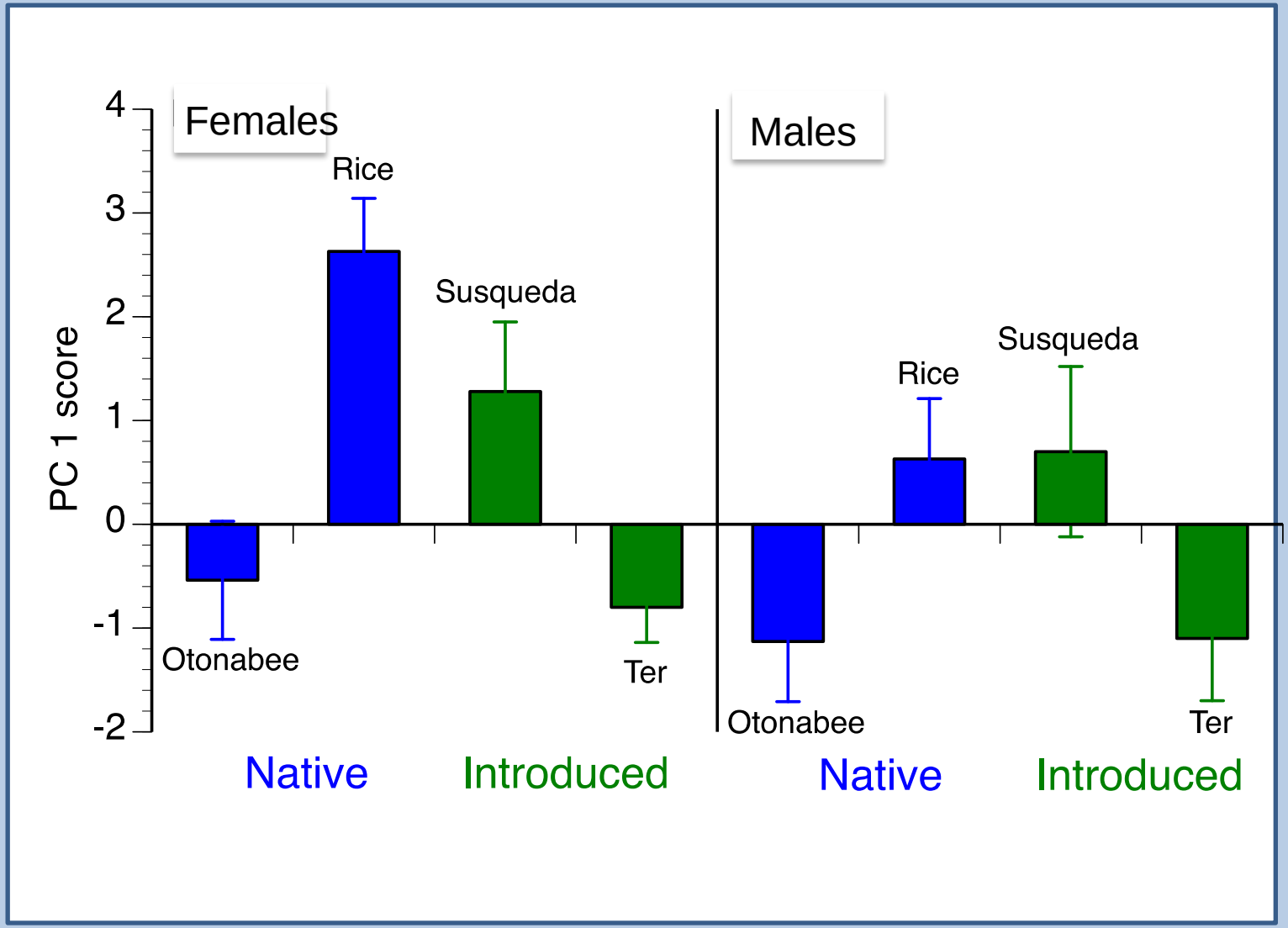
Boldness: native vs introduced



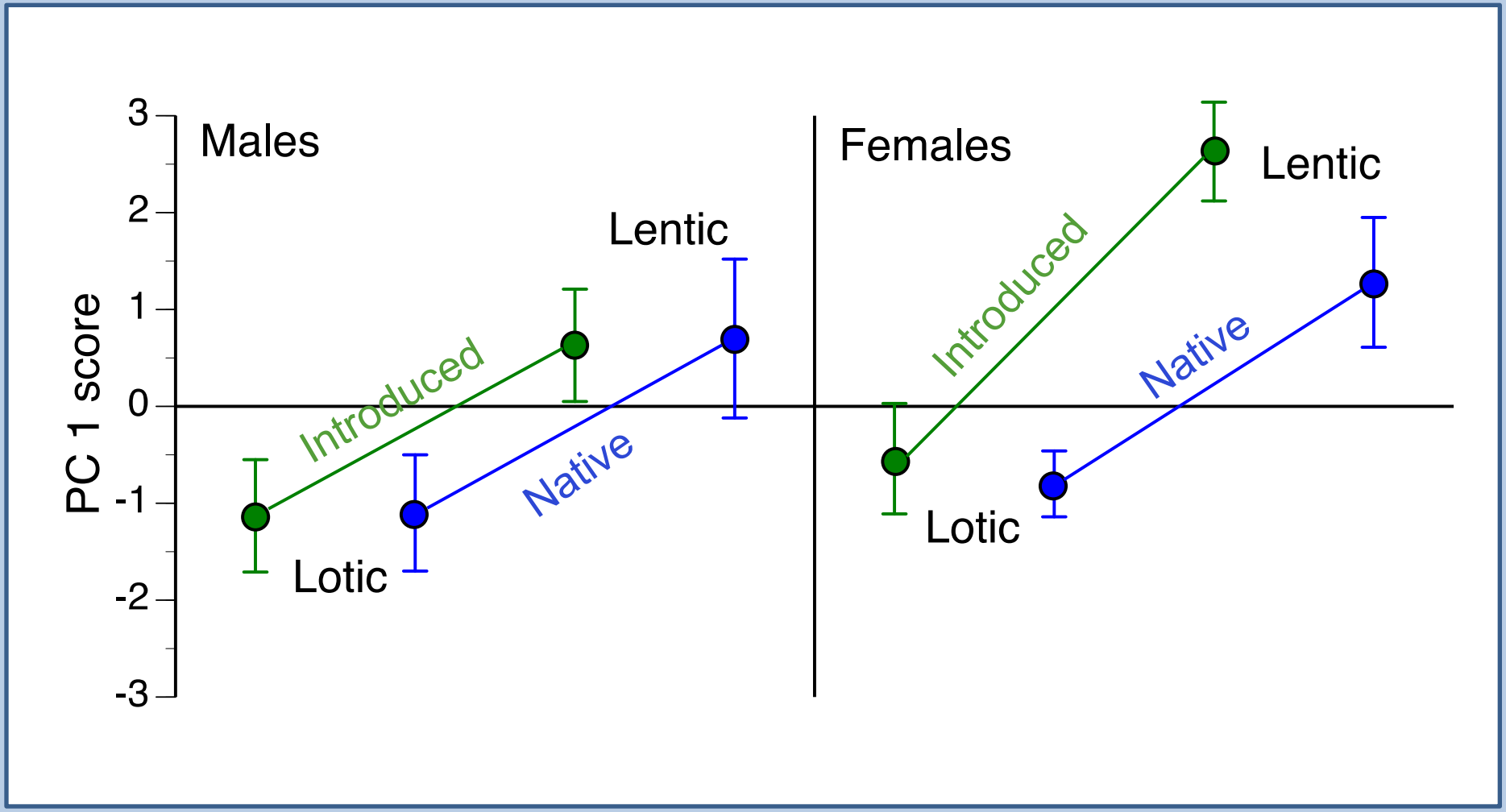
Dispersal potential: Native vs introduced

PC1 (78% of variation) highly correlated with:

- total distance travelled (0.97)
- mean velocity (0.97)
- amount of time in motion (0.92)



Dispersal potential: lentic vs lotic



Conclusions

- Bolder fish on the invasion front with higher dispersal potential and higher metabolism
- Tentative support for spatial sorting as part of range expansion
- Evidence from pumpkinseed study does not show evidence that invasive populations are bolder or better dispersers than native populations
- No support for Olympic Village Effect
- Dispersal potential may be a function of habitat (resistance to upstream movement?)

No evidence that fish invasions produce “superfish”

Organizational Support

National Science and Engineering Research Council (Canada)

Ministerio de Ciencia y Tecnologia (Government of Catalonia, Spain)

Field & Lab Contributions

A. Vila-Gispert & R. Moreno-Amich (University of Girona, Spain)

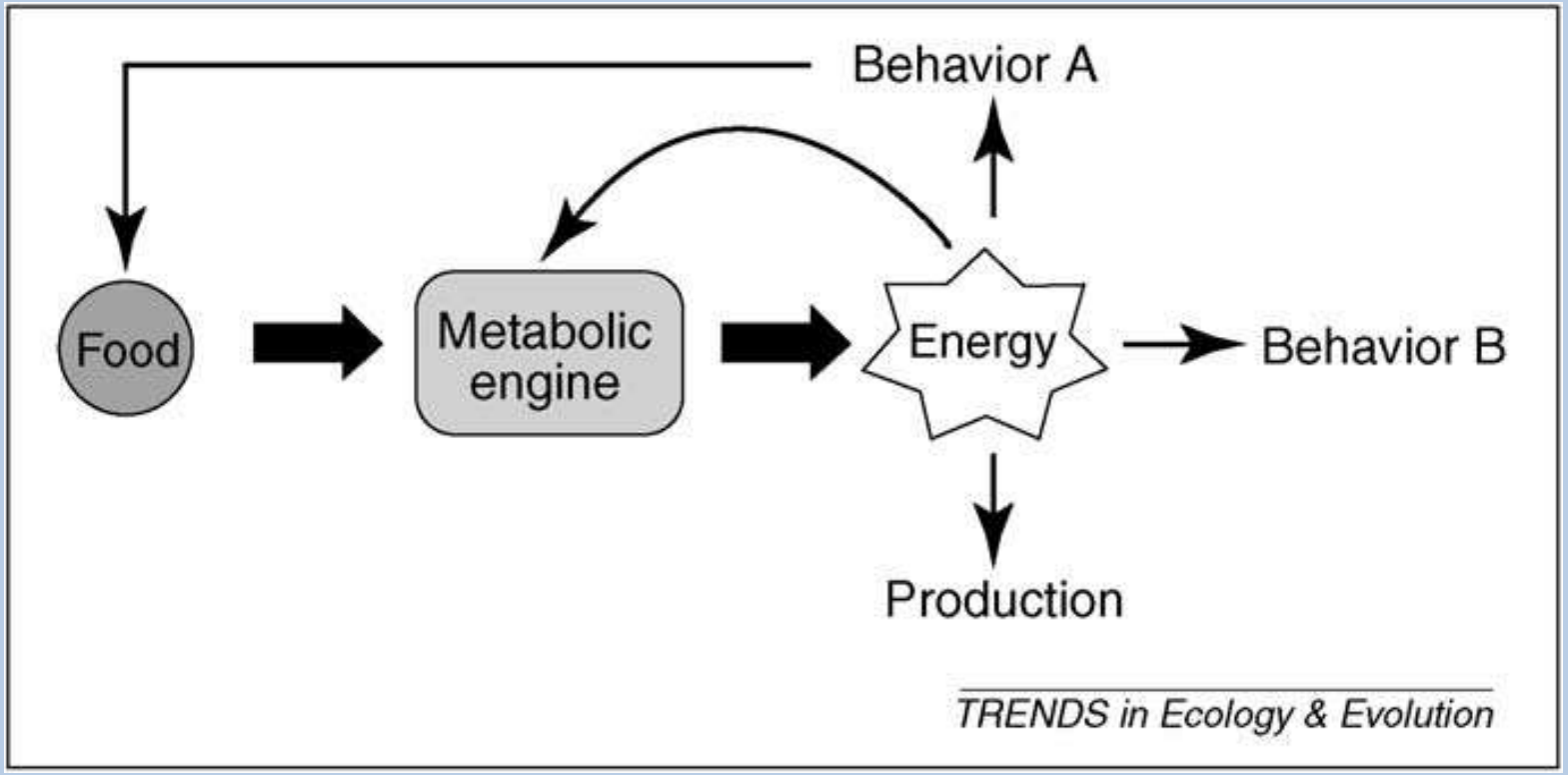
QUESTIONS?

Future Directions

- Sex effect - continue working with females
- Habitat effect - explore further in behaviour work
- Other expressions of personality
  - Aggressiveness
  - Physiology

Metabolic Rate

Hypothesized correspondence between metabolism and behaviour



Biro, P. A. & Stamps, J. A. 2010. Do consistent individual differences in metabolic rate promote consistent individual differences in behaviour? TREE 25

Predictions

Individuals found at an invasion front will differ from those away from the front in behaviour, movement and metabolism

- bolder
- greater movement
- higher metabolism

Collections

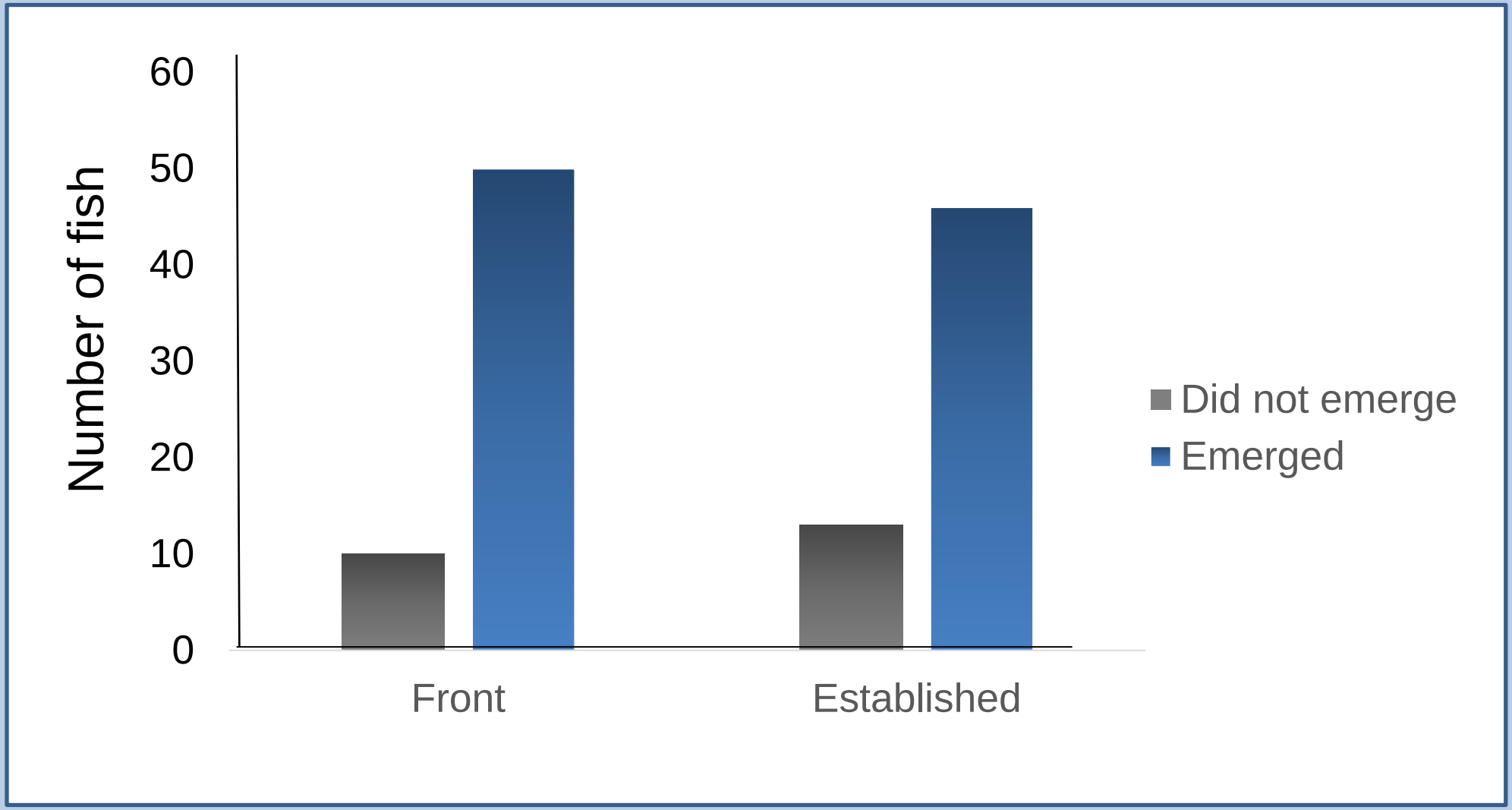
Time to emerge

	Established area	Front	Supported?
Behaviour	**Shy**	**Bold**	
Dispersal potential	Low	High	
Metabolism	Low	High	

Behaviour

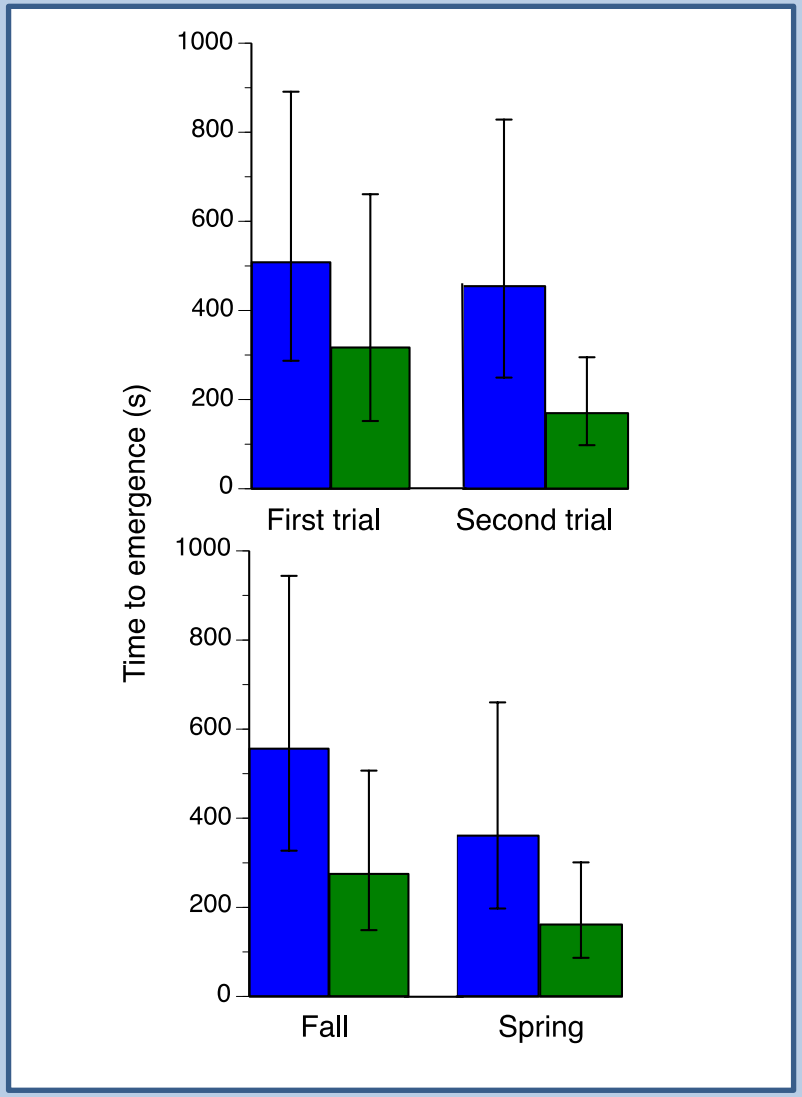
	Established area	Front	Supported ?
Behaviour	**Shy**	**Bold**	
Dispersal potential	Low	High	
Metabolism	Low	High	

Emergence from shelter



No significant difference between locations $\chi^2 = 0.55$, df = 1, $p > 0.05$

Time to emergence

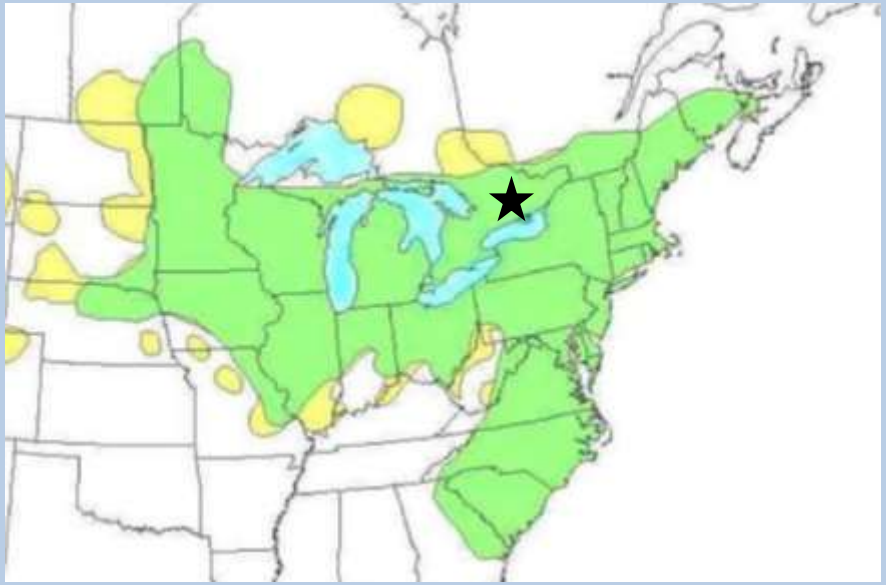


Invasion front

Established area

The pumpkinseed

Native to eastern and central North America



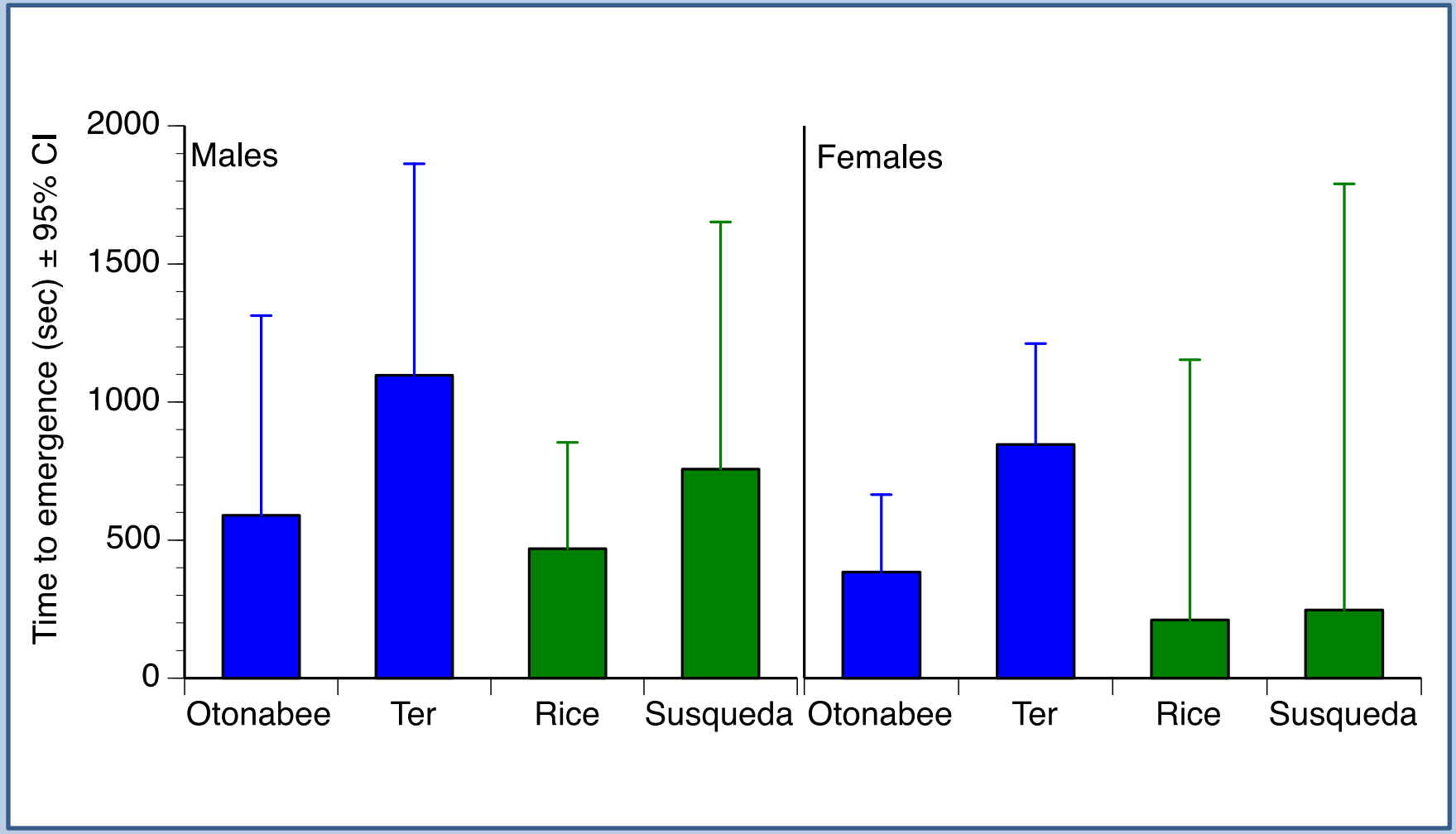
Established in 28 countries in Europe and Asia Minor

(*Fox et al. 2007*)

Post Hoc Hypothesis:

Fish originating from different habitats (river vs lake) exhibit differences in dispersal potential

Boldness: lotic vs lentic



Dispersal potential

- goby from established area
- time to emergence: 3434 sec