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Eco-evo-devo of migration syndromes

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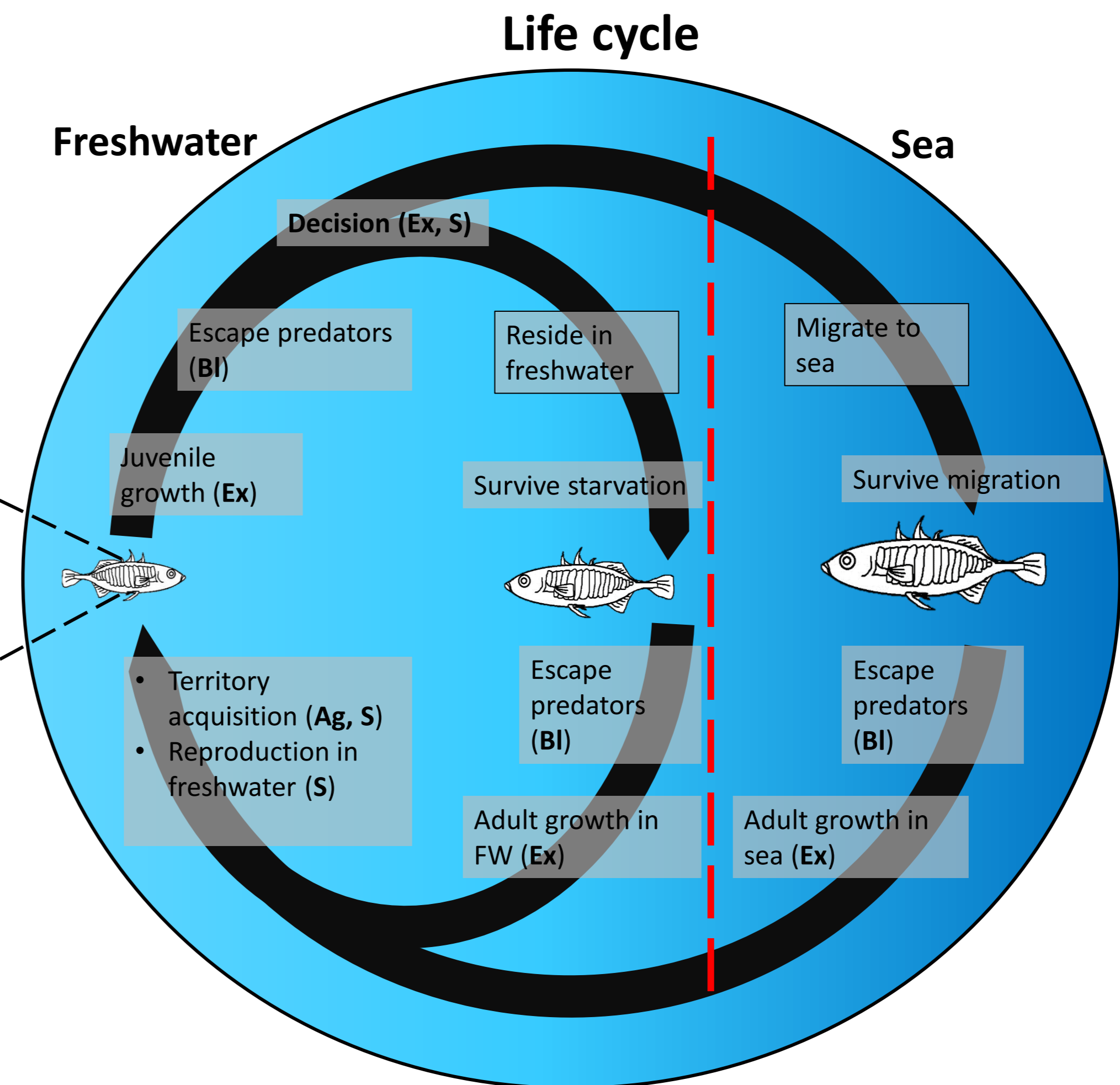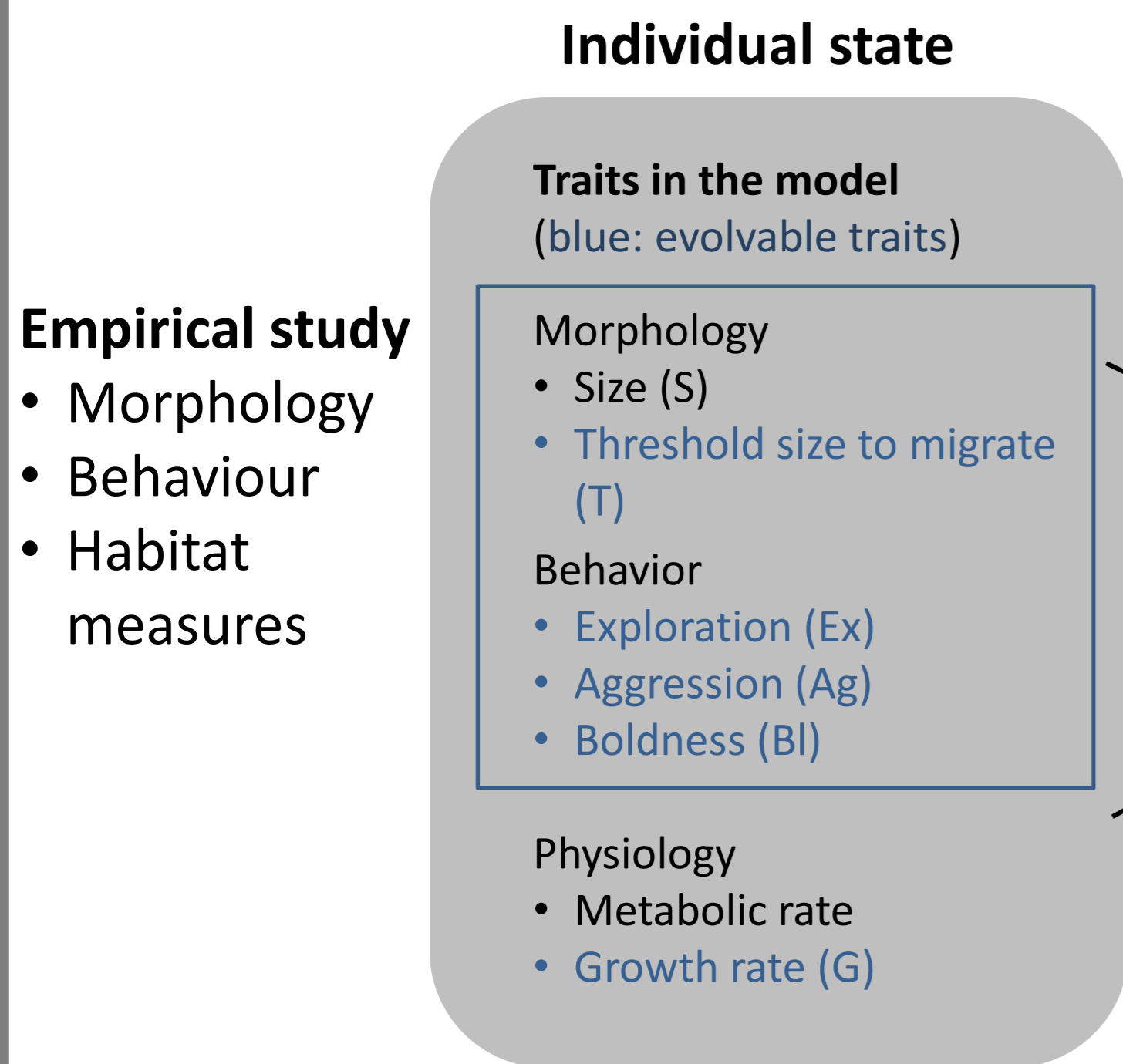
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Introduction

Many species exhibit **partial migration**: only a subset of the population migrates, while the rest stays at home. Understanding partial migration is important, since it effects the population dynamics, niche breadth, gene flow, and reproductive isolation. For this, it is important to realize that migrants are not a random sample of the population but differ systematically from residents in a whole suite of traits. We combine field studies, mesocosm experiments, and individual-based simulations to unravel this **'migration syndrome'** in partially migrating populations of three-spined sticklebacks in the Netherlands.
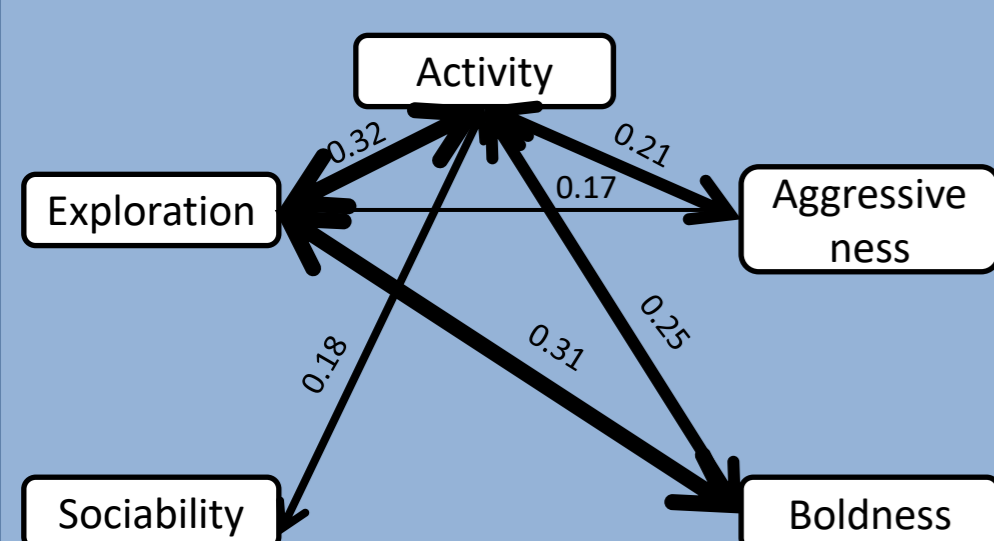
Model structure

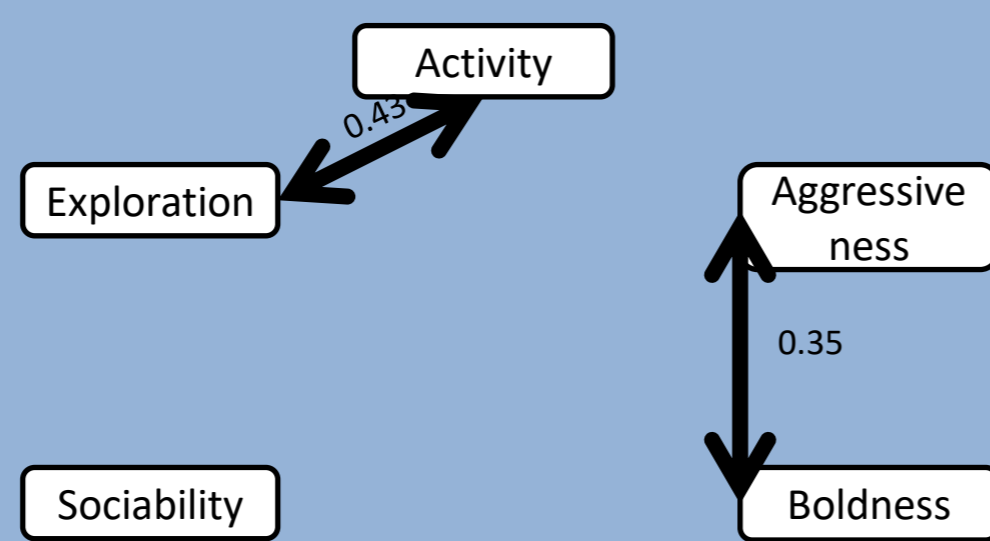### Individual state

Traits in the model
(blue: evolvable traits)

Morphology
- Size (S)
- Threshold size to migrate (T)

Behavior
- Exploration (Ex)
- Aggression (Ag)
- Boldness (Bl)

Physiology
- Metabolic rate
- Growth rate (G)

Empirical study
- Morphology
- Behaviour
- Habitat measures

Life cycle

Freshwater — **Sea**

- Decision (Ex, S)
- Escape predators (**Bl**)
- Reside in freshwater
- Migrate to sea
- Juvenile growth (**Ex**)
- Survive starvation
- Survive migration
- Territory acquisition (**Ag, S**)
- Reproduction in freshwater (**S**)
- Escape predators (**Bl**)
- Escape predators (**Bl**)
- Adult growth in FW (**Ex**)
- Adult growth in sea (**Ex**)

Modelling study
- Individual based-evolutionary simulations

Empirical results

Migrants (N=189)

Activity — Exploration — Aggressive ness — Sociability — Boldness
0.32, 0.21, 0.17, 0.18, 0.31, 0.25

Residents (N=76)

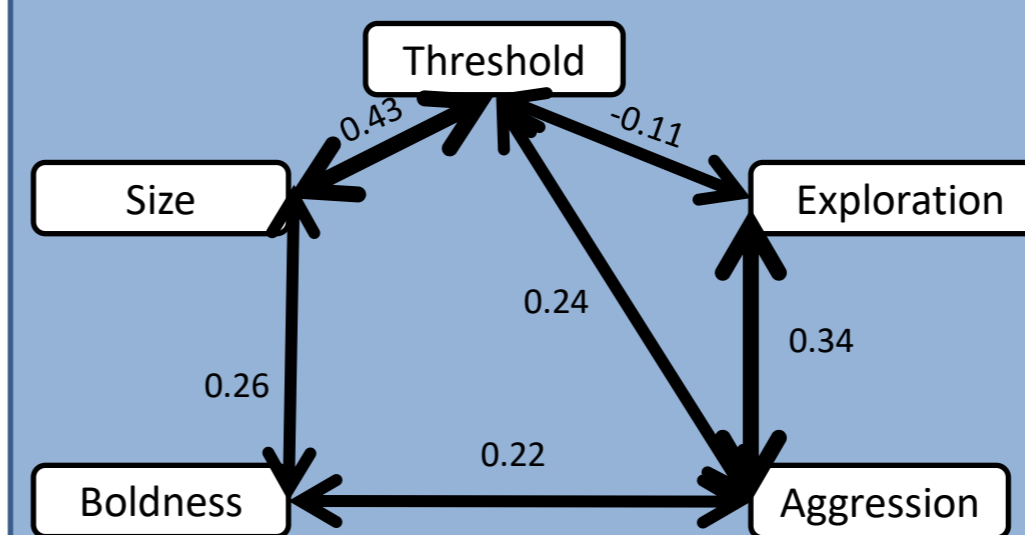Activity — Exploration — Aggressive ness — Sociability — Boldness
0.43, 0.35

Size: Migrants are substantially bigger – similar to previous studies.

Behaviour: Migrants exhibit significantly lower scores for all behaviours than residents (except shoaling).
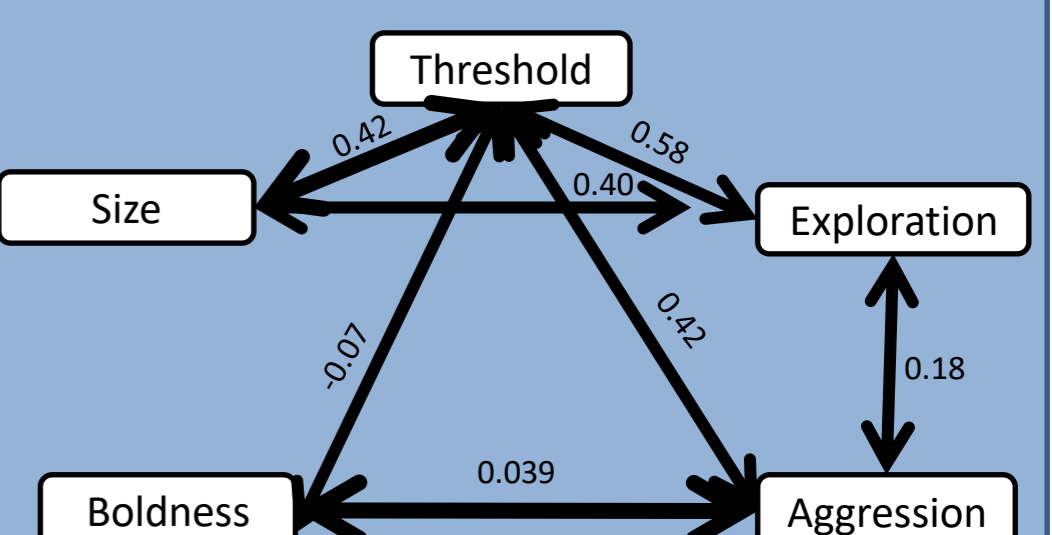
Degree of behavioural (co-)variation: As indicated by the graphs, migrants exhibit a very different correlation structure ('syndrome') than land-locked fish. This is in line with other studies.

Modelling results

Migrants

Threshold — Size — Exploration — Boldness — Aggression
0.43, -0.11, 0.24, 0.34, 0.26, 0.22

Residents

Threshold — Size — Exploration — Boldness — Aggression
0.42, 0.58, 0.40, -0.07, 0.42, 0.18, 0.039

Size: Migrants evolve to be bigger, with lower threshold.

Sufficient condition for partial migration: Density dependent mortality and fluctuation in carrying capacity.

Evolution of migration syndrome: Partial migration is only in those cases a stable evolutionary outcome where a clear migration syndrome evolved in parallel. In the absence of a syndrome, the polymorphism of migrants and residents disappears after a few generations.

Future direction

Deciphering why, how and when decision to migrate is taken: by field observations, controlled experiments (artificial breeding, cross-fostering), and modelling (decision making by evolving artificial neural networks).