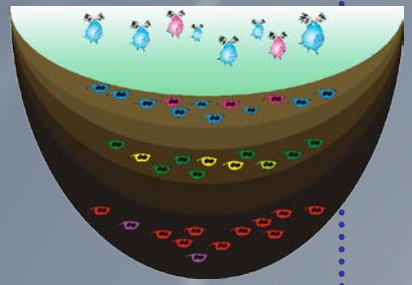
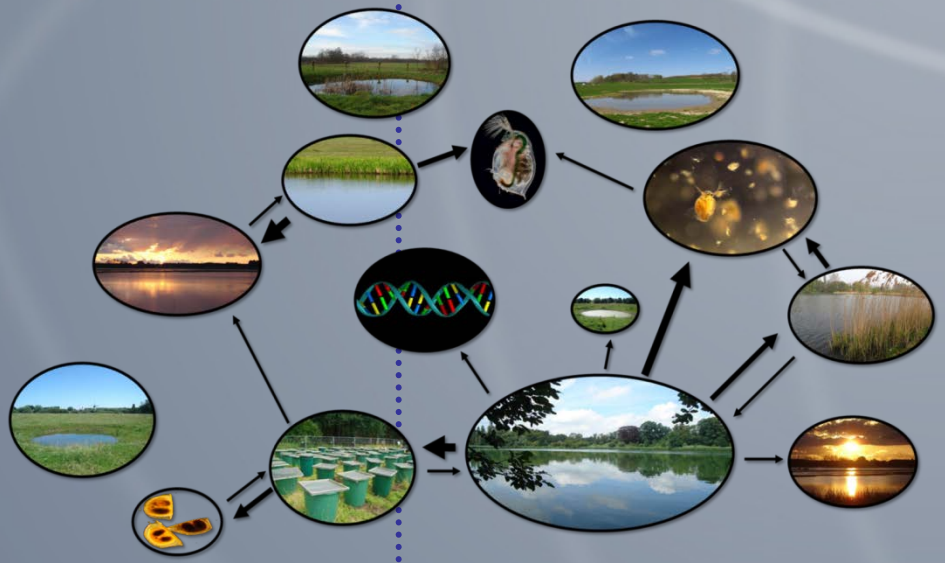


Aquatic Ecology, Evolution & Conservation

Colonization dynamics and adaptation as structuring factors in population genetic structure ?



‘sHertogenbosch – April 2014

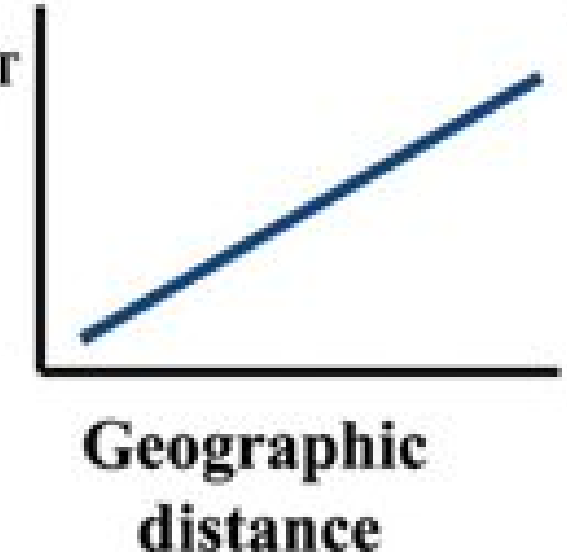
Luc De Meester

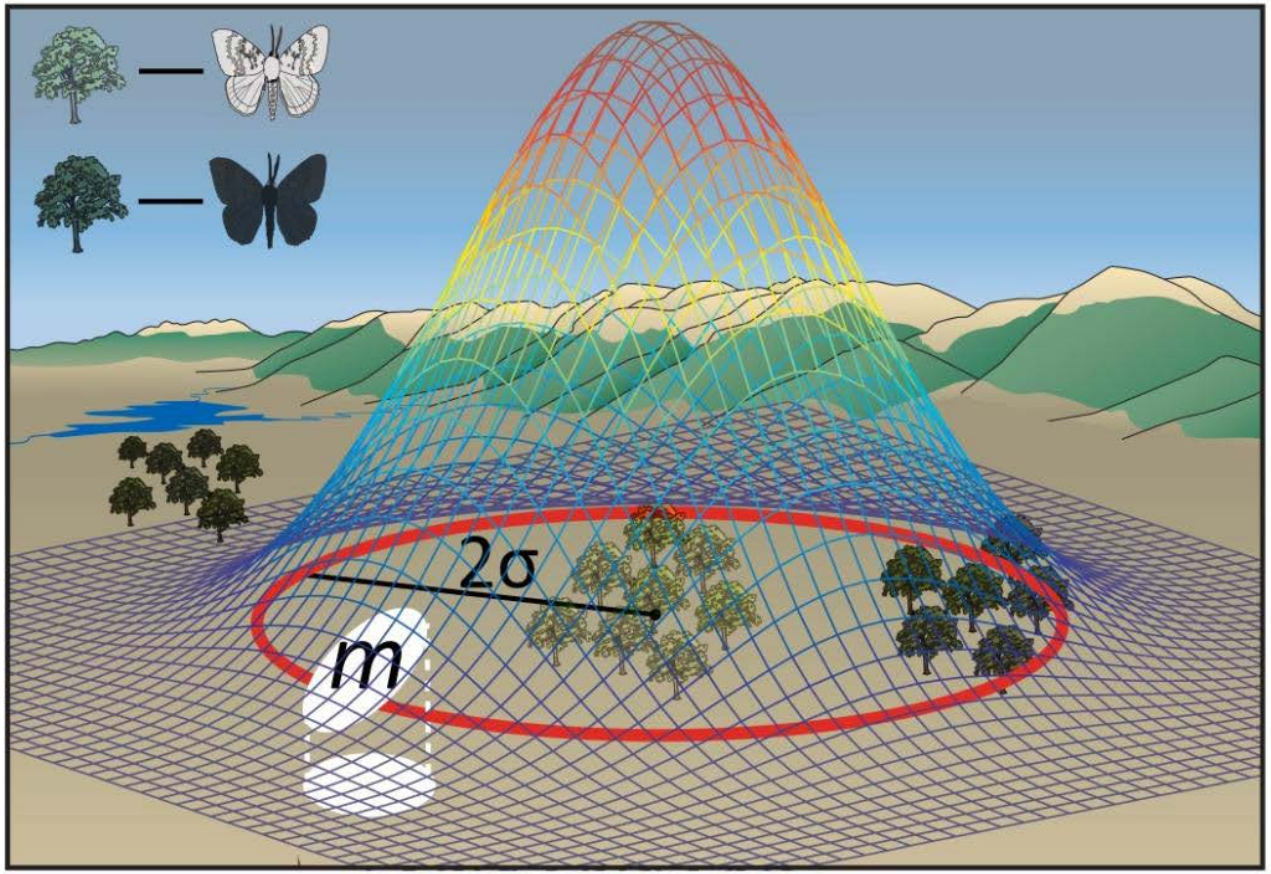
KU LEUVEN

Hieronymus Bosch

Aquatic Ecology, Evolution & Conservation

Richardson et al. 2014
TREE





One “wright”:
two standard deviations
from the mean
of the dispersal kernel

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Landscape genetic structure in relation to space and environment

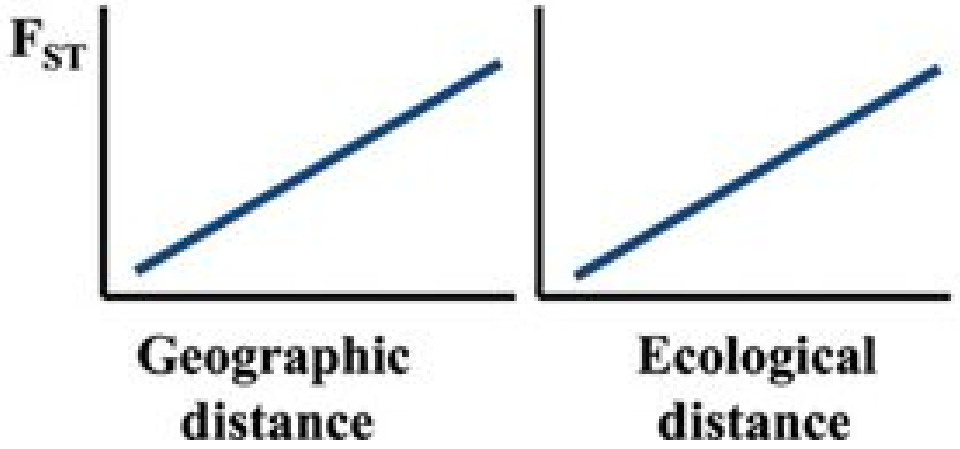
Luisa Orsini

Orsini et al. 2013
Invited review *Molecular Ecology*

Patterns:

Isolation by distance

Isolation by environment



Processes:

Isolation by dispersal limitation

Isolation by adaptation

Isolation by colonization

Aquatic Ecology, Evolution & Conservation

At what scale does local adaptation occur?

adaptation in the face of dispersal

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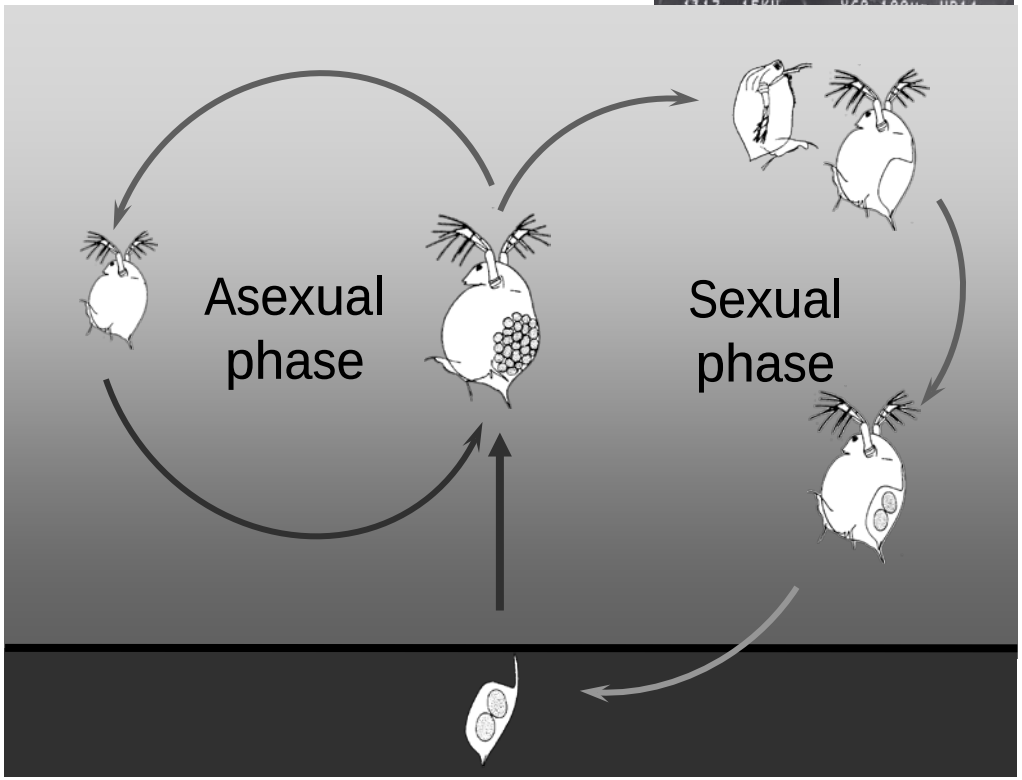
The ecological model, the water flea *Daphnia*

Strong ecological interactor

Short generation time
Clonal lineages (GxE, GxG, GxGxE,…)
Dormant stages

Genomics (Colbourne et al. 2011 Science)

Daphnia Genomics Consortium



Daphnia is a good disperser

(1) **rapid colonization of new habitats**
(e.g. Talling, 1951; Jenkins & Buikema,1998;
Louette & De Meester, 2005)

Louette et al. 2007 **1-3 clones per year *D. obtusa***

(2) widespread occurrence of clones of obligately parthenogenetic taxa
(e.g. Weider et al., 1999)

(3) rapid spread of exotic species
(e.g. *Daphnia lumholtzi* in NAm; Shurin & Havel, 2003; Mergeay et al. 2006)

(4) cladoceran community structure shows little evidence of dispersal limitation (Shurin, 2000; Cottenie et al. 2003; De Bie et al 2012)

(5) good data on **vectors**
Wind / Birds / Mammals
Figuerola 2003; Vanschoenwinkel et al. 2008; Waterkeyn et al. 20

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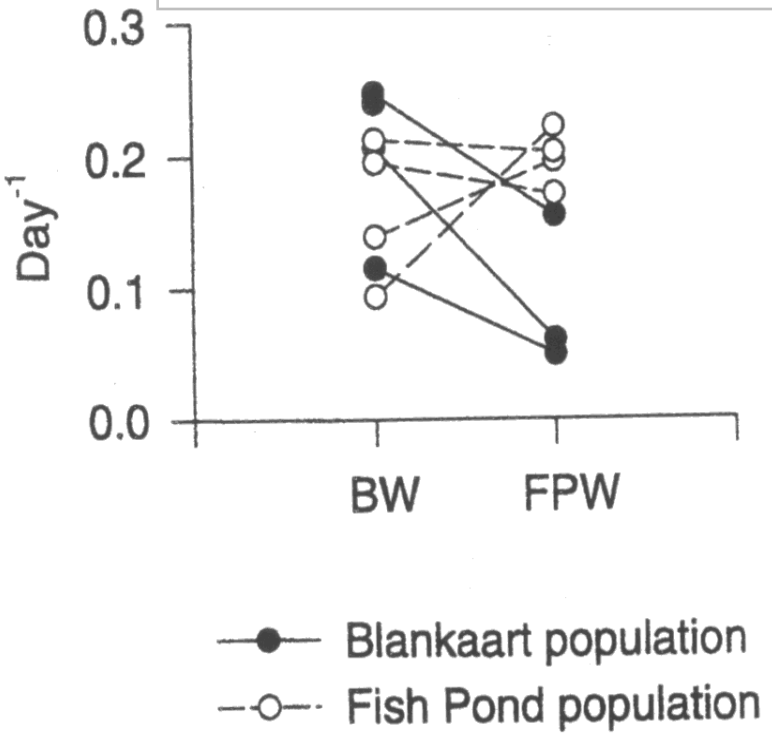
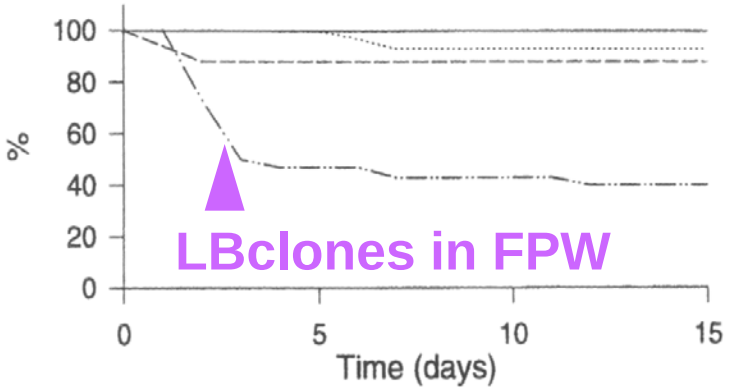
Local adaptation at the scale of neighouring ponds

Declerck et al., 2000



Steven Declerck



Daphnia galeata

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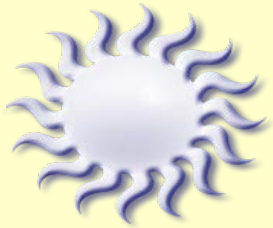
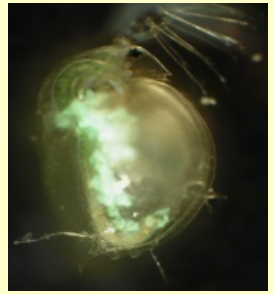
Local adaptation reported for a wide range of environmental gradients

Climate change Temperature

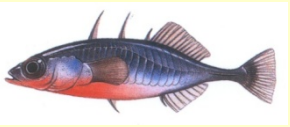


Land use Pollution

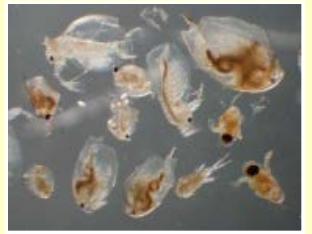
Parasitism



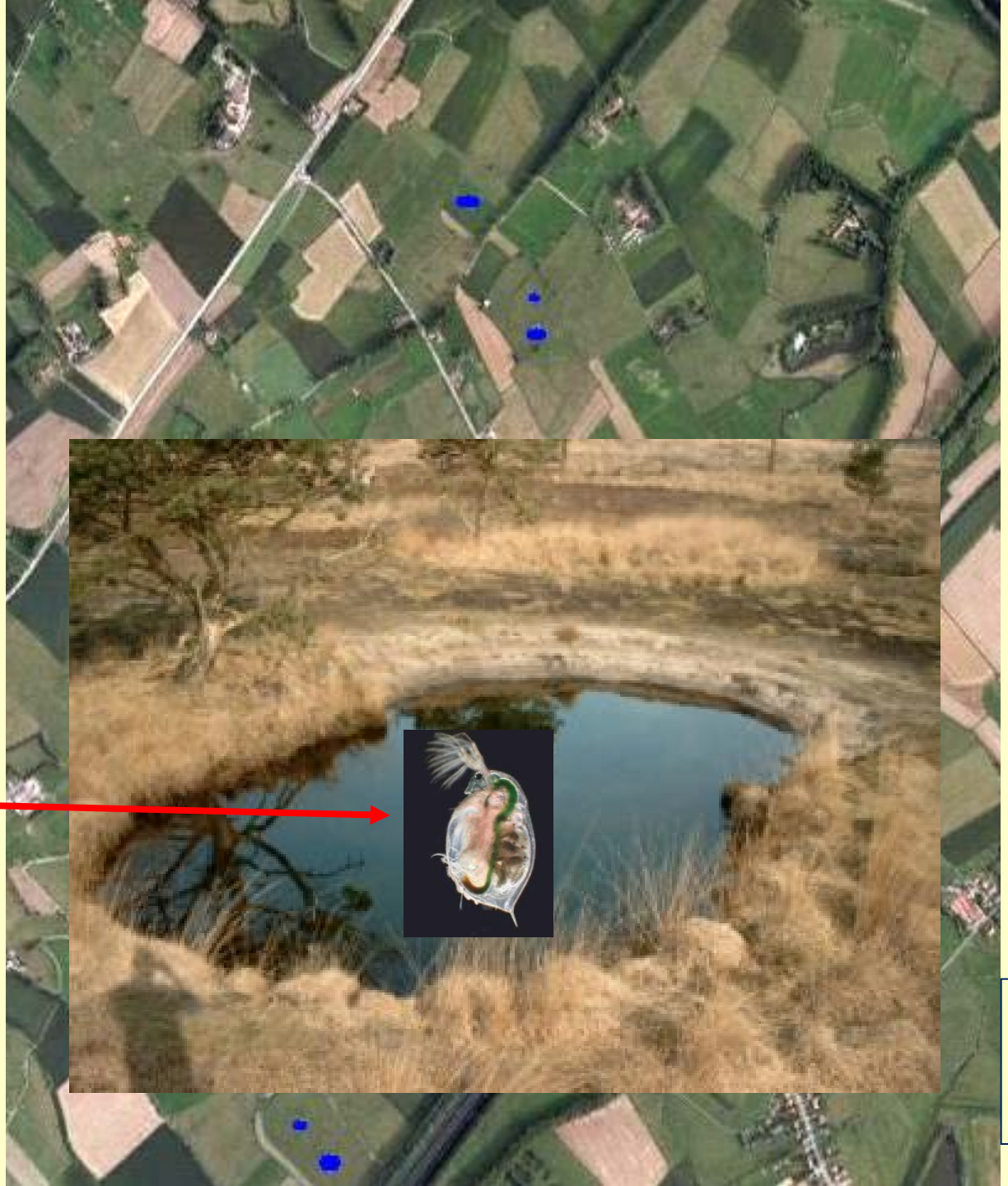
Predation



Competition



Salinity (Weider)
C:P (Jeyasingh, Weider)
UV (Pfrender, Miner)
…

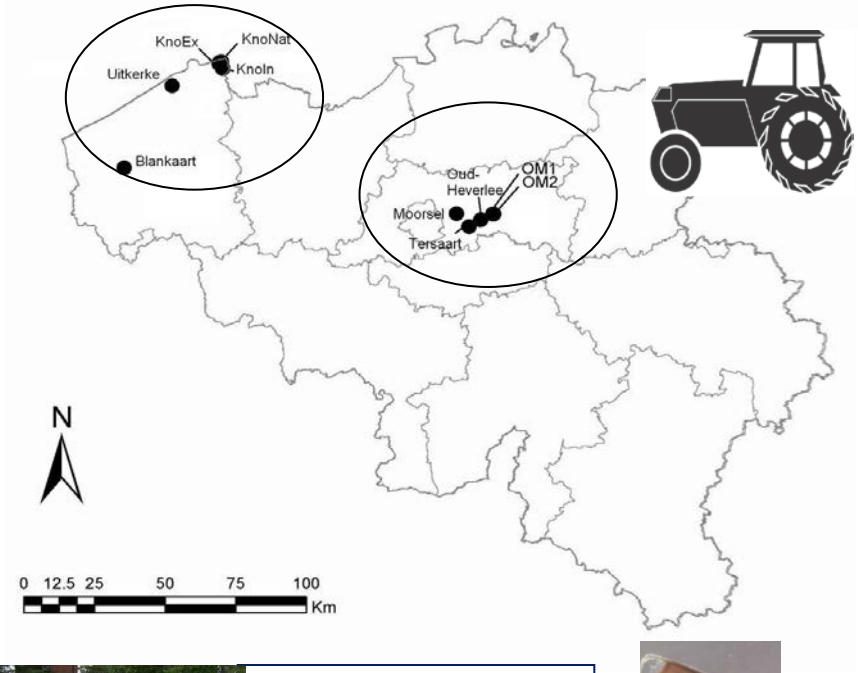


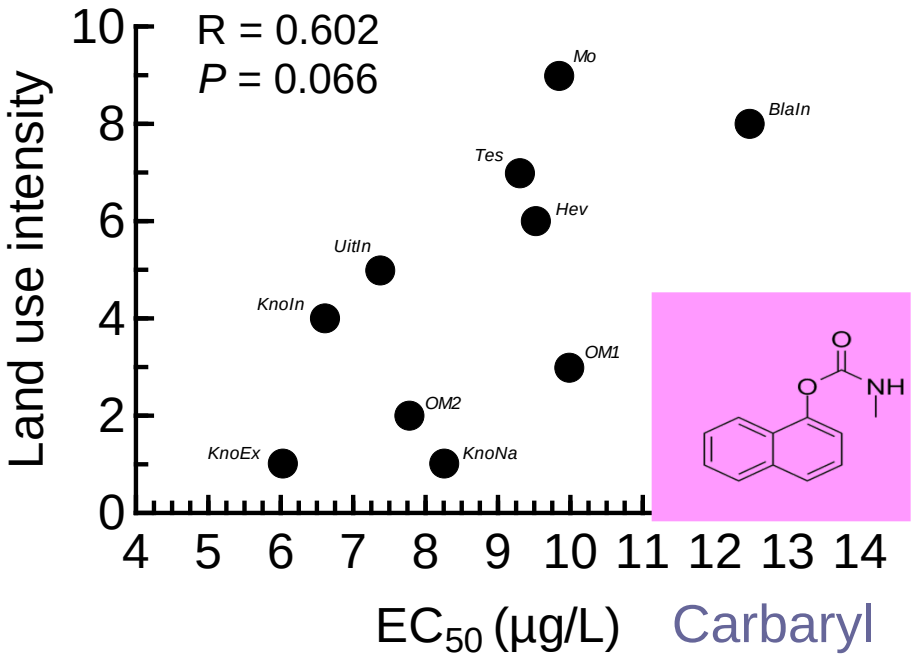
Land use
Pollution

Jansen et al. 2011
Evolution
Functional Ecology
Ecotoxicology

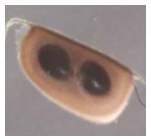
Genetic adaptation to land use and pollution – field survey

Coors et al. 2009
Aquatic Toxicology





Carbaryl



Jansen et al. 2011
Evolution
Functional Ecology
Ecotoxicology

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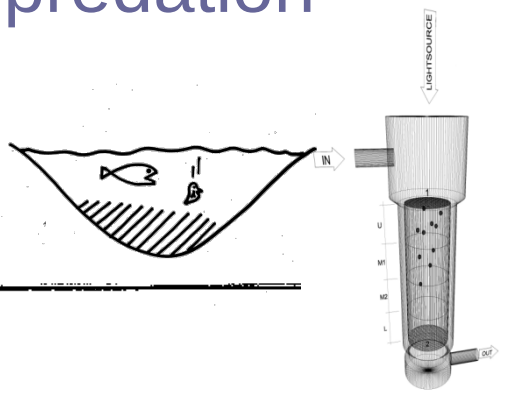
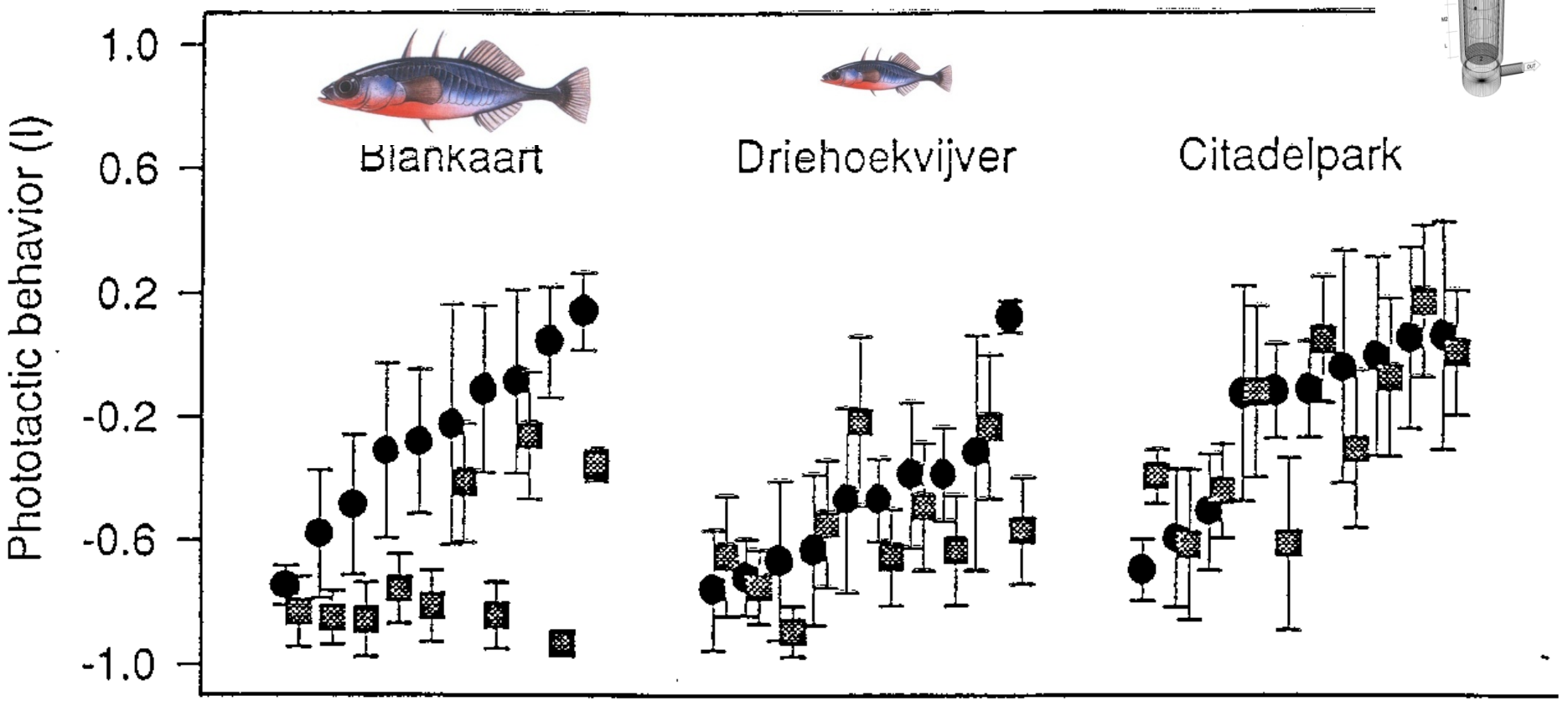
Predation

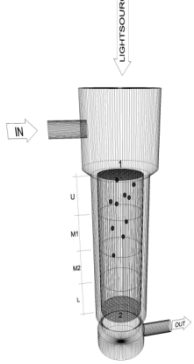
Genetic adaptation to fish predation – Comparison of three natural populations

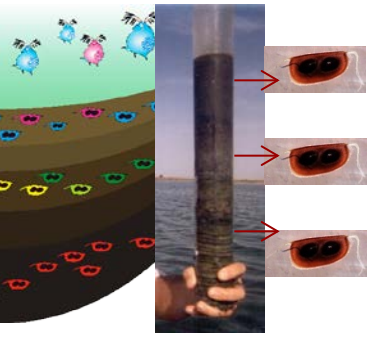


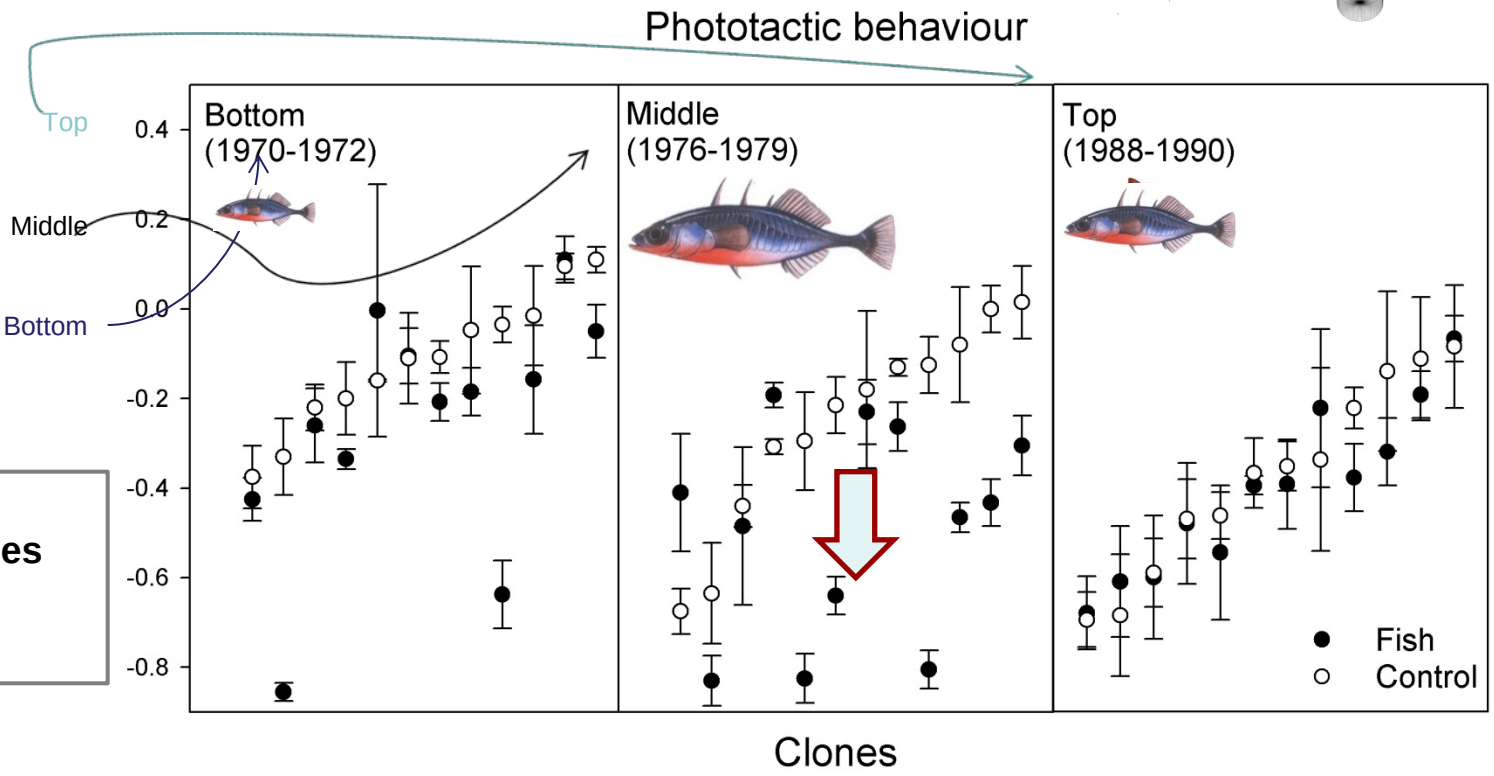


De Meester 1996
Evolution

Evolution of antipredator traits in *Daphnia*







No fish kairomones

Fish kairomones

POP x Fish

P< 0.05

No genetic differentiation for µsat markers

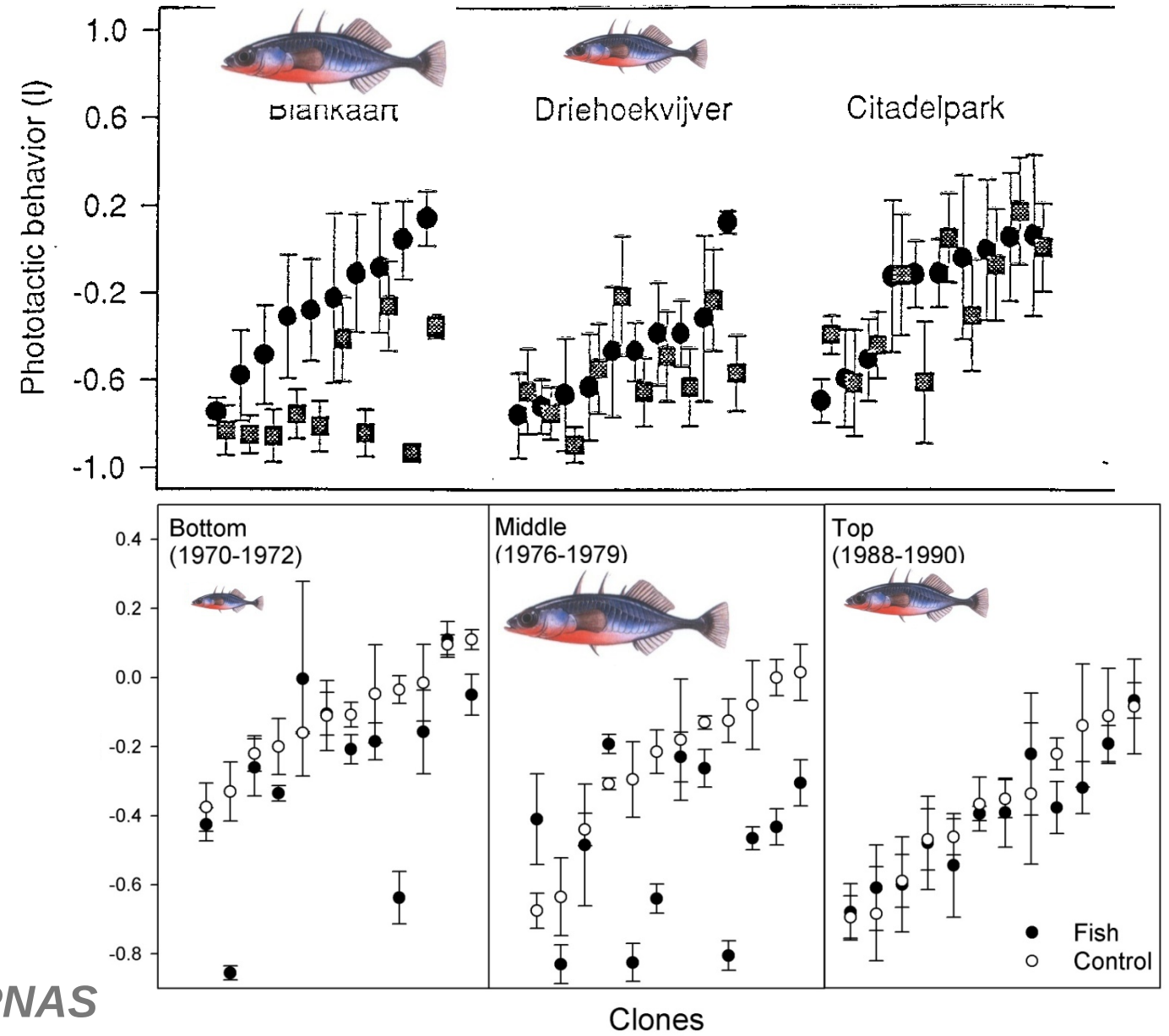
LOCAL EVOLUTION (6-10 years)

EVOLUTION OF PLASTICITY

KU LEUVEN

Cousyn et al. 2001 PNAS

Comparison space and time



De Meester 1996 *Evolution*

Cousyn et al. 2001 *PNAS*

Landscape genetic structure

Landscape genetic structure in relation to space and environment

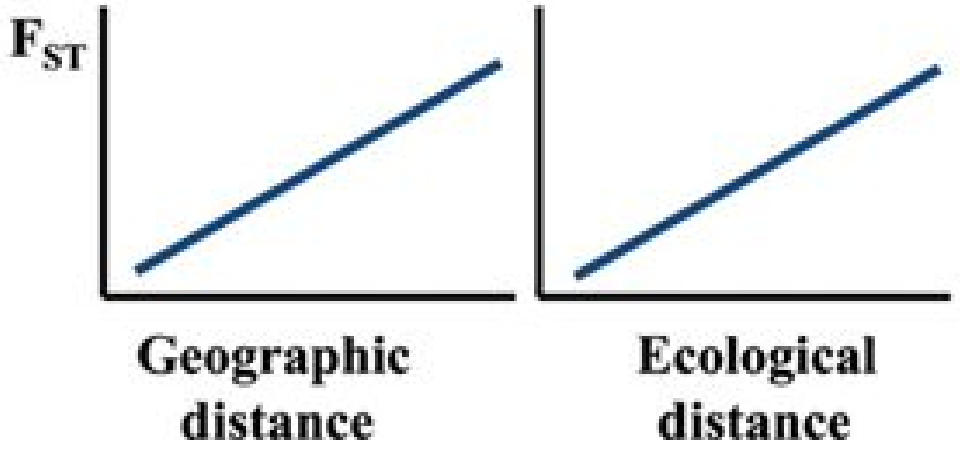
Luisa Orsini

Orsini et al. 2013
Invited review *Molecular Ecology*

Patterns:

Isolation by distance

Isolation by environment



Processes:

Isolation by dispersal limitation

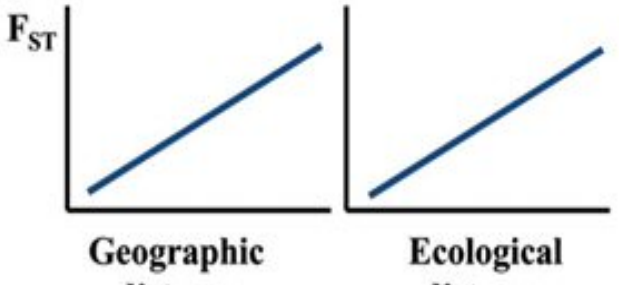
Isolation by adaptation **(Nosil et al 2008 *Evolution*)**

Isolation by colonization

Isolation by adaptation

Timema walking stick insects
Patrick Nosil, Sheffield

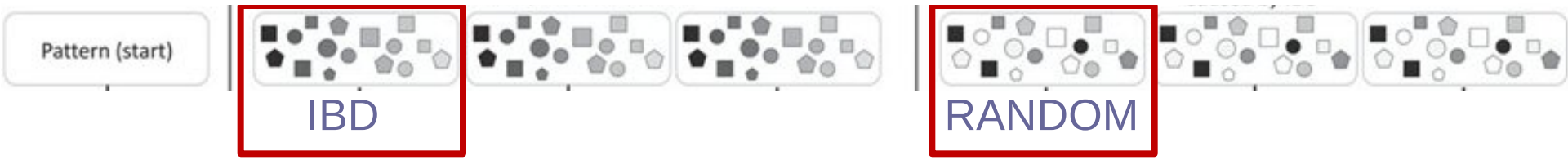
What is the resulting landscape genetic structure ?



"START"

Colonization: random or distance decay

through serial colonization



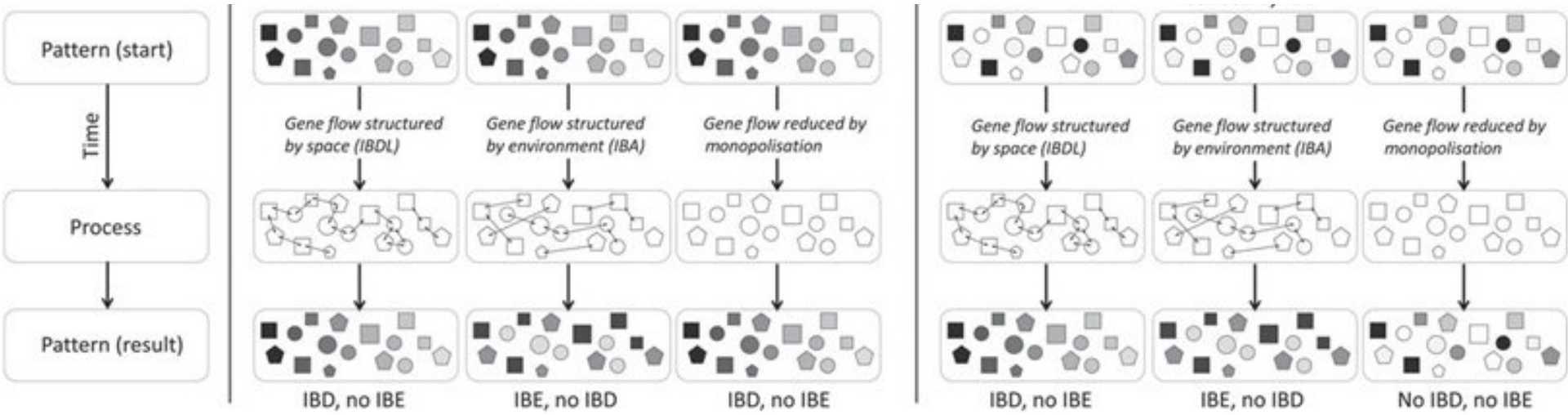
Isolation by dispersal limitation:
dispersal decays with spatial distance (dispersal kernel)

Isolation by adaptation:
reduced effective gene flow among ecologically different habitats

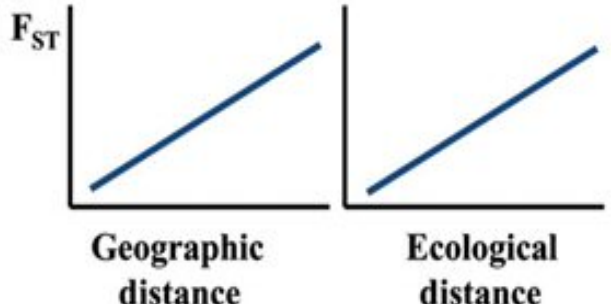
Monopolization: evolution-mediated priority effects

Processes:

IBDL IBA Monopolization IBDL IBA Monopol.

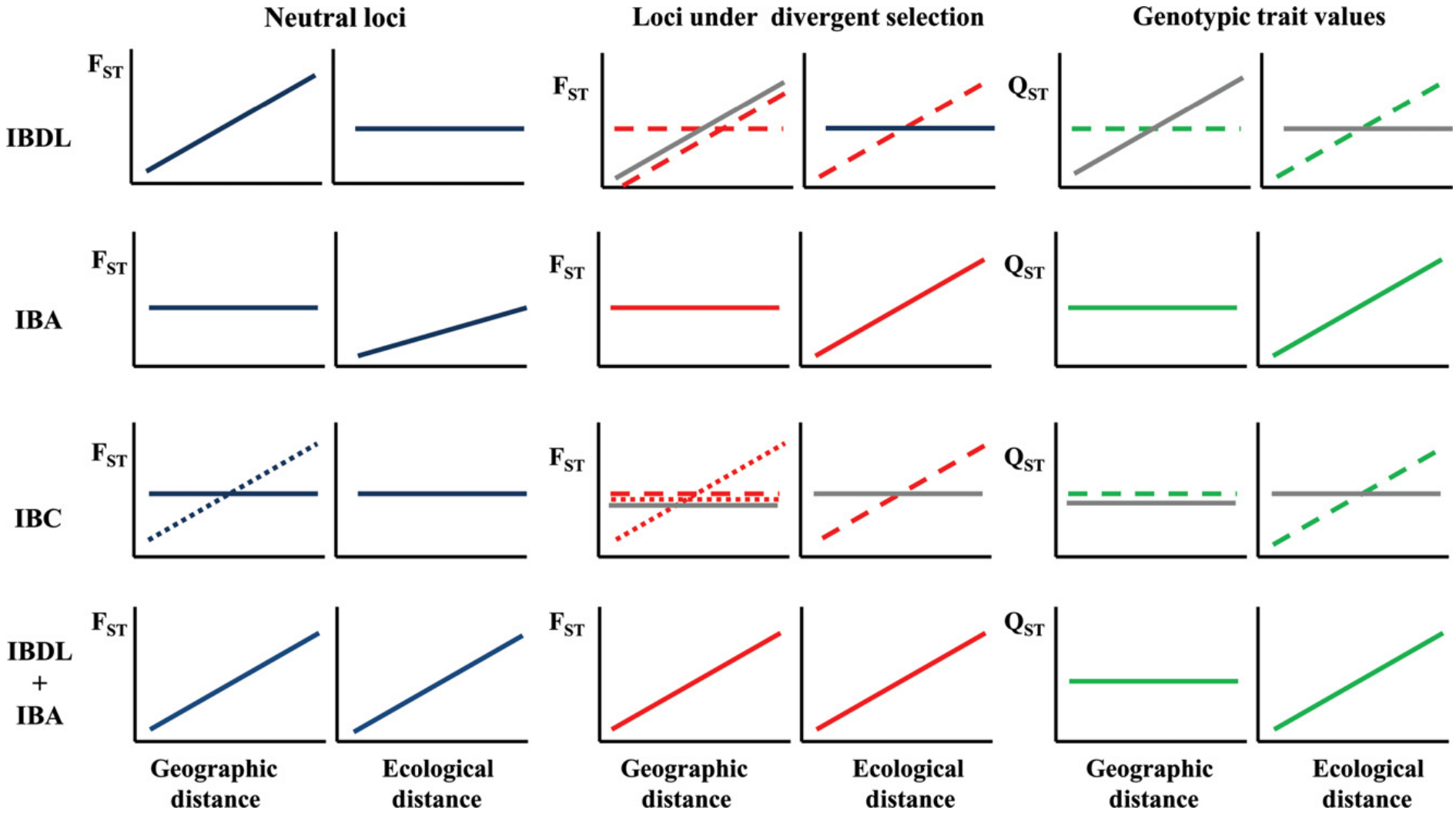


Resulting pattern IBD IBE IBD IBD IBE /



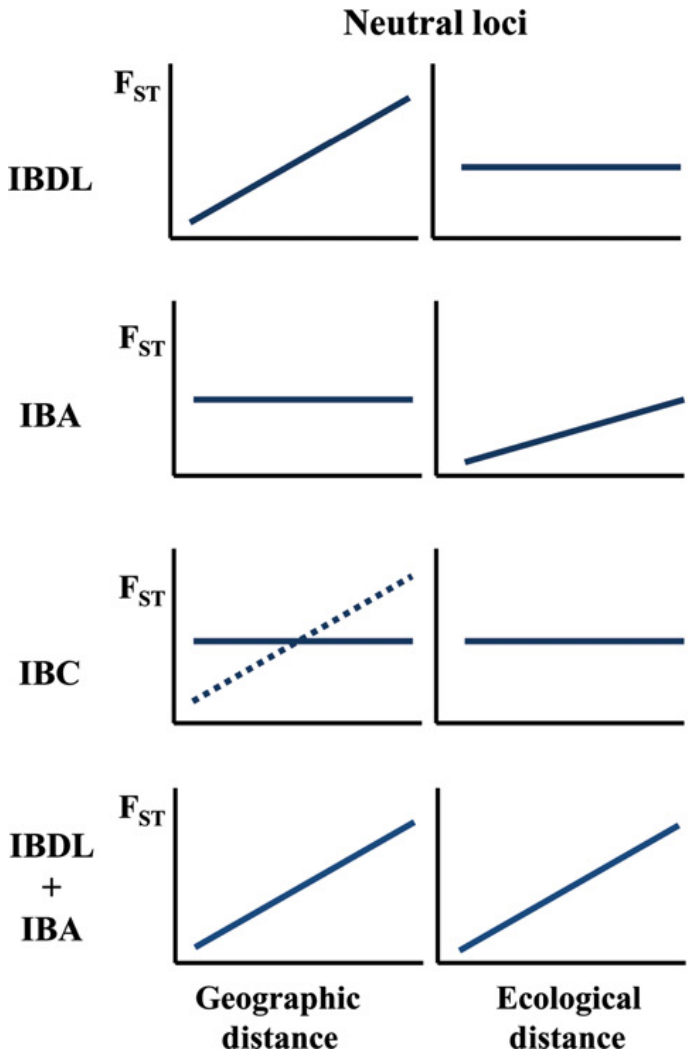
PREDICTIONS of landscape genetic structure in relation to spatial and environmental gradients

- Neutral loci
- Loci under selection / trait values



In most population genetic studies that explictly consider environmental gradients, a pattern of isolation-by-environment is detected .

In many studies that quantify genetic variation in ecologically relevant traits, patterns of local genetic adaptation are found.



Literature review on 32 studies that investigated both IBD and IBE and both neutral markers and markers under selection / traits:

-**IBA**	19 (21)
-IBDL contributes	11 (17)
-IBC+LA or Monopolization	7-11

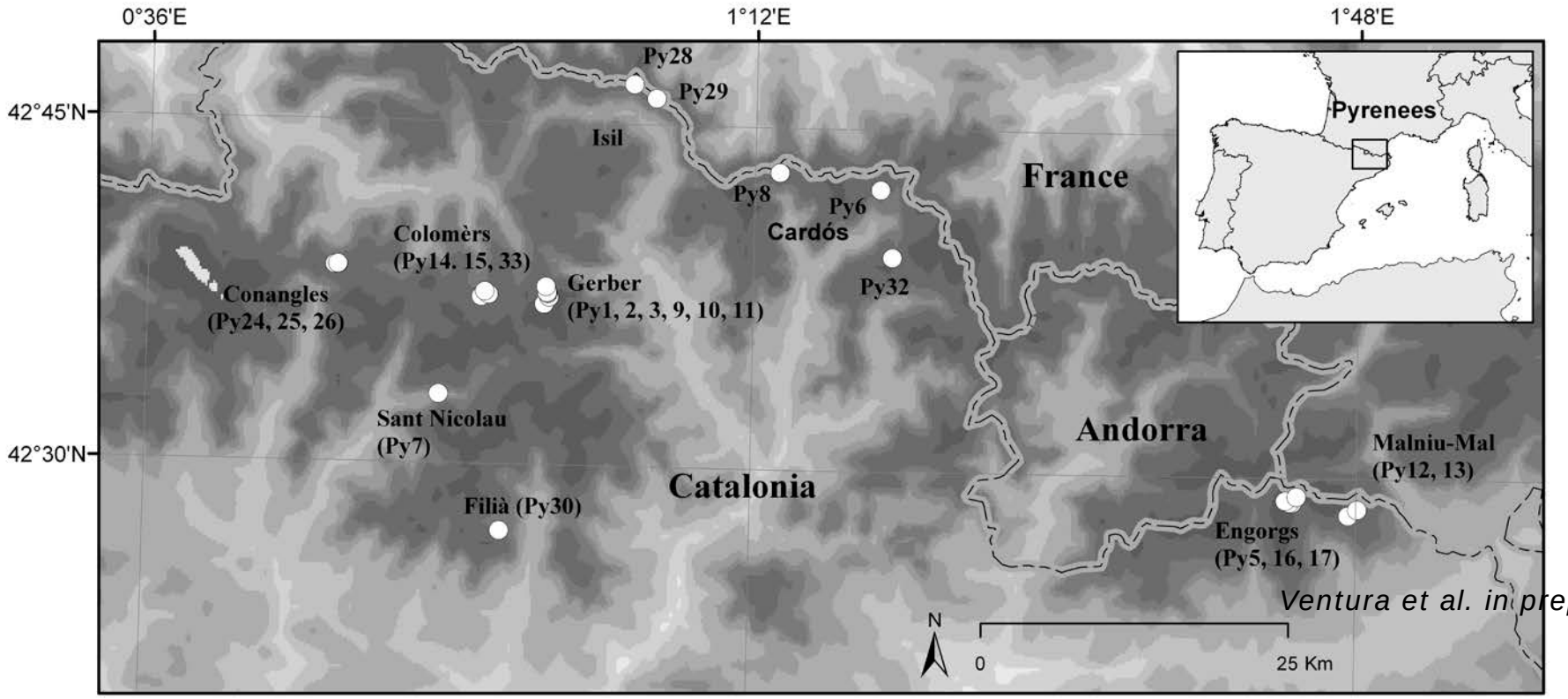
Selection and **adaptation** played a role in **all** of the studies

Example 2: Long-lasting founder effects

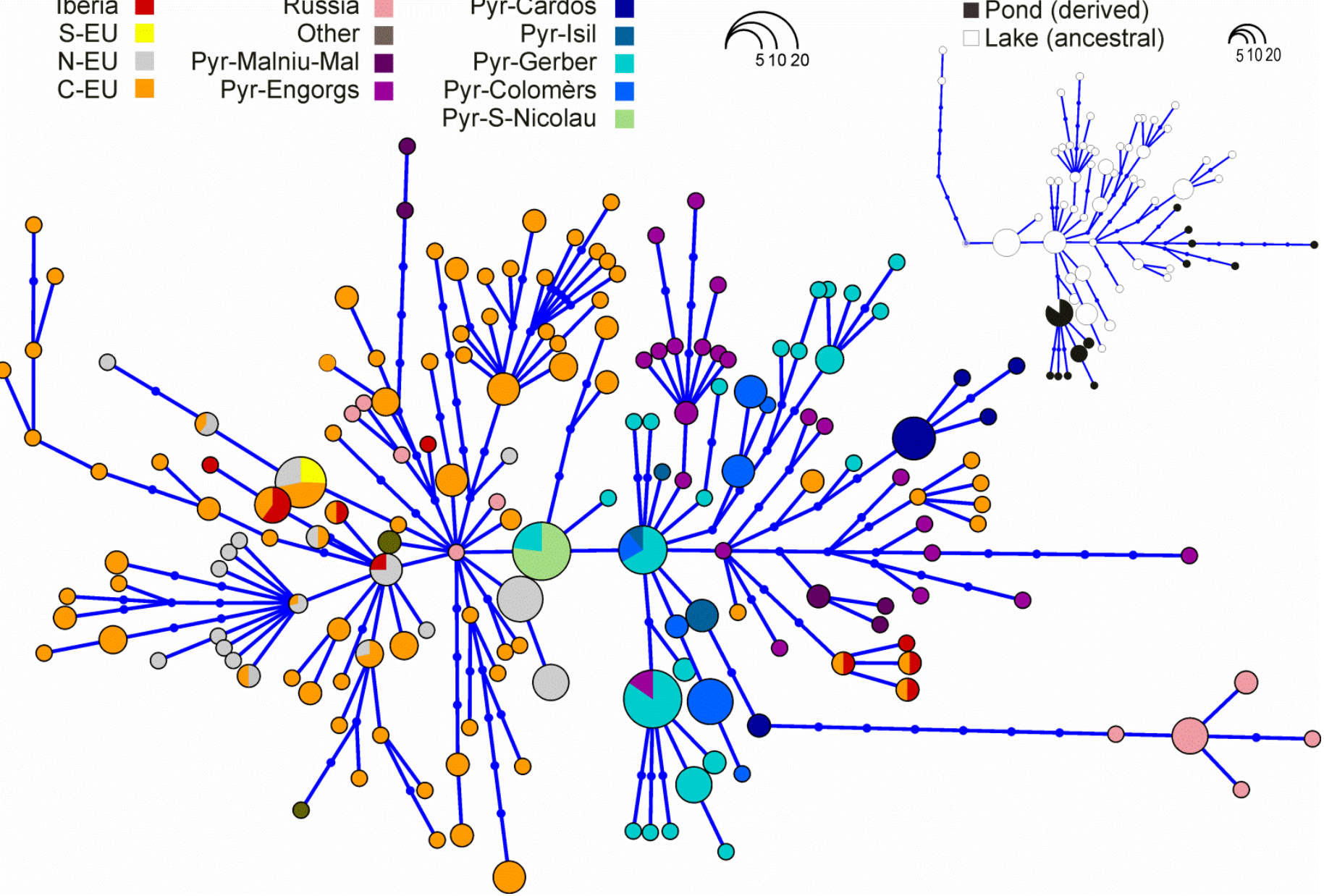
Joachim Mergeay

Ventura et al. 2014
Molecular Ecology

Study on persistent founder effects (15,000 years) in *Daphnia longispina* from 24 alpine lakes in Pyrenees:



Ventura et al. in prep.



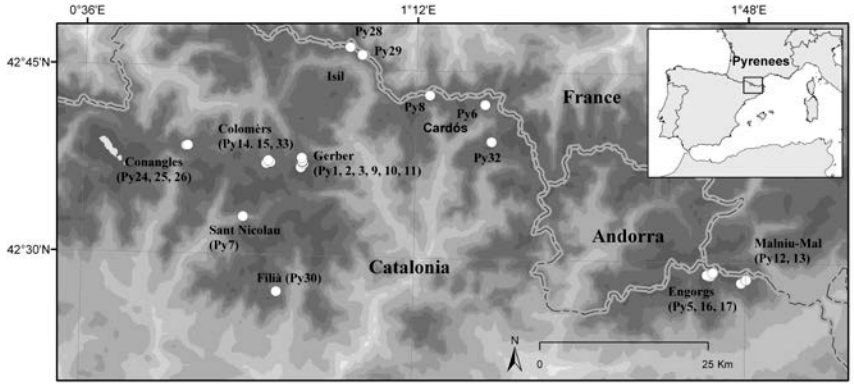
Haplotype (12S rRNA gene): single colonization event by *D. longispina*, followed by serial colonization

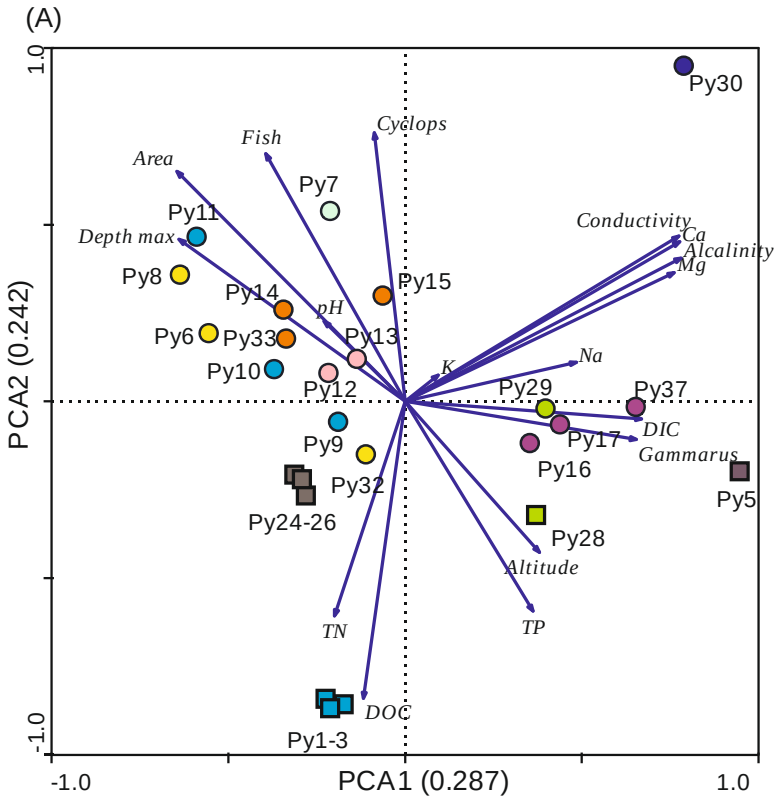
Extremely low effective gene flow among habitats / catchments

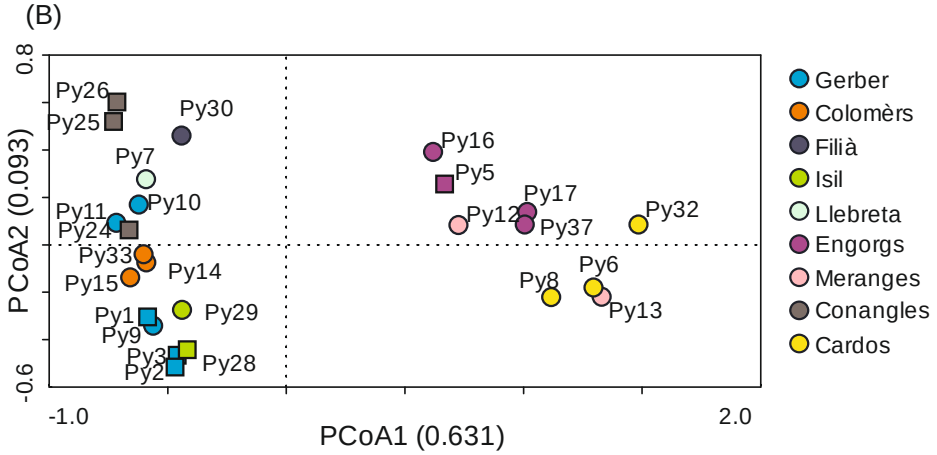
Aquatic Ecology, Evolution & Conservation

Genetic structure at 9 µsat loci reflects catchment irrespective of environmental conditions

Squares = ponds
Circles = lakes

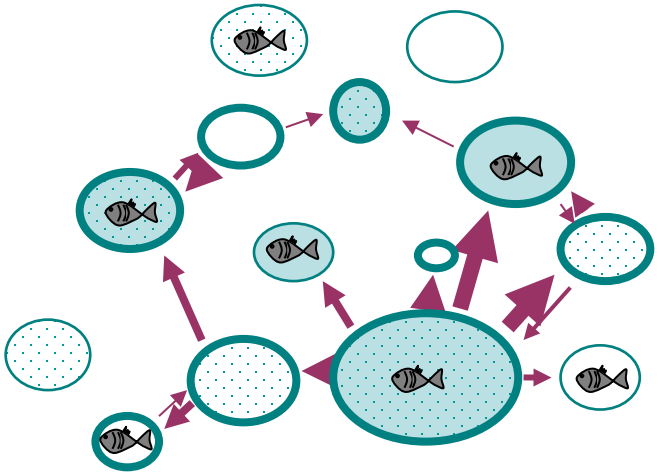


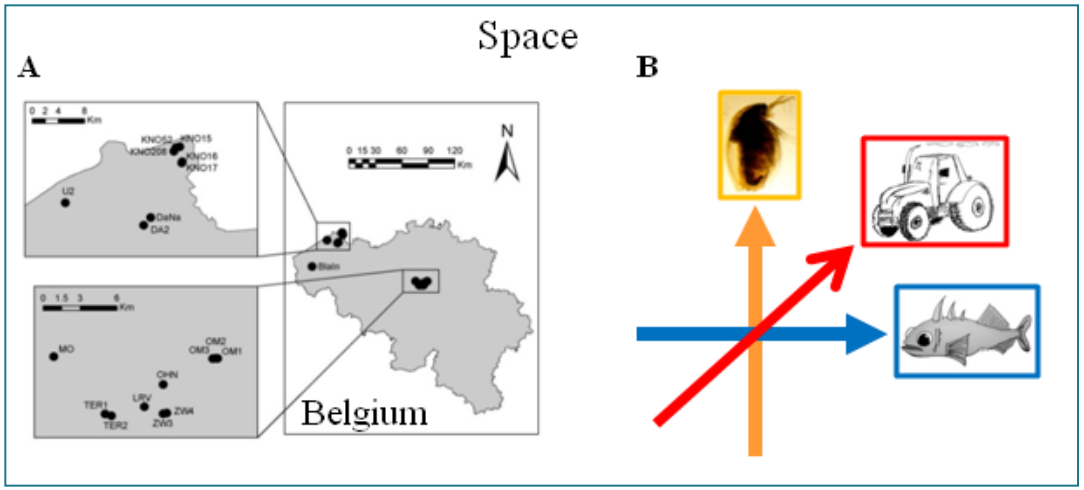




Example 4: *Daphnia magna* along a mosaic of environmental gradients – ponds in Belgium

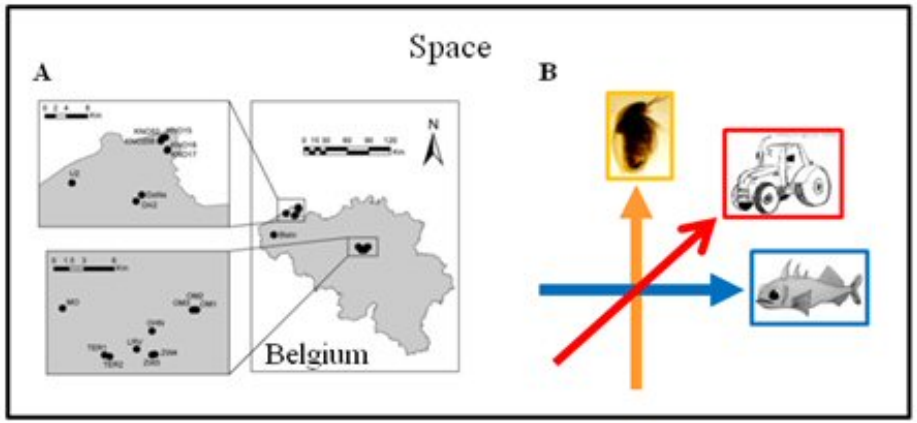
Luisa Orsini





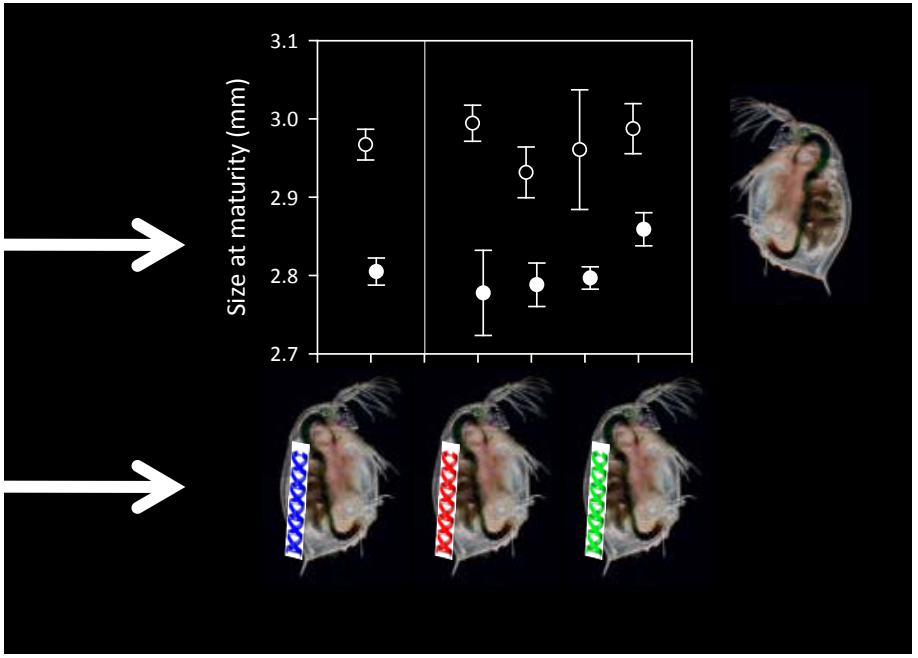
- **20 ponds** along **orthogonal gradients** of ***fish predation***, ***land use intensity*** and ***parasites*** (selection of habitats but along strong and orthogonal gradients to remove problem of collinearity)
- Quantify environmental variation [E] (selection)
- and spatial structure [S] (neutral processes, dispersal)

Quantify matrices of population structure – traits and neutral markers



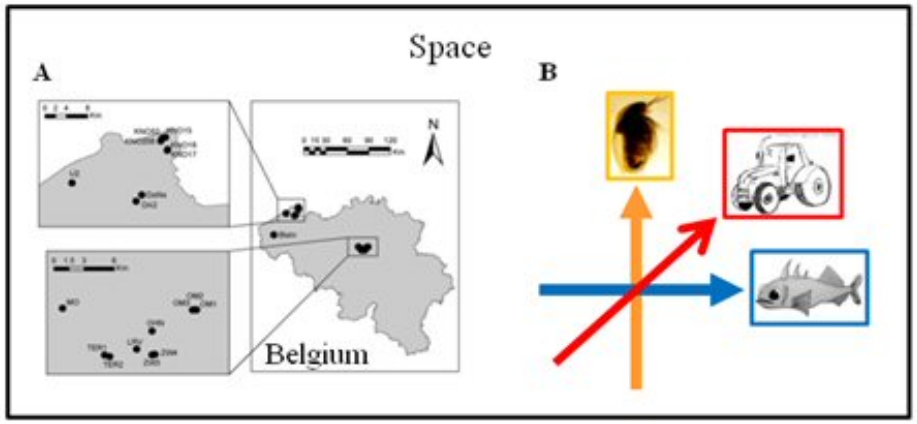
- genotypic variation in trait values within species (**genotypic values**) [Tw] (**trait variation in the metapopulation**) (quantitative genetic experiments)

- **genetic markers** [N] (µsats, SNP markers and mtDNA haplotypes)

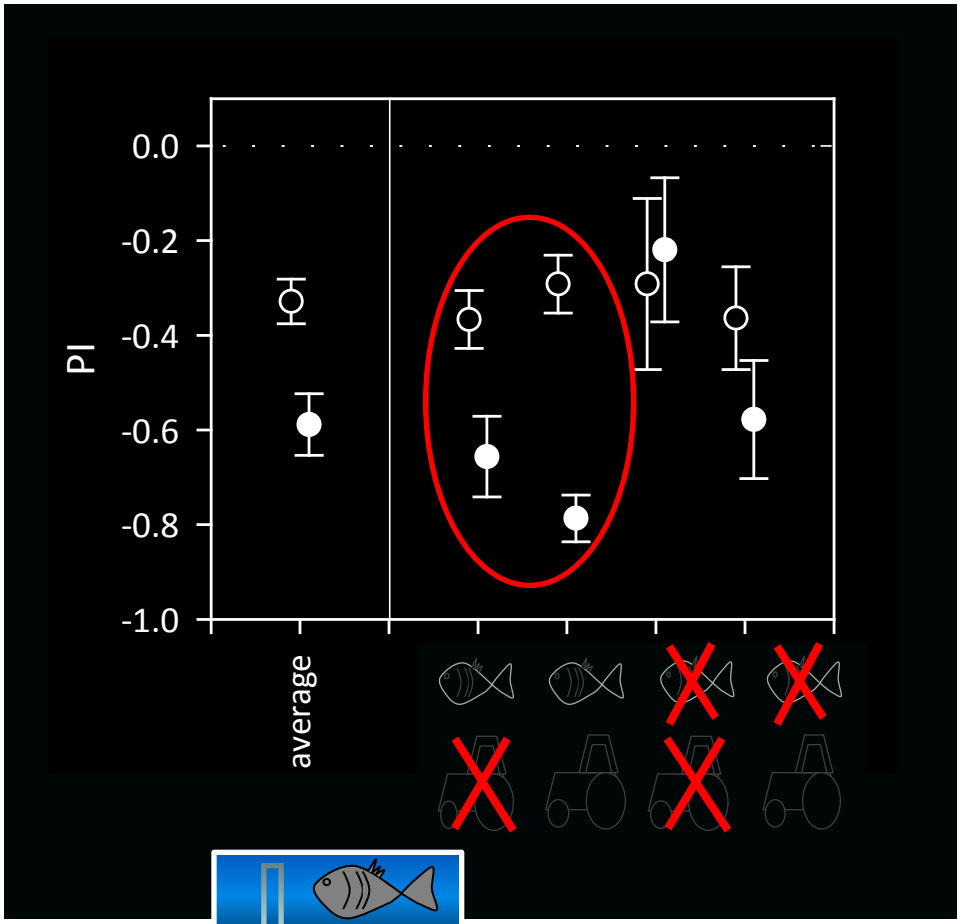


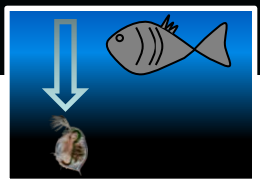
Evolution of trait values within the focal species *D. magna*

Orthogonal gradients
Traits



Rousseaux et al. In prep.





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Orsini et al. 2012 *Molecular Ecology*
Orsini et al. 2013 *Molecular Ecology*

Luisa Orsini

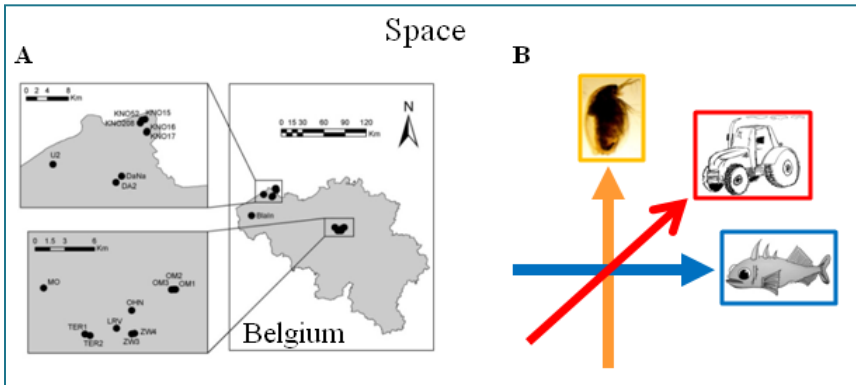
Analysis taking all environmental variables into account and variation at both **hypervariable markers** (186 µsats and SNPs) and **mt sequence variation** (colonization history)

Pattern:
-Strong genetic differentiation at most µsat and SNP markers, **no** association with E or S. Specific markers popped up as outliers for specific gradients (fish, parasites, land use).
-Low effective population sizes
-Few mt DNA haplotypes per population, ie few founders

Most likely mechanism is **selection-based reduction of effective gene flow** (partly) freezing colonization events (**IBC mediated by monopolization**)

Selection is key in this process, resulting in
(1) **local adaptation**,
(2) **reduced gene flow**,
(3) **enhanced genetic drift**

(Orsini et al. 2013 *Molecular Ecology*)



Landscape genetic structure in relation to space and environment

Luisa Orsini

Orsini et al. 2013
Invited review *Molecular Ecology*

Importance of assessing environmental gradients in population genetic studies

Patterns:

Isolation by distance

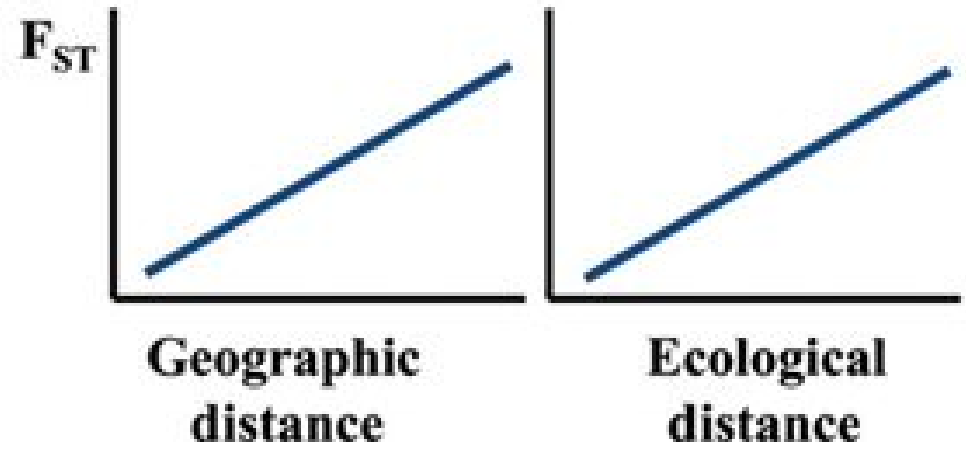
Isolation by environment

Processes:

Isolation by dispersal limitation

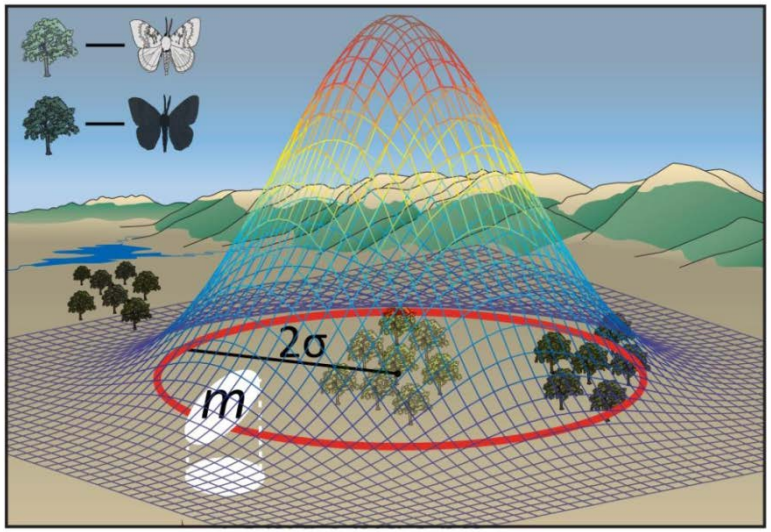
Isolation by adaptation

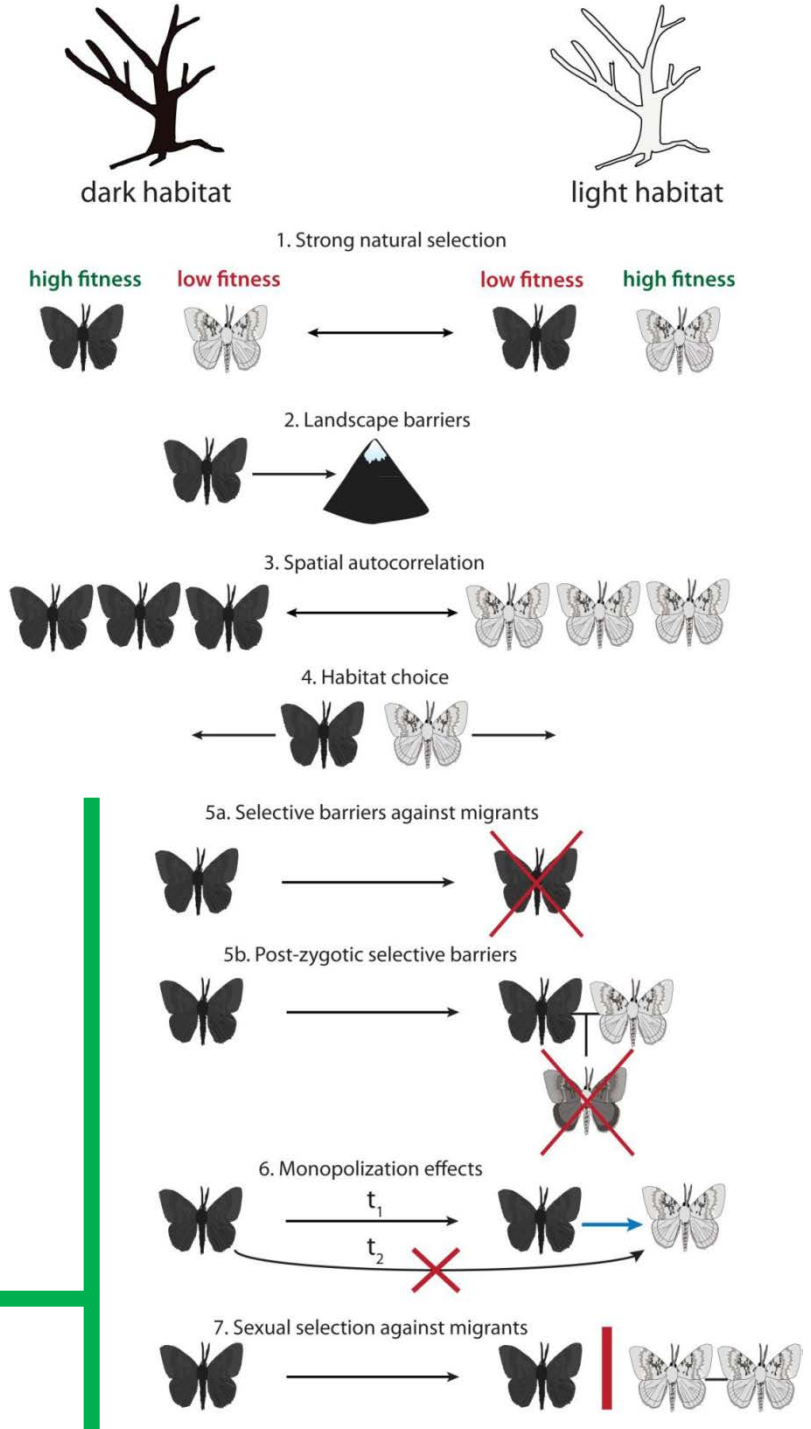
Isolation by colonization



Aquatic Ecology, Evolution & Conservation

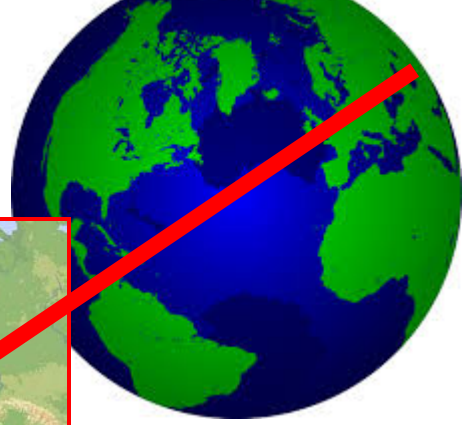
Richardson et al. 2014 TREE

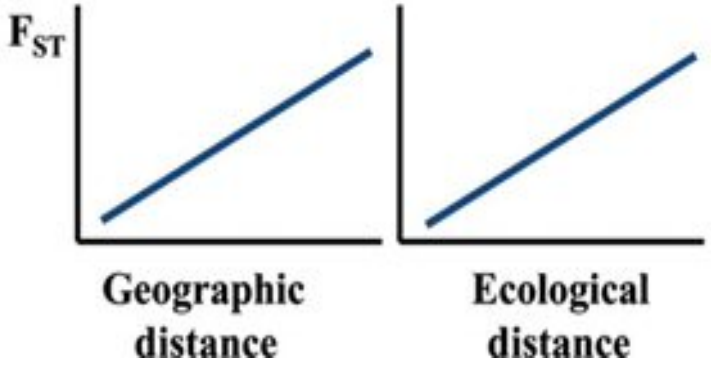




REDUCED GENE FLOW BECAUSE OF SELECTION

Geographic scales





The local team

Aquatic Ecology, Evolution & Conservation

KU LEUVEN



















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