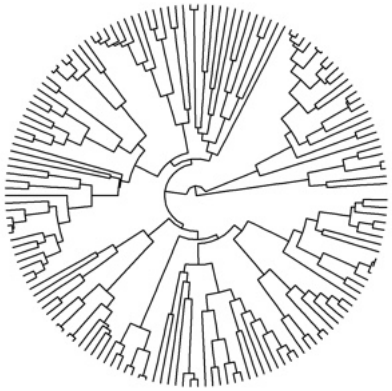
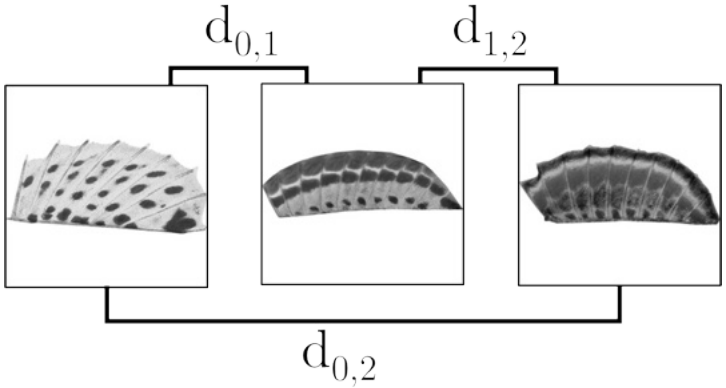




The influence of habitat on the patterns of sexual signals in a freshwater fish radiation

(*Etheostoma spp.*)

Iain R. Moodie, Tamra C. Mendelson, Julien P. Renoult

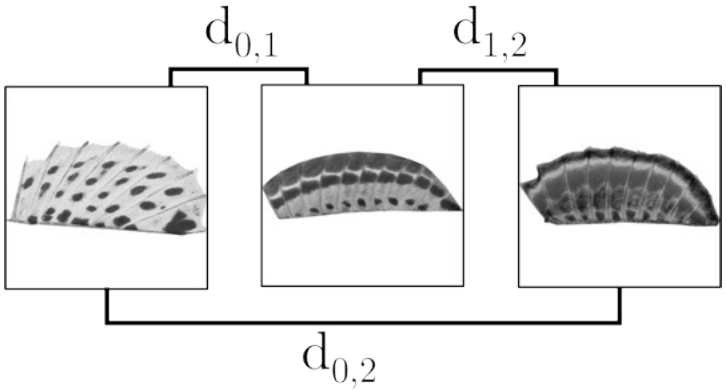
cnrs

UMR 5175
Centre d'Ecologie
Fonctionnelle
& Evolutive

NSF

MEME

Erasmus
Mundus



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& Evolutive

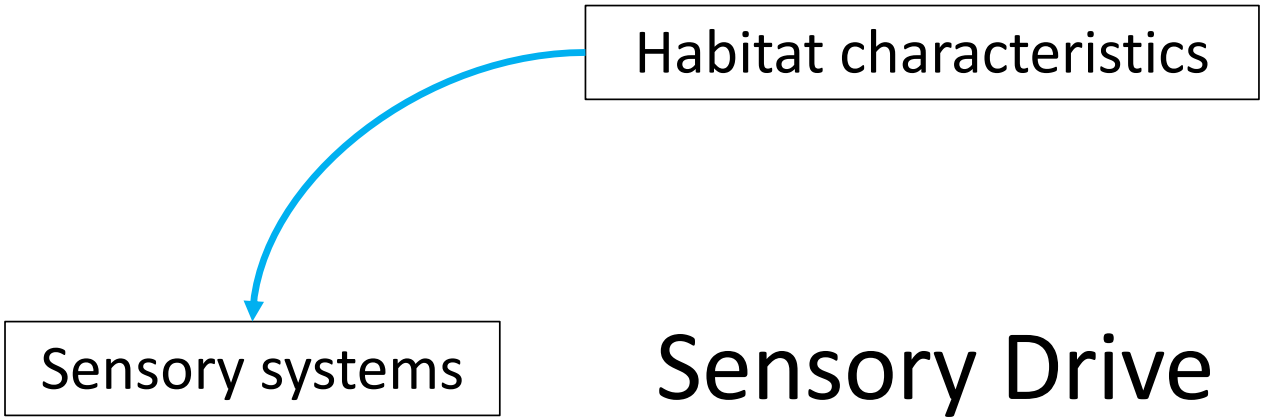
Erasmus
Mundus

Sensory Drive

Sensory systems

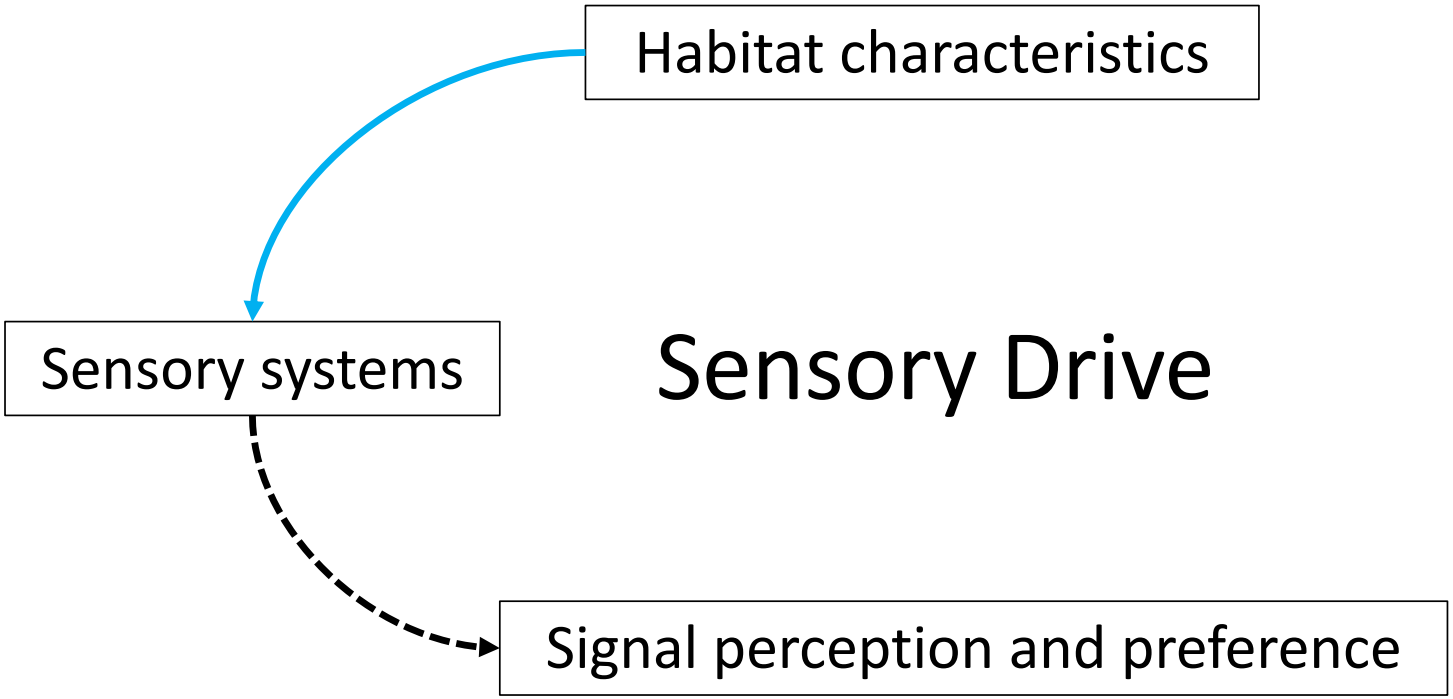
Sensory Drive

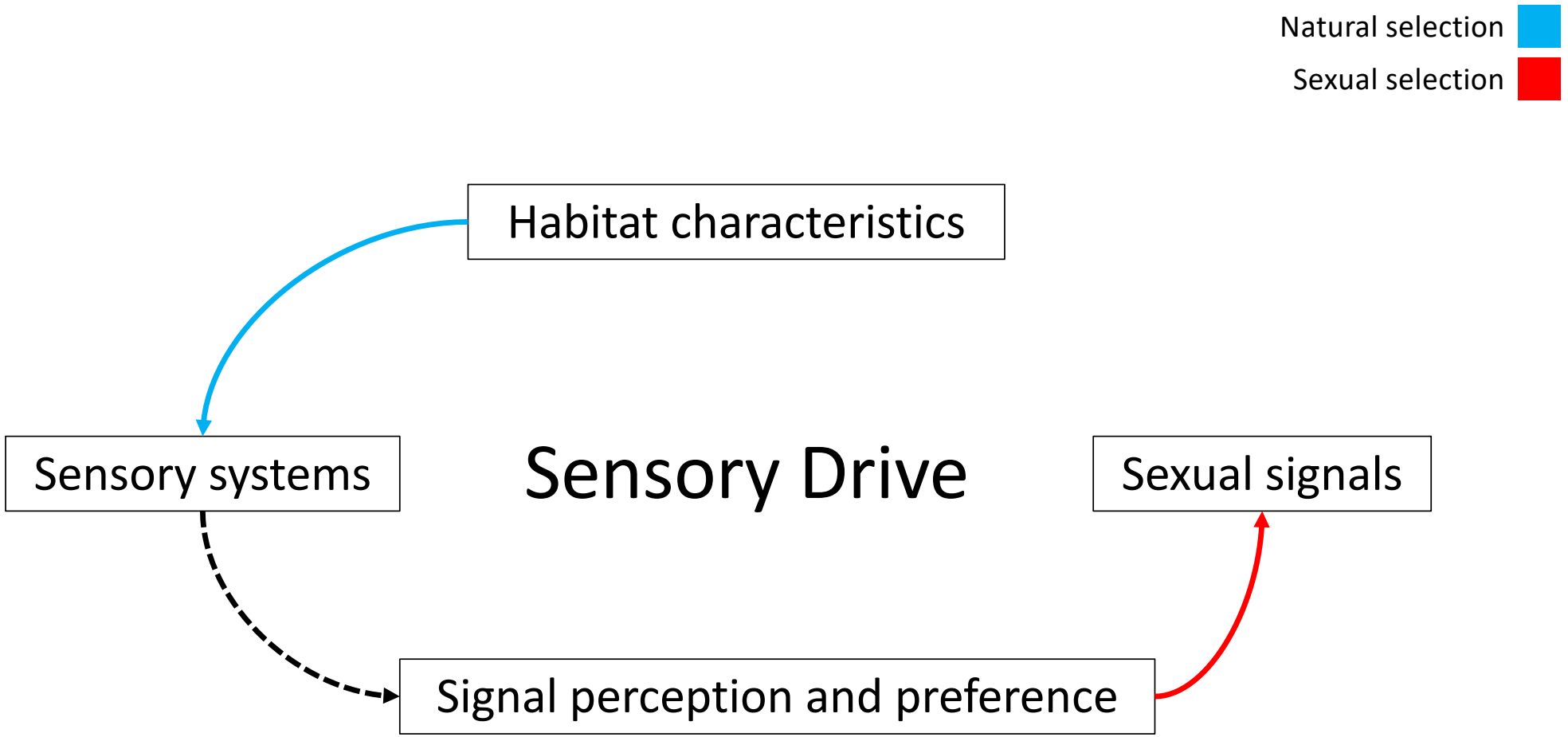
Natural selection



Sensory Drive

Natural selection




Natural selection
Sexual selection
Habitat characteristics
Sensory systems
Sensory Drive
Sexual signals
Signal perception and preference


Natural selection
Sexual selection
Habitat characteristics
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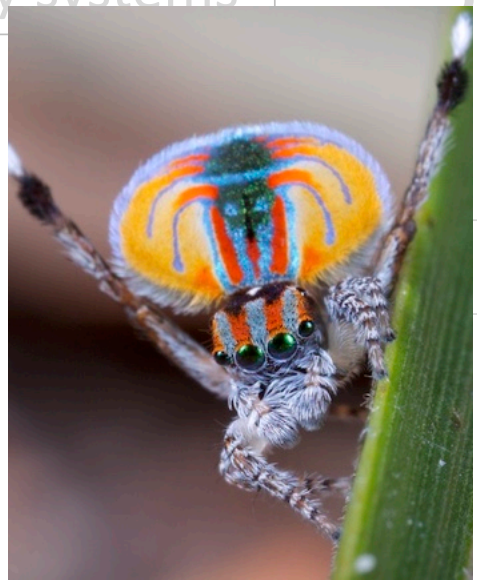
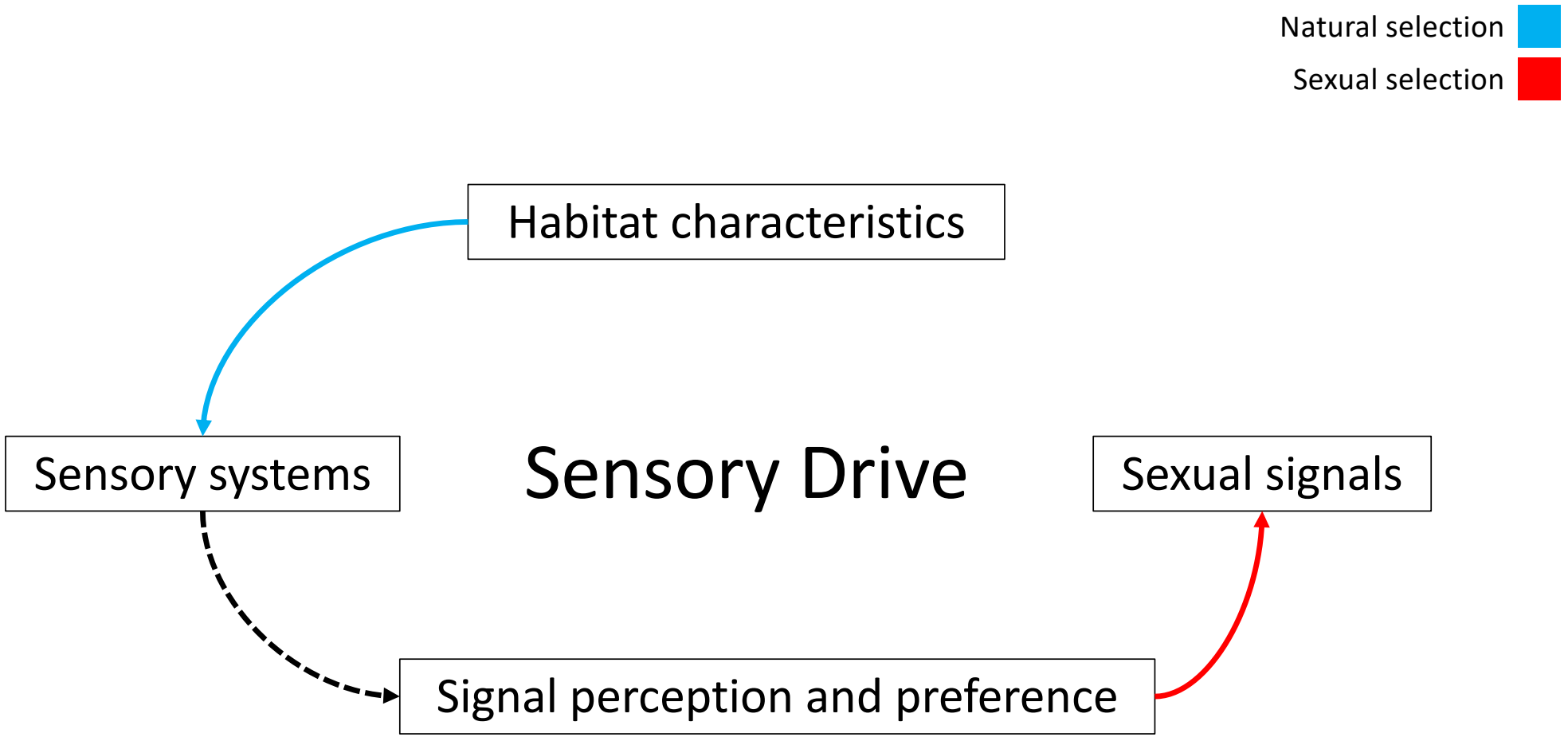
Sensory Drive
Sexual signals
Signal perception and preference

Natural selection

Sexual selection

Sexual signals




Natural selection
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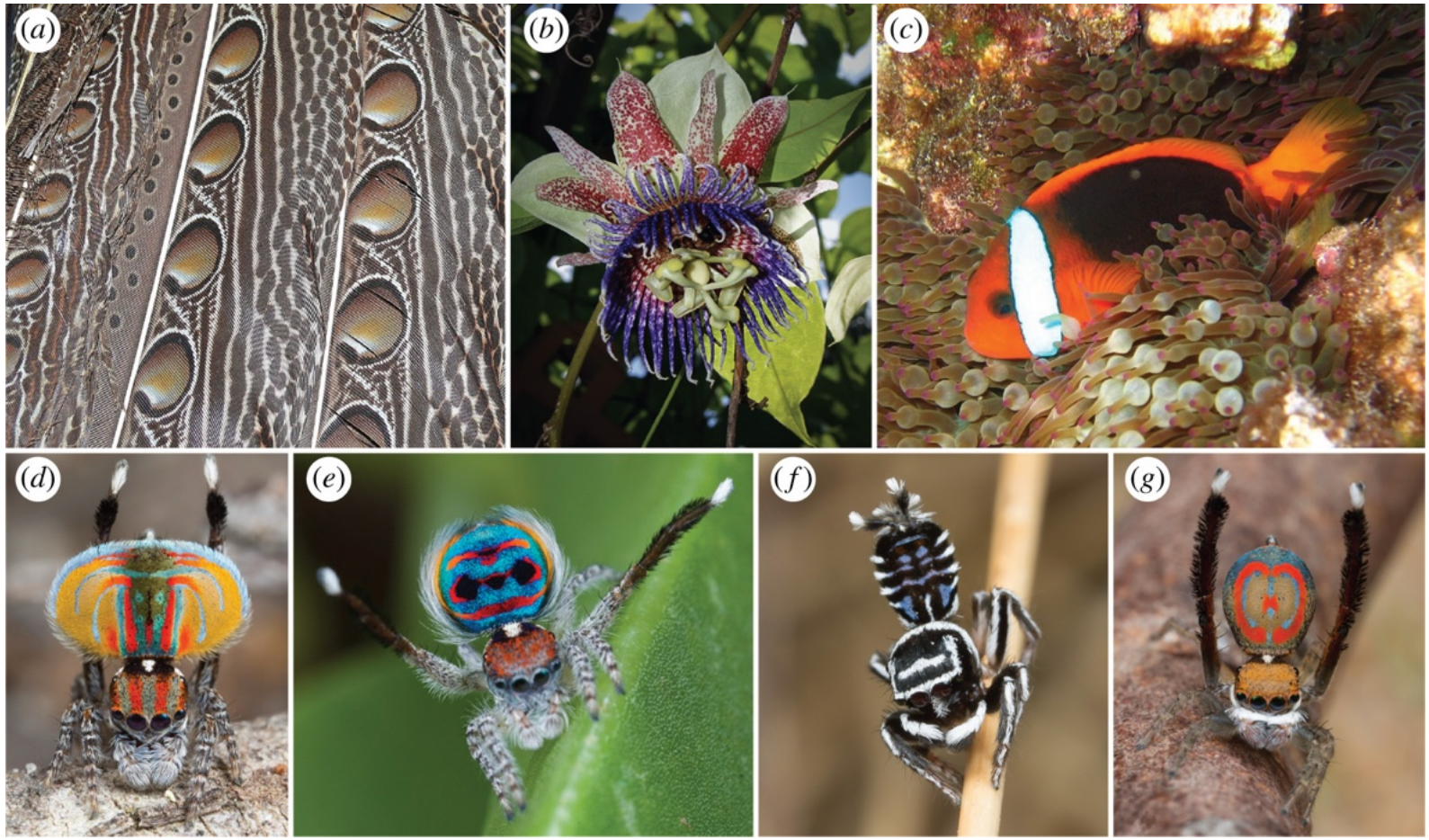
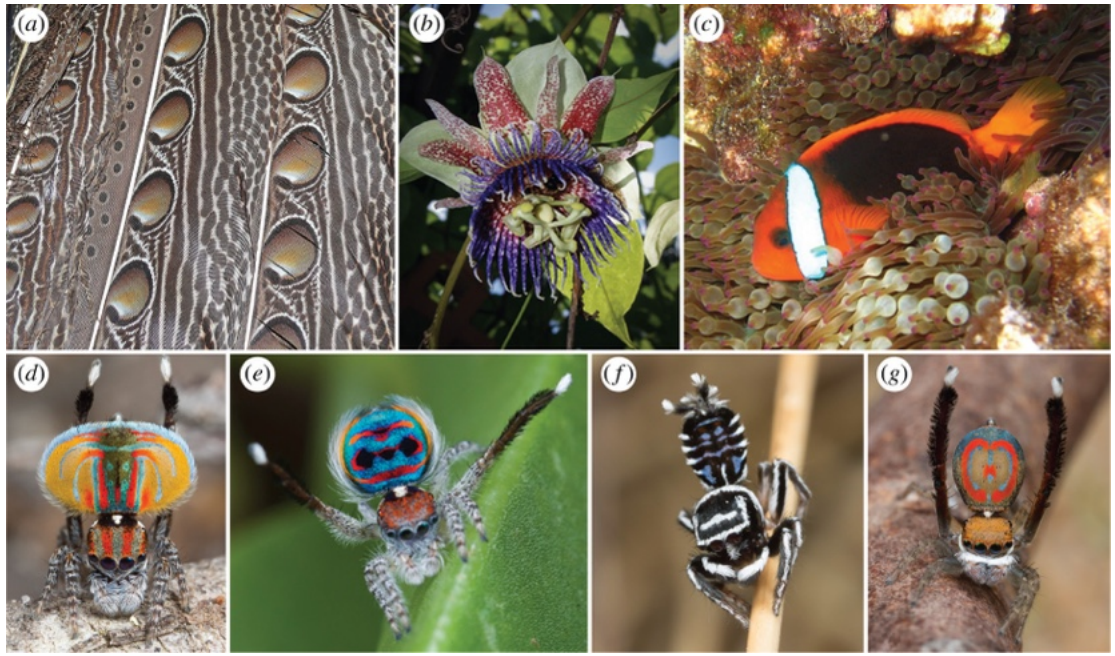


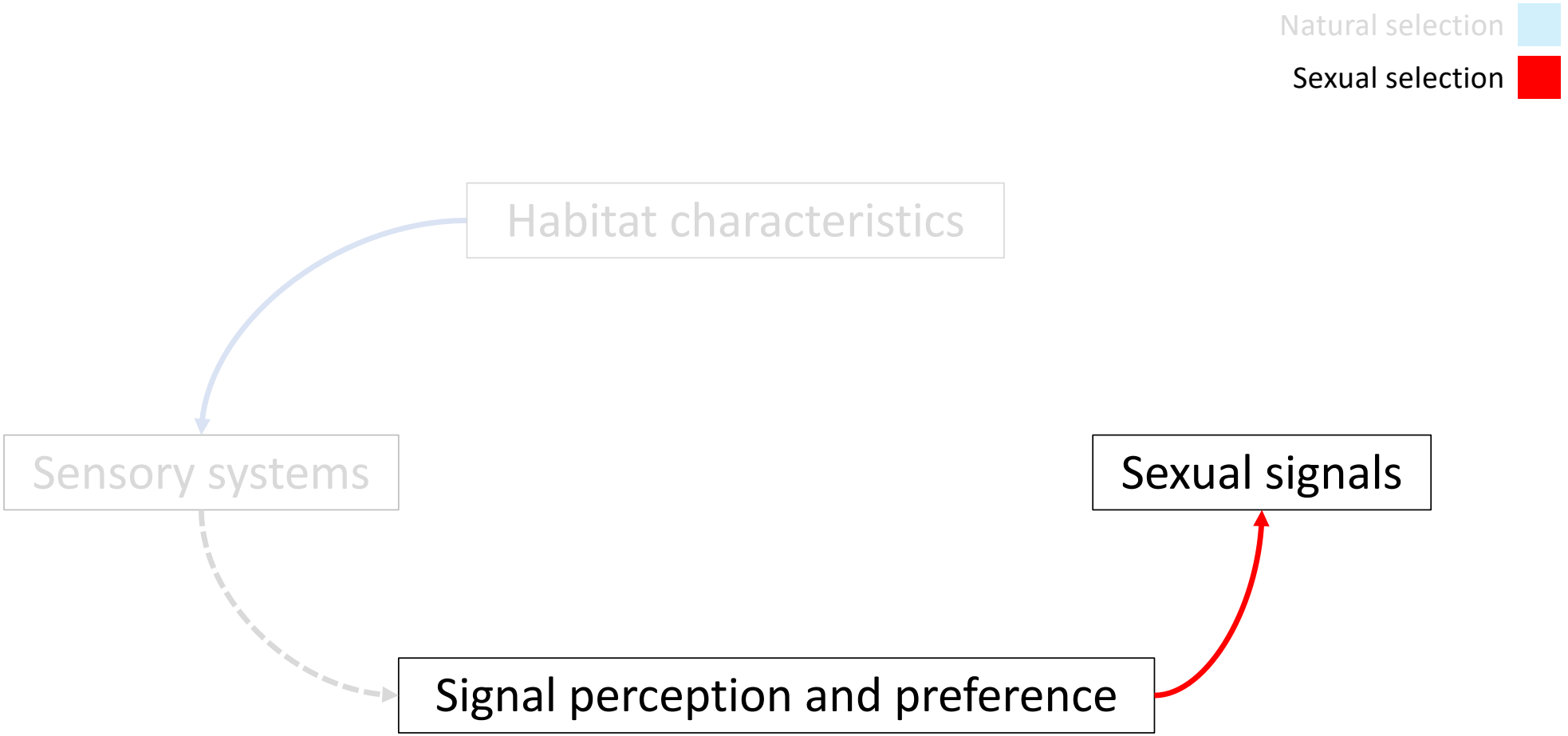
Renoult and Mendelson 2019

Processing bias: extending sensory drive to include efficacy and efficiency in information processing

Julien P. Renoult[1] and Tamra C. Mendelson[2]



Renoult and Mendelson (2019)


Natural selection
Sexual selection
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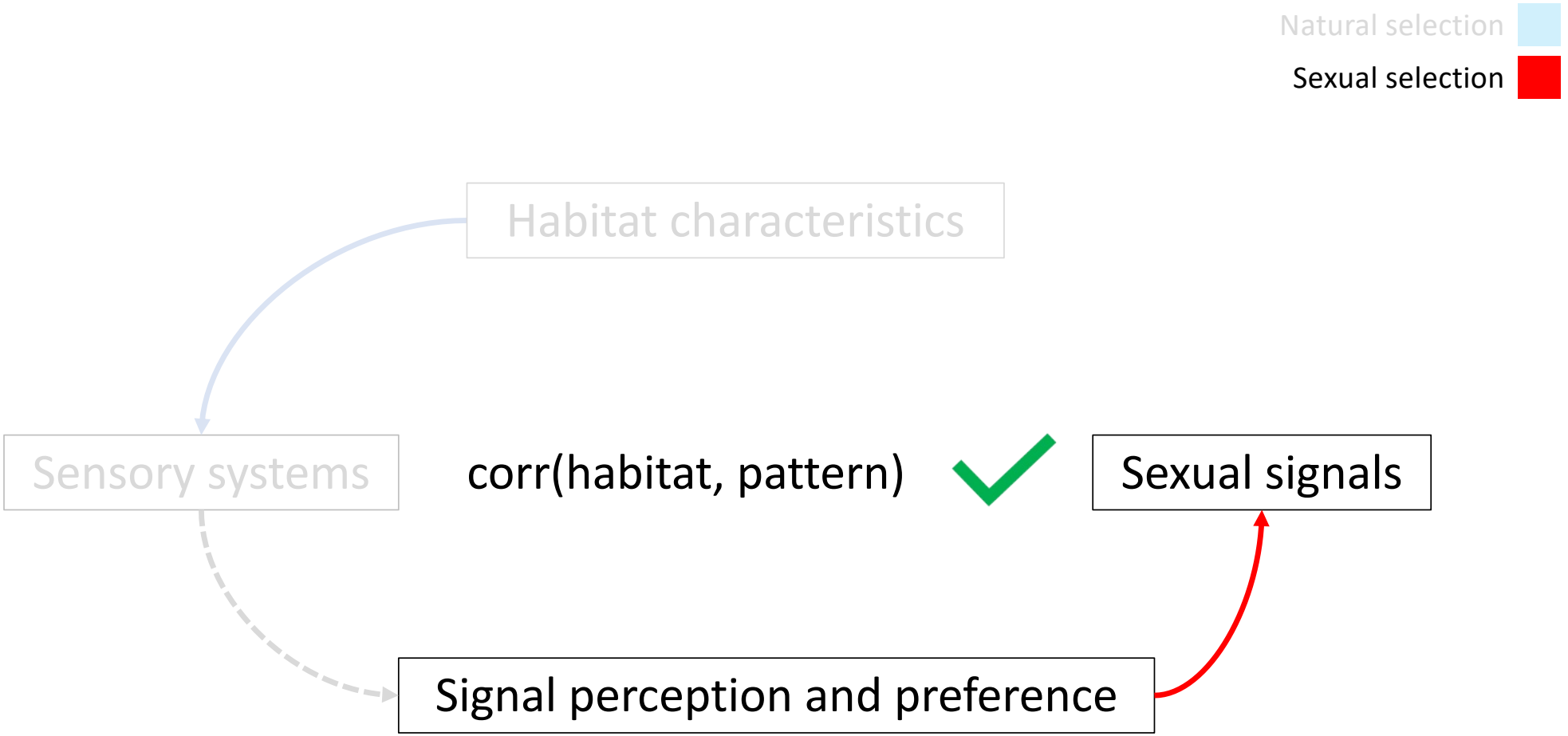
Sensory systems
Sexual signals
Signal perception and preference


Natural selection
Sexual selection
Habitat characteristics
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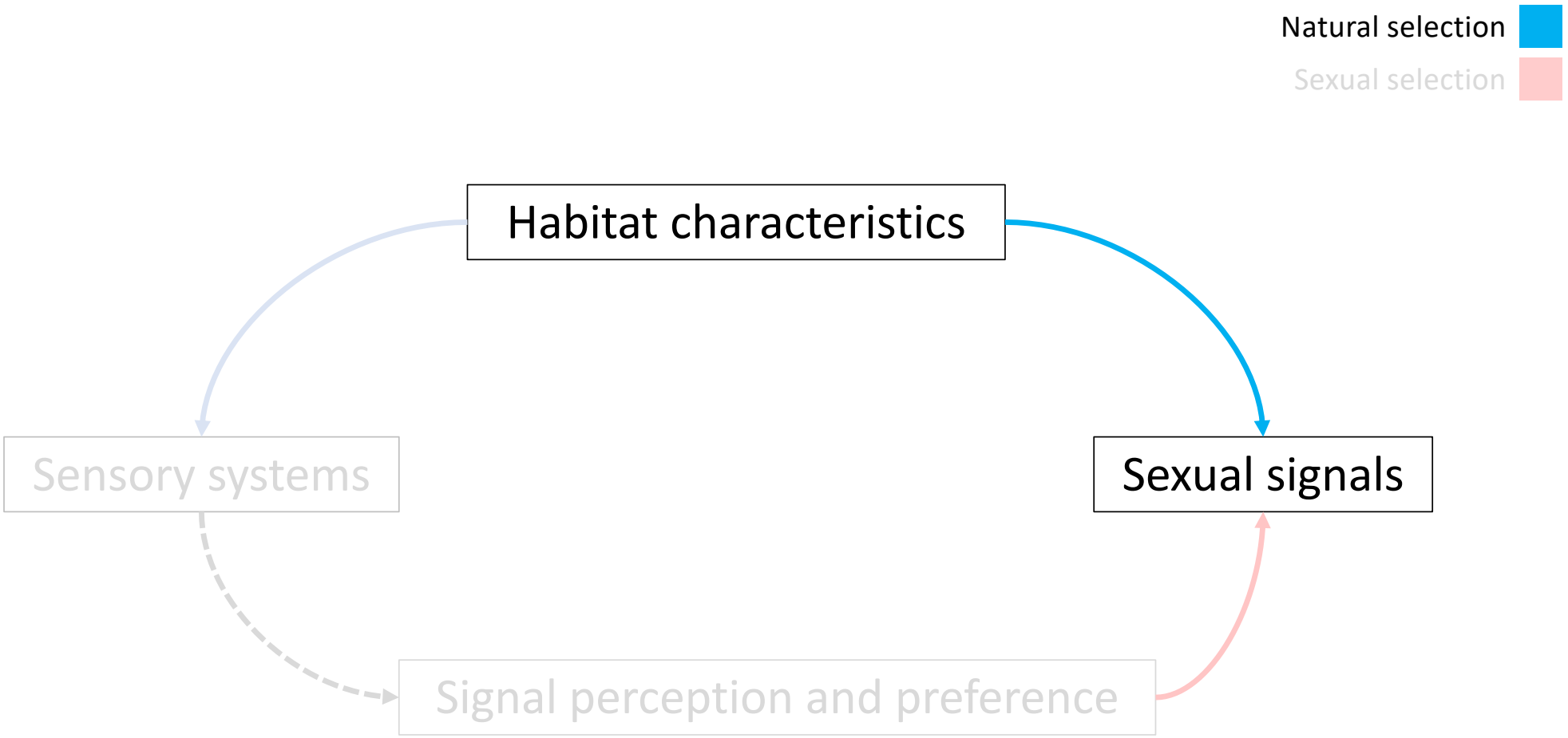
corr(habitat, pattern)
Sexual signals
Signal perception and preference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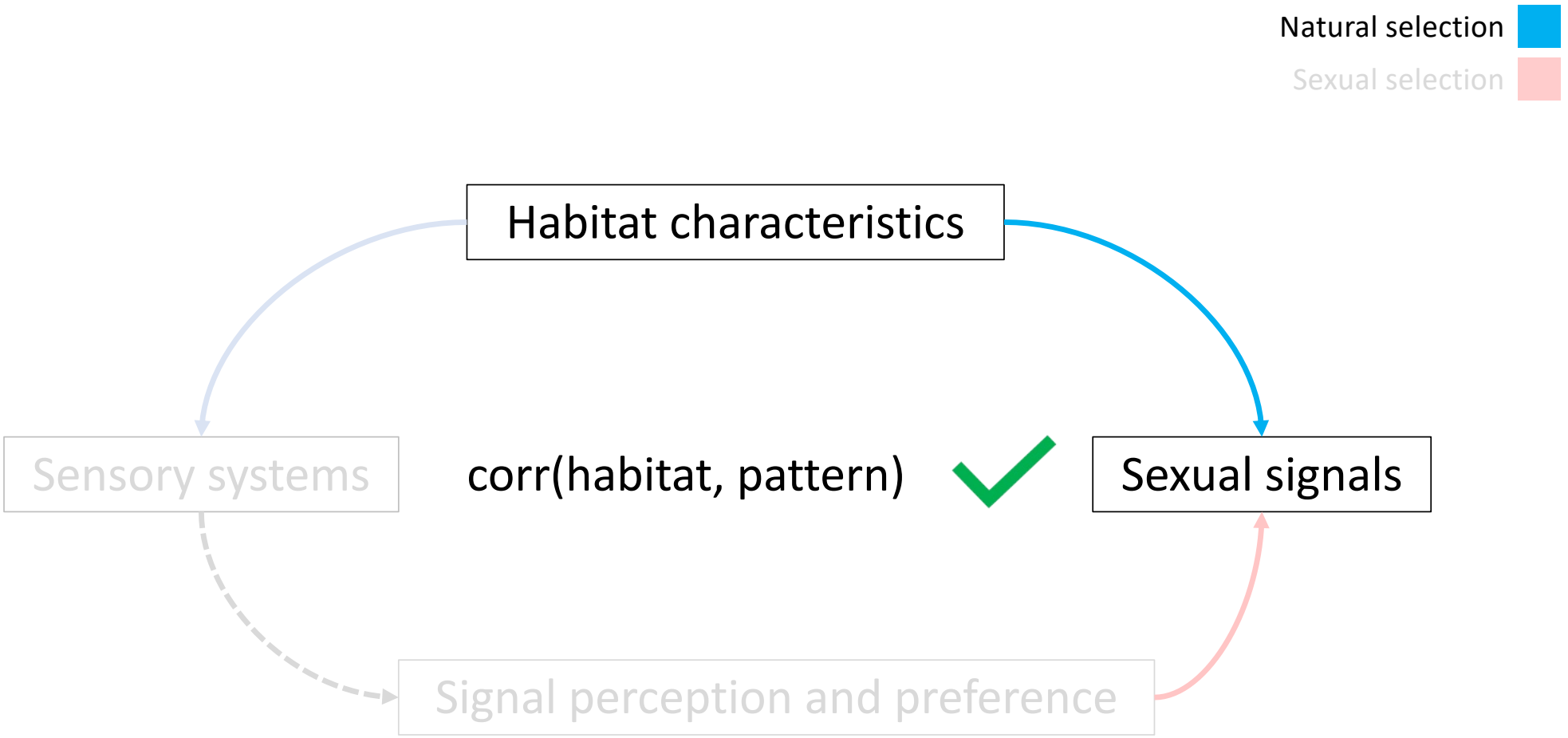

Natural selection
Sexual selection
Habitat characteristics
Sensory systems
corr(habitat, pattern)
Sexual signals
Signal perception and preference

Etheostoma (Family: Percidae)

Uland Thomas

Darters

Uland Thomas

Pattern

Natural selection

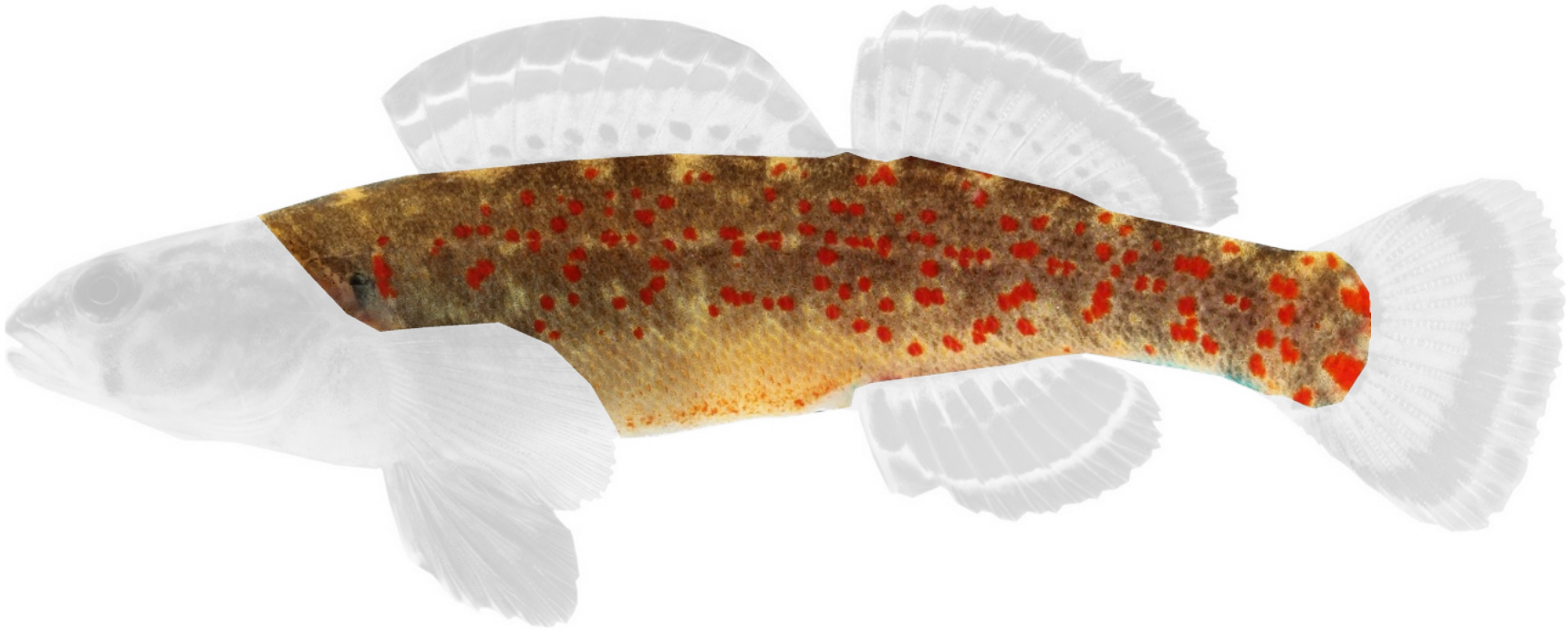
Sexual selection

Uland Thomas

Pattern

Natural selection

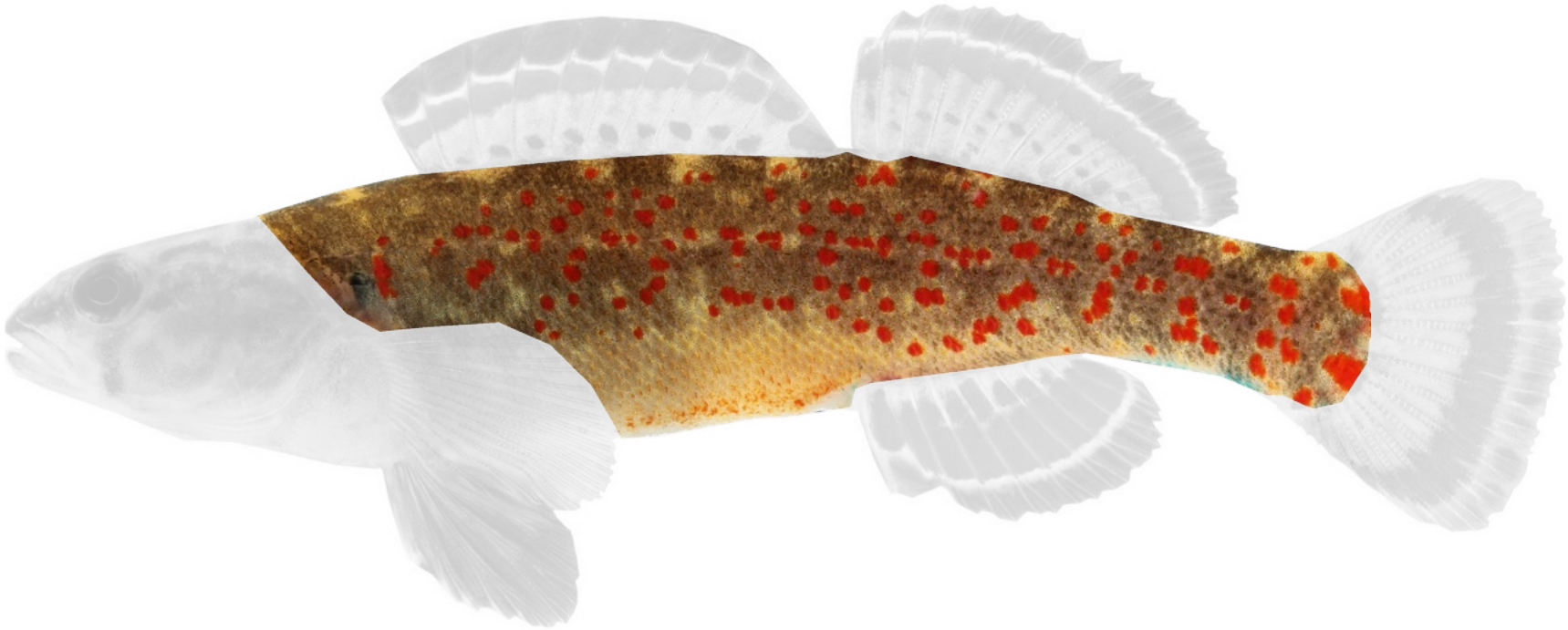
Sexual selection



Pattern

Natural selection

Sexual selection



Natural selection →

Sexual selection →

corr(habitat, pattern) = ✓

Pattern

Natural selection

Sexual selection

Pattern

Natural selection

Sexual selection

Sexual selection → corr(habitat, pattern) = ✓

Pattern

Natural selection

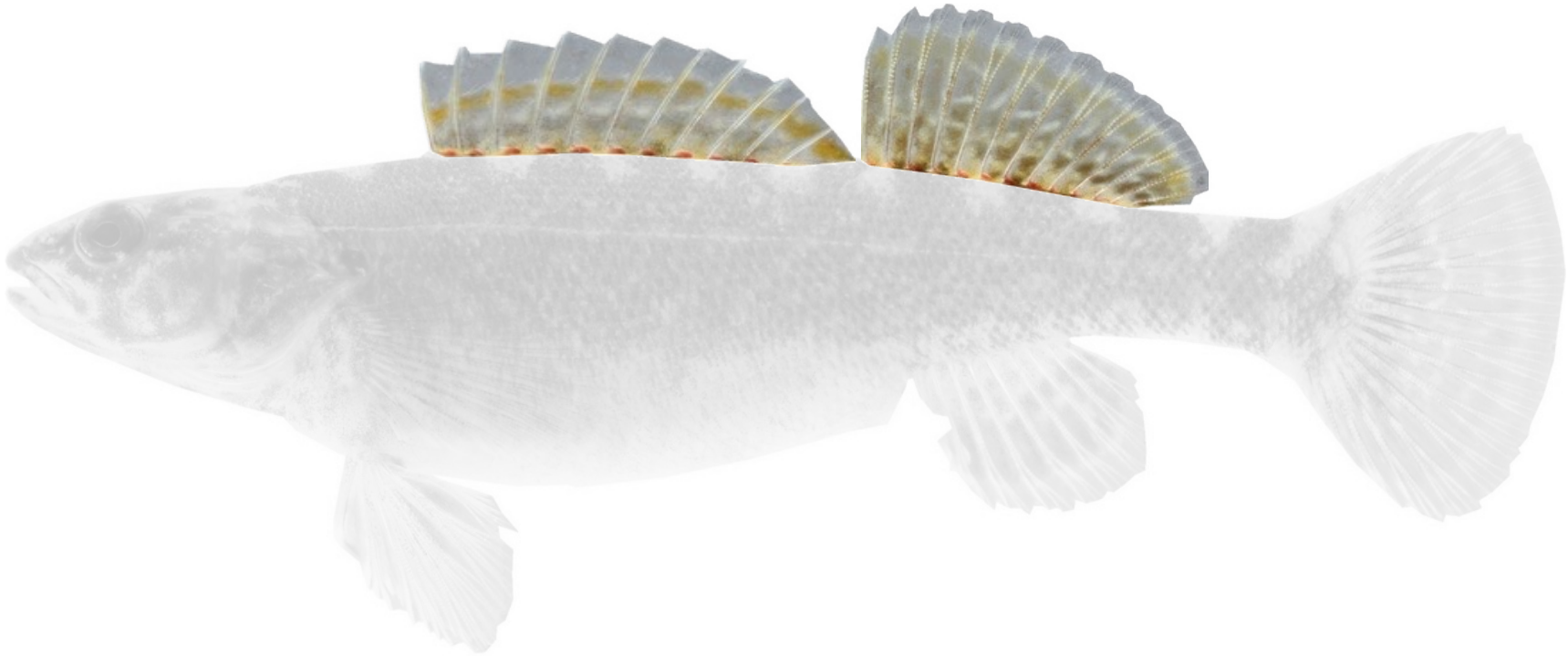
Sexual selection

Uland Thomas

Pattern

Natural selection

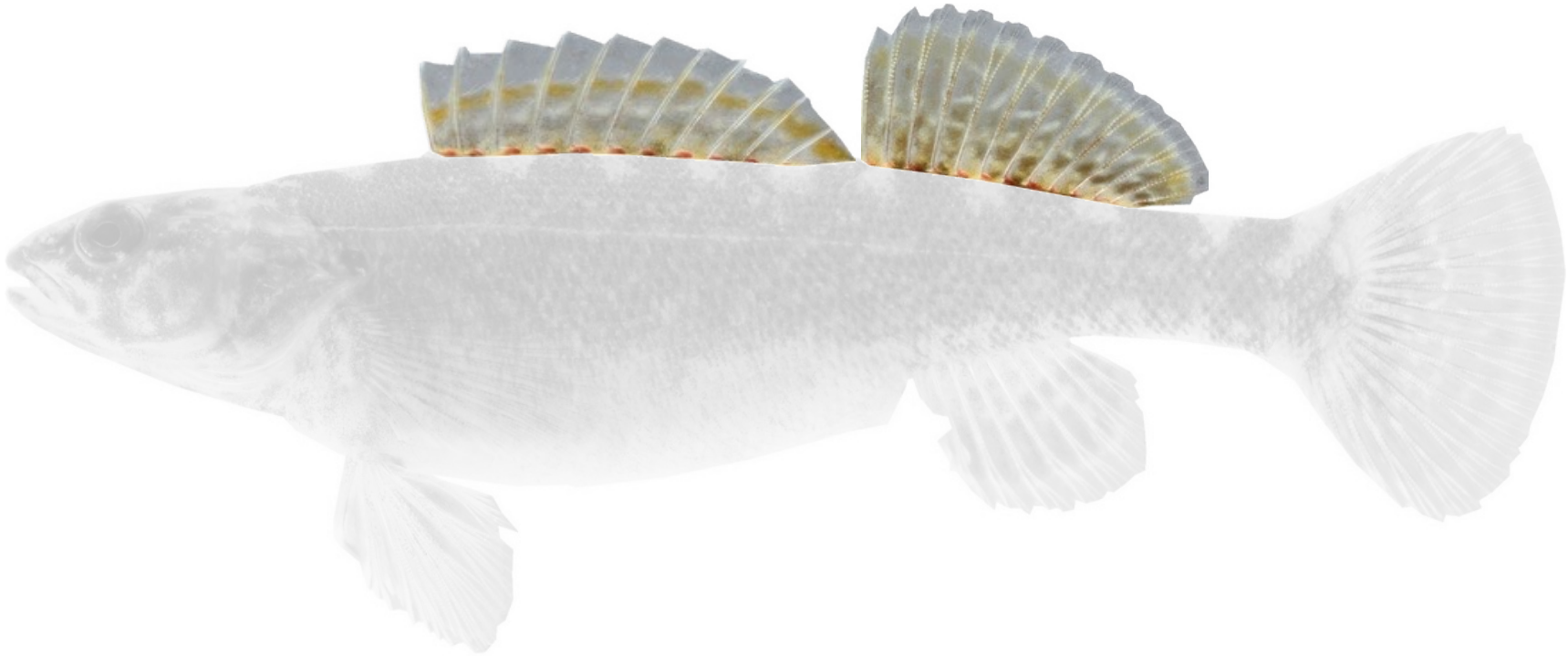
Sexual selection



Natural selection

Sexual selection

Pattern



corr(habitat, pattern) = ✕

Pattern

Natural selection

Sexual selection

Sexual selection → corr(habitat, pattern) = ✓

Methods

Species coverage

Species = 153/166

Both = 114

Male only = 37

Female only = 2

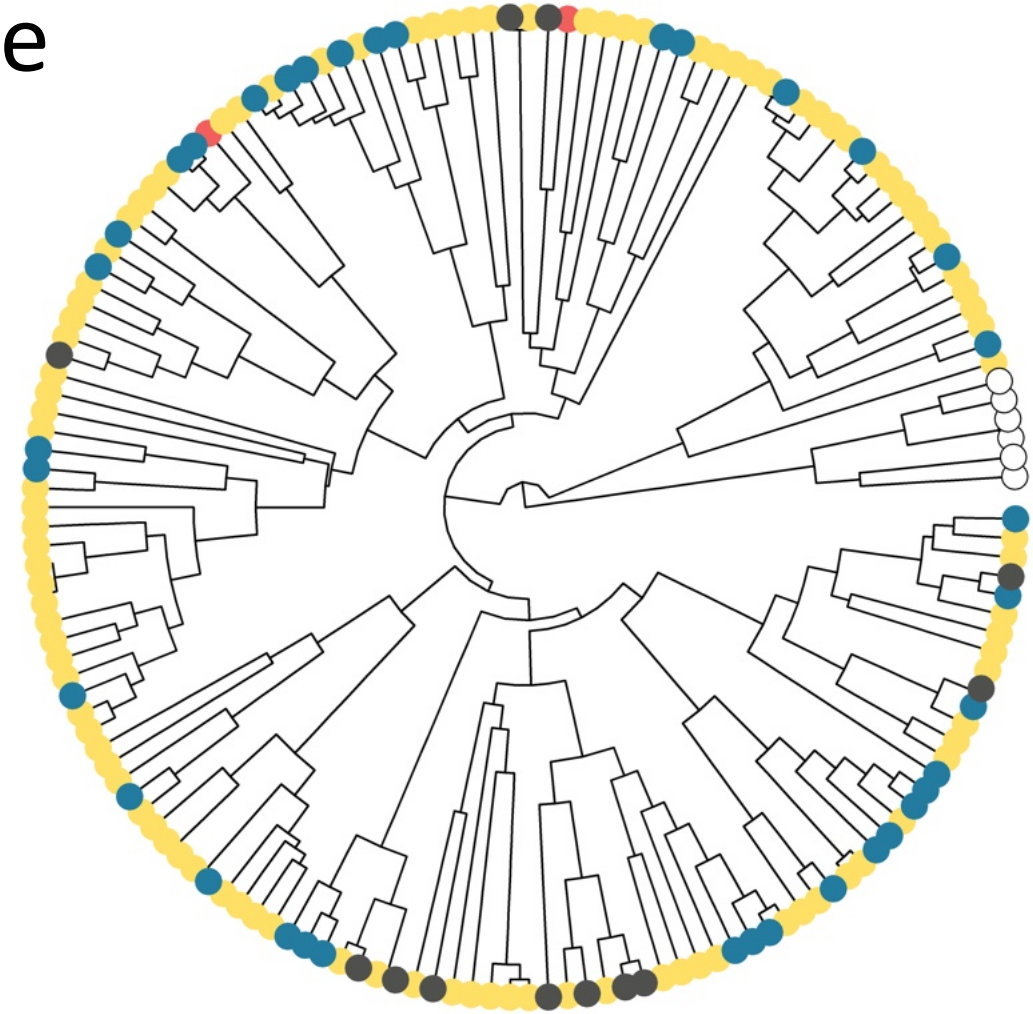
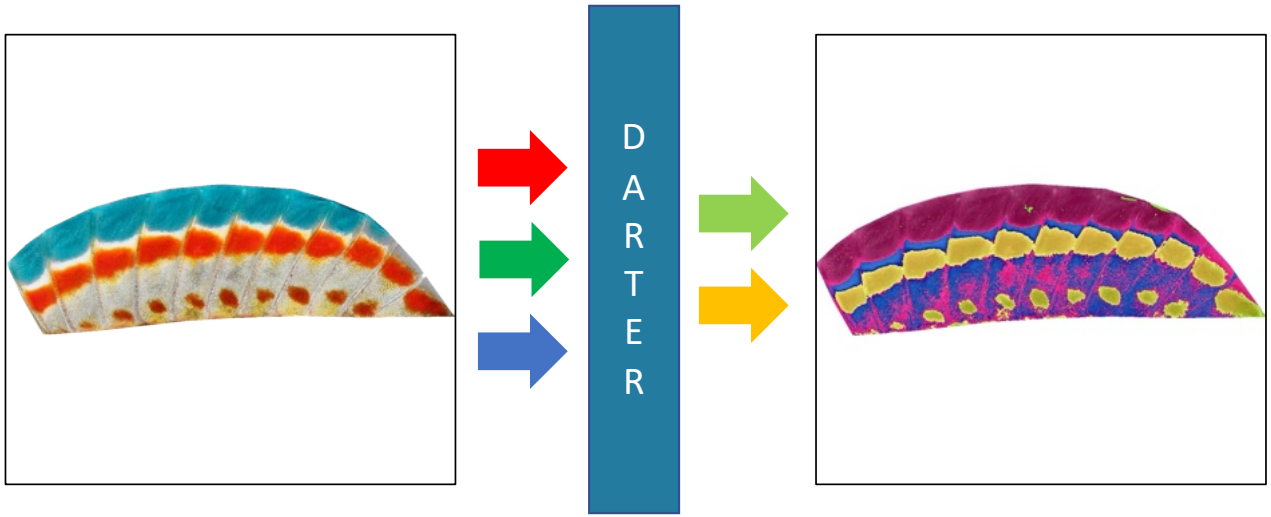


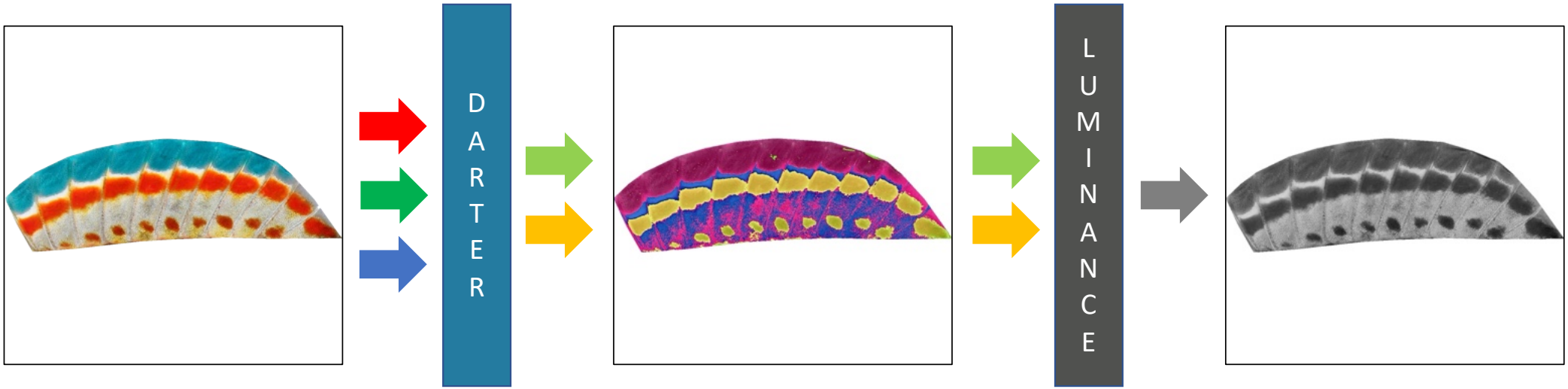
Image processing

Image processing



Hulse et al. (2020)

Image processing



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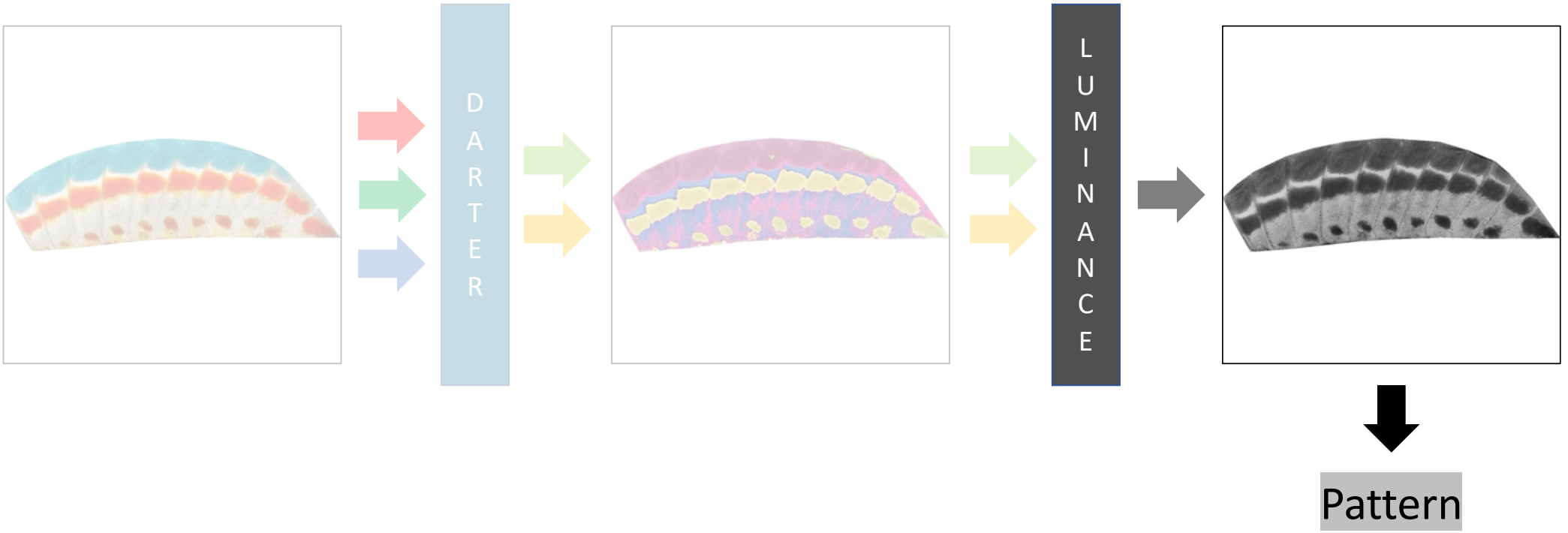
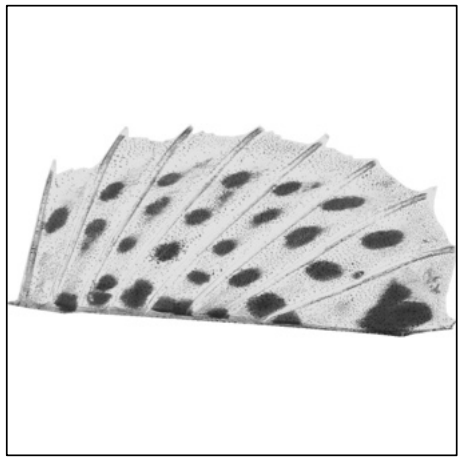
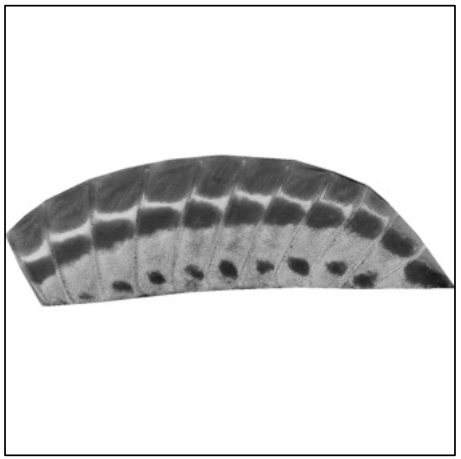
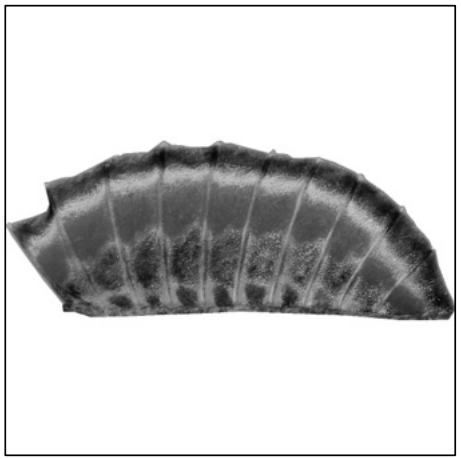


Quantifying differences in pattern



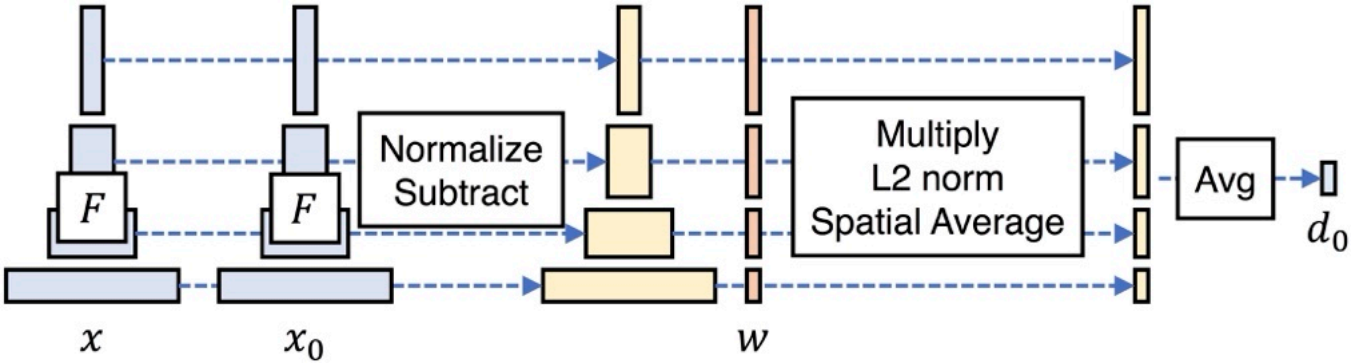


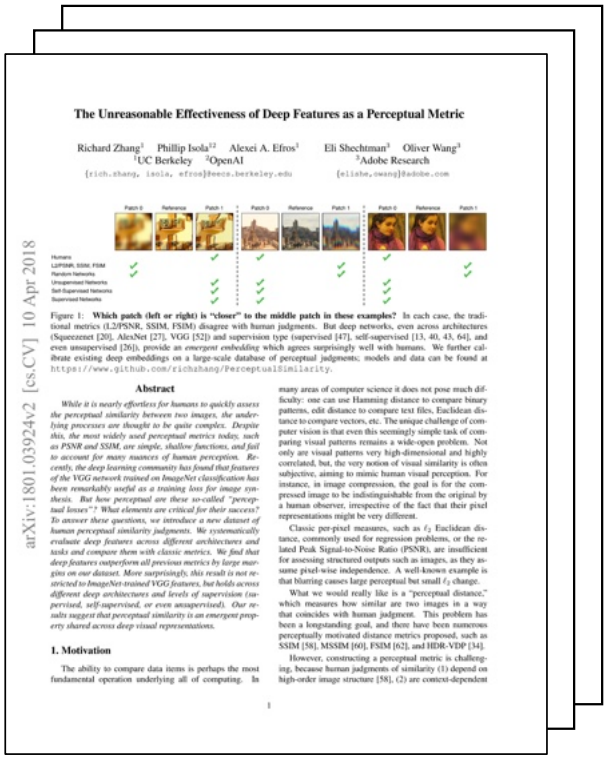


Quantifying differences in pattern

The Unreasonable Effectiveness of Deep Features as a Perceptual Metric

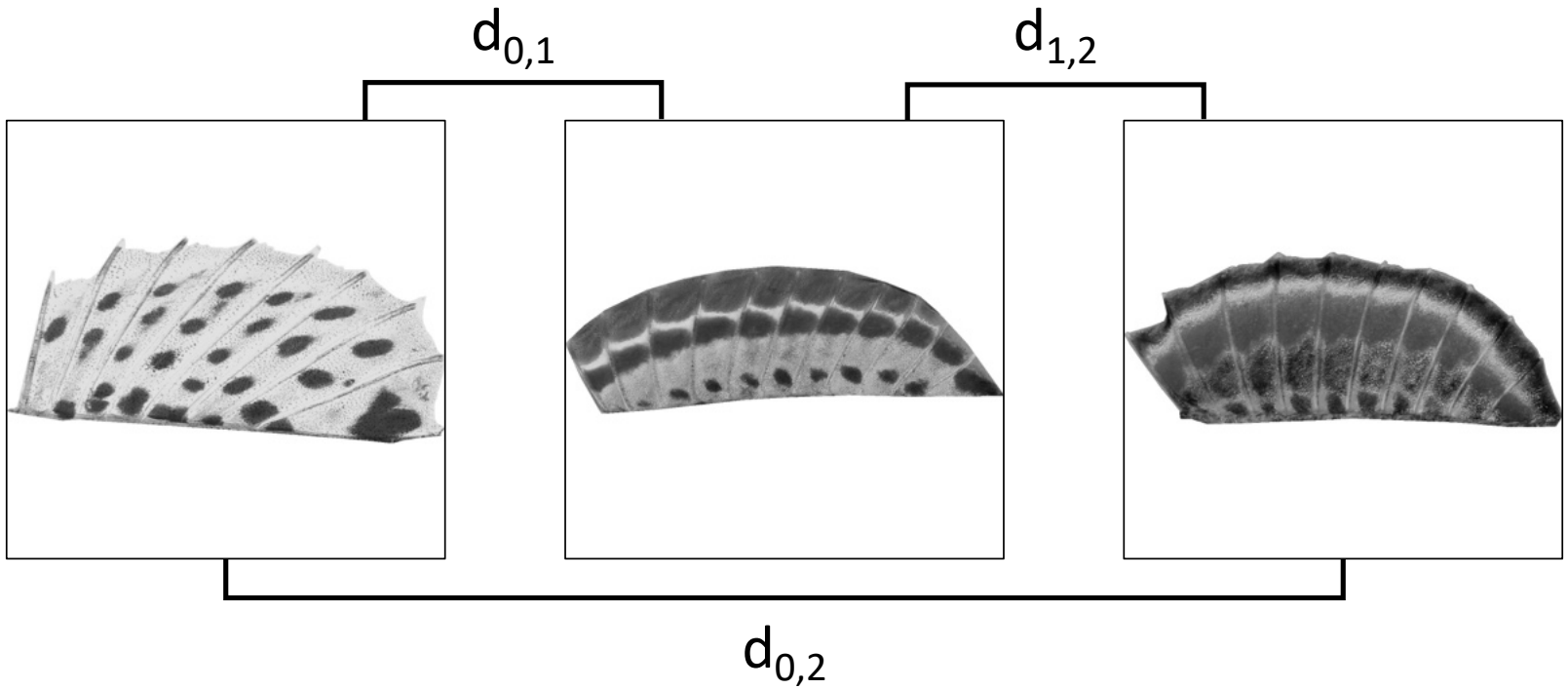
Richard Zhang[1] Phillip Isola[12] Alexei A. Efros[1] Eli Shechtman[3] Oliver Wang[3]
[1]UC Berkeley [2]OpenAI [3]Adobe Research



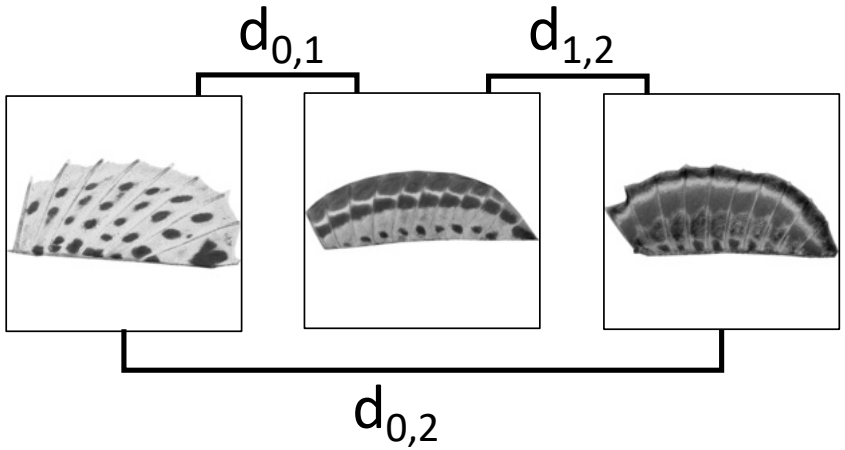


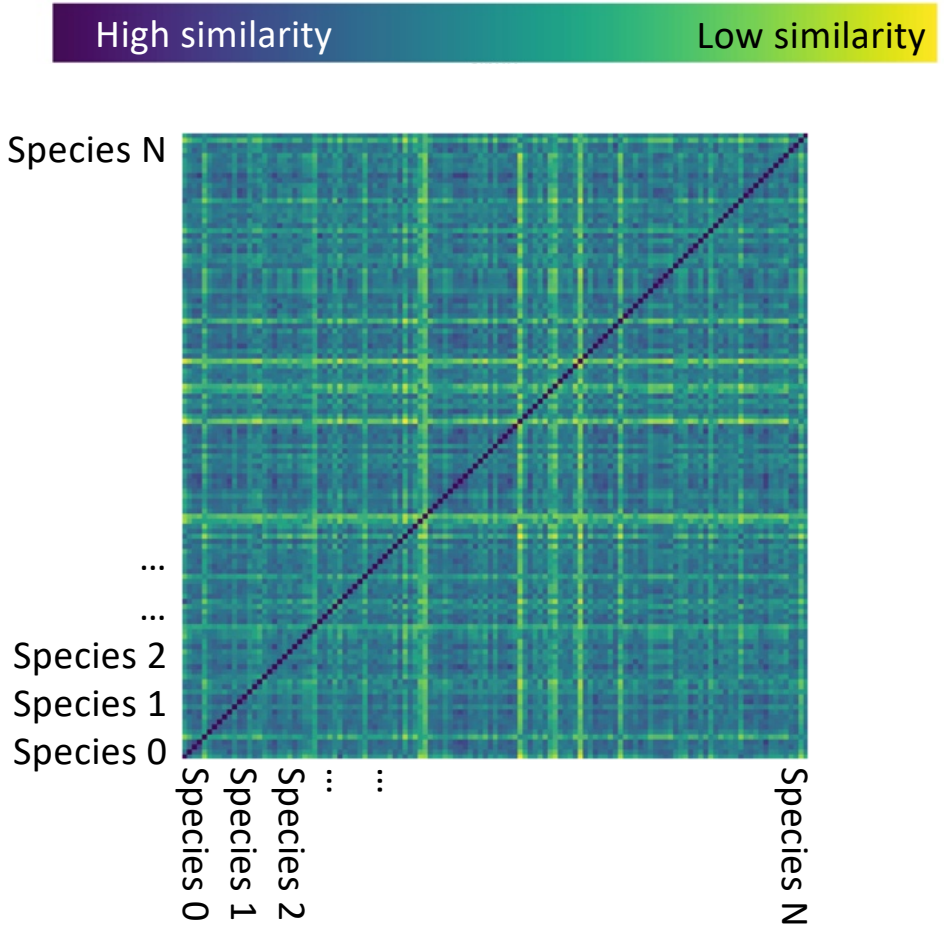
Zhang et al. (2018)

Perceptual distance: $d_{luminance}$

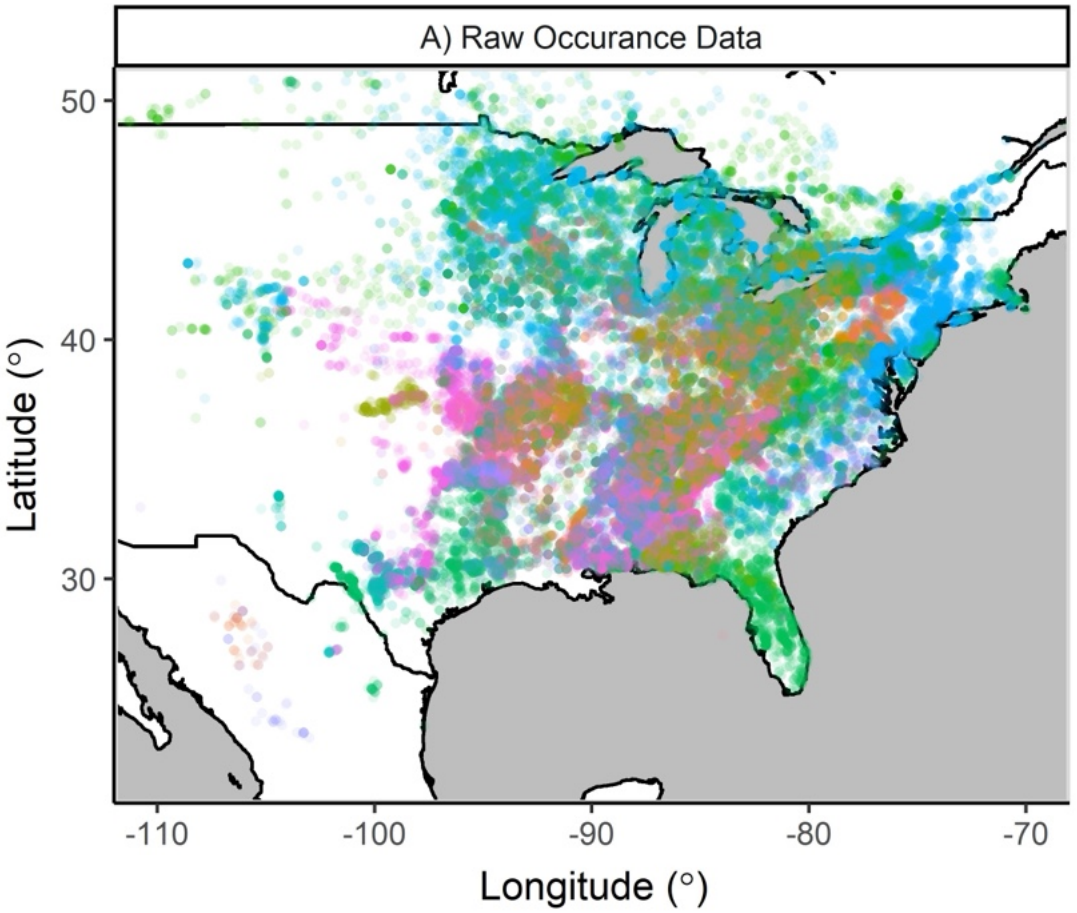


Perceptual distance: $d_{luminance}$





Quantifying differences in habitat



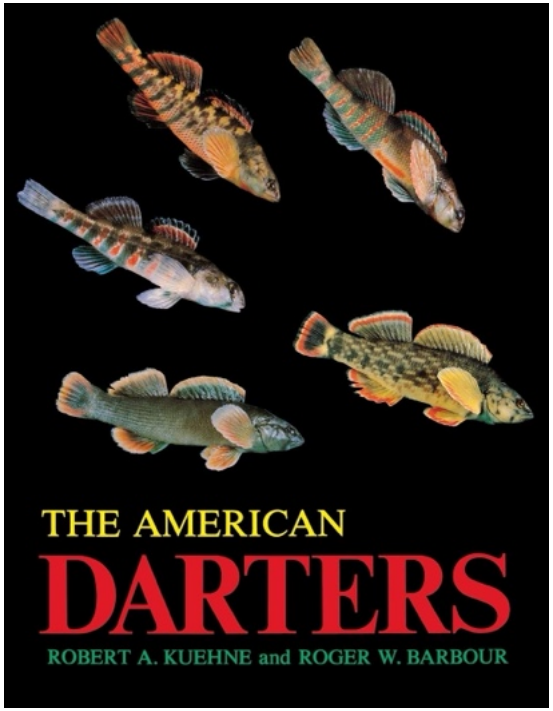
GBIF (2022)

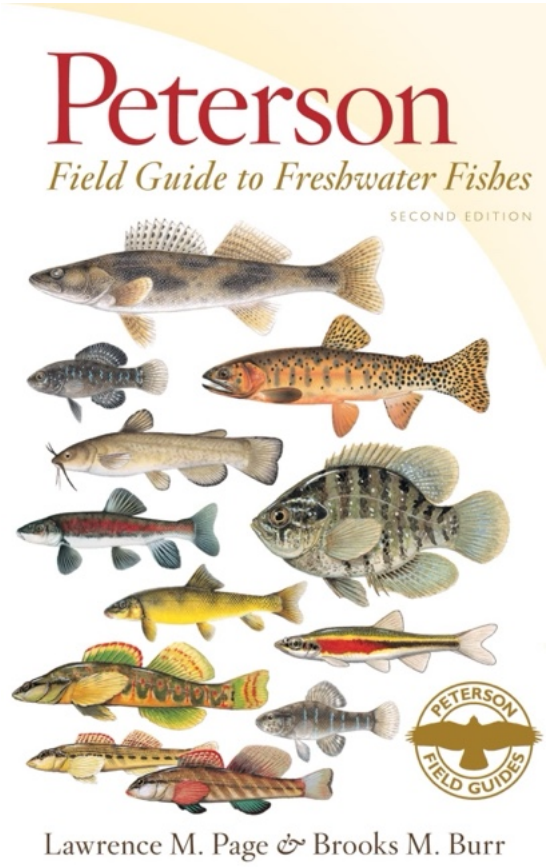
Quantifying differences in habitat

Ricketts (1999)

Quantifying differences in habitat

Quantifying differences in habitat



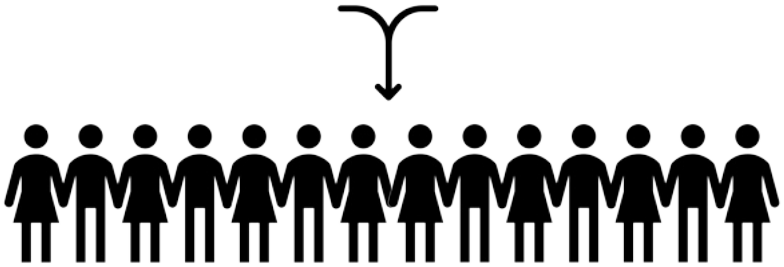


Quantifying differences in habitat

“strongly flowing water in riffles and chutes of medium sized to large upland rivers where substrate consists of coarse gravel, rubble, or boulders”

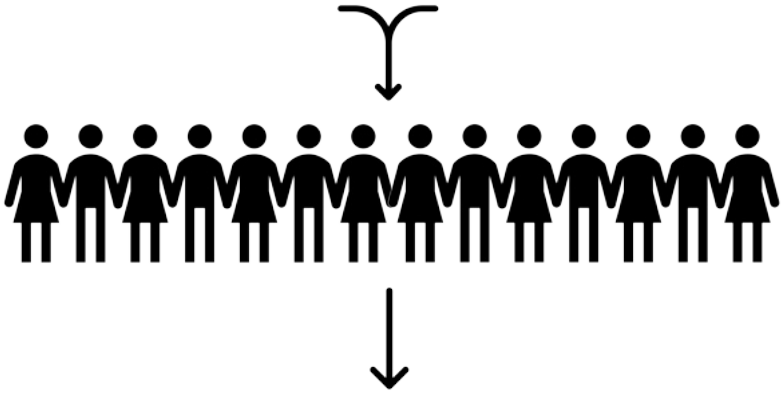
Quantifying differences in habitat

“strongly flowing water in riffles and chutes of medium sized to large upland rivers where substrate consists of coarse gravel, rubble, or boulders”



Quantifying differences in habitat

"strongly flowing water in riffles and chutes of medium sized to large upland rivers where substrate consists of coarse gravel, rubble, or boulders"

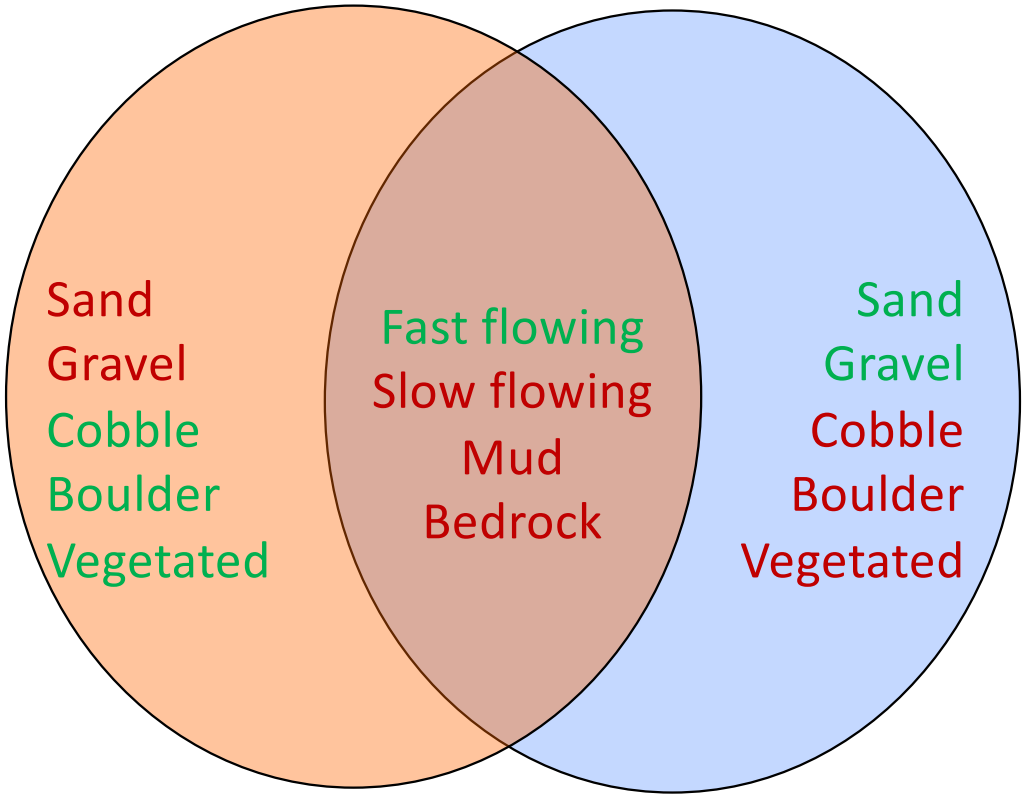


N = 12

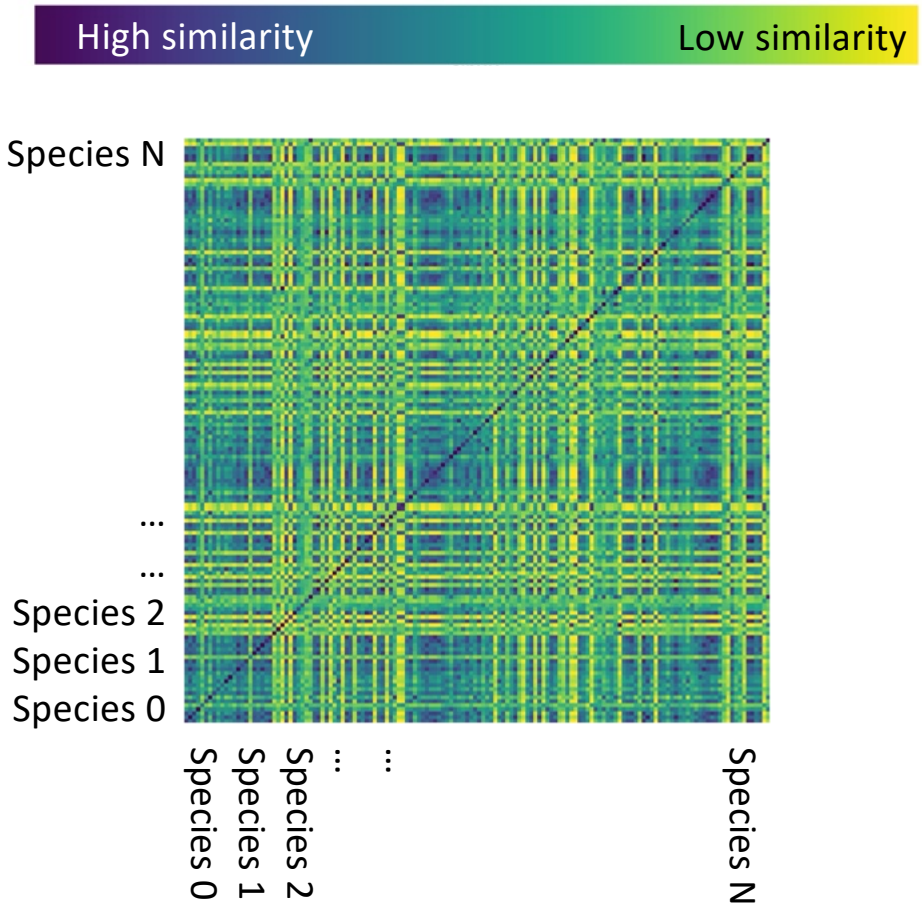
Fast flowing Gravel Cobble Bedrock Sand

Slow flowing Vegetated Mud Boulder

Quantifying differences in habitat

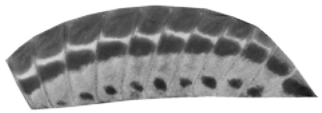


Inverse Jaccard index

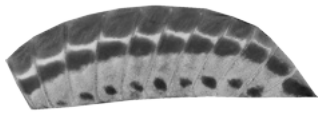


Hypothesis

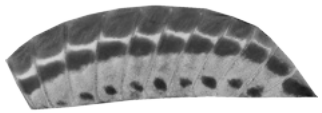
Hypothesis

♂ 

Hypothesis

♂  corr(habitat, pattern) = ✓

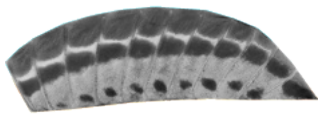
Hypothesis

♂ 

corr(habitat, pattern) = ✓

♀ 

Hypothesis

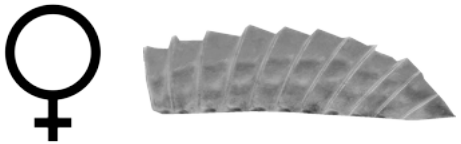
♂  corr(habitat, pattern) = ✓

♀  corr(habitat, pattern) = ✗

Hypothesis

corr(habitat, pattern) =

Sexual selection



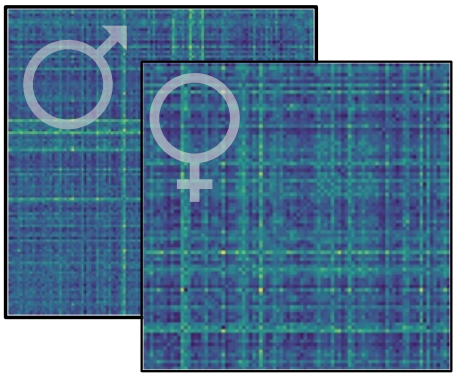
corr(habitat, pattern) =

Mantel tests

(with phylogenetic permutations)

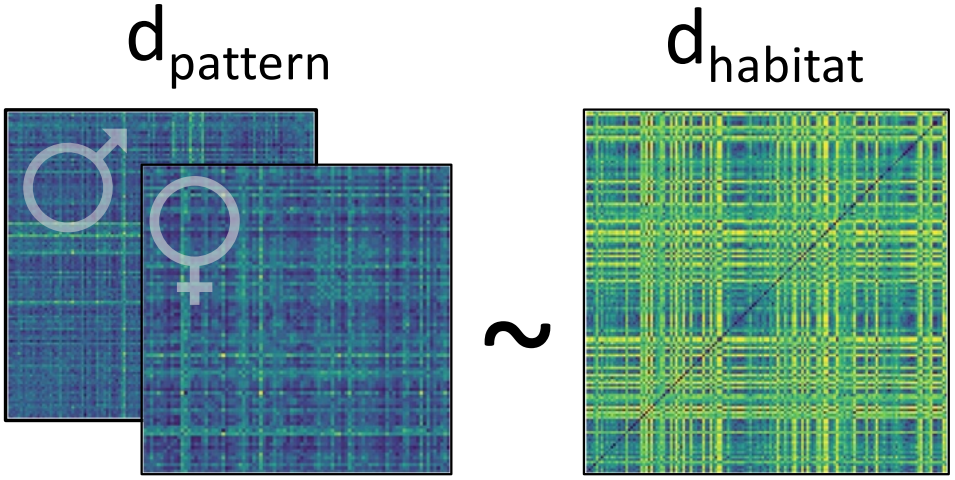
Mantel tests
(with phylogenetic permutations)

$d_{pattern}$



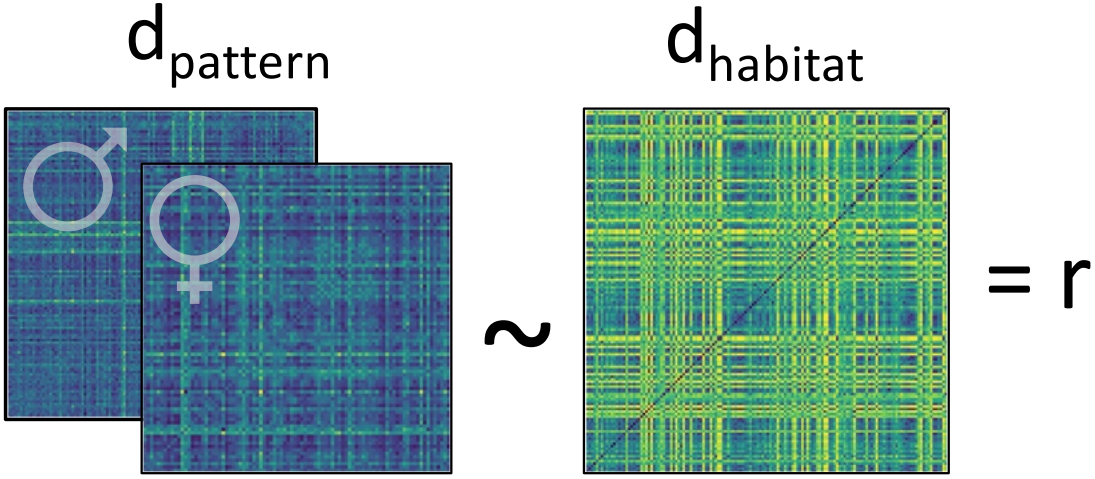
Mantel tests

(with phylogenetic permutations)



Mantel tests

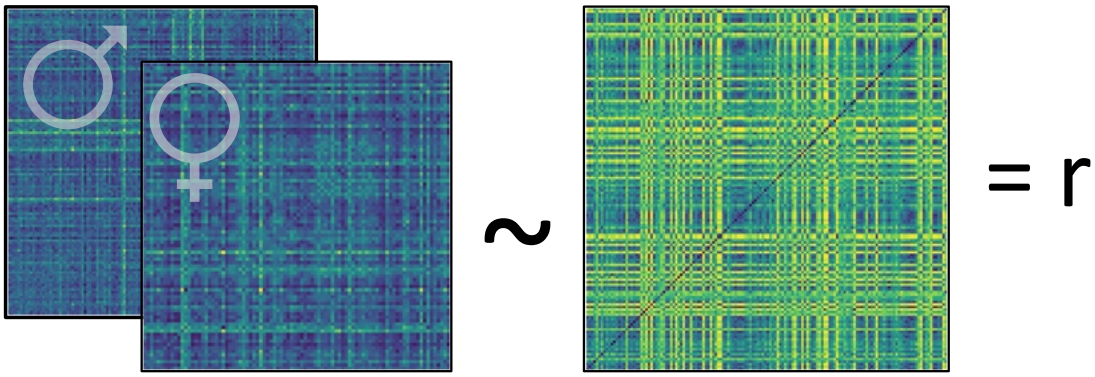
(with phylogenetic permutations)



Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$

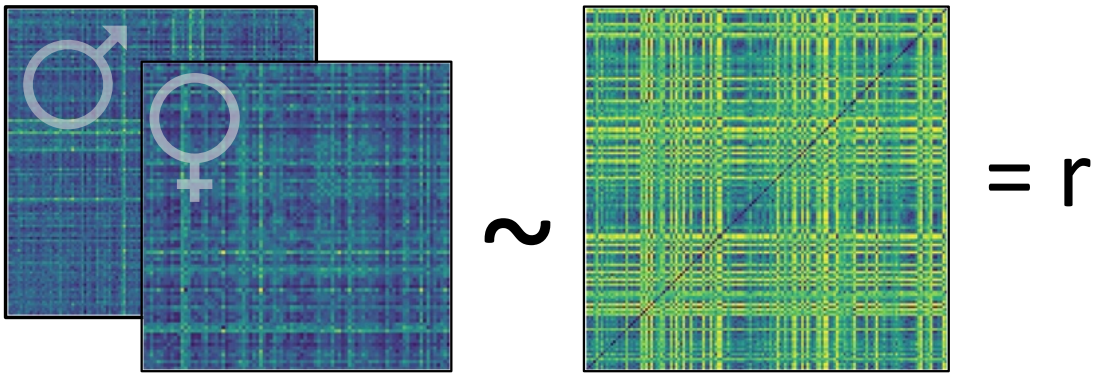


$\sim$ $= r$

Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$

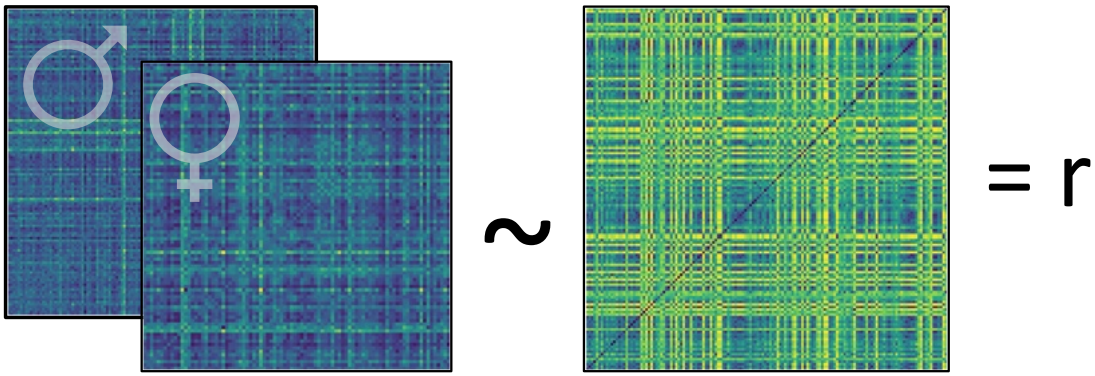
1000 permutations

(Harmon and Glor 2010)

Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$

1000 permutations

(Harmon and Glor 2010)

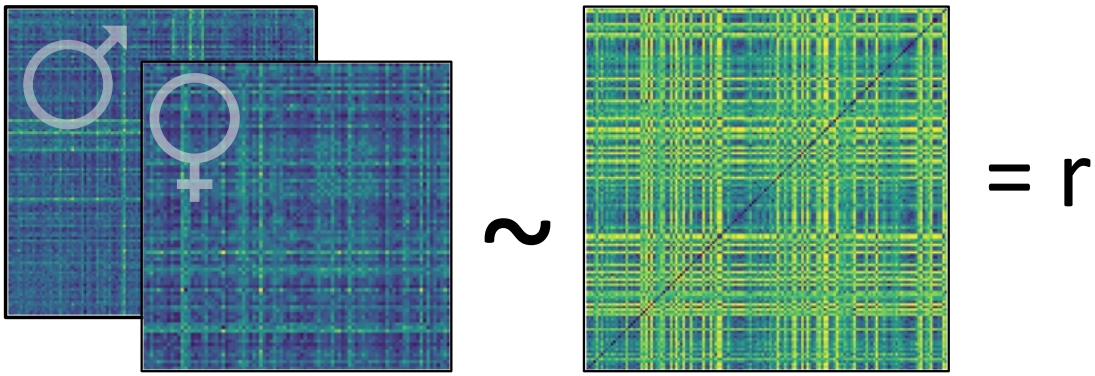
$\times$100 topologies

(Arbour and Stanchak 2021)

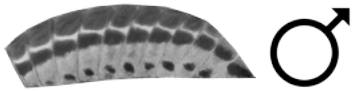
Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$



♂ $r = 0.300$, $p < 0.001$

1000 permutations

(Harmon and Glor 2010)

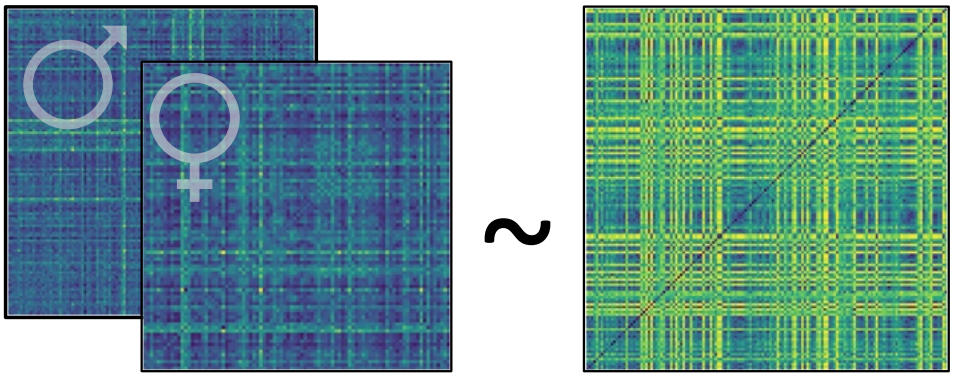
×100 topologies

(Arbour and Stanchak 2021)

Mantel tests

(with phylogenetic permutations)

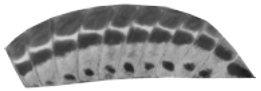
$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$

1000 permutations

(Harmon and Glor 2010)

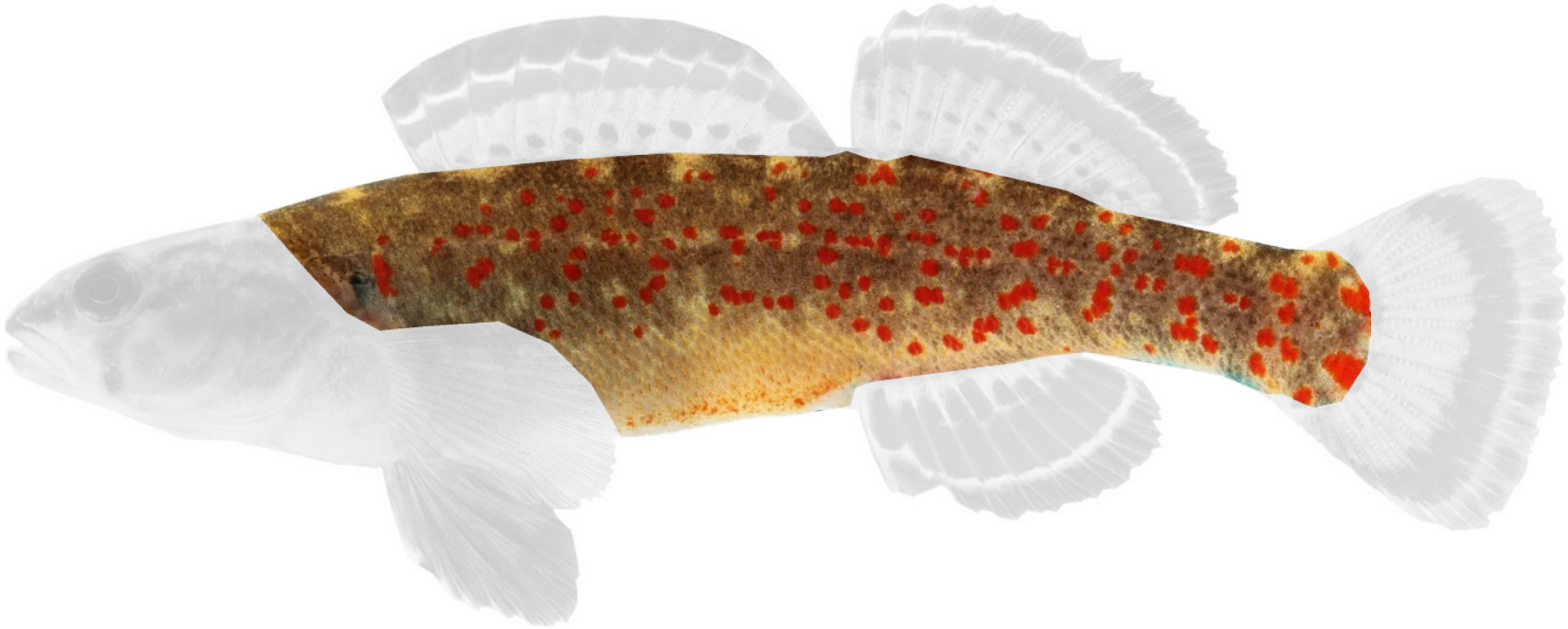


♂ r = 0.300, p < 0.001

♀ r = 0.166, p = 0.014

×100 topologies

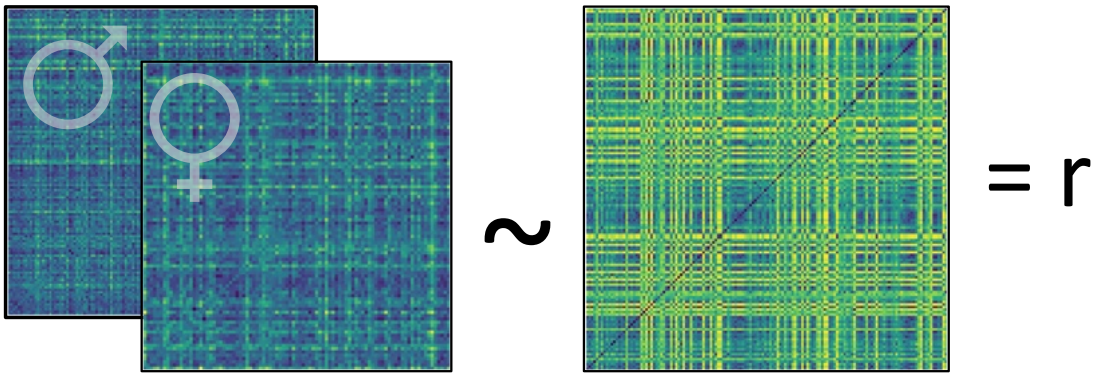
(Arbour and Stanchak 2021)



Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$

1000 permutations

(Harmon and Glor 2010)

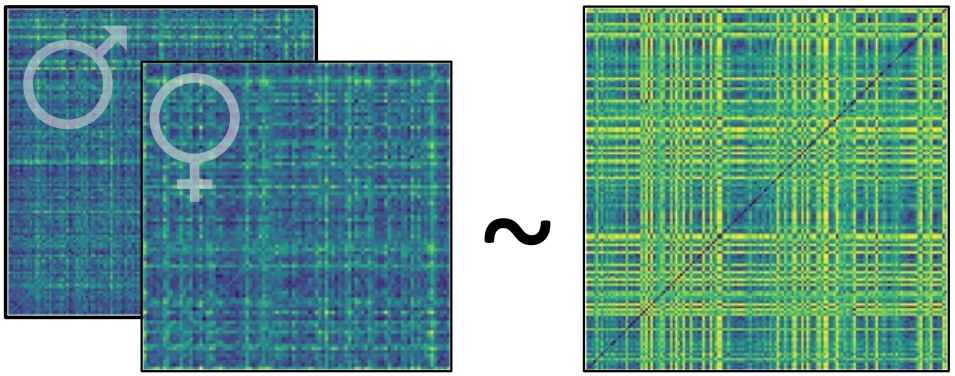
$\times$100 topologies

(Arbour and Stanchak 2021)

Mantel tests

(with phylogenetic permutations)

$d_{pattern}$ $d_{habitat}$



$\sim$ $= r$

1000 permutations

(Harmon and Glor 2010)

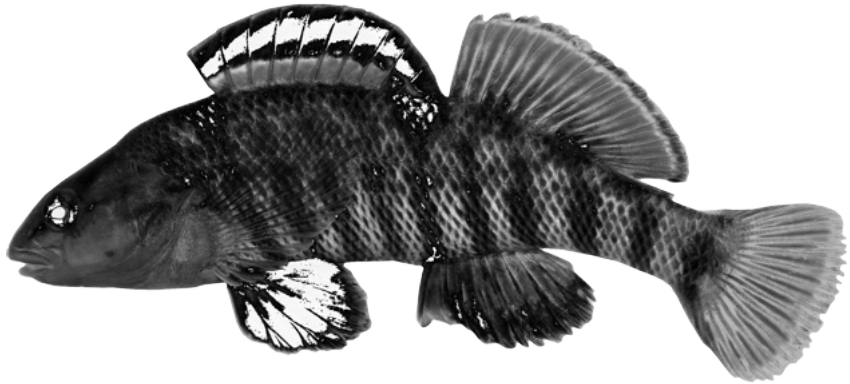
×100 topologies

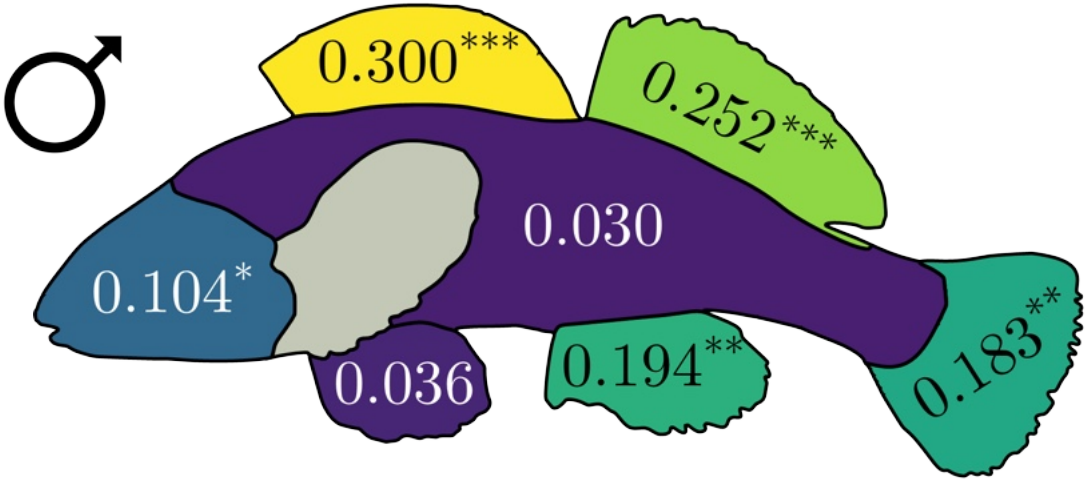
(Arbour and Stanchak 2021)

♂ r = 0.029, p = 0.213

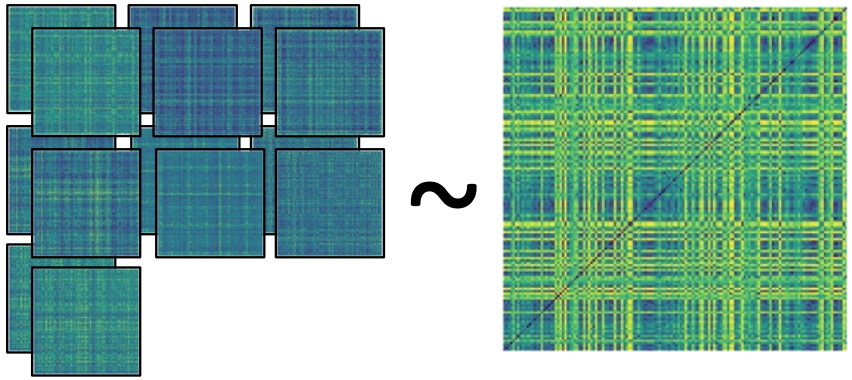
♀ r = -0.040, p = 0.602

Full results

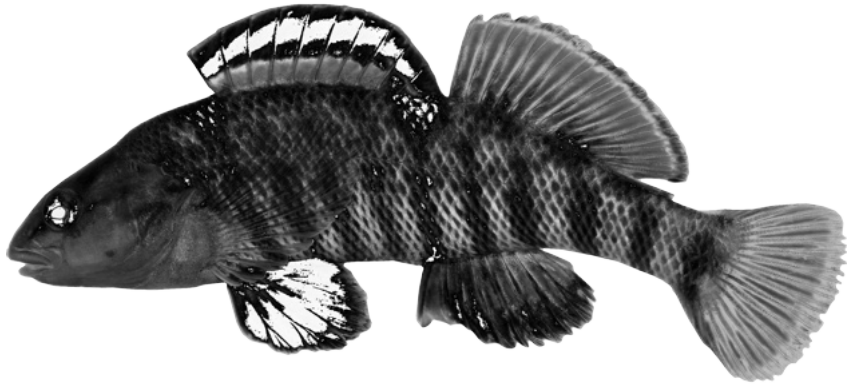




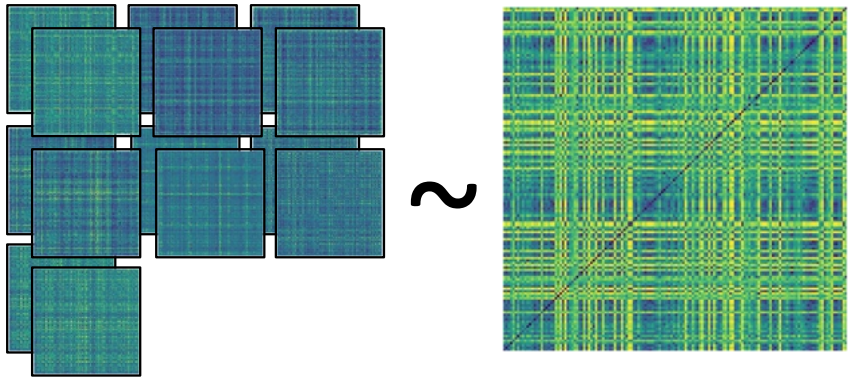
$d_{pattern}$ ~ $d_{habitat}$

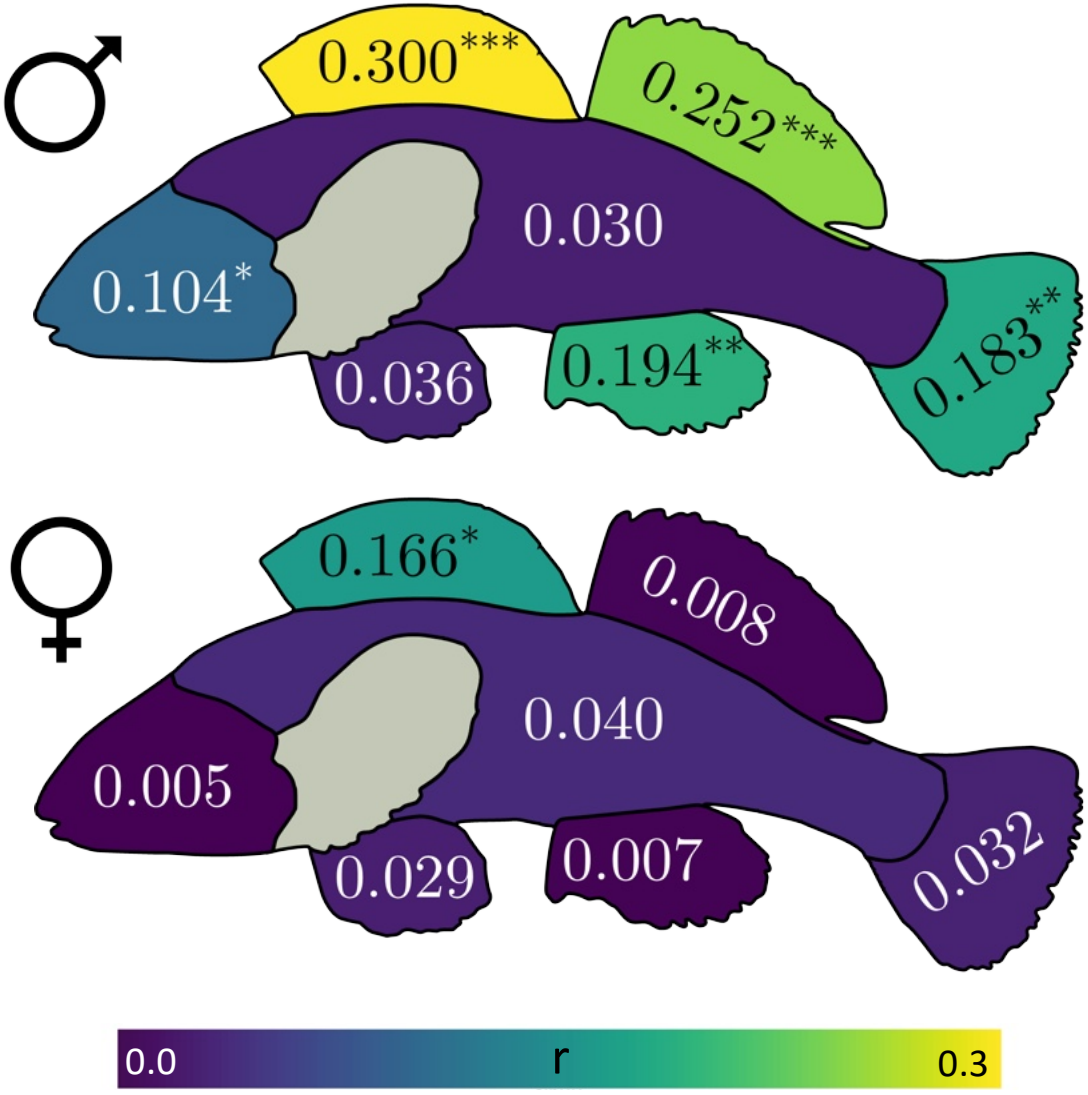


Full results



$d_{pattern}$ ~ $d_{habitat}$



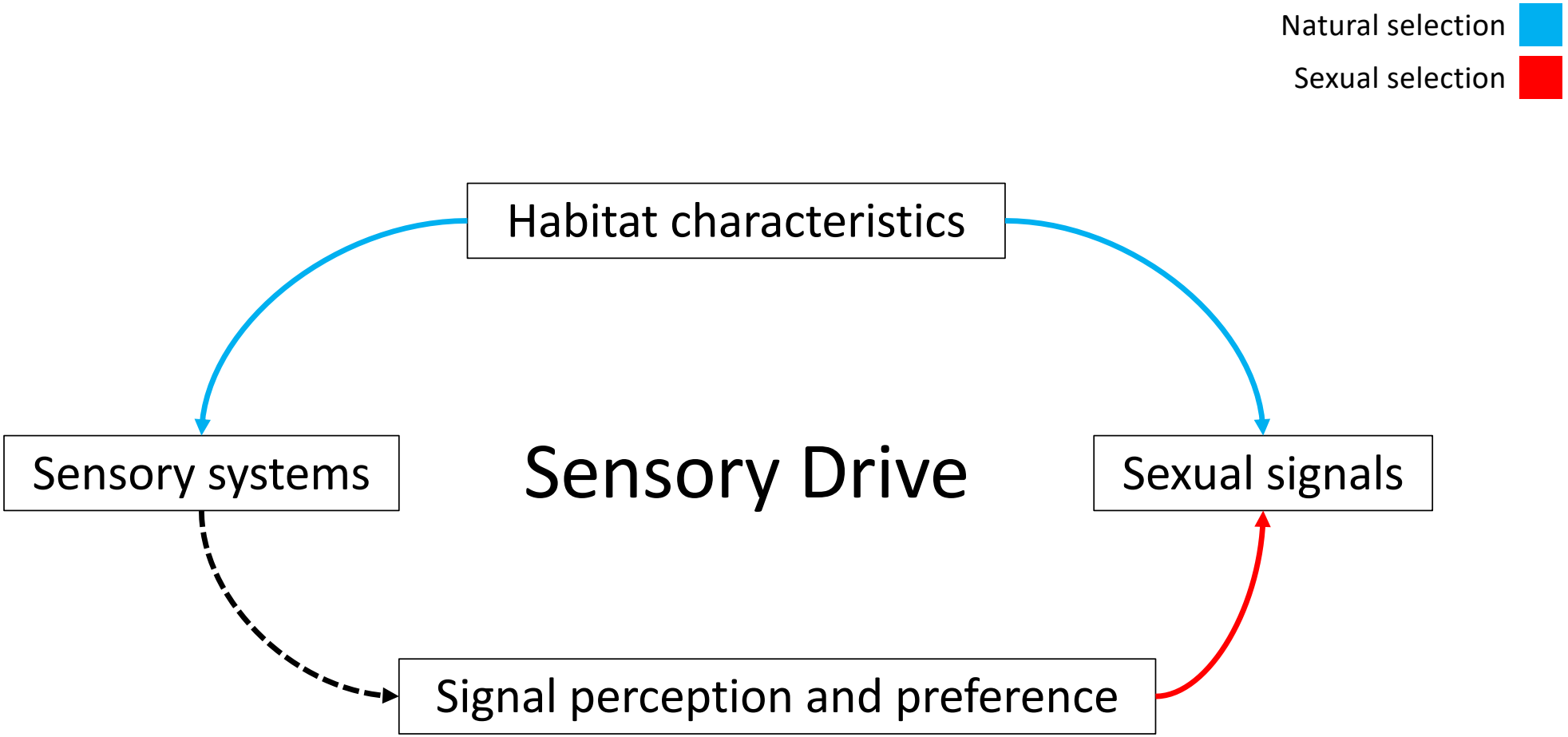


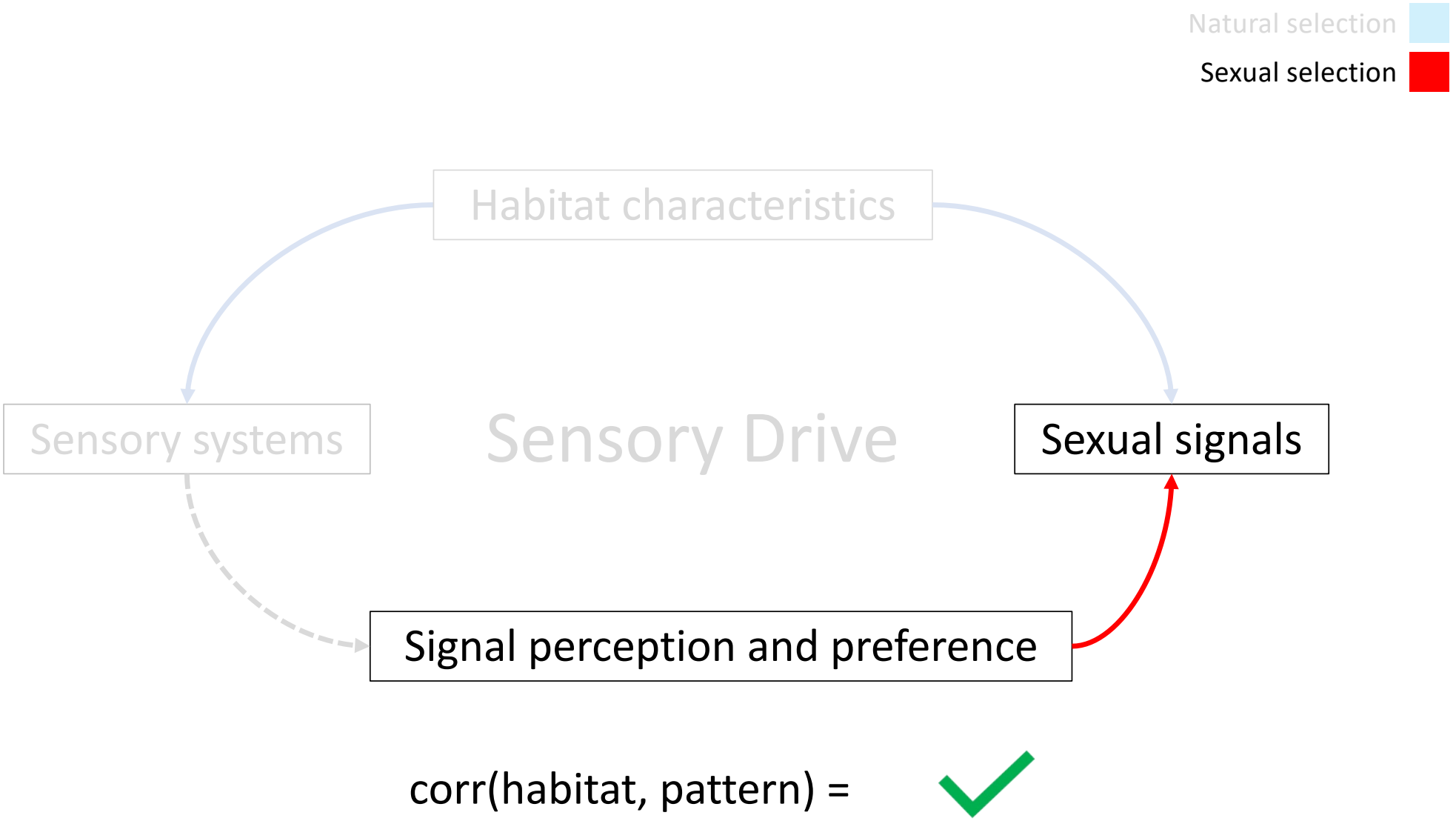
Summary

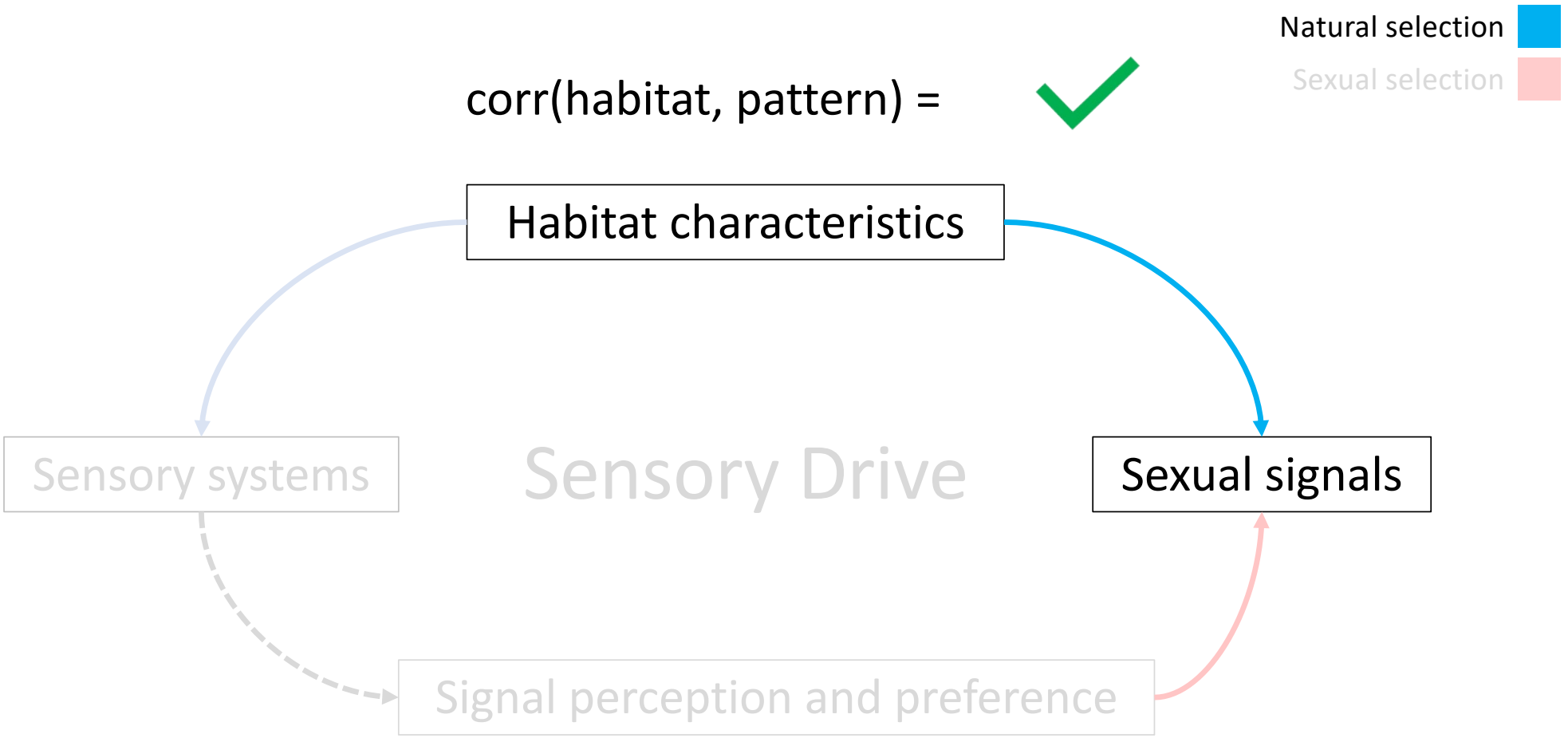
Summary

corr(habitat, pattern) = ✓ ♀♂

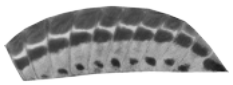
We expected:


Natural selection
Sexual selection
Habitat characteristics
Sensory systems
Sensory Drive
Sexual signals
Signal perception and preference

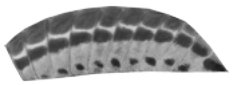
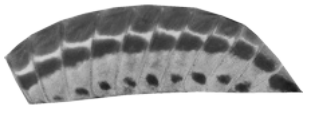

Natural selection
Sexual selection
Habitat characteristics
Sensory systems
Sensory Drive
Sexual signals
Signal perception and preference
corr(habitat, pattern) =


Natural selection
Sexual selection
corr(habitat, pattern) =
Habitat characteristics
Sensory systems
Sensory Drive
Sexual signals
Signal perception and preference

Summary

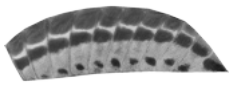
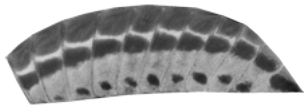
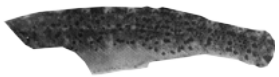
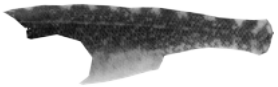
- corr(habitat, pattern) = ✓
  - ♂  > ♀ 

Summary

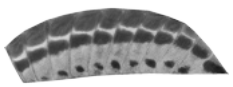
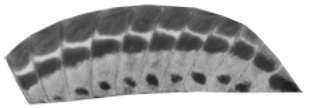
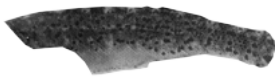
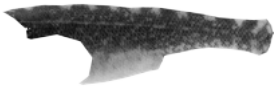
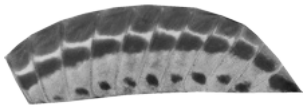
- corr(habitat, pattern) = ✓
  - ♂  > ♀  → ♂ 

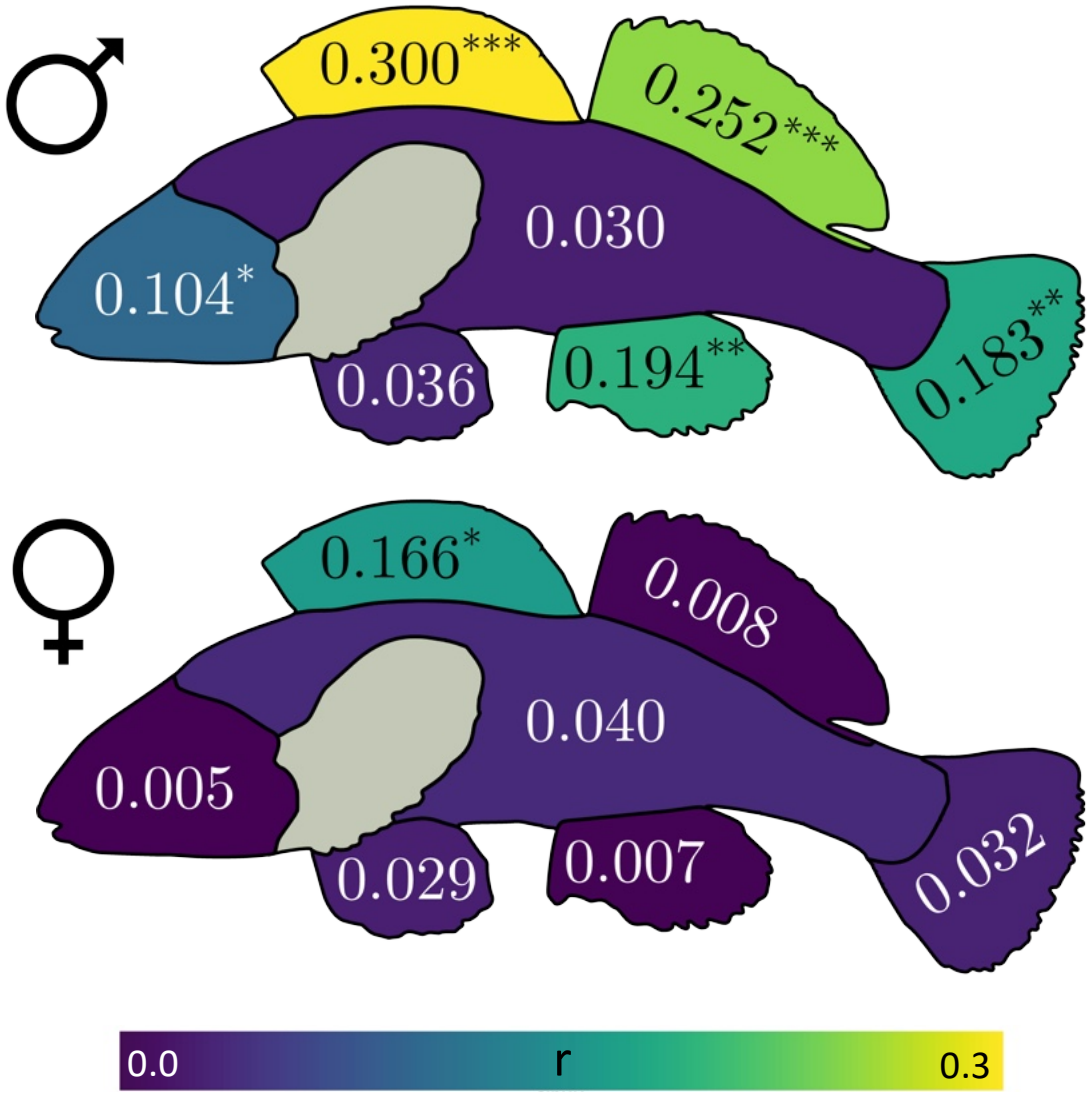
Sexual selection

Summary

- corr(habitat, pattern) = ✓
  - ♂  > ♀  → ♂ 
    Sexual selection
- corr(habitat, pattern) = ✗
  - ♂  ♀ 

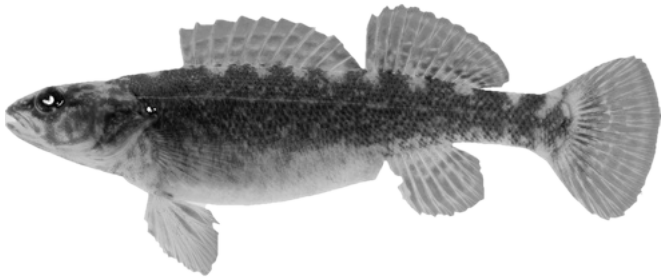
Summary

- corr(habitat, pattern) = ✓
  - ♂  > ♀  → ♂ 
    Sexual selection
- corr(habitat, pattern) = ✗
  - ♂  ♀  → ♂ 
    ~~Natural selection~~


♂
0.300***
0.252***
0.030
0.104*
0.036
0.194**
0.183**
♀
0.166*
0.008
0.040
0.005
0.029
0.007
0.032
0.0
r
0.3

Summary

corr(habitat, pattern) = ✓

♂  > ♀ 

With thanks to:

More info:

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Tamra Mendelson

Patrick Ciccotto

Yannis Begue

- EEVC research group
- Habitat experts
- Darter photographers
- MEME defence jury

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References