Genetics and Evolution of Freshwater Fishes

- The Iberian Peninsula as a case-study area
How many fish species are known to science?

About 30 000 species

How many fish species occur in European freshwater ecosystems?

577 species

Which fish family has the highest number of species?

Cyprinidae with 2420 species
How many fishes inhabit Portuguese freshwater ecosystems?

Total of 66 (1 extinct)

- Cyprinidae: 29
- Petromyzontidae: 13
- Mugilidae: 6
- Cobitidae: 4
- Salmonidae: 3
- Centrarchidae: 3
- Clupeidae: 3
- Ictaluridae: 2
- Percidae: 1
- Others: 1

Native species (46)

- Portuguese: 17
- Iberian: 10
- Other: 19

66 / 577 sp. in Europe (≈10%)

29 sp. endemic (≈5%)

Area of Portugal < 1%
Some representatives of native fish fauna

Illustrations by Claudia Baeta ©
The Iberian Peninsula as a Biodiversity Hotspot

Myers et al. (2000)
Why do we have this high diversity?

Southern European peninsulas as glacial refugia
Why do we have this high diversity?

The Iberian Peninsula refugia allowed the persistence of temperate species throughout the Ice Ages.

↓

Long term species survival and isolation from rest of Europe also led to differentiation and subsequent speciation.

↓

High endemism of Iberian plants and animals.

www.iceagenow.com
Why do we have this high diversity?

Features of the Iberian Peninsula:

• Geographic isolation at the westernmost tip of Europe. No river drainage crossing the Pyrenees.

• High physiographic complexity with many mountain ranges oriented east-west.

• Wide range of climates: Atlantic, Mediterranean, desert and Alpine.
Freshwater Fish tend to show very clear phylogeographic structure:

- Limited dispersal between river drainages (and sometimes within basins)
- Distribution of genetic lineages often tracks the history of river drainages

Eleven biogeographical provinces were delimited based on the freshwater fish assemblages & geographic contiguity.

Filipe et al. 2009 J Biogeography
Current river drainages resulting from tectonic uplift of the central Meseta and draining of endorheic lakes.

Casas-Sainz & Vicente 2009
*Luciobarbus* is an Iberian endemism.

Found throughout the IP except the northwestern rivers (occupied by *Barbus*).

Based on cytb sequences, two main lineages were found:

Distribution of genetic lineages associated with particular river drainages and biogeographic provinces.

Doadrio et al. 2002; Goméz & Lunt 2005
Nase – Pseudochondrostoma polylepis

Occurs in the Tejo and Mondego drainages, i.e. in two distinct biogeographic provinces.

Not consistent with expectations based on proposed biogeographic provinces.

Aboim et al. 2013
Nase – Pseudochondrostoma polylepis

Occurs in the Tejo and Mondego drainages, i.e. in two distinct biogeographic provinces.

Not consistent with expectations based on proposed biogeographic provinces.

Divergence between drainages, with Mondego population originating via founder event from Tejo possibly due to past river capture events.

Aboim et al. 2013
Permeable species boundaries in FW Fish

Luciobarbus revisited...

Morphospecies

- L. bocagei
- L. comizo
- L. graellsi
- L. guiraonis
- L. microcephalus
- L. sclateri
- L. steindachneri
- B. haasi

Gante et al. 2015
Permeable species boundaries in FW Fish

Luciobarbus revisited...

Lineages generally concordant with morphospecies, except for L. steindachneri.

Some species also possess mtDNA typical of other sympatric species.

Gante et al. 2015
Permeable species boundaries in FW Fish

Luciobarbus revisited...

7 nDNA loci

L. bocagei
L. comizo
L. graellsi
L. guiraonis
L. microcephalus
L. sclateri
L. steindachneri
B. haasi

Gante et al. 2015
**Permeable species boundaries in FW Fish**

*Luciobarbus* revisited...

7 nDNA loci

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*L. steindachneri* is a local hybrid species between two distinct pairs of sympatric species in Tejo and Guadiana.

Evidence of intraspecific differentiation between allopatric populations in *L. comizo*, *L. sclateri* and *L. guiraonis*.

Gante et al. 2015
Permeable species boundaries in FW Fish

*Luciobarbus* revisited...

Species boundaries in *Barbus* and *Luciobarbus* are semi-permeable: species are exchanging genes in areas of sympathy after an event of allopatric speciation.

Gante et al. 2015
Hybridization as an evolutionary strategy

*Squalius alburnoides* complex

Hybrid origin

a) Northern river drainages

*S. carolitertii* × Unknown ancestral sp.

b) Southern river drainages

*S. pyrenaicus* × Unknown ancestral sp.

*S. aradensis* × Unknown ancestral sp.

Collares-Pereira 1985; Carmona et al. 1997; Sousa-Santos et al. 2006
**Squalius alburnoides complex**

- **Diploid and polyploid females**
  - 60-80%

- **Diploid and polyploid males**
  - 20-40%

Collares-Pereira 1985
Squalius alburnoides complex

Cytogenetic  Mt DNA  Nuclear DNA

2n  Hybrid  PA

3n  Hybrid  PAA

2n  Hybrid  PPA

Squalius pyrenaicus

Hybrid  Non-hybrid  AA

♀

♂

A – Ancestral lin.
P – S. pyrenaicus

Squalius alburnoides complex - currently


A – Ancestral lin.
P – S. pyrenaicus
**Squalius alburnoides complex - currently**

- **A** – Ancestral lin.
- **P** – *S. pyrenaicus*

Squalius alburnoides complex - currently

Normal meiosis

Clonal transmission

Exclusion of the P. pyrenaicus genome

Normal meiosis (reductional)

Altered meiosis (nonreductional)

A – Ancestral lin.
P – S. pyrenaicus

Hybridization as an evolutionary strategy

*Squalius alburnoides* complex

The ancestral paternal species is not known and likely extinct.

This lineage persists as diploid AA males – “all-male lineage”.

However, the long-term survival of the ancestral paternal species needs the hybrid *S. alburnoides* as hosts.