



# Comparative phylogeography of two symbiotic dorvilleid polychaetes with contrasting host and bathymetric patterns

Patricia Lattig, Isabel Muñoz, **Daniel Martin**, Pere Abelló,  
Annie Machordom





*Iphitime cuenoti* Fauvel, 1914



*Ophryotrocha mediterranea*  
Martin, Abelló & Cartes, 1991



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✓ Family Dorvilleidae





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- ✓ Family Dorvilleidae
- ✓ Symbionts of brachyuran crabs



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- ✓ Family Dorvilleidae
- ✓ Symbionts of brachyuran crabs
- ✓ Inhabit the branchial chambers



*Iphitime cuenoti*  
Fauvel, 1914

✓ ***Iphitime*: 7 species (all crab symbionts)**



***Iphitime cuenoti***  
**Fauvel, 1914**



- ✓ ***Iphitime*: 7 species (all crab symbionts)**
- ✓ **NE Atlantic and Mediterranean**



***Iphitime cuenoti***  
**Fauvel, 1914**



- ✓ *Iphitime*: 7 species (all crab symbionts)
- ✓ NE Atlantic and Mediterranean
- ✓ Sexual dimorphism



*Iphitime cuenoti*  
Fauvel, 1914



Male



Female

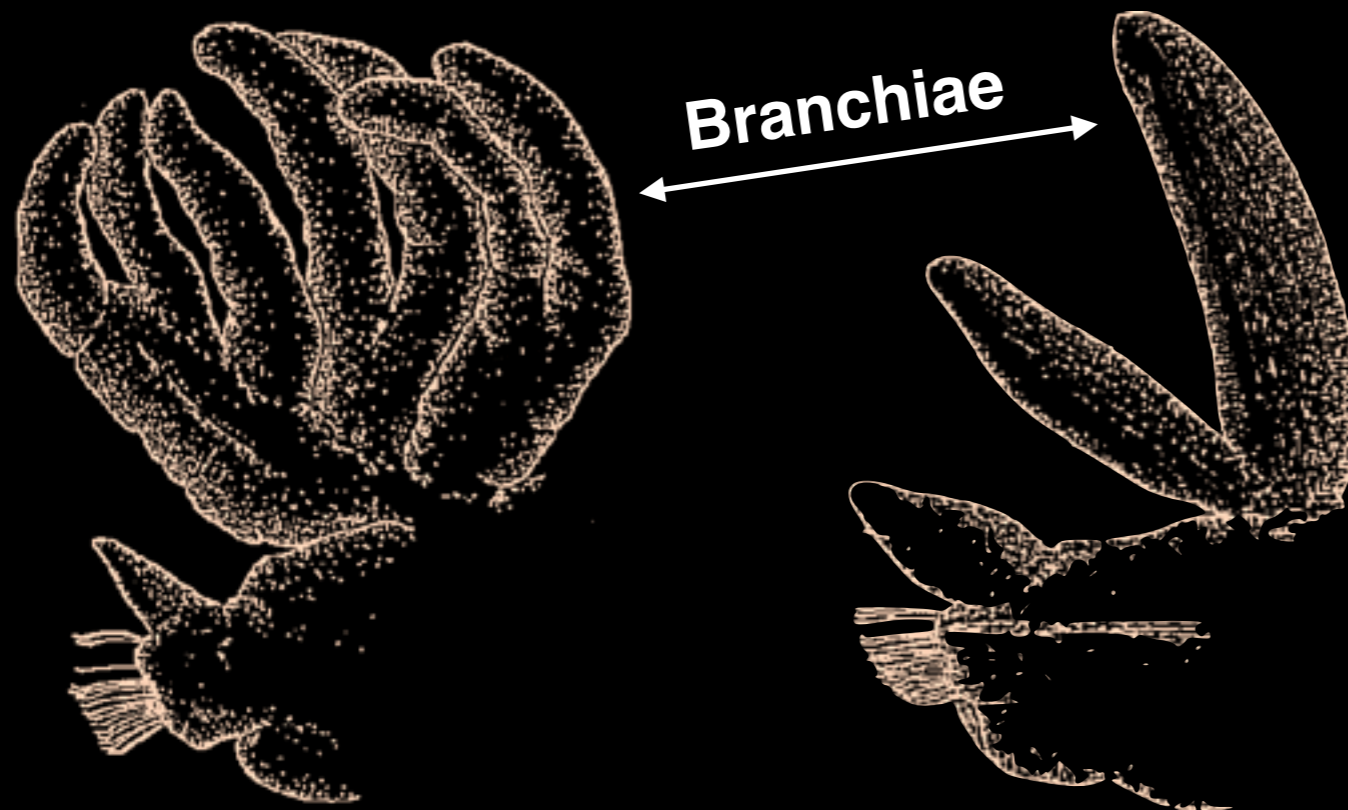




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*Iphitime cuenoti*  
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# HOSTS



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- ✓ *Liocarcinus depurator* (70 - 400 m)
- ✓ *Macropipus tuberculatus* (100 - 500 m)
- ✓ *Goneplax rhomboides* (350 - 600 m)
- ✓ *Bathynectes maravigna* (550 - 650 m)



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- ✓ 819 specimens of *M. tuberculatus*, 11.5% infested
  - ✓ 10.9% in females, 11.9% in males.
- ✓ Low numbers in *G. rhomboides* and *B. maravigna* prevented to estimate prevalence.





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Fauvel, 1914

✓ ***Ophryotrocha*: ≈ 60 species (3 symbionts)**



***Ophryotrocha  
mediterranea***  
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- ✓ Found only in *Gerion longipes* (550-660 m)



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- ✓ **Found only in *Gerion longipes* (550-660 m)**
- ✓ **156 specimens, prevalence 25%**
  - ✓ **30% in males, 0% in females**



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- ✓ **No sexual dimorphism**
- ✓ **Found only in *Gerion longipes* (550-660 m)**
- ✓ **156 specimens, prevalence 25%**
  - ✓ **30% in males, 0% in females (too small)**



***Ophryotrocha mediterranea***  
Martin, Abelló & Cartes, 1991







# SAMPLING





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- ✓ MEDITS (Mediterranean 2012) & ARSA (Gulf of Cádiz, 2013)





## SAMPLING

- ✓ MEDITS (Mediterranean 2012) & ARSA (Gulf of Cádiz, 2013)
- ✓ Bottom trawling on board of the B.O. Cornide Saavedra





# OBJECTIVE





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To analyse the phylogeographic patterns



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- ✓ Current genetic diversity (mtDNA COI)



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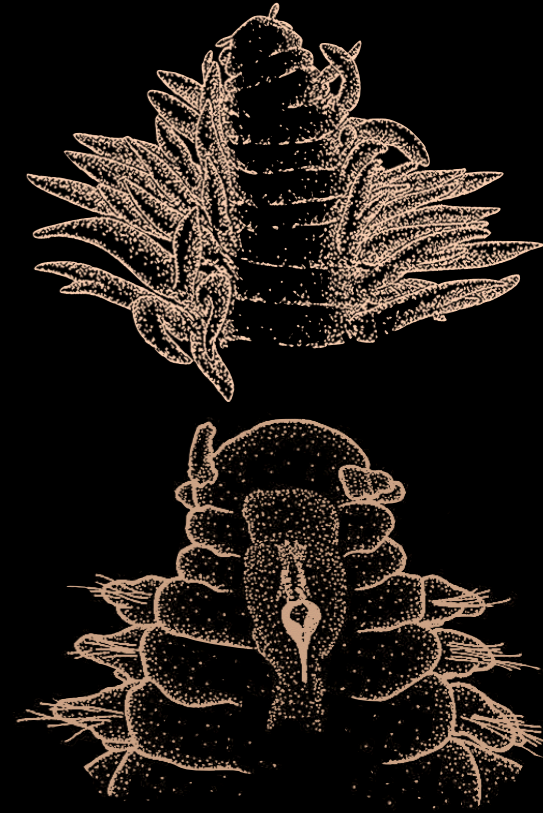
- ✓ Current genetic diversity (mtDNA COI)
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## OBJECTIVE

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## OCEANOGRAPHIC FRONTS

- ✓ Gibraltar Strait
- ✓ Almería-Oran Front
- ✓ Ibiza Channel





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## REGIONS





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✓ Cádiz





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## REGIONS



- ✓ Cádiz
- ✓ Alboran



- ✓ Alboran



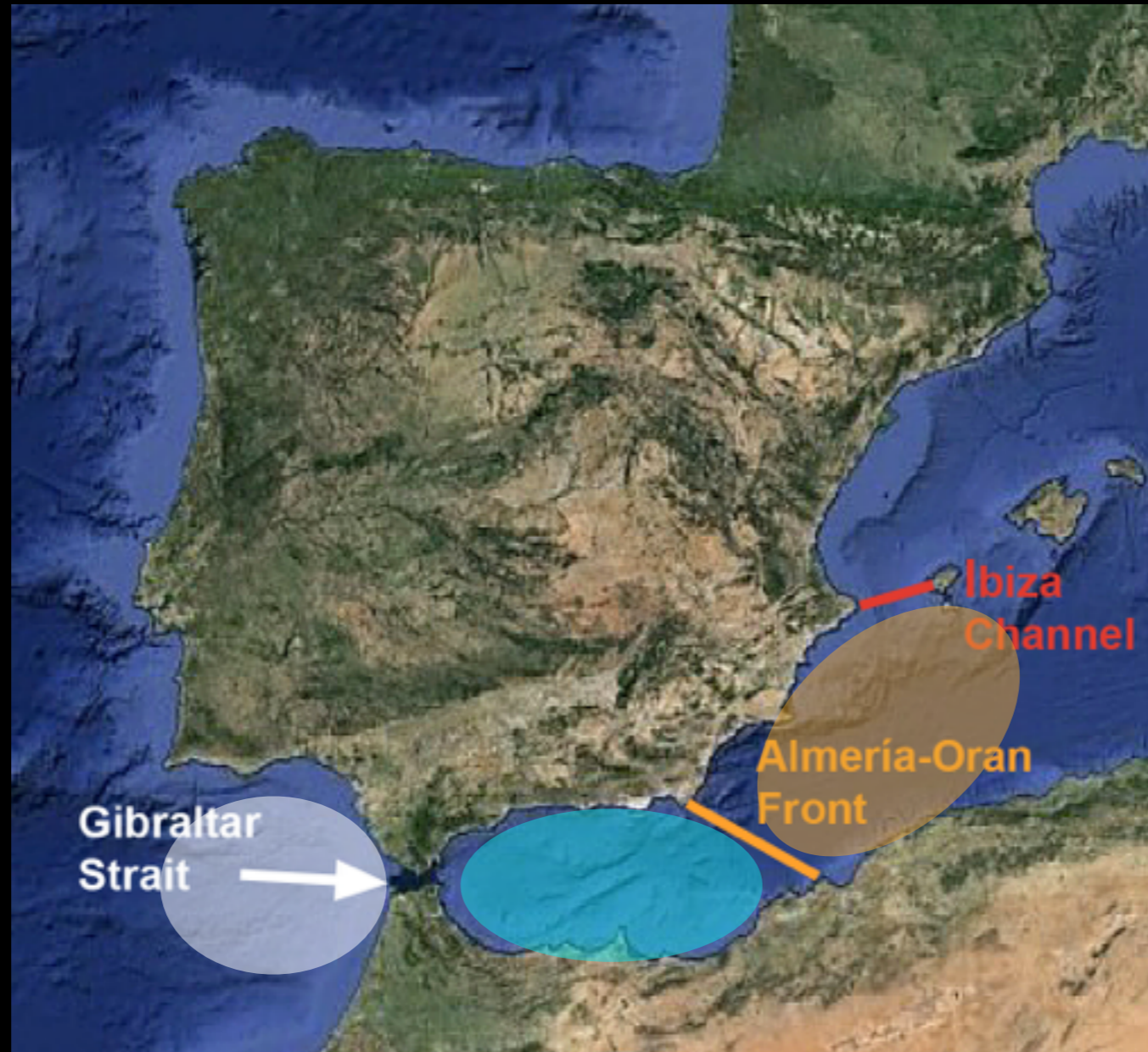
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## REGIONS



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- ✓ Alacant



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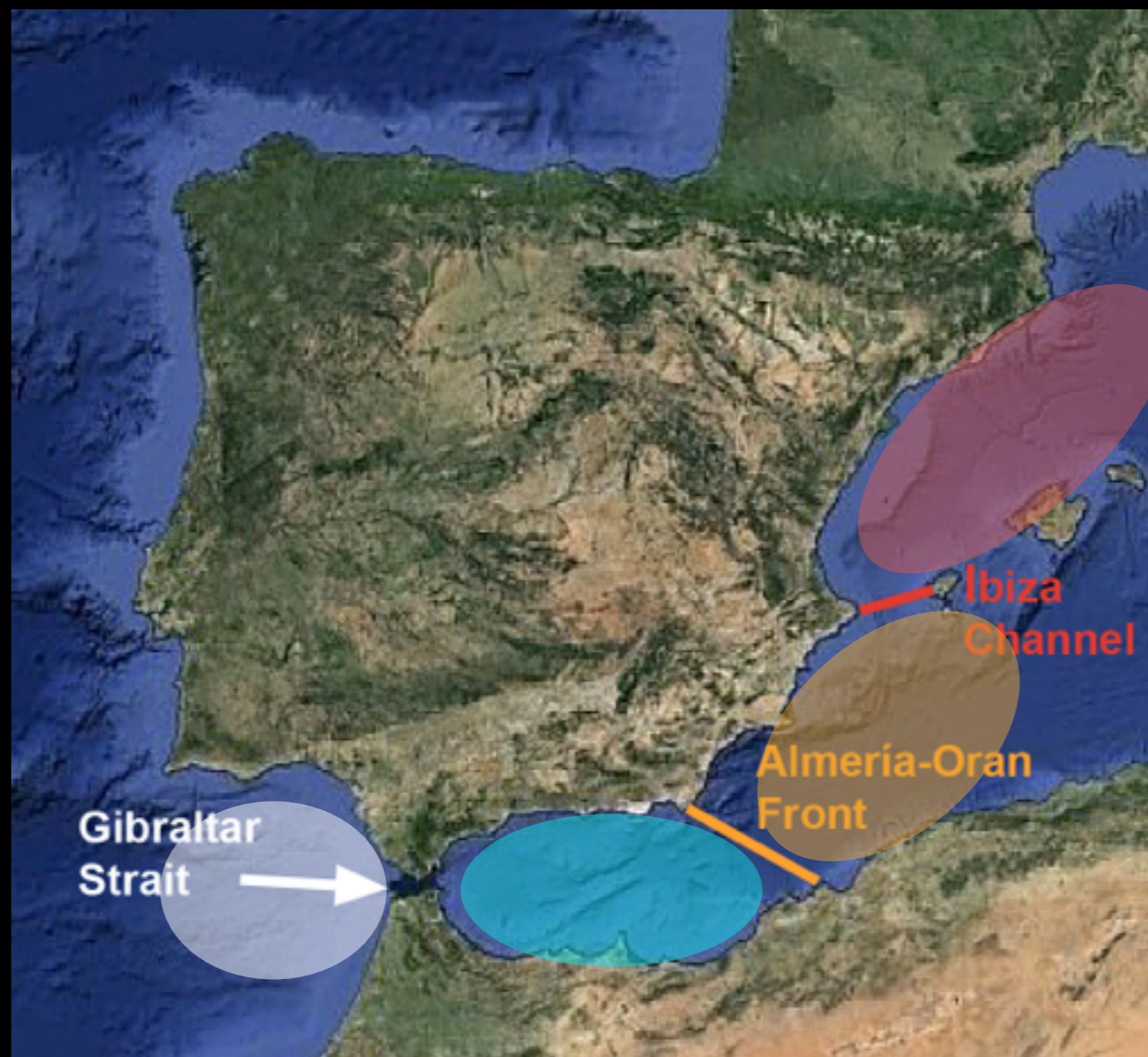
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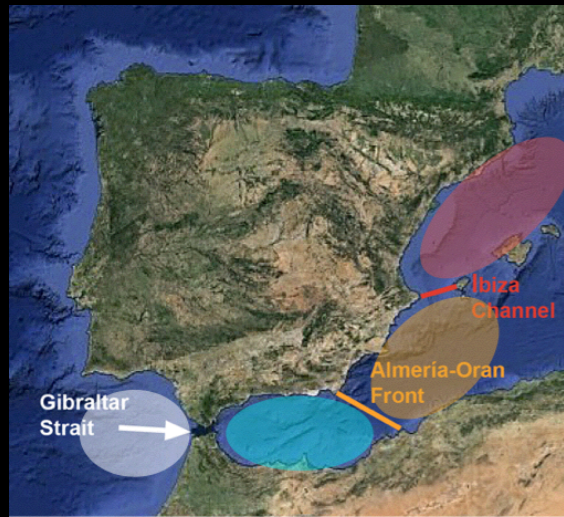
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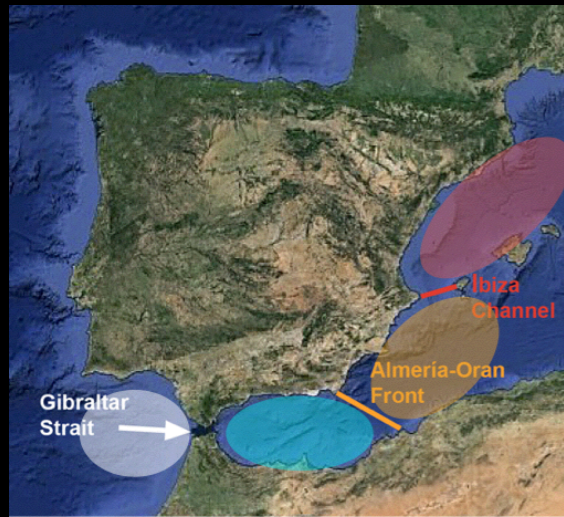
- ✓ Cádiz
- ✓ Alboran
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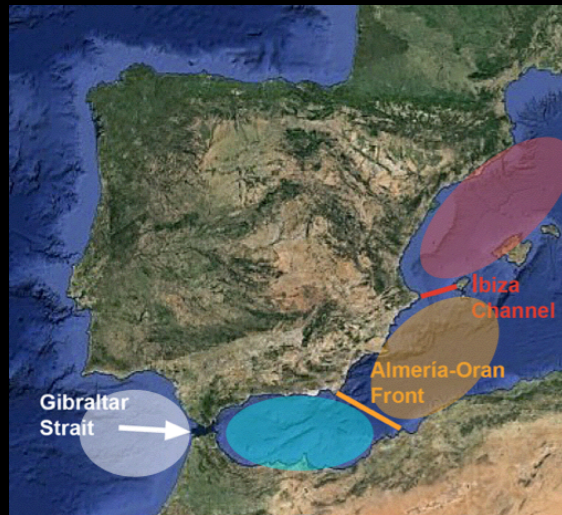






# *Iphitime cuenoti*



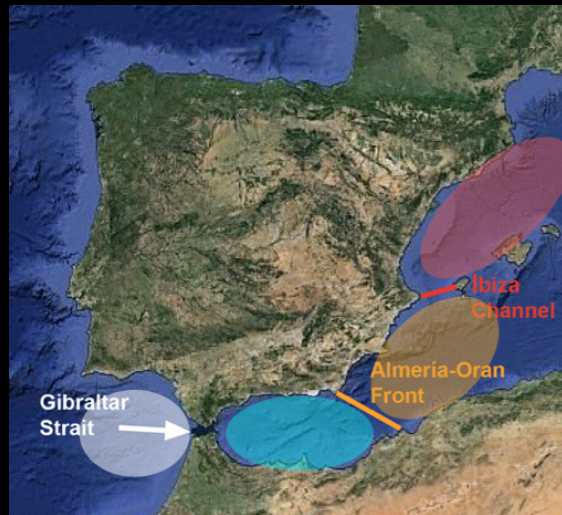


## *Iphitime cuenoti*



Pairwise  $F_{st}$  estimates based on mtDNA COI

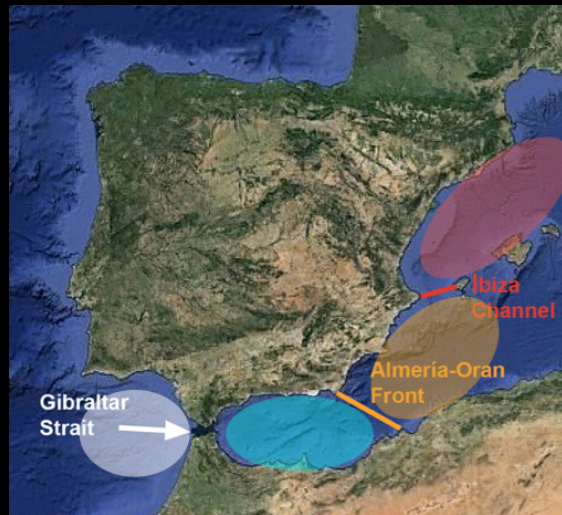
	CÁDIZ	ALBORAN	ALACANT
ALBORAN			
ALACANT			
VALENCIA & CATALUNYA			



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	CÁDIZ	ALBORAN	ALACANT
ALBORAN	0.009, N.S.		
ALACANT			
VALENCIA & CATALUNYA			0.012, N.S.



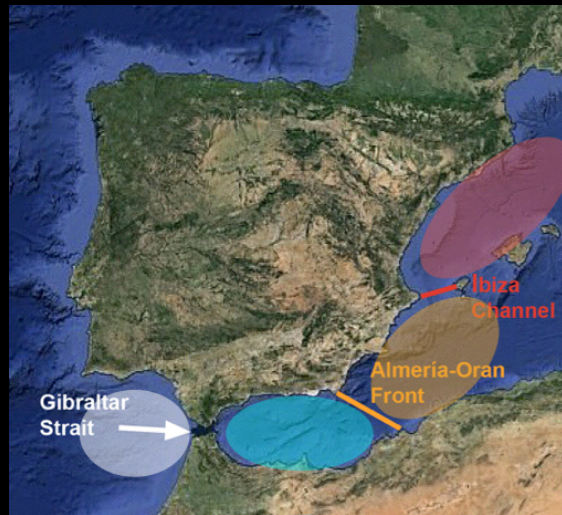
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Pairwise Fst estimates based on mtDNA COI

	CÁDIZ	ALBORAN	ALACANT
ALBORAN	0.009, N.S.		
ALACANT	0.158, p<0.05		
VALENCIA & CATALUNYA	0.127, p<0.05		0.012, N.S.

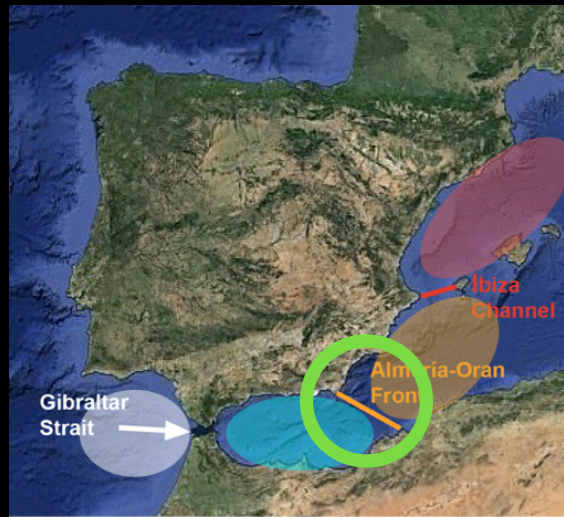




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	CÁDIZ	ALBORAN	ALACANT
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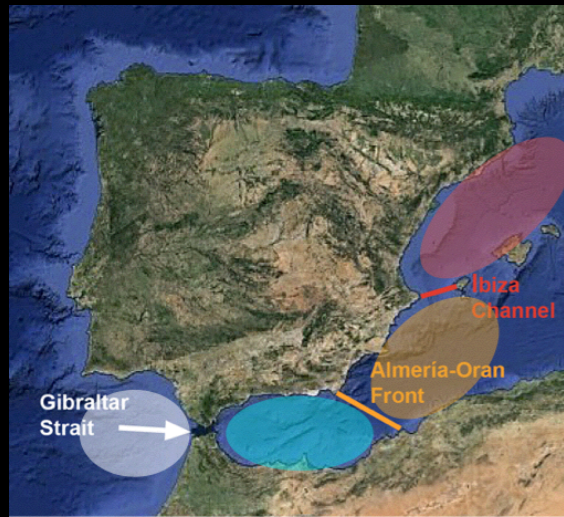
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**Significant but weak barrier effect for the Almería-Oran Front**

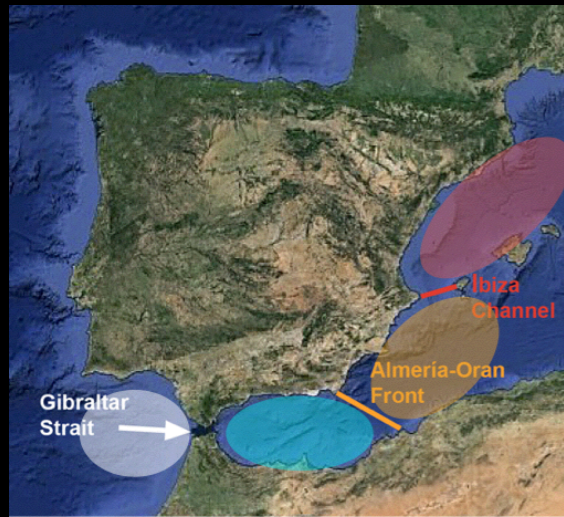


# *Iphitime cuenoti*



## HAPLOTYPE NETWORK

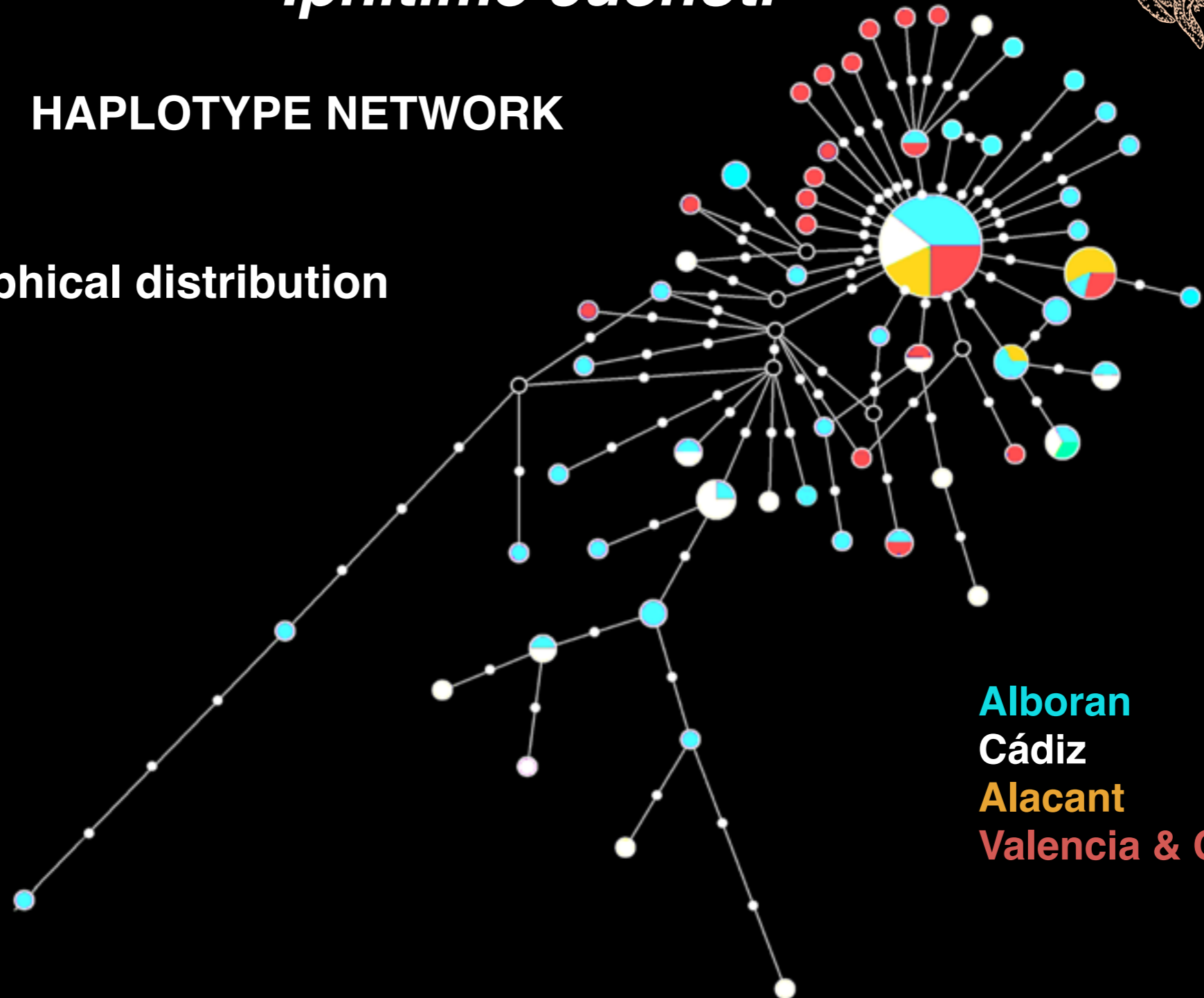




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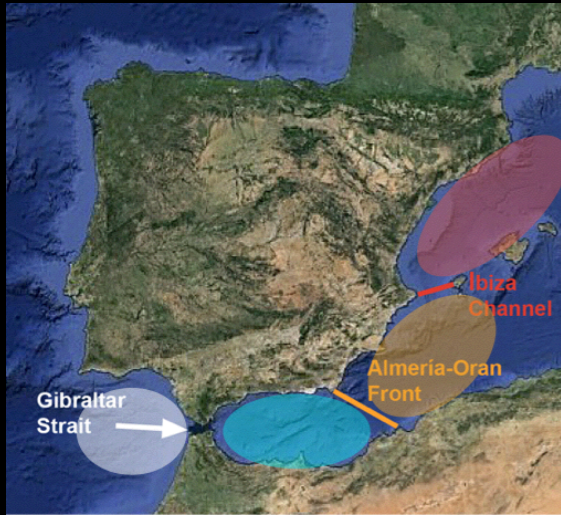
## HAPLOTYPE NETWORK

### Geographical distribution



Alboran  
Cádiz  
Alacant  
Valencia & Catalunya





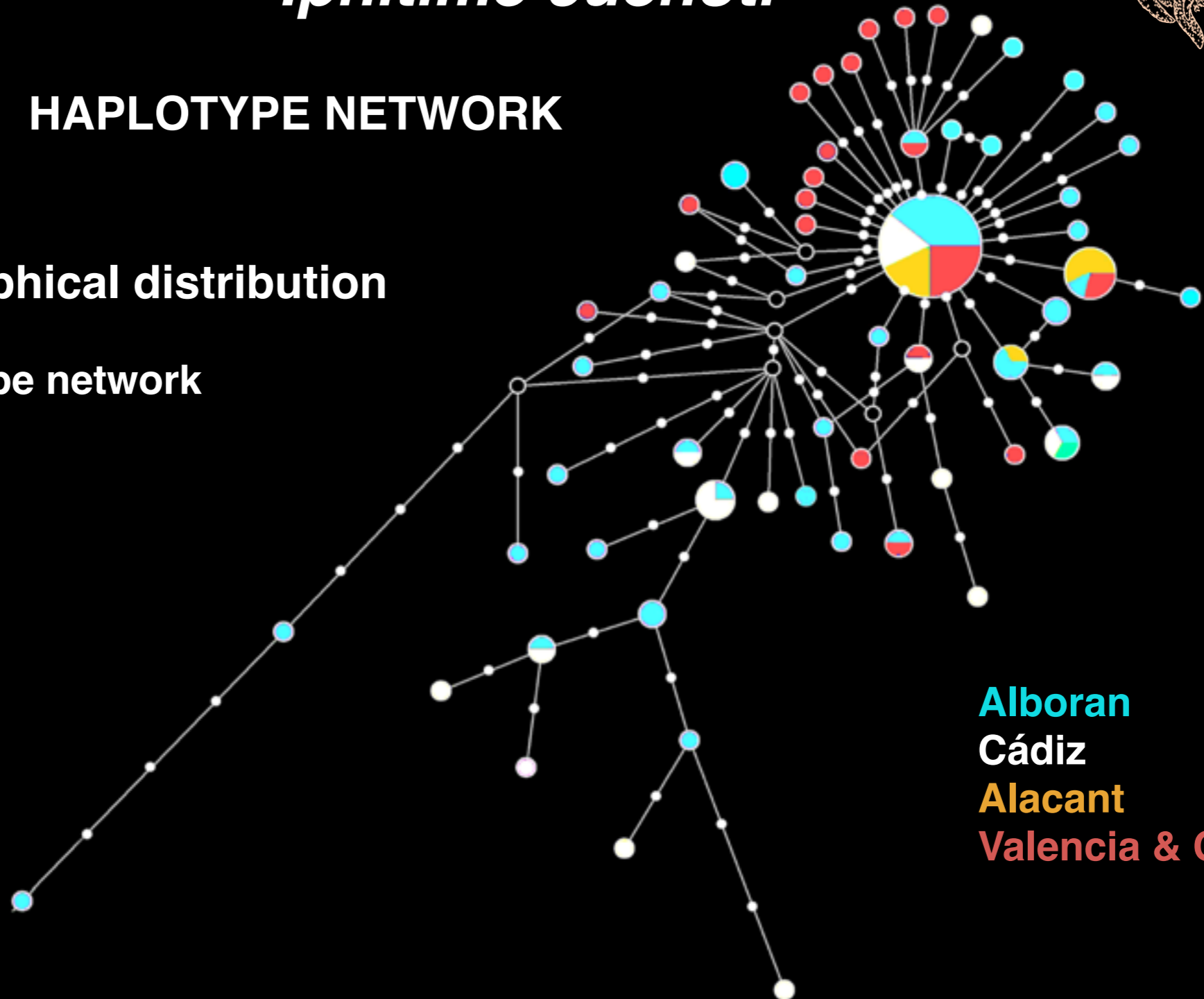
# *Iphitime cuenoti*



## HAPLOTYPE NETWORK

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✓ Star-like haplotype network

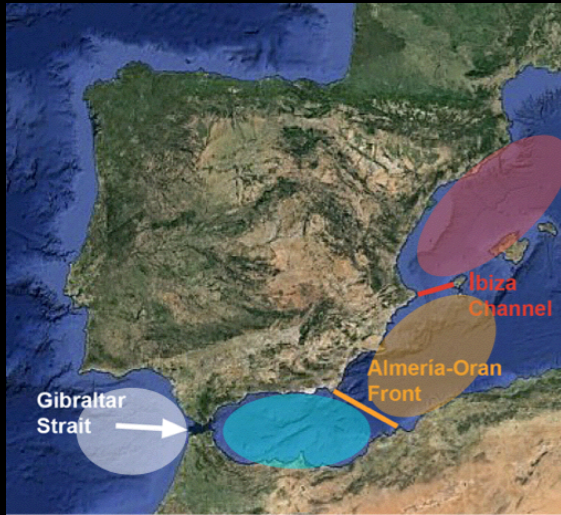


Alboran  
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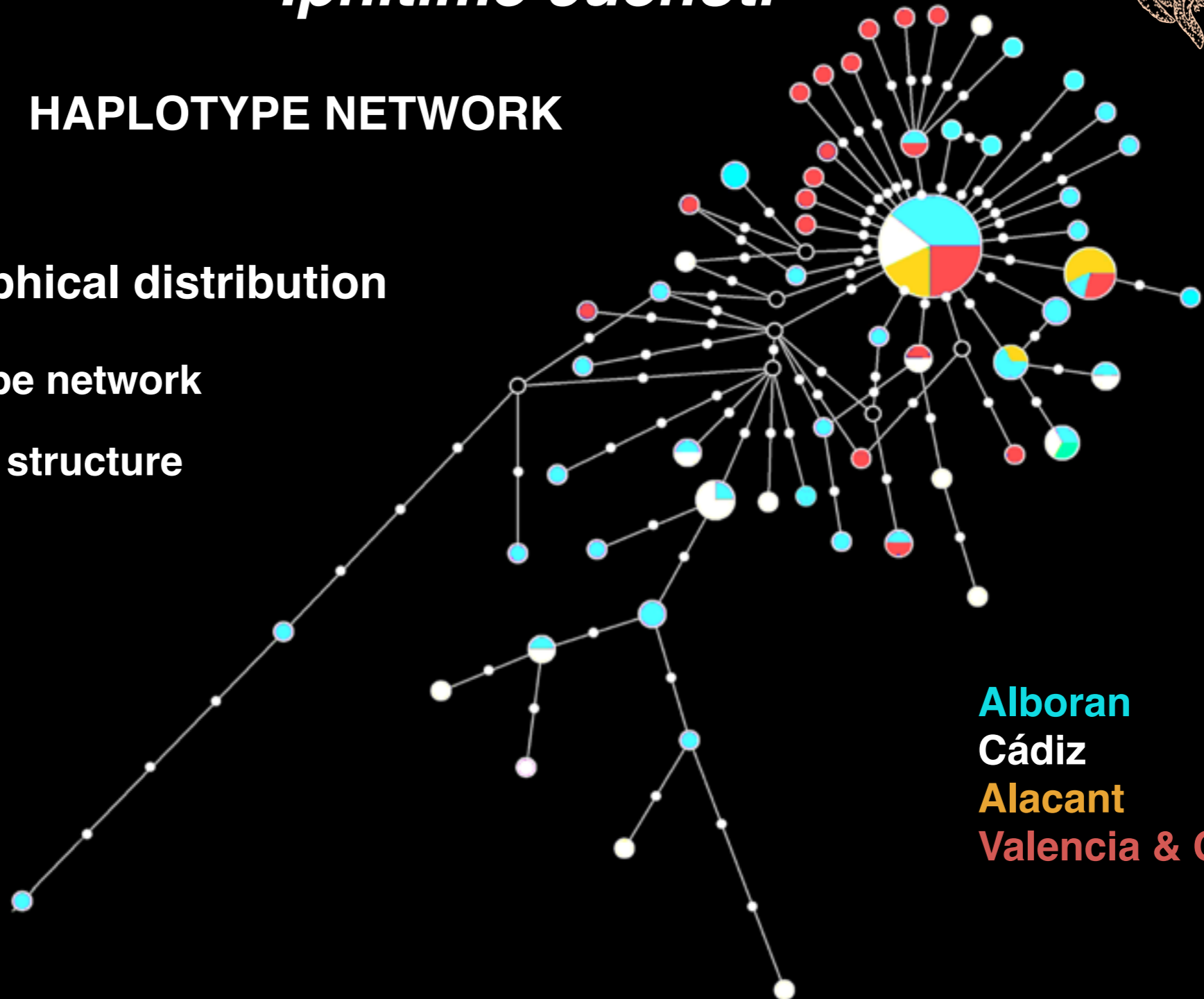
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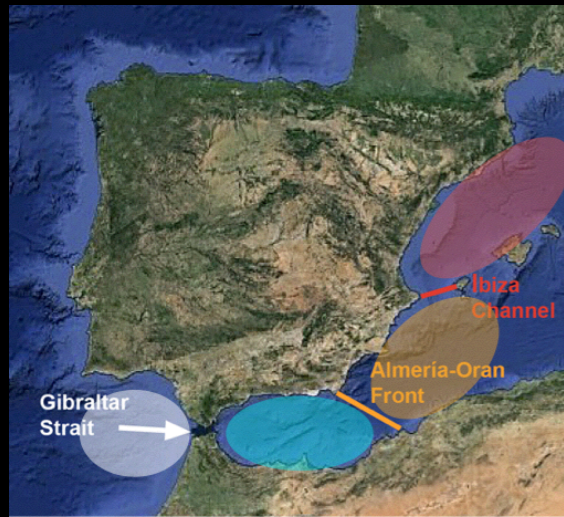
### Geographical distribution

- ✓ Star-like haplotype network
- ✓ Weak population structure



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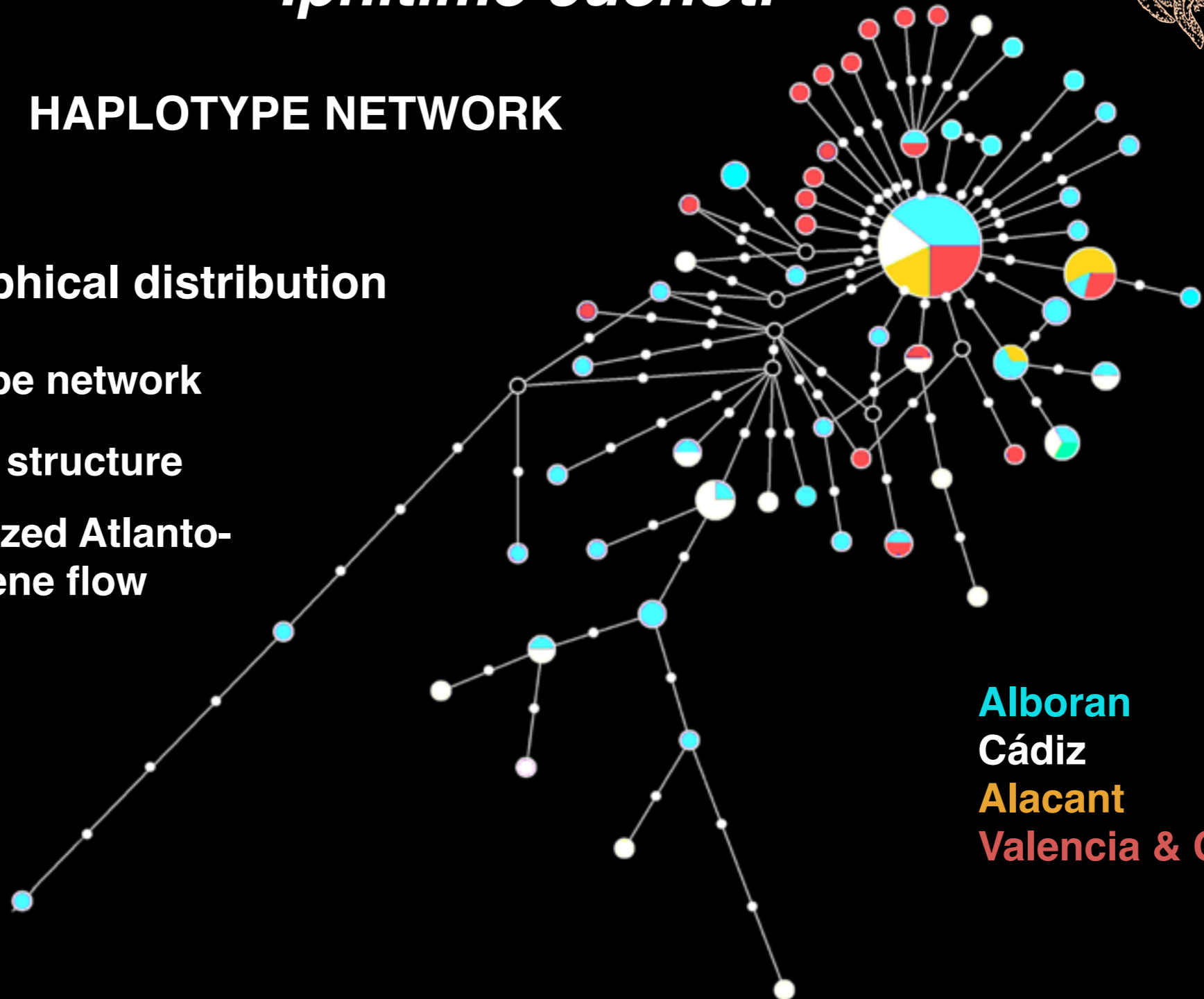


# *Iphitime cuenoti*

## HAPLOTYPE NETWORK

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## *Iphitime cuenoti*

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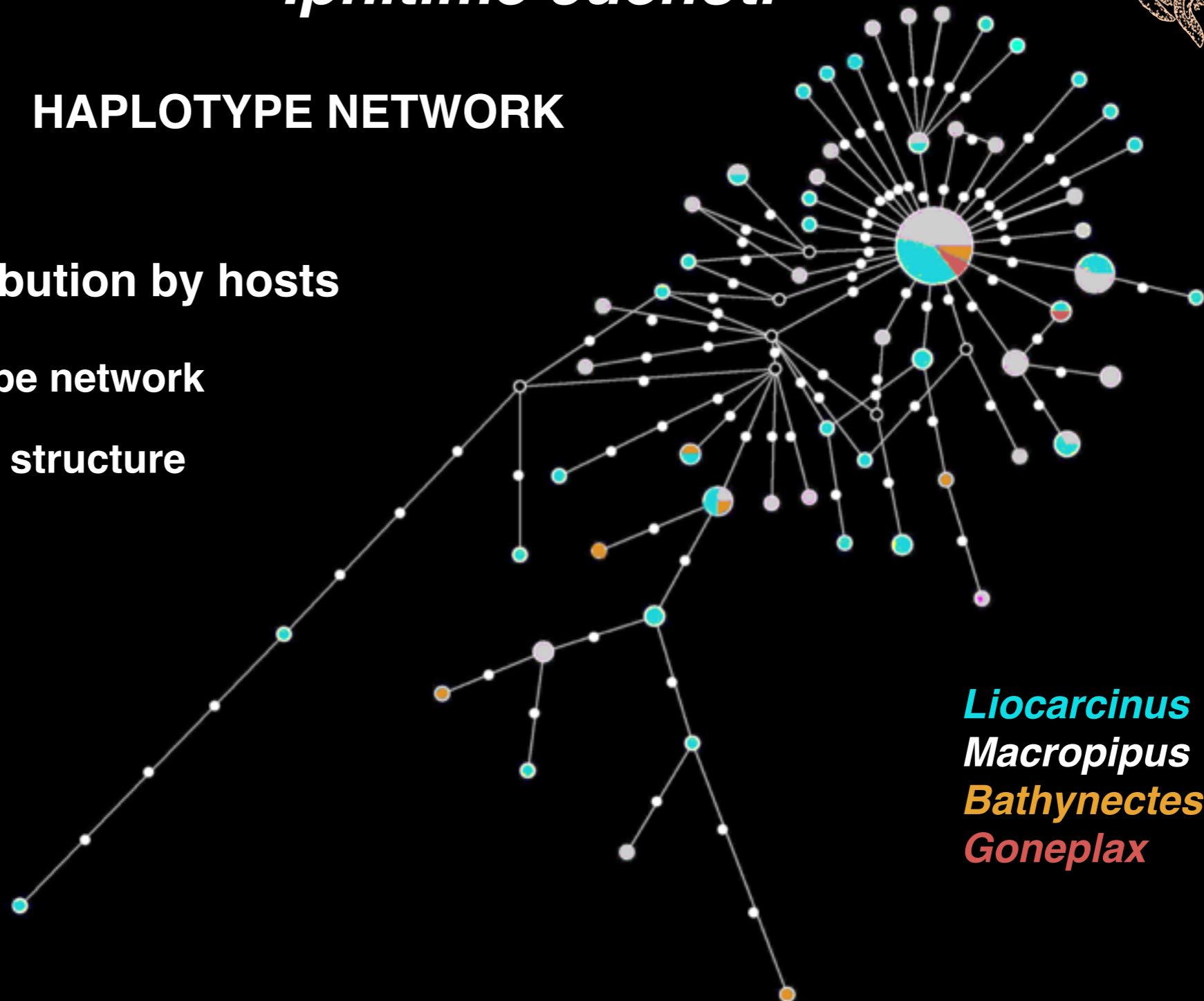
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### HAPLOTYPE NETWORK

#### Distribution by hosts

- ✓ Star-like haplotype network
- ✓ Weak population structure



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*Macropipus*  
*Bathynectes*  
*Goneplax*



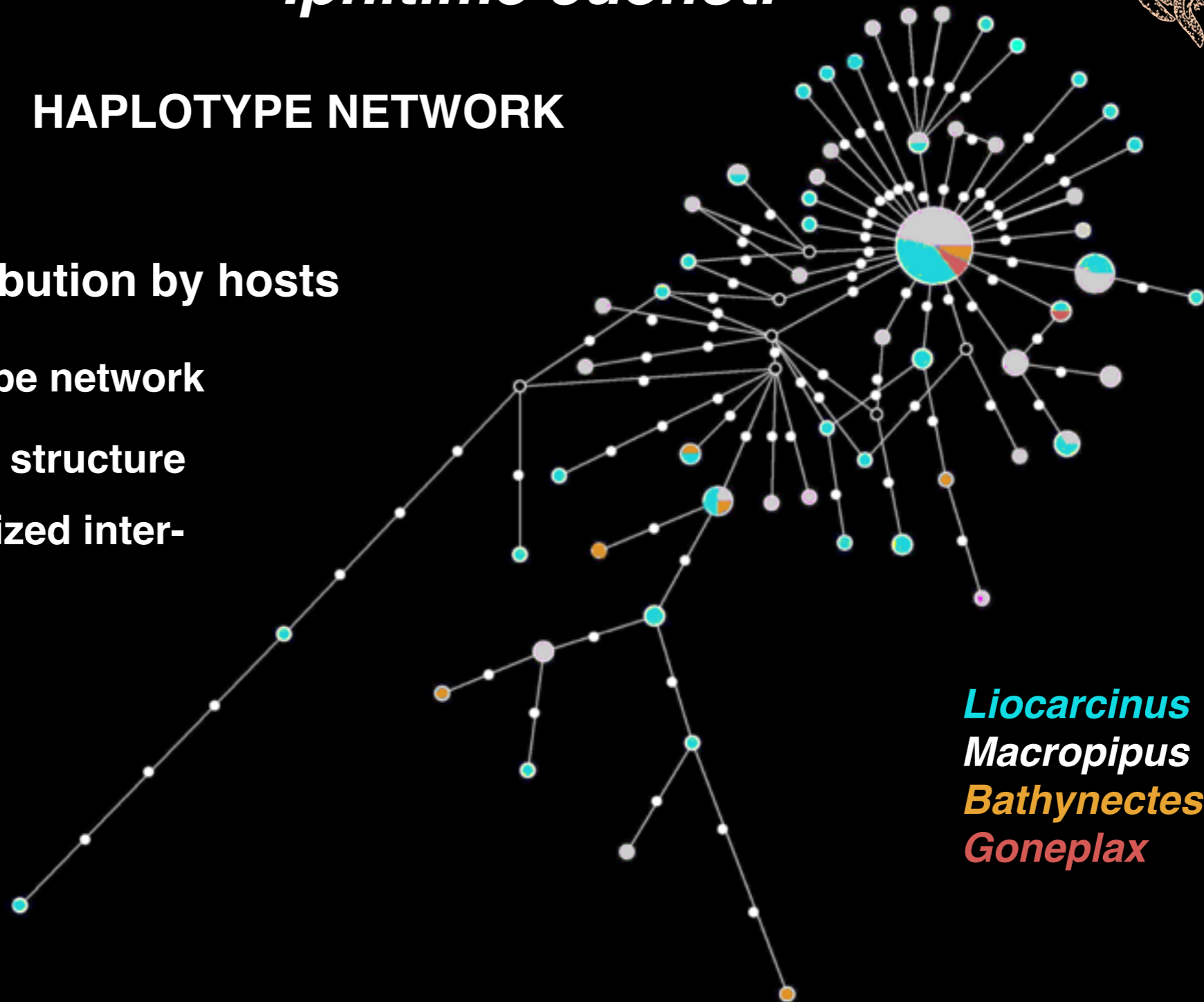
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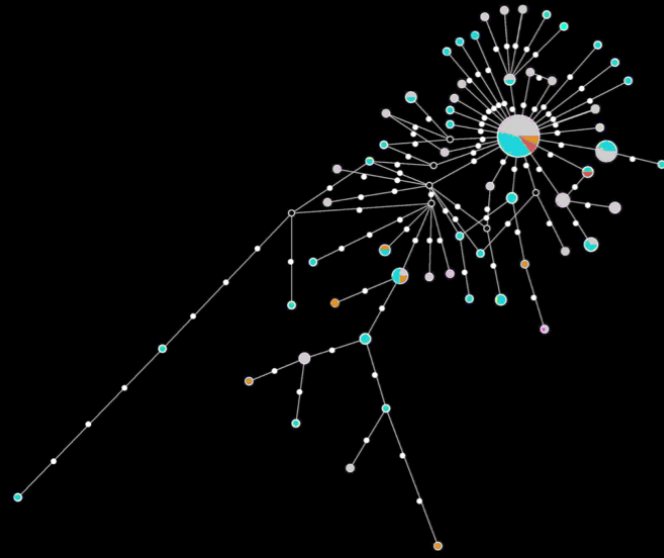
### Distribution by hosts

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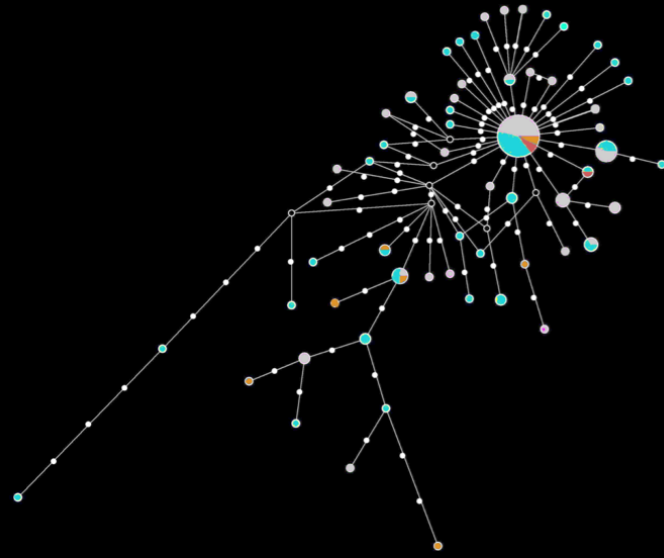
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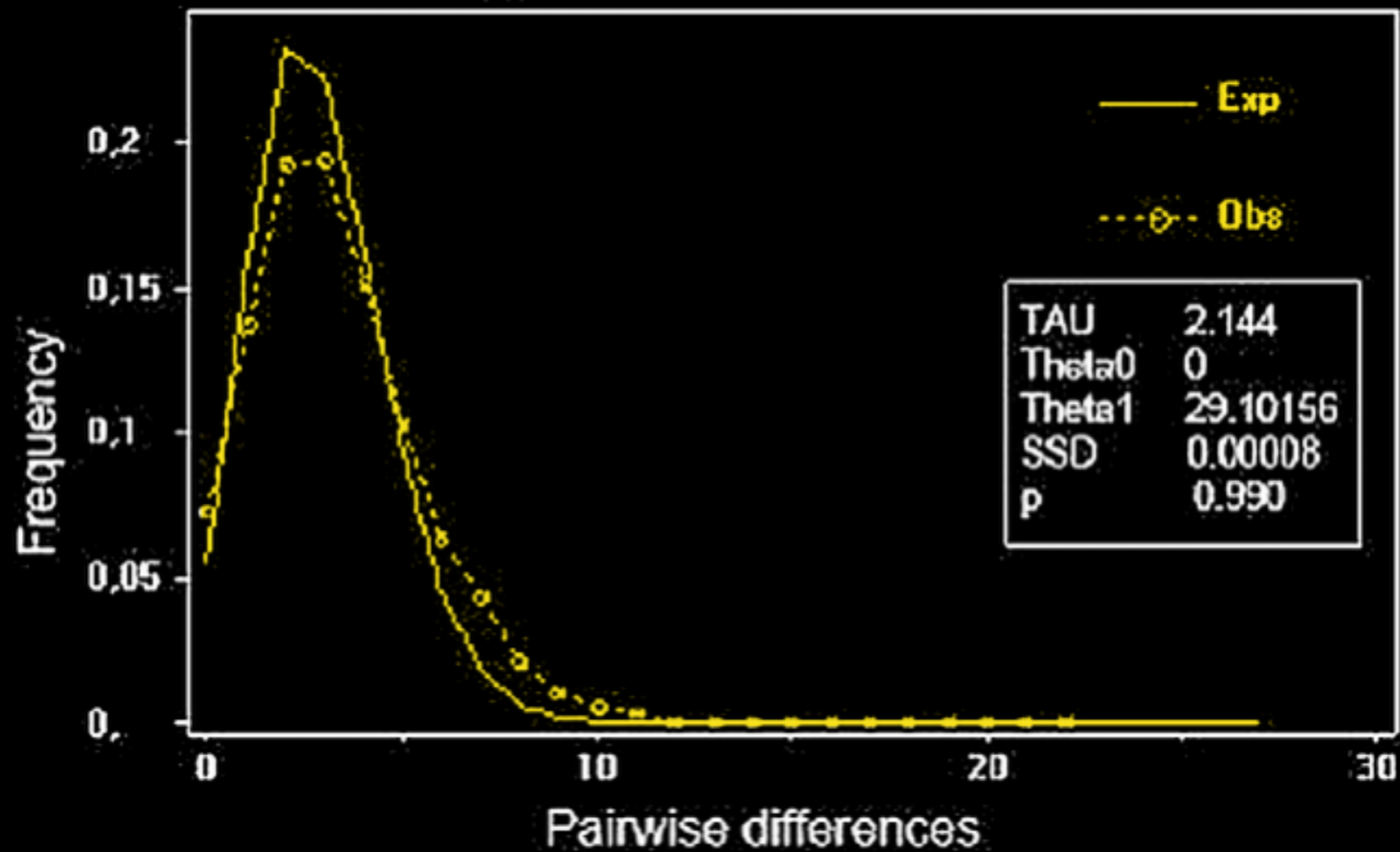
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MISMATCH DISTRIBUTIONS

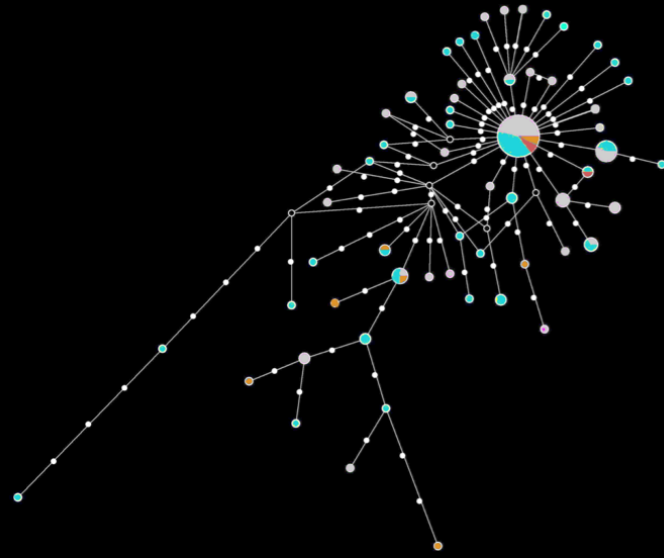




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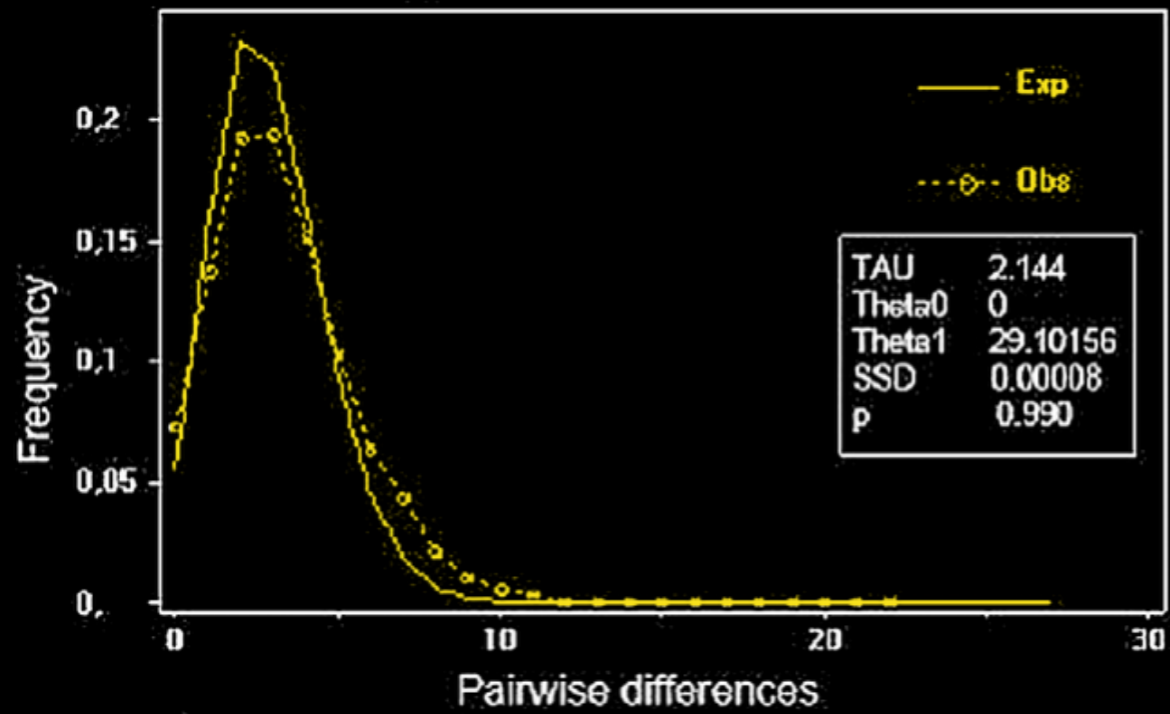
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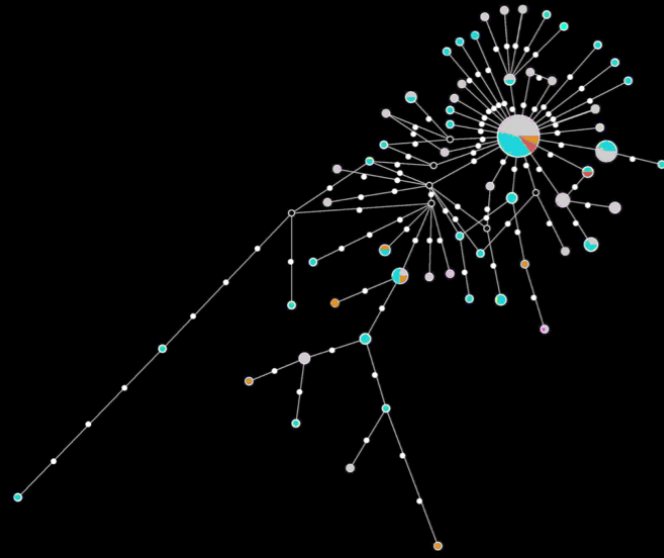


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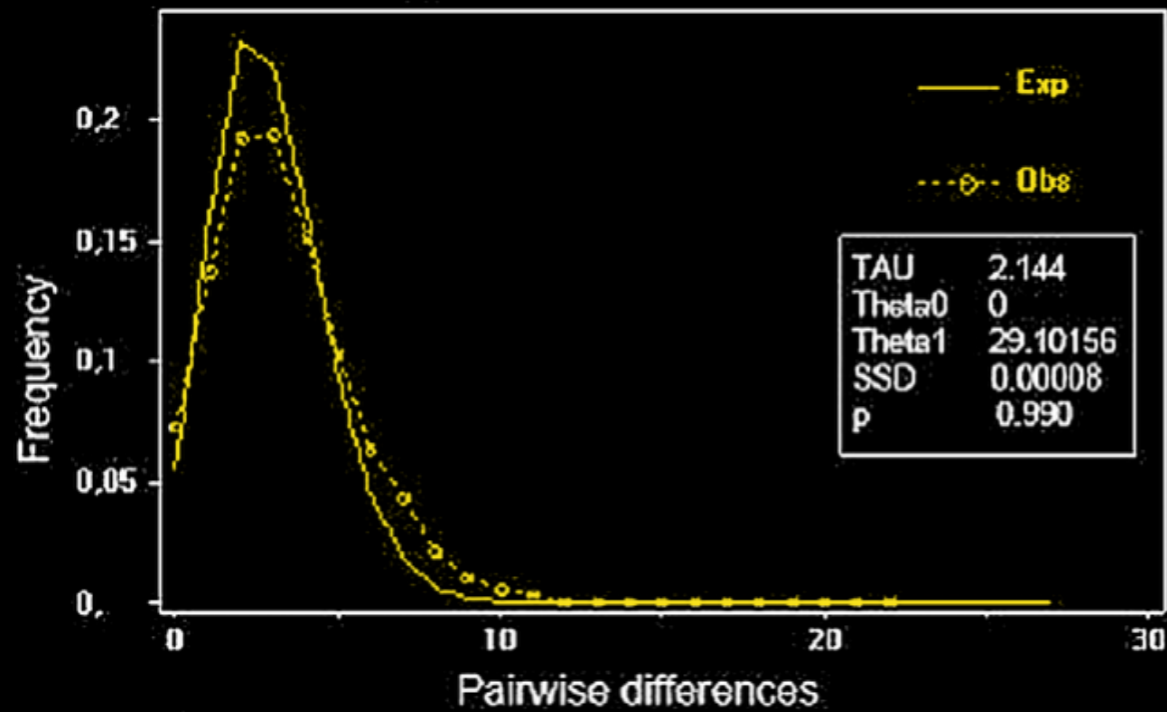




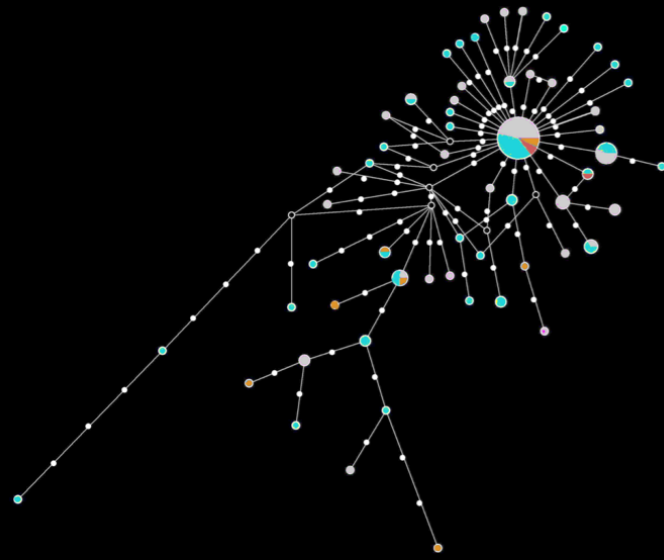


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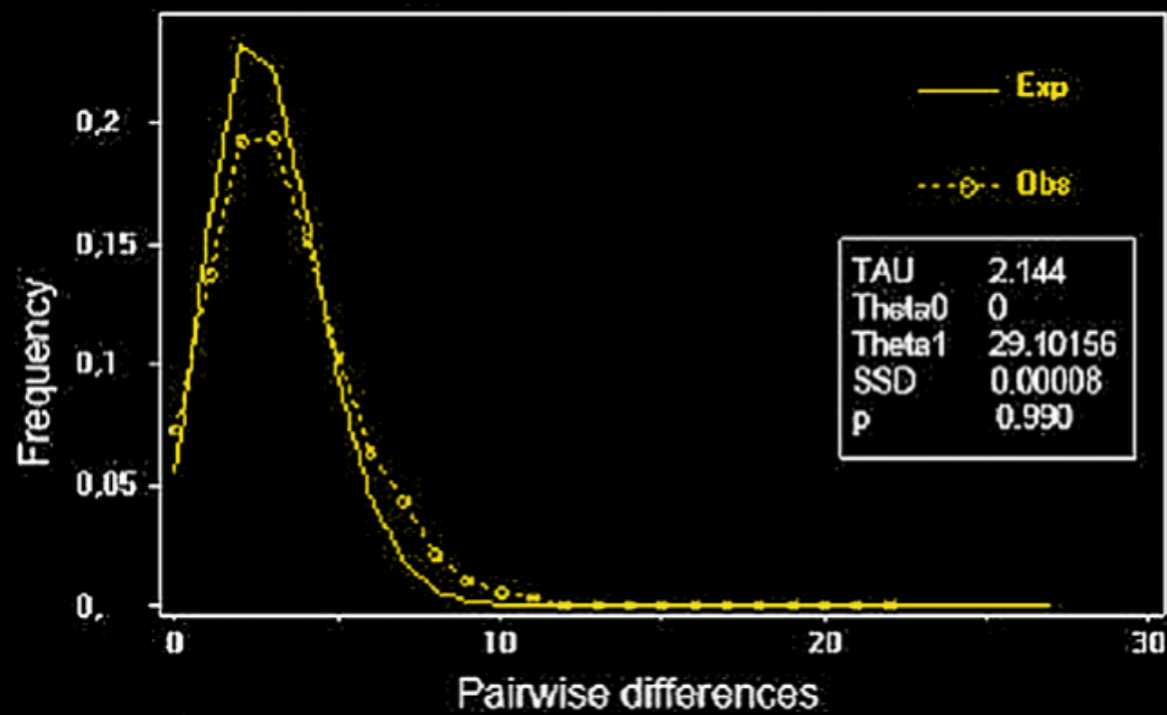


✓ Unimodal haplotype distribution

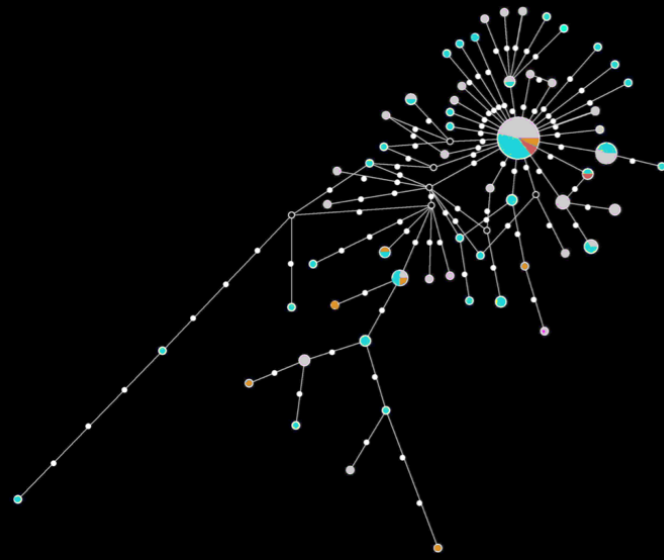


## *Iphitime cuenoti*

### MISMATCH DISTRIBUTIONS

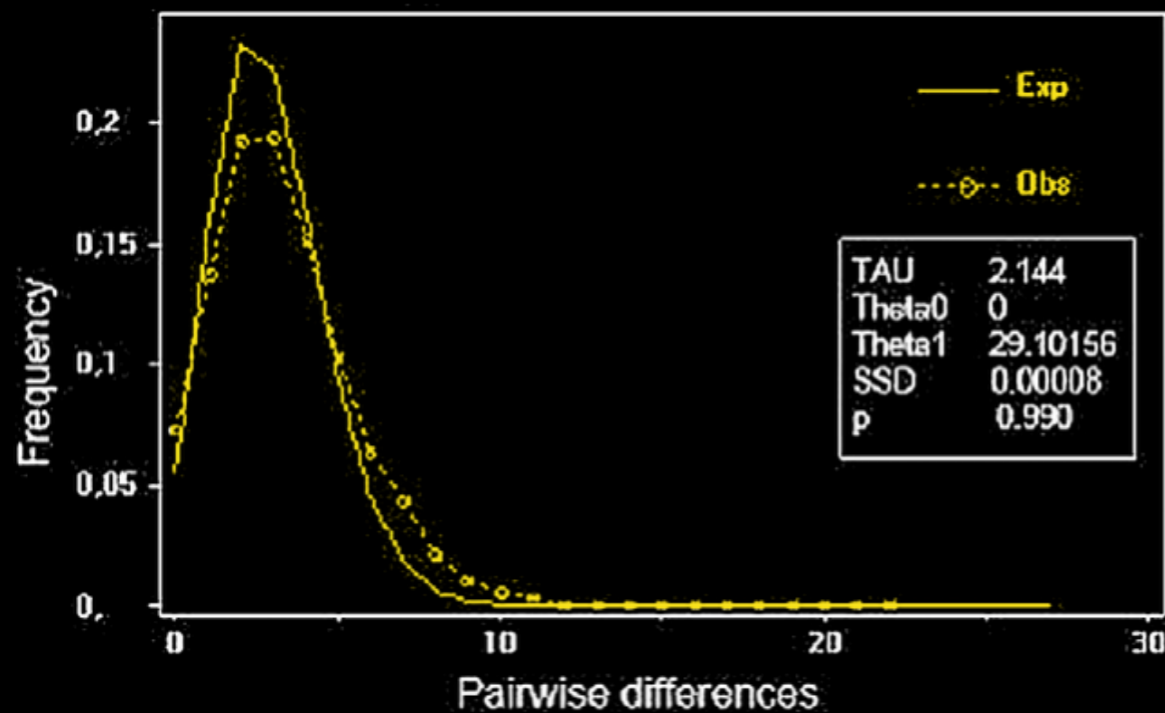


- ✓ Unimodal haplotype distribution
- ✓ Most recent expansion 90 thousand years ago



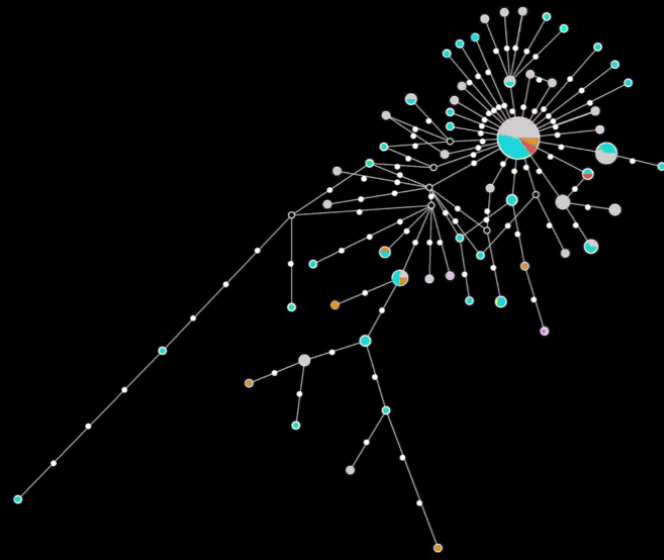
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### MISMATCH DISTRIBUTIONS



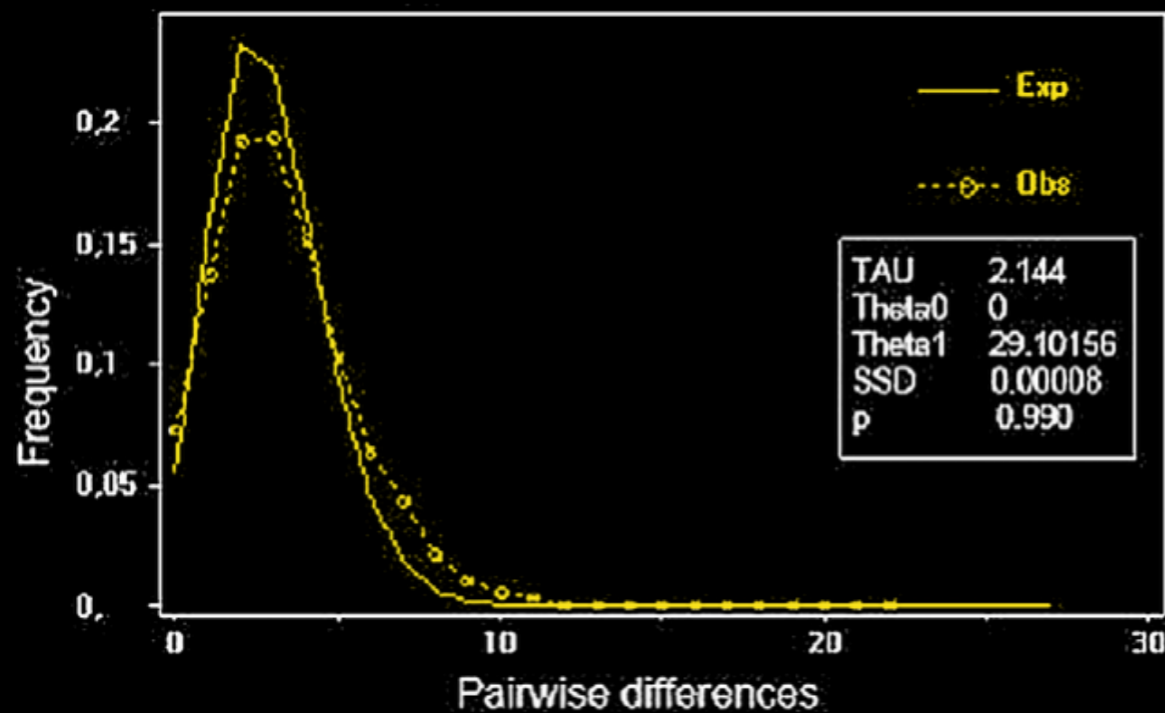
- ✓ Unimodal haplotype distribution
- ✓ Most recent expansion 90 thousand years ago
- ✓ After the Pleistocene glaciations





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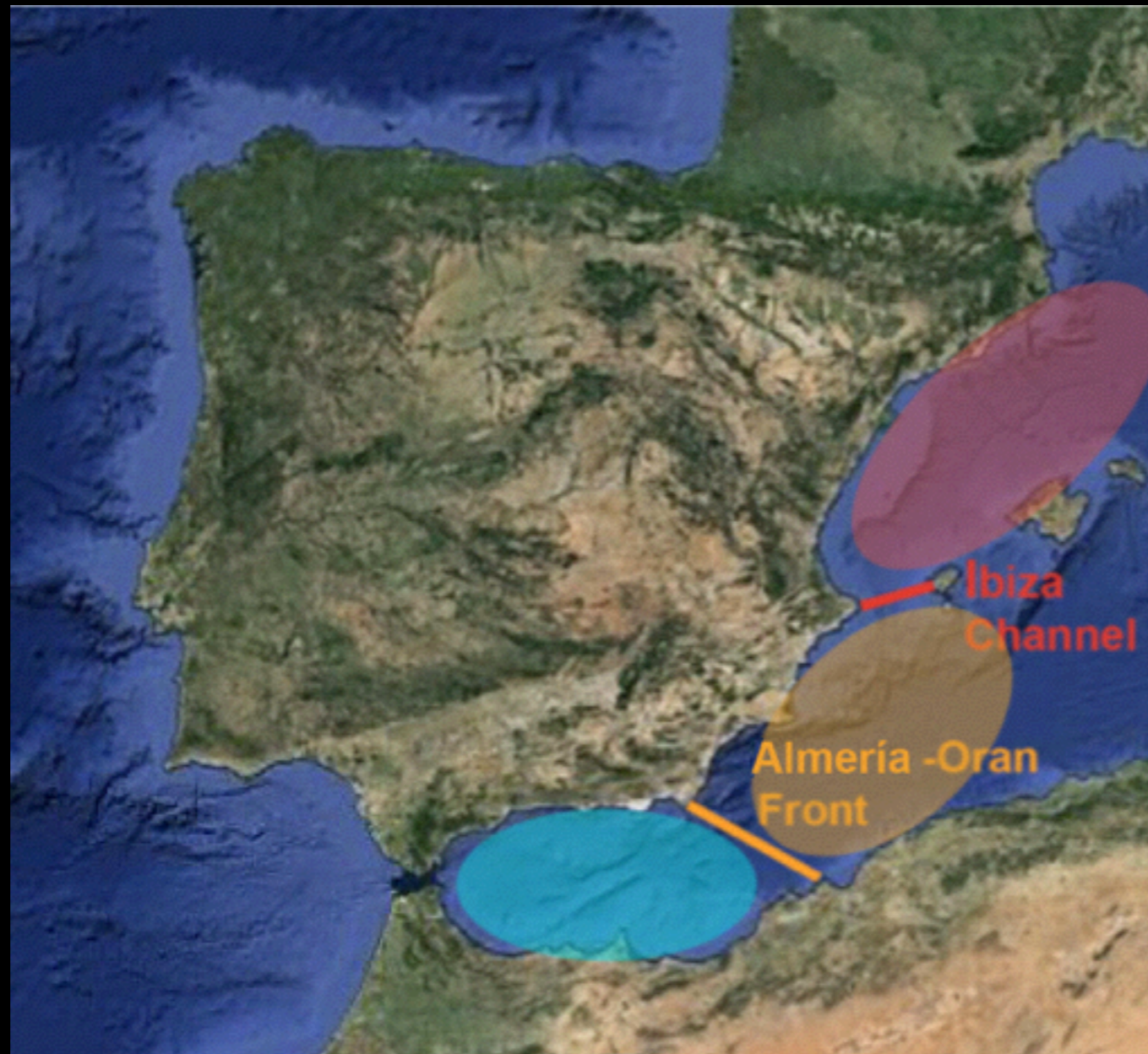
### MISMATCH DISTRIBUTIONS



- ✓ Unimodal haplotype distribution
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- ✓ After the Pleistocene glaciations
- ✓ Günz Mindel Interglacial Period

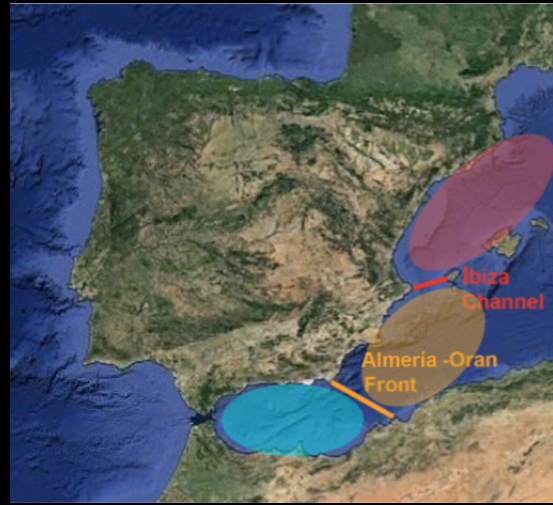


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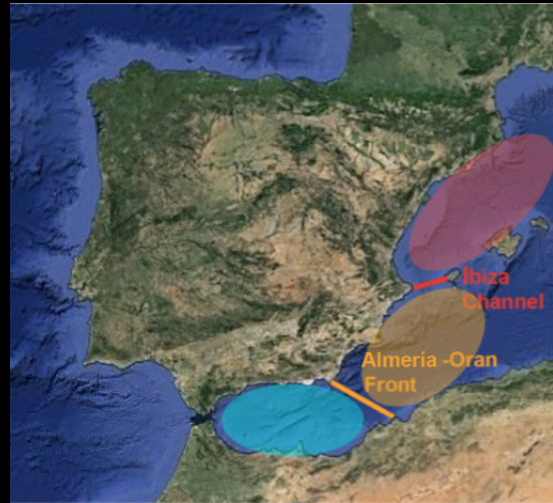
- ✓ **Alboran**
- ✓ **Alacant**
- ✓ **Valencia & Catalunya**





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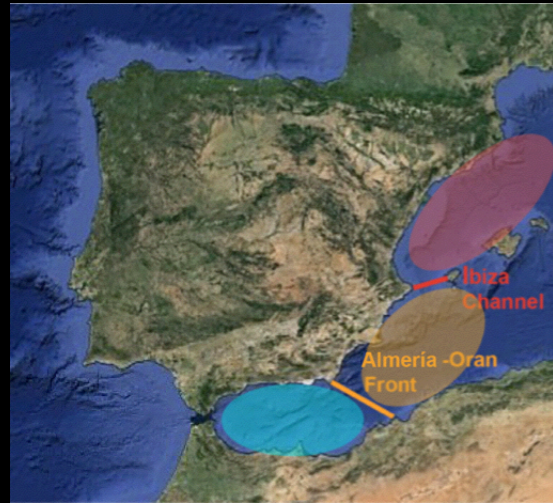


# *Ophryotrocha mediterranea*



Pairwise  $F_{st}$  estimates based on mtDNA COI

	ALBORAN	ALACANT
ALACANT		
VALENCIA & CATALUNYA		



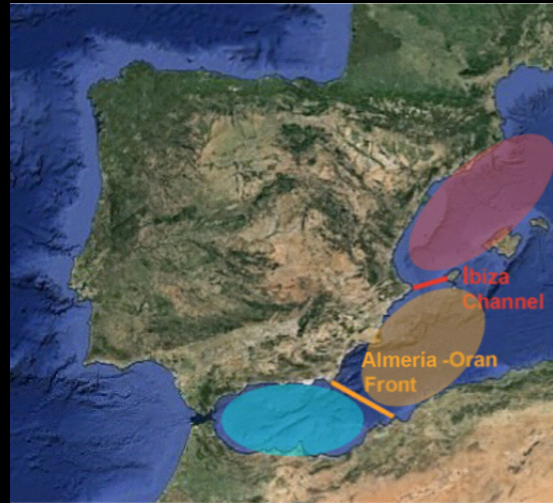
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ALACANT		
VALENCIA & CATALUNYA		0.002, N.S.



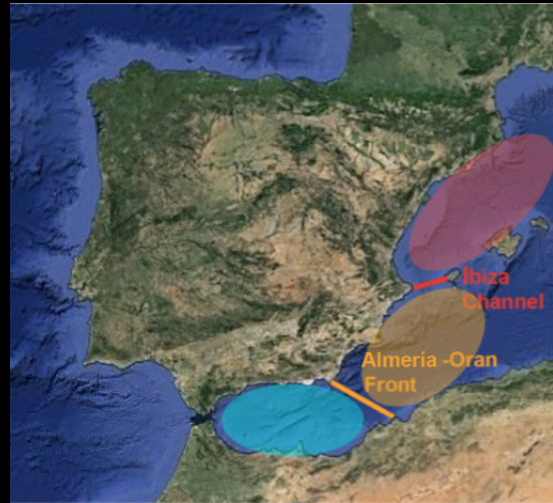


## *Ophryotrocha mediterranea*



Pairwise  $F_{st}$  estimates based on mtDNA COI

	ALBORAN	ALACANT
ALACANT	0.083, N.S.	
VALENCIA & CATALUNYA		0.002, N.S.

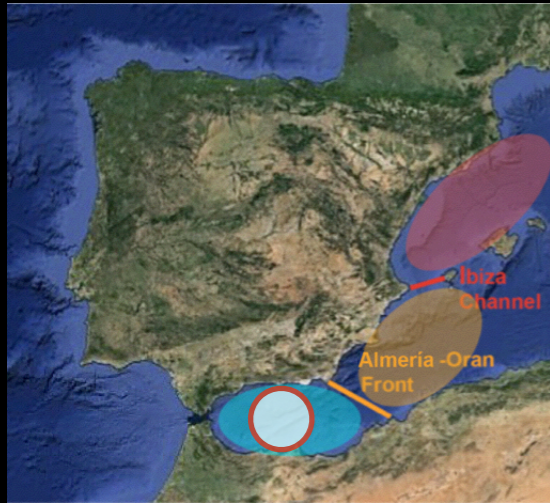


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ALACANT	0.083, N.S.	
VALENCIA & CATALUNYA	0.118, $p < 0.05$	0.002, N.S.



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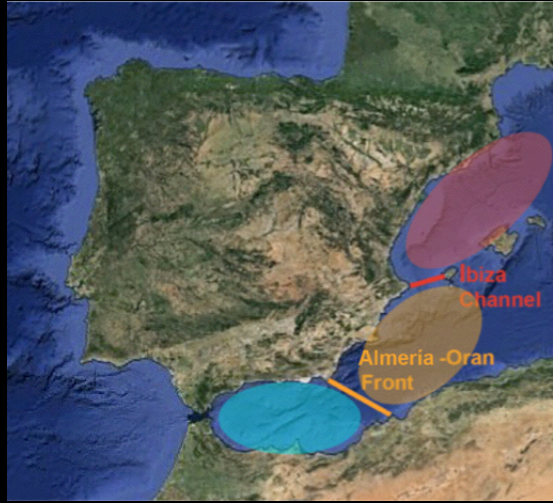


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VALENCIA & CATALUNYA	0.118, $p < 0.05$	0.002, N.S.

**Eastern Alborán differs significantly (0.272)**

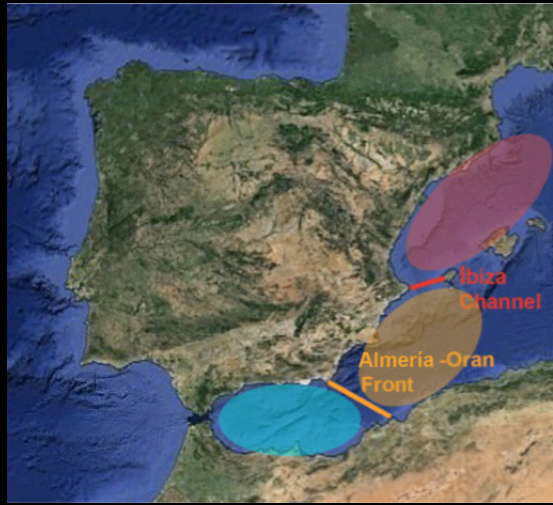




# *Ophryotrocha mediterranea*



**Alboran**  
**Alacant**  
**Valencia & Catalunya**

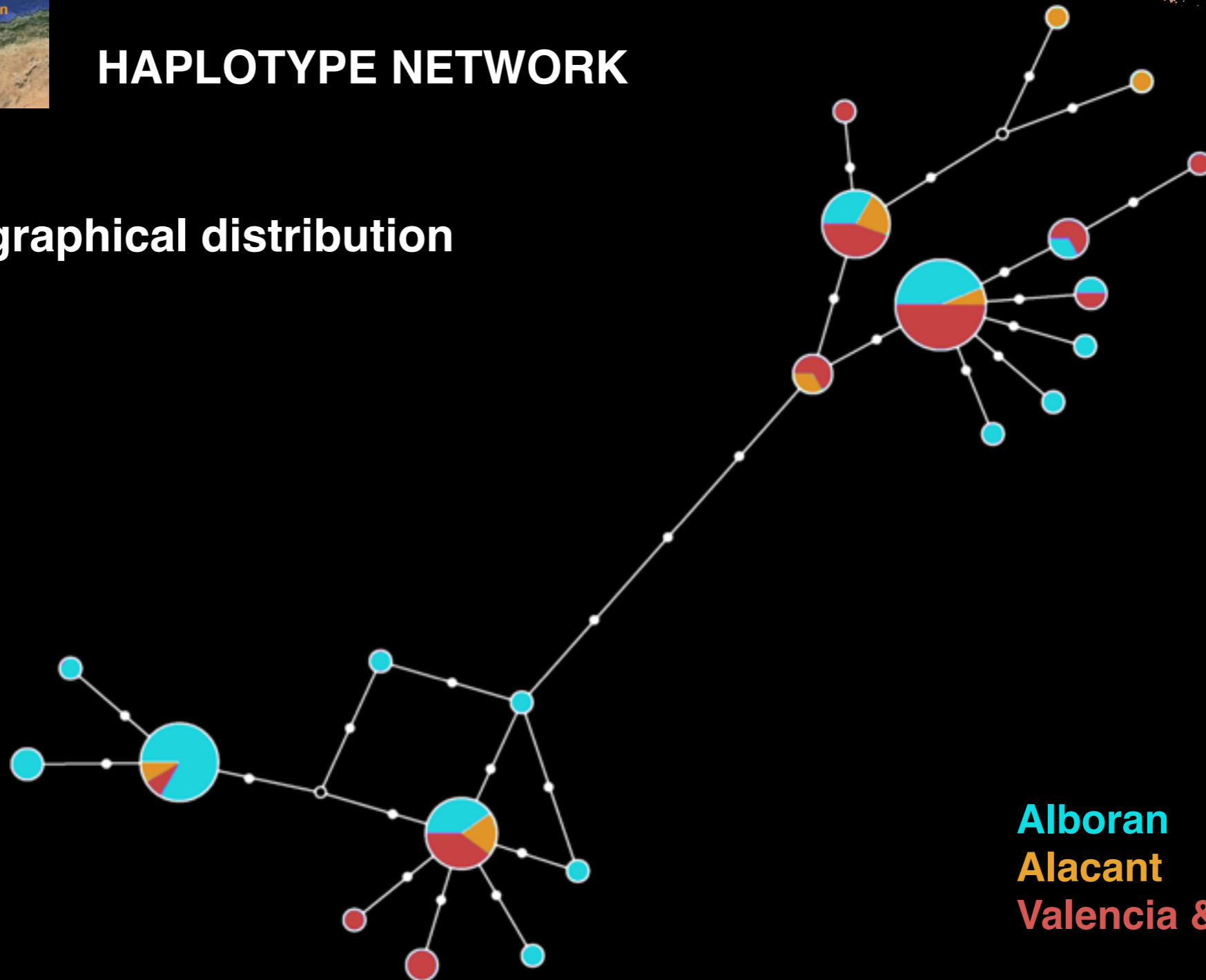


# *Ophryotrocha mediterranea*



## HAPLOTYPE NETWORK

### Geographical distribution



Alboran  
Alacant  
Valencia & Catalunya



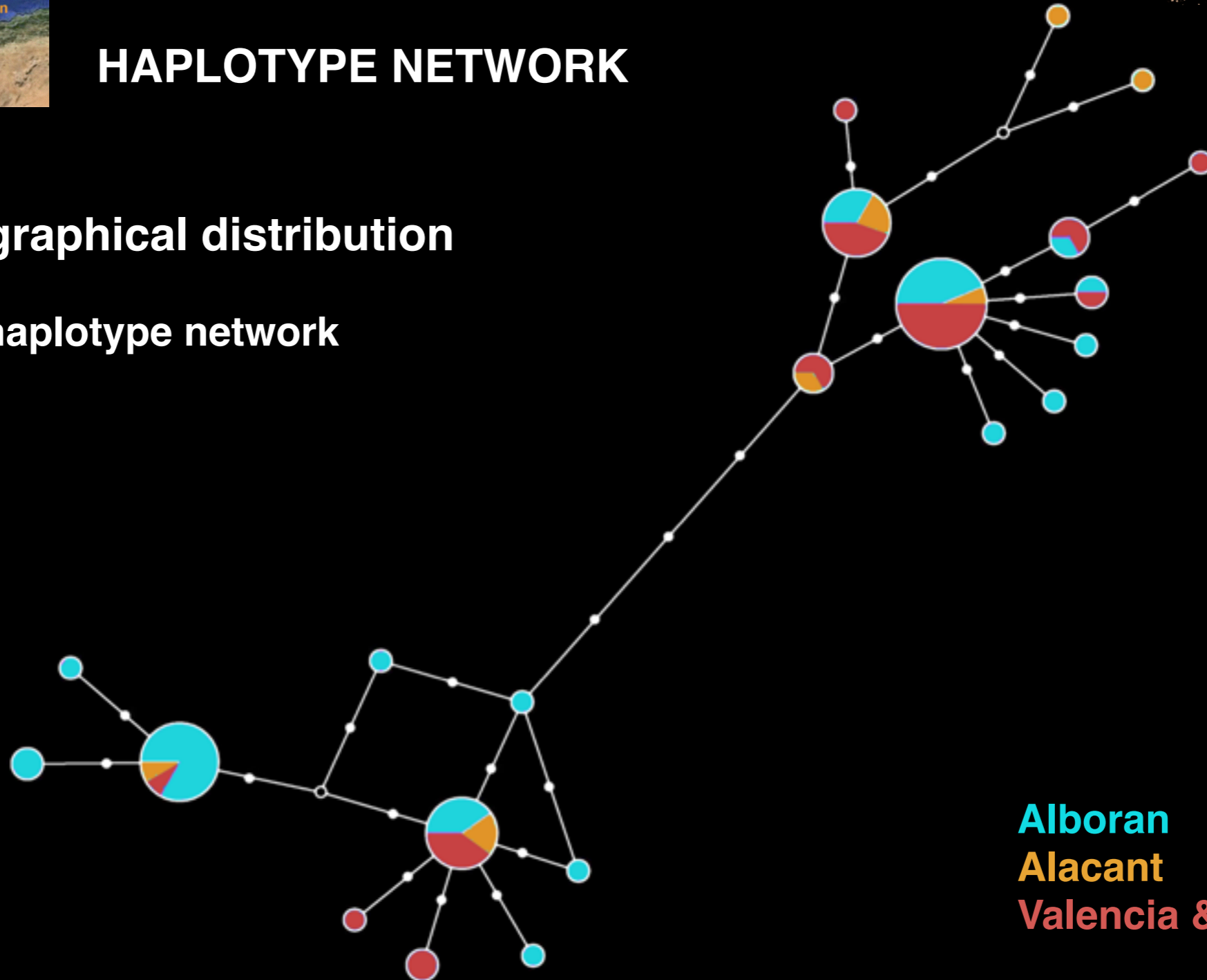
# *Ophryotrocha mediterranea*



## HAPLOTYPE NETWORK

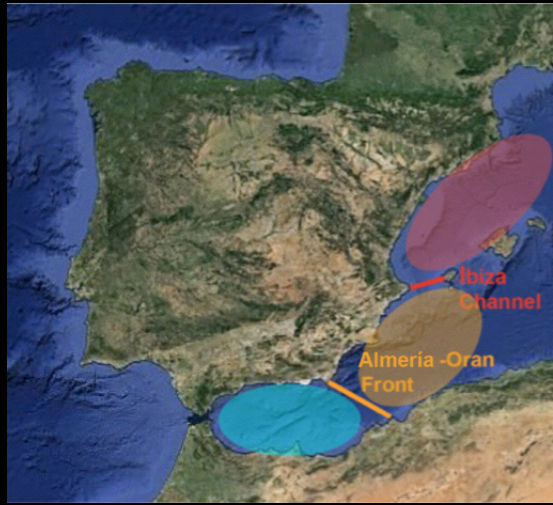
### Geographical distribution

✓ Dumble-like haplotype network



Alboran  
Alacant  
Valencia & Catalunya





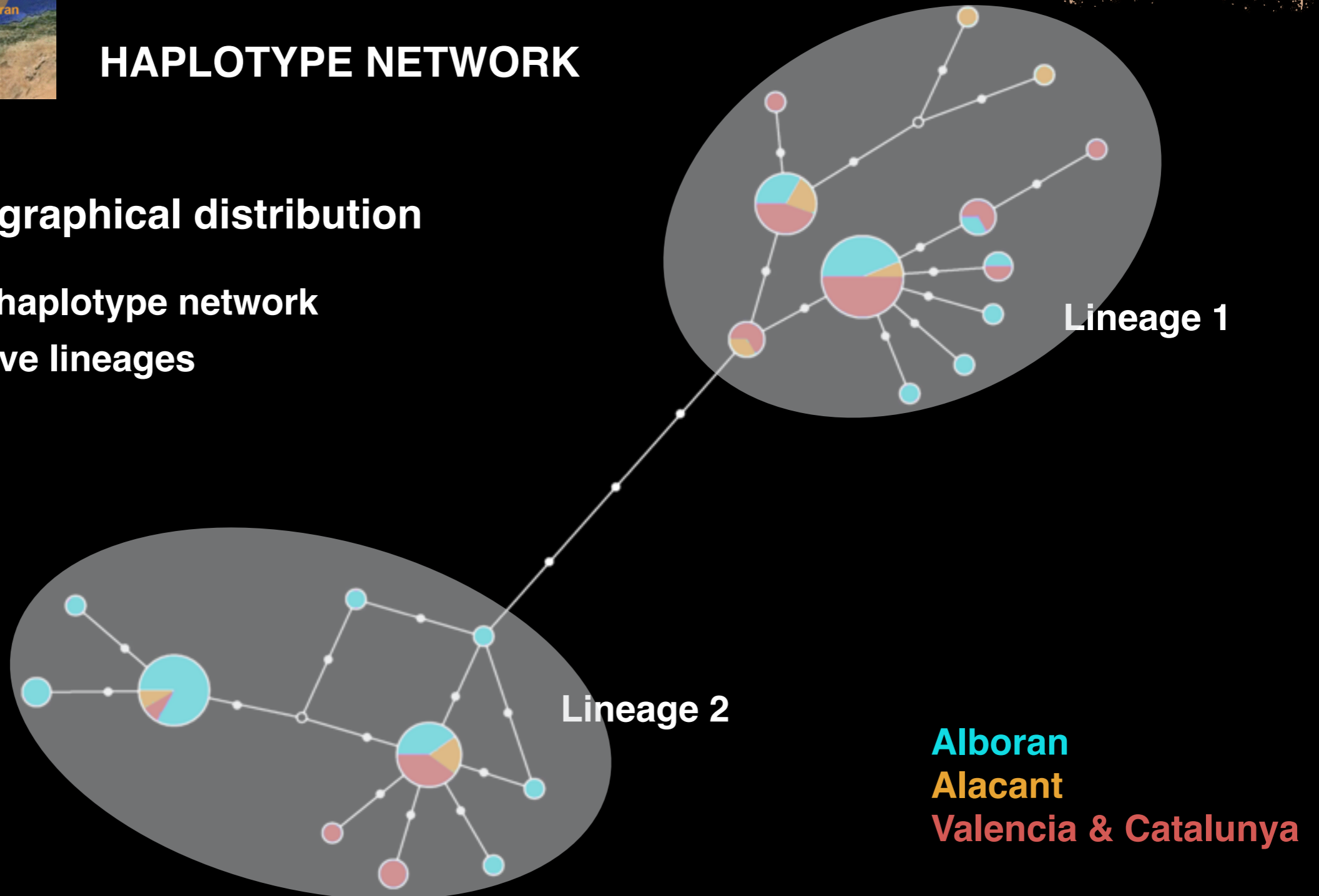
# *Ophryotrocha mediterranea*



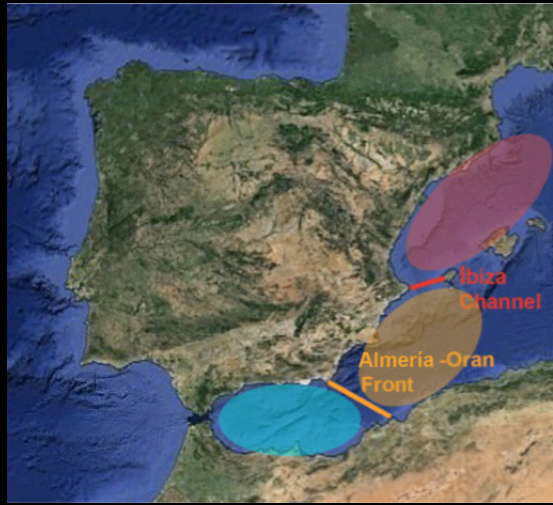
## HAPLOTYPE NETWORK

### Geographical distribution

- ✓ Dumble-like haplotype network
- ✓ Two distinctive lineages



**Alboran**  
**Alacant**  
**Valencia & Catalunya**



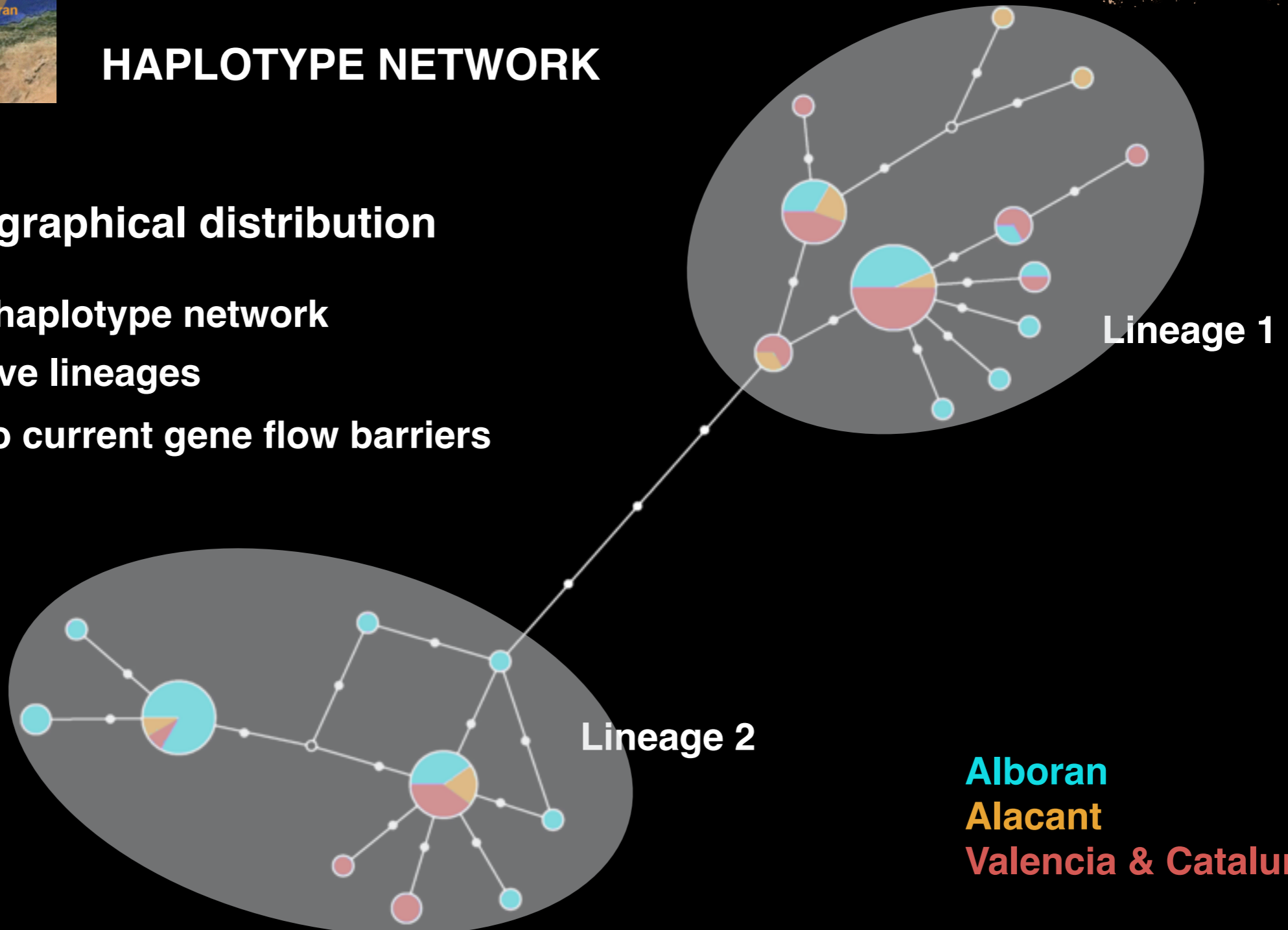
# *Ophryotrocha mediterranea*



## HAPLOTYPE NETWORK

### Geographical distribution

- ✓ Dumble-like haplotype network
- ✓ Two distinctive lineages
- ✓ Not related to current gene flow barriers



Alboran  
Alacant  
Valencia & Catalunya



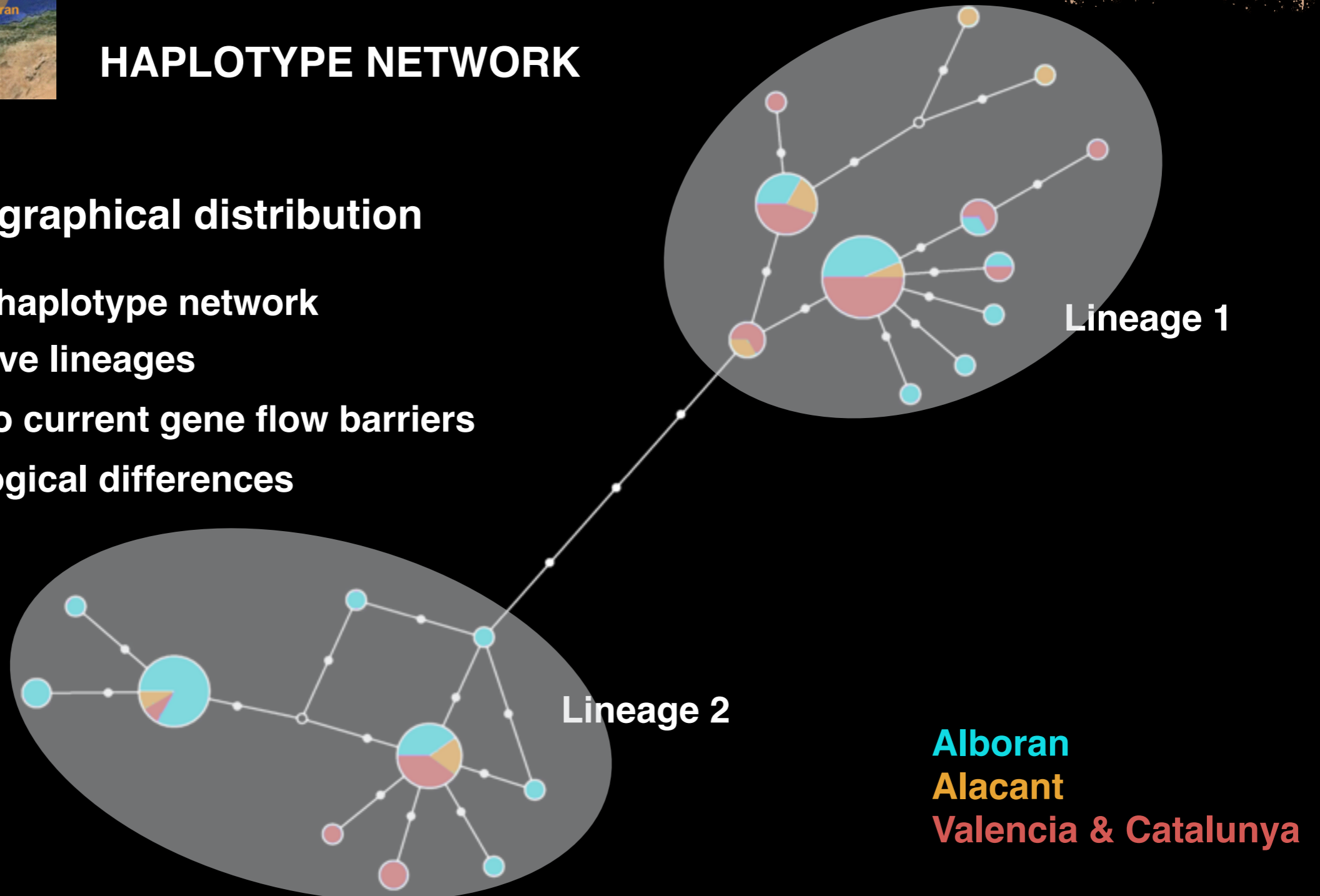
# *Ophryotrocha mediterranea*



## HAPLOTYPE NETWORK

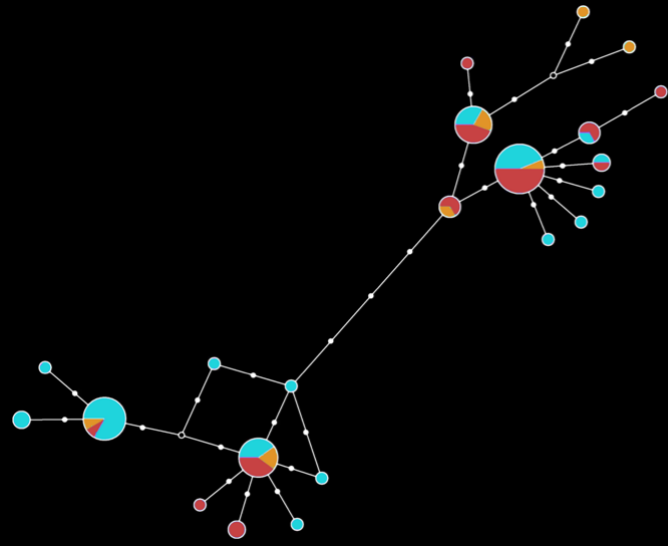
### Geographical distribution

- ✓ Dumble-like haplotype network
- ✓ Two distinctive lineages
- ✓ Not related to current gene flow barriers
- ✓ No morphological differences



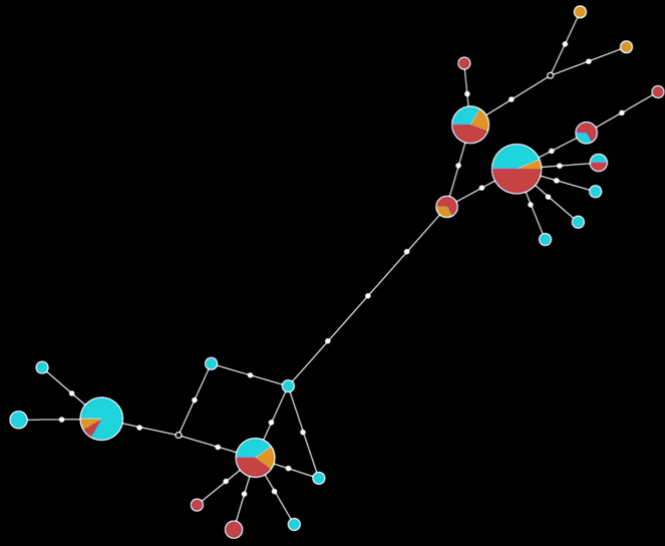
Alboran  
Alacant  
Valencia & Catalunya





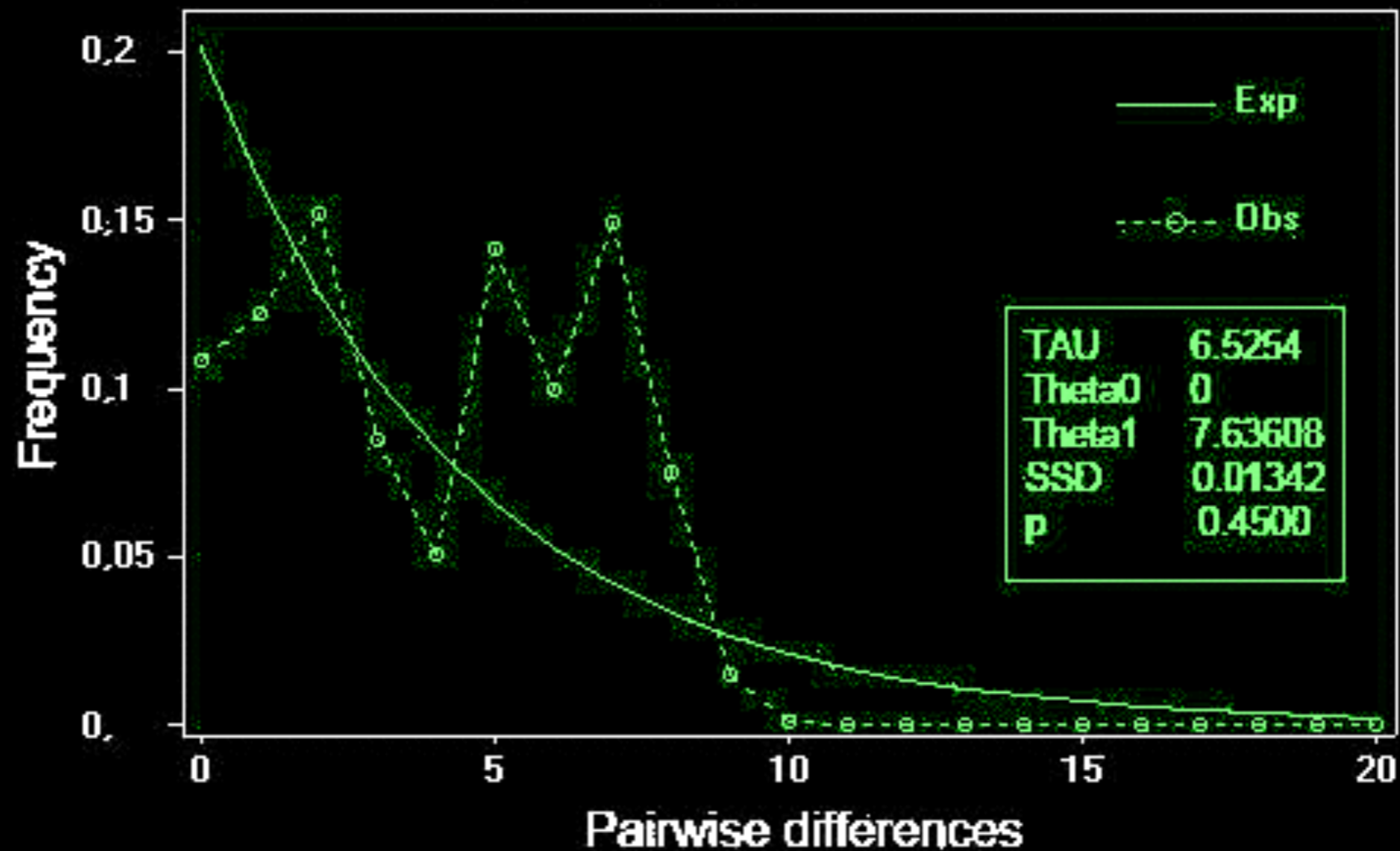
*Ophryotrocha mediterranea*

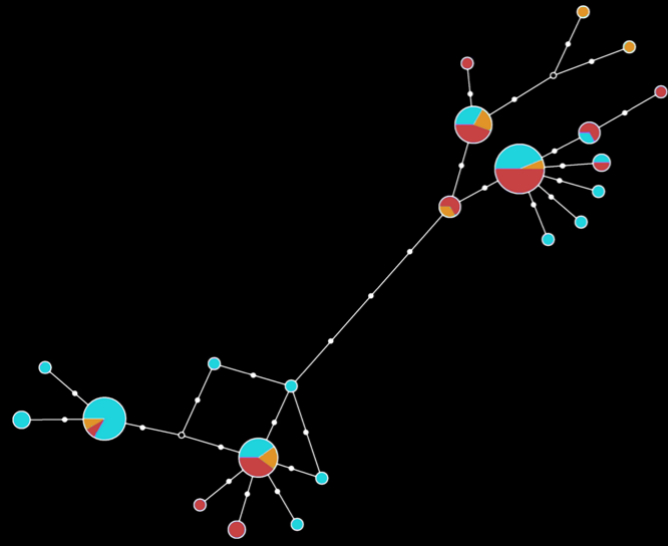




# *Ophryotrocha mediterranea*

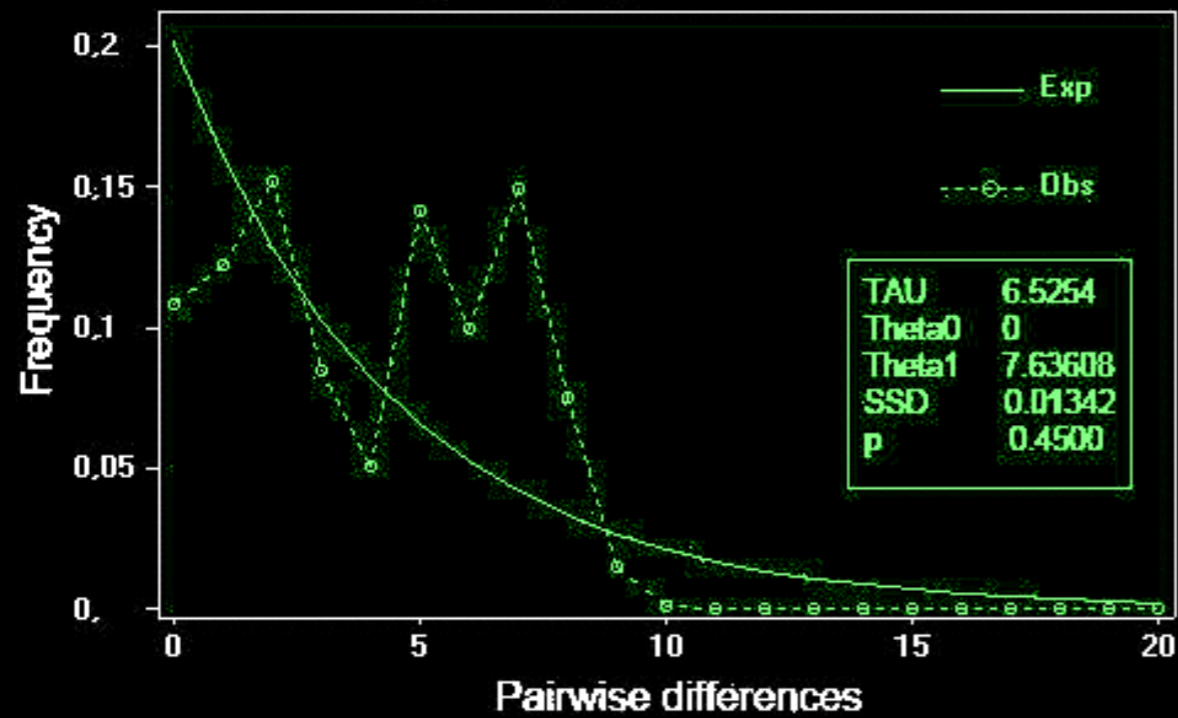
## MISMATCH DISTRIBUTION



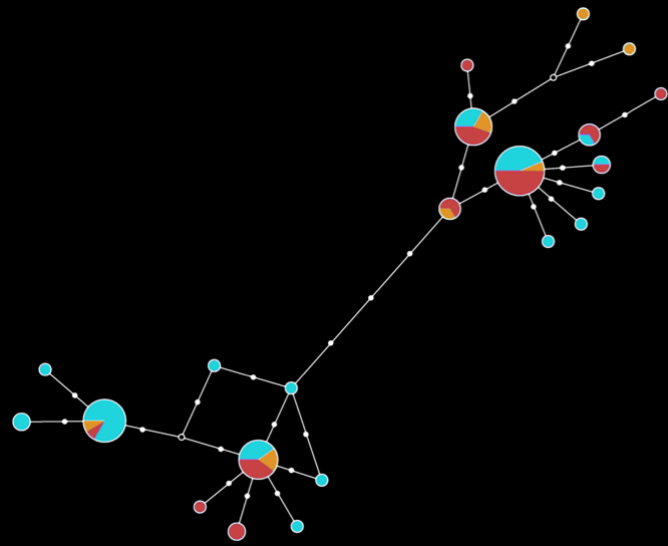


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

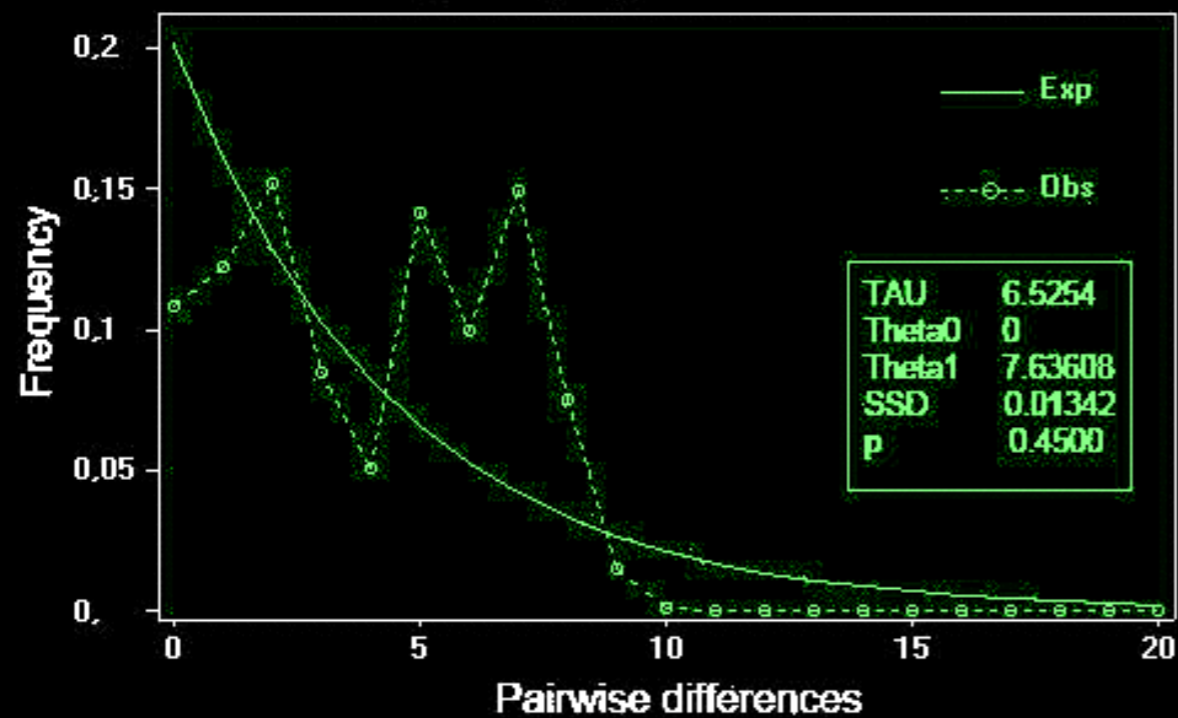




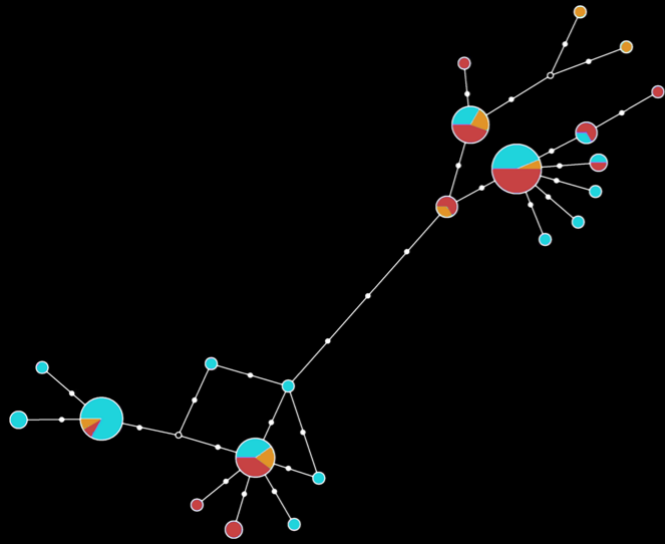


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

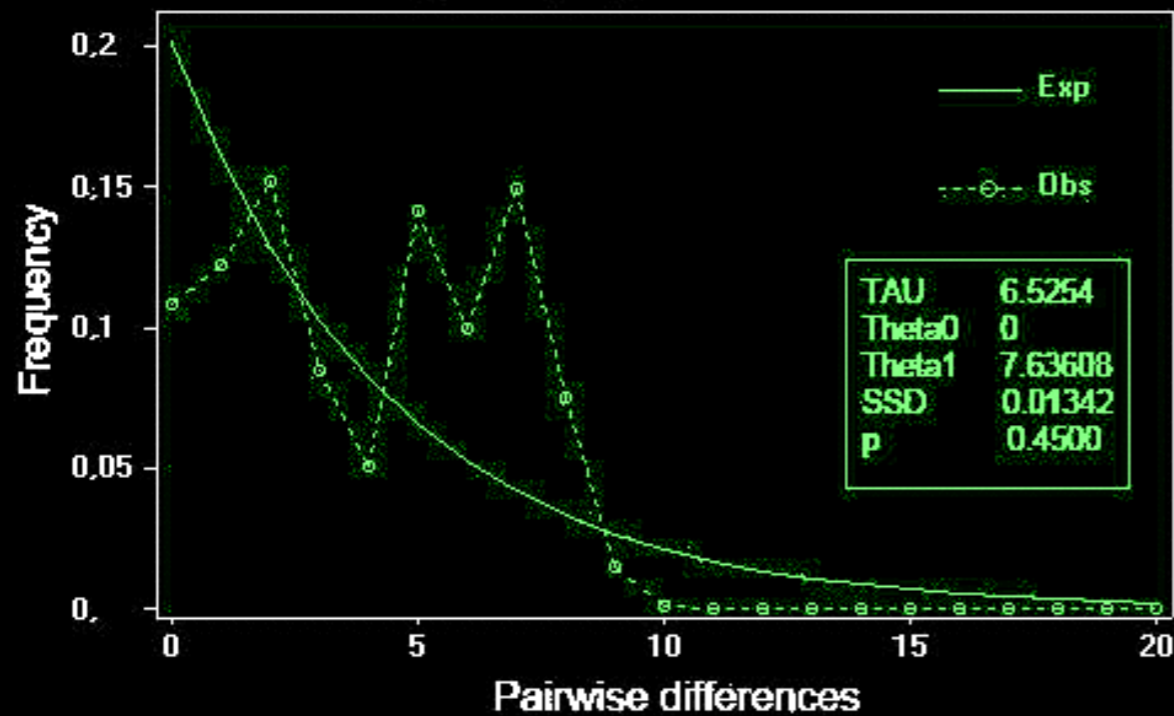


✓ Bimodal haplotype distribution

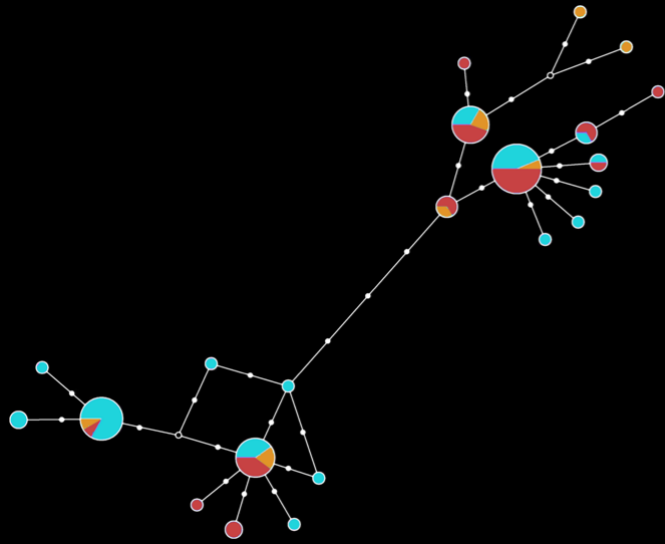


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

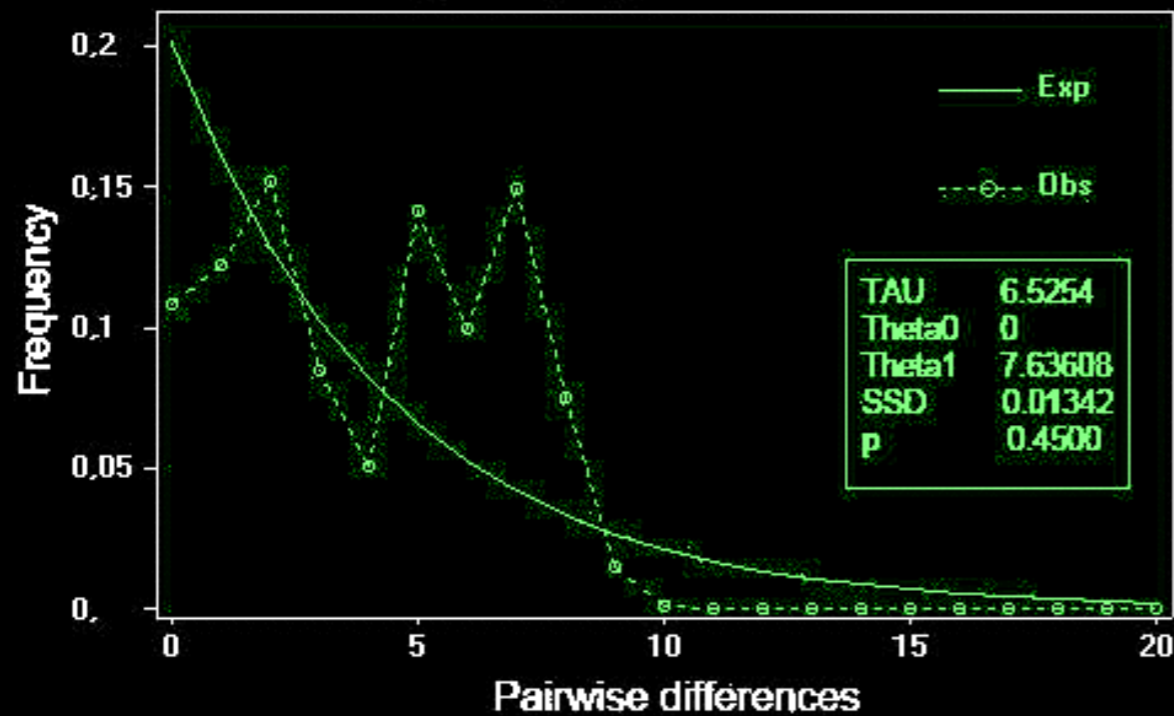


- ✓ Bimodal haplotype distribution
- ✓ Most recent expansion 250 thousand years ago



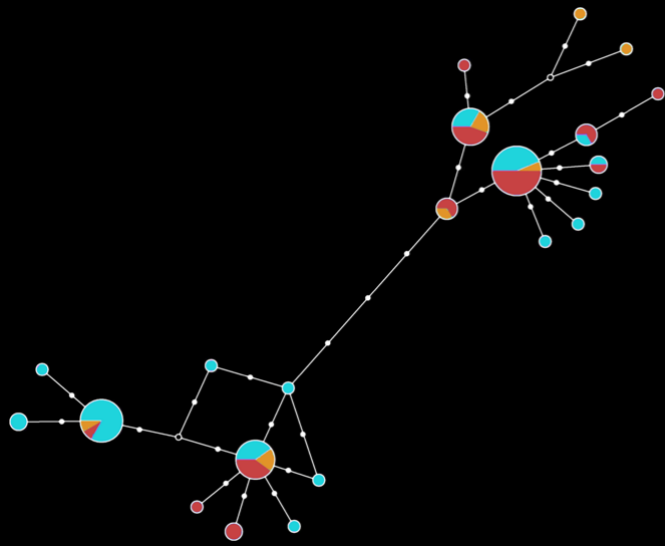
# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION



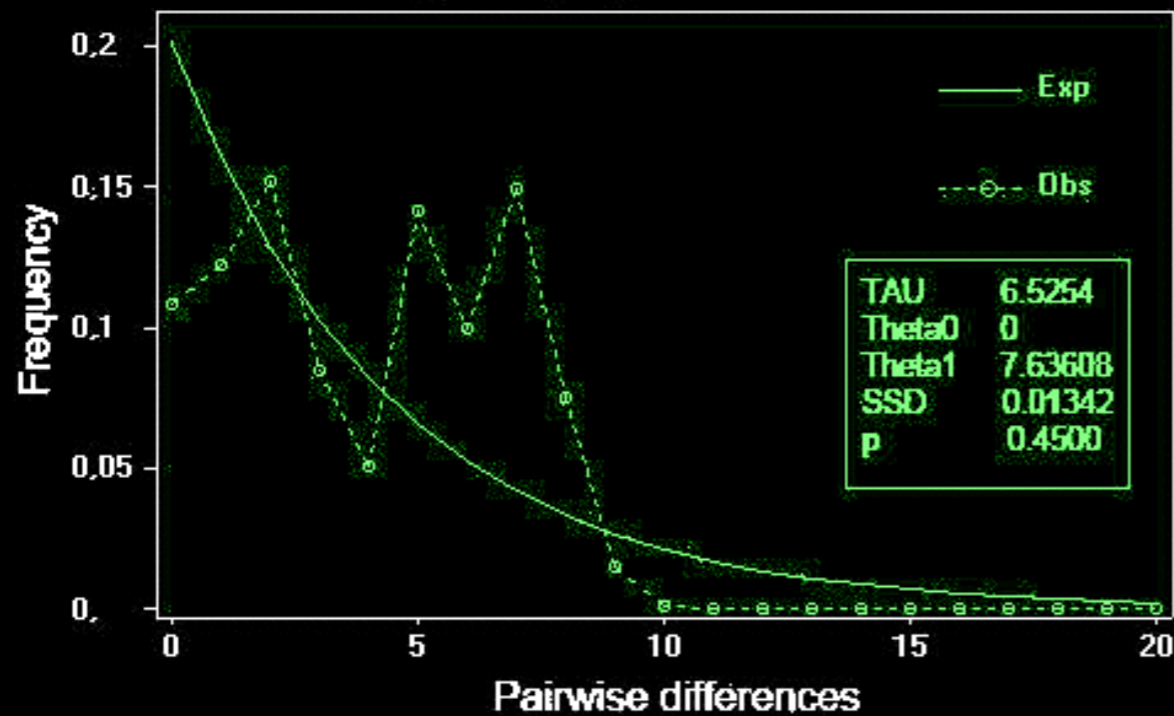
- ✓ Bimodal haplotype distribution
- ✓ Most recent expansion 250 thousand years ago
- ✓ Unique metapopulation



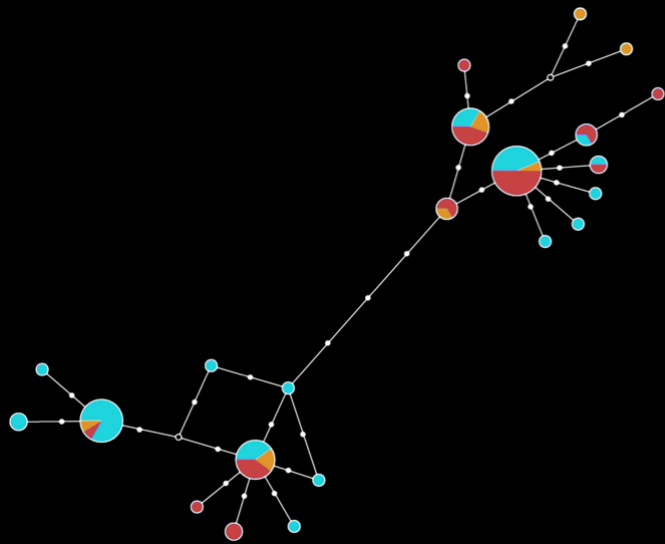


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

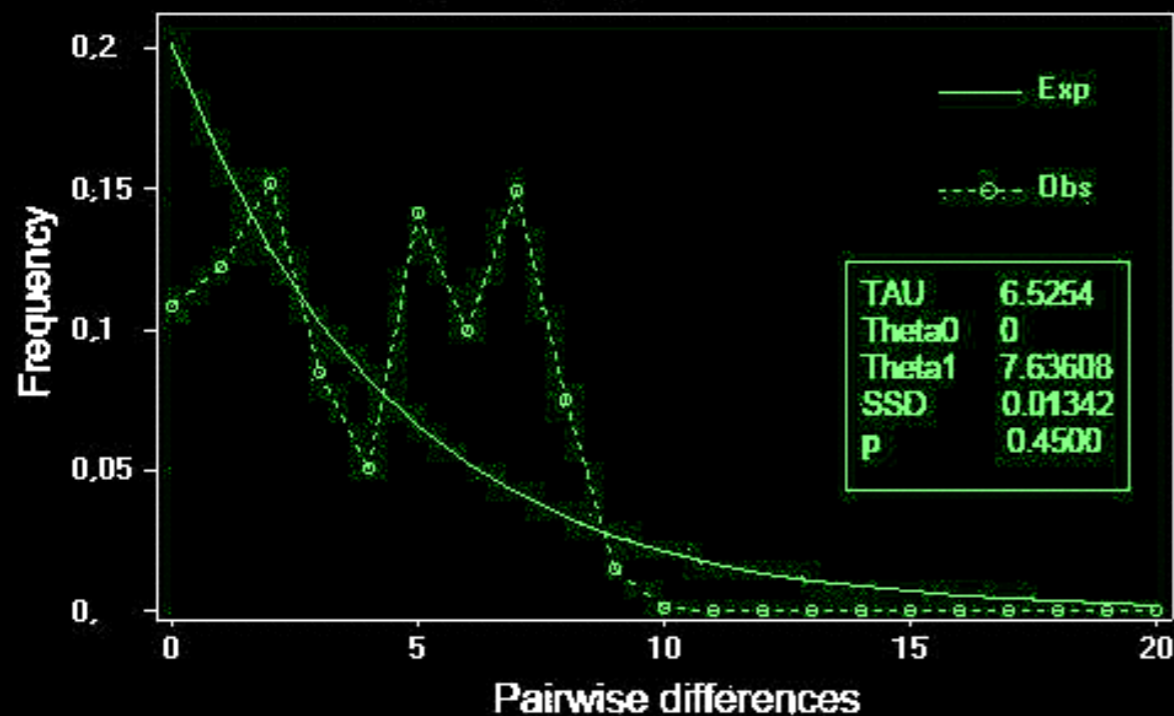


- ✓ Bimodal haplotype distribution
- ✓ Most recent expansion 250 thousand years ago
- ✓ Unique metapopulation
- ✓ Two distinct lineages

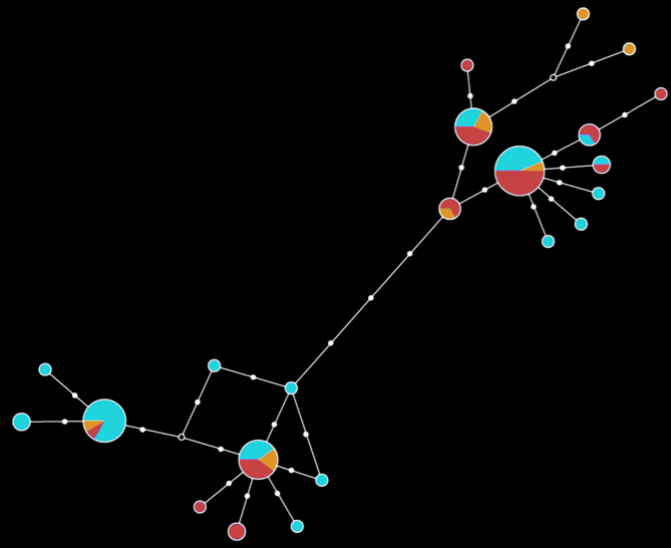


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

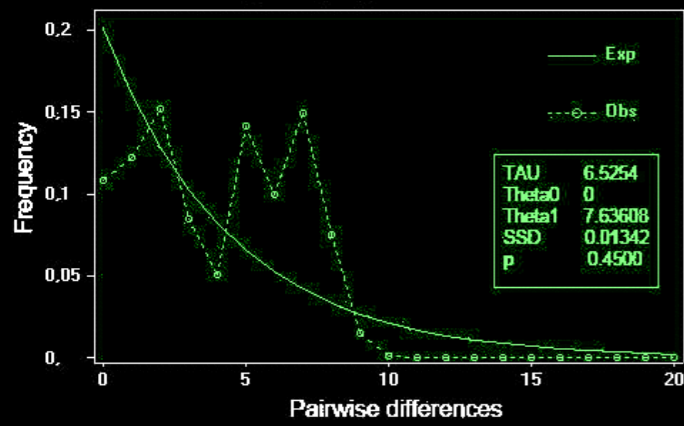


- ✓ Bimodal haplotype distribution
- ✓ Most recent expansion 250 thousand years ago
- ✓ Unique metapopulation
- ✓ Two distinct lineages
- ✓ Secondary contact as a result of expanding after being isolated

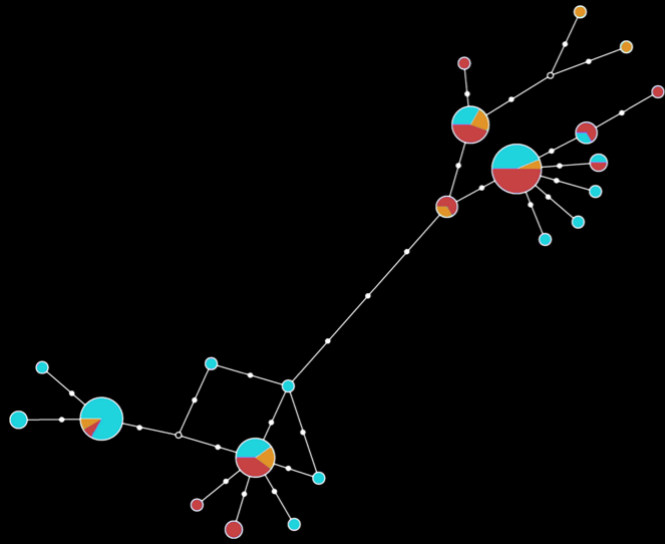


# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION

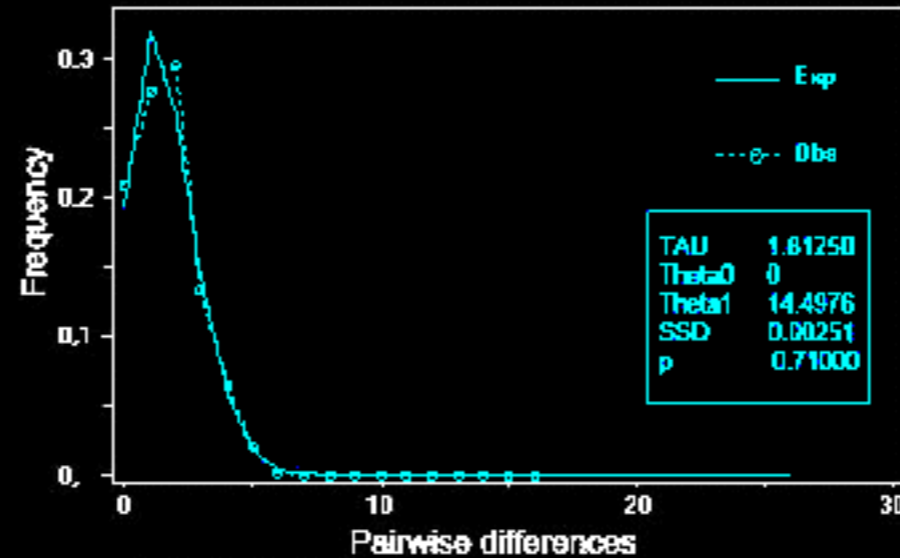
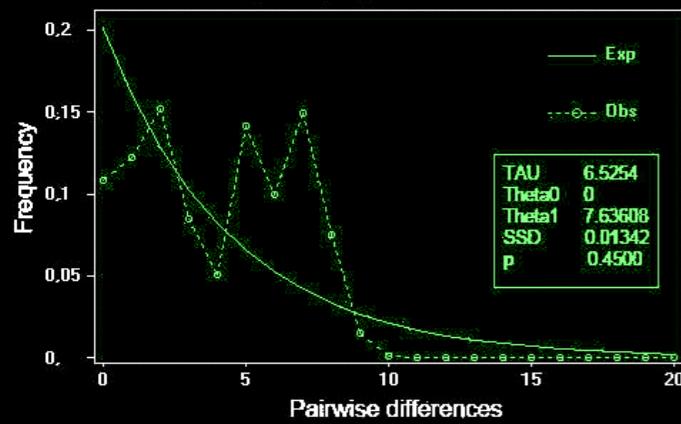






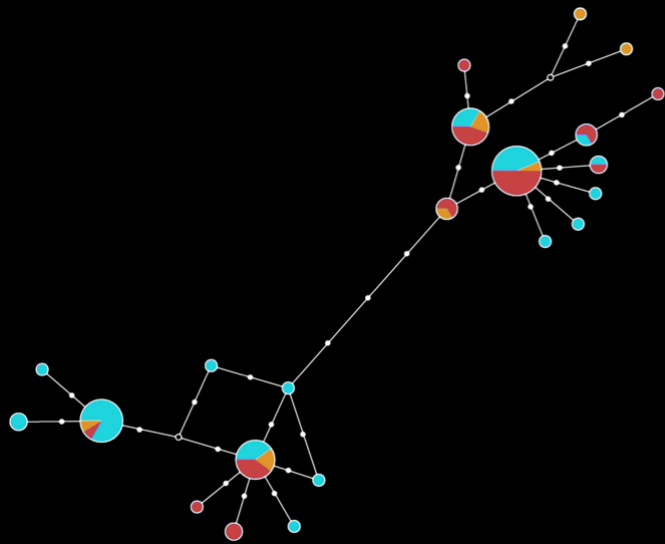
# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION



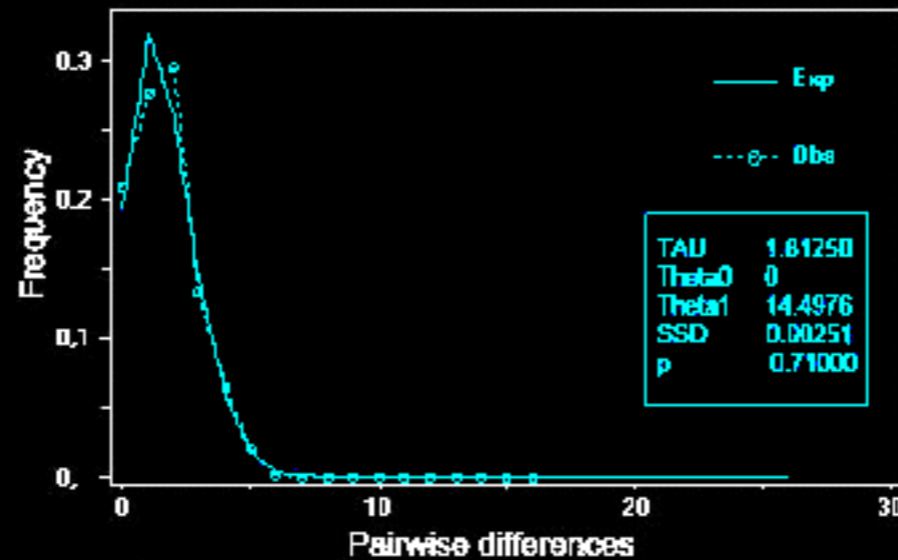
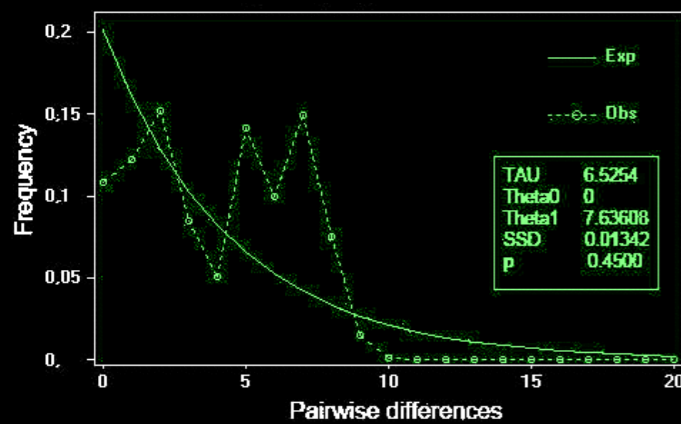
Lineage 1 secondary expansion

- ✓ 73 thousand years ago
- ✓ Pleistocene Günz Mindel Interglacial Period



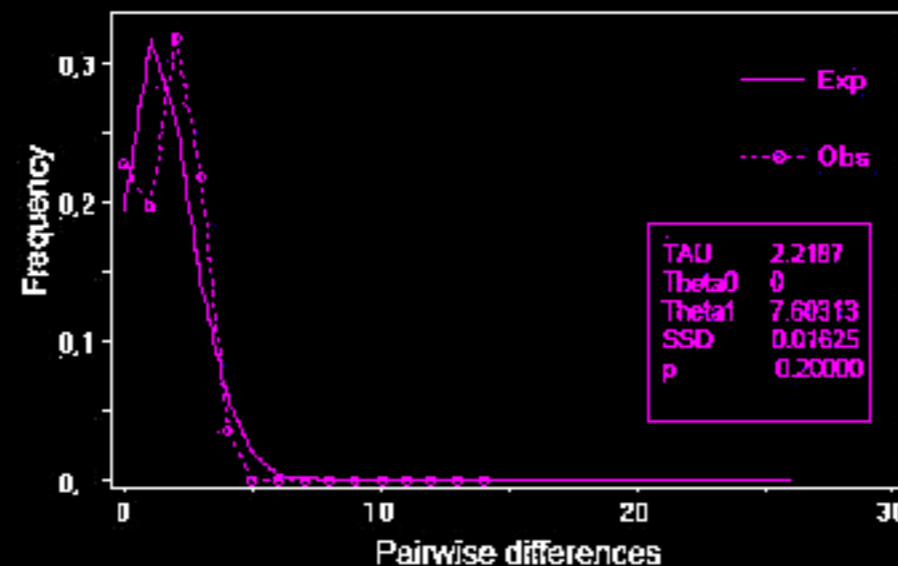
# *Ophryotrocha mediterranea*

## MISMATCH DISTRIBUTION



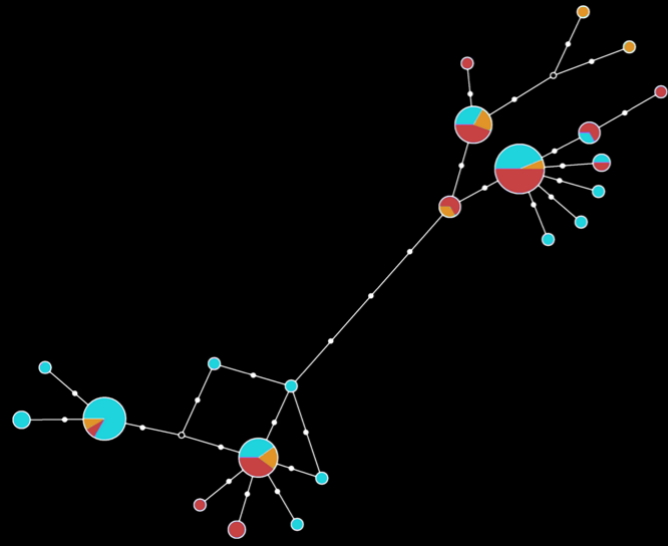
### Lineage 1 secondary expansion

- ✓ 73 thousand years ago
- ✓ Pleistocene Günz Mindel Interglacial Period



### Lineage 2 secondary expansion

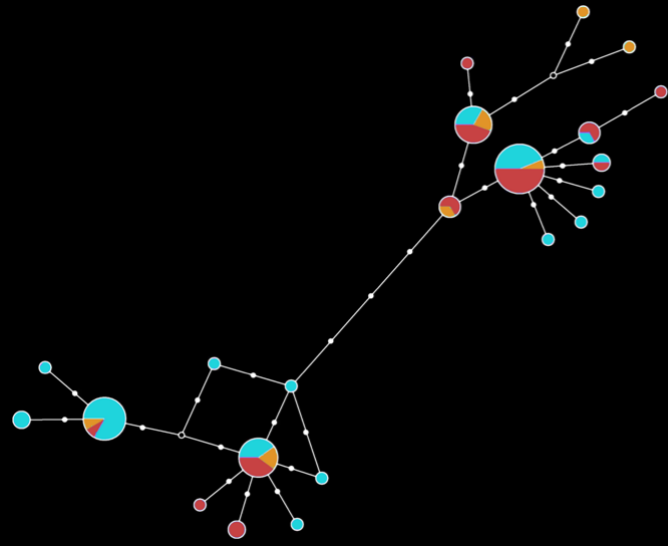
- ✓ 89 thousand years ago
- ✓ Pleistocene Günz Mindel Interglacial Period



# *Ophryotrocha mediterranea*



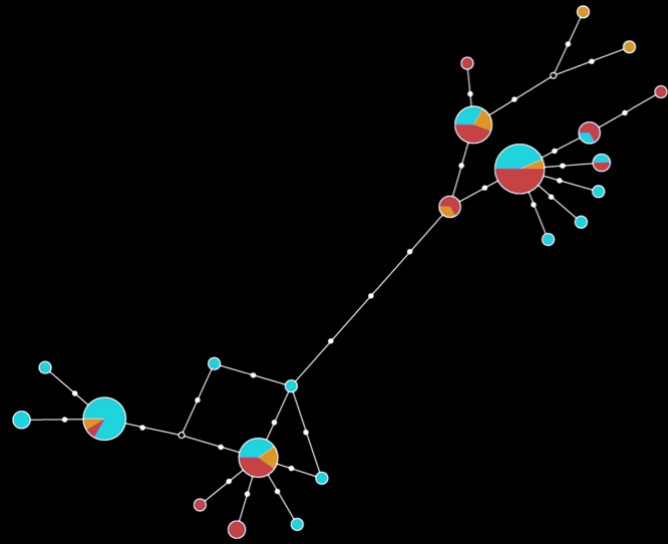




# *Ophryotrocha mediterranea*

## GENETIC DIVERGENCE



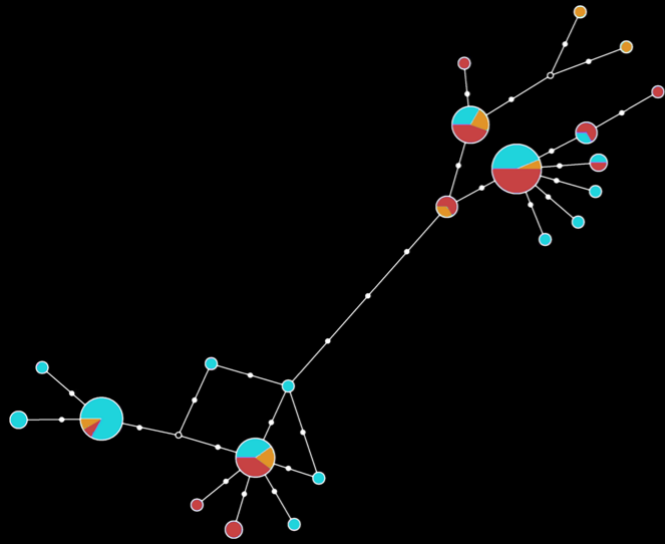


# *Ophryotrocha mediterranea*

## GENETIC DIVERGENCE



✓ Lineage 1 vs. Lineage 2 vs. *Ophryotrocha geryoncola*  $\approx$  1%,

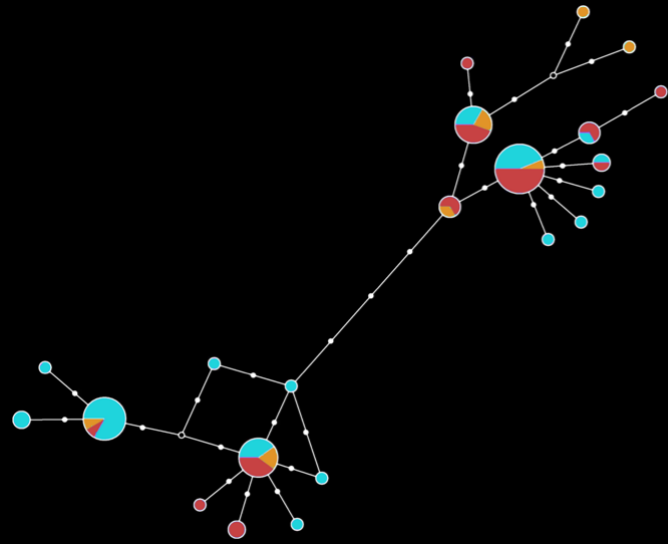


# *Ophryotrocha mediterranea*

## GENETIC DIVERGENCE



- ✓ Lineage 1 vs. Lineage 2 vs. *Ophryotrocha geryoncola*  $\approx$  1%,
- ✓ Vs. non-symbiotic species (*O. adherens* and *O. puerilis*)  $>$  20%



# *Ophryotrocha mediterranea*

## GENETIC DIVERGENCE

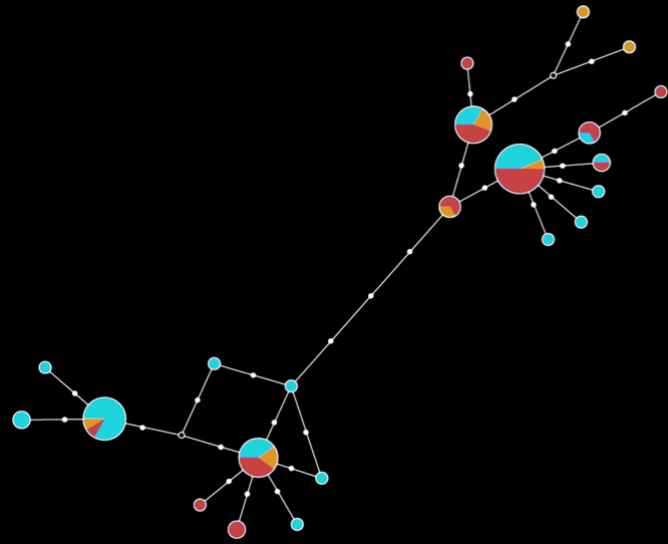


- ✓ Lineage 1 vs. Lineage 2 vs. *Ophryotrocha geryoncola*  $\approx$  1%,
- ✓ Vs. non-symbiotic species (*O. adherens* and *O. puerilis*)  $>$  20%

Wiklund et al. (2012)

- ✓ Subspecies rised to valid species = 18%





# *Ophryotrocha mediterranea*

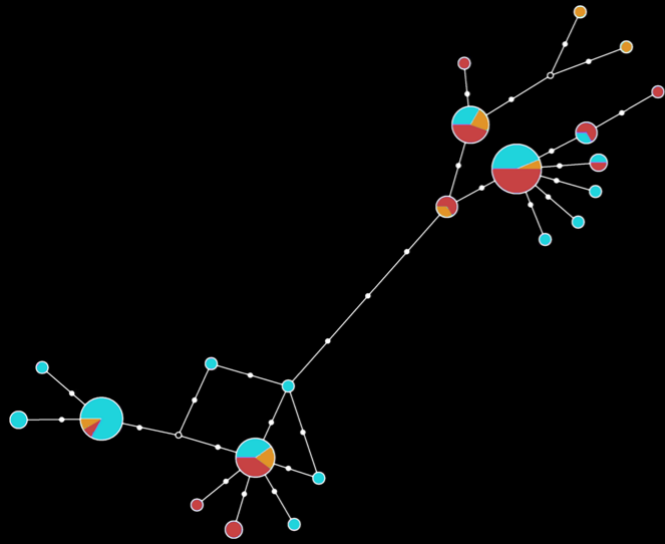
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- ✓ Lineage 1 vs. Lineage 2 vs. *Ophryotrocha geryoncola*  $\approx$  1%,
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### Wiklund et al. (2012)

- ✓ Subspecies rised to valid species = 18%
- ✓ Morphologically similar species as valid, independent taxa = 6%



## *Ophryotrocha mediterranea*

### GENETIC DIVERGENCE



- ✓ Lineage 1 vs. Lineage 2 vs. *Ophryotrocha geryoncola*  $\approx$  1%,
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Wiklund et al. (2012)

- ✓ Subspecies rised to valid species = 18%
- ✓ Morphologically similar species as valid, independent taxa = 6%

*O. mediterranea* could be a junior synonymy *O. geryoncola*



## SUMMARY



## SUMMARY

*Iphitime cuenoti*





## SUMMARY

*Iphitime cuenoti*

- ✓ Population with weak structure



## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations



## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations
- ✓ Highly homogeneous gene flow



## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations
- ✓ Highly homogeneous gene flow
- ✓ Weak barrier effect at the Almería-Oran Front





## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations
- ✓ Highly homogeneous gene flow
- ✓ Weak barrier effect at the Almería-Oran Front
- ✓ Infests several hosts (no specificity)



## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations
- ✓ Highly homogeneous gene flow
- ✓ Weak barrier effect at the Almería-Oran Front
  
- ✓ Infests several hosts (no specificity)
- ✓ Wide bathymetric range



## SUMMARY

### *Iphitime cuenoti*

- ✓ Population with weak structure
- ✓ Recent expansion after the Pleistocene glaciations
- ✓ Highly homogeneous gene flow
- ✓ Weak barrier effect at the Almería-Oran Front
  
- ✓ Infests several hosts (no specificity)
- ✓ Wide bathymetric range
- ✓ Hosts vertical swimming capacity

# SUMMARY





## SUMMARY

*Ophryotrocha mediterranea*



## SUMMARY

### *Ophryotrocha mediterranea*

- ✓ Initial expansion 250 thousand years ago



## SUMMARY

### *Ophryotrocha mediterranea*

- ✓ Initial expansion 250 thousand years ago
- ✓ Two isolated lineages



## SUMMARY

### *Ophryotrocha mediterranea*



- ✓ Initial expansion 250 thousand years ago
- ✓ Two isolated lineages
- ✓ Later contact as a result of expansion after the Pleistocene glaciations



## SUMMARY

### *Ophryotrocha mediterranea*



- ✓ Initial expansion 250 thousand years ago
- ✓ Two isolated lineages
- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation

## SUMMARY

### *Ophryotrocha mediterranea*



- ✓ Initial expansion 250 thousand years ago
- ✓ Two isolated lineages
- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation
- ✓ Homogenized gene flow

## SUMMARY

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- ✓ Initial expansion 250 thousand years ago
- ✓ Two isolated lineages
- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation
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- ✓ Single (slightly) differing population in Eastern Alborán

## SUMMARY

### *Ophryotrocha mediterranea*



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- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation
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- ✓ Single (slightly) differing population in Eastern Alborán
- ✓ Local oceanographic constraints (deep-sea current regime)



## SUMMARY

### *Ophryotrocha mediterranea*



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- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation
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- ✓ Low molecular divergence (Lineage 1 vs. Lineage 2 vs. *O. geryoncola*)

## SUMMARY

### *Ophryotrocha mediterranea*



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- ✓ Later contact as a result of expansion after the Pleistocene glaciations
- ✓ At present: unique metapopulation
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- ✓ *O. mediterranea* could be a junior synonymy of *O. geryoncola*

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### *Ophryotrocha mediterranea*



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- ✓ Further studies of the Atlantic species



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- ✓ Relevant morphological differences
- ✓ Further studies of the Atlantic species
- ✓ Separated by an active barrier vs. extremes of a cline



## FUNDING



- ✓ **JAE-DOC program of the Consejo Superior de Investigaciones Científicas**
- ✓ **Plan Estatal de Investigación Científica y Técnica y de Innovación:**
  - ✓ **CTM2010-22218: Deep-water submarine canyons and slopes in the Mediterranean and Cantabrian seas: from synchrony of external forcings to living resources**
  - ✓ **CGL2011-23306: Evolutionary approach to the taxonomy and phylogeny of the Orden Scleractinia (Cnidaria: Anthozoa: Hexacorallia)**
  - ✓ **CTM2013-43287-P: Evolutionary implications, ecological roles and vulnerability to oceanic changes in marine symbiosis.**
- ✓ **Programme of Consolidated Research Groups of the Generalitat de Catalunya.**
  - ✓ **2014SGR120: CRG on Marine Benthic Ecology.**





Patricia Lattig, Isabel Muñoz,  
Annie Machordom



# MANY THANKS FOR YOUR ATTENTION



Patricia Lattig, Isabel Muñoz,  
Annie Machordom