

Key processes for the rapid diversification of *Cheirolophus* (Asteraceae) on Macaronesian archipelagos

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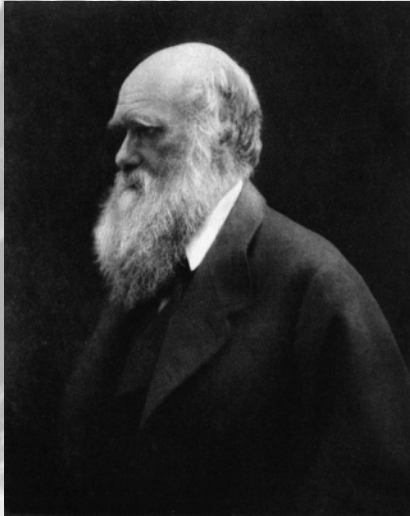


Gobierno de Canarias
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de Investigaciones Agrarias

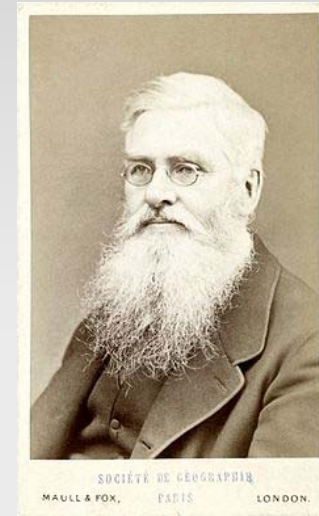


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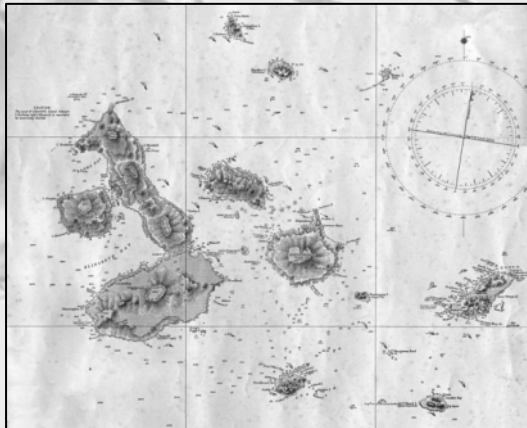
Islands and evolutionary research



Charles R. Darwin
(1809 – 1882)



Alfred R. Wallace
(1823 – 1913)



Galapagos Islands (1836)



Malay archipelago (1869)

Plant diversification on oceanic islands



Hawaii archipelago



Galapagos archipelago



Macaronesian archipelago



Argyroxiphium sandwicense



Dubautia arborea



Dubautia menziesii



Scalesia pedunculata



Scalesia pedunculata



Scalesia incisa



Echium candicans



Echium wildpretii



Echium simplex

The Macaronesian archipelagos

- Five archipelagos:

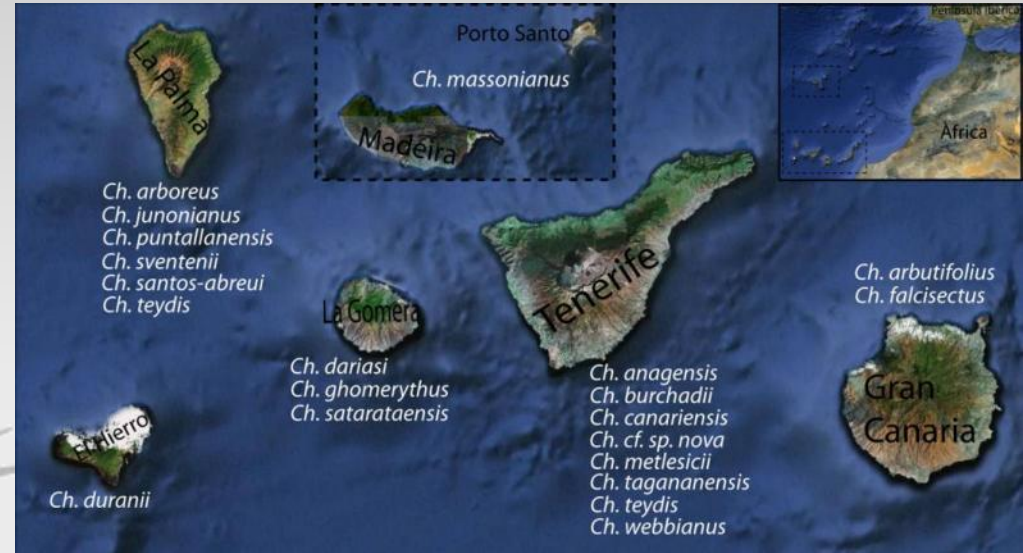
- Azores
- Madeira
- Savage Islands
- Canary Islands
- Cape Verde



- General island features
- Global biodiversity hotspot
- Wide geological age ranges
- Variety of ecological conditions



The Macaronesian *Cheirolophus*



Ch. falcisectus

The IUCN Red List of Threatened Species™ 2013.2

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Enter Red List search terms

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Home > *Cheirolophus falcisectus*

Cheirolophus falcisectus

VIEW MAP

RECENTLY ADDED	NEW	DATA	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	EXTINCT IN THE WILD	EXTINCT
0	0	0	1	0	0	1	0	0	0

Summary | Classification Schemes | Images & External Links | Bibliography | Full Account

Taxonomy (live)

Kingdom	Phylum	Class	Order	Family
PLANTAE	TRACHEOPHYTES	MAGNOLIOPSIDA	ASTERALES	COMPOSITAE

Scientific Name: *Cheirolophus falcisectus*
 Species Authority: Svent. ex Montalongo & Moraleda
 Common Name(s):
 Spanish - Cabezón de Gulgaí, Cabezón Rosado

Taxonomy Assessment Information
 Geographic Range
 Distribution
 Habitat and Ecology
 Threats
 Conservation Actions
 View Printer Friendly

17 Macaronesian *Cheirolophus* endangered



9 included in the IUCN red list

The Macaronesian *Cheirolophus*



Woody increase

Large and numerous inflorescences

Morphological and habitat diversity



Ch. arbutifolius



Ch. burchardii



Ch. satarataensis



Ch. junonianus



Ch. teydis

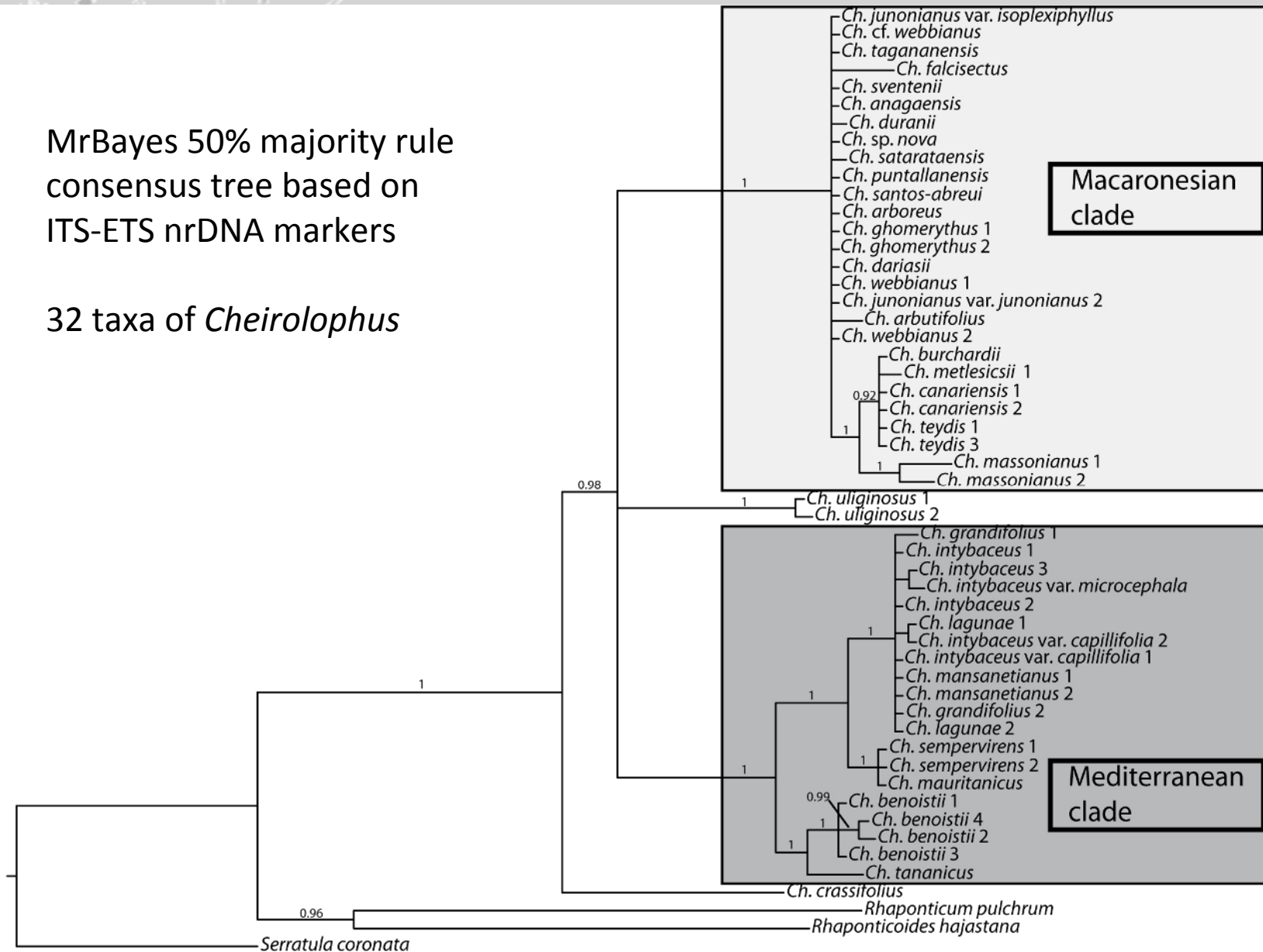


Ch. puntallanensis

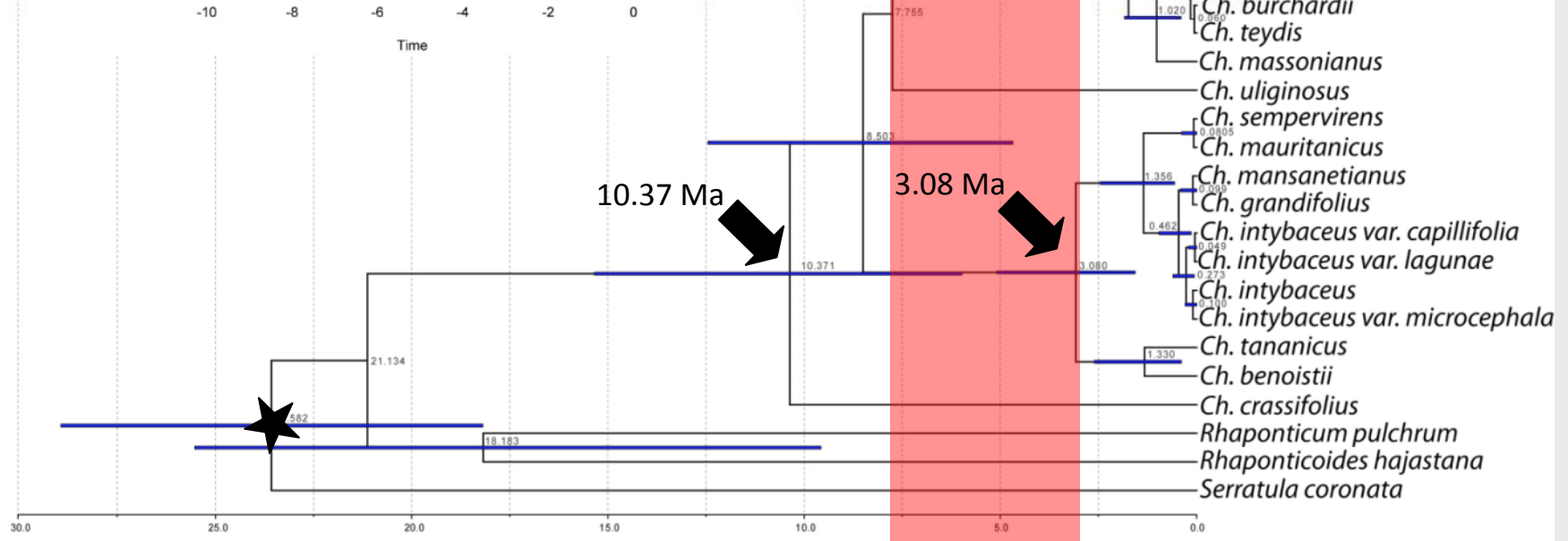
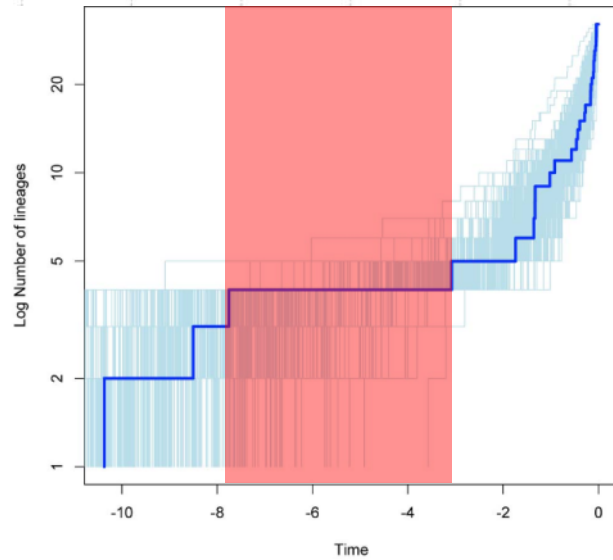
Early evolutionary history of *Cheirolophus*: nrDNA data

MrBayes 50% majority rule consensus tree based on ITS-ETS nrDNA markers

32 taxa of *Cheirolophus*

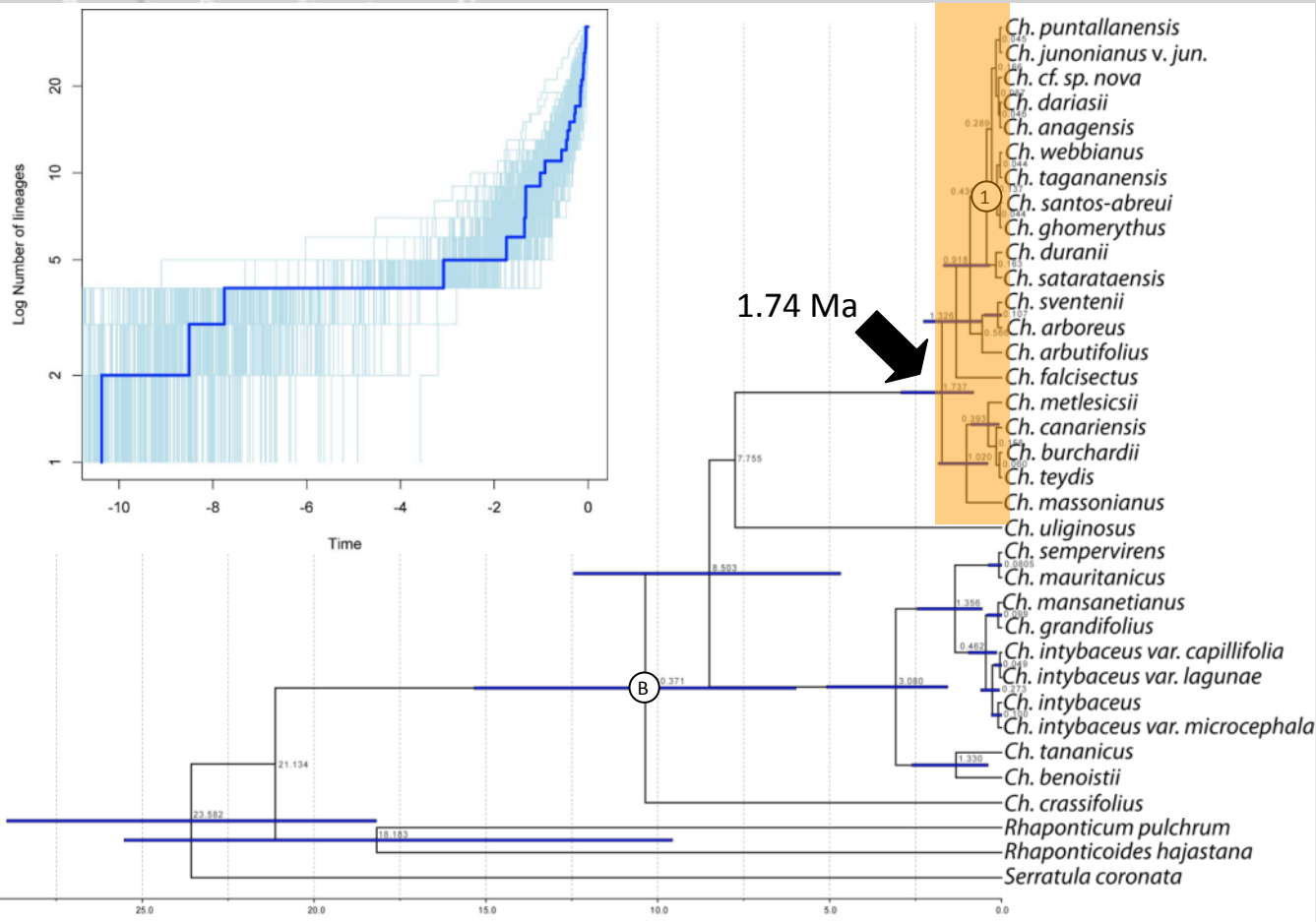


Early evolutionary history of *Cheirolophus*: nrDNA data



★ 24.51 Ma; Barres et al. (2013).

Radiation of *Cheirolophus* in Macaronesia: nrDNA data



- Higher diversification rates in Macaronesian species than for the whole genus (P < 0.05; Magallon & Sanderson 2001)
- Medusa (Alfaro *et al.* 2009) detects significant acceleration in the rate within the Macaronesian radiation (rB = 0.00022 to r1 = 6.55)
- Diversification rate in the Macaronesian clade: **0.34-2.84 species/MY**

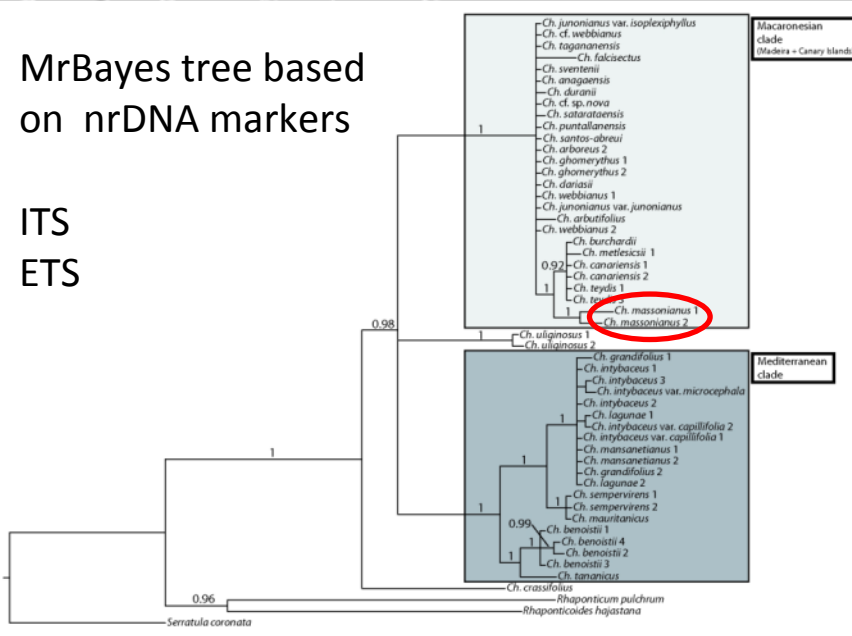
One of the fastest insular plant radiation ever reported (see Knope *et al.* 2012)

The highest per-unit-area rate of diversification observed to date in plants?
 (4.09 x 10⁻⁵ - 3.41 x 10⁻⁴ species/MY· km²)

Radiation of *Cheirolophus* in Macaronesia: incongruence between nrDNA and cpDNA data

A
MrBayes tree based on nrDNA markers

ITS
ETS

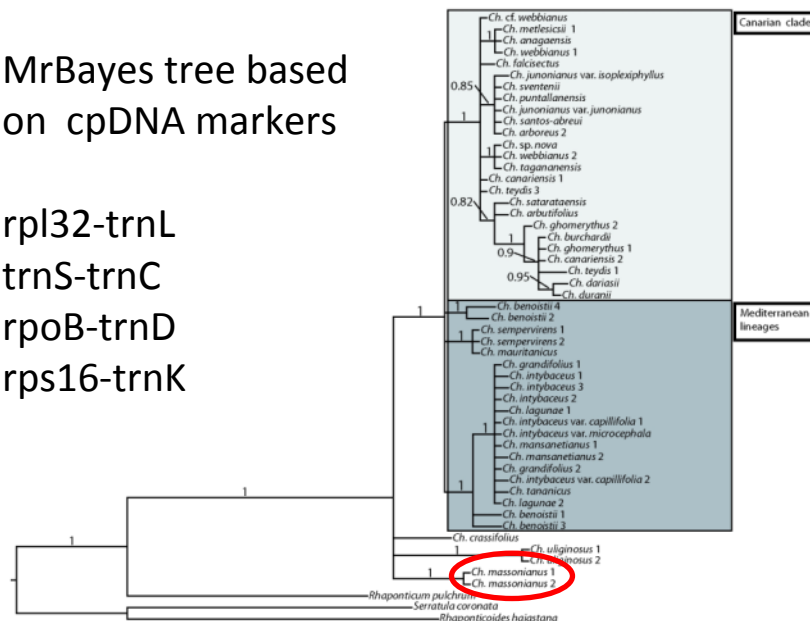


Strong incongruence between nuclear and plastid DNA in the Madeiran endemic *Ch. massonianus*

- Incomplete lineage sorting vs. hybridization hypotheses
 - Plastid signal seems too old for ILS
 - 2C value in *Ch. massonianus* (1.44 pg) is intermediate between continental (1.58 pg) and Canarian species (1.38 pg) (Garnatje et al. 2007)

B
MrBayes tree based on cpDNA markers

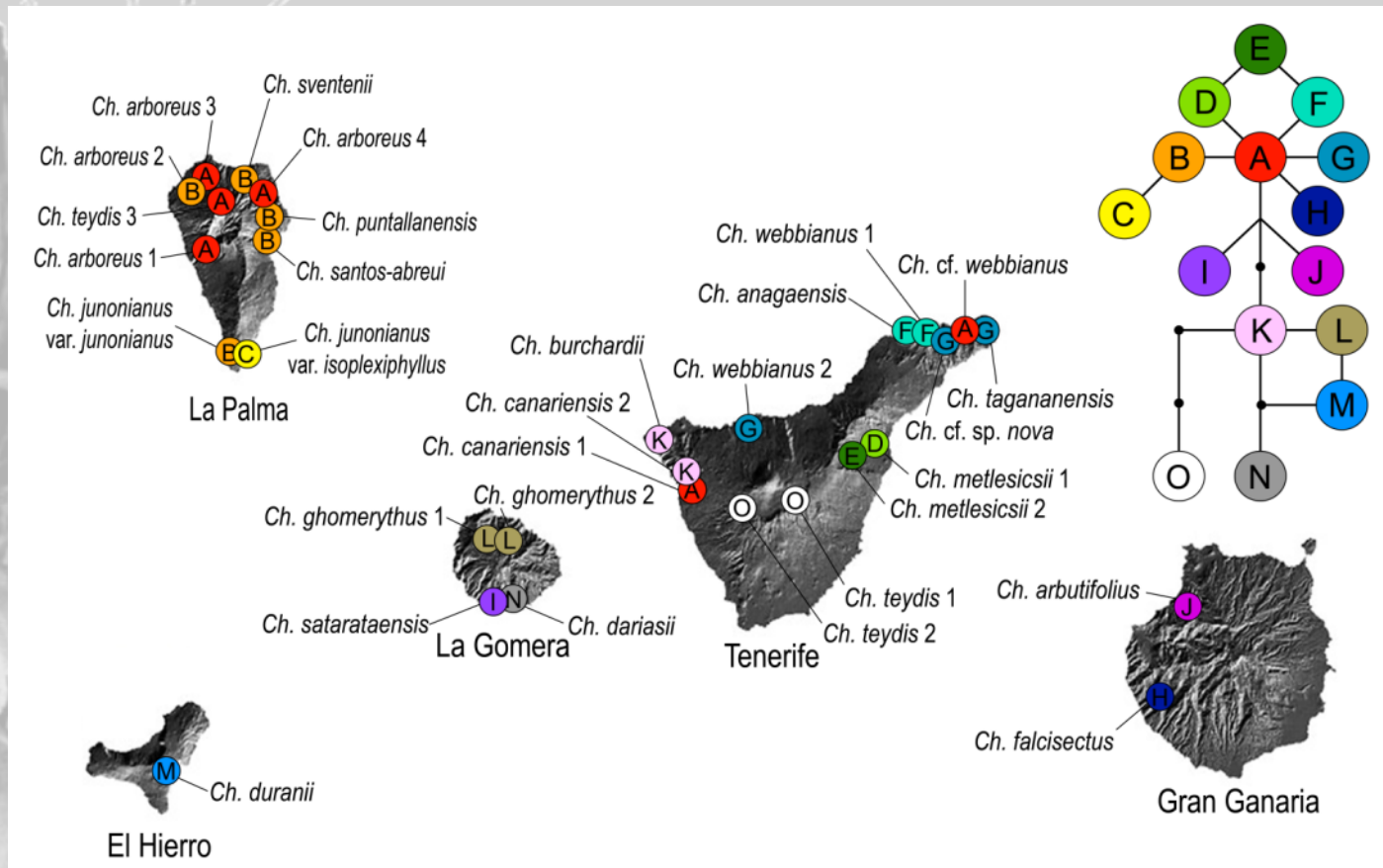
rpl32-trnL
trnS-trnC
rpoB-trnD
rps16-trnK



Hypothesis: hybridization and chloroplast capture from continent



Radiation of *Cheirolophus* in Macaronesia: cpDNA data

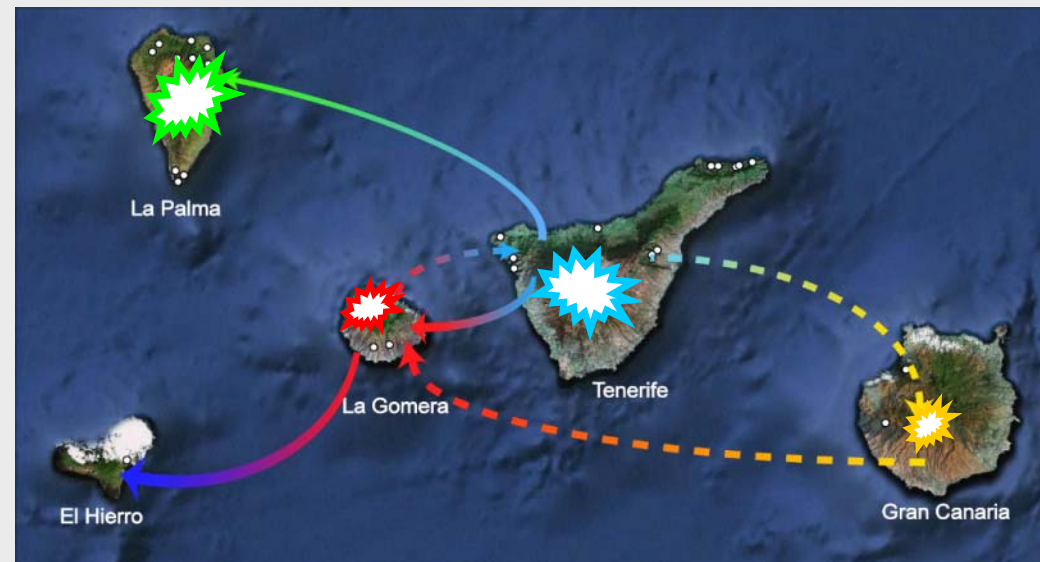
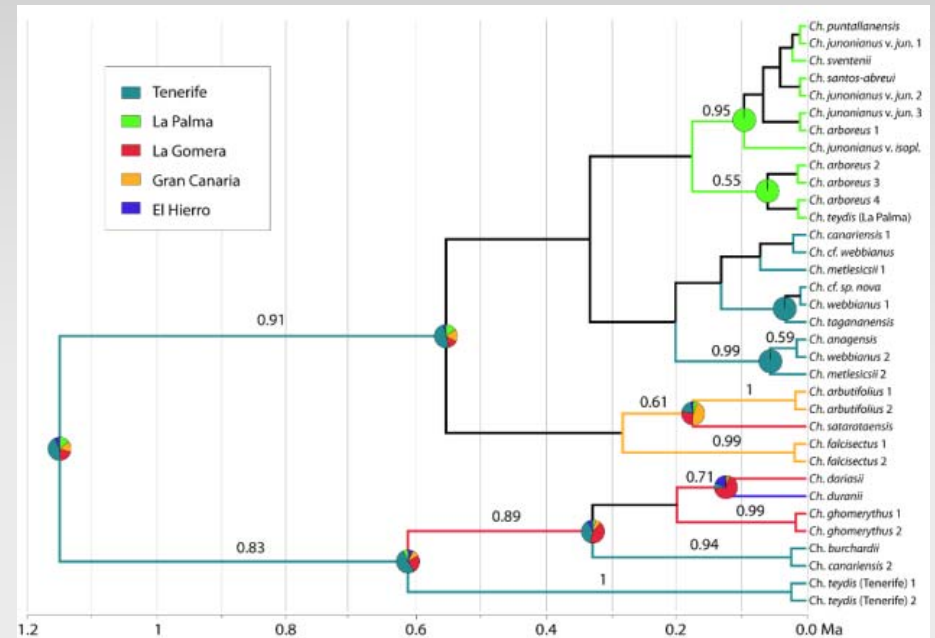


- Four cpDNA regions; 32 Canarian *Cheirolophus* populations; 15 cpDNA haplotypes
- No intra-population diversity has been found
- Clear geographic pattern: only haplotype A is present in two different islands

Radiation of *Cheirolophus* in Macaronesia: cpDNA data

- Multiple processes involved in radiation:

- Colonization between islands
- Intra-island allopatry
- Incipient ecological adaptation

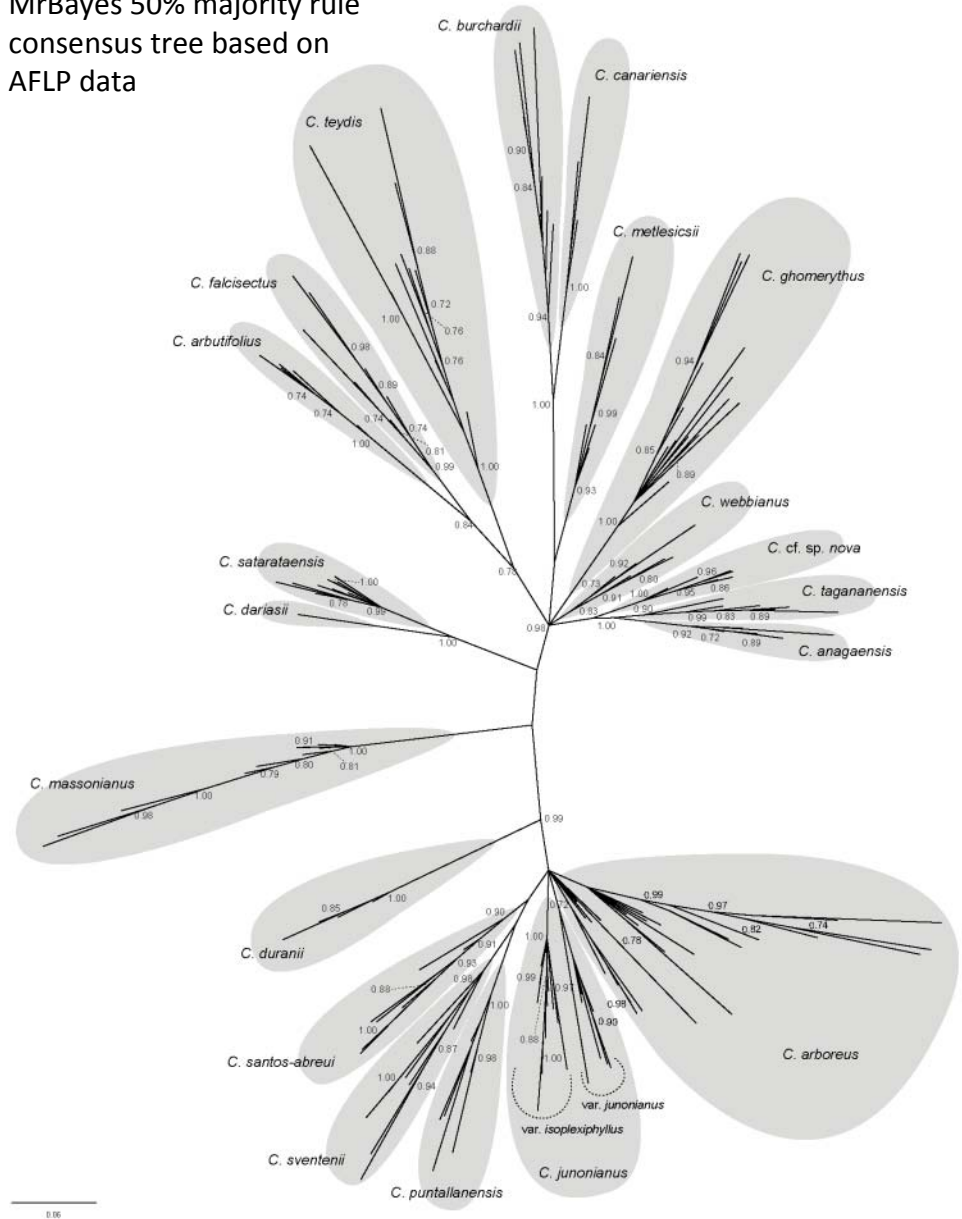


Radiation of *Cheirolophus* in Macaronesia: AFLP data

- 172 individuals
- Three primer combinations
- 249 AFLP loci

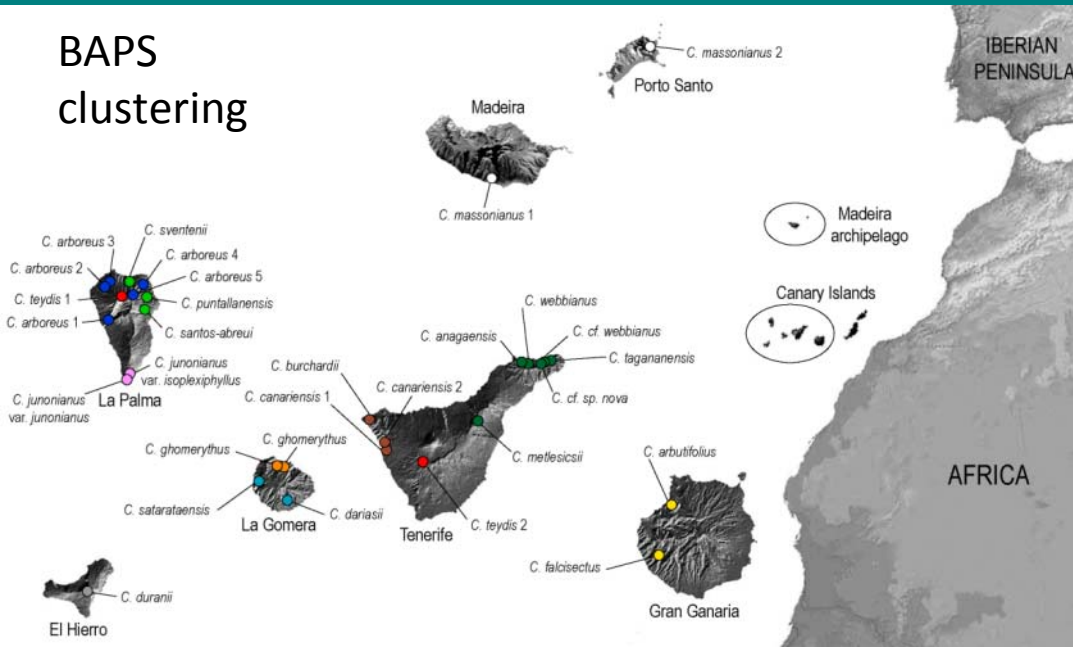
- Genetic distinctiveness among species
- Relationship between species not fully resolved
- Star-like tree pattern supporting explosive radiation

MrBayes 50% majority rule consensus tree based on AFLP data

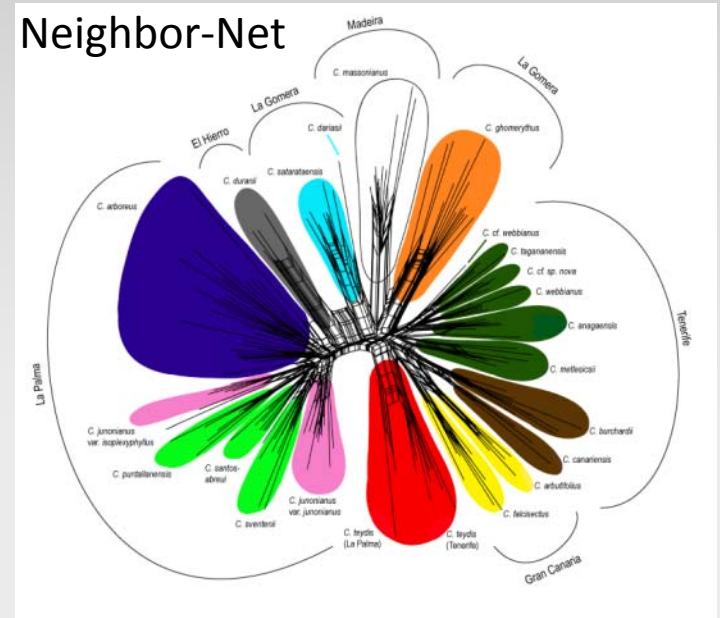


Radiation of *Cheirolophus* in Macaronesia: AFLP data

BAPS clustering



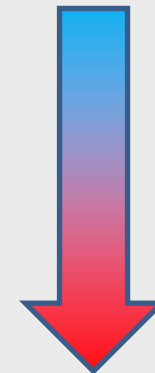
Neighbor-Net



- Geographic pattern of genetic differentiation
- Major role of intra- and inter-island allopatric speciation
- Evidences for ecological divergence



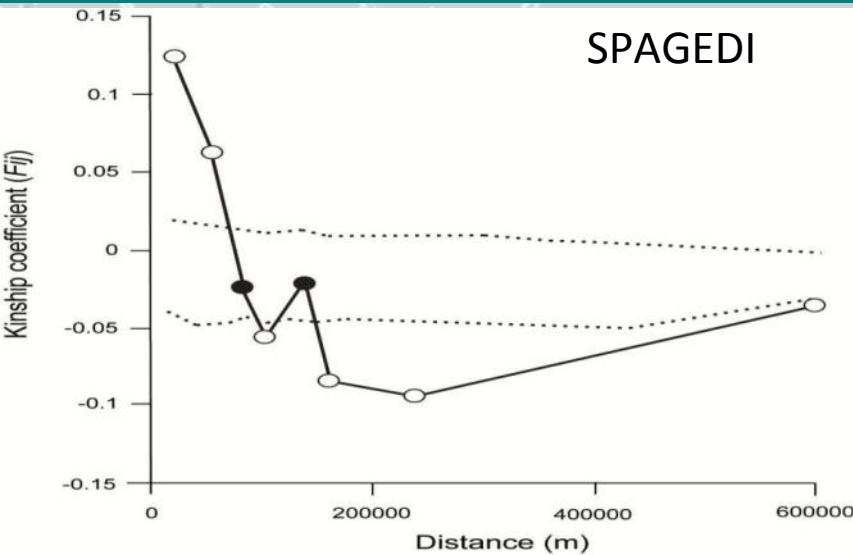
humidity



aridity



Radiation of *Cheirolophus* in Macaronesia: AFLP data

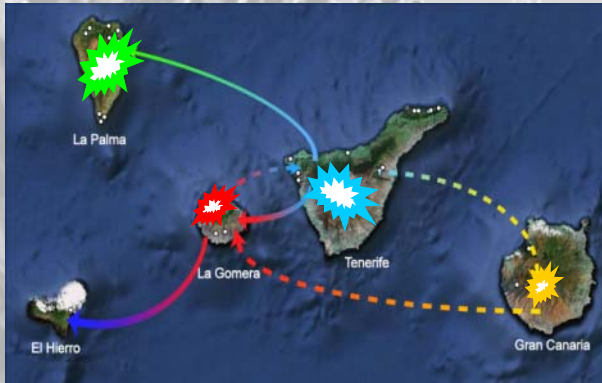


- Strong isolation-by-distance signal
- High values of genetic fragmentation indexes (DW = 198.9 – 350.8)
- Low values of heterozyosity within populations (mean H_j = 0.07892)

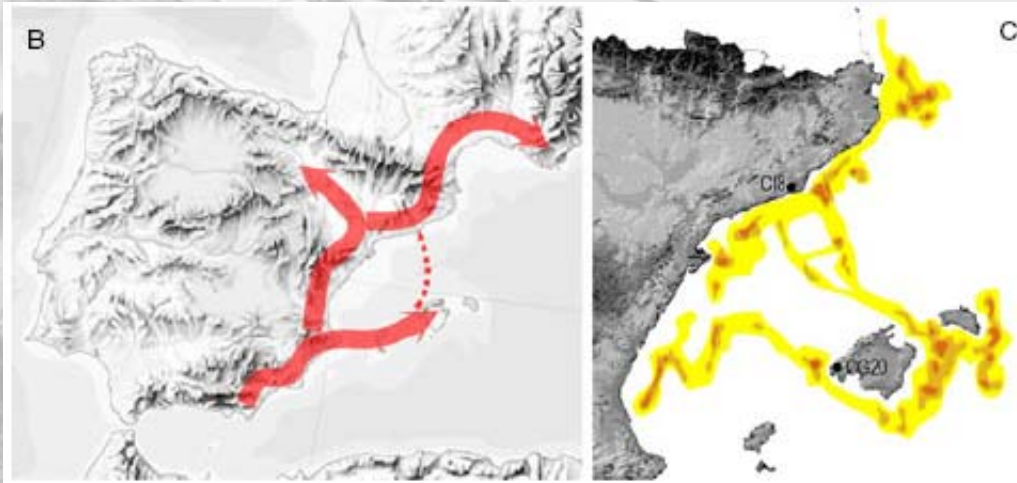


Photo by R. Vilatersana & L. Barres

Radiation of *Cheirolophus* in Macaronesia: AFLP data



- Multiple colonizations intra- and inter-islands
- Sporadic long distance dispersal ability



Ch. intybaceus AFLP study; Garnatje et al. (2012)

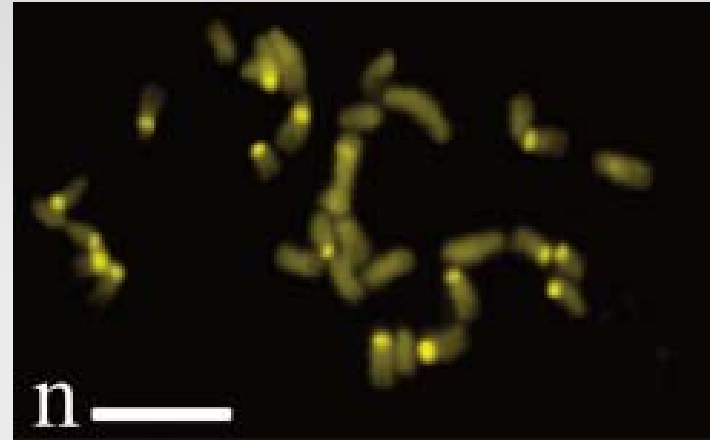


Calonectris diomedea

Radiation of *Cheirolophus* in Macaronesia: AFLP data



Ch. webbianus



Chromosomes of *Ch. webbianus*

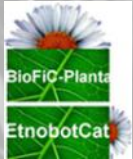
Other plant features favoring allopatric speciation:

- Pseudo-self-compatibility -> Colonization success
- Polyploid origin ($x = 15$) -> Higher genetic diversity

Conclusions

- Macaronesian diversity of *Cheirolophus* is the result of a recent and explosive radiation
- Allopatric speciation, incipient adaptive radiation and hybridisation events were involved in this process
- The unlikely combination of poor genetic flow ability but good conditions for sporadic long-distance colonization may well have facilitated diversification in *Cheirolophus*

Thanks for your attention!



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