

Climate change and the evolutionary challenge of Mediterranean biodiversity

Bruno Fady, Alberte Bondeau, Marc Bally, Wolfgang Cramer, Thierry Gauquelin, Jean-Pierre Féral, Anne-Christine Monnet, Séverine Thomas, France van Wambeke, Anne Chenuil, et al.

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Climate change and the evolutionary challenge of Mediterranean biodiversity



C. Pujos / ONF



F. Zuberer / CNRS

B. Fady, M. Bally, A. Bondeau, F. Carlotti, A. Chenuil, W. Cramer, J-P. Féral, T. Gauquelin, A-C. Monnet, S. Thomas, F. Van Wambeke, D. Aurelle

bruno.fady@inra.fr







Institut Pythéas Observatoire des Sciences de l'Univers Aix*Marseille Université





Climate change and the evolutionary challenge of Mediterranean biodiversity





Ecological gradients and genetic adaptation to climate change in the Mediterranean

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The Mediterranean paradox: High (taxonomic, genetic, functional) biodiversity despite long-term human pressure

- Land: 1.8 % of earth's land mass; 20 % of flowering plants and ferns; 5,500 endemic plant species.
- Sea: 0.8% of the surface of the global ocean; 4 to 18% of the world biodiversity
- Birth of agriculture: 10-12,000 years ago
- \sim Total current population: 500 millions + \sim 270 millions tourists annually



Current climate change pattern: ~+0.2°C / decade 2nd half 20th century, increased summer drought

Climate change in the Mediterranean: unprecedented biome composition change is expected



Left: Percentage of land that underwent a biome composition change during the Holocene based on pollen archives compared to present day composition.

Right:

Biome composition change that can be expected under different climate change scenarios

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Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide. => a wealth of highly diverse landscapes and micro-habitats



average of the global land surface. **c**, A global map of climate velocity calculated using the 2050–2100 Special Report on Emissions Scenarios (SRES) A1B emissions scenario temporal gradient.

Steep habitat / ecological gradients: also in marine systems

Strong temperature stratification of shallow sea water during the summer in the north-western Mediterranean



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Looking for differentiation and signatures of selection in Mediterranean marine and terrestrial forests along ecological gradients







 \rightarrow Mediterranean ecological gradients = strong potential for local adaptation (temperature, light, drought, etc)

(Cailleret et al., GCB 2016; Garrabou et al., SciRep 2017; Ledoux et al., MolEcol 2010; Linares et al., Ecology 2007; Nathan & Muller-Landau, TREE 2000)

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Similarities between Mediterranean marine and terrestrial forests:

- **sessile** engineer species: long-lived anthozoans or algae, conifers and broadleaves
- "pulse like" recruitment;
- propagule dispersal possible across entire gradient;
- range shift limitations under climate change:

* marine: no possibility of northward expansion;

* terrestrial: no possibility of upward expansion on low mountains;

- **mortality** linked to heat wave events (T° + pathogens).





(Crisci et al., SciRep 2017; Haguenauer et al., JEMBE 2013; Pivotto et al., RSOS 2015)

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Mediterranean marine forests : gorgonians

- evolution along depth / temperature gradient
- thermotolerance differences (shallow > deep)
- variable differentiation between depths





40 m depth colonies

20 m depth colonies



Eunicella cavolini (Yellow gorgonian)

-> determinism / heritability of fitness differences?

Mediterranean marine forests :

- genomic (RAD-Seq) structure along depth gradients (8-40 m) in *Corallium rubrum;*

- significant differentiation among sites (++) and different depths (+);
- Higher differentiation between shallow than between deep populations.

=> Barriers to gene flow in shallow populations / cryptic species?

Outlier loci, see poster P-0585, S

poster P-0585, S. 66 (Aurelle et al.) on Sunday







(Roschanski et al, MolEcol 2016)

Evidence of signature of selection for drought and frost along steep ecological gradients in the conifer tree *Abies alba* in southern France









Modeling the rate of adaptive evolution of spring leaf unfolding after 5 generations along a steep altitudinal gradient (Fagus sylvatica)



(A): Neutral

- (B): adaptive evolution
- (C): adaptive evolution without mortality



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Conclusion (1) - implications for research:

Rapid local adaptation at short spatial scale is possible along steep ecological gradients.

Experimental design for detecting local adaptation: genome scan replicates *sensu* Lotterhos & Whitlock (MolEcol 2015) and reciprocal transplants.

See project GenTree: http://www.gentree-h2020.eu/





Mediterranean = steep ecological gradients = ideal biome for research on signatures of selection and local adaptation!

evolution

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Conclusion (2) – Evolutionary application for *in situ* **conservation:**

Conservation planning needs to focus on areas where there are steep ecological gradients which can foster natural selection and adaptation (e.g. coastal depth gradients; mountain sides).

Include evolutionary thinking in conservation planning!

See session S76. Evolutionary management of wild populations Wed, 22 August, starting 09:25 (Rabelais room)