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 Wambreke, Anne Chenuil, et al.

To cite this version:
Bruno Fady, Alberte Bondeau, Marc Bally, Wolfgang Cramer, Thierry Gauquelin, et al.. Climate change and the evolutionary challenge of Mediterranean biodiversity. 2. Joint Congress on Evolutionary Biology (EVOLUTION 2018), Aug 2018, Montpellier, France. 2018. hal-02737804

HAL Id: hal-02737804
https://hal.inrae.fr/hal-02737804
Submitted on 2 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Climate change and the evolutionary challenge of Mediterranean biodiversity


bruno.fady@inra.fr
Climate change and the evolutionary challenge of Mediterranean biodiversity

Ecological gradients and genetic adaptation to climate change in the Mediterranean
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
- Total current population: 500 millions + ~270 millions tourists annually

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

(Coll et al., PloS-ONE 2010; Médail & Quézel, AMBG 1997; Fady & Conord, DivDist 2010; Thompson 2005)
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
Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide.
=> a wealth of highly diverse landscapes and micro-habitats

(Loarie et al, Nature 2009)
Steep habitat / ecological gradients: also in marine systems

Strong temperature stratification of shallow sea water during the summer in the north-western Mediterranean
Looking for differentiation and signatures of selection in Mediterranean marine and terrestrial forests along ecological gradients

→ Mediterranean ecological gradients = strong potential for local adaptation (temperature, light, drought, etc)
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 ($T^\circ +$ pathogens).

Mediterranean marine forests: gorgonians
- evolution along depth / temperature gradient
- thermotolerance differences (shallow > deep)
- variable differentiation between depths

Cumulative necrosis risk response to experimental thermal stress (27°C)

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.

$\text{F}_{\text{ST}}$  

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

$\Rightarrow$ Barriers to gene flow in shallow populations / cryptic species?
Evidence of signature of selection for drought and frost along steep ecological gradients in the conifer tree *Abies alba* in southern France

(Roschanski et al, MolEcol 2016)
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
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!
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)