**Fire shapes plant traits**

**Introduction & Evidence from the Mediterranean Basin**

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**CONTENTS**

- How our perception of fire has changed
- Misconceptions: Adaptation vs Exaptation
- Contributions from macro- and micro evolutionary approaches
- Mediterranean Basin examples

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**Fires as disasters**

- They burn ecosystems!
- Static, short view
- Outdated view

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**Fire as an ecosystem process**

- Ecosystems regenerate after fire
- Fire changes community structure and ecosystem functioning
- Now widely accepted
- Example: Grass – fire cycle (feedbacks)

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**Fires as an old phenomena**

- Charcoal: from Silurian (>415 My) ...
- Periods of higher [O₂]: high flammability
- Started to be recognised

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**Fire as an old ecosystem process**

- Expansion of C₄ grasses, Miocene (Keeley & Rundel 2005)
- Expansion of Angiosperms, Cretaceous (Bond & Scott 2011)
Fire as an evolutionary process

- Growing evidence that fire acted as a selective force in the evolution of plants (adaptations to fire)
- Hard to believe for many...
- “Fire traits are not adaptations but exaptations”

Adaptation vs Exaptation

Is fire shaping traits?

- Macro-evolutionary approaches:
  - Molecular data: time-calibrated phylogenies
  - Correlated evolution
  - Ancestral reconstructions

Macro-evolution: early studies

- Pinus
  - Basal split between fire-prone and non-fire-prone pines
  - No dating

- Pausas & Verdú 2005 Oikos

Macro-evolution: recent evidence (2011)

- The blooming of molecular data: dated phylogenies

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Trait State</th>
<th>Age (Ma)</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lindstroemia regale</td>
<td>Seed production</td>
<td>164</td>
<td>He et al. 2011 New Phytol.</td>
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</tbody>
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Is fire shaping traits?

- Macro-evolutionary approaches:
  - Molecular data: time-calibrated phylogenies
  - Correlated evolution
  - Ancestral reconstructions

- Micro-evolutionary approaches
  - Trait divergences between populations under different fire regimes
  - Differential fitness among phenotypes
  - 2 examples from the Mediterranean Basin
1. Trait divergence: flammability

Seeder species

- Adult
- Open spaces
- Recruitment

Plant flammability

(heritability)

H: recurrent fires enhance flammability

Flammability: *Ulex parviflorus*

Obligate seeder

E: Spain

Selective environments:

HiFi: Recurrently burned
NoFi: Oldfield colonization

Flammability: HiFi > NoFi

Trait divergence

2. Trait divergence: serotiny

- Adult
- Open spaces
- Recruitment

Serotiny

(heritability)

H: recurrent fires enhance serotiny

Fire enhances serotiny

HiFi: Populations recurrently burned in crown-fires
LowFi: Populations rarely burned in crown-fires

Serotiny = # closed (≥2yr) / total cones

Conclusions

- Phylogenetic studies unambiguously show that fire has been a selective force shaping traits for very long, at least since Palaeocene (~60 My), but probably longer (studies are coming)

- There is field evidence suggesting that currently, different fire regimes selects different traits (natural selection in action)
  - More studies, including genetic studies (heritability, etc.) are still needed
The co-evolution of serotinous cones and thick bark

Thanks!

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