

Range expansion of the pine processionary moth (*Thaumetopoea pityocampa*) in relation to climate warming

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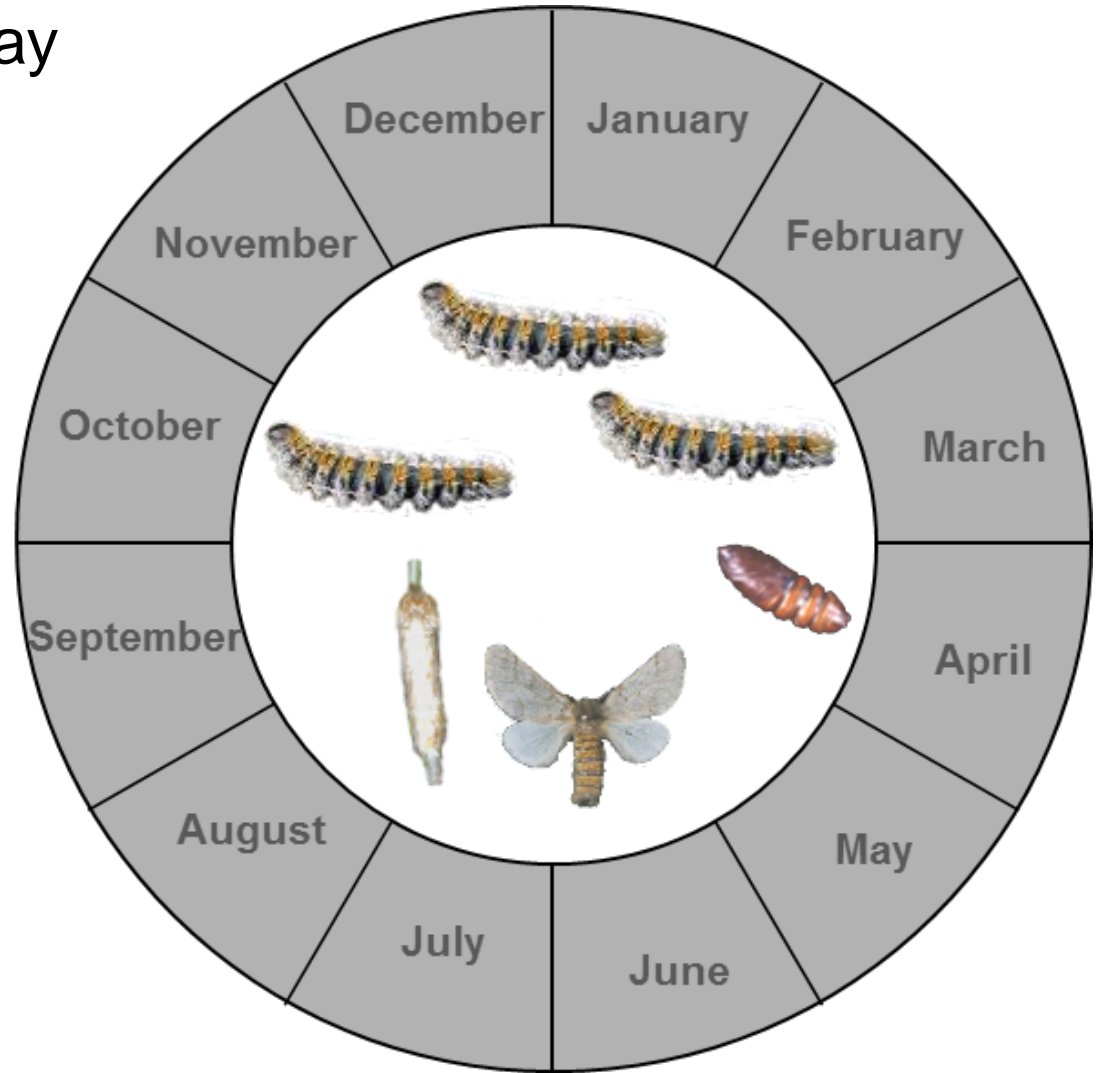
Swedish Agricultural University, Sweden

INRA, France

A winter-feeding insect with flexible duration of the larval stage



Day



Night

What affects the larval performance in winter

1) **Immediate temperature effects**

- Super cooling point (-7°C)
- Lower Lethal Temperature (-17°C)

Hoch et al. (2009)

2) **Cumulative temperature effects on feeding**

→ larvae starve unless:

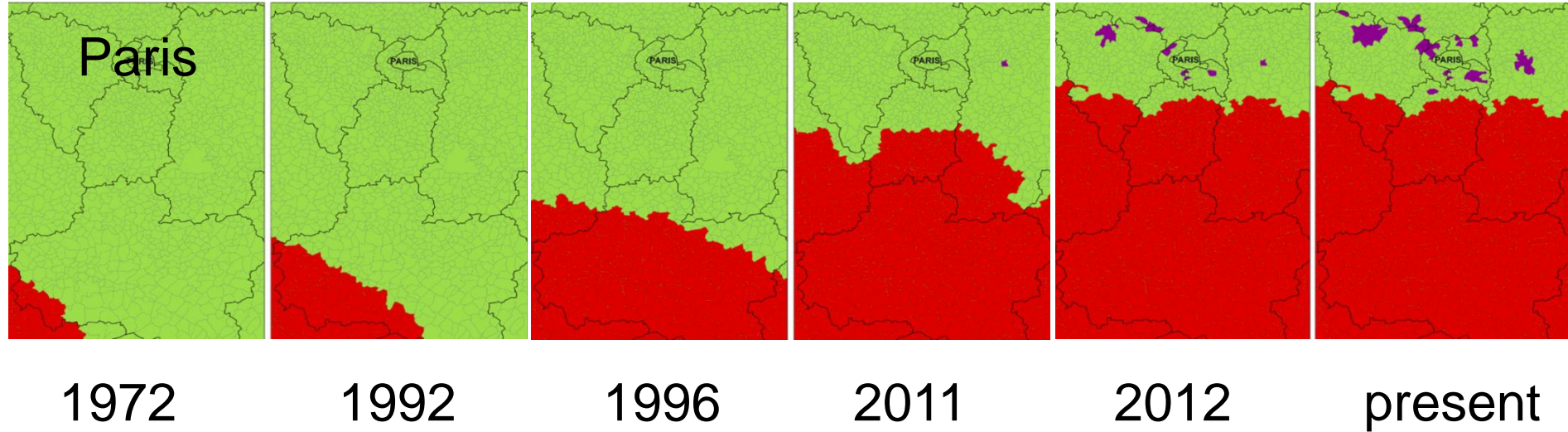
night air temp > 0°C

AND

previous daytime tent temp > 9°C

Battisti et al. (2005)

Last four decades → latitudinal and elevational range expansion

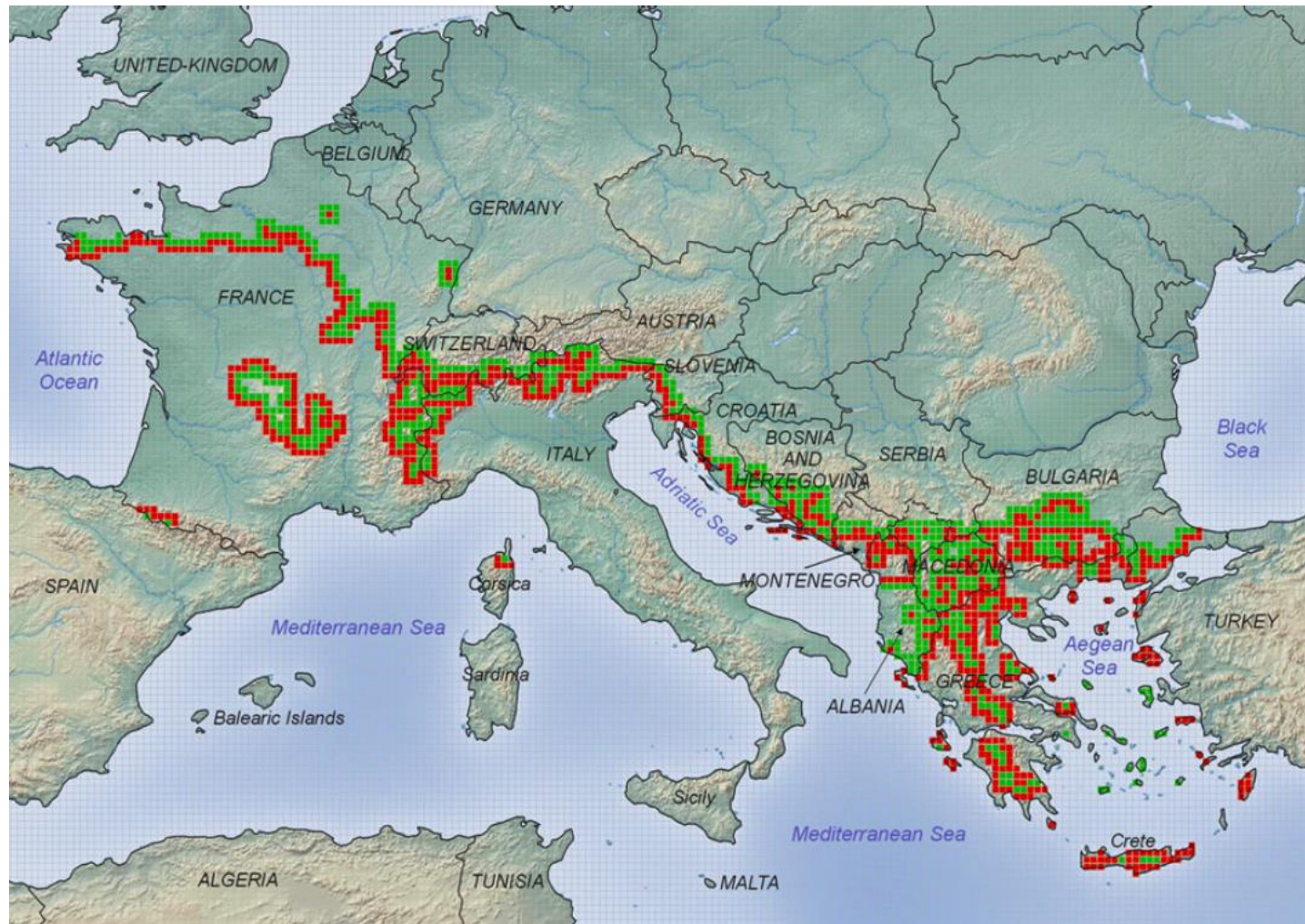


Alps



Roques et al., 2014

Present upper range (red squares 16x16 km) and contiguous available range still free (green squares)

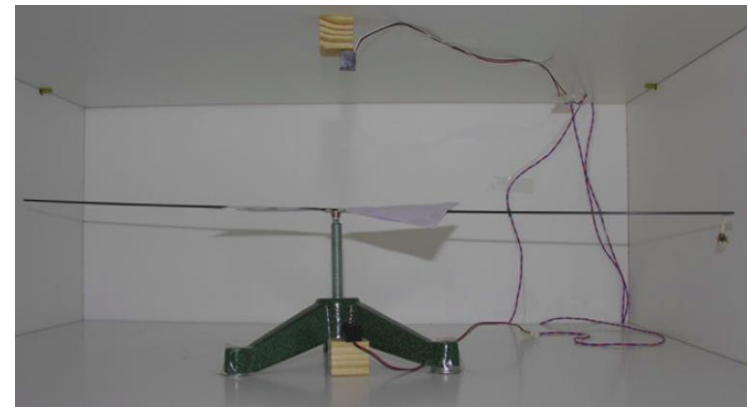
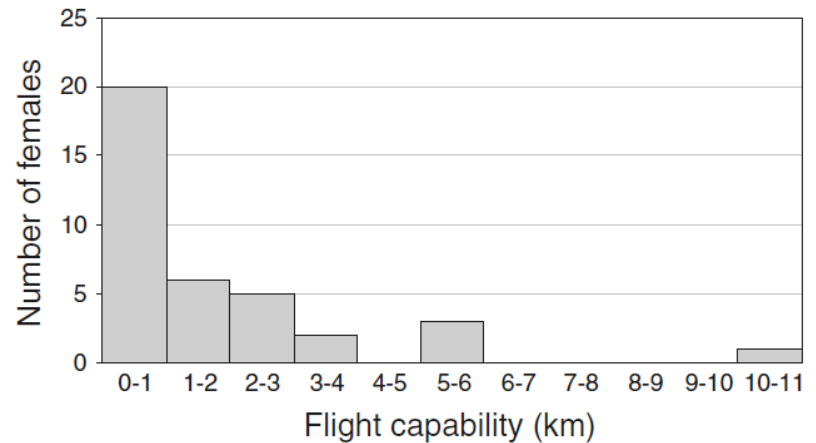


Dispersal is continuous in nature:

- latitudinal shift of 2.7 km/year
- elevational shift of 7 m/year

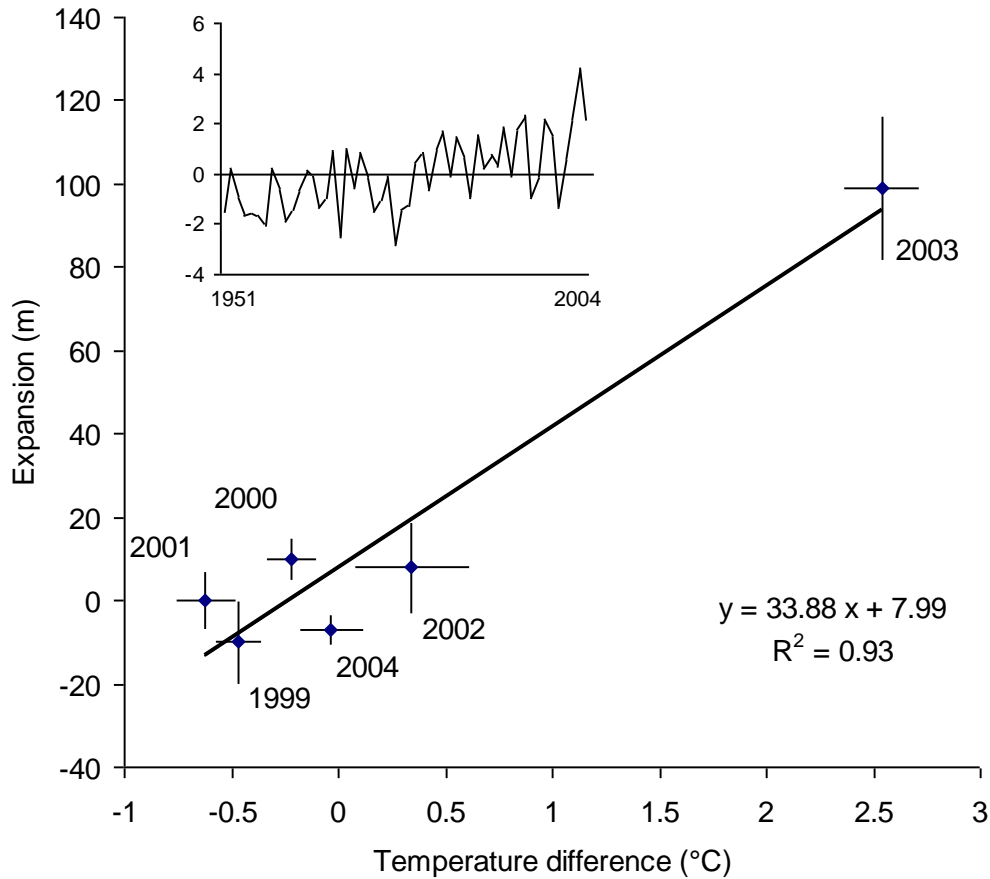
averaged over 40 years

and supported by flight mill data



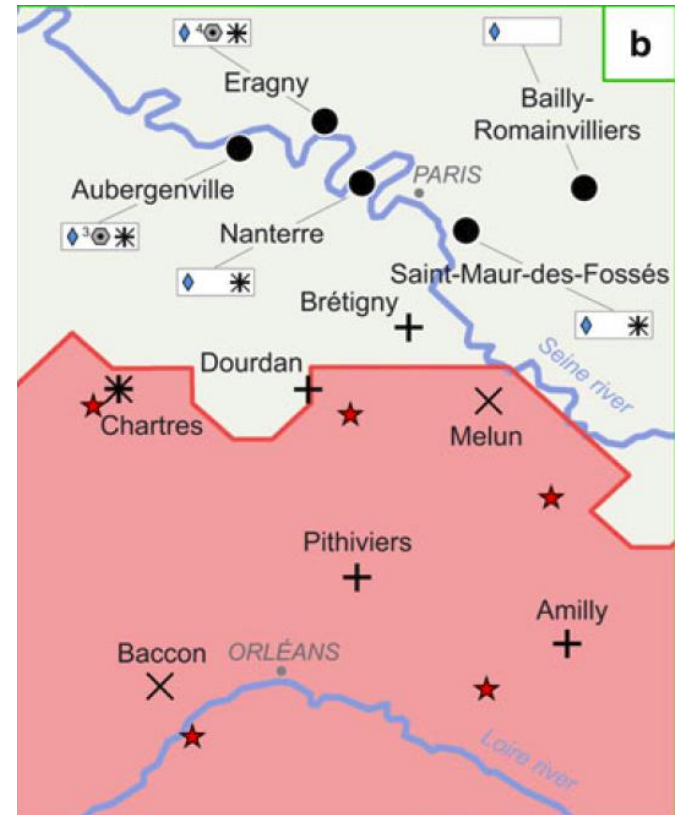
But long distance jumps may occur

Because of warm summer



Battisti et al., 2006

Human-mediated



Robinet et al., 2011 and 2013

Summary

1) **Larvae tolerate cold** (physiological and behavioral adaptations)

→ development possible in environments outside the original range

2) **Pupae can enter prolonged diapause**

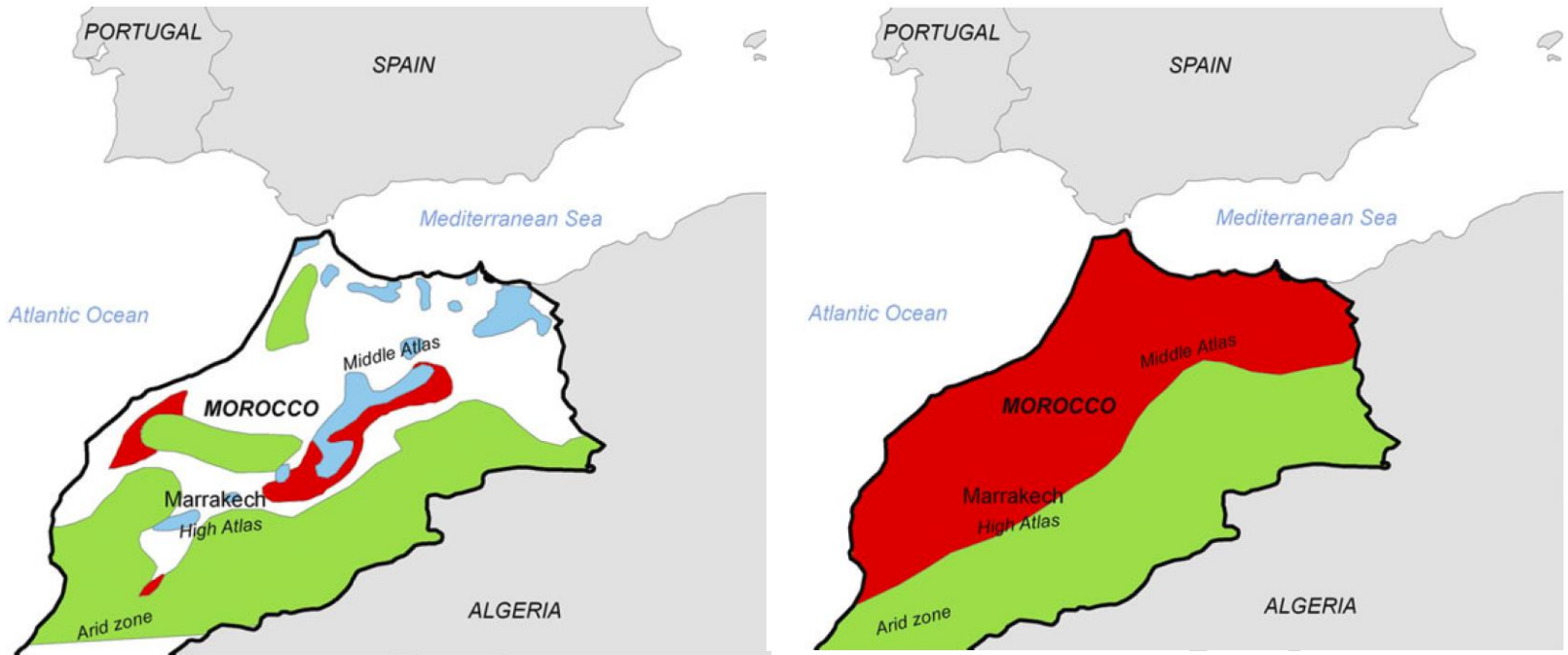
→ bet-hedging strategy balances larval mortality events



population persistence at extreme sites

What happens at the southern edge of the range

- No retraction at the edge of Sahara (Maghreb countries)
- Expansion to high elevation (outbreaks on Atlas cedar and pine plantations in High Atlas mountains)



1979

Green: unsuitable areas
Blue: potential expansion
Red: range

present

Synthesis

- **expansion of *T. pityocampa* depends on temperature**
 - expansion rate depends on dispersal capacity
 - dispersal is enhanced during warmer-than-average summers
- **human driven range expansion is important**
- **climate change in general and extreme climatic events both contribute to species range dynamics**