Can butterflies stand the heat? The physiological consequences of increased warming in diapausing *Pieris rapae* butterflies

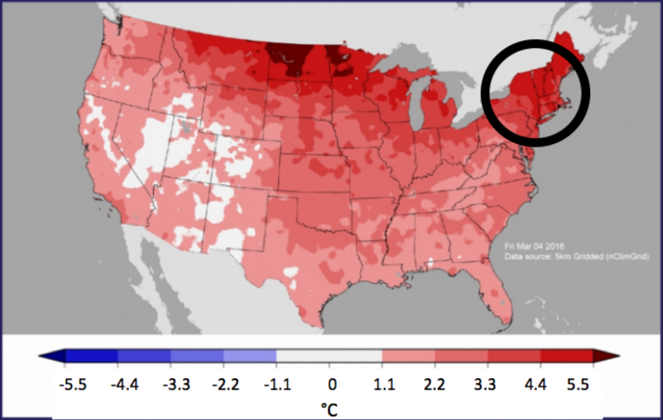
Emily Mikucki

2/1/2017

Mean temperature departure from average

Dec. 2015 – Feb. 2016 (Winter)

Base Period: 1901 – 2000

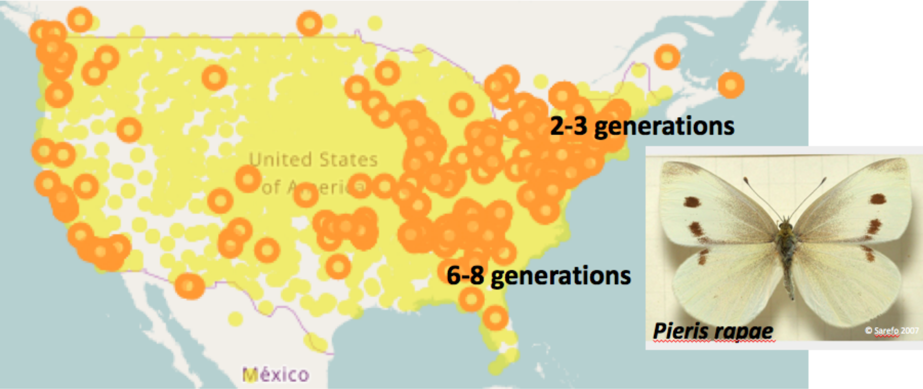


NOAA National Centers for Environmental Information

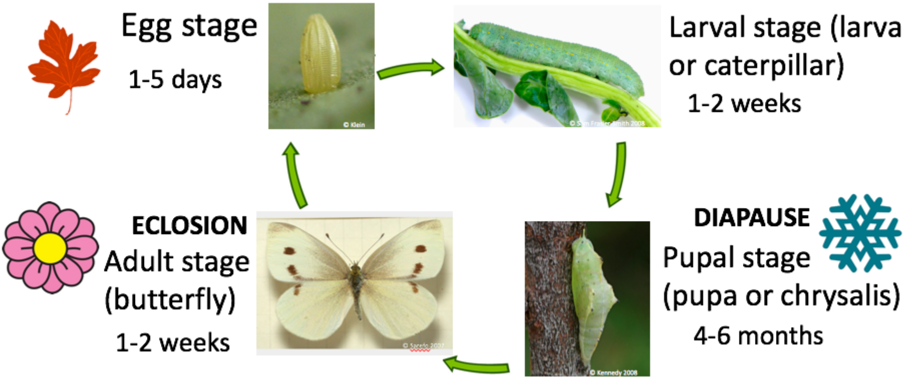
Overwintering organisms will be exposed to novel thermal conditions under winter warming

What are the physiological consequences of temperature anomalies on diapausing Pieris rapae?

Cabbage white good system for studying species' responses to climate change



Seasonal metamorphic cycle of a VT cabbage white



Environmental factors that induce diapause have been previously studied (over 40 years ago!)

GEOGRAPHIC VARIATION OF DIAPAUSE IN INSECTS*

by

Sinzo MASAKI

Laboratory of Entomology

Appl. Ent. Zool. 5(4) : 213--224 (1970)

Photoperiodic Induction of Diapause in *Pieris rapae crucivora* BOISDUVAL (Lepidoptera : Pieridae)

Ent. exp. & appl. 8 (1965): 27—32. *North-Holland Publishing Co., Amsterdam*

Inhibition of Diapause in *Pieris rapae* L. by Brief Supplementary Photophases

Insect Physiology Laboratory, Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville (Maryland, U.S.A.), October 29, 1962.

LIGHT-DARK CYCLES AND DIAPAUSE INDUCTION IN *PIERIS RAPAE* (L.)

BY

ROY J. BARKER[1] and CHARLES F. COHEN

Diapause is primarily induced by reduced photoperiod

Population	Diapause Induction
Tokyo, Japan (Kono 1970)	13 hours $\geq$ light $==>$ Diapause
Maryland, USA (Barker 1962)	13 hours $\geq$ light $==>$ Diapause
Vermont, USA	?

Diapause induction varies across photoperiods and temperatures in a VT population

Treatment	16L:8D	14L:10D	12L:12D		8L:16D
Temperature	22°C	25°C	22°C	12°C-32°C	22°C
Percent of pupae that entered diapause (N≈30)	0%	20%	78.5%	95%	100%

Diapause is primarily induced by reduced photoperiod – latitude

Population	Diapause induction	Latitude
Tokyo, Japan (Kono 1970)	13 hours ≥ light → Diapause	35.6895° N
Maryland, USA (Barker 1962)	13 hours ≥ light → Diapause	38.9847° N
Vermont, USA	14 hours ≥ light → Diapause	44.4759° N

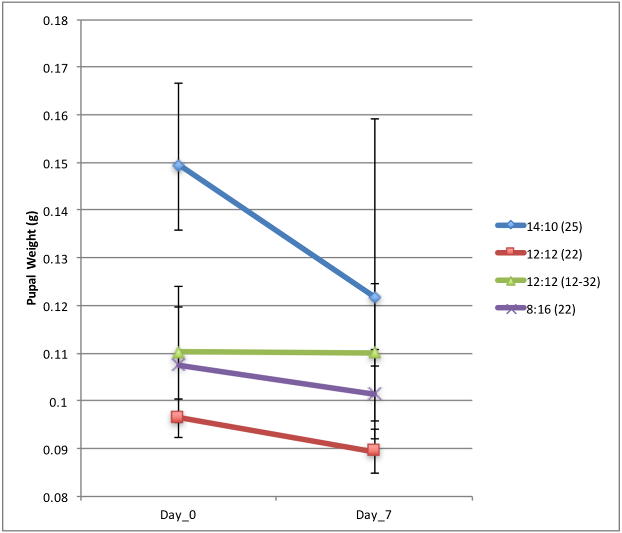
Conclusions: Diapause induction

- Photoperiod differentially induces diapause in different populations (potentially due to latitude)
- VT populations enter diapause under longer photoperiod (14L:10D)
- Potential interaction between photoperiod and temperature that affects the diapause response

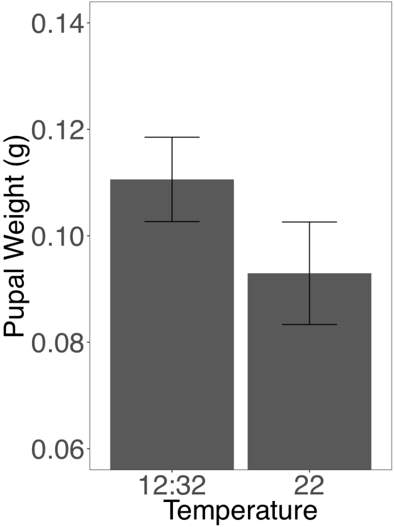
Short-term increased warming in diapausing pupae

Treatment	14L:10D	12L:12D		8L:16D
Original temp.	25°C	22°C	12°C-32°C	22°C
Experimental temp. (+5°C)	30°C	27°C	27°C	22°C (CONTROL)
Number of diapausing pupae (N≈10)				

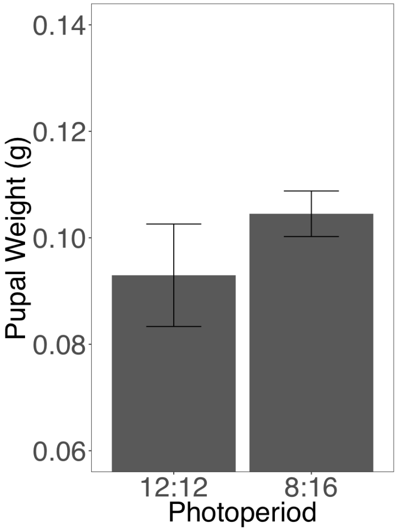
Pupal weight decreased under short-term warming



Temperature affects pupal weight under 12L:12D photoperiod



Photoperiod does not affect pupal weight under 22°C

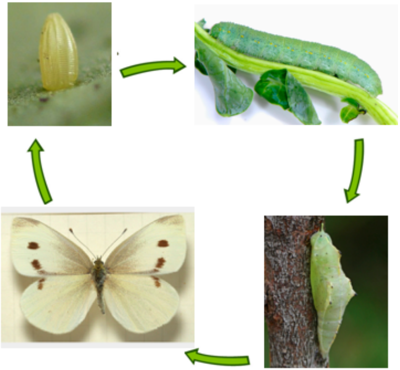


Conclusions: Short-term warming

- Pupal weight decreased under short-term warming
- P. rapae pupae from the fluctuating temperature treatment lost the least weight under short-term warming
- Photoperiod had no effect on pupal weight under increased warming
- Will P. rapae be resilient under increased temperature variation/winter warming?

What are the physiological consequences of temperature anomalies on diapausing Pieris rapae?

- Diapause induction & exit
- Metabolic rate
- Pupation length
- Survial & success to eclosion



Future Directions

1. The physiological consequences of short-term & long-term winter warming
2. VT populations vs. NC populations: differential responses to winter temperature and seasonal anomalies?

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The UNIVERSITY of VERMONT