Can butterflies stand the heat?

The physiological consequences of increased warming in diapausing *Pieris rapae*

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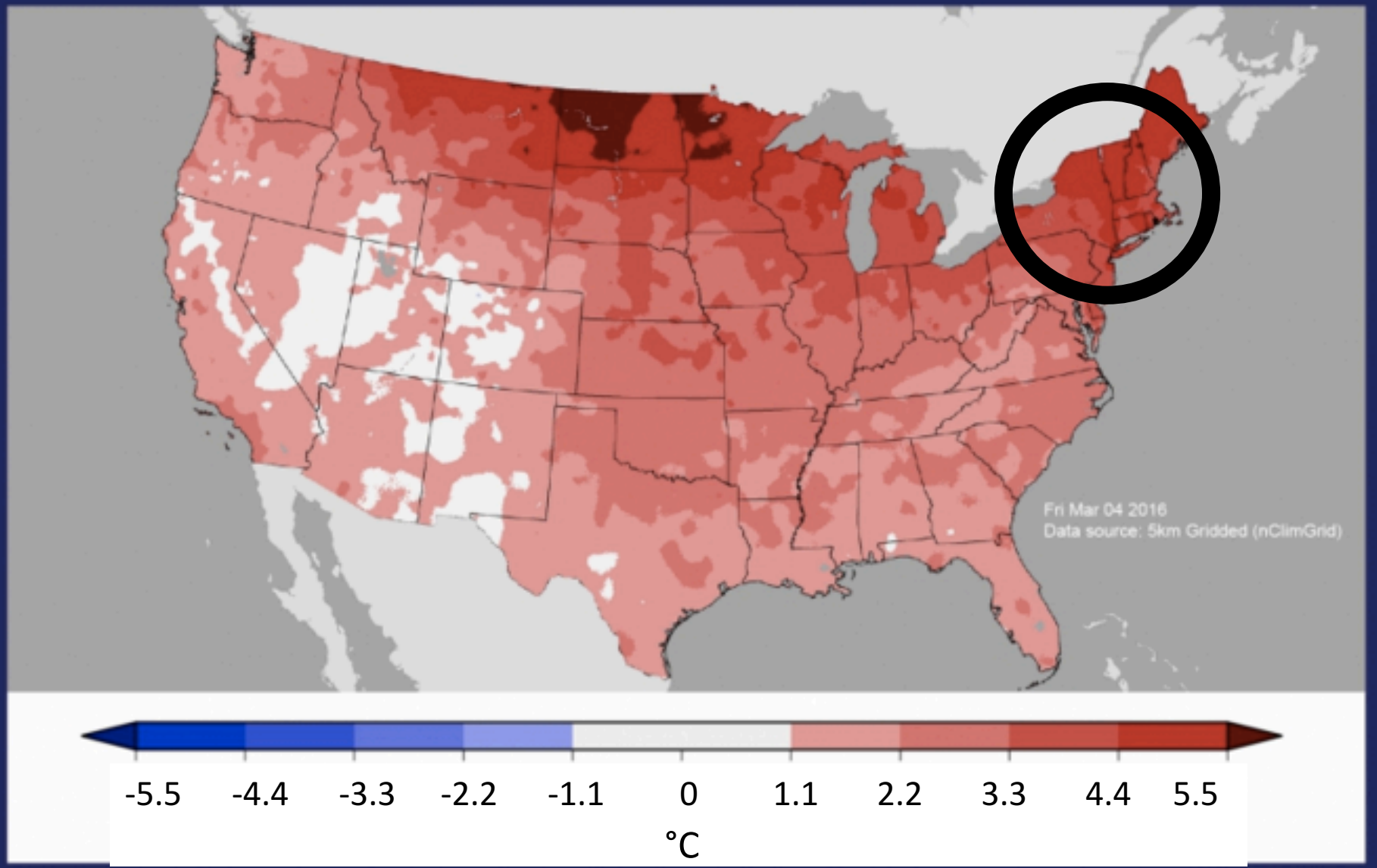
Mean temperature departure from average

Dec. 2015 – Feb. 2016 (Winter)

Base Period: 1901 – 2000

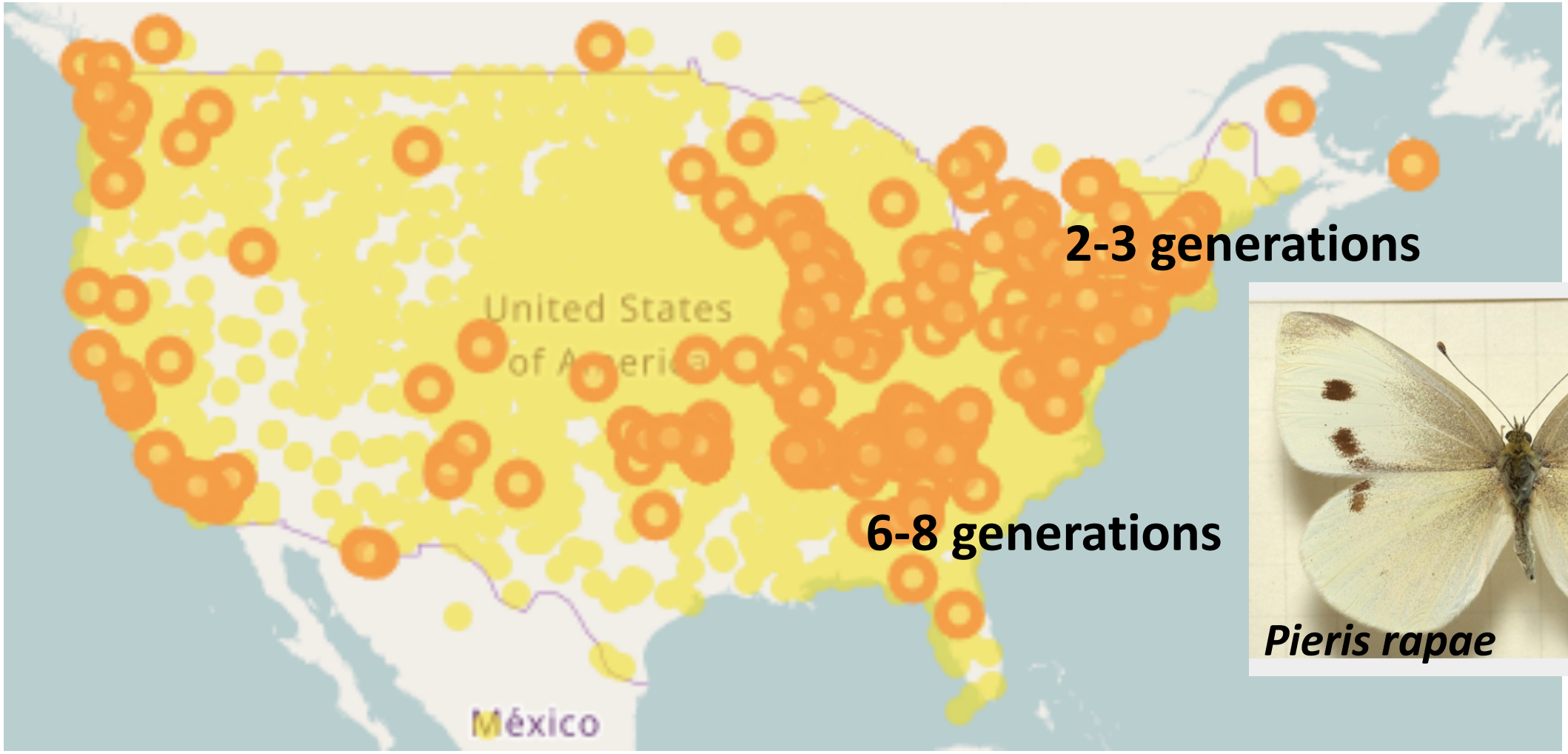


NOAA National Centers for Environmental Information

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



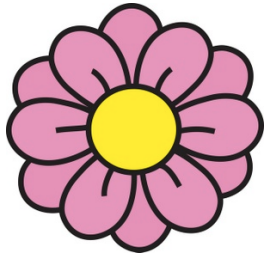
Seasonal metamorphic cycle of a VT cabbage white

Egg stage

1-5 days

Larval stage (larva or caterpillar)

1-2 weeks



ECLOSION

Adult stage (butterfly)

1-2 weeks

DIAPAUSE

Pupal stage (pupa or chrysalis)

4-6 months

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 ≥ light → Diapause**
Maryland, USA (Barker 1962)	**13 hours ≥ 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 specific?

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**

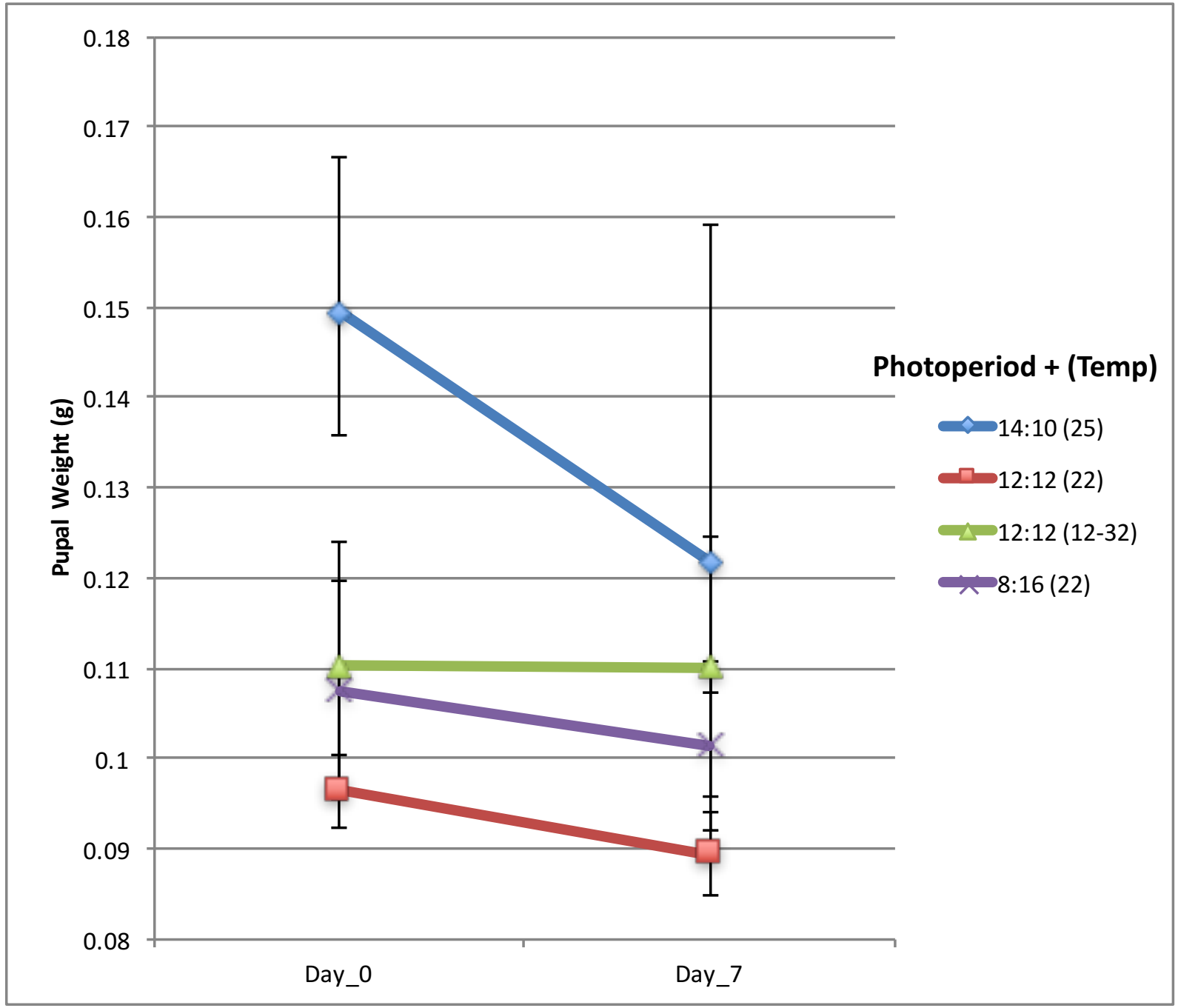
Conclusions: Diapause induction

- 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

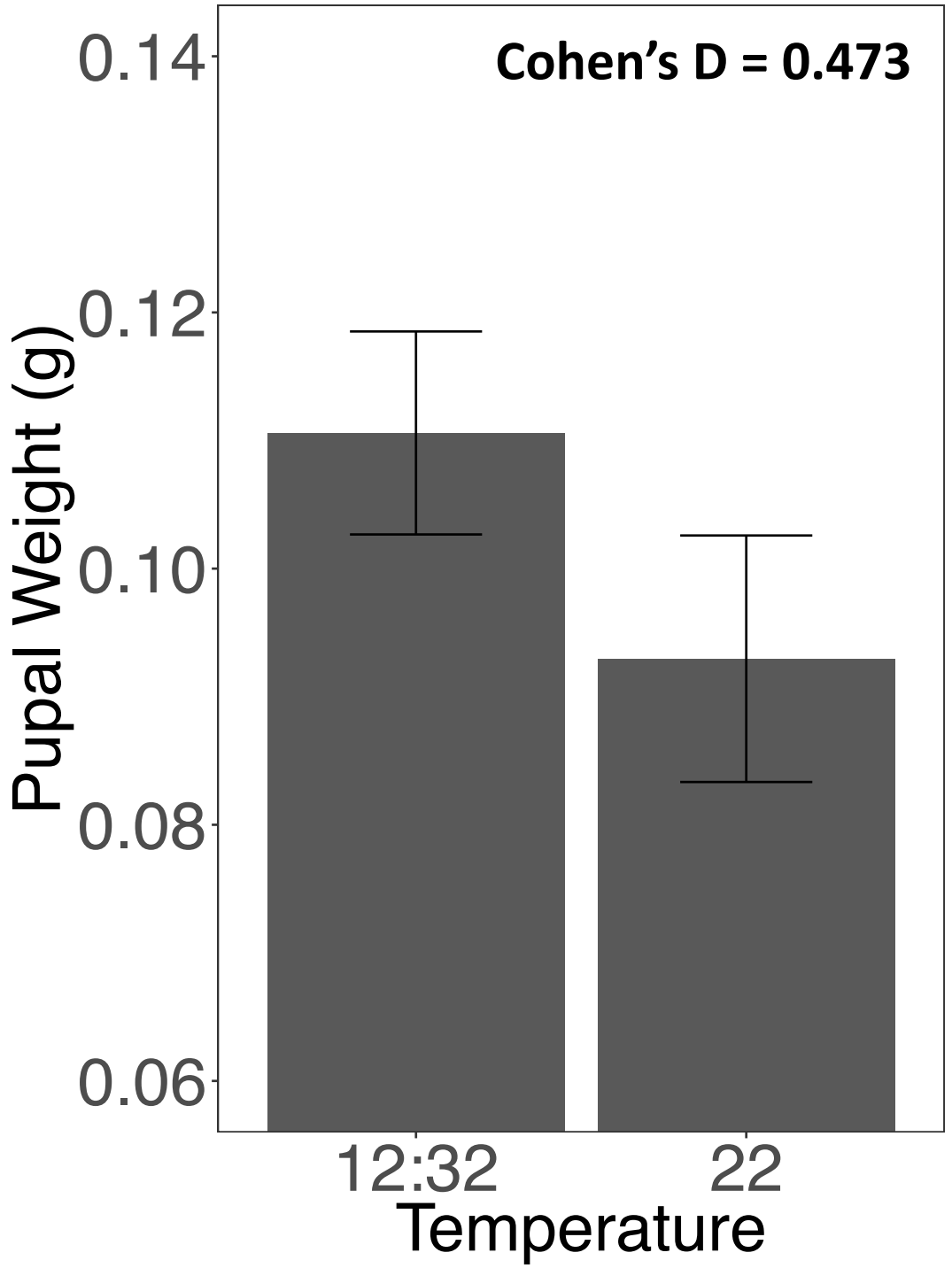
Short-term increased warming in diapausing pupae

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)				

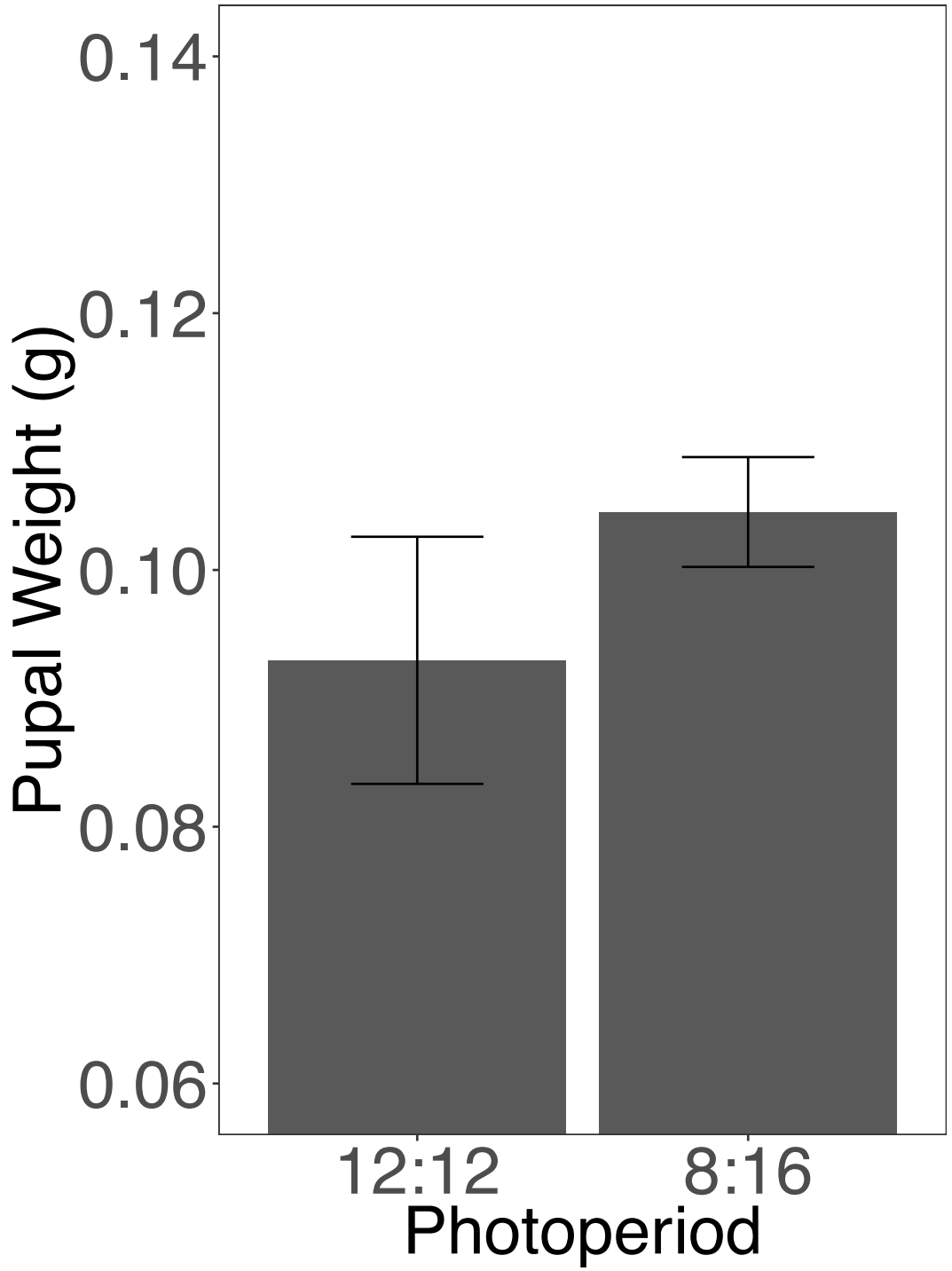
Pupal weight decreased under short-term warming



Temperature affects pupal weight under 12L:12D photoperiod



Photoperiod does not affect pupal weight under 22°C

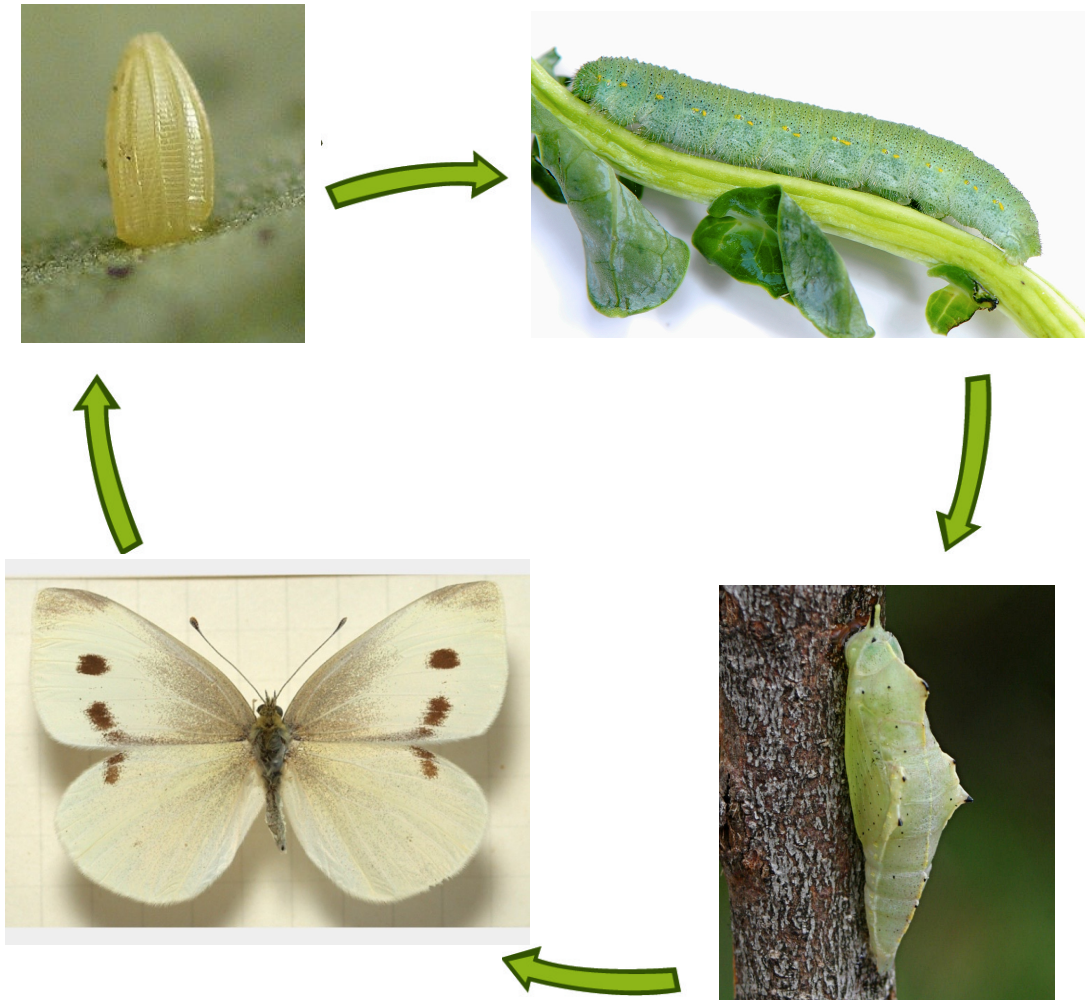


Conclusions: Short-term warming

- 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
- Survival & 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?

Acknowledgements

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