The Importance of Dormancy and Dormancy Management to Biological Control and Area-Wide approaches

Dan Hahn – summarizing the work of others

Department of Entomology and Nematology

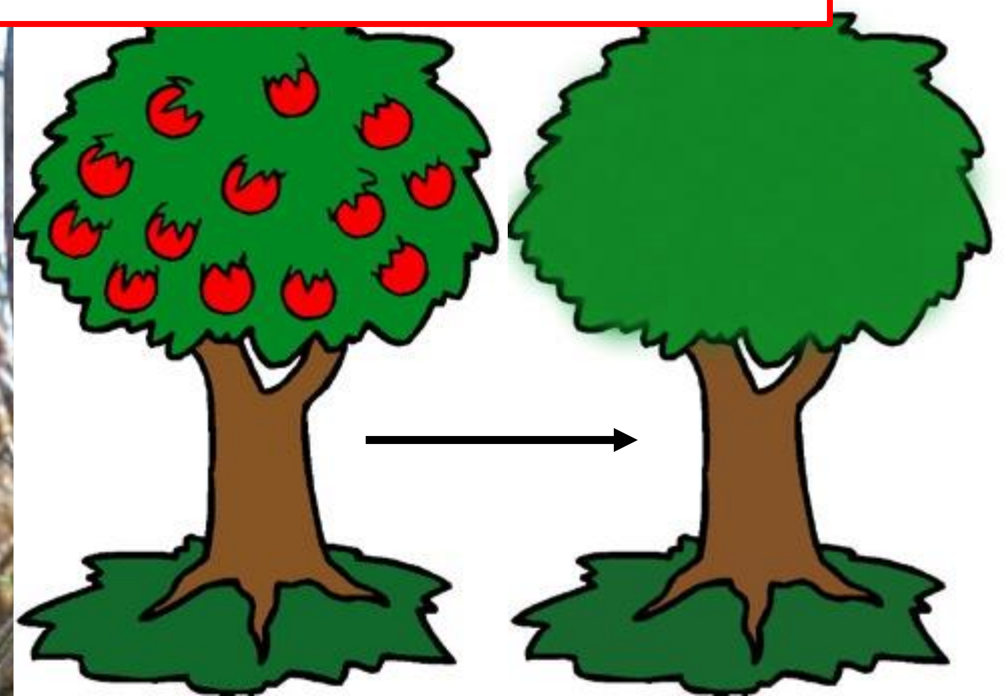
University of Florida, Gainesville, FL





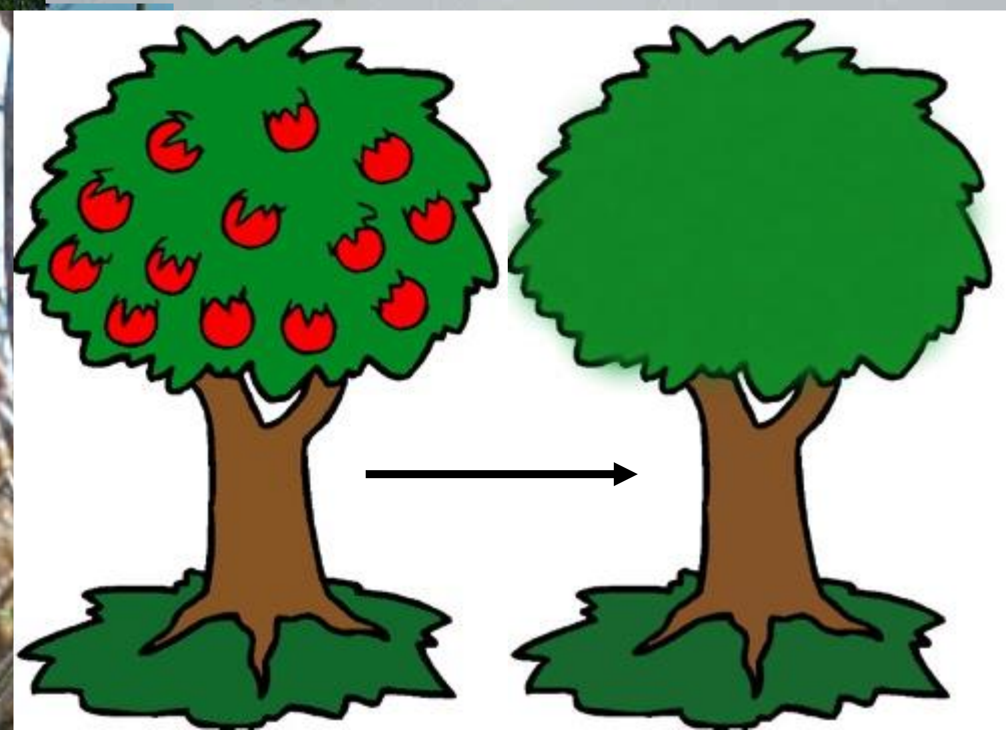
Because life is hard…Stress Biology





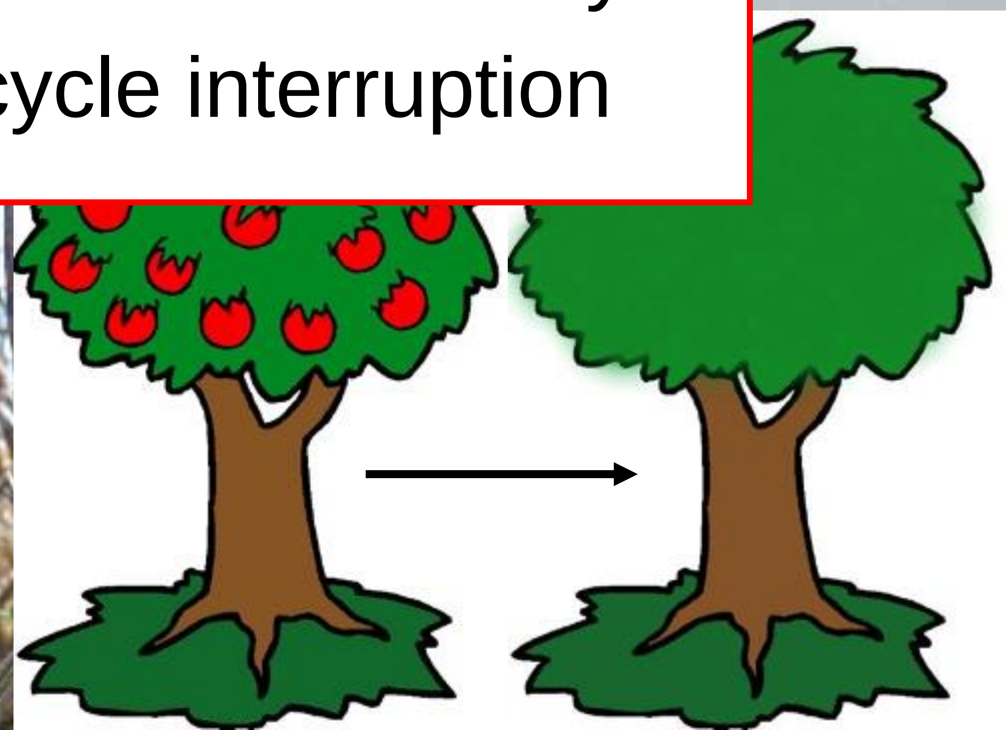






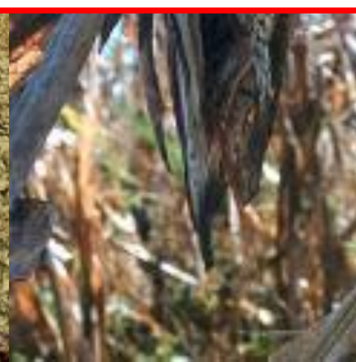

Dormancy – environmentally induced lifecycle interruption

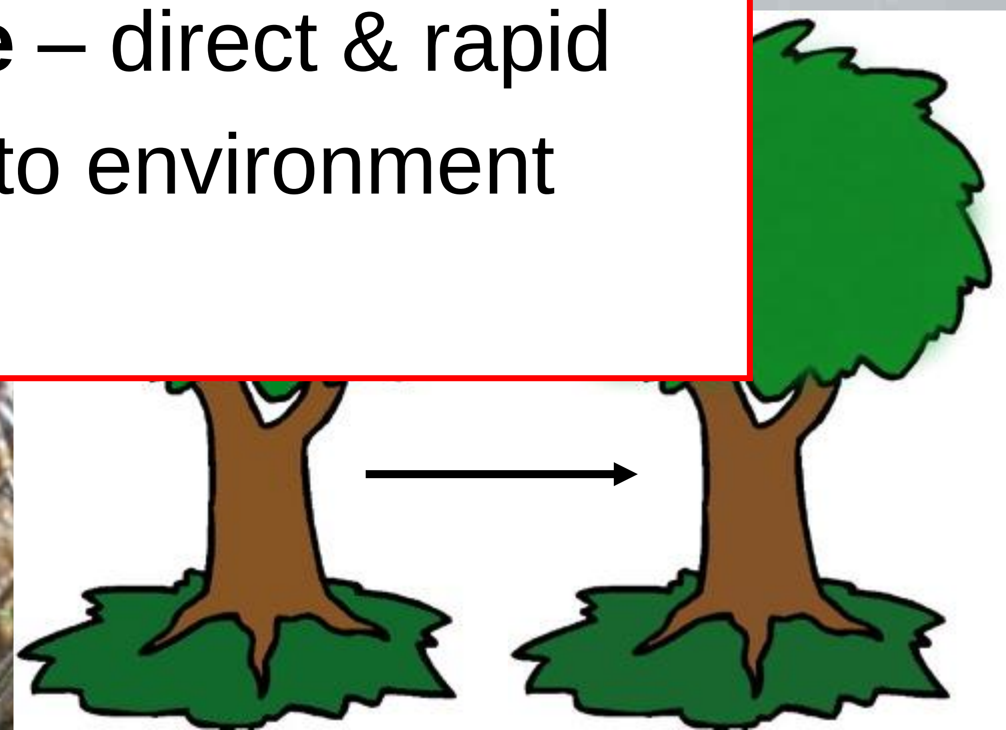


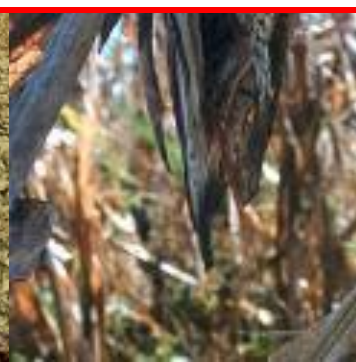


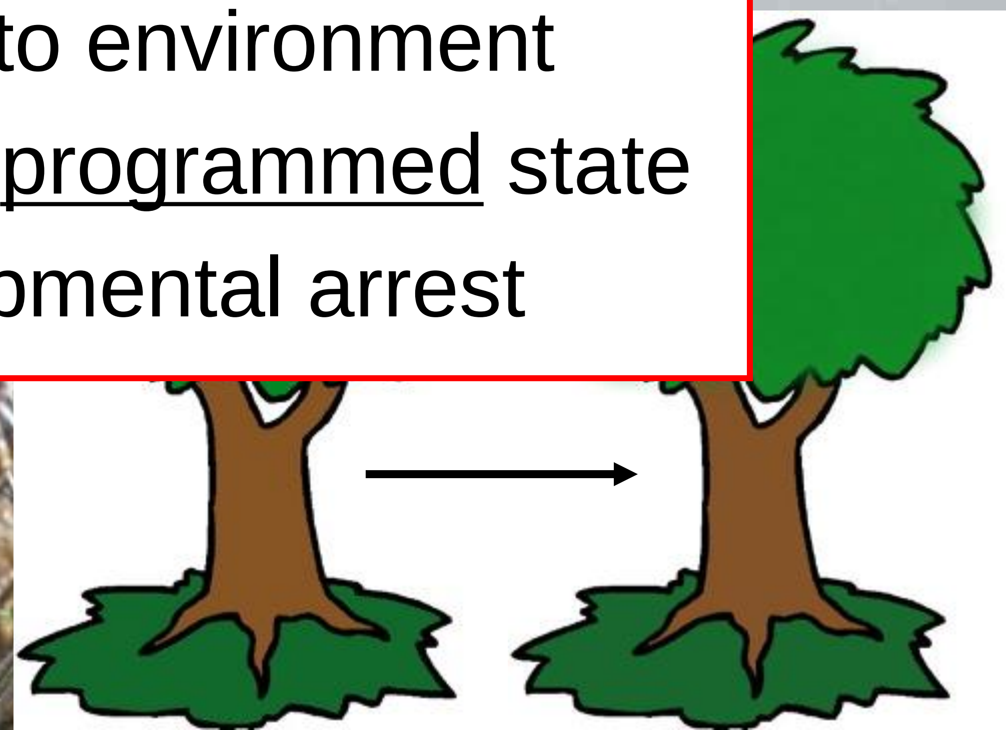
Dormancy

Quiescence – direct & rapid response to environment





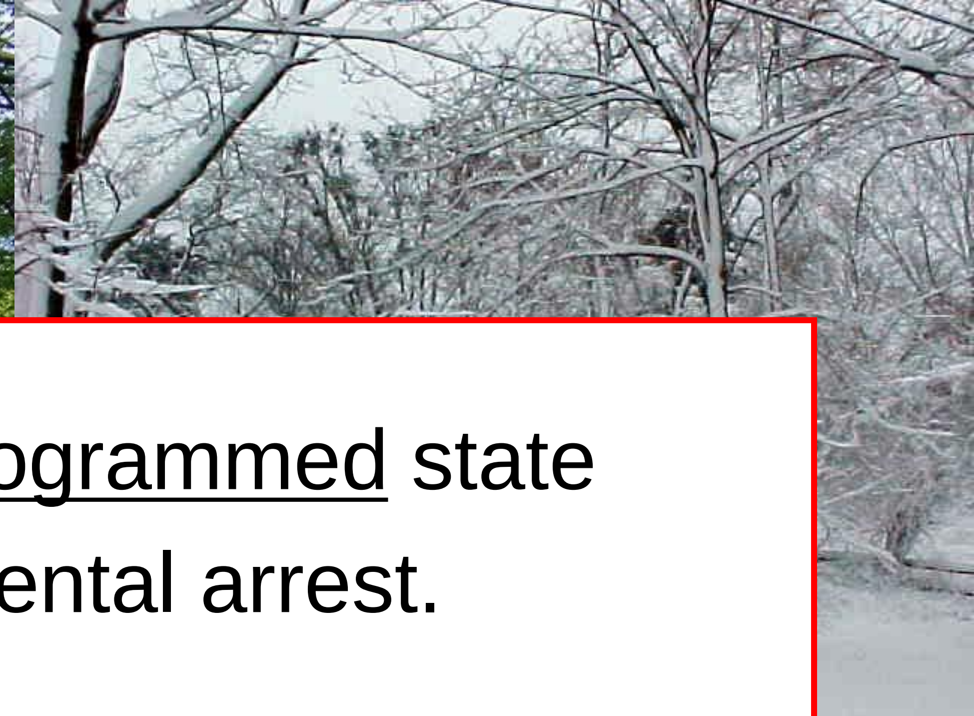




Dormancy

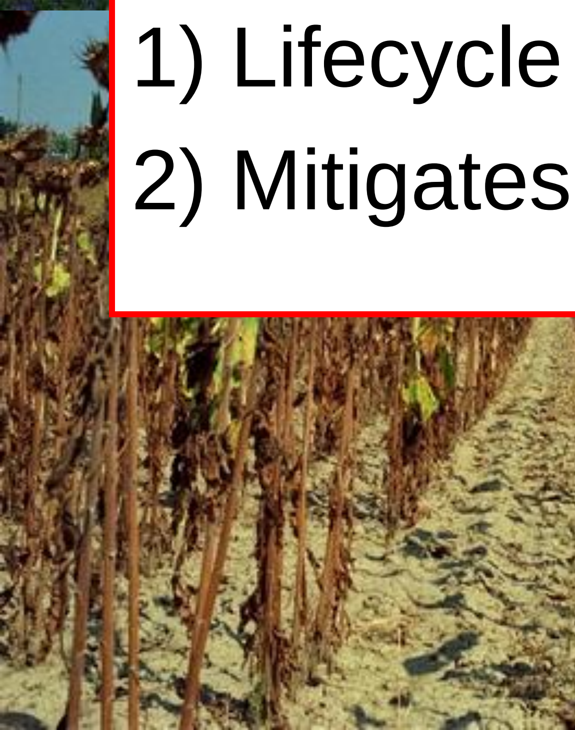
Quiescence – direct & rapid response to environment

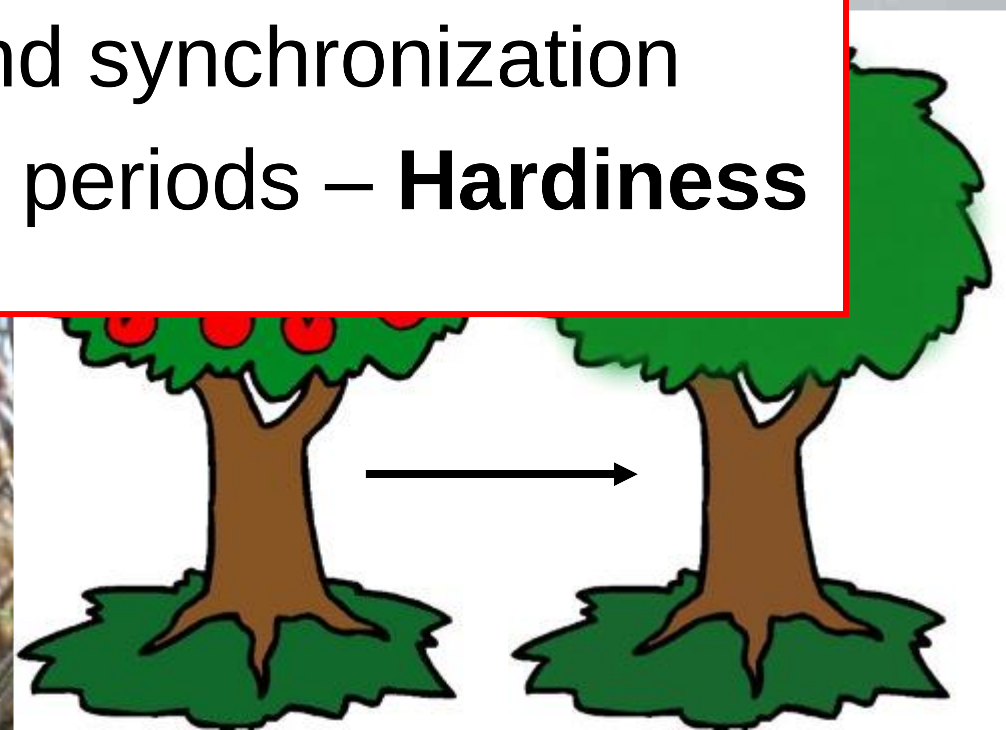
Diapause – a <u>programmed</u> state of developmental arrest



Diapause – a programmed state of developmental arrest.

1) Lifecycle timing and synchronization
2) Mitigates stressful periods – **Hardiness**





Challenges for Biological Control

Saltcedar an invasive shrub is displacing Freemont's cottonwood, an iconic riparian tree in the SW US.

Saltcedar (*Tamarix* spp.) is a water hog, changes soil chemistry, and outcompetes the cottonwood.

Challenges for Biological Control

Saltcedar has a longer growing season in the south Than beetle active season. Leads to loss of control.

Saltcedar (*Tamarix* spp.) biological control by *Diorhabda* spp. beetles. Hultine et al. 2015 Int. Comp. Biol.

What sets diapause timing in the beetle?

Could one reduce the diapause?

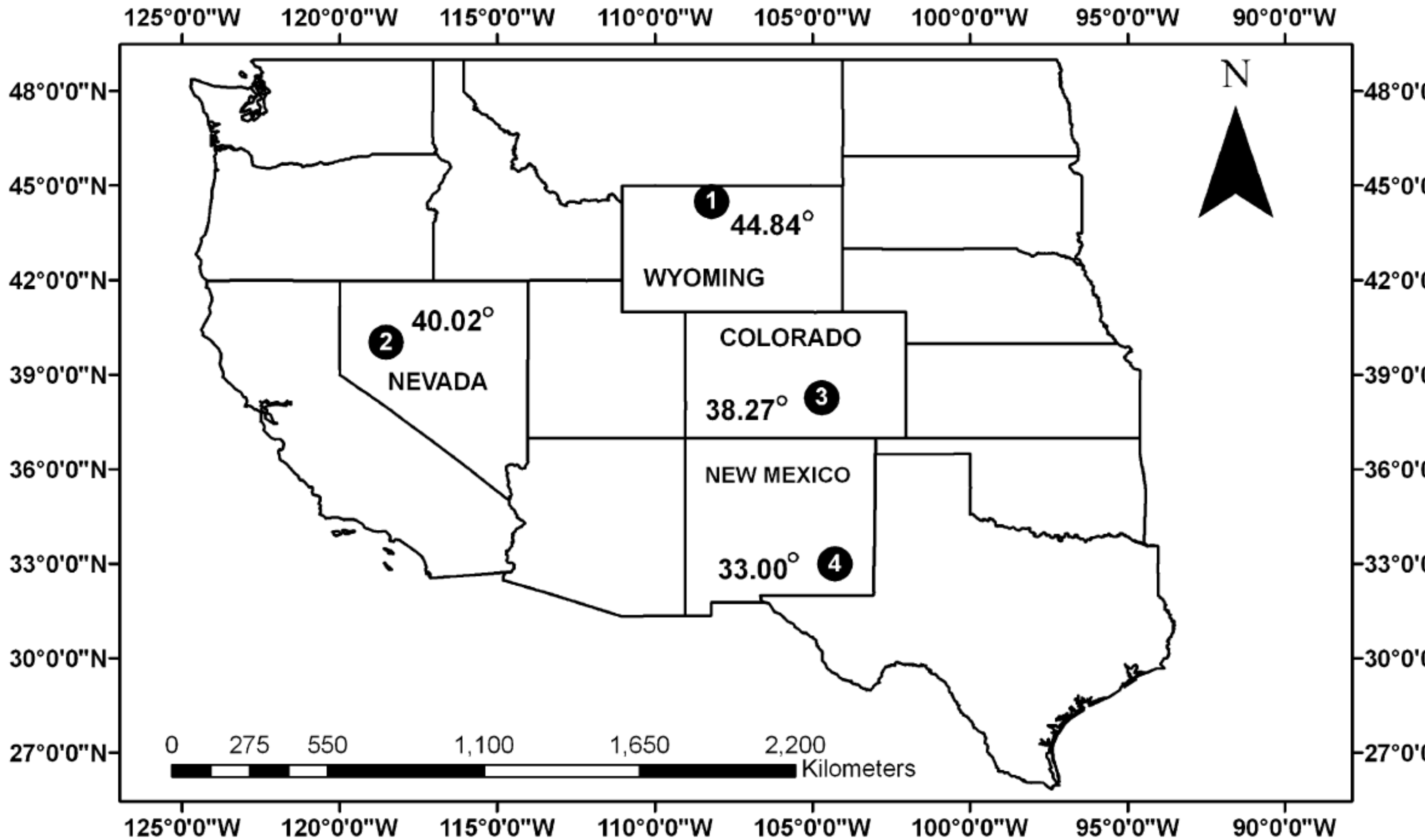


Fig. 2 Photographs showing *Tamarix* in southeastern Utah before and after defoliation by *D. carinulata*. The photographs were taken two weeks apart in July 2007.

When do most insects enter diapause?
Should be earlier in the north & later in south.

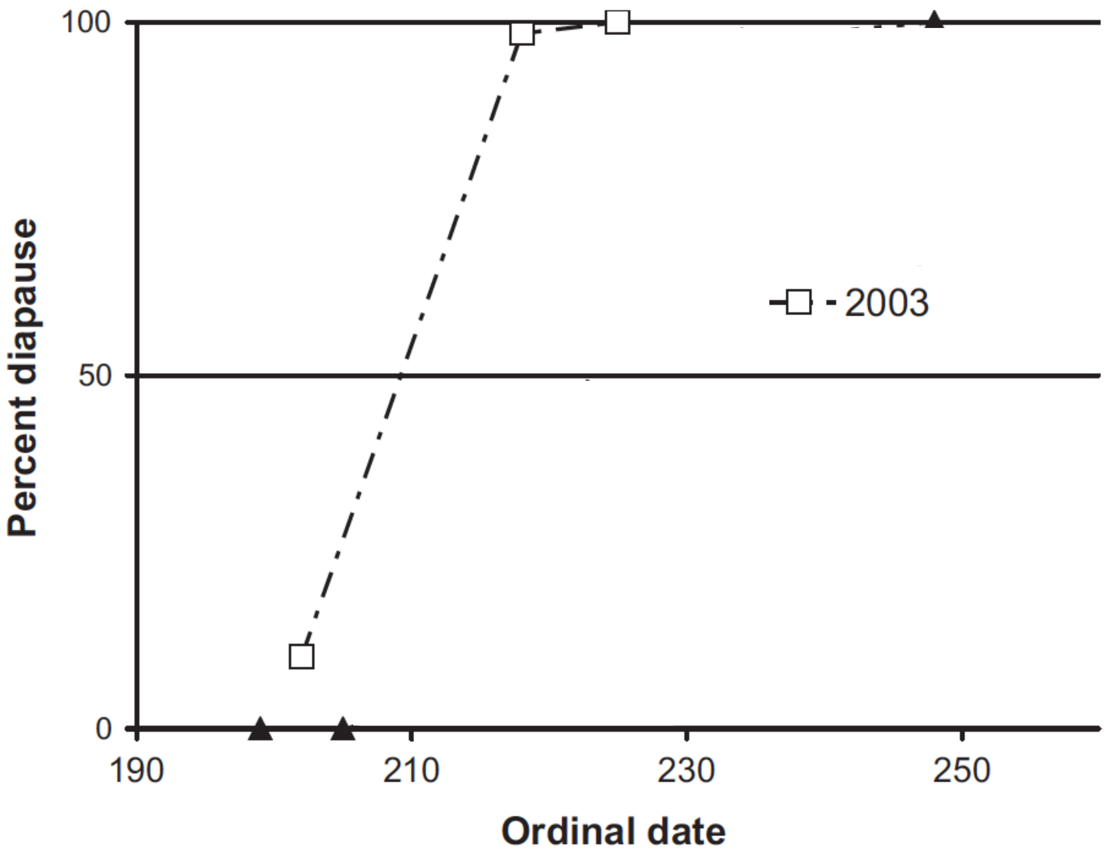


Figure 2 Diapause incidence in the field at the Pueblo, Colorado site during the summer of 2008. The 2003 values are from Bean et al. 2007a and are shown for comparison. The population reached 50% diapause on ordinal day 223 (August 10, 2008), while in 2003, the population reached 50% diapause on day 207 (July 26).

Bean et al. 2012 Evol. Appl.

Beetles are entering diapause later in 2008 than 2003, consistent with adaptive evolution.

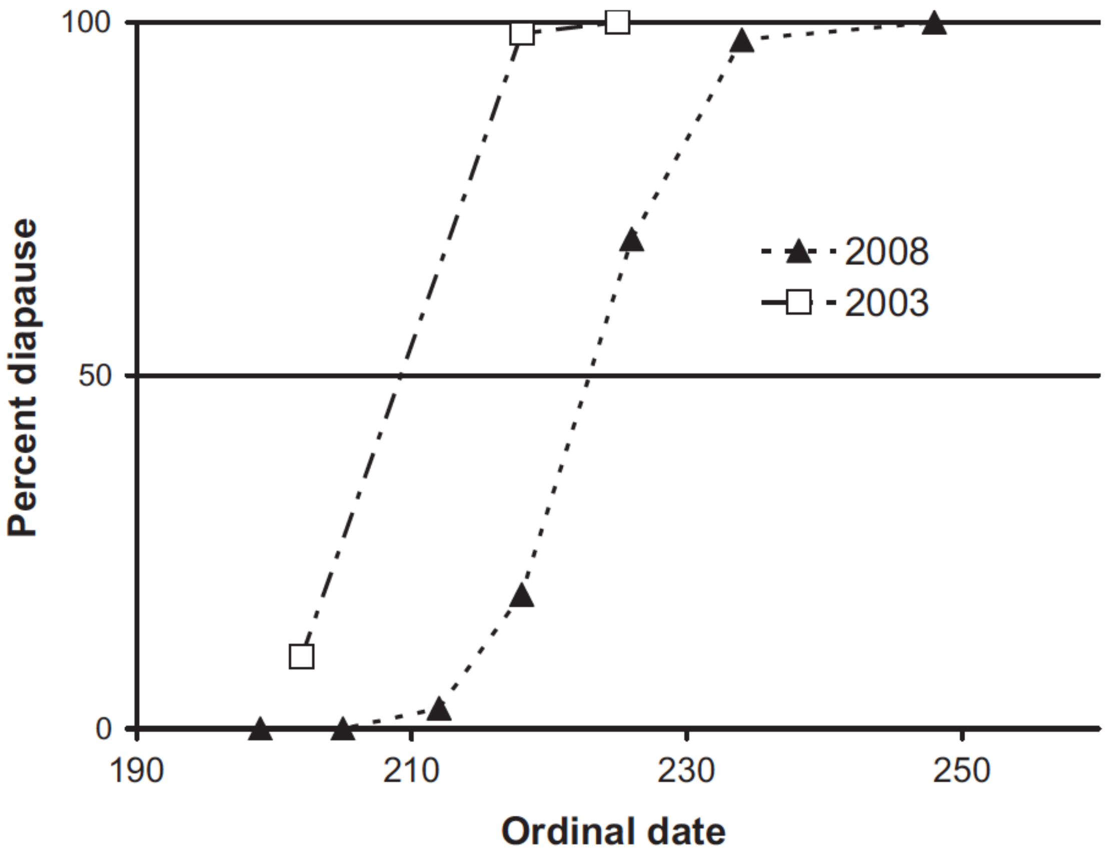


Figure 2 Diapause incidence in the field at the Pueblo, Colorado site during the summer of 2008. The 2003 values are from Bean et al. 2007a and are shown for comparison. The population reached 50% diapause on ordinal day 223 (August 10, 2008), while in 2003, the population reached 50% diapause on day 207 (July 26).

Bean et al. 2012 Evol. Appl.

Genetic variation for diapause!

How do we improve likelihood of better matching between hosts and biological control agents?

Traditional approach – agents from different regions

Other approaches:

1) Assess genetic variation in dormancy & hardiness
2) Maximize that variation
   - Large populations sizes
   - Deliberate admixture
   - Selective breeding – greater plasticity & hardiness

Challenges for SIT & Augm. Biocontrol

Mass Rearing

- Have to produce enough and at the right time
- Obligate dormancy is a roadblock

How to tackle this problem?

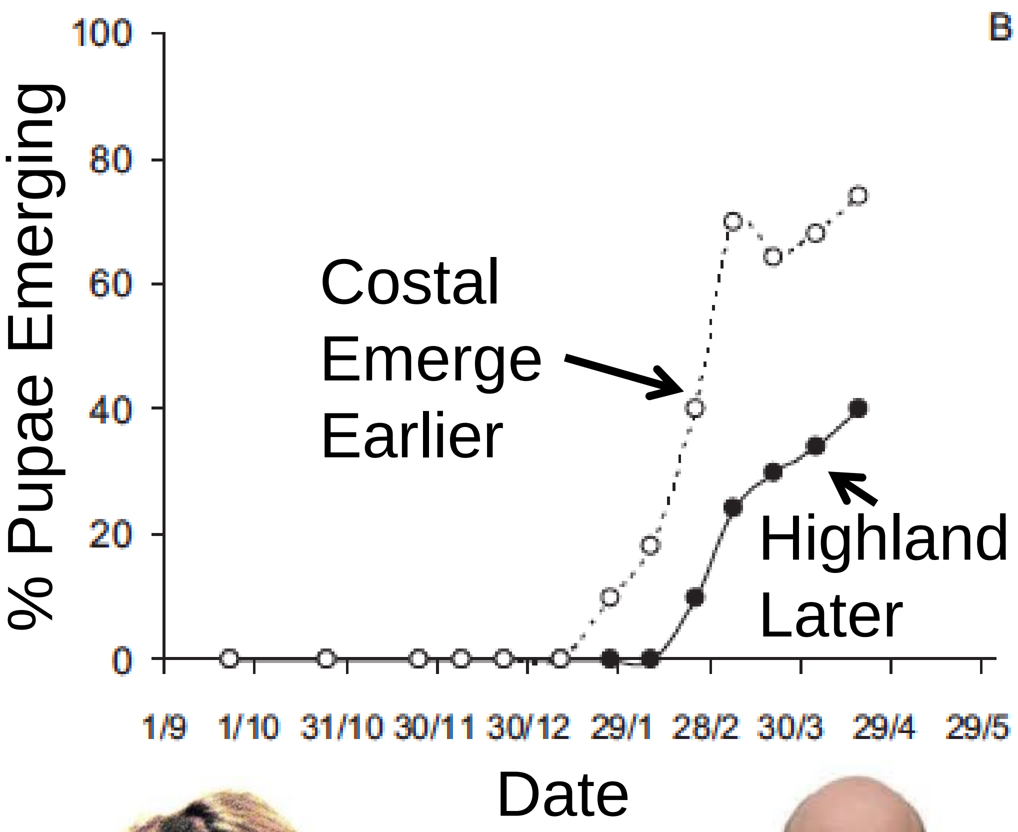
Is there geographic variation in obligate diapause timing?

Figs from Papanastasiou et al. 2011 J. Insect Physiol.



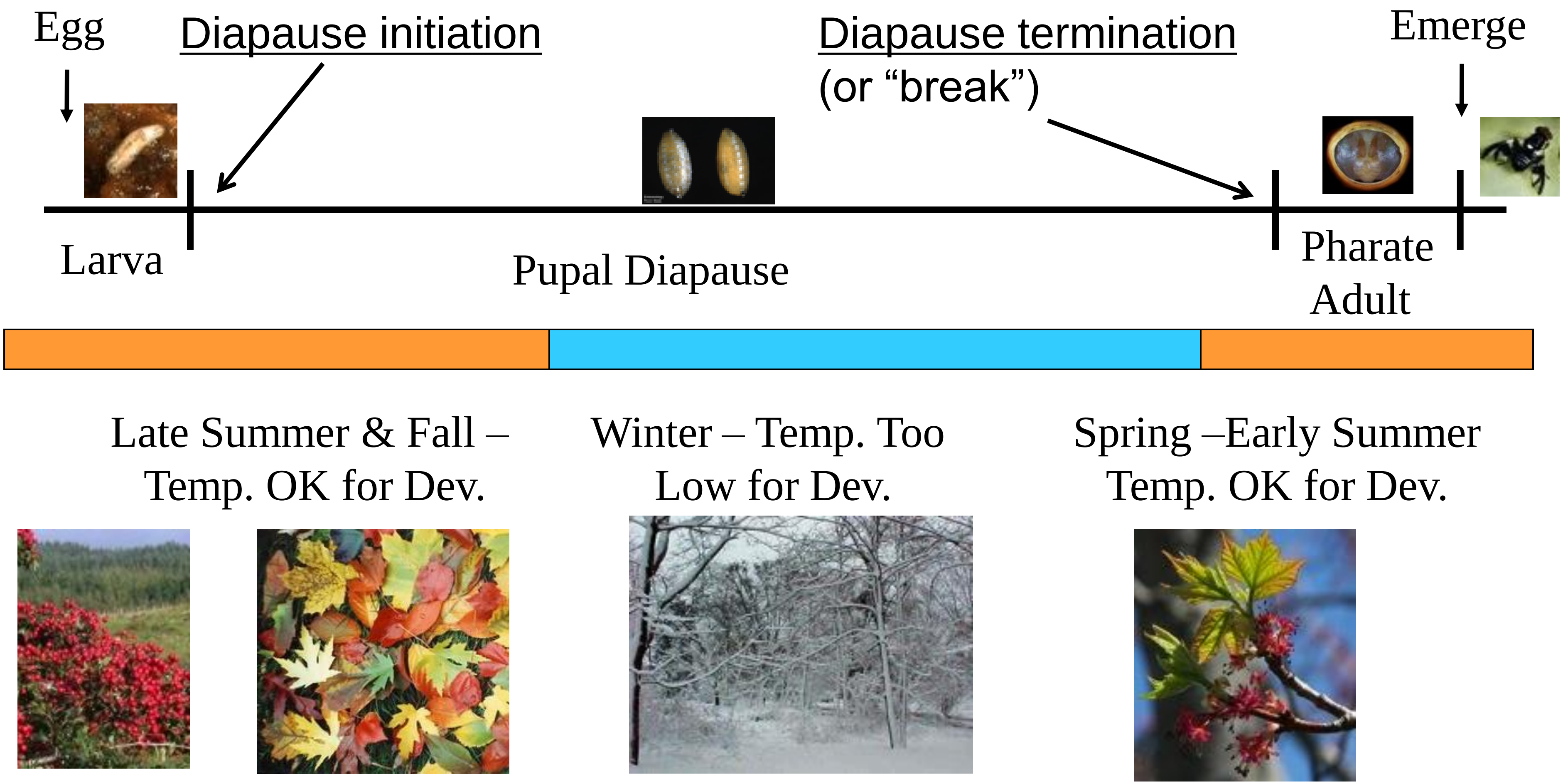
How to tackle this problem?

Geographic variation in obligate diapause



Figs from Papanastasiou et al. 2011 J. Insect Physiol.

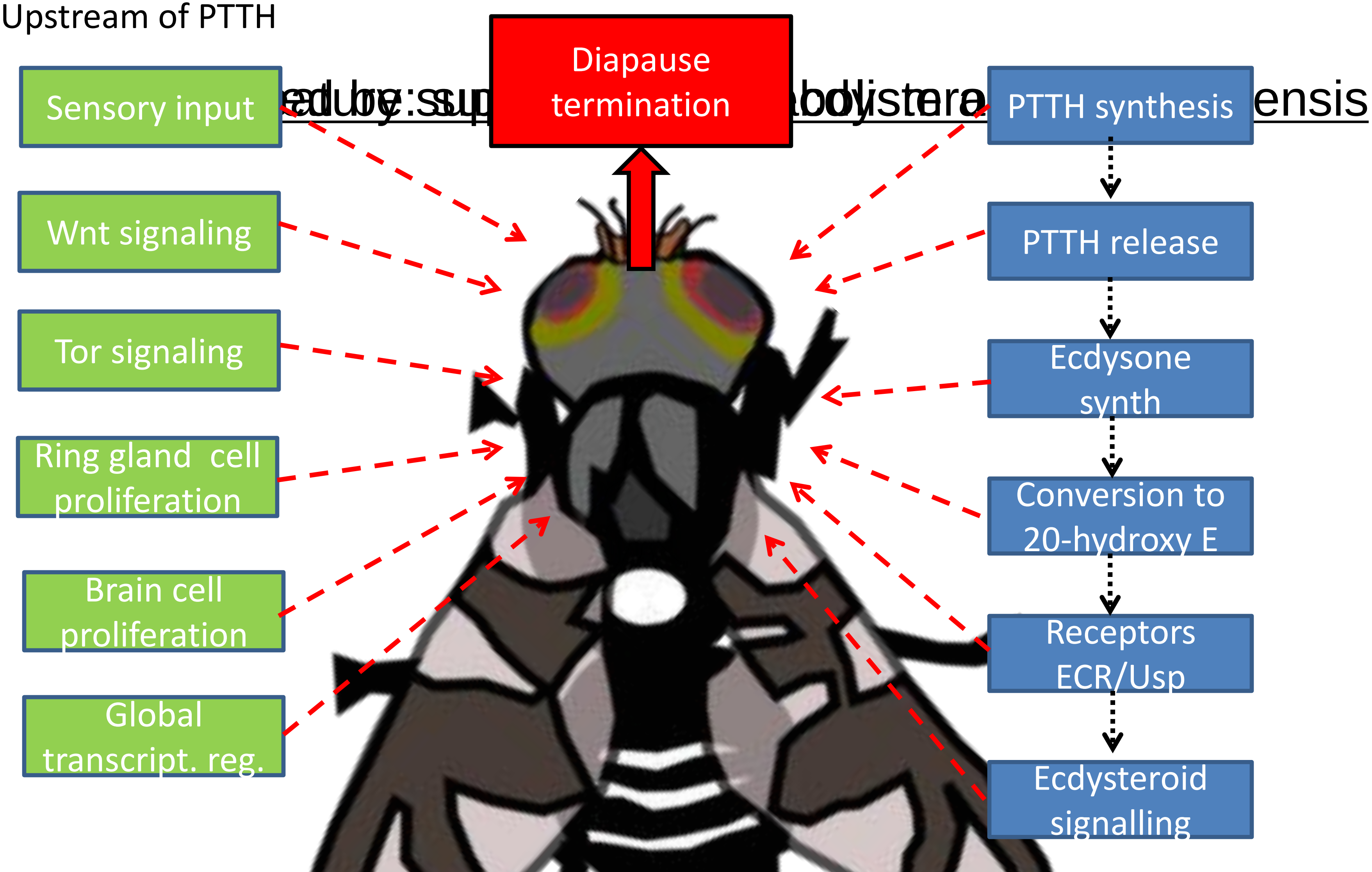
Rhagoletis Diapause



Diapause Regulation

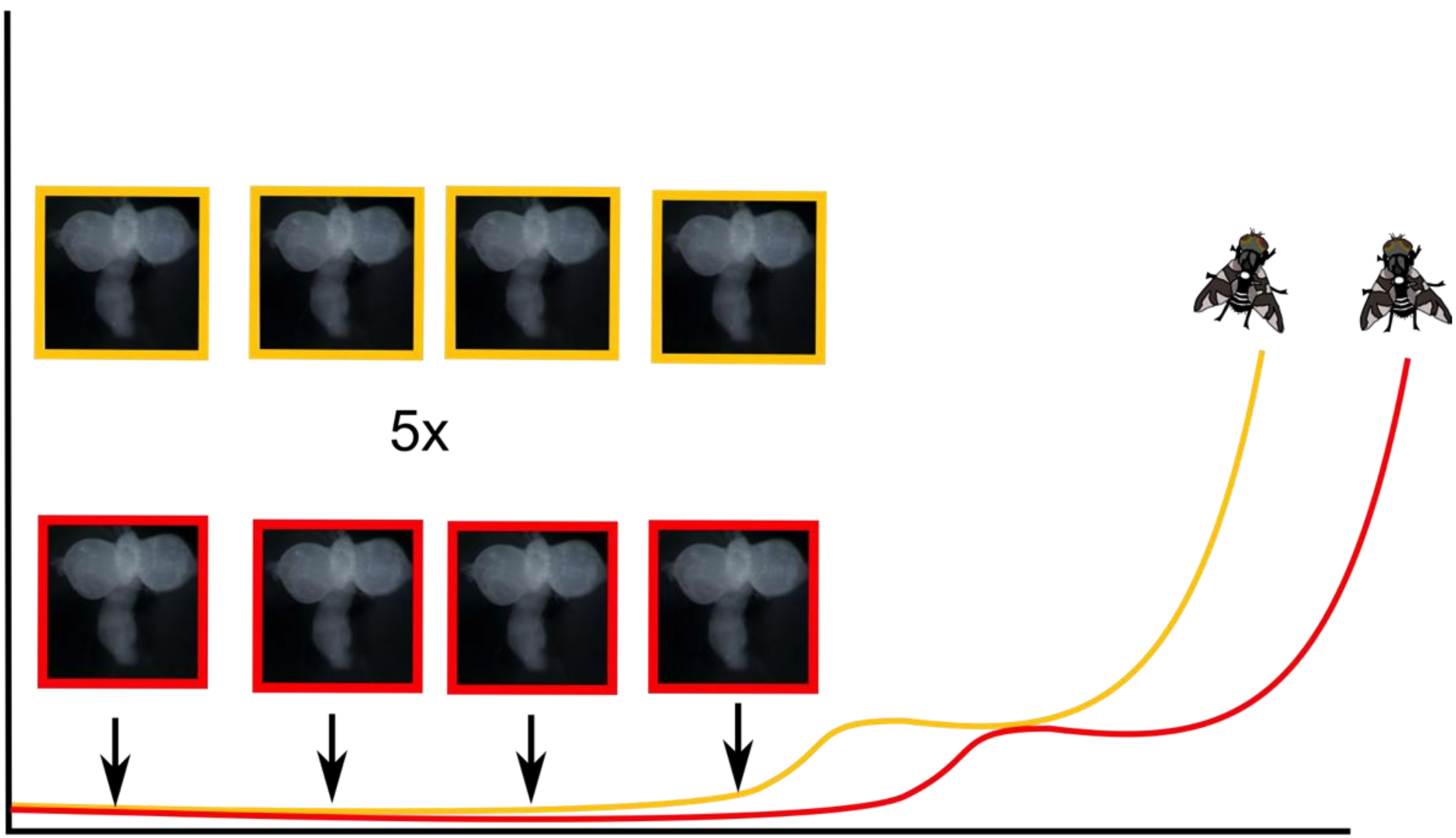
Pre-programmed alternative developmental pathway

Upstream of PTTH



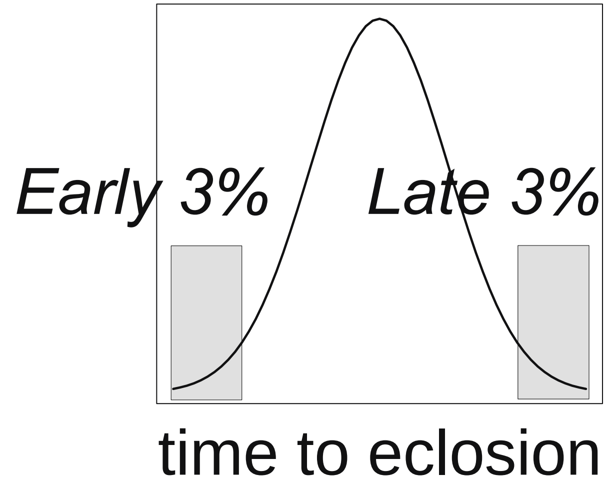
How can we pull apart mechanisms for timing?

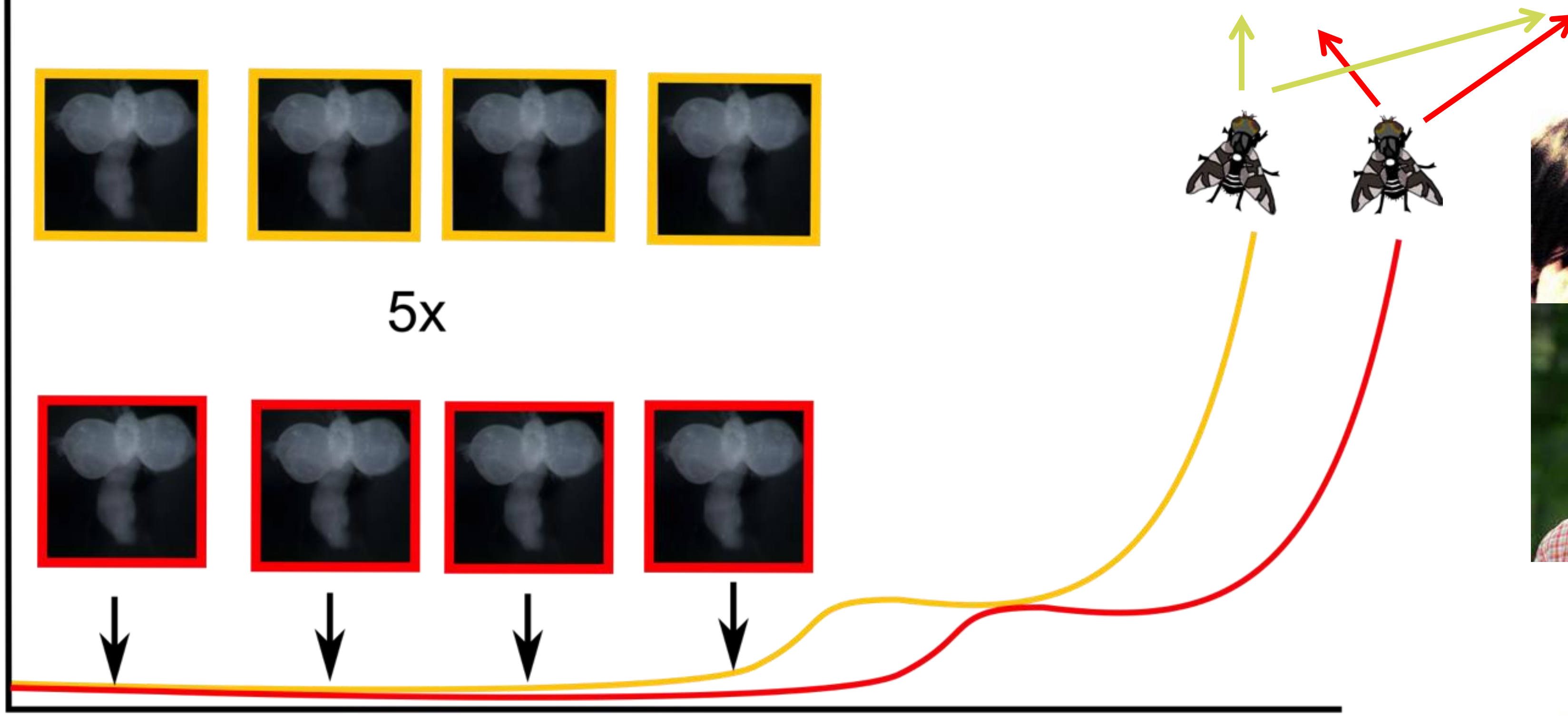
RNAseq of *Rhagoletis* brains and ring glands leading up to critical time of developmental divergence.



Transcripts and SNPs associated with timing

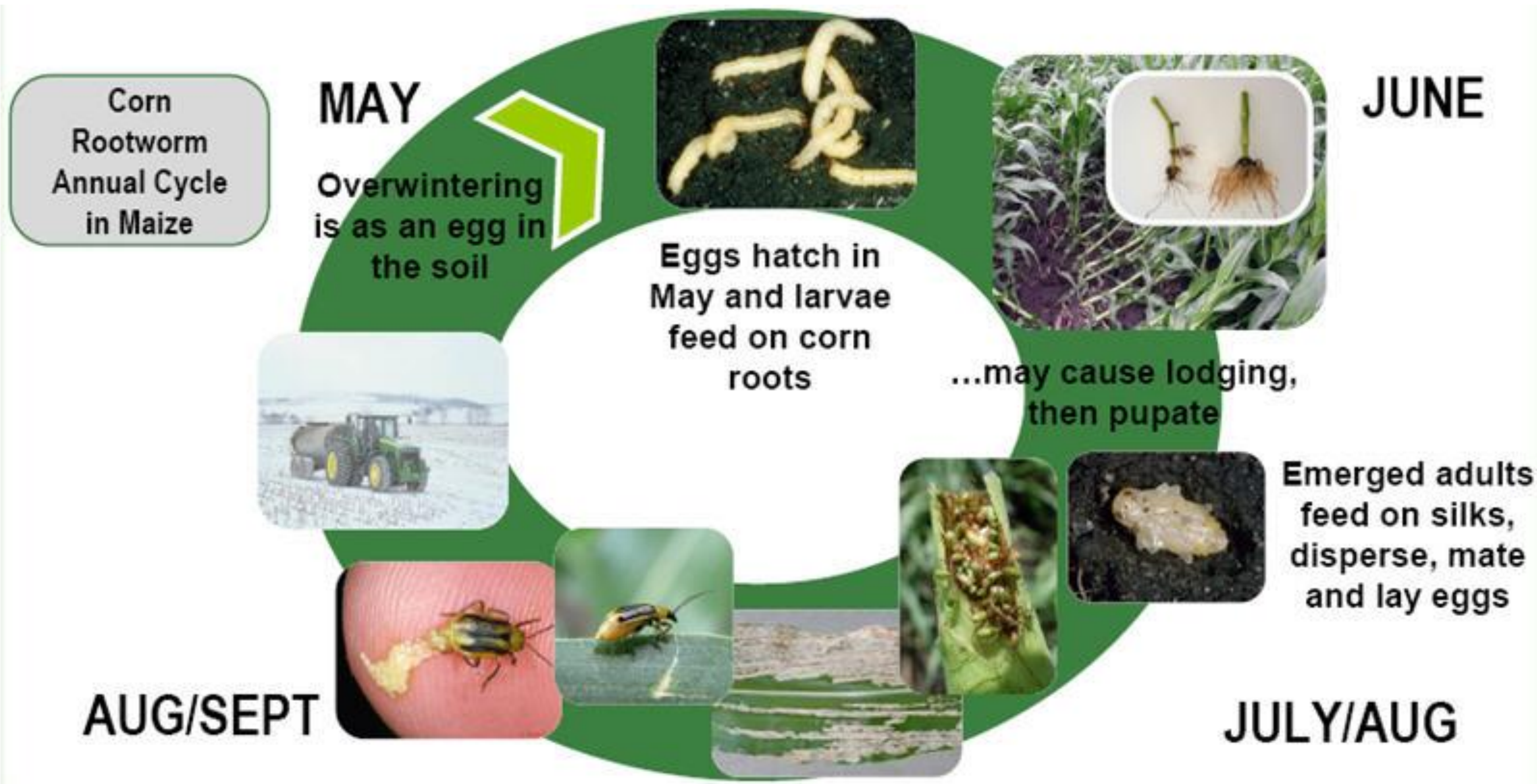
RNAseq of *Rhagoletis* brains and ring glands leading up to critical time of developmental divergence, and bulk segregant Pool-seq of eclosion timing within each popul.





Mass Rearing

- Have to produce enough and at the right time
- Non-obligate dormancy can be trouble



Challenges for SIT & Augm. Biocontrol

- Have to produce enough and <u>at the right time</u>
- Stockpile insects in dormancy until needed

Could diapause or other dormancy strategies help with production of seasonal pests?

Challenges for SIT & Augm. Biocontrol

- Have to produce enough and <u>at the right time</u>
- Stockpile insects in dormancy until needed

FAO/IAEA Int. Conf. on Area-Wide
Control of Insect Pests,
Penang, May 28 to June 2, 1998

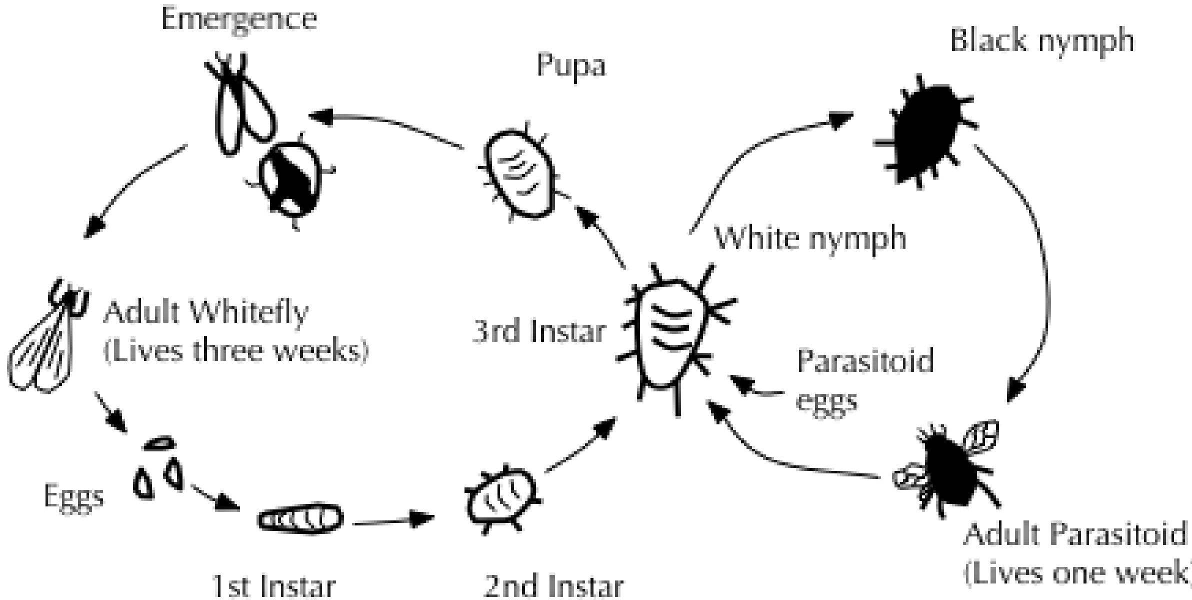
INCORPORATION OF DIAPAUSE INTO CODLING MOTH MASS-REARING: PRODUCTION ADVANTAGES AND INSECT QUALITY ISSUES

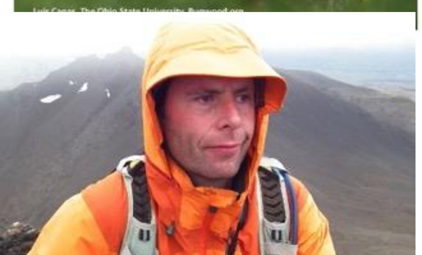
Stephanie Bloem[1], Ken A. Bloem[2], and Carrol O. Calkins[1]
[1]*USDA-ARS YARL, 5230 Konnowac Pass Road, Wapato, WA, 98951, U.S.A.;*
[2]*OK-CM SIR Program, Box 1080 Osoyoos, BC, Canada VOH 1 VO,*

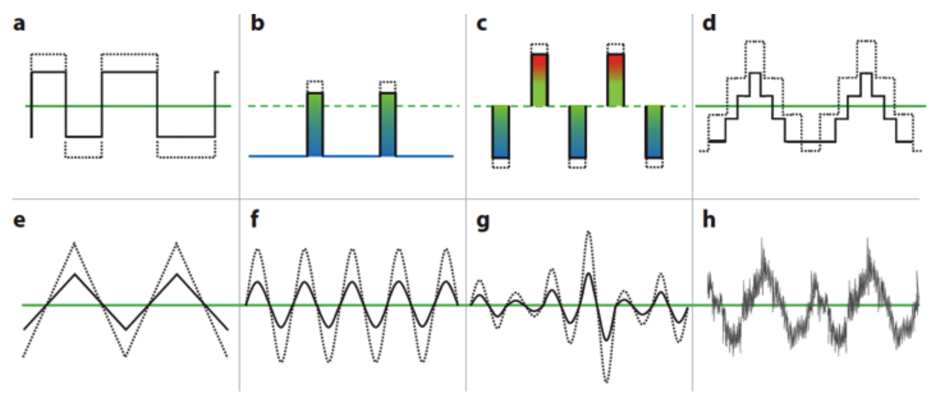
For the past 3 years we have investigated the incorporation of diapause as an alternate rearing strategy in codling moth (CM), *Cydia pomonelia* (Lepidoptera: Tortdcidae), mass-rearing at the Sterile Insect Release (SIR) facility in southern British Columbia, Canada. In the field,

Challenges for SIT & Augm. Biocontrol

- Have to produce enough and <u>at the right time</u>
- Stockpile insects in dormancy until needed

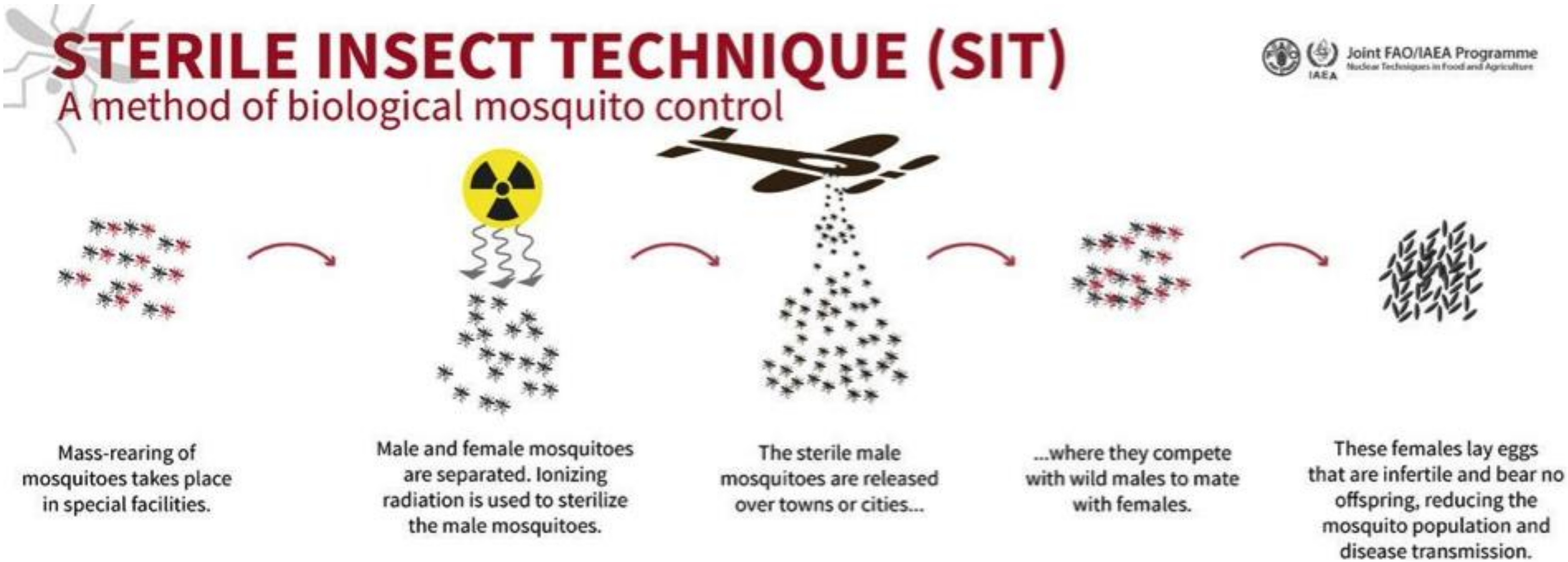






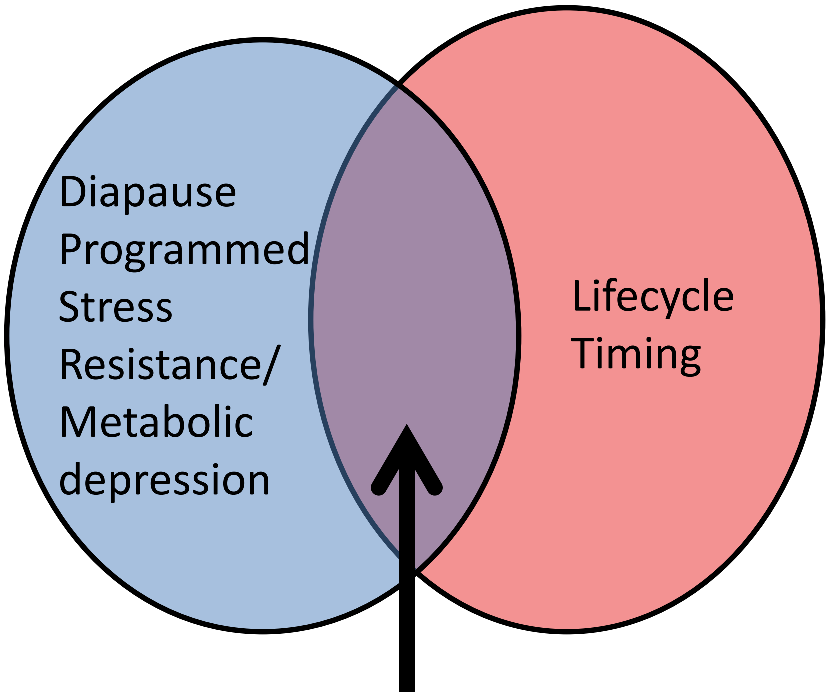
Colinet et al. 2015
Ann. Rev. Entomol.

Could Dormany Mechanisms Help Buffer Stresses of SIT?



Male Performance May be Decreased by Stress at Colonization, Rearing, Sex Sorting/Handling, Irradiation, Shipping, Release, etc.

Diapausing insects face many challenges so they enhance multifaceted defenses, prevention!

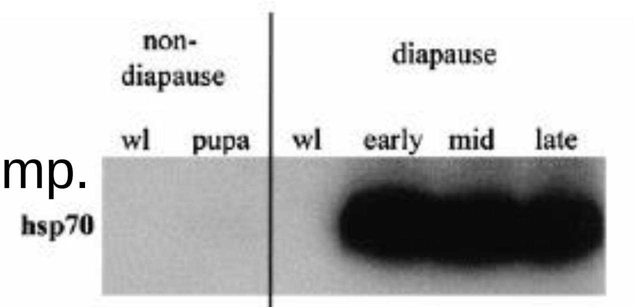


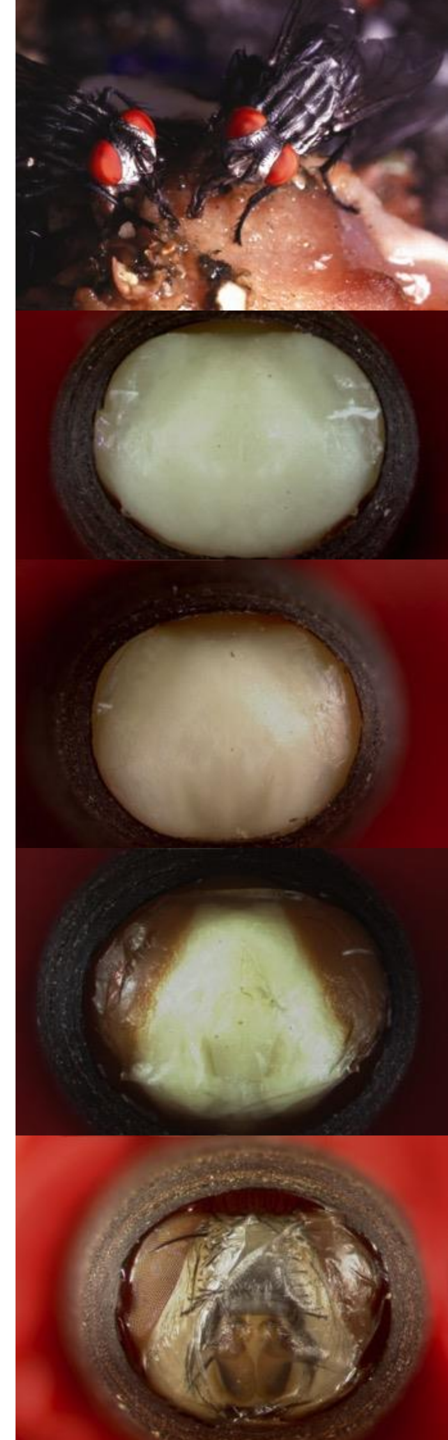
Overlapping Mechanisms

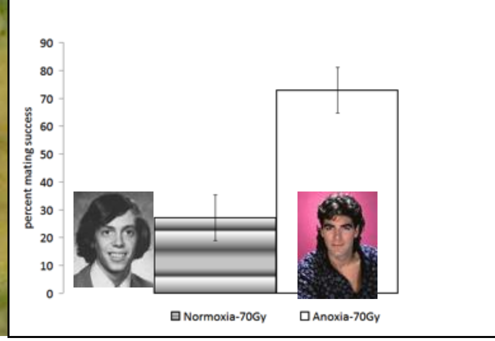
Diapausing pupae are programmed hardy to:

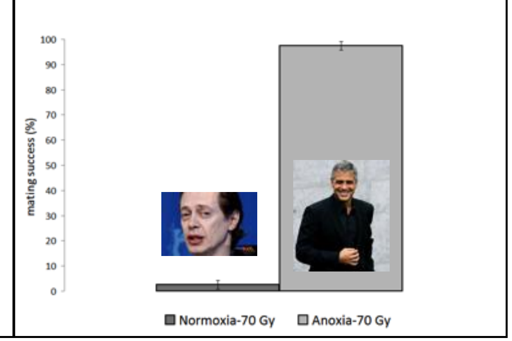
Cold
Desiccation
Anxoia
Pathogens
Oxidative stress

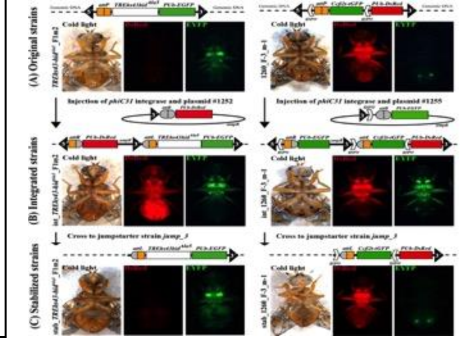
Denlinger et al. 2005 Comp. Ins. Biochem. Physiol.











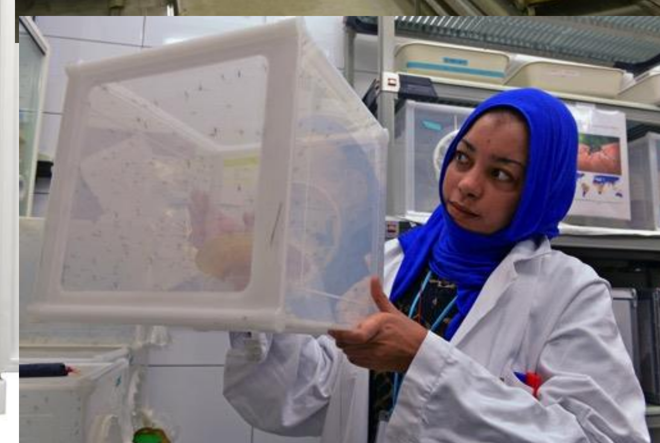
Hormetic & Transgenic Approaches to Boost Stress hardiness and Improve Male Performance in SIT

GC Lopez, Nick Teets, Vanessa Dias, Al Handler, & Marc Schelteg





Maintaining genetic integrity of strains, long-term stock storage.



-Goldenrod gall fly can freeze solid during overwinter diapause

-Diapausing larvae remain frozen for months

-Also Antartic Midge (*Belgica antartica*)

-Also *Chymomyza costata* (Drosophilid)

Conversion of the chill susceptible fruit fly larva (*Drosophila melanogaster*) to a freeze tolerant organism

Vladimír Koštál[a,b,1], Petr Šimek[a], Helena Zahradníčková[a], Jana Cimlová[a], and Tomáš Štětina[b]

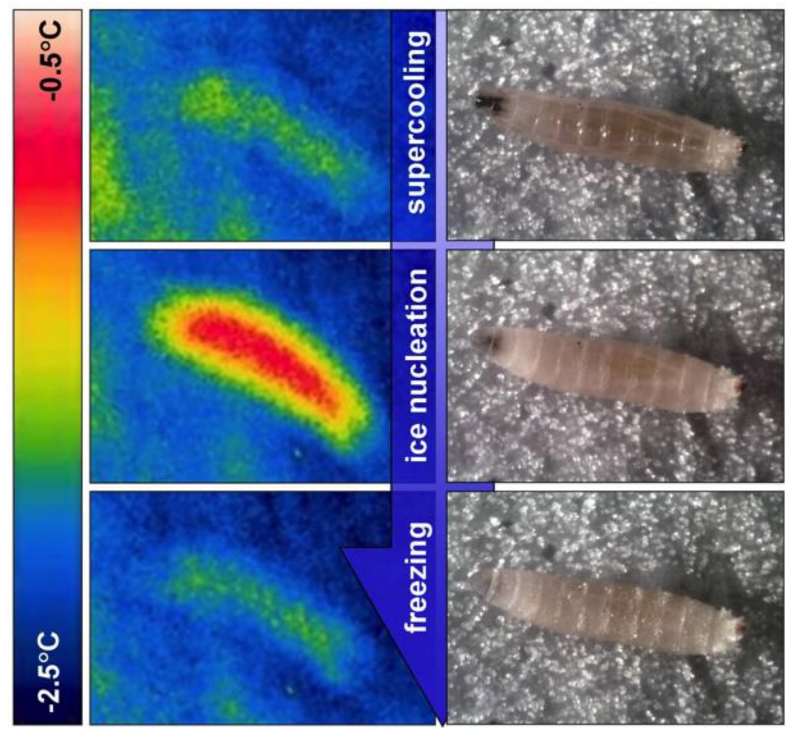
[a]Institute of Entomology, Biology Centre ASCR (Academy of Sciences of the Czech Republic), Branišovská 31, 370 05 České Budějovice, Czech Republic; and [b]Faculty of Science, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic

Edited by David L. Denlinger, Ohio State University, Columbus, OH, and approved January 17, 2012 (received for review December 5, 2011)

Among vertebrates, only a few species of amphibians and reptiles tolerate the formation of ice crystals in their body fluids. Freeze tolerance is much more widespread in invertebrates, especially

they accumulate high levels of the free amino acid L-proline—an innate cryoprotectant (proline in further text) (20).

In this study, we investigated whether the principles underlying



IAEA CRP – could dormancy management tools be used to :

1. manage life cycles for mass rearing?

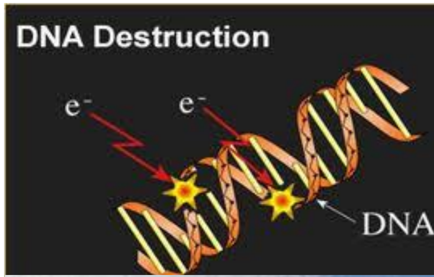
2. maintain genetic integrity of strains?

3. enable or enhance shelf life of sterile insects & enemies for release upon demand?



IAEA CRP – could dormancy management tools be used to :

4. reduce radiation injury
   & performance loss?
5. decrease damage from handling, shipping, & release?
6. develop novel pest management?
   -inducing “ecological suicide”?



Thanks to…

IAEA/FAO Insect Pest Control – Dormancy CRP