

# Warming impact on herbivore population composition affects top-down control by predators

Ying-Jie Wang<sup>1</sup>, Takefumi Nakazawa<sup>2</sup>, and Chuan-Kai Ho<sup>1</sup>

<sup>1</sup> Institute of Ecology and Evolutionary Biology, National Taiwan University

<sup>2</sup> Department of Life Sciences, National Cheng Kung University



# Warming impact on herbivore population composition affects top-down control by predators

Ying-Jie Wang<sup>1</sup>, Takefumi Nakazawa<sup>2</sup>, and Chuan-Kai Ho<sup>1</sup>

<sup>1</sup> Institute of Ecology and Evolutionary Biology, National Taiwan University

<sup>2</sup> Department of Life Sciences, National Cheng Kung University

*Thank you for coming!*



# Warming impact on herbivore population composition affects top-down control by predators

Ying-Jie Wang<sup>1</sup>, Takefumi Nakazawa<sup>2</sup>, and Chuan-Kai Ho<sup>1</sup>

<sup>1</sup> Institute of Ecology and Evolutionary Biology, National Taiwan University

<sup>2</sup> Department of Life Sciences, National Cheng Kung University



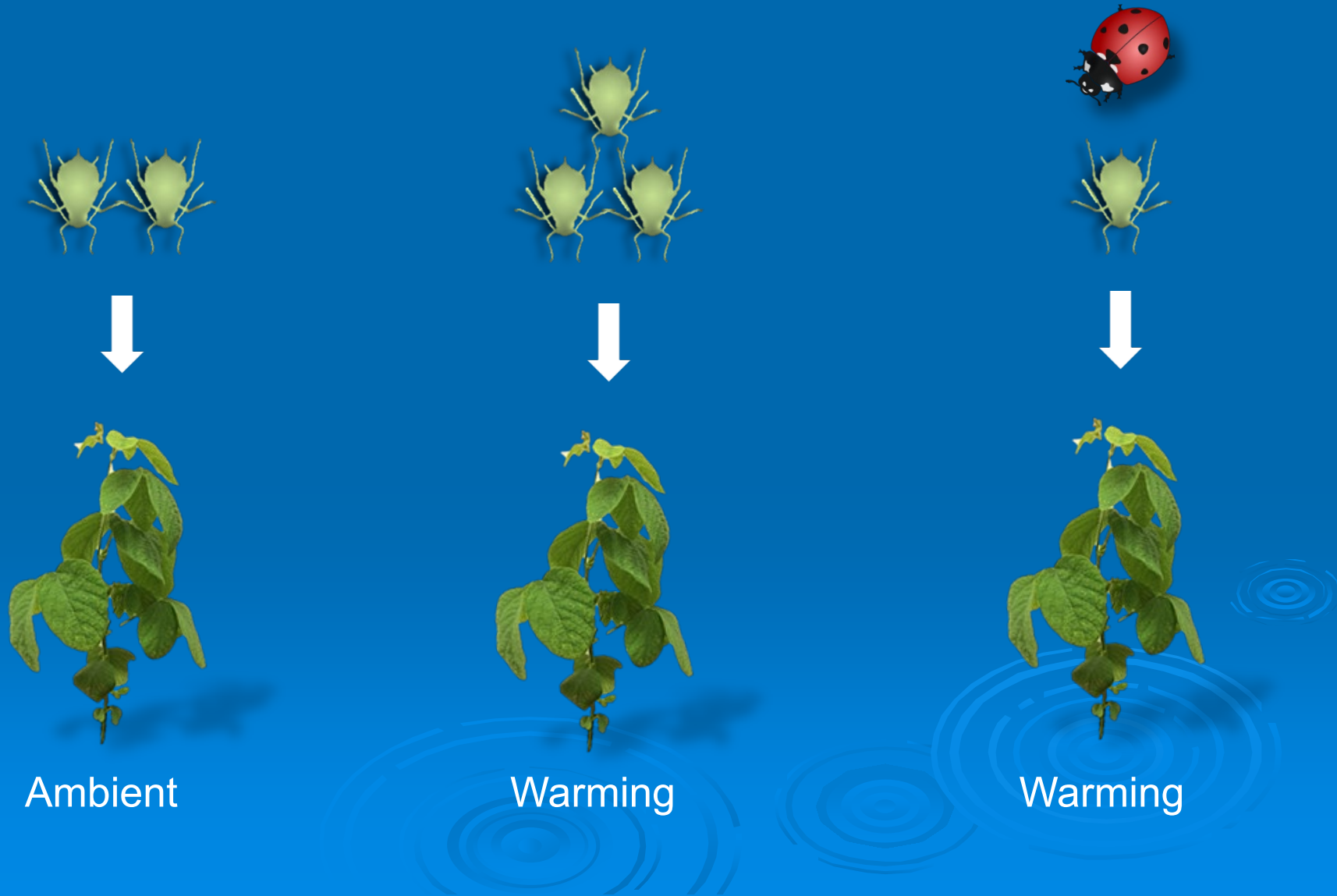
## ➤ Background

- Herbivores exert TD control on plant growth, development, and production in natural and agricultural systems (Oerke 2006, Nability et al. 2009, Stephens and Wesoby 2015)
- Climate warming



## ➤ Background

- Warming impact on herbivores > Benefit or damage plants

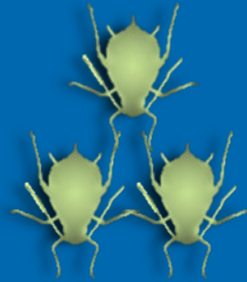


## ➤ Knowledge gaps

- Population size



Ambient



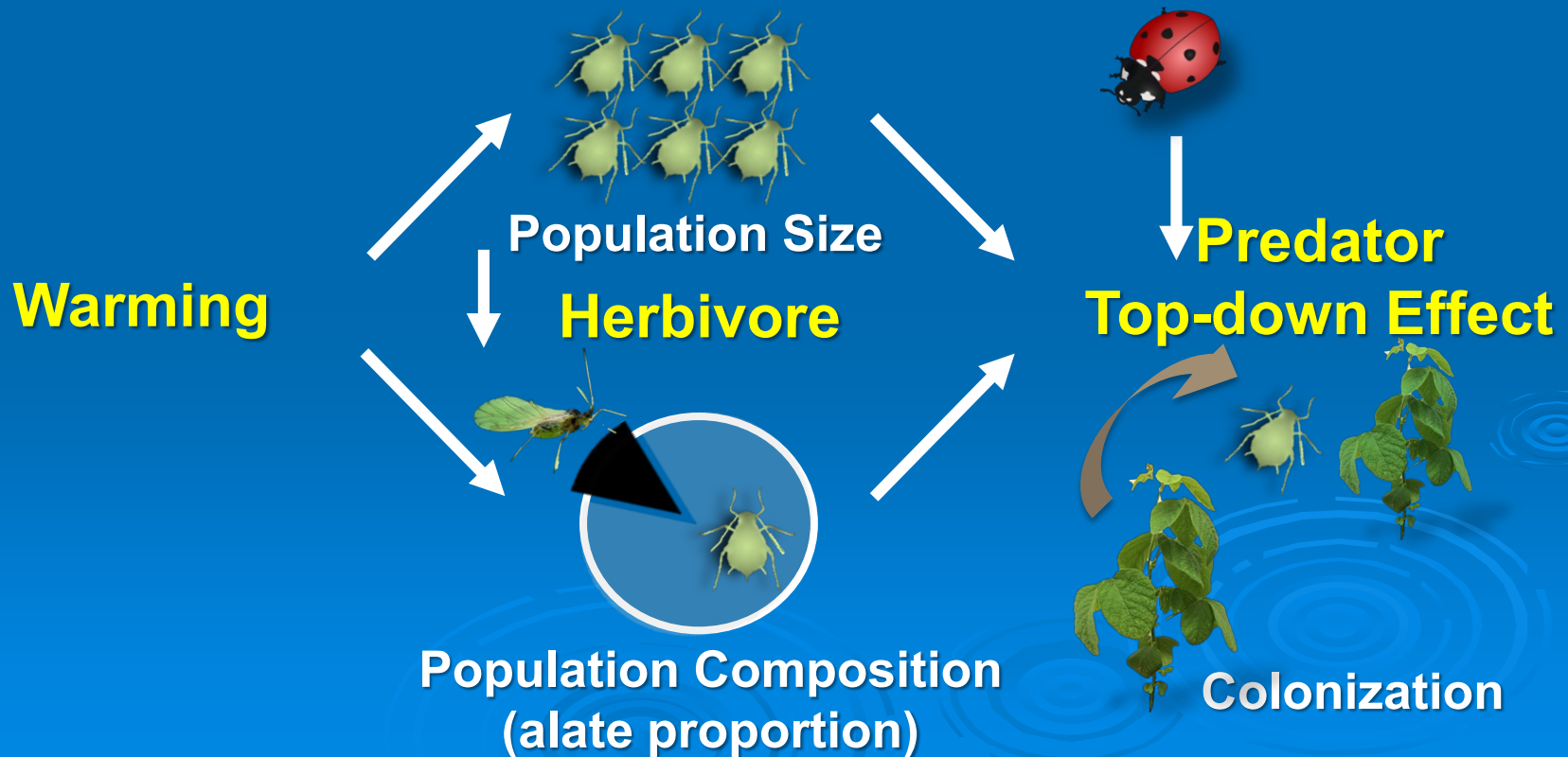
Warming



Warming

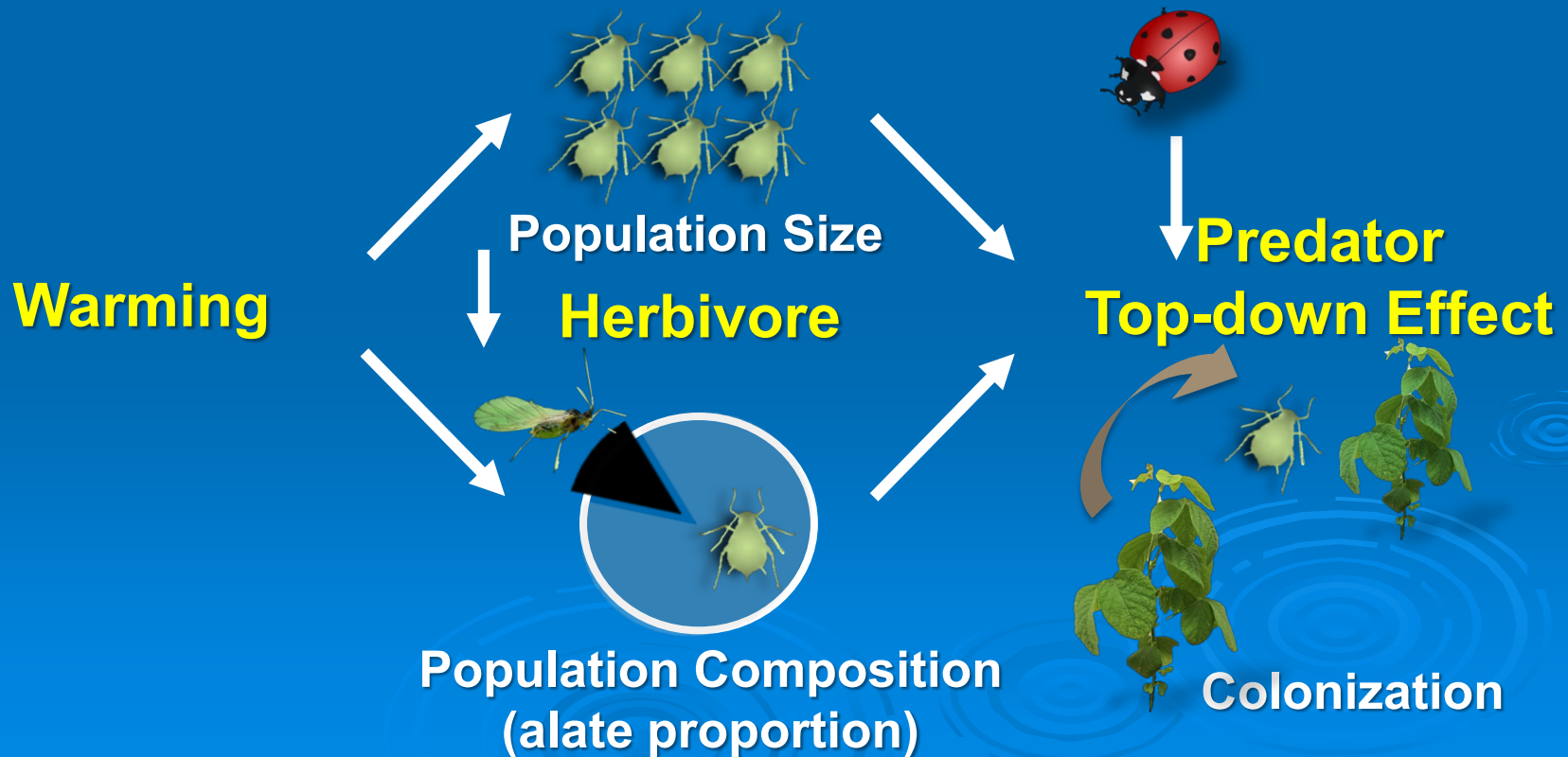
## ➤ Knowledge gaps

- 1) Warming on population size and population composition
- 2) Colonization with/without predators



## ➤ Aims

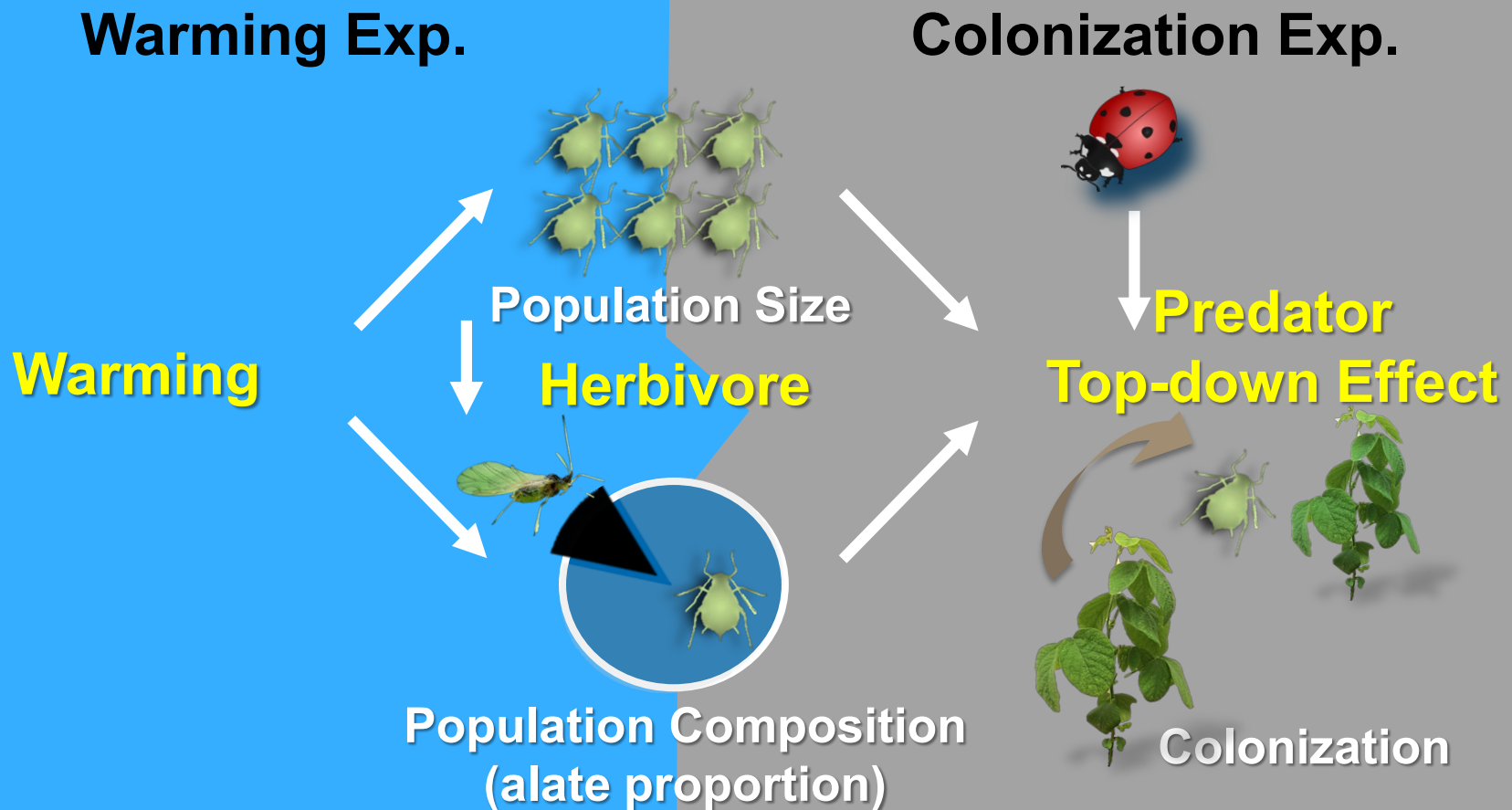
- 1) How would 2-4°C warming affect the population size and composition (alate vs. apterous) of aphids?
- 2) How would this impact subsequently interact with ladybug (predator) effect in influencing aphid colonization?





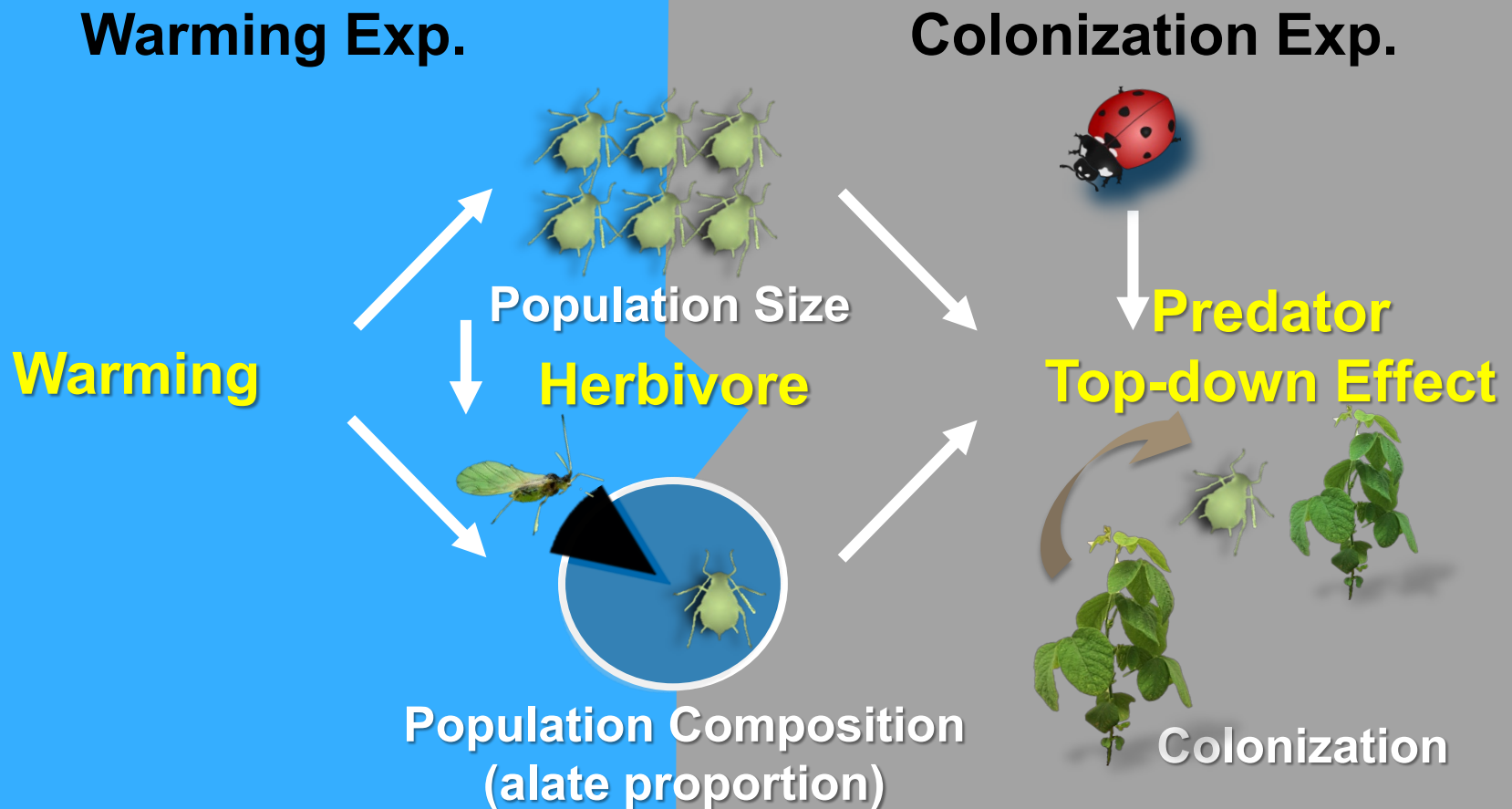
## ➤ Methods

- 1) How would 2-4°C warming affect the population size and composition (alate vs. apterous) of aphids? **Lab**
- 2) How would this impact subsequently interact with ladybug (predator) effect in influencing aphid colonization? **Field**



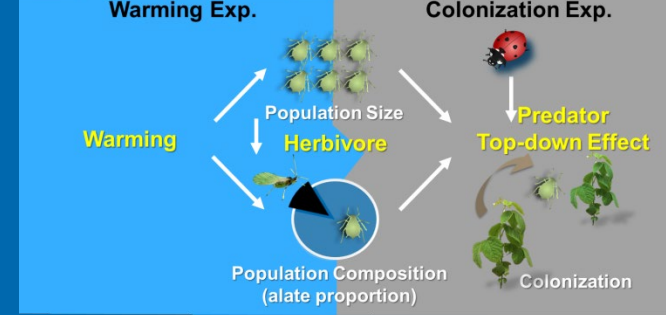
## ➤ Methods

- Soybean (*Glycine max*), soybean aphids (*Aphis glycines*), and seven-spotted ladybugs (*Coccinella septempunctata*)
- A typical tri-trophic system
- Important crop, pest, and biocontrol agent



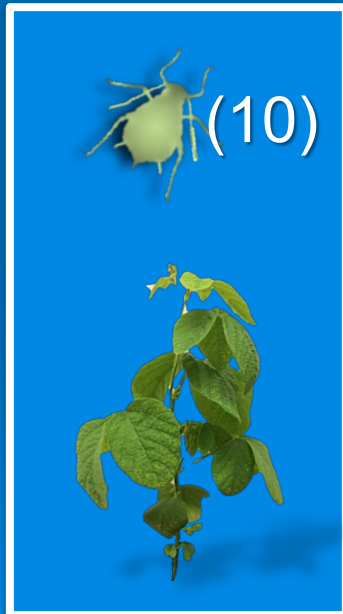
## ➤ Methods – Warming Exp.

- Soybean growth season: 24.7°C
- IPCC prediction by 2100
- Soybean aphids' OTR: 25-30°C (McCornack et al. 2004)



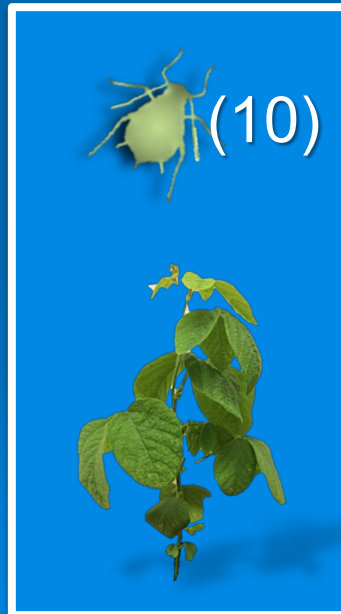
**24.5°C**

**Ambient**



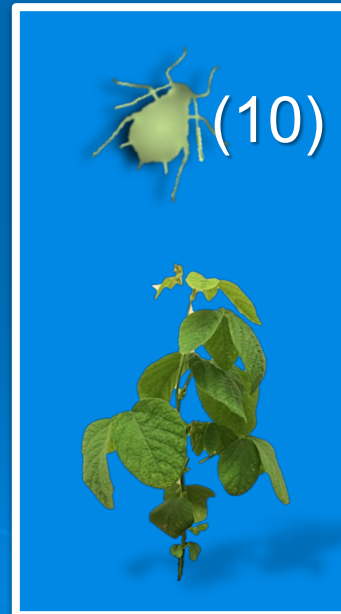
**26.5°C**

**+2°C**



**28.5°C**

**+4°C**



**N = 30**

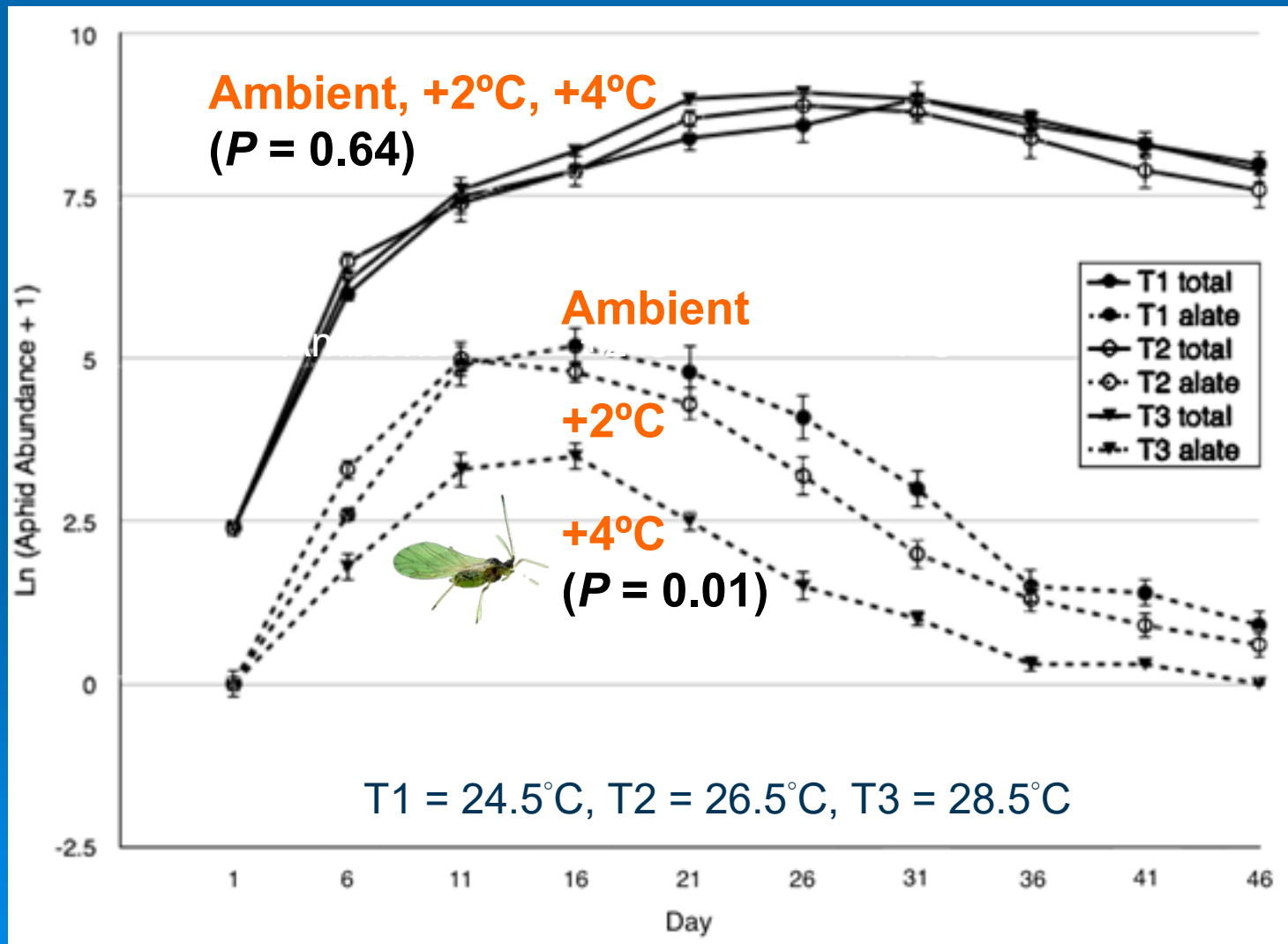


**45 days**



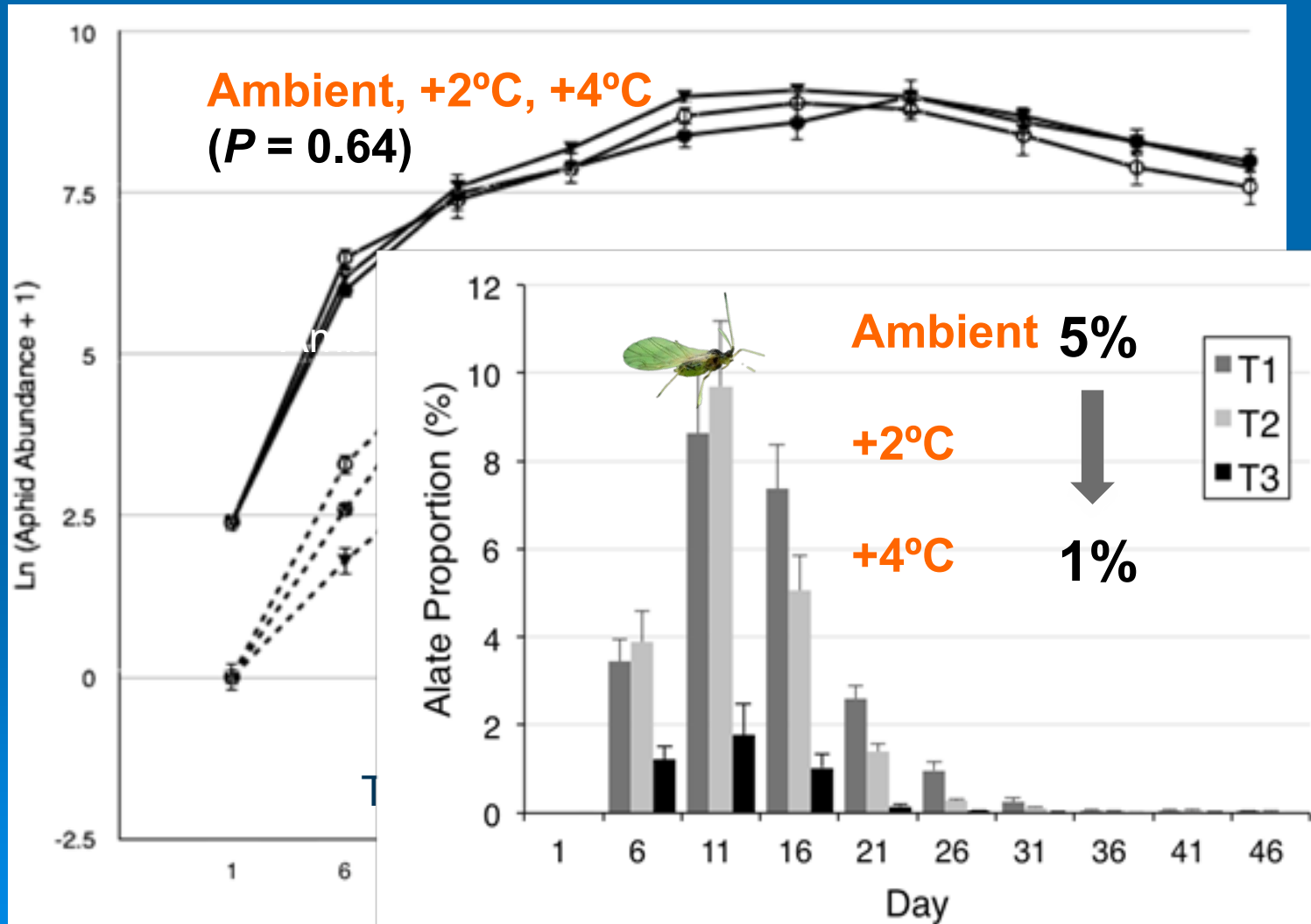
## ➤ Results – Warming Exp.

- Warming (2-4°C) did not affect overall aphid population size, but reduced alate production (**changed pop composition**).



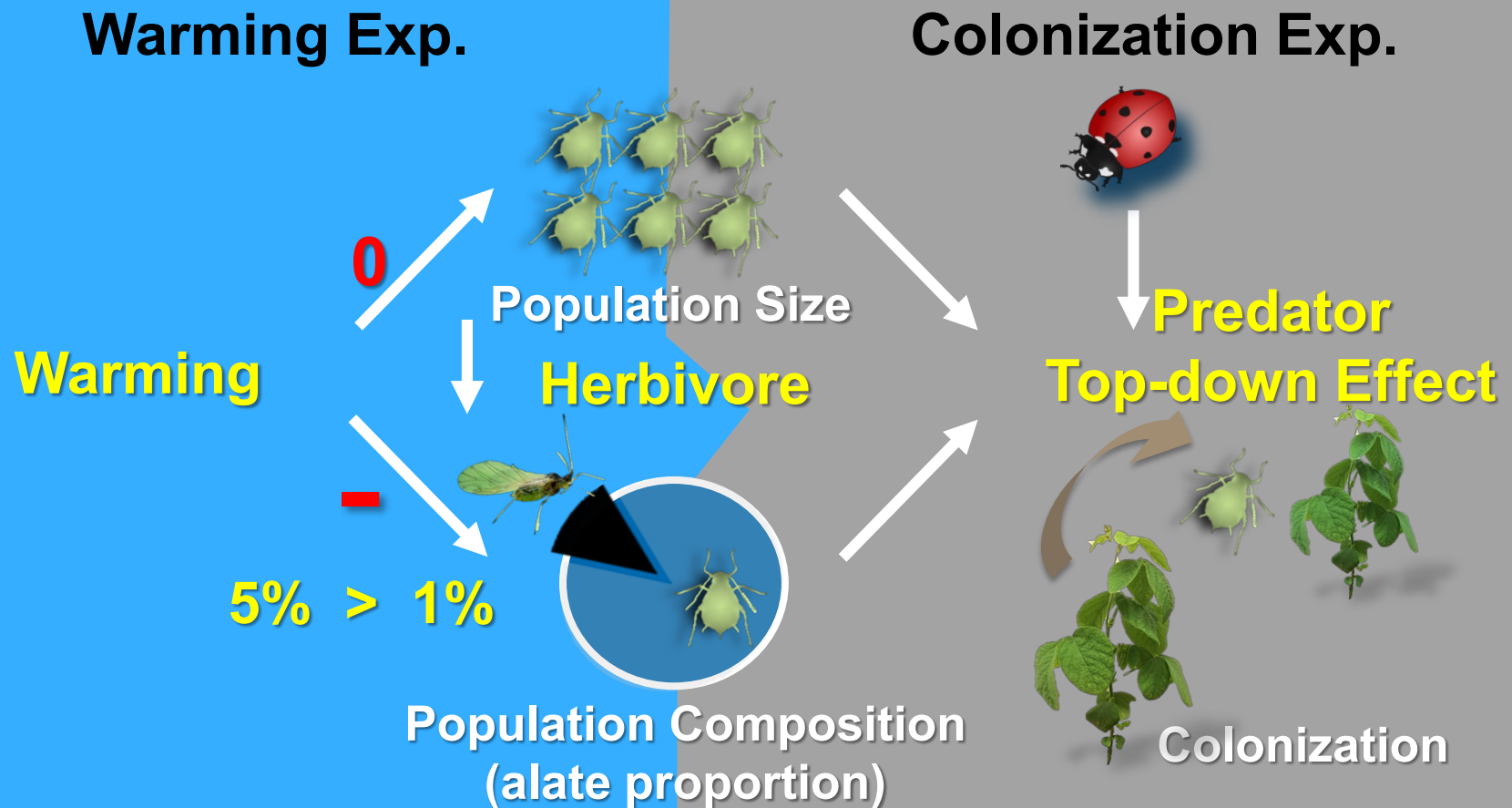
## ➤ Results – Warming Exp.

- Warming (2-4°C) did not affect overall aphid population size, but reduced alate production (**changed pop composition**).



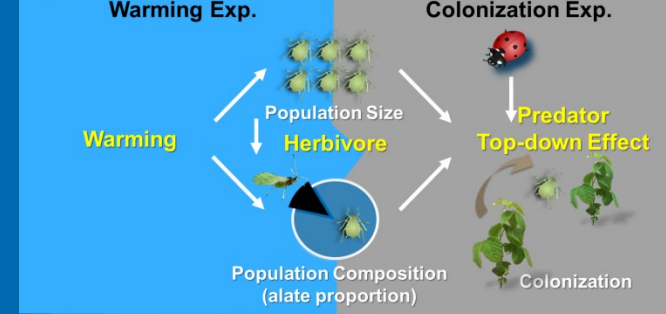
## ➤ Results – Warming Exp.





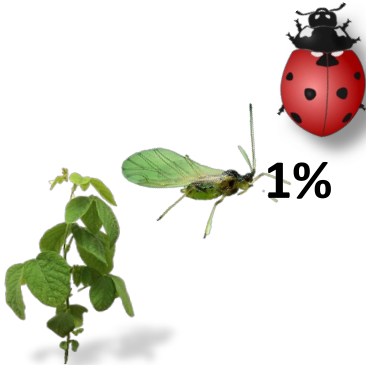
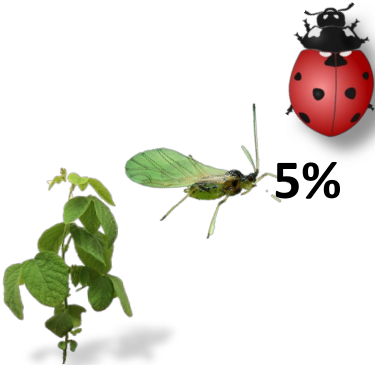
- Warming (2-4°C) did not affect overall aphid population size, but reduced alate production (**changed pop composition**).



## ➤ Methods – Colonization Exp.

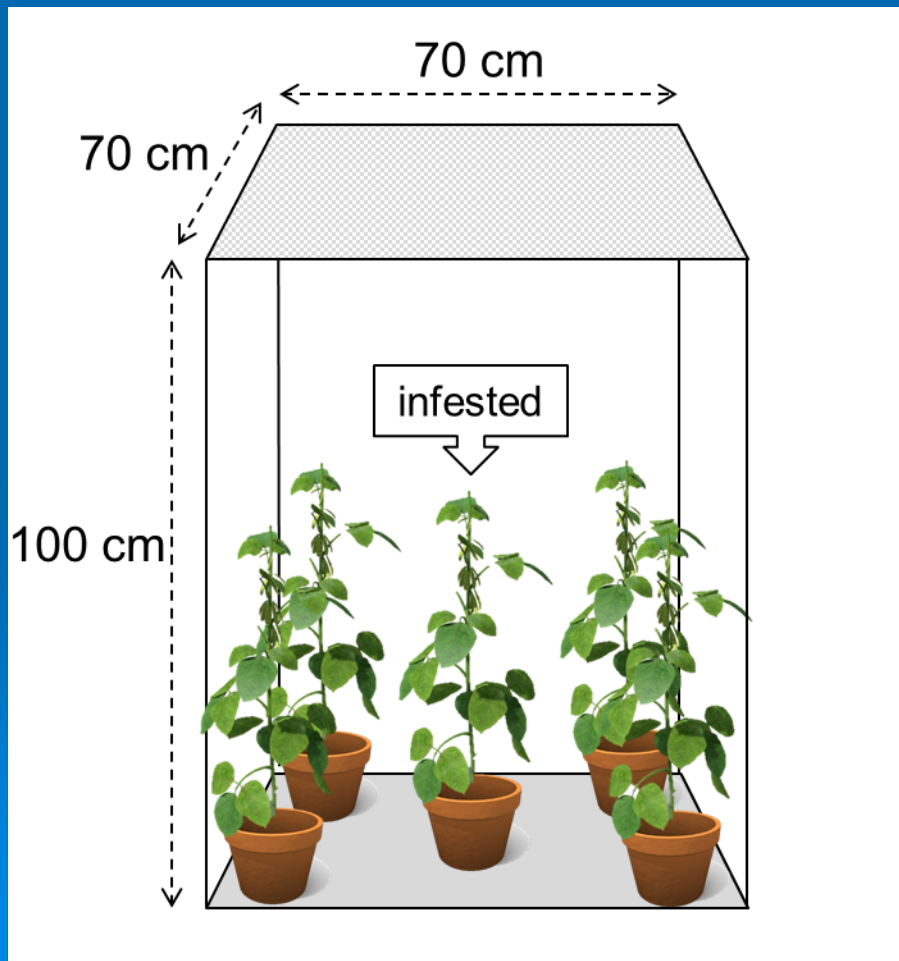
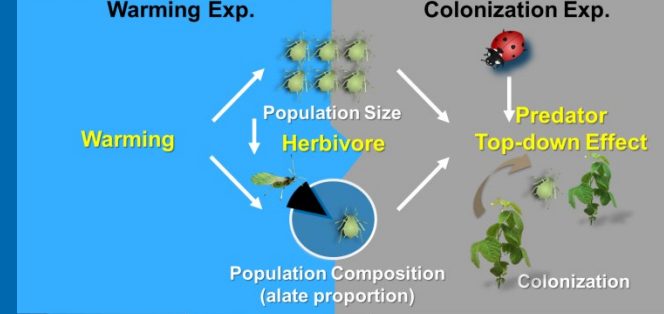
- 2 x 2 factorial design
- Aphids (400), LB (1, 0)



		Alate proportion	
		1% (warming)	5% (ambient)
Ladybug treatment			
			

## ➤ Methods – Colonization Exp.

- 2 x 2 factorial design
- Aphids (400), LB (1, 0)
- Aphids on central and 4 neighbor plants



$N = 20$

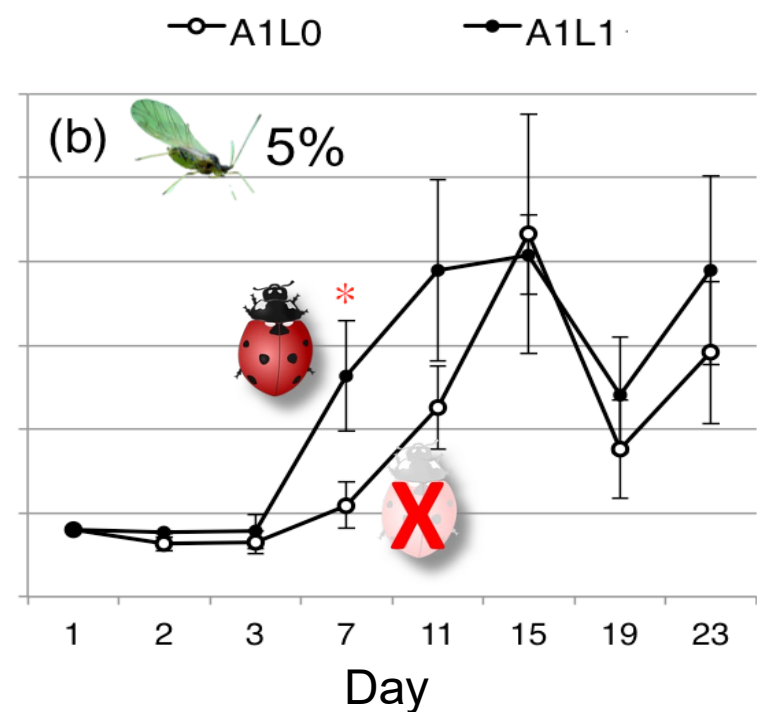
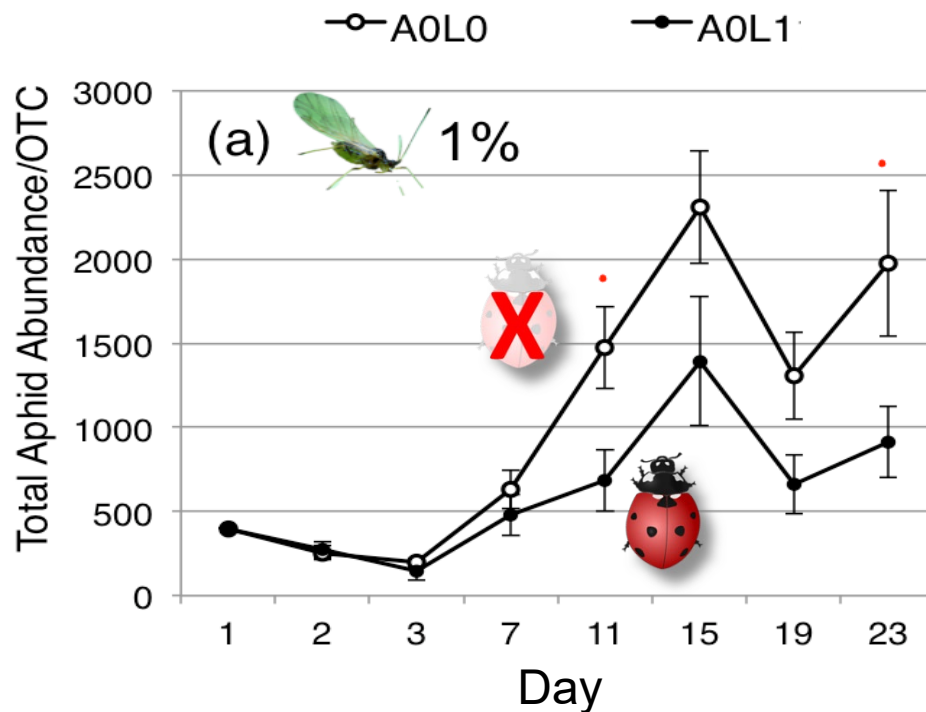
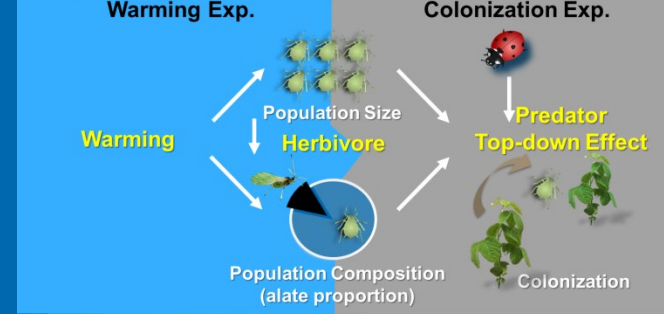


23 days



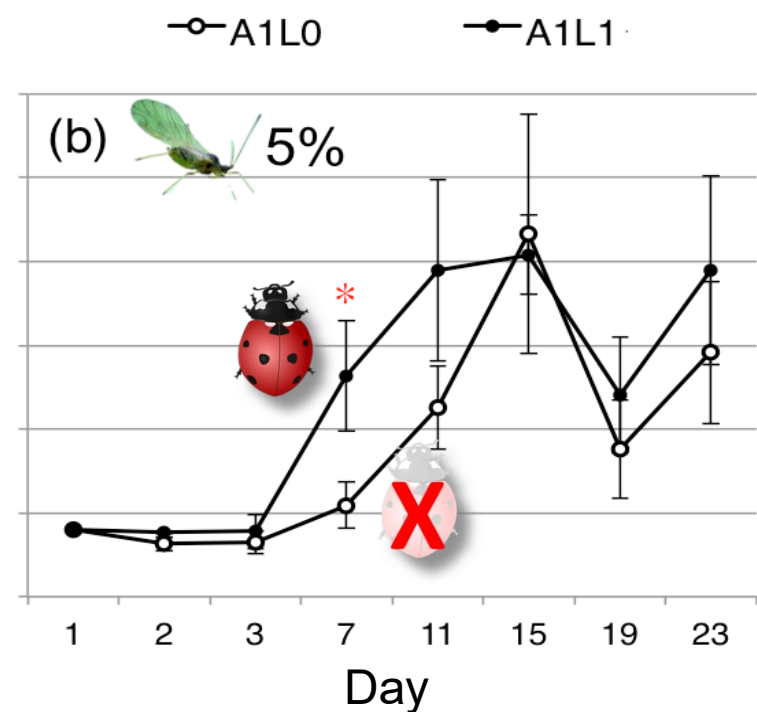
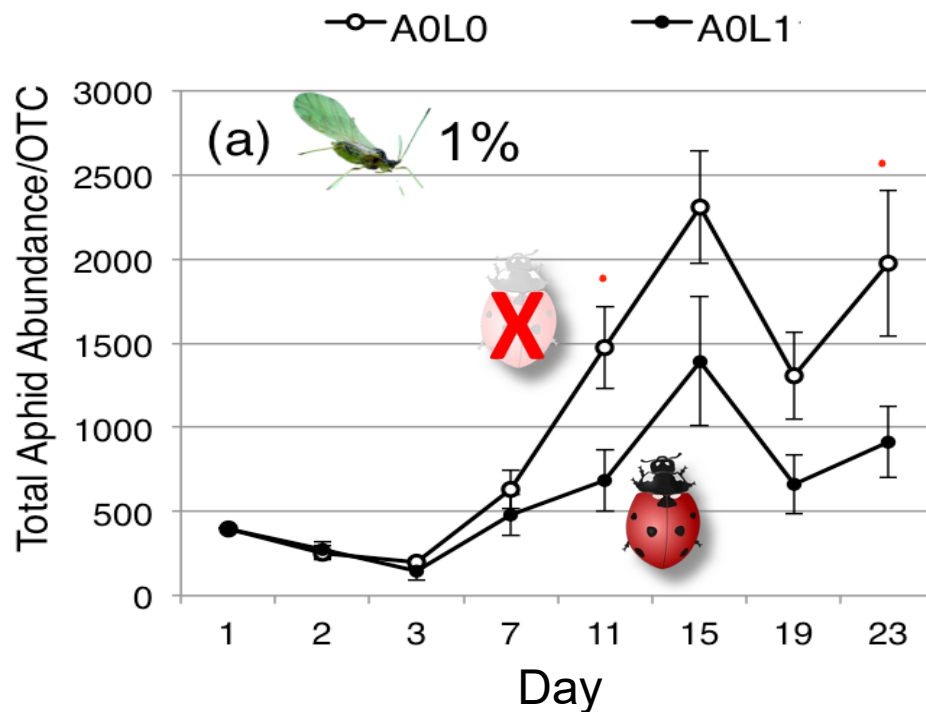
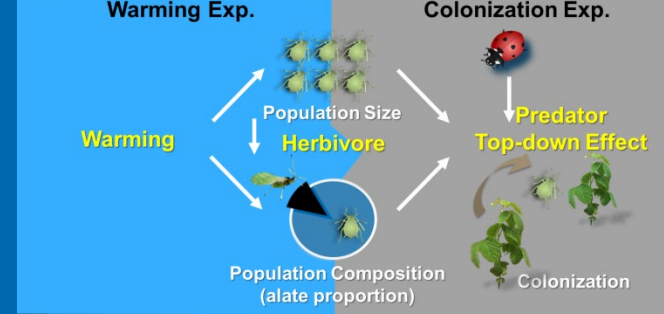
## ➤ Results – Colonization Exp.

- Alate proportion x Ladybug treatment ( $P = 0.037$ )
- Higher alate (5%, ambient): aphids colonized faster
- Ladybugs' presence could “promote” aphid colonization.



## ➤ Results – Colonization Exp.

- Alate proportion x Ladybug treatment ( $P = 0.037$ )
- Lower alate (1%, warming): aphids colonized slower
- Effective TD control (biocontrol) on aphids by ladybugs



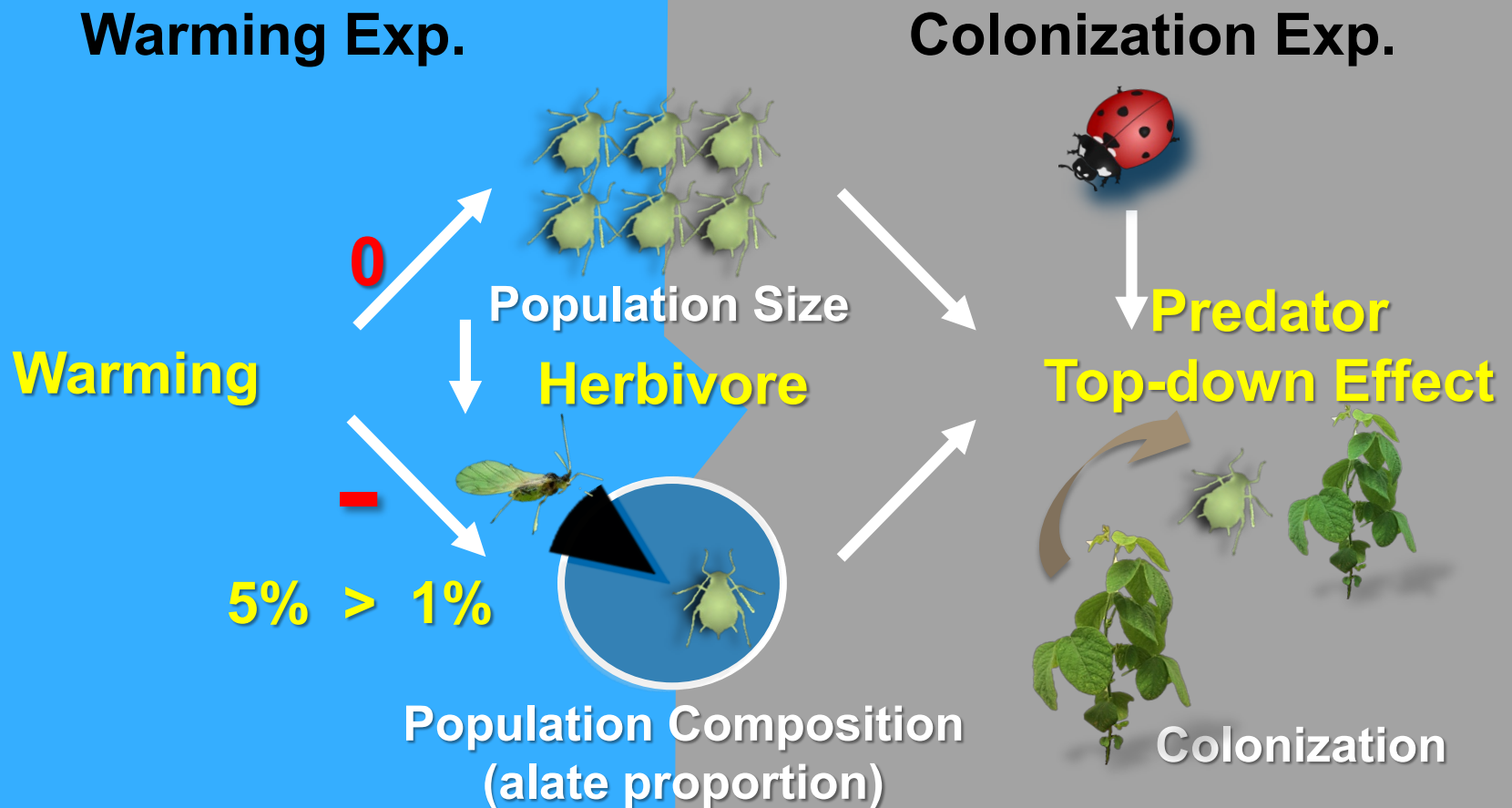
## ➤ Discussion

- TD control of plants by herbivores is critical for determining wild plant dynamics and crop production (food security).



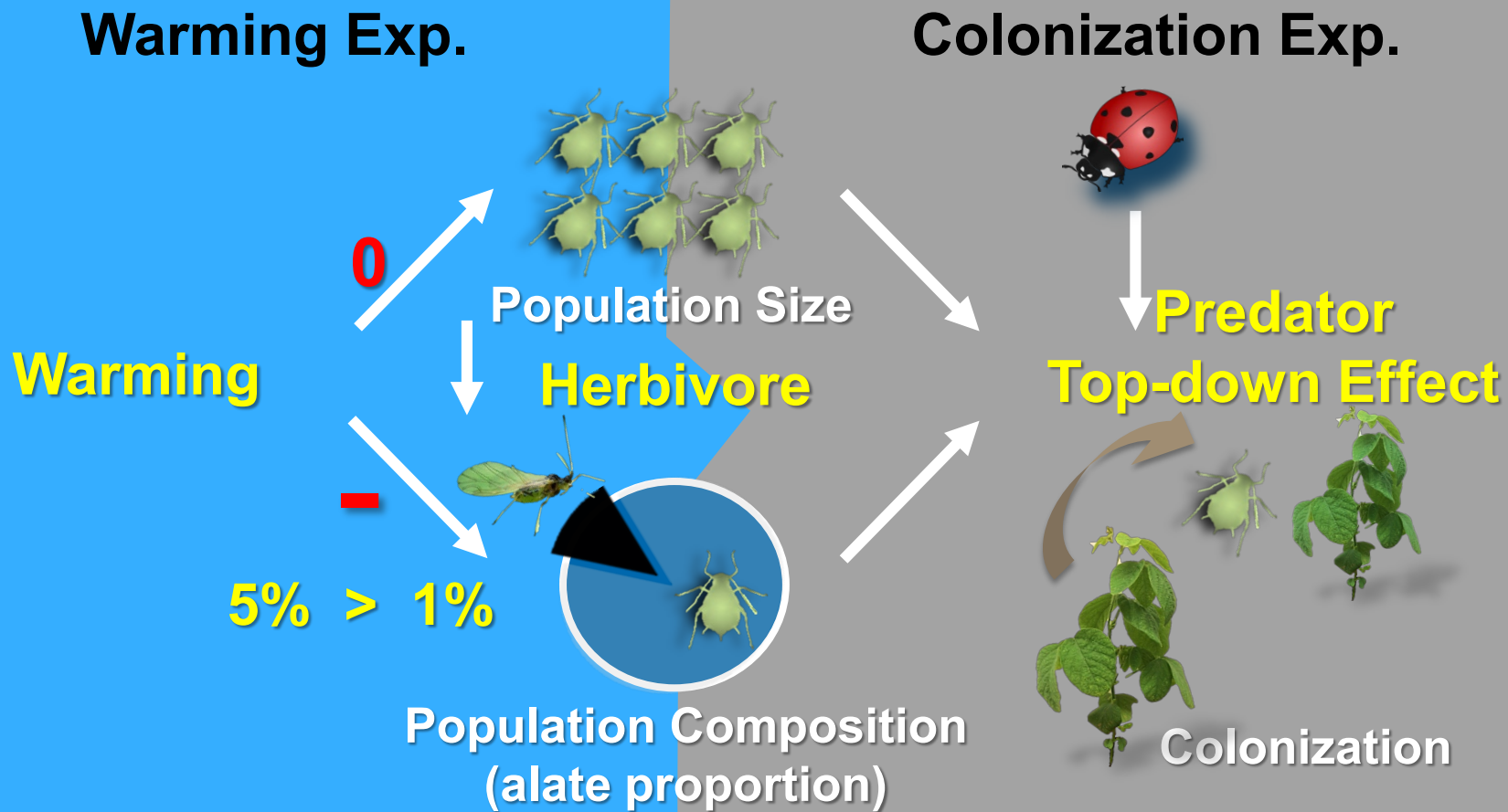
## ➤ Discussion

- TD control of plants by herbivores is critical for determining wild plant dynamics and crop production (food security).



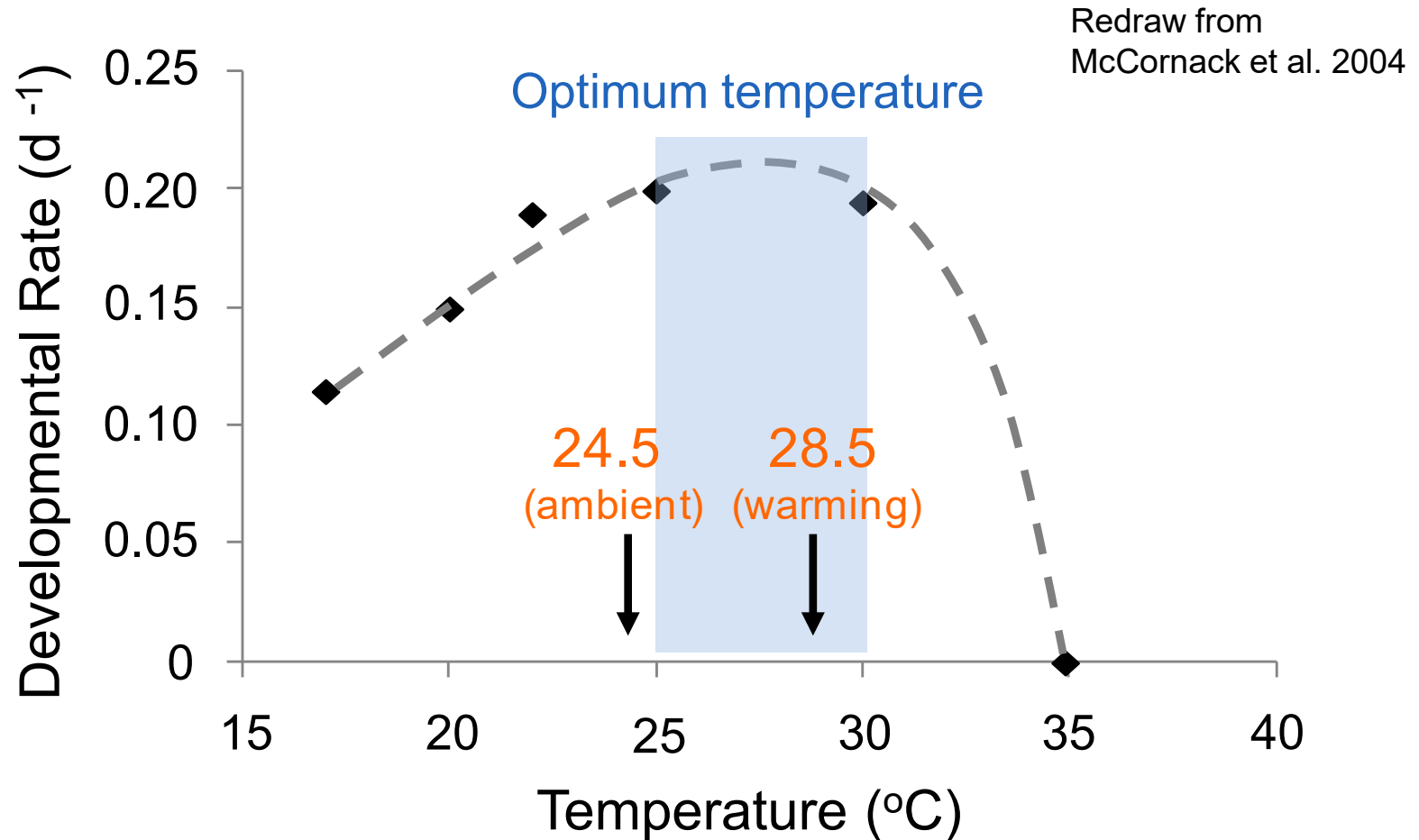
## ➤ Discussion

- Why no change in population size? **4°C warming**



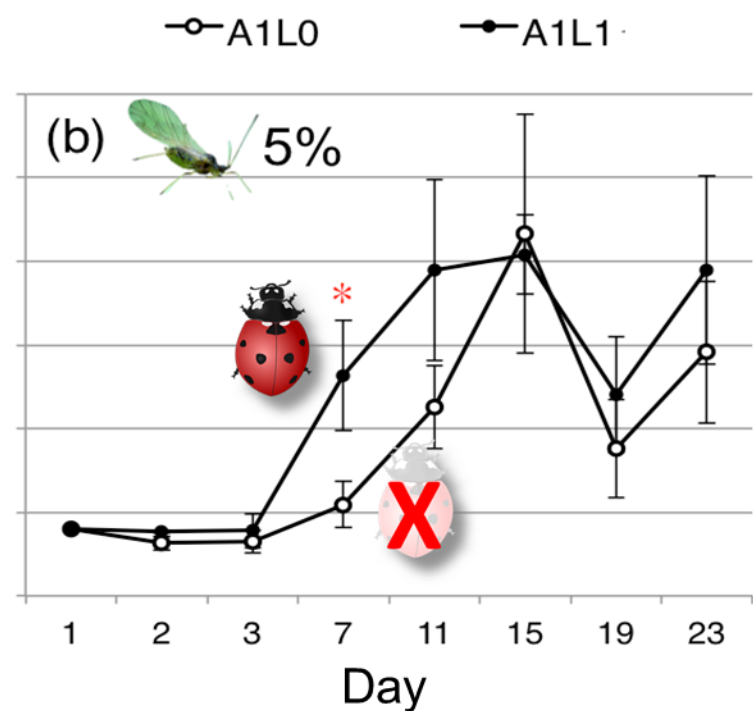
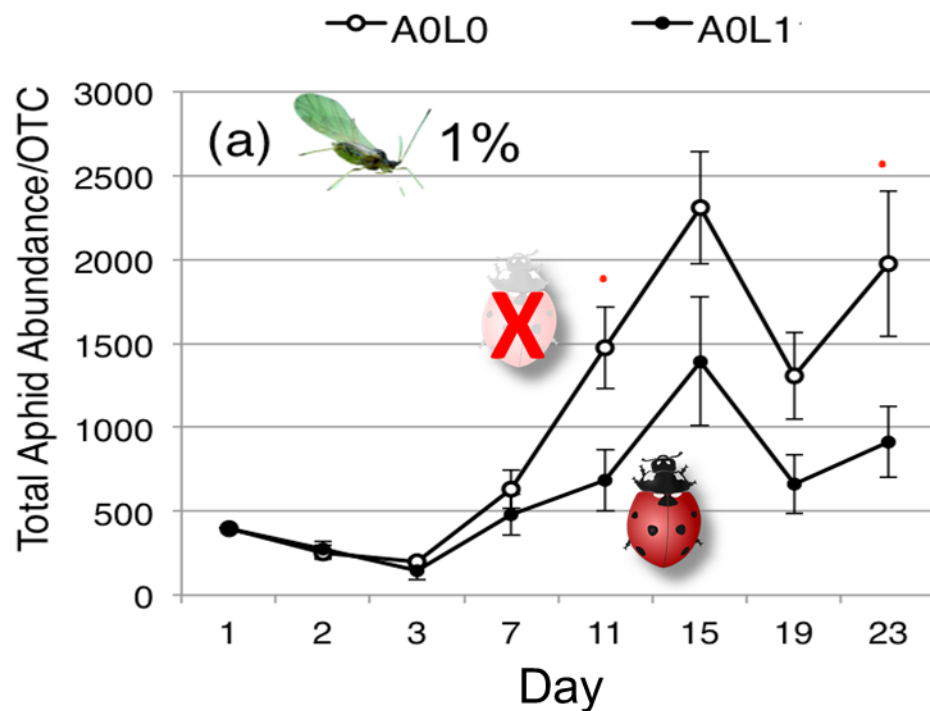
## ➤ Discussion

- Why no change in population size? **4°C warming**



## ➤ Discussion

- Interaction between herbivore population composition (alate proportion) and predator presence (ladybugs)

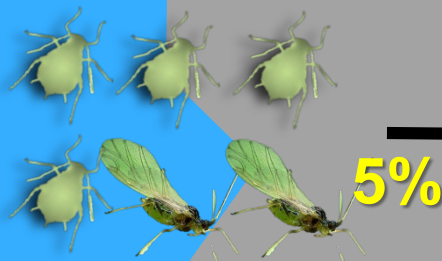


## ➤ Discussion

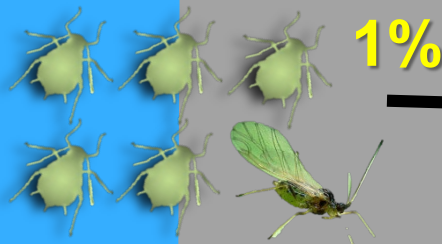
- Interaction between herbivore population composition (alate proportion) and predator presence (ladybugs) **Why?**

### Warming Exp.

Ambient



Warming



### Colonization Exp.

Predator  Effect

enhance aphid colonization

inhibit aphid colonization

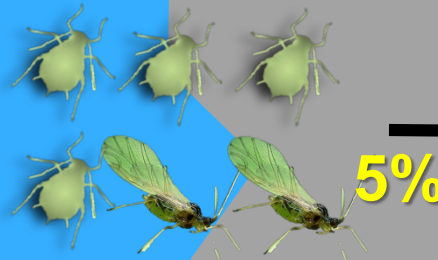


## ➤ Discussion

- Randomness > Reduce predator efficiency
- Predation risk > Aphid alarm pheromone > Higher intrinsic growth rate of aphid population (Barribeau et al. 2010)

### Warming Exp.

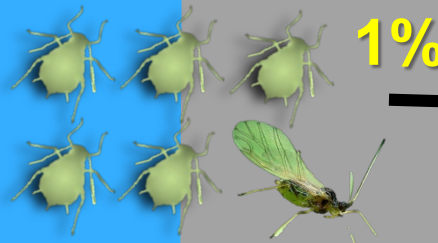
Ambient



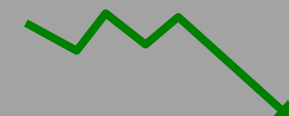
enhance aphid colonization



Warming



inhibit aphid colonization



### Colonization Exp.

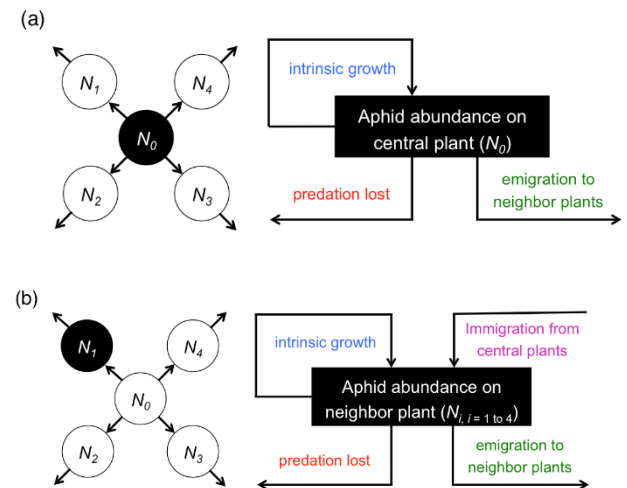
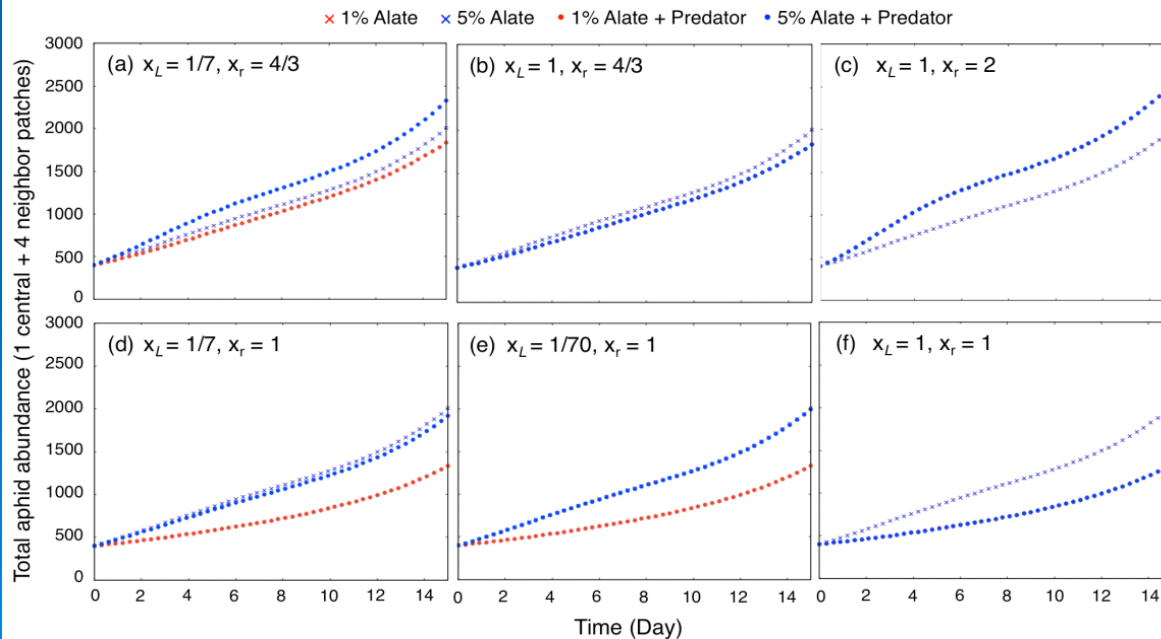
Predator  Effect

# ➤ Discussion

- Randomness > Reduce predator efficiency
- Predation risk > Aphid alarm pheromone > Higher intrinsic growth

$$\frac{dN_0}{dt} = x_r r N_0 \left(1 - \frac{N_0}{K}\right) - x_L L \frac{N_0^2}{(h + N_0) \sum_{j=0}^4 N_j} - d (N_0)^2 \quad (D1a)$$

$$\frac{dN_i}{dt} = r N_i \left(1 - \frac{N_i}{K}\right) - x_L L \frac{N_i^2}{(h + N_i) \sum_{j=0}^4 N_j} - d (N_i)^2 + \frac{pd(N_0)^2}{4} \quad (i = 1 \text{ to } 4) \quad (D1b)$$



## ➤ Conclusions

- Warming may affect herbivore population composition and then influence predators' top-down control on herbivore colonization.
- This mechanism may be crucial but underappreciated in climate change ecology because population composition (wing form, sex ratio, age/body size structure) shifts in many species under environmental change.



# Thanks!

We study *climate change* impact on *plants and animals*.  
Welcome collaboration!

