Predation of Aphids in Organic Prunes: How Many Predators are Enough?

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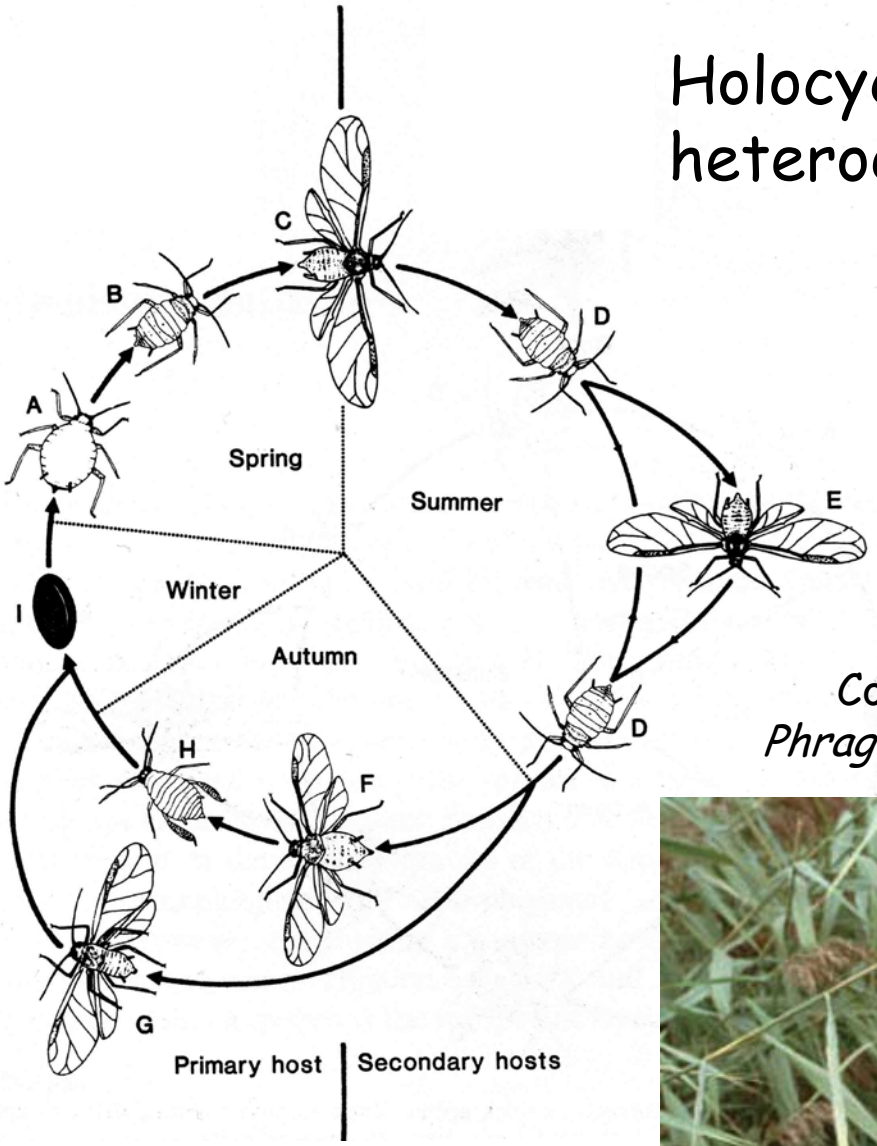
Mealy Plum Aphid, *Hyalopterus pruni* (MPA) in Organic Prune Production in California

- Reduces tree growth
- Produces copious honeydew
- May interact with irrigation to increase fruit splitting

Aphid Life Cycle – Mealy Plum Aphid (MPA)

Prune
Prunus domestica

Holocyclic and heteroecious



Common Reed
Phragmites australis

Predation in Organic Prunes

- In organic prunes MPA are preyed upon by a wide range of aphid predators

- How may predators are needed to achieve adequate control of MPA?

Predator Assemblage of MPA in California Relative Abundance

Chrysoperla plorabunda

Leucopis spp.

Aphidoletes aphidimyza

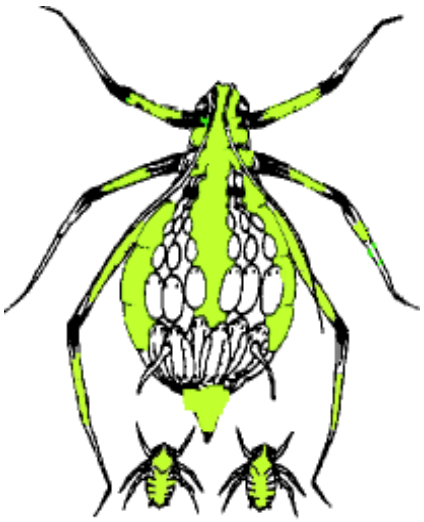
Chrysopa nigricornis

Harmonia axyridis

Hippodamia convergens

Understanding Predation: Theoretical Basis

For aphids, population size (N) results from a balance between reproduction and mortality and can be represented by a simple model of exponential growth (r) and predation (gP):



$$dN/dt = rN - gP$$

The integrated form of this model is:

$$N_{t+1} = N_t e^{rt} + gP/r\,(1-e^{rt})$$

Xia et al. (2003)
Van der Heide et al. (2006)

So for zero growth ($N_{t+1} = N_t$):

$$gP = rN_t$$

the daily predation capacity (gP) must balance the potential for aphid reproduction (rN_t)

How Many Predators are Enough?

This is determined by two factors:

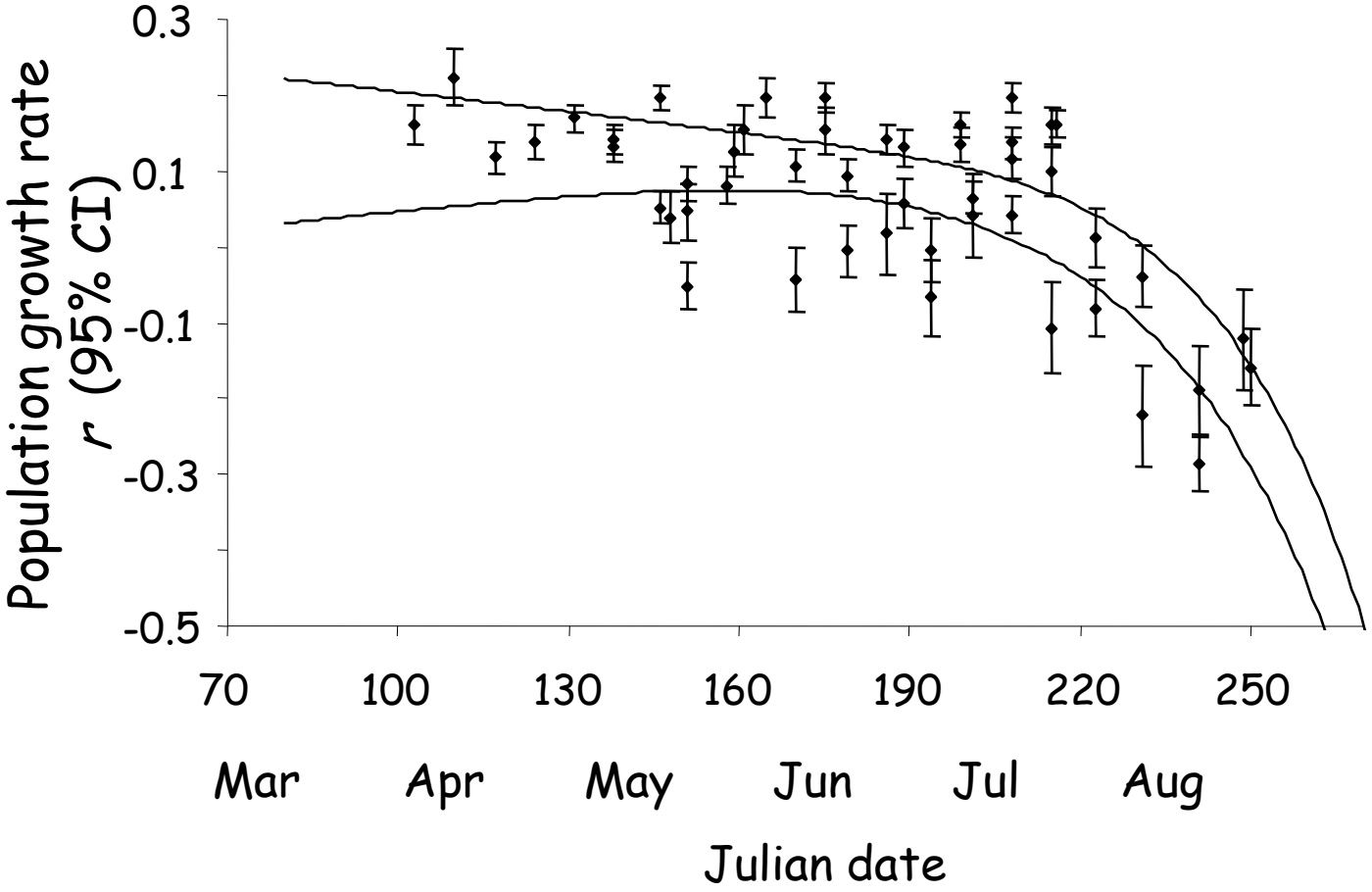
r - the seasonal change in aphid population growth

g - the per capita daily predation capacity

Estimating *r* : Seasonal Changes in MPA Population Growth

- Estimated from small individual colonies of MPA enclosed in gauze bags (to exclude predators) over a 1 wk period
- Monitored on new shoots in 3 fully-irrigated orchards for each of 2 yrs
- Estimated as $r = (1/t)\ln(N_{t+1}/N_t)$

Estimating *r* : Seasonal Changes in MPA Population Growth



Latham & Mills (2010)

$y = 0.127 - (0.00005*\exp[0.0354*x])$

$F_{2,46} = 22.67$, $R^2 = 0.47$, $P < 0.001$

Estimating *g*: Per Capita Predation Capacity

(Mills 2005)

- Laboratory estimation - # prey consumed over 24h in artificial arenas by individual predators

- Field cage estimation – difference in prey abundance after 24h between cages with and w/out predators

- Field gut detection – quantify immunological or molecular markers in the gut content of individual predators

- Direct field observation – point observations from many predator individuals or continuous monitoring of single individuals for feeding events

Estimating g: Per Capita Predation Capacity

Per capita daily predation rate g_{ij} was estimated by direct observation from 30 trees in each of 2 orchards in June (peak predator abundance):

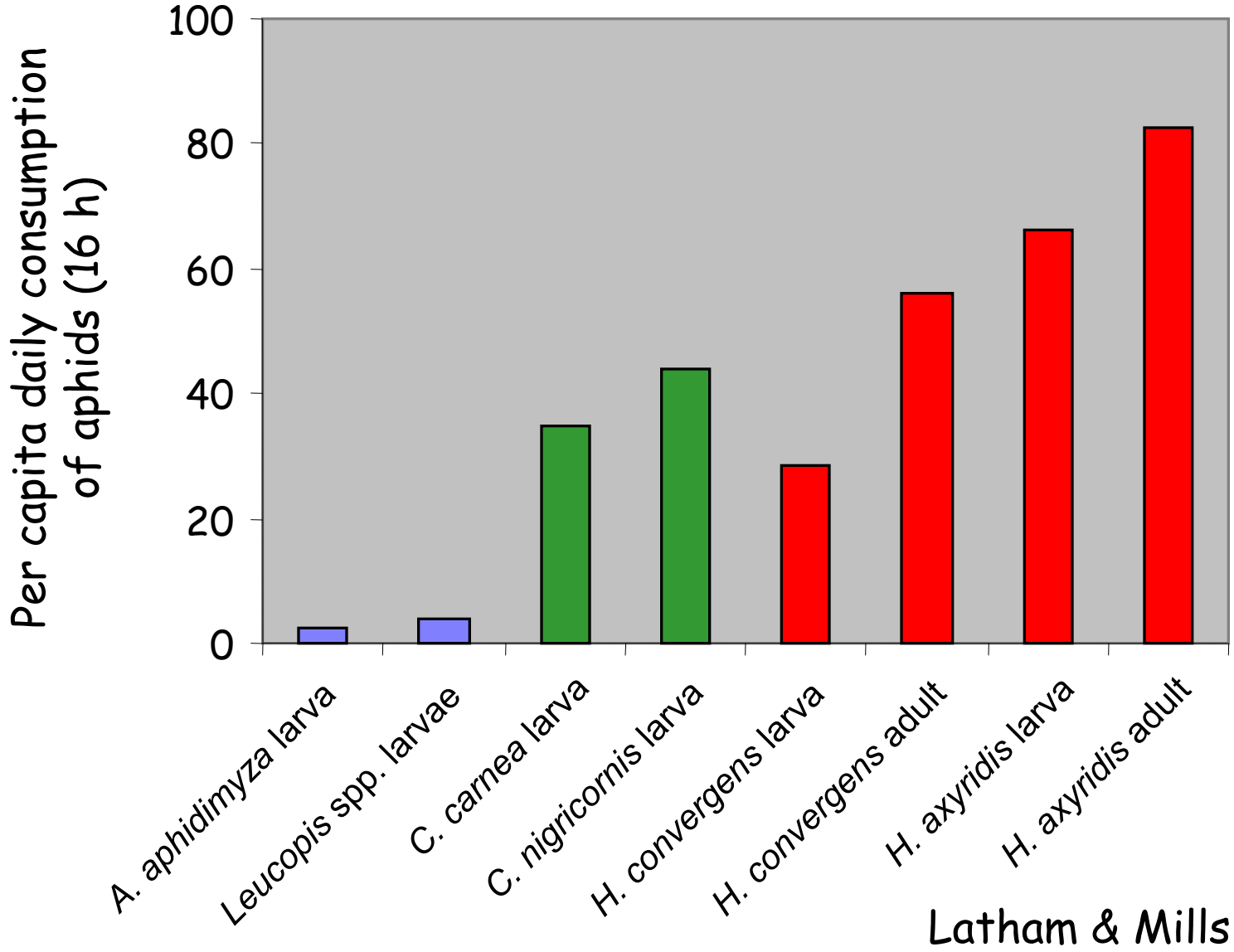
$$g_{ij} = (t_a * f_{ij}) / t_{c_{ij}}$$

t_a - active period each day, assumed equal to daylight hours (11-16h)

f_{ij} - proportion of t_a spent feeding by predator of stage j and species i

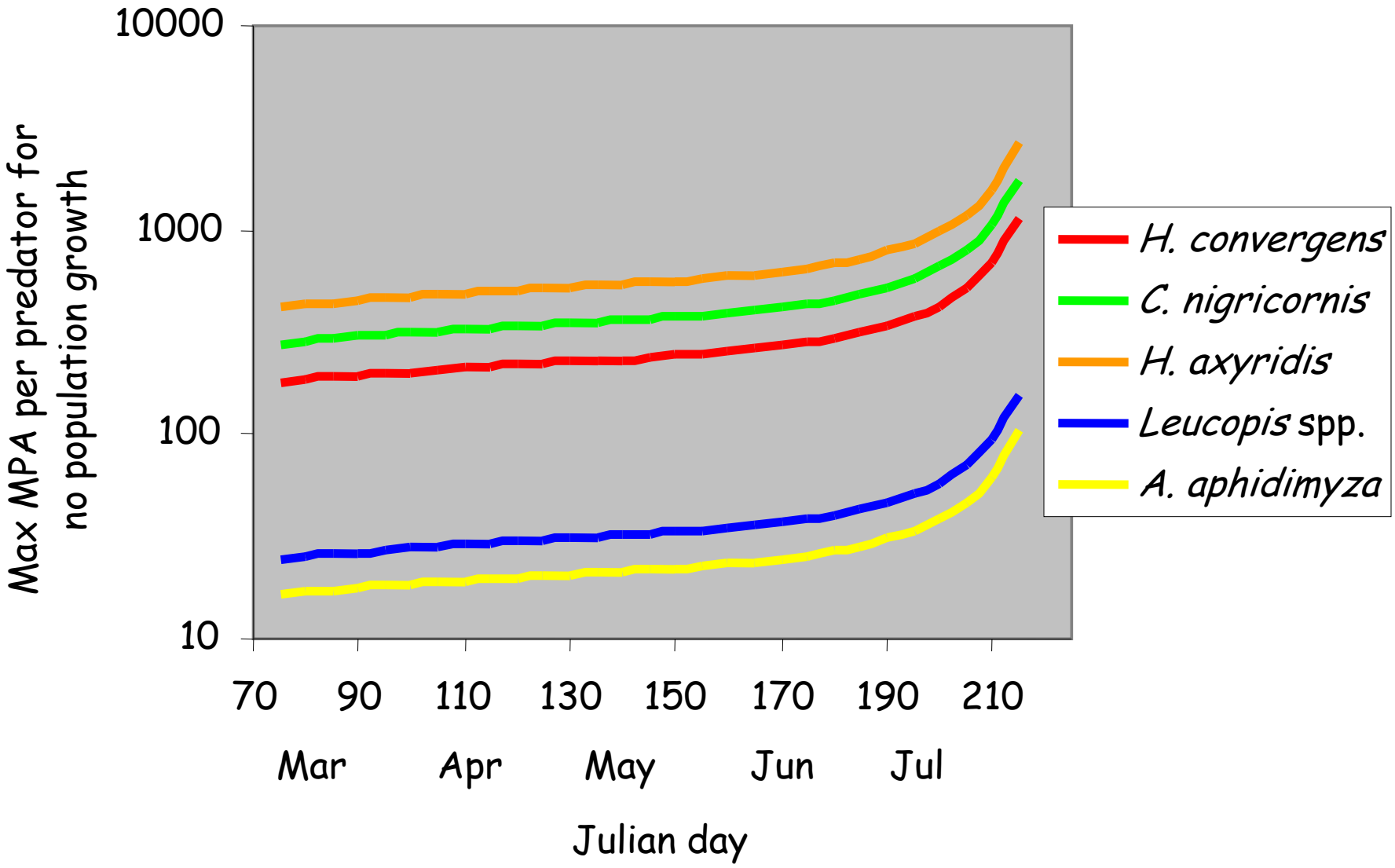
$t_{c_{ij}}$ - consumption time for single aphid by stage j of species i, h

Estimating *g*: Per Capita Predation Capacity

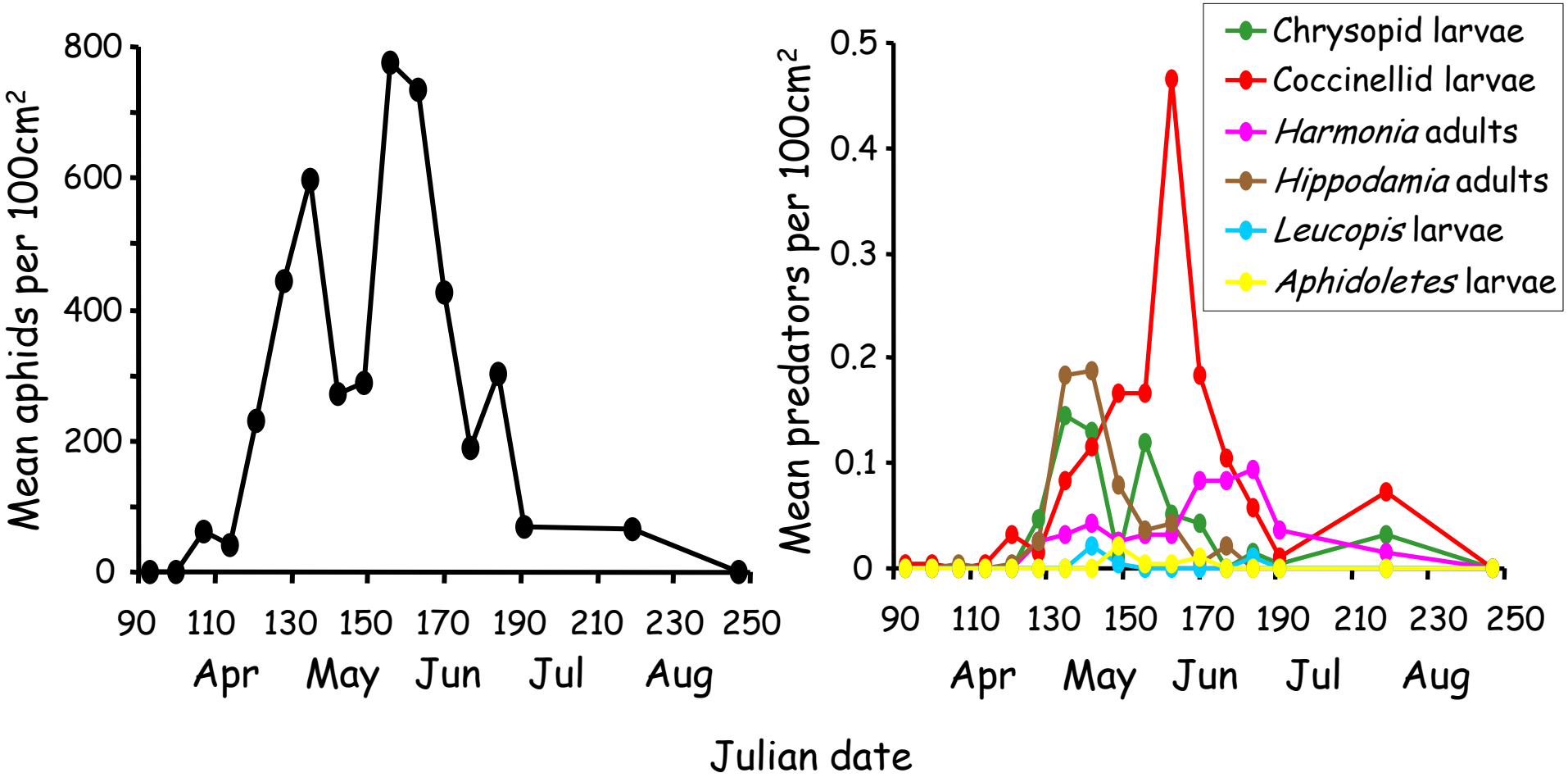


Latham & Mills (2010)

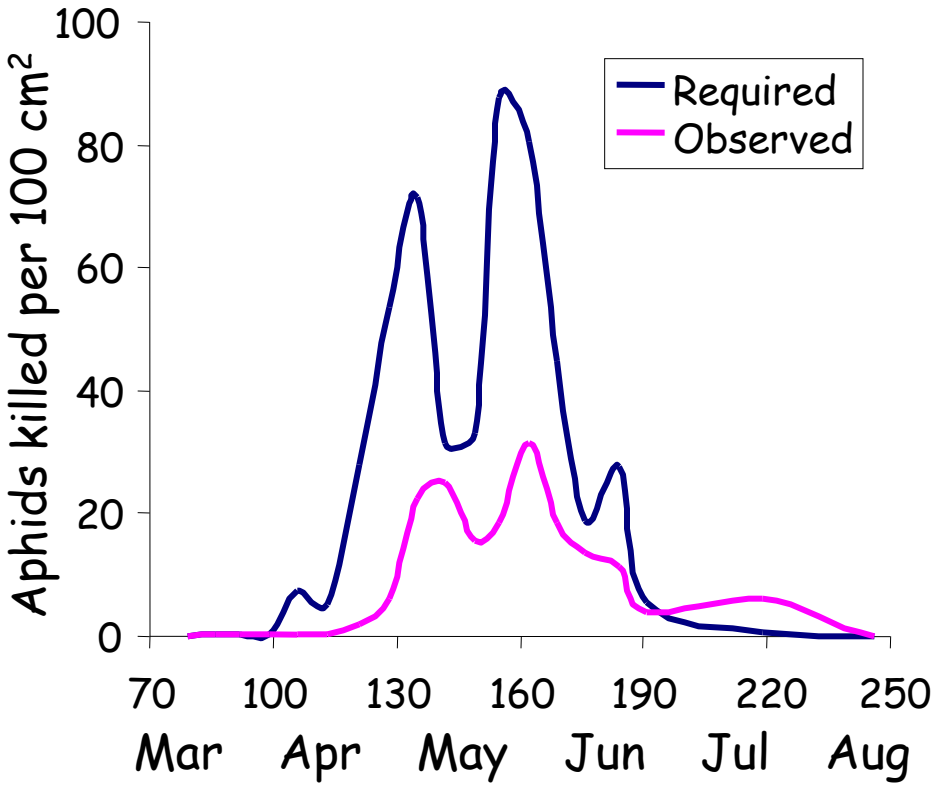
How Many Predators are Needed for MPA?
Max MPA per Predator Larva

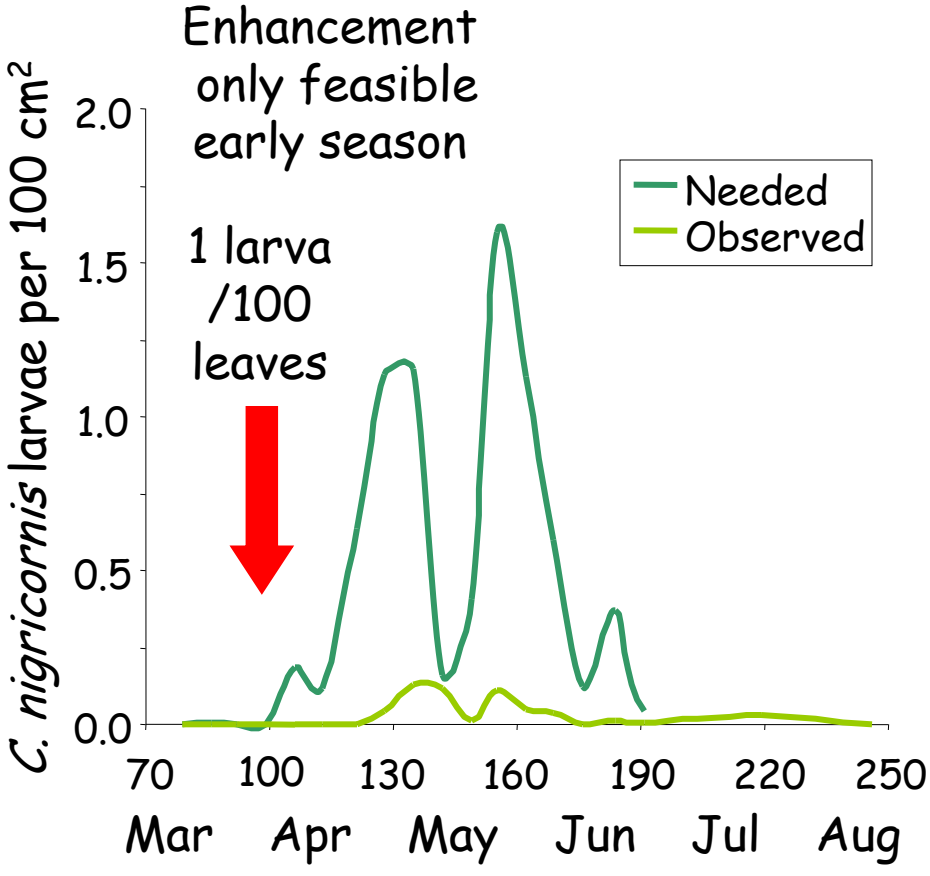


MPA and Predator Densities in Prunes
Sutter Orchard 1997



How Many *C. nigricornis* Larvae are Needed?
Sutter Orchard 1997





Julian day

Conclusions

- Simple models can help to evaluate the feasibility of predator enhancement

- Natural predator densities don't prevent outbreaks of MPA in organic prunes

- If feasible, predator enhancement for MPA must occur early-season before natural populations are active

- Increase of *gP* through importation of parasitoid, or reduction of *r* through deficit irrigation may be more feasible than increasing the number of predators to a sufficient level in organic prunes