A global test of the drivers of shifting phenology and asynchrony

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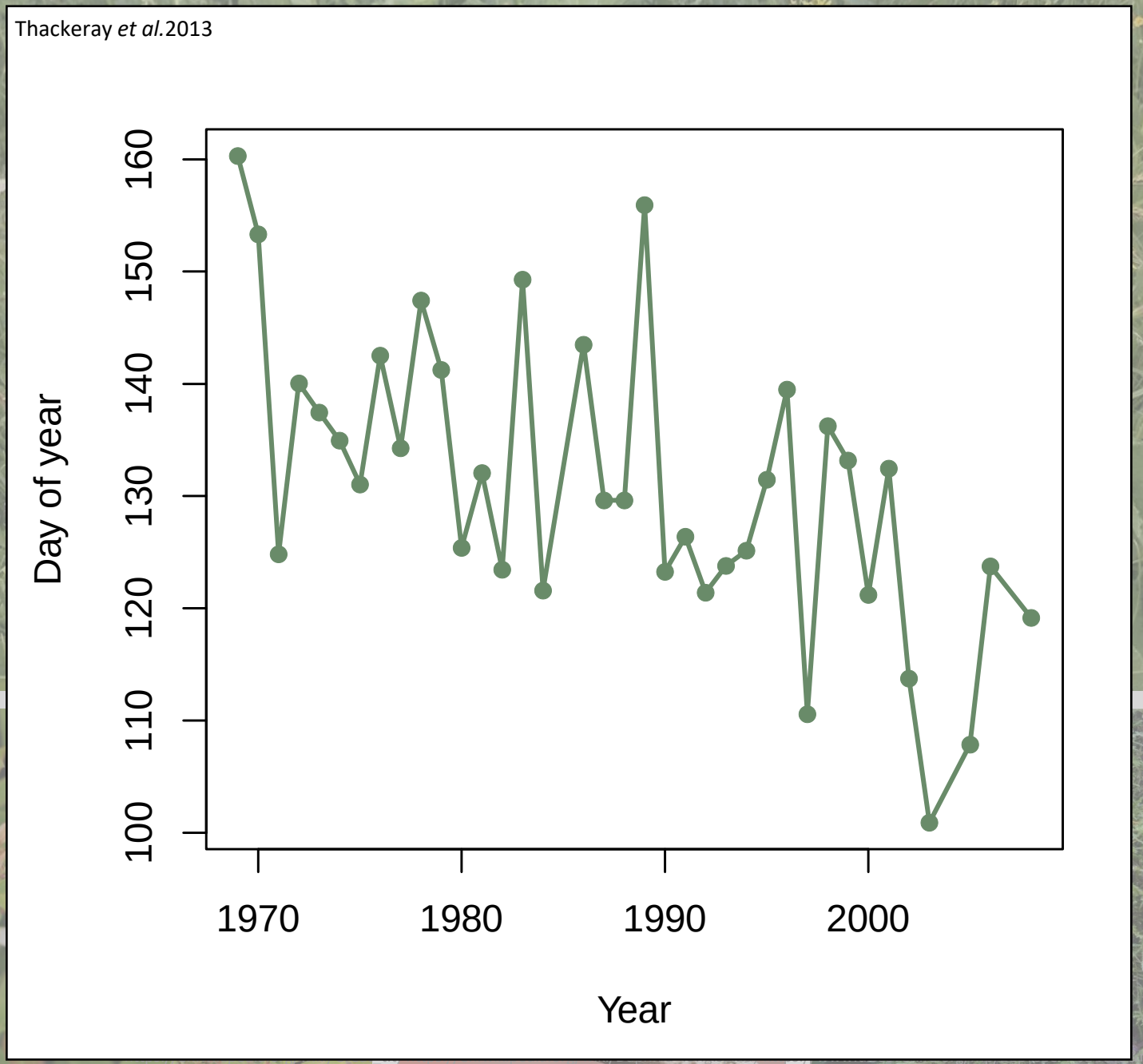
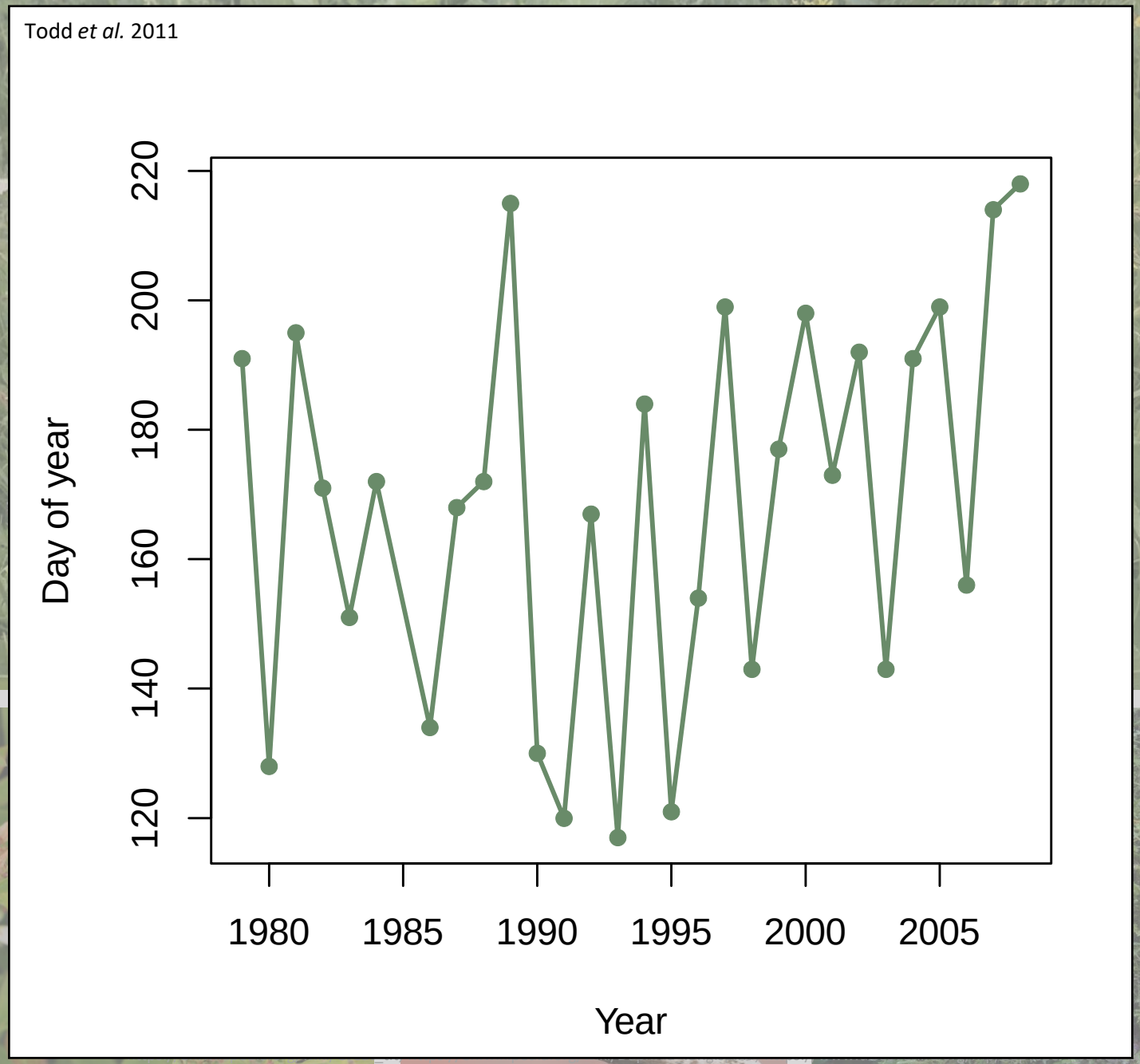
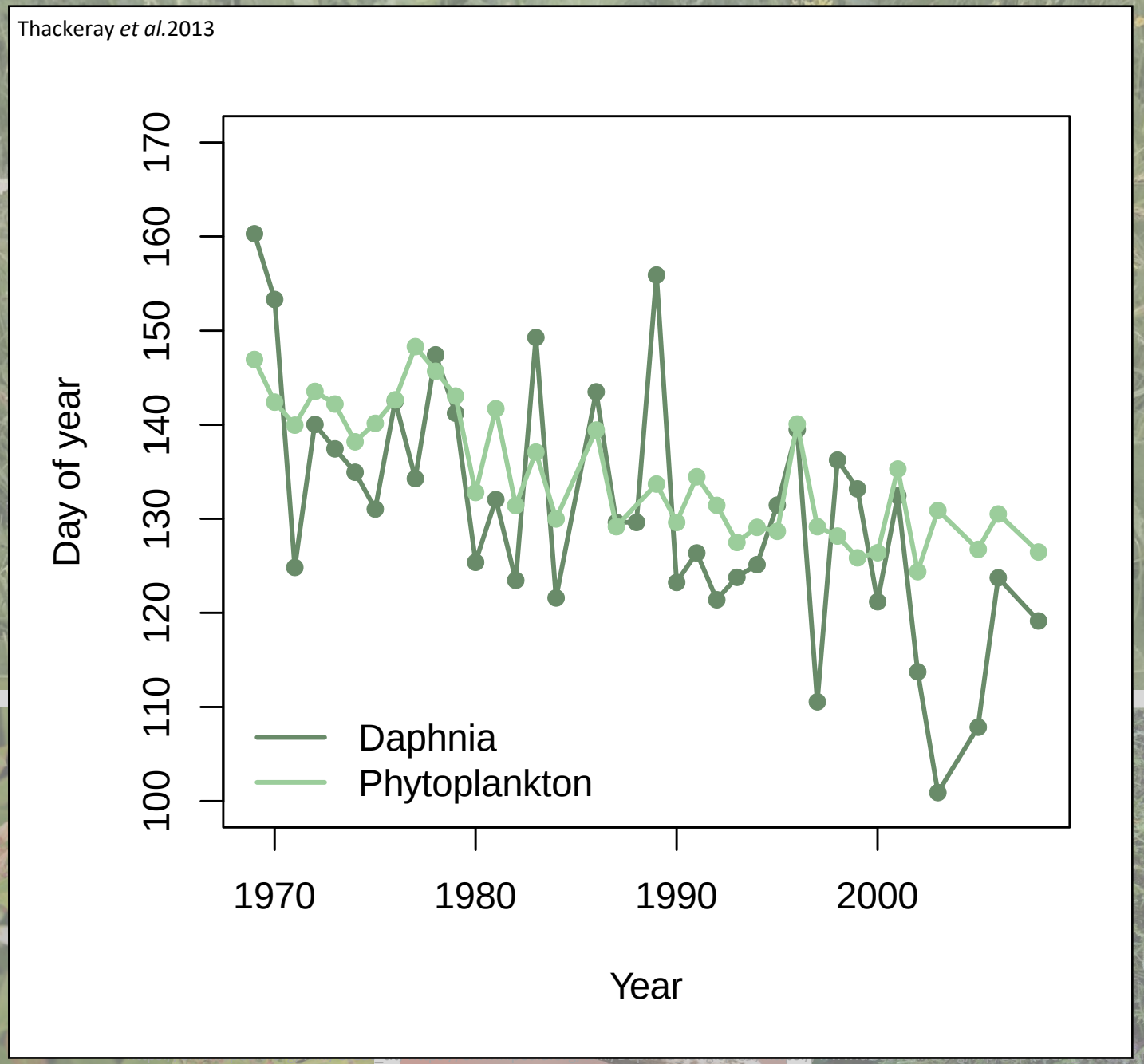
Thackeray *et al.*2013



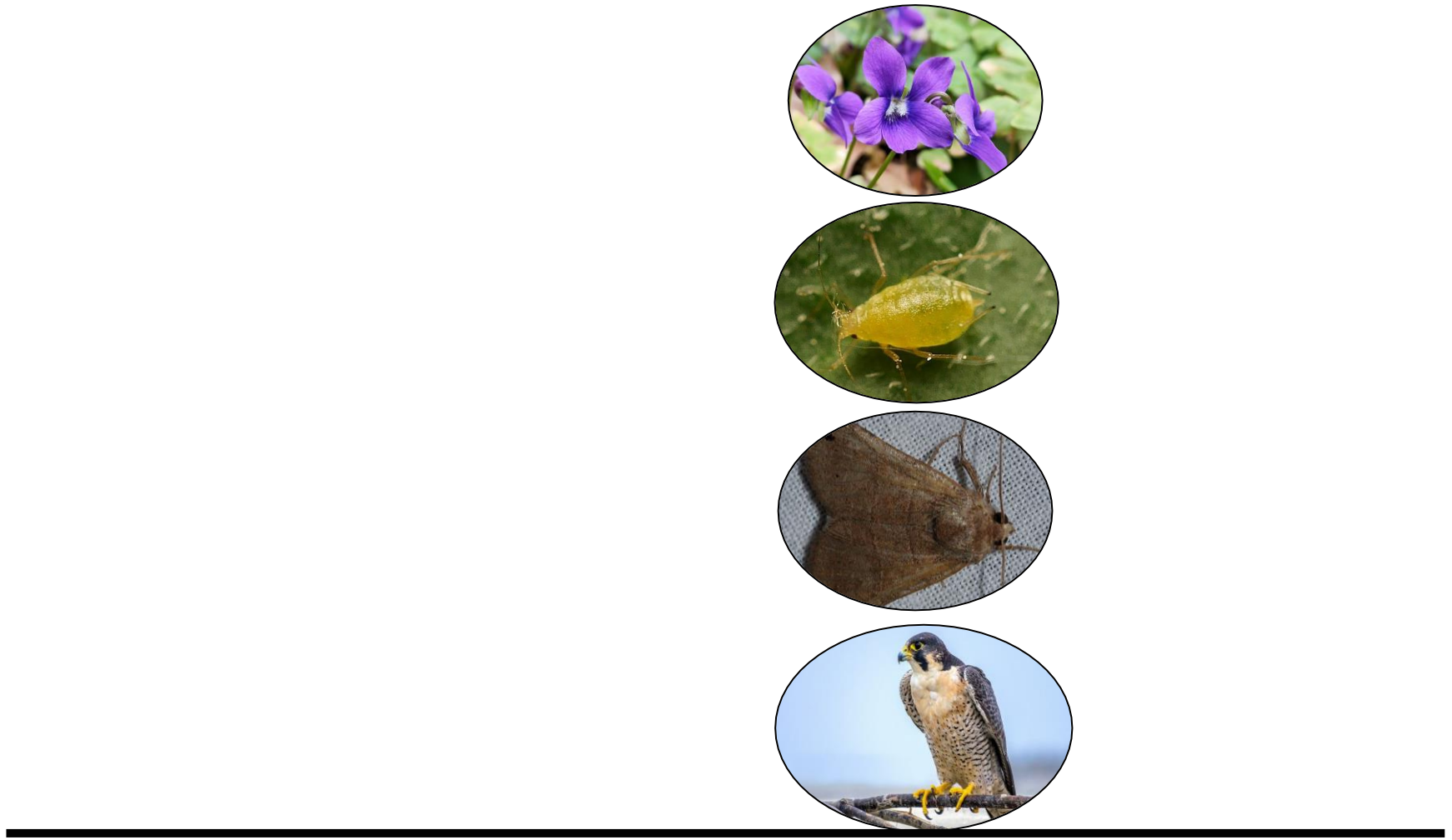
Todd *et al.* 2011



Thackeray *et al.*2013



Thackeray *et al.* 2016 & Cohen *et al.* 2018 find lower trophic levels to respond more to changes in temperature



Advancing

Photo credit: Morcup, Alexis, Reago, Mosharaf Hossain

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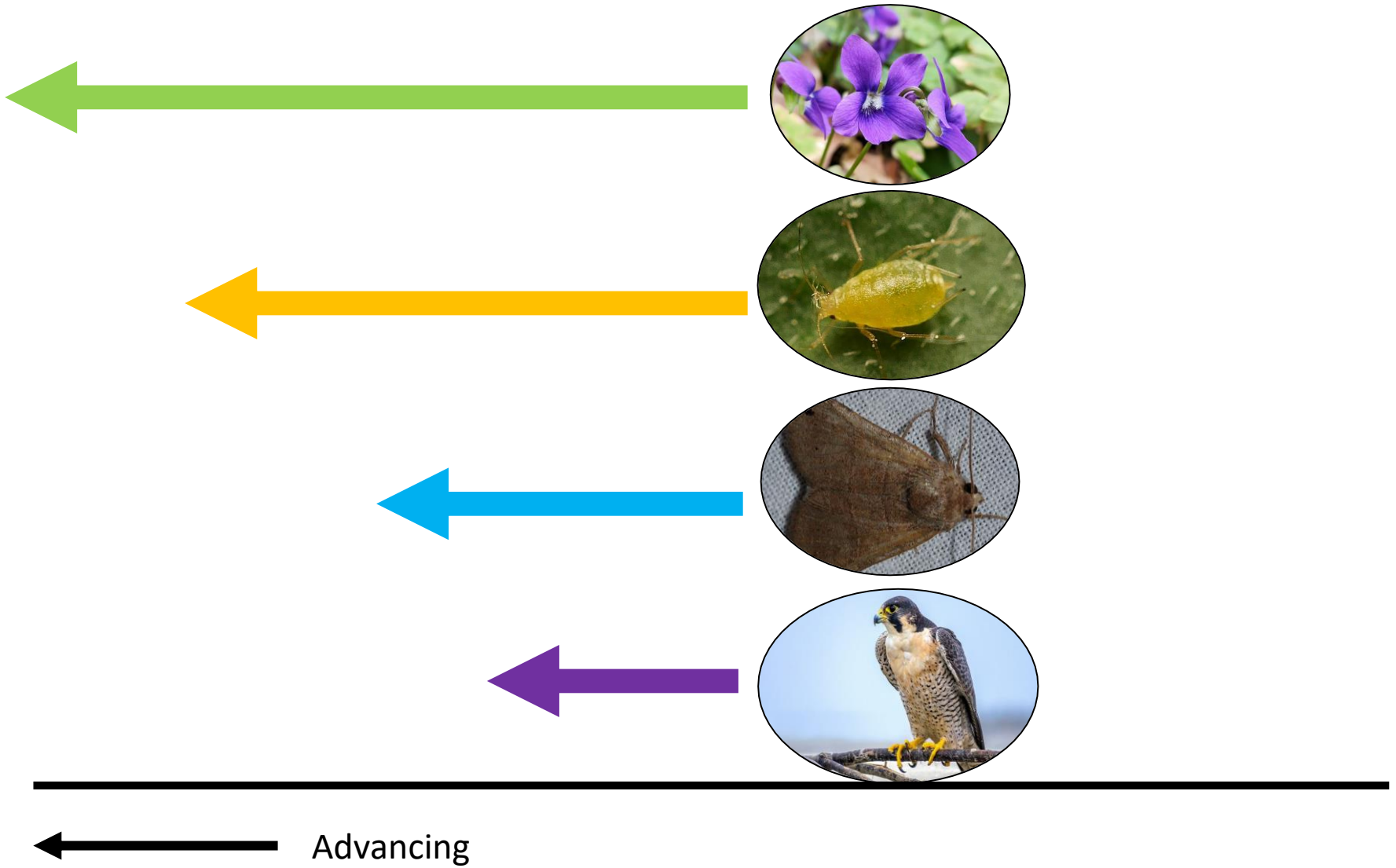

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Kharouba *et al.* 2018 found no consistent directionality in species synchrony

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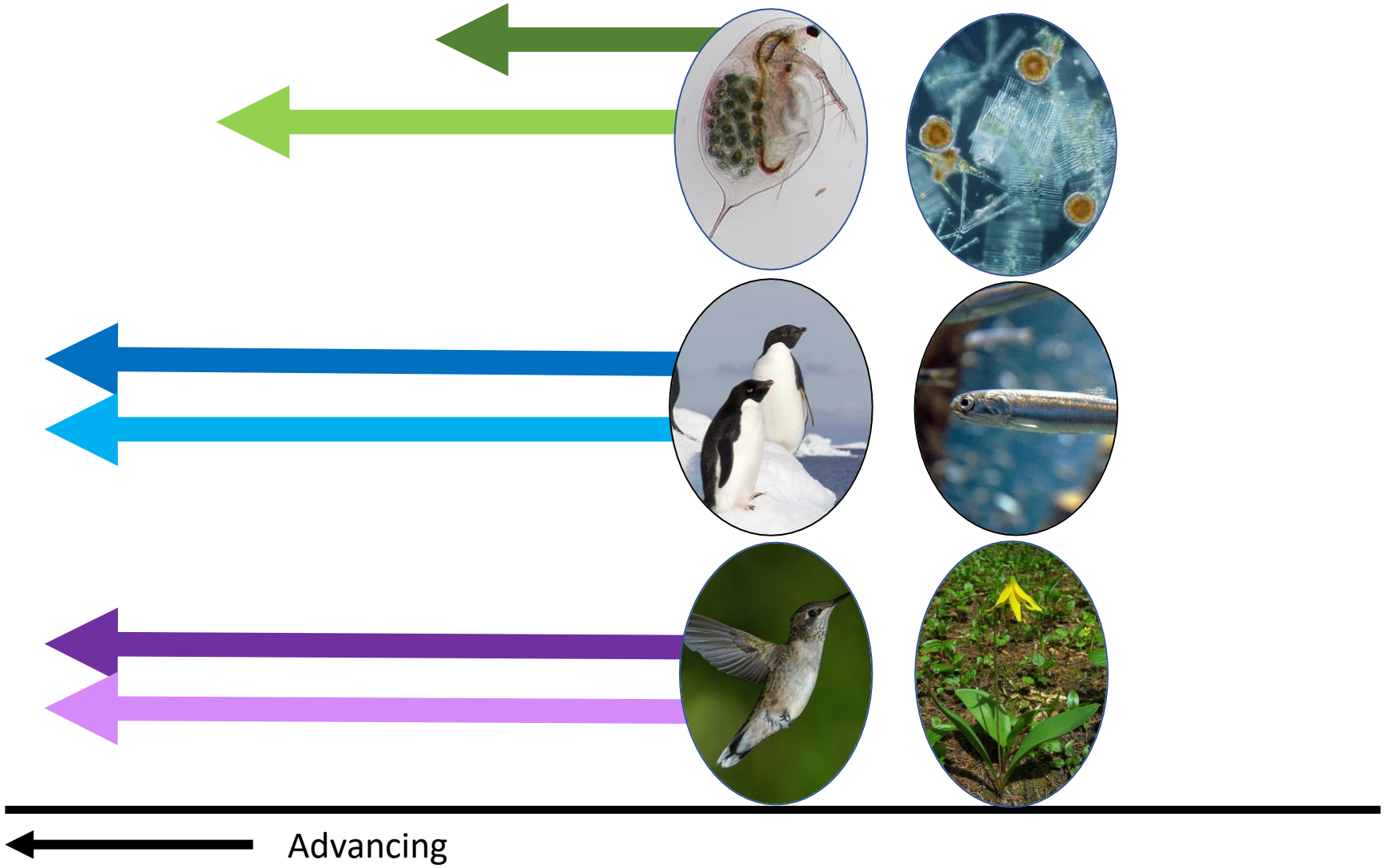

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Kharouba *et al.* 2018 found no consistent directionality in species synchrony

What drives differences in asynchrony across diverse groups of species?

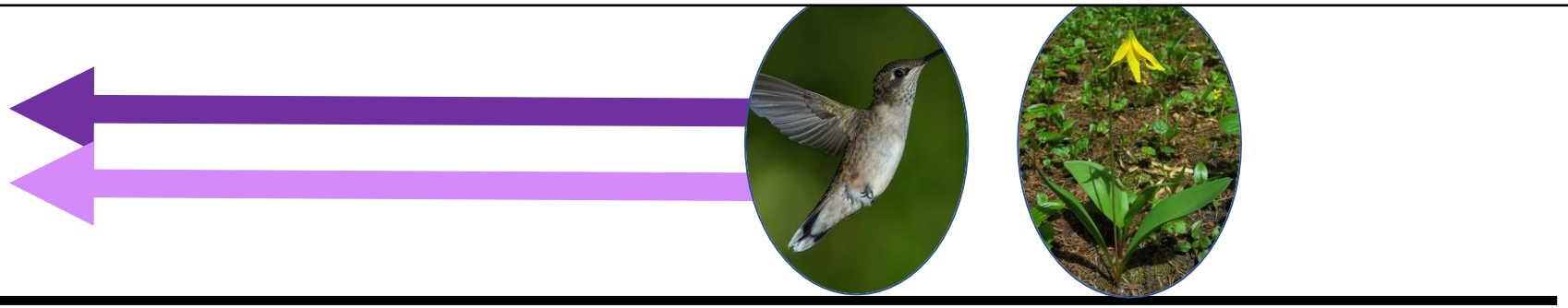

Photo credit: Dieter Ebert, Neon_jat, Kingfisher, Gregory Smith, Pslawinski, Jason Hollinger

Our dataset consists of:

- Long-term time series

- Including diverse species, phenological events, & geography

- Our dataset includes:
  - 1200 unique species
  - 147 different studies
  - 176 pairs of interactions

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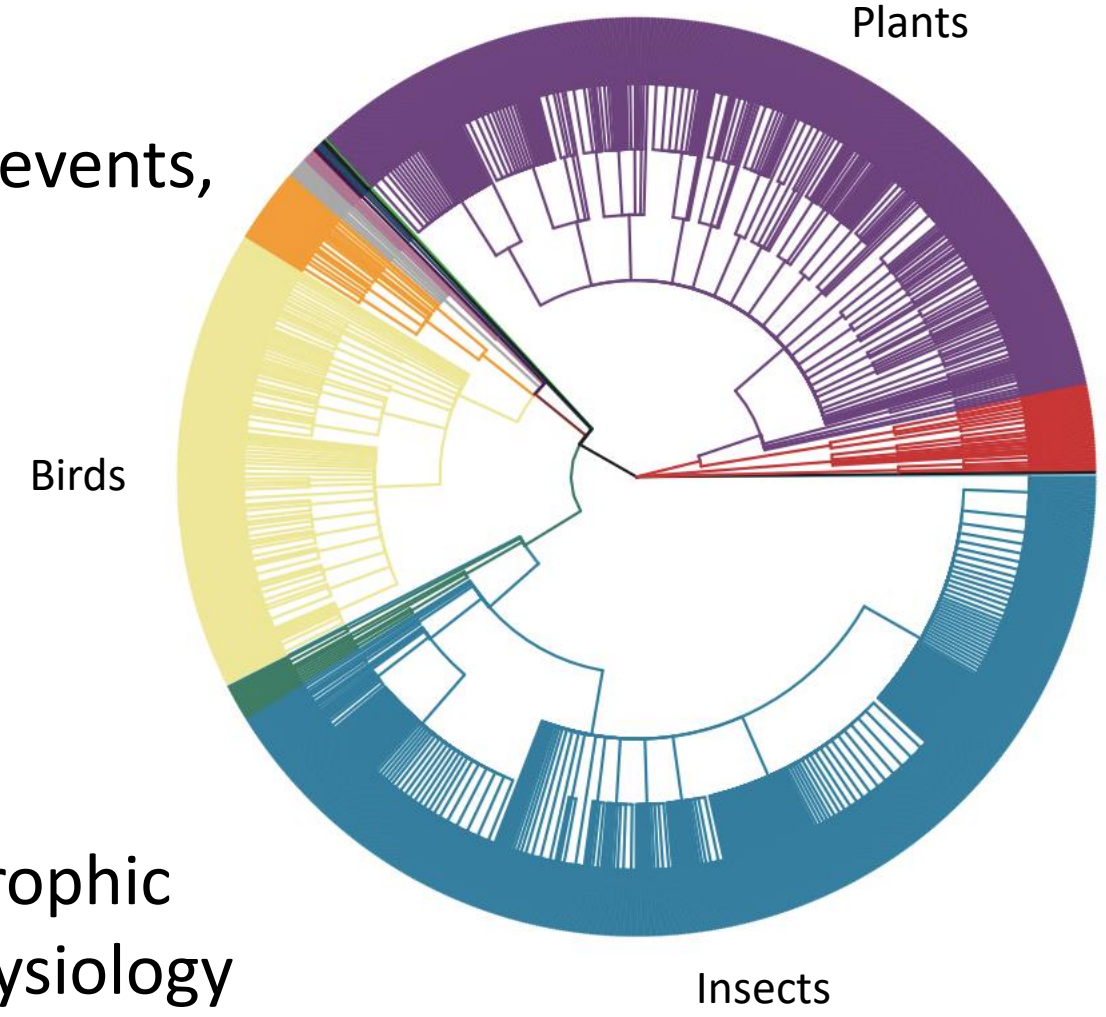
  - 176 pairs of interactions
- Each species was categorized by their trophic level, habitat type, food source, and physiology



Our model:

- Bayesian hierarchical model:
    - doy: day of year
    - β: the change in phenology

$$\hat{doy}_i = \alpha + \alpha_{sp_i} + \beta(year_i)$$

$$doy \sim N(\hat{doy}, \sigma_{doy})$$

$$\alpha_{sp_i} \sim N(\mu_{sp}, \sigma_{sp})$$

$$\beta_{sp_i} \sim N(\mu_b, \sigma_b)$$

- Includes a hinge at 1980
- Phylogenetic variance covariance matrix included on the intercept and slope

We simulated random species pairs to compare changes in synchrony between single and paired species data:

Species
Sp 1
Sp 2
Sp 3
Sp 4
Sp 5
Sp 6
Sp 7
Sp 8
Sp 9
Sp 10

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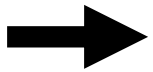

Type of interaction	Consumer Type	Species
Pollination	R	Sp 1
Pollination	R	Sp 2
Pollination	R	Sp 3
Pollination	C	Sp 4
Pollination	C	Sp 5
Pollination	C	Sp 6
Herbivory	R	Sp 7
Herbivory	R	Sp 8
Herbivory	C	Sp 9
Herbivory	C	Sp 10

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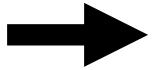
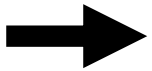
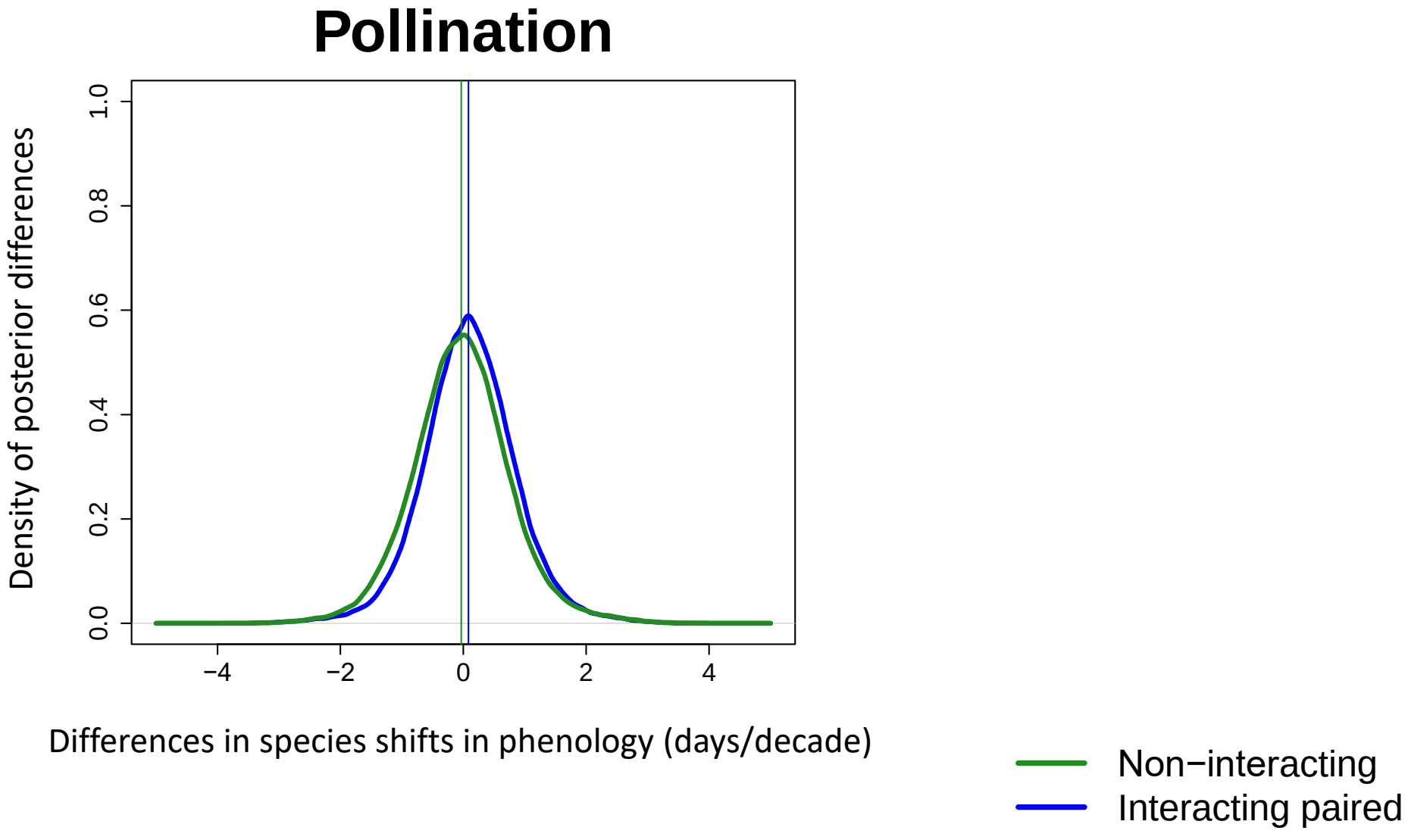


Type of interaction	Consumer Type	Species
Pollination	R	Sp 1
Pollination	R	Sp 2
Pollination	R	Sp 3
Pollination	C	Sp 4
Pollination	C	Sp 5
Pollination	C	Sp 6
Herbivory	R	Sp 7
Herbivory	R	Sp 8
Herbivory	C	Sp 9
Herbivory	C	Sp 10



Type of interaction	Resource Sp	Consumer Sp
Pollination	Sp 2	Sp 6
Pollination	Sp 3	Sp 4
Pollination	Sp 1	Sp 5
Herbivory	Sp 7	Sp 9
Herbivory	Sp 8	Sp 10

Species synchrony was the same for both simulated and real species pairs:



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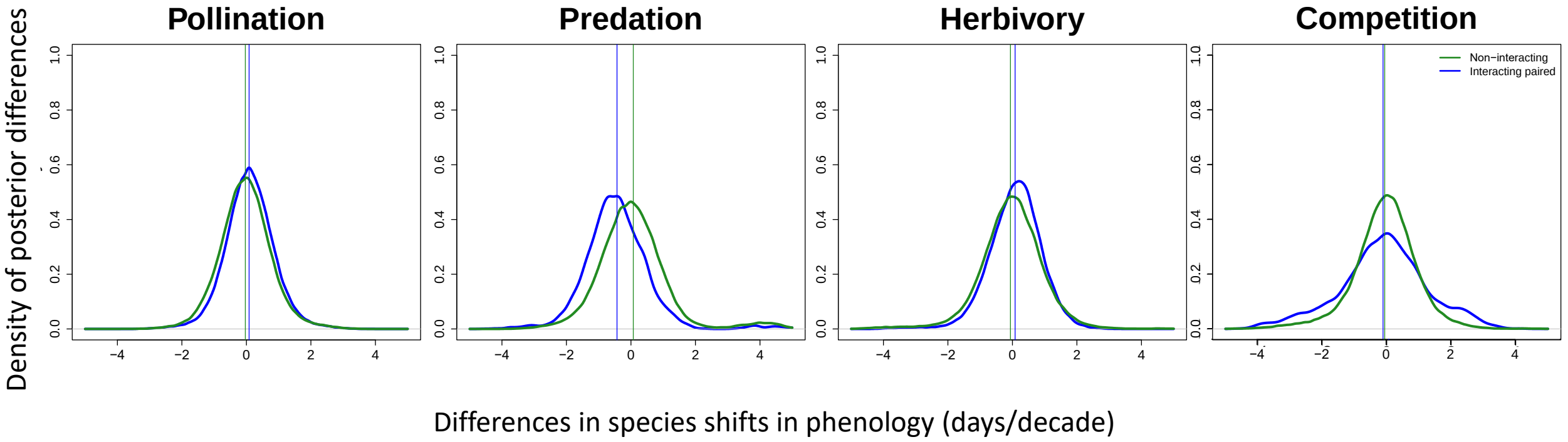


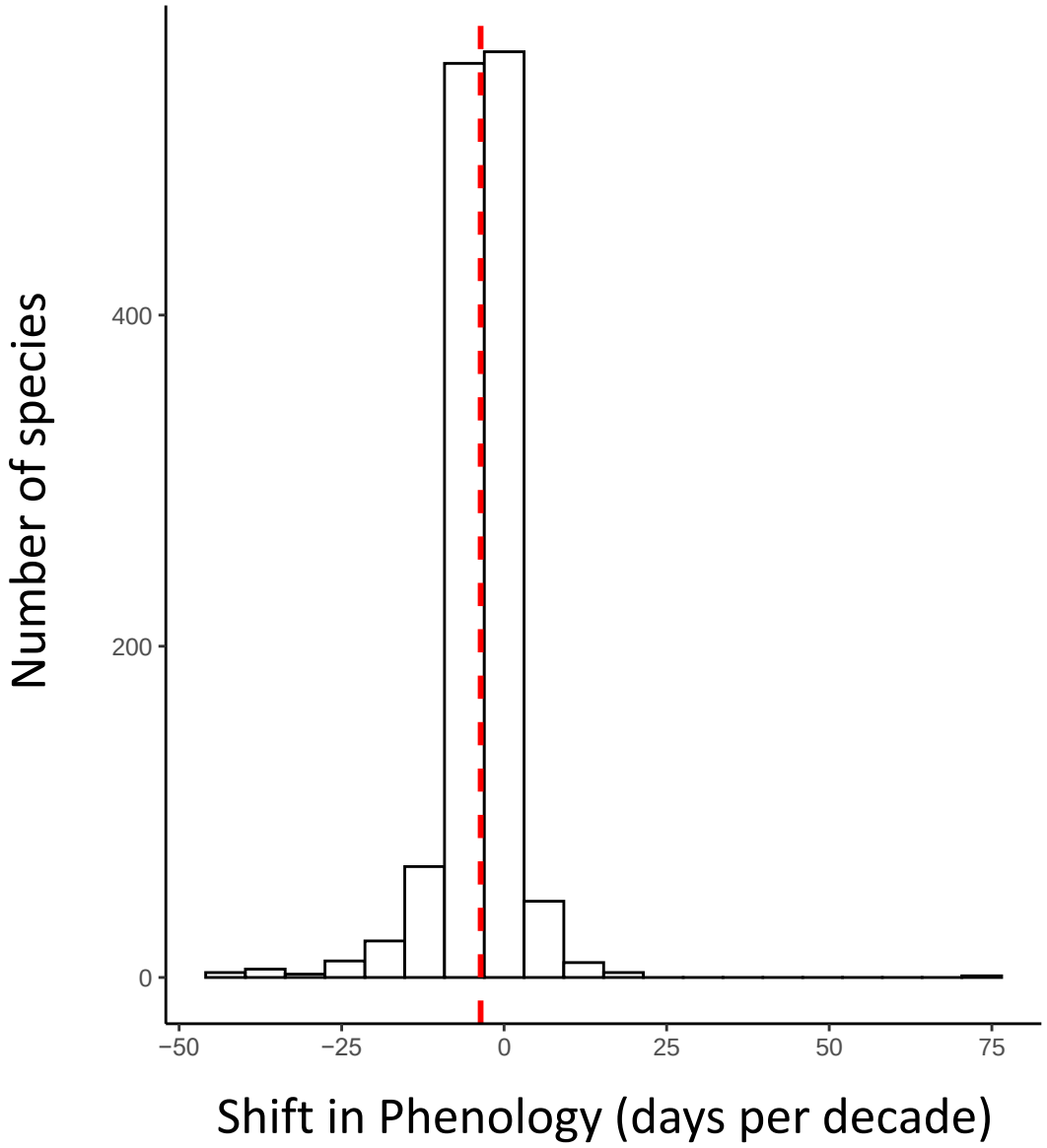
Non−interacting
Interacting paired

Possible drivers of phenological shifts

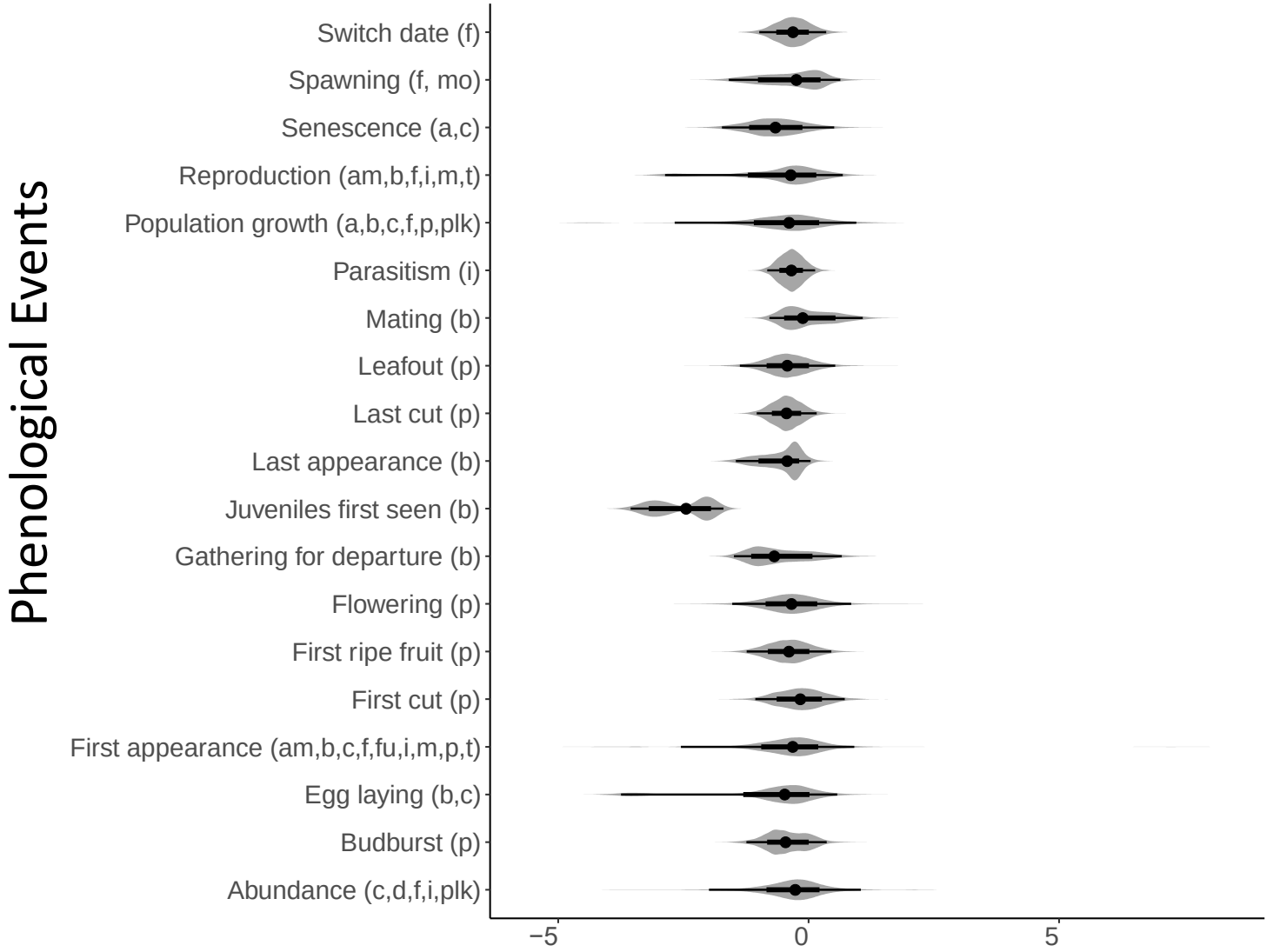
- Phylogenetic effects
- Latitudinal trends
- The magnitude of temperature change
- Naturally high interannual variation

Most species have advanced phenologically:

- Phenological events shifted by 3.1 days/decade on average
- Clades were similar phenologically (λ_{slope} = 0.42)
- Shifts in phenology were not explained by phylogeny ($\lambda_{intercept}$ = 0.07)



Shifts in phenology did not differ across groups of species:



a = algae
am = amphibians
b = birds
c = copepods
d = diatoms
f = fish
fu = fungi
i = insects
m = mammals
mo = mollusks
p = plants
plk = plankton
t = turtles

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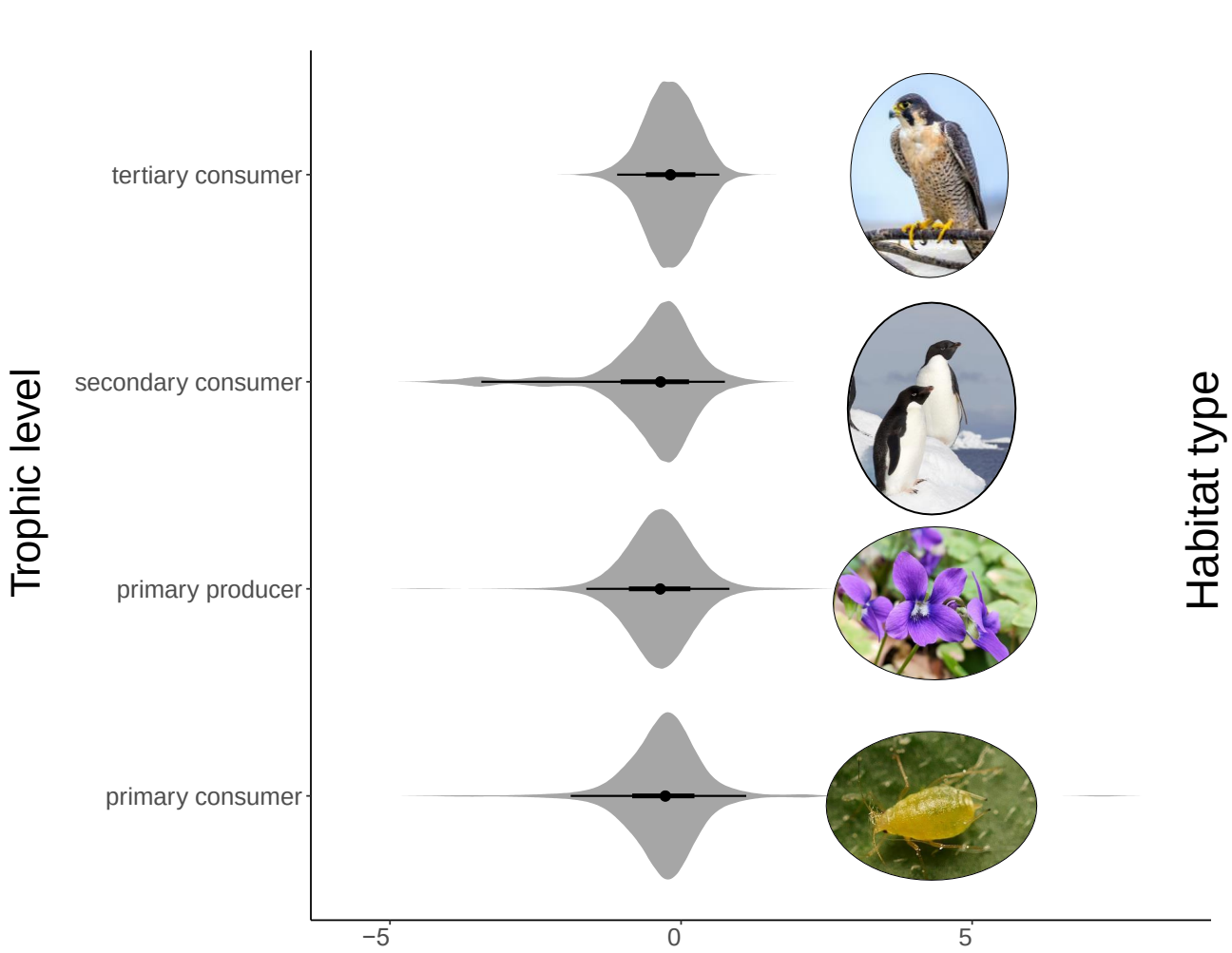
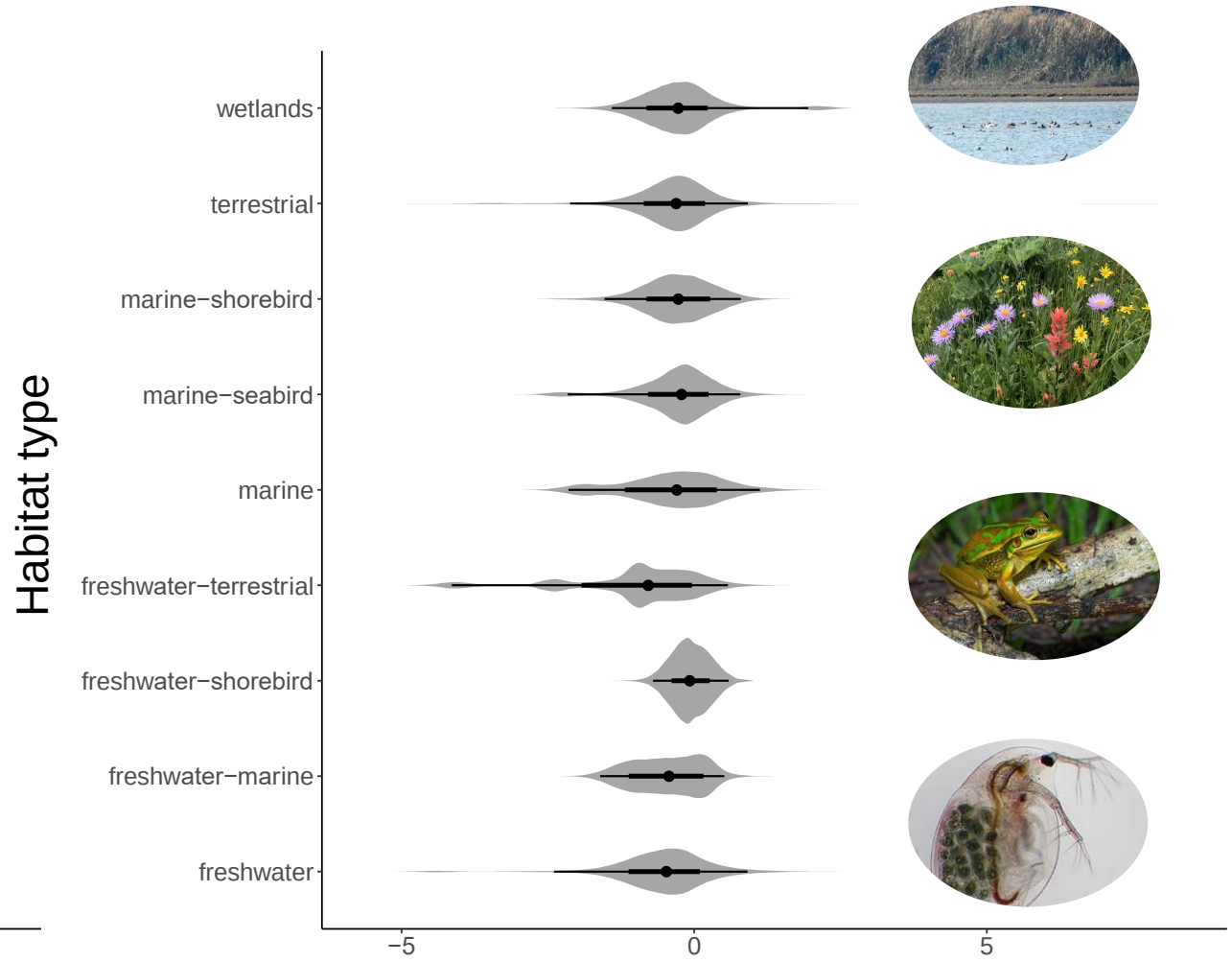
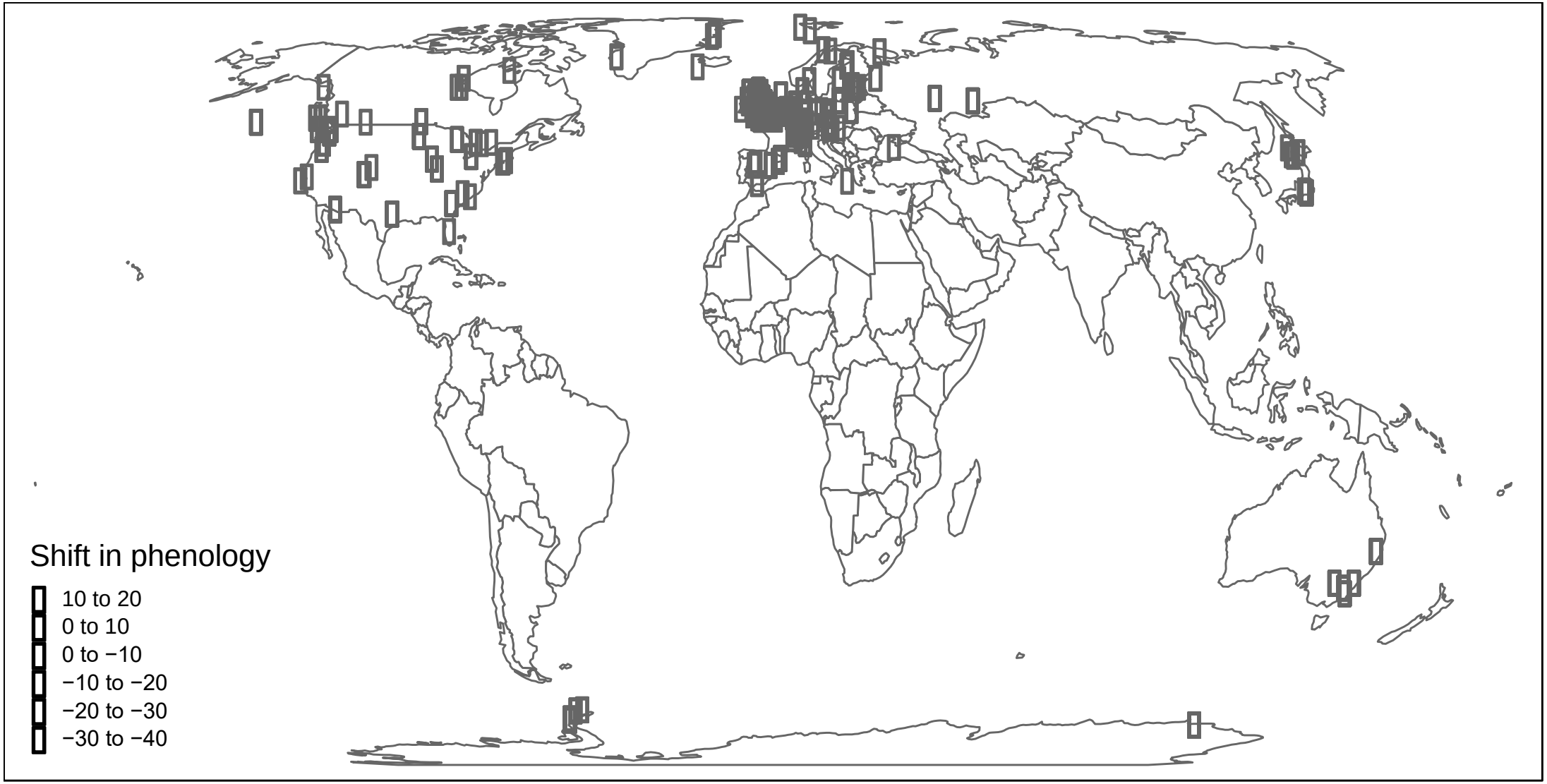




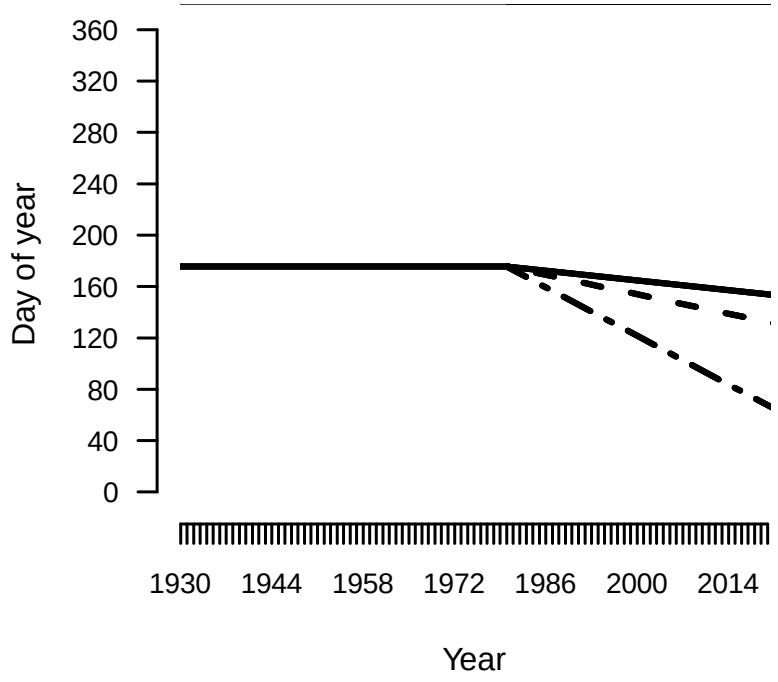
Shift in Phenology (days/decade)

Changes in phenology do not show clear latitudinal gradients:

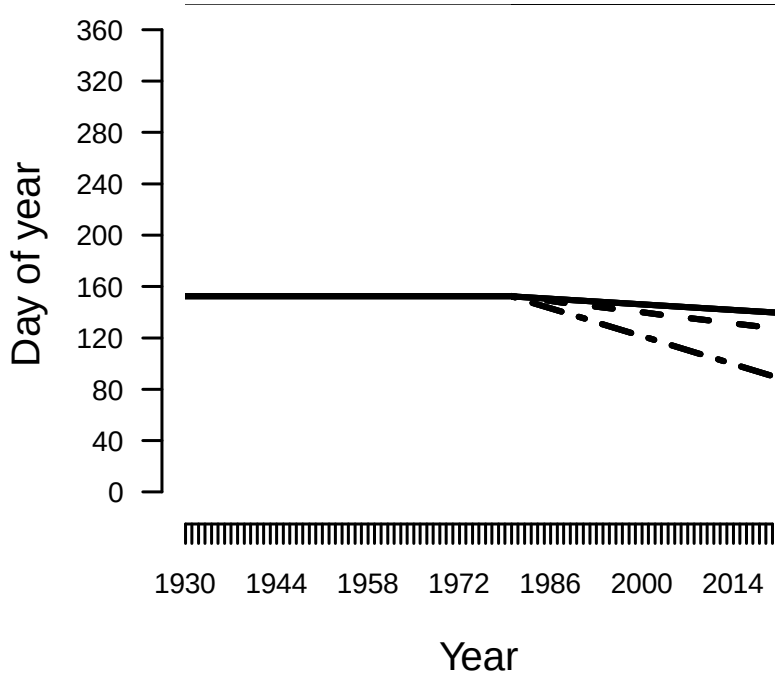


Shifts in phenology to date do not exceed the extent of variation in phenologies

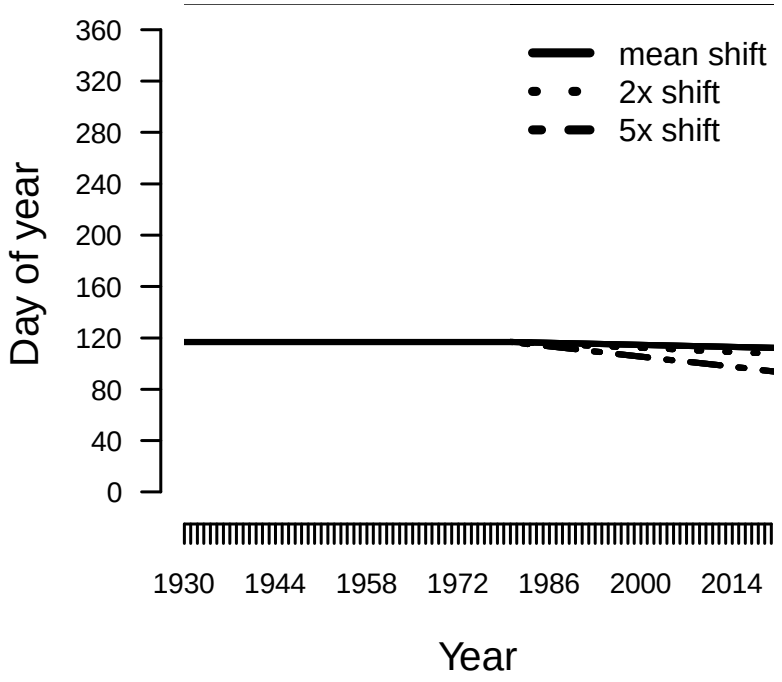
25%: *E. schoeniclus* first appearance



Mean: *M. trinervia* flowering



75%: *A. elatius* flowering



Conclusions:

- Species phenologies are advancing on average
- Similar inferences on changes in synchrony can be made from single and paired species data
- Changes in synchrony could be driven by other factors like temperature or buffered by the high degree of natural variation in phenologies

This work was greatly helped and improved thanks to:

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