Some reasons not to ignore phylogeny in phenological research

Jonathan Davies, McGill University
Plants and animals are responding to climate change in several ways.

By the middle of this century, winter temperatures are expected to rise dramatically in Canada.
Plants and animals are responding to climate change in several ways

1. species are shifting in their distributions, tracking favourable environments.

Janos Bogardi & Koko Warner, Nature Reports Climate Change
Plants and animals are responding to climate change in several ways

2. species are adjusting the timing of their history events, for example, flowering or breeding earlier, growing for longer and emerging or migrating sooner.
Plants and animals are responding to climate change in several ways

3. when environmental changes outpace species ability to shift in space or time, population sizes are decreasing, ultimately leading to local or even global extinctions.
species are adjusting the timing of their history events, for example, flowering or breeding earlier, growing for longer and emerging or migrating sooner.
Why is phylogenetic conservatism important?

A

B

C

K = 0.18

K = 0.93

K = 1.62

Ackerly 2009
Why is phylogenetic conservatism important?

i. Strong conservatism in phenology may allow us to predict species responses when we have information only on evolutionary relationships

See recent paper by Mazer et al. (submitted)
Why is phylogenetic conservatism important?

ii. But strong conservatism might also suggest limits to species adaptive responses
Why is phylogenetic conservatism important?

iii. Phylogenetic conservatism means that closely related species cannot be regarded as statistically independent.
What Conventional Statistical Methods Assume

What Evolution Provides
Species as independent
15 species, 2 clades
Species non-independent
Species as independent?

![Graph showing correlation between change in temperature and advance in time of first flower.](image)
An interesting exercise in estimating phylogenetic signal in the time of first flower
The data:

~4000 species across 23 sites

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Species</th>
<th>Median # observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinoor, UK</td>
<td>384</td>
<td>37</td>
</tr>
<tr>
<td>Fargo, ND</td>
<td>214</td>
<td>12.5</td>
</tr>
<tr>
<td>Gothic, CO</td>
<td>79</td>
<td>30</td>
</tr>
<tr>
<td>Hubbard MA</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Harvard MA</td>
<td>57</td>
<td>12</td>
</tr>
<tr>
<td>Konza, KS</td>
<td>152</td>
<td>8</td>
</tr>
<tr>
<td>Luquillo, PR</td>
<td>63</td>
<td>16</td>
</tr>
<tr>
<td>Mohonk, NY</td>
<td>18</td>
<td>35</td>
</tr>
<tr>
<td>Sevilleta, NM</td>
<td>71</td>
<td>9</td>
</tr>
<tr>
<td>Tucson, AZ</td>
<td>463</td>
<td>22</td>
</tr>
<tr>
<td>UW-Milwaukee, WI</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>385</td>
<td>17</td>
</tr>
<tr>
<td>Wauseon, OH</td>
<td>24</td>
<td>11</td>
</tr>
</tbody>
</table>

Cook et al. in press
The tree:

Phylogenetic tree for 4000 taxa with tip labels shaded by day of year of first flower
Estimating differences in day of year of first flower – circular statistics

Difference between January and December is one month not 12
Estimating differences in day of year of first flower – circular statistics

Difference between January and December is one month not 12

Cosine transformation

\[ y = \cos x \]
Estimating differences in day of year of first flower – circular statistics

Shortest pathway between some months not feasible
Phylogenetic signal (Blomberg’s K)
Blomberg’s K within individual sites

![Bar chart showing Blomberg's K values for different sites]

(K = 1 = BM)
Blomberg’s K within individual sites compared to global K across sites (K = 0.255)
Start of spring varies geographically

1996 SI First Bloom Dates

http://www.usanpn.org/files/shared/images/Schwartz_SI_Bloom_1996_0.png
Spring index based on first bloom dates for cloned lilacs & honeysuckles

Syringa chinensis (lilac)
Lonicera tatarica (bush honeysuckle)
L. korolkowii (bush honeysuckle)

Average 1961-1990 Spring Indices (SI) First Bloom Date
(January 1st = 1)

Courtesy of Mark D. Schwartz
UW-Milwaukee
Phenological curves (day of year)
Phenological curves (day of year)

Phenological curves (adjusted for start of spring)
Blomberg’s K within individual sites compared to global K across sites

K = 1.0

K = 0.255
Blomberg’s K within individual sites compared to global K across sites adjusted by spring index

Blomberg’s K within individual sites compared to global K across sites adjusted by spring index
Blomberg’s K within individual sites compared to global K across sites adjusted by spring index, K = 0.19!
Many thanks to the NCEAS working group on Forecasting Phenology

Elizabeth Wolkovich, UBC
Susan Mazer, UC-Santa Barbara
Mark Schwartz, University of Wisconsin-Milwaukee
Nathan Kraft, University of Maryland
Steve Travers, North Dakota State University
Jenica Allen, University of Connecticut
Toby Ault, University of Arizona
Julio Betancourt, USGS Tucson
Kjell Bolmgren, Swedish University of Agricultural Science
Elsa Cleland, UC-San Diego
Benjamin Cook, NASA Goddard Institute for Space Studies
Theresa Crimmins, USA-National Phenology Network (NPN)
Greg McCabe, USGS
Abe Miller-Rushing, USA-NPN
Camille Parmesan, University of Texas-Austin
Nicolas Salamin, University of Lausanne