A Deep Time Approach to Studying Environmental Change

Dena M. Smith
STEPPE – Geological Society of America
CU Museum and Geological Sciences
University of Colorado - Boulder
dena@colorado.edu
Lak et al., 2008
X-ray tomography
Soriano et al., 2010
compound eyes (ommatidial facets), edge to edge 2 mm, kohls '05
Insect Fossil Record

First insects appear in the Early Devonian (396-407 Ma)
All modern insect orders have been fossilized
Find full range of morphologies
Find full range of ecologies
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0000360
Fossil Insects as Environmental Indicators
Modern climate change

- The Earth’s average surface temperatures have increased by $0.6 \pm 0.2 \, ^\circ C$ over the last century (IPCC 2001).
Modern climate change

- This has had a dramatic affect on the world’s biota.
- We still don’t know what species traits will make some groups more likely to respond, and which traits make groups more vulnerable to extinction.

NRC, 2010
CLIMATE CHANGE IN THE EOCENE-OLIGOCENE
Colorado fossil deposits

- Creede: 2.5
- Pitch Pinnacle: 12
- Florissant: 12.7
- Green River: 18
Key taxa

Green River Formation  16 orders
Florissant Formation   18 orders
DIPTERA –

Green River
Florissant

~4,000 specimens
DIPTERA –

Green River
Florissant

~4,000 specimens

<table>
<thead>
<tr>
<th>Family</th>
<th>Green River</th>
<th>Florissant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibionidae</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Tipulidae</td>
<td>40</td>
<td>35</td>
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<tr>
<td>Chironomidae</td>
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<td>20</td>
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<tr>
<td>Asilidae</td>
<td>25</td>
<td>10</td>
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<tr>
<td>Cecidomyiidae</td>
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<td>5</td>
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<tr>
<td>Mycetophilidae</td>
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<td>2</td>
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<td>Bombyliidae</td>
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<td>5</td>
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<tr>
<td>Empididae</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Syrphidae</td>
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<td>2</td>
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<tr>
<td>Limoniidae</td>
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<td>Schizomyzidae</td>
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<td>Sciaridae</td>
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<td>1</td>
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<tr>
<td>Chaemaemyiidae</td>
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</tr>
<tr>
<td>Others</td>
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<td>10</td>
</tr>
</tbody>
</table>
DIPTERA –

~4,000 specimens

- Bibionidae
- Tipulidae
- Chironomidae
- Asilidae
- Cecidomyiidae
- Mycetophilidae
- Bombyliidae
- Empididae
- Syrphidae
- Linoniidae
- Schizomyzidae
- Sciaridae
- Chaemaemyiidae
- Others

Green River
Florissant
Bibionidae

*Plecia* – warm loving

*Bibio* – cool loving
Next steps

- Analyze how taxonomic composition, richness and abundance distributions have changed during this dramatic cooling event.

- Determine feeding preferences to understand how life history characteristics determine which groups had the strongest response to environmental change.
Next steps
A deep-time approach to studying diversification and response to environmental change

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- 7 institutions & 2 partners
- 500,000 fossil insect specimens (images and associated metadata)
- iDigPaleo collections database, mobile apps, education modules, internships for graduate and undergraduate students
- Funded through NSF – Advancing the Digitization of Biological Collections
Partners - PIs

American Museum of Natural History – David Grimaldi
CU Museum of Natural History – Dena Smith & Talia Karim
Illinois Natural History Survey - Sam Heads
Museum of Comparative Zoology – Harvard – Brian Farrell
University of Kansas Biodiversity Institute – Michael Engel
Virginia Museum of Natural History – Alton Dooley
Yale Peabody Museum of Natural History - Susan Butts and Chris Norris
Collaborating Institutions

Florissant Fossil Beds N.M. – Herbert Meyer

National Museum of Natural History - Smithsonian –Kathy Hollis, Finnegan Marsh, Conrad Labandeira
iDigPaleo - Hub

iDigPaleo will be used to aggregate specimen data and low resolution images from collaborators and then to serve these data to the National Hub at iDigBio (www.idigbio.org) and the Paleontology Portal (www.paleoportal.org).
iDig Paleo - Hub

Central resource to interact with bio and geo cyberinfrastructure initiatives.
Broader Impacts

• Development of mobile apps and modules (NGSS)

• Testing of activities in EVOLUTIONs after school program at Yale-Peabody

• SHRMP (Science High School Research Mentoring Program) at AMNH
A deep-time approach to studying diversification and response to environmental change

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