A Deep Time Approach to Studying Environmental Change

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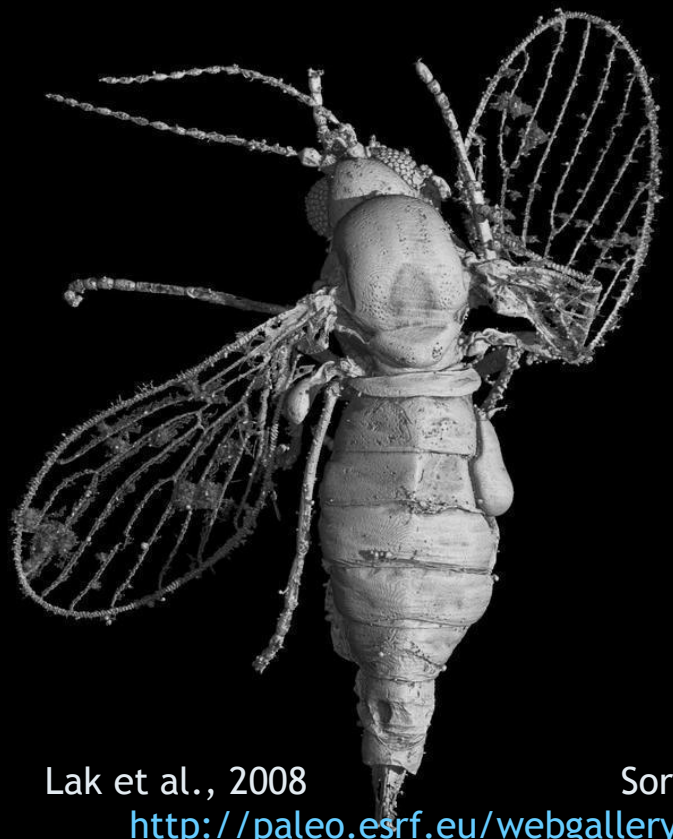


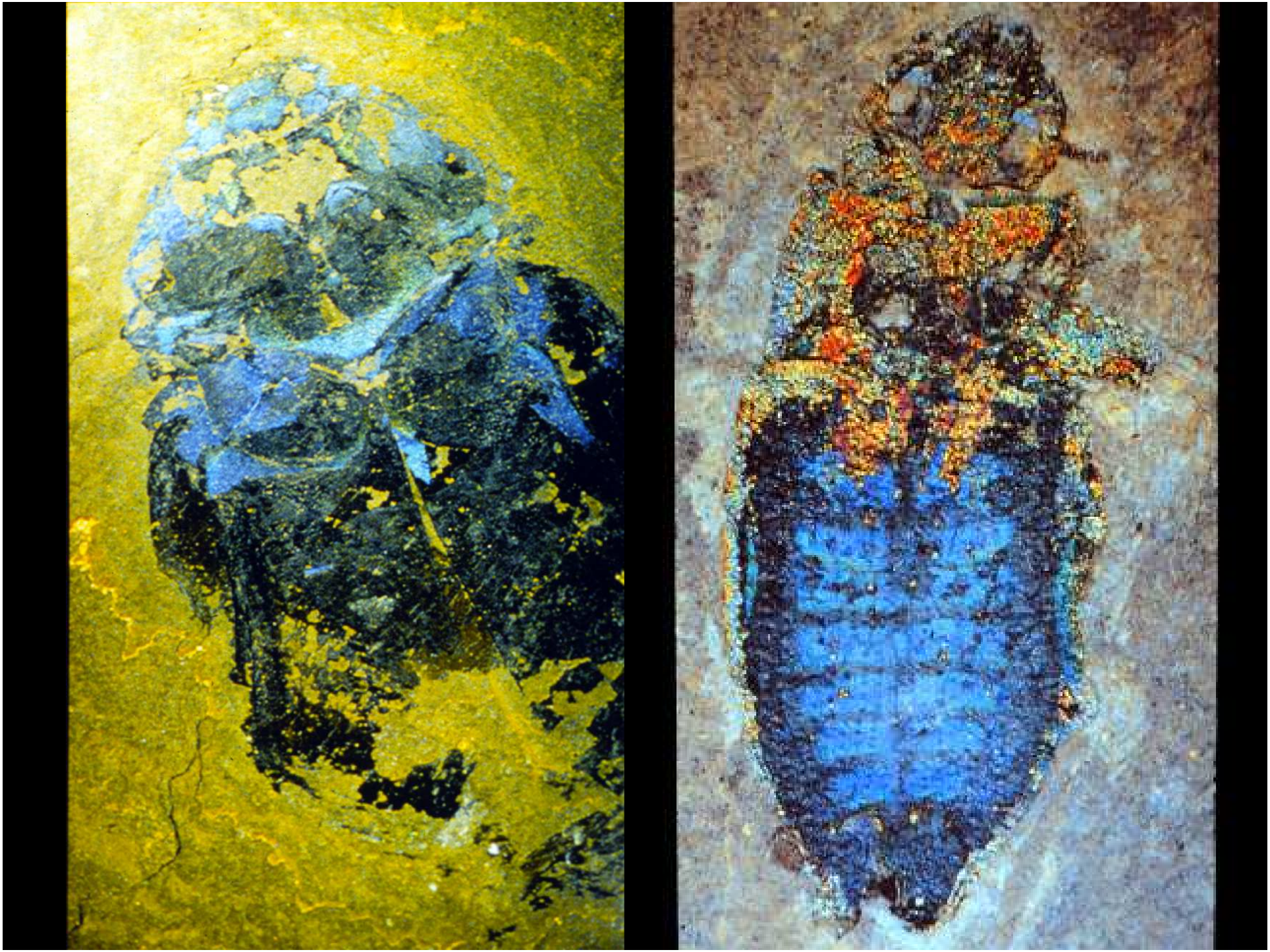

Lak et al., 2008 Soriano et al., 2010

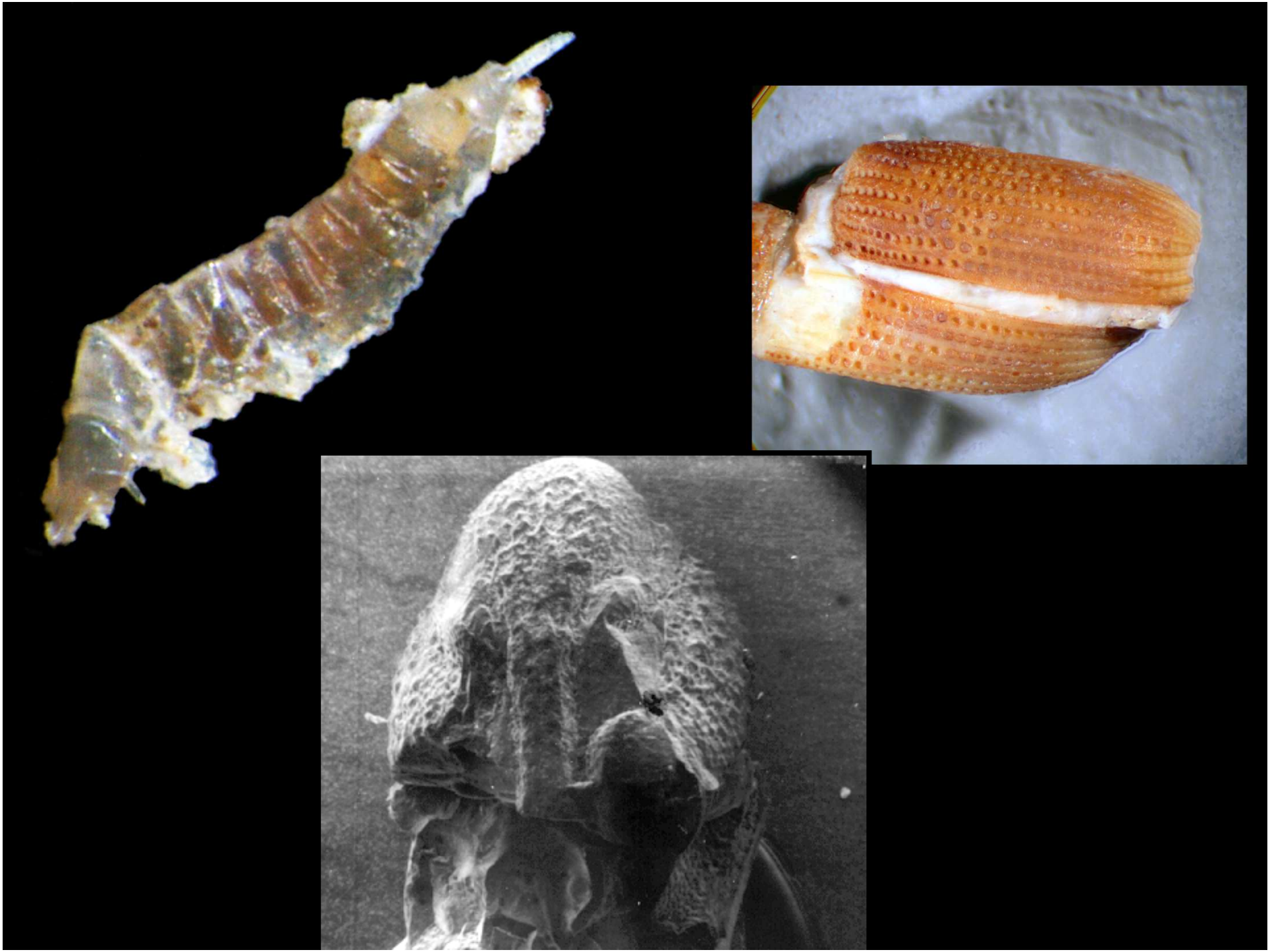
http://paleo.esrf.eu/webgallery/index.php

X-ray tomography


body length 9 mm
kohls '05


compound eyes (ommatidial facets), edge to edge 2 mm, kohls '05





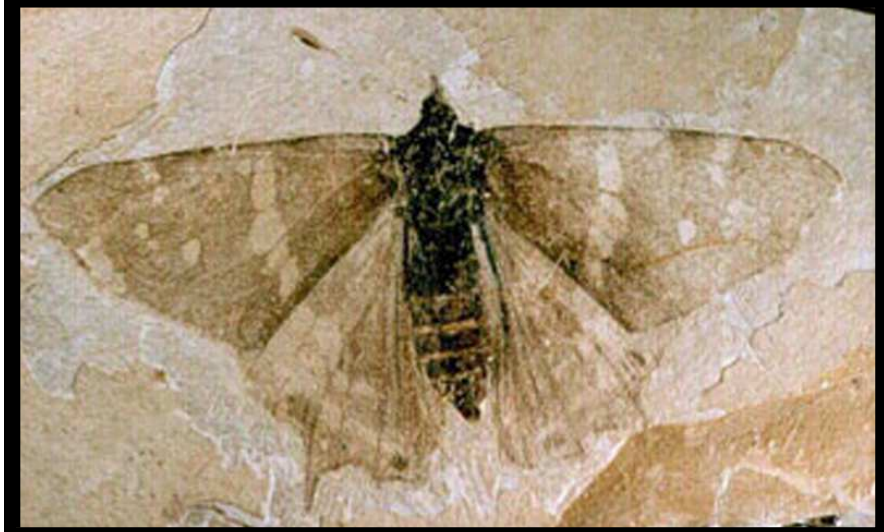
Insect Fossil Record

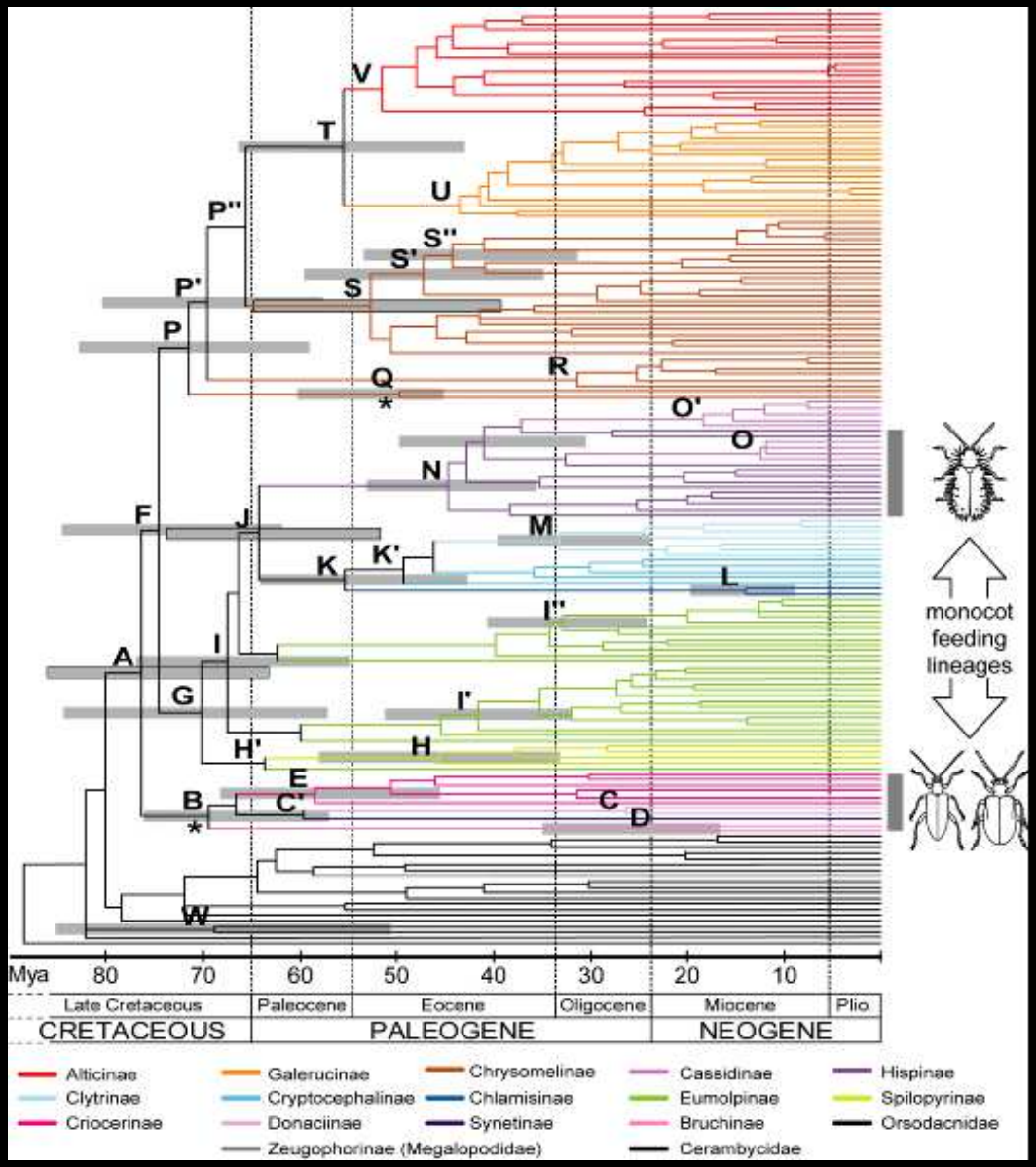
First insects appear in the Early Devonian (396-407 Ma)

All modern insect orders have been fossilized

Find full range of morphologies

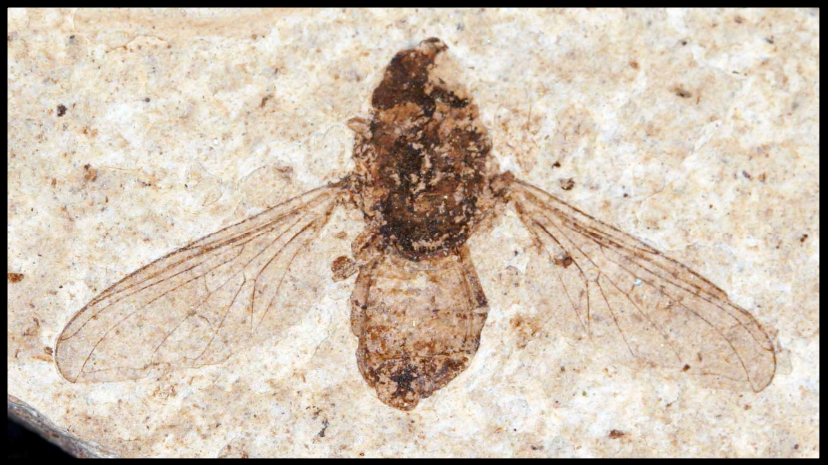
Find full range of ecologies

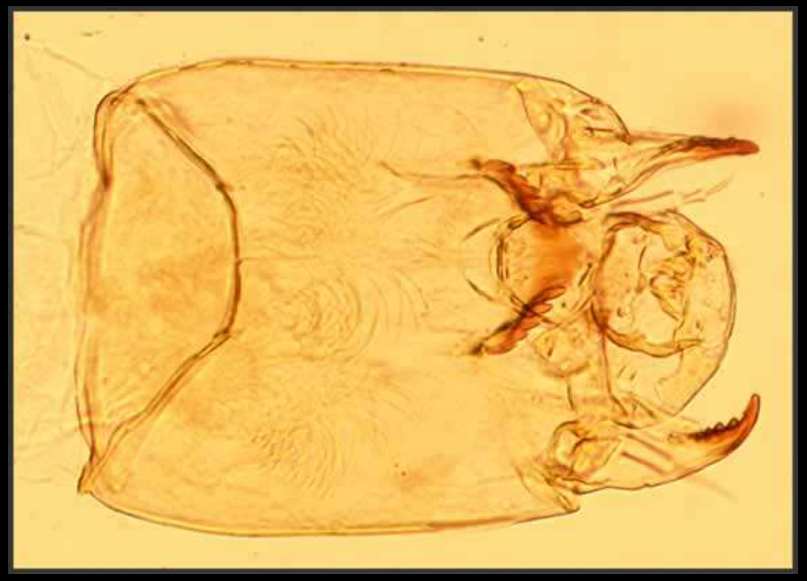




Gómez-Zurita J, Hunt T, Kopliku F, Vogler AP (2007) Recalibrated Tree of Leaf Beetles (Chrysomelidae) Indicates Independent Diversification of Angiosperms and Their Insect Herbivores. PLoS ONE 2(4): e360. doi:10.1371/journal.pone.0000360
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0000360

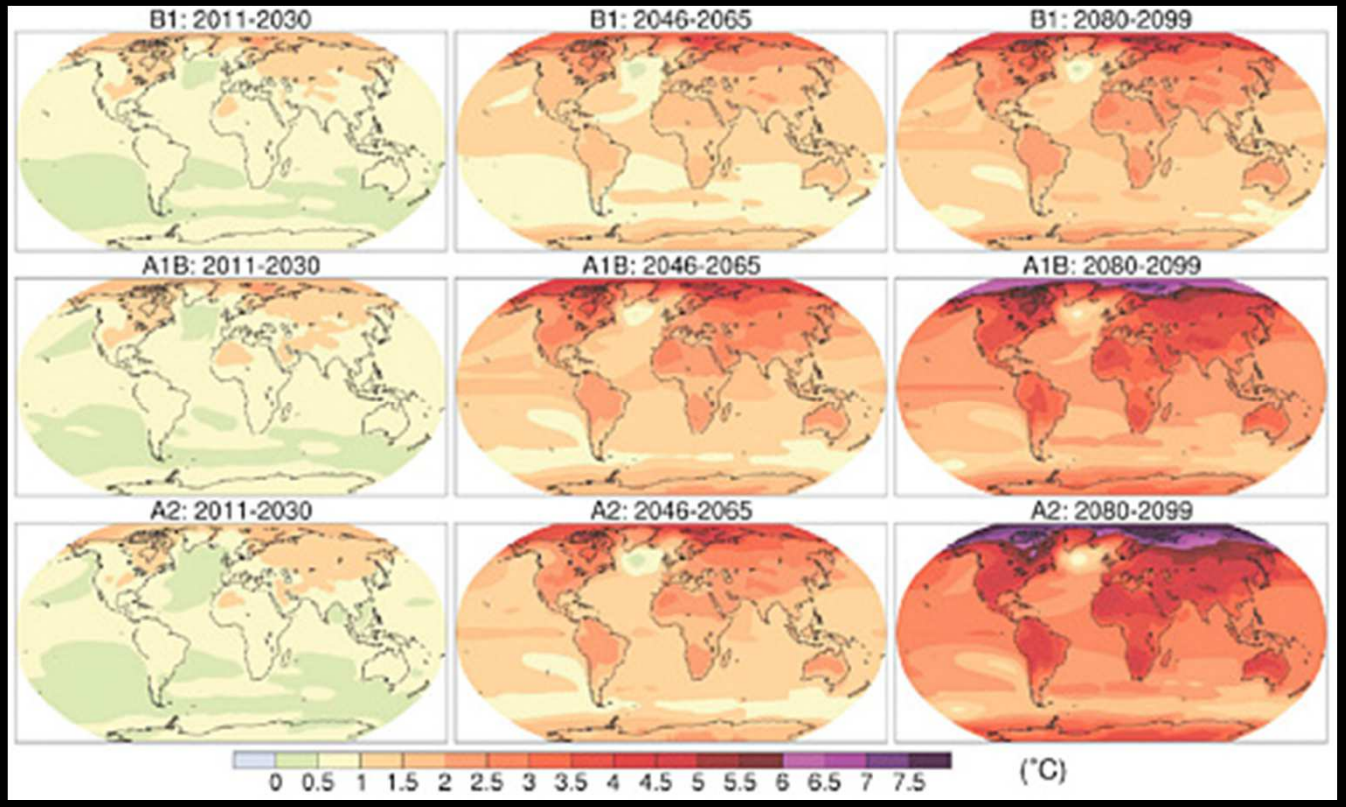
Fossil Insects as Environmental Indicators





Modern climate change

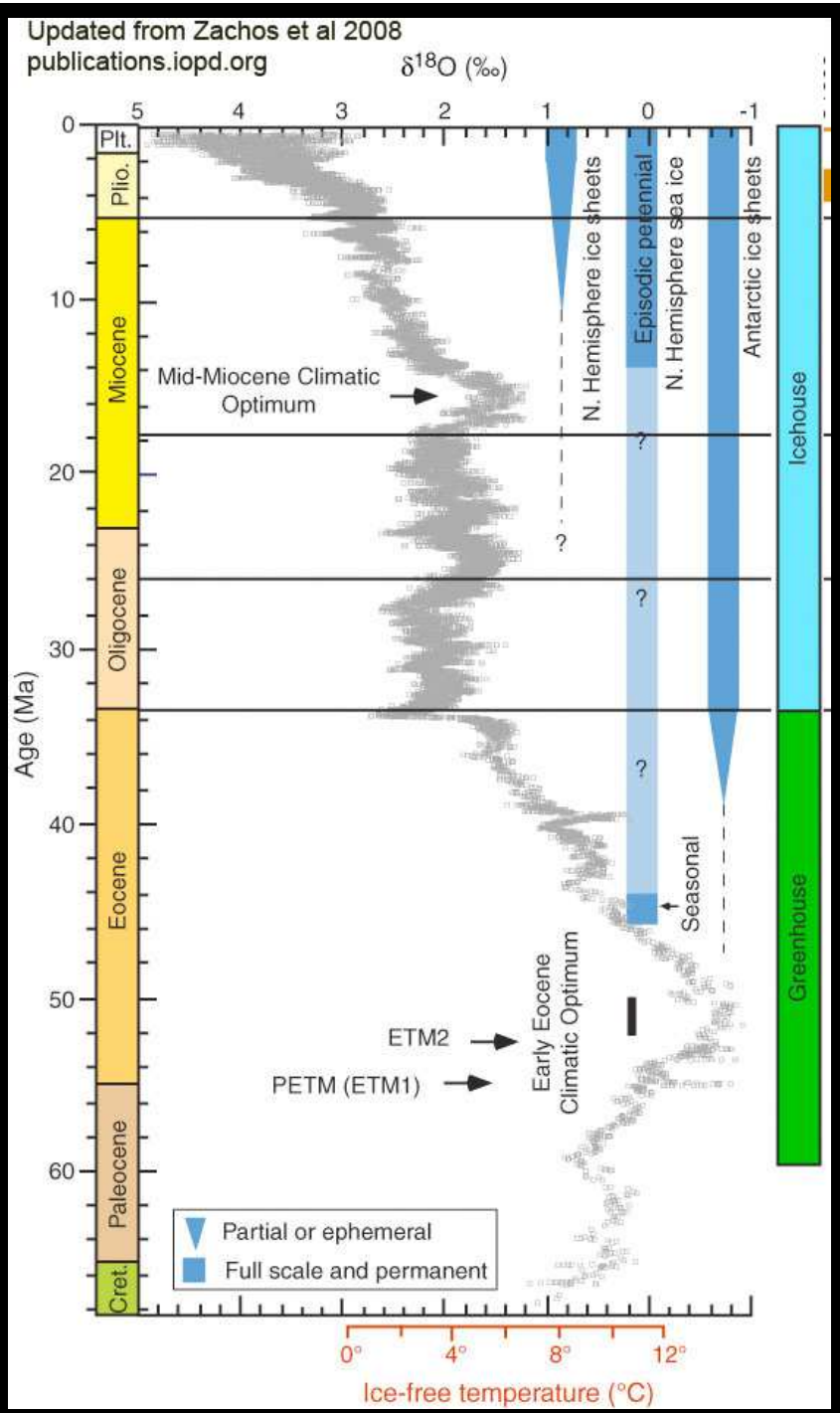
- **The Earth's average surface temperatures have increased by 0.6 ± 0.2 °C over the last century (IPCC 2001).**

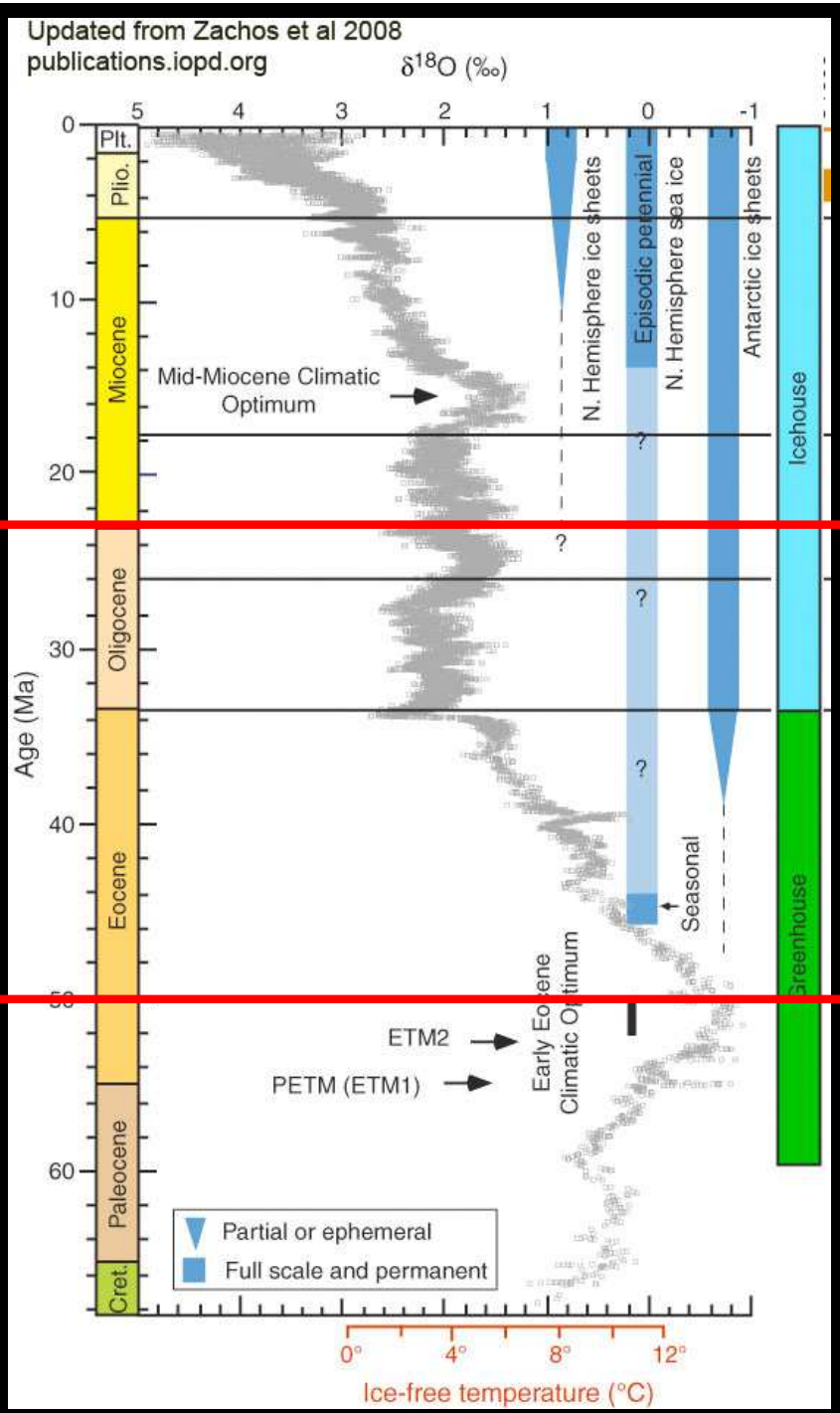


Modern climate change

- **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.**


Updated from Zachos et al 2008
publications.iopd.org
δ18O (‰)
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
Age (Ma)
Plt.
Plio.
Miocene
Oligocene
Eocene
Paleocene
Cret.
Mid-Miocene Climatic Optimum
N. Hemisphere ice sheets
Episodic perennial
N. Hemisphere sea ice
Antarctic ice sheets
Icehouse
Greenhouse
Seasonal
Early Eocene Climatic Optimum
ETM2
PETM (ETM1)
Partial or ephemeral
Full scale and permanent
0°
4°
8°
12°
Ice-free temperature (°C)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Partial or ephemeral
Full scale and permanent
0°
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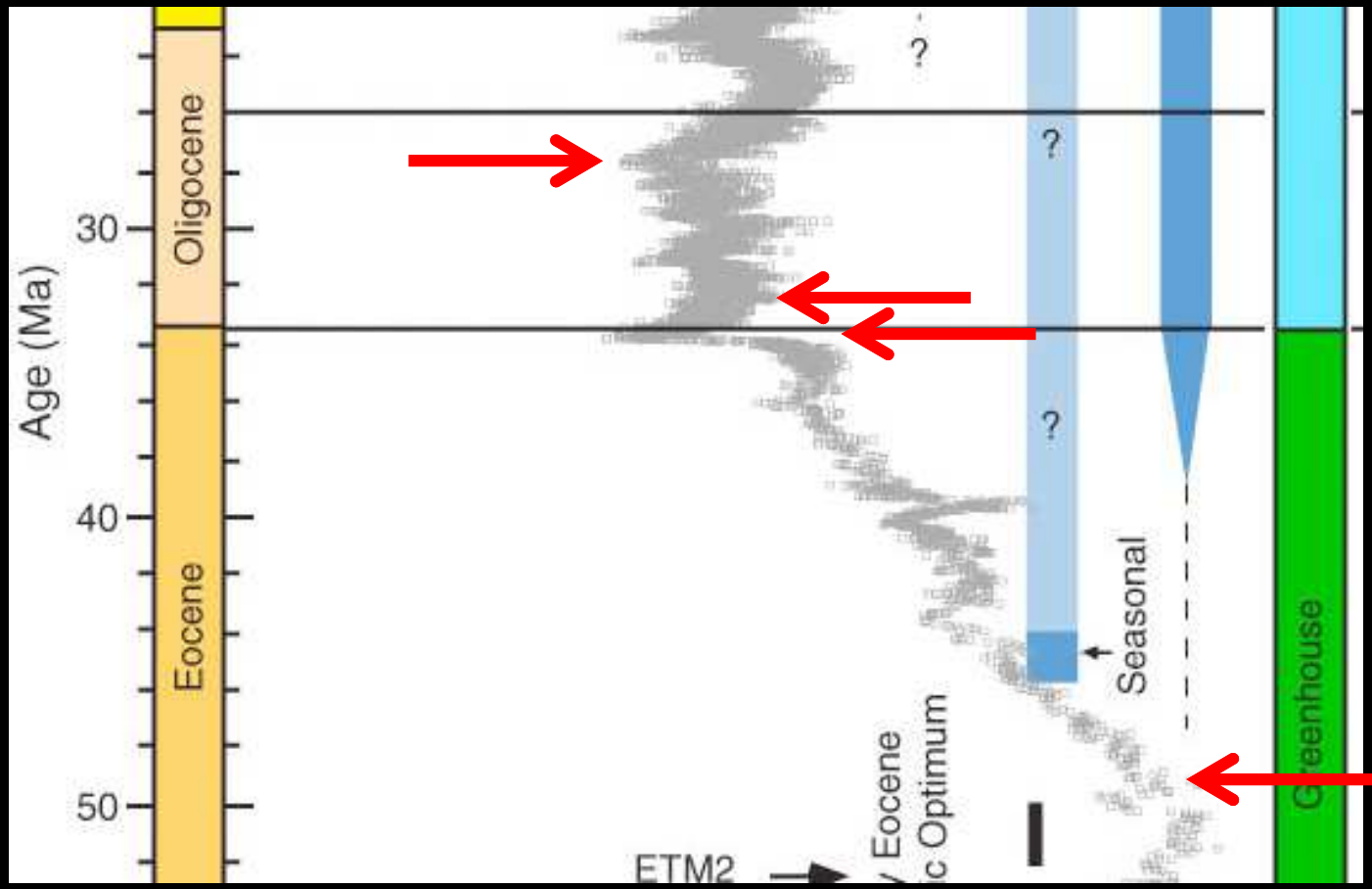
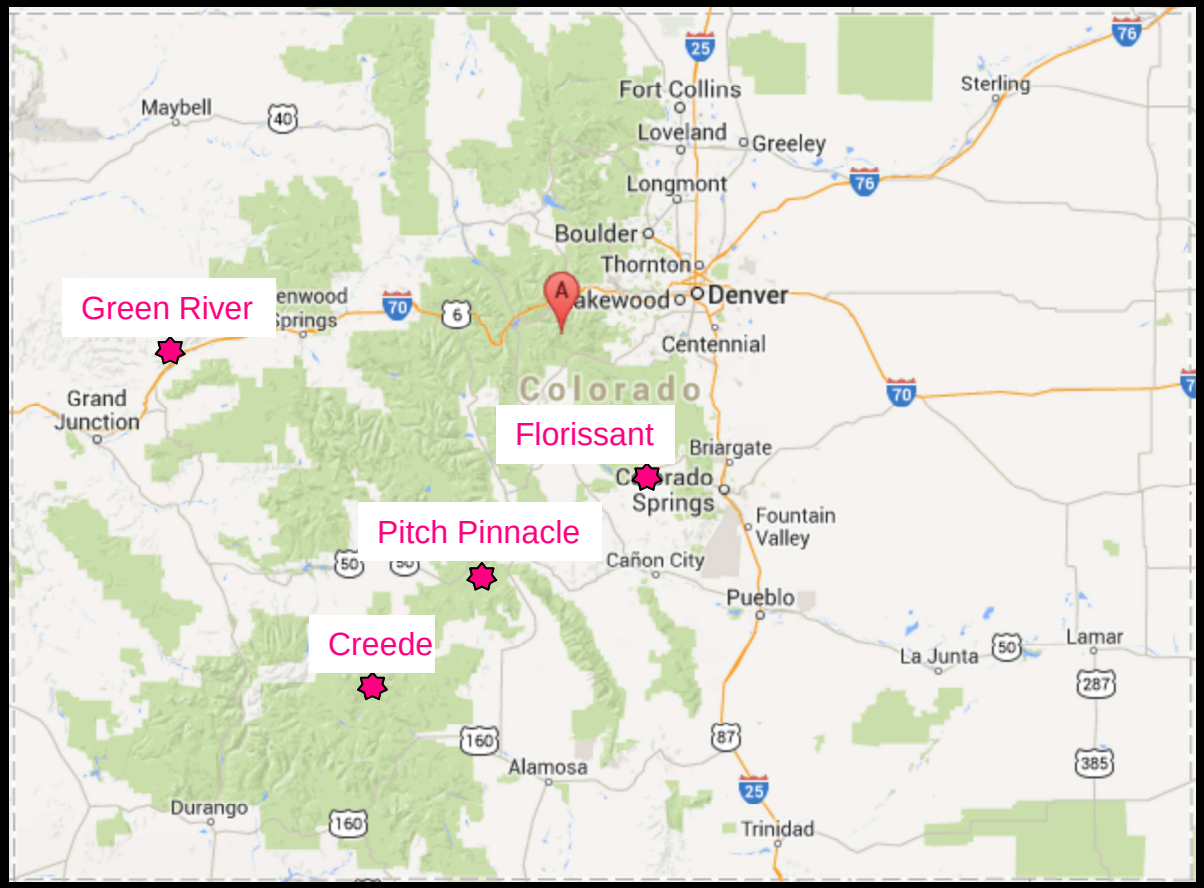
8°
12°
Ice-free temperature (°C)

CLIMATE CHANGE IN THE EOCENE-OLIGOCENE



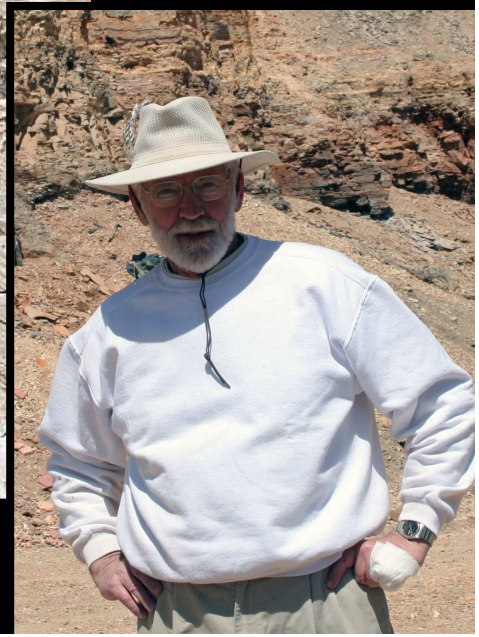
Colorado fossil deposits

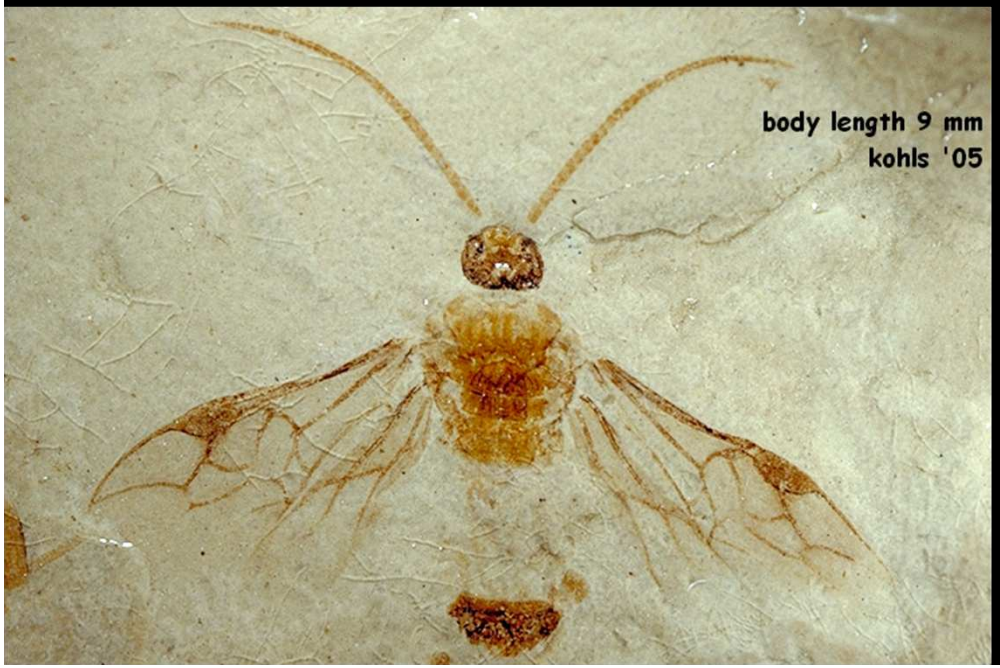


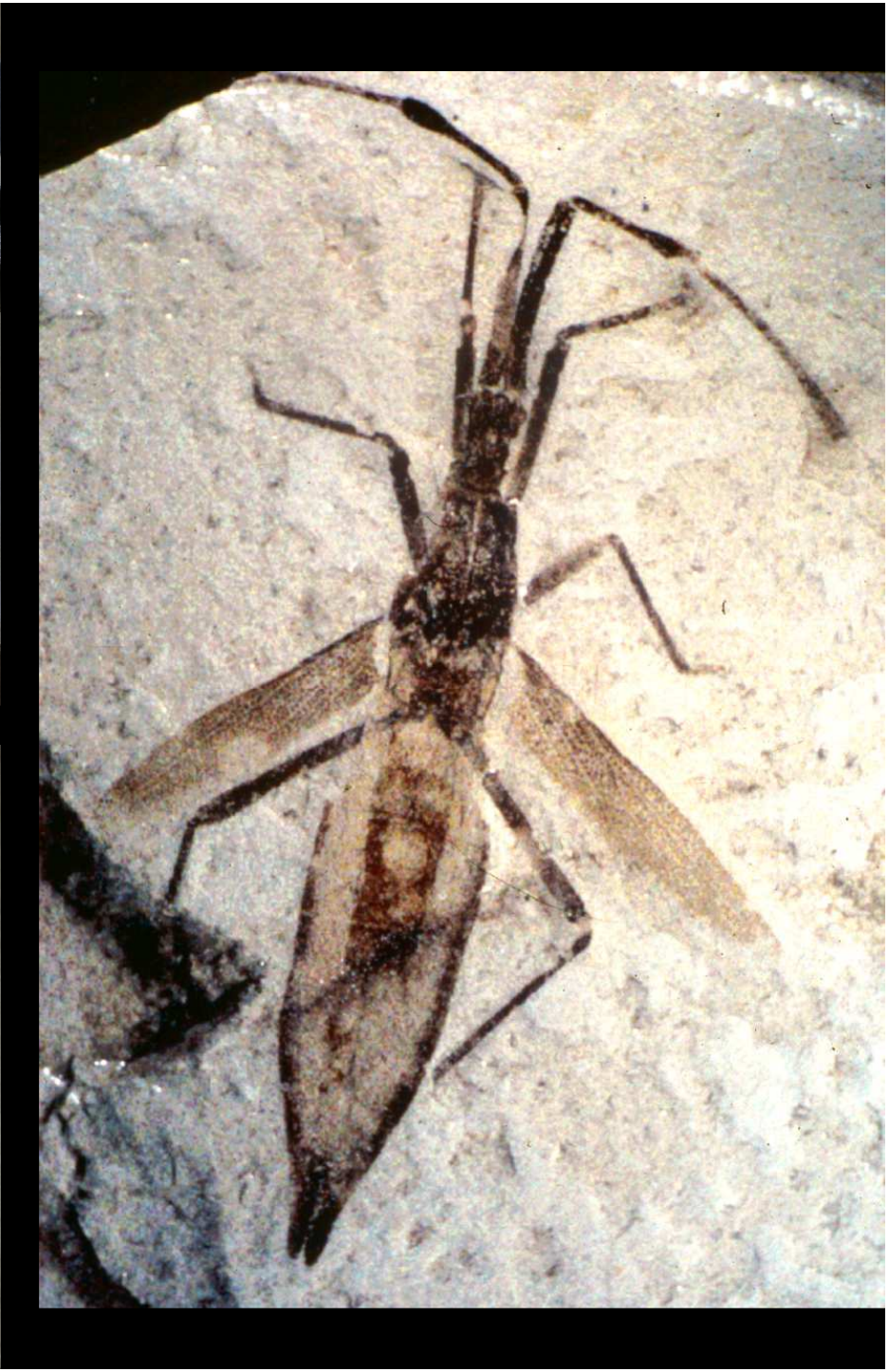
MAT (°C)

Creede	**2.5**
Pitch Pinnacle	**12**
Florissant	**12.7**
Green River	**18**

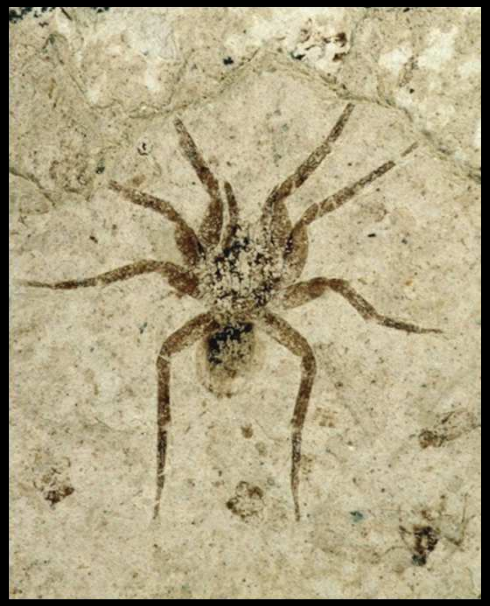

A GROOVE
B GROOVE
SITE 5

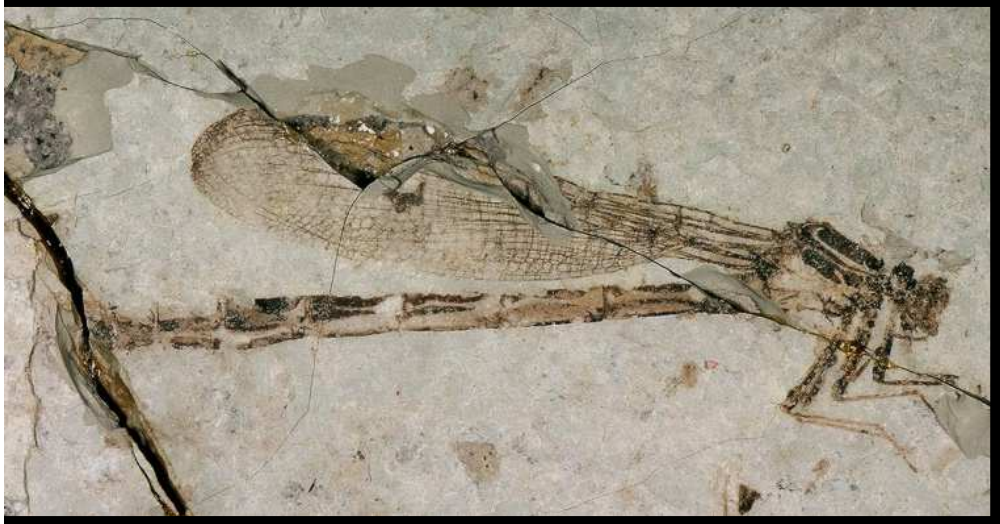


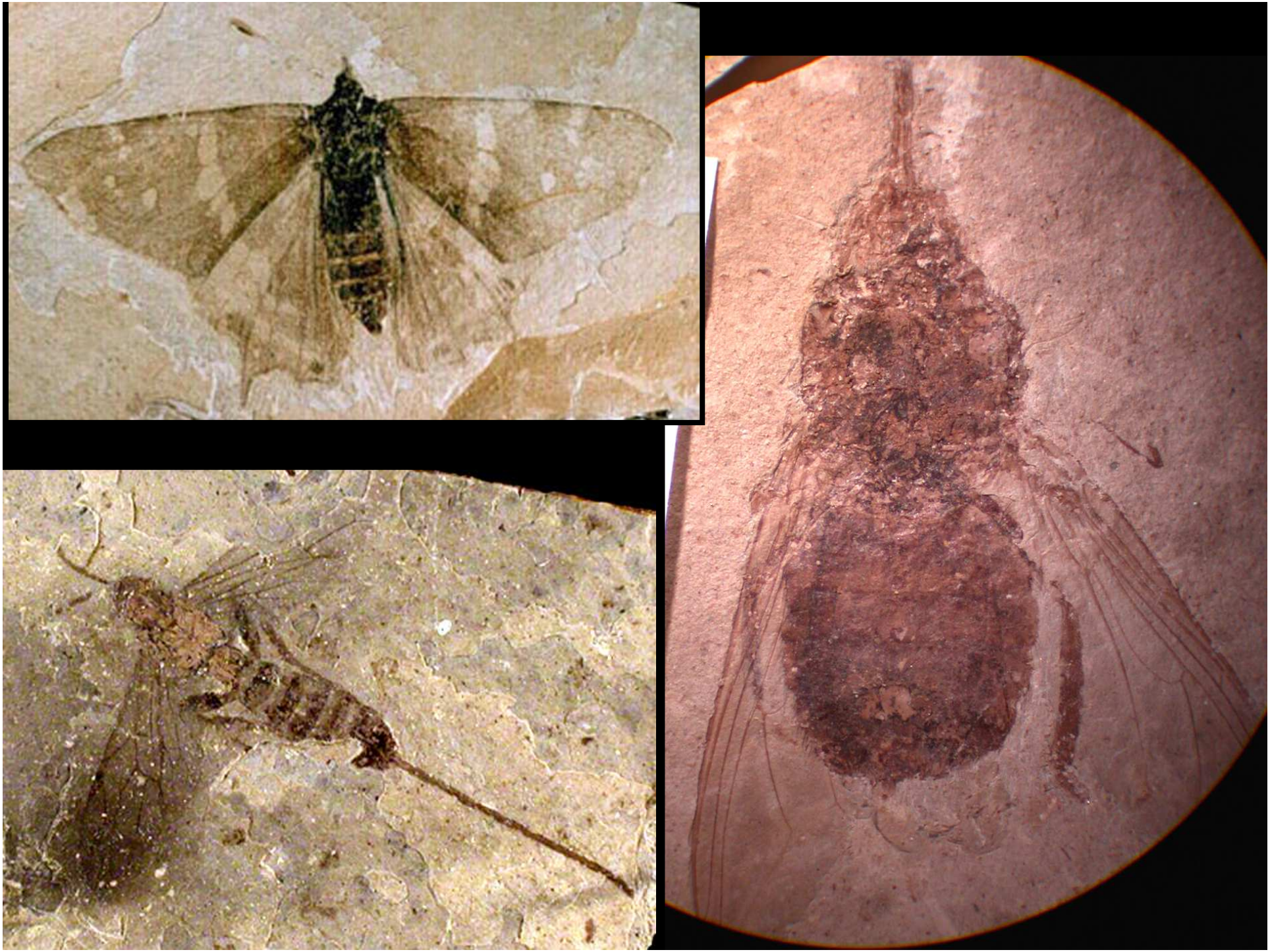

body length 9 mm
kohls '05

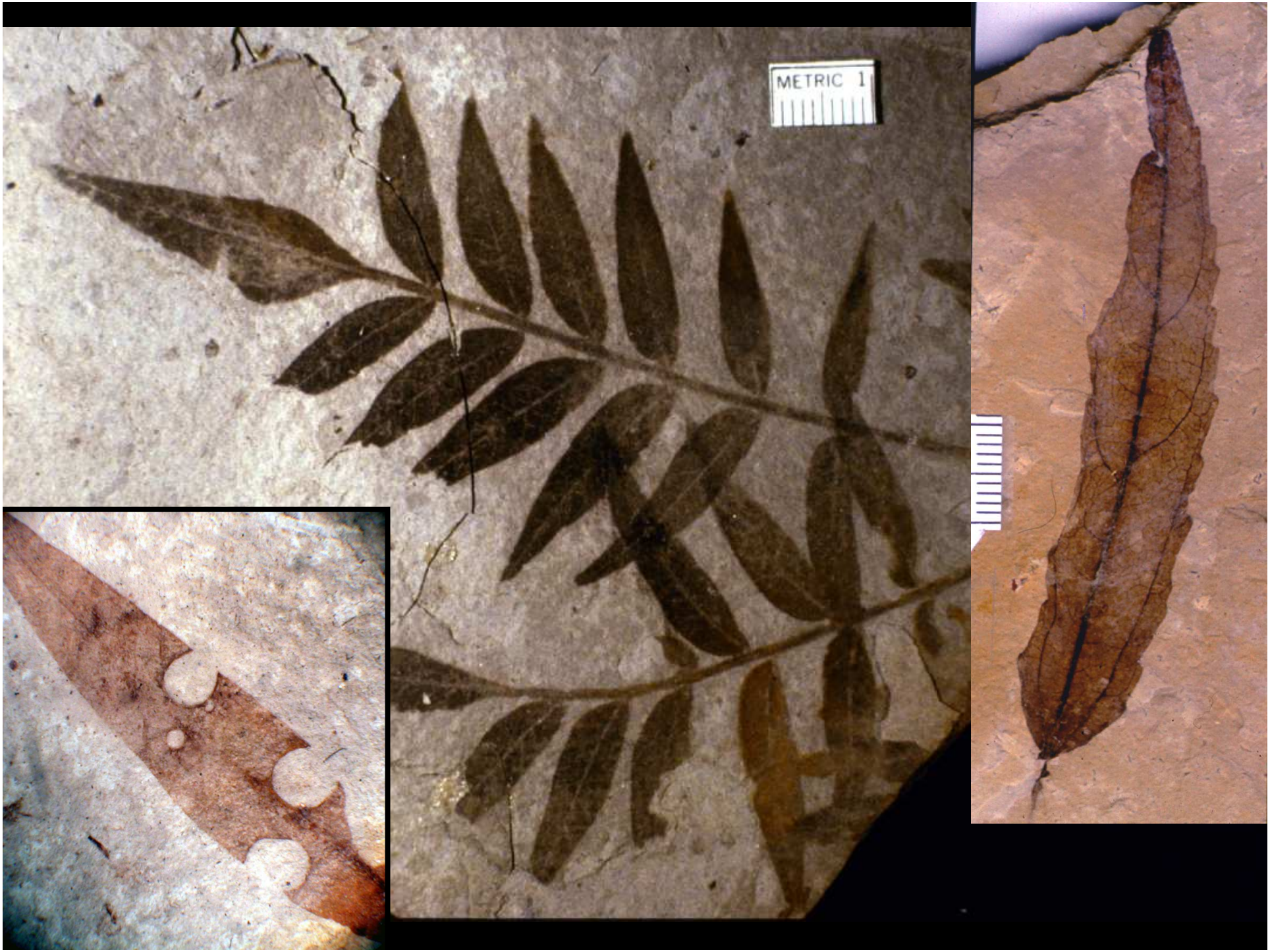


Florissant



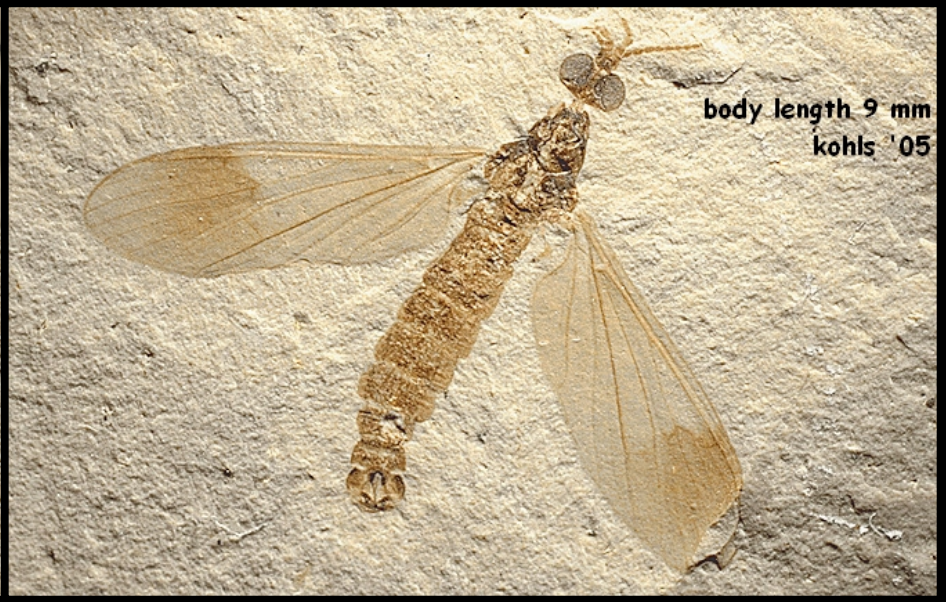




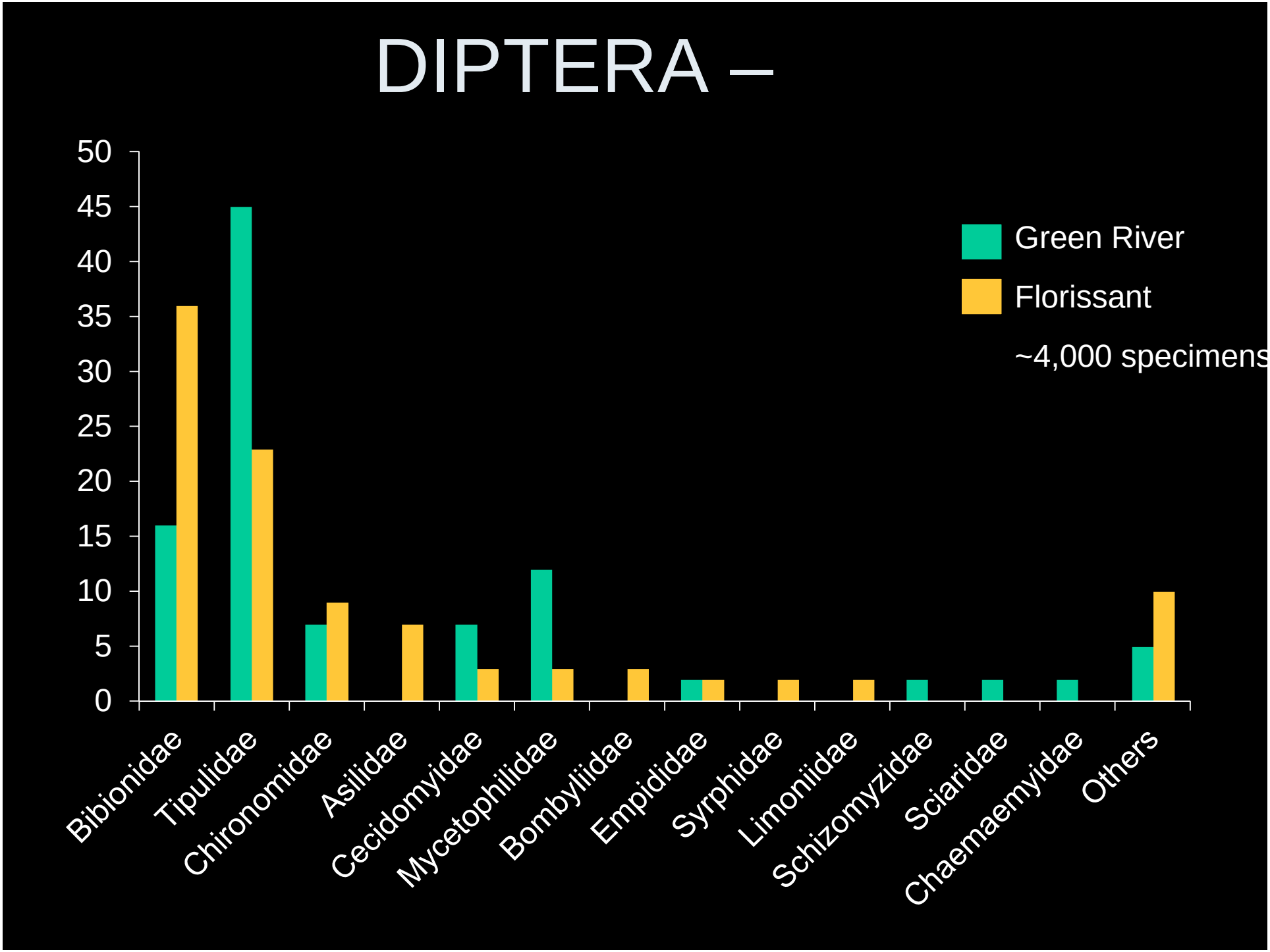

METRIC 1

Key taxa

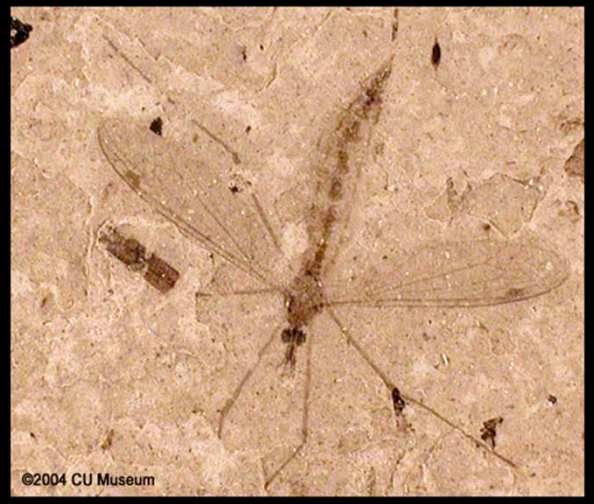
Green River Formation	16 orders
Florissant Formation	18 orders



DIPTERA –


50
45
40
35
30
25
20
15
10
5
0
Green River
Florissant
~4,000 specimens
Bibionidae
Tipulidae
Chironomidae
Asilidae
Cecidomyidae
Mycetophilidae
Bombyliidae
Empididae
Syrphidae
Limoniidae
Schizomyzidae
Sciaridae
Chaemaemyidae
Others

DIPTERA –



Green River

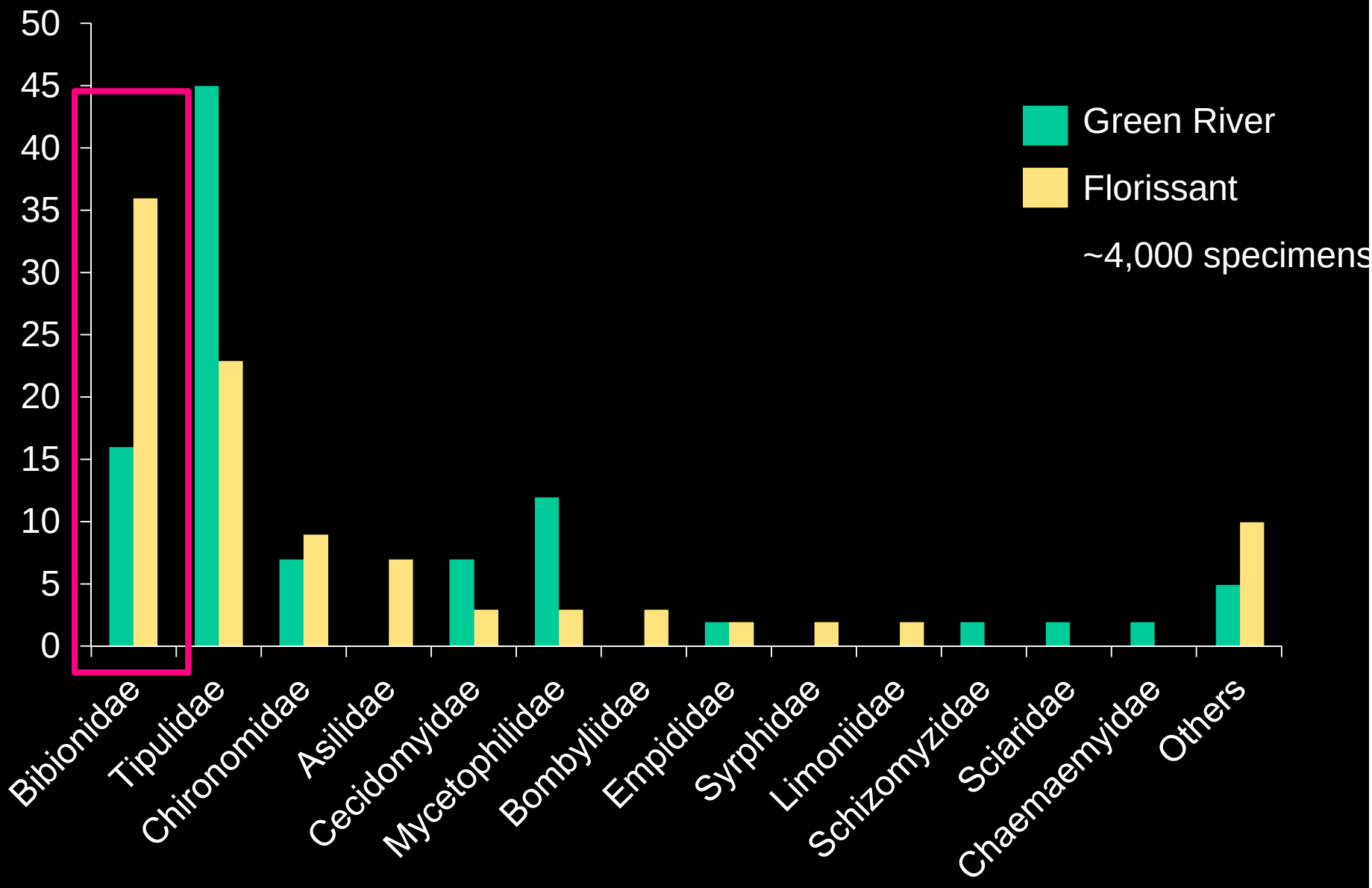
Florissant

~4,000 specimens

50
45
40
35
30
25
20
15
10
5
0

Bibionidae
Tipulidae
Chironomidae
Asilidae
Cecidomyidae
Mycetophilidae
Bombyliidae
Empididae
Syrphidae
Limoniidae
Schizomyzidae
Sciaridae
Chaemaemyidae
Others

DIPTERA –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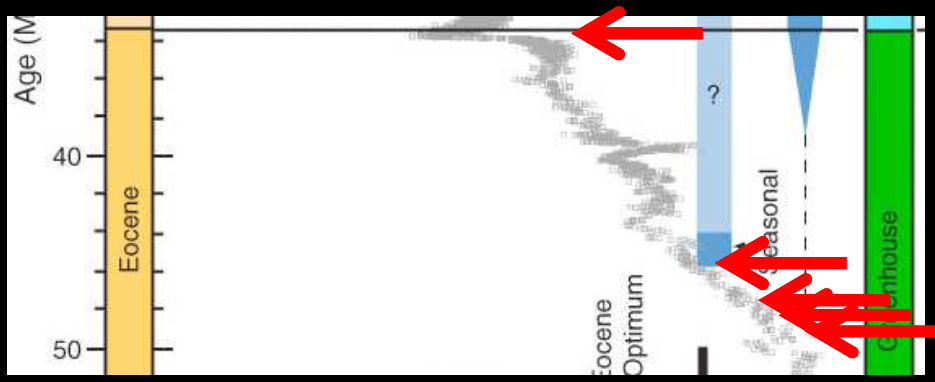
Bombyliidae
Empididae
Syrphidae
Limoniidae
Schizomyzidae
Sciaridae
Chaemaemyidae
Others

Bibionidae

Plecia – warm loving

Bibio – cool loving



Next steps

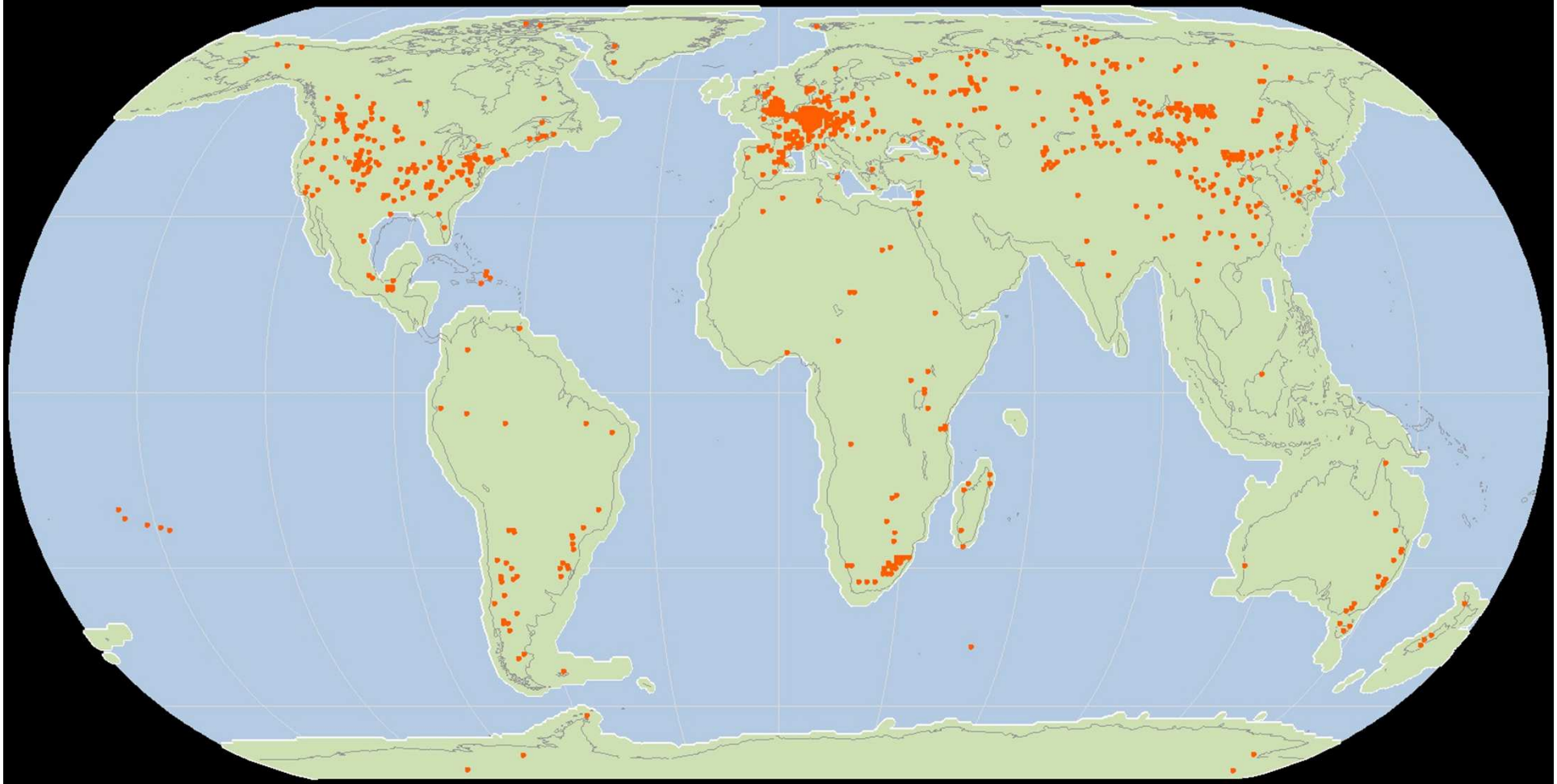
- Analyze how taxonomic composition, richness and abundance distributions have changed during this dramatic cooling event.

- Determine feeding preferences to understand how life history characteristics determine which groups had the strongest response to environmental change.

Next steps


Canada
United States
except for Hawaii and Alaska
Mexico
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Ontario
Seattle
Spokane
Portland
Salem
Eugene
Olympia
Helena
Bismarck
Fargo
Duluth
Minneapolis
St. Paul
Pierre
Boise
Carson City
Sacramento
San Francisco
Salt Lake City
Cheyenne
Denver
Omaha
Lincoln
Des Moines
Chicago
Madison
Milwaukee
Lansing
Detroit
Cleveland
Columbus
Indianapolis
Springfield
Kansas City
Topeka
Jefferson City
St. Louis
Frankfort
Charleston
Harrisburg
Trenton
Philadelphia
Dover
Annapolis
Washington, D.C.
Richmond
Norfolk
Raleigh
Nashville
Memphis
Columbia
Atlanta
Charleston
Birmingham
Montgomery
Jackson
Tallahassee
Jacksonville
Tampa
Miami
Key West
Bahamas
Cuba
Tropic of Cancer
New Orleans
Baton Rouge
Houston
San Antonio
Corpus Christi
Austin
Dallas
Little Rock
Oklahoma City
Tulsa
Santa Fe
Albuquerque
Phoenix
Tucson
El Paso
Los Angeles
San Diego
Montpelier
Augusta
Concord
Boston
Providence
Hartford
New York
Albany
Lansing
Milwaukee
Madison
Chicago
Detroit
Cleveland
Harrisburg
Trenton
Philadelphia
Dover
Annapolis
Washington, D.C.
Richmond
Norfolk
Raleigh
Columbia
Charleston
Atlanta
Montgomery
Jacksonville
Tallahassee
Tampa
Miami
Key West
Bahamas
Cuba
Tropic of Cancer
New Orleans
Baton Rouge
Houston
San Antonio
Corpus Christi
Austin
Dallas
Little Rock
Oklahoma City
Tulsa
Santa Fe
Albuquerque
Phoenix
Tucson
El Paso
Los Angeles
San Diego
0
500 km
0
500 mi

Next steps

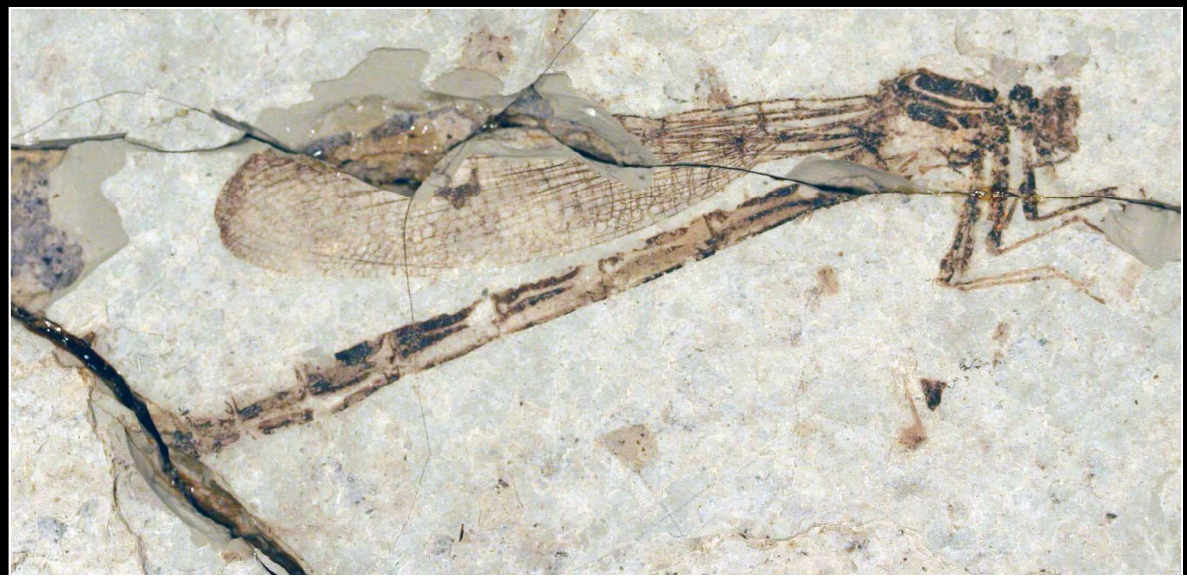


Fossilworks.org, 4 May 2014

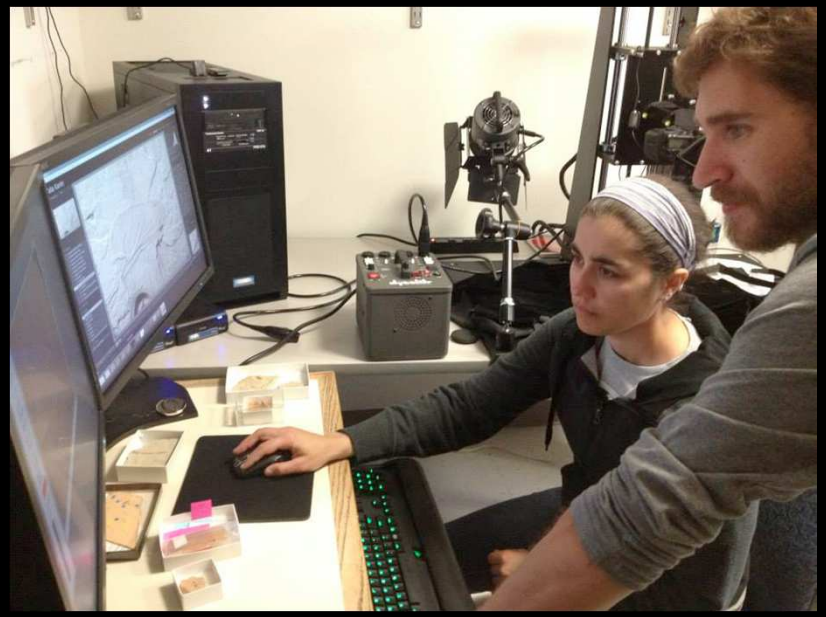
fossil insect COLLABORATIVE

A deep-time approach to studying diversification and response to environmental change

fossilinsects.colorado.edu

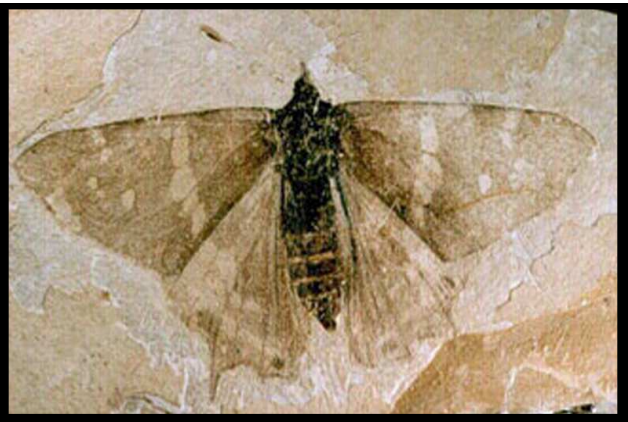


fossil insect COLLABORATIVE



fossilinsects.colorado.edu

- 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

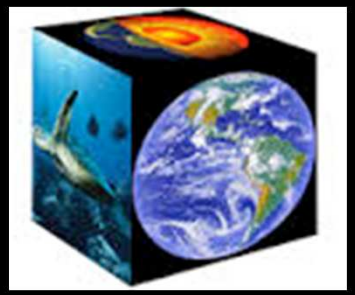
iDigPaleo will be used to aggregate specimen data and low resolution images from collaborators and then to serve these data to the National Hub at iDigBio (www.idigbio.org) and the Paleontology Portal (www.paleoportal.org).

Paleontology TCN Projects

iDigBio
Integrated Digitized Biocollections

iDig Paleo - Hub

Central resource to interact with bio and geo cyberinfrastructure initiatives.



GBDB

Geobiodiversity Database

Promoting collaborations based on global and regional database

Paleobiology Database

NEOTOMADB.ORG

GBIF

INTEGRATED EARTH DATA APPLICATIONS

iedadata.org

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

fossil insect COLLABORATIVE

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