SILENT STORIES

-- Biotic Interactions of Insects with Plants and Other Associates in Two Mid Mesozoic Ecosystems of Northeastern China

SHIH, CK, GAO, TP, LABANDEIRA, CC, LI, LF, WANG, M, LIN, XD and REN, D

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Fossil Sites
JINZHOU
BEIJING
SHANGHAI
Russia
Mongolia
China
North Korea
South Korea
Yellow Sea
East China Sea
Taiwan
Hong Kong
Philippines
Luzon
South China Sea
Gulf of Tonkin
Vietnam
Laos
Thailand
Cambodia
Myanmar (Burma)
Bay of Bengal
India
Bangladesh
Bhutan
Nepal
Pak.
75°
90°
105°
120°
135°
45°
30°
15°
0 500 km
0 500 mi

Two Formations in the Mesozoic of NE China

Jiulongshan Fm.
Middle Jurassic,
Yanliao Biota

Heilongjiang

Jilin

Liaoning

Inner Mongolia

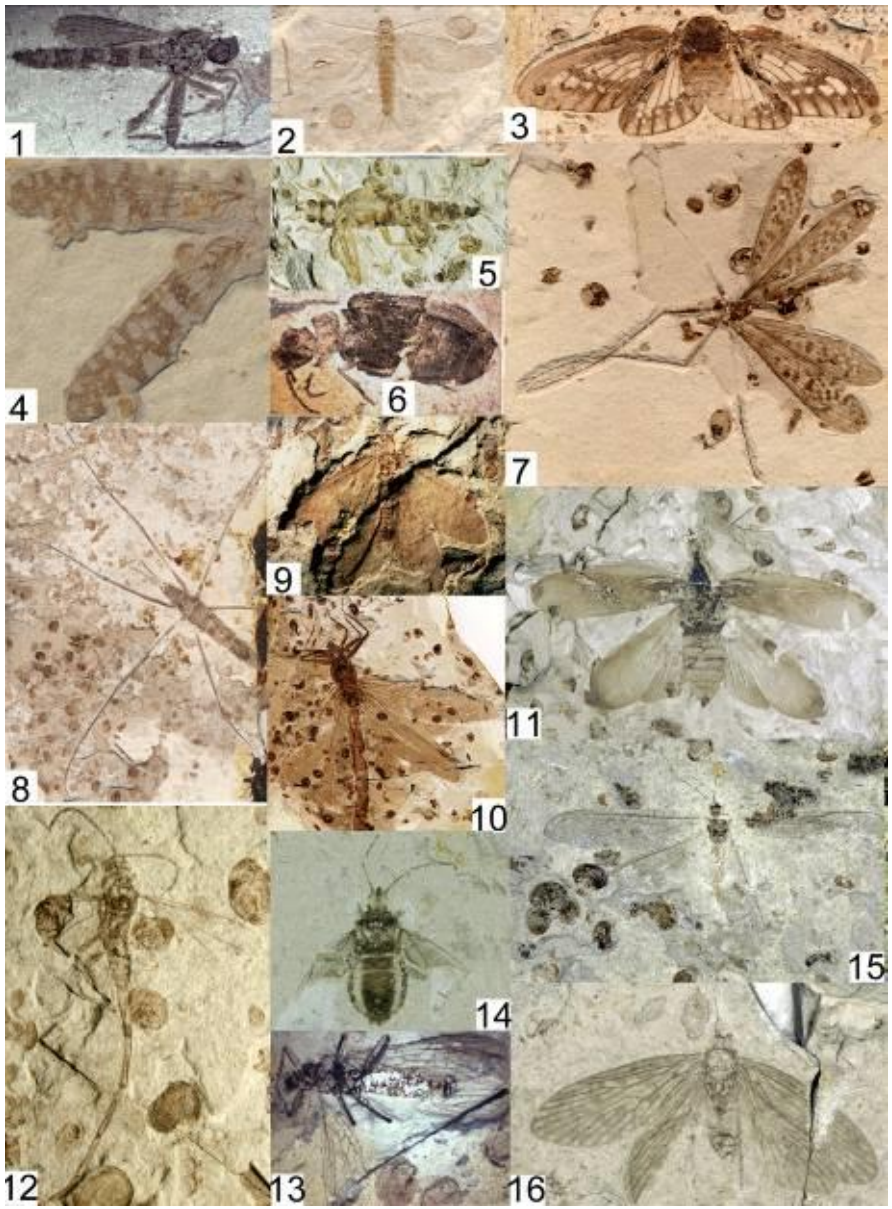
Beijing

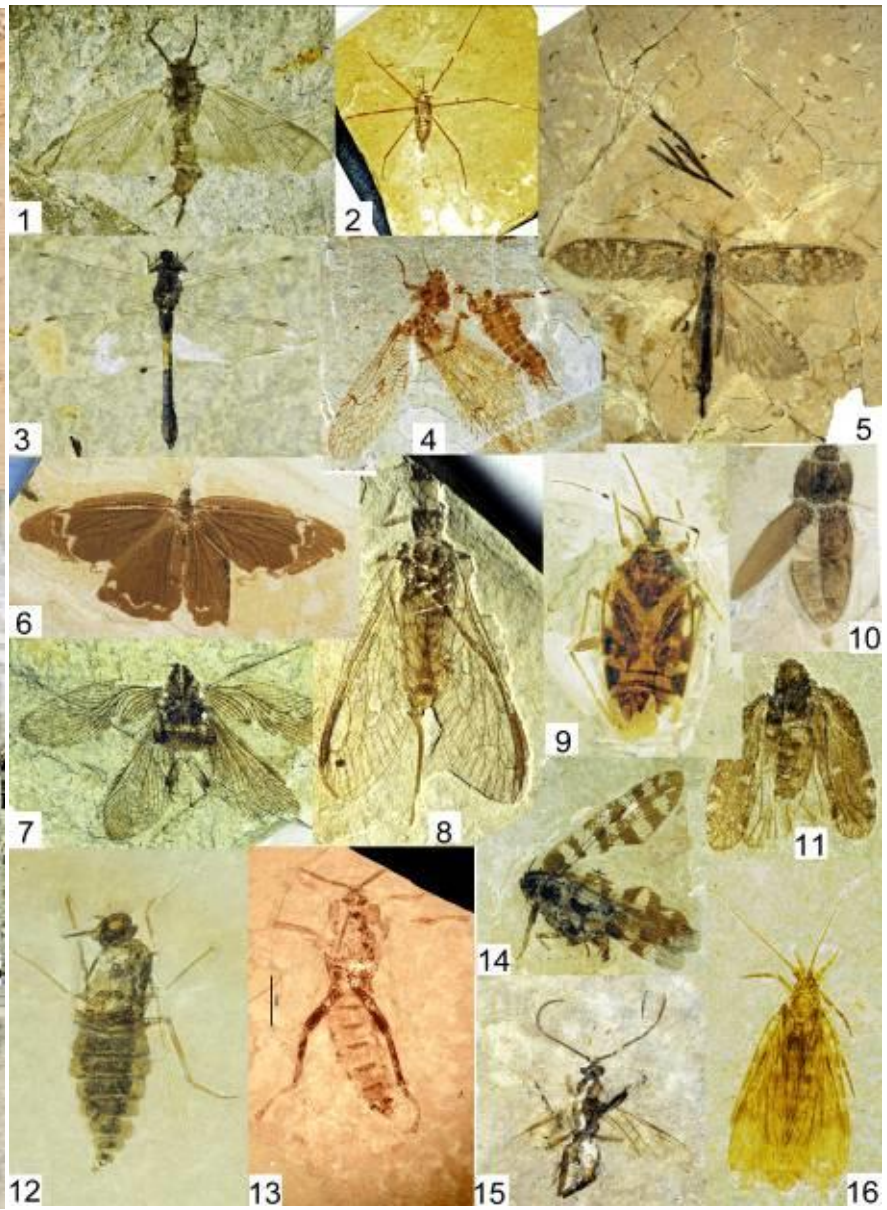
Hebei

Yixian Fm.
Lower Cretaceous,
Jehol Biota

Insect Fossil Treasures – CNU Collection

more than 250,000 insect fossils





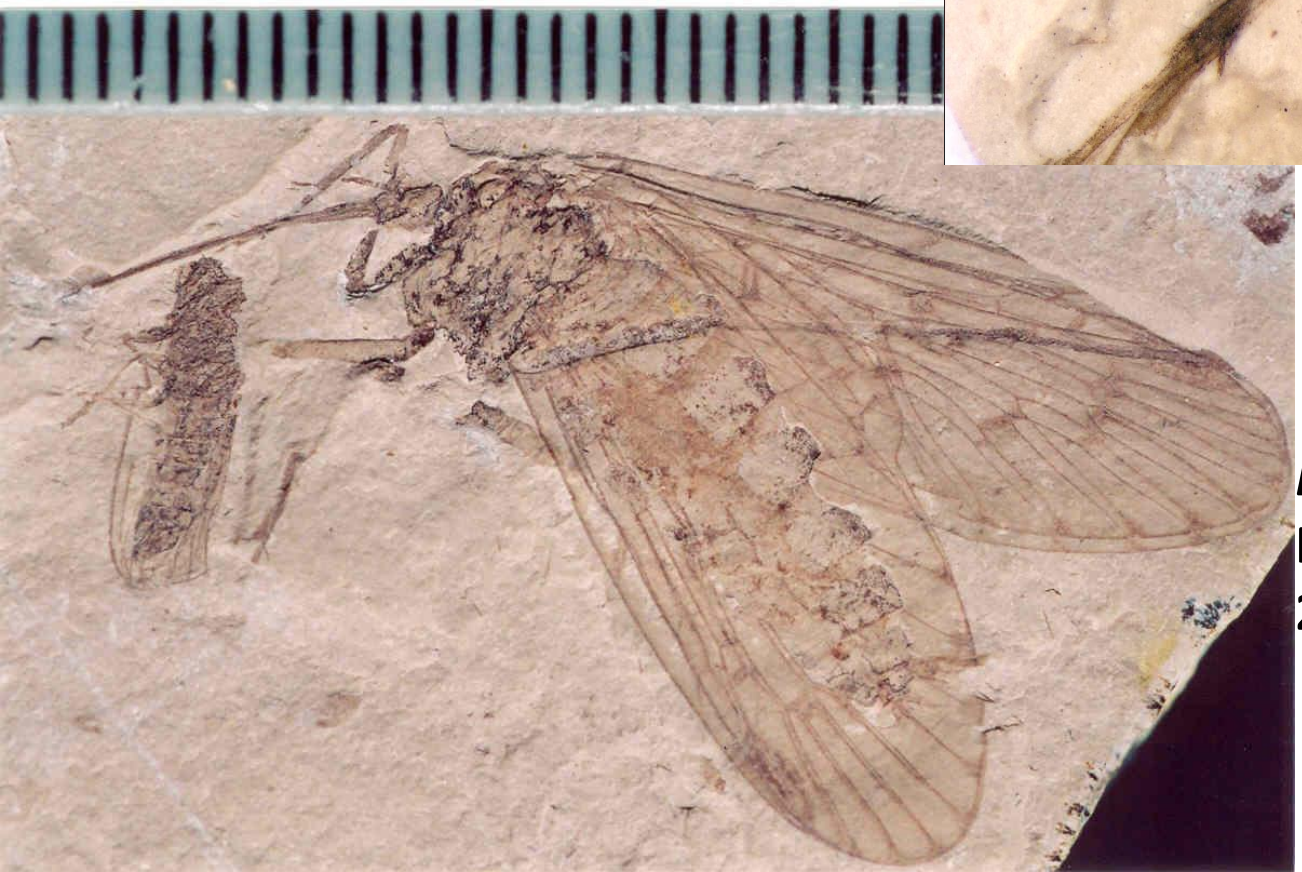
Insect Associations with Plants

Pollination or “flower” visits

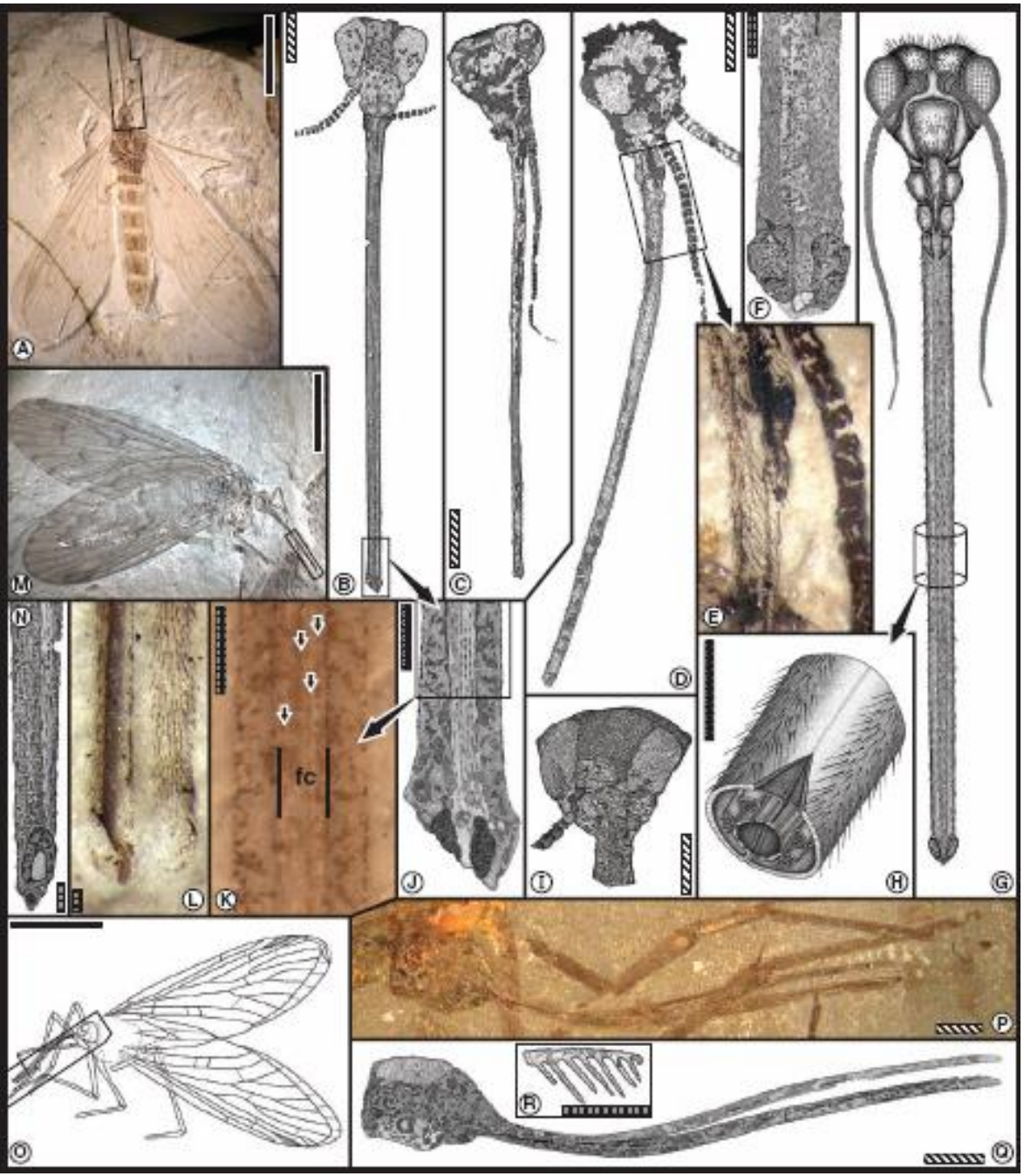
Photos by Jason Shih and CK Shih

Siphonate Mecopterans

"A probable pollination mode before angiosperms: Eurasian, long-proboscid scorpionflies," Ren et al. 2009, Science



Lichnomesopsyche gloriae **Ren, Labandeira et Shih, 2010.**



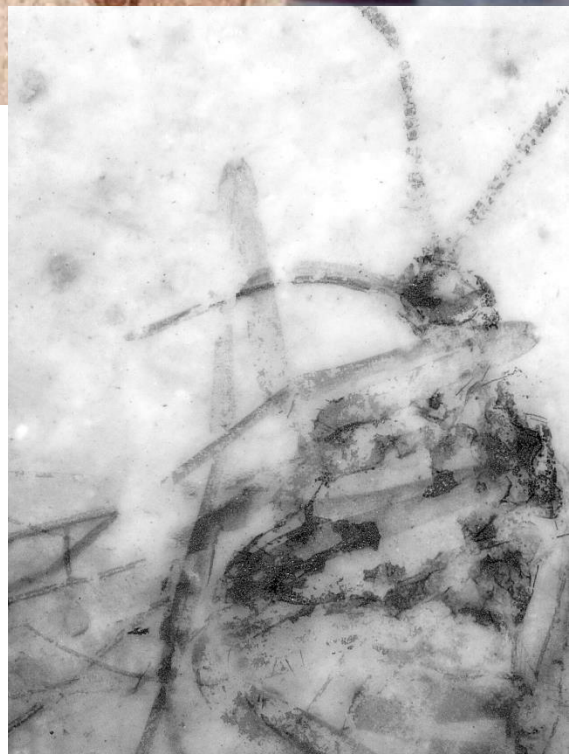
Mesopsychidae

- Siphonate mouthparts, from 9-14 mm, associated with the ovular tube of gymnosperms
- Fed on gymnosperm pollination drops
- Engaged in pollination mutualisms with gymnosperms during the Mid-Jurassic

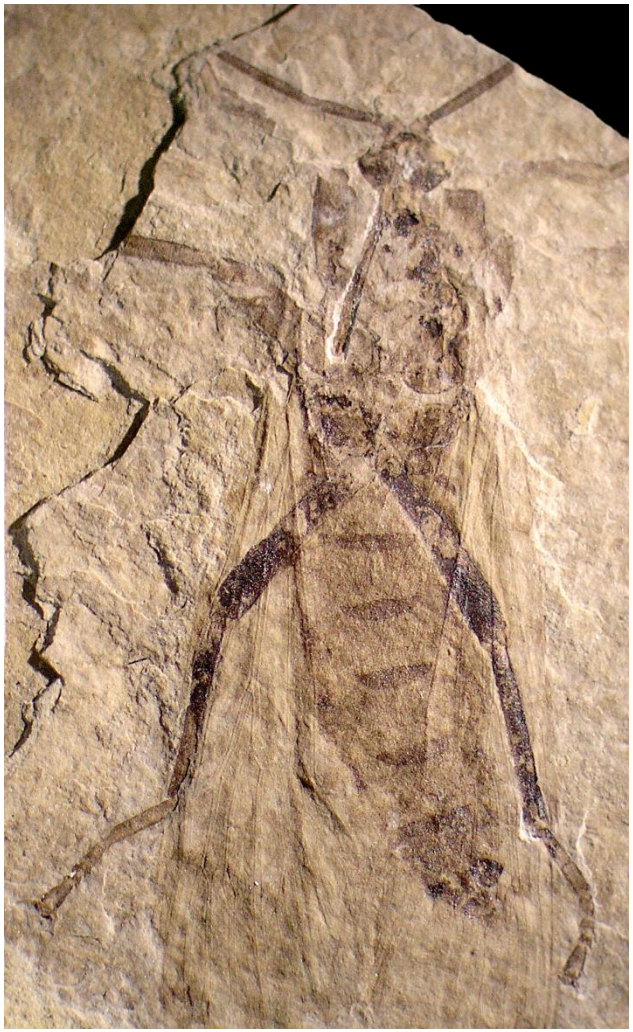
(Ren et al. 2009, Science)

Siphonate Mecopterans - Pseudopolycentropidae

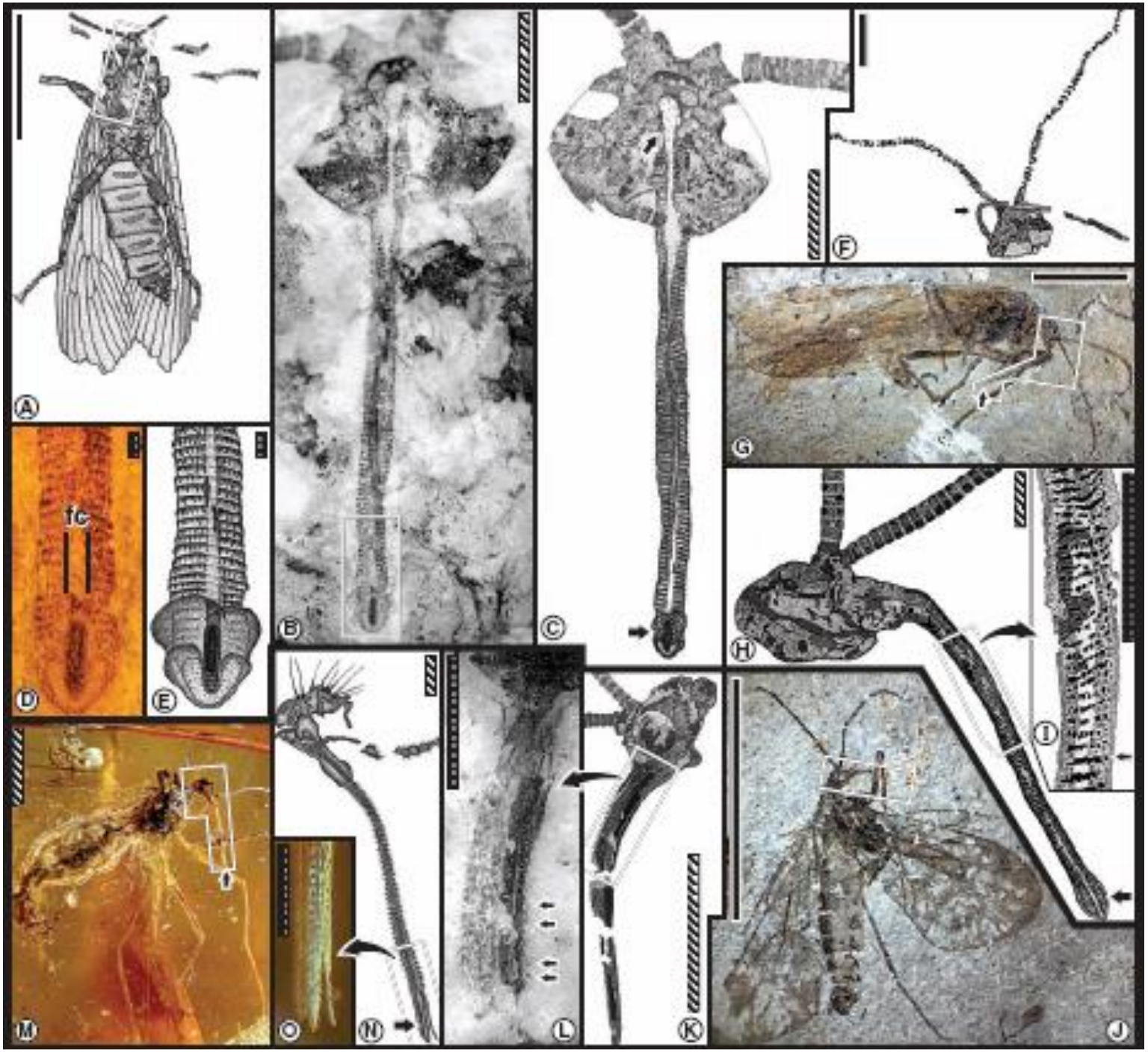
Pseudopolycentropus janeannae
Ren, Shih et Labandeira, 2010



Siphonate Mecopterans - Aneuretopsychidae



***Jeholopsyche liaoningensis* Ren, Shih et Labandeira, 2011.**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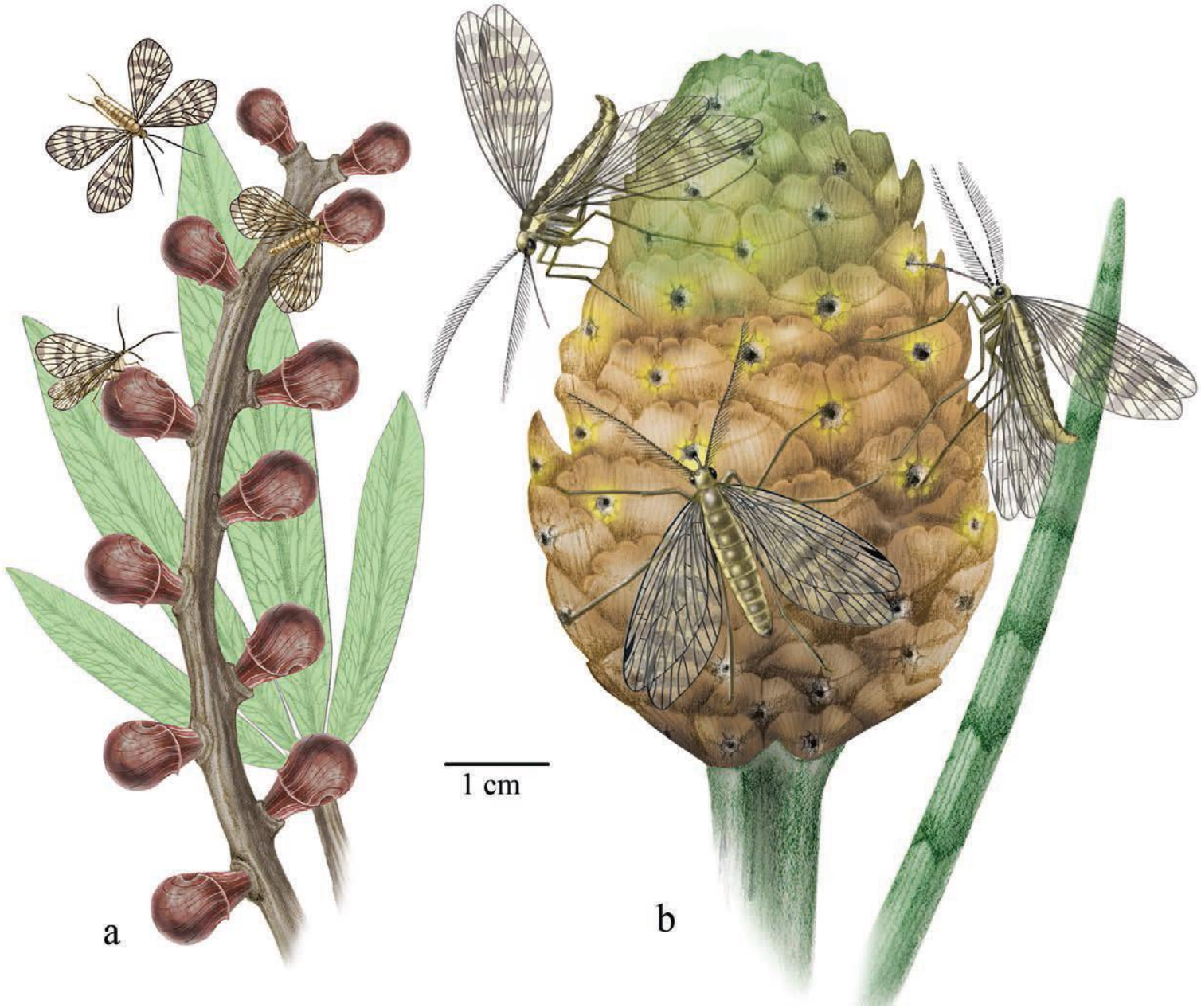
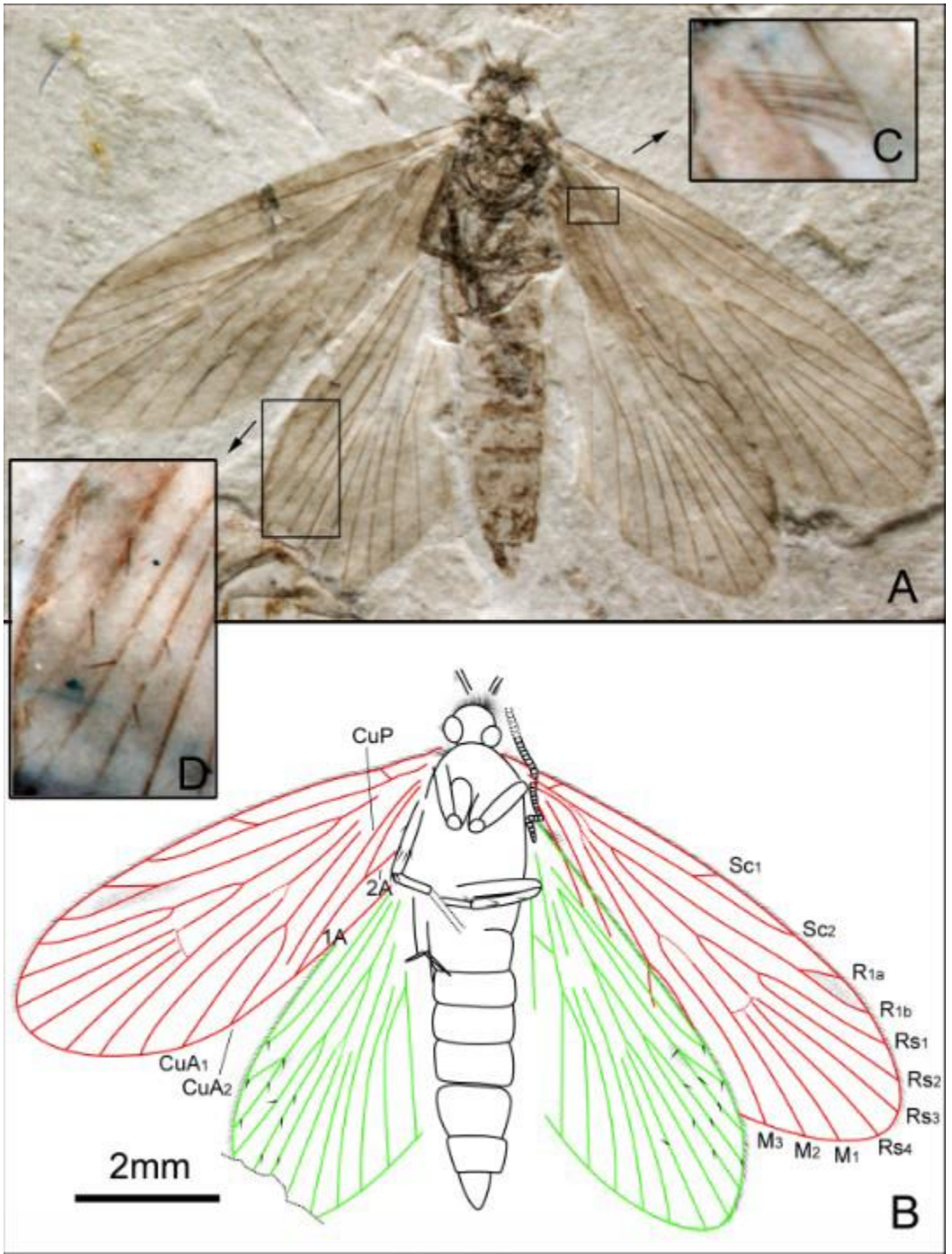


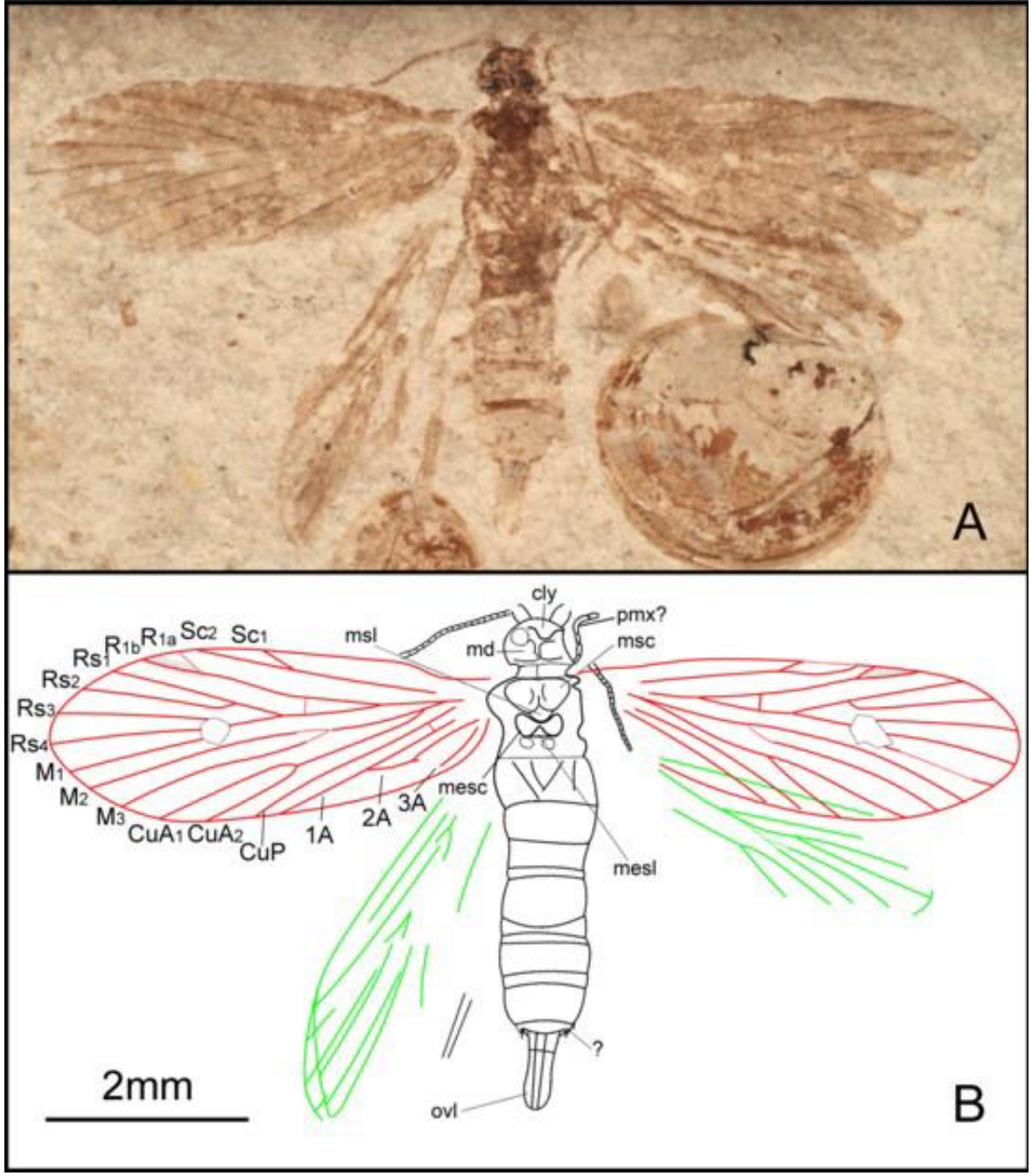
Pollination of a. *Pseudopolycentropus janeannae* b. *Lichnomesopsyche gloriae* for gymnosperms. (Art by Mary Parrish, National Museum of Natural History)

Lepidoptera – Beauty and Grace



(A) (B) *Spiniferlepidopterix elachiptera* Zhang, Shih Labandeira et Ren 2013, (C) a cluster of bristles on hind wing. (D) spines on hind wing.

Zhang et al. 2013. PLoS ONE



Mouthparts most likely for pollen feeding

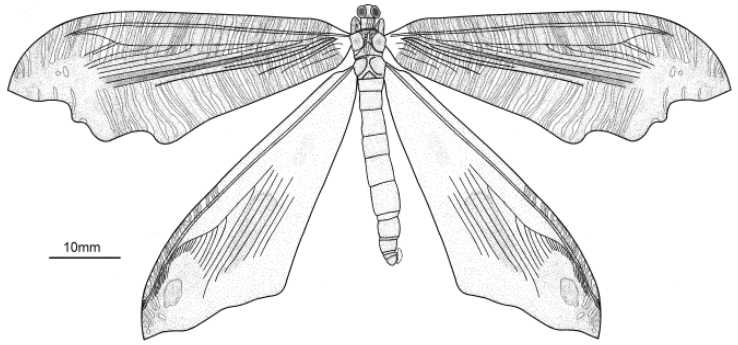
***Sinolepidopterix dualis* Zhang, Shih Labandeira et Ren 2013. PLoS ONE**


Mimesis and Camouflage
Photos by Jason Shih or CK Shih

Neuroptera - Ancient Pinnate Leaf Mimesis Among Lacewings

Pre angiosperm origin for leaf mimesis

Bellinympha filicifolia **Wang, Ren, Liu et Engel, 2010. PNAS**



***Bellinympha dancei* Wang, Ren, Shih et Engel 2010. PNAS**

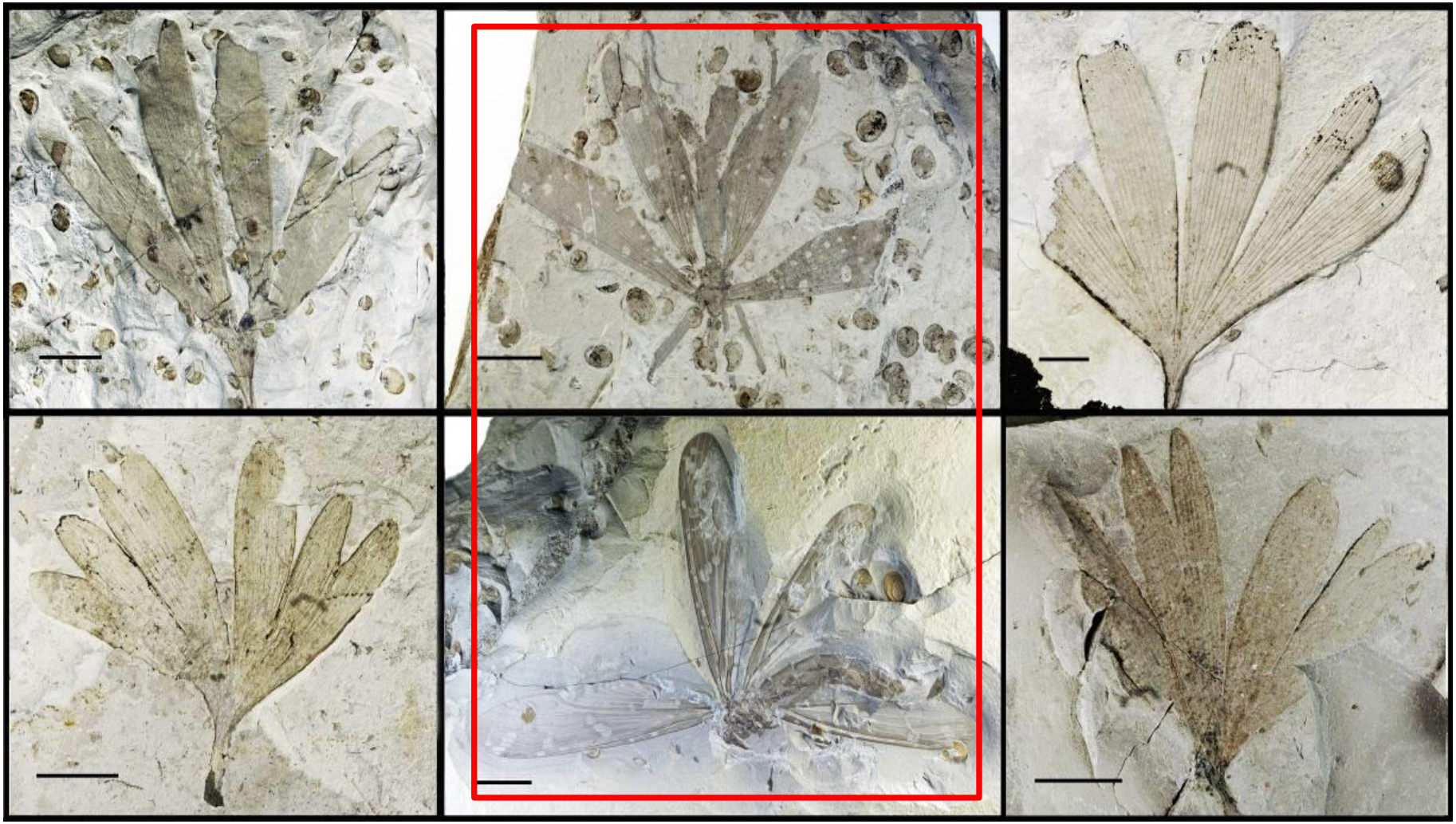
Artwork by Zhihua Ma

Venation of *Bellinympha filicifolia* imitated leaves of gymnosperms

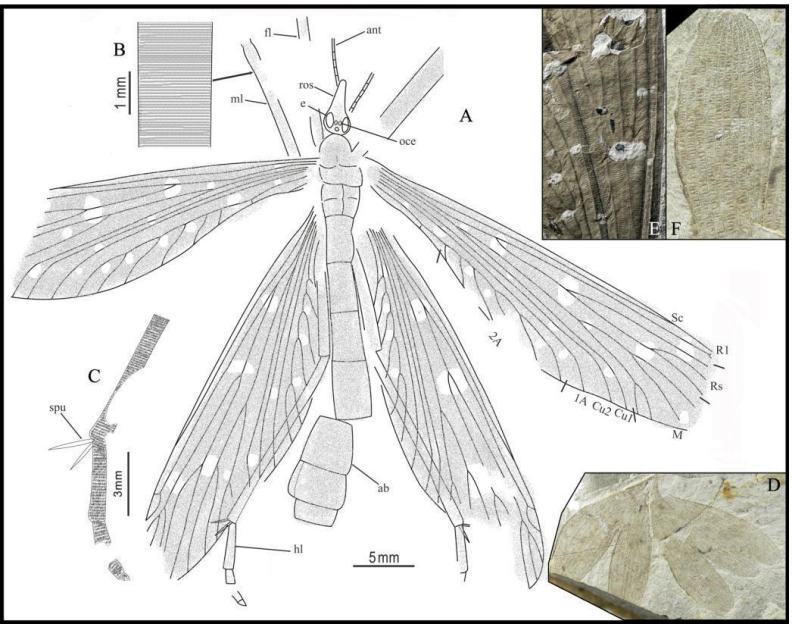
(Wang et al. 2010. PNAS)

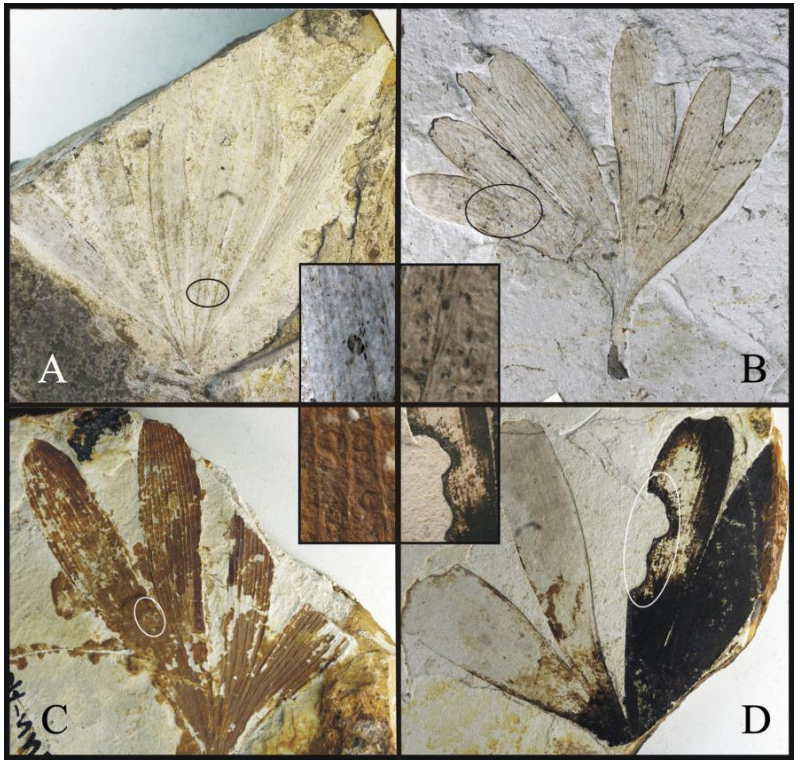
Jurassic Mimicry

between a hangingfly (Cimbrophlebiidae) & a ginkgo leaf from China

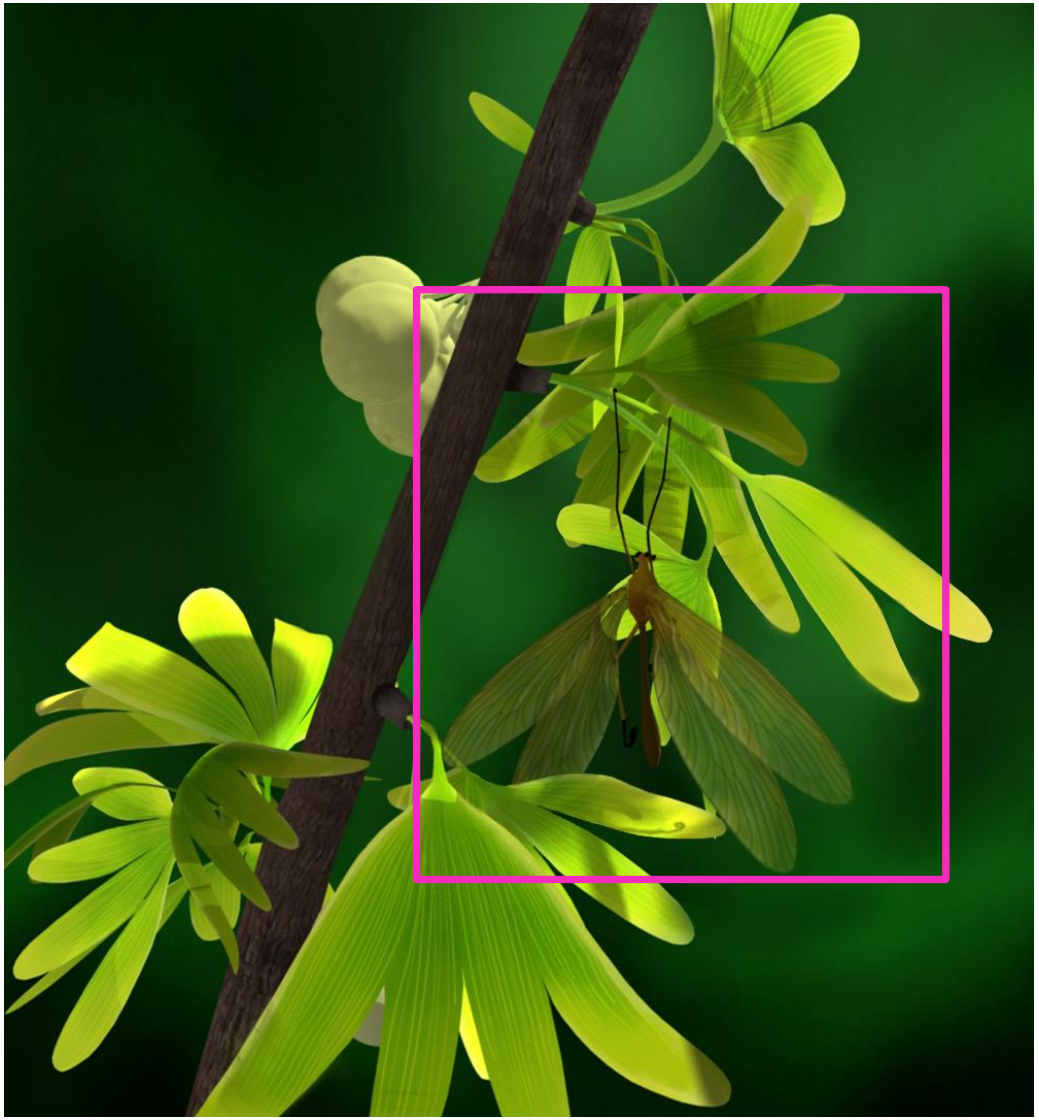


Juracimbrophlebia ginkgofolia **Wang, Labandeira, Shih and Ren, 2012. PNAS**





Named as one of the top 10 new species in 2012 by International Institute for Species Exploration (IISE)

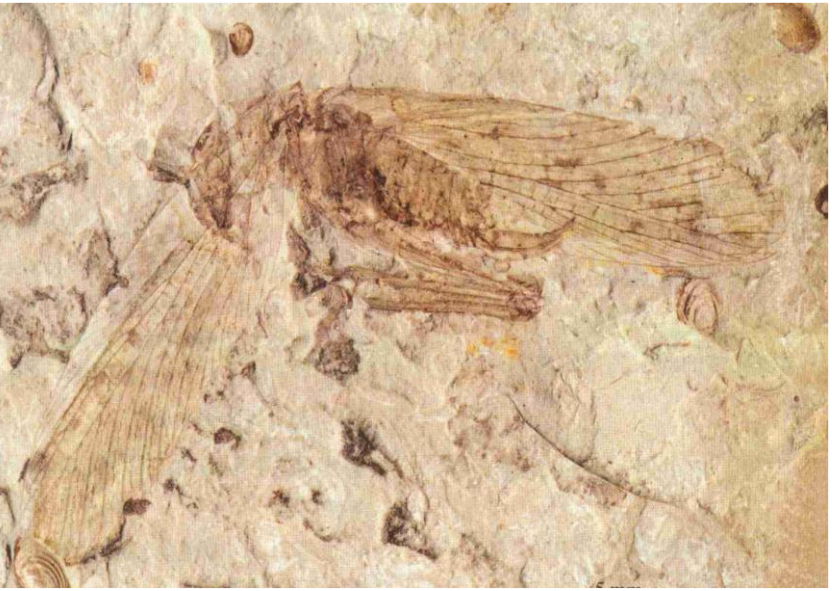


Artwork by Chen Wang

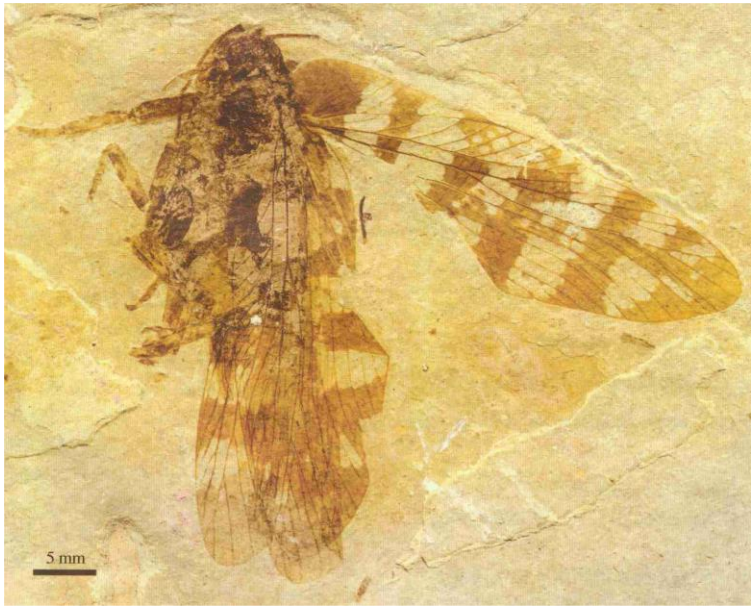
Herbivore

Photos by Jason Shih and CK Shih

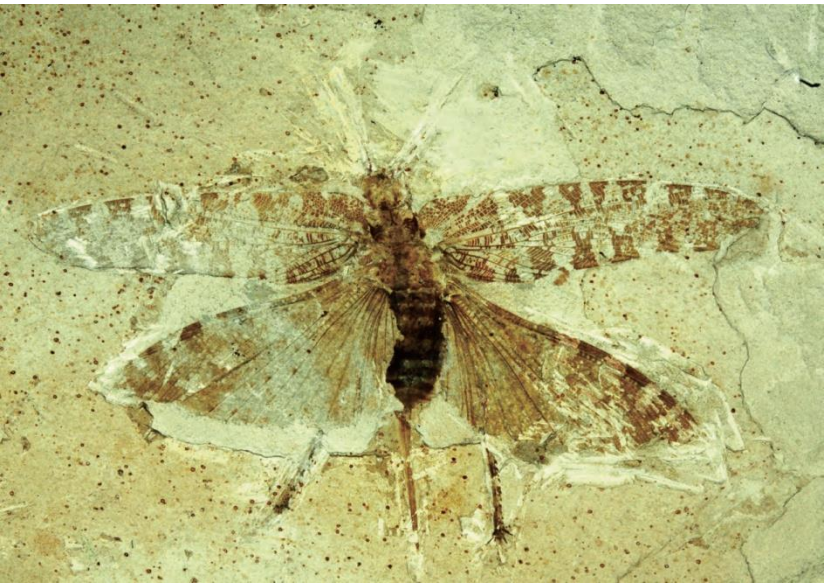
Orthoptera – The Sound of Chirping



Aboilus cornutus **Li, Ren et Wang, 2007**



Bacharaboilus jurassicus
Li, Ren et Wang, 2007



Parahagla sibirica **Sharov, 1968 (female)**

Head of
Allaboilus gigantus
Ren et Meng, 2006

Homoptera - 17 Years Underground

***Anthoscytina aphthosa* Ren, Yin et Dou, 1998**

Palaeontinodes reshuitangensis
Wang et Zhang 2007

Daohugoucossus shii
Wang, Ren et Shih, 2007

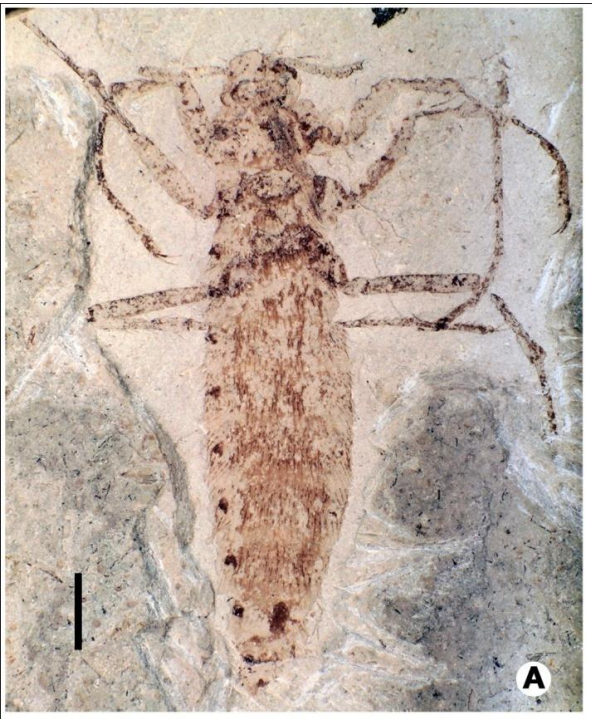
Insect Associations with Vertebrates

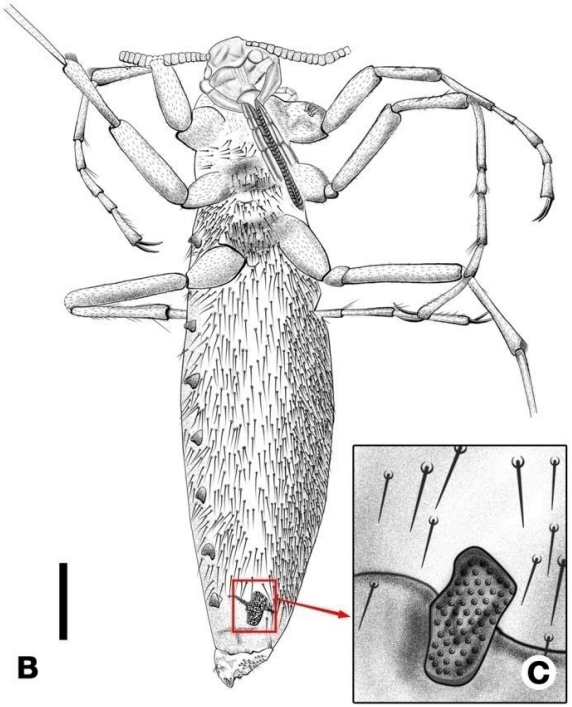
Blood-Sucking Insects – the earliest fleas

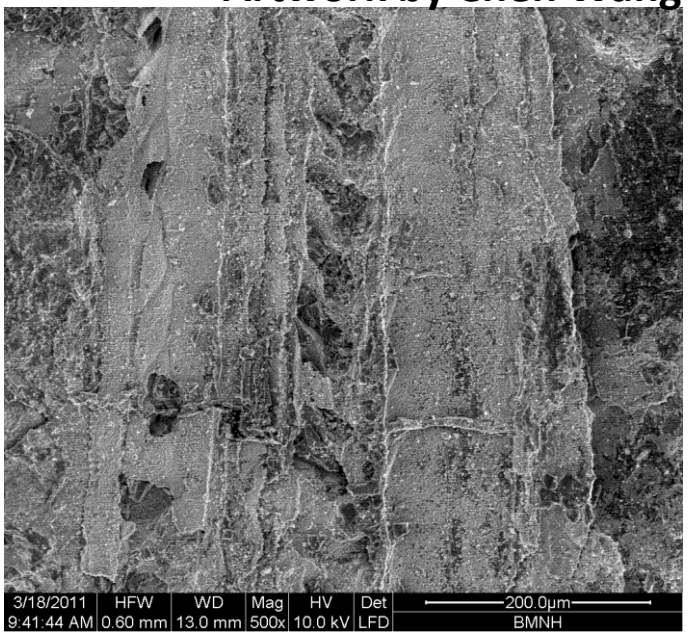
- Long serrated stylets for piercing tough and thick skin or hides of hosts
- Primitive ectoparasites: lived on and sucked the blood of relatively large hosts, eg. feathered dinosaurs, pterosaurs, and medium-sized mammals

Artwork by Chen Wang

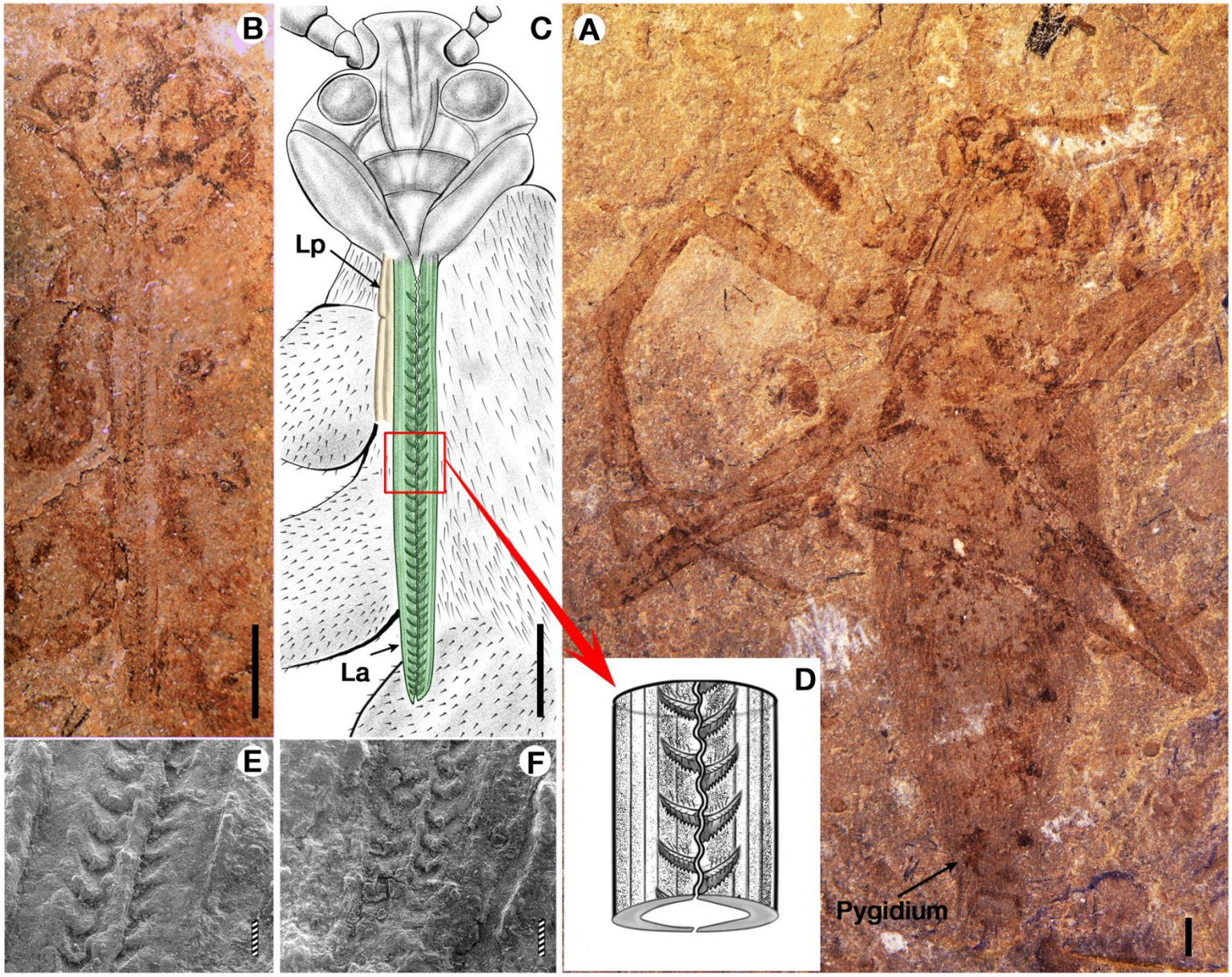
Pseudopulex jurassicus **Gao, Shih et Ren 2012.**





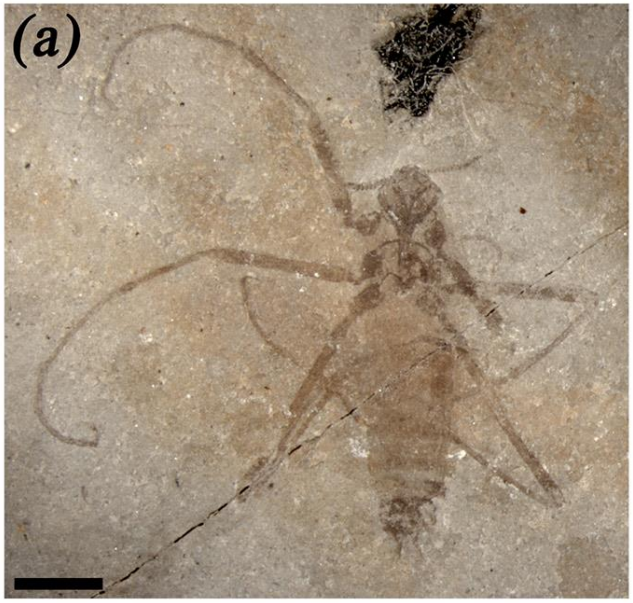


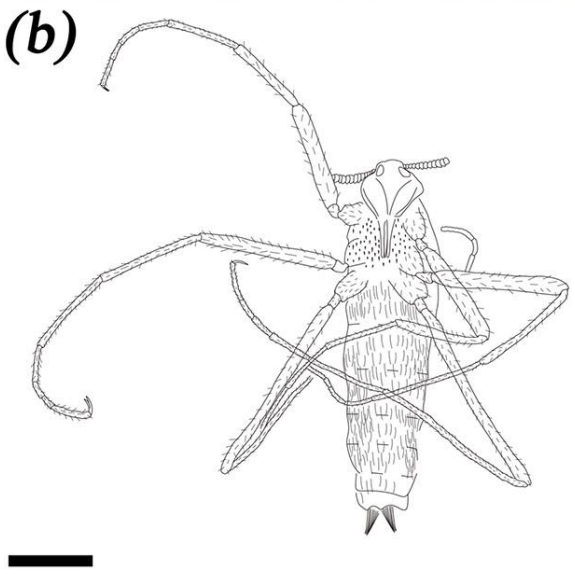
Blood-Sucking Insects: Basal Fleas

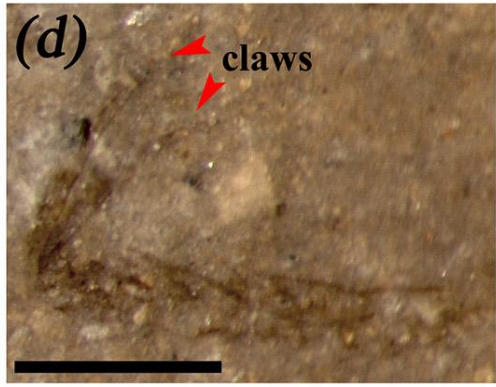


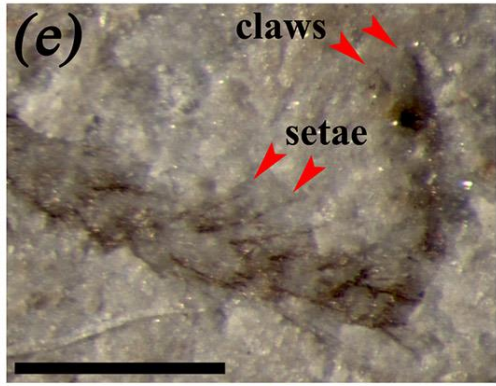
Pseudopulex magnus **Gao, Shih et Ren 2012. Current Biology**

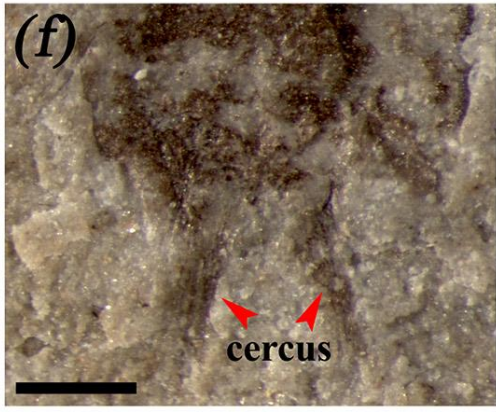
Transitional Fleas





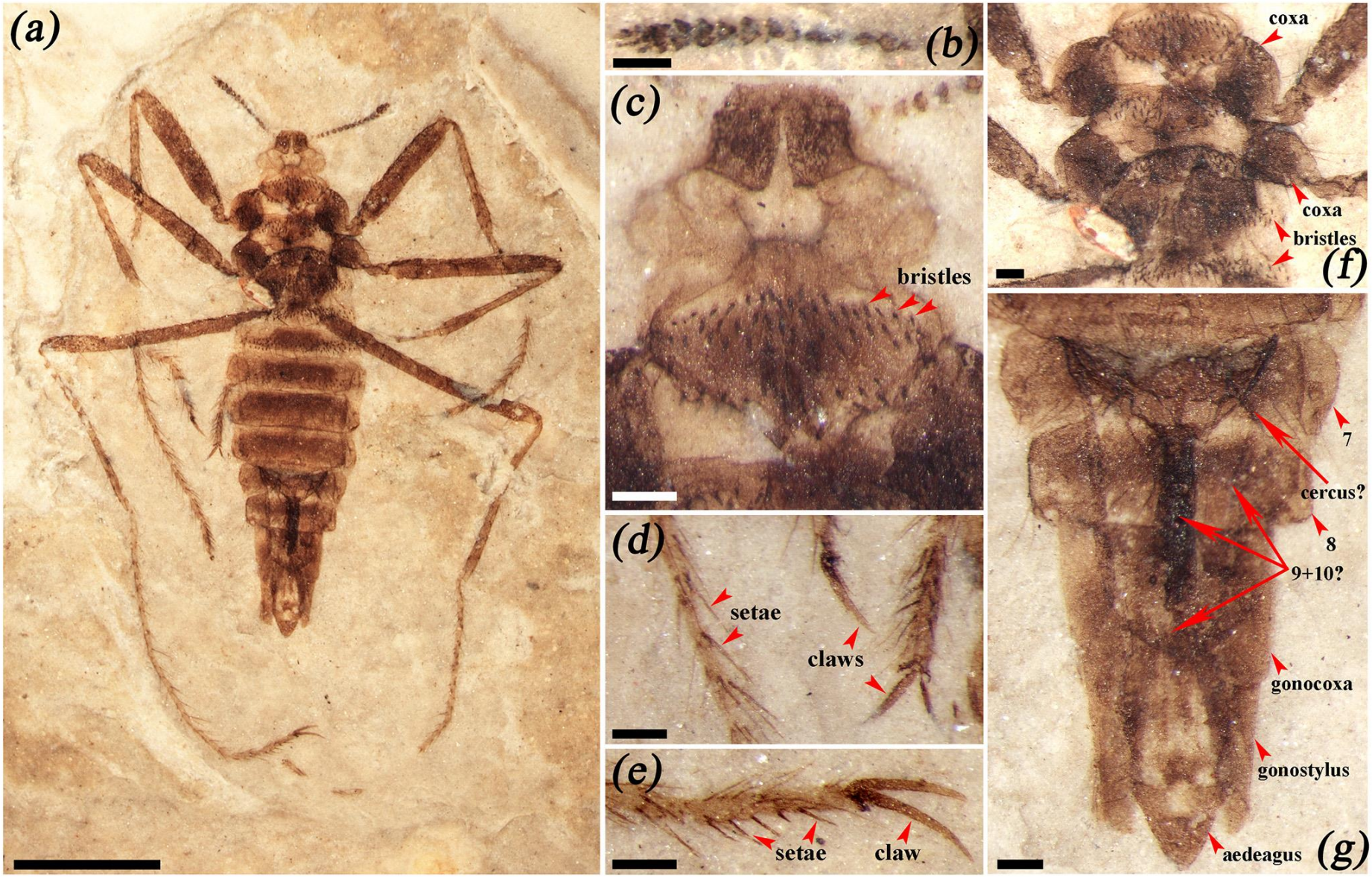






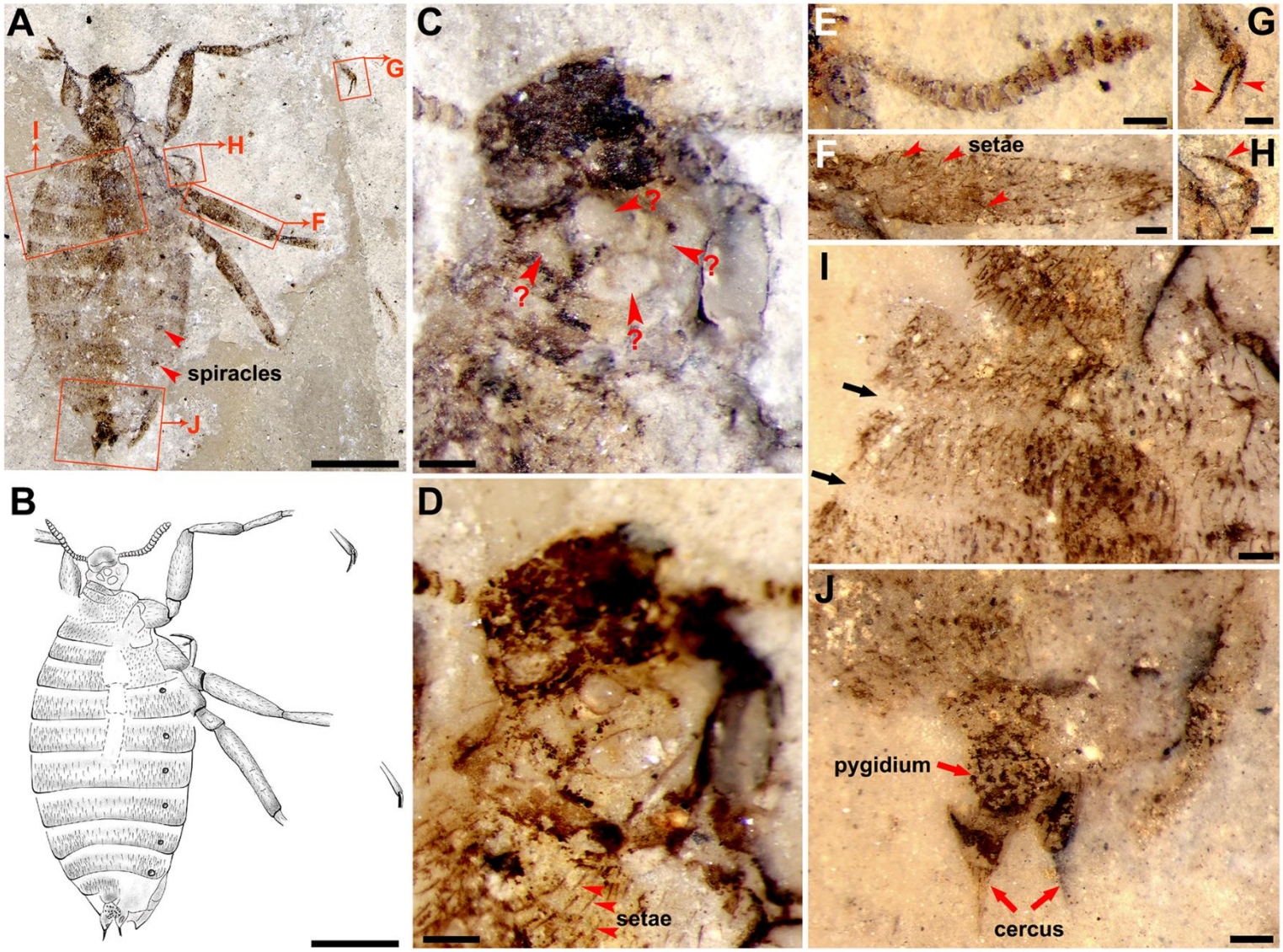
Saurophthirus exquisitus **(female) Gao, Shih, Rasnitsyn, et Ren 2013. Current Biology**

Transitional Fleas (conti.)

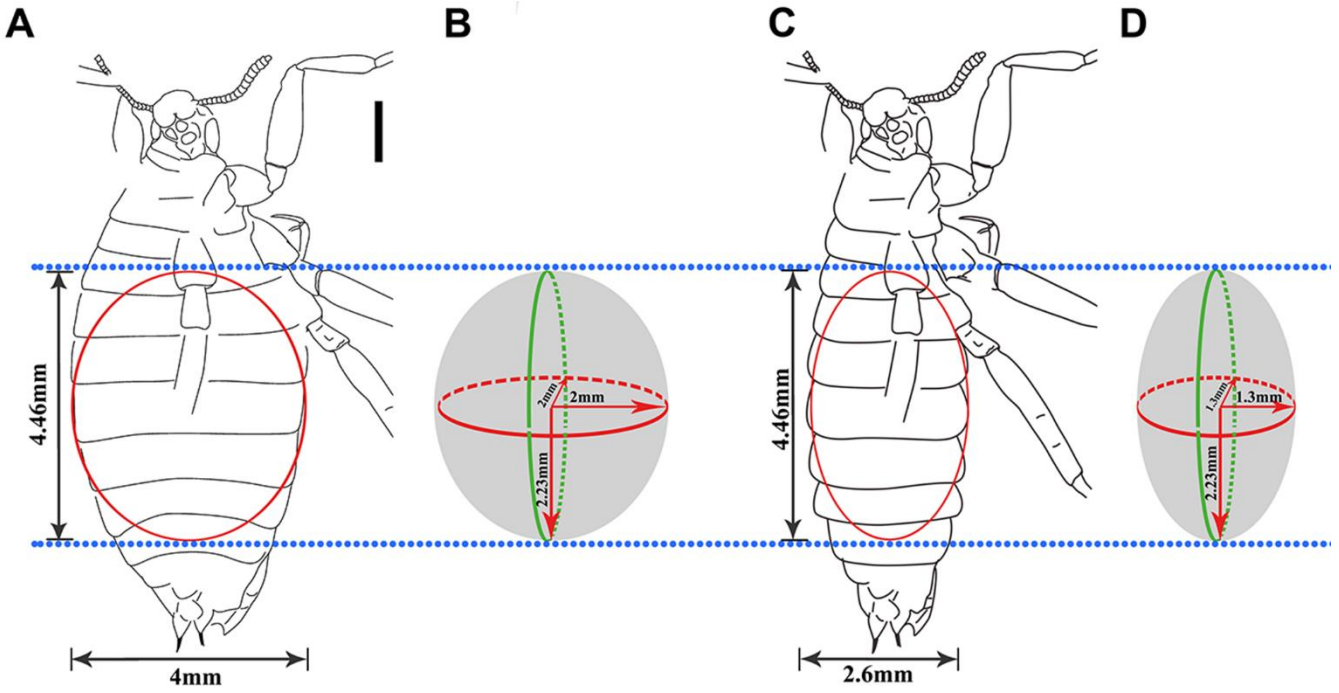


Saurophthirus exquisitus (male) Gao, Shih, Rasnitsyn, et Ren 2013. Current Biology

A Transitional Flea with Fully Distended Abdomen

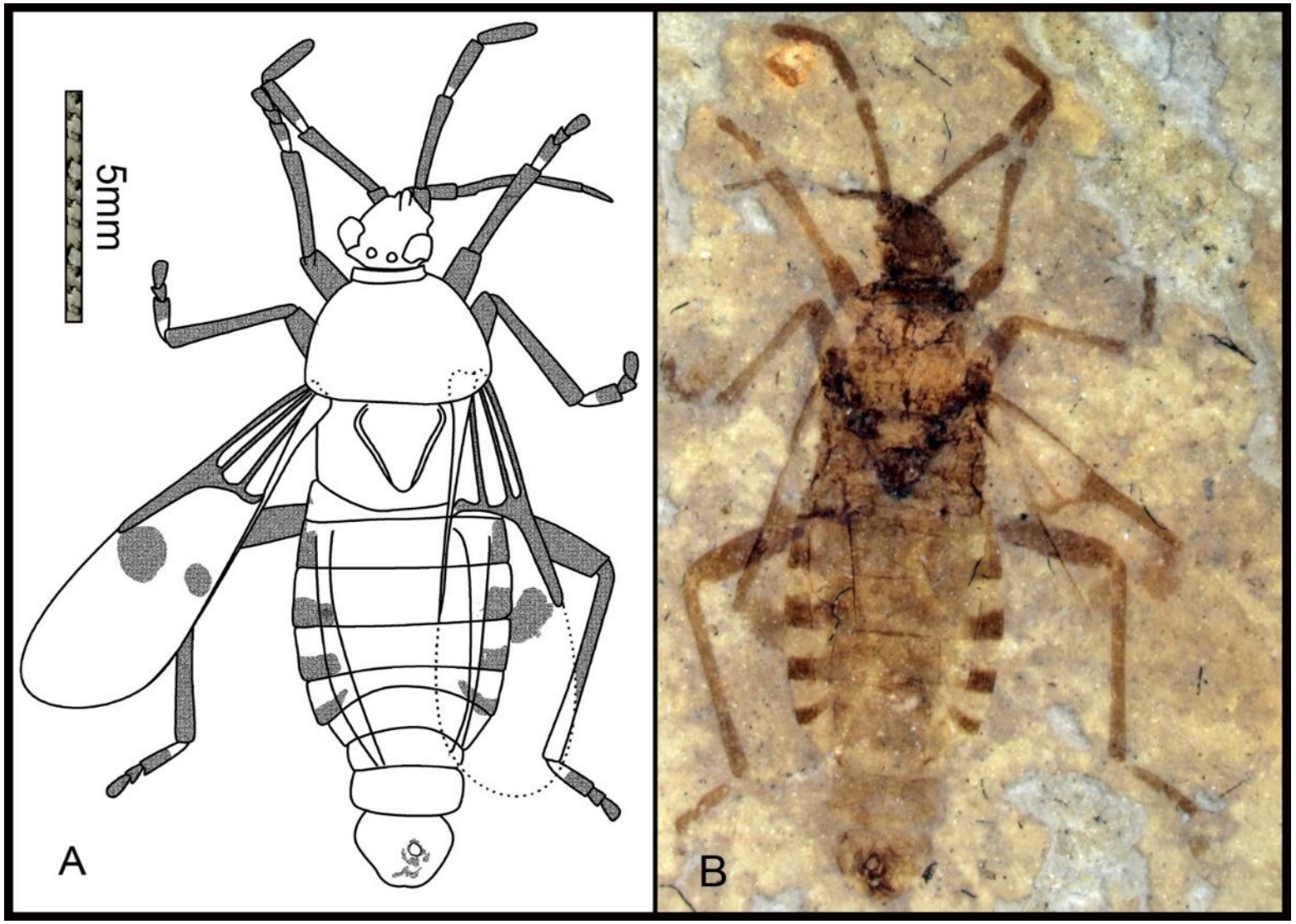


Pseudopulex tanlan (female) Gao, Shih, Rasnitsyn, et Ren 2014. BMC – Evo. Biology

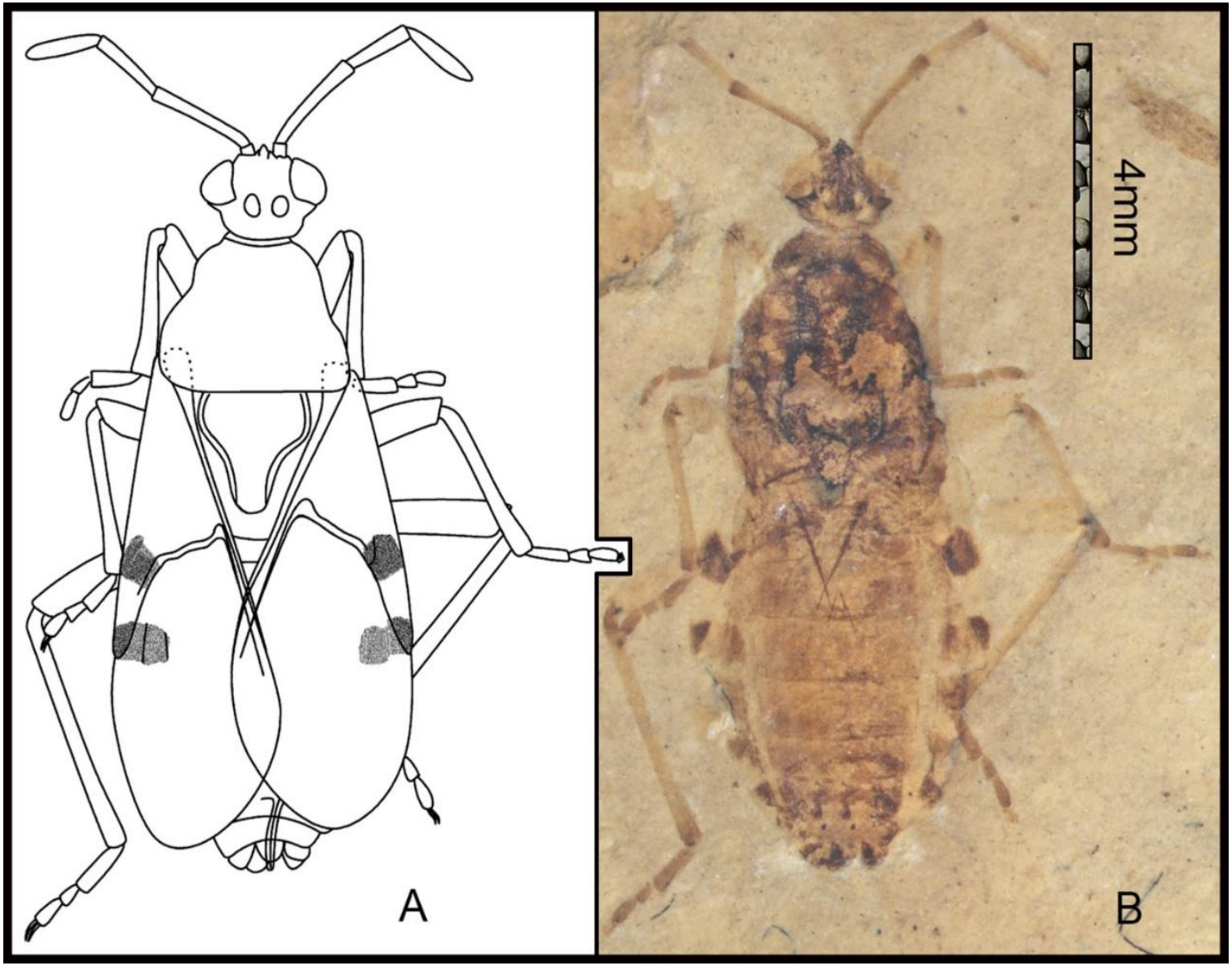


P. tanlan **might have consumed 0.02 milliliter (ml) of blood, which is about 15 times of the intake volume by extant fleas.**

The Earliest Record of Blood-feeding True Bugs from the Early Cretaceous of China



Torirostratus pilosus **(male) Yao, Shih, et Engel, 2014. Current Biology**



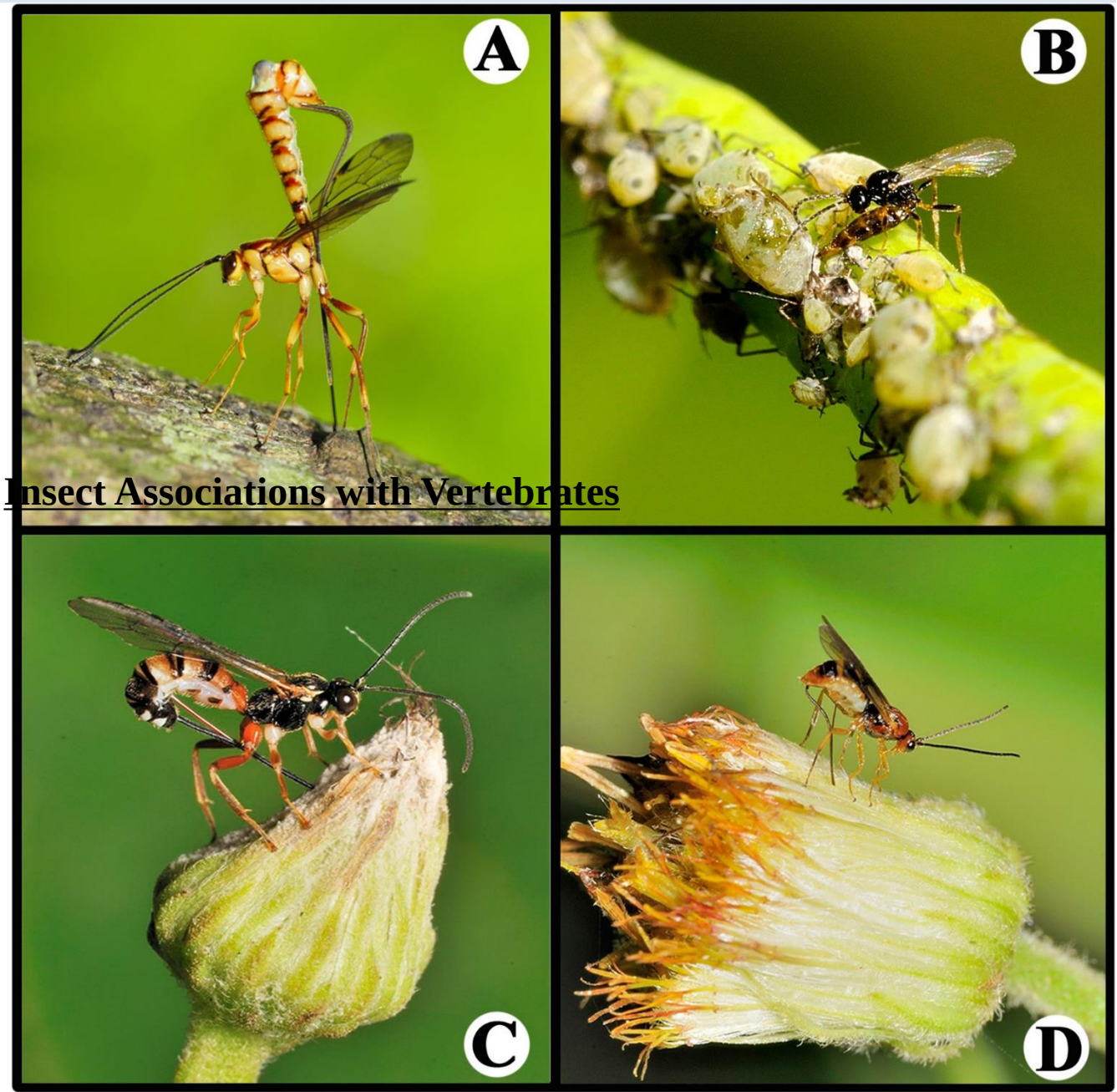
Flexicorpus acutirostratus **(female) Yao, Cai, et Engel, 2014. Current Biology**

Ecological reconstruction of blood-feeding torirostratid true bugs feeding on blood from a sleeping feathered dinosaur.

Artwork by Chen Wang

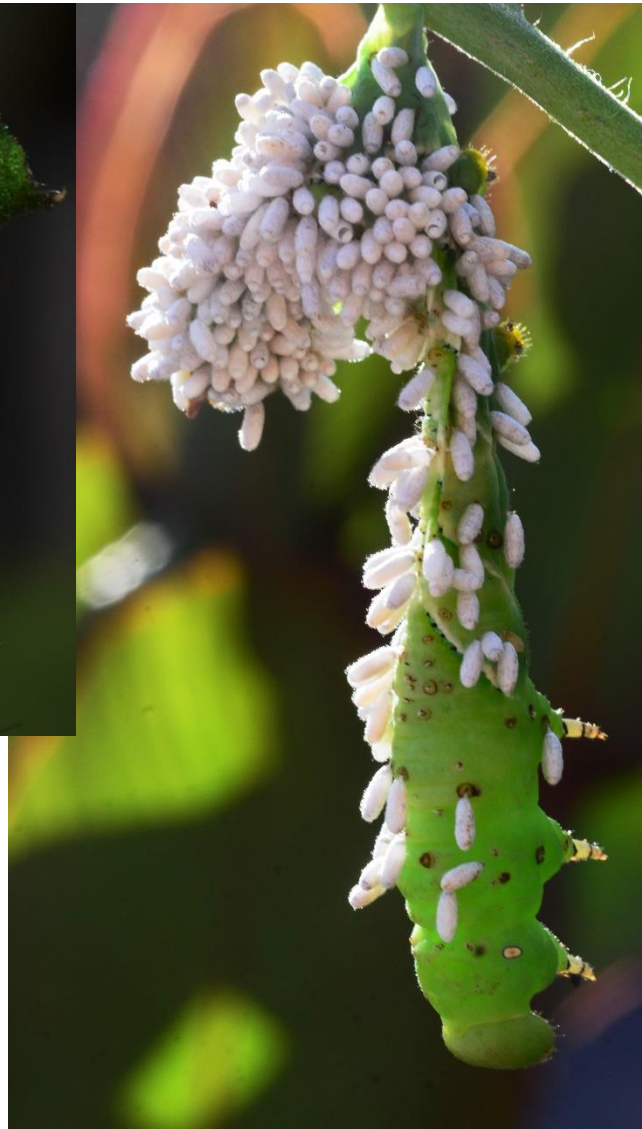
Insect Associations with Other Insects

Parasitoid Wasps

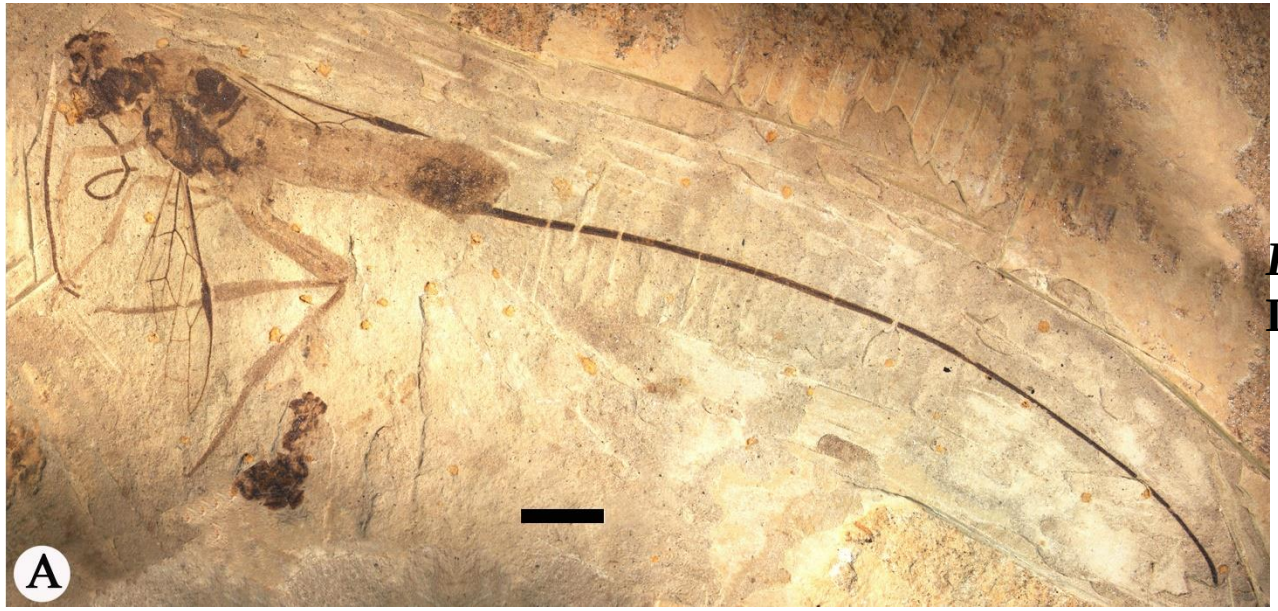


Photos by Jason Shih

Insect Associations with Vertebrates

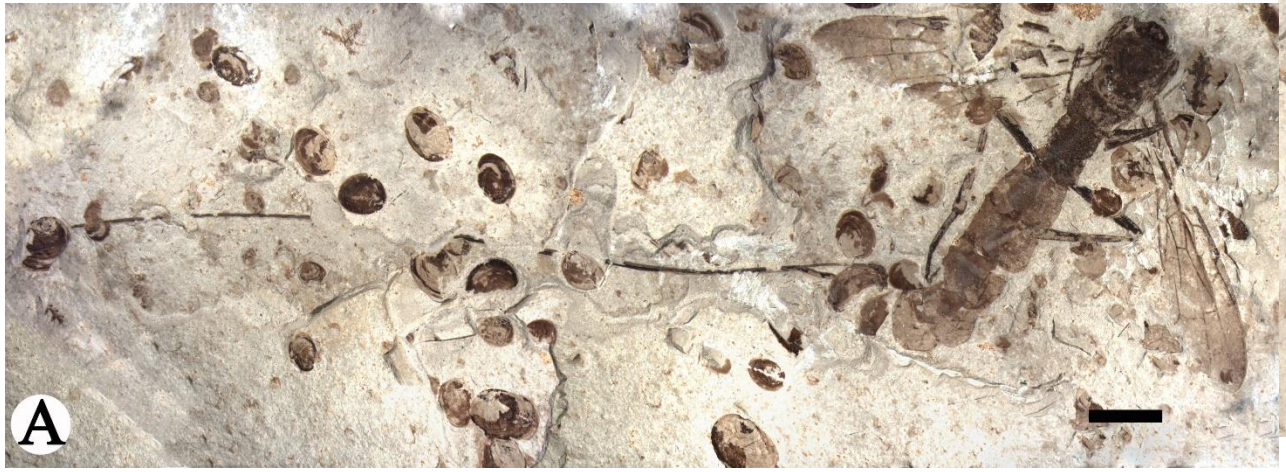


Parasitoid Ephialtitidae

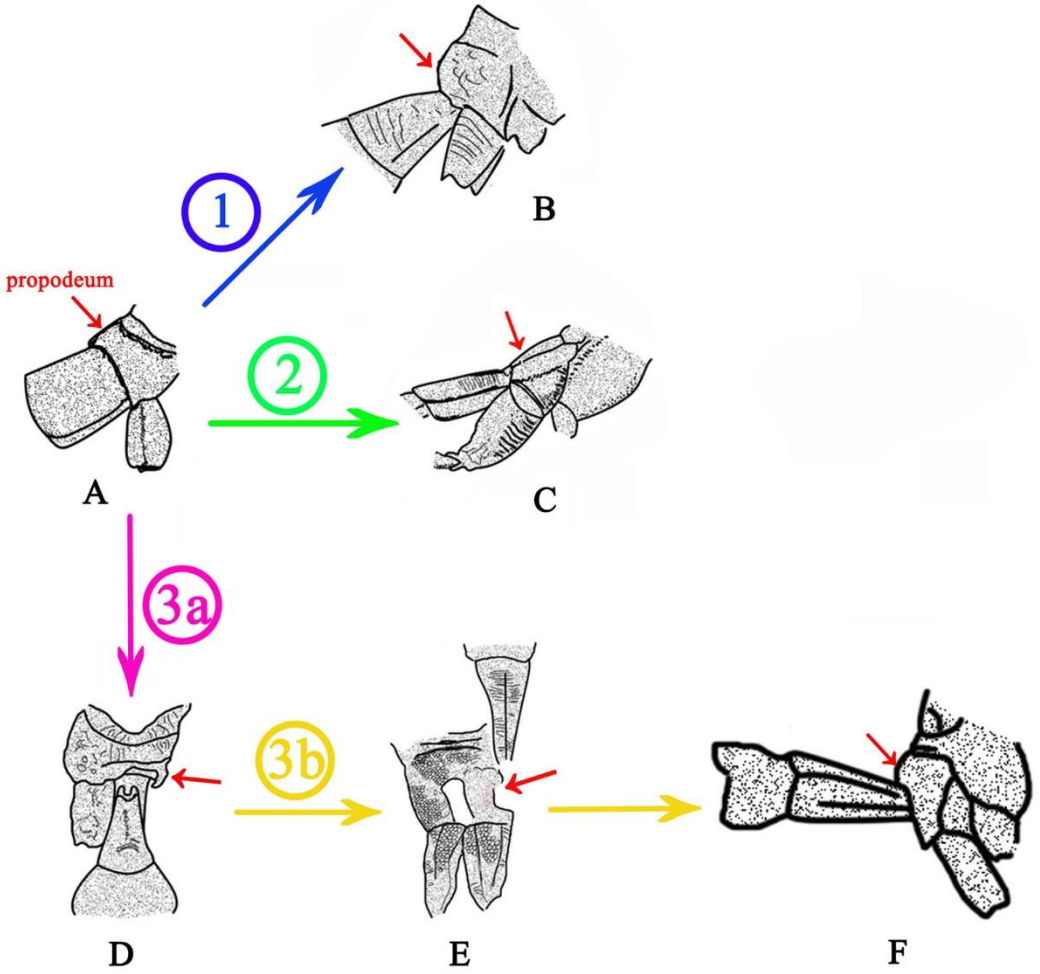


Acephialtitia colossa **Li, Shih, Rasnitsyn & Ren, 2015**

Proephialtitia acantha
Li, Shih, Rasnitsyn & Ren, 2015



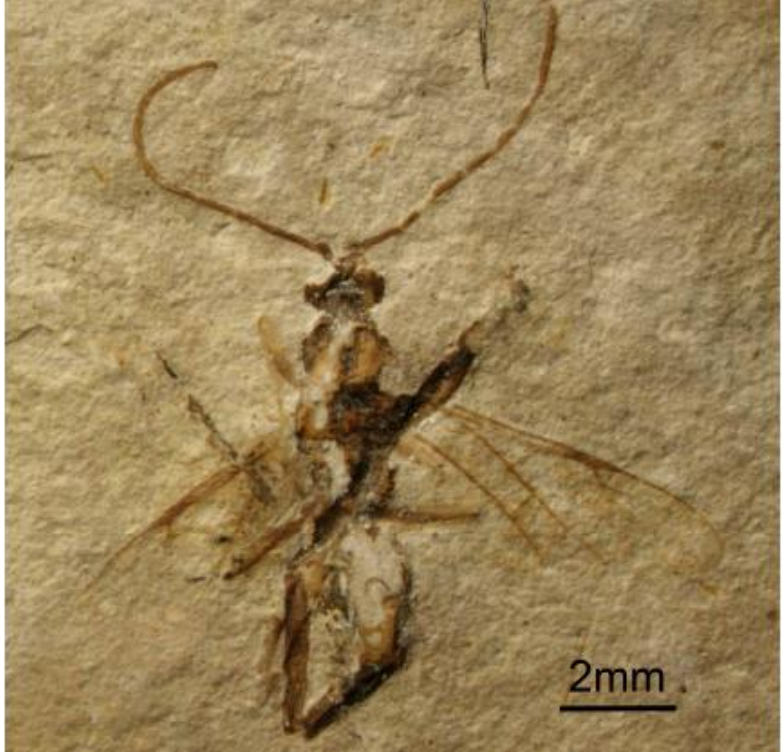
Proephialtitia tenuata **Li, Shih, Rasnitsyn & Ren, 2015**



Main transformation pathways: ① – pathway towards Kuafuidae and further to main taxa of Apocrita; ② – pathway towards Stephanidae; ③ – pathway towards basal Evanioidea. (BMC-Evo. Biology Li et al. 2015)

Parasitoid Pelecinids

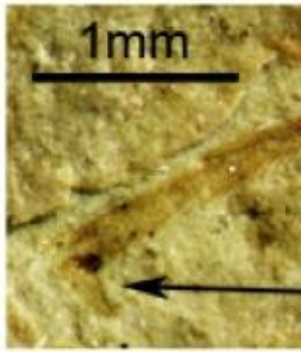
Archaeopelecinus tebbei Shih, Liu et Ren, 2009. An. of Ento. Soc. of Am.



Shoushida regilla Liu, Shih et Ren, 2009

Pelecinus polyturator (Drury) Schletterer, 1890

Pelecinids



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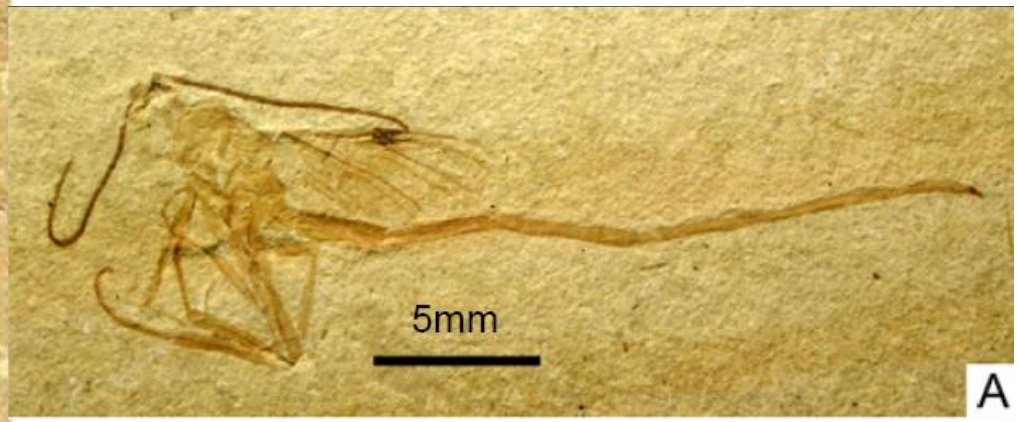
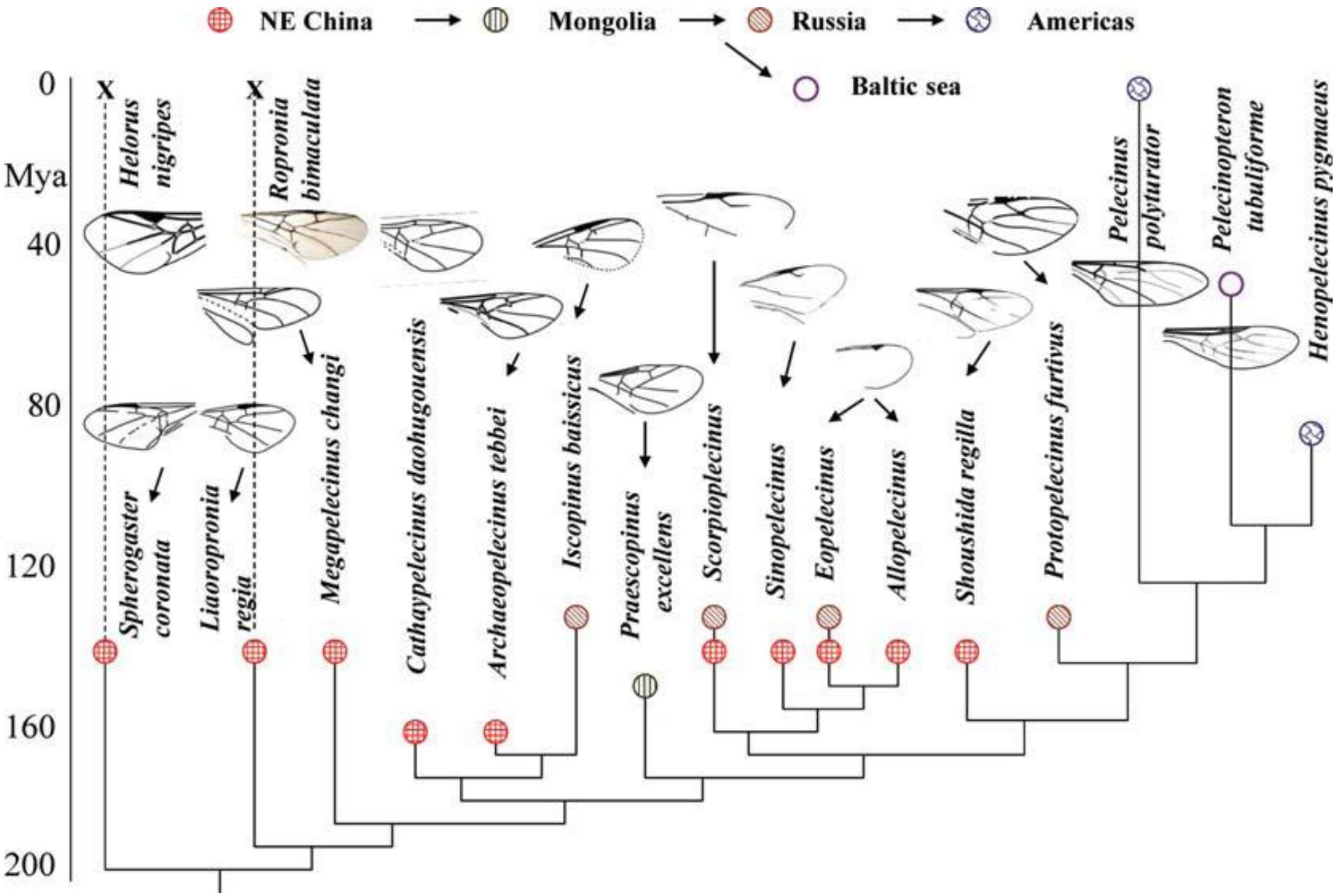


Megapelecinus nashi **Shih et al. 2010**

Megapelecinus changi **Shih et al. 2010, An. of Ento. Soc. of Am.**

Pelecinidae and two outgroups with their respective characteristic forewings in geological context



Predation

Photos by Jason Shih or CK Shih

Odonata - Terminators with Wings

Falsisophoaeschna generalis
Zhang, Ren et Pang, 2008

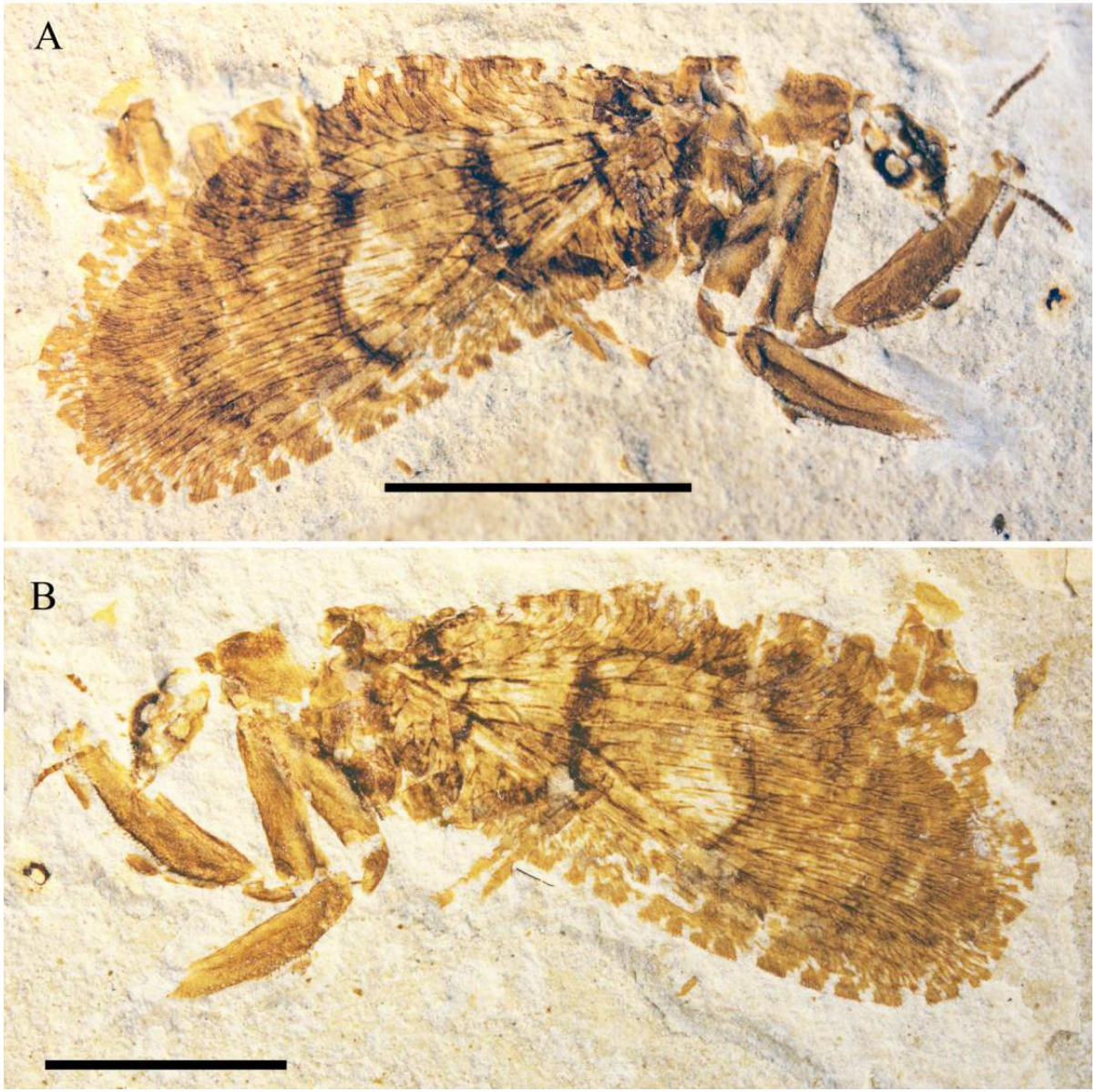
Sinoeuthemis daohugouensis
Li, Nel, Shih, Ren et Pang 2013

Sophoaeschna frigida
Zhang, Ren et Pang, 2008

***Sopholibellula eleganta* Zhang, Ren et Zhou, 20**

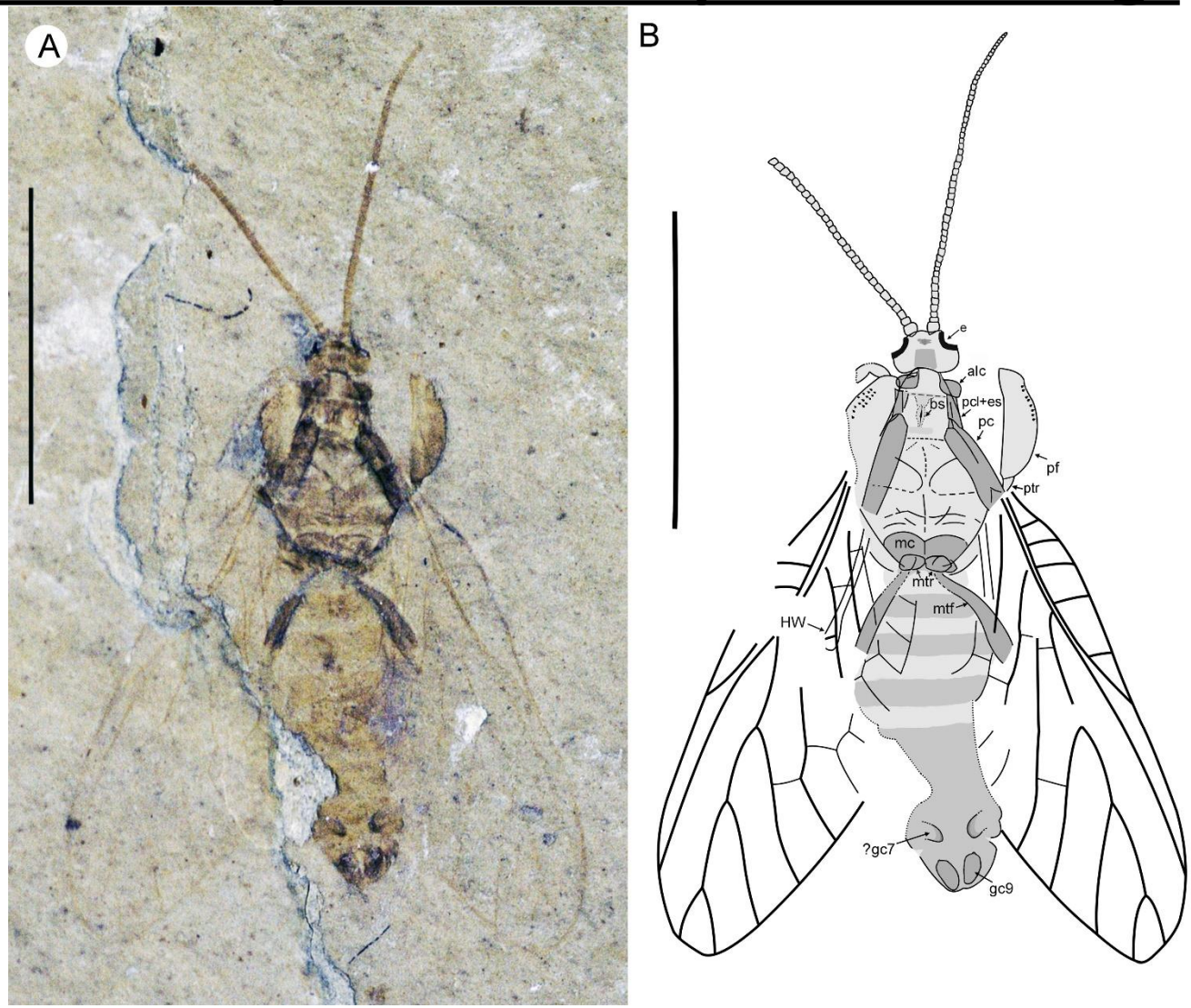
Neuroptera – Grace with Lace, but…..

Mantispidae with raptorial forelegs



Archaeodrepanicus nuddsi **Jepson, Heads, Makarkin et Ren 2013**

Dipteromantispidae with raptorial forelegs



Dipteromantispa brevisubcosta **Makarkin, Yang et Ren 2013**

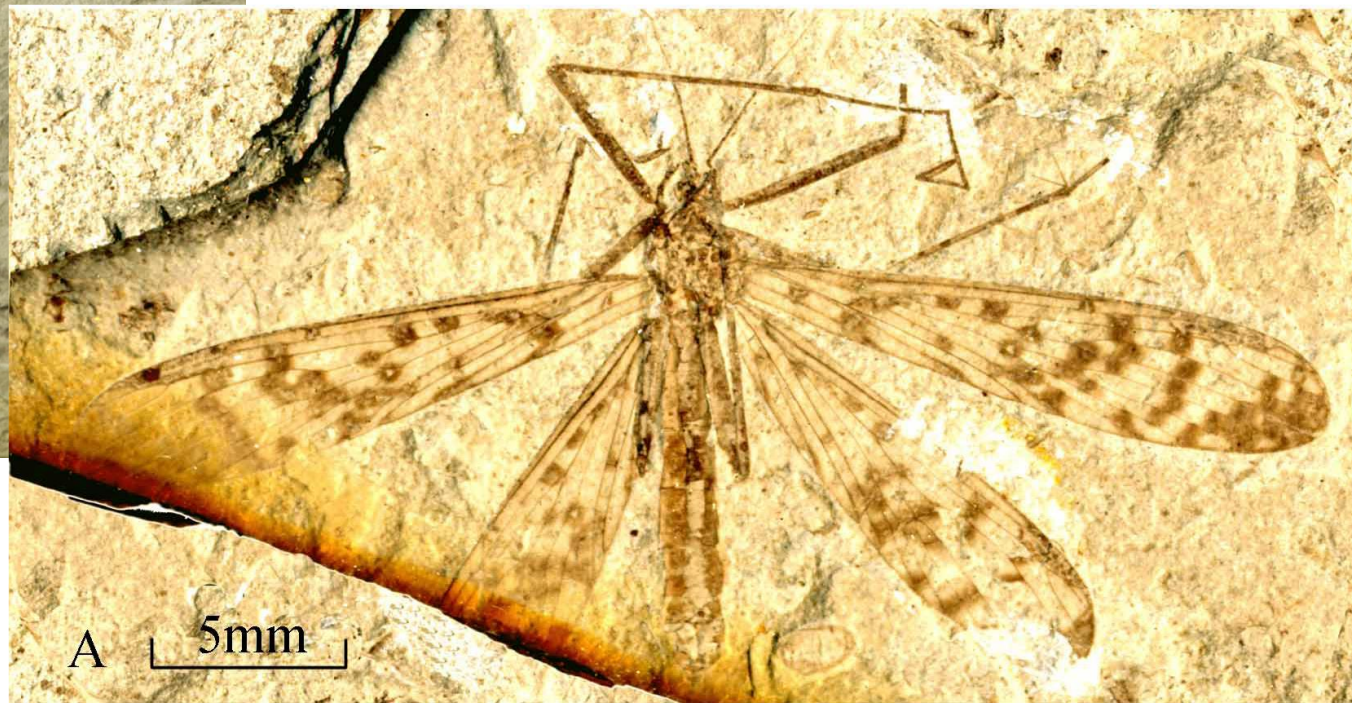
- **Well-developed forewings with reduced venation**
- **Hind wings extremely modified as small halteres**

Mecoptera

Hangingflies:
Bittacidae and Cimbrophlebiidae

Telobittacus bellus **Yang, Shih et Ren 2013**

Formosibittacus macularis **Li, Ren et Shih, 2008**



Extreme Sexual Display

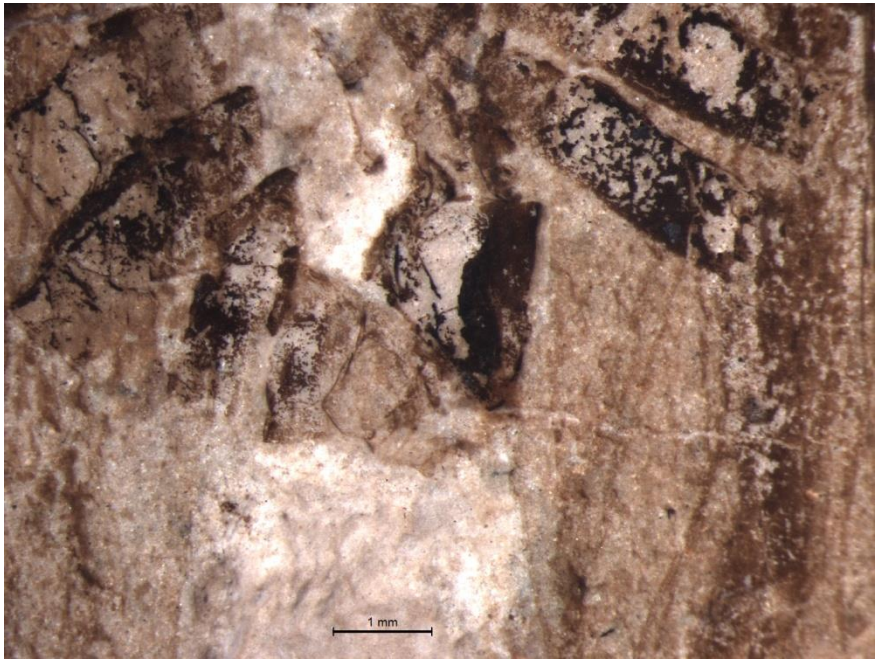
The earliest case of exaggerated male organ in a scorpionfly

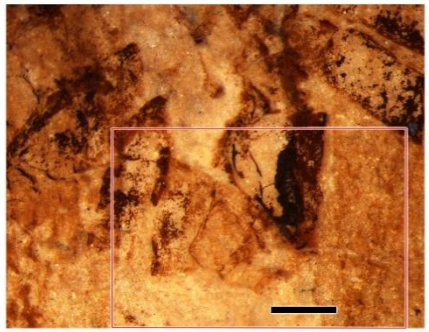
Fortiholcorpa paradoxa Wang, Shih et Ren 2013. PLoS ONE

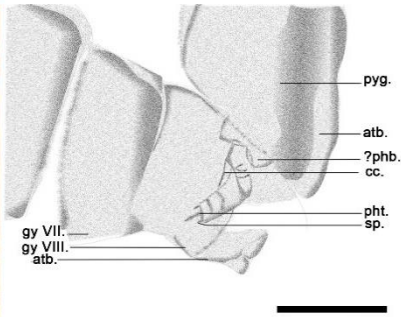
Artwork by Chen Wang

Reproduction

Forever Love: The Hitherto Earliest Record of Copulating Insects







Anthoscytina perpetua **Li, Shih et Ren, 2013. PLoS ONE**

Artwork by Chen Wang

Photo by Jason Shih

Reported by the New York Times on page A-12, 11/7/2013, and by numerous on-line media.

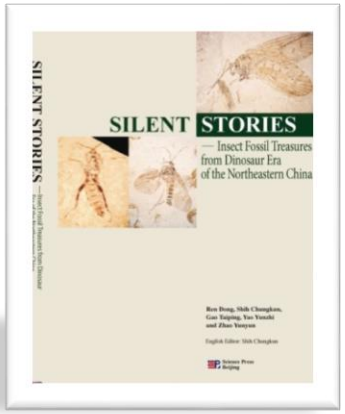
Summary

1. **The Mesozoic Era was biotically richer and more complex than previous realized.**
2. **Insects in both Yanliao and Jehol Biota were diverse systematically, biologically and ecologically.**
3. **In the ecosystems, insects played important roles in maintaining food chains and circulation of substances and energy by close biotic interactions with plants, vertebrates and other insects.**
4. **Our research provide a rare glimpse of lost worlds of these interactions, some of which were now extinct or less diverse.**

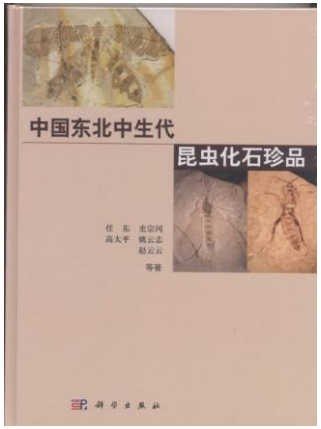
Papers

More than 200 SCI papers including 7 respectively in Science (2009), PNAS (2010, 2012a, 2012b) and Current Biology (2012, 2013, 2014).

Books



2010



2012

Future Action Plans

- **To continue building on our strengths & upgrading research capabilities**
- **To enhance cooperation with collaborators in China and internationally**
- **To apply high-tech instruments and better methodologies**
- **To publish high-quality papers and books on our research**
- **To arrange for exhibitions in CNU or in museums outside China**

Thank you for your attention!

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