

For the Love of Insects



“In terms of biomass and their interactions with other terrestrial organisms, insects are the most important group of terrestrial animals.”

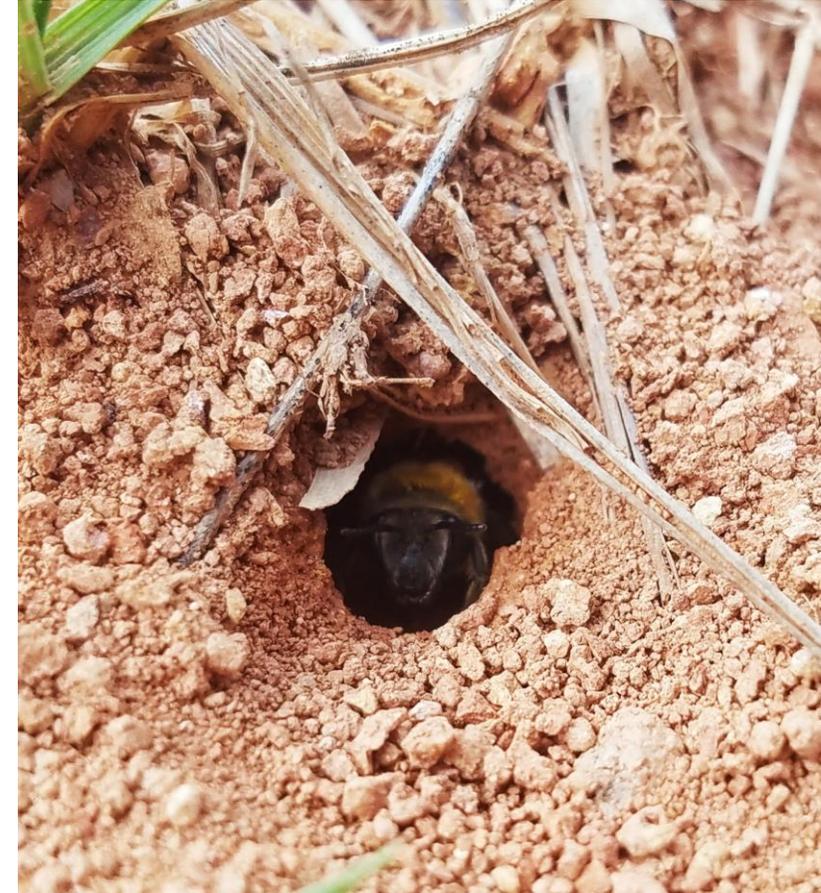
--Grimaldi and Engel, 2005





Outline

- The Most Successful Animals on Earth: a Brief (Entomological) Journey through Time
- Insect Physiology and Development
- Common Insects and their Identification





Whence and Whither: Insect Origins and Evolution

Before diversity, there was evolution...

A ~500 million year journey...

- **Insect Flight:** 400 mya
- **Modern insect orders:** 250 mya
- **Primitive mammals:** 120 mya
- **Modern mammals:** 60 mya





Insect Origins and Evolution

Before diversity, there was evolution...

The Jointed Animals

Phylum: Arthropoda

- 75% of all species on earth are arthropods
- Internal/External specialization of body parts = *tagmosis*
- Hardened exoskeleton
- Articulated body plates
- Paired, jointed appendages



sciencenewsjournal.com



Ordo, Sil

450

Origin
of terr.
ecos.

Tagmosis: highly specialized body segments found in all arthropods;

insects: head, thorax, abdomen; *spiders:* cephalothorax and opisthosoma



Insect Origins and Evolution

Before diversity, there was evolution...

Epiclass HEXAPODA: Late Silurian/Early Devonian

Class Entognatha

Order Diplura

Ellipura

Order Protura

Order Collembola

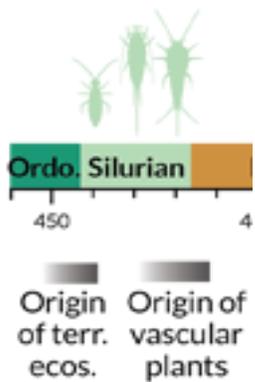
Class Insecta (= Ectognatha)

Hexapoda

- 6 legs; 11 abdominal segments (or fewer)
- Entognatha: Protura, Diplura, and Collembola
- Ectognatha: Insects



taxondiversity.fieldofscience.com



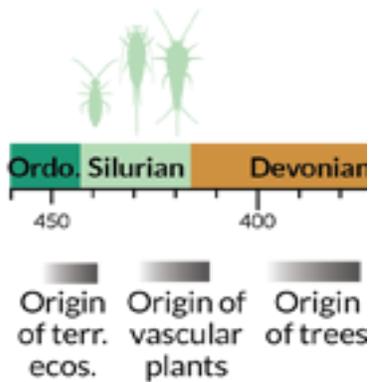


Insect Origins and Evolution

The First Insects: Apterygota

Archaeognatha: The Jumping Bristletails

- ~500 spp. worldwide; wide range of habitats;
- 4 Families (2 extinct) which occur mostly in rocky habitats
- Mostly detritivores, but scavenge dead arthropods or eat exuviae;
- Indirect mating behavior; parthenogenetic



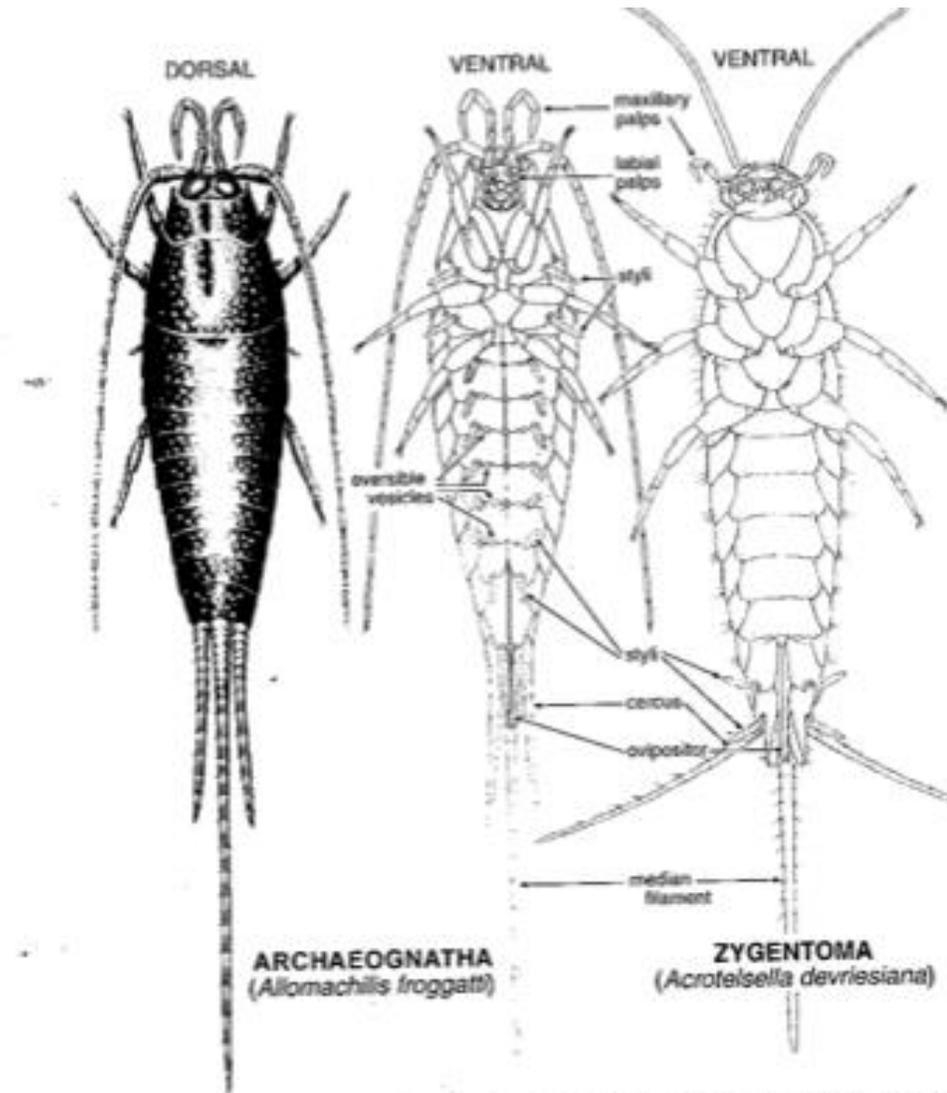
© melvyn yeo

Apterygota: without wings

Bristletail mating dance



Insect Origins and Evolution



5.1. Representative basal, wingless insects: a bristletail (Archaeognatha) and a silverfish (Zygentoma). These are modern species belonging to groups that evolved at least as early as the Devonian, 400 mya. Redrawn from *Insects of Australia*.

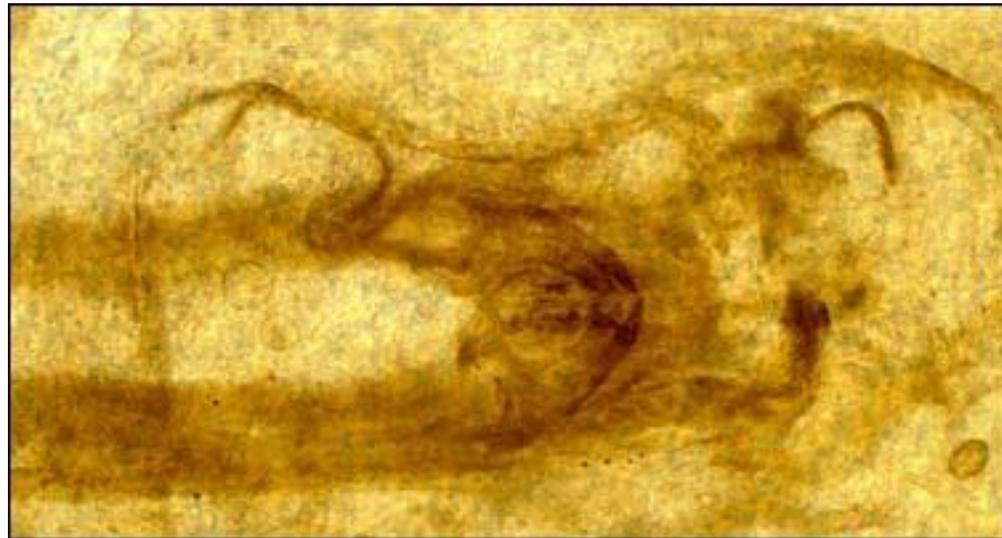


Insect Origins and Evolution

I hate to be *that* guy...

Rhyniognatha sp.

- Supports insect evolution around 438-408 mya;
- Commonalities with modern, winged insects
- Evolution of flight could have occurred much earlier in insect evolution

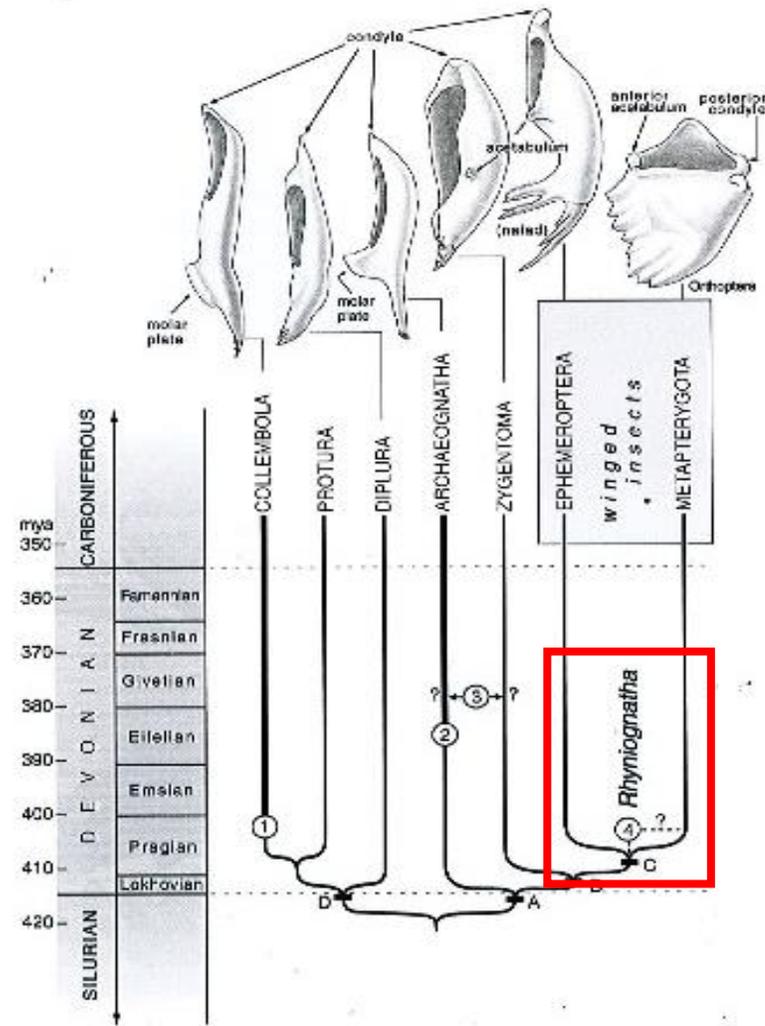




Insect Origins and Evolution

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EVOLUTION OF THE INSECTS



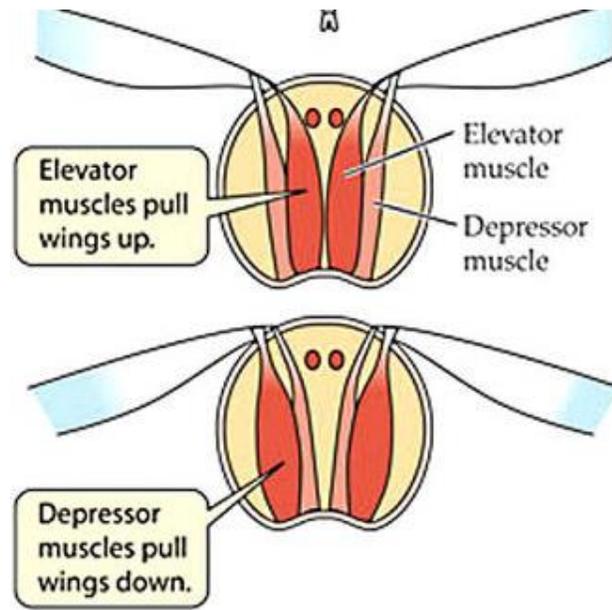
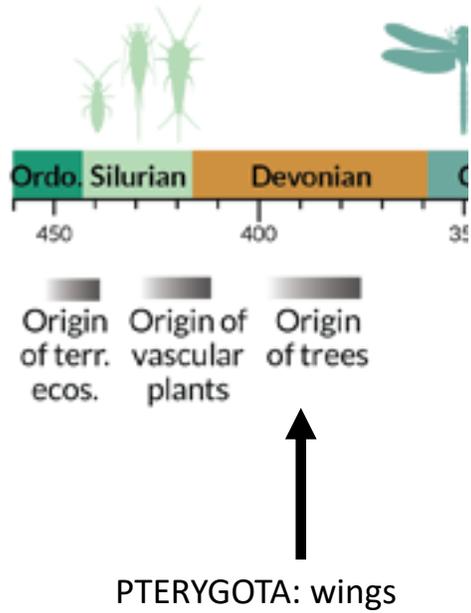
5.9. Phylogeny of basal insect lineages indicating the position of *Rhyniognatha*, the oldest insect, as based on the structure of mandibles. Fossils (numbers): 1, *Rhyniella precursor*; 2, 3, undescribed; 4, *Rhyniognatha first*. Characters (letters): A, insectan (see text), B, dicardylic mandibles, C, wings, D, entognathous mouthparts.



Insect Origins and Evolution

Paleoptera

- Ephemeroptera (Mayflies)
- Odonata (dragonflies)*

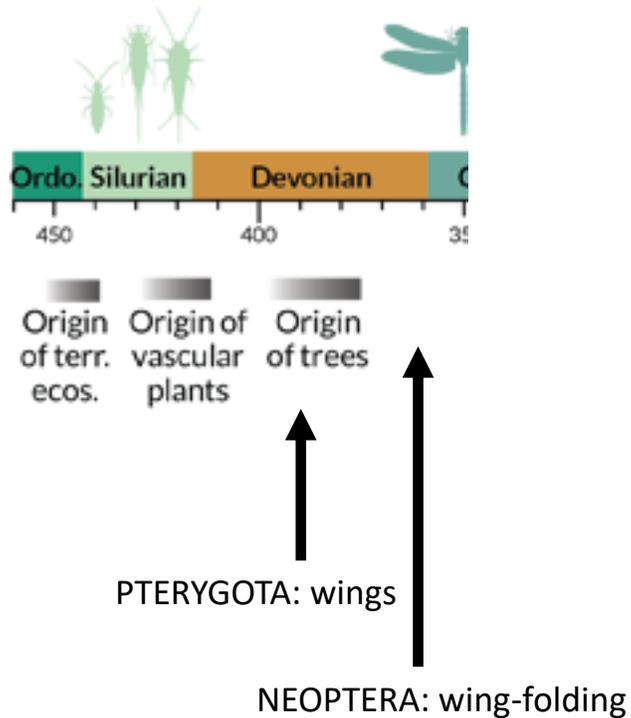


*Direct flight only present in this order

Paleoptera: primitive/basal winged condition



Insect Origins and Evolution

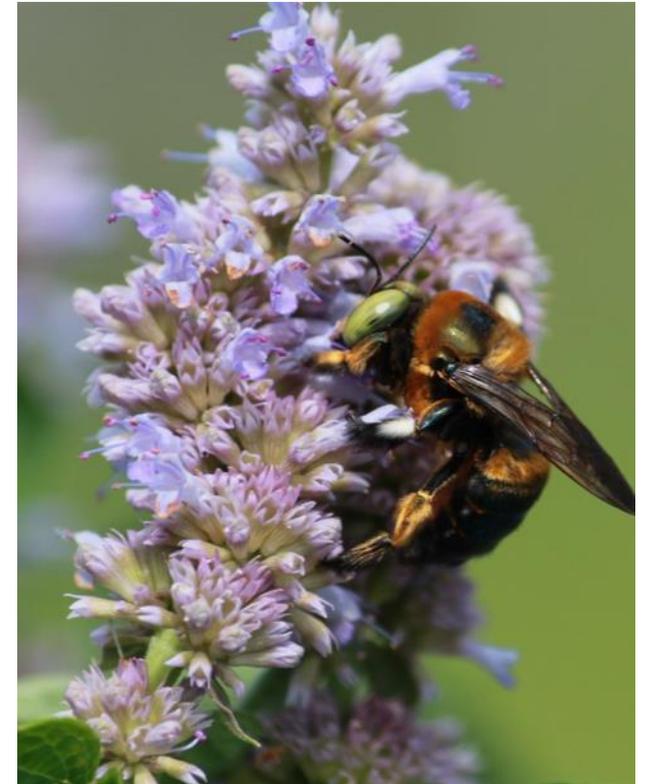


Paleoptera

- Ephemeroptera (Mayflies)
- Odonata (dragonflies)

Neoptera

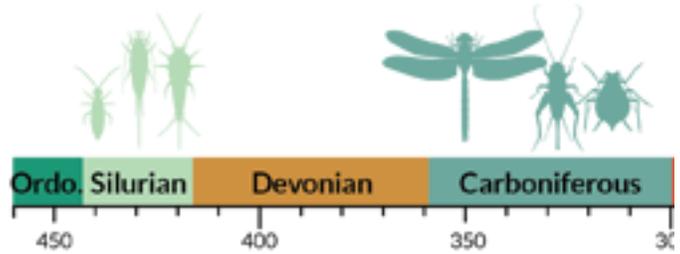
- All other winged insects



Neoptera: extant/most recent winged condition



Insect Origins and Evolution



Origin of terr. ecos. Origin of vascular plants Origin of trees

Radiation seed plan



HOLOMETABOLA: larvae

- Beetles
- Bees/Wasps



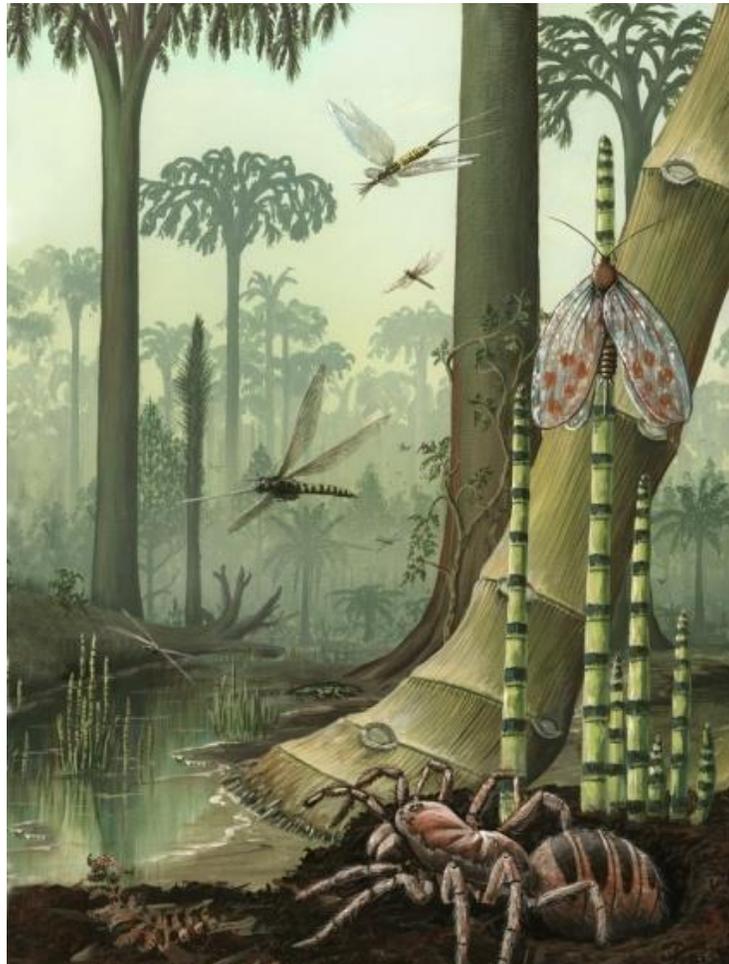
Print from: *Botanicals: Butterflies and Insects*, Overstreet, 2008.



Insect Origins and Evolution

If we lived in the Carboniferous Period:

- Arthropods in general would be much larger than today

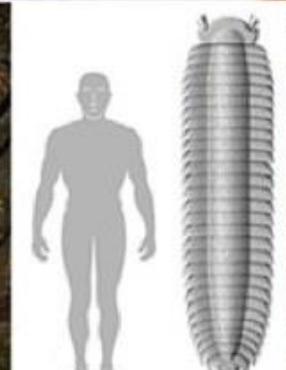




Insect Origins and Evolution

If we lived in the Carboniferous Period:

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- The largest centipede (*Arthropluera* sp.) averaged about 8' long

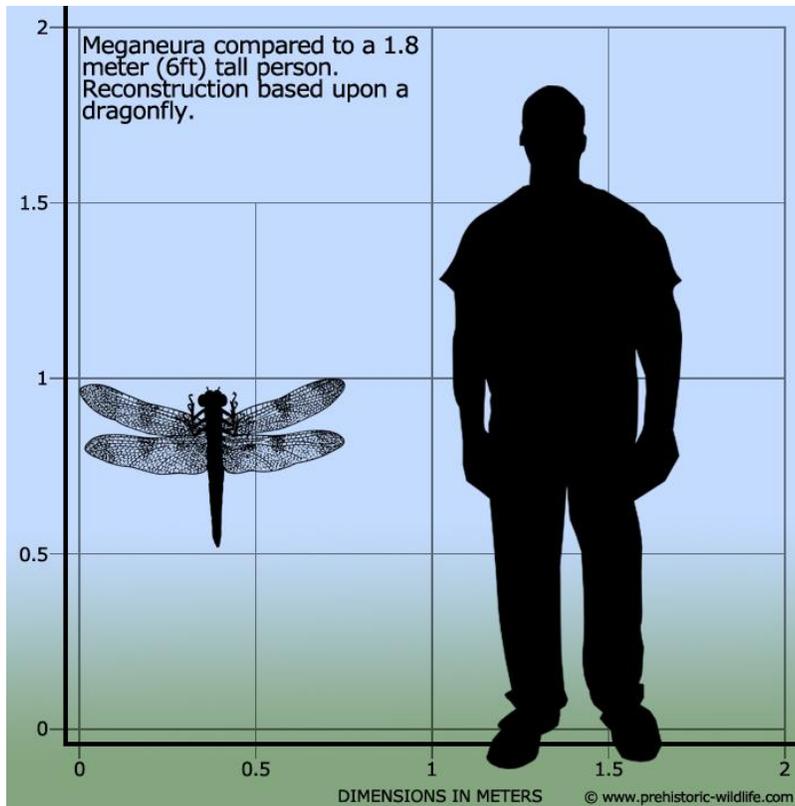




Insect Origins and Evolution

If we lived in the Carboniferous Period:

- Arthropods in general would be much larger than today
- The largest centipede (*Arthropluera* sp.) averaged about 8' long
- The largest dragonfly (*Meganeura* sp.) was about the size of the average seagull

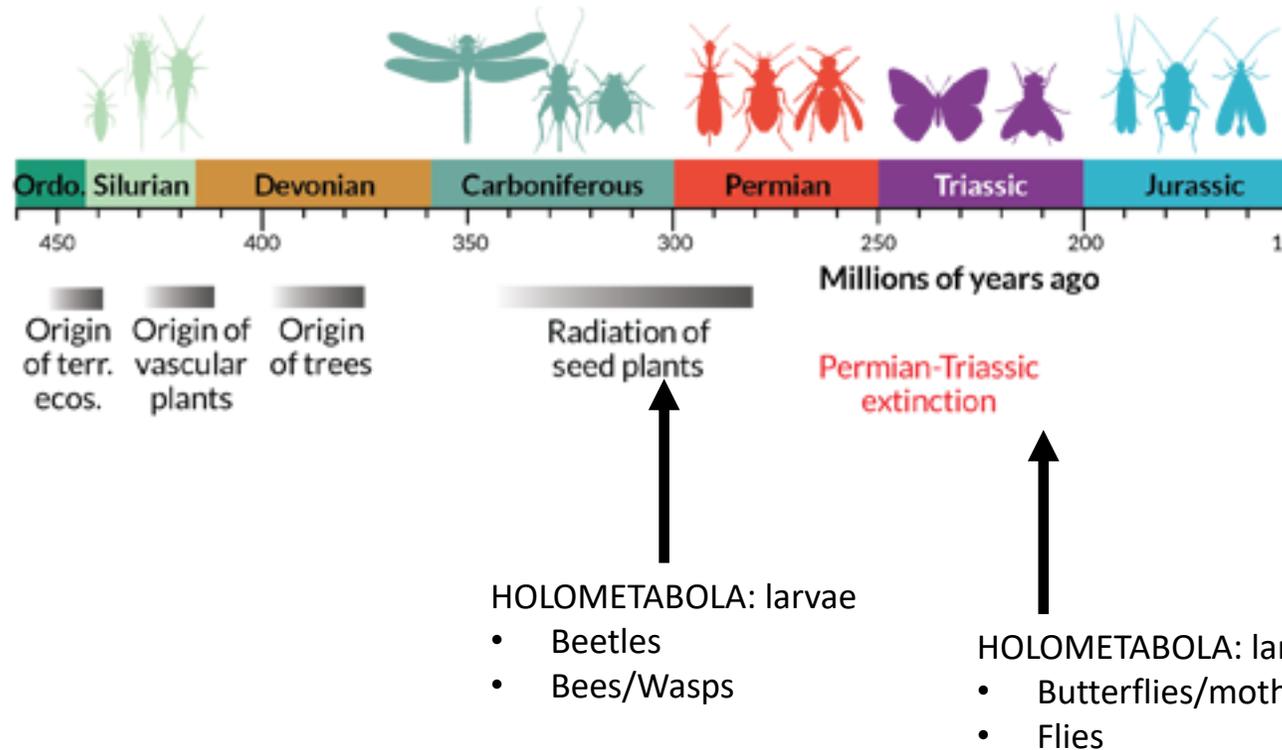




Insect Origins and Evolution

Before diversity, there was evolution...

...and insects are the most diverse organisms in the history of life!

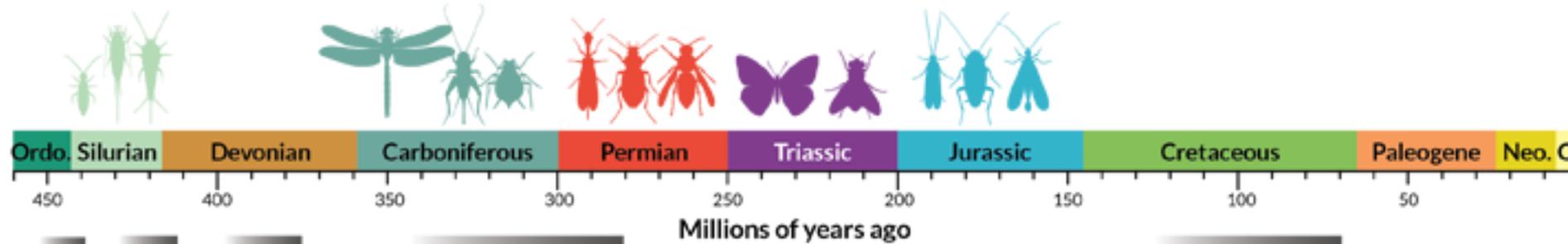


Leehermania prorova; Staphylinidae; ResearchGate



Insect Origins and Evolution

The Cretaceous (145-65 mya)



Origin of terr. ecos.
Origin of vascular plants
Origin of trees

Radiation of seed plants

Millions of years ago

Permian-Triassic extinction

Angiosperm radiation
Cretaceous - Paleogene extinction

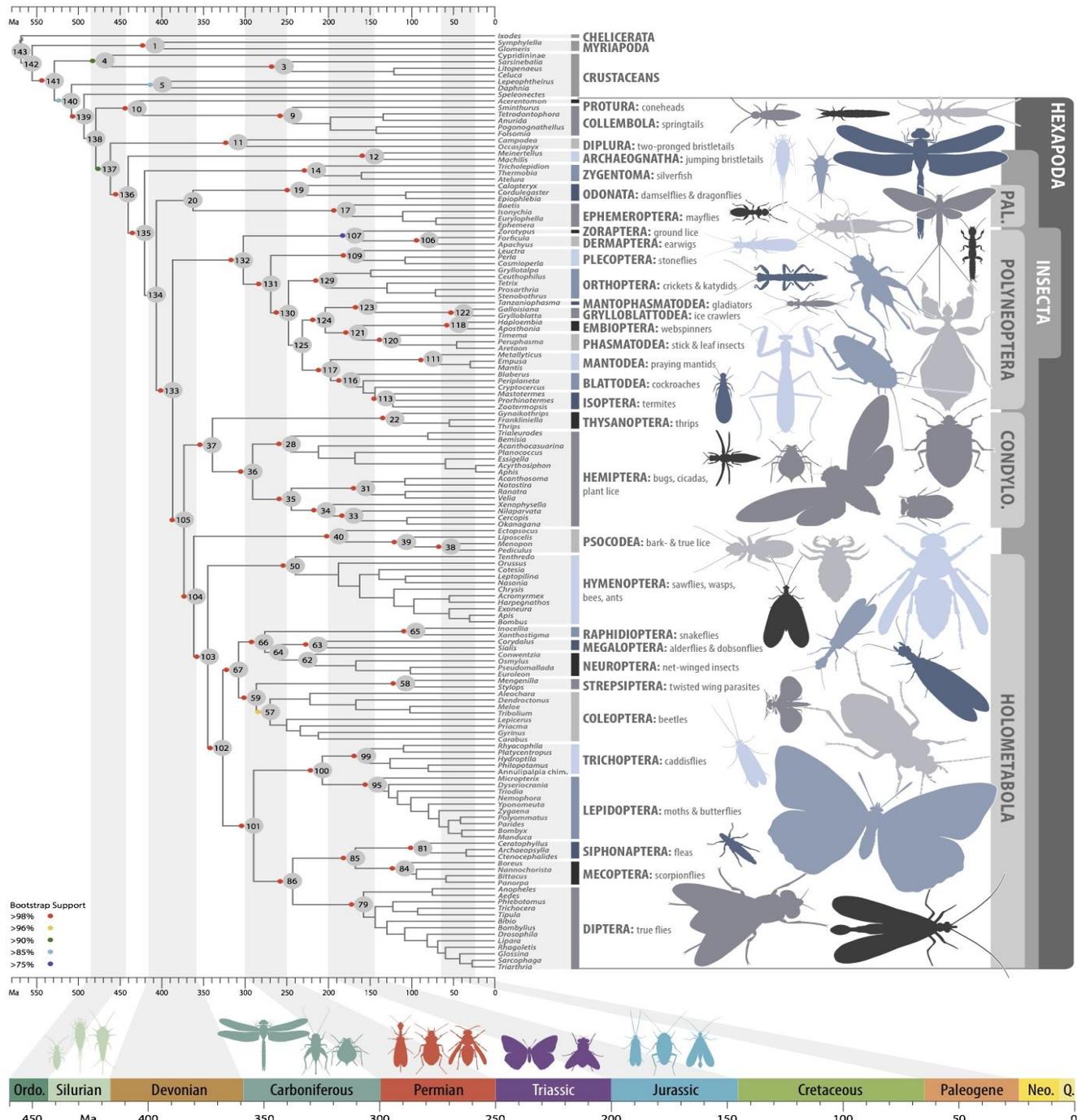
Hexapods

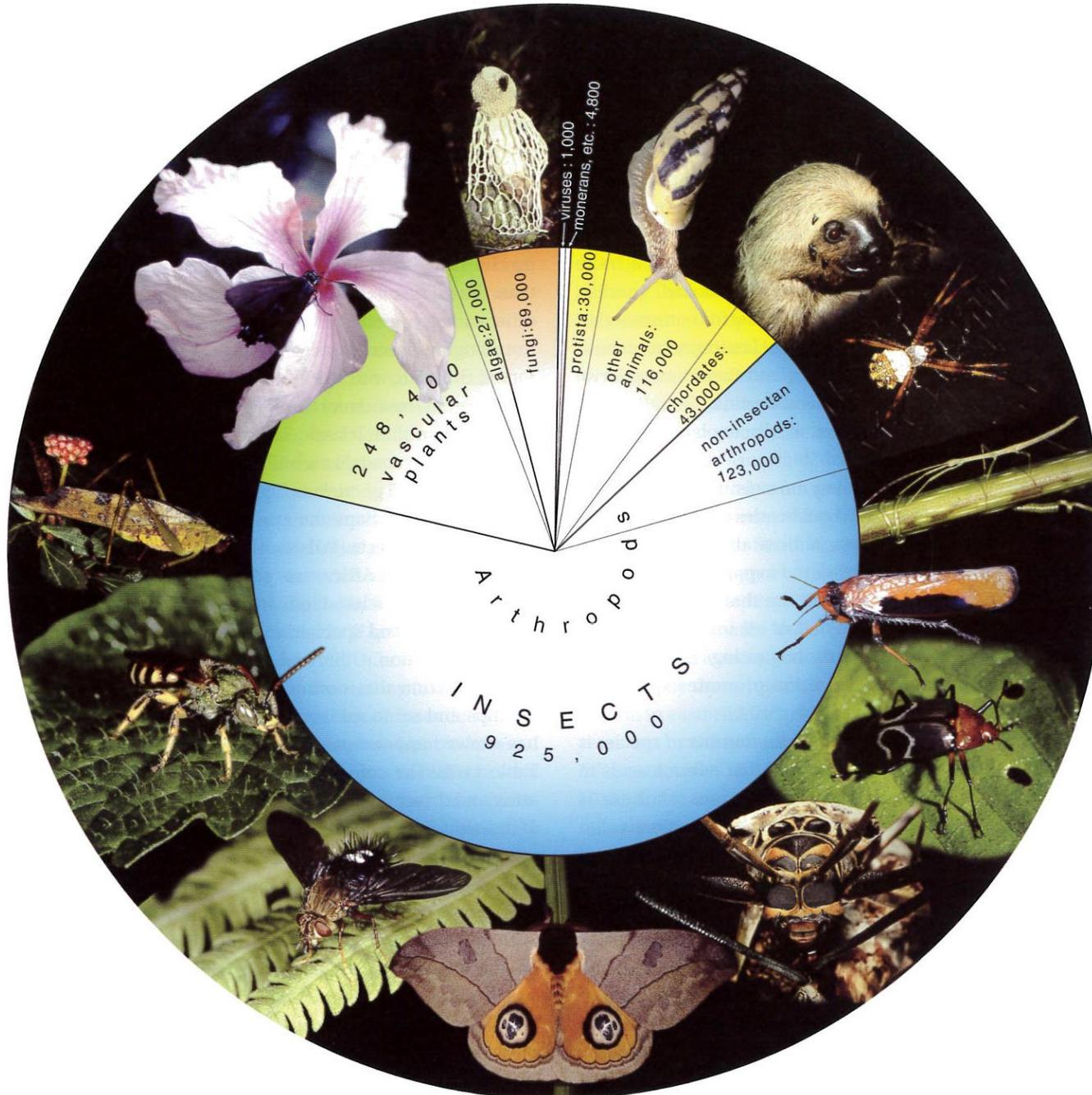
Winged Insects

Earliest modern insect orders

Half or more of modern insect families appeared during this time

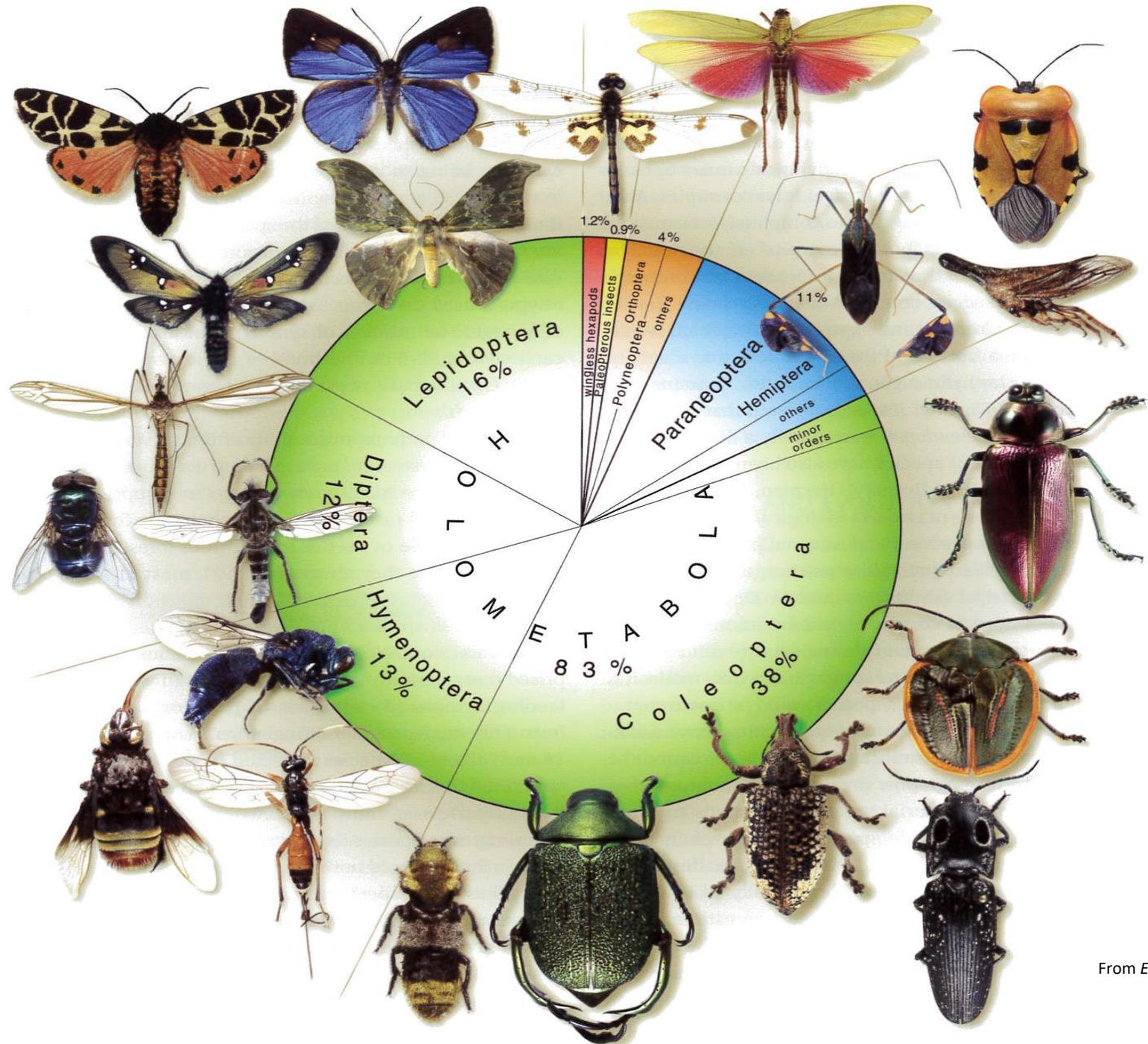
The longest arms race on the planet: flowering plants and insects





1.3. The diversity of life shown as proportions of named species.

From *Evolution of the Insects*, Grimaldi and Engel, 2005.



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Insect Origins and Evolution

Insects are unmatched in:

- Longevity





Insect Origins and Evolution

Insects are unmatched in:

- Longevity
- Diversity of adaptations

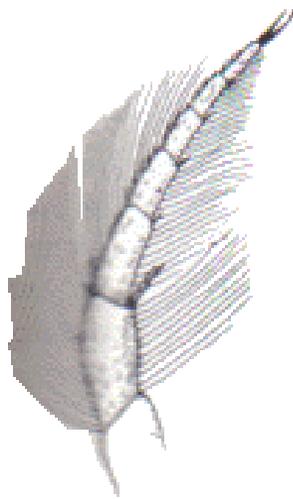




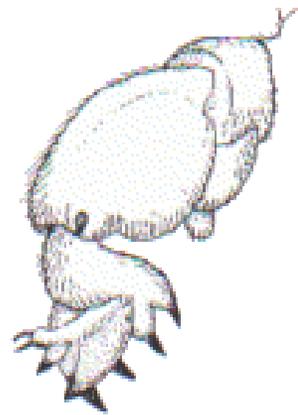
Insect Origins and Evolution

Insects are unmatched in:

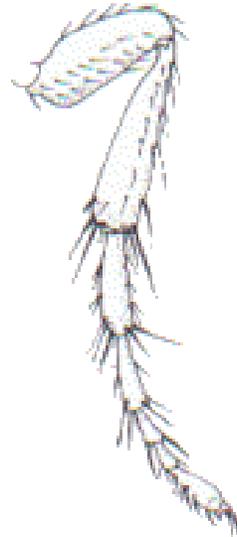
- Longevity
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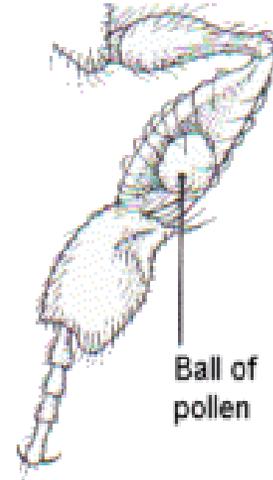
**Swimming Leg
(Diving Beetle)**



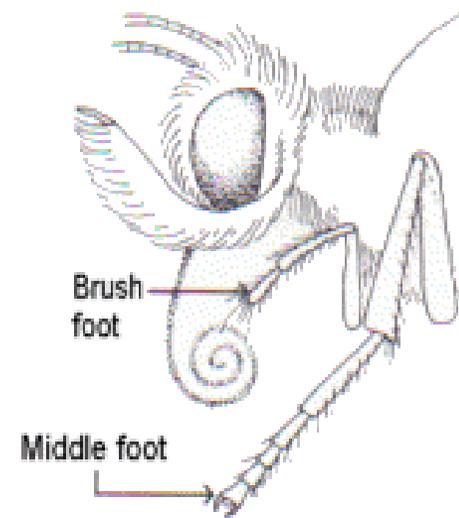
**Digging Leg
(Mole Cricket)**



**Jumping Leg
(Human Flea)**



**Pollen-Carrying Leg
(Worker Honeybee)**



**Eye-Cleaning Brush Foot
(Butterfly)**



Insects Take to the Skies!





Evolution of Flight

The development of flight remains a mystery

- Wings as we know them are incredibly complex structures and completely **monophyletic (homologous)** across all insect orders*



*Except Odonata

Monophyletic: having a shared ancestor

Homologous: referring to shared physical structures



Evolution of Flight

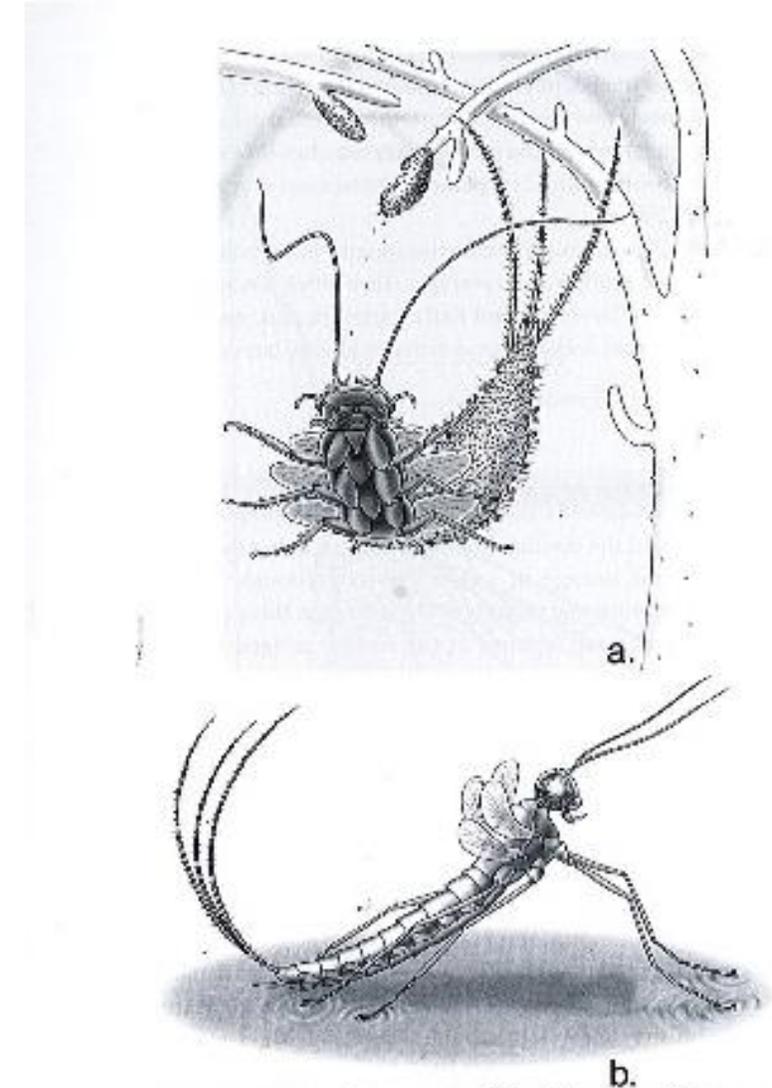
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- Several theories exist on how flight developed:
 - **Paranotal lobes:** existing lobes allowed early insects to control their descent while falling from tall plants (Hamilton 1971; Quartau, 1986; Hasenfuss, 2002)

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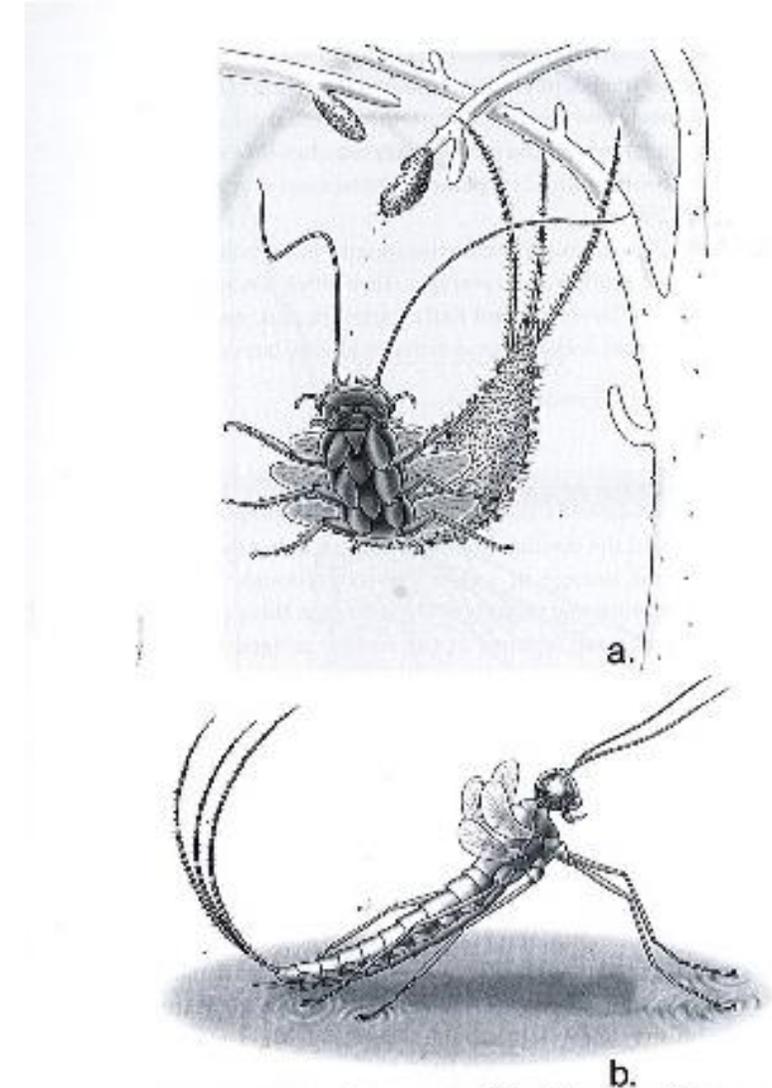
6.2. Alternative hypotheses on the origin of wings from either paranotal lobes (a) or from modified gills (b).



Evolution of Flight

The development of flight remains a mystery

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 - **Paranotal lobes:** existing lobes allowed early insects to control their descent while falling from tall plants (Hamilton 1971; Quartau, 1986; Hasenfuss, 2002)
 - **Gill Theory:** gills are homologous with wings of aquatic immature insects; used for 'sailing' or skimming across water (Kukalova-Peck, 1978, 1991)
 - The 'winged condition' has terrestrial origins and precluded fully aquatic insects;
 - Wings would have had to evolve twice: one for wingless, one for winged
 - Carboniferous-period insects were large in size with large wings = precluded skimming
 - **Hybrid theory for evolution of flight?**



6.2. Alternative hypotheses on the origin of wings from either pronotal lobes (a) or from modified gills (b).



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