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Bugs on the Wing

Holotype wing of the extinct *Cimbrophlebia brooksi*, which is 49.5 million years old. From "Boot Hill" of the Klondike Mountain Formation, Washington, USA.

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Insects first appeared around 400 million years ago, long before mammals or flowering plants. Even before dinosaurs.

Then, around 315 million years ago, they were the first creatures to learn to fly.

Insect wings are actually the most durable part of their body, and the most likely to appear in the fossil record, giving us a pretty good idea of insect development.

Their size increased in direct relation to the amount of oxygen in the atmosphere. Once oxygen hit 30 percent—9 percent higher than today—the largest insects had wingspans over 2 ft!

Around the same time, avian dinosaurs developed, and large insects were easy prey—to survive, they became smaller, faster, and more agile.

Dragonflies developed speed; they're able to hit 35 miles an hour but have the most primitive kind of wing.

Flies developed maneuverability; their shorter, folding wings allow them to dart into small openings.

Other insects evolved new uses for wings. The front wings of beetles became hard covers, to protect them from predators or while burrowing.

The wings of some moths became camouflage, to blend into specific environments. Butterflies developed brightly colored wings to attract mates or to warn enemies they're poisonous.

Grasshoppers and crickets can even use their wings to fill the air with sound.

We tend to take winged insects for granted or consider them a nuisance. But next time you see a dragonfly hunting mosquitoes or hear a cicada sing, you're witnessing evolutionary biology hundreds of millions of years old.

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Background: Bugs on the Wing

Synopsis: Insects were the first animals to develop wings and take to the skies. Flight made it possible for them to rapidly expand their territory to find new food sources and safe places to live away from predators. As atmospheric oxygen increased, they grew to larger and larger sizes, until birds began competing with them for food and preying on them. Insects have evolved many upgrades to take advantage of their incredible wings.

- There are more living insect species than all other living animal species; more than 750,000 have been identified, and scientists think another million species on Earth today have not yet been described.
  - Insects have jointed legs for feeding and movement, which means they are arthropods, like shrimp, spiders, scorpions, and fossil trilobites.
  - Insects have a hard exoskeleton composed mainly of chitin.
  - Their bodies have a head with two antennae at one end; an abdomen at the other end; and a thorax, with two legs on each of three segments, in between. The thorax usually has two pairs of wings attached to it, but some insects have just one pair, and others have lost both pairs.
  - The amazing success and diversity of insects are attributed to the fact that they were the first animals, and the only invertebrates, to develop the capability to fly, so they could spread out and dominate the land.
- Only 7,000 fossil insect species have been found because their bodies are fragile and lack hard parts, and also because they lived on land and were less likely to be quickly buried (and thus preserved) in sediments, like marine fossils were.
  - Wings are usually what are fossilized because, even though they look very fragile, they are the insect's most resilient body part—and predators would have consumed the nutritious insect bodies.
  - Wingless fossil insects occur in rocks as old as 395 million years, from the middle of the Devonian Period. The diversity and geographic spread of these fossils lead scientists to estimate that insects actually evolved earlier—at the end of the Silurian Period, about 415 million years ago—but were not easily preserved.
  - A gap in the fossil record follows: no known insect fossils exist for the whole Mississippian subperiod of the Carboniferous Period, a gap of about 80 million years.
    - This was the most important time in insect evolution; after this gap, in 315-million-year-old Pennsylvanian rocks, ten genera of insects had evolved and spread all over the world—but now they had wings!
    - Given this critical gap in the fossil record, scientists can only speculate about how the wings evolved.
- Insect size can be directly correlated with oxygen level in the atmosphere; for about 200 million years, as oxygen increased and decreased, insect size did the same.
  - About 300 million years ago, when atmospheric oxygen levels increased to their highest point, at over 30 percent (it's at 21 percent today), some winged insects grew into giants—some had wingspans of up to 28 inches!
  - However, during the Cretaceous Period about 150 million years ago, O_2 levels went abruptly up, but insect size went abruptly down. Avian dinosaurs had evolved, so smaller insects that could outmaneuver them survived, while larger insects were easier prey.
  - Another insect size transition occurred around the end of the Cretaceous, possibly related to the mass extinction that enabled more-specialized evolution of birds from the less-agile nonavian dinosaurs.

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References: Bugs on the Wing

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Wing Secrets That Help Insects Rule the World | Wired
Transparent, Thin and Tough: Why Don't Insect Wings Break? | Science Daily
Reign of the Giant Insects Ended with the Evolution of Birds | UC Santa Cruz News

Contributors: Juli Hennings, Harry Lynch

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Background: Bugs on the Wing

- Insects have developed many functional uses for wings in addition to flight.
  - Dragonflies can fly as fast as 35 miles per hour. They have the most primitive type of wings, though, like a fixed-wing aircraft, so they have to stay in open air rather than small spaces.
    - Other insects that evolved folded wings can fly through small openings.
  - The front wings of beetles such as ladybugs have evolved into wing covers; the second set of wings are used to fly.
    - These beetles use the wing covers as protective shells so they can fend off predators and burrow into the ground to scavenge for food.
  - Some insects use their wings as camouflage, blending into leaves or tree bark. Those with transparent wings can blend into anything.
  - Insects use their wings to attract mates.
    - Butterflies have colored scales on their large wings that are fortified by veins that act like struts.
  - Bees have small, lightweight wings that can hook together to act like a more aerodynamic larger wing that they flap at 230 beats per second.
    - They can expand the arc of their wing strokes when they need more power to carry heavy loads of pollen or nectar.
  - Grasshoppers, crickets, and cicadas can use their wings to make sounds.
- Insects are our biggest competitors for food, but they also scavenge to keep Earth clean and pollinate plants to keep it productive. We can't live without them!

This marmalade fly, a type of hoverfly, is about one-half inch long.

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