Structure & Materials of the Insect Wing

Article by Samantha Chalut

Background

To this day,
the true origins of insect flight remains obscure, as the earliest winged insects show evidence of being fully adept at flight.

An insect's wings are outgrowths of the exoskeleton that enable it to fly; this includes two pairs of wings known as the forewing and hindwing (although a select few insects lack hindwings). The current designs of an insect wings have evolved over hundreds of millions of years to produce many variations, each with it's own design tradeoffs. These tradeoffs may include specializations in the flight performance aspects such as efficiency, versatility, maneuverability, or stability.

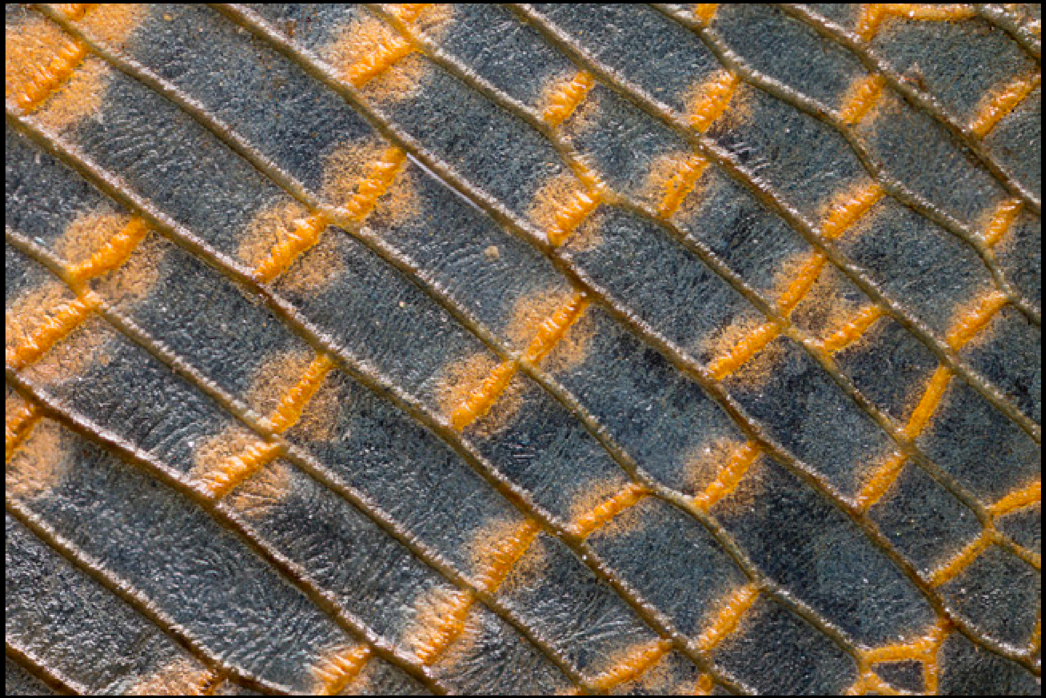
Evolution

The earliest insects had four wings, independently functioning forewings and hindwings. The well-known insects, damselflies and dragonflies, have kept this design. Since then, insect wing designs vary where either the forewing or hindwing are specialized for force production, while many other insects are functionally 2 winged through attaching the smaller hindwings to the forewings.

Structure

The structure and design of an insect wing is essential, as it must endure functionally over the insect's lifespan. They must be capable of enduring collisions or tearing without failure. To achieve this insect wings can deform readily, even reversibly, through its overall structure.

In many cases aerodynamic efficiency is improved through the coupling of the forewing and hindwing. This is achieved in a few different ways. Most commonly, the wings are coupled through a row of small hooks on the forward margin of the hindwing, locking onto the forewing. Another form of coupling is seen where the jugal lobe of the forewing covers a portion of the hindwing, or even where they broadly overlap.



Grasshopper forewing vein celled intersections

The coupling of a cicada forewing and hindwing

Structure

Structurally, numerous longitudinal veins intersect cross-connections that form closed cells in the membrane that strengthen the wing.

Not all structural and design components of an insect's wings serve flight purposes. Specialized designs can range from mechanical protection, camouflage, signaling, or thermoregulation. On the other hand, not all design elements of an insect wing have a known purpose or any effect on flight performance, like tails or scalloped edges on a butterfly or moth wing.

Materials

Wings are primarily composed of cuticle. Cuticle is a multilayered material composed of chitin microfibers fixed in a protein matrix. The cuticle is arranged in tubular supporting veins and thin deformable membranes. Overall membrane thickness in insect wings ranges from less than 0.5 microns (small, thin wings) to over 1mm thick (protective forewings of beetles), even varying widely within an individual wing.

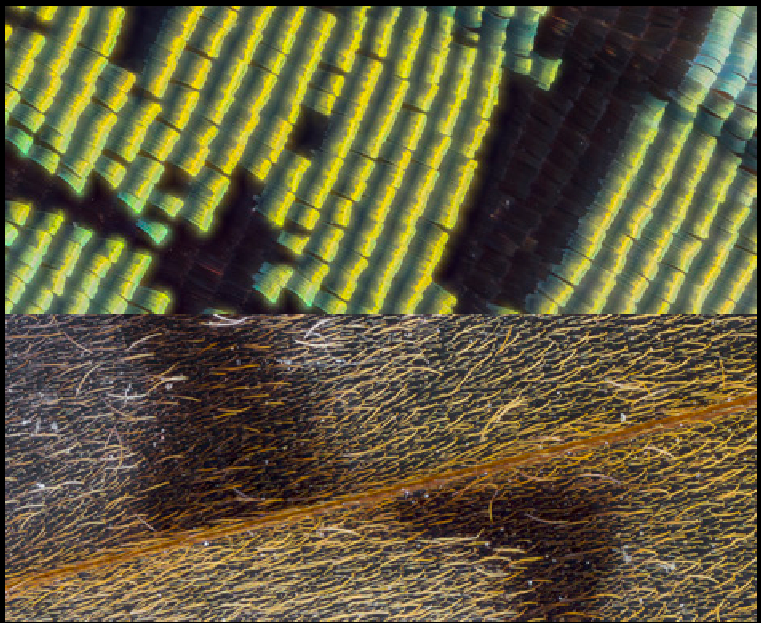
Lanternfly wing material

Some insect wings are iridescent under different angles of light with varying cuticle layer constructions. Shown here is the damselfly wing.

Materials

On butterflies and moths the wings are covered with minute scales that are often blade-like (lamellar) and sometimes hair-like. The scales of a butterfly or moth provide many varying functions including insulation, thermoregulation, producing pheromones, gliding in flight, signaling, camouflage, and mimicry.

Eyespots on wings are often perceived as mimicry of a different animal to deceive predators.



Examples of blade-like and hair-like scales respectively

Venation

Insect wings are composed of tubular supporting veins through the deformable membrane. The main longitudinal veins transmit fluid, oxygen, or sensory information, while the cross veins are rarely fluid-filled and serve various structural roles. The patterns that these veins create are called venation patterns. These patterns display a wing's structural diversity. The venation is typically denser near the base of the wing and leading edge, in addition to the cuticle thickness and vein diameter decreasing from base to tip. Moreover, the regional stiffness of the insect wing typically declines, sometimes drastically, from base to tip. Venation arrangements allow for stress distribution, provide strength at high stress points, and reduce mass at wing tips.

Additional Information

Insects Photographed

Cicada Pomponia Intermedia (Thailand)
Wingspan: 16.5 cm

Damselfly Microstigma Rotundatum (Peru)
Wingspan: 15 cm

Lanternfly Saiva Cardinalis (Thailand)
Wingspan: 5.5 cm

Grasshopper Phymateus Saxosus (Madagascar)
Wingspan: 11.25 cm

Butterfly Haetera Piera (Peru), female
Wingspan: 6 cm

Moth Urania Leilus (Peru), female
Wingspan: 10 cm

Equipment & Technique

All images photographed with Canon 6D and 100mm & 65mm macro lenses shot with transilluminated lighting technique.

About

The photographer and article author Samantha Chalut currently attends the Rochester Institute of Technology and is in her 4th year studying Imaging & Photographic Technology.

For more information on the article and its included images contact srchalut@gmail.com

Resources

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