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INSIDE JEB

Butterflies see wing colours change as mother-of-pearls flutter by

A mother-of-pearl butterfly (*Protogoniomorpha parhassus*).

For centuries, our predecessors experimented with exotic pigments to create opulent ceramics and illuminated manuscripts. It was only in the 18th century that we discovered Mother Nature's alternative colour palette, produced by light reflecting from microscopic layers in feathers, skin and insect shells in a similar way to the shimmering rainbow hues of soap bubbles and oil films. 'Earlier in my career, I was devoted to insect vision, but I was also constantly intrigued by the often brilliant colours of butterflies', says Doekele Stavenga, from the University of Groningen, The Netherlands, who became increasingly fascinated by the intriguing physics of these so-called 'structural colours'. After decades of investigating the startling shades of butterflies from all over the globe, he most recently turned his attention to the shimmering common mother-of-pearl butterfly (*Protogoniomorpha parhassus*) from Africa in the hope of discovering how they produce their opalescent glow.

As butterfly wings are coated in scales, Stavenga suspected that thin layers in these structures were the cause of the mother-of-pearl butterfly's delicate iridescent pink hue. However, to be sure, he first had to shine light through the fragile wings. 'The structural coloration of the wings was immediately and strikingly clear when comparing light reflecting from the wing with light that passed through it', says Stavenga, who saw the rosy shade vanish when the wing was illuminated from beneath. And when Bodo Wilts, a colleague from the University of Fribourg, Switzerland, scrutinised the scales in fine detail using an electron microscope, they could clearly see box-like structures in the scales that would scatter light to produce the butterfly's pearlescence. Next, Stavenga focused a spot of bright white light on a wing from above, producing a fuchsia-coloured beam as the structures in the scales reflected only red and blue wavelengths, confirming that the delicate colour is produced by reflecting structures in the scales and not a rose-toned pigment in the wing.

However, Stavenga also knew that the tones produced by these light-reflecting colour-generating structures depend on the position of a viewer relative to the structure, potentially altering the colour of an object as it moves. Could the wings of mother-of-pearl butterflies flash different tones as the animals flutter by? This time, Stavenga shone white light at angles ranging from directly above the wing to almost horizontally to one side (an oblique angle of 70 deg), recording the wavelengths that were reflected by the scales to find out whether the shade varied from different angles. Impressively, the wing's hue switched from pink to yellow as the light shifted from above to one side. And, when he calculated how the colours would change in the eyes of a butterfly – which see UV tones but not the red hues that we can see – the wings became a brighter shade of yellow and the light was more strongly polarized, making the wings stand out for creatures such as butterflies that see polarization.

The mother-of-pearl butterfly's wings are perfectly tuned to generate flashes of colour as they flit past, and Stavenga suggests that the fluttering insect's flickering light show could help them to stand out from the crowd. 'Only in the last decade has the importance of butterfly wing scales acting as thin film reflectors like soap bubbles become well recognized, and the mother-of-pearl butterfly is certainly the brightest, exemplary case', he says.

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