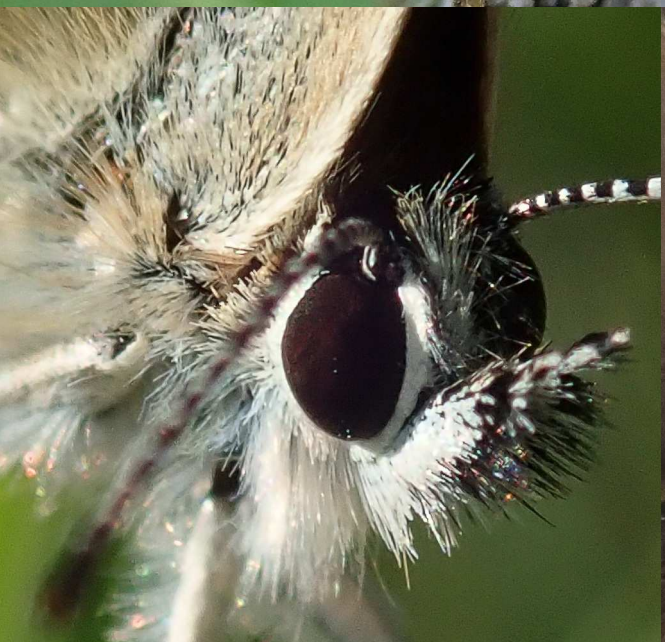
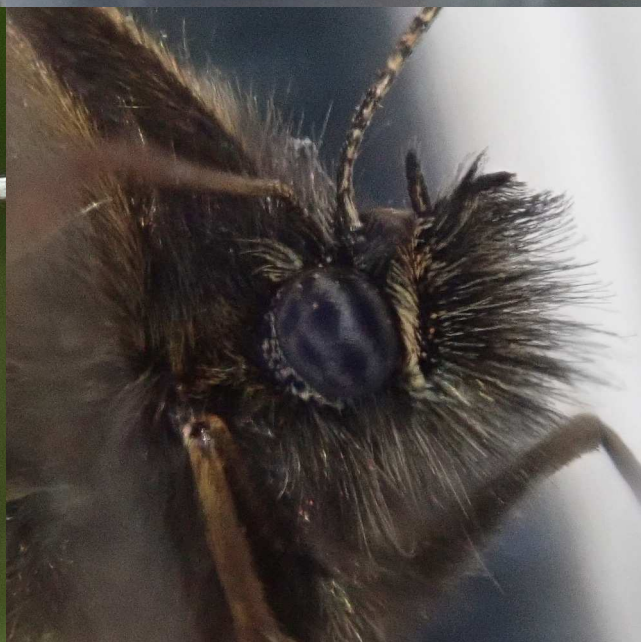
A Hidden View.....

Inside the Eye of a Butterfly

by Simon Berry



Introduction

I am an Optometrist and I am interested in photography, although very much an amateur. This book is an introduction to some of the 3D scans I have taken of butterfly's eyes.

The scans were taken using an OCT scanner. As far as I am aware this is the first time that a butterfly's eye has been scanned using this technique.

I have interpreted some parts of these scans but I should say that I am not an entomologist and so some of my interpretations of the anatomy may be a bit simplistic.

I have many more scans of other insects and these can be made available to anyone who may be interested.

No butterflies have been harmed in creating this book. They are fantastic creatures and I would not want to see them harmed for the sake of a picture.

All photographs have been taken in the wild.

All scans are of live Butterflies that were released back to their original habitat.

Simon

A Hidden View.....

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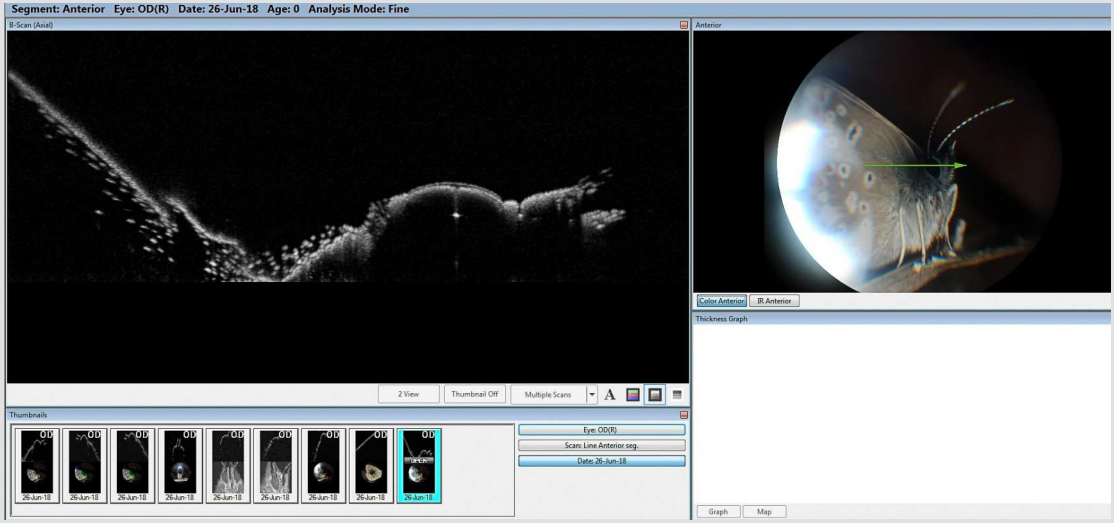
Interpreting the Scans

The black and white scans in this book are taken using an OCT scanner. They represent a live cross-section through the Butterfly eye. Using this technique it is possible to view parts of the Butterfly anatomy that have not been viewed in a live insect before.

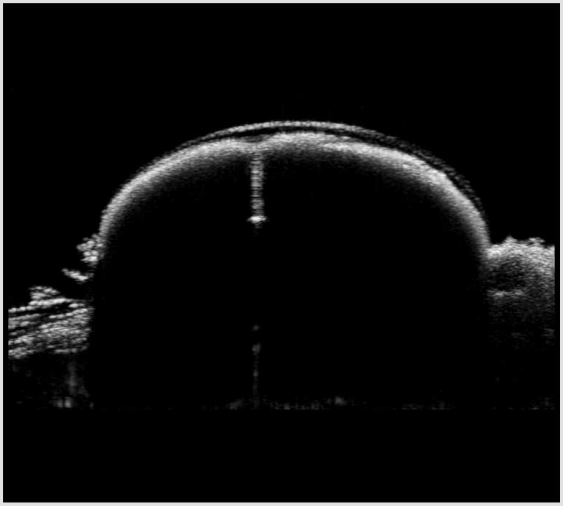
The scanner also takes a photo at the same time as the scan. The green arrow on the photograph shows where the cross-sectional scan has been taken. These photos have been included amongst most of the scans.

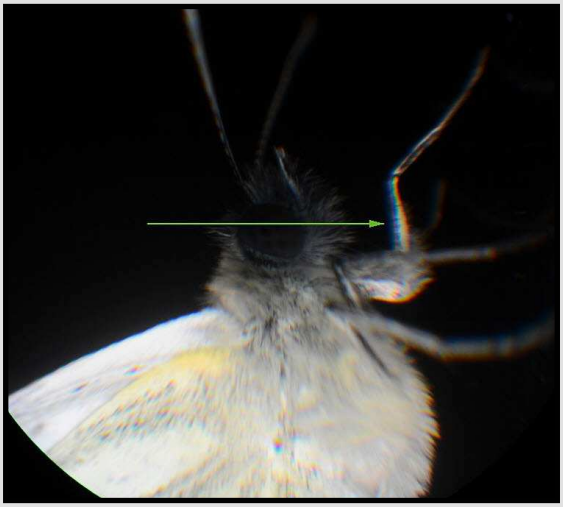


The picture above shows the OCT machine being used. It shows the screen shot from a Northern Brown Argus being scanned.

The OCT scanner uses infra-red light to build up a 3D image of biological structures. It is mostly used in Ophthalmology. It can reveal a cross-section of the tissue by using a technique that can be thought of as a form of optical ultrasound

The wavelength of infra-red light penetrates deeper into tissue than visible light. The OCT can show structural detail to the level of where the infra-red light penetrates. It doesn't penetrate right the way through the structure and hence some parts of the anatomy will remain hidden.



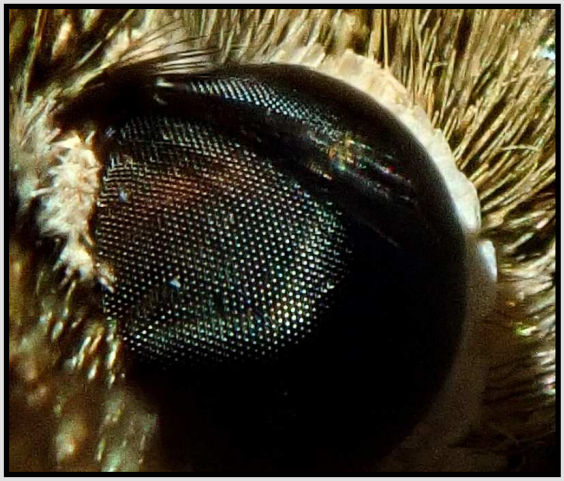


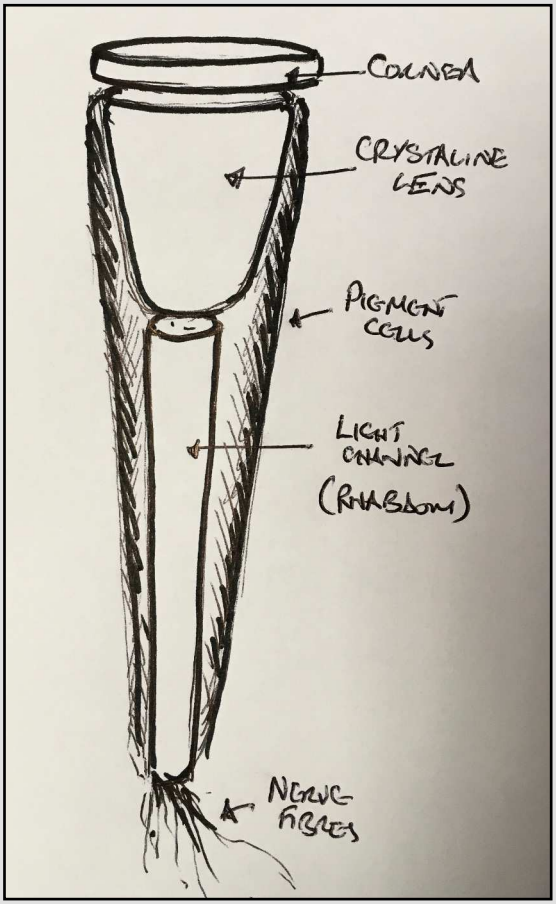
The images above show an OCT scan of a Green Veined White (left) and the photo showing the slice through the eye that the scan has been taken.

The Compound Eye in OCT

Butterfly eyes are termed compound eyes. They are made up of hundreds of individual units called ommatidia.

The information from each ommatidia is like the pixel in digital image. They combine to build up a picture of the world around.



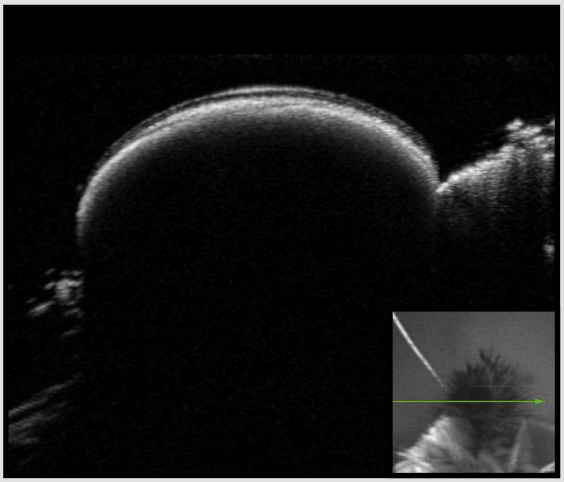


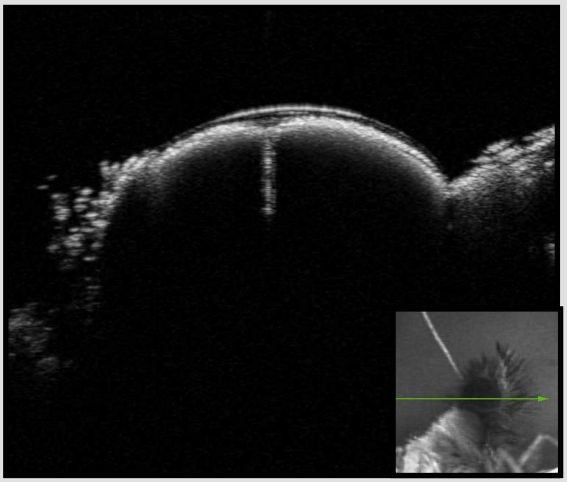
Using an OCT scanner it is possible to image some of the detail of the ommatidia and how they are arranged.

In most Butterfly eyes the individual ommatidia are separated by pigment cells that absorb stray light. The light from the OCT cannot penetrate through the pigment cells. However, if an individual ommatidiam is lined up correctly then the light from the OCT can pass through the light channel and show the depth of the structure.

This is also termed the pseudopupil and can be seen on photographs of insects as a black circle, giving the illusion of a pupil.

The below images show a scan of an Orange Tip Butterfly. They are slices of a scan a fraction of a millimetre apart. The scan of the left shows how light is absorbed and very little under the surface is visible, the scan of the right shows the light channel.



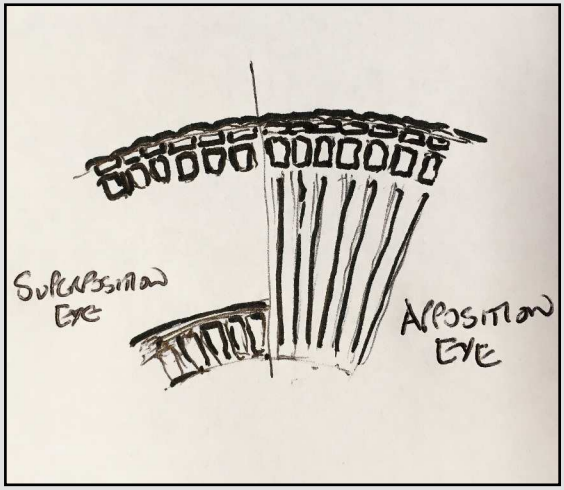


Different Types of Compound Eyes

Some of the scans in this book demonstrate different features of the Butterfly eye anatomy.

There are two types of compound eye found in insects; an apposition eye and a superposition eye.

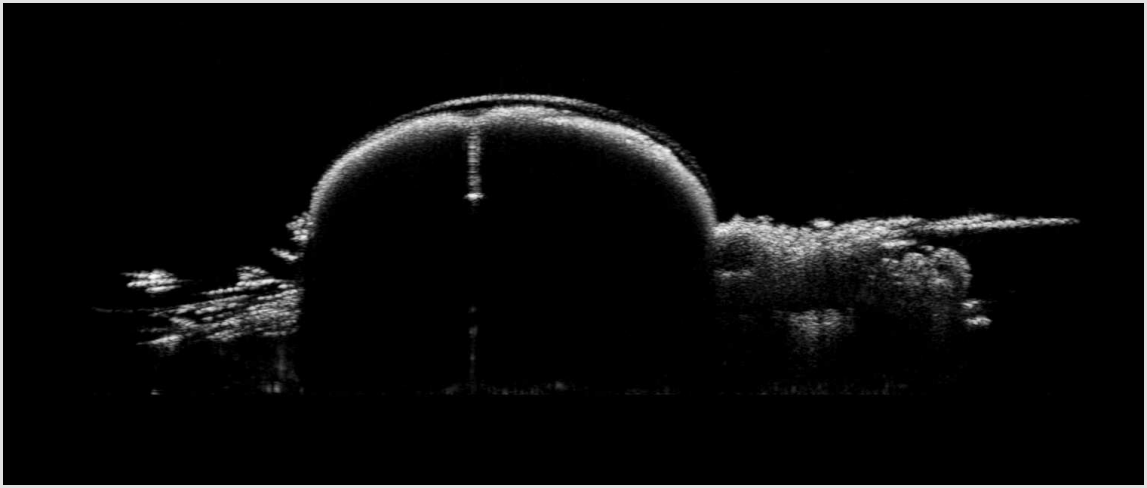
The anatomy of each type of eye is a little different.



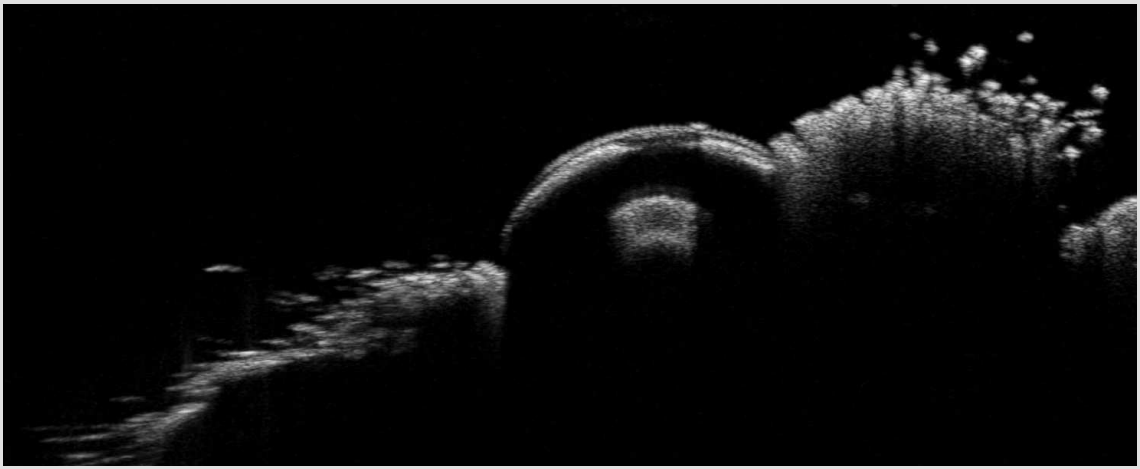
Most butterflies possess an apposition compound eye. This works by each individual ommatidia forming it's own image. These are stitched together in the insect brain to create a picture of the world around them.

Skipper Butterflies possess a superposition eye. In these type of compound eye there is a space between the crystalline cone and the light sensitive rhabdom.

This is the type of eye generally found in nocturnal insects including most moths. It is more sensitive to low light and builds up a single image rather than lots of individual ommatidia being combined together.



The apposition eye of a Green Veined White Butterfly



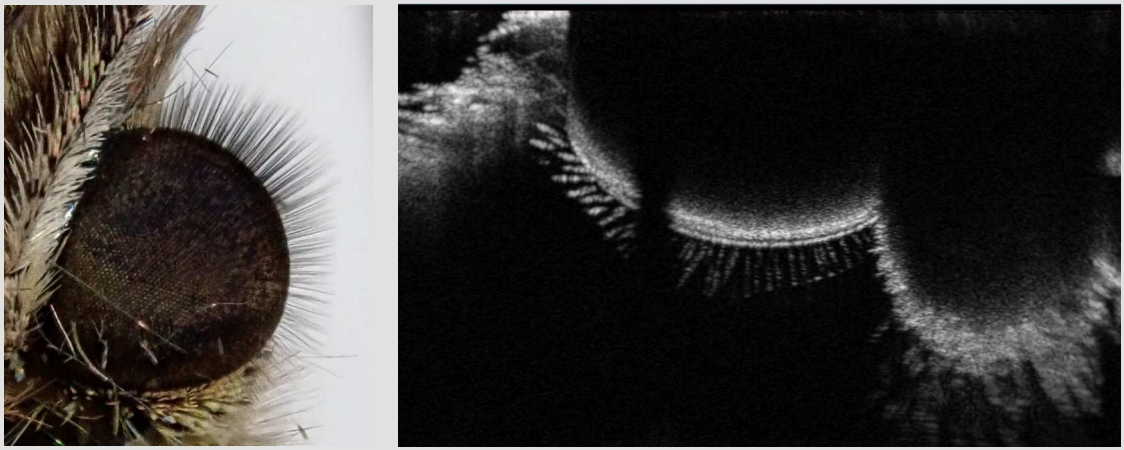
The superposition eye of a Small Skipper Butterfly

Different Types of Compound Eyes

As you will see from the scans, some species of Butterfly have fine hairs covering their eyes.

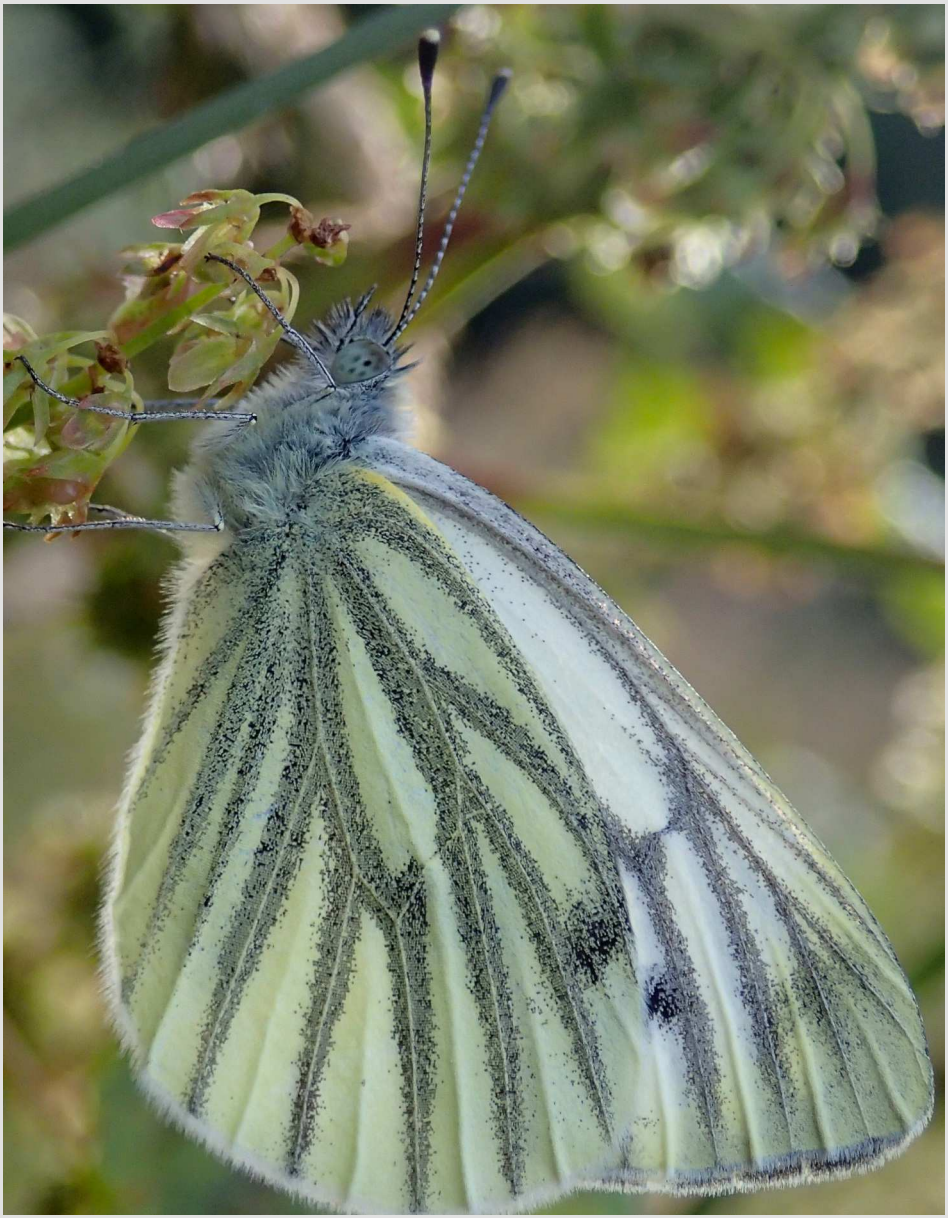
The biological function for these hairs is still argued about. It is generally thought that they might provide a protective function, similar to eyelids in a human eye. Other people think they might be sensitive to wind direction and offer the insect another sense to interpret the world.

It is interesting to note that all species of Butterfly in this book that migrate also possess these hairs.



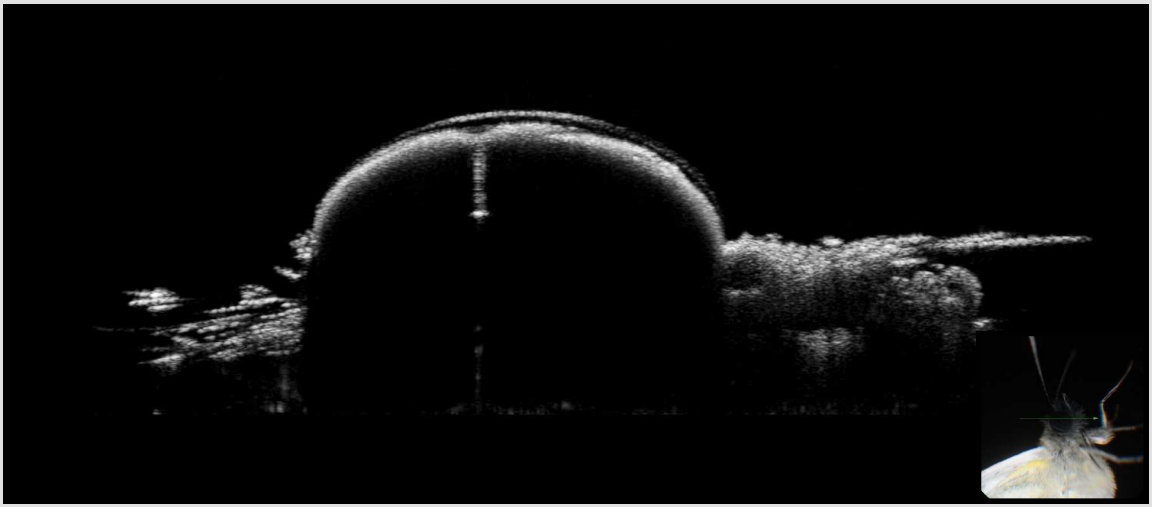
The fine hairs on the eye of a Speckled Wood (left) and Painted Lady Butterfly (Right)

.....Inside the Eye of a Butterfly

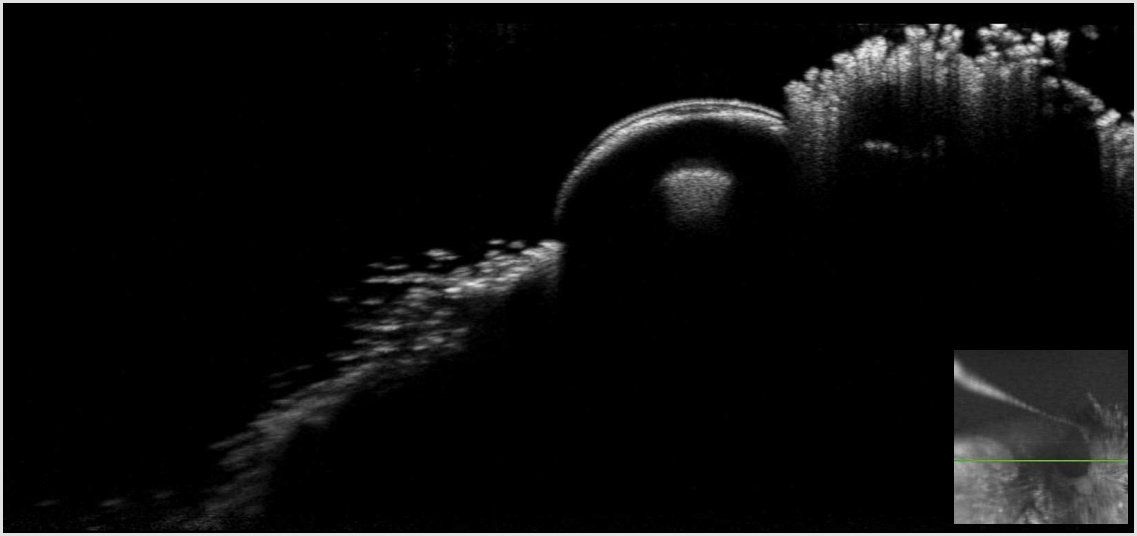


The Green Veined White

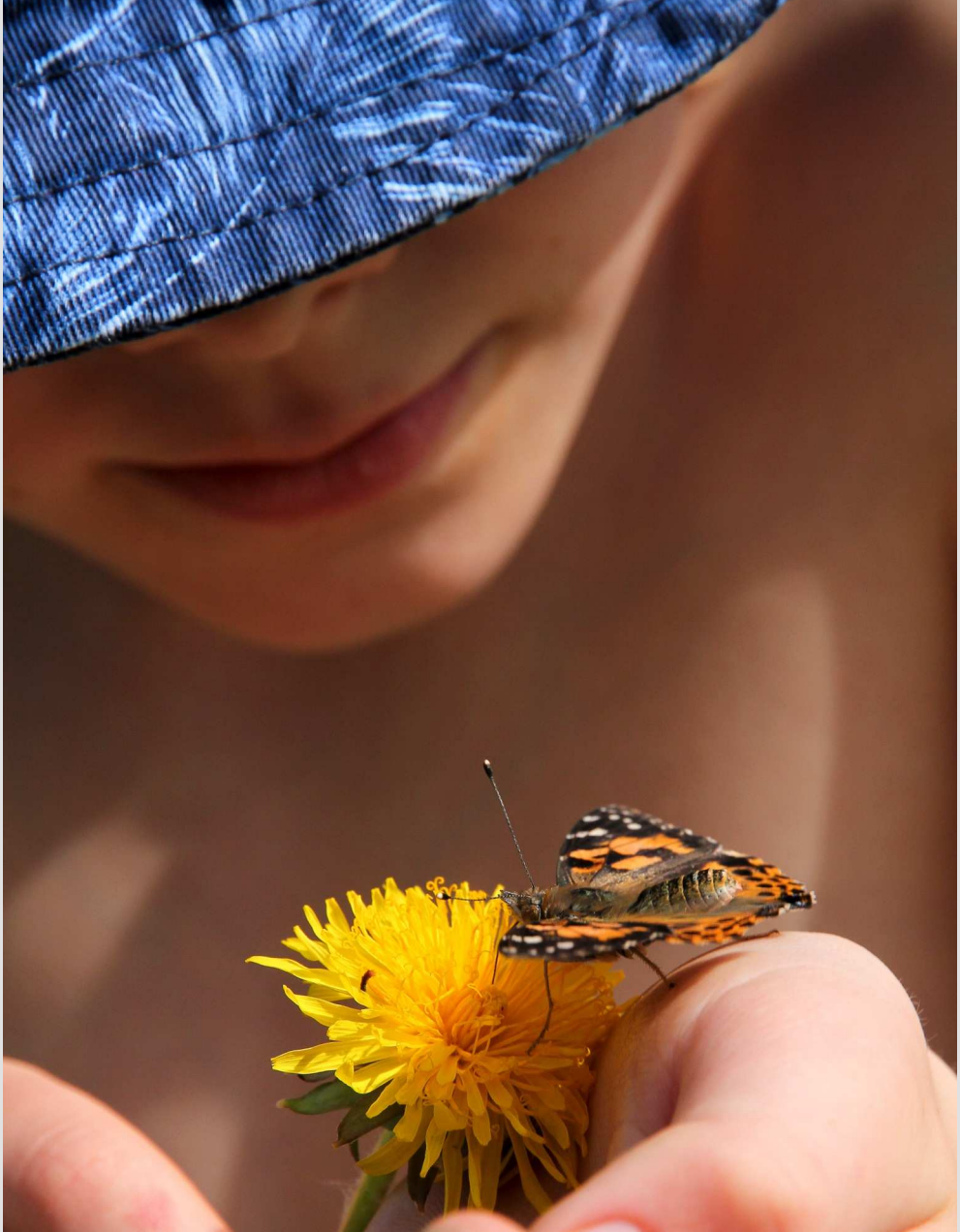
The pseudopupil as scanned from the front



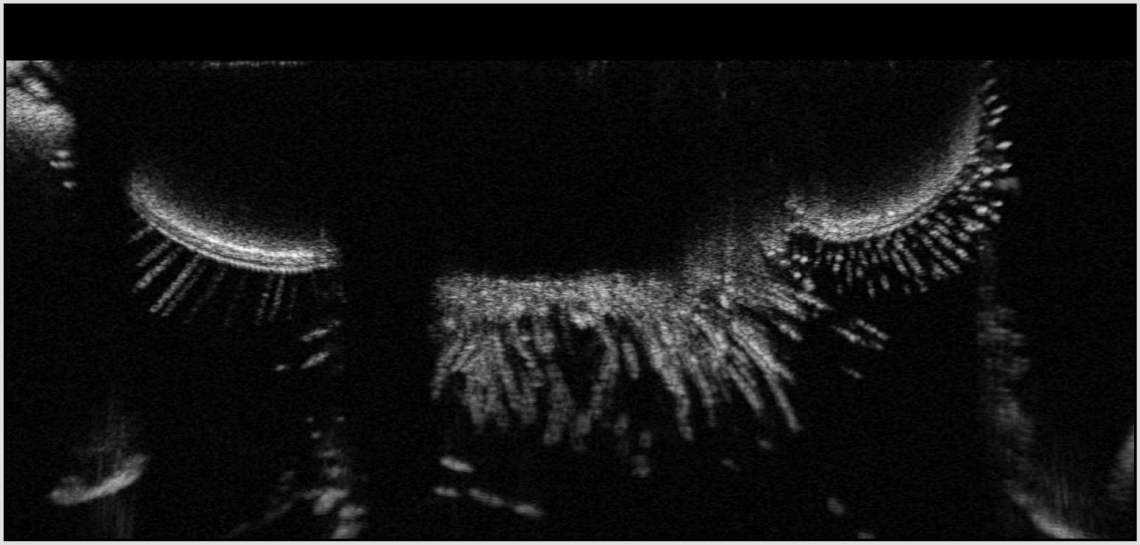
The pseudopupil as scanned from the side

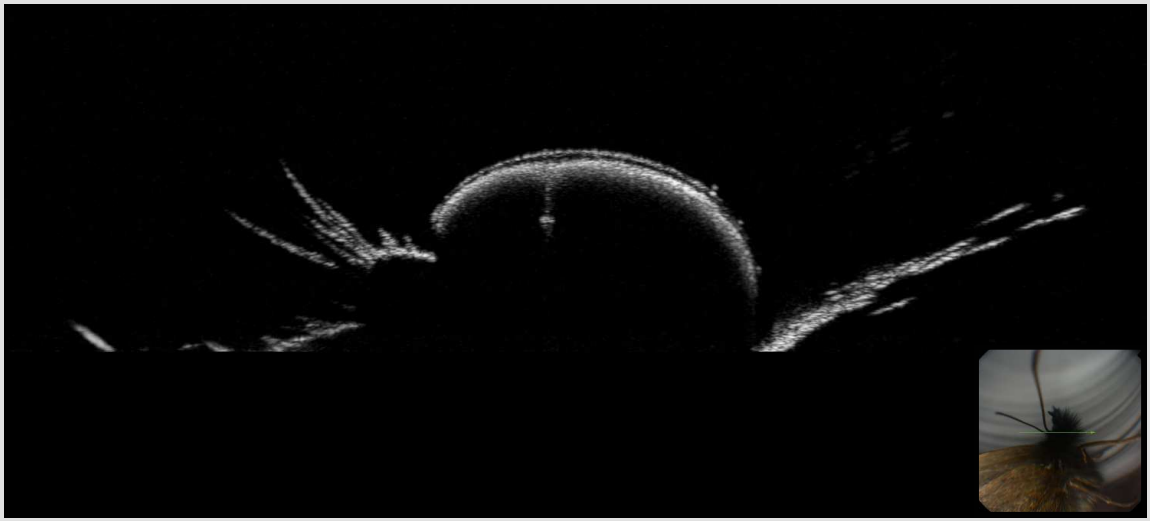


The Small Skipper

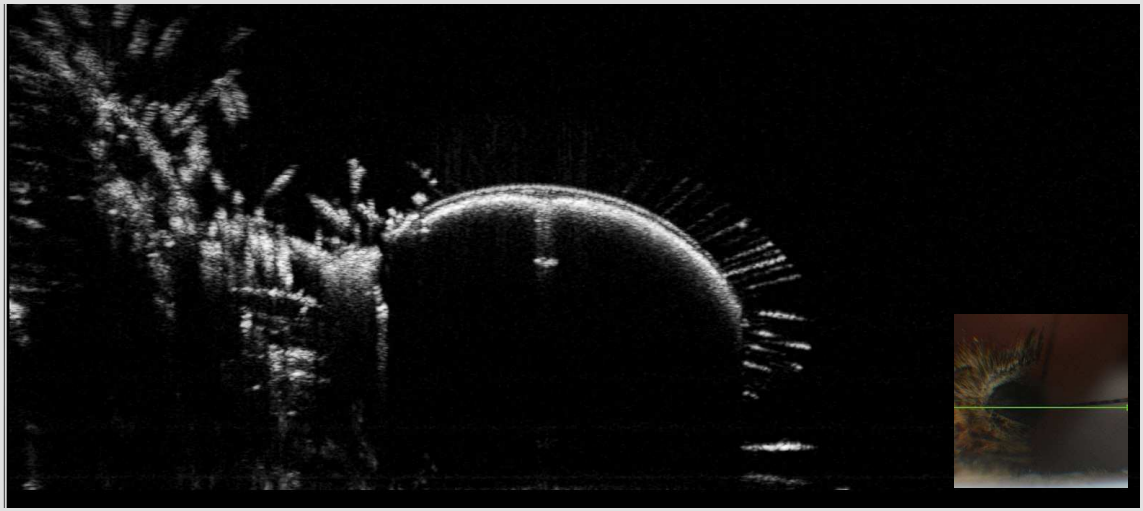


The Painted Lady

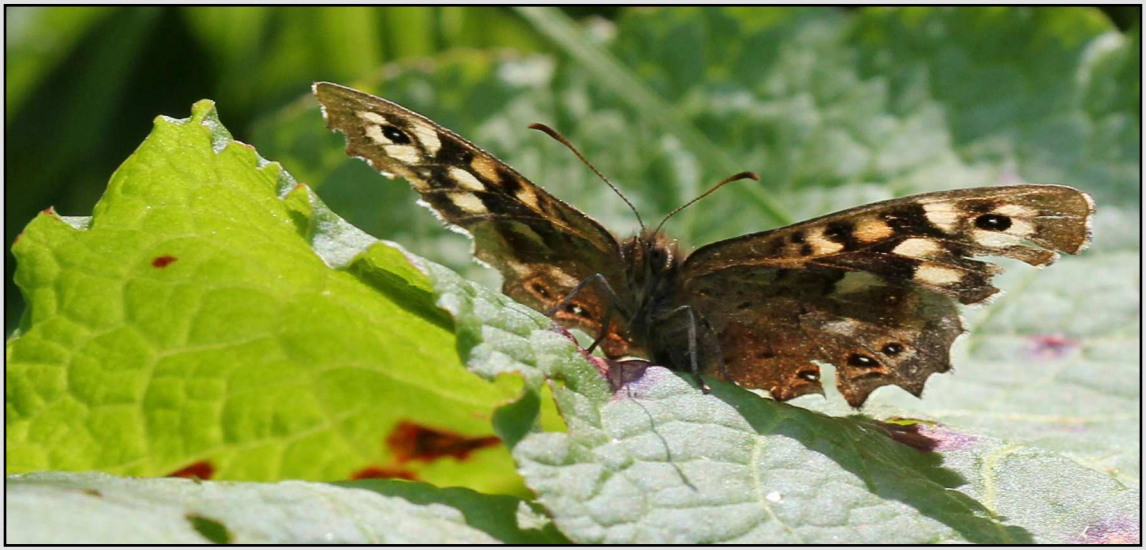




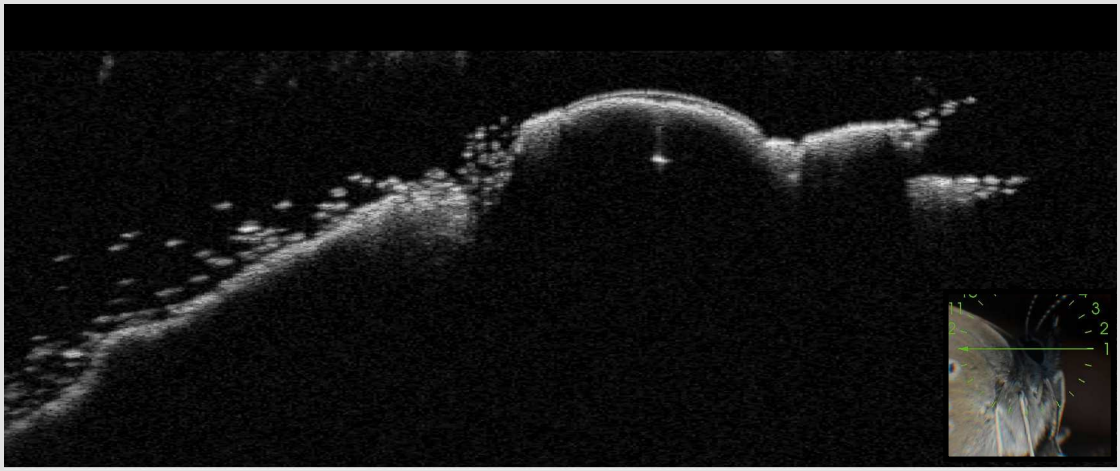
The Ringlet

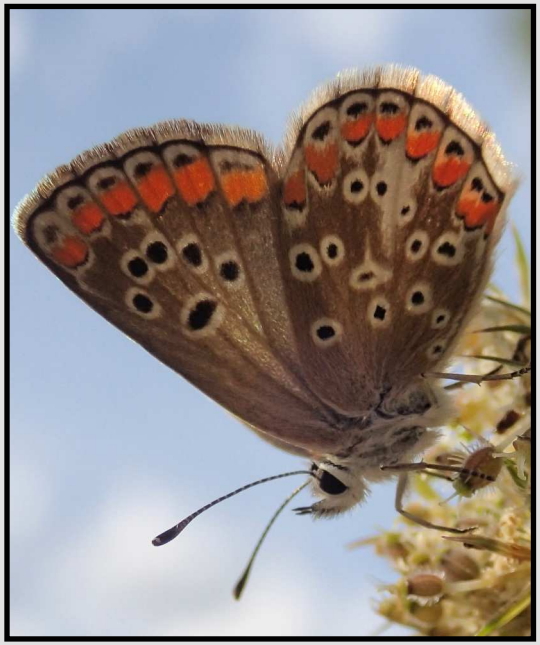


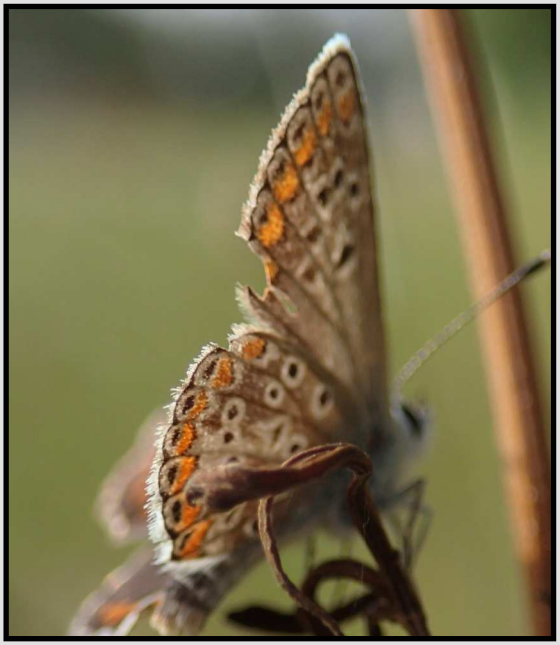
The Speckled Wood

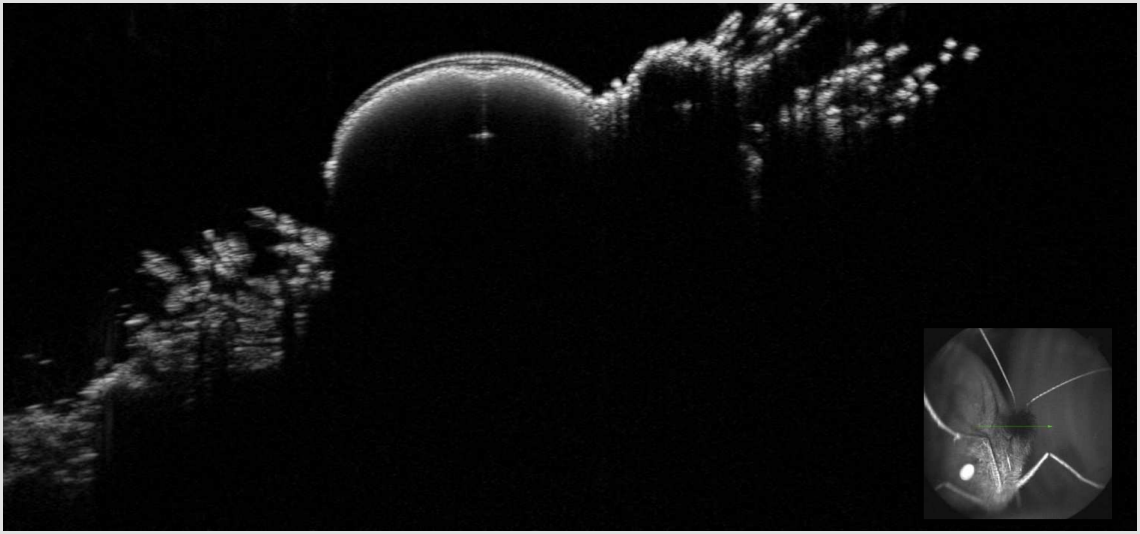


The Brown Argus

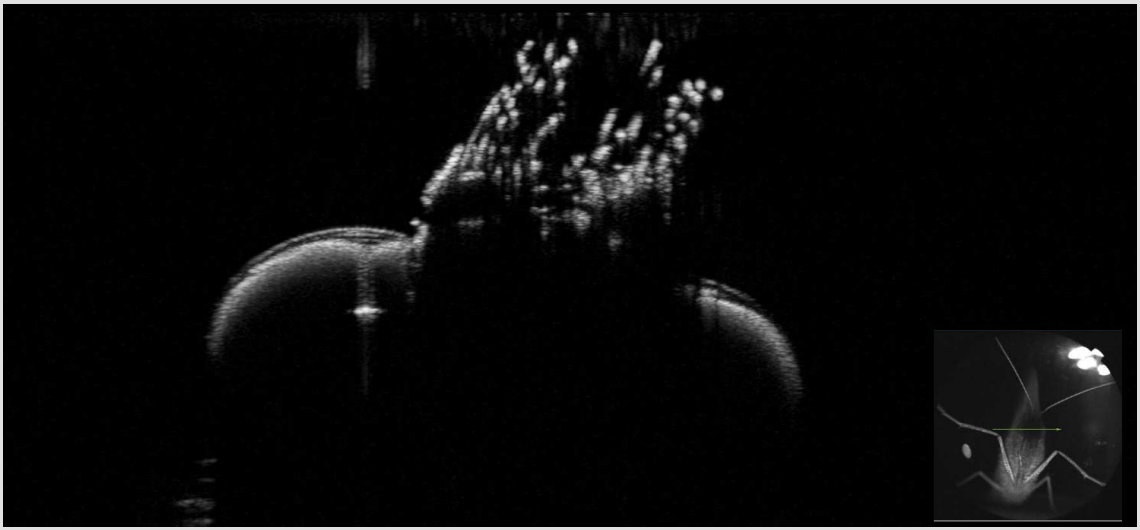


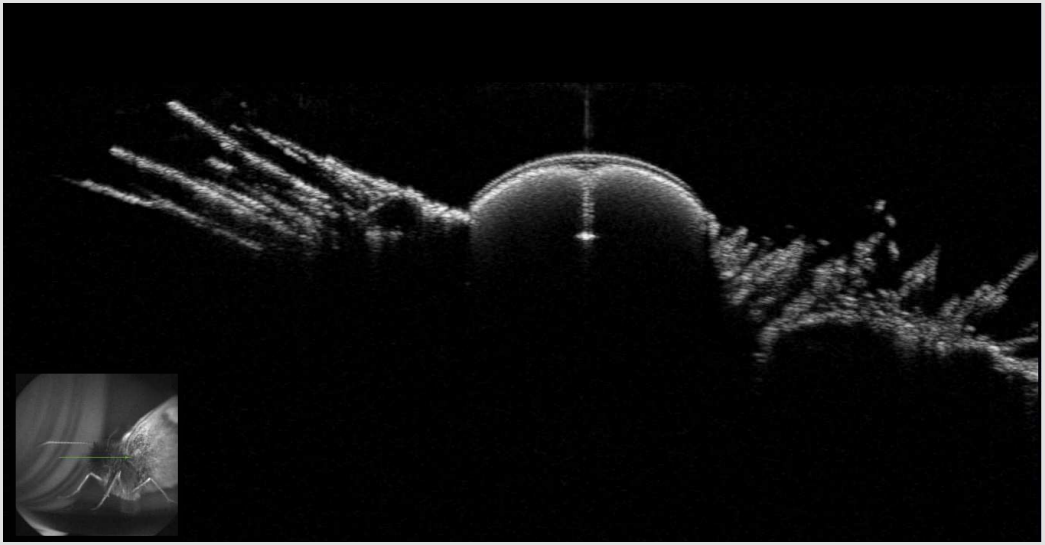




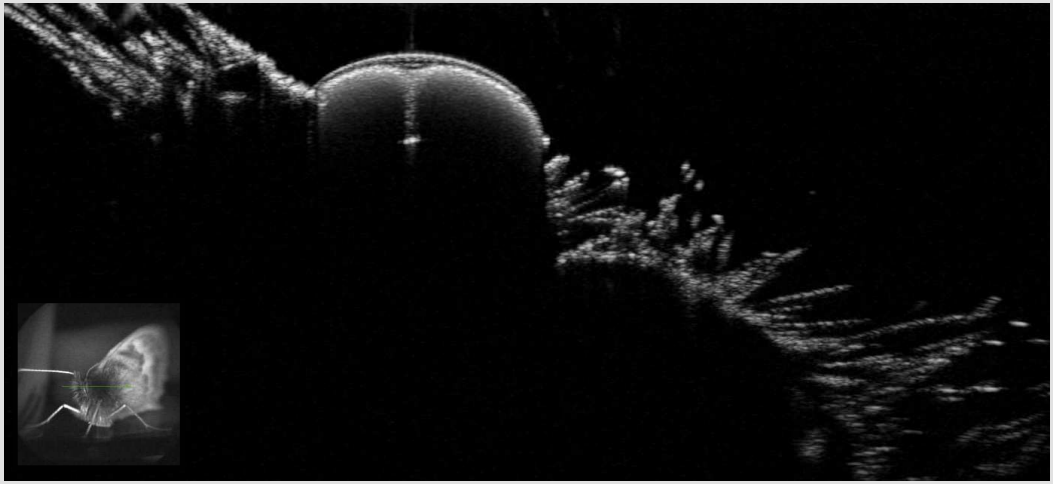


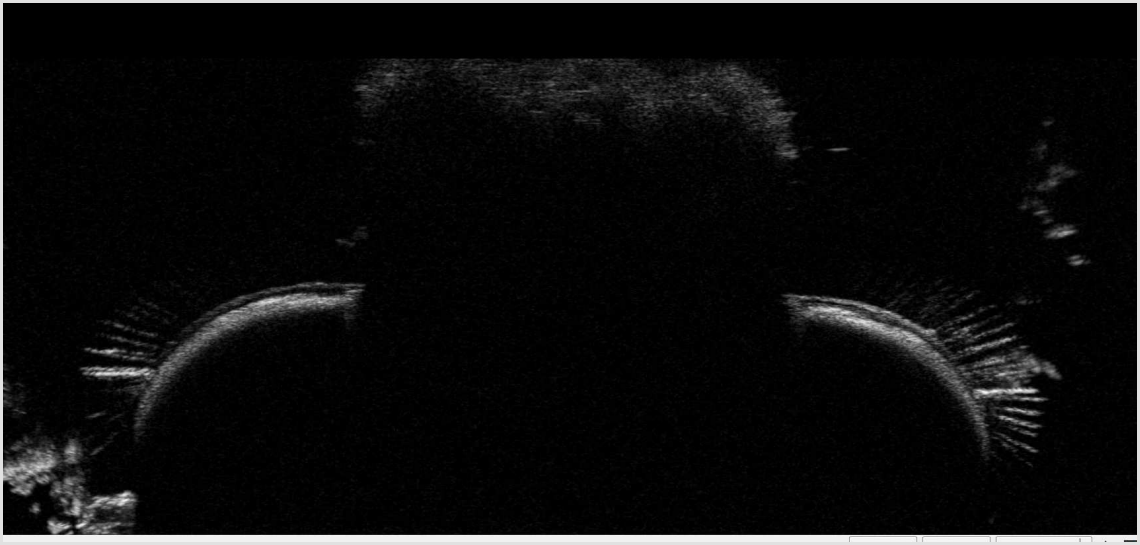
The Meadow Brown



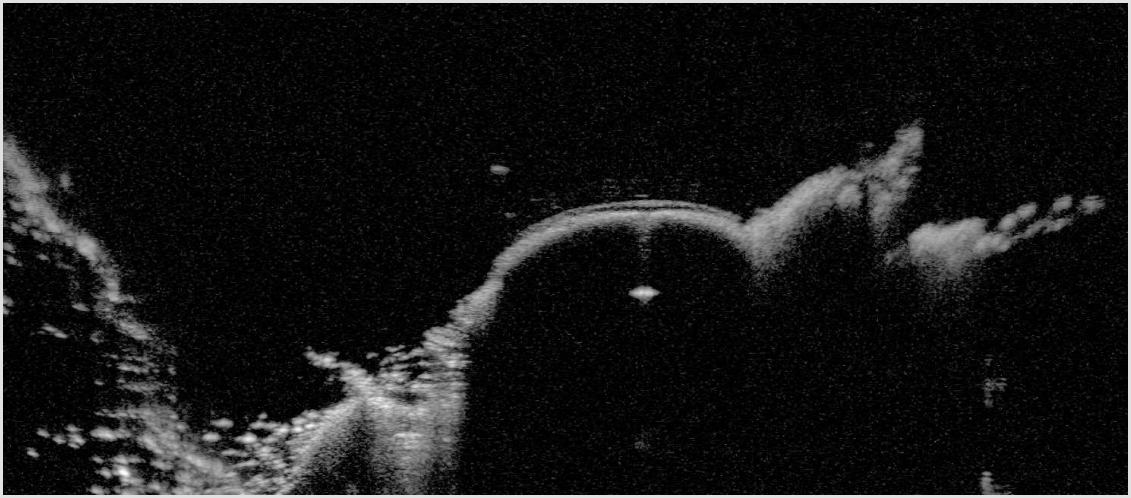


The Small Heath

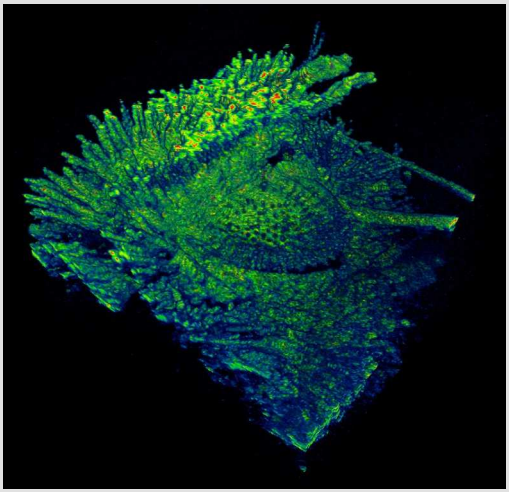


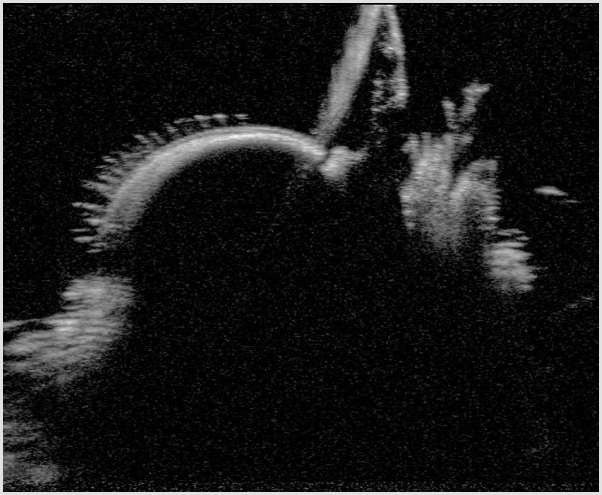


The Red Admiral



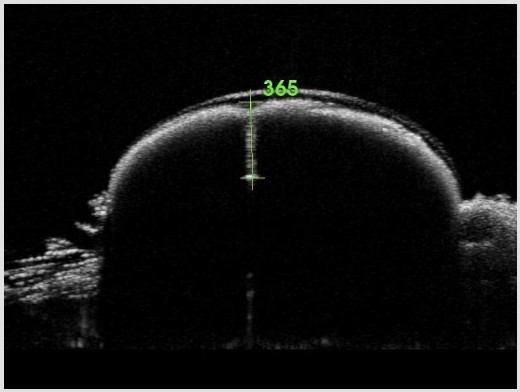
The Common Blue



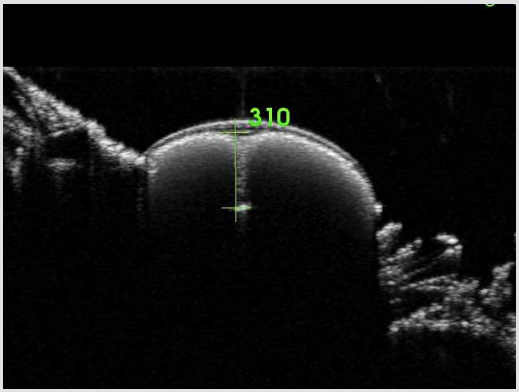


A Little Detail

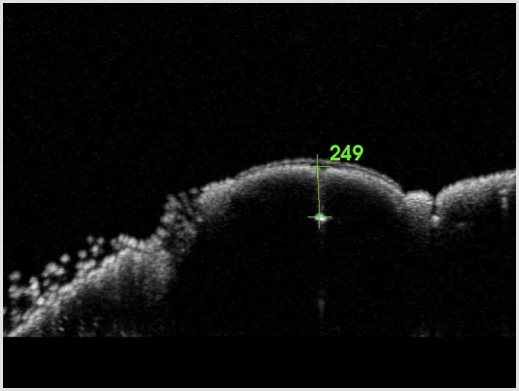
The OCT is able to measure what it scans. Here are the size of the ommatidia for a few of the Butterflies (in microns.)



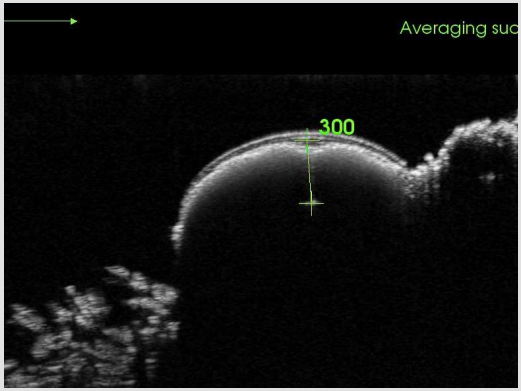
Green Veined White



Small Heath



Northern Brown Argus

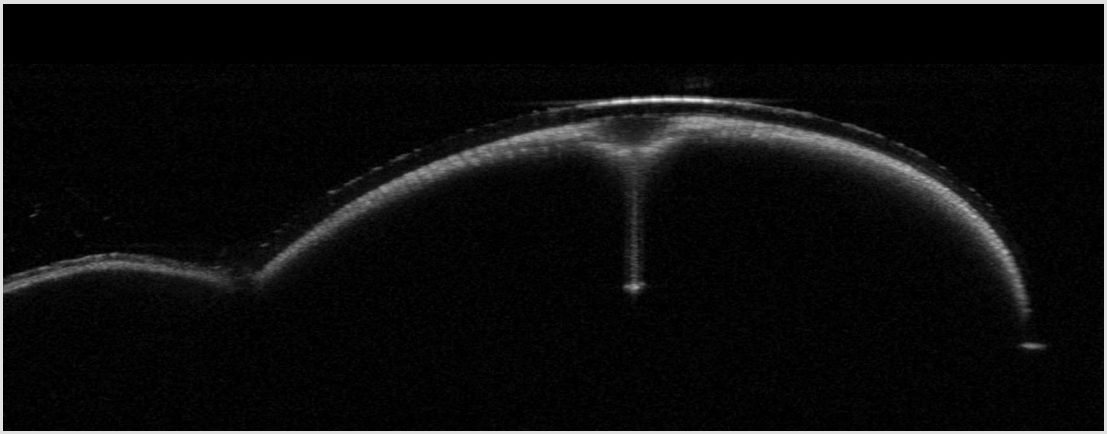


Meadow Brown

Other Compound Eyes

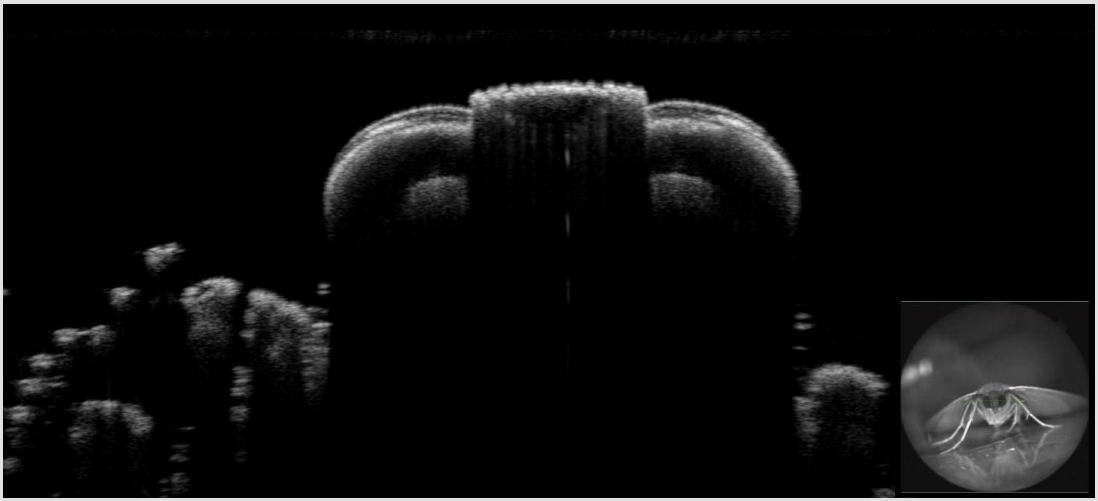
The compound eyes of the butterfly are too small for the OCT to resolve individual ommatidia in cross section. However with larger compound eyes it is possible to see the ommatidia.

The scan below shows the compound eye of a dragonfly. It is possible to see the pattern of the individual ommatidia as a subtle linear pattern.



The compound eye of the moth is a good example of a superpostion compound eye. This type of compund eye is more senstive to low light and is found in noctural insects.

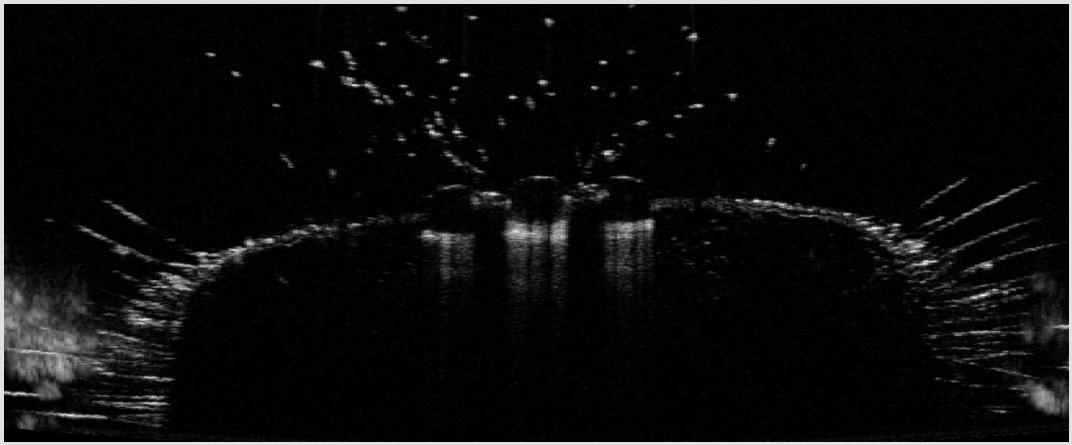
The Superposition eye of the Large Yellow Underwing Moth



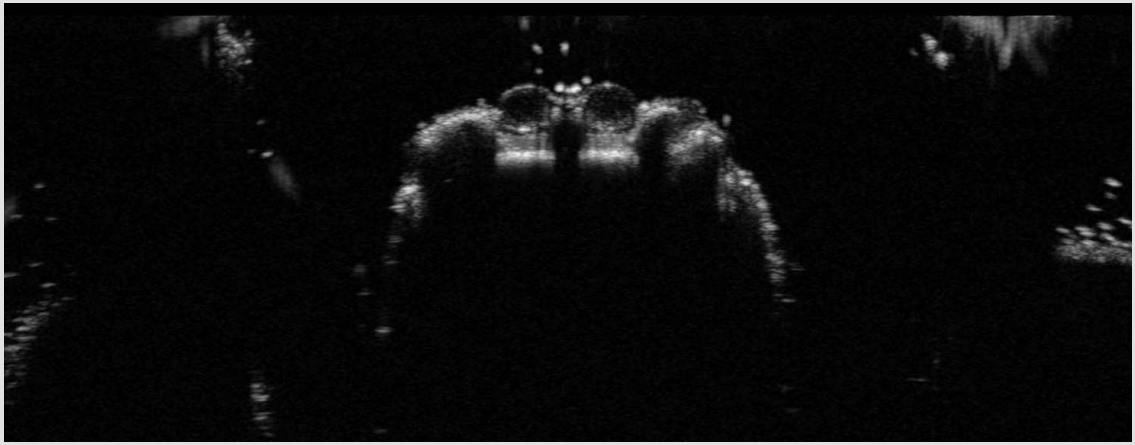
A Few 'Simple' Eyes

Many insects have simple eyes, or ocelli. These are small optical structures with only one lens. The OCT tecnhology can show the structure and shape of the ocelli.

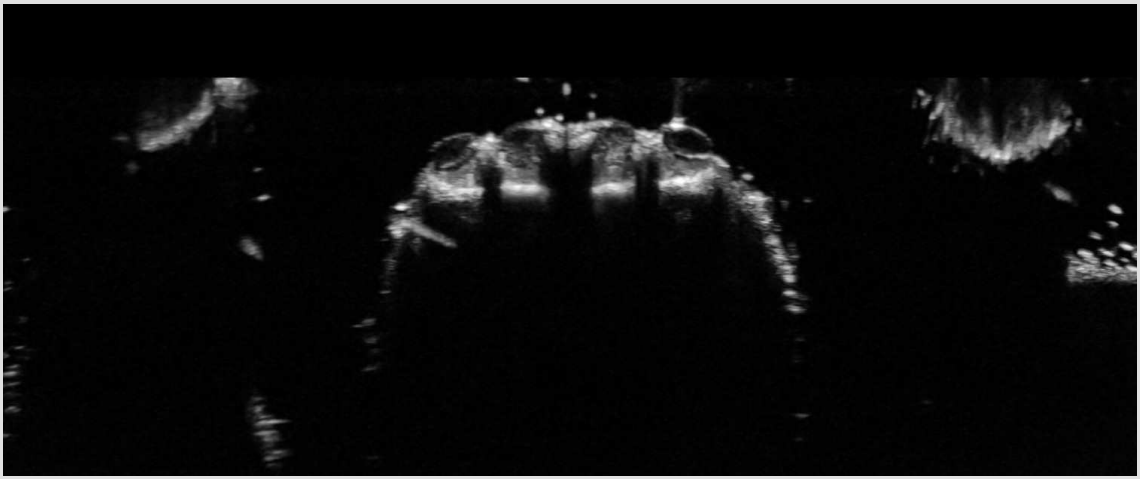
Bees have two large compound eyes on the side of their heads, but also three of small simple eyes on the top of their head. The scan below shows these three ocelli all lined up.

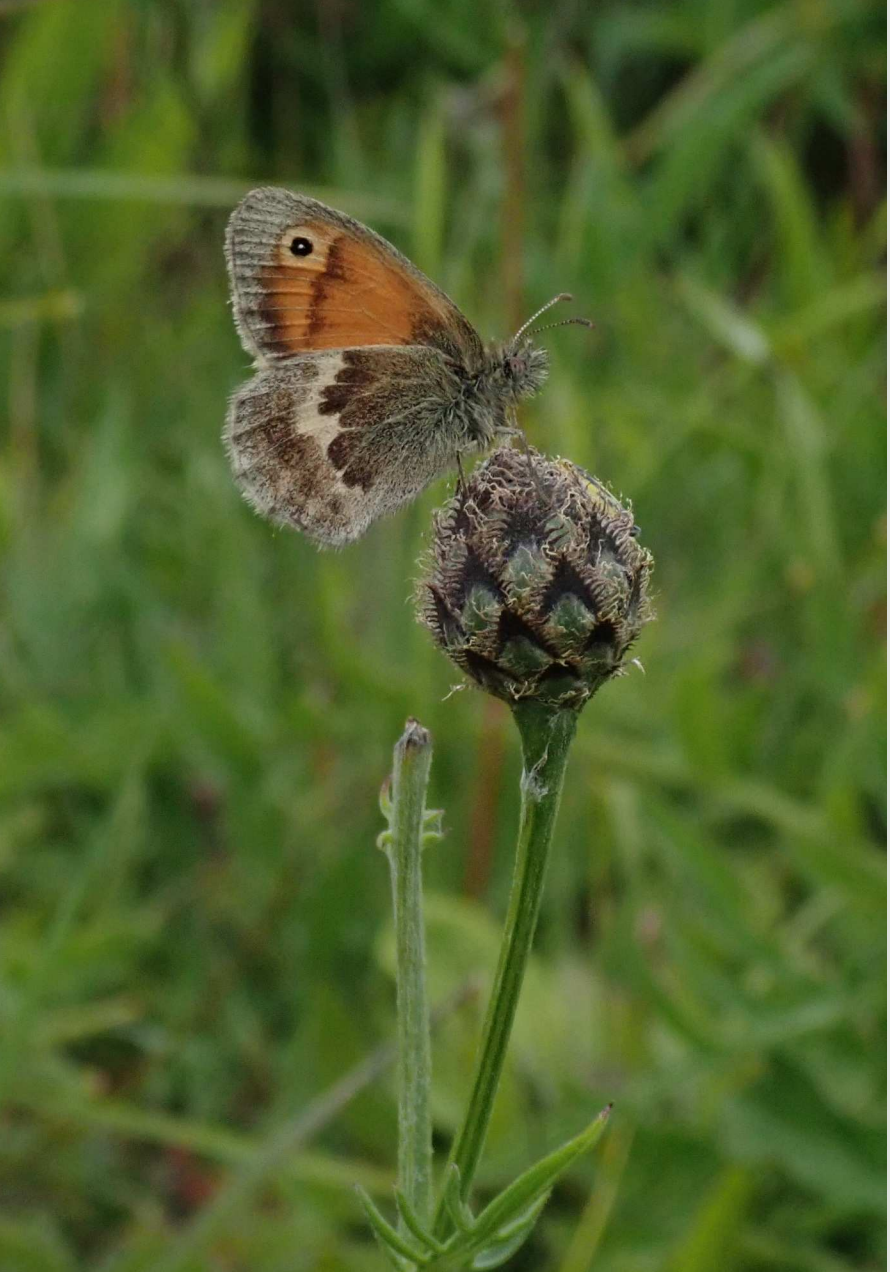


House spiders have 8 simple eyes. Using the OCT it is possible to see that the structure of these small eyeballs are not all the same. On the opposite page, the top scan show circular ocelli on the front of the head, the bottom scan shows oval ocelli just next to them.

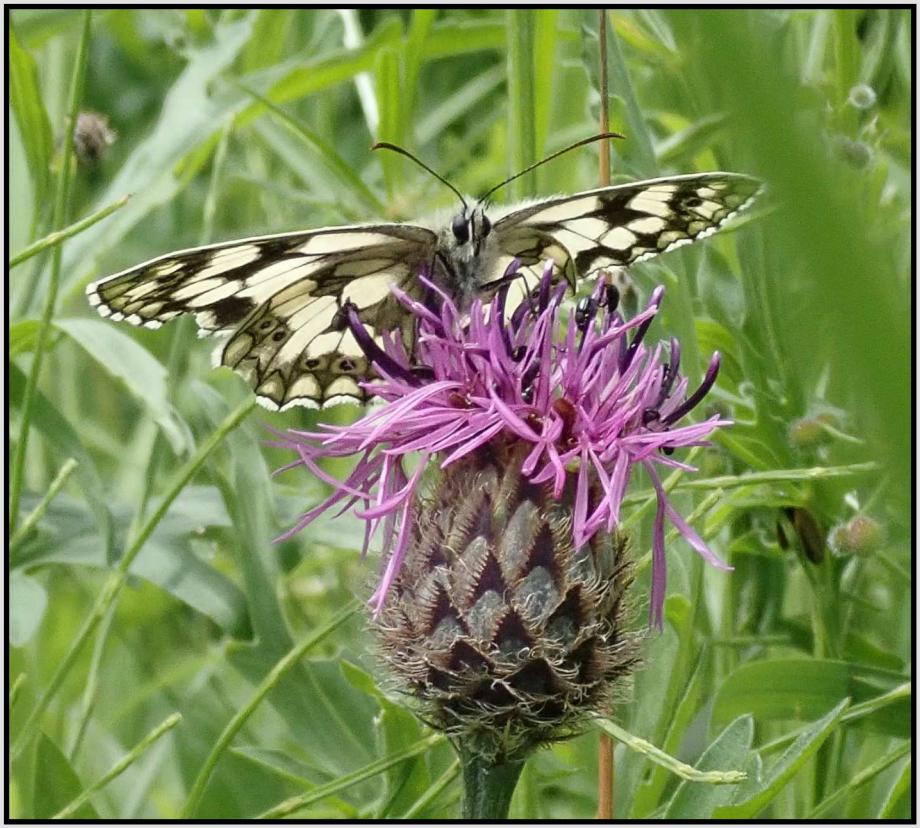


The ocelli of the House Spider





Index of scans



I hope some of this short book showed you something unique.

It would be great to hear from anyone interested in any of the scans.
Or anyone that would like to use them.
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