Flying-foxes are very visible visual bats

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If you have been close to flying foxes then you would agree that their eyes seem to be inquiring, even perhaps, penetrating, as they peer into your face. I don't think the same can be said about all animal eyes. Bandicoots and rabbits for example have eyes that can be described as 'vacant' or 'empty'. You know what I mean.... the lights are on but nobody's home. In terms of development, adaptation, and survival, it is impossible to separate the considerable astuteness of flying foxes from the high ability of their eyes.

Dim light or night darkness helps the close-up flying fox observer to sense the width and depth of the dark globes of flying fox eyes. By torchlight you can glimpse the large, black hole of the pupil of the eye which may occupy just about the whole diameter (about 1cm) of the front of the eye in the larger flying fox species. Too long under the torch beam and the pupil shrinks to just about pinprick size. The beam, and for that matter daylight, cause the fringe of tissue, the iris surrounding the pupil to constrict, reducing the pupil's diameter. The quick contraction of the iris cuts down the amount of excessive light entering the eye. By this means the flying fox very easily adapts visually to its daylight surrounds - usually the camp (daytime roost). In its responses the iris represents the sensitivity and finesse of the flying fox eye.

Dim light or night darkness bring the flying fox eye into its own. By shining a torch beam into the trees where flying-foxes are feeding and holding the torch level with your own eyes, you will see the pale yellow light of their eyes. The beam of light enters the flying fox eye, is reflected inside the eye and comes straight back to you through the flying fox's pupil. Although the flying fox will be interested in keeping its eyes on you, the beam will tend to create a blizzard of visual information for the flying fox so it is not likely to see you at distance and in the glare of the beam.

Eyeshine

Flying fox eyeshine is at least in essence similar to the eyeshine of other animals such as cats, cows, sheep and foxes. In those other animals, the reflective surface inside the eye allows the light sensitive part of the eye - the retina - two chances to read the message of the light. It does this once as the light first passes through the retina on the way to the back, inside wall of the eye, and then again courtesy of the rebound of the light off the specially reflective wall. The second pass reinforces the first. Normally at night the light would be moon- or starlight weakly illuminating some feature of the flying fox's surrounds. Except during periods of the fuller moon, there is only very dim light, but that is all the flying fox needs. Have you noticed how flying foxes stay at the camp and don't set off foraging at sunset if the evening and night are pitch black as a consequence of dense cloud cover? Doesn't happen often but heavy tropical storm clouds do interrupt foraging by blocking moon- and starlight. In other words, so reliant are flying foxes on their eyes that no light means hunger.

Strangely, although flying fox species such as the grey-headed and black (*Pteropus poliocephalus* and *P. alecto* respectively) show eyeshine, it is not clear in these species what the reflective machinery is. In any other animal like the cat the components are obvious under the microscope if not to the naked eye. The part of the eye responsible for the reflection is called the tapetum, a Latin word derived from the ancient Greek, tapes, meaning a small cover, carpet or tapestry. As a tapestry on the back inside wall of the cat's eye, the tapetum of course works like a mirror. In other species such as the Queensland blossom bat (*Syconycteris australis*) and the bare-backed fruit bat of far north Queensland and Papua New Guinea (*Dobsonia mollucense*) the tapetum is easily seen without the aid of a microscope. It leaves the question as to whether the grey-heads and the blacks (other Pteropus species too) reflect the light on the basis of some physical principle other than by the mirror-like arrangement of a tapetum. The really curious thing about flying fox eyes is the odd form of the surface of the back, inside wall. It is textured like a sound-proof recording studio wall. A surface of sharp bumps. Perhaps, this has something to do with light bounce off the back wall. It may also have a role in trapping the minuscule amount of nocturnal light with which the flying fox has to work. No other animal has this arrangement. All other animals, including nocturnal mammals and birds have simple, smooth walls. Why is this arrangement unique to flying foxes? The jury is still out. Let's know if you have any ideas.

Acuity

One piece of evidence pointing to the high sensitivity and finesse of flying fox sight does not await the jury. Thirty or so years ago the resolution capability, or the image-forming sharpness..... in a word the acuity of flying fox vision, was measured in dim light by a German scientist (Neuweiler). Of course the method involved no verbal communication between tester and tested. However, in principle the test is similar to the way our eyesight is checked using an eye chart. In equivalence terms, the flying fox had only the benefit of the light of a struck match and an eye chart positioned at its standard human checking distance of 20 feet or 6 metres. The upshot of the test was that flying fox visual acuity far and away exceeded ours. In bright light we beat the flying fox hands down because our eyes are primarily adapted to daytime light levels. In the frame of its own amazing lifestyle, including nocturnal flight, the flying fox has superb eyes working for it.

Two-eye analysis -texture, distance, shape

A powerful, and obvious measure of flying fox visual acuity is resident in the position of the eyes. In invoking again the image of bandicoots and rabbits, you will recall that their eyes are on the side of their head, and look to a great extent sideways and backwards. Bandicoot and rabbit vision is limited compared to the fine vision provided by frontally-positioned eyes such as in the cat, the monkey and us. The ability to bring both eyes into play when assembling information on the detail of an object of interest gives the brain receiving the information the chance to compare both sets of information and offer very fine, precise analyses of textures, distances and shape. It seems flying foxes are actually facilitating the two-eye analyses when they bob and sway from side to side. The kookooburra acts similarly when examining something of intense interest. By momentarily shifting eye positions in space, an overlap of the subtly different images formed by each eye allows assessment of depth of field and distance. Relative to bandicoots and rabbits, flying foxes have eyes to the fore. Furthermore, special arrangements are represented by identifiable patterns of populations of the eye's processing units (cells of the retina). These are based on this forward positioning. The patterns in the flying fox and the cat can, for most intents and purposes, be considered the same. Therefore, the visual ability of the flying fox compares very favourably with that of the cat.

Colour or black & white vision?

The psychological tests to check whether flying foxes see colours haven't been done. You might expect colour not to be an issue in the black and white world of the dimly lit night. Most of the traditional flying fox foods such as eucalypt blossoms range in colour from cream to white and so attract the flying fox eye by maximum reflection under moonlight. But as the larger species of flying foxes are quite adept at exploring and exploiting their realm during daylight when colours are best displayed, there may be a place for flying fox colour detection.

Light-sensitive cells of the eye of all mammals are generally and broadly divided into two groups - rods and cones. The rods are designed to catch as much light as possible and detect rapid movement. They are particularly useful for us say, in a darkened room or when attempting to catch a fleeting image of something fast moving and potentially threatening out of the corner of our eye. In us, cones serve to give the finest possible view of something of intense interest. Your'e working them hard right now as you read. In addition, cones sort out the primary colours. As rods and cones get their names from their shape when viewed under the microscope, they are fairly easily distinguished from each other. We have plenty of both types. Of course as expected, flying foxes have plenty of rods for night-light sensitivity. In fact, flying foxes have almost 100% rods. However, just every so often among the rods up crops a cell that does not look like a rod. It doesn't quite look like a cone either, but it looks closer to the normal cone than to the normal rod. It was referred to as a cone-like cell by the English scientists who first saw it (Pedler and Tilley). The presence of this cell, numerically inferior as it is, leaves open the question of colour processing in flying foxes. Could psychological tests detect colour recognition in flying foxes when the hardware is so likely to be very specialised?

Always more to know

While there is some knowledge on flying fox vision, like just about everything else there is a whole lot not known. For the reason of editorial constraint there are also some parts of the story that can't be squeezed in here. They certainly have a powerful visual system.