MAX PLANCK SOCIETY

Press Release

B 2003 (19) October 10th, 2003

Bats scan the rainforest with UV-eyes

German and Guatemalan researchers discover new mechanisms for ultraviolet vision in mammals

Bats from Central and South American that live on the nectar from flowers can see ultraviolet light (Nature, 9. October 2003 p. 612-614). This was discovered by York Winter, a German researcher at Munich University and the Max-Planck-Research Centre for Ornithology together with colleagues from Germany and the University of Guatemala. As bats generally lack cone pigments in their eyes, the flower bats capture the ultraviolet with the rhodopsin of their rod pigments. This mechanism was unknown in mammals until now. The researchers discovered this ability while keeping the bats in an environment with computer controlled artificial flowers equipped with small signal lights. Flower visiting bats seem to need UV-vision, because the flowers they visit in the rainforest are characterised by a strong reflection of UV-spectrum light at night. It remains open whether the unusually high UV-sensitivity found in these bats involves a further photo-mechanism that is as yet unknown for mammals.

Modern mammals lost their ability to see ultraviolet in the course of evolution, contrary to birds and lower vertebrates. Of the originally four cone pigments of ancestral vertebrates, the higher mammals have retained only two. Therefore, most mammals are dichromats and have an only limited colour resolution. Only the primates have regained a third cone pigment by gene duplication and hence, tri-chromatic vision with high colour resolution. In night-active bats the reduction of the visual system went even further: they lost functional cones altogether and retained only the rods as photoreceptors. Rods are also present in the human retina for black and white vision during low levels of light intensity. The ability for UV-vision in some other mammal species is due to one cone pigment.

There is only little light at night. But compared to daylight, the colour spectrum is shifted towards short, UV-wavelengths. The flowers that are pollinated by bats in the central and south American rainforest utilise this fact by having their petals strongly reflect UV radiation. But what does a mammal do, if the need for UV-vision arises again, but the necessary anatomical structure has been lost? The flower-visiting bats use their rod receptor for UV-perception and catch the UV-photons with the so-called beta-band of their photoreceptor, a peak of minor sensitivity for light absorption. In these mammals, therefore, only a single photoreceptor is responsible for the perception of light radiation over the whole wavelength spectrum from about 310 nm to 600 nanometres. Interestingly, bats achieve an absorption efficiency in the UV bandwidth of nearly 50 percent of their photoreceptors major peak of absorbance (alpha-band). This is nearly five times the value expected from in-vitro

Max Planck Society
for the Advancement of Science
Press and Public Relations Department

Hofgartenstraße 8
D-80539 Munich

PO Box 10 10 62
D-80084 Munich
E-mail: presse@mpg-gv.mpg.de
Internet: www.mpg.de

Responsibility for content:
Dr. Bernd Wirsing (-1276)

Executive Editor:
Dr. Andreas Trepte (-1238)

Biology, Medicine:
Dr. Christina Beck (-1306)

Chemistry, Physics, Technology:
Helmut Hornung (-1404)
Eugen Hintsches (-1257)

Humanities:
Susanne Beer (-1342)

Online-Editor:
Michael Frewin (-1273)

ISSN 0170-4656

measurements of beta-band absorption in rhodopsin molecules. Whether this indicate a novel mechanism for light perception in the bats eye that is still unknown for mammals remains open.

Fig.: *Nectar-feeding flower bat (Glossophaga soricina) at a bat-pollinated flower (Paliavana prasinata, Gesneriaceae) in the Caribbean rainforest. The tree-growing bromeliad projects its inflorescences into open space, where bats can easily approach. Every night for the duration of a month, the plant opens a single one of its white flowers. Bats lick the nectar from hovering flight and later the pollen attached to the fur on their head as protein supplement.*

Image: Max Planck Research Centre for Ornithology/York Winter

The researchers discovered that bats can see UV-light in so called psychophysical experiments that only involve behavioural observation. The animals learnt over several months in a computer-controlled artificial environment that only flowers with a small signal light will also give food. The researcher made use of the bats ability to react to the lit flowers by changing the wavelengths of the signal lights and varying their intensity. This showed that the bats could still see the signal lights on the flowers far into the UV range. All the same, bats are colour blind. Attempts to teach them colour discrimination remained unsuccessful.

Light receptors are less sensitive under bright light. The scientists used this fundamental property to investigate the cause for UV-sensitivity in bats. They immersed the artificial environment of the bats in a one colour, monochromatic background light. At the same time, the researchers reduced the intensity of the signal lights at the artificial flowers and were thus able to measure, at which light intensity the bats could still see the lights. This experiment was repeated with different background colours, so called adaptation lights. The results showed that independent of the colour of the background light the decreases of visual sensitivity of the animals was uniform over the whole spectrum of wavelengths. This is the case when only a single photoreceptor is active in the eye.

That bats can see ultraviolet is also due to the fact that a UV-filter is lacking from their eyes lenses. Normally, the UV-absorbing lens protects a mammals eye from UV-radiation. UV-light not only damages the retinal cells but it also causes an optical problem. The angle of light refraction depends on the wavelength of the light. A point of light is refracted at the lens, the refractive surface of the eye. As different wavelengths are refracted at different angles, a light of many colours such as one containing UV, will lead to an out-of-focus image on the retina of the eye. But the smaller the size of the eye, the less disturbing this effect will be. Thus UV-vision should only be expected in small, nocturnal mammals such

as the bats with their small, 2 mm eyes.

The search for UV-vision in mammals has so far mainly focused on specialised cone types. This new finding, which originated from research on the ability of animals to orient in space, now points in a new direction for those mammals not dependent on colour vision: They have the potential to utilise a fundamentally different mechanism.

Original work:

York Winter, Jorge López & Otto von Helversen
Ultraviolet vision in a bat
Nature, vol. 425, p. 612-614, 2003

Contact:

Dr. York Winter
Max Planck Research Centre for Ornithology, Seewiesen
Tel.: +49-8157-932-233 and +49-89-5902-284
E-mail: winter@mpi-seewiesen.mpg.de