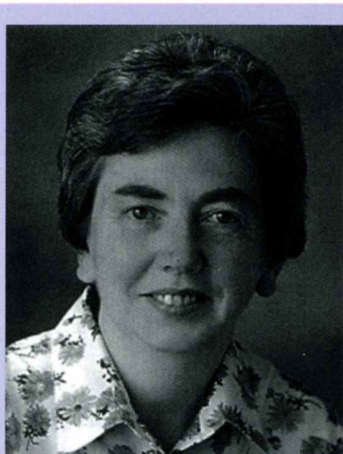
Lesley Goodman Award Public Lecture Series on Insect Vision

Sponsored by the Royal Entomological Society through the Lesley Goodman Award

- February 2007, London -



Lesley Goodman

Lesley Goodman read Zoology in Cambridge and did her PhD at the University of Liverpool. She later joined Queen Mary College in London where she devoted her professional life to encouraging the study of insect physiology and behaviour. One of her main research fields was the structure and function of insect ocelli. Prior to her death in 1998 she set up the LJ Goodman Insect Physiology Research Trust with the aims of "advancing the education of the public in the knowledge, understanding and appreciation of all aspects of insect physiology". Accordingly, the Goodman Award promotes research, exhibitions, meetings, lectures, and seminars in this area. Applications can be sent to the registrar of the Royal Entomological Society, London before 31st of January each year. Further information can be found on the internet pages of the Royal Entomological Society.

[1,2] *Thomas F. Döring* & [1] *Lars Chittka*

[1] *School of Biological and Chemical Sciences, Queen Mary University of London, Mile End Road, E1 4NS, London, UK*

[2] *Division of Biology, Imperial College London, Silwood Park, Ascot, SL5 7PY, UK*

In an entomologists' magazine it goes without saying that insects are fascinating creatures. Yet in a world where new entomologists don't grow on the trees it is always useful to spell out why exactly insects are so thrilling. Also, as entomologists recognize that the support for their matters, such as insect conservation, increasingly depends on well-coordinated public relations activities, they are on the look-out for attractive insect stories that easily grasp public attention.

One of the entomological fields that abound with such stories is insect vision. Research into the visual senses of insects has revealed surprising abilities of insects. For instance, it was found already in the 19th century that insects are able to see ultraviolet light (Lubbock 1882) and many can perceive the polarisation pattern of light. The dung beetle *Scarabaeus zambesianus* even uses polarised moonlight for orientation (Dacke et al. 2004). In order to bring these fascinating topics to the attention of a wider audience, we organised a public lecture series at Queen Mary, University of London earlier this year. The series was sponsored by the Lesley Goodman Award from the Royal Entomological Society (see box above).

In two of the talks, Almut Kelber from Lund University, Sweden, and Lars Chittka from London gave insights into what insects are able to do with their eyes. For example, many insects have four or even five types of colour receptors, where humans have only three – and we can only begin to understand what it is like to perceive colour in four or more dimensions (Briscoe & Chittka 2001). Even more surprisingly, some insect species can see colours by night. Under starlight illumination, the nocturnal hawkmoth *Deilephila elpenor* surpasses humans in colour discrimination tasks by far (Kelber et al. 2003). Or consider the fact that the butterfly *Papilio protenor* can "see" with its penis: on the male genitalia photoreceptors have been found that enable the males to perfect their copulatory posture (Arikawa 1993).

But apart from such arabesques, there are also more sober reasons why it is interesting to study insect vision – and potentially attracting public interest. For example, an important motivation for studying vision in insects is the potential for applications in electronics. In our lecture series, Claire Rind from Newcastle University related a case study in which locust vision was used to develop a collision avoidance system in cars. Flying in swarms of

Figure 1: A hoverfly with some pollen dust on the eyes. Photograph Simon Fellous.

millions of individuals, locusts are experts at avoiding collisions. Specialised neurons in the brain detect rapidly approaching objects and this information is used by the locust to evade approaching fellow locusts (or predators). These pathways have provided inspiration for an artificial collision avoidance system in Volvo cars (Yue et al. 2006). In an experiment which won her the IgNobel Prize, Claire Rind showed her locust a film clip from the Star Wars movie (Rind & Simmons 1992). The response of the specific collision neuron could be measured when the locust watched a rapidly approaching spacecraft.

Another motivation for studying insect vision is that it offers the possibility to improve and optimise pest regulation strategies in agriculture (Döring & Chittka 2007). In fact, for many agriculturally relevant insect species, vision plays a major role in locating food sources or mates. It is therefore possible to elegantly interfere with the vision-based behaviour of pest insects in order to guide them away from crop plants. These non-toxic ways of insect pest control include several strategies, e.g. the use of coloured traps, visually repelling mulches, or UV screens in greenhouses.

Besides these applied issues, the study of insect vision can also provide valuable insights into general neurobiology, and ultimately into our own behaviour and brains. Simon Laughlin from Cambridge University exemplified this with his lecture on speedy vision. Many insects, such as flies and wasps, can fly extremely fast. A consequence of this is that the internal images of the objects they are passing move very quickly across their retinas. The ability to cope with high speed images is usually measured by a flicker fusion frequency test, and in his lecture Professor Laughlin gave a lively demonstration of this test to the audience. Under non-experimental conditions, humans usually perceive light that flickers 50 times per second as a continuous light. Flies, however, can detect flicker that is about six times faster, 300 times per second. Such fast vision is of special importance for the males, when they are following fast flying females, but – as is well known to anyone who has ever tried to catch a fly – fast vision also allows timely evasion from approaching predators. Although insects have evolved the fastest animal vision known, not all insect species have fast vision. As Simon Laughlin pointed out, this is because "living in the fast lane is expensive". For example, in a fly the energy needed by the eye can make up 10% of the total metabolic energy consumption in the resting animal, and – in terms of energy – fast eyes are more expensive than slow ones. This observation has also improved the understanding of human brains, and the importance of energy consumption in the evolution of vision and brains (Niven et al. 2007).

The study of insect vision underlines how different organisms vary so greatly in their perception of the world. In the case of insects, this perspective has opened up worlds that are completely hidden to our own senses. In fact, one of the very reasons why scientists study insect vision seems to be that it is so magnificently alien. For example, flower-visiting bees can learn to associate any flower colour (including ultraviolet) with nectar reward, and despite their miniature brains, they can discriminate similar colours as well as humans. On the other hand, some tasks that are easy to solve for human observers are surprisingly difficult for bees. A white object presented on a green background, for example, is easy to detect for humans - but bees have a hard time solving this task.

As we have shown here, vision related topics are good candidates for entomological issues to be transported to the public. Also, insect vision as a research field certainly still promises many exciting and surprising facts to be discovered.

References

Arikawa, K. (1993) Valva-opening response induced by the light stimulation of the genital photoreceptors of male butterflies. *Naturwissenschaften* **80**: 326-328.

Briscoe, A.D. & Chittka, L. (2001) The evolution of color vision in insects. *Annual Review of Entomology* **46**: 471-510.

Dacke, M., Byrne, M.J., Scholtz, C.H. and Warrant, E.J. (2004) Lunar orientation in a beetle. *Proceedings of the Royal Society B* **271**: 361-365.

Döring, T. & Chittka, L. (2007) Visual ecology of aphids – a critical review on the role of colours in host finding. *Arthropod Plant Interactions* **1**: 3-16.

Kelber, A., Balkenius, A., and Warrant, E.J. (2003) Scotopic colour vision in nocturnal hawkmoths. *Nature* **419**: 922 - 925

Lubbock, J. (1882) Ants, Bees and Wasps: a record of observations on the habits of social Hymenoptera. London: Kegan Paul, Trench, Trubner, and Co.

Niven, J.E., Anderson, J.C. and Laughlin, S.B. (2007) Fly photoreceptors demonstrate energy-information trade-offs in neural coding. *PLoS Biology* **5**: e116.

Rind, F. C. and Simmons, P. J. (1992) Orthopteran DCMD neuron: a reevaluation of responses to moving objects. I. Selective responses to approaching objects. *Journal of Neurophysiology* **68**: 1654-1666.

Yue, S., Rind, F.C., Keil, M.S., Cuadri, J. and Stafford, R. (2006) A bio-inspired visual collision detection mechanism for cars: Optimisation of a model of a locust neuron to a novel environment. *Neurocomputing* 69: 1591-1598.

Primary School game is the 'Bees Knees'

Primary schools across the country will be buzzing with excitement this autumn thanks to an interactive, classroom game devised by RES entomologists to celebrate the upcoming DreamWorks Animation computer animated comedy *Bee Movie*.

The RES has teamed up with DreamWorks to produce a free teacher's resource which features characters and artwork from the forthcoming film. The game aims to educate primary pupils about bees and the important role they play in the eco-system. The resource, called 'Into the Hive', has been developed for Key Stage 1 and 2, and can be played with up to four teams in the classroom. With the teacher acting as the quiz master, children pick a character from the film and follow their path to make it back to the hive before the other teams, answering bee-related multiple choice questions along the way. The questions included in the game have been checked and approved by RES Bee scientists Dr Juliet Osborne and Dr Nigel Raine.