Structural color in insect eyes

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Many insect species have darkly colored eyes, but bright colors or patterns are frequently featured. A prominent example is formed by the eyes of tabanid flies, which are marked by distinct, metallic colours, due to multilayers in the corneal facet lenses. In the deer fly *Chrysops relictus* the facet lenses strongly reflect orange-green light. The multilayers thus reduce the orange-green light entering the photoreceptors. Fly eyes contain photoreceptors with various spectral sensitivities. Presumably the reduced orange-green transmission of the deer fly's facet lenses results in a narrowed sensitivity spectrum of those photoreceptors which have a green-absorbing visual pigment, thus presumably improving color discrimination. The horse fly *Haematopota fluvialis* has also clearly iridescent facet lenses, but the transmission reduction is only minor, which makes it unlikely that the multilayer structures function as spectral filters.

Extensive multilayers exist also in the compound eyes of butterflies. Tracheoles that supply the air for the respiratory needs of the photoreceptor cells are strongly folded into a multilayer structure, forming a so-called tapetum situated precisely beneath the visual waveguides that contain the visual pigment. This structure gives rise to the butterfly eye shine, which is observed by epi-illumination microscopy. Light that enters the eye is propagated in the visual waveguide until it is absorbed, but the light fraction that has escaped absorption is reflected by the tracheolar multilayer reflector, so that it has another chance of being absorbed. A small fraction of the reflected light leaves the eye again as the eye shine. The eye shine phenomenon has shown to be an important tool for unraveling the visual properties of butterfly eyes. Its coloration appears to be very characteristic for the butterfly species. Many species have very different eye shine colors in different eye regions, and the coloration is often heterogeneous. This is due to variation in the multilayer tapetum, but also to the presence of screening pigments that act as spectral filters. The eye shine shows that butterfly eyes have different degrees of complexity, which can be related to the evolution of butterflies from moths.