Eye regionalization and opsin gene duplication in butterflies: the dorsal region retains basic arrangement

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To clarify evolutionary relationship between gene duplication of visual pigment opsins and their functionalization, we studied the eye regionalization and opsin expression pattern in the eyes of butterflies. Unlike "typical" insects having a set of three opsins (ultraviolet- (UV), blue- (B) and long wavelength- absorbing (L) types), species of Papilionidae and Pieridae have multiple L and B opsins, respectively. Whether and how the newly acquired opsins modify the function of photoreceptors where the opsins are expressed is not well documented. Here we analyzed four species of butterflies (Papilionidae: *Papilio xuthus*, *Parnassius glaciais*, Pieridae: *Pieris rapae*, *Colias erate*) with particular attention to their eyes' dorso-ventral specialization. Clearly, the newly acquired opsins tend to be expressed only in the ventral region, whereas the dorsal region retained more ancestral traits like moths and nymphalids that have the basic set of three opsins. In the ventral region, some opsins are even co-expressed in single photoreceptors. The results suggest that the new opsins contribute to enrich the spectral property of the ventral region, probably for detecting flower colors, whereas the dorsal region has been exposed to a selective pressure suppressing the effect of duplicated opsins for retaining its basic function.