

# Evolutionary ecology of the visual opsin gene sequence and its expression in turbot (*Scophthalmus maximus*)

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## Abstract

Abstract As flatfish, turbot undergo metamorphosis as part of their life cycle. In the larval stage, turbot live at the ocean surface, but after metamorphosis they move to deeper water and turn to benthic life. Thus, the light environment differs greatly between life stages. The vision system plays a great role in organic evolution, but reports of the relationship between the visual system and benthic life are rare. In this study, branch- and branch-site models were implemented in the CODEML program within PAML4.9i to compare the selective constraints acting on the visual opsin genes of five flatfish species, including turbot and four freshwater species. Based on synteny and spectral tuning sites analyses, we demonstrated that RH2C may be an important subtype of green opsin gene that was retained by turbot and possibly other flatfish species during evolution. Moreover, E122Q and M207L substitutions in RH2C, which were found to be under positive selection, may contribute to the survival of turbot in the bluish colored ocean. Real-time PCR results suggested that heterochronic shifts in opsin expression may be an important strategy for turbot to adapt to benthic life. Finally, turbot exhibited a bounded plasticity of opsin expression in response to different photic environments, which seems to be a mechanism for rapid adaption to changing environmental light. Keywords: turbot, benthic life, adaption, opsin, heterochronic shift, plasticity

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