Ancestral duplications and highly dynamic opsin gene evolution in percomorph fishes

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Single-gene and whole-genome duplications are important evolutionary mechanisms that contribute to biological diversification by launching new genetic raw material. For example, the evolution of animal vision is tightly linked to the expansion of the opsin gene family encoding light-absorbing visual pigments. In teleost fishes, the most species-rich vertebrate group, opsins are particularly diverse and key to the successful colonization of habitats ranging from the bioluminescence-biased but basically dark deep sea to clear mountain streams. In this study, we report a previously unnoticed duplication of the violet-blue short wavelength-sensitive 2 (SWS2) opsin, which coincides with the radiation of highly diverse percomorph fishes, permitting us to reinterpret the evolution of this gene family. The inspection of close to 100 fish genomes revealed that, triggered by frequent gene conversion between duplicates, the evolutionary history of SWS2 is rather complex and difficult to predict. Coincidentally, we also report potential cases of gene resurrection in vertebrate opsins, whereby pseudogenized genes were found to convert with their functional paralogs. We then identify multiple novel amino acid substitutions that are likely to have contributed to the adaptive differentiation between SWS2 copies. Finally, using the dusky dottyback Pseudochromis fuscus, we show that the newly discovered SWS2A duplicates can contribute to visual adaptation in two ways: by gaining sensitivities to different wavelengths of light and by being differentially expressed between ontogenetic stages. Thus, our study highlights the importance of comparative approaches in gaining a comprehensive view of the dynamics underlying gene family evolution and ultimately, animal diversification.
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