Researchers solve puzzle of origin and formation of specialized body plan in flatfishes

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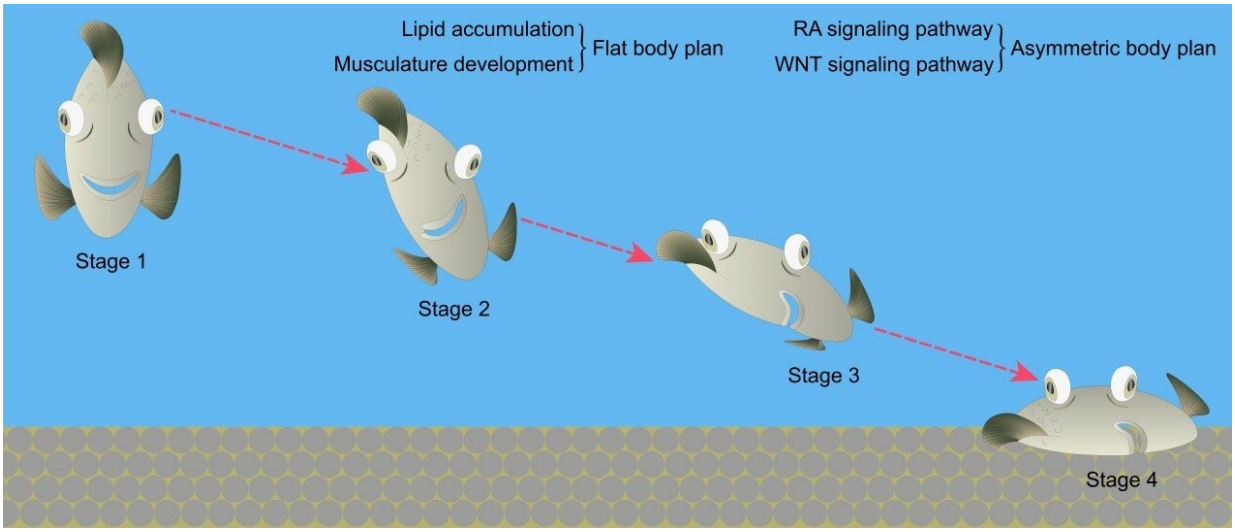

The metamorphosis process of flatfishes. Credit: Dr. LI Yongxin

The colonization of the seafloor is one of the most important events in evolutionary history, leading to an explosive radiation and large-scale morphological diversification of marine phyla. Flatfishes are one of the most successful groups of seafloor colonizers and have evolved the most specialized body plan (i.e., flat and asymmetrical) among the teleosts. However, the origin and formation mechanism of the peculiar morphology of flatfishes had long been unclear.

Now, researchers from the Kunming Institute of Zoology of the Chinese Academy of Sciences (CAS), the South China Sea Institute of Oceanology of CAS, the Institute of Hydrobiology of CAS, Zhejiang Ocean University and Northwestern Polytechnical University, have unraveled the evolutionary and genetic origins of the specialized body plan of flatfishes through comparative genomic analysis. The study was published in *Nature Genetics*.

By analyzing ten de novo-assembled genomes and eight already-published genome sequences from teleost species, the researchers found that Pleuronectoidei and Psettodoidei (the only two suborders of Pleuronectiformes) do not form a monophyletic group, indicating that they each descended independently from their percoid ancestors.

Several genes related to visual perception, immune response, hypoxia tolerance and cardiac function were found to have experienced significant alteration in flatfishes, possibly suggesting a similar remodeling of their visual, immune, respiratory and circulatory systems in benthic adaptation to seafloor colonization.

Genes associated with musculature development and lipid accumulation were also found to have experienced marked changes. Experiments on one fat-related gene showed fast lipid oxidization and decreased fat accumulation in flatfish and thus may correlate with the evolutionary origin and development of flatfishes' flat body plan.

Wnt and retinoic acid (RA) signal pathways have been found to play key roles in normal body axis development. The researchers also found that multiple genes from these pathways have undergone remarkable genetic alteration in flatfishes, suggesting they play a role in the evolution of an asymmetric body plan.

To find gene evolution and expression evidence, the researchers studied

Paralichthys olivaceus as a representative species. They found that multiple genes in both RA and Wnt signaling pathways exhibited obvious transient expression fluctuations during metamorphosis, which include marked left-right asymmetrical expression beginning with the pre-metamorphic stage, climbing to an asymmetrical climax during the pro-metamorphic and metamorphic climax stage and then recovering to symmetry in the post-metamorphic stage.

The findings of this study substantially clarify the long-standing controversy (i.e., monophyletic origin vs. non-monophyletic origin) over the phylogeny of flatfishes. At the same time, the genes highlighted in this study offer a blueprint for future functional characterization of the molecular mechanisms underlying the unusual body plan of flatfishes.

More information: Zhenming Lü et al, Large-scale sequencing of flatfish genomes provides insights into the polyphyletic origin of their specialized body plan, *Nature Genetics* (2021). DOI: 10.1038/s41588-021-00836-9

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