Content archived on 2024-05-27

The interaction and the genetic basis of naturally versus sexually selected traits in the adaptive radiations of cichlid fishes

Reporting

Project Information

INTERGENADAPT

Grant agreement ID: 201067

Project closed

Start date
1 August 2008

End date
31 July 2013

Funded under
Specific programme: "Ideas" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013)

Total cost
€ 750 000,00

EU contribution
€ 750 000,00

Coordinated by
UNIVERSITAT BASEL
Switzerland

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Final Report Summary - INTERGENADAPT (The interaction and the genetic basis of naturally versus sexually selected traits in the adaptive radiations of cichlid fishes)

More than one and a half centuries after the publication of Charles R. Darwin’s The Origin of Species, the identification of the processes governing the emergence of novel species remains a fundamental question to biology. Why is it that some groups have diversified in a seemingly explosive manner, while other lineages have remained unvaried over millions of years? What are the external factors and environmental conditions that promote diversification? And what is the molecular basis of adaptation, evolutionary innovation and diversification? A key to these and related questions is the comparative study of exceptionally diverse yet relatively young species assemblages that have radiated in geographically well-defined areas, such as the Darwin’s finches on the Galapagos archipelago, the Caribbean Anoles lizards or the cichlid fishes in the Great Lakes of East Africa. Lakes Tanganyika, Malawi, and Victoria are each teeming with a unique set of hundreds of endemic cichlid species, which are likely to have evolved in the last few millions to several thousands of years only. East Africa’s cichlid species differ greatly in ecologically relevant, hence naturally selected, characters such as mouth morphology and body shape, but also in sexually selected traits such as coloration. One of the most fascinating aspects of cichlid evolution is the frequent occurrence of evolutionary parallelisms, which has led to the question whether selection alone is sufficient to produce these parallel morphologies, or whether a developmental or genetic bias has influenced the direction of diversification. In this project, we examined in detail three particular characters of cichlid fishes, (i) thick lips that evolved independently in different cichlid assemblages; (ii) the highly adaptable pharyngeal jaw apparatus; and (iii) egg-dummies on the anal fins of male haplochromines, which play an important role in the breeding cycle of these mouthbrooding fishes. We were primarily interested in the molecular and developmental basis of these traits and the questions whether the same developmental and genetic pathways are involved in the origin of evolutionary parallelisms in cichlid radiations. By examining the cichlid species-flock of Lake Tanganyika, we first discovered that convergent evolution in body and jaw morphology occurs frequently within a cichlid adaptive radiation and that convergent forms often occur together in the same habitat. This is at odds with the at odds with the prevailing assumption that two similar forms cannot co-exist in nature (competitive exclusion principle). We then showed that convergent morphologies often involve the action of similar sets of genes. For example, the two thick-lipped cichlids from Central America and East Africa, respectively, show similar signatures of gene expression in their lips. With regard to the egg-spot phenotype, we found that the insertion of a transposable element upstream of an androgen-receptor co-factor was causally related with the emergence of this trait, which is characteristic for the most derived and species-rich lineage of cichlids, the haplochromines. Together, we provide exciting new insights into the mechanisms underlying evolutionary innovation and diversification and, once more, show that the adaptive radiations of cichlid fishes in East Africa are an ideal model system in evolutionary biology.

Last update: 8 March 2016

Permalink: https://cordis.europa.eu/project/id/201067/reporting