Evolutionary origins of complex ecological adaptations

Berichterstattung

Projektinformationen

ComplEvol

ID Finanzhilfevereinbarung: 638333

Projektwebsite

DOI
10.3030/638333

Projekt abgeschlossen

EK-Unterschriftsdatum
27 Mai 2015

Startdatum
1 Juni 2015

Enddatum
31 Mai 2020

Finanziert unter
EXCELLENT SCIENCE - European Research Council (ERC)

Gesamtkosten
€ 1 498 275,00

EU-Beitrag
€ 1 498 275,00

Koordiniert durch
THE UNIVERSITY OF SHEFFIELD
United Kingdom

Periodic Reporting for period 4 - ComplEvol (Evolutionary origins of complex ecological adaptations)

Berichtszeitraum: 2019-12-01 bis 2020-05-31

Zusammenfassung vom Kontext und den Gesamtzielen des Projekts

During evolution, organisms adapt to diverse environmental conditions by evolving new morphological and/or biochemical traits, some of which are of impressive complexity. This is for example the case of eyes, wings or complex biochemical pathways, which all involve multiple components. The evolution of such complex traits has always intrigued evolutionary biologists, including Charles Darwin, and is still only partially understood. How can natural selection on random mutations lead over time to novel complex ecological adaptations that allow organisms to thrive in diverse environments?

This question was addressed in this project by studying a species complex that presents exceptional variation in a key ecological adaptation, namely C4 photosynthesis. This trait results from multiple anatomical and biochemical components that function together to increase plant productivity in warm, high light environments. Capitalizing on a species complex of grasses that includes C4 as well as the ancestral C3 photosynthetic types and multiple intermediate states, the project combines methods from different fields to infer (i) the history of mutations that generated components for C4 photosynthesis during the dispersal into different ecological conditions, (ii) the factors controlling the spread of these mutations among populations, (iii) the effects of these mutations on the properties of the encoded C4 enzymes, (iv) the effects of different anatomical and biochemical C4 components on the performance of the plants (fundamental niche), and (v) the relationships between these components and the distribution of individuals in contrasted environments (realised niche).

Arbeit, die ab Beginn des Projekts bis zum Ende des durch den Bericht erfassten Berichtszeitraums geleistet wurde, und die wichtigsten bis dahin erzielten Ergebnisse

A large collection of Alloteropsis semialata accessions was assembled through repeated field trips, collaborations with colleagues abroad, and using museum collections. These accessions have been genotyped, using genome sequencing, genomic scans and transcriptome sequencing, and phenotyped at the biochemistry, anatomy and physiology levels.

Our investigations have revealed an outstanding diversity of photosynthetic types within the grass Alloteropsis semialata. We have shown that mutations for C4 traits appeared in distinct populations after geographical isolation. Depiction of the phenotype revealed that the initial C4 trait could be reached via relatively few anatomical and biochemical modifications, and many of the properties classically associated to C4 photosynthesis evolved later, during a phase of secondary adaptation. Genetic exchanges following secondary contacts among previously isolated populations allowed mixing of C4 secondary adaptations, assembling a more complex version of the C4 trait. The adaptation of C4 photosynthesis was moreover fuelled by introgression from closely related species but also lateral gene transfer from distinct species. These processes, which happened recurrently during the geographical spread of the species, generated a large spectrum of photosynthetic variants, which successfully colonized many habitats. We conclude that frequent hybridization can boost the functional diversification of complex traits of ecological importance.

Fortschritte, die über den aktuellen Stand der Technik hinausgehen und voraussichtliche potenzielle Auswirkungen (einschließlich der bis dato erzielten sozioökonomischen

Auswirkungen und weiter gefassten gesellschaftlichen Auswirkungen des Projekts)

Our investigations have shown that the early origins of C4 photosynthesis required relatively few anatomical and biochemical changes, with most properties frequently observed in C4 plants corresponding to secondary adaptations of the C4 machinery. We have further identified an unprecedented level of interspecific genetic exchanges, with large DNA blocks recurrently spreading functional DNA among distantly related grasses and providing shortcuts to biochemical adaptation. Finally, we have shown that the phylogeographic history and intraspecific dynamics of genetic exchanges play an important role in building a diversity of complex traits.

Alloteropsis semialata growing in a grassland in Zambia

Letzte Aktualisierung: 1 April 2024

Permalink: https://cordis.europa.eu/project/id/638333/reporting/de