7 June 21

Plasticity in Plants depends on adaption to ecology

Role of plasticity as a support for future adaptation depends on specific challenges species have to face as they evolve their specialized ecology / Cologne based research team gather data for first atlas of the evolution of gene expression response to stress in plants

An international group of researchers have found out that the ability of certains plants to adapt to future environmental challenges by altering their physiology, which is called plasticity, is not predefined, but will always depend on the specific challenges species have to face as they evolve their specialized ecology. The scientists studied the Arabidopsis thaliana compared to two of its close relatives, A. lyrata and A. halleri, before and during exposure to severe drought stress.

Following an approach pioneered in the de Meaux lab, the scientists characterized the plasticity and evolution of the expression of tens of thousands of genes. This large set of observations provided the group with the unique opportunity to study the rules that governed the evolution of plasticity in this system. The authors could evaluate the number of mutations that evolved in the A. lyrata and A. halleri lineages to increase or decrease gene expression plasticity. Their results show that this rate changes between species. In the drought tolerant species A. lyrata, they detect many more mutations promoting the evolution of a stronger plastic reaction than in its sister species A. halleri, which has more difficulties to survive the stress.

The study by the laboratory of Juliette de Meaux, from the Institute of Plant Sciences, and Andreas Beyer, CECAD, Dr. Kim Steige and Dr. Fei He is released today in Nature Communications.

All living organisms have the ability to alter their physiology or even their development in response to the environment. This phenomenon, which is called plasticity, can be very important for the survival of organisms exposed to adverse environments, such as the exposure to severe drought or cold. Plasticity represents a potential, the potential to create an organism that is able to face the challenge of a different environment. If evolution could exploit this potential and use plasticity as a stepping stone, new and more fit organisms could evolve more rapidly and adaptation to new environments could happen much faster.

The viewpoint that plasticity might be a stepping stone for evolving new abilities has historical roots in Evolutionary Biology. However, how often this happens has remained debated. Not everyone believed plasticity would be helpful. Indeed, it has been argued that plasticity is only beneficial in a very narrow set of conditions and will be disadvantageous in most new environments. If it is disadvantageous, plasticity will be predominantly lost during adaptation.

The scientists present data that, for the first time, allows evaluating whether plasticity supports adaptation in complex multicellular organisms. There, they compared the well-known model plant species Arabidopsis thaliana to two of its close relatives: A. lyrata and A. halleri, before and during exposure to severe drought stress. Using high throughput sequencing strategies on these species that differ in their reaction to the stress, they characterized the plasticity and evolution of the expression of tens of thousands of genes. This large set of observations provided the group with the unique opportunity to study the rules that governed the evolution of plasticity in this system. Their data reveals that the evolution of gene expression is tightly related to pre-existing plasticity. With an approach implemented in their experiment, which has been pioneered in the de Meaux lab, the authors could evaluate the number of mutations that evolved in the A. lyrata and A. halleri lineages to increase or decrease gene expression plasticity. Their results show that this rate changes between species. In the drought tolerant species A. lyrata, they detect many more mutations promoting the evolution of a stronger plastic reaction than in its sister species A. halleri, which has more difficulties to survive the stress. Using a population genetics approach, which they implemented in collaboration with Peter Keightley, University of Edinburgh, they observed that new amino-acid variants in these genes are maintained at lower frequency in A. lyrata than they are in A. thaliana, confirming that those genes which evolved increased plasticity in this lineage are indeed exposed to stronger selection.

„This work documents the dynamic evolution of plasticity in complex organisms that are confronted with environmental changes“, explains Professor de Meaux. „It shows however that its role as a support for future adaptation is not predefined, but will always depend on the specific challenges species have to face as they evolve their specialized ecology. This first atlas of the evolution of gene expression response to stress in plants will also hopefully provide a valuable resource assisting in the development of drought tolerant plants in CEPLAS (Cluster of Excellence on Plant Science).“

Inhaltlicher Kontakt:

Professor Dr. Juliette de Meaux

Institute of Plant Science

+49 221 4708213

jdemeaux@uni-koeln.de

Presse und Kommunikation:

Robert Hahn

+49 221 470-2396

r.hahn@verw.uni-koeln.de

Zur Publikation:

https://dx.doi.org/10.1038/s41467-021-23558-2

Verantwortlich: Dr. Patrick Honecker MBA – patrick.honecker@uni-koeln.de