*Nature Reviews Genetics* | AOP, published online 11 September 2013; doi:10.1038/nrg3576


EVOLUTIONARY GENETICS

# A complex case of resource management

> the genetic basis of what might seem like simple trade-offs in life-history traits can in fact be complicated

As any parent knows, reproduction is costly: it involves using resources that could be put to other purposes. Trade-offs in resource allocation are well established as having important roles in the evolution of life-history traits, but the details of the underlying genetics are poorly understood. A new study now suggests that these trade-offs do not result from simple switches in allocation of resources between reproduction and somatic development, but rather from more complex genetic mechanisms.

The perennial plant *Arabidopsis lyrata* grows in diverse environments across different continents. Genetics analysis in this non-model species benefits from its sequenced genome and the fact that it is a close relative of the laboratory favourite *Arabidopsis thaliana*. Remington and colleagues carried out reciprocal transplantation studies, in which *A. lyrata* plants from different populations were grown in two sites: one in North America and one in Norway. When planted in the North American site, plants from two of the populations — one from North America and one from Norway — showed particularly large differences in resource allocation. A local North American population allocated more resources to reproduction, whereas a Norwegian population put more resources into somatic growth, suggesting local adaptation in both cases. $F_2$ offspring from a cross between these two populations showed intermediate phenotypes. Principal components analysis suggested that there is a trade-off in these populations between reproduction and vegetative growth, and this seems to have a genetic basis.

The authors next carried out quantitative trait locus (QTL) mapping using the $F_2$ progeny of the Norwegian and North American populations. They identified five QTLs that affected resource allocation, each of which had contrasting effects on reproduction and vegetative growth. As predicted, alleles from the North American population resulted in more resources being allocated to reproduction, which is consistent with local adaptation. Interestingly, rather than directly affecting flowering, as might be expected in a simple model, each of the five alleles affected aspects of pre-flowering development, and each did so by different mechanisms. The authors used an approach called structural equation modelling to evaluate various models for how the effects of the QTLs could explain the resource allocation differences. This modelling suggested that differences in early vegetative growth are the most important factor, with these effects being transmitted through developmental networks to affect vegetative and reproductive growth at later stages.

Finally, when the populations were transplanted to the Norwegian site, these resource allocation trade-offs were no longer seen. This finding suggests that interactions between genes and the environment are important in local adaptation.

This study reveals that the genetic basis of what might seem like simple trade-offs in life-history traits can in fact be complicated. It also illustrates the necessity of genetic studies in naturally occurring populations and in ecologically relevant conditions to investigate the basis of adaptation.

*Louisa Flintoft*

**ORIGINAL RESEARCH PAPER** Remington, D. L. *et al.* Complex genetic effects on early vegetative development shape resource allocation differences between *Arabidopsis lyrata* populations. *Genetics* http://dx.doi.org/10.1534/genetics.113.151803 (2013)
**FURTHER READING** Roff, D. A. Contributions of genomics to life-history theory. *Nature Rev. Genet.* **8**, 116–125 (2007)



© 2013 Macmillan Publishers Limited. All rights reserved