

How disturbance affects the establishment of new polyploid plant species

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March 2019

1 Summary

Polyploidisation is thought to be fundamental in the diversification of plant species. Both mutation and hybridisation that leads to additional sets of chromosomes (polyploidy) are commonplace in plant taxa, having occurred in almost all lineages. While polyploids have been studied for over a century, the factors that drive the success of their establishment in the face of reproductive disadvantages and high extinction rates are still unclear. Polyploids are often recorded in recently disturbed locations but disentangling the other processes at play in natural environments has proved difficult. This research will contribute to answering a classic problem of plant biology as well as providing insight for the fields of forensics and conservation.

2 Background

Polyploidisation is thought to be fundamental in the diversification of plant species. Plants have an extremely high tolerance for polyploidy and it is a ubiquitous feature in the lineages of most plant taxa. Furthermore, polyploidisation often causes saltational speciation and is found to coincide with a large proportion of speciation events ([Wood et al., 2009](#)). However, studies on the extinction rates of polyploids propose that many of these new lines are evolutionary dead ends that tend to become extinct at the establishment phase due to reproductive disadvantages ([Arrigo and Barker, 2012](#)). Therefore, understanding demographics at the establishment phase is critical to predicting polyploidisation of plant species. Reproductive disadvantages include lack of mates, diploid pollen swamping, and triploid sterility. There are benefits, however, which may offset these costs. Polyploids are frequently linked with distinct traits such as; “gigas effects” which increase plant organs; reversal of selfing inhibition; enhanced capabilities for buffering of deleterious mutation (due to increased heterozygosity); and hybrid vigour (heterosis) ([Woodhouse et al., 2009](#); [Ramsey and Ramsey, 2014](#)). All of which are thought to counteract the reproductive disadvantages of polyploidy and instead make this mutation key to the invasive and adaptive potential of plants.

Despite the long-term study of polyploidy in plant taxa, fundamental questions regarding demographic establishment and mediation of adaptation to new environments are yet to be understood.

Polyploids can be organised into two broad groups: autopolyploid/allopolyploid. Autopolyploids arise mitotically via genome duplication events during gametogenesis in selfing individuals, whereas allopolyploids arise meiotically from unreduced gametes via hybridization of sexually reproducing individuals. In natural populations, both types of polyploid maintain distinct spatial distributions relative to progenitors and other diploids, suggesting the importance of polyploidy as a mechanism of ecological divergence. However, recent niche modelling has not supported this theory and proposes that glacial retreat and environmental disturbance may be more influential ([Godsoe et al., 2013](#)). This study will focus on disturbance as a predictive factor of polyploid establishment.

3 Issue

While polyploids have been studied for over a century, the factors that drive the success of their establishment in the face of reproductive disadvantages and high extinction rates are still unclear. Polyploids are often recorded in recently disturbed locations but disentangling the other processes at play in natural environments has proved difficult (Ramsey and Ramsey, 2014). Due—in part—to lack of predictive power with regard to demographics of polyploids, population assignment of these taxa is especially difficult. Elucidating the effect of disturbance on the distribution of polyploids could, therefore, have great importance to those in both forensics and conservation (Field et al., 2017).

4 The Research Question

How does disturbance on a landscape affect the establishment of new polyploid plant species?

4.1 Methodology

This study aims to determine how environmental disturbance effects polyploid distribution by means of an individual based model (IBM), a method which has not yet been applied to this classic problem of plant biology. IBMs model discrete individuals with varied traits and simulate a given process so that resulting patterns can be analysed. The model we will create will simulate plant diversification via polyploidisation over time. Disturbance level of the landscape will be manipulated so that patterns of ploidy across the simulated landscape can be analysed in relation to disturbance. This will test how important disturbance really is for predicting polyploid distribution.

4.2 Results

Results from the model will be analysed and written up as a report. The model itself will be published as an R package which will provide functions that users can utilise to manipulate and run their own simulations.

Is it suitable for CRAN?

If appropriate a poster session and/or interactive web app may also be output.

I think I'd like to include this for Carnegie as theirs is 12 weeks.

References

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