International Oaks

The Journal of the International Oak Society

Proceedings

8th International Oak Society Conference

October 18-21, 2015

Issue No. 27/ 2016 / ISSN 1941-2061

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International Oak Society Officers and Board of Directors 2015-2018

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Cover illustration. Wendy Brockman (*Quercus palustris*).
Photos. p. 9: James MacEwen (Michael Heathcoat Amory); p. 10: Guy Sternberg (8th International Oak Society Conference participants); p. 11: Charles Snyers d'Attenhoven (*Quercus stellata*); p. 13: Béatrice Chassé (*Q.* ×*fernowii*).

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***Quercus bicolor* at Starhill Forest Arboretum (Charles Snyers d'Attenhoven).**

Best Under Stress: Does An Episodic Hybrid Advantage Suppress Reproductive Barriers in Oaks?

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The effects of hybridization in oaks (*Quercus*) are poorly understood. Even among allopatric species, intrinsic reproductive barriers appear weak. Why have these barriers not arisen despite millions of years of separation? We hypothesize that, under episodic climate stress, hybrids have a periodic advantage that suppresses the development of intrinsic reproductive barriers, resulting in a highly conserved genomic architecture among interacting species. This conservation preserves a general oak "lineage pool" which allows species to emerge, split, and fuse according to changes in long-term climate trends.

Given that selection is most intense in seedlings, we will determine the relative fitness of hybrid and parental seedlings under drought, flooding, and permissive conditions. We will also use genetic mapping with ddRADtags to infer their genomic architecture. We have used 18 EST-SSR markers (mapped in *Q. robur* L.) to identify the parentage of the progeny of two F_1 hybrids. We have genotyped 256 germinated progeny, 70 progeny that failed to germinate, and all potential pollen parents within 500 m (including *Q.* ×*warei* Green & Hess, *Q.* ×*schuettei* Trel., *Q. robur, Q. bicolor* Willd., and five other species). We inferred parentage using CERVUS. Parentage assignment was successful with positive LOD scores for 167 progeny. Our analysis indicates that most progeny are backcrosses to *Q. robur*. Starting fresh in Fall 2015, we have collected thousands of acorns to be used in a four-year study to test our hypothesis of a periodic hybrid advantage under climate stress. We expect these data to help us understand why oaks, and other forest trees, have not developed strong reproductive barriers over millions of years of ecological speciation.

Best Under Stress: Does An Episodic Hybrid Advantage Suppress Reproductive Barriers in Oaks?

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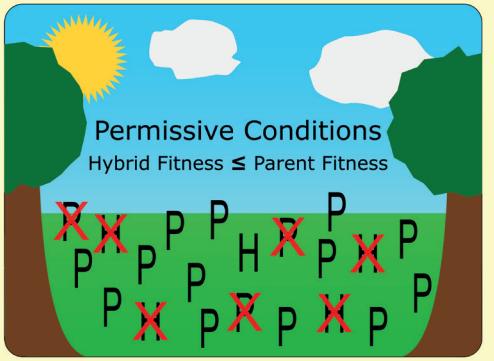
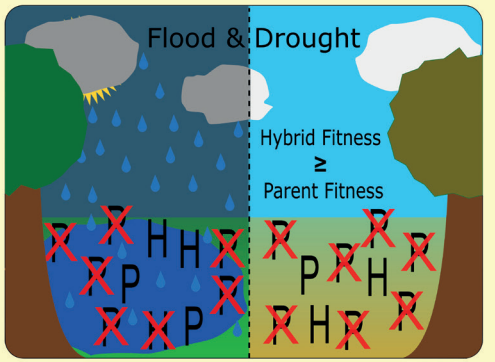
Introduction:

The effects of hybridization in oaks (Quercus) are poorly understood. Even among geographically separated species, intrinsic reproductive barriers appear weak. Why have these barriers not arisen despite millions of years of separation? We hypothesize that, under episodic climate stress, hybrids have a periodic advantage which suppresses the development of intrinsic reproductive barriers, resulting in a highly conserved genomic architecture among interacting species. This conservation preserves a general oak "lineage pool" which allows species to emerge, split, and fuse according to changes in long term climate trends.

Our study focuses on examining the progeny of two F_1 hybrid crosses, *Q.* ×*warei* (*Q. bicolor* × *Q. robur*) and *Q.* ×*schuettei* (*Q. bicolor* × *Q. macrocarpa*) located on the University of Missouri campus. We will evaluate the relative fitness of hybrid and parental seedlings under drought, flooding, and permissive conditions. Many of the F_1 hybrids are more stress tolerant than either parent species. We will also analyze their genetic architecture and search for novel gene combinations. We expect these data to help us understand why oaks





Results & Conclusions:

- One *Q. robur* is the predominant pollinator for the *Q.* ×*warei* with the highest seed set
- These backcrossed progeny enable us to leverage the *Q. robur* genome sequence and will generate enough progeny for phenotypic testing
- The other *Q.* ×*warei* has a variety of pollinators, but a low seed set (likely due to its geographic placement between two tall buildings)
- There does not appear to be any difference in pollinator for acorns that germinate and acorns that fail to germinate
- Our parentage analysis shows that we have enough statistical power to study the mechanisms that sustain weak species boundaries in oaks.

and many other forest tree taxa have not developed strong reproductive barriers over millions of years of ecological speciation.

Hypotheses:

1. F_1 hybrid seedlings will survive severe abiotic stress better than parental species.
2. Under permissive conditions hybrid seedlings will have little or no survival advantage.
3. Genomic architecture will be highly conserved across sympatric species pools.
4. Conserved genomic architecture will persist even under allopatric speciation.

P = Parent Species Seedlings
H = Hybrid Seedlings
X = Deceased

Materials and Methods:

Collect Acorns from Hybrid Trees

↓

Detect the pollen parent using 18 EST-SSR markers from *Q. robur*

↓

Subject groups of hybrid and parent species seedlings to stress tests (drought, flooding)

↓

Collect Phenotypic data (Survival, growth metrics)

↓

Use high throughput sequencing of genetic markers (ddRADtags) for parents and progeny

↓

Construct genetic maps

↓

Assess genomic architecture in both hybrid and parent species

↓

Locate novel combinations of stress resistant/tolerant genes using QTL analysis and the *Q. robur* genome

Acknowledgements:

The authors would like to thank Arpita Konar, Andi Noakes, and Lauren Fiedler for their sacrifices of time and supplies to support this project. WC acknowledges support from the National Science Foundation through a Graduate Research Fellowship (DGE-1313583). WC thanks his advisor JRS for her time and constant mentoring to help him become a better scientist and human citizen. He also thanks his wife for her patience with not seeing him much recently, as well as his mother for instilling in him a love for the outdoors and encouraging him to reach his lofty goals.

Table 1: Pollen Parentage Assignment
The distribution of pollen parents for two different *Q.* ×*warei* for acorns that either germinated or failed to germinate in 2014.

Q. ×*warei* #3	Pollen Parent	Number Pollinated	Putative Species
TOTAL	22082	132	*Q. robur fastigiata*
	22080	15	*Q. robur fastigiata*
	22133	1	*Q.* ×*warei*
	22091	1	*Q. bicolor*
GERMINATED	22082	86	*Q. robur fastigiata*
	22080	10	*Q. robur fastigiata*
	22133	1	*Q.* ×*warei*
FAILED TO GERMINATE	22082	46	*Q. robur fastigiata*
	22080	5	*Q. robur fastigiata*
	22091	1	*Q. bicolor*

Q. ×*warei* #2	Pollen Parent	Number Pollinated	Putative Species
GERMINATED	22133	7	*Q.* ×*warei*
	22127	3	*Q. lyrata*
	22112	3	*Q. robur*
	22098	2	*Q. bicolor*
	22100	1	*Q.* ×*jackiana*
	22104	1	*Q. bicolor*
	22122	1	*Q. macrocarpa*