Genetic Control of Pericarp Strength and the Role of Genomic Structural Variants

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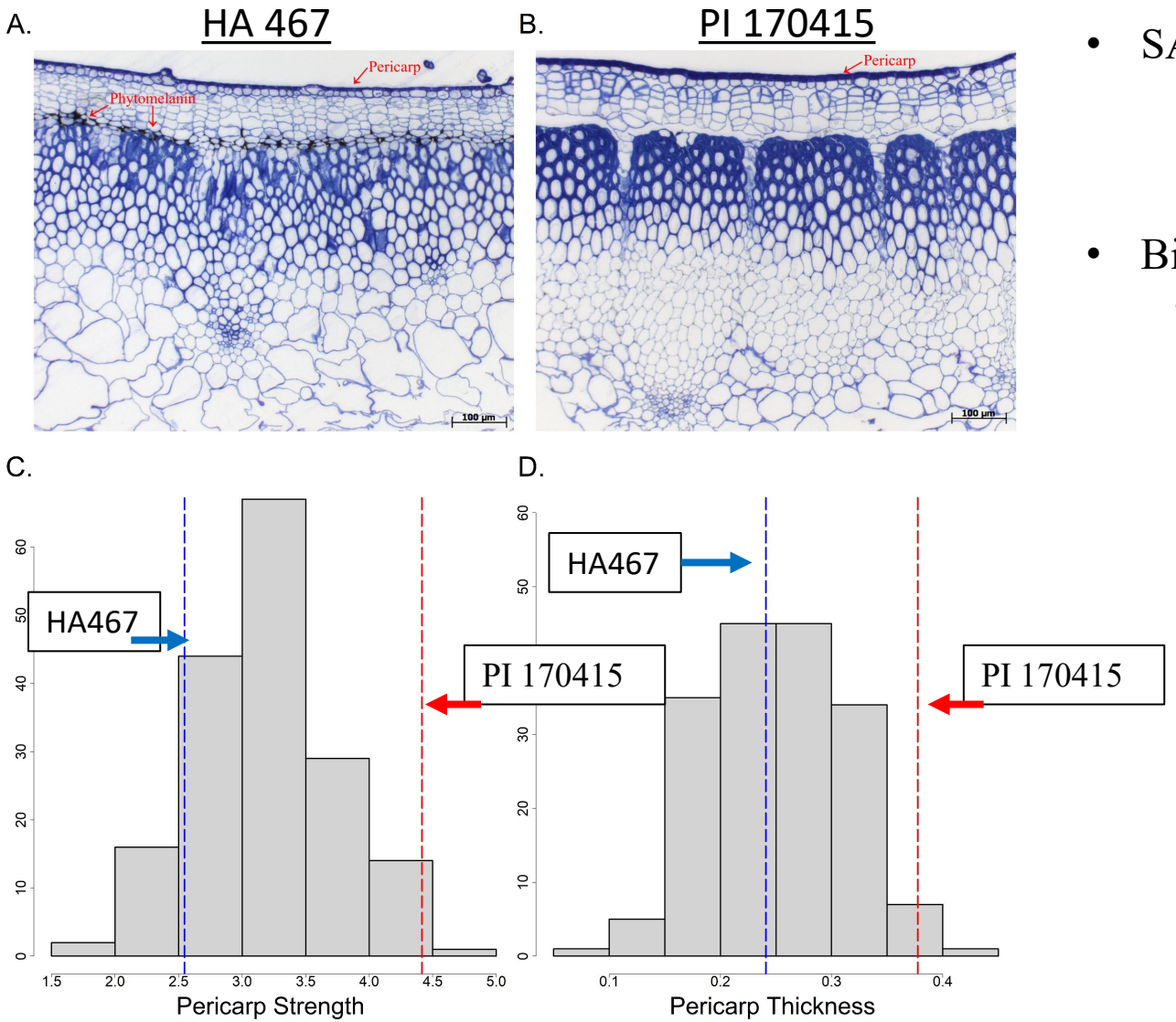
Pericarp Strength: Background

- Pericarp protects the seed for damage
  - Insect damage
    - Banded sunflower moth (*Cocylis hospes*)
    - Sunflower head moth (*Homoeosoma electellum*)

- Pericarp thickness negatively correlated with oil content
- Goal is to improve pericarp strength while maintaining high oil content

Janet J. Knodel & Jarrad R. Prasifka

Pericarp Strength: GWAS & Linkage Mapping



- SAM Population
  - Pericarp thickness
  - Oil content
- Bi-Parental RIL population
  - HA 467 (thin pericarp) × PI 170415 (thick pericarp)
    - Pericarp strength
    - Pericarp thickness
    - Strength independent of thickness
      - Residual of strength regressed on thickness
    - Oil content
    - Banded sunflower moth damage

Genetic Mapping

- GWAS (Genome Wide Association Study)
  - Iteratively tests association between a SNP and trait value

	SNP1	**SNP2**	**SNP3**	**SNP4**	**SNP5**
Yield	A G	A C	T G	T G	A C
	85 80	72 87	107 52	84 83	50 102

Pericarp Strength: Results

SAM Panel

RIL Population

Pericarp Strength				
0.50***	Pericarp Thickness		-0.81***	
0.84***	-0.05	Strength Independent of Thickness		
-0.54***	-0.67***	-0.21*	Oil content	
0.19*	0.17	0.12	-0.28*	Banded Moth Damage

-, not significant; *, p value less than 0.05; **, p value less than 0.001; ***, p value less than 0.0001

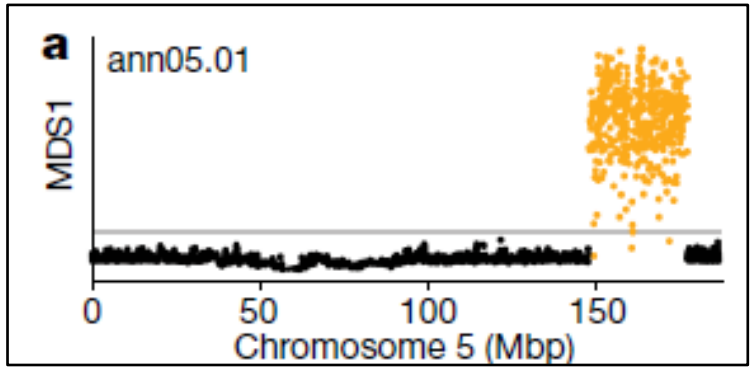
Pericarp Strength: Results

Bi-Parental QTL Mapping						
Trait	Chr.	Left Marker	Right Marker	PVE	LOD	Effect
Pericarp Strength	5	62,522,539	62,626,373	12.68%	5.91	0.19
	14	21,728,213	21,772,687	9.19%	4.43	-0.16
Pericarp Thickness	2	176,970,777	177,057,599	7.15%	4.27	0.02
	4	207,204,709	207,328,329	8.06%	4.97	-0.02
	15	61,508,948	61,985,314	11.50%	6.92	-0.02
	16	193,951,480	196,960,718	7.21%	4.61	-0.02
	16	216,467,659	216,525,958	8.44%	4.85	-0.02
Strength independent of thickness	5	62,522,539	62,626,373	17.34%	7.82	0.19
	14	79,423,855	79,937,827	9.41%	4.68	-0.14
Oil content	15	58,617,255	58,864,941	11.57%	3.59	1.77
BSM Damage	13	24,188,305	25,346,013	12.01%	4.60	2.05
	15	68,101,718	70,008,248	8.92%	3.59	-1.77

Sunflower Association Mapping Panel				
Trait	Chr.	Position	LOD	Effect
Oil content	15	144,019,238	7.08	-1.82
Pericarp Thickness	7	153,182,010	7.22	0.06
	10	111,456,652	6.97	0.07
	10	122,754,494	7.16	0.06
	12	9,810,492	6.64	0.05
	16	198,639,052	7.16	0.04

Pericarp Strength: Chr 5 Inversion

Trait	Chr.	Left Marker	Right Marker	PVE	LOD	Effect
Pericarp Strength	**5**	**62,522,539**	**62,626,373**	**12.68%**	**5.91**	**0.19**



Article

Massive haplotypes underlie ecotypic differentiation in sunflowers

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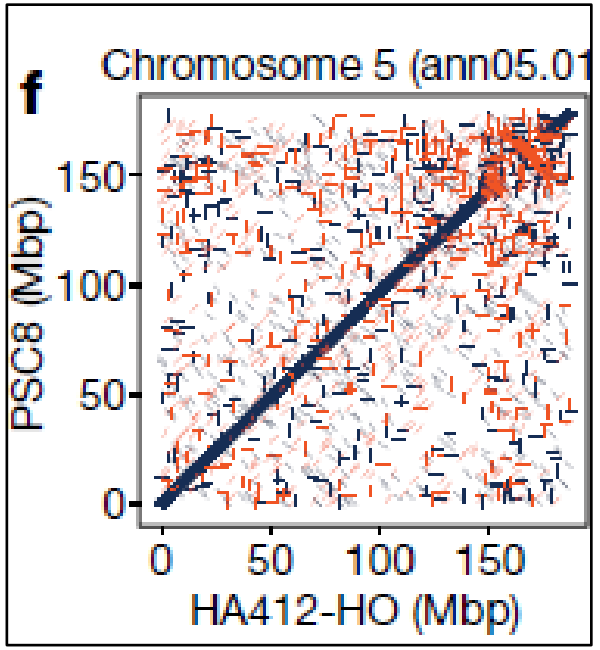
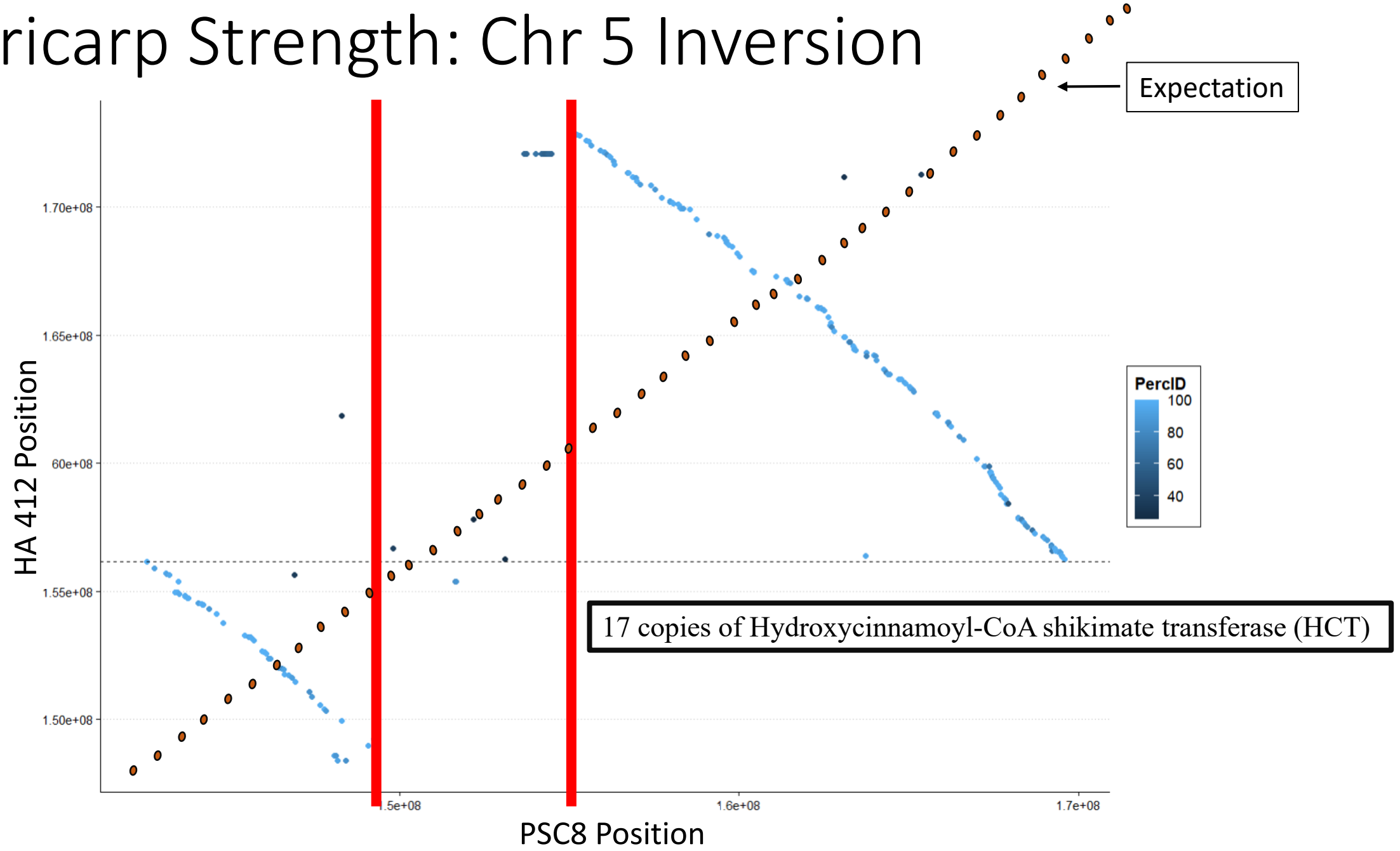


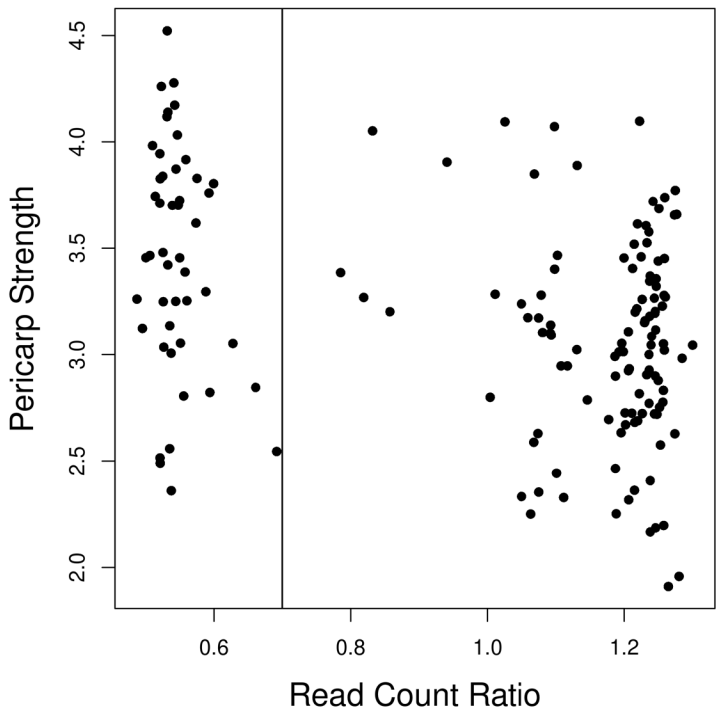
Pericarp Strength: Chr 5 Inversion



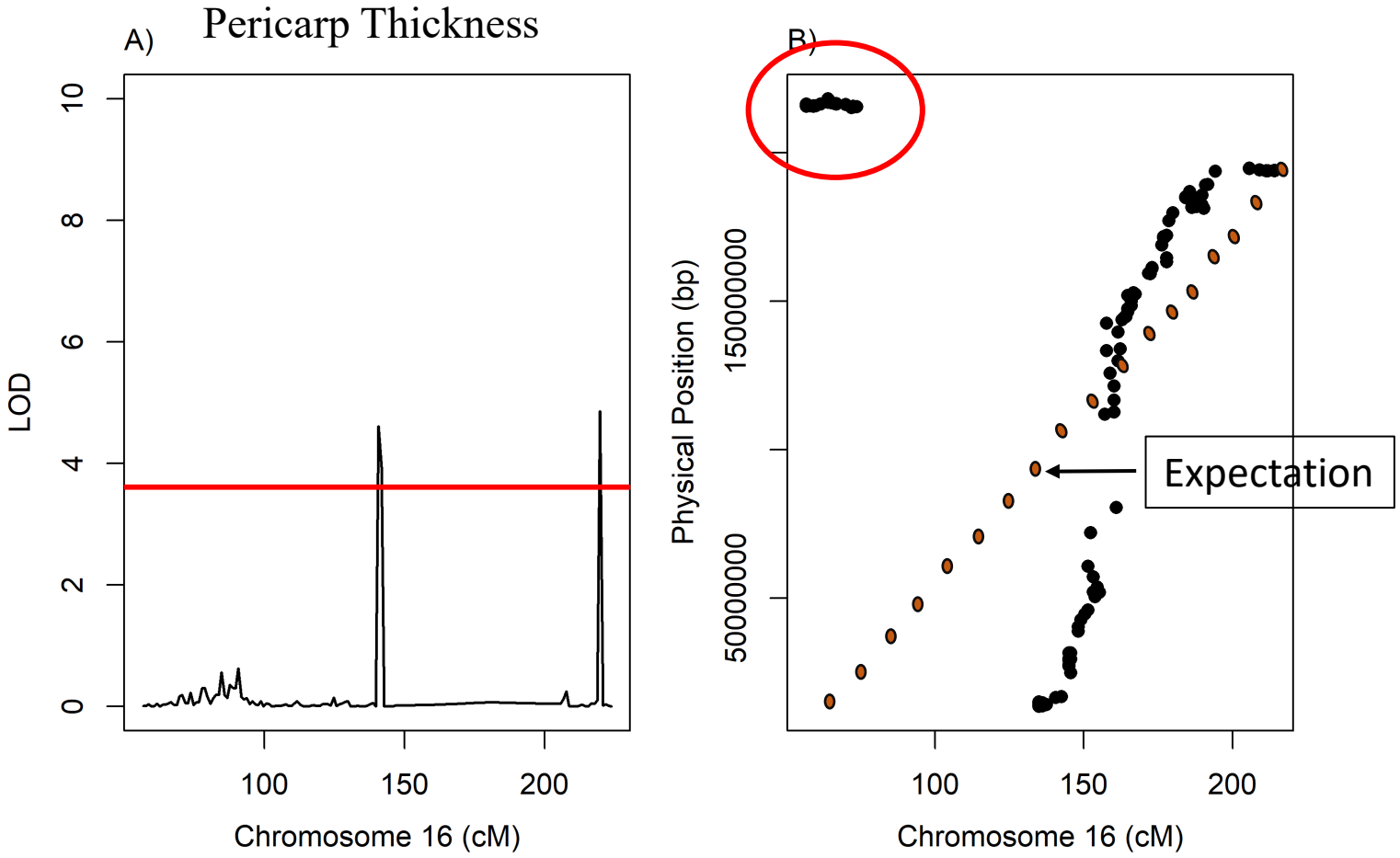
17 copies of Hydroxycinnamoyl-CoA shikimate transferase (HCT)

Pericarp Strength: Chr 5 Inversion

Type III ANOVA				
(A)	Likelihood χ^2	Df	p-value	
Inversion	8.403	1	0.004	
S05_62626373	1.905	1	0.167	
Likelihood ratio test				
(B)	Residual Df	Df	Deviance	p-value
Pericarp Strength ~ S05_62626373	155			
Pericarp Strength ~ S05_62626373 + Inversion	154	1	2.013	0.004



Pericarp Thickness: Chr 16 Structural Variation



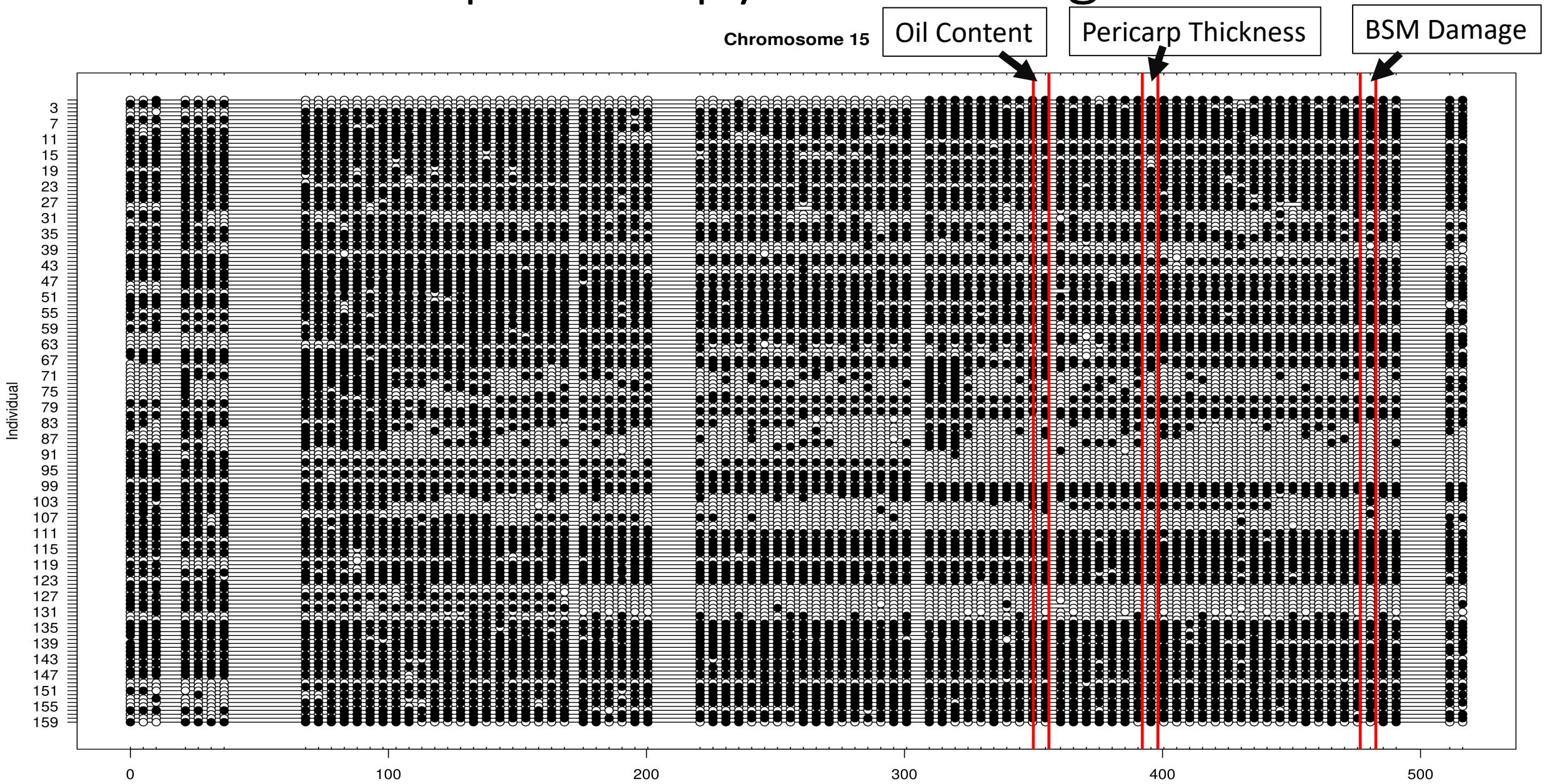
Oil Content: pleiotropy vs. linked genes

Bi-Parental QTL Mapping						
Trait	Chr.	Left Marker	Right Marker	PVE	LOD	Effect
Pericarp Thickness	**15**	**61,508,948**	**61,985,314**	**11.50%**	**6.92**	**-0.02**
Oil content	**15**	**58,617,255**	**58,864,941**	**11.57%**	**3.59**	**1.77**
BSM Damage	**15**	**68,101,718**	**70,008,248**	**8.92%**	**3.59**	**-1.77**

Bi-Parental QTL Mapping

	Chromosome	Position	Pericarp thickness	Banded sunflower moth damage	Oil content
Pericarp Thickness	15	61,508,948	-0.020	0.218	-0.101
Oil Content	15	68,101,718	-0.003	0.038	1.767
BSM Damage	15	58,617,255	-0.002	-1.768	-0.192

Oil Content: pleiotropy vs. linked genes



Implications for Breeding

- Oil content and pericarp thickness
  - Evidence suggests linked, unrelated genes. Not pleiotropy
  - It should be possible to increase pericarp strength with minimal impact on oil content
    - Target uncommon recombination events on chromosome 15

- Strength independent of thickness should be used

- Two structural variations influenced traits of interest
  - Incorporate PI 170415 (PSC8) inversion on chromosome 5 into breeding material
  - Informs future marker development

Questions!

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