Stick Insect Genomes Reveal Natural Selection's Role in Parallel Speciation (Soria-Carrasco *et al.*)

Om Vaknalli (18376)
2nd Year BS-MS Natural Sciences, IISER-Bhopal
17th June 2019, IISER-Bhopal

About the paper:

Authors: Víctor Soria-Carrasco, Zachariah Gompert, Aaron A. Comeault, Timothy E. Farkas, Thomas L. Parchman, J. Spencer Johnston, C. Alex Buerkle, Jeffrey L. Feder, Jens Bast, Tanja Schwander, Scott P. Egan, Bernard J. Crespi, Patrik Nosil.

Publication Details: Science (IF: 37. 205), 16 May 2014: Vol. 344, Issue 6185, pp. 738-742
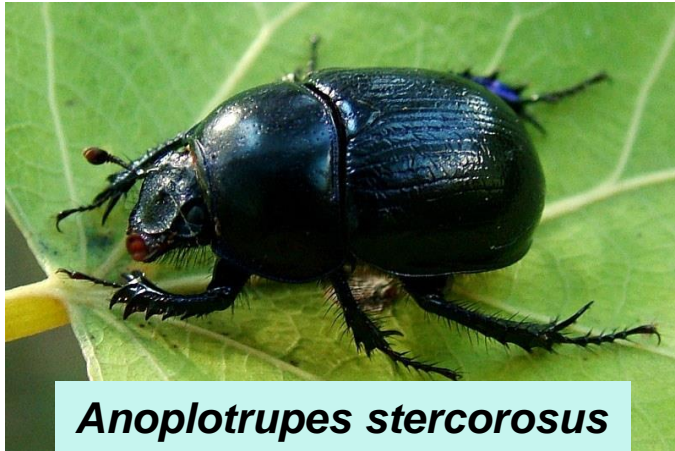
274 Citations

Web-link: https://science.sciencemag.org/content/344/6185/738

Introduction:

- **Parallel Evolution**

- **Parallel Speciation**

Geotrupes spiniger

Anoplotrupes stercorosus

Sphaeridium lunatum

Sources: BioLib.cz (top),
arthropodafotos.de (Extreme left),
Insektarium (left)

Introduction: The Main Question

- **What is the genomic basis of parallel speciation?**

Introduction: The Model Organism

Timema cristinae (Cristina's Stick Insect) on *Ceanothus spinosus*

Introduction: The Model Organism

T.Cristinae on *Adenostoma fasciculatum*

Ceanothus spinosus

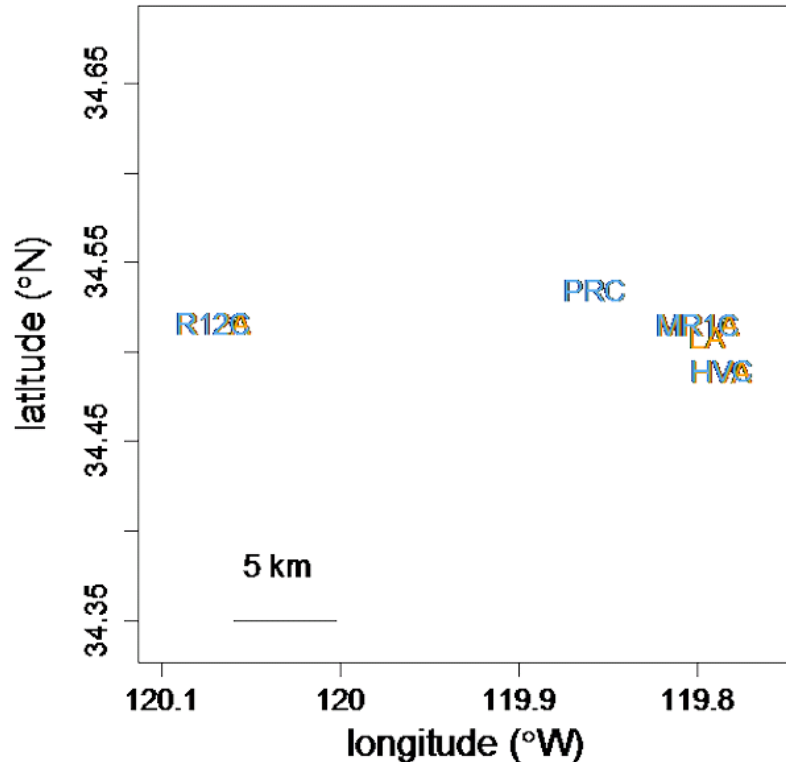*Adenostoma fasciculatum* flowers

Adenostoma fasciculatum
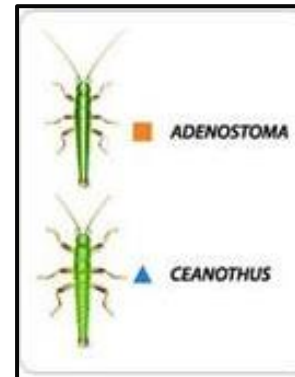
Questions, Methods and Results

- **What are the effects of adaptation on genomic divergence?**

- **Can the underlying genetic changes driving the divergence of populations into new species be predicted or repeated?**

Questions, Methods and Results

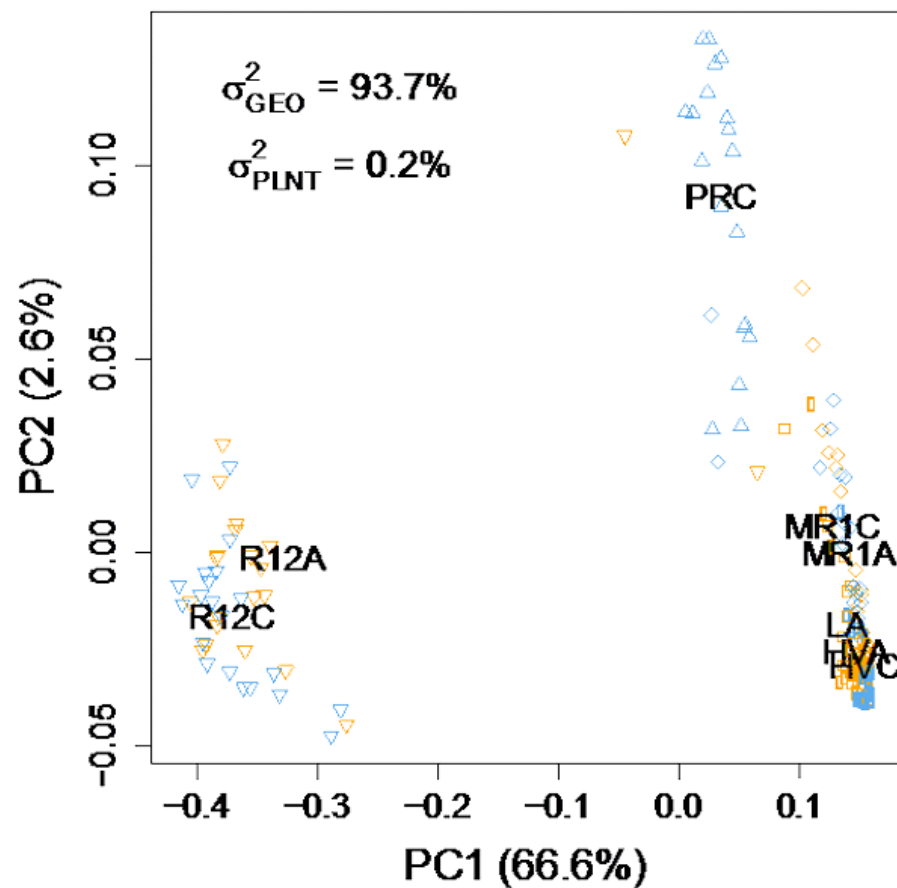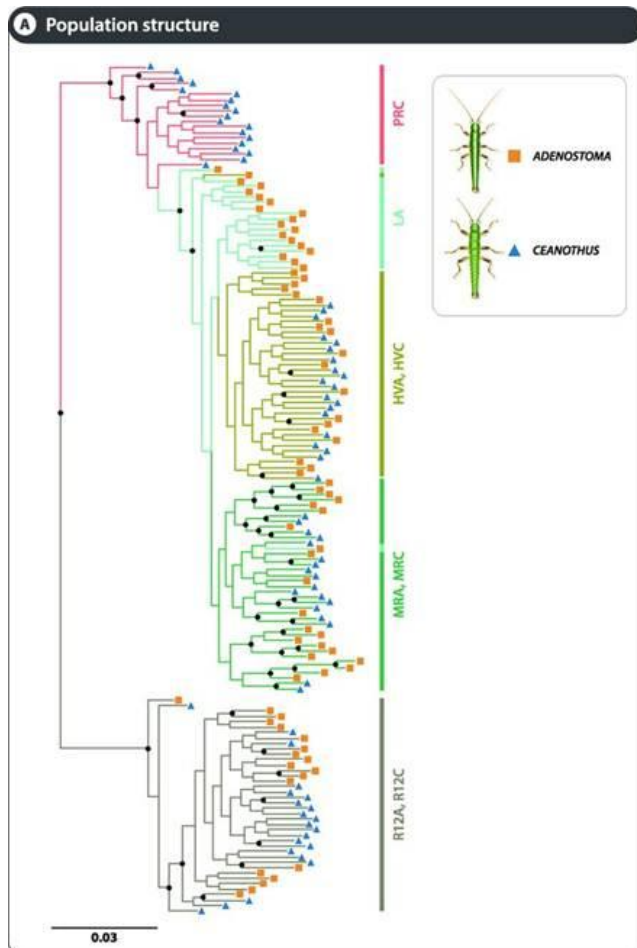| Population Pair	HVA × HVC	MR1A × MR1C	R12A × R12C	LA × PRC
	Population characteristics			
Geography	adjacent	adjacent	adjacent	separated
Gene flow ($N_e m$)	28	37	93	11
No. individuals sequenced (per individual population)	20, 20	20, 20	21, 21	19, 19

Sources (for this slide and next slide): Science
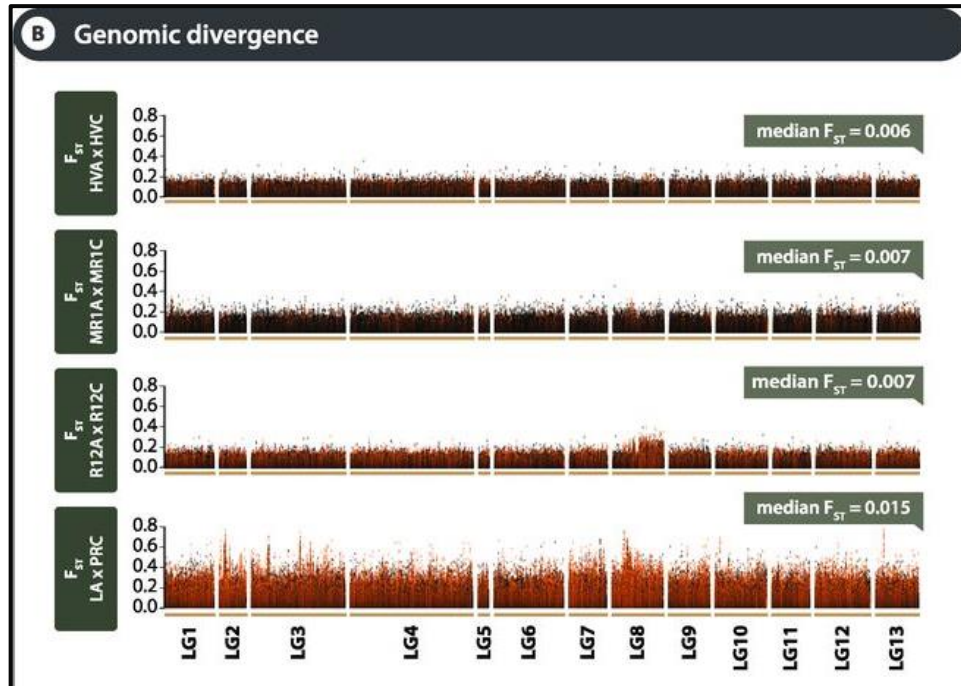
Questions, Methods and Results

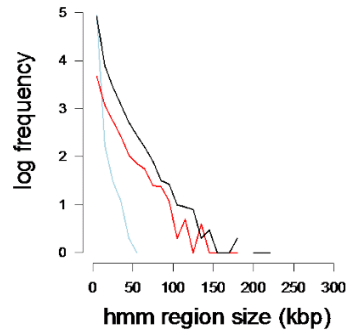- **Does genomic divergence vary geographically between different ecotype pairs?**

A Population structure

$\sigma^2_{GEO} = 93.7\%$

$\sigma^2_{PLNT} = 0.2\%$

Questions, Methods and Results

Population Pair	HVA × HVC	MR1A × MR1C	R12A × R12C	LA × PRC
Population characteristics				
Geography	adjacent	adjacent	adjacent	separated
Gene flow ($N_e m$)	28	37	93	11
No. individuals sequenced (per individual population)	20, 20	20, 20	21, 21	19, 19
Genome characteristics from all SNPs				
Mean MAF	17%	20%	19%	20%
Mean F_{ST}	0.013	0.015	0.015	0.031
Median F_{ST}	0.006	0.007	0.007	0.015
Range of F_{ST}	0.000–0.358	0.000–0.461	0.000–0.398	0.000–0.8000
90th quantile	0.035	0.041	0.041	0.083
95th quantile	0.050	0.058	0.056	0.116

B Genomic divergence

F_{ST} HVA × HVC — median F_{ST} = 0.006

F_{ST} MR1A × MR1C — median F_{ST} = 0.007

F_{ST} R12A × R12C — median F_{ST} = 0.007

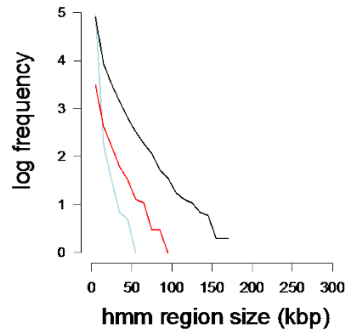F_{ST} LA × PRC — median F_{ST} = 0.015

LG1 LG2 LG3 LG4 LG5 LG6 LG7 LG8 LG9 LG10 LG11 LG12 LG13

Sources: Science

Questions, Methods and Results
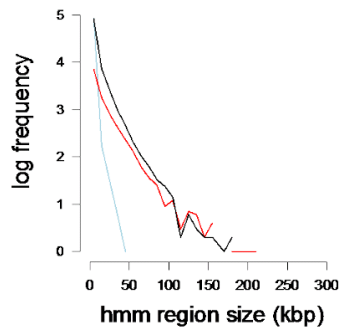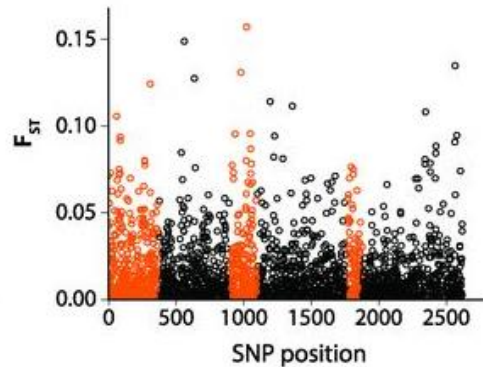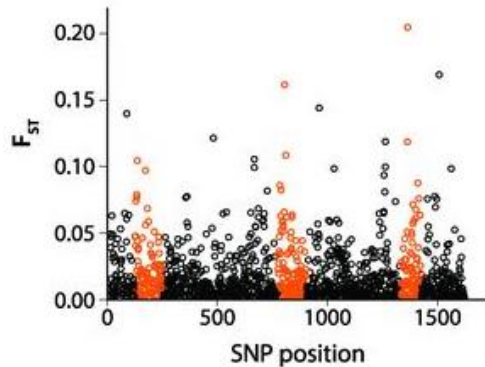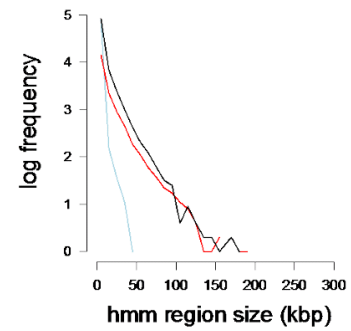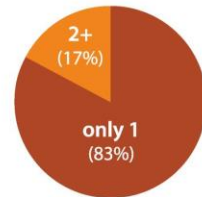

Distribution of the size of HMM regions (colours are: blue = low differentiation regions, black = moderate differentiation regions, red/orange = high differentiation regions). Absolute frequencies across the four categories are shown.
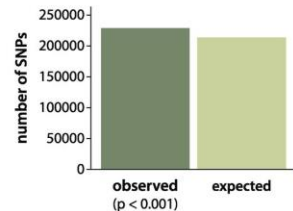
Questions, Methods and Results

Test for parallelism of highly divergent SNPs. Quantiles refer to the empirical F_{ST} distribution.

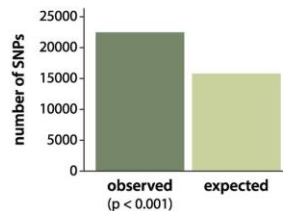|	Observed number of SNPs	Expected number of SNPs	p-value	Enrichment (observed / expected)
>90th quantile in 2 population pairs	228,347	213,423	<0.001	1.07
>90th quantile in 3 population pairs	22,366	15,809	<0.001	1.41
>90th quantile in 4 population pairs	945	439	<0.001	2.15
>90th quantile in 2 or more population pairs	251,658	229,671	<0.001	1.10
>99th quantile in 2 population pairs	4757	2582	<0.001	1.84
>99th quantile in 3 population pairs	94	17	<0.001	5.53
>99th quantile in 4 population pairs	0	0	n/a	n/a
>99th quantile in 2 or more population pairs	4851	2600	<0.001	1.87

A Number of population pairs a SNP had high F_{ST} for
2+ (17%)
only 1 (83%)

B High F_{ST} in 2 population pairs
number of SNPs
observed expected (p < 0.001)

C High F_{ST} in 3 population pairs
number of SNPs
observed expected (p < 0.001)

D High F_{ST} in 4 population pairs
number of SNPs
observed expected (p < 0.001)

Sources: Science
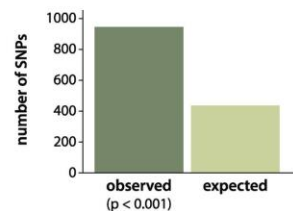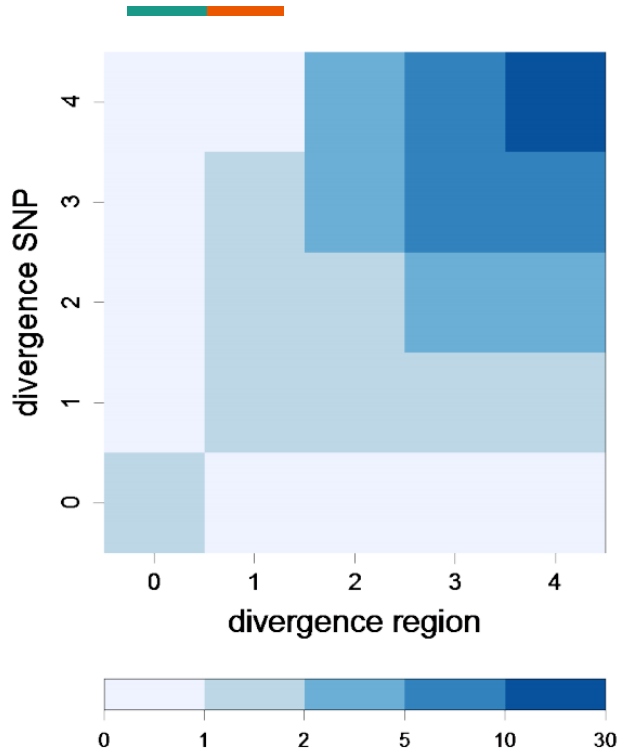
Questions, Methods and Results
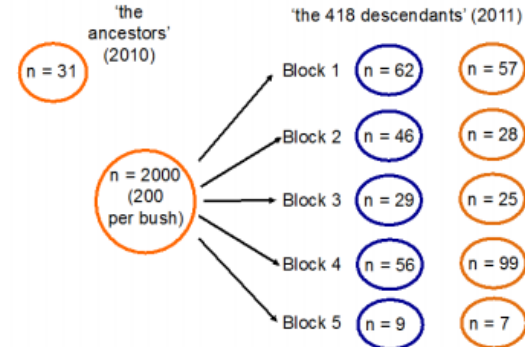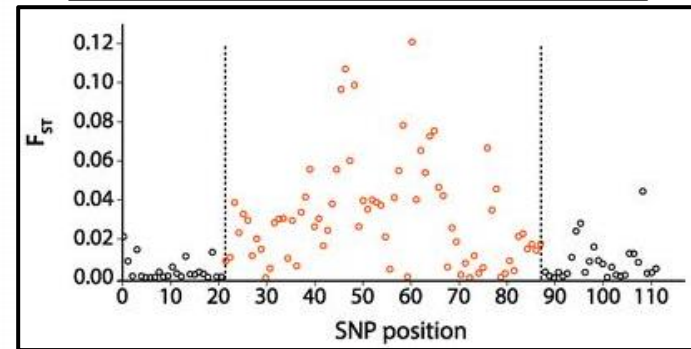
Questions, Methods and Results

B) maf distribution LA

- **What other factors affect the parallel genetic divergence?**

Questions, Methods and Results

- What are the functions of genomic regions exhibiting parallel divergence?

Sources: BugGuide

Conclusion

- **Early parallel speciation** ⟹ **Non-parallel genetic divergence**
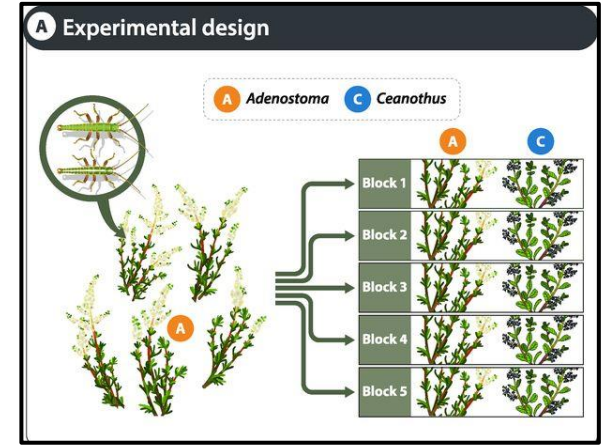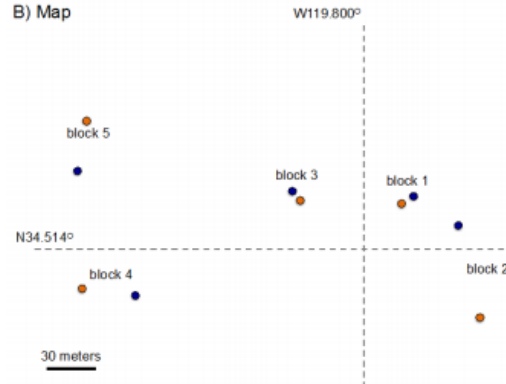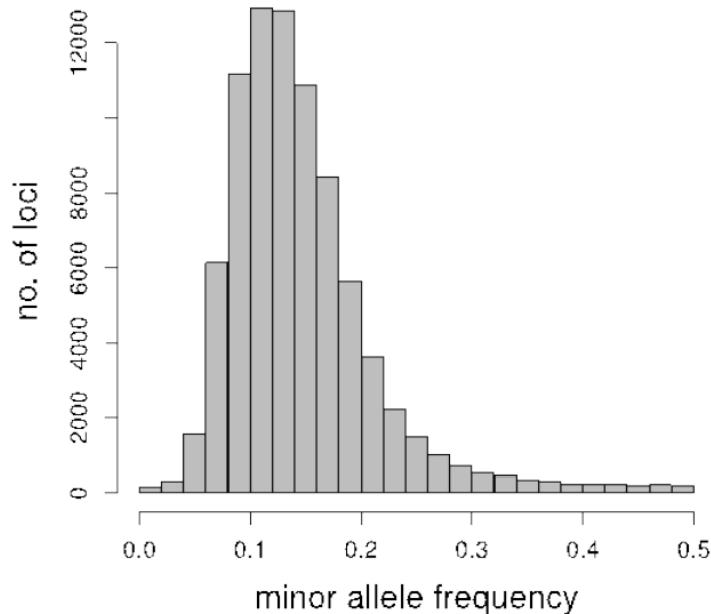- **Some regions show parallel divergence**
  - **More coding genes than expected**
- **Divergent selection** ⟹ **Repeated genomic divergence**
- **"Though repeated evolutionary scenarios would likely result in idiosyncratic outcomes, there may be a repeatable component driven by selection that can be detected, even at the genome level and during the complex process of speciation", quoted from Soria-Carrasco *et al.*, 2014**

References

- 1. D. L. Stern, Nat. Rev. Genet. 14, 751–764 (2013).
- 2. R. D. H. Barrett, H. E. Hoekstra, Nat. Rev. Genet. 12, 767–780 (2011).
- 3. M. K. Burke, Proc. R. Soc. London Ser. B 279, 5029–5038 (2012).
- 4. D. M. Weinreich, N. F. Delaney, M. A. Depristo, D. L. Hartl, Science 312, 111–114 (2006).
- 5. J. R. Meyer et al., Science 335, 428–432 (2012).
- 6. J. B. Losos, Lizards in an Evolutionary Tree: Ecology and Adaptive Radiation of Anoles (Univ. California Press, Berkeley, CA, 2009).
- 7. F. C. Jones et al., Nature 484, 55–61 (2012).
- 8. G. L. Conte, M. E. Arnegard, C. L. Peichel, D. Schluter, Proc. R. Soc. London Ser. B 279, 5039–5047 (2012).
- 9. Heliconius Genome Consortium, Nature 487, 94–98 (2012).
- 10. D. Schluter, L. M. Nagel, Am. Nat. 146, 292–301 (1995).
- 11. J. L. Feder, S. P. Egan, P. Nosil, Trends Genet. 28, 342–350 (2012).
- 12. H. Ellegren et al., Nature 491, 756–760 (2012).
- 13. S. H. Martin et al., Genome Res. 23, 1817–1828 (2013).
- 14. H. Ellegren, Trends Ecol. Evol. 29, 51–63 (2014).
- 15. P. Nosil, Am. Nat. 169, 151–162 (2007).

References

- 16. P. Nosil et al., Proc. R. Soc. London Ser. B 279, 5058–5065 (2012).

- 17. P. Nosil, B. J. Crespi, C. P. Sandoval, Nature 417, 440–443 (2002).

- 18. Z. Gompert et al., Ecol. Lett. 17, 369–379 (2014).

- 19. H. D. Rundle et al., Science 287 , 306-8. (2000)

- 20. P. Holter, The American Naturalist (2004)

- 20. Evolution by Mark Ridley, 3rd Edition

Any Questions/Suggestions?

Acknowledgements

- I would like to thank Prof. Nagarjun Vijay for giving me this opportunity to present.
- Special thanks to Mr. Aswin Soman for guiding me through the nitty-gritties of presentation.
- Lastly, I thank everyone here for taking the time out from your schedules to attend this presentation.

Thank-you!