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Comparing Differences for Non-Introgressing Genes in Chickadees

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Wagner et al. 2020

The Hybrid Zone

- Black-capped (*Poecile atricapillus*) and Carolina (*Poecile carolinensis*) chickadees hybridize in a specific zone ranging from New Jersey to Kansas
- This hybrid zone is moving north due to climate change (Taylor et al 2014). Warming winter temperatures allow for Carolina chickadees to push further north into black-capped range.
- Male Carolina chickadees are more dominant, and female black-capped seem to prefer them to male black-capped in extra-pair copulation events (Reudink et al. 2007).

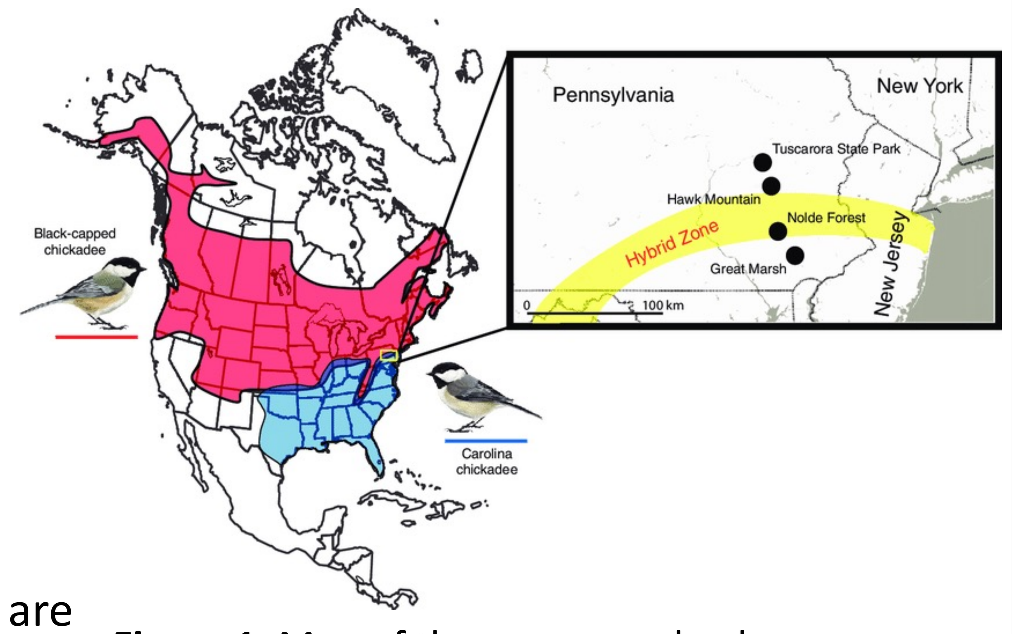


Figure 1. Map of the range overlap between black-capped and Carolina chickadees (Wagner et al. 2020).

Introduction

- Black-capped and Carolina chickadees are closely related, genetically distinct species. They retain the ability to hybridize, but their offspring have low fitness (Taylor et al. 2014).
- There are low introgression rates for specific loci that might contribute to reproductive isolation.
- Both chickadee species are non-migratory. Black-capped endure low winter temperatures, but Carolina chickadees historically occupy warmer environments. This suggests that there may be divergent genes that help with cold survival that don't introgress well across the hybrid zone. We are aiming to uncover a piece of why these genes are not being introgressed.

Questions

- Which genes do not introgress well into hybrid chickadee offspring? What functions do those genes have?
- Do the non-introgressing genes have more differences in nucleotide sequence than random genes?

Methods: Gene Alignments

- We annotated full length transcript sequences of both black-capped and Carolina chickadees using BLAST.
- We aligned the top ten non-introgressing genes using the program Geneious, along with ten random genes from the whole genome to serve as a comparison.

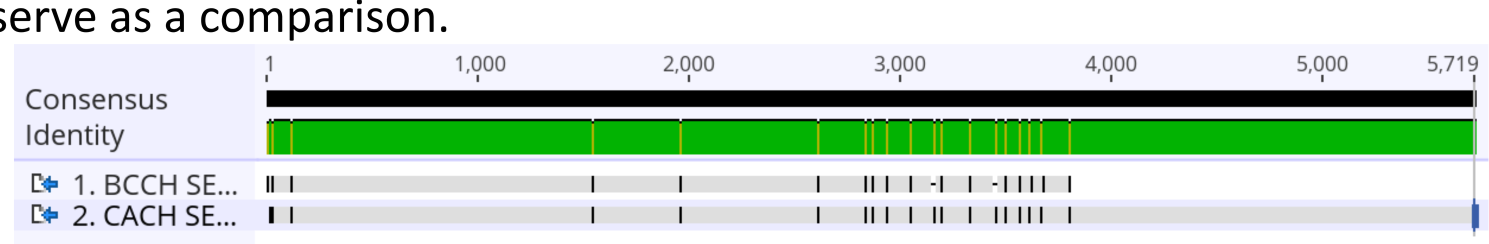


Figure 2. An alignment of one of the randomly chosen genes, SEMA3C.

Reduced Hybrid Fitness

- Hybrids seem to have lower fitness than their parents, and do not survive low winter temperatures well (Reudink et al. 2007).
- It is hypothesized that the hybrids have lower thermogenic capacity, a higher basal metabolic rate, less muscle growth, and less neuron growth; all of which decrease the chances of survival in winter (Olson et al. 2010).

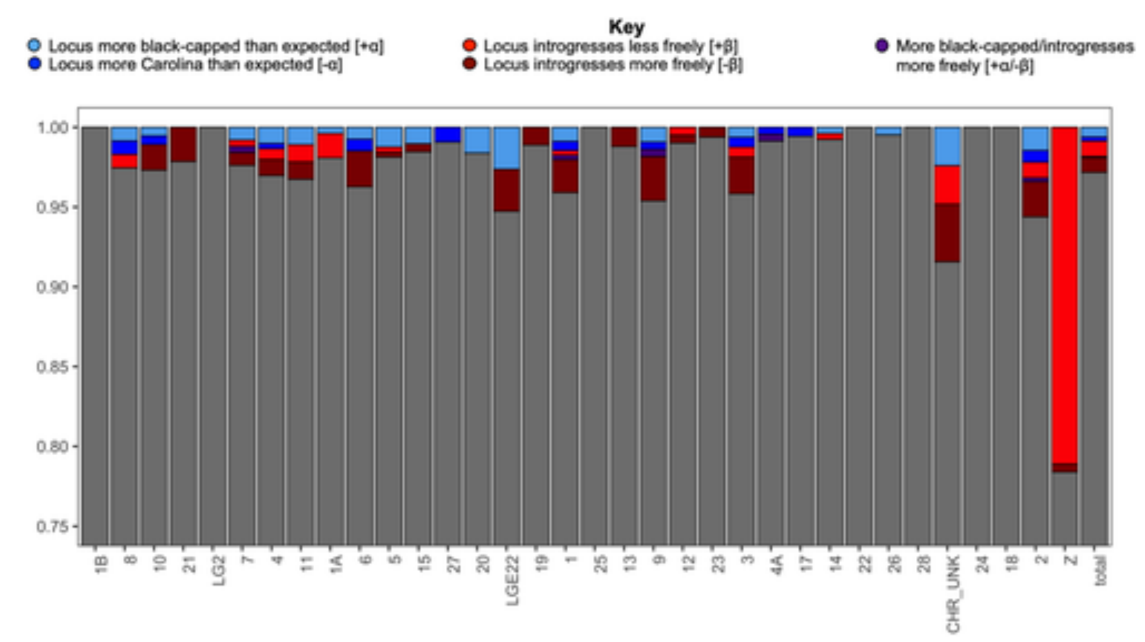


Figure 3. An example of how genes can be introgressed more or less freely between black-capped and Carolina chickadees in the Missouri hybrid zone (Alexander et al. 2022).

- Hybrids exhibit poor spatial memory compared to black-capped chickadees. Good spatial memory is needed in winter to remember where food caches are located (McQuillan et al. 2018).

Top Ten Genes
ABCA1
COMMD10
ISOC1
DGKQ
AUH
SPTLC1
SVEP1
ALDH7A1
GAK
SHC3

Ten Random Genes
SEMA3C
ACACA
ARHGEF11
F6D6
ZFYVE9
SLC6A4
ZFAND2B
FOXP1
ZNF335
FARS2

Non-Introgressing Genes

- Introgression is defined as the distribution and movement of alleles across species boundaries. Loci that are involved in reproductive isolation have very low rates of introgression (Taylor et al. 2014).
- The low rates of introgression for specific loci suggest that they may contribute to reduced hybrid fitness.

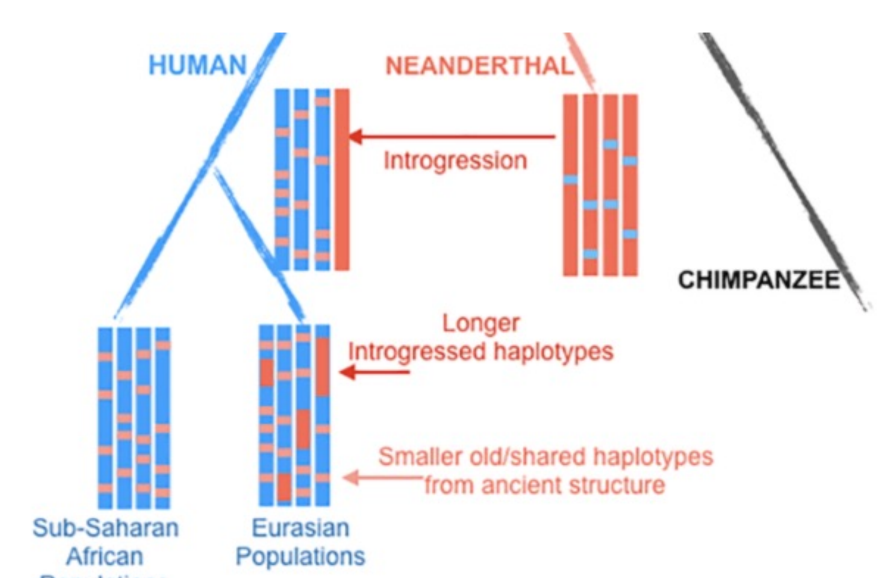


Figure 4. An example of what hybridization across two species can look like using the human - Neanderthal relationship. Genes are inherited by the hybrid, and then introgressed back into parent populations. (Gokcumen 2019).

Methods: Measuring Gene Difference

- We calculated the percent difference of nucleotides for each whole alignment.
- We compared the mean percent sequence identity for both the top ten non-introgressing genes and the ten random genes.

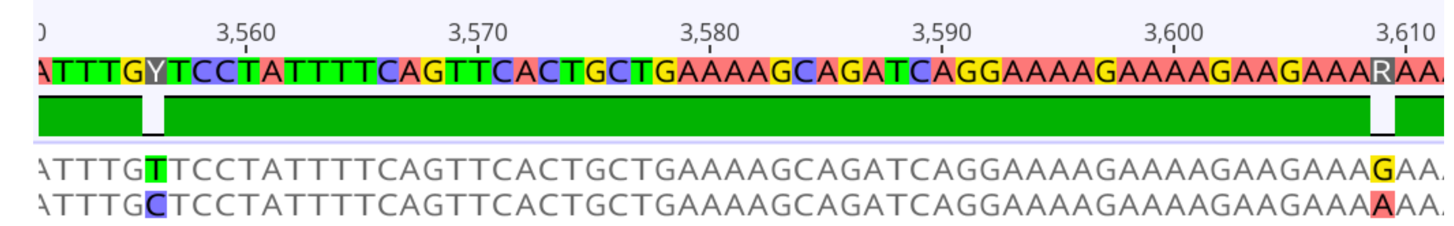
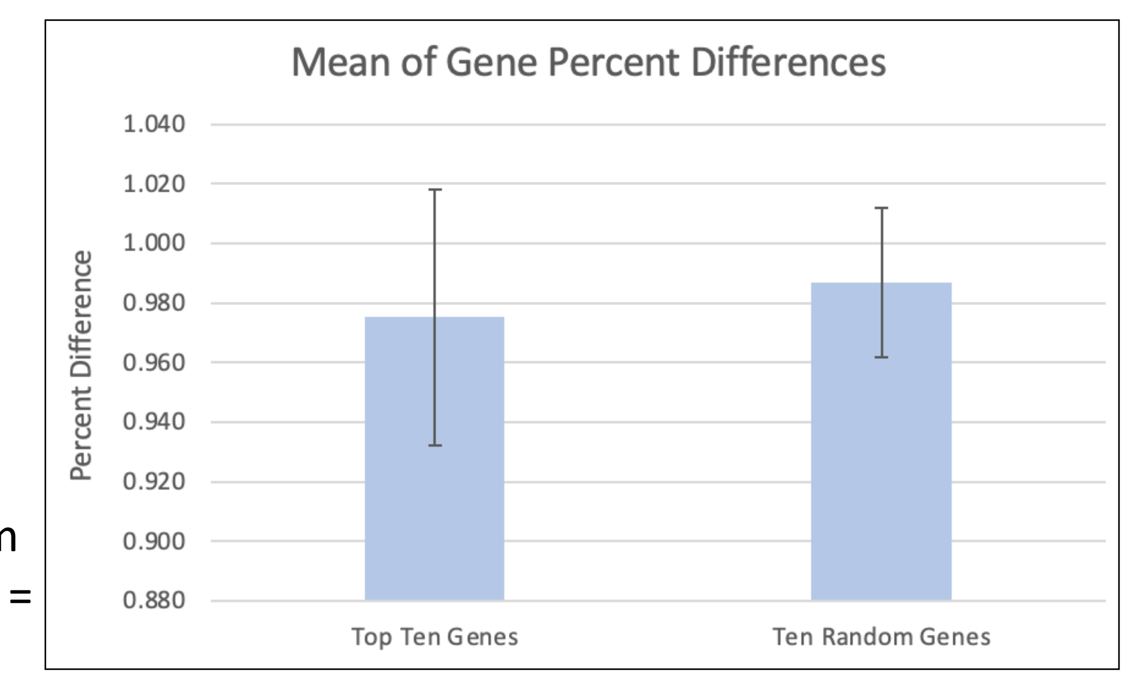


Figure 5. A portion of a black-capped and Carolina chickadees alignment. The nucleotide differences are highlighted.

Results

- We found that the top ten non-introgressed genes tend to have more nucleotide differences on average than the ten random genes (p-value = 0.0169).



- This result demonstrates that loci that do not introgress across species boundaries are more divergent than random loci.

Next Steps: Determining if those differences are due to natural selection, or another factor.

Acknowledgments and Literature Cited

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