Cognitive deficiency in hybridized chickadees

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INTRODUCTION

BACKGROUND

- Hybrid animals often demonstrate diminished learning and memory capabilities, reducing their likelihood of survival and fitness (Coyne and Orr 2004, McQuillan *et al.* 2018)
- Many species of chickadees rely heavily on spatial memory, since they cache food for later retrieval
- Black-capped and Carolina chickadees hybridize across a narrow zone of overlap between their distributions; hybrid chickadees are typically less adept at storing and retrieving food caches, driving selection against hybrids and preserving species diversity (McQuillan *et al*. 2018)

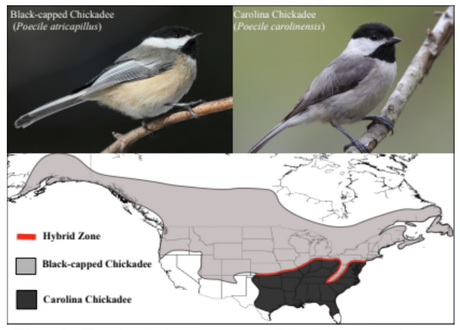

Fig. 1. Territorial ranges of Black-capped and Carolina chickadees, with hybridization zone depicted in red

- Differences in memory capability are reflected neurologically in the enhancement of the hippocampus, a region of the brain that deals with spatial memory (Roth *et al.* 2011); cognitive differences within hybrids have been studied behaviorally, but we wanted to pinpoint the neurological basis

OUR FOCUS

- We investigated neuroanatomical differences in spatial memory capabilities between Black-capped and Carolina chickadees, and then hybrid chickadees by comparing hippocampal volume within the hippocampus of different specimens
- Our research seeks to examine how cognitive abilities in hybrid species, specifically learning and memory, contribute to post zygotic reproductive isolation by driving selection against hybrid species
- **We predicted that hybrid chickadees would display smaller volumes as a basis for deficient memory capabilities of hybrid animals.**

METHODS

- In performing this research, we captured 28 black-capped, 44 Carolina, and 22 hybrid chickadees (Total N=94)
- We collected all birds in eastern Pennsylvania
- The birds were tested on cognitive tasks; afterwards, they were sacrificed, perfused, and their brains were extracted
- The brains were frozen at -80°C and then sectioned at 40µm coronal sections using Leica 3050 S Cryostat
- We mounted and stained the sections using Nissl (Roth & Pravosudov, 2009)
- The total hippocampal volume was estimated with the Cavalieri method in Stereologer
- We assessed hippocampal volume/telencephalon volume as a ratio to standardize the data by accounting for individual variation in overall brain size

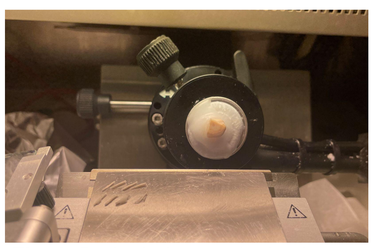

Fig. 2. Brain during sectioning in cryostat

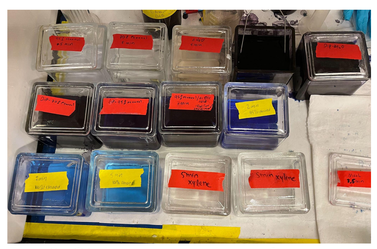

Fig. 3. Staining procedure of mounted chickadee brain tissues

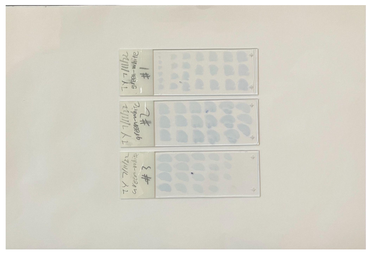

Fig. 4. Slides with mounted chickadee brain tissue

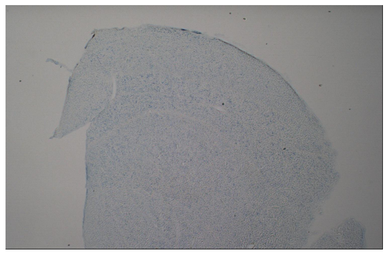

Fig. 5. Chickadee brain section, including hippocampus, during analysis procedure

RESULTS

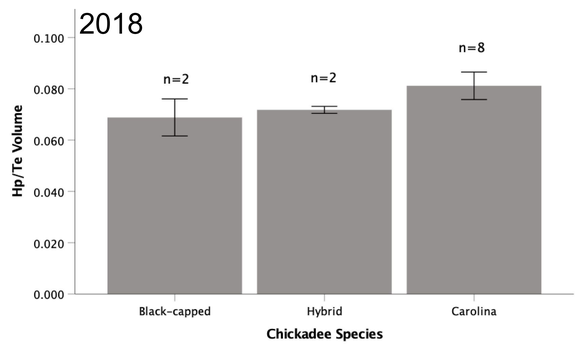

Fig. 6. Relative hippocampal volume across different chickadee species. Hippocampal volumes of chickadees harvested in 2018 did not significantly differ among species (ANOVA: F(2,8)=2.914, p=0.112). Error bars represent +/- 1 standard error.

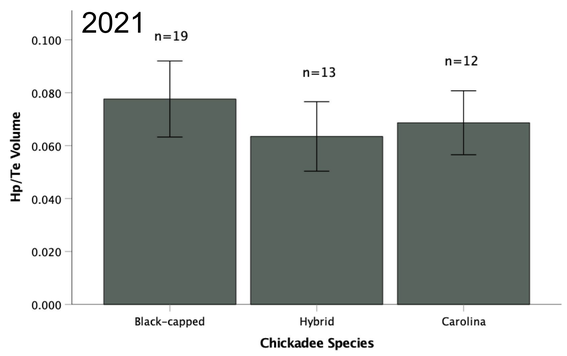

Fig. 7. Relative hippocampal volume across different chickadee species. Hippocampal volumes of chickadees harvested in 2021 did significantly differ among species (ANOVA: F(2,8)=40=4.644, p=0.015). Error bars represent +/- 1 standard error.

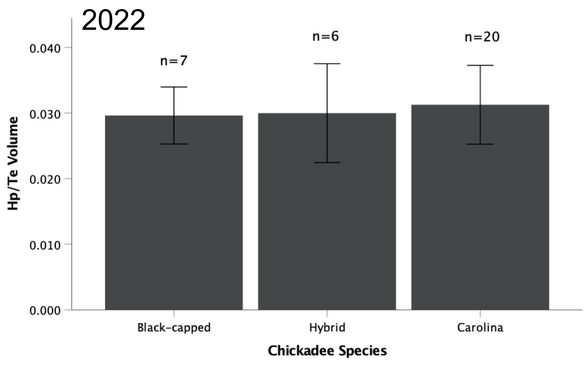

Fig. 8. Relative hippocampal volume across different chickadee species. Hippocampal volumes of chickadees harvested in 2022 did not significantly differ among species (ANOVA: F(2,29)=0.823, p=0.449). Error bars represent +/- 1 standard error.

OVERALL FINDINGS

Overall, hippocampal volume did not significantly differ between Black-capped, Carolina, and hybrid chickadees in 2018 and 2022. Although there was a significant difference between groups in 2021, this trend was not consistent across other years.

DISCUSSION

- **Overall, hippocampal volume did not conclusively explain differential spatial memory abilities between chickadee species**
- This lack of significance could be a function of small sample sizes
- There was a significant difference in 2021, the year with the largest sample size

LIMITATIONS

- Because of sizable differences between data for different years, we analyzed hippocampal volumes from each year separately, resulting in small sample sizes that reduced the power of our analysis
- These discrepancies between data of different years could be explained by differing individual techniques of different researchers

FUTURE DIRECTIONS

- Differences in cognitive ability ultimately arise from brain plasticity, which derives from the dynamic capacities of dendritic spines (Segal, 2017); more connectivity indicates more learning and memory
- Our next steps include quantifying dendritic spine density and comparing between different species
- We will also use immunohistochemistry techniques to analyze and compare rates of neurogenesis in the hippocampus
- Additionally, we will compare neuron densities between species

CONCLUSION

Although hippocampal volumes did differ significantly in 2021, this trend was not present in the other years. Our overall lack of significance is likely related to small sample sizes.

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