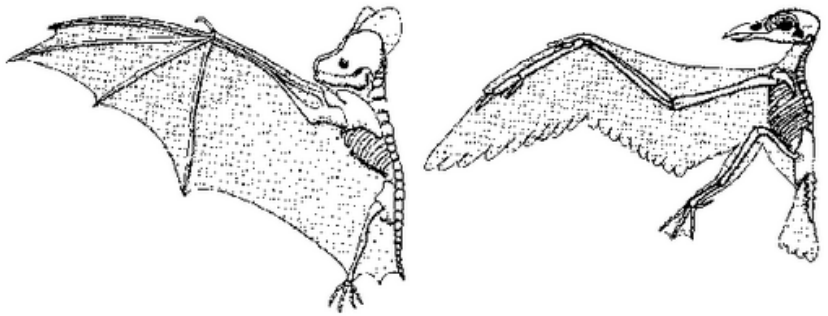
Convergent Evolution of Behaviours

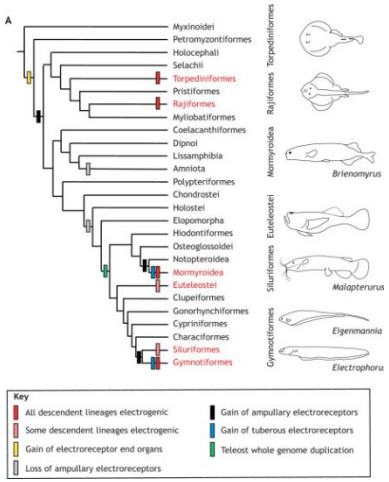
Zijian Huang

2025-12-26

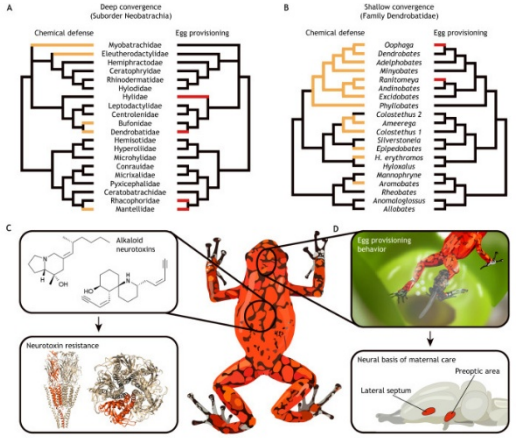
Example of Convergent Evolution



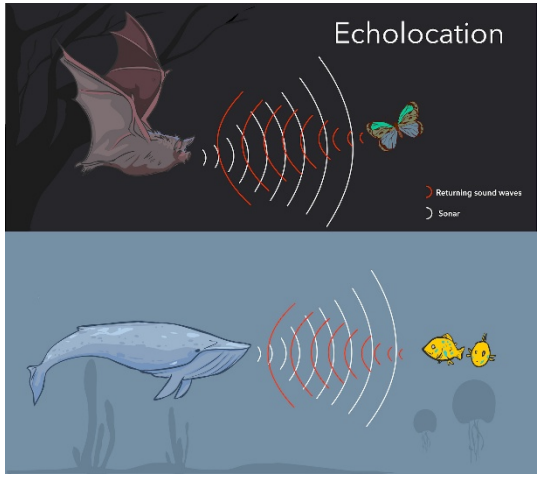
bird's and bat's wings



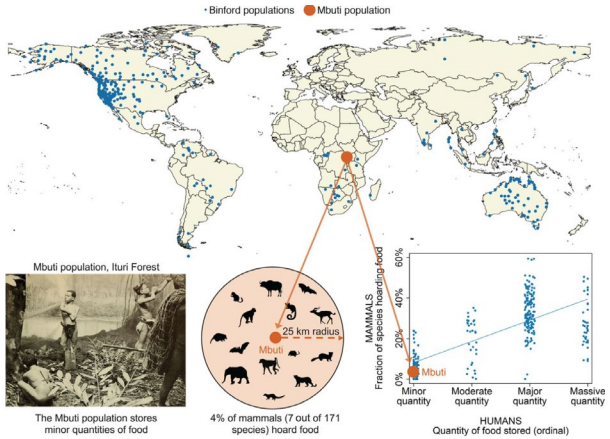
electric discharge in fishes



toxin-producing behavior in frogs



ultrasonic reception organ of bat and whales



less food hoard behavior in species lived near to Mbuti

Questions

1. On the level of behavior: Will different lineage evolve same behavior trait under the same ecological pressure

2. On the level of molecular: Is convergent evolution of complex behavior underpinned by convergence at the molecular level

3. On the level of gene regulatory network: Does convergent evolution of behavior share same gene regulatory network.

Article Information

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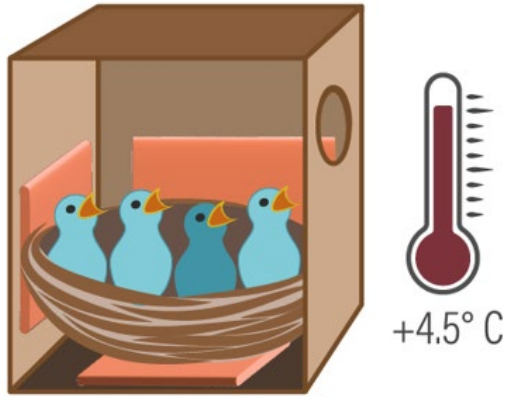
Evolution of behavior



Interaction between behavior and environment

Why certain behaviors arise or persist under certain environments.

Article | Published: 28 April 2025

Repeated behavioural evolution is associated with convergence of gene expression in cavity-nesting songbirds

Sara E. Lipshutz, Mark S. Hibbins, Alexandra B. Bentz, Aaron M. Buechlein, Tara A. Empson, Elizabeth M. George, Mark E. Hauber, Douglas B. Rusch, Wendy M. Schelsky, Quinn K. Thomas, Samuel J. Torneo, Abbigail M. Turner, Sarah E. Wolf, Mary J. Woodruff, Matthew W. Hahn & Kimberly A. Rosvall

Nature Ecology & Evolution **9**, 845–856 (2025) | Cite this article

Higher level of territorial aggression in obligate cavity nesters

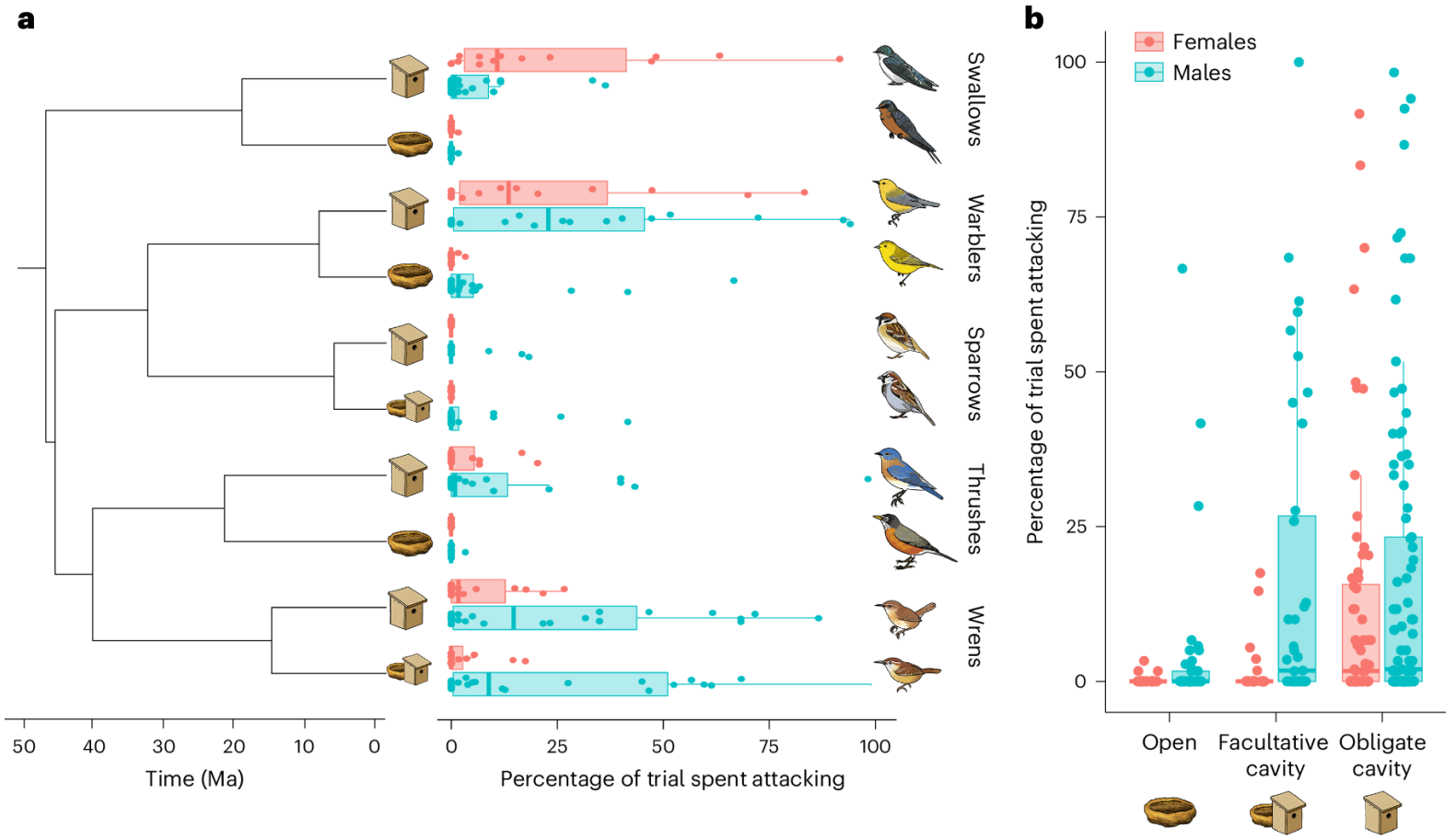
obligate cavity nesters

facultative cavity nesters

open nesters

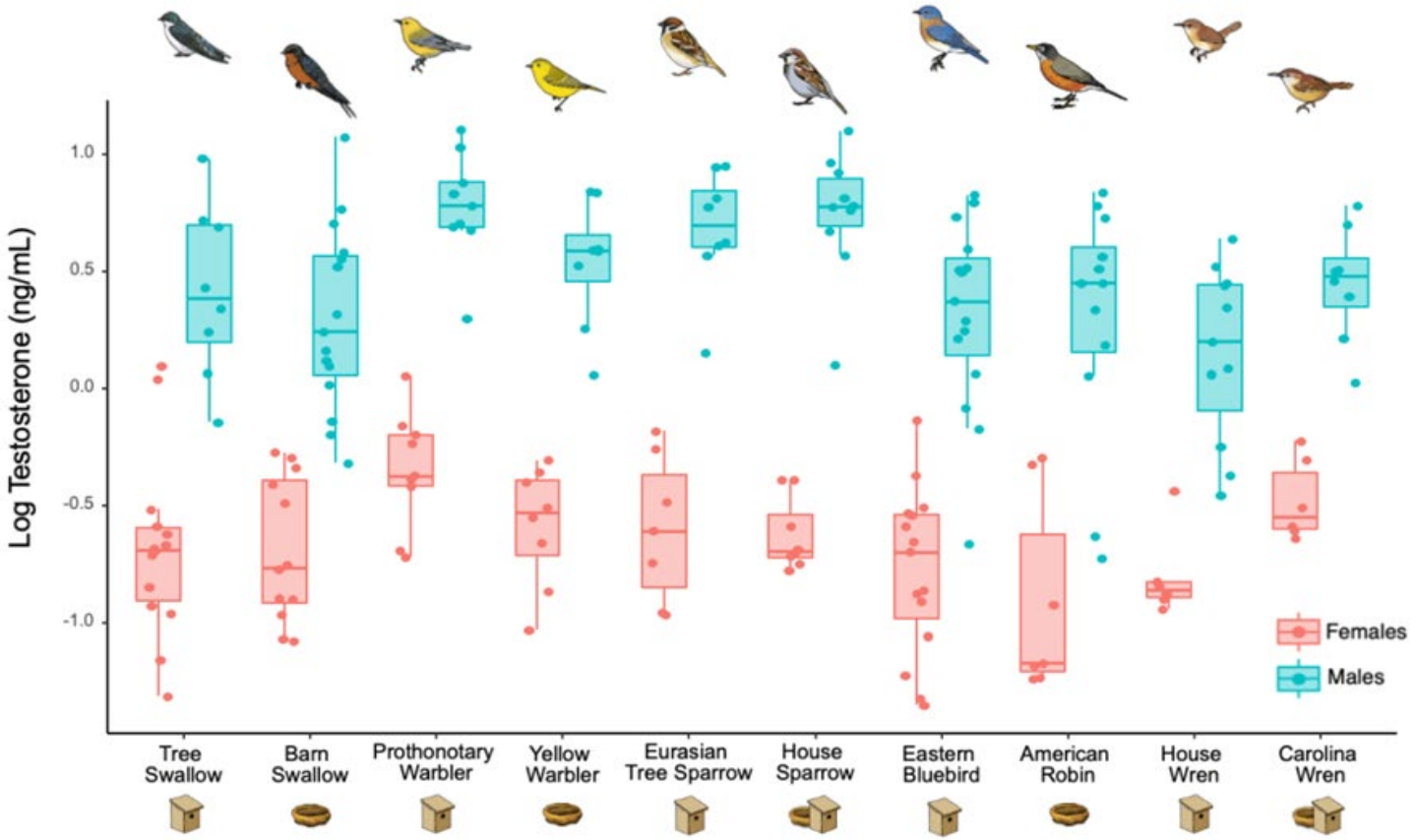
Hypothesis: there is a convergence of high level of aggression in obligate secondary cavity nesting species.

Behavioral convergence across independent evolutionary origins



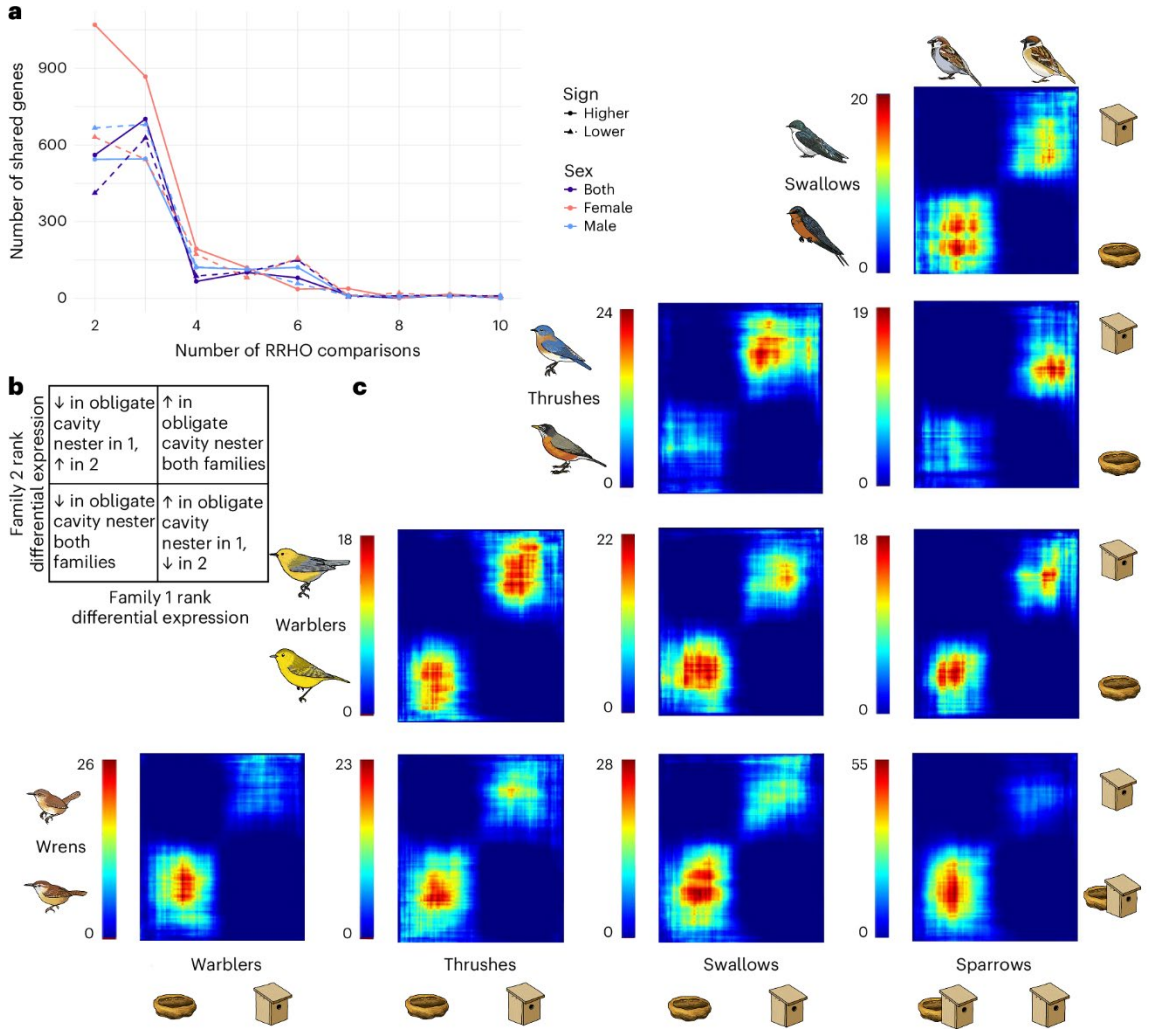
This result establishes clear **behavioral convergence**, especially driven by **female aggression**, across multiple independent evolutionary events.

Testosterone levels are not associated with nest strategy

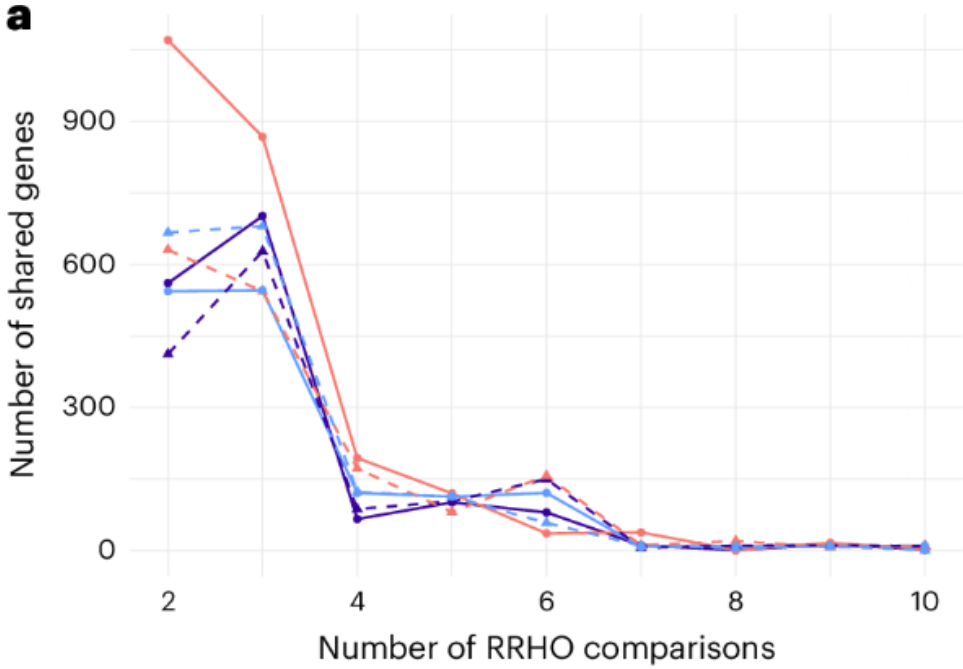


Denied the hypothesis that different level of aggression driven by testosterone levels

Limited convergence in gene expression identity



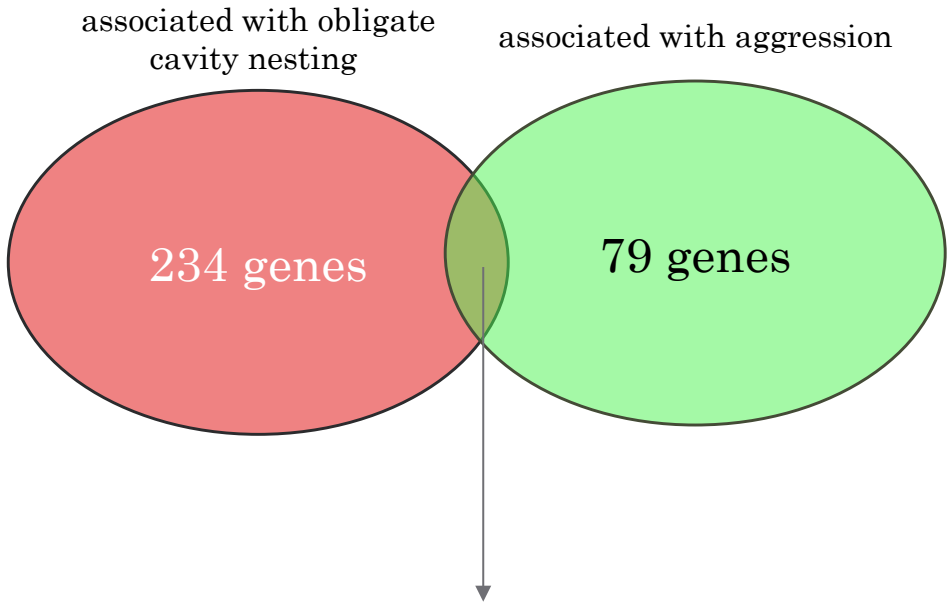
RRHO method: rank-rank hypergeometric overlap



Most gene expression changes are lineage-specific, with only a very small shared core.

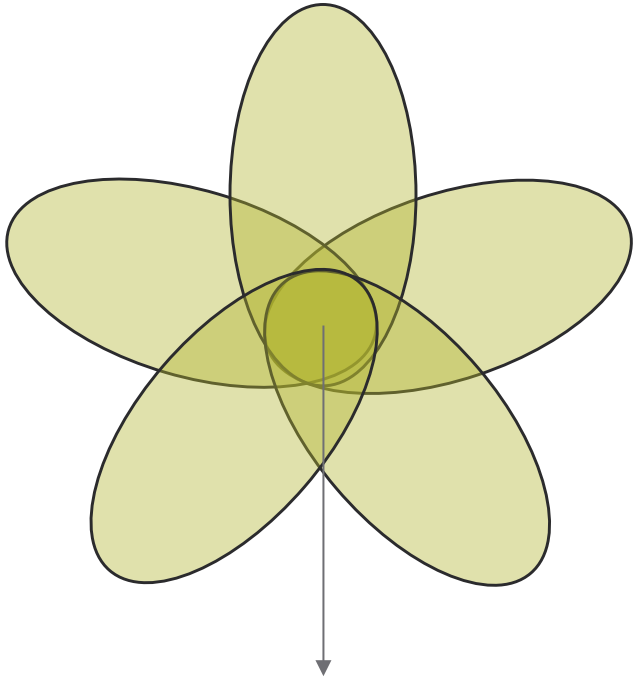
Testing Convergent Evolution with Phylogenetically generalized linear mixed models (PGLMM)

Expression ~ Strategy + Sex + Aggression + Sex × Strategy + Aggression × Strategy



RNASEH2B, *ERN1*, *UGGT2*, *TAF1B* , *HIGD1A*

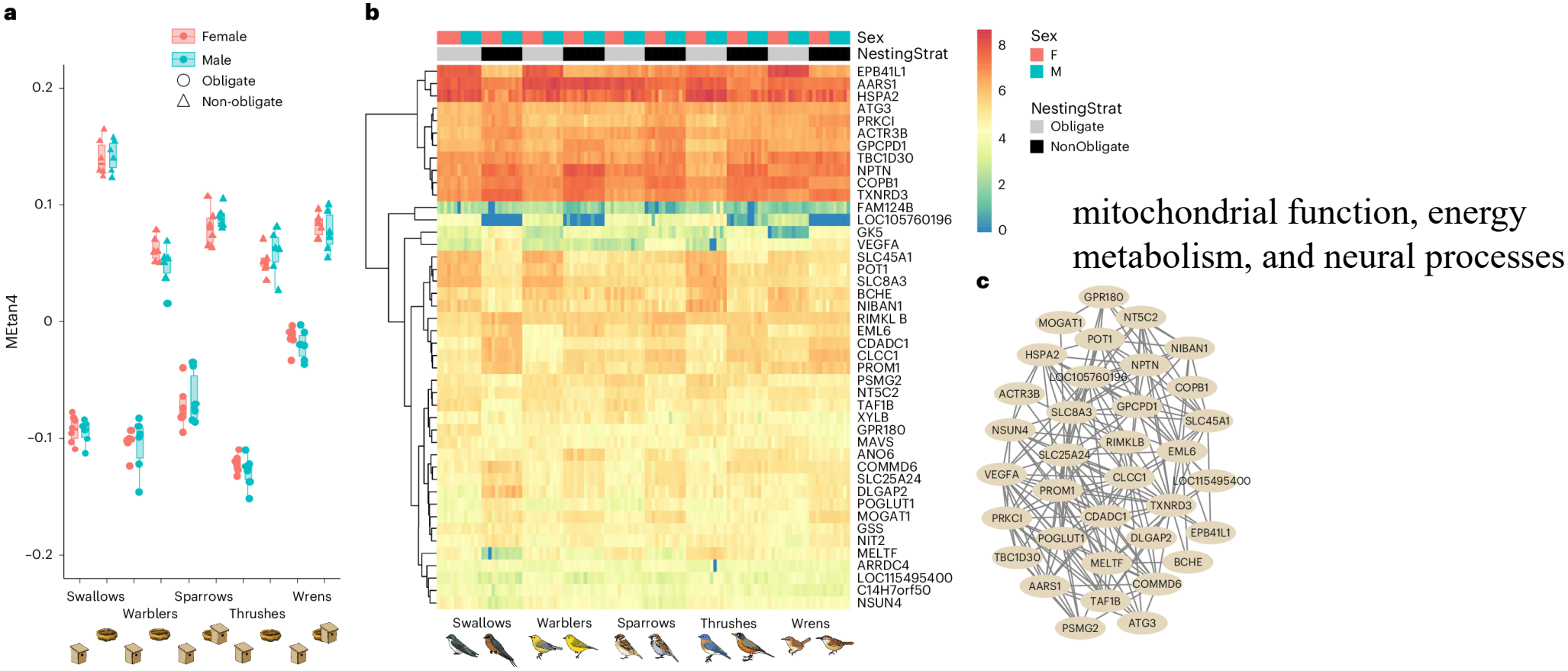
protein processing and stress response



40 genes associated with nest strategy in all 5 families

ATP and mitochondrial function, behavior or psychiatric risk

Convergence at the gene network level



mitochondrial function, energy metabolism, and neural processes

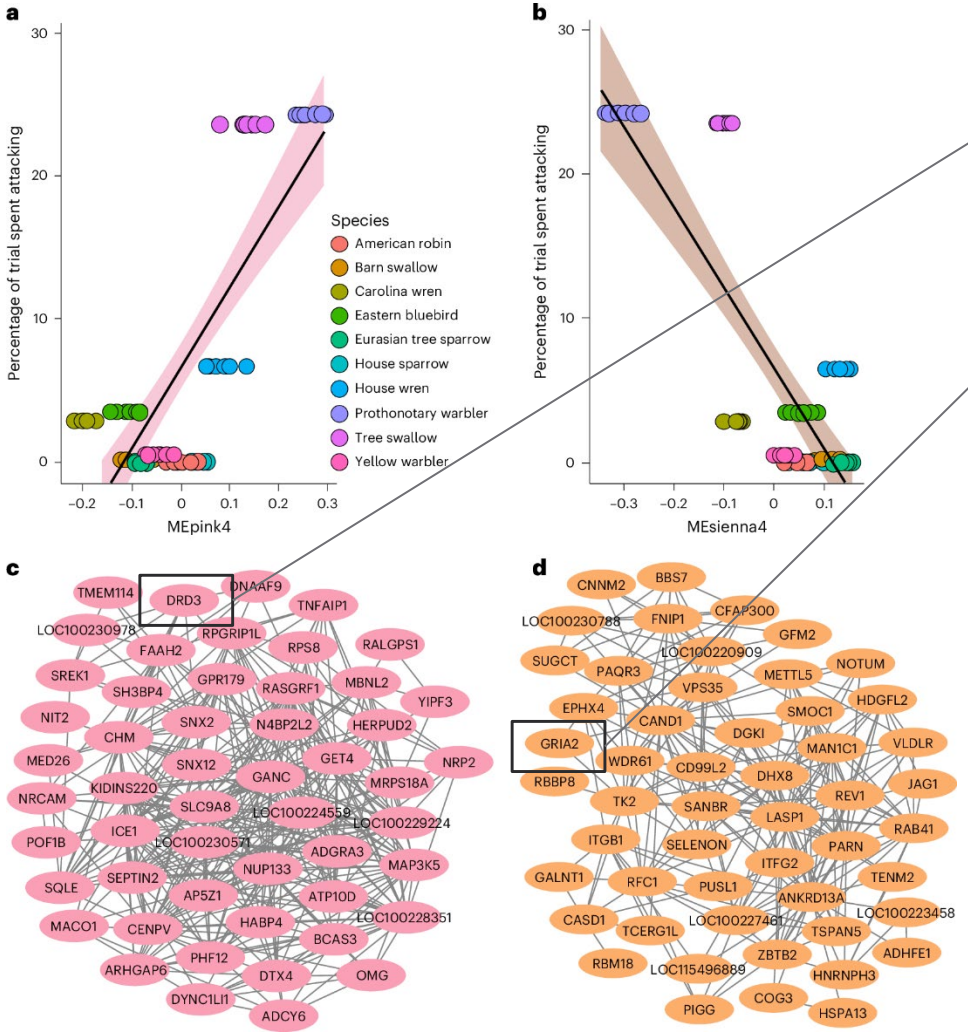
Convergence emerges more clearly at the **regulatory network level** than at the level of individual genes.

Female-specific molecular routes to aggression

2 genes with established connections to aggression

DRD3, a dopamine receptor in the pink4 network

GRIA2, a glutamate receptor in the sienna4 network



Female aggression is associated with **distinct gene regulatory networks**, highlighting sex-specific evolutionary pathways.

Take-home messages

•Convergent evolution of behavior exists under shared ecological pressure
Across five independent avian lineages, obligate cavity nesters have repeatedly evolved higher territorial aggression, demonstrating clear behavioral convergence under shared ecological pressure.

•Aggression is not explained by testosterone
Differences in aggressive behavior among nesting strategies are not associated with testosterone levels

•Behavior is linked to gene expression, but most genes are lineage-specific
Gene expression patterns are associated with nesting strategy and aggression, yet the majority of differentially expressed genes differ among lineages

•Molecular convergence emerges at the gene network level
While single-gene convergence is rare, phylogenetically informed analyses reveal convergent shifts in gene co-expression modules related to neural function and energy metabolism.

•Sex-specific gene networks underlie convergent behavior
Female aggression is associated with distinct gene regulatory modules that differ from those in males, highlighting sex-specific molecular pathways in behavioral evolution.

What do we learn from the study

This paper give us 2 new method to conduct cross-species comparison

1. RRHO methods to compared the differences of comparison between groups
2. PGLMM conducted on both genes and modules to link the traits to genes.

However, it has several severe weakness:

1. Only includes bioinformatic analysis, without any experimental data
2. Only includes large scale analysis, not find a key candidate gene

Thanks for your attention!

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