Reconstructing a Cichlid Phylogeny and Investigating the Evolution of Feeding Strategies

Bailey Jannuzzi, Brett Carlson, Sarah Sylvester

BIOL 4300

UTAH VALLEY UNIVERSITY

Background into Cichlids

- Super diverse family (~1700 recognized species)[3,9,15]
- Models for studying adaptive radiation[3,11,17]
- Morphology can be highly plastic[8]
- Hard to reconstruct evolutionary histories

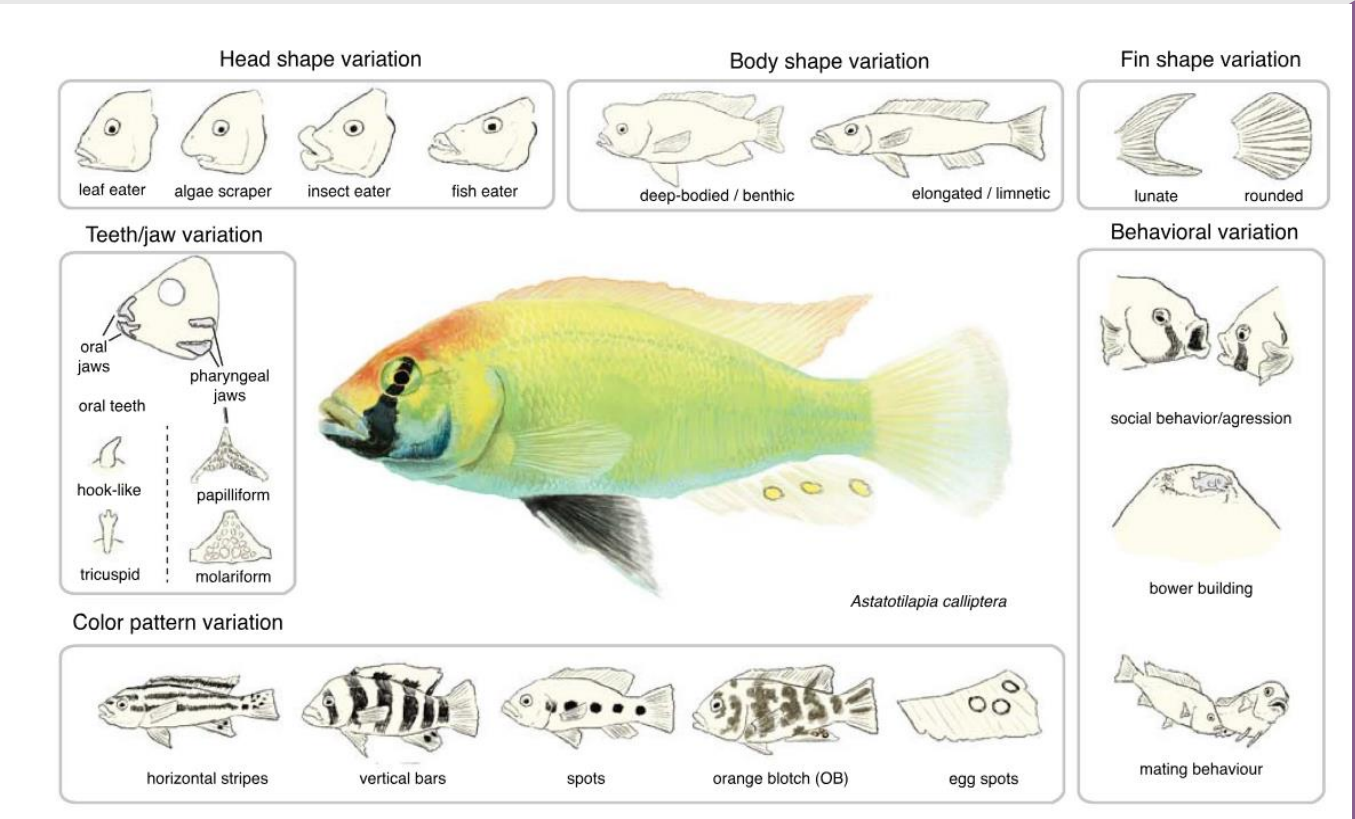

Fig 1: Visual summary of different morphological variations in East African cichlid fish.[12]

Project Motivation

- Abundance of studies investigating Cichlid diversity and evolution
- Confidence in finding data through Fishbase and NCBI
- Many published trees containing varying numbers of Cichlid species[4,5,8]
- Previous studies have investigated feeding habits and jaw morphology, but have not mapped traits on their phylogeny[8,9]

Diversity in Feeding Strategies (Grazer)

Image 1: *Tropheus moorii* (Blunthead Cichlid) from iNaturalist

- Herbivorous diet: epilithic algae
- Small, downward facing mouth
- Needs stable rocky environment

Diversity in Feeding Strategies (Active Predator)

Image 2: *Cichla temensis* (Speckled Peacock Bass) from iNaturalist

- Carnivorous diet
- Large, strong jaw
- Deep open-water environments

Diversity in Feeding Strategies (Generalist)

Image 3: *Coptodon zillii* (Redbelly tilapia) from iNaturalist

- Varied diet
- Flexible morphology
- Seasonal environments

Diversity in Feeding Strategies (Micro-predator)

Image 4: *Cyprichromis leptosoma* (Slender Cichlid) from iNaturalist

- Zooplankton
- Small, precise mouth
- Open water environment

Diversity in Feeding Strategies (Detritivore)

Image 5: *Pseudosimochromis curvifrons* from iNaturalist

- Decomposing organic material
- Specialized mouth for shifting

Project Objectives

1. Reconstruct a phylogeny of the Family Cichlidae

2. Map feeding strategies onto the constructed tree to investigate the evolution of these traits across the phylogeny

Data Collection

- Created a data frame of all valid cichlid species
- Searched NCBI for gene hits (COI, PTR, CYTB, ND2, ND5)
- Filtered tables to include taxa that had hits for at least the COI, PTR, and CYTB genes
- Generated FASTA file for each gene
- Diet and location information was also gathered from Fishbase and iNaturalist

*Data/code is available via project GitHub

Phylogenetic Reconstruction

- Data: DNA supermatrix with 69 species
- Software: IQ-TREE2
- Model: TPM2+F+R5
- Support: 1000 ultrafast bootstrap
- Outgroup: *Planiliza haematocheilus*

Initial Tree + Support[5,13,14]

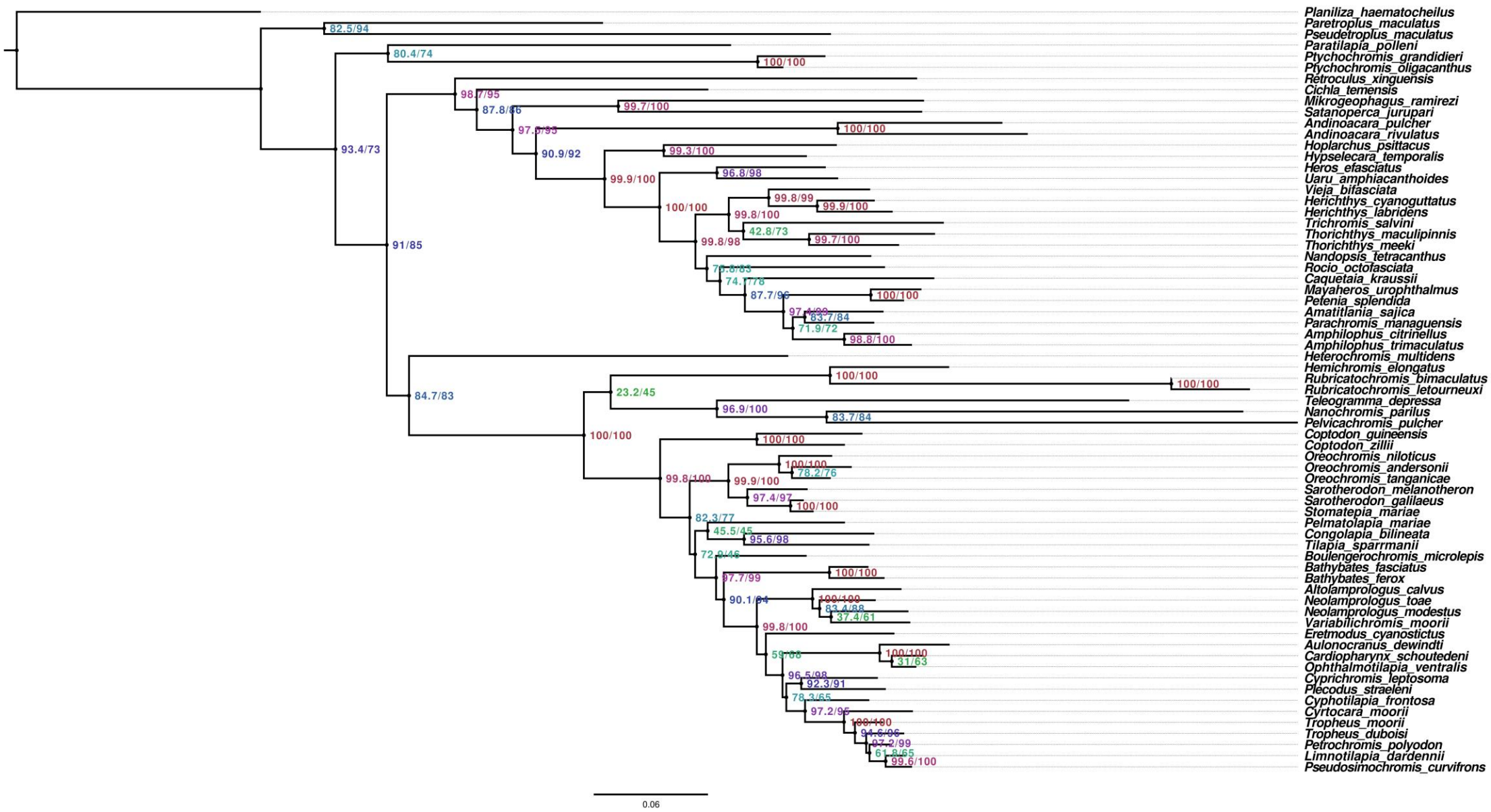

Fig 2: Phylogeny of 68 Cichlid species, rooted on *Planiliza haematocheilus.* Bootstrap values for each node are display: green coloring on lower end, red being on the highest end. Depicted with FigTree.

Trait Mapping

- Difficult to find jaw morphological data
- To address this:
  1) Species diet information was collected instead
  2) Data was categorized into feeding strategies:
     - Active predator
     - Micro predator
     - Generalist
     - Grazer
     - Detritivore

Results

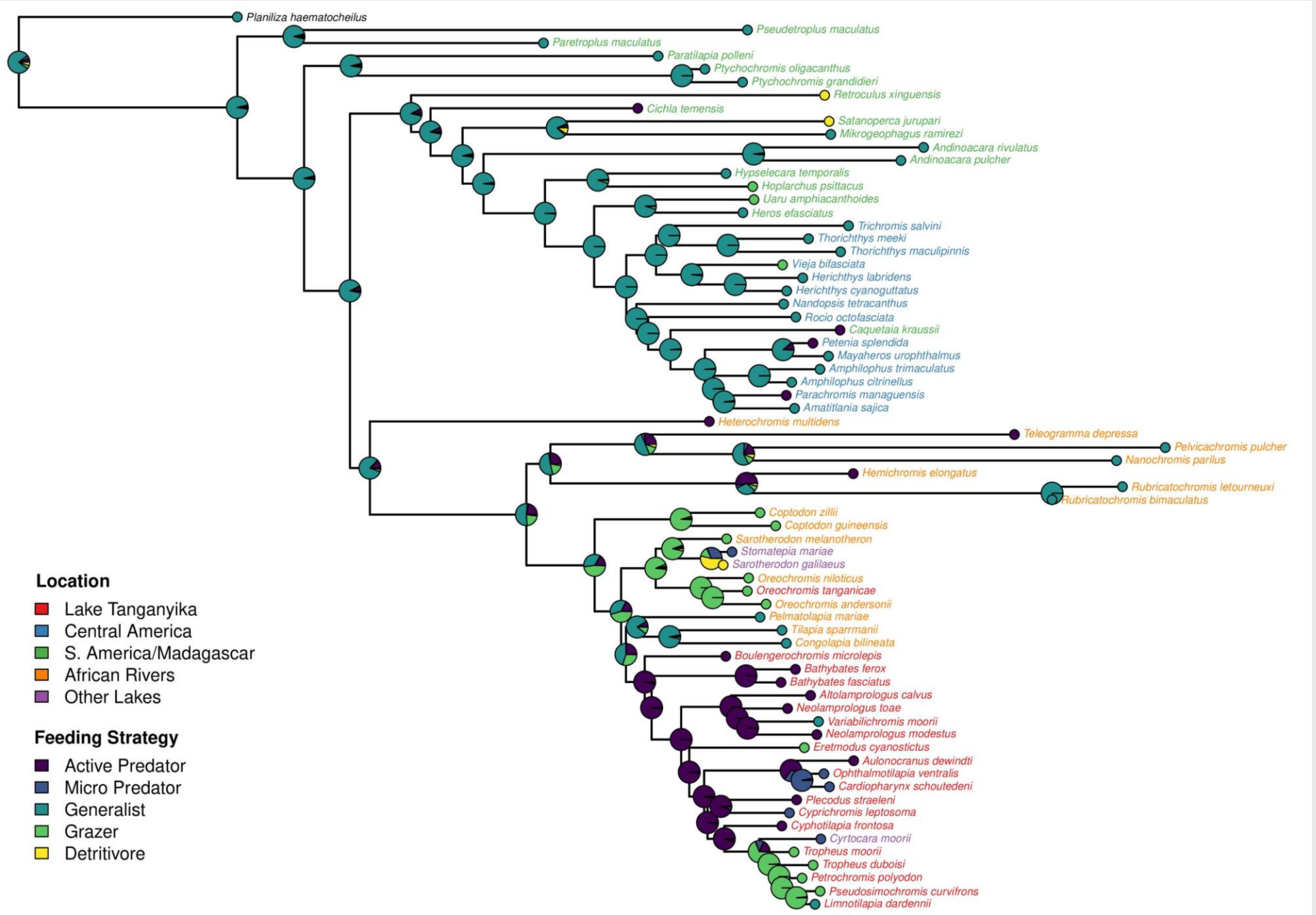

Fig 3: Phylogeny of 68 Cichlid species, rooted on *Planiliza haematocheilus.* Pie charts at each node show the reconstructed ancestral state likelihoods for feeding strategy. Species names are colored by location.

Results

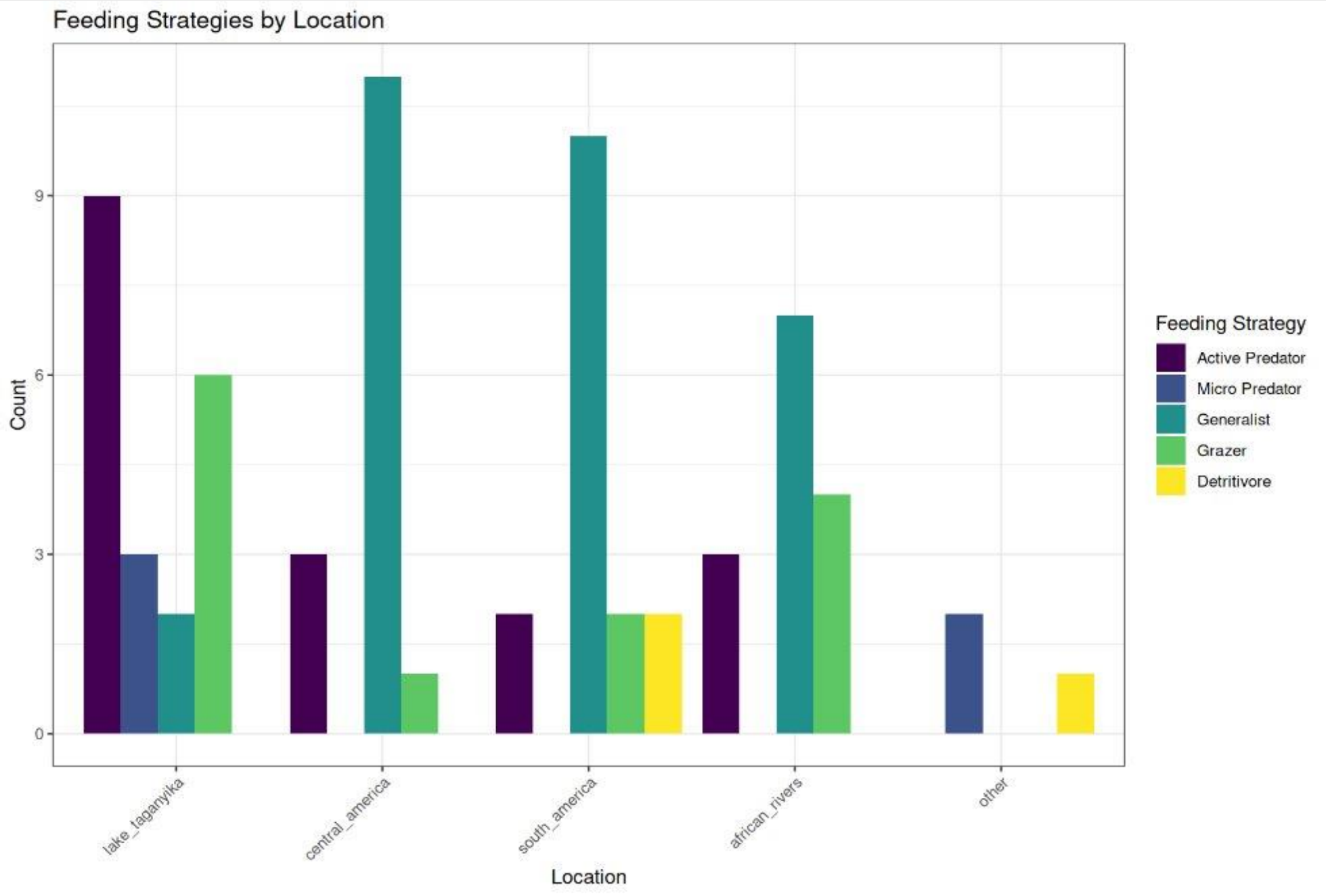

Fig 4: Composition of the feeding strategies observed at each location.

Key Results

1) Lake Tanganyika has the greatest diversity in feeding strategy
2) A generalist diet is likely the ancestral state
3) River locations had more generalists
4) Open waters had more carnivores and grazers
5) Detritivores and micro-predators appear a lot less than other strategies

Implications

- Ecological diversification[2,8]
- Understanding evolutionary constraints[7]
- Conservation efforts[2]
- Links between morphology and diet[8]

Limitations

- Phylogeny only encompasses 68 taxa
- Varying levels of detail on diet composition
- Only 5 simplified diet groups
- Not accounting for things like phenotypic plasticity and hybridization[6]

Future Directions

- Incorporate more genetic and historical data to generate a more accurate tree that can account for hybridization events.[6]
- Gathering more widespread data into jaw morphology and diet across more species and locations.[11]
- More sequencing

Questions?

References

Review papers marked by *.

1. Acero, A., et al. (2024). The Complete Genome Sequences of 7 Hypoplectrus species (Serranidae, Perciformes). Biodiversity Genomes, 2024, 10.56179/001c.117765.
2. Abour JH, López-Fernández H. Continental cichlid radiations: functional diversity reveals the role of changing ecological opportunity inthe Neotropics. Proceedings Biological Sciences 2016;283:20160556.
3. Astudillo-Clavijo, V., et al. (2023). Exon-based Phylogenomics and the Relationships of African Cichlid Fishes: Tackling the Challenges of Reconstructing Phylogenies with Repeated Rapid Radiations. Systematic Biology, 72(1), 134–149.
4. Betancur-R., R., et al. (2013). The Tree of Life and a New Classification of Bony Fishes. PLoS Currents, 5, ecurrents.tol.53ba26640df0ccaee75bb165c8c26288.
5. Betancur-R, R., et al. (2017). Phylogenetic classification of bony fishes. BMC Evolutionary Biology, 17(1), 162.
6. Blumer, L. M., et al. (2025). Introgression dynamics of sex-linked chromosomal inversions shape the Malawi cichlid radiation. Science, 388(6752), eadr9961.
7. *Burress, E. D. (2015). Cichlid fishes as models of ecological diversification: Patterns, mechanisms, and consequences. Hydrobiologia, 748(1), 7–27.
8. *Gidmark, N. J., et al. (2019). Functional Morphology and Biomechanics of Feeding in Fishes. In V. Bels & I. Q. Whishaw (Eds.), Feeding in Vertebrates (pp. 297–332). Springer International Publishing.
9. López-Fernández, H., et al. (2010). Multilocus phylogeny and rapid radiations in Neotropical cichlid fishes (Perciformes: Cichlidae: Cichlinae). Molecular Phylogenetics and Evolution, 55(3), 1070–1086.
10. Malinsky, M., Svardal, H., Tyers, A.M. et al. Whole-genome sequences of Malawi cichlids reveal multiple radiations interconnected by gene flow. Nat Ecol Evol 2, 1940–1955 (2018). https://doi.org/10.1038/s41559-018-0717-x

References

11. Nicholas, B., & López-Fernández, H. (2024). Analysis of the whole pharyngeal jaw adds nuance to the continental radiation of Neotropical cichlids. Evolutionary Journal of the Linnean Society, 3(1), kzae038.

12. Sanciangco, M. D., et al. (2016). Phylogenetic placement of enigmatic percomorph families (Teleostei: Percomorphaceae). Molecular Phylogenetics and Evolution, 94, 565–576.

13. *Santos, M. E., et al. (2023). East African cichlid fishes. EvoDevo, 14.

14. Sparks, J. S., & Smith, Wm. L. (2004). Phylogeny and biogeography of cichlid fishes (Teleostei: Perciformes: Cichlidae). Cladistics, 20(6), 501–517.

15. *Thacker, C. E., & Near, T. J. (2025). Phylogeny, biology, and evolution of acanthopterygian fish clades. Reviews in Fish Biology and Fisheries, 35(2), 805–845.

16. Tripathy, B., et al. (2024). Comprehensive molecular phylogeny and diversification of snappers (Actinopterygii: Perciformes: Lutjanidae) from the Odisha coast, Bay of Bengal, India: taxonomy and distribution. Organisms Diversity & Evolution, 24(4), 541–555.

17. Varella, H. R., et al. (2023). Revision of the generic classification of pike cichlids using an integrative phylogenetic approach (Cichlidae: Tribe Geophagini: subtribe Crenicichlina). Zoological Journal of the Linnean Society, 198(4), 982–1034.

18. Zhang, X., et al. (2025). The first complete mitochondrial genome of Biotodoma cupido (Cichiliformes: Cichlidae) and its phylogeny. Frontiers in Genetics, 16.

19. Froese, R. & D. Pauly. Editors. 2025. FishBase. World Wide Web electronic publication. www.fishbase.org, version (04/2025).

20. iNaturalist. (n.d.). iNaturalist. https://www.inaturalist.org

Project GitHub: https://github.com/Sarah-Ghiaie/phylogenetics_carnivory_fish_morphology