The 1st International Online Conference on Taxonomy



03-04 December 2025 | Online

Taxonomy and systematics of *Gymnorhamphichthys* (Rhamphichthyidae: Gymnotiformes)

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INTRODUCTION & AIM

- The ability to delimit species and clades is essential to understand their ecology, evolutionary history, and asses their conservation need.
- *Gymnorhamphichthys*, known as sand knifefishes, is a genus of South American weakly electric fishes. The clade has five valid species, most of which have broad geographic distributions with substantial phenotypic variation. These variations resulted in a convoluted taxonomic history, lack of clear diagnostic features and misidentification¹.

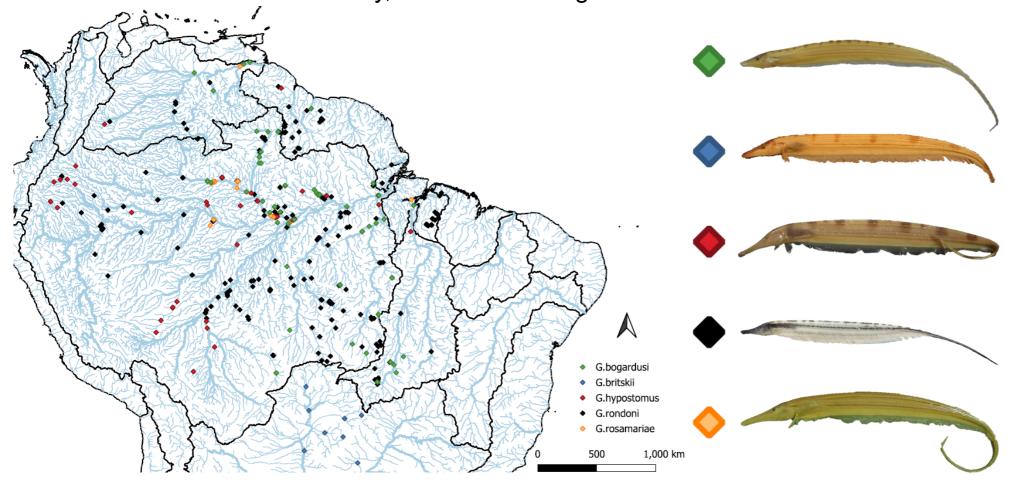


Figure 1: Map representing the geographic distribution of Gymnorhamphichthys species. Green = G. borgadusi, blue = G. britskii, red = G. hypostomus, black = G. rondoni and yellow = G. rosamariae.

Since older taxonomic methodologies failed to distinguish between possible pseudo cryptic species, we expect newer methodologies such as micro-computed tomography, 3D morphometrics and multi loci molecular sequences to allow us to elucidate patterns of diversity within this clade.

METHOD

 Data was collected from specimens in museums across North America (ANSP, FMNH, UF, USNM), Brazil (INPA, MZUSP, MNRJ, DZUFMG, LBP, PUC-Minas) and Europe (MHNG).

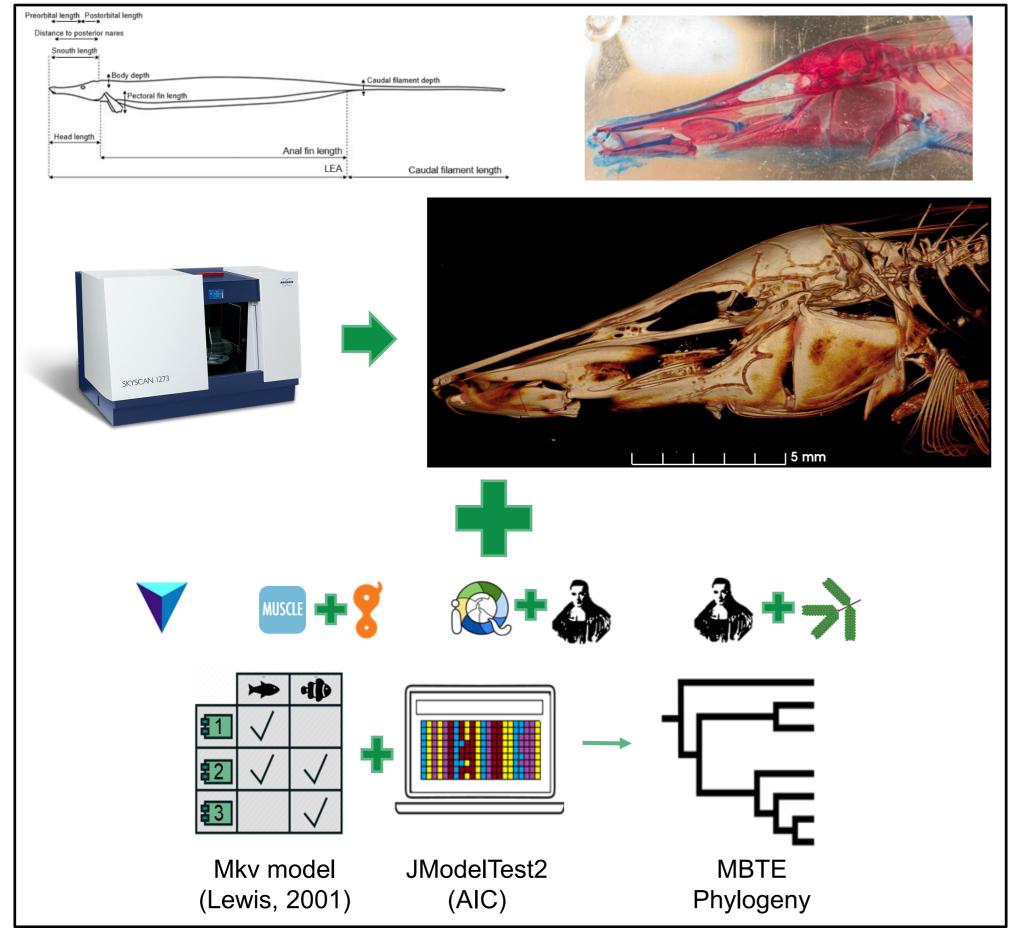


Figure 2: Methodology scheme. All museums specimens were measured, Clear and stain specimens and CTScans were used to evaluated osteological characters. All genetic data avaliable (Genbank plus new sequences) for the large subunit ribosomal RNA gene (16S), cytochrome B (cyt b) and cytochrome c oxidase subunit I (COI) and one nuclear, myosin heavy chain (6Myh6)were used to construct a phylogenetic tree (ML and Bayesian). Lastly, a MBTE Phylogeny is going to be constructed in 2026.

Future Work



- 3D Geometric morphometrics to help us differentiate pseudocrypt species
- geomorph² → Phylogenetic signal
- BioGeoBEARS³ → Ancestral geographic ranges and range evolution
- phytools⁴ → Ancestral morphological and ecological traits.

PRELIMINARY RESULTS

- Preliminary results support the five valid species already described with external and internal characters, molecular data, and ecological traits.
- Two possible new species from Guyana and Trombetas region are being evaluated.
- Four distinct populations of *G. hypostomus*.

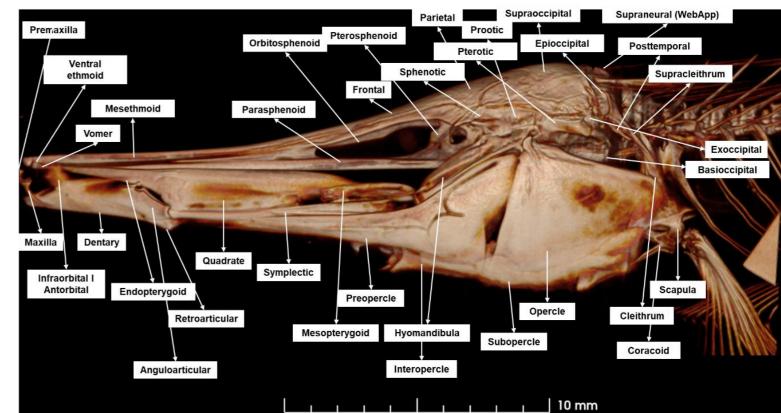


Figure 3: Microtomography of Gymnorhamphichthys hypostomus from WGRC specimen E2015120305. This specimen was identified by having large dark saddle-shaped pigment bars over the dorsal midline, 178-211 anal-fin rays, long snout, shorter distance from tip of snout to posterior nares (Carvalho, 2013).

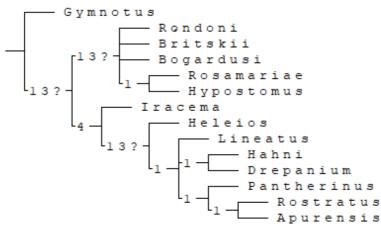


Figure 4: Morphological tree with 141 morphological characters, numbers represent Bremmer support

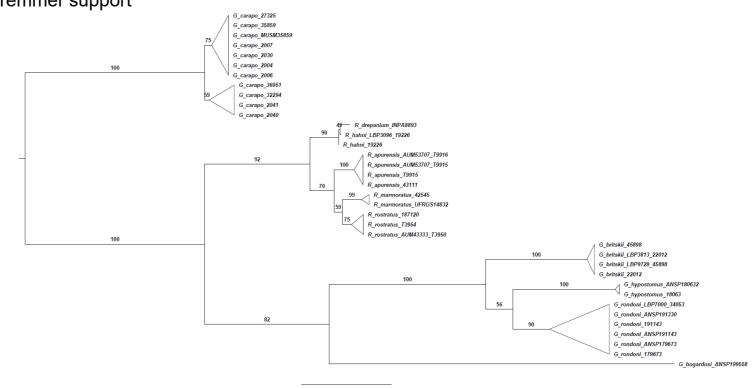


Figure 5: Maximum Likelihood phylogenetic tree from two mitochondrial genes (CytB + 16S). Genes were accessed via Genbank.

Table 1: Ecological traits of all five species of Gymnorhamphichthys⁵

	G. bogardusi	G. britiskii	G. hypostomus	G. rondoni	G. rosamariae
Body size	Small				
Water chemistry	All water types	Whitewater	All water types		Clear and blackwaters
Macrohabitat	streams &			Low-gradient streams & small rivers	Low-gradient channels & margins of large rivers
Mesohabitat	Benthic of large river channels	Benthic of large river channels. Seasonal floodplains of large rivers	Benthic of large river channels	Lotic streams	Benthic of large river channels
Microhabitat	Benthic, sand				
Trophic	Benthic invertebrates				
Behavior	Migratory. Passive electroception: sensory use of weak ambient electric fields. Active electroreception & electrogeneration using electric organs				

EXPECTED FUTURE RESULTS

- Gymnorhamphichthys have a higher alpha taxonomy than currently known.
- Rhamphichthyidae originated in blackwaters streams of the Guyana shield.
- Gymnorhamphichthys originated on the Western Amazon.

FUTURE WORK / REFERENCES

1. Carvalho TP. Systematics and evolution of the toothless knifefishes Rhamphichthyoidea Mago-Leccia (Actinopterygii: Gymnotiformes): diversification in South American freshwaters. University of Louisiana at Lafayette. 2013. 2. Adams D. et al. Geomorph: software for geometric morphometric analyses. R package version 4.0.9. https://cran.r-project.org/package=geomorph. 2024. 3. Matzke N. BioGeoBEARS: Biogeography with Bayesian (and Likelihood) Evolutionary Analysis in R Scripts. University of California, Berkeley, CA. 2013. 4. Revell L. phytools 2.0: an updated R ecosystem for phylogenetic comparative methods (and other things). PeerJ, 12: e16505. doi:10.7717/peerj.16505. 2024. 5. Albert JS. et al. An ecological trait matrix of Neotropical freshwater fishes. Scientific data, 12(1), 1127. 2025.