

# Phylogenetic and Geometric Morphometric Approach to Examining Morphological Adaptations in Burrowing *Alpheus* Snapping Shrimp

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## Introduction

*Alpheus* snapping shrimp are one of the most diverse genera of arthropods inhabiting coral reef ecosystems. The enlarged snapping claw (major chela, Fig. 1) is considered a “key innovation” that has allowed these shrimps to occupy and thrive in a wide range of microhabitats. The morphology of the major chela is highly variable in snapping shrimps and has traditionally been used to classify them into one of seven species groups. However, phylogenetic relationships based on molecular analyses disagree with morphological-based species groups (Hurt et al. 2021). Discrepancies between morphological traits and molecular characters may reflect convergent evolution in response to habitat preferences.

Members of the *A. brevivrostris* species group are primarily defined by their unique snapping claw morphology; they exhibit a spade-shaped major chelae that lacks definitive sculpturing. Species in this group are primarily known to occupy burrows in various substrates, and many species are symbiotic with a diversity of taxonomic groups, including goby fishes and echiuran worms, and vary in their burrowing behaviors. Non-symbiotic burrowers dig their own burrows, goby symbionts dig burrows for both animals while the goby keeps watch, and echiuran symbionts occupy burrows excavated by their echiuran host. Fine-scale differences in chelae morphology may reflect specialized adaptations for these different life histories and burrowing strategies

Here we combine geometric morphometrics and molecular-based phylogenetic analyses to examine chela morphology in burrowing snapping shrimps in the *A. brevivrostris* species group. Techniques developed in this study will ultimately be used to test for convergent evolution and specialization of chelae morphology for burrowing behavior.



Top Left: *Alpheus christofferseni* with echiuran worm (Arthur Anker 2006)



Bottom Right: *A. randalli* with a goby (Etienne Gosse 2011)

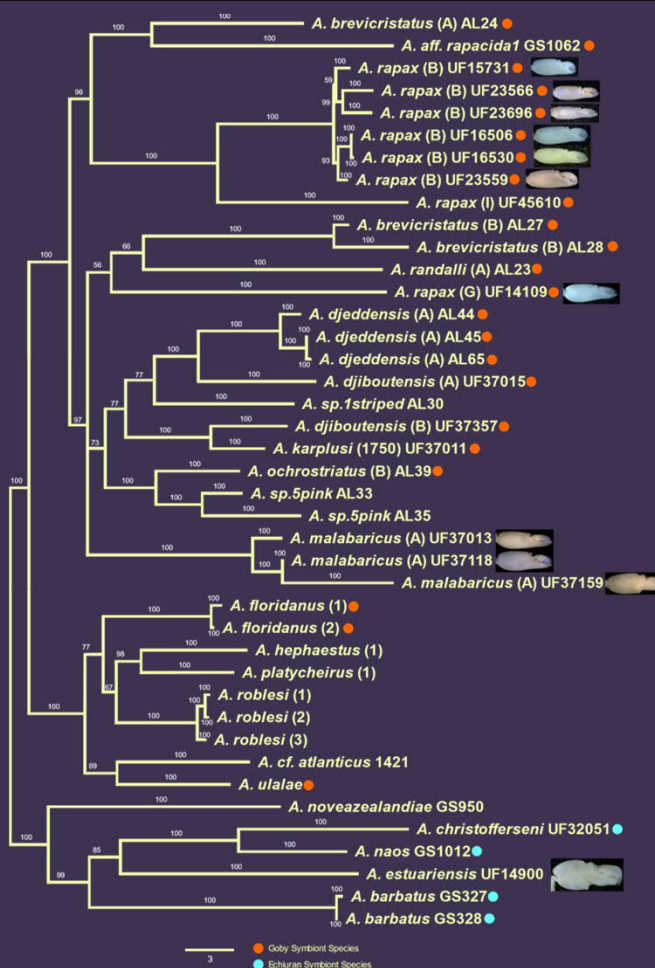


Figure 2. Phylogenetic tree of burrowing *Alpheus* specimens. Symbiont species are marked by orange (goby) and light blue (echiuran worm).

## Methods

Snapping shrimp species were acquired from the Florida Natural History museum, the Oxford University Museum of Natural History, and field collections held at Tennessee Technological University. Shrimp were sequenced for four loci: mitochondrial 16S rRNA, 12S, and the 3' and 5' regions of the cytochrome oxidase I gene. A Bayesian phylogenetic tree was constructed using maximum likelihood on a concatenated set of these 4 loci.

A digital stereomicroscope was used to photograph and digitize the major chela of each shrimp. Multiple images were taken per chela and stacked using Photoshop version 23.3. Landmarks and semilandmarks were digitized using the tpsSeries (Rohlf, 2015)

## Discussion and Future Directions

The phylogeny (Fig. 2) shows a clear separation among echiuran symbionts and goby symbionts. Goby-symbioses (orange dots) may have evolved independently several times. Despite being phylogenetically separated, both groups of symbionts are expected to have similar adaptations as non-symbionts due to their burrowing life history. Subsequent landmark analyses will be performed on the major chelae.

While analysis using landmarks has yet to be performed, many of the individuals under the same species name show notable differences in widths and notching (*A. rapax* “B”, Fig. 3), suggesting some within-species variation. Ultimately, we plan to expand our current phylogeny and morphometric analysis as more species of shrimps are added, allowing us to conduct a more robust analysis.

Figure 1. A lateral view of the major chela from *A. estuariensis* (UF14900) showing landmark locations.

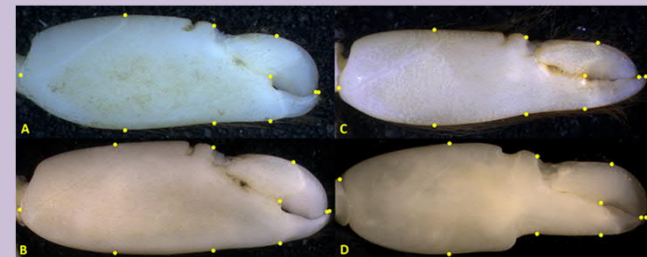


Figure 3. A comparison of major chelae from three *A. rapax* (B) specimens (A:UF15731, B:UF23559, and C:UF23566) and one *A. malabaricus* specimen (D:UF37159) showing the lateral view with landmarks.

## References

Hurt, C., Hultgren, K., Anker, A., Lemmon, A. R., Lemmon, E. M., & Bracken-Grissom, H. (2021). First worldwide molecular phylogeny of the morphologically and ecologically hyperdiversified snapping shrimp genus *Alpheus* (Malacostraca: Decapoda). *Molecular Phylogenetics and Evolution*, 158, 107080.

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