Examination of the Morphology and Locomotion of an Extinct Triassic-Era Frog

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Geobiology & Paleobiology

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1. Introduction

- Anurans (frogs) today vary in locomotive behaviors which can be identified by their skeletal build[1]:
  - Jumping; walking; burrowing; hopping; swimming; walking/hopping; and swimming/jumping (Figure 4)
- Much of the fossil record covering the transition to hopping and jumping remains largely undocumented in early frogs[2]
- Previously known jumping frog lived 180 million years ago based on its ilium shape[2]
- New frog specimen from Chinle Formation (220-213 Ma) showed jumping may have originated earlier than previously known[2]

2. Objective

- Determine if the Upper Triassic frog ilium (Figure 1) was a jumper/swimmer or a walker/hopper by comparing it with extant frogs with known locomotive behaviors

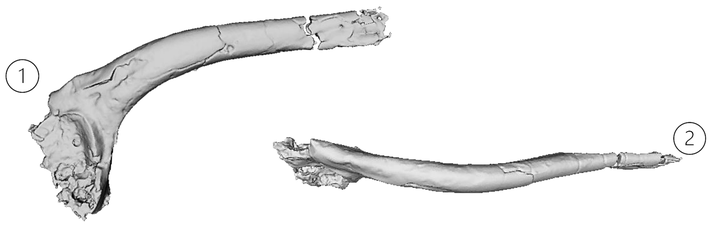

Figure 1. Specimen *DMNH-2018-05-0002.* Upper Triassic period partial frog right ilium mesh collected from the Chinle Formation figured in the right lateral view with the anterior to the right (1) and from the dorsal view (2)

3. Materials

- Mesh of a partial frog ilium from Upper Triassic era collected from the Green Layer of the Chinle Formation in Arizona (Figure 1) from Stocker et al. (2019)
- Meshes on Morphosource.com, CT scans, and locomotive behavior data of numerous studied species in Stepanova and Womack (2020) and Buttimer et al. (2020)

4. Methods

- Compile all modern and fossil frog ilia meshes
- Qualitatively compared fossil frog ilium with modern frog ilia based on categories set by Buttimer et al. (2020)

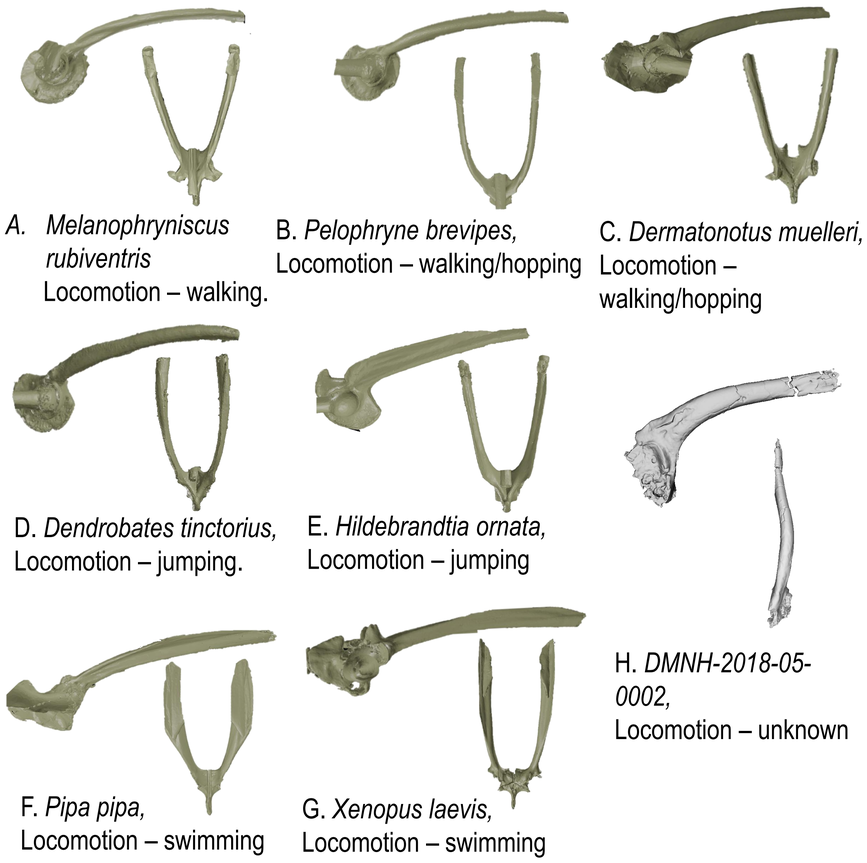

Figure 2. Right lateral and dorsal views (anterior to the right in lateral view or up in dorsal view) of ilium meshes of various species of living frogs (A-G) from morphosource.org project ID 00000C967 with known locomotive behavior [2,3]. Target specimen *DMNH-2018-05-0002* (H) shown for qualitative comparison.

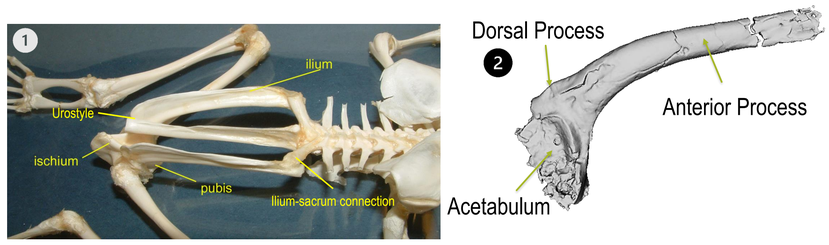

Figure 3. Labelled anatomical features of the (1) frog pelvic girdle (*Comparing The Human Hip to That of Other Vertebrates (sunyorange.edu))* and (2) frog ilium

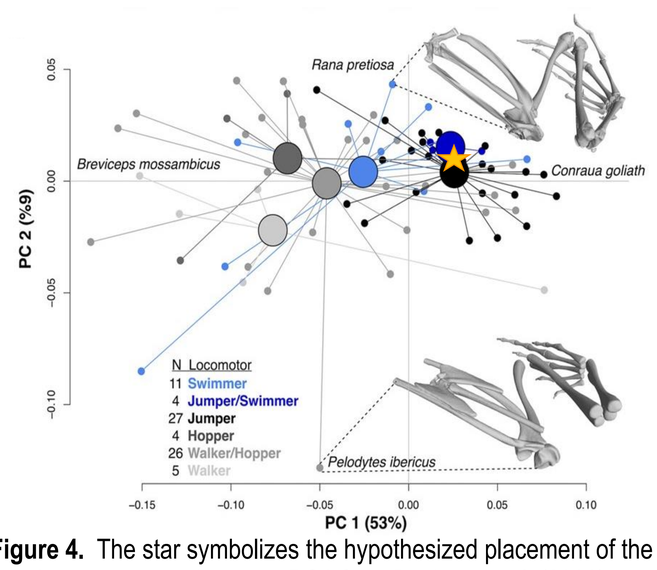

Figure 4. The star symbolizes the hypothesized placement of the frog ilium specimen on a morphospace PCA from Buttimer et al. (2020)

5. Results and Discussion

After comparing the specimen mesh to the living frogs (Figure 2), it was seen that:

- Anterior process is relatively taller than walking/hopping frogs
- Anterior process of average-long length
  - Infer that urostyle is likely average-long as well
    - Urostyle articulates with sacral vertebrae at the end of anterior process/ilium and the hind limbs at acetabulum, meaning the urostyle is likely similar in length to pelvic girdle (see figure 3 for labelled frog pelvic girdle)
- Anterior process remains relatively same width moving anteriorly and curves back toward the midline
  - Constant width matches walking/hopping frogs but not jumping
  - Recurve towards midline matches jumping frogs and could be compared to *P. brevipes*
- Connection of the anterior process and acetabulum is relatively thick
  - Thicker than walking/hopping, swimming frogs, and *D. tinctorius* jumping frog
  - Most like *H. ornata* jumping frog
- Acetabulum extends downward at ~90° angle downward from the anterior process
  - Shape and angle does not resemble swimming frogs but not unlike jumping, walking/hopping frogs

Note: Complete skeletal meshes were available for each living species examined but were not included as the only comparable materials on the specimen in question were parts of the pelvic girdle.

6. Conclusions

- Taller, thicker, and unflattened nature of acetabulum, anterior process, and shape of present part of the acetabulum suggests jumping or swimming
- The narrow nature of the anterior process in comparison to the swimmers suggests that this frog did not swim as a main locomotor mode
- Anterior process length indicates that the urostyle is likely relatively long
  - Unlikely that the *DMNH-2018-05-0002* specimen was a walking/hopping frog
  - Burrowing frogs were not examined directly but have similar morphological features to walking/hopping frogs[3], so it is also unlikely that this frog was a burrower
- <u>The hypothesized locomotion based on morphology is indicated in Figure 4 between a jumper and jumper/swimmer</u>

Note: The incomplete nature of this specific fossil makes it difficult to definitively determine its exact locomotive behavior.

Personal Takeaways

- All about frogs! Working with non-mammalian animals
- Use of meshes and Meshlab
- The variation in morphological evolution
- Variation in morphologies due to surrounding ecosystems and locomotion
- Experience completing independent research and communicating in a professional scientific setting

References

1. Buttimer, S.M., Stepanova, N. and Womack, M.C. (2020) *Integrative and Comparative Biology*https://doi.org/10.1093/icb/icaa043.
2. Stocker, M.R. *et al.* (2019 *Biology Letters*. https://doi.org/10.1098/rsbl.2018.0922.
3. Stepanova, N. and Womack, M.C. (2020) *Evolution*. https://doi.org/10.1111/evo.13981.

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