Florida Museum of Natural History: Department of Herpetology **Interspecific Variation in the Bony Labyrinth (Inner Ear) of Anurans.** Amber L. Singh, Lauren A. Gonzales, Daniel J. Paluh, David C. Blackburn

Introduction

The semicircular canals of the inner ear sense positional information of the body and angular acceleration of the head during movement. It is widely accepted that birds and mammals with agile and spatially complex movements will have a canal morphology that maximizes sensitivity to these behaviors. More specifically, agile animals have canals with larger radii of curvature and ipsilateral canal pairs that closely approximate 90°s. However, it is not well understood if changes in canal functional morphology in mammals are broadly applicable across vertebrates, or if morphological responses to movement have evolved independently. Interestingly, recent documentation of inner ear variation in caecilians and fossorial snakes, a group of predominantly limbless vertebrates, indicates that both groups may have adopted novel morphological traits thought to enhance sensitivity to movement below ground.

We present a survey of the morphological diversity of the bony labyrinth of anurans, to further investigate the potential influence of habitat and phylogeny on inner ear morphology in the clade Lissamphibia. Using 3-dimensional endocasts generated from high resolution CT scans, we document substantial variation in the size and shape of the semicircular canals and saccule across species. Implications regarding locomotor behaviors and phylogeny are discussed.

Methods

Materials

All specimens were housed at the Florida Museum of Natural History. CT scans were generated at the University of Florida's Nanoscale Research Facility using a GE V TOME X M 240 ultra-high resolution CT scanner. All specimens are listed in Table 1.

Data Collection

VGStudio MAX 3.0 was used to gather 3D volumes of the right inner ear of each specimen. Landmark data was then collected in Rstudio (Figure 1a and 1b) and for the purpose of this study, only focused on the semicircular canals. A total of 16 (9 fixed and 7 sliding) landmarks were placed on each specimen. Points shown in blue are fixed landmarks. points shown in orange are sliding landmarks. Fixed landmarks were chosen according to the most identifiable points consistent through each specimen. The sliding landmarks were then chosen to best show the range of curvature of, and between, each of the semicircular canals.

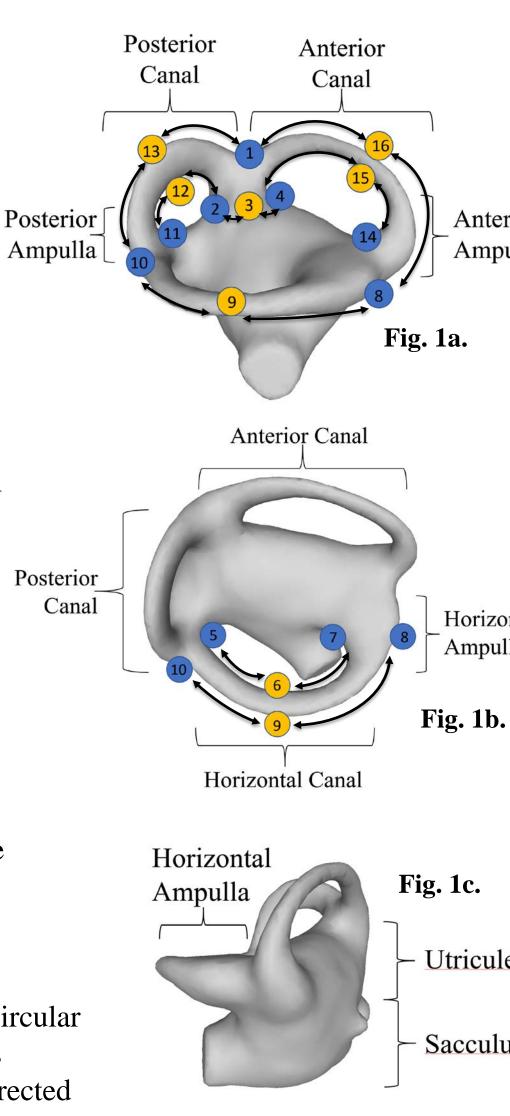
Analysis

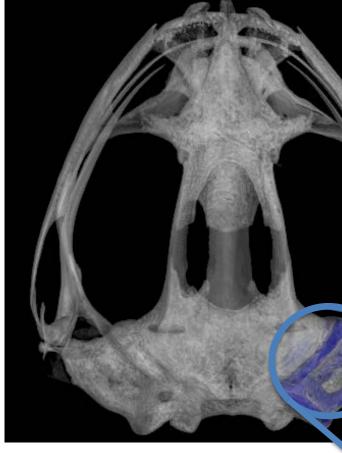
A Principal Component Analysis (PC) of semicircular canal variation was performed using Procrustes tangent coordinates (16 landmark variables corrected for variation in position, orientation, and size). The Procrustes-aligned specimens were plotted (Figure 2 and 4) and grouped by ecological category (color) and clade membership (shape). Allometry was examined by assessing the multivariate regression between semicircular canal shape and canal centroid size based on Procrustes distances.

Images

Each frog image (with the exception of *Pseudacris* ornata) corresponds with one of the inner ears expanded in either the PCA plot, or the allometry plot. The image of *P. ornata* (right) corresponds with the expanded image of the skull showing the placement of the inner ear.

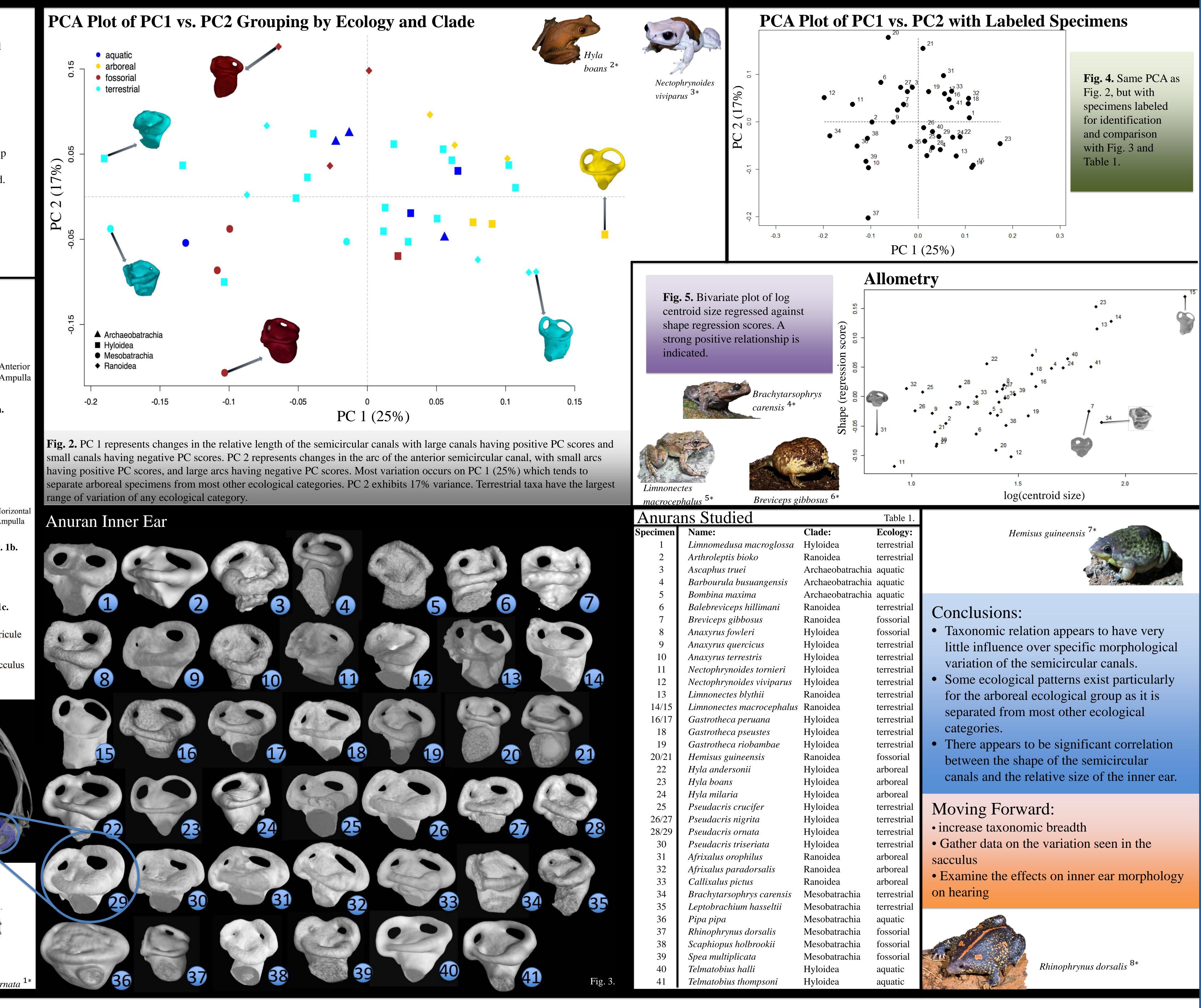
Photo credit: ¹US Geological Survey; ²William Quatman; ³ John W. Wilkinson; ⁴ Thai National Park; ⁵ Merlijn Van Weerd; ⁶ Mike Buckham; ⁷ Eigenes Werk; ⁸ Ryan Photographic. *All photos were altered from their original format.





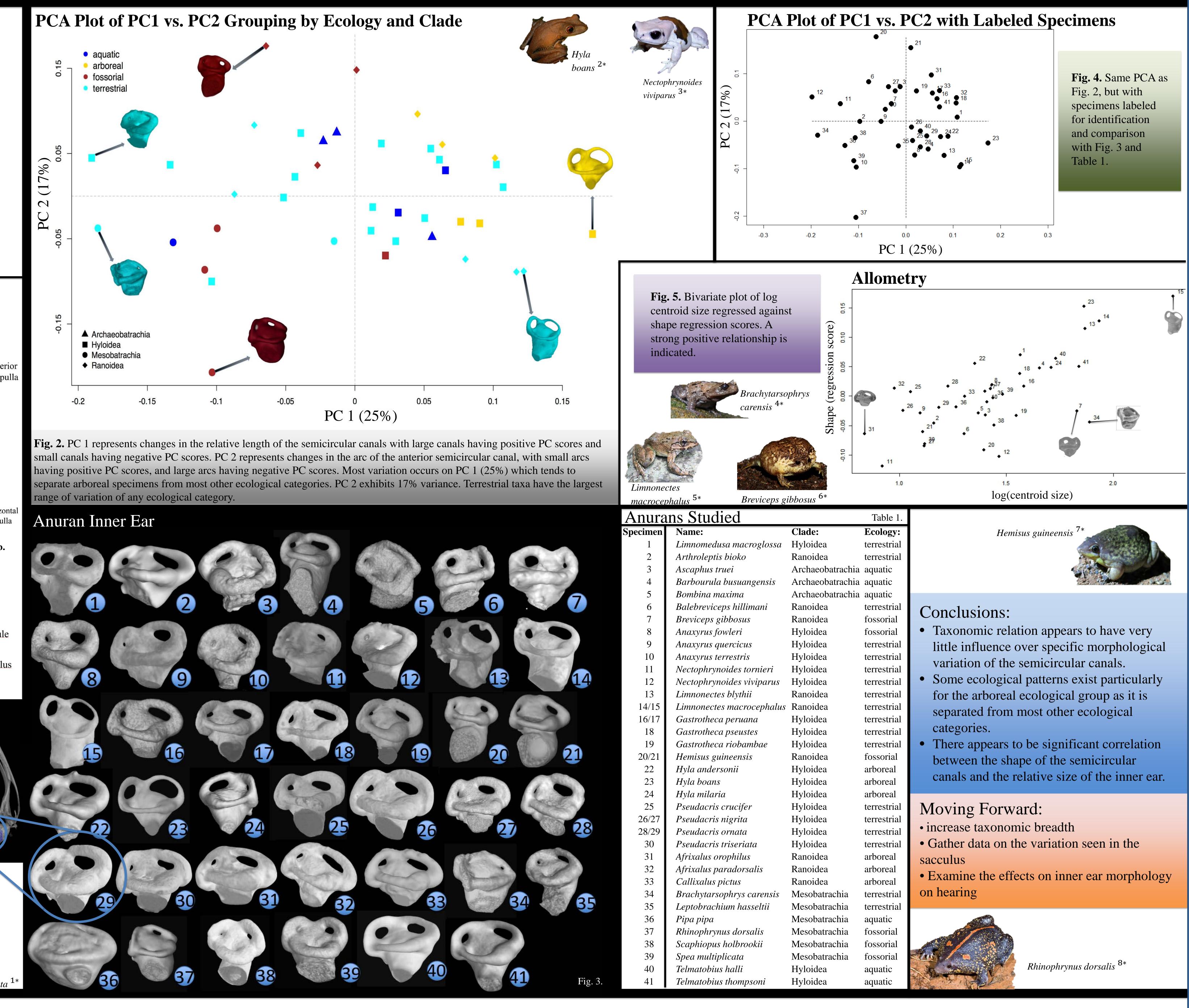






Utricule

Sacculus





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