Evolution and Development of the Autopodium In Microteiid Lizards (Squamata: Gymnophthalmidae)

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The Gymnophthalmidae lizard family exhibits remarkable skeletal variation across the Neotropics, including two snake-like lineages: Gymnophthalmini (forelimb reduction) and Bachiini (hindlimb reduction). These lineages display gradients of limb modifications from partial autopodial loss (manus and pes) to complete reduction, coupled with body elongation and girdle restructuring. This study characterizes limb reduction patterns in Gymnophthalmidae, emphasizing autopodium and girdle structures. While previous studies examined limb reduction directly, recent work demonstrates that girdles provide crucial information about morphological transitions and substrate use associations. We employed two complementary approaches: 1) comparative skeletal anatomy characterizing limb elements (autopodium, zeugopodium, stylopodium) and girdle structures across species with varying reduction degrees; 2) 3D geometric morphometrics analyzing CT scan data to quantify pectoral and pelvic girdle shape variation across representative lineages. We investigated developmental genetics to examine molecular signatures related to identified morphological patterns, focusing on HOX genes involved in limb and axial skeleton development. Genomes of two Gymnophthalmidae species (*Calyptommatus sinebrachiatus*, *Tretioscincus oriximinensis*) and one Teiidae (*Salvator merianae*) were annotated to examine genetic mechanisms underlying differential limb reduction. Analyses revealed positive selection in several HOX genes in the limbless lineage (*Calyptommatus*), suggesting genetic modifications associated with limb loss. This combination of skeletal morphology with developmental genetics provides insights into evolutionary changes at structural and genetic levels, contributing to understanding morphological and molecular evolution in squamates and vertebrate adaptive radiation.

A Kinetic, Physical Model of a Dogfish Shark Skull As a Tool for Motion Simulation and Active Learning

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Understanding how the bones, muscles, and other internal structures of animals move during behaviors is challenging. X-ray Reconstruction of Moving Morphology provides an approach to precisely quantify in vivo internal motions, but is time-consuming and requires specialized equipment. Digital motion simulations can estimate motion but such simulations often require computational expertise. To test the potential of physical models to provide a more accessible motion simulation tool, I created a physical model of the dogfish shark skull (*Squalus acanthias*). I combined dissections, photogrammetry, and microCT scanning of a preserved specimen to digitize the anatomy, including all the cartilages, muscles, and ligaments of the skull. I then fabricated a physical model first using ribbons for ligaments and then replacing most of the ligaments with magnets. I also added hooks for attaching rubber bands, representing the cranial muscles. Our physical model can be manually manipulated to reproduce all of the described motions of the dogfish skull (e.g., jaw protrusion-retrusion, jaw opening-closing, hyoid depression). The weak force of the magnets relative to the rubber bands does make motion with the rubber bands attached more difficult. However, it makes assembly and disassembly far easier in a classroom context. Our model shows that physical models, even with several layers of abstraction (e.g., magnets, rubber bands), can be an accessible tool for estimating and teaching animal form and function.

Intraspecific Cranial Variation In *Amphisbaena vermicularis* (Squamata: Amphisbaenidae)

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Amphisbaenians are highly specialized burrowing reptiles possessing robust skulls adapted for digging. We employed microcomputed tomography and geometric morphometrics to analyze cranial variation in 26 specimens (10 females, 16 males) of *Amphisbaena vermicularis*, a species distributed across northeastern and central-western Brazil, collected from various locations in Piauí and Maranhão states. Our findings revealed conserved cranial morphology that remained stable regardless of snout-vent length or geographic origin. Procrustes analysis showed no significant relationship between skull shape and size (R^2=0.0244; p=0.6582), suggesting strong biomechanical constraints associated with fossorial habits. While males exhibited slightly larger skulls than females (Procrustes ANOVA of centroid size, p=0.0183), we found no shape differences between sexes, indicating a potential trade-off between sexual selection pressure and digging functionality. PCA demonstrated that 83% of morphological variation was concentrated in the first two principal components, with subtle population-level differences that may reflect local adaptations to distinct soil types. The Guadalupe specimens (n=17) displayed a tendency toward narrower skulls, possibly associated with more compact soils. These results highlight the morphological stability of *A. vermicularis* skulls, reinforcing their subterranean specialization. The absence of sexual dimorphism in skull shape contrasts with patterns observed in other squamates, suggesting that functional demands of digging outweigh other evolutionary factors. Our study emphasizes the importance of integrated approaches combining morphology, ecology, and genetics to understand cranial evolution in these unique reptiles.

Hindlimb Morphology and Locomotor Ecology of the South American Notoungulate *Miocochilius anomopodus*

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South American notoungulates were a diverse group of mammals representing a large proportion of endemic South American faunal diversity before the Great American Biotic Interchange, with no modern analogues. Among them, *Miocochilius anomopodus*, a late-diverging Colombian interatheriid, stands out for its potential cursorial adaptations atypical of other Interatheriidae. Studying *M.*

nomopodus offers insights into the selective pressures behind these adaptations and how phylogeny may have constrained convergence with other cursorial mammals, particularly artiodactyls and perissodactyls. We used three-dimensional geometric morphometrics of the femur and calcaneus in *M. anomopodus*, comparing it with approximately 25-50 extant small-bodied mammals. Calcanei from three fossil Perissodactyla species were used to assess morphological convergence on 'intermediate' fossil perissodactyls. Principal component analyses reveal that femoral morphology places *M. anomopodus* at the intersection of fossorial, arboreal/scansorial, and semiaquatic species, with broader and shorter femora than cursorial taxa. Calcaneal morphology places it between fossorial and cursorial groups, with differences in shape and orientation of the talar facets. These contrasting reconstructions suggest that *M. anomopodus* did not fully converge on any single modern ecological niche and potentially retains varying degrees of phylogenetic inertia from its reconstructed fossorial ancestry. This highlights the complexity and challenges of reconstructing locomotor behavior in extinct taxa and the unique evolutionary trajectories within extinct South American endemic fauna.

Toward a Phylogenetic Framework for *Rhinella* (Anura: Bufonidae): Integrating Ct-Scanned Fossils and Extant Species

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Toads of the genus *Rhinella* are small to medium-sized bufonids widely distributed across the Neotropics, exhibiting significant morphological and biological diversity. The genus is recognized as monophyletic and is divided into two major clades: *R. marina* and *R. margaritifera*. Traditionally, osteological characters have been used to study the taxonomy and evolutionary relationships within the group. However, conventional techniques have limitations in capturing the full extent of morphological variation in both extant and fossil specimens, making their classification challenging. To address this, the present project aims to use microcomputed tomography (CT scanning) to build a comprehensive osteological atlas of *Rhinella*. This will allow for a detailed assessment of intraspecific variation in skeletal traits and improve taxonomic resolution. In this context, a primary goal of the project is to develop a phylogenetic hypothesis for *Rhinella* using Total Evidence, to phylogenetically place all known fossil specimens related to the genus. Currently, more than 30 extant species of *Rhinella* and two fossil specimens — which are currently being described — have been CT scanned. This approach has already revealed morphological features that had not been previously considered, and a morphological matrix is being developed as a foundation for the upcoming phylogenetic analyses.

Post-Mortem Age Determination of Two South American Wild Canids (*Lycalopex vetulus* and *Cerdocyon thous*)

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Although South America is the most speciose continent for canids, with 11 extant species, few studies focused on the age estimation of their skeletal remains, which is key to several types of morphological analysis and population dynamics inferences. Previous studies showed that diet directly affects dental wear, as more abrasive items wear down teeth more rapidly. In addition, recent studies showed that *Lycalopex vetulus* and *Cerdocyon thous* share numerous food resources, which raises the question of how overlapping diets impact the dentition of different species during their ontogeny. Here we aimed to investigate the relationship between the diet and post-mortem age determination for adult specimens of *L. vetulus* (n = 24) and *C. thous* (n = 20). We compared cranial and dental age categories, which are the most widely adopted proxies of age for mammals, using skull base sutures (presphenoid, basisphenoid and basioccipital) and superficial teeth wear for age estimations. Cranial and dental age groups of both species did not match in 40,90% of the cases; for many specimens of both species, middle-aged skulls exhibited higher dental age. This inconsistency was more noticeable in *L. vetulus* (60%), which presented a higher degree of dentine exposure, suggesting its greater consumption of insects, especially ground termites, resulting in an abrasive diet due to the accidental consumption of sand and other minerals.

Ontogenetic Development of Pneumatized Cervical Vertebrae in Flagellicaudatan Sauropods

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A key factor allowing gigantism in sauropod dinosaurs was their bird-like lung with pneumatic diverticula that permeated the body. In addition to elevating lung efficiency, these air-filled diverticula resulted in a comparatively low body density and increased the body-air contact surface for heat exchange, which is particularly important for large-sized animals. Diverticula growth from the lung towards the body's extremes during ontogeny has been inferred from external vertebral morphology, but the exact process of internal pneumatization remains poorly understood. We assess the ontogenetic development of internal cervical vertebral pneumaticity in a sample of flagellicaudatan sauropods from the Jurassic Morrison Formation of Wyoming, representing a hatchling, juvenile, and subadult ontogenetic stage. We used micro-CT scanning to examine internal bone structure and produce 3D models of the vertebrae and their internal pneumatic chambers. Crenulated bone texture in the hatchling indicates that diverticula reached the anterior-most cervical vertebrae very early in ontogeny. However, in this individual, penetration of diverticula only occurred in middle and posterior cervical neural arches, with left-right asymmetry. Older juveniles show internal pneumaticity in anterior cervical neural arches. Penetration of the centra was only observed in