

Form and Function in the Xenarthra—an Introduction to the Symposium Proceedings Volume

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Abstract This special issue of the *Journal of Mammalian Evolution* represents the proceedings from a symposium held in conjunction with the 9th International Congress of Vertebrate Morphology (ICVM IX, Punta del Este, Uruguay, July 29, 2010), and entitled “Form and Function in the Xenarthra.” This symposium was the third on xenarthran biology to be presented in association with the ICVM meetings. In this brief introduction to the symposium proceedings, we plan to discuss the justification for the symposium, to provide a brief history of previous symposia and their results, and to introduce the contents of the present volume.

Keywords Xenarthra · Symposium · ICVM · Proceedings

Among modern and fossil New World fauna, the Xenarthra constitutes one of the most characteristic, but also most enigmatic mammalian clades. Due in part to the very peculiar anatomy and physiology of its members, its phylogenetic relationship with other clades of Placentalia remains

uncertain (Delsuc and Douzery 2008; Gaudin and McDonald 2008), and the early fossil history of the group remains very poorly known (Rose et al. 2005; Billet et al. 2011). Xenarthra has recently been hypothesized to group together with Afrotheria to constitute a new Gondwanan supraordinal clade, Atlantogenata (Murphy and Eizirik 2009).

The Xenarthra is generally considered to represent one of four major supraordinal branches of the phylogenetic tree of placental mammals, and is the only one of those branches that traces its origin to South America, forming an important part of that continent’s unique endemic mammalian fauna. Xenarthra includes the Pilosa (Folivora-sloths and Vermilingua-anteaters) and Cingulata (armored xenarthrans, comprising living armadillos and kin) (Gardner 2005a, b). Collectively, these taxa display important functional, ecological, and morphological diversity. Xenarthra has always fascinated scientists because of its array of highly unusual morphological, locomotory, physiological, and reproductive features, including examples such as the suspensory locomotory mode of modern tree sloths—a nearly unique trait in vertebrate evolution (Hildebrand and Goslow 2001; Nyakatura et al. 2010)—or the very peculiar reproductive strategy of armadillos of the genus *Dasybus*, which always give birth to four (*D. novemcinctus*) or eight-ten (*D. hybridus*) monozygotic, i.e., genetically identical offspring (Galbreath 1985). In addition, Xenarthra presents original apomorphies like xenarthry (additional articulations between thoracic and lumbar vertebrae—see Gaudin 1999), absence of enamel in teeth (in all but the extinct armadillo *Utaetus* and the extant armadillo *Dasybus*—see Martin 1916; Kaltoff 2011), and the presence of dermal ossifications in the skin (in cingulates and some sloths—see Engelmann 1985). Lastly, it is noteworthy that Xenarthra is one of a select few placental mammal orders in which the extinct diversity far exceeds that of the living members. There are 31 extant xenarthran species arrayed in 14

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Fig. 1 Photograph of attendees at the third ICVM xenarthran symposium. This symposium took place at ICVM-9 in Punta del Este, Uruguay in 2010. Pictured standing, from left to right: Sergio Vizcaino, Tim Koneval, François Pujos (co-convener), Pablo Cetica, Mariela Cordeiro de Castro, Mariella Superina, Richard Fariña, Susana Bargo, Juan Carlos Femicola, Unknown, Alex Hubbe, John Nyakatura, and Jim Loughry. Kneeling, from left to right: Jeremy Bramblett, Tim Gaudin (co-convener), Nick Milne, Nestor Toledo, Gery De Iuliis, and Greg McDonald



genera (Gardner 2005a, b), but the extinct ground sloths number over 90 described genera alone, and the extinct glyptodonts encompass at least 64 genera (McKenna and Bell 1997).

In the past three decades, morphologists have begun to concentrate their efforts on the systematics, evolution, and ecology of Xenarthra. The number of publications on these topics has increased notably, and nowadays the “X group” consists of over 30 scientists who work closely to increase our knowledge of the clade. The xenarthran symposia held in conjunction with the ICVM meetings have been an important catalyst for this work.

The first xenarthran symposium took place at ICVM-6 in Jena, Germany in 2001. It was convened by Sergio Vizcaino and Richard Fariña, two of the leading South American xenarthran workers, and it ultimately resulted in the publication of a proceedings volume in 2003 (Fariña et al. 2003). This volume represented the first compendium of papers focused solely on xenarthran biology in nearly 20 years (since Montgomery 1985), and included both review papers and original research. A second symposium, entitled “Recent Advances in Xenarthran Studies,” was convened by Gery De Iuliis and Greg McDonald, two esteemed North American workers and contributors to the present volume, at ICVM-8 in Paris in 2007. Although no formal proceedings volume was produced, many of the findings presented were incorporated in the landmark book “The Biology of the Xenarthra” (Vizcaino and Loughry 2008). Edited by two of the contributors to the present volume, one of whom was also a convener of the original ICVM xenarthran symposium (i.e., S.V.), this book represented a long-overdue, comprehensive updating of the Montgomery (1985) book, covering a variety of aspects of xenarthran biology, including systematics, evolution, ecology, genetics, physiology, and conservation.

The goal of the most recent ICVM Xenarthra symposium, entitled “Form and Function in Xenarthra,” was to

update the community of vertebrate biologists regarding the latest research findings on xenarthran biology, and to continue the research momentum created by previous symposia. We felt it was of particular importance to preserve two features that characterized previous symposia: 1) the international nature of the gathering, and, 2) the diversity of topics considered, treating both living and extinct taxa in subjects ranging from molecular systematics to hematology to paleobiology. In both respects we feel that our symposium was a rousing success. There were a larger number of contributions from xenarthran workers than were associated with any of the previous symposia (as befitting the Uruguayan venue, the first ICVM meeting to be held in South America). There were six talks in the formal symposium, but the oral session immediately following our symposium included three additional contributed papers on xenarthran locomotion. There were three additional xenarthran talks associated with other ICVM symposia, and 11 poster presentations on xenarthrans. Contributors were drawn from five continents and eight countries (Argentina, Australia, Brazil, Canada, Germany, Japan, Uruguay, and the USA—Fig. 1), and they presented on topics ranging from sperm morphology, tree sloth locomotion, and CT image analysis of the masticatory system in anteaters, to basal metabolic rate estimations and nasal cavity anatomy in extinct glyptodonts. The present proceedings volume includes papers drawn from four of the six talks in the official symposium (Pujos et al.; Femicola and Porpino; and Toledo et al.; two speakers, Superina and Loughry, collaborated to produce a single paper), and three papers from the ICVM session on locomotion (Milne et al.; Nyakatura; McDonald).

In the past years, considerable advances have been made by Gaudin, Femicola, and others in our understanding of the phylogenetic relationships of Folivora and Cingulata. The

paper by Pujos, in collaboration with three other specialists on fossil sloths [Gaudin, De Iuliis, and Cartelle], discusses the appearance and diversification of morpho-functional adaptations in sloths (e.g., quadrupedal versus bipedal locomotory styles; arboreal and aquatic adaptations; etc.), intra-specific variation and the possible existence of sexual dimorphism, diversity of mastication and diet, as well new prospecting areas and discoveries of peculiar new forms. It also maps locomotory and feeding adaptations on a phylogenetic tree of sloths to examine patterns of morpho-functional evolution in a phylogenetic context. Fernicola and Porpino present the latest results of their phylogenetic analysis of the clade Glyptodontoidea, a group that was previously practically unstudied from a phylogenetic standpoint, in particular comparing traditional classifications based on osteoderm characters with their more recent results using endoskeletal features.

Along with improvements in our knowledge of xenarthran phylogeny have come important advances in our study of the paleobiology of the large and significant evolutionary radiation of extinct xenarthrans. Sergio Vizcaíno, Richard Fariña, and their collaborators have been at the forefront of this work, and Vizcaíno is involved in two of the papers that address aspects of xenarthran paleobiology in the present volume—a paper by Toledo et al. on functional adaptations in Santacrucian sloths, using morphometric data to infer locomotory function; and, a paper by Milne et al. on allometric and group difference in femoral shape across various living and extinct xenarthran taxa, and the functional implications of these patterns. There is an additional contributed paper by McDonald in the broad area of paleobiology, addressing the evolution and function of pedolateral stance in ground sloths.

As in past symposia, an important portion of the symposium was dedicated to modern forms. This proceedings volume includes two papers dedicated to extant taxa. The first is an ecomorphological contribution by Superina and Loughry, examining how the presence of a carapace constrains ecology, physiology, and reproduction in modern armadillos. The second contribution is a paper by Nyakatura addressing the convergent evolution of suspensory locomotion in tree sloths, examining the adaptive traits involved in the two taxa, and the functional constraints that may have led to their convergent evolution.

It is our hope that this volume serves as an impetus for additional symposia, and for additional research on this fascinating, sometimes bizarre, and still very much understudied group of placental mammals, the armadillos, sloths, and anteaters that together comprise the order Xenarthra. There is still much to learn about this group, and such studies are likely to yield insight not just into the biology of these particular mammals, but given their phylogenetic

standing and biogeographic significance, into the evolution of Neotropical faunas and placental mammals in general.

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