

## Experiment Report Form

**The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.**

Once completed, the report should be submitted electronically to the User Office via the User Portal:

<https://www.esrf.fr/misapps/SMISWebClient/protected/welcome.do>

<b>Deadlines for submission of Experimental Reports</b>
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Experimental reports must be submitted within the period of 3 months after the end of the experiment.

### **Experiment Report supporting a new proposal (“relevant report”)**

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a “*preliminary report*”),
- even for experiments whose scientific area is different from the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as “relevant report(s)” in the new application form for beam time.

<b>Deadlines for submitting a report supporting a new proposal</b>
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- 1<sup>st</sup> March Proposal Round - **5<sup>th</sup> March**
- 10<sup>th</sup> September Proposal Round - **13<sup>th</sup> September**

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

### **Reports on experiments relating to long term projects**

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

### **Published papers**

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

### **Instructions for preparing your Report**

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.



<b>Beamline:</b> ID17	<b>Experiment title:</b> Respiratory and appendicular function in an early herbivorous dinosaur	<b>Experiment number:</b>
	<b>Date of experiment:</b> from: 21 July 2016 to: 26 July 2016	<b>Date of report:</b> August 25 <sup>th</sup> , 2021
<b>Shifts:</b> 15	<b>Local contact(s):</b> Vincent Fernandez Paul Tafforeau	<i>Received at ESRF:</i>
<b>Names and affiliations of applicants</b> (* indicates experimentalists): <b>Jonah Choiniere, University of the Witwatersrand</b>		

## Report:

See previous report for details of experiment. This report documents research outcomes.

The data generated in this experiment were used for the Honours degree of Viktor Radermacher at the University of the Witwatersrand, which was awarded with distinction in January 2018. Mr Radermacher was able to attend the ESRF summer school as part of that degree.

The following research has been published using the data from this experiment:

Radermacher, V. J., Fernandez, V., Schachner, E. R., Butler, R. J., Bordy, E. M., Hudgins, M. N., ... & Choiniere, J. N. (2021). A new *Heterodontosaurus* specimen elucidates the unique ventilatory macroevolution of ornithischian dinosaurs. *Elife*, 10, e66036.  
<https://doi.org/10.7554/eLife.66036>

Ornithischian dinosaurs were ecologically prominent herbivores of the Mesozoic Era that achieved a global distribution by the onset of the Cretaceous. The ornithischian body plan is aberrant relative to other ornithodiran clades, and crucial details of their early evolution remain obscure. We present a new, fully articulated skeleton of the early branching ornithischian *Heterodontosaurus tucki*. Phase-contrast enhanced synchrotron data of this new

specimen reveal a suite of novel postcranial features unknown in any other ornithischian, with implications for the early evolution of the group. These features include a large, anteriorly projecting sternum; bizarre, paddle-shaped sternal ribs; and a full gastral basket – the first recovered in Ornithischia. These unusual anatomical traits provide key information on the evolution of the ornithischian body plan and suggest functional shifts in the ventilatory apparatus occurred close to the base of the clade. We complement these anatomical data with a quantitative analysis of ornithischian pelvic architecture, which allows us to make a specific, stepwise hypothesis for their ventilatory evolution.

Bronzati, M., Benson, R. B. J., Evers, S. W., Ezcurra, M. D., Cabreira, S. F., Choiniere, J., . . . Nesbitt, S. J. (2021). Deep evolutionary diversification of semicircular canals in archosaurs. *Current Biology*. doi:<https://doi.org/10.1016/j.cub.2021.03.086>

Living archosaurs (birds and crocodylians) have disparate locomotor strategies that evolved since their divergence ~250 mya. Little is known about the early evolution of the sensory structures that are coupled with these changes, mostly due to limited sampling of early fossils on key stem lineages. In particular, the morphology of the semicircular canals (SCCs) of the endosseous labyrinth has a long-hypothesized relationship with locomotion. Here, we analyze SCC shapes and sizes of living and extinct archosaurs encompassing diverse locomotor habits, including bipedal, semi-aquatic, and flying taxa. We test form-function hypotheses of the SCCs and chronicle their evolution during deep archosaurian divergences. We find that SCC shape is statistically associated with both flight and bipedalism. However, this shape variation is small and is more likely explained by changes in braincase geometry than by locomotor changes. We demonstrate high disparity of both shape and size among stem-archosaurs and a deep divergence of SCC morphologies at the bird–crocodylian split. Stem-crocodylians exhibit diverse morphologies, including aspects also present in birds and distinct from other reptiles. Therefore, extant crocodylian SCC morphologies do not reflect retention of a “primitive” reptilian condition. Key aspects of bird SCC morphology that hitherto were interpreted as flight related, including large SCC size and enhanced sensitivity, appeared early on the bird stem-lineage in non-flying dinosaur precursors. Taken together, our results indicate a deep divergence of SCC traits at the bird–crocodylian split and that living archosaurs evolved from an early radiation with high sensory diversity.

Chapelle, K. E., Benson, R. B., Stiegler, J., Otero, A., Zhao, Q., & Choiniere, J. N. (2020). A quantitative method for inferring locomotory shifts in amniotes during ontogeny, its application to dinosaurs and its bearing on the evolution of posture. *Palaeontology*, 63(2), 229-242.

Evolutionary transitions between quadrupedal and bipedal postures are pivotal to the diversification of amniotes on land, including in our own lineage (Hominini). Heterochrony is suggested as a macroevolutionary mechanism for postural transitions but understanding postural evolution in deep time is hindered by a lack of methods for inferring posture in extinct species. Dinosaurs are an excellent natural laboratory for understanding postural transitions because they demonstrate at least four instances of quadrupedality evolving from bipedality, and heterochronic processes have been put forward as an explanatory model for these transitions. We extend a quantitative method for reliably inferring posture in tetrapods to the study of ontogenetic postural transitions using measurements of proportional limb robusticity.

We apply this to ontogenetic series of living and extinct amniotes, focusing on dinosaurs. Our method correctly predicts the general pattern of ontogenetic conservation of quadrupedal and bipedal postures in many living amniote species and infers the same pattern in some dinosaurs. Furthermore, it correctly predicts the ontogenetic postural shift from quadrupedal crawling to bipedal walking in humans. We also infer a transition from early ontogenetic quadrupedality to late-ontogenetic bipedality in the transitional sauropodomorph dinosaur *Mussaurus patagonicus* and possibly in the early branching ceratopsian *Psittacosaurus lujiatunensis* but not in the sauropodomorph *Massospondylus carinatus*. The phylogenetic positions of these ontogenetic shifts suggest that heterochrony may play a role in the macroevolution of posture, at least in dinosaurs. Our method has substantial potential for testing evolutionary transitions between locomotor modes, especially in elucidating the role of evolutionary mechanisms like heterochrony.

McPhee, B. W., Benson, R. B. J., Botha-Brink, J., Bordy, E., & Choiniere, J. (2018). A giant dinosaur from the earliest Jurassic of South Africa and the transition to quadrupedality in early sauropodomorphs. *Current Biology*, 28(19), 3143–3151.

Sauropod dinosaurs were dominant, bulk-browsing herbivores for 130 million years of the Mesozoic, attaining gigantic body masses in excess of 60 metric tons [1, 2]. A columnar-limbed, quadrupedal posture enabled these giant body sizes [3], but the nature of the transition from bipedal sauropodomorph ancestors to derived quadrupeds remains contentious [4, 5, 6]. We describe a gigantic, new sauropodomorph from the earliest Jurassic of South Africa weighing 12 metric tons and representing a phylogenetically independent origin of sauropod-like body size in a non-sauropod. Osteohistological evidence shows that this specimen was an adult of maximum size and approximately 14 years old at death. *Ledumahadi mafube* gen. et sp. nov. shows that gigantic body sizes were possible in early sauropodomorphs, which were habitual quadrupeds but lacked the derived, columnar limb postures of sauropods. We use data from this [new taxon](#) and a [discriminant analysis](#) of [tetrapod](#) limb measurements to study postural evolution in sauropodomorphs. Our results show that quadrupedality appeared by the mid-Late Triassic (Norian), well outside of Sauropoda. Secondary reversion to bipedality occurred in some lineages phylogenetically close to Sauropoda, indicating early experimentation in locomotory styles. Morphofunctional observations support the hypothesis that partially flexed (rather than columnar) limbs characterized *Ledumahadi* and other early-branching quadrupedal sauropodomorphs. Patterns of locomotory and body-size evolution show that quadrupedality allowed Triassic sauropodomorphs to achieve body sizes of at least 3.8 metric tons. *Ledumahadi*'s Early Jurassic age shows that maximum body mass in sauropodomorph dinosaurs was either unaffected or rapidly rebounded after the end-Triassic [extinction event](#).

Research is still ongoing using the data generated in this experiment to understand the early evolution of locomotion in dinosaurs, as part of a collaboration between Viktor Radermacher, Jonah Choiniere, and John Hutching (Royal College of Veterinary Surgeons).



