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Sauropod dinosaurs and their Role in the Evolution of Endothermy – Scientific Report

Extant non-avian Reptilia are considered ectothermic animals. Dinosaurian reptiles, however, gave rise to birds, which are endotherms. This important evolutionary step from ecto- to endothermy might therefore have taken place in the Dinosauria, and different researchers suppose various thermophysiological strategies in this group, some of them unreported in extant animals. Since histology provides one line of evidence to investigate this important question, I visited the histological laboratory of the Steinmann Institut für Geologie, Mineralogie und Paläontologie at the University of Bonn, Germany. Since Dinosauria is such a diverse group, my project was part of a group project together with Christophe Hendrickx and Dr. Octávio Mateus from the Universidade Nova de Lisboa, Portugal. The main focus of my project was on sauropod dinosaurs of different ontogenetic ages, to see if there are changes in bone structure from very young juveniles to old adults, which might indicate changes in thermophysiology as well.

My short visit began with a short course in histology, including lab work. Basic knowledge about bone in general and dinosaurian bone structure in particular was presented, and its implications were discussed in the class. After this course, I was able to look at various thin sections of sauropod dinosaurs of different ontogenetic stages, in order to investigate possible changes in bone texture during growth. These observations on sauropods were then compared to thin sections of known endo- and ectothermic animals.

Histological research has shown that bone as a living tissue can exhibit various textures, which is associated with changes in growth rate and bone shape during ontogeny. The two main types of bone texture are the slowly growing lamellar-zonal bone and the fast growing fibrolamellar bone. In extant animals, these two bone types show a very clear correlation with thermophysiological strategies: lamellar-zonal bone comprises most of the skeleton of ectotherms, whereas fibrolamellar bone can only be found in endothermic animals, because the organism needs to have a high metabolic rate to support fast growth. However, it remains unclear what evolved first: was the change to a faster growth inducing the development of this novel type of bone tissue, or were high growth rates only possible after the evolution of fibrolamellar bone?

The comparison of sauropod bone with those of extant animals revealed that sauropod thin sections are virtually indistinguishable from mammalian bone. Juvenile sauropods grew at a similar rate as recent mammals and birds, indicating that they had a high metabolic rate. Growth slowed down during ontogeny, but not as much as in mammals. Bone texture changes from early juveniles to old adults, which is best visible in longbones: during ontogeny, vascularization of the bone decreases, whereas organization increases. This means that in young sauropods, bone is deposited very fast and irregularly, with large open canals for blood supply and nerves. As the animal grows older, the canals start to be filled in with bone and to become oriented circumferentially. In very old adults, shortly before growth ceases, a thin layer of lamellar-zonal bone is laid down, indicating slow growth in the last years of life. Whereas this might imply also a change in thermophysiological strategy, one has to take into account that mammals decrease their growth rate without changing from endo- to ectothermy. Furthermore, in sauropods, this change seems to appear only in the very last ontogenetic stages, and sexual maturity is interpreted to be reached much earlier. In contrast to mammals, sauropods therefore continue to grow quite fast as adults.

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Histology as one line of evidence on thermophysiological strategies thus implies a high metabolic rate for sauropods. However, based on histology alone it remains arguable to draw conclusions on thermophysiological strategies, especially regarding the fact that there might have been strategies among dinosaurs, which are not seen in extant organisms, making comparisons difficult. Further studies are therefore needed before being able to publish satisfying results. Since also the other dinosaurian groups studied in our group project all show fibrolamellar bone, such further research would have to focus on the first vertebrates to show this type of bone tissue, or to include studies on the proper body temperature. Therefore, no publication will result from this visit alone in the near future. However, we plan to continue investigating this important evolutionary step from ecto- to endothermy in different ways, and will of course acknowledge the ESF for their support in a final publication.

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